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DOCTORAL DISSERTATION

Complex Adaptive Systems Thinking Approach to IT Investment

Doctoral dissertation submitted to obtain the degree of
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Co-promoter: Prof. Dr Lode Vereeck

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ONDERNEMERSCHAP EN INNOVATIE

Abstract

The main research idea of this thesis is to develop a strategic IT investment framework using primarily military concepts as a basis.

On the one side we discuss the most influencing military thinkers in Belgian Defense Karl von Clausewitz and in the USA John Boyd (together with Karl von Clausewitz). On the other hand, the causes and consequences of a fairly new concept Network-Centric Warfare (NCW) are investigated because NCW has dramatically changed the way in which military operations are undertaken and it is based on an intensive use of Information and Communication Technology (ICT).

The first group of research questions deals with the relevance of military theories (von Clausewitz, Boyd's OODA (Observe – Orient -Decide - Act), United States Marine Corps Command-and-Control (USMC C2) spectrum and NCW) for a contemporary company.

The second major group research questions whether it is good idea to combine Complexity Thinking (CxT) and Systems Thinking (ST) to study Complex Adaptive Systems (CAS). We believe ST is necessary in addition to CxT because ST focuses also on the design of human-made CAS (based on restrictions imposed by humans in the organization and in the environment). Special attention is given to the extension of the Cynefin Framework which is a generic sense-making framework (situational awareness). It defines different spaces each with specific characteristics for management (as IT-investments) and leadership.

The purpose of our CAS*T framework (Complex Adaptive Systems Thinking) is to determine leverage points in the organization in general and IT in particular (adapting Enterprise Architecture). Since situational awareness is essential, we propose our Intelligence Base.

Concerning the research methods, we note that specific to this study we start from the military sciences to create an IT investment framework in the business domain. This requires abstraction of military concepts to transform them into business concepts. That is why we have only used qualitative methods for this reason based on our own experiences (in Defense), literature (mainly military as previously indicated), interviews (open questions, exchanging experiences) and correspondence (article, e-mail).

We have used the scientific inquiry version of John Boyd's OODA: Observe – Orient – Formulate Hypotheses (Decide) – Test (Act).

The testing was done through publications (articles, chapters), conferences (presentation papers), interviews (feedback) and correspondence (feedback).

Keywords: Complex Adaptive System (CAS), Systems Thinking (ST), CAS*T, Cynefin Framework, Observe-Orient-Decide-Act (OODA), USMC, Command-and-Control (C2), Investments, Information Technology, Mental Models, Intelligence Base.

Abstract

Het objectief van dit onderzoek is om een strategische IT-investering kader te ontwikkelen dat zoveel mogelijk gebaseerd is op militaire concepten.

Aan de ene kant bespreken we de meest invloedrijke militaire denkers in de Belgische Defensie Karl von Clausewitz en voor de VS John Boyd (samen met Karl von Clausewitz). Aan de andere kant hebben we een vrij nieuw concept *Network-Centric Warfare* (NCW) gebaseerd op een intensief gebruik van Informatie en Communicatie Technologie (ICT). NCW heeft drastisch de manier waarop militaire operaties worden ondernomen, veranderd. Aldus onderzoeken we de oorzaken en gevolgen van NCW.

De eerste groep van onderzoeksvragen gaat over de relevantie van de militaire theorieën (von Clausewitz, Boyd's OODA (*Observe - Orient -Decide - Act*), United States Marine Corps Command-&-Control (USMC C2) spectrum en NCW) voor een eigentijdse onderneming.

De tweede grote groep onderzoeksvragen bekijkt of het combineren van Complexiteitsdenken (Cxt) en Systems Thinking (ST) relevant is om CAS te bestuderen. Wij menen dat ST noodzakelijk is omdat ST voornamelijk gericht is op het ontwerpen van socio-culturele Complex Adaptieve Systemen (CAS) (op basis van beperkingen opgelegd door mensen in de organisatie en door de omgeving). Speciale aandacht wordt besteed aan de uitbreiding van het Cynefin Framework dat een generieke *sense-making* kader is (*situational awareness*). Het definieert verschillende ruimtes elk met specifieke eigenschappen voor het beheer (zoals IT-investeringen) en leiderschap.

Het doel van ons CAS * T kader (*Complex Adaptive Systems Thinking*) is om hefbomen in de organisatie in het algemeen te bepalen en in IT in het bijzonder (het aanpassen van Enterprise Architecture). Sinds situational awareness essentieel is, stellen wij onze Intelligence Base voor.

Betreffende onderzoeksmethodes, bijzonder aan deze studie is dat het uitgaat van de militaire wetenschappen om een IT-investeringskader in het business domein te creëren. Dit vereist een abstractie van militaire concepten om ze vervolgens om te zetten in business concepten. Daarom hebben we enkel gebruik gemaakt van kwalitatieve methoden op basis van onze eigen ervaringen (in Defensie), literatuurstudie (voornamelijk militaire zoals eerder aangegeven), interviews (open vragen, ervaringen uitwisselen) en correspondentie (artikel, e-mail).

We hebben de wetenschappelijke onderzoeksversie van John Boyd's OODA gebruikt: *Observe - Orient - Hypotheses (Decide) - Test (Act)*.

De tests werden uitgevoerd door middel van publicaties (artikelen, hoofdstukken), conferenties (presentatie papers), interviews (feedback) en correspondentie (feedback).

Trefwoorden: Complex Adaptief Systemee (CAS), Systems Thinking (ST), CAS * T, Cynefin Framework, Observe-Orient-Decide-Act (OODA), USMC, Command-en-Control (C2), Investeringen Informatie Technologie, Mentale modellen, Intelligence Base.

I

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It is with pain in my heart, that Hilde and Ghislain cannot witness the accomplishment of this work. Hilde Winnen, my late wife believed in me and encouraged me to start with this challenge. Prof. dr. ir. Ghislain Hoffman, my mentor, and above all a great friend guided me in my professional career and helped me to keep hold of the holistic approach in all parts of my life and my work.

I would like to acknowledge the continued support of my promoter Prof. dr. Roger Mercken, who was a great guide in our work, Prof. dr. Lode Vereeck, co-promoter and the other members of the Jury for their advice and guidance in structuring and completing this research: Prof. dr. Ghislain Houben, Prof. dr. Piet Ribbers, Prof. dr. Alea Fairchild and Prof. dr. Piet Pauwels.

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I would like to state my appreciation to Gene Bellinger and especially to Dave Snowden for reviewing earlier drafts of my thesis and for clarifying respectively systems and complexity thinking.

Dr. ir. Koenraad Vandenborre and I have spent many hours and cups of coffee discussing and writing papers. It was a fruitful collaboration with much exchanging ideas and information. Therefore I would like to thank him and to wish him success with his work.

Last but not least, I would like to thank my wife Mandy for her support and encouragement, and for the long hours of reading texts about military and business subjects, and for the remarkable accomplishment of helping me to take the final steps to finish this thesis.

Hoeilaart, April 16, 2015

Marc Rabaey

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Abbreviations

ABM	Agent-Based Model
ACOS	Assistant Chief of Staff
AIS	Agent Information System
BAA	Bounded Action Area
BAF	Belgian Air Force
BIA	Business Intelligent Agent
BPEIS	Business Process Embedded Information System
BSC	Balanced Score[C]ard
C2	Command-and-control
CAS	Complex Adaptive System
CAS*T	Complex Adaptive Systems Thinking
CCP	Chinese Communist Party
CHOD	Chief of Defense
CKO	Coherent Knowledge-based Operations
CT	Complexity Theory
CxT	Complexity Thinking
DCF	Discounted Cash Flow
DG	Directorate General
DOD	Department of Defense (USA)
EA	Enterprise Architecture
EAI	Enterprise Application Integration
EARF	Enterprise Architecture Research Forum
EDP	Electronic Data Processing
EIS	(ACOS) Evaluation Information System
ESB	Enterprise Service Bus
IC	Intelligence Community
ICT	Information and Communication Technology
IE	Information Environment
Int B	(CAS*T) Intelligence Base
IO	Information Operations
IT	Information Technology
IW	Information Warfare
KM	Knowledge Management
KPI	Key Performance Indicator
LP	Leverage Point
MOD	Ministry of Defense
NCB	Network-Centric Business
NCW	Network-Centric Warfare
NDM	Naturalistic Decision Making
NPS	Naval Postgraduate School
NPV	Net Present Value
OODA	Observe-Orient-Decide-Act
OOHT	Observe-Orient-Hypothesize-Test
PV	Present Value
RFI	Request for Information
RFP	Request for Proposal
ROA	Real Option Analysis
ROI	Return on Investment
ROV	Real Option Valuation
SOA	Service-Oriented Architecture

SoS	System-of-systems
ST	Systems Thinking
TOGAF	The Open Group's Architecture Forum
USMC	United States Marine Corps
WS	Web Services
WHO	World Health Organization

1. Introduction and Research Questions

1.1. IT is everywhere

In 1985 I could say that I knew most of all techniques, programming and systems in CVIMD ([1]). At the end of 2002, when I left the IT of the Medical Service of the Belgian Defense, this was not the case anymore, although I knew much more than in 1985.

The reason was that *things got complicated* but most of all because there were much more systems (hardware, software, middleware, applications, services) and they were all interconnected through a network (though on different levels).

Moreover IT evolved from Electronic Data Processing (EDP) to technology that entered in the daily life of people and business, and it doesn't stop evolving and intervening. IT is ubiquitous and just like electricity IT will become a commodity.

Sometimes it is integrated in other systems, sometimes it is clearly a defined and recognizable system. We see these phenomena also in the military. So is IT enabling concepts as Network-Centric Warfare (NCW), which along with the move from platform-centric to network-centric warfare, changed also the command-and-control (C2).

1.2. Reductionist Thinking

Not only military thinking is changing, but also business thinking. The time has come to broaden the traditional approach to leadership and decision-making. There are many reasons but the principal reason is that for twenty to thirty years leaders assumed that concepts/tools like business process re-engineering and Six Sigma, which are very rigid methods based on linear assumptions of causality, could satisfy their need of decision making and moreover you could do anything within a measurement structured environment (Snowden, 2010). So Snowden & Boone (2007) “believe the time has come to broaden the traditional approach to leadership and decision making and *form a new perspective based on complexity science.*” [italics added].

During my studies at the Belgian Royal Military Academy ([2]) I was taught differently and analytical thinking was the only right way to think. After my studies at the Royal Military Academy I went straight into the Information Technology (IT) of the Belgian Defense Medical Service: a domain of pure analytical thinking. So, we were trained in analytical thinking and my job demanded that way of reasoning, we all became reductionist thinkers. As a matter of fact, from primary school on, we were trained to become masters in reductionist thinking. It is not a surprise that it has been a long journey to start from pure analytical thinking to (accept and practice) holistic thinking.

In CVIMD everything went well (only EDP) until new projects were started. Analysis did not and could not capture the whole picture of the working environment of our clients. Something in our thinking or methods had to change, our journey from reductionist toward holistic thinking based on *complexity science* had started.

I started the studies of commercial engineer at EHSAL ([3]) which helped me a lot with the request for proposal of the upgrade of the IT of the Medical Service, the evaluation and the realization of the upgrade. Here I could see how beneficial it was to be able to look at problems from different perspectives: business, engineering, medical and military. Our thesis was about IT-investments in an automated administration (Rabaey, 1991). It was based on the value of information, however the conclusion was that this method was very subjective (contextual) even inside an organization.

1.3. Art of War and Investments in IT

One of our suggestions for further research was to develop a strategic IT investments framework for all kinds of organization based on the principles and rules of the Art of War (Bernard, 1976) and related military concepts. In literature on the mapping between Art of War and business strategy, we have found many sources (Cohan, 2004; Fayard, 2004; Krause, 1995; 1997; Michaelson, 2001; Yua, 1991), but we did not find any reference of a mapping between Art of War and IT investments, which was and is an original idea.

So, that was our starting point for our doctoral thesis, but remarkably one of our conclusions is that (in the context of complexity theory (CT)) these principles and rules of the Art of War are of no use for the

1 CVIMD Centrum voor Verwerking van Informatie van de Medische Dienst (Dutch: Electronic Data Processing (EDP) of the Medical Service of the Belgian Defense.

2 In Dutch: “Koninklijke Militaire School”; in French “Ecole Royale Militaire” http://www.rma.ac.be/ I studied Military and Social Science, specialization Hospital Management

3 Economische Hogeschool Sint-Aloysius, now merged into Hogeschool Universiteit Brussel (HUB) http://www.hubkaho.be/

military (Rabaey, forthcoming1). Still regarding the investments in IT we will introduce Complex Adaptive System (CAS) and Systems Thinking (ST) into the enterprise.

ST has many forms, but we are basing our concept on the ST defined by Gharajedaghi (2011). In the context of enterprise, ST is in essence a holistic approach to organize an enterprise in function of its environment. Sterman (2010) defines ST as “the ability to see the world as a complex system, in which we understand that 'you can't just do one thing' and that 'everything is connected to everything else' ” (p. 4).

Our combination of CAS and ST is called Complex Adaptive Systems Thinking (CAS*T) where investments are in essence organizational changes of a CAS.

In this light, and after a military career of more than 30 years of experience, we propose a new concept of management, which will not only incorporate the IT view but also a global (holistic) view on the enterprise. So our aim is not only to present tools, but also a philosophy and a framework. As for must business, the tools may be important, but the vision and the strategy to use these tools are much more important.

1.4. Complexity

Many definitions of complexity exist (Holmdahl, 2006) but the definition of Mikulecky (2001) comes very close on how ST approaches systems: Complexity is the property of a real world system that is manifest in the inability of any one formalism being adequate to capture all its properties. Complexity Theory (CT) as related to complexity is not a subset of an existing science, on the contrary CT is a new set of ideas that transcends the physical, biological and social sciences (Schneider et al., 2006).

ESD (n.d.) distinguishes three types of complexity, which can be thought of as generating three types of complex systems:

- Static/Structural complexity – associated with problems of complex structure, which is the domain of Operational Research and Computer Science.
- Dynamic/Behavioral complexity – associated with problems of complex behavior. This is basically the degree to which the outputs (behavior) of a system are difficult to connect to the inputs (Sterman, 2010).
- Analytical/Evaluation complexity - associated with problems that are difficult to evaluate. Systems exhibiting analytical complexity involve value disputes and multidimensionality, complicating the evaluation of and choice between policy options. This suggests that the system in question is improperly defined.

Another distinction is made by Manson (2001), namely algorithmic, deterministic and aggregate complexity.

- Algorithmic complexity', in the form of mathematical complexity theory and information theory, contends that the complexity of a system lies in the difficulty faced in describing system characteristics.
- Deterministic complexity' deals with chaos theory and catastrophe theory, which posit that the interaction of two or three key variables can create largely stable systems prone to sudden discontinuities.
- Aggregate complexity concerns how individual elements work in concert to create systems with complex behavior (p. 405).

Complexity research increasingly considers systems of linked components, or aggregate complexity. Algorithmic and deterministic complexity rely onl simple mathematical equations and a number of assumptions of how complex systems work. Aggregate complexity instead attempts to access the holism and synergy resulting from the interaction of system components (p. 409).

Since our subject are organizations we will limit our discussion to dynamical/behavioral and aggregate complexity.

1.5. Research

1.5.1. Research Idea

The main research idea is to develop a strategic IT investment framework starting from military concepts and use as much as possible these concepts, therefore we will limit discussions of non-military concepts.

We will on the one hand discuss the most influencing military thinkers in Belgian Defense Karl von Clausewitz and John Boyd for the USA (together with Karl von Clausewitz). Although Sun Tzu is an even more referred military thinker, we will not study his works because it requires a thorough knowledge of Eastern (Chinese) philosophy.

On the other hand, a fairly new concept Network-Centric Warfare (NCW) based on an intensive use of

Information and Communication Technology (ICT) has dramatically changed the way in which military operations are undertaken. So we will investigate the causes and consequences of NCW.

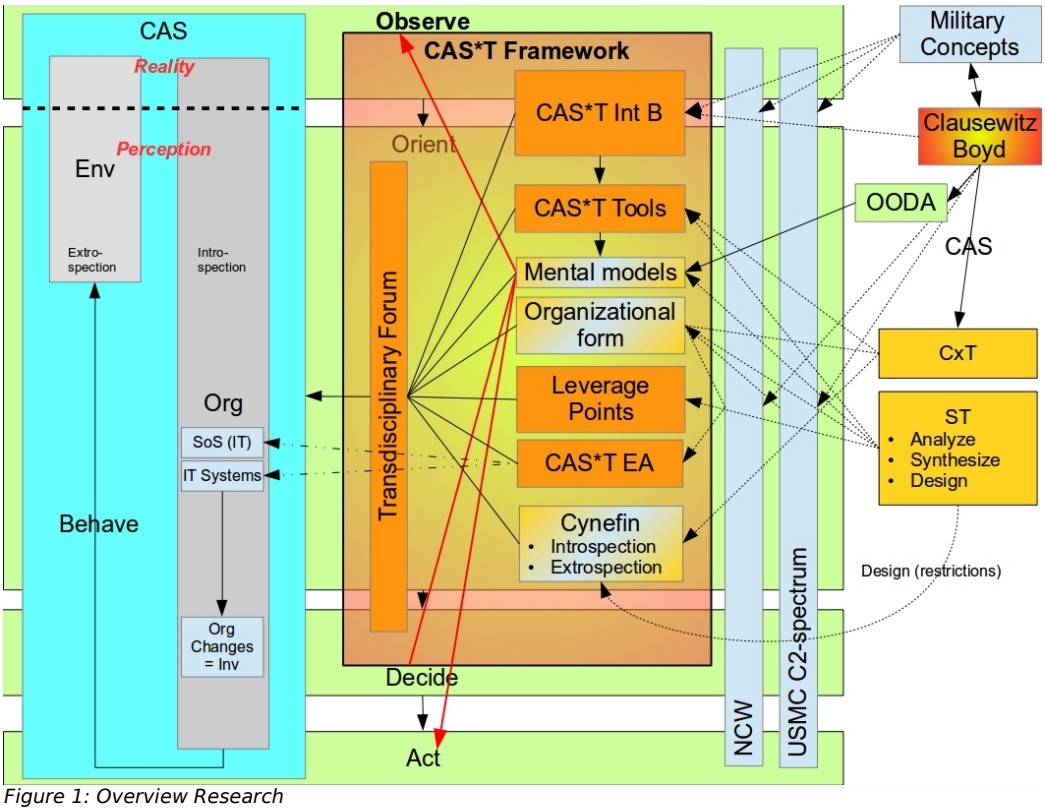

Figure 1: Overview Research

Figure 1 gives an overview of the research. The current business world is compressed in time and space, and in general it seems to be in the same situation as armed forces engaged in war, thus complex and/or chaotic.

1.5.2. Research Questions

1.5.2.1. Karl von Clausewitz: relevance

Karl von Clausewitz wrote *On War* in the beginning of the 19th century. Since he is still influencing, which elements are timeless and are still relevant for contemporary organizations (strategy, investments)?

We believe there is a fair opportunity as Beyerchen (1993, 1997) points out that Karl von Clausewitz was describing War as a complex (adaptive) system but not with the actual vocabulary of CT.

1.5.2.2. John Boyd: OODA for organizations

John Boyd developed an individual complex decision-making framework OODA (Observe-Orient-Decide-Act). Can this OODA be used in an organizational decision-making framework for IT, especially CAS organizations?

1.5.2.3. USMC C2-spectrum

Based on the theories and concepts of Karl von Clausewitz and John Boyd, the United States Marines Corps (USMC) has developed a flexible, adaptive command-and-control (C2) system capable to be deployed in different situations: USMC C2-spectrum. Should civilian organizations adopt also this philosophy or concepts? Different types of C2 imply different types of leadership and organizational forms, how can a civilian organization determine when what to use. We believe the well-known Cynefin framework can be extended in this respect.

Related to this is the universal rule of the Art of War: Continuously Seeking Intelligence. To continuously gather intelligence is an important rule in the theories and concepts of Karl von Clausewitz, John Boyd and USMC C2-spectrum. Can a civilian organization implement this rule by using a concept like CAS*T Intelligence Base and use it for the situational awareness?

1.5.2.4. Mental Models

The Orient-phase of the OODA-loop is the seat of the mental models which determine how an organization is structured, how it is operating and thus is relevant for investing. How can these mental models and the underlying concepts be used to invest in the organization in general, and in IT in general (EA)?

Which tools can be used to construct these mental models (CAS*T-tools)?

1.5.2.5. Cynefin Framework

Mental models are a cognitive representation of the environment and so they indicate how much an organization is aware of its situation. The Cynefin framework is a sense-making framework, how can the Cynefin framework be used to assess the situational awareness and its own perception?

The Cynefin framework defines different spaces each with specific characteristics. What consequences have these characteristics for management and leadership in general and IT-investments in particular?

1.5.2.6. Network-Centric Warfare: centralization and decentralization

ICT made NCW possible (compression time/space) and the NCW philosophy itself made decentralized execution possible. However the organizational form types needed to be adapted, how can ST help with this and what are the consequences to build IT-systems (Enterprise Architecture, EA)?

1.5.2.7. Investment techniques

Besides the investment question related to Cynefin framework, are option games a useful extension of Real Option Valuation (ROV) to integrate interactions with the environment?

Can the leverage points hierarchy be used to know where and how to invest (organizational changes) so that investments are more effective and efficient?

How can a transdisciplinary approach contribute more to assess investments in general and in IT in particular?

1.5.2.8. Systems Thinking

Complexity Thinking (CxT) and Systems Thinking (ST) handle CAS. Is ST necessary in addition to CxT because ST focuses also on the design of human-made CAS (based on restrictions imposed by humans in the organization and in the environment). Hence CAS*T-framework?

1.5.3. Research Methods

Special about this study is that it starts from the military sciences to create an IT investment framework in the business domain. This requires abstraction of military concepts to transform them into business concepts.

We have only used qualitative methods for this reason. The sources are:

- Own experiences;
- Literature (mainly military as previously indicated);
- interviews (open questions, exchanging experiences);
- Correspondence (article, e-mail).

We have used the scientific inquiry version of John Boyd's OODA: Observe – Orient – Formulate Hypotheses (Decide) – Test (Act).

The testing was done through publications (articles, chapters), conferences (presentation papers), interviews (feedback)and correspondence (feedback).

1.6. Structure of the thesis

In chapter *2 Organizations as Complex Adaptive Systems* we define first what a (human-made) organization is and how it is related to its environment which leads us to discuss strategy. But to understand better how strategy is formed, we need to examine mental models. These implicit models determine the self-awareness and functioning of the organization in a complex environment. In order to handle these complexities, we need other ways of thinking than the reductionist thinking, like Complexity Thinking (CxT) and Systems Thinking (ST). We pay especially attention to the transdisciplinary approach. Further we explore Complex Adaptive Systems (CAS) and their possible organizational configuration. Then we explain the idea of CAS*T (Complex Adaptive Systems Thinking) which is making the bridge between two distinct concepts to handle CAS: CxT and ST.

The Balanced Scorecard (BSC) case in chapter 2 is to show how the actual culture of a CAS is determined

by its evolution (path dependence).

Chapter *3 War as Complex Adaptive System* holds the military topics like command-and-control system (C2) which needs to be adapted to the situation in which the unit is. Then we study the relationship between tactics and strategy, especially the tacticization of the strategy.

NCW is then explained to show how decentralized execution is done in a complex and chaotic environment. The organizational configuration is a hybrid structure between a biological and networked organization.

Next we discuss the observe-orient-decide-act (OODA) of John Boyd. Originally a complex decision making process for a pilot, we bring it at the level of a CAS, thus also in the business domain. The orient-phase is the seat of the mental models, which influence the observation, decision-making and execution, thus the whole functioning of and thinking in the organization and therefore also the IT-investments.

It is remarkable that a lot of reductionist military philosophies are based on the work of Karl von Clausewitz *On War* while we have discovered through the works of Beyerchen (1992, 1997) that von Clausewitz was using CxT though without the vocabulary of it. Based on his work and that of Boyd and NCW we conclude that War is a CAS.

The US Marine Corps (USMC) have integrated all this into the C2-spectrum. However it is too specific for the USMC that we cannot *copy-paste* it to other organizations; thus also for the situational awareness assessment.

This brings us to chapter 4 A Generic Sense-making Framework: Cynefin, more precisely the Cynefin framework. The Cynefin framework makes the organization and/or its parts aware of the possible contexts of the organization and/or its parts, more precisely the interactions of agents and the systems.

There are four spaces. Two ordered spaces (simple, complicated) where the system is predictable and rule-based. In the unordered spaces we have chaotic space in which there are no rules; and then you have complex space in which the rules are and agents change each other and they are constantly interacting with each other. The fifth domain space the disordered one (Snowden, 2010).

Dettmer (2011) uses the Cynefin framework to determine which management methods and tools can be used in which context. Important to note is that systems can move from one space (or context or domain) to another without the enterprise knowing about it (necessity to have an intelligence system).

We extend this framework and give examples of how it can be used to improve the situational awareness and to determine which type of leadership and management philosophies should be used.

In the context of investments, Real Option Valuation (ROV) was a possible technique, however although ROV gives flexibility to the decision-makers, it lacks the interactions between the enterprise and its environment. Our promoter asked us to study the possible use of game options, a combination of game theory with ROV. The results haven been presented at the annual conference on procurement at the US Navy Postgraduate School (NPS).

The case BASF shows that information systems should not be in the same space as their users. Important is that all the agents have access to the different resources and above all can collaborate with each other.

In chapter 5 The consequences of CAS*T for EA, we will examine IT as system in an organization or integrated in of a system-of-systems, especially in the context of an enterprise architecture (EA).

EA is “the continuous practice of describing the essential elements of a socio-technical organization, their relationships to each other and to the environment, in order to understand complexity and manage change.” (EARF, n.d.). In the beginning, EA was more an IT-framework, but over time it started to handle more than only IT in the enterprise. It is crucial for the success of implementing and using EA, that EA is adapted to function in a context that may permanently change.

Therefore in the CAS*T framework, we propose an additional phase - the Business Process Embedded Information System (BPEIS, or Agent Information System (AIS)) - and an additional layer, the knowledge layer. So as part of the CAS*T framework, we conceived CAS*T-EA, which is one of our original concepts presented in this thesis.

The purpose of the CAS*T tools (also in chapter 5) is not only to describe CAS but also to make the mental models more explicit, so that we can find easier the leverage points in the CAS. The proposed tools are phylogenetic trees, cognitive mapping, Bayesian networks, Causal Loop Diagrams, Stock Flow Diagrams (see appendix 1) and Agents Based Modeling.

In addition of these tools, using the Cynefin framework, the organization can adapt its (emergent) strategy. It can self-organize and try to influence the environment, also a CAS, to create a better context for its strategy. In both cases the hierarchy of leverage points should be used to determine at which level the organization should intervene.

CAS are interacting with its environment where mostly much uncertainty exists. In order to reduce the uncertainty and/or to act by accepting a certain level of uncertainty, the CAS will create intelligence. In chapter 2 we have seen that intelligence is necessary to update the mental models and for a CAS to co-evolve with its environment. In chapter 3 we have focused on the role of intelligence in the process of decision-making.

In chapter 6 CAS*T Intelligence Base, we are putting these functions into our framework and are also discussing the other function of intelligence namely to increase and update our knowledge and our original concept of intelligence base, originally developed for the military but that can be used in a civilian and/or business context. After this we will discuss the Evaluation Information System (failure) and the triple loop learning.

Until now, we have discussed CAS*T in the context of the organization (CAS) in a CAS environment.

In chapter 7, we make our final conclusions and we are proposing projects and further research concerning CAS*T and investment techniques.

We have added appendices of which in one we go in more depth on Cloud Computing (CC). Our promoter Prof. dr. Roger Mercken instructed us to examine CC, a new technology that makes a lot of progress nowadays (appendix 3 Investments in Cloud computing (CC)). As a result, we have published a number of chapters in different scientific books related to EA (Rabaey, 2012; 2014), CC (Rabaey, 2012a; 2012b; 2014). Although we had many contacts with big CC players on the market, none could or would give us enough data to make a case for testing our original concept.

2. Organizations as Complex Adaptive Systems

2.1. Definition of Organization

Holmdahl (2006) writes that one purpose of organization science is to facilitate design, or in other words, to change and improve upon organizations. A very important aspect is the fit between the organization and its environment achieved through evolution and adjustment. Obolensky (2010) refers in this context to the Evolution Theory of Darwin in which the survival of the fittest was not about the strongest or physically fittest, but about the fittest for purpose or the best fit of the situation, thus environment.

In this regard, Holmdahl (2006) esteems that it is convenient to see the organization as an organism that survives by continuous adjustment to its environment. If the organization is an organism or a collection of organisms then the environmental assessment (we call it situational awareness) must be a critical focus for long-term survival and success.

In this context, we would like to define an sociocultural (men-made) organization as follows: An organization is as a set of

- Agents;
- An environment;
- Interactions – formal as well as informal – within and betw120%een the two above categories;
- One or more purposes;
- and that is capable of learning.

2.2. Definition of Strategy

Strategy can be defined in many ways. For the purposes of our research, we will formulate a definition taking into account a number of characteristics.

2.2.1. Environment and Strategy

An organization is an open, purposeful system that interacts with its environment. It will first observe the internal (organization) and external (environment) situation before making decisions to act, or more in general to behave (not-acting is also a behavior). These behaviors will be observed by other actors (agents) in the environment and they will react upon it (ignore, collaborate, compete, agree, disagree, etc.). Of course, the organization itself will behave in a similar way upon the actions or reactions of the other actors.

All of these actions and reactions will have effects that cannot always be fully assessed beforehand. It is possible that the effects are just the opposite of the goals defined by the organizational strategy. But, what is strategy? “Once upon a time, everybody knew the answer to this question. A strategy specified a precommitment to a particular course of action. Moreover, choosing a strategy meant optimizing among a set of specified alternatives on the basis of an evaluation of their relative value and the probability of their possible consequences. [...] But it is fair to say that this notion of strategy is falling into increasing disfavor in the business world, to the extent that the CEOs of some important and successful firms will not permit the word 'strategy' to be uttered in their presence.” stated Lane and Maxfield (1996) in their article *Strategy and complexity: Fostering generative relationships.*

To John Boyd, the aim or purpose of strategy is to improve our ability to shape and adapt to unfolding circumstances, so that we (as individuals or as groups or as a culture or as a nation-state) can survive on our terms (Holmdahl, 2006).

Strategy has a connotation of control, which is unrealistic in a complex environment as our world is now today. Since we cannot have control, we have to observe our own organization and its environment to be able to respond in the most appropriate way. That is why in the *Art of War* the only rule for the first principle (balance goals and means) is the permanent collection of intelligence (interpreted information observed in the organization and environment) (Bernard, 1976). So it is very important to continuously monitor the organization and environment.

In this context, Lane et al. (1996) define strategy as “a process consisting of a set of practices, in which agents inside the firm structure and interpret the relationships, inside and outside the firm, through which they both act and gain knowledge about their world.” (p. 225)

The goals may be to gain resources (possessions) and/or to gain power (social order). The government can regulate these transactions.

Before given our own definition of strategy, we will discuss other definitions starting from the military.

2.2.2. Strategy: Babylonian confusion

Originally related to military affairs, the word “strategy” nowadays has several different meanings and can sometimes be confused with the word “tactics”. For some people, when something is of great

importance to the director of an organization, then they may see it as strategic. To others strategy has to do with long term, or expensive investments (John Kay in Mintzberg et al. (2005, p14-15)).

The Oxford Dictionary defines *strategy* as

1. a plan designed to achieve a particular long-term aim and
2. the art of planning and directing military activity in a war or battle.

The dictionary also refers to tactics as contrasted with strategy, where *tactic* is

1. an action or strategy *(sic)* planned to achieve a specific end and
2. (tactics) the art of disposing armed forces in order of battle and of organizing operations.

The non-military meaning of strategy focuses on a plan for achieving a long-term goal. The question arises what long-term means, so the definition is flue. An aim to be achieved in two months can be essential to the survival of an organization, and therefore strategic, regardless of the relatively short period of time defined. As Henry Kissinger once said: “Strategy is the mode of survival of a society” (Osinga, 2005).

Holland (2008) shows that strategy (game theory), control policy (control theory) and reaction net (biology) have a lot in common, even that conceptually they are the same because it is about Complex Adaptive Systems (CAS). Adaptation occurs when agents learn from each other or change strategy as they gain experience.

The “Dictionary of Military Terms” DOD (1999) defines strategy as “The art and science of developing and using political, economic, psychological, and military forces as necessary during peace and war to afford the maximum support to policies, in order to increase the probabilities and favorable consequences of victory and lessen the chances of defeat.”

2.2.3. Grand Strategy

To Professor Bernard (1976) this is the Grand Strategy (p.26). He defines also operational strategy as the strategy exercised in the theater of war. As a matter of fact, strategy is a situational term, meaning that the word strategy needs an adjective to indicate on which level, or in which position the term is being used.

In his chapter “The Theory of Strategy”, Liddell Hart (1991) uses more than one definition of strategy, by using adjectives (pp.319-333). His definition of (military) strategy is “the art of distributing and applying military means to fulfill the ends of policy.”([4]) The military strategy is an application of the grand strategy: “For the role of grand strategy -higher strategy- is to co-ordinate and direct all resources of a nation, or band of nations, towards attainment of the political object of war – the goal defined by fundamental policy. ... Furthermore, while the horizon of *(military)* strategy ([5]) is bounded by the war, grand strategy looks beyond the war to the subsequent peace.” So, the grand strategy defines the objectives for the military strategy. If the objectives are attained (through the output of military actions) then the output may have the outcome (situation in peace time) as wished by the government.

Clausewitz's work ends with an analysis of the most important functions of political and military leadership in war, and more fully integrates war into social and political intercourse. (Paret, 1986, p.198). Leadership is important and the link between leadership and strategy is crucial for the grand strategy, as well as for the military strategy. Cohen (2004) remarks that good plans are made and implemented under the guidance and direction of good leaders at all levels. (p.x). Therefore the relationship between the leaders of the different strategies (grand strategy, military strategy, diplomatic, economical, and so on) must be clear. It is obvious that he had a hierarchal view on organizations.

The link between politics and military was not only for Karl von Clausewitz (1997) essential. Bülow ([6]) also “insisted on the need of a single unifying intelligence at the head of a state.” There could be no separation between politics and war. Successful generals must understand foreign affairs, like successful diplomats must understand military actions (Palmer, 1987, p.117).

2.2.4. Beyond the military

Strategy does no longer belong exclusively to the military or political domain (Grand Strategy). Some authors have broadened the meaning of strategy beyond the military. In Rabaey (2004) we define strategy as “the art to concentrate (combine) all resources of an organization or network of organizations, to achieve its main goal”.

John R. Boyd gives a more dynamic dimension to strategy: ”*(Strategy is)* a mental tapestry of changing

4 Policy in the sense of War Policy: “a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions”. War Policy is a part of the General Policy (of a nation) which is “a high-level overall plan embracing the general goals and acceptable procedures especially of a governmental body” (Definitions coming from Webster on-line).

5 Therefore we speak also of military strategy, which is to DOD (1999): “The art and science of employing the armed forces of a nation to secure the objectives of national policy by the application of force or the threat of force.”

6 Heinrich Dieter von Bülow (1757-1807), Prussian military writer. He was one of the first authors to write about “political space”, which later evolved into geopolitics.

intentions for harmonizing and focusing our efforts as a basis for realizing some aim or purpose in an unfolding and often unforeseen world of bewildering events and many contending interests". Its aim was to "improve our ability to shape and adapt to unfolding circumstances, so that we (as individuals or as groups or as a culture or as a nation-state) can survive on our own terms." (Hammond, 2001, p.161).

Due to the unpredictable unfolding circumstances when a plan starts to be executed the environment has already changed and the commander needs to adapt his plan. Therefore the organization needs to collect information on a permanent basis (observe). For its survival, it has to process a permanent stream of information into intelligence, so that the commander can reorient effectively and efficiently his plan of action.

2.2.5. Emergent Strategy

2.2.5.1. From 'As-Is' to 'To-Never-Be'

An organization is moving from a situation "as-is" towards a situation "to-be" interacting with its environment to attain goals in the future. However this is only possible when cause and effects are known. But even if cause and effects could be known, due to interactions within and with its environment, an organization has to adapt its strategy. This may concern the way to reach the "to-be", or the goals to attain, and therefore also the way to attain them.

Morecroft (2009) mentions that *Resource Based View* theory explains why an enterprise has a competitive advantage, namely that this enterprise has resources which are rare, inimitable, valuable and non-substitutionable. However he gives an example of the motorbike industry where two companies have basically the same resources (materials), nevertheless one company has a competitive advantage because of the way it manages and coordinates the processes. So the means or resources could be relevant, but to us the capabilities, which include structure, functions and processes, thus the organization, are even more important.

Hence we are stating that an organization harmonizes its resources with the *will* to attain the self-defined goals in its environment. The way to behave (act / non-act) is its strategy. We have three factors: goals, means (capabilities) and will. All these have to be harmonized at the same time (and at the same place), otherwise one factor can become a product of the other two. Additionally the interdependent relationships are part of the harmonization process and cannot be determined beforehand.

Therefore to Colonel Reed (2006) extensive planning even combined with the best intentions, does not guarantee success. Better prediction is not the answer, nor is it possible. In a complex world where order is circumstantial, any reliance on plans is rather futile (Holmdahl, 2006).

Since an organization and its environment are co-evolving, we can in general agree with Snowden (2013) who declares that the evolution from "as-is" situation towards "to-be" is unrealistic and thus not useful because the environment is so quickly changing that when you have obtained your "to-be-goals" they would not be anymore desirable or relevant. So we may say that the initial strategy is from 'As-Is' to 'To-Never-Be'.

Nevertheless planning is very important (Holmdahl, 2006, p.66):

- During planning, management's discussion on possible future scenarios creates a "memory of the future" so that when circumstances unfold they are met with prepared actions conform a shared vision of the organization on its future.
- A shared knowledge of plans may be used as a coordination mechanism for individual improvisation.
- Plans can be conceived as actions unfold, making economizing with scarce resources easier.
- The planning process can yield organizational learning, shared mental models, in fact a meta-language.

Separation between the observers and the planners (e.g. between first line operators in contact with customers/users and senior management) is a source of information filtering and delay, which can be dangerous in a fast paced environment. The solution is to merge action with planning, resulting in a bottom- up design more efficient than any top-down design (Wesensten et al, 2005).

So we may not abandon completely planning, certainly not in the ordered spaces, but even in a complex situation except for the time-line concept, the planning process can be useful. Moreover, if by a lively preparatory communication the organization's agents have acquired a shared understanding of proper actions and shared mental models, then they can effectively think as one whole (Artigiani 2005).

2.2.5.2. Evolutionary Biology

Watts (2004) suggests that evolutionary biology might offer an exemplar for an overarching theory of war than quantitative or hard sciences such as physics. "Behind that suggestion lay the suspicion that the parallels between the various levels of war and the hierarchy of biological organisms may be more than superficial. A key concept of evolutionary biology is emergence, meaning 'that in a structured system, new properties emerge at higher levels of integration which could not have been predicted from a

knowledge of the lower-level components.' Emergence ... is one of the two major pillars in the explanatory framework of modern biology, the other being the concept of genetic programs that evolve through natural selection. Emergence is also the fundamental concept of the relatively new field of artificial life. Typical experiments in this field involve setting up artificial worlds or environments inside a computer. These worlds generally contain 'agents, an environment, and rules that define and govern agent-agent, agent-environment, and environment-environment interactions.' ... [E]mergence refers to 'the appearance of higher-level properties and behaviors' possessed by the 'whole' rather than by any of its individual parts, the point being that 'an air molecule is not a tornado and a neuron is not conscious'." (p.85)

Knowledge (based on passed experience and information coming from inside and outside the organization) is contained in the different domains of the organization (business and resources). But it is only by bringing them together that the organization can bring its consciousness to a higher level, and therefore can be open for emergent phenomena.

In the case of warfare, Watts (2004) continues: "What this line of thought suggests, is that the most general aim of combatants at every level of combat -tactical, operational, and strategic- is to achieve emergent effects at the next higher level. This formulation [...] recognizes the inherent uncertainties of combat interactions between opposing polities, military forces, and individual combatants. The various agents just mentioned -from opposing polities to individual combatants- can, of course, be understood as instances of complex systems. Indeed, because military units and polities contain individual humans, one ends up with complex systems inside other, higher-order complex systems. This perspective obviously parallels biological hierarchies." (p.86)

2.2.5.3. Adaptive Strategy

As a consequence of the small iterations, the emergent phenomena, and the complexity of the system itself and its environment, no plan survives the initial stages of a campaign (military, nor business). Figure 2 shows that the plan established at time t-1 is based on the situation or state S_{t-1} and the project of the situation at t, being S'_t. The plan is executed but at time O an observation (of one or more events) is being made which after reflection has as consequence that the original plan has to be adapted because of the (re)actions of the other parties (friends, foes, neutral parties). The observation could be ad hoc or through a cycle. So at time t based on the S_t and the project of the situation at t+1, being S'_{t+1} the plan is adapted. This can take some time before the plan is executed. And the cycle continues with observation O+1 and after reflection the Situation S_t has to be adapted. The cycle starts all over again on time t (Situation S'), time t+1 (Situation S+1).

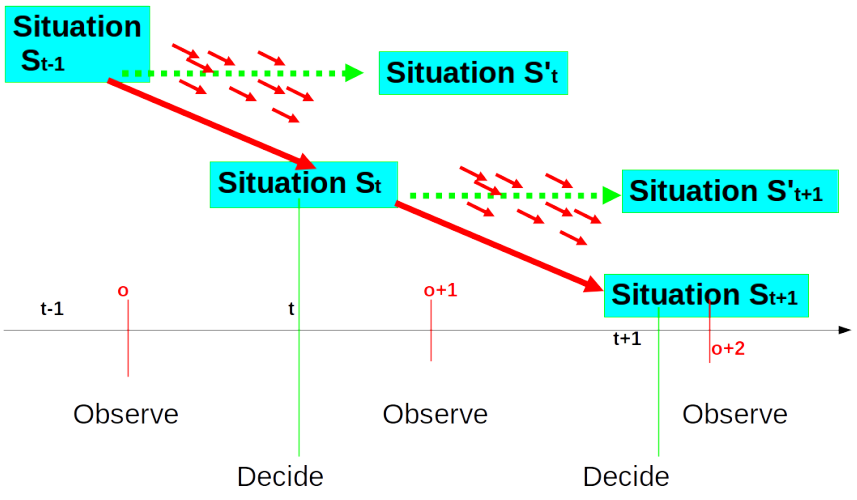

Figure 2: Emergent Strategy

2.2.6. Shared Vision

Shared vision is not the same as common vision. Common vision can be ad hoc and/or there is no commitment needed. A shared vision is an agreed common vision with a commitment to work together to attain one or more shared goals belonging to the whole which is more than the sum of its parts.

A conditio sine qua non for a good strategy and its execution, is that a shared vision exists supported by shared culture. Taggart (2011a) emphasizes that shared vision emerges from personal visions, and this is how energy is formed and commitment created.

This (emergent) energy is necessary to adopt and adapt the (emergent) strategy and its execution. Taggart (2011a): “Managers must therefore walk a fine line when they express their own visions. To master the discipline of building shared vision requires that managers understand that visions are not announced from the top or that they come from strategic planning processes.

The traditional approach to creating a vision for the organization has largely failed in most organizations because employees have been unable to connect with the vision developed by management. In other words, the vision that’s communicated to employees has not built on the personal visions of others. They’re not enrolled in the vision. The consequence has typically been apathy and a lack of energy on the part of people.”

This energy is what keeps a networked organization together. The agents are capable of keeping the big picture of the organization in mind (not only their part) so that they can suggest relevant strategy updates to the network.

So, in a networked organization, which has no formal structure, we can hardly speak of a grand strategy but of a shared vision. In what follows grand strategy can be read as a shared vision for a networked organization.

In the case of a hierarchical organization this can only be obtained if the leader is the personification of a shared vision on the condition that if the leader is accepted by the personnel, the people are willing to execute the strategy (based on that shared vision). Moreover there must be a good bi-directional, respectful communication between the brain of the organization (leader) and the employees, otherwise it will be difficult to have an adequate responding (adapting) organization and emergent strategy.

Mikulecky (2001) states that the system has within itself a model of its environment that it uses to influence present behavior in anticipation of future events. The members of the organization take actions they feel that will move towards desired futures. This is only the case if the desired futures are compatible with the shared vision, supported by the whole organization, for which Holmdahl (2006) claims that a (networked) organization is thus at least partially a product of human intention.

This implies that the shared vision of an organization takes into account the organization itself (self-awareness) and the environment (situational awareness). This is essential for the generative learning (working towards desired futures) as for reactive learning (coping with issues to survive). An ant colony is capable of the first, a human organization is capable of both. The human organization is what we will discuss.

So, shared vision ([7]) is not only important to strategy but also to learning (Senge, 2006). In this case, shared vision provides a focus and energy for learning. “Senge means generative learning rather than adaptive learning, that is, expanding an organization's capacity to create its own future, rather than be created by events of the moment.” (Flood, 1999, p. 24).

Schneider et al. (2006) have another approach. The binding factor is of the members of an organization is the organizational identity. They correctly state that an organization's identity can be the primary constraint on its adaptive capacity. An identity that is too rigid will discourage adaptation by encouraging narcissism and a lack of reflexivity, exemplifying a frozen system. An identity that is too malleable is also problematic; it may encourage an organization to become hyper-adaptive and allow image to replace substance, leading to non-adaptive chaotic system (pp. 357-358).

However we state that shared vision is the basis and that organizational identity is just a consequence of the accepting of a shared vision (based on the actual mental models and derived culture ((Figure 3)) ([8]).

Finally, that organization will develop a strategy, based on what it has learned and the will to act (or not) with its capabilities (or means at a lower level) to attain its self-chosen goals in its environment. It gives direction where the organization wants to go to or what it will be or attain.

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7 Gharajedaghi (2011) calls it shared image.

8 Regarding fanatic terrorism, followers have a lack of own developed (strong) mental models. So they join a group and take over the mental models of the terroristic group (probably based on dogma's). As a consequence they will identify them with the group (organizational identity). The terrorist group can also actively destroy the individual mental models (indoctrination eventually by force) and thus construct the mental models of the group in each individual.

2.2.7. Our Definition of Strategy

Based on our definition of organization and the discussion above we are defining strategy as the dynamic behavior of the organization and its agents as a result of the will to act with its means to attain its self-chosen goals in its environment.

As a consequence of the art of combining all resources of an organization with respect to goals and will, a dynamic, flexible and evolving plan is created and updated to achieve its main goals inside a defined environment. The organization or entity could be a country, an alliance, a group or even a person.

The adjective used to situate the strategy will define the context. The observation of the environment (the collection of information) and the orientation (the production of intelligence) permit the entity to adapt accordingly its goals, means, will and actions resulting in a highly desirable dynamic strategy.

2.3. Mental models

The grand strategy or shared vision is the most abstract and high-level strategy in an organization and it finds its roots in the shared culture, which emerges from the interactions of personal visions: the mental models.

2.3.1. Representation of the perception of the real world by mental models

2.3.1.1. Definition of Mental Models

Shared vision is created in the mind of people based on their mental models. Basically, mental models are the representation of a person's perception of his interacting and co-evolving environment based on

- his experiences in that environment;
- his learning from other members in his environment.

According to Business Dictionary mental models are the set of beliefs, ideas, images, and verbal descriptions that one consciously or unconsciously forms from his experiences and which (when formed) guide his thoughts and actions within narrow channels. These representations of perceived reality explain cause and effect, and lead us to expect certain results, give meaning to events, and predispose us to behave in certain ways. Although mental models provide internal stability in a world of continuous change, they also blind people to facts and ideas that challenge or defy our deeply held beliefs. They are, by their very nature, fuzzy and incomplete. And everyone has different models (that differ in detail from everyone else's) of the same concept or subject, no matter how common or simple ([9]).

This interpretation supposes that everything can be explained with cause-and-effects and implicitly accepted patterns. David Snowden (2013) is agreeing with the fact that humans are patterns-based intelligent human beings. However as discussed in the section on emergent strategy, not everything can be foreseen in a chain with all cause-and-effects. A fact however is that mental models are guiding people in their observations, thinking, decision making and acting.

According to Jones et al. (2011), mental models are cognitive representations of external reality. “The notion of a mental model was originally postulated by the psychologist Kenneth Craik who proposed that people carry in their minds a small-scale model of how the world works. These models are used to anticipate events, reason, and form explanations. Decades later, psychologist Johnson-Laird (1983) further developed Craik’s idea of a mental model in his research on human reasoning. For Johnson-Laird, a mental model is a reasoning mechanism that exists in a person’s working memory. His research, carried out within the domain of experimental psychology, supports Craik’s claim that people reason by way of thought experiments using internal models” ([10])

Shared vision is important for the successful planning and execution of the organization's strategy. A shared vision is also a reflection of the culture of an organization. Mental models of the members are instantiated from mental models stored in long-term memory (of the organization, a set of agents).

Jones et al. (2011) are referring to cognitive anthropology, which explores how cultural knowledge is organized in the mind. Studying culture at a cognitive level, cognitive anthropologists use schema to explain cultural understanding. A schema is “a generic version of (some part of) the world built up from experience and stored in memory”. As a consequence, cultural schema’s are developed through shared experiences. Over time, as a given group of people internalize their shared experiences, cultural meaning is created, which individuals use to perceive and relate to the world around them.

“Cultural models are discussed in a similar light to collective mental models and shared mental models in that they all refer to a degree of shared understanding among a group people. The field of organizational research takes a keen interest in collective mental models on the assumption that 'effective team functioning requires the existence of a shared or team mental model among members of a team'. […] A shared mental model is the mental model constructed and shared when individuals interact together in a team setting, it represents the shared cognition among groups of individuals.” (Jones et al., 2011).

9 Last accessed on January 21, 2015 at http://www.businessdictionary.com/definition/mental-models.html#ixzz3PkiUEH00

10 See also http://mentalmodels.princeton.edu/about/what-are-mental-models/

2.3.1.2. Mental Models – Mindset – Paradigm

These terms are often used interchangeably, inter alia Donella Meadows in her discussion of leverage points, though according to Merriam-Webster Dictionary ([11]) there are differences:

- Mind-set:
  - a mental attitude or inclination
  - a fixed state of mind
- Paradigm:
  - example, pattern; especially: an outstandingly clear or typical example or archetype
  - an example of a conjugation or declension showing a word in all its inflectional forms
  - a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated; broadly: a philosophical or theoretical framework of any kind

Not exactly synonyms, but the first meaning of mind-set and especially the third meaning of paradigm come close to what mental models are.

In addition due to the fact that a paradigm can be linked to a discipline, like strategy these terms are situational (contextual). So a paradigm shift can be in IT (cloud computing) or organizational (sociocultural) or any other domain, therefore an additional word must describe the context in which type of mental models, mind-set or paradigm are being used. By convention if the term has no adjective, then the highest level is assumed.

2.3.2. A stock of Mental Models

CAS tend to adapt to their environments by organizing themselves (self-organize) into more highly ordered states instead of disorder. Donella Meadows (1997) stated that this self-organization basically is a matter of an *evolutionary* raw material — a highly variable stock of information from which to select possible patterns — and a means for experimentation, for selecting and testing new patterns. For biology it is DNA, for technology the raw material is stored in scientific libraries. As such, a human being disposes over a stock of patterns and for each pattern there is corresponding (learned) action (behavior).

In this context, Meadows (1997) refers to human culture as the store of behavioral repertories accumulated over hundreds of thousands of years. They are a stock out of which social evolution can arise. If a culture does not evolve anymore because of the belief of its upper supremacy, that culture will die. The mental models are the source of the culture as seen in our original figure 3. So if a culture wants to survive, it needs to let evolve the mental models (through the double loop) because the environment is always changing.

If an organization is not aware of these models there is a risk of less good or worse decisions. Senge (2006, p. 164) quotes Chris Argyris, who has worked with mental models and organizational learning for forty years: “Although people do not [always] behave congruently with their espoused theories [what they say], they do behave congruently with their theories-in-use [their mental models].” Indeed mental models are active and they shape how we act, how we decide, how we think (by definition) but also how we observe. Albert Einstein: “Our theories determine what we measure.” (Taggart, 2011).

But how are these mental models transferred?

2.3.3. Memes to Transfer Mental Models

The concept of memes can explain the transfer. A meme is a unit of cultural information, such as a cultural practice or idea, that is transmitted verbally or by repeated action from one mind to another (Free Dictionary). A similar definition is found on Wikipedia: a meme is an idea, behavior, or style that spreads from person to person within a culture. A meme is carried from one mind to another through writing, speech, gestures, rituals, or other imitable phenomena. An analogy with genes can be made to that they self-replicate, mutate, and respond to selective pressures.

“Proponents theorize that memes may evolve by natural selection in a manner analogous to that of biological evolution. Memes do this through the processes of variation, mutation, competition, and inheritance, each of which influence a meme's reproductive success. Memes spread through the behavior that they generate in their hosts. Memes that propagate less prolifically may become extinct, while others may survive, spread, and (for better or for worse) mutate. Memes that replicate most effectively enjoy more success, and some may replicate effectively even when they prove to be detrimental to the welfare of their hosts.” (Wikipedia Meme, n.d.) ([12]).

11 See http://www.merriam-webster.com/dictionary

12 For a ST approach we refer to Rabaey (2013a).

2.3.4. Mental models are dynamic

In the context of a learning organization, Senge (2006) defines mental models as conceptual structures in the mind that drive a cognitive process of understanding. The discipline of mental models aims to train people to appreciate that mental models do indeed occupy their minds and shape their actions (Flood, 1999) or behavior.

Since an organization should continuously reshape itself to respond to the permanently changing environment, it should continuously monitor that environment (Bernard, 1976; further elaborated in (Rabaey, 2011, Rabaey et al., 2013)). But not only the environment has to be monitored to detect opportunities and threats, but also the organization itself has to be monitored (Lane et al., 1996). Organizations are open, purposeful and adaptive sociocultural systems, knowledge about its internal operation and construction is equally as important as the mental models on the environment.

An iterative process to interpret the observed facts is necessary: the intelligence process. Intelligence is not only needed to support decision making, but it also increases and updates the knowledge of an organization on itself and on its environment.

This continuously iterative process implies dynamics. Jones et al. (2011) noticed that the dynamic character of a mental model is discussed in the literature in three ways, in relation to reasoning, causal dynamics, and learning.

- *Reasoning*
  A mental model is constructed in working memory and can then be run like a computer simulation allowing an individual to explore and test different possibilities mentally before acting. Working memory is the system responsible for selecting information from the environment (observation) and manipulating information (orientate) for the purpose of reasoning and learning. Changes made to a mental model in the simulation process represent what would happen if such changes took place in reality.
- *Causal dynamics*
  "The capacity of a mental model to represent (perceived) cause-and-effect dynamics of a phenomenon is studied from a systems dynamics and naive theory ([13]) perspective. Systems dynamics use the mental model construct in a pragmatic sense: as a tool to better understand complex, dynamic systems to ultimately improve their design and usability. […] A widely cited definition of a mental model in this context is that of Rouse and Morris who consider a mental model in terms of its functionality and conceive it as a cognitive structure that enables a person to describe, explain, and predict a system's purpose, form, function, and state. Given the focus on dynamic phenomena, a mental model in this field has been conceived of as a model that is built of "causal knowledge about how a system works".
- *Learning*
  "The capacity of mental models to change over time through experience and learning is another dynamic quality. Researchers, mainly from the fields of human-computer interaction (HCI), education, and organizational studies, take interest in the difference between lay (or student) and expert mental models in terms of knowledge content and organization. Research shows that lay understanding is characteristically concrete while expert understanding is more abstract. This highlights the idea that the formation of a mental model in a person's mind is the result of both biology, i.e., an ability inherent to the human mind, and 'learning'. [Therefore] the nature and richness of models one can construct and one's ability to reason develops with learning domain-specific content and techniques".

Finally Jones et al. (2011) notice that systems dynamics researchers focus on the role of mental models in information feedback loops. They are particularly interested in the problems which hinder information feedback in a system and therefore hinder learning.

The dynamic is depicted in following figure 3.

2.3.5. Single and Double Learning

13 Jones et al. (2011): Research explores how people develop an understanding of causal processes associated with physical or mechanical systems. Studies have led theorists to assert that mental models are formed through analogical thinking. […] when a person explains a domain with which they are unfamiliar, they tend to draw on a familiar domain, which they perceive as similar. This involves tapping into an existing mental model and importing its relational structure to another domain. For example, a mental model of water flow may be used to explain electrical current; entities and relations corresponding to the former are mapped on to the model representing the latter. Studies show that phenomena that cannot be perceived directly are often explained this way.

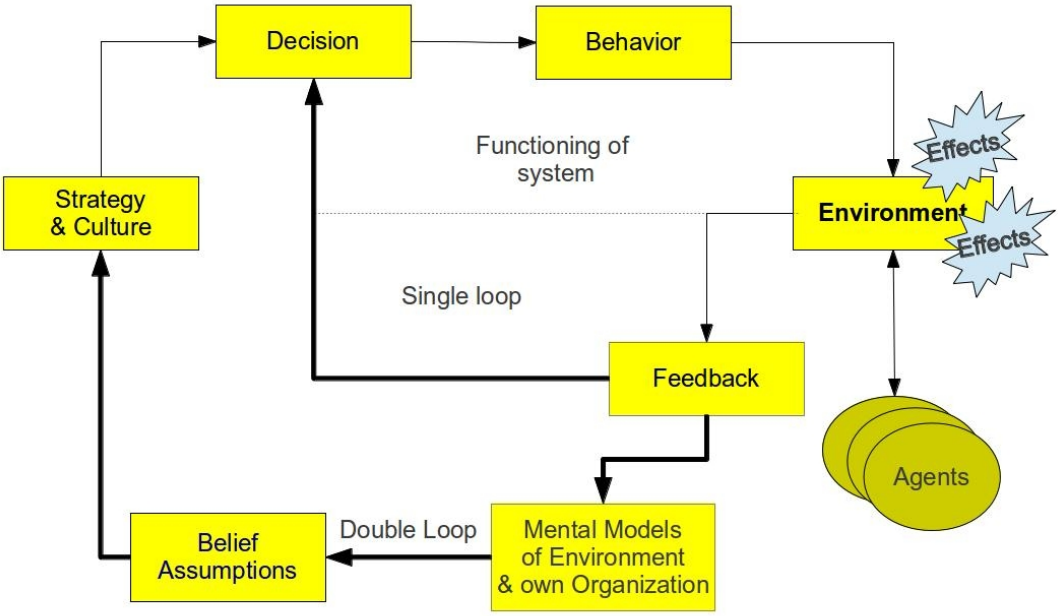

Figure 3: Single and Double Loop

Action Research ([14]) and more in particular Argyris and Schön (1978) have the single and the double loop learning (Figure 3). If the results are in line with the action strategies, the intention and the governing variables (or governing values), nothing has to be changed. If the results do not match the intention (of the action strategies) then the first (single) loop learning is activated, meaning that another strategy will be developed, but with respect for the current governing variables. If however there is also a mismatch with the belief system, then the governing variables have to be adapted through the double loop; this may lead to a redefinition of the scope of the business (market).

Sterman (2010) added mental models to the double loop, which shows very well the influence of mental models on strategy and culture ([15]) via the belief-structure, and thus on the decision-making.

The most important issue with mental models is that people and organizations are not always aware that they have mental models and that these models influence the decision making and the functioning in the organization. Sometimes brilliant ideas are rejected because they are in conflict with (in this case) the implicit mental models.

Of course when people and/or organizations know explicitly their mental models then they can test them. Therefore they can adjust quicker these models, which will improve the way they will observe the environment, interpret the observations and orient the decisions and thus they could act (behave) more appropriate than in the case they would not have adapted their mental models.

14 O'Brien (2001): "Action research…aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in order to create collective changes which take the organism forward in a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary aspect of the research process."

15 Gharajedaghi (2011): culture is the operating system of an organization.

2.3.6. Structure, function and process

The mental models are defining how and which strategy is being developed. Since strategy is determining the choice and use of capabilities/resources of the organization to attain the goals of the organization, strategy is therefore responsible for *organizing the organization:* structure, functions and processes. Structure defines components (capabilities) and their relationships. Functions are defining the outcomes or results to be produced. Processes explicitly define the sequence of activities and the know-how to produce the outcomes. The context defines the unique environment in which the system is situated (Gharajedaghi, 2011) which requires permanent observing and intelligence (further elaborated in Rabaey et al., 2012). Sterman (2010) and Gharajedahi (2011) state that assessing the whole (organization) requires understanding structure, function and process at the same time, and moreover the assessors have to be aware that they are interdependent.

"System structure determines system behavior. An unintended system behavior will not vanish merely by pushing system parts to work harder, because system structure is the fundamental cause of the problematic system performance. Developing a profound understanding of system structure is necessary for locating the leverage solutions for improving system performance." (Lee, n.d., p. 3). Senge (1990, p. 58): "The harder you push, the harder the system pushes back." So to study the own organization, people should focuse more on the relationships among system parts, rather than on its parts.

So figure 3 includes implicitly the structure of the organization. If the structure is not satisfying the needs anymore, strategy will adopt another structure, other functions and/or processes. As such, these organizational changes are demanding time, effort and/or financial resources and are as a matter of fact, investments.

2.4. Complex Adaptive Systems

For every complex problem there is always a simple solution … and it is wrong
- H.L. Mencken

2.4.1. Systems

The study of systems in different domains as engineering and economics shows systems to be constantly changing, with components that are tightly connected and highly sensitive to change elsewhere in the system. They are nonlinear (disproportional effect), unpredictable and resistant to change and seemingly obvious solutions sometimes worsening a problem. So systems are dynamic architectures of interactions and synergies.

Joyce (2011), Matthews (2012) and Russell Ackoff (1994a, 1999) are stating that a system is a whole consisting of parts, each of which can affect the behavior of the whole or its properties. The parts don't necessarily do it all the time but they can. Furthermore, each part of the system, when it affects the system, is dependent for its effect on some other parts. In other words the parts are interdependent, therefore no part of the system or a collection of parts has an independent effect on it.

As such, a system is a whole that cannot be divided into independent parts without loss. Moreover the essential or defining properties of a system are properties of the whole which none of its parts have and thus when a system is taken apart it loses its essential properties. As an example, if one takes all of the different cars on the market today, and asks a group of engineers which has the best engine, which has the best transmission, which has the best alternator etc. and they take these best parts and try to put them together, it is unlikely one would get a working automobile; the parts wouldn't fit, let alone it would be the best car in the world. It's the working together that is the main attribute of systemic thinking Ackoff (1994a).

The performance of a system is never the sum of the performance of its parts taken separately, it is the product of its interactions. The performance of a system is based upon how the parts interact and fit, never just on how they act separately. There are many instances where improving the performance of a part will make the performance of the whole worse ([16]). The doctrine of the Western world is "divide and conquer"; if every separate part of the organization is managed well, then the whole system will improve. To Ackoff (1999) this is absolutely false. This is completely counterintuitive, the classic Western world is committed to managing the actions of the parts, not their interactions. Most improvement programs orientate themselves towards improving the parts separately, not the whole. For continuous improvement, the whole should be the focus.

Some organizations are not the only ones that interact (as a whole) with the environment, but also their constituent parts (network of interdependent agents). So another issue is to define the relevant boundaries of a system (Flood, 1999). Nowadays in this omni-interconnected world with synergies, outsourcing and joint ventures (amongst others), it is hard to determine exactly the boundaries of an

16 Ackoff (1994a) says that an architect starts by drawing first the house (the whole) then he adds the rooms; the parts. He only improves the room in such a way that it also improves the "whole" house. Sometimes a part needs to be made worse to make the whole better. If the architect can make the room worse, but make the house better, then he will do it. After all, the objective is to build the best house, not the best rooms.

organization (system, whole). Donella H. Meadows: “Where to draw a boundary around a system depends on the questions we want to ask.” (Matthews, 2012a).

2.4.2. Complexity Theory

In the domain of quantum physics Strongman (2013) gives a general view of what Complexity Theory (CT) is. He refers to Brachthauser who defines CT as a term used to describe the theoretical and applied focus of systems thinking in an “environment of turbulence, flux, fragmentation, disequilibrium and uncertainty” ([17]).

CT is characterized by systems in which large networks of components with non-central control and simple rules of operation produce complex behaviors, sophisticated information processing, and adaptation. CT is also characterized “by non-trivial emergent and self-organizing behaviors, varying ontological states, of agency, of being, or of activity, and differing combinations of sets of relationships. [CT] is different from ambiguity, but may produce many outcomes, possibilities, from either groups of whole or fragmented subjects, nodes or network of connections, interacting parts, characterized by an unpredictability of emergent factors, parts, and behaviors” (p. 1).

CT deals with systems that are large collections of interacting agents. The complexity is due to the inability of one language or perspective to describe all the properties of the system one is observing, therefore one need to have more than one language and/or perspective (Nikolic, 2010). A perspective has to be understood as a scientific discipline, so we need more than one discipline to describe a system, or the discipline should be holistic that combines the relevant disciplines.

The philosophical interpretation of Nikolic (2010) regarding complexity is that nobody has the full control over (social, ecological) systems (despite what politicians, managers or conspiracy theorists are saying), but we all have influence on that system.

In his keynote speech “How not to manage complexity”, Snowden (2013) compares fascism to anarchy. The former likes very much structures while the latter wants as less as possible structure. In reality chaos is more present than structure. His metaphor is then also a (tiny) ship (of order) on a vast ocean of chaos. Related to this, he defines three types of systems:

- Linear systems when the level of constraints is very high and the behavior is fully predictable (linear material course). So the same thing will produce the same effect if we do the same thing again. His examples in the industry are amongst others Six Sigma ([18]), Business Process Management (BPM). It is the engineering obsession of the last 40 to 50 years.
  In this context, Colonel Reed (2006) remarks that systems tend to endure because of goal displacement, when complying with bureaucratic processes becomes the objective rather than focusing on organizational goals and values.
- On the other hand we have complete unconstrained systems with complete independence that never happens naturally. It only can be artificially induced. By getting a large number of people completely independent of each other without any interaction to make mathematical judgments gives one a capability of the new approach to evidence-based policy.
  But how realistic is this? For instance market predictions through social computing is not the case because people are interacting with each other (the first made guess influences already the whole system).
- The third type is a Complex Adaptive System (CAS). The system is likely to constraint the agents' behavior but the agents are also modifying the system as they interact with it. So the system and agents are in co-evolution as it is called in biology. They constantly modify each other over time, which means the same thing will never happen again the same way. The key idea here: they are not causal but they are dispositional. Cantle (2011), states that complex behavior can arise from simple rules. The complexity is due to the interactions between CAS and its environment, but also the internal interactions (between the nodes/parts/agents).
  Holden (2005, p. 654) uses the following definition of CAS: “A complex adaptive system is a collection of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent’s actions changes the context for other agents.” Holland (2008) adds explicitly an important element to this definition, namely that the agents are learning.

17 Brachthauser, C. (2011). Explaining global governance – a complexity perspective. *Cambridge Review of International Affairs.* 24 (2). pp. 221-224 .

18 Snowden (2012): Six Sigma is over-focusing on efficiency at the cost of effectiveness. If you eliminate all superfluous capacity, which may legitimate in certain domains, you loose adaptive capacity when the context shifts. 3M abandoned Six Sigma because it was destroying the capacity to innovate.

2.4.3. Need for Another way of Thinking

2.4.3.1. Reductionist Thinking

Reductionism is the mainstream Western thinking that separates science (one form of study of things) from our lives and the world in which we live ([19]). It sees practitioners and researchers as independent external observers (a concept that is rejected by quantum physics). “This leads people to think about phenomena as entities that can be fully appreciated as detached real things, behaving according to fixed causal relationships.”

Science has in our minds fragmented the world and our lives. It has alienated so-called parts, like people, from the patterns and rhythms of life in which we participate. The richness and mystique of living is deflated to a mental model with an unrealistic and mind-blowing simplicity of the type, 'A caused B'.” So socially when we have a problem then we will look for a black sheep to be the cause of our problem.

“People, especially those […] with formal power, may attempt to detach themselves from patterns of interrelationships and emerging difficulties to which they have a systemic attachment and moral responsibility”. (Flood, 1999) So reductionist thinking directs people to seek solutions in terms of causal factors.

Reductionist (analytical) thinking has mainly three steps (Joyce, 2011):

- Decomposing the system;
- Studying the behavior of the parts;
- Reassembling the parts and trying to explain the behavior of the (whole) system based on the behavior of the parts.

So the product of analysis shows you how things are working, never why they are working the way they do.

In this context, Flood (1999) observes also the difficulties of the people conditioned by the mental model of reductionism and causal thinking to flip over to a consciousness of systemic awareness. As a matter of fact, reductionism and holism are two ways of thinking, which are poles apart.

Reductionist thinking is looking for (deterministic or probabilistic) causal laws. This can be possible in non-social sciences, but for social sciences people are changing and they change the environment, which influences the people, etc (interdependent and co-evolution). White (1995) shows that reductionist thinking in risk management failed and that a holistic thinking should be used to treat risks. Systemic thinking argues that behavior is most usefully understood as the results of loops where variables are interrelated.

Regarding the feedback principle of CAS, the result of behavior is always scanned and its success or failure modifies future behavior; outputs, outcomes, and impacts are always scanned, and the desirability or undesirability of those items modifies future behavior.

The causality principle of CAS has two types of feedback (Independence Partners, 2011): the negative feedback produces stable equilibrium, while the positive leads to instability. In a context of fixed variables, the feedback system is deterministic. However sociocultural systems are composed of agents that can agree to change the context, therefore this dynamic behavior is capable of producing unexpected variety or novelty through spontaneous self-organization. “This is where a complex of variables interrelates with multiple feedback, which spontaneously creates new order. Spontaneous means that what emerges is not predictable.” So the emergence is unpredictable because it results from details of dynamics that are inherently unknowable to the human mind.

So not only the environment, but also the organization self is changing in a dynamic and unpredictable way and this is the context in which the management of an organization has to work. It must be able to absorb the unpredictable internal and external changes, therefore management tools must be an enabler and not a de facto inhibitor of change.

Management must keep the pareto principle in mind: “In any large, complex system, roughly 80% of the effects, outputs, outcomes, and impacts will be the direct result of roughly 20% of the inputs or interactions “(Independence Partners, 2011). Moreover certain patterns of functioning (structure) recur again and again. Senge (2006) calls them system archetypes or generic structures and are a cyclic chaining of negative and/or positive loops. Senge notes that not many different systems archetypes exist, which indicates that not all management problems are that unique.

2.4.3.2. Complexity Thinking

Complexity Thinking (CxT) is one other way of thinking. Holmdahl (2006, pp. 53-54) discusses the

19 Discussion based on Flood (1999, pp. 84-86).

complexity thinking school of thought. This school takes hold of the fact that no real complex system is completely closed; all complex systems are more or less open, and therefore they stress the following points as limitations to our ability to know for sure:

- All boundaries are emergent and temporary (given a sufficiently long time scale), neither purely natural nor purely a function of our description, sometimes making boundary recognition and allocation problematic. Boundaries in the rigid traditional sense do not exist. The boundaries analysts infer around a system are more a feature of our need for a bounded description rather than a feature of the system itself.
- Everything is connected to everything else – radical holism: the universe is the only true whole.
- No part can be fully understood without understanding its relationship with the whole, the whole is reflected in every part and all models leave something out.
- Absolute knowledge of the part would require complete knowledge of the whole (the incompressibility of complex systems) – a practical absurdity and a theoretical impossibility.
- There are no real parts; all boundaries that delimit a part from its whole are temporary and often illusory: no-boundary hypothesis, all boundaries are emergent

In spite of the epistemological caveats from the complexity thinking school, for practical purposes it is useful to define boundaries and treat organizations as open complex [adaptive] systems, thereby disregarding the errors and approximations with such an approach (Cilliers, 2005; Holmdahl, 2006).

2.4.3.3. Systems thinking

Systems Thinking (ST) provides key insights concerning the management of complexity. For this reason, the WHO is promoting ST: Savigny & Adam (2009) state that there are four revolutions currently underway that will transform health and health systems, being life science; IT; social justice and equity; and ST to transcend complexity. Gharajedaghi (2011) sees a paradigm shift from analytical to holistic thinking.

Savigny et al. (2009) are defining ST as an approach to problem-solving that views problems as part of a wider “dynamic” system, where a deeper understanding is necessary of the linkages, relationships, interactions and behaviors among the elements that characterize the entire system.

Basically, ST is based on the concept that the whole is greater than the sum of its parts. The delta, is the difference between the whole and its parts, namely the interdependences between the parts themselves and between the whole and its parts (Gharajedaghi, 2011).

An important difference between reductionist thinking and ST is that the former only mentions analysis as “intellectual interpretation” of the data. According to Gharajedaghi (2011) the intellectual interpretation in ST consists of two more elements than analysis, namely synthesis and systems design.

Analytical thinking assumes that the whole is nothing more than the sum of the parts. This implies that understanding of the structure is both necessary and sufficient to understanding the whole and therefore knowing the structure means knowing the system. Synthetic thinking is linked with the functional approach. By defining a system by its outcome (functions), synthesis puts the subject in the context of the environment, which can also be a (larger) system. Dynamic thinking is focusing on the processes, so it looks to the how-questions for the necessary answer to define the whole.

Since an organization and its environment are co-evolving, Gharajedaghi (2011) states that the inquiry of the organization should be a continuously iterative cycle based on function, structure, process and context (figure 4 ([20])).

20 *Figure 4* Figure *Iterative Process of Inquiry* in Gharajedaghi (2011, p.93)

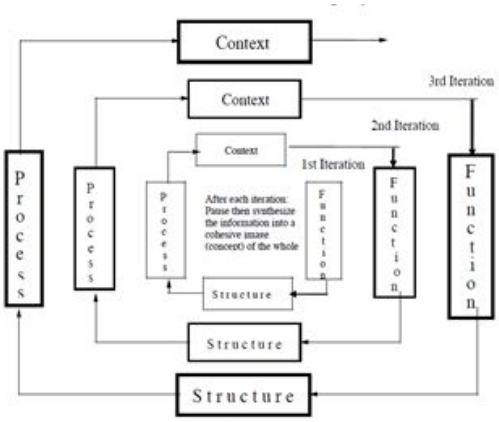

Figure 4: Iterative Process of Inquiry

This inquiry is related to the three ways of thinking (Gharajedaghi, 2011):

- Analytical thinking implies the understanding of the structure, which is the second step in the loop.
- Synthetic thinking is linked with the functional approach. Functions and context are respectively the first and fourth step in the iterative process of inquiry.
- Dynamic thinking is focusing on the processes and is the third step.

Before implementing ST in a reductionist thinking organization, the shared and individual mental models need to change. Taggart (2011) writes that from a management perspective, the mental models of an organization (and its leaders) are extremely important because of the associated consequences, whether good or bad. It is hardly possible, if not impossible, to develop ST if the mental models are ingrained in past experiences and beliefs.

Taggart (2011): “To be an effective systems thinker requires the discipline of mental models. These two disciplines fit together naturally. [ST] concentrates on how to modify assumptions in order to show the true causes of problems. Mental models, in contrast, look at revealing our hidden assumptions.

For managers, it becomes essential that they take the time to reflect on their existing mental models until their assumptions and beliefs are brought out into the open. Until then, their mental models will not change and it’s pointless to attempt to engage in systems thinking.”

2.4.3.4. Transdisciplinary

Systems and complexity thinking are thus handling complex systems and situations. Previously, we noted that the complexity is due to the inability of one language or perspective to describe all the properties of the system one is observing, therefore one need to have more than one language and/or perspective. In this context, Ackoff (1999) states that ”Effective research is not disciplinary, interdisciplinary, or multidisciplinary; it is *trans*disciplinary. ST is holistic; it attempts to derive understanding of parts from the behavior and properties of wholes, rather than derive the behavior and properties of wholes from those of their parts. Disciplines are taken by science to represent different parts of the reality we experience. In effect, science assumes that reality is structured and organized in the same way universities are.” Adam et al. (2009) are calling this disciplinary “silos”.

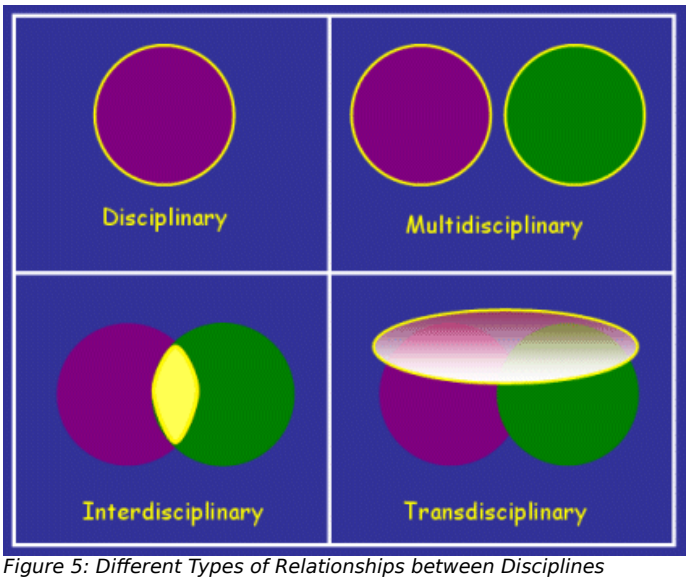

Figure 5: Different Types of Relationships between Disciplines

Figure 5 ([21]) shows the different types of relationships between disciplines. Hent (n.d.) states that transdisciplinary approaches involve multiple disciplines and the space between the disciplines (thus the whole is more than the sum) "with the possibility of new perspectives 'beyond' those disciplines. Where multidisciplinary or interdisciplinary inquiry may focus on the contribution of disciplines to an inquiry, transdisciplinary inquiry tends to focus on the inquiry or issue itself".

- Disciplinary: Epistemologies, assumptions, knowledge, skills, methods within the boundary of a discipline. eg. Physics; History; Psychology
- Multidisciplinary: Using the knowledge/understanding of more than one discipline. eg Physics and History; Biology and Architecture
- Interdisciplinary: Using the epistemologies/methods of one discipline within another. eg. Biochemistry; Ecophilosophy; Astrophysics
- Transdisciplinary: Focus on an issue such as pollution or hunger both within and beyond discipline boundaries with the possibility of new perspectives.

With complexity and systems thinking in mind, we will discuss now Complex Adaptive Systems (CAS).

2.5. Complex Adaptive Systems Thinking (CAS*T)

Before we can discuss CAS*T, we have to further define some specific characteristics of CAS.

2.5.1. Organization / Environment

We would like to note that CAS can be used in two ways. A system consists of a network of many adapting and somehow competing agents who adapt to each other (Holland, 2008; Rabaey et al., 2003). Here CAS is an environment.

Alternatively, agents may have a shared goal and vision, thus collaboration is obviously more important, although a form of competition may exist between the agents. The agents belong to a whole, thus CAS in this case is an organization.

The meaning of CAS – environment or organization – has to be determined from the context.

An organization can be part of a bigger organization and can itself be constituted of other organizations, thus an organization-of-organizations. In engineering, sociology and other domains, a system-of-systems "is a collection of task-oriented or dedicated systems that pool their resources and capabilities together to

21 *Figure 5*. Different Types of Relationships between Disciplines Reprinted from TRANSDISCIPLINARY INQUIRY incorporating holistic principles. In *Holistic Education Network Tasmania, Australia.* Retrieved February 21, 2014 from http://www.hent.org/transdisciplinary.htm

create a new, more complex system which offers more functionality and performance than simply the sum of the constituent systems. Currently, systems of systems is a critical research discipline for which frames of reference, thought processes, quantitative analysis, tools, and design methods are incomplete" (Wikipedia SoS, n.d.).

We do not fully agree with this definition because it is a bottom-up approach only. It can also be a top-down approach, for instance the organization of the armed forces; politics will define the general purpose and structure of defense, building blocks will then be conceived. However one approach does not exclude the other, so both approaches can be used simultaneously as long the interfaces between the different (internal) systems are well defined.

It is not by surprise that Techtarget in its discussion on Service Oriented Architecture (SOA) defines system-of-systems as follows: "System of systems (SoS) is the viewing of multiple, dispersed, independent systems in context as part of a larger, more complex system. A system is a group of interacting, interrelated and interdependent components that form a complex and unified whole."(Techtarget SoS, n.d.).

And here we see already the link between SoS (CAS) and ST: "The goal of an SoS architecture is to get maximum value out of a large system by understanding of how each of the smaller systems work, interface and are used. Such designs require ST -- a holistic approach to analysis that focuses on the way constituent parts interoperate, work over time and function within the context of a larger, evolving system.

In the data center, independent constituent parts of a large system are connected through SoS-defined software interfaces called middleware. Such programs ensure that constituents do not compete for subtasks within the larger system and provide messaging services so that constituent systems can communicate." (Techtarget SoS, n.d). Rabaey et al. (2003; 2007a) discuss business intelligent agents (BIA) and the use of semantic web services (Semantic SOA) which can act autonomously but interdependently so that an unexpected or unpredictable behavior can emerge (see below emergence as a characteristic of CAS).

2.5.2. Characteristics of CAS

Complex systems and CAS are incompressible, which means that it is impossible to have a total account of a complex system that is less complex than the system itself without losing some of its aspects. Therefore incompressibility is one of the most important aspects of complex systems and CAS when considering the development of any analytical methodology, or epistemology, for making sense of such systems (Cilliers, 2005; Holmdahl, 2006).

Despite their diversity, CAS share certain fundamental behaviors (compiled and adapted from Gore, 1996; Lowe & Ng, 2006; Savigny et al. 2009a; Cantle & Allan, 2011; Holland, 2008).

- "Purposeful"

A CAS has a purpose and it determines it itself. This characteristic is important for ST especially in a networked structure of interdependent but autonomous agents, in contrast to hierarchal top-down based structure where only a central unit commands and controls the organization.

- "Emergence"

Interactions among agents in CAS may lead to emerging global (or system-wide) properties that are very different from the behavior of individual agents. In other words a CAS produces properties that may not belong to any of the individual agents, thus the CAS created by these interactions can be very different from its agents and cannot be understood in terms of those agents.

These properties which cannot be predicted from prior knowledge of the agents, in turn affect the environment that each agent perceives influencing its behavior in a synergistic feedback loop. Thus the "whole" of a complex system is far greater than the sum of its parts and the whole has properties not held by any of its agents.

Colonel Reed (2006) states that recognizing the patterns of a system over time is a higher-order level of thinking. "A systems thinker might step back from the problem, take a broader view, and consider what is happening over time." (p.13). Cantle et al. (2011), Rabaey (2013) conclude that emergence requires a holistic approach (ST and CxT) before studying the parts. The study of an organization may thus not be based only on the decomposition into business units (business agents), or the so called core business.

- "Adaptive Self-Organization"

CAS tend to adapt to their environments and to self-organize. Rather than tending toward disorder or entropy, CAS spontaneously crystallize into more highly ordered states.

Enterprise mapping used in (long term) endeavors or for the global enterprise must therefore be flexible

to adjust to these spontaneous self-organizations. Goals, procedures, processes, stakeholders may change continuously and thus these maps must be continuously reviewed (via intelligence processes).

Mauboussin (2011, p. 89) in his Harvard Business Review article “Embracing Complexity” uses the ant colony as an example of a CAS in nature: ‘Complex adaptive systems are one of nature’s big solutions, so biology is full of great examples. Ant colonies are solving very complicated, very challenging problems with no leadership, no strategic plan, no Congress.”

- “Information Processing”

CAS exhibit the ability to process information sensed from the environment and react to it based on internalized models. Information processing is closely related to a system’s ability to learn and adapt near the edge of chaos. It creates interacting feedback loops which cause highly nonlinear behavior (Cantle et al., 2011). If the CAS is an organization then the management will be confronted with counterintuitive and non-intended consequences.

Snowden (2013) remarks that humans are fundamentally pattern based intelligent beings. The energy cost of actually seeing things differently is so high that they do not do it unless they are forced. The basic fact is that most of the time, we make decisions without thinking about it but based on trained responses (found in our mental models). This will have consequences for the observation of the environment.

- “Evolution to the Edge of Chaos”

Holmdahl (2006) notes that CAS, driven to critical state (edge of chaos) has its own highest computational capacity, meaning the system cannot be simulated with sufficient accuracy faster than the system itself develops, so prediction through simulation can never be accurate.

All dynamic systems exist in one of three regimes:

- A stable regime in which disturbances tend to die out;
- A chaotic regime (the province of chaos theory);
- The phase transition between stability and chaos.

Whereas increasing disturbances in the environment cause some systems to move from stability to chaos, CAS “learn” from their environments and add new functions to cope with previously unknown situations (causes and symptoms are separated in time and space). Thus they increase their complexity and adapt along the edge of chaos. According to complexity theorists the same type of growth in complexity occurs in nature, man-made systems as well as societies, business and economies.

- “Large number of elements with rich interactions”

A CAS is a special case of complex systems, the distinguishing feature of CAS is that a CAS interacts with its environment and adapts in response to a change. As already mentioned, a CAS is resilient; therefore, it can tolerate certain levels of stress or degradation. As a result, sustainability of a CAS can be achieved if its adaptive capacity is not destroyed (Gaziulusoy, 2011). Snowden (2012) gives an example of 3M which abandoned Six Sigma because it was destroying the capacity to innovate. 3M was loosing adaptive capacity when the context was shifting (footnote 18, p.17).

When the number of elements is relatively small, the behavior of the elements can often be represented by a formal description in conventional terms. Therefore some organizations are not CAS.

Cilliers (2004) states that when the number becomes sufficiently large, conventional means not only become impractical, they also cease to assist in any understanding of the system. This is a fundamental problem when quantitative tools are used to simulate the organization. Moreover the interactions usually have short range and contain feedback loops, and they may occur on several levels (Holmdahl, 2006) in case of a hierarchal structured organizations or in many different parts (between agents) in a networked organization.

Holden (2005) lists other characteristics as defined by Cilliers (2004). The large number of elements must interact in a dynamic way with much exchange of information. These interactions are rich, nonlinear, and have a limited range because there is no over-arching framework that controls the flow of information. Since these agents are tightly-linked (high degree of connectivity); a change in one agent affects the others (Savigny et al., 2009a).

- “Nonlinear”

A CAS is vulnerable to certain leverage or “tipping” points at which an apparently small intervention can result in one or more substantial system-wide changes. Such interactions cannot only be negative but also positive, where it can be managed in a way that leads to synergies (Savigny et al., 2009a).

To Cilliers (2004, p.25) the nonlinear nature of the interactions in CAS has two important consequences. Firstly, it becomes quickly impossible to keep track of causal relationships between components when there are a lot of simultaneous nonlinear interactions amongst those components. Secondly, we can deduce that CAS are incompressible based on the fact of their nonlinear nature. Therefore modeling CAS

is a problem because some parts have to be left out and we do not know beforehand what the consequences will be. So something that may not appear to be important now may turn out to be very important later, or vice verse, due to the fact that we cannot track a clear causal chain. Thus, no matter how a model of a CAS is constructed, it will be flawed, and worse, we do not know in which way it is flawed.

- “Evolution and Innovation”

The past is influencing the future. A CAS evolves and history becomes very important to track (evolutionary path dependency), because of the constantly changing environment and configuration of the CAS, due to their interaction. So without a registration of the history, the original conditions and configurations can never be reconstructed. Moreover future development is dependent on how a CAS came to be in the actual state.

Who says evolution, says innovation. Since equilibrium is very rare in the situation of a CAS, it has to innovate to adapt to new changes in its environment.

- “Dynamic Borders”

CAS are open systems with feedback loops, both enhancing, stimulating (positive) or detracting, inhibiting (negative). Cilliers (2004) remarks that to describe an open system, it is difficult to define the borders. “Instead of being a characteristic of the system itself, the scope of the system is usually determined by the purpose of the description of the system, and is thus influenced by the position of the observer. This process is called framing.” (p.24).

So when describing the organization, it must not only be clearly understood what will be described, but also why: what is the purpose of the observer in choosing that particular (sub-)system. However the organization has to adapt to the environment, so it is possible that the initial motivation and settings are after a while not relevant anymore. Moreover the complexity in the system is due not only to the feedback loops but also to a result of patterns of interaction between the elements, thus an internal dynamic exists.

- “Lack of an Equilibrium”

CAS adjust and readjust at many interactive time scales. A consequence is that due to the internal and external dynamics (changes), a CAS operates under conditions far from equilibrium, which means that there is continual change and response to the constant flow of energy in the system.

Change is a constant in all sustainable systems. If they don't change then ultimately they will collapse since they are part of wider systems that do change (Savigny et al., 2009a). In this context, Cilliers (2004) remarks that equilibrium is another word for the death of a system.

CAS are embedded in the context of their own histories, and no single element or agent can know, comprehend, or predict actions and effects that are operating within the system as a whole. However people make predictions, and those predictions are influencing the behavior of the system and its parts (feedforward).

- “Tightly linked”

Interconnected and interdependent

- “Governed by feedback and feedforward”

See nonlinearity for the feedback. Feedforward is putting strategy into CAS. The very fact of introducing a strategy document in the organization will already influence the system before it has even any results or before the strategy has been implemented (Cantle et al., 2011).

According to Hart (2013), feedback is an approach that uses information about current results to influence operation in the same time frame: the present. It includes modifications to a system based on results, thus feedback produces a reactive response. Feedforward is an approach that uses knowledge about the system and the expectations of how a CAS could be, and investigates possible paths from the future to the present. Thus, the difference between feedback and feedforward is that the former is reactive while the latter is rather proactive.

- “Counterintuitive”

Cause and effects (symptoms) are often distant in time and space, defying solutions that pit causes close to the effects they seek to address. Savigny et al. (2009a) remark concerning people that interventions (projects) designed to change people's behavior require measuring the intervention effects over a longer period of time to avoid making incorrect conclusions of no or limited effects.

As a consequence of the counterintuitive behavior, Cantle et al. (2011) state that non-intended outcomes may exist.

- “Resistant to change”

Seemingly obvious solutions may fail or worsen the situation. Given the above characteristics of CAS, it is sometimes difficult and delicate to develop a priori an effective policy without a highly thorough understanding of the CAS. System characteristics can render the system policy resistant, particularly when all of the actors within a CAS have their own, and often competing goals (Savigny et al., 2009a). Too strictly imposed policies by governments or mother-companies may cause considerable resistance to change, and therefore cause immobility and ineffectiveness.

Leadership ([22]) will consist to put every agent on the same page, so that everyone has the same shared general goals and shared vision (of the CAS).

2.5.3. What we don't know about CAS

In general, ESD (n.d.) notes that failing to recognize these characteristics in a system, especially a CAS, may lead to underestimation of the dynamic (behavioral) complexity of the system. Therefore predictions of system behavior may be seriously flawed, while unwarranted confidence in these predictions (in analogy with mechanic systems) may be maintained.

Investments are done to prepare the organization for a desirable future, but due to characteristics of CAS (organization and/or its environment) that future is unpredictable, therefore organizations' investments should take these characteristics into account.

Moreover Holland (2008) states in his talk on “modeling CAS” that for three essential elements of CAS we do not have a theory or a model:

- All CAS exhibit lever points which are points where a simple intervention causes a lasting, directed effect. But there is no theory where or how to look for lever points.
- All CAS have a hierarchal organization of boundaries enclosing boundaries. But there is no general theory or model that tells us what mechanisms cause the formation of boundaries in a uniform way.
- Open-ended evolution occurs when an initially simple system exhibits increasing diversity of interaction and signaling. But there are no computer models that exhibit open-ended evolution.

By taking into account the other above mentioned characteristics of CAS, we can state that running an organization is an art like the art of war, rather than an exact science.

2.5.4. Simple Rules

Eisenhardt et al. are advocating the use of simple rules (in CAS): “Most managers quickly grasp the concept of focusing on key strategic processes that will position their companies where the flow of opportunities is most promising. But because they equate processes with detailed routines, they often miss the notion of simple rules. Yet simple rules are essential. They poise the company on what's termed in CT as 'the edge of chaos', providing just enough structure to allow it to capture the best opportunities. It may sound counterintuitive, but the complicated improvisational movements that companies [like Amazon, Google, Cisco] make as they pursue fleeting opportunities arise from simple rules.” (2001, p. 110). Of course, the fact of having to work on different levels (single loop and double loop) makes that simple rules may turn an organization into a very complex system (Cantle et al., 2011).

It is not by surprise that Helmuth von Moltke the Elder ([23]) stated that “an order shall contain everything that a commander cannot do by himself, but nothing else” (Holborn, 1986, p.291). The different levels of strategy certainly do not imply very complicated and complex rules or processes of developing, maintaining and disseminating these strategies, on the contrary.

As a summary, Snowden (2013) and Cantle et al. (2011) state that you have to manage a CAS as a whole. You have to manage the dispositions as a whole, which actually means you need to manage in the present. Predictions are impossible. What matters is accurately described in the present, and step by step the CAS has to evolve (Nikolic, 2010), it can not jump into the future (intractability). CAS manages the evolutionary potential of the present rather than constantly failing to achieve an idealized future state which might not be the best place to get anyway (Snowden, 2013).([24])

22 A leader should be a personification of the shared vision of a CAS.

23 Helmut Karl Bernhard von Moltke (1800-1891). “During thirty years as the Prussian Chief of the general staff Helmut von Moltke led the unification of the German states and established Germany as the dominant European power. Moltke is credited as being the innovator of the modern military staff system. He also perfected a rapid-mobilization system using rail systems and improved command and control of field operations through unit organizations and the use of the telegraph” (Lanning, 1997, p.150).

24 To Snowden (2013) ST is all about the closing of the gap between “as is” and the “to be” situations of an organization. It is based on the obsessional use of engineering. Complexity thinking is the actual necessary paradigm shift in management, not ST. However the ST theory of Gharajedaghi is very much the same as what Snowden is meaning with complexity thinking. See also Strongman (2013). CAS*T makes the bridge between both concepts.

2.5.5. CAS IT-investment and Organizations

Although some organizations have a small number of agents, and legally an organization has static borders, we believe it is wise to treat organizations as a CAS as Hovhannisian (2001), Holmdahl (2006) and Cantle et al. (2011) are stating.

Those organizations are segmented rather than monolithic, and characterized by information flows and interactions between the agents. The way this happens is very relevant to understanding the working of the whole and its components because it influences the culture (and subcultures), the hierarchy and the structure and it has an impact on the speed of communication and interpretation of the (internal and external) information.

According to Cantle et al. (2011) companies are CAS because they consist of people who are:

- Adhering to cultural norms, beliefs and principles;
- Following processes, learning, adapting, interdependent;
- Communicating, using initiative, often irrational and above all they are interacting.

Hovhannisian (2001) points out that if only the components of an organization are analyzed (Taylorian decomposition) and not the whole (like with ST), analysts are not getting the full picture. They are missing the links, the interconnections between agents, and how the whole interacts with its environment. Cantle et al. (2011) emphasize that the study of CAS is interdisciplinary (and so must be the applicable tools) and that emergence requires a holistic (systemic) approach before studying the parts. Flood (1999) sees a common characteristic of the different approaches by Russel L. Ackoff, C. West Churchman, Stafford Beer, Ludwig von Bertalanffy and himself, namely the interdisciplinary. Sally Bean (2011) names it multidisciplinary.

However Gaharajedaghi (2004) states: “On the other hand, contrary to a widely held belief, the popular notion of a multi-disciplinary approach is not a systems approach. In fact, the ability to synthesize separate findings into a coherent whole seems far more critical than the ability to generate information from different perspectives.“

Without a well-defined synthesizing method the process of discovery using a multi-discipline approach would be an experience as frustrating as that of the blind men trying to identify an elephant. Positioned at a different part of the elephant, each of the blind men reported his findings from his respective position, as: It’s a snake; It’s a pillar; It’s a fan; It’s a spear!”

From the point of view of CT regarding organizations, Holmdahl (2006) states that the uttermost connection between organizational sciences and CT lies in the use of for theories of change management, which differs from the traditional models of organizational change (table 1)([25]).

Traditional Models of Organizational Change	**CAS Model of Organizational Change**
Few variables determine outcome	Innumerable variables determine outcome
The whole is equal to the sum of the parts (reductionism)	The whole is different from the sum of the parts (emergence). The whole is more than the sum of its parts (ST)
Direction is determined by design and power of a few leaders	Direction is determined by emergence and the participation of many agents
Individual or system behavior is knowable, predictable, and controllable	Individual or system behavior is unknowable unpredictable, and uncontrollable
Causality is linear: every effect can be traced back to a specific cause	Causality is mutual; every cause is also an effect, and every effect is also a cause
Relationships are directive	Relationships are empowering
All systems are essentially the same	Each system is unique
Efficiency and reliability are measures of value	Responsiveness to the environment is the measure of value
Decisions are based on facts and data	Decisions are based on tensions and patterns

25 Adapted from *Complexity Aspects of Product Development,* p.55 by L. Homdahl, 2006, Published doctoral dissertation, Otto-von-Guericke-Universität Magdeburg, Germany

Traditional Models of Organizational Change	CAS Model of Organizational Change
Leaders are experts and authorities	Leaders are facilitators and supporters

Table 1: Traditional vs. complex organizational change

The consequences for IT-investments techniques used in a CAS (organization) are that they should be different from the traditional investment techniques. Innumerable variables are determining the outcome and the individual or system behavior is unknowable unpredictable, and uncontrollable, thus it is hard to have a long investment horizon, certainly when the direction is determined by emergence (emergent strategies) and the participations of many agents ([26]).

Each system is unique (statistical data coming from similar cases) and the decisions are based on tensions and patterns, thus not facts and data, which are used by all classical investment techniques. Moreover the leaders -normally the decision-makers- are not really leading but are facilitators and supporters due to the participation of many agents in the direction of the organization.

The fact that causality is mutual while in some cases there are no cause-and-effects (or otherwise visible only a posteriori), makes that investment plans are not unidirectional in time (sequential chain of cause-and-effects), and feedback loops have to be considered. Still restrictions and controlling may exist, such as simple rules (Eisenhardt and Sull, 2001) and regulations or institutional and budgetary restrictions. They ensure that an agent's behavior is limited and in this way changing the aggregate behavior and helping the CAS to behave in a predictable way (Janssen et al., 2006). If you have a nuclear plant, you want security and equilibrium. Thus constraints are very desirable in that case, but in other cases predictably is unwanted.

In his discussion on organizations seen as complex systems, Lars Holmdahl (2006) states that processes are irreversible and they cannot be fully controlled or planned. Informal structures (the shadow system) self-organize, emerge, and persist in a way that is remarkably robust to changes in the formal organizational structure, which implies a hierarchal organization. So next to the formal structure there is an informal structure of self-organization. That is why organizational development practitioners should detect first the shadow system so that they can intervene in the shadow system. The informal structure plays an enormous role in the success of investments, which are organizational changes.

In this context Snowden (2002) states that organizations need to realize the degree of their dependence on informal networks. The sheer number of informal and semi-formal communities within an organization is too great to permit only formal management. "The danger is of chronic self-deception in the formal organization, partly reinforced by the camouflage behavior of individuals in conforming to the pseudo-rational models. A mature organization will recognize that such informal networks are a major competitive advantage and while ensuring scalability through automated processes and formal constructions will leave room for the informal communities to operate."

We can conclude that it is quite unrealistic to predict what an organization will be or do in the far future, certainly when it is impossible to detect when lever points will happen in the organization, let alone in other organizations which over time are co-creating the context of the organization and some of which may not exist yet.

2.5.6. Organizational Configuration

From the point of view of ST, Gharajedaghi (2011) sees besides the paradigm shift from analytical thinking to holistic thinking, another paradigm shift, namely in the organizational configuration from the 'mindless view' (the organization is a machine that cannot change anything by itself), over the 'uni-minded view' (the organization is a body with brains deciding how to adapt) to the 'multi-minded view' (the network is the organization).

We do not completely agree with the term paradigm shift. Even in these complex times, networked organizations are not always the best solution (nuclear plant). So there may have been a paradigm shift in the way organization can be lead in the Western world, but the three forms can be used. This will be determined by the situation the organization or its parts are in. Thus situational awareness is very important in the survival of the organization; a wrong structure may obstruct the organization to adapt effectively to its situation.

Structures should also be dynamic, what was adequate a time ago, may now not be the case anymore. Moreover "[s]ometimes we forget that [organizations] are created [or designed] by people, based on an idea about what should happen [given the situation] at a given point in the time." (Reed, 2006, p. 10). In this context the analysis, synthesis and design should be continuously done based on a permanent assessment of the environment, so that the organization can adequately co-evolve with its environment.

There is however also a terminology problem. The use of lower level models is problematic when applied to higher level systems, thus the language of simple machines creates blind spots when used as a metaphor for higher level models (Reed, 2006). Therefore all leaders must know the semantics of the highest level of modeling, and for that matter of all levels.

26 Obolensky (2010) talks about polyarchy.

2.5.6.1. The Mindless View

The mindless system is a mechanistic view of the organization. It is a particular form of known-known (known knowledge, known information), because the mindless system is more or less isolated. Only big "earthquakes" cause the mindless system to change.

Everything is based on efficiency, control and predictability of its operation. The parts of a mindless mechanical system, just like the whole, have no choice to behave how they want, and are therefore energy-bound.

All thinking and design has been done beforehand and laid down as rules. Mechanistic organizations are good for producing exactly the same product time and time again with precision and efficiency. But they can only solve old problems since all thinking is abolished and substituted for fixed rules (Holmdahl, 2006).

Since mindless organizations cannot be self-organizing and are constantly in equilibrium, two of the main characteristics of CAS, we will not discuss any further this type of organization.

2.5.6.2. The Uni-minded View

While the above mentioned systems behave mechanistically, most organizations definitely do not. Organizations tend to be open systems, interacting frequently and freely with other systems and the external environment. Organizations (De Beuckelaer, 2002) or "[c]omplex systems tend to behave more "organically"—that is, more like biological organisms." (MCDP-6, 1996, p.45). So, in changing and unpredictable environments that call for innovative changes, one could conceive of organizations as living and uni-minded organisms (systems).

Gharajedaghi (2011) writes that in this case a system is considered just like a human being, with a purpose of its own (thus an organization matching our definition), that is survival in its environment. To survive, these systems have not only to interact with the environment (other acting systems) in terms of information, energy, or material permeation through the system boundary, but according to conventional wisdom, biological beings have also to grow (biological view).

The organization is totally under the control of a single brain, the executive function, which receives information (feedback) from a network of sensors and issues directions that activate relevant parts of the system. Most of the time this happens in the single loop (figure 3).

The organization can be seen as a 'white box' in which intentional design of work and the organization helps enable organizational change. In this view, leadership (the brains of the system) is based on enlightened self-interest that aims at a win-win outcome. Therefore organization's governance does not only address the conformance aspect but also the performance aspect of governance and highlights strategic considerations such as value creation and resource utilization.

2.5.6.3. The Multi-minded View

Many things about the behavior of a social system refer to the interaction rather than the individuality of its members. Each social system manifests certain characteristics that it may retain even if all its individual members are replaced.
- Ervin Lazlo, 1972

The third view is the sociocultural or the 'Multi-minded' system. The most significant characteristic of a sociocultural system is the way a purpose is chosen. An organization is purposeful if it can produce the same outcome in different ways in the same environment and different outcomes in the same or different environments, which is the case for uni-minded and multi-minded organizations.

But for the latter, it is considered a voluntary association of purposeful members in which the bonding is achieved by a second-degree agreement ([27]), which is an agreement based on a common perception. This is formed by the culture (figure 3), the shared image, which incorporates their experiences, beliefs, attitudes, and ideals. It is the ultimate product and reflection of their history and the manifestation of their identity: man creates his culture and his culture creates him (Herzog, n.d.; Meadows, 1997). However, we are stating that the original source are the mental models of the organization (figure 3).

In the multi-minded view, the agents are very autonomous and have a lot to say about the organization of the whole, consensus is essential to the alignment of a multi-minded system (Herzog, n.d.). As a consequence for command-and-control (C2)([28]), Weijnen et al. (2008) confirm that a classic hierarchal C2 is not anymore accepted since no agent is superior to any other, therefore a very good communication and coordination system is necessary. Thus in the case of a multi-minded organization, C2 could stand for Communication-and-Coordination.

It must be stressed that although it is an evolution in management theory, the organization must make a "choice" which system (view) it will use. For instance, during certain military operations it is excluded that soldiers start discussing with their officers what to do next and why. Although Gharajedaghi (personal

27 "In first-degree agreements actors may agree on a course of action for completely different reasons. (The leftist and the Islamist in Iran agreed to topple the Shah's regime for completely opposite reasons.) Second-degree agreement, on the other hand, requires an agreement on the why question" (Gharajedaghi, 2011, p. 60).

28 Command is top-down, while control is feed-back bottom-up. C2 will be further discussed in section 3.1.

communication, 2011)([29]) for this case said that hybrid forms exist: uni-minded in the decision of the objectives, multi-minded in the execution.

To Gifford (n.d.), the consultation is based on the idea that modern leaders and managers need genuinely to consult with the organization as a whole: there should be a broad consensus before major policies are implemented, and significant issues should have been discussed. The empowerment lays in the fact that modern leaders should give their teams the goal and the direction, and then trust them to make the best decisions for themselves.

So basically what he states is the situation in a multi-minded organization with a shared identity and a shared vision. The consequence is that new emerging plans or actions are more likely to be better implemented and executed by all the agents: they have 'bought in'.

Rightly Gifford (n.d.) concludes that "[i]t is not easy to devise management systems that embrace these principles effectively, but modern organizations are moving in this direction because they have to. Today's highly-educated and mobile knowledge-workers will not tolerate a 'production line' approach to their working life; they expect to be consulted and they expect to make a contribution. And the leader who is not harnessing all of the skills, knowledge and experience of their colleagues is both wasting an immense pool of talent and failing to engage colleagues in a mutual effort to create a successful organization."

2.6. CAS*T

The idea of CAS*T (Complex Adaptive Systems Thinking) is making the bridge between two distinct concepts: Complexity Thinking (CxT) and Systems Thinking (ST).

Some confusion is caused by both *camps*, ST and CxT, on how they define concepts. We are stating that organizations are CAS, which have specific characteristics that should be known to design organizations (ST). In the case of designing a CAS, CxT people will say that its a contradiction: CAS are self-organizing so how can you design them? However most organizations are a legal entity, meaning that they have formal boundaries, and ST should facilitate the design of the formal organization.

Moreover the different types of structures (mindless, uni-minded, multi-minded) are not an evolution and each can be very adequate in different circumstances. A mindless organization can be the perfect organization form when the characteristics of a (full) CAS could damage the optimal performance (adapting) of the natural organization.

Basically the self-organization is an emergent phenomenon caused by the interactions between the agents and the interactions of the whole with its environment. The more restrictions are put on these interactions (relationships) the less possibilities to spontaneously reorganize, thus the more a design is needed.

CAS is sometimes seen as an organization (i.e. multi-minded), and sometimes as an environment (i.e. market). The former can be a legal entity where ST is essential to reflect the (legal, formal) reality and to manage it, keeping in mind the environment and the shared vision and the agents (members) having a second-degree agreement.

ST has no use for the latter, because it is the environment. That is why in CAS*T we make a difference between a CAS (organization) and a CAS (environment). Once this distinction made, less confusion can be made (in ST and CxT).

So, it is all about defining the border of a system, of an organization. Once defined (i.e. border of a legal entity), we have an introspection (the internals of an organization, CAS (organization)) and an extrospection ([30]) (CAS(environment)). Both are necessary to obtain the best possible situational awareness (figure 6).

29 Gharajedaghi wrote a book on Systems Thinking (Gharajdaghi, 2011). We asked him following question: "What about a military structure? It is nowadays more than a uni-minded system, but it cannot be a multi-minded system, because a soldier or a unit cannot go into discussion about the goals of the whole. So, isn't there a form in between? I call it for now a hierarchical multi-minded system. They should act autonomously and take the chance to act when the opportunity is there, but without having to ask permission to act. I will not go into detail about the responsibility and chain of command, but don't you think that there can be some intermediate form?"
His answer:" In my humble opinion, structure of the army depending on its level of development might either be a uniminded system with only reactive parts or uniminded system with responsive and reactive parts or a multiminded system with mostly responsive and limited active parts." e-mail December 19, 2011.

30 Extrospection: examination or observation of what is outside oneself —opposed to introspection. (Merriam-Webster: last accessed on September 9, 2012 at http://www.merriam-webster.com/dictionary/extrospection).

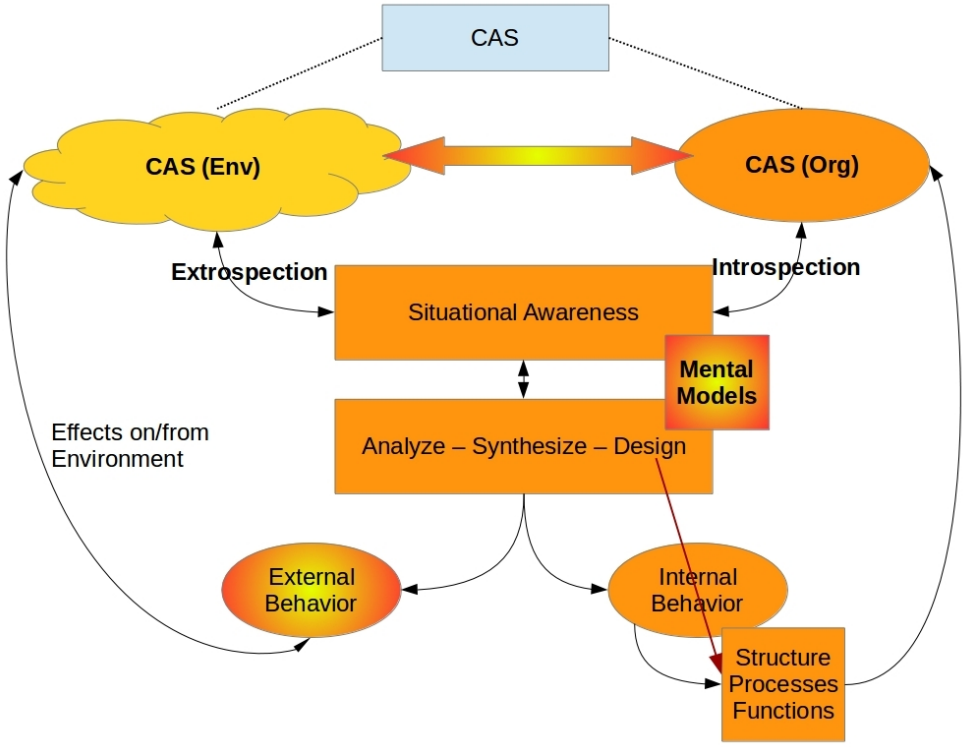

Figure 6: CAS as Organization and Environment

Of course the mental models are determining how we are observing the environment and the organization and how we are interpreting the information and how we are deciding and acting. The organization as a metaphor of a living being, will (re)act in an analogous manner.

The CAS (organization) may change the internal behavior by adapting its design (configuration of structure, processes and functions). Analyzing, synthesizing and designing are done simultaneously, one may not be in function of the other two.

So, the purpose of CAS*T is to guide an organization to adopt the best possible disposition with the appropriate command-and-control (C2), so that the organization can adapt as good as possible to its (changing) environment in function of its (probably changing) goals. Situational awareness of the organization (CAS) is crucial in the surviving of the organization in its environment (CAS).

It must be clear that this cannot be a science like chemistry, but an art.

2.7. Conclusions on Organizations as CAS and CAS*T

The mental models, which are cognitive representations of external reality, are of prime importance. An individual who is member of an organization also has a cognitive representation of this organization. So even if we focus on the (shared) mental models of an organization, it is necessary to know how members are perceiving their organization, thus introspection. From the point of view of the organization, its perceived environment is extrospection.

The culture of an organization is instantiated from these mental models, therefore the mental models determine how we observe the world, how we interpret these observations, how we decide and how we act, thus also how we assess, decide and execute investments.

The members of an organization have a shared vision and they are committed to attain the shared goals (second-degree agreement). These organizations are CAS, and so may their environment be. To avoid confusion we are mentioning respectively CAS (environment) and CAS (organization). In the latter we have agents (=members) with second-degree agreement.

To adapt mental models the single and double learning loops of Action Research can be used (see figure 3, p.15). So mental models are dynamic and can evolve, put in the context of CAS, mental models are co-

evolving with the environment of the organization.

Although CAS are self-organizing, the CAS (organization) may have constraints so that it cannot fully decide how it should organize itself. That is why we have introduced ST for designing (at the same time analyzing, synthesizing) these CAS (organizations) (figure 6 p.30). ST is holistic; it attempts to derive understanding of parts from the behavior and properties of wholes, rather than derive the behavior and properties of wholes from those of their parts.

Therefore we need a transdisciplinary approach because transdisciplinary inquiry tends to focus on the inquiry or issue itself. Hent (n.d.) states that transdisciplinary approaches involve multiple disciplines and the space between the disciplines (thus the whole is more than the sum) with the possibility of new perspectives 'beyond' those disciplines.

Figure 7 shows our representation of the different approaches. Disciplinary inquiry gives the opinion of one specific discipline. Multidisciplinary is synthesizing after adding the result of the respective disciplinary inquiries. Interdisciplinary inquiry is based on the new discipline overlapping the original disciplines. Transdisciplinary is holistic and goes beyond the borders of the original disciplines.

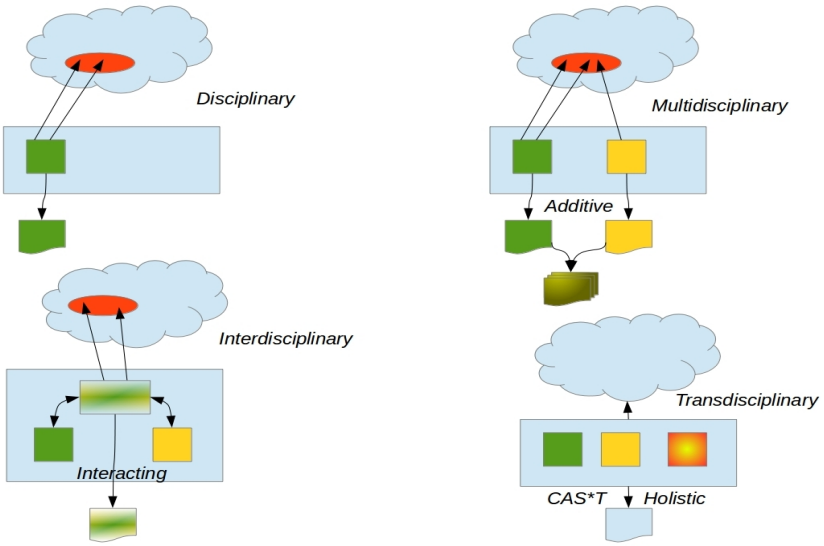

*Figure 7: CAS*T Transdisciplinary Approach*

We are bringing CxT, ST and the transdisciplinary approach together in our CAS*T framework. The purpose of CAS*T is to guide an organization to adopt the best possible disposition with the appropriate C2, so that the organization can adapt as good as possible to its (changing) environment in function of its (probably changing) goals. Situational awareness of the organization (CAS) is crucial in the surviving of the organization in its environment (CAS).

Since CAS (organization) is in ever changing environment, strategy should be dynamic. It is not a piece of paper to hang at a wall for the next five years. Understanding CAS is accepting emergent strategy. In his discussion on the organizations seen as complex systems, Lars Holmdahl (2006) states that processes are irreversible and they cannot be fully controlled or planned. Informal structures (the shadow system) self-organize, emerge, and persist in a way that is remarkably robust to changes in the formal organizational structure, which implies a hierarchal organization. So, next to the formal structure there is an informal structure, where self-organization is primarily to be found. That is why organizational development practitioners should detect first the shadow system so that they can intervene in the shadow system. Of course, the informal structure plays an enormous role in the success of investments, which are organizational changes.

In the next chapter we go more in detail on complexity and complex decision-making in a military context.

3. War as Complex Adaptive System

In this chapter we will discuss war as a CAS. First we discuss Command-and-control (C2), then Network-Centric Warfare (NCW) and the OODA-cycle. It is shown that the thoughts of von Clausewitz on nonlinearity of warfare are still relevant today for deciding on investments in information systems, but that the military sense-making framework USMC C2 is not generic enough and that the Cynefin sense-making framework discussed in the next chapter is a better choice.

3.1. Command-and-control (C2)

We have mentioned General von Moltke (19th century) regarding operation orders but what is nowadays the point of view on orders and C2? The US Marine Corps (USMC), strongly influenced by Colonel aviator John Boyd, has published in 1996 its doctrine on C2: MCDP-6, which anno 2015 is still applicable. The main idea is that war and the armed forces are CAS, and that therefore the C2 should be adapted accordingly. There is no single C2-type that fits all circumstances in which a CAS can be.

3.1.1. C2 and complexity

Major Kolenda (2003) describes five critical postulates about the enduring nature of war:

- Information in war is “essentially dispersed.”
- War is Chaotic.
- Combatants in war are CAS.
- War is a nonlinear phenomenon.
- War is the realm of uncertainty.

In this context, “[m]ilitary organizations and military evolutions are [CAS]. War is an even more complex phenomenon—our complex system interacting with the enemy's complex system in a fiercely competitive way. A [CAS] is any system composed of multiple parts, each of which must act individually according to its own circumstances and which, by so acting, changes the circumstances affecting all the other parts. … A squad-sized combat patrol, changing formation as it moves across the terrain and reacting to the enemy situation, is a complex system. A battle between two military forces is itself a complex system.” (MCDP-6, 1996, p. 44).

In CAS*T, the combat patrol is a CAS (organization), while the battle is a CAS (environment).

The element of recursion or system-of-systems is also known: “Each individual part of a [CAS] may itself be a [CAS] … creating multiple levels of complexity. But even if this is not so, even if each of the parts is fairly simple in itself, the result of the interactions among the parts is highly complicated, unpredictable, and even uncontrollable behavior. Each part often affects other parts in ways that simply cannot be anticipated, and it is from these unpredictable interactions that complexity emerges. With a [CAS] it is usually extremely difficult, if not impossible, to isolate individual causes and their effects since the parts are all connected in a complex web. The behavior of [CAS] is frequently nonlinear which means that even extremely small influences can have decisively large effects, or vice versa. Clausewitz wrote that '*success is not due simply to general causes. Particular factors can often be decisive—details only known to those who were on the spot, while issues can be decided by chances and incidents so minute as to figure in histories simply as anecdotes.*' The element of chance, interacting randomly with the various parts of the system, introduces even more complexity and unpredictability.” (MCDP-6, 1996, pp. 44-45)

Their approach to C2 is to find a way to cope with this inherent complexity of (war) interactions, which distinguish it from the typical view of C2 (MCDP-6, 1996, pp. 46-47):

- C2 must be sensitive to changes in the situation (endogenous and exogenous), therefore it provides the means to changing conditions, thus continuously adapting.
- The action-feedback loop makes C2 a continuous, cyclic process and not a sequence of discrete actions.
- C2 is not that controlling anymore but coordinating. Every agent is informing and receiving information, and C2 is therefore an activity of reciprocal influence.
- The commander is not anymore above, but is an integral part of the CAS (reciprocal influence).
- As such, this view recognizes that it is unreasonable to expect C2 to provide precise, predictable, and mechanistic order to a complex undertaking like war.

C2 is also an information system. It is composed of people (users), information (input-output) and the C2 infrastructure (hardware, software, network). Basically two types of information exist. The first is to sense the environment (situational awareness). The second is to direct and coordinate actions in the execution of the decisions.

C2 is also a process, a collection of related activities. As a matter of fact, C2 is not a procedure (a specific sequence of steps for accomplishing a specific task). Of course, C2 may include procedures, but the main point is that C2 is something what -in this case- marines do at all levels. This brings us tot the Observe-Orient-Decide-Act (OODA) process (or better known as the OODA-CYCLE) of John Boyd.

3.1.2. The importance of Continuous Assessment

The fuel of C2 is the continuous assessment of the environment. Colonel Reed (2006) emphasizes that leaders of complex organizations certainly in complex environments need ST to be able to function. ST tends to see things in terms of loops and patterns aided by constant assessment of what “is” happening, rather than flow charts and reliance on what should be happening.

He refers to the work of Sydney Finkelstein ([31]) who examined over 50 of the world's most notorious business failures. Not lack of competence was the cause, on the contrary in most cases the executives failed to see or accept what was actually happening. The pragmatic focus of ST on determining what is actually happening serves as a preventative of self-delusional wishful thinking. To Reed the executives were trapped by their own faulty mental models.

Rightly he states that the continuous assessment process which is characteristic of ST - but certainly necessary for a CAS organization – is essential in a volatile, rapidly changing environment. He notes that it takes time and good habits of critical reflection to engage in this kind of learning, both for individuals and organizations.

3.1.3. Uncertainty: Compressing Time and Space

Actors do not know beforehand if their actions will have the desired outcomes, because they do not know how the other actors will act, thus deciding is making choices under uncertainty. Moreover, the world grows smaller, therefore more and more actors are coming into the direct environment around the organization, so the number of players is increasing.

In addition due to Information Technology (IT) the speed of transactions is increasing. Uncertainties can be, amongst other reasons, due to wrong information, lack of information and/or knowledge, lack of time to analyze information or a wrong collection of information. Moreover, Artigani (2005) states that uncertainty is not often reducible to information, thus perfect information will not remove uncertainty.

Major Walters (1994) states that uncertainty is prevalent on the battlefield because the nature of war is nonlinear, resulting in a multitude of complex problems. These problems are complex because battlefield events (CAS environment) are the products of an unquantifiable number of variables, infinitely interacting with each other in a dynamic system—war. “Yet we know that many of the events and activities in battle and war that we apply linear concepts to, really are not linear at all, but highly nonlinear, just as we know theories of relativity and quantum physics have gone beyond classical physics in explaining the complexities of everyday life.” (p.5).

Jaktevicius (2007) cites John Boyd (p. 47): “As Boyd has pointed out elsewhere in his 'Discourse on Winning and Losing' a successful entity must cope with uncertainty, imprecision, and mismatches by recognizing that they are fundamental to reality. At the same time, it is valuable to have the ability to utilize these aspects of reality in positive ways rather than becoming immobilized by them.”

So time to observe, to think, to decide and to act, or better the lack of time has an important impact on the degree of uncertainty. As a consequence, time is another important element that determines uncertainty and affects C2. We can always wait for more information to reduce uncertainty, but to Artigani (2005) even perfect information will not remove uncertainty. However a CAS must co-evolve with its environment. Reacting quickly may be a question of live or death, and gaining and processing may take valuable time, the CAS may not have.

The defining problem of C2 that overwhelms all others is the need to deal with uncertainty caused by the compressing of time and space. Were it not for uncertainty, C2 would be a simple matter of managing resources.

Since war and business are CAS, we may postulate that uncertainty is an emergent attribute of a CAS. As the USMC puts it (MCDP-6, 1996): “Uncertainty is not merely an existing environmental condition; it is a natural byproduct of war.” And as we know, war is a CAS (environment). As such phrased in platitudinous terms: Uncertainty is certain (Walters, 1994).

3.1.3.1. Detailed and Mission C2

According to the USMC two basic responses exist to solve the fundamental problem of uncertainty. Firstly to pursue certainty as the basis for effective C2, which implies a detailed C2 where the commander holds a tight rein. Therefore detailed C2 must be centralized and formal. Orders and plans are detailed and explicit, and to be successful the commander requires strict obedience and he will minimize subordinate decision-making and initiative. Thus discipline and coordination are imposed from above to ensure

31 Why Smart Executives Fail

compliance with the plan. This is typical for a uni-minded organization. That is why USMC describes detailed C2 as coercive.

The second response is to accept uncertainty as a fact and to learn to function in spite of it, which by contrast with the detailed C2 is called the mission C2 and is spontaneous. Rather than increasing the level of certainty a commander is seeking, by mission C2 the needed degree of certainty is being reduced. No imposed orders from above but the spontaneous cooperation of all the agents is the success of the operation. Subordinates are guided by their knowledge of the requirements of the overall mission (MCDP-6, 1996). The original operation order (mission) is transformed by each level accordingly until the most atomic unit has been reached (Rabaey, 2004). As already noted, Helmuth von Moltke the Elder: “An order shall contain everything that a commander cannot do by himself, but nothing else” (Holborn, 1986, p.291). Thus allowing subordinates significant freedom of action and requiring them to act with initiative. This demands more of leaders at all levels and requires rigorous training and education. By decentralizing decision-making authority, mission C2 seeks to increase tempo and improve the ability to deal with fluid and disorderly situations (MCDP-6, 1996).

The lower down in the hierarchical order of the organization the leader is, the less control he has over the resource aspects and over the scope of his business levels. Therefore in this ever faster changing world, the structure must become less hierarchical, in order that more flexibility be gained. Moreover armed forces are a hybrid organization: uni-minded organizations with big autonomy in execution (Personal communication with Gharajedaghi, 2011), which is in accordance with the shared vision. This implies that the commanders need to be able to exchange information (intelligence) not only vertically but also horizontally.

3.1.3.2. Intelligence

According to CT, predictions are impossible (Snowden, 2013; Nikolic, 2010), so reason the more that an organization always has to collect intelligence (Bernard, 1976). The continuous process of observing, creating and disseminating of intelligence is a conditio sine qua non for the harmonization of means and goals (strategy). Intelligence is the product resulting from the collection, evaluation, analysis, integration, and interpretation of all available information that concerns one or more aspects of the other actors and their actions in the environment, and that is immediately or potentially significant to the planning and operations of an organization (Rabaey, 2012b).

3.1.4. Dimensions of Decision Making

The three dimensions of decision making are rational, emotional and cultural (Gharajedaghi, 2011, pp.33-37). A rational choice is the domain of the self-interest of the decision-maker. It reflects the perceived interest of the decision maker at that certain moment of time and is related to extrinsic values (instrumental).

In an economical context (see also (Rabaey, 2011)), rationality has more to do with the ratio of benefits to costs instead of the philosophical meaning of reasoning. Related to the investments and/or resource allocation issues, it is all about uncertainty management. Uncertainty is more than risk management, which is the identification, assessment, and prioritization of risks (based on uncertainties) followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. Uncertainty is a state in which the outcomes are unknown and perhaps unknowable.

Literature on behavioral economics (Ariely, 2009; Montier, 2010), intuitive management (Burke et al., 1999), psychology (Libet, 2011; Pucket et al., 2011) and naturalistic decision-making (Brooks, 2007; Berryman, 2007; Shattuck & Miller, 2006) confirms that decision-making is not always rational. A lot has to do with how people and their brains are coping with uncertainty and the perception of uncertainty.

The emotional dimension of decision making is the domain of beauty and excitement and deals with intrinsic values (stylistic). In contrast to rational choice, which is risk aversive, emotional choice is not. As a matter of fact, uncertainty is an important attribute of excitement and challenge. An uncertainty can be positive (opportunity) or it can be negative (threat).

The cultural dimension is about ethical norms of the collectivities to which the decision maker belongs (figure 3). The ethical values are the constraining elements of the decision process. Culture delivers the default values when the decision maker fails to choose one explicitly. In the OODA-cycle of Boyd cultural heritage is a factor of the “Orientation” of the decision-making process.

Besides the mental models and culture (double loop), the decision-making process (OODA) is also situated in a strategic framework and tactical, operational context (single loop).

3.1.5. Military Contexts

3.1.5.1. Tactics

IT is about the support of automated applications in the information system ([32]) of an organization. Just as

32 The term "information system" means a discrete set of information resources organized for the collection,

for civil organizations, information is of great importance to the military leaders. Information ([33]) is the base material for the production of intelligence. The purpose of intelligence is to improve the decision making capability of a military organization by (ACOS Eval, 2006):

- raising the awareness of the organization with regard to relevant situations;
- improving the knowledge of the organization and its members;
- improving the inference rules.

Once the observation (collecting of information) and orientation (processing information into intelligence) have been finished, the leader can make his decision and give his order to his subordinates. They will then execute the orders (by using the same process). The subordinates will then inform the leader of the execution of the orders (feedback).

This is the situation of a detailed C2. As already discussed above, the situation is different for mission C2: global objectives are defined by a centralized command, but the derived objectives and execution are decentralized. Nevertheless at each level intelligence must be gathered for its own situational awareness.

Every level (hierarchal organization) or every node (networked organization) however must develop and execute its own strategy based on the perception of its situational awareness in addition to its objectives, means and will. Although we already have discussed strategy, it is necessary to discuss in the context of OODA how strategy is related to technology and tactics.

3.1.5.2. Strategy and Technology

Bülow remarked that the commanders must have the technicians under control. “The supreme command must rise above the specialists and the experts. The technique of fortification, the theory of artillery fire, military medicine, logistics, said Bülow, are only preparatory sciences. The science of employing all these things fittingly for the strengthening and defense of society is true military science. This is the real business of generalship. Hear this plainly: when a chief of state is obliged to leave the guidance of the state's energies in war to a squad of mere specialists trained in the preparatory sciences, the inevitable outcome will be fragmentation and cross-purposes, of which the first result will be weakness ... and the end result dissolution; because the binding power of intelligence is missing, which unites the materials in one building, or in one purpose” (Palmer, 1986, pp.117-118). The collaboration between the techniques (disciplines) must have a common goal, thus transdisciplinary.

So, Grand Strategy may not be dictated by technology. However, the enormous technological leaps of the past decades and their contribution in the realization of the different strategies is important. In the discussion on the principles and rules of the Art of War, we had proposed the “Resources strategy” ([34]) because the co-ordination and the collaboration of the different technologies can no longer fall under the sole responsibility of the tactical commander. Despite this fact, it is of the utmost importance that these new advances in technology be integrated into military and non-military strategies alike. ([35]).

3.1.5.3. Tactics Defined

Sometimes tactics ([36]) are confused with strategy. This is due to the fact that in the 18th Century some military thinkers such as Guibert wrote that “tacticque” is the maneuvering of troops, where as “Grand Tactics” is what we would now define as strategy, and “Elementary Tactics” is what we would now define as tactics. To Guibert ([37]) this definition would still be too narrow, and to him all tactics were Military Science (Palmer, 1986, p.107).

Concepts should be made simple, however not too simple as Bülow has done. “Bülow defined strategy as 'all military movements out of the enemy's cannon range of vision, and tactics as all movements within this range.' This definition is due to the fact that Bülow was seeking for the mathematical principles that would reveal a rational structure in the chaos that is war. Karl von Clausewitz rejected this definition

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processing, maintenance, transmission, and dissemination of information, in accordance with defined procedures, whether automated or manual. (Whitehouse, 2013)

33 The term "information" means any communication or representation of knowledge such as facts, data, or opinions in any medium or form, including textual, numerical, graphic, cartographic, narrative, or audiovisual forms. (Whitehouse, 2013)

34 Resources in the sense of “a stock or supply of materials or assets that can be drawn on in order to function effectively” (Oxford on-line). Belgian Defense has Directorates General as Human Resources (DGHR), Material Resources (DGMR) and Budget-Finance (DGBF), which support the core business whilst delivering qualified personnel, systems, services and budget, so that operations, processes and projects can be executed.

35 For further discussion about strategy and technology, we refer to “Science, Strategy and War: The Strategic Theory of John Boyd” by Frans Osinga (2005, 2007)

36 Webster on-line: Etymology: New Latin tactica, from Greek taktikE, from feminine of taktikos

1 : a device for accomplishing an end

2 : a method of employing forces in combat

37 Count Jacques Antoine Hippolyte de Guibert (1743-1790) was French writer. He became quickly famous at the age of twenty-one with his “Essai général de tactique” (Palmer, 1986,, p.106)

because the terms are depending on the technologies used at any given moment. He proposed the following definitions: 'Tactics constitute the theory of the use of armed forces in battle; strategy forms theory of using battle for the purpose of war'."(Paret, 1986, p.190).

One of the critics of Shy on the theory of Jomini ([38]) is that even though Jomini makes the distinction between "politics", "strategy" and "tactics", "he also wanders freely between them, citing principles and prescribing actions as if he himself had forgotten that all three zones were regulated by different laws" (Shy, 1986, p.174).

These examples of the different definitions of tactics (and strategy) demonstrate why there is such a Babel-like confusion. Even now, terms such as operational strategy and tactics are interchanged.

According to the Dictionary of military terms (DOD, 1999), Tactics are "1. The employment of units in combat. 2. The ordered arrangement and maneuver of units in relation to each other and/or to the enemy in order to use their full potentialities."

Just like with the term strategy, adjectives can be used. "Grand Tactics" are "the art to place weapons and services in such a way that the collaboration between them is assured". The "tactic of a weapon" is the "study of Grand Tactics from the point of view of methods related to a weapon or branch, for example infantry, artillery and air force. Tactics in general is "the art to achieve in battle the best result out of the combat means: troops, weapons and material" (Bernard, 1976, p.27). Therefore our definition: "Tactics are the art to optimize the combination of resources of an entity in the execution of the plan shaped by the operational strategy."

3.1.5.4. Relationship Strategy and Tactics

The difference between effectiveness and efficiency is sometimes explained as follows: 'Effectiveness is doing the right things, while efficiency is doing the things right'. So effectiveness is carrying out the right actions, whereas efficiency is carrying out the actions right. The essential difference between strategy and tactics is the same. As Cohen (2004) wrote; "Tactical implementation should be directed toward implementing the right thing – a good strategy. Good tactical implementation of a bad strategy is doing the wrong thing in the right way" (p. ix).

3.1.5.5. Tacticization of Strategy

a) Quick wins

Michael Handel (2001) introduces *Tacticization of Strategy* in his book *Masters of War* ([39]). In the introduction he quotes Mao Tse-tung ([40]): "Without a good plan for the whole campaign, it is absolutely impossible to fight a really good first battle. That is to say, even though victory is won in the first battle, if the battle harms rather than helps the campaign as a whole, such a victory can only be reckoned a defeat. […] Hence, before the first battle one must have a general idea of how the second, third, fourth, and even the final battle will be fought. ... It is absolutely essential to have a long-term plan." Here a long-term plan should be considered as an expression of a shared vision (Grand Strategy), taking into account that the future is unpredictable. This is why thinking at the next battles is not enough, you have to keep in mind what situation you want to have after the campaign.

Outstanding performance on the tactical and operational level may cause political and military leaders to emphasize short-run success on the battlefield while neglecting the development of a coherent long-range strategy. When a strategy is not clearly formulated, then it emerges by default thus not aligned with the shared vision, which can be disastrous in a prolonged war, since tactical and operational successes may not add up to a "winning" strategy. Examples are Hannibal in the Second Punic War and Napoleon, they could never secure a "final strategic victory", lower-level operational considerations were defining the strategy in war.

Colonel Reed (2006) adds the urgency or *busyness* to the picture. Everything has to go fast thus rapid-fire short-term solutions have to solve long-term problems (today's solutions = tomorrow's problems). A common symptom of this phenomenon can be seen in leaders who unrealistically demand (linear) simplicity and certainty in a complex and uncertain environment (preferably on two presentation slides). Reed asks whether speed and decisiveness in decision-making, so valued at the tactical level, work to the detriment of good decisions at the strategic level. Even more dangerous to Reed is that without reflection necessary for the decision-making, people will certainly not take time to reflect to learn, which is however very important for a learning organization which CAS is.

In the business world if the so-called quick wins are not aligned with the business strategy, then these quick successes can imperil the execution of that business strategy.

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38 General Baron Antoine Henri de Jomini (1779-1869) was a Swiss writer and was an officer in the French and Russian Armies. He stated that War is an Art, not a science. (Jomini, 1992, pp. v-vi)

39 This section 3.1.5.5 is for a great part based on the Appendix E: "The Tacticization of Strategy" (Handel, 2001, pp.353-360)

40 Handel quotes Mao Tse-tung, "Selected Military Writings", pp.130-131.
The "Selected Military Writings" can be found on http://www.marxists.org/reference/archive/mao/selected-works/military-writings/index.htm (last consulted November 2013).

b) Holistic view

Handel (2001) continues to quote Mao Tse-tung to emphasize the need to consider “the situation as a whole”, which is in fact the essence of strategic thinking (ST). However not only at the strategic level, one needs to think holistically, but at every level. Strategy is a contextual term.

Mao Tse-tung warns of the danger of “Tacticization of Strategy”: “The view that strategic victory is determined by tactical success alone is wrong because it overlooks the fact that victory or defeat in war is first and foremost a question of whether the situation as a whole and its various stages are properly taken into account.”([41])

To Mao Tse-tung, the holistic view or the situation as a whole is of great importance for the strategy: “If there are serious defects or mistakes in taking the situation as a whole and its various stages into account, the war is sure to be lost. 'One careless move loses the whole game' refers to a move which affects the situation in a partial nature rather than a move which is decisive for the whole situation. As in chess, so in war. But the situation as a whole cannot be detached from its parts and become independent from them, for it is made up of all its parts.”

We will propose a holistic approach to assess and decide on the IT-investment strategy (programs) of all the resources in an organization. These investments viewed from the holistic perspective, will be aligned to the business and resource strategies of that organization. In this way, IT solutions (thus investments) will be assessed with respect to the business objectives (business strategy) and will be considered along with the rest of the resources (resources strategies), so that IT will not be ruling the business processes (operational strategy). In this way, the “Tacticization of strategy” of the organization by IT-tactics is reduced. Investments however will not be stand-alone projects (in one or more functional domains) but organizational changes with respect to the whole (organization) in a transdisciplinary way.

c) Hierarchical level of analysis

“The situation as a whole” implies a dynamic relationship between the different levels of war: strategic level, operational level and tactical level. In theory, the relationship is hierarchical (See Figure8, ([42])).

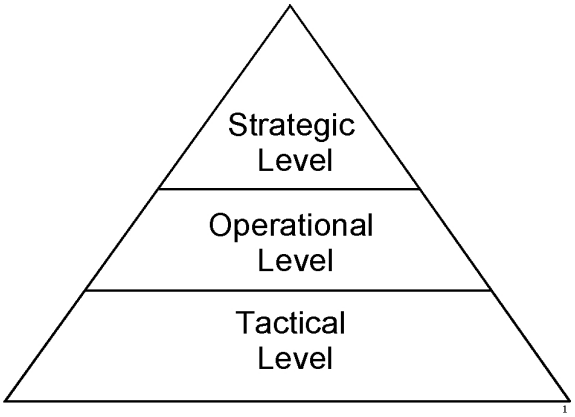

Figure 8: The traditional hierarchy of influence and decision-making in war

Handel depicts the dynamic relationship among the different levels of war as in figure 9 ([43]), in which the relative importance of each level in the direction and control of war is signified by the size of the box representing it. Moreover, this figure shows the actual reciprocal relationships among the various levels of waging war. Note that operational/tactical are switched as compared to a normal management point of view in business.

Handel states that throughout history the principal cause of tacticization of strategy has been the uncontrolled ambition of military field commanders or the tactically and operationally oriented thinking of political leaders. An additional cause emerged after the Second World war in the form of military-

41 Handel quotes Mao Tse-tung, “Selected Military Writings”, pp.81-82

42 Source: (Handel, 2001, p.354)

43 Source: (Handel, 2001, p.357)

technological developments, especially with the new third dimension of war: air war.

3.1.5.6. EBO, between Uni-minded and Multi-minded Organization

“The greatly enhanced capabilities of modern air-delivered precision-guided munitions can destroy almost any physical/material target that can be defined. This technological trend, combined with the reluctance of Western political leaders to take or inflict unnecessary casualties for non-vital secondary or tertiary national interests, has created a situation in which targeting has *de facto* becomes a substitute for proper strategic planning. […] the latest doctrinal developments in the U.S. military vision (Joint Vision 2010-2020) of the future of conventional war suggest the gradual blurring of the traditional distinctions between the strategic and lower operational and tactical levels of war. In other words, the expected quality of wartime intelligence (i.e. 'information dominance', 'information superiority', 'battlefield or battlespace transparency) – and accurate target acquisition in real time – will allow a faster paced 'sensor-to-shooter' war, in which there will be less time to consult the higher strategic and operational commands.”

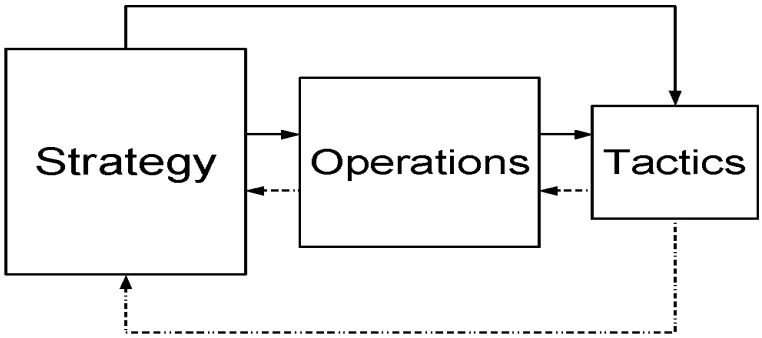

Figure 9: The three levels of war as a complex model of interaction

Major Mark G. Davis (2004) discusses some doctrinal issues around “Centralized Control / Decentralized Execution”, where through new technologies (mostly IT) a centralized control becomes more possible. However since the control is centralized, there seems to be a contradiction with “decentralized execution” ([44]). One issue is the emergence of effects-based operations (EBO([45])) and its impact on centralized control and decentralized execution.

Effects-based operations can be defined as “a process of obtaining a desired strategic outcome or 'effect' on the enemy through the synergistic and cumulative application of the full range of military and non-military capabilities at all levels of conflict”, and an effect is “the physical, functional, or psychological outcome, event or consequence that results from specific military or non-military actions” (Uchida, 2002).

Davis (2001) states “These operations [*EBO*] are conceived and planned in a systems framework that considers the full range of direct, indirect and cascading effects by the application of military, diplomatic, psychological, and economic instruments.” Due to this approach, military conquests have less priority than diplomatic, political or economic considerations. So the whole is the nation and its parts are the different state departments.

“Because of casual linkages among target sets and the danger of objective fratricide, effects-based operations must be orchestrated by a centralized planning and execution authority that has situational understanding of every aspect of the diplomatic, informational, economic, and military campaign.” EBO will have a myriad players to the targeting process, therefore it would be impossible for centralized control to coexist with a true EBO campaign strategy. Davis warns that the most significant danger is the Tacticization of the strategy, because of the way political and military leaders will be affected in their strategic thinking. The boundaries between the various levels are becoming less defined.

He concludes that “On the strategic level, centralized control influences decision-making in three ways.

44 For joint operations, centralized planning and direction is essential for controlling and coordinating of ALL forces available, thus also Air Force which is proponent of decentralized execution.

45 For a literature study on EBO until 2003, see Jobbagy (2003).

First, the operational level will be less critical because sensors and shooters are becoming strategic. Secondly, centralized control and the emphasis on the capability to destroy targets with precision-guided munitions will result in strategic success without first identifying political goals. Finally, centralized control increases the likelihood of intervention by political and military leaders removed from the fight. The danger of centralized control is subverting long-range strategy that looks beyond the capabilities of weapons platforms and destruction of targets."

So EBO is a violation of the concept of CAS. It is clear that for the Western military we are in between the uni-minded and the multi-minded view of an organization. The (political) creation of the overall shared vision thus Grand Strategy (of a nation or alliance) and the allocation of resources and/or capabilities are still centralized in a uni-minded organization, while the execution (Operational Strategy) is decentralized and the highest level of the military and political decision-making are counting on the fact that the subordinate levels are acting like CAS.

3.1.5.7. Strategic Corporal

"To date, US attempts to implement EBO have been focused mainly on the technological dimension of war. Successful conduct of EBO requires more than the acquisition of sophisticated software and hardware systems. Despite all human efforts to instrumentalize war, a Clausewitzian fog remains inevitable in human conflict. As a result, it will continue to be necessary to focus strongly on the human dimension of war. Soldiers have to operate in complex environments and to confront uncertainty. In this respect, professional military education and the fundamentals of war remain important in producing ground forces capable of judgment.

EBO require educated humans 'in the loop' of decision-making in order to control the dynamics of combat effectively. Former US Marine Corps commandant, General Charles C. Krulak's notion of a 'strategic corporal' having to exercise an exceptional degree of independence, maturity, restraint and judgment in the conduct of operations in the 21st century is likely to become an increasing reality in the future. In essence, success in EBO requires not only an array of technological devices, but a grasp of multidimensional skills by well-trained and knowledgeable military professionals who are capable of mastering chaos in the battle space. With the human dimension at the forefront, it may not be an exaggeration that one commentator has gone so far as to describe EBO as being the equivalent of 'PhD-level warfare'." (Ho, 2004, p. 104).

The strategic corporal and his team should be considered as autonomous but interdependent agents in a CAS (as organization), which is not the case with EBO. His team should collaborate in a transdisciplinary way to attain the goals of the whole.

3.1.5.8. Political control and the direction of war

Michael Handel (2001, p.357) states that the destruction of targets at will, does not add up to a clear or coherent strategy; nor does crippling the enemy's military and economic infrastructure automatically bring political and strategic success. Revolutionary improvements in military intelligence and target acquisition on all munitions will further increase the pressure as well as opportunities for the 'tacticization of strategy.' (see figure 10)([46]).

46 *Figure 10* Figure The relative importance of each level for political control and the direction of war. in Handel (2001, p.357).

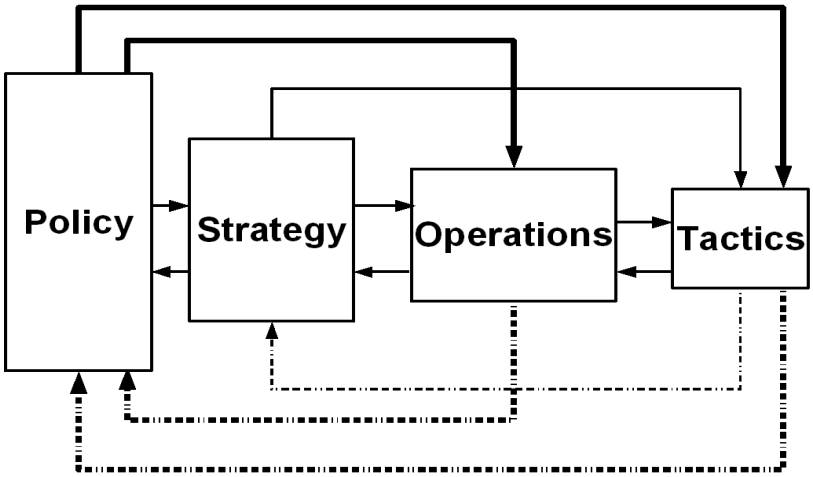

Figure 10: The relative importance of each level for political control and the direction of war.

"The long-term success of every war can be achieved only by first identifying its political objectives […] instead of first defining clear objectives and strategies, political leaders now decide to take action on the basis of the promise of air power to destroy targets at will, at a much lower cost in casualties and collateral damage. But the best and most suitable means should be decided only *after* the political objectives and purpose of the war have been identified. […] Targeting, destruction, and attrition are only *one* aspect of strategic planning."

3.2. Network-Centric Warfare (NCW)

Network-Centric Warfare (NCW) is a term giving by the US Navy, which defines the paradigm shift from platform-centric warfare to a more networked collaborative system.

Platform Centric Warfare is leading to a battle of attrition. "This method of warfare employs stand-alone components to provide overwhelming fire power and superior maneuver to seizing the initiative, while fixing, closing and ultimately destroying the enemy. Warfare of this type is heavily dependent on weaponry platforms to win frontal attrition-style wars. Platform centric warfare depends on a decisive battle, or series of decision battles, of a force-on-force type scenario. The tank, armored personnel carrier, helicopter, and artillery piece are all examples of conventional platforms that support platform centric warfare. Although this type warfare may employ limited digitalization, it is far from the sophistication expected in the network centric environment." (Bailey, 2004, p.1)

Cebrowski et al. (1998) wrote: "Network-Centric Warfare and all of its associated revolutions in military affairs grow out of and draw their power from the fundamental changes in American Society. These changes have been dominated by the co-evolution of economics, information technology, and business processes and organizations, and they are linked by three themes:

- The shift in focus from the platform to the network [multi-minded]
- The shift from viewing actors as independent to viewing them as part of continuously adapting ecosystem [CT]
- The importance of making strategic choices to adapt or even survive in such ecosystems [CAS]"

NCW enables a shift from attrition-style warfare to a much faster and more effective war fighting style characterized by the new concepts of speed of command ([47]) and self-synchronization ([48]).

47 Speed of Command is the process by which a superior information position is turned into a competitive advantage (Roberts et al., 2003, p. 14).

48 Self-Synchronization is the ability of a well-informed force to organize and synchronize complex warfare activities from bottom up (Roberts et al., 2003, p. 14).

3.2.1. Speed of Command

Cebrowski et al. (1998) defines “Speed of Command” as “the process by which a superior information position is turned into a competitive advantage. It is characterized by the decisive altering of initial conditions, the development of high rates of change, and locking in success while locking out alternative enemy strategies. It recognizes all elements of the operating situation as parts of a complex adaptive ecosystem ([49]) and achieves profound effect through the impact of closely coupled events.”

Speed of command consists of three parts:

- The force achieves information superiority, not necessarily by having more raw data but by having *a far better awareness or understanding of the battlespace*. From a technological point of view, information superiority requires excellent sensors, high-performance networks, display technology, and sophisticated modeling and simulation capabilities.
- Forces acting with speed, precision, and reach achieve the massing of effects versus the massing of forces. Speed of command emphasizes not the output but the outcome (effects in the CAS (environment). This is an answer to EBO with centralized control.
- The outcome should be the disruption of the courses of action of the enemy and the shock of closely coupled events, therefore disrupting the enemy's strategy. Thus intervening in the decision-making loop of the enemies. One of the strengths of NCW is its potential, within limits, to offset a disadvantage in numbers, technology, or position.

3.2.2. Self-Synchronization

Self-synchronization is “the ability of individual unit commanders to synchronize their unit’s individual efforts in order to mutually support other commander’s units, and accomplish the overall shared goal. Knowing the theater commander’s 'promulgated common intent' as well as being able to predict the reactions of other unit commanders allows each individual commander to decide independently how his or her unit will deploy.” (Thomson et al., 2005, p.10).

Cebrowski et al. (1998) define “Self-Synchronization” as “the ability of a well-informed force to organize and synchronize complex warfare activities from the bottom up. The organizing principles are unity of effort, clearly articulated commander's intent, and carefully crafted rules of engagement. Self-synchronization is enabled by a high level of knowledge of one's own forces, enemy forces, and all appropriate elements of the operating environment. It overcomes the loss of combat power inherent in top-down command directed synchronization characteristic of more conventional doctrine and converts combat from a step function to a high-speed continuum.

Military operations are enormously complex, and *complexity theory* [italics added] tells us that such enterprises organize best from the bottom-up. Traditionally, however, military commanders work to obtain top-down command-directed synchronization to achieve the required level of mass and fires at the point of contact with the enemy. Because each element of the force has a unique operating rhythm, and because errors in force movement needlessly consume combat power, combat at the operational level is reduced to a step function, which takes time and provides opportunity to the enemy. After the initial engagement, there is an operational pause, and the cycle repeats.”

To Alberts et al. (2003) self-synchronization does not imply chaos in the battlespace, because of the underlying assumptions of self-synchronization (p.27):

- Clear and consistent understanding of command intent;
- High Quality information and shared situational awareness([50]);
- Competence at all levels of the force; and
- Trust in the information, subordinates, superiors, peers and equipment.

Self-synchronization leads to emergent properties and efficiencies unattainable with top-down direction (Wesensten et al., 2005).

3.2.3. The NCW Logical Model

Alberts et al. (2003) define four minimum essential capabilities for a given operation (p.98):

- The ability to make sense of the situation;
- The ability to work in a coalition environment including non-military (interagency, international organizations and private industry, as well as contractor personnel) partners;
- Possession of the appropriate means to respond; and

49 Complex adaptive ecosystem is CAS (environment).

50 Thomson et al. (2005) defines (Shared) Situational Awareness: can be understood as the ability to regularly translate information and knowledge into a common understanding for those involved in military operation. (p.8)

- The ability to orchestrate the means to respond in a timely manner.

Only the third capability is not related to the C2 but to the tools of war and policy implementation. The three others are related to C2, and are directly involved with NCW.

McKenna et al. (2006, p.1), Thomson et al (2005, p.6) rephrase the four basis tenets as:

- A robustly networked force improves information sharing;
- Information sharing and collaboration enhance the quality of information and shared situational awareness,
- Shared situational awareness enables self-synchronization; and
- These, in turn, dramatically increase mission effectiveness.

The entry fee of the logical model for network-centric warfare is a high-performance information grid that provides a backplane for computing and communications. This grid enables the operational architectures of sensor grids and engagement grids. The purpose of the sensor grids is to rapidly generate high levels of battlespace awareness (first ability) and synchronize this awareness with military operations (second ability). The engagement grids exploit this awareness and optimize combat power (fourth ability).

Alberts et al. (1999) refer to Fleet Battle Experiment Delta conducted in October 1998 in conjunction with Exercise Foal Eagle '98. This experiment showed the enormous potential of self-synchronization. The result of the employment of these NCW concepts was the generation of a very high level of shared battlespace awareness, which was exploited to increase combat power.

This proves the improved adaptability, effectiveness, efficiency of multi-minded (thus networked) CAS (organization) in a CAS (environment).

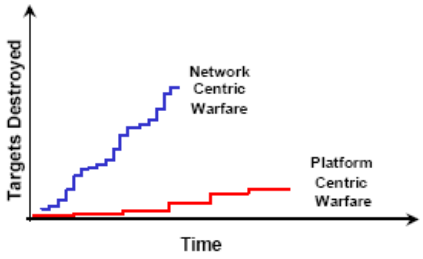

Figure 11: NCW - Fleet Battle Experiment Delta

Figure 11: NCW - Fleet Battle Experiment Delta demonstrates the significantly increased combat power that can be generated with NCW operations versus Platform Centric Warfare.

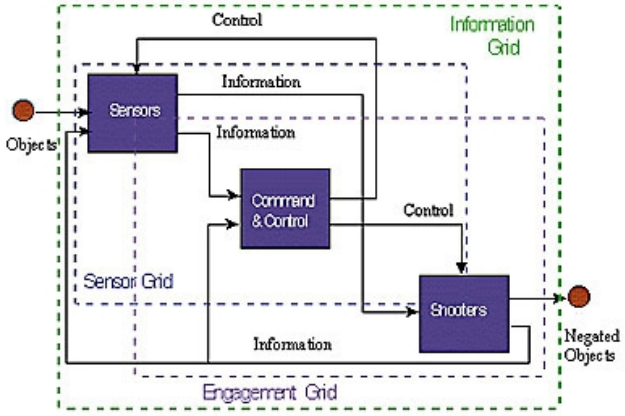

Figure 12: Logical Model for Network-Centric Warfare

Figure 12: Logical Model for Network-Centric Warfare depicts the architecture of NCW with the already mentioned three grids: Information Grid, Sensor Grid and Engagement Grid. Murdoch (2002) explains these grids as follows:

"The *sensor grid* could be composed of diverse sensors such as radar of various types, radio-frequency-emission and infrared receivers, low-light-level and other optical devices, acoustic systems, and people. These sensors could be in orbit, in the air, on the ground, or at sea. Some would be permanently in place, others plugged in as and where needed and available."

"The *information grid*, much of it permanently in place, would comprise, for example, communications satellites, data-transmission lines, microwave relays, computers, and command centers. The information grid would transmit sensor information, recommendations and orders, intelligence, and real-time information about operations, logistics, and other functions -information needed by leaders at all levels to plan, monitor, and control operations more effectively, efficiently, and responsively."

"The *transaction grid* would draw upon the sensor and information grids to pair weapons incorporated into it with targets and then guide weapons to targets as necessary. Some of the weapons available would require guidance all the way. Others (like sensor-fused weapons, 'brilliant' submunitions, and wide-area munitions) are autonomous, needing only to be guided into the general area of action, where they find and identify targets with their own sensors (typically employing infrared for vehicles, acoustic for armor, seismic for personnel) and then attack them on their own 'initiative.' "

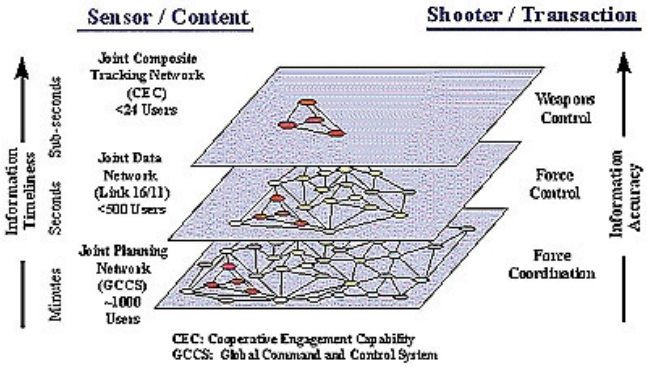

Figure 13: Emerging Architecture for Network-Centric Warfare

Figure 13 shows the time aspects in NCW. The information timeliness for treatment of the incoming

signals (which is shown on the left) and the information accuracy for targeting procedure in the organization which is depicted on the right. One can see the surface of the planes as a representation of the surface of the battlespace (which is of course three-dimensional in reality). This battlespace integrated into one NCW-environment can be very big.

As such, NCW "offers the flexibility, operational reach, and battlespace awareness needed to operate on the strategic, operational, and tactical levels at once. It will enable disparate and distant forces to attack targets of various kinds -centers of gravity, critical vulnerabilities, operational functions, tactical forces- simultaneously. In short, combat would no longer have to proceed in the traditional step-by-step, or serial, manner; neither would there be any single axis of effort or point of main attack. Combat would instead be multidimensionally and comprehensively joint." (Murdock, 2002). It shows also the compression of time and space in this situation.

However there is a problem of assessing the functioning of NCW and its architecture. Fewell et al. (2003) state that a numerous descriptions and definitions of NCW exist. Most of them are relational in nature and therefore dependent on the initial state. The scope of NCW is so wide that it is very difficult to single out particular capabilities to assess their effectiveness with regard to the whole of the NCW.

Referring to the business world, the same question can be asked about Service-Oriented Architecture (SOA): to which extent has the SOA capability been achieved? The problem of assessment is that the implementation of SOA is in function of a mindset and therefore it is not a prescriptive framework with specifications. So we see here again the difference between Clausewitz (mindset: causing people think about it, creating a framework for conducive thinking) and Jomini (prescriptive framework). So, if some Western armed forces are more Clausewitzian, then it will be difficult to apply USA philosophy of NCW (Jomini) in these Clausewitzian armed forces. This also explains why SOA solutions (or ICT-solutions in general) are successful in one company but that it cannot be successfully "copied-and-pasted" in other companies.

3.2.4. NCW and C2

Working within a NCW paradigm also raises issues of authority and accountability. It will be critical to explore both the pragmatic and ethical implications of decentralizing authority and the redefined role of leaders. Concerns can be raised about the potential for micromanagement by commanders as a result of their having both access to more information about subordinates and the ability to 'reachforward' ([51]) to a greater extent than was previously possible, thus tacticization of strategy is also possible.

In addition, the need for increased accountability may oblige people to provide more information than previously. As such, sourcing low diagnostic information or attempting to integrate more than needed may lead to a degradation of the quality of judgments. This challenge will likely be compounded by time pressure. (Thomson et al., p.14)

3.2.5. Human and Socio-cultural aspects

"In spite of a ponderous acquisition process, technology insertion is ahead of and disconnected from joint and service doctrine and organizational development. The problem is cultural and systemic. A process for the co-evolution of technology, organization, and doctrine is required. [...] Change is inevitable. We can choose to lead it, or be victims of it. As B. H. Liddell Hart said, 'The only thing harder than getting a new idea into the military mind is getting an old one out.' " (Cebrowski et al., 1998).

Indeed, to Alberts et al (1999, p.196), Thomson et al. (2005, p.6) and English et al (2005, p. 97) people are very important in NCW, for it is the people that turn the concepts into realities and that fill in the gaps and inconsistencies within and among organizations, systems and battlespace knowledge. Collectively, people create and maintain culture, so in order to make NCW work, the military needs to be educated and trained to develop NCW attitudes and expertise, which requires considerable investments.

Once integrated into the mental models of people, NCW is still only useful if the information provided by the system is useful, causing the same people to act more effectively.

To the Australian Defense, this makes the human dimension fundamental to NCW (McKenna et al. ,2006, p.1). Therefore, on the human level not only the culture and/or mental models are of importance but also the psychological and mental ability to operate as human in NCW. In her study "Knowledge Warriors: Are they born or made?" Christine A.R. MacNulty concludes that not every soldier can be trained to be a knowledge wall ([52]) user, let alone a "Knowledge Warrior" (2001). Therefore the understanding of the individual mental models and cognitive processes are vital, because the limitations of human cognition will be the major drawback of NCW-operations (Thomson et al., 2005, p.14).

Apart from the individual aspects of a nation, the social characteristics, and therefore its forces, are very

51 Reachforward, an extremely beneficial capacity means the emerging ability of commanders, far removed from theater, to use the same infrastructure to manage tactical events that take place in theater in real time (Thomson et al., 2005, p.11)

52 The Knowledge Wall is a multi-screen, multi-modal workstation specially designed to enhance collaboration and decision making. This Knowledge Wall is a real advance in the technology to facilitate network-centric operations (MacNulty, 2001, p.2).

important. Canadian studies warn not to “copy-and-paste” the US concept of NCW onto the Canadian Forces, because of the different situation of Canada to that of the USA (English et al., 2005), (Thomson et al., 2005). Idem dito for the Australian Defense (McKenna et al. ,2006, p.6). This should be the same for Belgian Defense if it would ever be able to implement NCW. Translated (back) to the business environment, technology is only an enabler for business, and every use of technology should be optimized for the own organization instead of 'copy-paste' of others' uses.

3.2.6. NCW as a Theory of War

In this context, English et al. (2005, pp. 6-8)([53]) open a parenthesis on the definition of 'Theory of War', because of definitions of the word 'theory' that emphasize its speculative nature in some common usage. “This usage of theory, defined in one dictionary as 'a speculative or conjectural view of something,' accords closely to the understanding of Prussian strategist Carl von Clausewitz (1780- 1831) as to how theories should be used. Clausewitz’s approach was strongly influenced by Kantian philosophy, and he used the dialectic approach of thesis, antithesis, and synthesis to study the subject of war. In his book On War he constantly revised his hypotheses and he moved back and forth between the ideal and the real states of war. Many of the writings found in the American professional military literature, however, quote Clausewitz out of context as if he had written a book of instruction on the conduct of war. But he did not; he wrote a treatise to help us better understand the phenomenon of war through debate and the synthesis of competing concepts.”

The consequences of this speculative approach to theories have important implications for NCW theory. “It could be argued that NCW 'theory' is no more than a series of largely untested hypotheses or assumptions that should be subjected to research and a Clausewitzian dialectic to determine their usefulness. While this approach is nothing new in the history of military theories, there are profound implications when one observes how completely NCW has been embraced as the benchmark for US Department of Defense (DoD) transformation, and by extension some other Western nations’ military transformation. In many policy documents NCW is often portrayed, not as a speculative theory, but as an authoritative doctrine on future warfare. Accepting it as such and embracing it completely may be a high risk activity as the transformation of militaries and their future may be based on untested speculation.”

The basic philosophy of US Department of Defense (US DoD) is based on the theory of Jomini. In contradiction with Clausewitz, who advocates reasoning, Jomini defines war as a set of rules, and his theory is therefore prescriptive ([54]). “His conception of war has been surprisingly durable in the present age of computer-mediated warfare where the Jominian paradigm underpins much of the Western approach to modern warfare. In today's world, where our lives are strongly influenced by scientific notions, we usually expect a theory to be able to explain causality or why things happen. Therefore, when many military professionals see the word 'theory' attached to a concept, they expect it to have considerable explanatory power.“ This is of course in direct conflict with the notion of CAS.

“A number of organizations have adopted NCW as though it were an integrated view of the fundamental principles underlying a science or its practical applications. In this view of a theory, if its principles are correctly applied, the theory is generally accepted to have explanatory power.” Since NCW is technology driven and that this technology can direct low-level operations from very high level decision making, the risk of tacticization of strategy is very high.

“The latest policy statement on NCW, *The Implementation of Network-Centric Warfare* ([55]), offers an interesting paradox in its analysis as it attempts to combine aspects of both Clausewitz’s and Jomini’s approaches to its own theoretical approach.

On the one hand it concludes that 'classic strategic theories of war may require adaptation to a changing environment [...] [but that] they remain fundamentally intact. [*This is in contradiction with the concept of CAS*] The logic of waging war and of strategic thinking is as universal and timeless as human nature itself.' Furthermore, The Implementation of Network-Centric Warfare acknowledges that a large number of theorists at the end of the 20th century proposed a number of alternative frameworks for war in the future.

On the other hand, by adopting the concept of the 'information age' as its foundation, *The Implementation of Network-Centric Warfare* has not attempted a synthesis of previous theories of war, but has pinned its hopes on one specific interpretation of war. The Toffler’s interpretation of war occurring in waves ([56]), with the current wave being based on information, has been challenged by a number of

53 The double quoted text in this section are excerpts from this source.

54 The United States Marine Corps (USMC) is clausewitzian and sees war as a CAS (environment) and the fighting units as CAS (organizations).

55 *The Implementation of Network-Centric Warfare* is the text of Cebrowski et al. (2005)

56 “The first wave wars is an agricultural war, which bore the characteristics of a seasonal war and soldiers were paid by land instead of money. The industrial revolution made the second wave war possible. Its range in time lasted roughly from the late 17th century to the end of the 20th century and it manifests itself in such different wars as

commentators including Steven Metz, currently teaching at the US Army War College's Strategic Studies Institute. He argues that 'Quintessentially American, the Tofflers concentrate on technology feasibility with little concern for the strategic, political, social, psychological or even ethical implications of changing military technology.' He states that their theories are particularly attractive to the US military because of their relatively simple, if flawed, interpretation of war. Therefore, despite its recognition of the importance of the human in the latest NCW policy documents, it is important to remember that NCW theory is founded on an essentially technological approach to war." Applied on a prescriptive base (Jomini), this theory leads to tacticization of strategy.

As mentioned above, another "problem with applying NCW theory is based on US military culture. *The Implementation of Network-Centric Warfare* recognizes that the theoretical constructs of the classic theorists of war 'remain fundamentally intact,' and among the classical theorists Clausewitz is cited most frequently as the basis for the doctrinal writings of the US services. However, his theories are in some respects at odds with the assumptions underlying NCW, and this situation may cause difficulty in adapting NCW to current or future doctrine. Furthermore, as Paul Johnston has demonstrated, the characteristics, historical experience and culture [derived from the mental models] of an armed force may have an important impact on both how armed forces plan to fight and how they actually perform on the battlefield. If implementing NCW requires major cultural changes in armed forces, its advocates should take into account that successful cultural change often takes a considerable amount of time and that such change is usually measured in years, and even decades, as major culture change may require paradigm shifts in the organization."

3.2.7. NCW and Tacticization of Strategy

We have already warned on several occasions for the danger of the tacticization of strategy with NCW.

Sensors and shooters are directly connected, which may not pass through C2. An unfortunate consequence of this could be that more and more the bypassed leaders between the highest level and the "shooter" can not generate added value. "The technological wave that spawned [NCW] has created conditions that threaten to remove the initiative of subordinate commanders -the antithesis of the original goal of empowering them through enhanced speed of command and self-synchronization" (Roberts et al., 2003, p. 1). As a consequence tactical and operational considerations through this system (of IT-enabled NCW) may affect the strategic thinking on political and military level.

More important than the technological IT-network is the creation of effective social networks. "NCW is not a theory of war […] [but] a series of largely untested hypotheses or assumptions […] This model has been widely criticized for its over reliance on technological explanations for changes in war, and this is one of the reasons why NCW has been characterized as a technophile's approach to war. It would seem prudent, therefore, to base any new approach to future war on a synthesis of various theories of war, comprising their best features, rather than on one controversial model. (English et al., 2005, pp. 91-92). Actually, NCW is more about networking than networks (Alberts et al., 1999, p. 2). The real 'power' of networks is in the potential to form groups. As such, the Canadian model emphasizes collaboration and shared knowledge as well as the mechanisms that enable these capabilities (Thomson et al., 2005, pp. 6-7).

3.2.8. Information Superiority and Decision Superiority

Information superiority is an imbalance in one's favor in the information domain with respect to the adversary. The objective of decision superiority is to turn an information superiority into a competitive advantage. "However, having information superiority does not ensure decision superiority, and information superiority in itself is meaningless. That is where the commander must apply the operational art of balancing centralized control with decentralized execution to turn information superiority into decision superiority. […] Though the time from detect to strike is improving, the full effect of NCW will not come to fruition unless the decision making process is centered at the optimum level" (Santicola, 2005, p. 12)

A fundamental criticism of NCW is "that its origins in 1990s business and technical processes were not necessarily conducive to a 21st century theory of war. The idea that in using NCW a military can achieve information dominance over an enemy in much the same way that some successful corporations have used information to dominate their markets is a dubious proposition at best, according to some critics, as unlike customers, enemies will usually try to frustrate attempts to gather intelligence, especially using the technical means favored by NCW." (English et al., 2005, p.97).

Moreover, the party that has information superiority may disseminate other information, and thus

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the Napoleonic wars, the Civil War, the two World Wars and the wars in Korea and Vietnam. According to the Tofflers, the third wave war started in the late 1970s, early 1980s and it is largely based on knowledge. They also see today's world divided in first, second and third wave states, each with its own distinct agendas. This situation creates friction and turmoil and promotes what the Tofflers call "the rise of the soft edge state" or the shift from a world of nations to a myriad of feudal first wave states, traditional second wave states and modern third wave city-states. Chief executive officers (CEO) of multinational companies and religious leaders will have a more prominent role in the future world system" (Studer, 2005, pp.3-4)

changing the real world for the others into “a virtual world” dominated and governed by the party with information superiority. Be it now in the political, economic, military or any other type of situation.

English et al. (2005) continue that even if NCW is able to fuse information into a common operating picture, the education, culture, and personalities of those viewing the picture will result in diverse interpretations of what is presented. Furthermore, a number of commentators have noted that the more efforts that are taken to standardize both the information and the interpretation of that information, the more likely it is that creativity and originality will be stifled. This suppression of creativity and originality will work against the development of command-by-influence in a NCW environment. To ensure that commanders are able to make optimal use of networked [mission] C2 systems, it is suggested that they should be within the “Balanced Command Envelope” to ensure the required symmetry amongst the competency, authority, and responsibility necessary for effective command. Furthermore, it has been argued that information technology will not guarantee self-synchronization in a NCW environment if commanders at all levels do not have the attributes required to do their jobs. (pp. 97-98).

3.2.9. NCW and CAS

The confusion with NCW is that it is seen as a philosophy of War or even worse as a theory of War supported by advanced ICT. A better approach is to see NCW as a support for coordination and communication between agents of a CAS (organization) who are in a very hostile and threatening CAS (environment). In other words the ICT-related systems offer new possibilities for the armed forces (CAS organizations) to survive and to attain the self-chosen goals (in alignment with the higher political goals, thus shared vision).

The danger exists that ICT is pushing the characteristics of CAS away and let linear thinking military leaders and their political superiors focus on technology, opening the door wide open for the tacticization of strategy. Only armed forces like the USMC whose commanders understand CT and CAS can use NCW in an adequate way.

Moreover NCW as technology must fit the culture of the armed forces, stating otherwise the new possibilities of NCW-technology must be integrated in the mental models of the armed forces ('analysis-synthesis'), so that structure, processes and functions can be 'designed' in the best possible way (ST) with respect to self-organization (CAS) taken into account the hostile CAS (environment).

The bottom line is that a defense of one country (or group of countries) cannot copy-and-paste the 'implementation' of a NCW from another country. Mainly because the NCW-technology has to be integrated into the mental models of the country, thus culture, thus grand strategy, thus goals and capabilities, thus structures (even networked), thus operational strategy (figure 3). Related to Boyd's OODA-cycle it is the co-evolving of the Orient-phase.

This is not only true for NCW (technology) in our military context but also for Service Oriented Architecture and Cloud Computing in a business context.

3.2.10. Holistic Thinking and Technology

Handel (2001) refers to (the successes of) Mao Tse-tung to promote the holistic approach of the *war-business* in which the shared vision personified by the leader is very important.

Technology is no substitute for a good strategy. Technology can be an essential part of the capabilities to attain the overall goal(s). If a commander relies too much on technology to have a quick wins then it will jeopardize the whole campaign. Worse, if politicians start to intervene directly into the execution of military operations then the tacticization of the strategy is a fact.

Finally another reason for the tacticization of strategy is that in the actual context of the world fully detailed C2-led armed forces are too slow to react in this continuously changing environment. The (political) leaders want to skip the hierarchy. Therefore a new style of “leading the troops” is needed.

3.3. OODA

John Boyd and his OODA-cycle and philosophy are not common knowledge or not well understood. The fact that Boyd's theory is based amongst others on nonlinearity, chaos theory and organic systems, makes his theory less accessible to the world of linear managers and leaders. We will not extensively discuss the theory of John Boyd. We refer to the excellent works of Frank Osinga (2005; 2007). We will limit ourselves to key elements and a comparison to the well-known quality circle Plan-Do-Check-Act (Deming).

3.3.1. OODA-CYCLE

In essence, the “OODA Loop is about gathering information and making choices quickly once this information is examined and processed in order to be time-competitive and thus change the course and nature of one’s organization before opportunities to strategically reorient wane.” (Jatkevicius, 2007, p.47).

So, one observes his environment, especially his adversaries (Observe). “Having observed the situation, we next orient to it—we make certain estimates, assumptions, analyses, and judgments about the

situation in order to create a cohesive mental image. In other words, we try to figure out what the situation means to us." (MCDP-6, 1996, p. 63) (Orient). Based on this evaluation, the person will decide (Decide) his action (Act). At first sight, this looks like so many other business cycles like Plan-Do-Check-Act. However in figure 14, we can see many feedback and feedforward loops, which may indicate that we are dealing with a CAS. Holmdahl (2006) writes that OODA is not a cyclic development, but OODA is a perpetual process of ongoing activities.

Moreover OODA has a special loop "Implicit guidance and control" starting from the Orient-phase to the Observe-phase and to the Action-phase, which we will discuss later more in detail.

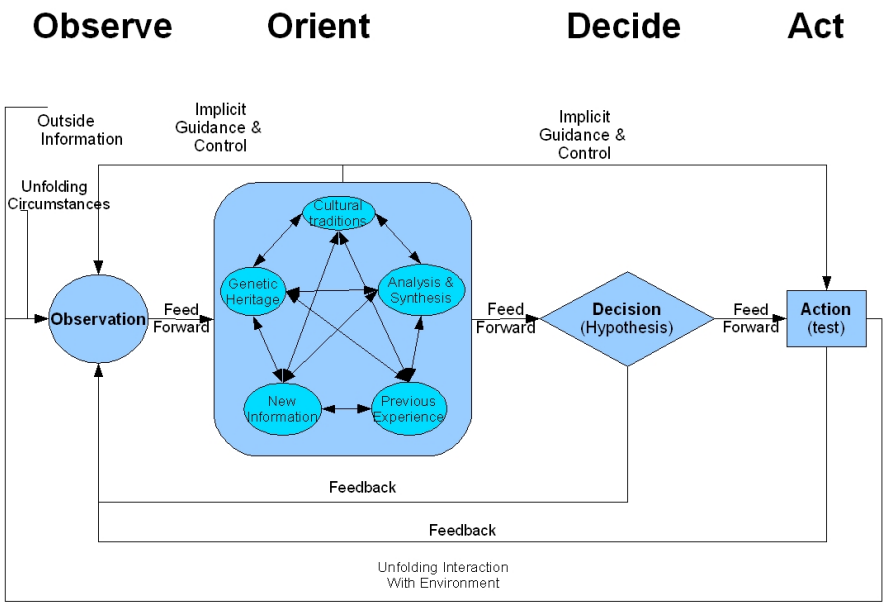

Figure 14: Extended OODA-Cycle

The OODA-loop is not always used to act. In most cases it will be used as OOHT (Observe-Orient-Hypothesize-Test) because of the assessment of the intelligence gained. It is even possible that there is no testing and that the observers are instructed to focus on additional events or phenomena in the unfolding environment.

3.3.2. Orient is omnipresent

To Osinga (2007) the orient-phase is the most important (the Big 'O'), where analyses and synthesis are done. But it is also the seat of mental models that are influencing all activities in the organization. Jatkevicius (2007) states that orientation "to the environment in which we must function and compete directs all of our planning, prioritizing, and decision-making. It is influenced by previous experience and cultural traditions and it dictates the way organizations observe, decide, and act." (p. 48).

Observe: If somebody observes than it is guided (influenced) by his mental models (which orient him). As such the orientation determines what somebody is observing. If the observed doesn't match the mental models or its concepts are not part of the mental models, then chances are high that it is rejected. It demands a special attitude and open mindedness to detect and accept new *things.*

- Orient: Orientation is the adaptation to the observed reality. To be able to accept new things (observed reality), Boyd suggests to destroy old mental models and construct new ones. It is a synergy between reductionist analysis (trying to understand what has been observed) and

synthesis (creating new solutions, new knowledge). We will go more in depth in section 3.3.5 Destruction and Construction.

- Decide: The synthesis is a hypothesis of a new future (probably new reality) on which a person or organization will decide to create or shape that new reality. Anyhow the purpose is to affect the recently observed reality.
  Clearly the orientation determines the desired future and how decisions are made.

- Act (behave): So our actions will alter the observed reality hoping to shape it into a desired reality. How we act is also determined by the same elements how we orient (experiences, culture, etc.), so orientation (thus mental models) is influencing the way we act.

3.3.3. Observe in the Extended Loop

Argyris et al. (1996) and Vakili et al. (2007) state that people are selective in the data acquisition from their environment (attention and problem definition). To Senge et al. (1994) this is due to mental models, when people are making or framing decisions.

Snowden (2002; 2013) states that humans are fundamentally pattern based intelligent beings. Most humans make decisions on the basis of past or perceived future patterns not through rational choices between alternatives ([57]), an understanding of patterns is, therefore, key to managing behavior within organizations and in relationship to markets and environmental factors.

The energy cost of actually seeing things differently is so high that they do not do it unless they are forced. This is the case for system-wide patterns, called coherence. System-wide coherent patterns are more stable than other self-organized patterns. Because of the mutually reinforcing dynamics, the effort required to change the pattern is greater than the effort to maintain it (Snowden, 2013). When the system reaches a state of coherence, the available energy of the system is aligned and focused on system-wide behaviors, rather than diverse and disruptive behavior of individual agents or sub-system clusters (Holmdahl, 2006, p.57).

The basic fact is that most of the time, we make decisions without thinking about it but based on trained responses. This will have consequences for the observation of the environment, thus OODA-loop.

Snowden (2013) continues, people are only 5% aware of what they see in front of them. This partially data scan is then linked to hundreds of thousands stored memories to actually come up with a unique form of action related to what people have found first (patterns): people are not optimizing they are satisficing ([58]). We evolved to make decisions very quickly based on some partially data scan recognition. So we are pattern based intelligent beings not information processing machines. As Snowden (2013) states “carbon is not silicon”. Technology is good in augmenting human intelligence but will never replace human thinking. The reality is that human judgment is based on perception.

So, in our discussion we have to consider that the observation function will not catch all information (certainly not when done by people), because of the pattern scanning. These patterns are influenced by our mental models. It is therefore very crucial to be aware of our mental models (make them as much as possible explicit) hold in the “Orient” part. For this reason there is a feed back loop from Orient to Observe and a feed forward in the opposite direction (figure 14). However the “Implicit guidance and control” has an additional and more important function (see below). Information and request for information are also running back and forward between Orient and Observe. Orient has only one feedforward, namely coming from Observe; all the other inputs are feedbacks.

Regarding decision making, it can be opportune to wait to make a decision until more information is available (to reduce the uncertainty = detailed C2) so that management can delay, stop, restart, continue or start projects (options thinking). Instead of making a detailed plan, an organization can take an intermediate decision by keeping the final goals in mind. In this case the little red arrows shown in figure 2 *Emergent Strategy (*p. 10) are a representation of the new information that an organization can collect to adapt its road map (through options) towards the final objectives.

So postponing a decision can be of great value to the organization, because of the fact that better decisions can be made in the future. This is also the case for decisions regarding investments in resources and technologies (Real Option Values).

Nevertheless, what if something relevant happens between O and O+1; or between O+1 and O+2 that needed immediately response? Or an event can happen which is relevant for the organization but it is

57 Snowden (2002) refers to Klein, G. (1998), *Sources of Power: How People Make Decisions.* MIT Press, Cambridge, MA.

58 Satisficing is a decision-making strategy or cognitive heuristic that entails searching through the available alternatives until an acceptability threshold is met. This is contrasted with optimal decision making, an approach that specifically attempts to find the best alternative available (Wikipedia Satisficing, n.d.).

unaware of this event. Therefore delaying can be very harmful.

At least the organization should observe continuously (figure 15) so that through continuous assessment it can adapt almost continuously to the changes in the environment (CAS).

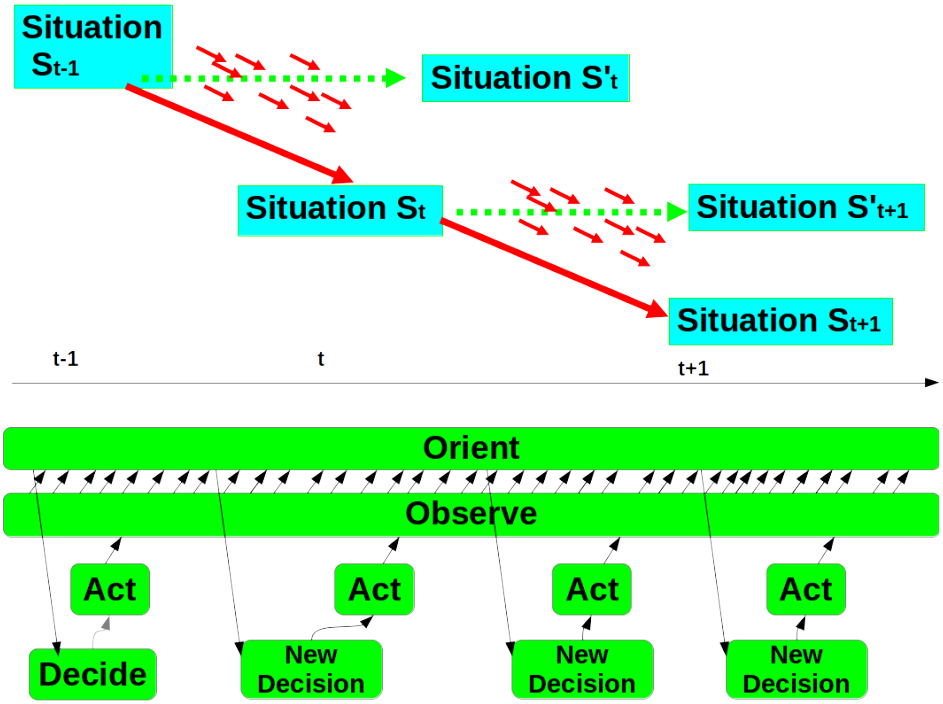

Figure 15: Emergent strategies and continuously observing

3.3.4. Orient in the Extended Loop

In the so-called extended or real loop of OODA, the connections between the four phases are not any more sequential, but are interconnected, indicating a high probability for nonlinearity and emergence. The most important phase is “Orient”. Therefore we will discuss “Orient” more in depth.

Five elements make part of “Orient”:

- Cultural Traditions
- Genetic Heritage
- Previous Experiences
- Analysis & Synthesis
- New Information

Translated to an organization we have following elements

- Cultural Traditions: Culture and Values
- Genetic Heritage: Organization, Structure, History
- Previous Experiences: Knowledge
- Analysis & Synthesis
- New Information

In the original image of the OODA-cycle, there are no bidirectional arrows with genetic heritage, only

unidirectional starting from it. We have anyway placed bidirectional arrows because of our interpretation of genetic heritage for the organization, which is a CAS. Moreover the evolutionary path of a CAS is relevant to the CAS, but the evolutionary aspect means that genes are changing. These changes are not only the results of the co-evolution of the CAS and its environment, but also of its self-organizational capabilities, thus through the interactions between all five elements.

Cultural traditions are reflected in the culture of an organization. Culture is very important factor because of the way values are being used in the preparation of decision, and even in the acquisition and use of (management) techniques in the organization.

The element “previous experiences” should be transformed into knowledge, wherein we have implicit (what is in the mind of the people) and explicit knowledge (stored in an information system, manually (like on paper) or automated (like in electronic files)).

The five elements of the orient-phase are interrelated. Osinga (2007) quoting and discussing Boyd: “Orientation is an interactive process of many sides implicit cross-referencing projections, empathies, correlations, and rejections that is shaped by and shapes the interplay of genetic heritage, cultural tradition, previous experiences and unfolding circumstances.”

Coram (2002) concludes that the complex interactions of these elements make that every person will behave differently. “These human differences make the Loop unpredictable. In addition, the orient phase is a nonlinear feedback-system, which, by its very nature, means this is a pathway into the unknown. The unpredictability is crucial to the success of the OODA Loop”.

And it is this dynamic which Boyd later attempts to capture in his graphic rendering. Again Boyd is master of synthesis, but at first reading this description may also baffle a bit. So a short explanation is warranted. The description indicates that orientation is a dynamic process which results in views, images, mental models and impressions. This process is (and should be) continuous and is constituted by the development and maintenance of interactions of various kinds with the environment (co-evolution). The interactions are however also subject to modification, as much as the views, images and impressions. A long term and rather immutable formative factor shaping this process is genetic heritage. A medium term factor is culture, while a short term factor in shaping ideas and interactions is constituted by previous experiences. Boyd offers his own illumination:

> 'Orientation is the Schwerpunkt. It shapes the way we interact with the environment – hence orientation shapes the way we observe, the way we decide, the way we act.' ([59])

In this sense Orientation shapes the character of present observation-orientation-decision-action loops - while these present loops shape the character of future orientation. So from a discussion on the pervasive element of friction and the solution offered by harmony and initiative, from the stated need for adaptability, focus, direction, insight and vision, Boyd has developed the argument that orientation is the center of gravity for C2. Orientation is the key factor - and variable - that enables or hinders generating harmony and initiative so that one can or cannot exploit variety/rapidity.” (Osinga, 2005, pp. 236-237).

3.3.5. Destruction and Construction

Related to the Orient-phase is the process of *Destruction & Construction* and it is very important in the theory of John Boyd (Osinga, 2007; Coram, 2002; Hammond, 2001; Holmdahl, 2006). It stands for the fact that one must destroy, abandon his mental models to be able to construct a new one based on new intelligence or new insights.

The concept that it is constructive to be able to abandon ones ideas is not new, as strategist Yagyu Munenori (1571-1646) talked about the necessity of not allowing ones mind to tarry, and strategist Miyamoto Musashi (ca:1585-1645) said: “It is a matter of harboring an open, free and fluid mind” (Holmdahl, 2006, p. 68).

Boyd based his *Destruction & Construction* on the synthesis of three insights (Hammond, 2001, pp. 119-120):

- The second law of thermodynamics: all observed natural processes generate entropy. To Boyd, entropy is a concept that represents the potential for doing work, the capacity for taking action of the degree of confusion and disorder associated with any physical or information activity. So energy will be “lost in the numerous interactions on the battlefield. In other words, interactions will never be perfectly elastic and the transfer of energy will result in waste. As interactions themselves occur in a nonlinear fashion, the energy lost cannot be predicted.” (Walters, 1994, p.26).
  High entropy implies a low potential for doing work, a low capacity for taking action or a high degree of confusion of disorder. Low entropy implies just the opposite. The tendency is for entropy to increase in a system that is closed or cannot exchange information and/or energy with its environment. Important is that over time, entropy increases, energy dissipates, efficiency decreases, and confusion and disorder increase. Thus the character or nature of a system, its

59 In figure 14, we can see the arrows coming from the “Orient” phase to “Observe” and “Act” as 'Implicit Guidance and Control' and to “Decide” as 'Feed Forward'.

consistency, does not remain constant and is unpredictable.
Schneider et al. (2006) note that the second law of thermodynamics indicates that CAS evidence the property of emergence rather than entropy ([60]).

- Werner Heisenberg (1901-1976) is best known for his uncertainty or indeterminacy principle. It states that it is impossible to determine both the position and momentum of subatomic particles with high accuracy. That is, uncertainty, rather than certainty, lies at the base of our physical universe and theoretical understanding of it. The most relevant consequence of this principle is to change the laws of physics to relative statements instead of absolute certainties. We can have a proximate understanding based on measurement, but not an absolute one.
  Atop this insight, Boyd placed an idea borrowed from Heisenberg: the process of observation changes what is being observed (Coram, 2002). This certainly true in sociocultural observations. The observed will change his behavior which will lead to changes in the mind of the observer, thus changing the process of observing, which changes the behavior of the observed, in other words, a continuous cycle.
- Kurt Gödel (1906-1978) demonstrated proof of a theorem stating that the various branches of mathematics are based in part on propositions that are not provable within mathematics itself, though they can be proved by logic external to mathematics. That is, it is impossible to embrace mathematics within a single system of logic. So, Gödel proved that any consistent system is incomplete. USAF Colonel Boyd concluded: “Gödel's proof indirectly shows that in order to determine the consistency of any new system, we must construct or uncover another system beyond it. Over and over this cycle must be repeated to determine the consistency of more and more elaborate systems.” Thus, there is always something beyond the system – no explanation is self-contained.

Entropy of an organization is directly related to the lack of exchange with its environment (energy, information and derived from it, intelligence). One of the main reasons is the not (co-)evolving of its mental models.

Gödel's theorem proves indirectly the radical holism: the universe is the only true whole (everything is connected to everything else).

The uncertainty principle shows us that uncertainty is more the rule than the exception, which is confirmed by Artigiani (2005) when he writes that uncertainty is not reducible to information (perfect information will not remove uncertainty).

The main conclusion of USAF Colonel Boyd is that analysis is not enough. Reductionist analysis can lead to understanding but not to creativity. It is an *onanistic* activity, gratifying only to the person doing the analyzing. He talked of *paralysis of analysis* (Coram, 2002, p.324). The power lies in the synthesis by taking various sometimes unrelated components and putting together to form a new whole (Coram, 2002; Hammond, 2001). However, to Gharajedaghi (2011) in ST the creation of the new whole is the design phase (analysis, synthesis, design). Regarding successful designers, Holmdahl (2006) remarks that creative thinkers in general and designers in particular seem to have the ability to change the direction of their thinking thus generating more ideas (p. 68).

This is in line with the way complex problems may be solved. Through quick iterations between work and learning, people are acting before they are able to fully comprehend a problem, so they act in order to understand the problem, creating partially predictable events, making problem definition evolve. As such there is a synergy between emergence of the work process and product, coupled with quick action-learning loops (p.64).

3.3.6. The OODA-cycle is more than a cycle

3.3.6.1. Speed of the cycle

Plehn (2000) concludes that “[w]hat a speedy decision loop does confer is flexibility and freedom of action. One can pursue one’s own goals in consonance with the unfolding tactical, operational and strategic situation if one has a faster decision cycle than the enemy. The opponent can still act and react with a slower OODA Loop, but those actions may no longer be relevant to the situation. A speedy OODA Loop is simply a facilitator for continued action—it is not a recipe for success if one’s own actions are inappropriate to the situation.” So doing the right thing right.

Colonel Reed (2006) pinpoints this as the problem of busyness. While it may be important to orient on values, goals and objectives, the urgent often displaces the important. Simple cause-and-effect thinking (linear thinking) combined with a culture of busyness can result in decision makers who rapid-fire short-term solutions at long-term problems without taking time to think about the actual impact of those solutions. The today's solutions become tomorrow's problems.

60 CT focuses on system adaptation and evolution more so than maintenance and homeostasis . CT suggests that CAS may experience unique or idiosyncratic paths, due to their sensitivity to initial conditions, indicating their property of path dependence rather than equifinality (Schneider et al., 2006, p. 356).

The more than ever prevailing characteristics of our information age are variety and rapid, ongoing change. Technological improvements continue to compress time and space, forcing higher operating tempos and creating a greater demand for information. The consequence of this is fluid, rapidly changing situations in the environment, places the organization in the same situation as a pilot. Under pressure of time, an organization does the same thing as a pilot in an OODA loop, namely the competitor who acts on (more) correct information and/or can act faster on it, is in the best position to force its competitor to lose the battle. Therefore a good quick loop is quickly observing and informing, quickly understanding (orient) of what is happening in the environment, knowing what to do (how to behave), being able to do that (behave accordingly) and quickly learning from that behavior in the environment (based on MCDP-6, 1996).

Vakili et al. (2007) concludes that time is one of the obstacles to use ST, although time to reflect is essential for not only decision making but also for learning (Senge, 1994). But as already mentioned, situational awareness is more important. The continuous cycle of observe-orient assures that situational awareness is obtained to support decision-making (and acting).

The organizational mindset of Vakili et al. (2007) is still uni-minded view or detailed C2. One of SUN Microsystems slogans was *The Network is the Computer*, in the context of the networked CAS organization, this slogan could be adapted to *The Network is the Decision-Maker.* Due to the distribution of intelligence and knowledge in combination with the situational awareness time to decide and act can be very fast (mission C2).

3.3.6.2. The Implicit Guidance and Control

John Boyd has his concept of implicit guidance and control, which implies an explicit guidance exists: observe-orient-decide-act. Nevertheless, although Boyd has put explicitly “implicit guidance and control”, this concept is not well understood. Here we are referring to our discussion on mental models, and why we sometimes need to make them explicit if possible, but at least to be always aware of the mental models.

Youngman (n.d.) confirms our findings, by quoting “John Boyd” and “Nonaka and Takeuchi” regarding the implicit models in “Orientation”.

Boyd ([61]): “Without our genetic heritage, cultural traditions, and previous experiences, we do not possess an implicit repertoire of psychophysical skills shaped by environments and changes that have been previously experienced. Without analysis and synthesis, across a variety of domains or across a variety of competing independent channels of information, we cannot evolve new repertoires to deal with unfamiliar phenomena or unforeseen change. Without a many-sided implicit cross-referencing process of projection, empathy, correlation, and rejection (across many different domains or channels of information), we cannot even do analysis and synthesis.

Without OODA loops, we can neither sense, hence observe, thereby collect a variety of information for the above processes, nor decide as well as implement actions in accord with those processes. Or put another way, without OODA loops embracing all the above and without the ability to get inside other OODA loops (or other environments), we will find it impossible to comprehend, shape, adapt to, and in turn be shaped by an unfolding, evolving reality that is uncertain, ever-changing, and unpredictable.”

Indeed, in CAS*T sense-making is very important for a CAS (organization) to be aware of its environment and of the effects of itself and other organizations (agents in a bigger whole CAS (environment)).

Sense-making consists of observation and orientation. These components are the base of a good decision-making for a behavior (act, adapt). We will discuss a military and a civilian sense-making framework that we are extending for CAS*T.

Nonaka and Takeuchi” ([62]): “Orientation is: the worldview, the schemata, the mental models, the views of reality, the insights, intuitions, hunches, beliefs and perceptions of the various participants. We create working models of the world by making and manipulating analogies in our minds. With these working models we perceive and define our world.”

Robert Coram (2002) writes: “The OODA Loop ([63]) is often seen as a simple one-dimensional cycle, where one observes what the enemy is doing, becomes oriented to the enemy action, makes a decision, and then takes an action. This 'dumbing down' of a highly complex concept is especially prevalent in the military, where only the explicit part of the Loop is understood. The military believes speed is the most important element of the cycle, that whoever can go through the cycle fastest will prevail. It is true that speed is crucial, but not the speed of simply cycling through the Loop. By simplifying the cycle in this way, the military can make computer models. But computer models do not take into account the single most important part of the cycle - the orientation phase, especially the implicit part of the orientation phase.”

61 Hammond, G. T.,(2001) *The mind of war: John Boyd and American security*. Smithsonian Institution Press, pg 189.

62 Nonaka, I., and Takeuchi, H., (1995) *The knowledge-creating company: how Japanese companies create the dynamics of innovation*. Oxford University Press, pg 60.

63 Because of all the possible combinations of elements in and between the phases, Coram (2002) states that we cannot speak of a loop.

(pp. 334-335).

Concerning the two links “implicit guidance and control” starting from Orient, Boyd is referring also to the intuition and/or the guts as the “Fingerspitzengefühl” (finger tips feeling). The implicit guidance and control is to be able to react quickly and/or take an unexpected opportunity. In these cases ”it seems one is then able to bypass the explicit ‘Orientation’ and ‘Decision’ part of the Loop, to ‘Observe’ and ‘Act’ almost simultaneously. The speed must come from a deep intuitive understanding of one's relationship to the rapidly changing environment. This is what enables a commander seemingly to bypass parts of the Loop. It is this adaptability that gives the OODA Loop its awesome power. Understanding the OODA Loop enables a commander to compress time – that is, the time between observing a situation and taking an action. A commander can use this temporal discrepancy (a form of fast transient) to select the *least*-expected action rather than what is predicted to be the *most*-effective action. The least-expected action disorients the enemy. It causes him to pause, to wonder, to question. This means that as the commander compress his own time, he causes time to be stretched out for his opponent. The enemy falls farther and farther behind in making relevant decisions. It hastens the unraveling process.” (Coram, 2002, pp. 335-336).

So the point is not to win the battle, but to make the opponent to lose the battle.

Youngman (n.d.) summarizes: “Thus we can see that the OODA Loop, at one level, might be interpreted as an iterative explicit loop. But it is also a model of our implicit nonlinear reaction to circumstances once the reaction has been learned. The OODA Loop is both a model of the context of discovery and the context of justification. … the orientation worldview (Weltanschauung) differs not on aspects of detail complexity, but rather on aspects of dynamic complexity.”

3.3.6.3. Intuition

If a commander can skip the orient-decide and thus act immediately then he can run his loop quicker (short cut), which is a consequence of the implicit guidance and control. We can also call it intuition. Intuition and insights distinguish military geniuses from 'normal' commanders.

Murdock (2002) in his article about the 'Principles of War on the Network-Centric Battlefield: Mass and Economy of Force' writes that some rules of thumb such as one based on a number like “three-to-one”([64]) have lost their application. “The 'rule' is virtually useless in contemporary contexts; it will be even less relevant in the future.

All this may explain in part why Clausewitz was so circumspect about numbers and their implications for combat. To be sure, he felt that numbers were important; if all things between opposing forces except numbers were equal, he held, numbers would determine the result. However, Clausewitz argued that other factors, particularly leadership and maneuver, affected the outcome of battle just as profoundly, citing historical examples in which smaller forces defeated larger. Such inherent complexity is one reason that we speak of operational 'art' instead of 'science'. In spite of all efforts to reduce such matters to calculation, they come down to the intuition, the coup d’oeil, of the commander. Mass can not be understood simplistically--nor can economy of force.” (Murdock, 2002). So, even with all this technology the intuition of the commander can be decisive in attaining the desired effects of the individual and therefore higher levels.

So if intuition or *Coup d'oeil* is an intellect that, even in the darkest hour, retains some glimmering of the inner light, which leads to truth, as Karl von Clausewitz wrote (p117), what is vision? To Major Walters (1994) there “seems to be a relationship between the terms, first, in the way both are aimed at helping us conceptually organize the chaos of the battlefield, and second, through the use of the *eye* as metaphor. If the emphasis of intuition is on *inner*, then the emphasis of vision is on the *outer*. One might consider intuition as interpolation and vision as extrapolation. Intuition is the way we sub- or preconsciously manipulate and combine previous experience to intuit new experience. Vision is the way we project our thought and ideas forward, represented by terms such as, goal, objective, or endstate."

3.3.6.4. Maneuver Thinking

In battle, most of the time it is not a very good idea to wait for more information – war is chaotic – but to use the information of the situational awareness (transformed into intelligence) to act or behave (OODA-cycle). Although emerging strategy, there is always a concept of planning. The solution of Wesensten et al. (2005) is to merge actions with planning which results in a bottom-up design.

Major Kolenda (2003, p. 101) suggests that armed forces will be most effective if following concepts are mastered:

- Decentralization: create and exploit a knowledge advantage by empowerment at the appropriate levels.
- Complexity: gain a complexity advantage by maximizing the number of meaningful interactions with which the enemy must cope simultaneously or nearly so.
- Resilience: sustain balance and equilibrium in our own force while creating and exploiting instability and disorder in the enemy.

64 The force ratio that an attacker on land needs over a defender

- Tempo: sustain an intensity of operations over time with which the enemy cannot cope.

This is typical for concepts based on the OODA philosophy of USAF Colonel Boyd, and to Jatkevicius (2007) especially tempo or time-competitiveness, a key tenet of maneuver theory.

It has been integrated in the US Marine Corps Doctrinal Publications (MCDP-1, 1997) on Warfighting based on maneuver warfare. General Krulak emphasizes that military doctrine (derived from the mental models) should not be allowed to stagnate, especially an adaptive doctrine like maneuver warfare. Doctrine must continue to evolve based on growing experience, advancements in theory, and the changing face of war itself. So doctrines applied on CAS are CAS themselves.

General Krulak (MCDP-1, 1997) had several goals with the new concept of maneuver warfare. “One goal is to enhance the description of the nature of war” thus CAS environment and adapting the mental models (Orient in OODA), “for example, to emphasize war's complexity and unpredictability and to widen the definition of war to account for modern conflict's expanding forms. Another goal is to clarify the descriptions of styles of warfare. A third goal is to clarify and refine important maneuver warfare concepts such as commander's intent, main effort, and critical vulnerability. It is my intent to do this while retaining the spirit, style, and essential message of the original.”

“Very simply, this publication describes the philosophy which distinguishes the U.S. Marine Corps. The thoughts contained here are not merely guidance for action in combat but a way of thinking. This publication provides the authoritative basis for how we fight and how we prepare to fight. This book contains no specific techniques or procedures for conduct. Rather, it provides broad guidance in the form of concepts and values. It requires judgment in application.”

Due to USAF Colonel Boyd, the USMC has undergone a paradigm shift from prescriptive doctrine (based on Jomini) to maneuver thinking (based on von Clausewitz and John Boyd). So, the USMC is aware to be a CAS, in contradiction to what Artigiani (2005) has written, namely that without it, the military were operating complex organizations. Unfortunately, this is still the case for some national defenses.

In this context, we can refer to Holmdahl (2006) who discusses Maneuver Thinking (pp. 70-71).

It was found that a culture of maneuver thinking resulted in the most effective and efficient strategy. It was the military answer to the uncertainty and lack of trustworthy information in military operations of war. One of the basic principles of maneuver warfare is *Auftragstaktik*. Major Nelsen II (1987) translates it to mission-oriented tactics (which is related to the mission C2 of USMC)([65]).

Auftragstaktik is based on the following fairly simple hypothesis:

- As no plan, and thus no orders, remain valid after contact with the enemy, and
- as the very nature of combat is confusion and uncertainty, one must
- develop a system of command that allows rapid changing of plans at every level to seize the fleeting opportunities that combat confusion offers, which thus means that:
    - command initiative must be devolved to the lowest tactical levels, and
    - no formal orders can be given other than by commanders who are in physical contact with troops at the point of contact; while, at the same time,
    - all commanders, down to section level, must react to developing combat situations in accordance with the tactical and operational INTENT, as opposed to precise orders, expressed by higher commanders two links up the chain-of- command so that
    - all are functioning, one might say, in harmony. And, finally,
    - this “harmony” is dependent on a common mobile military culture, or philosophy, that is enshrined in the army's doctrine and ingrained in the minds of all soldiers through a system of war maneuvers, Kriegspiele – staffrides and promotion values rigorously applied by the General Staff.

Auftragstaktik relies on and thrives in a culture of initiatives at all levels, self-organization, tolerance of failure, intuitive communication, and almost thinking in one another’s brains. It relies on empowering professionals at the lowest possible levels, which is the most effective guarantor for excellence (Kolenda, 2003).

Jatkevicius (2007) links maneuver warfare to OODA. Maneuver warfare involves radical decentralization of authority which leads in speeding up of the OODA (decision) cycle, essential in war but also valuable in organizations. As such, maneuver theory is fundamentally about what Boyd called “time competitiveness” (tempo) which is a constant positioning of the organization faster than others (OODA) responding to opportunities before others see them, thus establishing the organization as perceptive to user needs and utterly relevant.

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65 Auftragstaktik was the product of an evolutionary process of the Prussian Army dating from the 19th century. The Drill Regulations of the Infantry (1888) stipulated that commanders should give subordinates general directions of what was to be done, allowing them freedom to determine how to do it. This approach would stimulate development of the "thinking leader" who was used to making tactical judgments in his own right. Such leaders would less likely freeze up when faced with new situations in the absence of detailed instructions from above. (Nelsen II, 1987)

Since everything has to go fast, failures may happen. However, "[f]ailure is not always defined by the taking of risk, of orienting and acting first, and accepting blame for misreading the environment. Rather, it is defined by not accepting the realities of the OODA Loop principles in the first place and refusing to operate under its conditions. Such a mindset translates to little risk and little reward. The first principle is an honest and active orientation to the operating [CAS] environment of the [CAS] organization." (p. 51).

Holmdahl (2006) lists other basic concepts of maneuver thinking:

- *Einheit*: Mutual trust and cohesion based on shared experience and shared mental models are the basis for leading by mission statements and commanders intent. ([66])
- *Fingerspitzengefühl*: Intuitive skills based on extensive experience and deep knowledge that make spontaneous improvisation possible (as discussed during *Implicit Guidance and Control* of OODA.
- *Schwerpunkt*: The effective focus of our activities that all subordinate units shall support (main effort). However, it is important to be able to quickly shift focus, so agility is also needed (quickly responding to new situations in the environment (CAS)).

Clearly, mindless organizations and uni-minded organizations will have problems to implement Auftragstaktik, certainly in a CAS environment. Gharajedaghi (personal communication, 2011) suggests that a hybrid form of uni-minded and multi-minded organization could survive, as a matter of fact, the example was an army. In that case, if armed forces are not in a complex space (thus not in operations or in training) then they can have the uni-minded form, while in operations (and/or in training) the armed forces are then in a multi-minded form.

Obviously this is not the case for enterprises and other organizations, the world societies and economies (both CAS environments) nowadays are always operational. However not all situations are complex (USMC C2 spectrum: detailed C2 ↔mission C2).

Obolensky (2010) remarks that organizations have evolved from functional silo-based structures to cross-functional matrix structures and that now organizations are moving to CAS (organizations) ([67]). However we believe that organizations can be composed of different forms (in the context of system-of-systems) and that more important is the way of thinking. Obviously the maneuver thinking is the best adapted to support the functioning of the CAS (organizations) in CAS (environments).

This has its repercussion on C2. Holmdahl (2006, p.72) observes that ordering people [top-down in a CAS organization] is not in line with either findings from complexity-based organizational science or maneuver thinking. Instead *complex leadership* involves creating the conditions that enable productive, but largely unspecified, future states. Leaders cannot control the future because in [CAS] organizations, unpredictable (and sometimes unexplainable) internal dynamics will determine future conditions. Rather, complex leaders need to influence networks.

Obolensky (2010) states that the more complex things are, the less action is needed from leaders providing they have put in place the necessary environment, processes and culture.

Leadership thus becomes a question of inspiring, guiding, and supporting committed subordinates and encouraging them to perform freely within set limits (MCDP-6, p. 83).

Thanks to this philosophy USMC was able to reshape itself, to survive in a new era, and its success made them an example for excellence. "Unlike other military bureaucracies, USMC has demonstrated flexibility to changing environments both on and off the battlefield, best exemplified by its willingness to articulate goals, then provide problem-solving authority to junior officers and noncommissioned officers on the battlefield in a process the Germans know as Auftragstaktik, known in America as directive control. This downward thrust of authority is a basic principle of maneuver theory.

[…] USMC developed maneuver theory to an advanced level by emphasizing the need to drive change and not be driven. They have applied it in combat and in interagency politics. Subordinate to this, USMC has emphasized small unit initiative as a way of achieving battlefield goals." (p.49).

3.3.6.5. Boyd and NCW

a) Influence of Boyd

Three Boydian ideas in particular have found their place in NCW (Osinga, 2008, p. 39):

- The idea of maneuver conflict;
- The image of a swarm-like organization of netted but relatively autonomously operating units, acting in 'synch' through an 'Auftragstaktik'-based (hence mission) C2 set up and sophisticated information systems; and
- The idea that information superiority will offer a decisive advantage because it allows a more rapid and accurate completion of the OODA loop, or decision cycle.

66 This is not the same as *Unity of Command* in the Belgian Art of War. On the contrary, it implies that the commander has always control and that he is controlling his troops (detailed C2 versus mission C2).

67 From chimneys to CAS via the matrix (Obolensky, 2010).

Whereas standard Pentagon solutions to uncertainty involved increasing investments in C4ISTAR ([68]) equipment, Boyd aimed for creating adaptable and learning organizations consisting of informally networked teams that could comfortably operate in an insecure environment, due to their reduced information requirements. If everyone understands clearly, and is attuned to, the organization's purpose and/or the commander's intent, explicit communication beyond the objective is superfluous. Because of the shared outlook one knows what to do and what one can expect of others, be it supporting units, higher commands etc., implicit communication will suffice. Self-organization will be the result, a key NCW tenet. (Osinga, 2008, p. 40).

Osinga (2008) concludes that Boyd would likely not agree with the way technology has come to be such a dominant factor and with the expectations of some proponents that NCW would 'lift the fog of war'. On the other hand, he would agree with its organizational tenets and operational aspirations (p. 43). Adopting a network structure is not an option but an imperative, for case studies strongly suggest that institutions can be defeated by networks and it may take networks to counter networks (p.42).

b) Still need for OODA in NCW?

Cebroswki & Garstka (1998) state that in "contrast, bottom-up organization yields self-synchronization, where the step function becomes a smooth curve, and combat moves to a high-speed continuum. The "Observe-Orient-Decide-Act (OODA) Loop" appears to disappear, and the enemy is denied the operational pause. Regaining this time and combat power amplifies the effects of speed of command, accelerating the rate of change and leading to lock-out. [...] One reason we say that no plan survives initial contact with the enemy is because situational awareness does not. In platform-centric military operations, situational awareness steadily deteriorates. It is re-established periodically, but it only then deteriorates again. Network-centric operations [...] create a higher awareness, and allow it to be maintained. Such awareness will improve our ability to deter conflict, or to prevail if conflict becomes unavoidable. This is not just a matter of introducing new technology; this is a matter of the co-evolution of that technology with operational concepts, doctrine, and organization. The enabler, of course, is technology." (Cebrowski et al., 1998).

c) Speed of Command

Just as McKenna et al (2006, p.7), Morua et al. (2002, p.2) and Hazen et al. (2004), Thomson et al. (2005) maintain explicitly the OODA-loop in NCW, when they discuss the speed of command. Speed of command can be understood as the "time required to complete one full cycle of Boyd's observe-orient-decide-act (OODA) decision loop" (Fewell et al., 2003, p.5). Speed of command will instantiate compressed decision making cycles. It will likely be a consequence of increased distributed decision making and information sharing among a dispersed force. As such, friendly forces should ideally be able to disrupt an enemy's decision loop by making quicker command decisions and frustrating an enemy's."

Though speed of command is desirable, but only when it is "unidirectional". Because it becomes more complicated when decision making is "multidimensional". In such cases, a "lag" makes it more likely that commanders will be able to distinguish those things that are relevant from those things that are spurious because the world is changing for many reasons outside one's own effects. This underscores the need to distinguish between how to judge, decide and when to act. Therefore NCW might contribute to commanders' ability to judge quickly and effectively, thereby allowing action to be deferred (Thomson et al. 2005, p.14).

The speed of command is not the same as the speed of decision-making. To Fewell et al. (2003) "decision speed should be regarded as the time taken to execute the 'orient' and 'decide' steps of the OODA-loop". This definition excludes the 'observe' step, a reason for that is that one can decide to have more information and therefore will start a new OODA-cycle, otherwise indicators for assessing decision speed will have difficulties to take into account the iterative actions Observe-Orient, Observe-Orient-Decide (p.20).

Indeed, the OODA loop process is portrayed as one of making decisions more quickly than an enemy. "But 'out-OODAing' an enemy is more a process of achieving temporal effects than just being faster (or slower) than an enemy in decision making. Fadok (1995) argues that Boyd's approach is predominantly Clausewitzian because maneuvering inside the enemy's mental processes as depicted by the OODA loop is more a more philosophical, abstract and nonlinear approach than the approach advocated by Warden. In other words, Boyd's theory is about 'err-power'— how to make the enemy lose versus how to win ourselves." (English et al., 2005, p.56)

d) Awareness

If one wants to be aware of his environment to act, then he has to observe. Therefore, to Thomson et al. (2005), an important element is the situational awareness, especially in the context of NCW. It requires understanding of the individual within his or her perspective culture and military culture with its particular education. "Moreover, achieving shared situation awareness will require knowledge of the individual's position in the operation because commander's intent will be different for different people, creating a

68 C4ISTAR: Command, Control, Communications, Computers, Information/Intelligence, Surveillance, Targeting Acquisition and Reconnaissance

variety of operational pictures. It was pointed out that, ultimately, 'there are multiple realities', and “how we understand, determines what we see”. Thus, understanding how multiple realities emerge to reflect one shared reality will be invaluable for helping to achieve shared situation awareness.” (p.8).

e) Decision-Making Modeling

NCW has a fundamental assumption that improved information infrastructures will improve military decision-making and therefore military effectiveness. (Santicola, 2005, p. 12), (English et al., 2005, p.97), (Hazen et al., 2004, p.1). Hazen et al. (2004) continue that linking NCW applications to military effectiveness using modeling and simulation have had difficulties in modeling the decision-making aspects of the process and in particular modeling them such that effects due to NCW can be measured. (Hazen et al., 2004, p.1). Moreover NCW is a mindset, therefore it is difficult to assess a particular aspect of NCW (Fewel et al., 2003, p. 3)

For the purpose of of modeling NCW, Fewell et al. (2003) write that it is sufficient to quantify decision quality with just two characteristics: decision speed (see above) and decision soundness. 'Soundness is the degree to which the decision taken is the best possible'. “This can be interpreted in two ways: either the best possible decision under the circumstances prevailing at the time, or the best possible in an absolute sense. The first is appropriate when the focus is on the competence of the decision maker, the second when one is more interested in how improvements to the decision maker's support system and infrastructure can improve decision quality” (Fewell et al., 2003, p.20).

*3.3.6.6. Additional Remark about Postmodernism, Boyd and CAS*T*

The questioning of one's own mental models based on new information or on new insights (knowledge by the process of analysis-synthesis-design) may cause a paradigm shift (thus a big part of the mental models). Many postmodernist thinkers would say that this is typical postmodernism, the society is malleable.

In this context, *Destruction and Creation* could be a postmodern concept. It is therefore not a surprise that Osinga (2007, 2008) states that Boyd is the first postmodern strategist. The question we would like to answer here, *is CAS*T (based amongst others on the theory of John Boyd) a postmodern philosophy*?

“Postmodernism has to come to signify a break with traditional modes of behavior. This includes warfare. Two dominant strands of strategic thought have both earned the label of postmodern warfare: Network Centric Warfare (NCW) and Fourth Generation Warfare (4GW). One takes its inspiration from the postmodern information society, the other from the eroding authority and power of the modern-era political institutions. Both are also unified in a common conceptual father: the late USAF Colonel John Boyd, the first postmodern strategist ([69]) . Few people in the past three decades have surpassed his influence on western military thought, but, like Sun Tzu and Clausewitz, he has also often been superficially read and understood.” (Osinga, 2008, p.37).

Firstly in his discourse on NCW he doesn't bring any element of postmodernism. He states that the organizational structure must be fluid and that network network structure is essential, not a specific weapon or support system (NCW Report to Congress). “NCW derives its power from the strong networking of a well-informed but geographically dispersed force. Such forces must have the capability to collect, share, access, and protect information, as well as the capability to collaborate in the information domain, which enables a force to improve its information position through processes of correlation, fusion, and analysis. This will allow a force to achieve information advantage over an adversary in the information domain. Importantly, in the “Cognitive domain” the force must have the capability to develop and share high quality situational awareness’ and the capability to develop a shared knowledge of commander’s intent. This will enable ‘the capability to self-synchronize its operations.” (pp. 42-43).

This is all typical for a CAS (organization) which is evolving from a uni-minded organizational form towards a multi-minded (certainly in the execution), and has nothing to do with postmodernism. Gharajedaghi (personal communication, 2011) talks about a hybrid system (between uni-minded and multi-minded).

Secondly, the fourth generation warfare (4GW) ([70]) is more a guerrilla warfare against (mostly western) states using unconventional and asymmetrical methods. It is illogic that Boyd, as an military strategist of the USA would be the conceiver of 4GW which purpose is to fight the USA. Osinga (2008) writes that 4GW warriors are bound by shared ideology, values and worldview, but these are also characteristics of agents of a CAS (organization).

Osinga (2008) continues: “Politically 4GW involves transnational, national and subnational organizations and networks to convey a message to target audiences. Strategically it focusses on breaking the will of decision-makers. The message serves three purposes: to break the enemy’s will; to maintain the will of its own people; and to ensure neutrals remain neutral or provide tacit support to the cause. Operationally it

69 For a full discussion see Chapter 7 of Osinga (2007).

70 1GW: Information is not accurate. Armies do not know where the enemy is, but they have knowledge of the possible battlefields. Example is the Napoleonic War.
2 GW: Commanders know where the enemy is. Mass armies and fixed-artillery-to-men like WW I
3 GW: Speed and surprise. Fluid maneuvers. Try to des-”orient” the enemy: Blitzkrieg WW II.
4 GW: Guerrilla. Indirect actions to create, exploit and magnify uncertainty: Afghanistan.

delivers those messages in a variety of ways from high-impact, high profile direct military actions to indirect economic attacks such as those designed to drive up the price of oil, or assassinations of specific government and company officials. Tactically, 4GW forces avoid direct confrontation if possible, while seeking maximum impact. They use materials present in the society under attack, be it industrial chemicals or fertilizers.

This idea-driven fourth generation warfare will be a war fought at the ideological and moral level, with small highly maneuverable and agile cells employing standard guerrilla and terrorism tactics in a dispersed decentralized way, their actions informed, inspired, glued, and gaining coherence by shared programs, ideals and hatreds. 4GW opponents will deliberately not sign up to the Geneva conventions and use whatever means are available in a theater. There is a blurring of the distinction of peace and war and of the distinction between civilian and military. There will be no definable battlefields or fronts, instead the battlefield is highly dispersed and includes the whole of society. Terrorists use a free society's freedom and openness against it. Finally, 4GW warriors plan for long wars – decades rather than months or years. It is the antithesis of the high technology, short war the west favors." (pp. 47-78).

We don't see a difference between this new 4GW guerrilla fighters and the resistance during WW II, except for the means they have and the fact that the world of today has become smaller.

CAS*T is based on CAS and ST. Regarding CAS (organization) we have shown the intractability and the path dependence, therefore history plays an important role how a CAS (organization) has evolved into the state it is now. Moreover in the important Orient-phase of OODA, John Boyd himself defines three elements which are directly related to path dependence:

- genetic heritage (=> organization, structure);
- previous experience (=> knowledge);
- cultural tradition (=> culture and values).

Culture is directly derived from the mental models for which the evolution are very important for the survival of the CAS (organization) in its CAS (environment), thus co-evolution. This co-evolving shapes the CAS (organization) through self-organizing. This self-organization is at best in a multi-minded (networked) organizational structure which in the sociocultural, man-made CAS is only an evolution due to the increase of the complexity in the history of men, not because of the postmodern thinking of a malleable society.

Moreover Boone (2011) argues that postmodernism has given any new tools for historians, except for creating a new jargon (p. 232). He admits that the fundamental gap between past and history will never be closed. A historian creates ('makes') its own narration about a part of history (p. 248) just like a novel writer is making his story. Nevertheless facts can exist independently from our knowledge of events and although the observation of a researcher (historian) is grounded in a theoretical framework, there will always be a need for empirical checks. He concludes that historical research is an activity that is determined by the context in which it happens, so that it rarely results in definitive truths (p. 251).

As a matter of fact, people are not rational thus people are not acting on the base of a number of normative operation principles. Boone proposes an analytical narrativism where the historian just has to explain the facts in the sequence they have happened. The narration explains enough why a person (in our case CAS (organization)) has gone through a process from beginning to end (Boone, 2011, p. 243).

As stated before, it is difficult to know the exact initial conditions in which a process has started and even to know the exact evolution of a CAS. In addition humans are carbon, not silicon (Snowden, 2013). People are satisficing and not optimizing, nevertheless all these decisions have made the CAS (organization) how it is now, and it determines how it will co-evolve in the future.

Regarding the use of ICT in the so-called Information Age, we would like to warn for the tacticization of the strategy, as we have previously done for NCW. Additionally, information as fuel or as weapon for the organization in this Information Age, is not new. Most western version of Art of War before or after WW II find information (intelligence) very important.

Since complexity is the property of a real world system that is manifest in the inability of any one formalism being adequate to capture all its properties (Mikulecky, 2001). CT as related to complexity is not a subset of an existing science, on the contrary CT is a new set of ideas that transcends the physical, biological and social sciences (Schneider et al., 2006). So just like us, John Boyd came in contact with different sciences, a never-ending story or journey. That is why John Boyd, in contrast to Karl von Clausewitz, has never written an Opus Magnus because of complexity, meaning the interrelatedness of innumerable elements, all interesting to research. But the central topic in his and our work is CAS (organizations and environment) which causes a CAS (organization) to reassess constantly its mental models (culture, shared vision (grand strategy) – double loop) or operational strategy (single loop) in order to survive in a CAS (environment). ST is to manage it in the different structural views and for designing legal entities. As a consequence, we are answering negatively the earlier question if CAS*T is a postmodern philosophy.

3.3.7. Complex decision-making and OODA

3.3.7.1. Usefulness

The OODA of USAF Colonel Boyd is an adequate decision-making framework for CAS (organization) and in CAS (environment), but OODA can of course also be used in less complex environments. Originally conceived for international politics and armed conflicts, OODA is also suited for decision-making in a civilian context, especially for business in complex situations.

In this context we have discussed that mental models and the way the organization handles them are very crucial for the orient-phase (the big-O-phase to Osinga (2005,2007). The orientation (mental models) is present in the other phases, and as a matter of fact determines their functioning. Boyd understands this very well, that is why he introduced *Destruction and Creation* process of these mental models in the Orient-phase, so that the organization can evolve, and for that matter co-evolve with its environment.

OODA is not like so many other business cycles because of the feedback and feedforward loops. Holmdahl (2006) observes that OODA is not a cyclic development, but OODA is a perpetual process of ongoing activities.

The whole purpose is not to have a faster OODA-cycle than the adversaries, but to jeopardize the OODA of the adversaries. The aim is not to win the war, but to make the adversaries to lose the war.

We have stressed on many occasions the need for intelligence to be aware of the situations in which the organization is. So the observe-phase delivers the fuel (situational awareness) to the orient-phase.

In the next section we go deeper in the domain of situational awareness.

3.3.7.2. USMC: C2-spectrum as a sense-making framework

A commander cannot fly blind. Even if he wants to use his *Fingerspitzengefühl* (the observe-act shortcut), the commander can only be successful if he senses well the situation (observing and intuition). Of course, this also applies for commanders going completely through their OODA. Therefore C2 needs a very good sense-making framework to determine how and on which base decisions should be made, and which organizational structure and collaboration should be used.

The two approaches (detailed and mission C2) to the problem of compression of time and space, mark the theoretical extremes of a spectrum of C2 (See figure 16)([71]). In practice, no commander will rely entirely on either purely detailed or purely mission methods. Exactly what type of C2 he will use in a particular situation will depend on a variety of factors determined by the environment, his organizational capabilities and his opponents. None of the two types of C2 is better than the other. It will all depend on the situation, therefore the importance of the situational awareness. “While detailed [C2] may be appropriate in the performance of specific tasks of a procedural or technical nature, it is less than effective in the overall conduct of military operations in an environment of uncertainty, friction, disorder, and fleeting opportunities, in which judgment, creativity, and initiative are required. Militaries have frequently favored detailed [C2], but our understanding of the true nature of war and the lessons of history points to the advantages of mission [C2].” (MCDP-6, 1996).

At the right of figure 16 are the characteristics of a detailed C2 with the assumptions that war (environment, future) is deterministic and predictable, which is the case of science of war and mechanical and procedural tasks. Corresponding to these cases USMC determines how the units are organized (mechanistic), how to communicate (vertical), how the leaders should act (authoritarian) and how they handle uncertainty (seeking for order and certainty). The consequences are that all this leads towards centralization, coercion, formality, tight rein, imposed discipline, obedience, compliance, optimizing, ability mostly at top.

At the other side of the C2 spectrum is the mission C2: War is probabilistic and unpredictable and the way to handle this is to accept disorder and uncertainty. Leadership, communication and organization are completely different and it leads to decentralization, spontaneity, informality, loose rein, self-discipline, initiative, cooperation, “satisficing”, ability throughout.

The USMC C2 spectrum is a sense-making framework to help determine the commander how to organize his C2 with his units and possible sub-units.

71 *Figure 16.* Mission and Detailed C2 from “*MCDP-6 Command and Control*” by Department Of The NAVY, Headquarters United States Marine Corps, 1996, Washington D.C., p. 81.

	Assumes War is	
Probabilistic, unpredictable		Deterministic, predictable
	Uncertainty Handling	
Accepts disorder, uncertainty		Seeks order, certainty
	Tends to lead to	
Decentralization, spontaneity, informality, loose rein, self-discipline, initiative, cooperation, “satisficing”, ability throughout		Centralization, coercion, formality, tight rein, imposed discipline, obedience, compliance, optimizing, ability mostly at top
	Communications	
Implicit, vertical & horizontal, interactive		Explicit, vertical, linear
	Organization	
Organic, ad hoc		Mechanistic, bureaucratic
	Leadership	
Persuasive, delegating		Authoritarian, telling
	Appropriate to	
Art of War, Conduct of operations		Science of War, mechanical / procedural tasks

Figure 16: Mission and Detailed C2

The USMC C2-spectrum can also be used in a civilian context. However to be of more use (outside USMC) a sense-making framework should be more generic, which is the case of the Cynefin Framework proposed by Kurtz and Snowden (2003) in an article in the IBM Systems Journal. We will discuss Cynefin in the next chapter.

3.4. von Clausewitz and Nonlinearity of Warfare

Karl von Clausewitz and Sun Tzu have influenced a lot USAF Colonel John Boyd's thinking. The theory of Boyd is also the basis of the USMC doctrine, but logically the USMC also refers to von Clausewitz to explain its doctrine and its sense-making framework. Since von Clausewitz influenced also our work and inspired us to explore the domain of CT and CAS, we will highlight some elements of *On War* that is related to CT and CAS, using a contemporary vocabulary. It is remarkable that it took more than 150 years before military leaders started to think holistically instead of reductionist.

3.4.1. Eine wunderliche Dreifaltigkeit

Clausewitz proposed different definitions of war. With the first one he compared war to a duel, where in war the purpose is to force our will on the enemy. The two opponents are interacting with each other. Beyerchen (1992): “For Clausewitz, the interactive nature of war produces a system driven by psychological forces and characterized by positive feedback, leading 'in theory' to limitless extremes of mutual exertion and efforts to get the better of one another. The course of a given war becomes thereby not the mere sequence of intentions and actions of each opponent, but the pattern or shape generated by mutually hostile intentions and simultaneously consequential actions. The contest is not the presence or actions of each opponent added together. It is the dynamic set of patterns made in the space between and around the contestants. [...] Clausewitz contends that an actual war never occurs without a context; that it always takes time to conduct, in a series of interactive steps; and that its results are never absolutely final -all of which impose restrictions on the analytically simple 'pure theory' of war. Any specific war is subject to historical contingencies; thus he concludes that the theoretical basis for prediction of the course of the war dissolves from any analytical certainties into numerical possibilities. Wars, therefore, are not only characterized by feedback (a process distinctly involving nonlinearities), but

inseparable from their contexts."

So war is a confrontation between two or more CAS (organization) and is itself as such a complex system (CAS (environment)). Defense elements are CAS that are part of nation or alliance. To them the defense elements are agents next to economic, social and other agents which make also part of the nation or alliance. Since shared vision is very important the military strategies should be aligned to the grand strategy of the nation or alliance, meaning they all have to collaborate in a transdisciplinary way.

This leads us to his second definition of war, where war is merely the continuation of policy by other means. It cannot be static, here also interactions exist (feedback loops). Military gives feedback, so that at certain points (in the course of action/time), politics can change goals and means. "The ends-means relationship [...] does not work in a linear fashion. The constant interplay is an interactive, feedback process that constitutes an intrinsic feature of war. Clausewitz's conception is that the conduct of any war affects its character, and its altered character feeds back into the political ends that guide its conduct.

To reach an understanding of the character of war in general is a purpose of theory and, to describe how that theory functions, Clausewitz resorts to a third definition that he elucidates in terms of a striking metaphor of nonlinearity. In the last section of Chapter 1, Book One, he claims that war is 'a remarkable trinity' (eine wunderliche Dreifaltigkeit) composed of

- the blind, natural force of violence, hatred, and enmity among the masses of people;
- chance and probability, faced or generated by the commander and his army; and
- war's rational subordination to the policy of the government.

Clausewitz compares these three tendencies to three varying legal codes interacting with each other (the complexity of which would have been obvious to anyone who lived under the tangled web of superimposed legal systems in the German area before, during, and after the upheavals of the Napoleonic years). Then he concludes with a visual metaphor: 'Our task therefore is to develop a theory that maintains a balance between these three tendencies, like an object suspended between three magnets.' What better image could he have conjured to convey his insight into the profoundly interactive nature of war than this emblem of contemporary nonlinear science? [...] Clausewitz's message is not that there are three passive points, but three interactive points of attraction that are simultaneously pulling the object in different directions and forming complex interactions with each other." (Beyerchen, 1992).

This metaphor also can be used in a business context, where the first element is replaced by the "hard" (sometimes violent) competition and the third one, more generally speaking, the resources and business strategies being derived from the grand strategy of the enterprise.

The reason why people have problems with this way of thinking is given by Beyerchen (1992): "[T]he metaphor offers us insight into a mind realistically willing to abandon the search for simplicity and analytical certainty where they are not obtainable. The use of this image displays an intuitive grasp of dynamic processes that can be isolated neither from their context nor from chance, and are thus characterized by inherent complexities and probabilities. It encodes Clausewitz's sense of war in a realistic dynamical system, not an idealized analytical abstraction." This realistic dynamical system that war is, is what Davis et al. (2005) call a CAS (pp. 54-55).

Hereby we would like to stress the fact that will a system be adaptive, it not only has to have an awareness of the context, but also the awareness of its evolution (history). Above all the combination of both is very crucial in the surviving of an organization. John Boyd reflects this idea with three of the elements in the "Orient"phase of his OODA-cycle:

- "Genetic heritage" which can be translated to the evolutionary history of an organization;
- "Previous experiences" being the history of the facts and the lessons learned;
- "New information" coming from the 'observe' phase, so awareness of the context.

Somehow the "cultural traditions" can be seen as historical source, but only if these traditions are put and "explained" in the context of a historical evolution.

Situations in war (or conflicts) are never the same. It is therefore not appropriate to have prescriptive rules in waging war, especially in the planning phase ([72]), as a matter of fact, these principles and rules must be so general that they are more a reflection of "good common sense". Therefore besides the new information, it is necessary that a commander (or decision maker in business) bases his decisions on the basis of knowledge and experiences.

Karl von Clausewitz wrote following about knowledge ([73]): "One more requisite remains to be considered – a factor more vital to military knowledge than to any other. Knowledge must be so absorbed into the mind that it almost ceases to exist in a separate, objective way. In almost any other art or profession a man can work with truths he has learned from musty books, but which have no life or meaning for him. [...] It is never like that in war. Continual change and the need to respond to it compel the commander to carry the

72 This does not exclude the fact that an armed forces have to be trained, on the contrary. It is very essential for the effectiveness of armed forces that processes, functions and tactics are well known, and that they have been trained in preparation of the real actions.

73 Under the header of "Knowledge Must Become Capability" (Clausewitz, 1993, p. 170-171)

whole intellectual apparatus of this knowledge within him. He must always be ready to bring forth the appropriate decision. By total assimilation with his mind and life, the commander's knowledge must be transformed into a genuine capability." This is a single point of failure, better is to share knowledge and the vision.

3.4.2. Unpredictability

Even with a vast knowledge, in his decision making process, the commander is confronted with uncertainty, due to the unpredictability of war. Beyerchen (1992) writes "Clausewitz's emphasis on unpredictability is a key manifestation of the role that nonlinearity plays in his work. This emphasis links widely recognized, fundamental, enduring elements of On War. A look at what Clausewitz says about "interaction," "friction," and "chance" may allow us to explore his understanding of the nonlinear nature of war."

3.4.2.1. Unpredictability from Interaction

Beyerchen quotes von Clausewitz: "The essential difference is that war is not an exercise of the will directed at inanimate matter, as is the case with the mechanical arts, or at matter which is animate but passive and yielding, as is the case with the human mind and emotions in the fine arts. In war, the will is directed at an animate object that reacts."

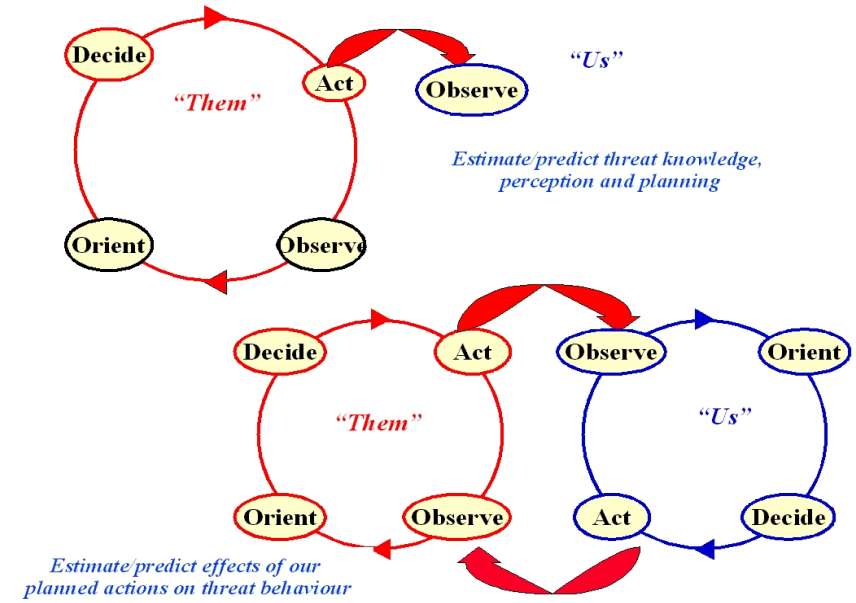

Figure 17: OODA and interaction

War is not a chess game where rules have to be followed. A lot of actions and reactions are possible between two or more parties (and mostly without "rules of the game"). Dr. James Llinas shows this interaction by presenting the OODA-cycle of the Red "Them" party and the Blue "Us" party (figure 17, ([74])). The Blue party observes the actions of the Red party, and decides to act on the Red's action (so reaction), on which the Red party will also react and so on.

The OODA loop process is portrayed as one of making decisions more quickly than an enemy. "But 'out-OODAing' an enemy is more a process of achieving temporal effects than just being faster (or slower) than an enemy in decision making. Fadok (1995) argues that Boyd's approach is predominantly Clausewitzian because maneuvering inside the enemy's mental processes as depicted by the OODA loop is more a philosophical, abstract and nonlinear approach than the approach advocated by Warden. In other words, Boyd's theory is about 'err-power'— how to make the enemy lose versus how to win ourselves." (English et al., 2005, p.56).

But it is not only a "game" of action and reaction, both parties are anticipating the actions of the other

74 Source: Presentation of Llinas (2005) at INFORMATION SYSTEMS TECHNOLOGY PANEL SPECIALISTS' MEETING hold at NC3A in THE HAGUE, The Netherlands, 8-9 November 2005

party in the “orient”-phase, knowing that the other party is observing their own actions (Observe), but not knowing exactly how the other party will assess these actions (“orient”) and “decide” (Figure 18, ([75])). It is an interaction between two parties where each party is the observer and is at the same time the observed, which influences the orientation-phase of these two parties.

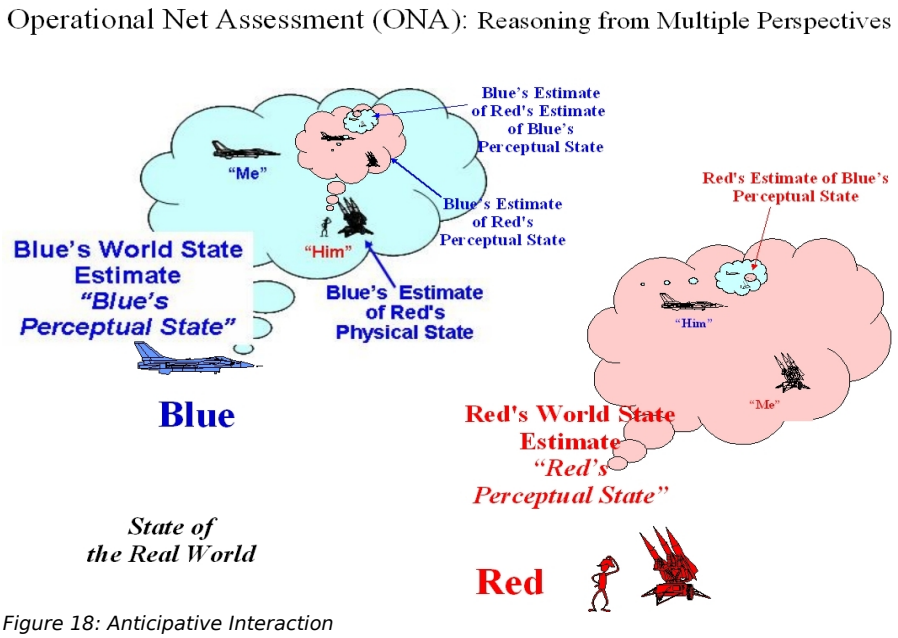

Figure 18: Anticipative Interaction

It is therefore almost infeasible to produce a theory on such matters, because these anticipative interactions can only be theorized in qualitative and general terms, which cannot be used for prediction. In the business world, the same can be noticed. Related to investments in business (units and/or processes), the business people are confronted with the same scheme of anticipative interactions. Therefore, due to the (always scarce financial and other) resources, it is appropriate to decide investments in shorter, but “inter-coherent” cycles. This is in line with our approach that organizational changes (investments) should be taken step by step (emergent strategy).

Beyerchen (1992) states that Clausewitz understood this essential feature of nonlinearity and applied its consequences in his understanding of war: “the core cause of analytical unpredictability is the very nature of interaction itself”.

Figure 18 confirms what Beyerchen writes: “Interaction occurs not just between adversaries, but also in processes that occur on each side as a consequence of the contest. This is demonstrated in Book Four, as Clausewitz discusses the differing effects of victory or defeat on the battlefield. The consequences are often disproportionately felt”, and he quotes Clausewitz:“[T]he scale of victory does not increase simply at the rate commensurate with the increase in the size of the defeated armies, but progressively. The outcome of a major battle has a greater psychological effect on the loser than on the winner. This, in turn, gives rise to additional loss of material strength [through abandonment of weapons in a retreat or desertions from the army], which is echoed in loss of morale; the two become mutually interactive as each enhances and intensifies the other.”

Beyerchen (1992) concludes that such an amplifying feedback process is as nonlinear as those in any field, from turbulence in the atmosphere to the optics of the laser. Clausewitz is “willing to accept uncertainty and complex interaction as major factors in order to cope with what is happening along the hazy boundaries where the opposing forces in war, or contending categories in theory, are actually engaged. Facing up to the intrinsic presence of chance, complexity, and ambiguity in war is imperative. For Clausewitz, this is preferable to the risk of being blind-sided by the strictures of a theory artificially imposed on the messiness of reality in the name of clarity.”

Intelligence is very important to assess the situation. Crucial in this matter are the sensors (qualitative and quantitative), however it is the general policy that decides what the sensors can and must observe

75 Cfr. Footnote of 74.

which does not exclude feedforward). To get into the mind of the adversary, especially in the case of anticipative interaction, one need HUMINT (HUMan INTelligence). Certainly with the new types of warfare, where the adversaries are not states, but terrorist organizations, the social (ideology, culture) and psychological aspects have to be brought into maps, and therefore we need human intervention.

Advanced technology can be used, but looking at the reality, that is not certain any more, it will be very difficult to use it in the observing phase (of the **O**ODA-cycle). Only when the adversaries are using IT, it is possible to get more information directly about them with IT ([76]). Of course indirectly in the preparation phase (Orient in O**O**DA-cycle), IT and other advanced technology can be used.

As already mentioned, business people are confronted with the same issues, however their capabilities are much more restricted by national and international laws.

3.4.2.2. Unpredictability from Friction

“A key element of reality for Clausewitz is the ubiquity of 'friction,' the only concept that more or less corresponds to the factors that distinguish real war from war on paper. This concept is usually interpreted as a form of 'Murphy's Law': whatever can go wrong, will, and at the worst possible moment. That interpretation is not bad as far as it goes, but its presentation is usually skewed. The implication is that things go right until some exogenous factor ruins the situation. [...] The concept of friction is not just a statement that in war things always deviate from plan, but a sophisticated sense of why they do so. The analytical world, epitomized by the 'frictionless pendulum' or the 'perfectly spherical billiard ball on a frictionless surface' or 'low-amplitude vibrations' so common in elementary physics, is one of linear rules and predictable effects. The real world and real war are characterized by the unforeseeable effects generated through the nonlinearity of interaction.” (Beyerchen, 1992).

Everything looks ordered, however war is CAS (environment), due to the continuous violently interactions between the parties and sometimes due to the damage to the environment (like nuclear, chemical weapons, destruction of logistic depots or transport). Moreover the unpredictability increases due to nonlinearity of the interactions. Small interactions (friction) may have big consequences, so that estimated means are not sufficient to handle the emerging situation, or vice verse the used means were an overkill.

“'Friction' as used by Clausewitz entails two different but related notions that demonstrate the depth of his powers of observation and intuition.” The first one is related to the Second Law of Thermodynamics and the concept of entropy, which we have already discussed with Boyd's *Destruction and Construction*. “While the total energy involved in a process is always constant, the amount of useful energy is diminishing, dissipating into heat, friction, and so on. The broader philosophical significance was that it introduced into physics the idea of irreversible processes, of an 'arrow of time'. According to the Second Law, there is a certain trend in physical phenomena. Mechanical energy is dissipated into heat and cannot be completely recovered, as when hot and cold water are brought together. What such processes have in common is that they proceed in a certain direction - from order to disorder. Any isolated physical system will proceed spontaneously in the direction of ever increasing disorder. This unidirectional process was described in a new quantity called 'entropy'. Entropy is a quantity that measures a degree of evolution of a physical system.” (Osinga, 2005, p. 96).

Of course, certainly nowadays frictions are not locked up in a closed system. Nevertheless, due to isolated systems, this entropy for armed forces can be found in peace time as in war time, and be counteracted by training, discipline, regulations and so on. Beyerchen (1992) writes “New energy and effort are sucked into the open system, yet things still never go as planned; dissipation is endemic due to the interactive nature of the parts of the system.”

For the second meaning of “friction”, Beyerchen refers to information theory with the “noise” in the system. “According to information theory, the more possibilities a system embodies, the more 'information' it contains. Constraints on those possibilities are needed to extract signals from the noise. Clausewitz understands that plans and commands are signals that inevitably get garbled amid noise in the process of communicating them down and through the ranks even in peacetime, much less under the effects of physical exertion and danger in combat. His well-known discussion of the difficulty in obtaining accurate intelligence presents the problem from the inverse perspective, as noise permeates the generation and transmission of information rising upward through the ranks. From this perspective, his famous metaphor of the 'fog' of war is not so much about a dearth of information as how distortion and overload of information produce uncertainty as to the actual state of affairs.”

Related to friction, Beyerchen (1992) remarks that Clausewitz's basic intuition with friction is that organizations are always slower and more inflexible than the natural events they are intended to control. “Seen in this light, training, regulations, procedures, and so on are redundancies that enhance the probability of signal recognition through the noise.” Indeed, in our Evaluation (Management) Intelligence system, this problem could not be solved, because of the fact that relevant information coming from the network (in a push situation) is not always recognized as such amongst the noise.

As already mentioned above, “[o]n the basis of linear assumptions, one expects major obstacles to

76 Photos taken from satellite can be very useful, but then again to limit the “scope” where to search, humans have to intervene.

produce proportionately serious errors in responding to the message. Clausewitz emphasizes, however, the disproportionately large role of the least important of individuals and of minor, unforeseeable incidents. 'Friction' conveys Clausewitz's sense of how unnoticeably small causes can become amplified in war until they produce macroeffects, and that one can never anticipate those effects. The issue is not just that 'for want of a nail the shoe was lost....,' but that one can never calculate in advance which nail on which shoe will turn out to be critical. Due to our ignorance of the exact initial conditions, the cause of a given effect must, for all intents and purposes, often be treated as unavoidable chance." (Beyerchen, 1992). Which brings us to the next point, unpredictability from chance.

3.4.2.3. Unpredictability from Chance

"The connection between chance and uncertainty provides a means of understanding both, if we draw on the insights of the late XIXth century mathematician Henri Poincaré ([77]), whose understanding of the matter was powerful enough that he is a frequently cited source in nonlinear science today. Poincaré argued that chance comes in three guises: a statistically random phenomenon; the amplification of a microcause; or a function of our analytical blindness."

a) Statistically random phenomenon

"He described the first as the familiar form of chance that can arise where permutations of small causes are extremely numerous or where the number of variables is quite large. This form of chance can be calculated by statistical methods. The very large number of interactions produces a disorganization sufficient to result in a symmetrical (i.e., Gaussian or bell curve) probability distribution. Nothing significant is left of the initial conditions, and the history of the system no longer matters. [..] [Clausewitz] notes that 'absolute, so-called mathematical factors' are not sound bases for such calculations due to the 'interplay of possibilities, probabilities, good luck and bad' that are endemic in war."

When Clausewitz compares war to a gamble, he meant a game of cards, not dice and coin tossing, because this analogy suggests not only the capability to calculate probabilities, but also knowledge of human psychology in 'reading' the other players, sensing when to take risks, and so on ([78]). So here we hit one of the biggest points that linear versions of Art of War are inadequate, because they assume a more mechanical thus mathematical approach of War, rather than human beings interacting with each other all with their own mental models and derived from them culture, values, psychology, commitment to the cause, and so on where feedforwards and feedbacks are very important.

Beyerchen quotes Clausewitz: "Circumstances vary so enormously in war, and are so indefinable, that a vast array of factors has to be appreciated-mostly in the light of probabilities alone. The man responsible for evaluating the whole must bring to his task the quality of intuition that perceives the truth at every point. Otherwise a chaos of opinions and considerations would arise, and fatally entangle judgment. Bonaparte said in this connection that many of the decisions faced by the commander-in-chief resemble mathematical problems worthy of the gifts of a Newton or an Euler."

Correctly, Beyerchen (1992) remarks that a mathematician of the likes of Euler is unlikely to be making military decisions. The commander has to rely on judgment rooted in intuition, common sense and experience. "Statistical laws of probability alone will never suffice, because moral factors always enter into real war, and it is possible for the results of any given action to defy the odds. This is one of the most important facts that experience indeed provides."

b) The amplification of a microcause

This type of chance is inherent in the system itself, writes Beyerchen. Poincaré linked the crucial importance of the initial conditions to the idea that in the real world the precision of our information concerning causes is always limited. This is a root explanation for unpredictability in those nonlinear phenomena that exhibit chaotic regimes of behavior.

So, unnoticeable small causes can be disproportionately amplified. Decisive results can often rest on particular factors that are "details known only to those who were on the spot. "Attempts to reconstruct cause and effect always face a the lack of precise information. One "can never recover the precise initial conditions even of known developments in past wars, much less developments in current wars distorted by the fog of uncertainty. Interactions at every scale within armies and between adversaries amplify microcauses and produce unexpected macroeffects. Since interaction is intrinsic to the nature of war, it cannot be eliminated. The precise knowledge needed to anticipate the effects of interaction is unattainable. Unpredictability in war due to this second form of chance is thus unavoidable." (Beyerchen, 1992).

Principles and rules are distilled from historical cases, however the initial conditions are rarely known, thus neither the results of interactions based on these initial conditions, the emerging interactions (based on emergent strategies) and the contexts. Therefore this is another reason why the principals and rules of

77 Jules Henri Poincaré (29 April 1854 – 17 July 1912) was a French mathematician, theoretical physicist, engineer, and a philosopher of science. In his research on the three-body problem, Poincaré became the first person to discover a chaotic deterministic system which laid the foundations of modern chaos theory (Wikipedia). Last accessed at December 14, 2014 from http://en.wikipedia.org/wiki/Henri_Poincar%C3%A9.

78 See figure 17 *OODA and interaction* p.64 and figure 18 *Anticipative Interaction* p.65

linear Art of War is in complex situations dangerous to apply.

Hurst (2013) is neither in favor of principles derived from lessons learned, just as Snowden (2013). For decades management has been engineered. He states that following engineering approach can be described but not practiced:

- Find multiple examples of organizations that have coped with equivalent challenges successfully;
- Reverse-engineer the reasons for their success, looking for features that they share in common;
- Present these shared “success factors” as precepts, rules, and principles that should be implemented by all those who wish to achieve similar levels of success.

“The fundamental problem with the engineering approach is that simple mechanics do not drive outcomes in complex systems. Where causes and effects are constantly subject to dynamic adaptation, as they are in ecosystems, societies, and organizations, conditions cannot be reproduced.” Not only that, but above all the fact that the mental models of the researched organizations should be studied, which in most cases never happens.

Hurst (2013) implicitly defines organizations as CAS. Every organization is unique as its context in the evolution in time. There are differences between the philosophies on war of Karl von Clausewitz and Jomini, where the former is descriptive (how to think) and the latter prescriptive (what to do). The difference is very fundamental, Hurst in his replies on comments makes this statement very clear: the engineering approach is prescriptive. He prefers a descriptive approach, the ecological approach to learning from the past. In this case, human ecology is the relationship between human groups and their physical and socio-economical environment.

Hurst (2013) describes the ecological approach as follows:

- Study successful organizations to appreciate the rich contexts and processes involved – their histories – but not to distill generic precepts and principles from them.
- Focus intensively on the organization at hand to understand the opportunities and challenges – the potential – inherent in the current situation.
- Resolve to control the controllable, preempt the undesirable, and exploit the inevitable to produce outcomes that none could have anticipated.

Descriptive approaches support organic evolution in a constantly changing environment, which is hardly feasible with prescriptive approaches, unless the organization is uni-minded and has a very flexible and very performing C2. However a biological-based organization gets more and more trouble to cope with the pace and magnitude of external and internal changes. Multi-minded organizations though are more adapted to new situations. The strategy is an emergent phenomenon.

c) Function of our analytical blindness

Beyerchen shows that Clausewitz also describes the third type of chance discussed by Poincaré, the inability to see the universe as an interconnected whole ([79]): “Our weakness forbids our considering the entire universe and makes us cut it up into slices. We try to do this as little artificially as possible. And yet it happens from time to time that two of these slices react upon each other. The effects of this mutual action then seem to us to be due to chance.”

Beyerchen continues: “Thus the drive to comprehend the world through analysis, the effort to partition off pieces of the universe to make them amenable to study, opens the possibility of being blind-sided by the very artificiality of the partitioning practice. This form of chance is a particularly acute problem when our intuition is guided by linear concepts. [...] Clausewitz repeatedly stresses the failure of theorists, such as his contemporaries Jomini and Bulow, to obtain effective principles because they insist on isolating individual factors or aspects of the problems presented in war.”

Clausewitz accuses them of only considering unilateral action, whereas war consists of continuous interaction of opposites. For him, “the generation of any system of principles for the conduct of war is a desirable goal but an unattainable one. Such an act of synthesis is indeed attractive, because it becomes so easy to forget the filters we have imposed on our view of the phenomenon.”

Beyerchen (1992): “But his concerns, like those of many scientists wrestling with nonlinear phenomena today, are open systems which cannot be isolated from their environments even in theory, which are characterized by numerous levels of feedback effects, and which need to be grasped realistically as an interactive whole. Traditional analysis that aimed at breaking the system into simpler parts fails now just as surely as it did in Clausewitz's time, and for the same reasons.”

We presume that interconnectedness leads towards interdependency. The more we study systems, the more sophisticated the models (systems) becomes, the more interdependencies are pronounced (Gharajedaghi, 1999, pp. 15-16; Bryson, 2004, pp.296-298; Sherwood, 2002,pp. 1-7).

It is our view that an investment analysis tool as game options use a technique too limited to grasp the whole context of the opponents (Rabaey, 2011) to represent nonlinear situations.

79 Beyerchen quotes Henri Poincaré

3.4.2.4. Conclusions

Karl von Clausewitz described War as a CAS without the vocabulary related to CAS, CT, nonlinearity, or ST, but his approach is clearly not linear but holistic.

We have discussed the three types of unpredictability (from interaction, from friction and from chance). So the principles and rules of linear versions of Art of War are dangerous to use because reductionist thinkers will continue to think reductionist. It is only by recognizing that war (environment) and armies (organizations) (and for that matter market (environment) and enterprises (organizations)) are CAS which have particular characteristics as nonlinearity that leaders will start to think holistically and use linear techniques only in simple contexts. Other nonlinear techniques that support holistic thinking should be conceived in an integrated way following the transdisciplinary approach.

3.5. Conclusions on War as CAS

In chapter 2 *Organizations as Complex Adaptive Systems* we have seen that CAS has characteristics which cannot be adequately taken into account by reductionist thinking, or analytical thinking only. CxT and especially ST are better equipped to handle characteristics of CAS like nonlinearity, self-organization and emergence. These characteristics have also consequences for the development of the strategy in a CAS (organization).

In this chapter we have linked the previous discussion of strategy with aspects of tactics. Especially the tacticization of strategy has been noted as an obstruction of an adequate execution of strategy. We concluded that a holistic view on the subject was the only way to avoid tacticization of strategy.

NCW is more in line with CAS. Although based on the co-evolution of economics, IT, business processes and organization, NCW is well suited for military operations. It comes with two new concepts:

- speed of command: transforming information superiority into command superiority; and
- self-synchronization which is typical for a multi-minded CAS.

Self-synchronization together with speed of command enables a bottom-up approach to organize and synchronize complex warfare activities.

OODA of John Boyd is adequate for complex decision-making. The most important phase is “Orient”, which implicitly holds our mental models. As a consequence the orient phase is influencing the observation, the decision-making and the action (behavior). John Boyd himself paid a lot of attention to these mental models, especially in his work *Destruction and Construction.* It stands for the fact that one must destroy, abandon his mental models to be able to construct a new one based on new intelligence or new insights.

It is remarkable that in the early 19th century Karl von Clausewitz, whose work is still influencing military leaders, described war as a CAS (although not with its 21st century complexity terminology) and that it took more than 150 years before the reductionist thinking of military leaders started to change into a holistic thinking.

In the discussion on *Eine wunderliche Dreifaltigkeit,* we noted that due to the (always scarce financial and other) resources and the anticipative interactions, it is appropriate to decide investments (=organizational changes) in shorter, but “inter-coherent” cycles.

Another point is that the engineering (management) approach is prescriptive and therefore it is not suited for CAS (organization), for which the past explains the actual configuration of the CAS (organization). Descriptive ecological approach is ideal to learn from the past. In this case, human ecology is the relationship between human groups and their physical and socio-economical environment. Descriptive approaches support organic evolution in a constantly changing environment, which is hardly feasible with prescriptive approaches.

We started and ended this chapter with the discussion on the USMC C2-spectrum. C2 like leadership should adopt to the context in which the organization is in. Just as with NCW, C2 is all about situational awareness. The (ecological) context dictates the way the organization should behave (structure, function, process).

In the case of USMC, C2-spectrum is integrated in its mental models. So discussing its sense-making framework would imply a considerable knowledge of the USMC mental models. The Cynefin framework however is generic, that is why we will discuss the Cynefin framework in the next chapter.

4. A Generic Sense-making Framework: Cynefin

Snowden and Boone (2007) did not conceive a categorizing framework but a sense-making framework, thus being in a particular quadrant (domain) does not imply a value or a judgmental assessment of the organization.

The Cynefin Framework, which originates from Snowden's work in knowledge management is based on complexity science and is also applicable to strategy formulation. It provides a means of exploring different organizational contexts and selecting approaches accordingly. Thus Cynefin allows people and organizations to better understand the contexts within which they are operating (Snowden, n.d.; Bean, 2011) and for our research case of IT-investments, better understand how to invest.

4.1. Systems Thinking: Complicated or Complex

ST has a huge potential, first in deciphering the complexity of an entire system, and then in applying this understanding to design and evaluate interventions that improve the service of that system. ST can provide a way forward for operating more successfully and effectively in complex, real-world settings (Savigny & Adam, 2009). However not all systems or parts of a system (system-of-systems) are complex. They can be simple, complicated or chaotic. The Cynefin framework ([80]) can help an organization in determining which types of systems it has.

What is interesting is that Kurtz and Snowden (2003) put ST in the complicated domain (Figure 20), which they call the domain of the knowables where the thinking is analytical-reductionist. So apparently they use a concept that differs from the concepts of Ackoff or Gharajedaghi. It is clear that the authors had more systems engineering in their mind than (the evolved) ST.

The complex domain is the domain of CAS and pattern management. Kurtz and Snowden (2003) state that it is the "domain of complexity theory, which studies how patterns emerge through the interaction of many agents. There are cause-and-effect relationships between the agents, but both the number of agents and the number of relationships defy categorization or analytic techniques. Emergent patterns can be perceived but not predicted; we call this phenomenon retrospective coherence. In this space, structured methods that seize upon such retrospectively. "

However especially for CAS which are interacting with the environment to survive, it is necessary to have a global picture of the system in its environment. Additionally, certain properties cannot be deduced through a study of individual components and interactions (Lowe et al., 2006), thus a holistic view, which is provided by ST is needed.

Therefore to make the distinction between the ST versions useful in the complicated domain but not in the complex domain and the ST versions useful in the complex domain, we have called the latter the Complex Adaptive Systems Thinking (CAS*T), thus ST adopted for CAS (organization and environment). As already mentioned, this is not a contradiction. If we look at the characteristics of a CAS like self-organization and emergence then we can hardly design a CAS, it co-creates itself, co-evolves with its environment which is mostly unique for a specific space and specific time. Regarding the Cynefin framework, the answer is given by Snowden (Personal communication, 2014)([81]) in figure 19 ([82]). In the complex Cynefin space some constraints are implemented in a CAS. So some design (constraints) exist, thus CAS*T is not a contradiction.

80 The breakthrough of the Cynefin Framework came when it became a Harvard Business Review as cover story, Snowden & Boone (2007).

81 Dave Snowden conceived the Cynefin Framework. Mr. Snowden has reviewed a draft of our dissertation. Based on his review, there was an exchange of information.

82 *Figure 19* Cynefin Framework as of June 1, 2014 from "*Cynefin*" Retrieved July 14, 2014 from http://en.wikipedia.org/wiki/Cynefin

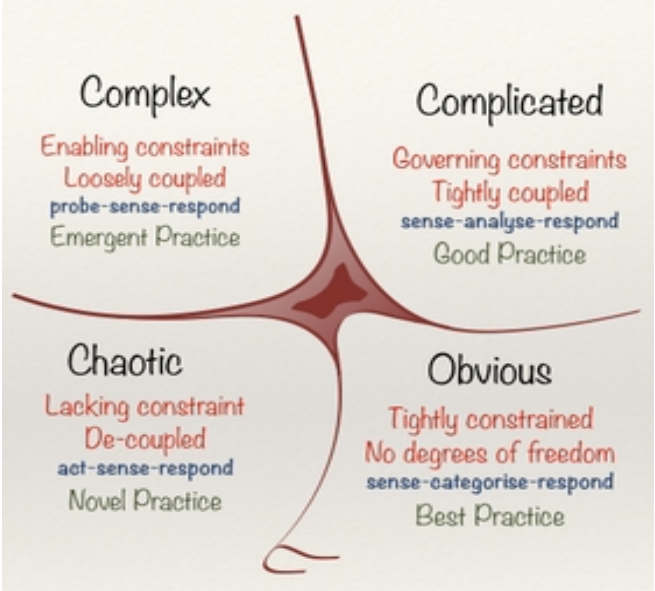

Figure 19: Cynefin Framework as of June 1, 2014

Kurtz and Snowden (2003) emphasize the Cynefin dynamic: “When people use the Cynefin framework, the way they think about moving between domains is as important as the way they think about the domain they are 'in', not least because a move across boundaries requires a shift to a different model of understanding and interpretation as well as a different leadership style. Understanding the differences between the different movements in the framework increases the response sophistication of a decision-making group to rapid change.” (p. 14).

It is therefore essential that an organization is using a philosophy and framework that can be used in as many possible domains. A system may move from the complicated domain to the complex, thus the management methods and tools may change. However the overall framework should cover both complex and complicated domains (similar logic for the simple domain). Probably this gives another perspective “Why Nobody is Doing Enterprise Architecture” stated by Bloomberg (2011). You have to know which game you are playing.

4.2. The Cynefin Framework

The Cynefin framework makes the organization and/or its parts aware of which possible contexts the organization and/or its parts can be in: obvious (simple), complicated, complex, chaotic and disordered. In figure 19 the disordered is the spot in the middle of it. The obvious and complicated domains are closer to ordered than unordered. Complex and chaotic domains are more unordered.

It must be stressed that the intention of Snowden and Boone (2007) was not to categorize systems. This would otherwise mean that it is better to be in that particular quadrant (domain) instead of other quadrants. The system is what it is and it is a in certain domain, so there is no value or judgmental assessment of the organization. The Cynefin Framework, which originates from Snowden’s work in knowledge management is based on complexity science and is also applicable to strategy formulation. It provides a means of exploring different organizational contexts and selecting approaches accordingly. Thus Cynefin is a sense-making framework which allows people and organizations to better understand the contexts within which they are operating (Snowden, n.d.; Bean, 2011).

Snowden (n.d.) states that in a categorizing framework the model precedes the data. These frameworks are fast, you just drop the data into the framework and you know where the subject is positioned. The danger is that you cannot see subtle differences until it is too late. So categorization is good for exploitation but very poor for exploration in times of changes. On the other hand, in a sense-making framework the data precedes the framework. The patterns or the framework emerges from the data in the social process.

Cynefin helps the organization to assess the necessary knowledge, the cause-and-effect relationships and the role (degree) of uncertainty. This has consequences for the volatility of knowledge; the higher the volatility, the more important the intelligence (process) is. Since dynamics are very important in CAS*T,

we can speak of dynamic knowledge.

But not all systems are CAS and components of CAS are not always complex. In their article in Harvard Business Review Snowden and Boone (2007) state that wise executives should tailor their approach for decision making to fit the complexity of the circumstances they face. Therefore, although the Cynefin matrix helps visualize and understand how systems operate within a variety of domains, it can also be an indicator of the type of organization it is: mechanical, biological or sociocultural ([83]). This will answer the question of whether the organization is fit to survive in a particular domain. Logically a mechanic-based organization will not easily survive in a complex domain, unless it is part of a higher system that is capable of dealing with complexity.

Bean (2011) states that current Enterprise Architecture (EA) practice (and indeed most management theory) is predicated on an assumption that organizations would be more effective if they exhibited a greater degree of order, but this may or may not be true in a rapidly changing world that is becoming more networked and diverse. She refers to Snowden who points out that the nature of CAS renders many current approaches to strategy and planning, where complicated and detailed plans are constructed, to be highly questionable. Snowden also points out that overly constraining a CAS, treating it as if it were an ordered one, can lead to chaos.

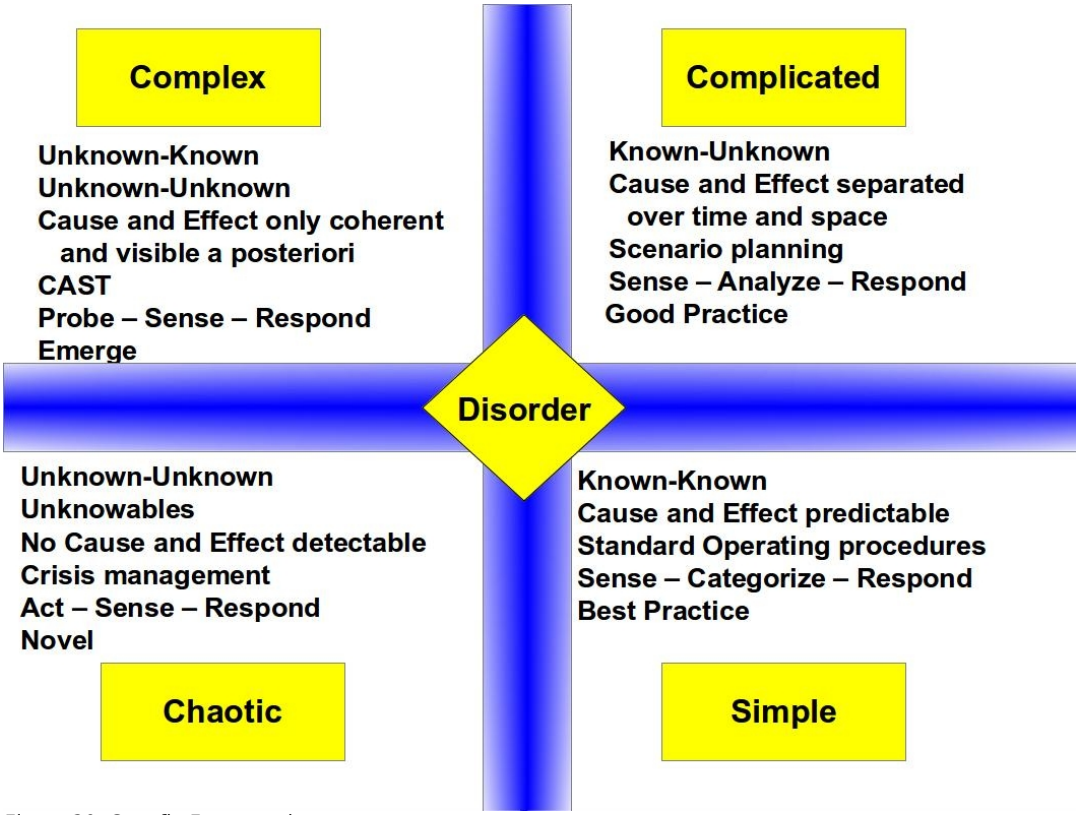

Figure 20: Cynefin Framework

4.2.1. Obvious Space

Previously called “Simple” space in which the variability of the environment is narrow. Uncertainty and turbulence are minimal. Here fits the detailed C2 where clear (known) cause-and-effect can be detected. The members of the organization know what to expect, and everyone shares a common understanding. It is the domain of the known-known ([84]), each event or action carries with it a limited number of potential

83 That is why we state that Cynefin in CAS*T should be used for the organization and for its environment.

84 The first part is about the state of the knowledge, the second about the state of information. Unknown-known

outcomes that are predictable. Here, one can predict and prescribe behavior (Snowden, 2002).

However there is a danger to oversimplify the situation. In this context, leaders often become complacent and too often react too late what can be catastrophic. The leader should sense the problems, categorize them and then respond with the best practices.

So restrictions can be positive but “on the negative side, the imposed structure [restrictions] can continue beyond its useful life” (Snowden, 2002).

Obvious contexts are heavily process-oriented situations typically managed through the application of standard practice. Both managers and employees have access to the information they need. Adhering to best practice makes sense, and for this process re-engineering is a typical tool. Some examples of systems that would fall into this domain would be automobile repair shops, retail merchandise stores, fast food restaurants, municipal government departments, church congregations, and help desks that follow prescribed patterns of questions and answers in responding to common problems (Dettmer, 2011).

EA in an obvious context will be more related to the “black box” situation. EA is seen as the glue between business and IT

4.2.2. Complicated Space

Here also the context is ordered and (knowable) cause-and-effects exist, only not everybody can see these relationships and therefore experts are needed to detect them, which makes human capital more important for the organization. But in this domain of known-unknowns, the experts can be overconfident in their own solutions. The so-called “maverick” solutions of non-experts are mostly rejected.

“The very thing that enables expertise to develop, namely, the codification of expert language in turn leads inevitably to entrainment of thinking. Exhortations to remain open to new ideas are unlikely to succeed. Management of this space requires the cyclical disruption of perceived wisdom. The common context of expertise is both an enabler and blocker to knowledge creation and from time to time context must be removed to allow the emergence of new meaning.” (Snowden, 2002).

Moreover, Holmdahl (2006) claims that in the complicated space the entrained patterns are at their most dangerous, as a simple error in an assumption can lead to a false conclusion that is difficult to isolate and may not be seen (p. 60).

Vakili et al. (2007) mention experience as a fundamental impediment (resistance to change) because previous experiences are determining the way we view and interpret our subsequent experience (Orient phase in OODA). Those experiences just like patterns are stored in our bag (Snowden, n.d.) from which we select solutions for later problems. “Another aspect of experience is that almost none of our everyday experiences appear to be the product of ongoing reciprocal processes, as a systems perspective (Vakili et al., 2007, p.13).

In this context there is no best practice, only good practice. Snowden (n.d.) emphasizes the difference between the two contexts regarding practices. In a complicated domain there are several different ways of doing things all of which are legitimate if you have the right expertise. Trying to force people to adopt one of them may be quite dangerous.

Dettmer (2011, pp. 11-12) states that an organization can function in an obvious context, but that itself can be complicated due to its structure. Specialized subunits (subsystems) have their own tools and methods, and the collaboration between these subsystems can be difficult. Certainly in a complicated domain, the myriad of interacting, interdependent parts can raise considerable issues. This leads to the creation of silos (specialized sub-systems) which are highly specialized and require specialized functional knowledge to operate.

This type of organization esteems that the whole (organization) is the sum of processes. Therefore their EA will focus on the business processes which have to execute the strategy to attain the aimed goals or objectives. Thus the organization wants to improve its processes. The organization is a white box and the EA is seen as the link between the strategy and the execution.

Snowden (n.d.) and Dettmer (2011, p.12) come to the same conclusion, they both warn against blindly improving the processes without looking at the organization as a whole greater than the sum of the processes. He quotes Deming: “Optimization is a process of orchestrating the efforts of all components toward achievement of the stated aim. Optimization is management’s job. Everybody wins with optimization. Anything less than optimization of the whole system will bring eventual loss to every component of the system. Any group should have as its aim the optimization over time of the larger system the group operates in. The obligation of any component is to contribute its best to the system, not to maximize its own production, profit, or sales, nor any other competitive measure. Some components may operate at a loss to themselves in order to optimize the whole system, including the components that take a loss.” In the logic of reductionist thinking, if all parts are optimized, then the whole is optimized. This logic is conflicting with previous observations.

He continues: “So, while the importance of whole-system thinking and system optimization was clearly important to Deming, that message was largely missed by analytically oriented managers, and the

means the information is present, but to the knowledge what to do is not.

consultants (both internal and external) who sought to serve them. The result has historically been a plethora of process improvement tools and methods, but precious few system-level improvement tools.

As a result, the typical decision-making pattern in the complicated domain, and in complicated systems, boils down to sense-analyze-respond."

Figure 20 shows scenario planning as tool for a complicated context. Flood (1999) in his discussion on the different authors in the domain of ST refers to Ackoff and CT about scenario-planning as a tool for ST in a learning organization. Something Flood develops also in his methodology combined with boundary judgments and subsequently deepening systemic appreciation. Therefore scenario-planning can also be used in the complex context (based on Senge, 2006). Moreover, when we will discuss later intractability and investments, agent modeling is used in simulations to determine the emergent patterns of different and many interacting CAS in different scenarios, which are in most cases in the unordered Cynefin domains.

The first two contexts are ordered and base their philosophies on "cause-and-effect". Mauboussin (2011, p. 90) states that this prevents leaders and managers from dealing effectively with complexity. "The biggest issue, in my mind, is that humans are incredibly good at linking cause and effect—sometimes too good. Ten thousand years ago most cause and effect was pretty clear. And our brains evolved to deal with that. But it means that when you see something occur in a [CAS], your mind is going to create a narrative to explain what happened—even though cause and effect are not comprehensible in that kind of system. Hindsight's a beautiful thing. Also, we have a tendency to think that certain causes will lead to particular effects. …. And we just don't know. I think that's the biggest single bias."

This was also the main idea in the report of the WHO (ST for health systems strengthening): "While retaining a rigorous scientific base, systems thinking requires us to go beyond cause-and-effect approaches." (Savigny et al., 2009).

Rabaey et al. (2012) discusses Naturalistic Decision Making (NDM) and the theories of Benjamin Libet on the subconscious mind. Decisions are emerging from the subconscious mind and after a short period are surfacing in the conscious mind (See also Walters (1994)). What applies to the complex context is that cause-and-effect and/or patterns cannot be seen a priori. After the fact it is probable that this cause-and-effect and/or emergent patterns will be revealed (retrospective coherence), only too late to be taken into consideration, so the decision (behavior) is an emergent phenomenon, just like the decision making of a human being (certainly in a stress situation).

Thus, the leaders and mangers of an organization should decide the strategies with emergent behavior. Due to the fact that the environment is constantly changing, the strategy needs constantly to be adapted. The more complex (chaotic) the situations are, the more adaptive management and leadership are needed.

Snowden and Boone (2007) stress the risk of entrained thinking, which is a conditioned response that traps decision makers in the practices, policies, techniques and rationales that have successfully put them where they are. Dettmer (2011, pp. 13-14) calls entrained thinking "complacency." It is a danger in the case of a simple context (leaders) and in the case of complicated context (experts). Without a good functioning intelligence system leaders and experts of such organizations are running behind the facts and the chances are high that they move to a chaotic context.

4.2.3. Tipping Point

So crucial in this discussion on Cynefin is the "cause-and-effect" relationship. Since we are on the border of ordered and unordered, it is the moment to reflect on the causes of tipping points and overshoot, which can cause unintended consequences and counterintuitive results.

Strongman (2013) remarked that there is a tension in complexity between chaos and order, between systems in inflation and systems in entropy. Managers still want to have ordered organizations although the increasing number of interactions with their environment moves them in complex domains and into CAS. Snowden (2013) makes a metaphor of a tiny ship (example of structure and order) on a vast sea of chaos. So even if the tiny ship is a huge carrier with 5.000 man aboard, it still will be a tiny ship (figure 21).

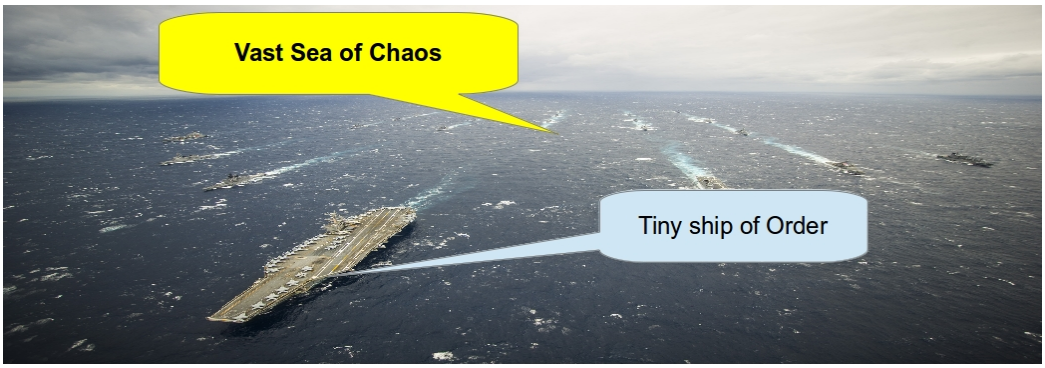

Figure 21: Tiny ship of order on vast ocean of chaos (based on Snowden (2013))

Cantle et al. (2011) describe some causes:

- Poor understanding of the level and the causes of the limit
    - Humans are not perfectly rational (see also works like (Ariely, 2009; Montier, 2010))
    - They suffer bounded rationality
- Mental Models are incomplete or there is insufficient time to consider them; as we have discussed some people are even not aware of their mental modes. Moreover people are pattern based intelligent beings, who focus only on 5% of the information (image) for them and pick up the first found so called matching pattern (thus satisficing, not optimizing)(Snowden, 2013).
- Tendency to be focused on indirect, delayed indicator for health of system
- Momentum in the system and positive reinforcing loops
- Long delays in deciding, responding and affecting change
- Competition and focus on short-term measures (long-term response may be different to short-term one).

These causes have as consequence that an organization might think that they are in complicated or obvious space, but in reality it is in one of the unordered spaces, and as we will discuss below ordered space management tools are not applicable in the complex or chaotic spaces.

4.2.4. Complex Space

The two following contexts or spaces are unordered. “Complex context” has unknown-unknowns and it is into this domain that much of contemporary business has shifted. There are no right answers and leaders should probe, sense and respond, meaning that the organization should look at emergent patterns, which by definition can be perceived, but not predicted (retrospective coherence). So, in a complex space, one manages to recognize, disrupt, reinforce and seed the emergence of patterns, so one allows the interaction of agents to create coherence and meaning (Snowden, 2002).

In the ordered domains, there is fail-safe design, in complex domain there are the fail-safe experiments. If an experiments succeeds, it will be amplified. If it starts to fail, then it will be abandoned, which will be typical for IT-investments in this domain. So what happens is a new order emerging, together with a new practice (an emergent practice); everything is novel. It may be a recombination of known things, but in any case it is unique. (Snowden, n.d.; Holland, 2008; Korhonen, 2012).

Holmdahl (2006) warns that structured methods, which seize upon retrospectively coherent patterns and codify them into procedures will confront only new and different patterns for which they are ill prepared. He concludes that relying on expert opinions based on historically stable patterns of meaning will insufficiently prepare us to recognize and act upon unexpected patterns.

Understanding requires a transdisciplinary approach on the nature of the system with the purpose to gain new perspectives on the situation before acting (Orient-phase).

Snowden (n.d.) and Holmdahl (2006) state that the methods of the known (obvious) and knowable (complicated) domains do not work in the complex space but narrative techniques are particularly powerful.

Regarding experimenting with projects or amplifying or abandoning them, this looks a lot like the

philosophy of (real) options, only the underlying necessary data is missing: the unknown-unknowns (see figure 22). That is why people as Professor Wouter de Maeseneire ([85]), intuitively say that real option thinking is more important than the ROV techniques.

Detailled C2 is not in its place in the complex context, nor in the chaotic, but mission C2 is. Snowden et al. (2007, p. 74) warn “If [the managers] try to overcontrol the organization, they will preempt the opportunity for informative patterns to emerge. Leaders who try to impose order in a complex context will fail, but those who set the stage, step back a bit, allow patterns to emerge, and determine which ones are desirable will succeed.” Therefore complex contexts demand a more experimental management approach that admits some failure in the pursuit of understanding (Dettmer, 2011, p. 16). Leaders might serve more as context setters and designers of learning experiences (Schneider et al., 2006), even so CAS leadership [in complex space] is often non-reliant upon formal authority structures (Schneider et al., 2006) as in mission C2.

Effective membership in a multi-minded system requires a role, a sense of belonging, and a commitment to participate in creating the group's future, so much that rolelessness is the major obstruction to integrating a social system. When an individual feels that his contributions to the group's achievements are insignificant, or when he feels powerless to play an effective role in the system's performance, a feeling of indifference sets in and the individual gradually becomes alienated from the very system in which he is supposed to be an active member of (Herzog, n.d.).

To address the problems of an unordered context, a multi-minded organizational structure is recommended (agility). Shared vision is of the utmost importance.

Holmdahl (2006) discusses product development in the context of agility and organizational structure. Somewhat similar to Gharajedaghi he makes a difference between a static and a dynamic view of an organization. If product development is started with a detailed specification and a detailed timeline (thus detailed C2) and if product development is seen as a question of delivering according to specification and to follow the plan (specified by management (uni-minded view)), then Holmdahl calls this a static product development. If on the other hand product development is continuous and flexible with agile adjustment to shifting circumstance, making use of new knowledge as it presents itself, and setting up the organization to react quickly to new impulses, then we have dynamic product development. The consequences of both – static and dynamic – views can be summarized in following table 2 ([86]):

Static View	**Dynamic View**
Govern with structure	Govern with visions and knowledge
Rigid forms	Flexible, formless
Central governing (detailed C2)	Decentralized, empowerment, individual responsibility (mission C2)
Linear thinking	nonlinear thinking, CAS
	Self-organizing
Detailed plan (equates to an ability to see into the future)	Not plan able, except coarsely or for near future only
Scientific Management, machine metaphor or in the best case (human) organism metaphor	CAS*T
Follow the plan	Flexible adjustment to change
	Govern with a vision

Table 2: A Comparison between the Static and the Dynamic View on Product Development

What has to be said about the managers, can also be said about the experts. Dettmer (2011) shows us a critical revelation about knowledge and tools: “in the complex domain, the knowledge of experts may be of limited value, and the effectiveness of cause-and-effect analysis is likely to be marginalized, or of short duration. This is not to say that expert knowledge is useless, only that it’s value in predicting future events is likely to be limited.” (p. 14). The main reason is that CAS is a learning organization in which its agents have also to learn continuously.

In this context, Snowden (2002) states: “Organizations tend to study past events to create predictive and

85 Interview with Professor Wouter de Maeseneire from the Vlerick Management School (February 9, 2007): Discussion about his book (de Maesneire, 2006)

86 Adapted from *Complexity Aspects of Product Development,* p.22 by L. Homdahl, 2006, Published doctoral dissertation, Otto-von-Guericke-Universität Magdeburg, Germany

prescriptive models for future decisions based on the assumption that they are dealing with a complicated system in which the components and associated relationships are capable of discovery and management. This arises from Taylor's application, over 100 years ago, of the conceptual models of Newtonian physics to management theory in the principles of scientific management. Subsequently, a whole industry had been built between business schools and consultancies in which generalized models are created from analytical study of multiple case histories. Scientific management served well in the revolutions of total quality management."

Furthermore the interactions between agents are multiple and interdisciplinary making it difficult for expert or a group of experts to grasp. Therefore the knowledge has to be shared over the network of agents (part of the intelligence base) and EA, when implementing the knowledge layer, becomes of great value to manage the knowledge. Last but not least, it should be transdisciplinary based.

4.2.5. Chaotic Space

It is the realm of unknowables. Chaotic contexts are highly uncertain and changes are so fast that it is nearly impossible to have the time to interpret the facts and to react. A bit counterintuitive, in this case the leader has to act first to create order, so that he can sense where stability is or not, to make it possible to transform the situation from chaos to complexity; thus act, sense and respond. Dettmer (2011) remarks that waiting for patterns to emerge may be a waste of time, or a recipe for disaster (p.16). So in this case a leader has not much time to think and must act quickly. George S. Patton can be quoted: "A good plan violently executed now is better than a perfect plan next week".

However, if a company enters a chaotic context on purpose then it is for innovation. If it enters by accident then it needs to stabilize quickly (Snowden, n.d.). Therefore, companies should look for and explore these contexts because they give the best opportunities, but any practice will be a novel practice.

So, "[w]e use the domain of chaos to disrupt in advance of need, in order to break down inappropriate or over restrictive models, combined with constrained starvation, pressure and access to new concepts and ideas. As a result we create radically new capability within the ecology, which will both transform the knowable domain of experts and stimulate the creation of new networks, communities and trust/experience relationships. While new alliances and relationships form from the creative stimulus of chaos." (Snowden, 2002)

Eisenhardt and Sull write about this phenomenon in their Harvard Business Review-article "Strategy as Simple Rules" (2001, P. 108): 'The secret of companies like Yahoo! is strategy as simple rules. Managers of such companies know that the greatest opportunities for competitive advantage lie in market confusion, so they jump into chaotic markets, probe for opportunities, build on successful forays, and shift flexibly among opportunities as circumstances dictate. But they recognize the need for a few key strategic processes and a few simple rules to guide them through the chaos." This certainly does not imply that no strategy at all is needed. "Each company follows a disciplined strategy - otherwise, it would be paralyzed by chaos. And, as with all effective strategies, the strategy is unique to the company. But a simple-rules strategy and its underlying logic of pursuing opportunities are harder to see than traditional approaches." (Eisenhardt et al., 2001, p.109)

4.2.6. Disorder

David Snowden (n.d.) states that if an organization does not know in which domain it is, then it is in the disorder space.

Bean (2011) stresses that Cynefin is a sense-making framework, not a categorization framework. It is intended to be socially constructed as an emergent property of people's interaction and discussion about factors and elements in a particular context. For this reason, there is a fifth domain in the center of the diagram, that of disorder, where people cannot agree on how something fits.

In the case of disorder, the manager will act according his preferred way of acting. If he has been working in a simple bureaucratic environment then he sees every problem as a failure of processes. If he is an expert then every failure is due to a lack of time or resources to do a good analysis. Natural complex workers like battlefield commanders or politicians, react to a crisis by bringing in as quickly as possible a lot of people from lots of different backgrounds in a desperate hope that somebody will come up with a good solution; nevertheless that can be a good strategy. In the last domain it is more in a fascist way that everybody has to do what they have been told to do (Snowden, n.d.).

The fact is that in this continuously (faster) evolving environment, apart from the knowledge network, the organizational structure also needs to be flexible. We are proposing a capability approach. A capability is composed of modules. Each module can be seen as a capability itself composed of other modules. By digging deeper we reach a certain point where the modules cannot be decomposed any further into other modules. This is the atomic module. It only has resources such as material and human resources to manage (Rabaey et al., 2007). Of course this reductionist approach is only one step in the iterative process of (holistic) inquiry. Each component can be a CAS and will have emergent properties which cannot be explained solely by analyzing the components and/or resources (see below Mind the "Cliff").

The following two sections will be based mainly on the excellent work of William Dettmer (2011):

“Systems Thinking and the Cynefin Framework: A Strategic Approach to Managing Complex Systems” except for the EA topics.

Figure 22 gives an overview of the leader’s task in the Cynefin Framework ([87])([88]).

	THE CONTEXT'S CHARACTERISTICS	THE LEADER'S JOB	DANGER SIGNALS	RESPONSE TO DANGER SIGNALS
SIMPLE	Repeating patterns and consistent events Clear cause-and-effect relationships evident to everyone; right answer exists Known knowns Fact-based management	Sense, categorize, respond Ensure that proper processes are in place Delegate Use best practices Communicate in clear, direct ways Understand that extensive interactive communication may not be necessary	Complacency and comfort Desire to make complex problems simple Entrained thinking No challenge of received wisdom Overreliance on best practice if context shifts	Create communication channels to challenge orthodoxy Stay connected without micromanaging Don't assume things are simple Recognize both the value and the limitations of best practice
COMPLICATED	Expert diagnosis required Cause-and-effect relationships discoverable but not immediately apparent to everyone; more than one right answer possible Known unknowns Fact-based management	Sense, analyze, respond Create panels of experts Listen to conflicting advice	Experts overconfident in their own solutions or in the efficacy of past solutions Analysis paralysis Expert panels Viewpoints of nonexperts excluded	Encourage external and internal stakeholders to challenge expert opinions to combat entrained thinking Use experiments and games to force people to think outside the familiar
COMPLEX	Flux and unpredictability No right answers; emergent instructive patterns Unknown unknowns Many competing ideas A need for creative and innovative approaches Pattern-based leadership	Probe, sense, respond Create environments and experiments that allow patterns to emerge Increase levels of interaction and communication Use methods that can help generate ideas: Open up discussion (as through large group methods); set barriers; stimulate attractors; encourage dissent and diversity; and manage starting conditions and monitor for emergence	Temptation to fall back into habitual, command-and-control mode Temptation to look for facts rather than allowing patterns to emerge Desire for accelerated resolution of problems or exploitation of opportunities	Be patient and allow time for reflection Use approaches that encourage interaction so patterns can emerge
CHAOTIC	High turbulence No clear cause-and-effect relationships, so no point in looking for right answers Unknowables Many decisions to make and no time to think High tension Pattern-based leadership	Act, sense, respond Look for what works instead of seeking right answers Take immediate action to reestablish order (command and control) Provide clear, direct communication	Applying a command-and-control approach longer than needed "Cult of the leader" Missed opportunity for innovation Chaos unabated	Set up mechanisms (such as parallel teams) to take advantage of opportunities afforded by a chaotic environment Encourage advisers to challenge your point of view once the crisis has abated Work to shift the context from chaotic to complex

Figure 22: Overview Cynefin framework

4.2.7. Mind the “Cliff”

Snowden (n.d.) emphasizes that the boundary between simple and chaotic domains is very different from the other boundaries. The principle here is that if a manager starts to believe that everything is simple; he starts to believe that everything is ordered; he starts to believe in his own myths; he starts to believe because of the past successes that he is invulnerable. The chances are high that he is moving with his

87 Snowden, D. J., & Boone, M. E. (2007). A Leader's Framework for Decision Making. (cover story). Figure. Harvard Business Review, 85(11), 68-76. Retrieved January 27, 2014, from Harvard Business Review.

88 The authors are referring to detailed C2 when they mention command-and-control.

company towards the chaotic space, and once passed the boundary the company falls over the edge into a big crisis.

Valkili et al. (2007) note that primacy (the state of being first or foremost) is one of the barriers to use ST, not CT, because it is another source of resistance to change, similar to experience. The way in which the organization first successfully copes with a situation sets a pattern, which is unusually persistent. Primacy can appear in choosing the means of decision-making, the way to choose alternatives or ends, and the alternatives themselves (pp. 13-14).

All the other boundaries are transitions from one domain to another (back- and forward), but that specific boundary going from simple to chaotic is very disturbing (crisis) and the recovery is very expensive.

Therefore it follows that companies should manage in the complicated and complex spaces and move only a very small amount of material into the simple space, because that is actually a highly vulnerable domain for rapid or accelerated change (Snowden, n.d.).

In any case situational awareness is crucial for the surviving of the organization. Holmdahl (2006): “Boundaries are possibly the most important elements of sense making, and especially the crossing of boundaries. A boundary might look different depending on from what direction it is approached. Important here is awareness of approaching the boundary, so that one can sense when change is incipient and respond before the boundary is crossed (perhaps to cross it purposefully, perhaps to avoid it), and of crossing the boundary, so that one can respond quickly to new conditions after one has arrived on the other side. It may be possible to manage the boundary and the perceptions surrounding it, so that one, for example, can put a deep chasm boundary in place for one’s adversary while maintaining a shallow -river boundary for one’s own use.” (p. 61).

4.3. Use of situational awareness

In the context of CAS*T and the discussion on situational awareness, we propose the use of Cynefin diagrams in a number of evaluations of the organization and its environment and its impact on the C2. This also helps to make the theory more concrete to support investment and other decisions.

In figure 20 Cynefin Framework (p.73) we have marked the *knowables* and unknowables:

- Obvious: known-known
- Complicated: known-unknown
- Complex: known-unknown and unknown-unknown
- Chaotic: unknown-unknown

From our previous discussions, we need to add another dimension: (un)awareness. Awareness is the knowledge or perception of a situation or fact (Oxford dictionaries). To the Free Dictionary, aware implies knowledge gained through one's own perceptions or by means of information.

Perception (Oxford dictionaries) is a way of regarding, understanding, or interpreting something; a mental impression. In the domain of psychology a perception is the neurophysiological processes, including memory, by which an organism becomes aware of and interprets external stimuli.

Relevant is that external stimuli (thus from the environment) are observed, understood and interpreted based on mental models (orient-phase in OODA).

So known facts can be ignored by mental models, hence it is not because knowledge is available that it can or will be used. This is important to understand the different approaches companies can have to solve a same problem. Instead of using the terms known and unknown, we are suggesting to use awareness and unawareness, which reflects more the subjective reality of a person or an organization.

Besides the awareness adds the intuition to the 'accepted' known, while the 'rejected' known is added to the unawareness. In the Cynefin framework we are replacing known/unknown by awareness/unawareness (figure 23). A difference has to be made between endogenous unawareness (inside the organization) and exogenous unawareness (outside the organization). Of course in every situation we have unawareness, certainly the exogenous, but for a simple situation for instance most things are known; not much intuition is needed. In a more complicated situation, the organization is aware that it has to observe for some events to continue functioning and/or make decisions. In the unordered part, we have a lot of unawareness; for a complex situation most of it is exogenous, for a chaotic situation, it is both.

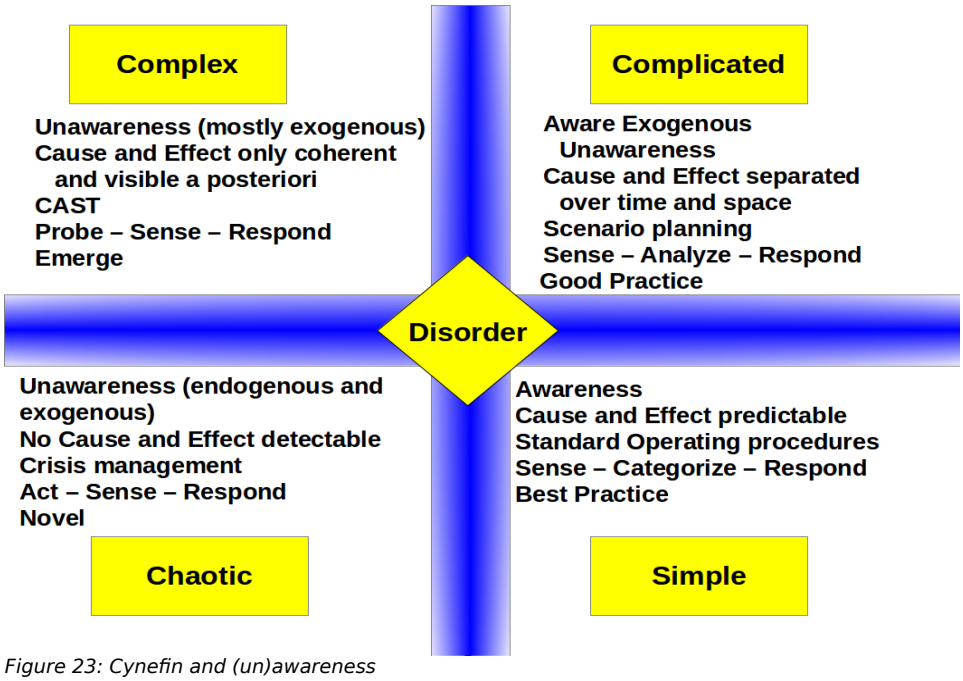

Figure 23: Cynefin and (un)awareness

4.3.1. Generic

Figure 24 shows this unawareness circle, it holds the full disordered space and parts of the ordered and unordered spaces. So in a space due to the fact that the organization is not aware of new events or of a changing element in the environment, the organization will only be thinking that it is in the aware sphere. Only through intelligence it can become aware of the unknown and eventually it will acquire the knowledge (change its perception). In these cases the organization can change its behavior to move back to the aware sphere of the space it would like to be, or is obliged to be.

The evolution of A → A1 → A2 is the situation of “mind the cliff”. If an organization starts to use Cynefin it is recommended to position itself first in the unaware sphere. B has determined that it is situated in the complicated space. However on the one hand, it is possible that it is in the unaware sphere of the complex space B3. On the other hand, by creating intelligence B can move to the aware spheres of the complicated (B1) or complex (B2) spaces.

The situation of C is that it is unaware of some relevant facts and it moves to the unaware sphere of the complicated space (C1) and it can even move to C2 in the complex space, which will be catastrophic because there the cause-and-effects are not timely detectable.

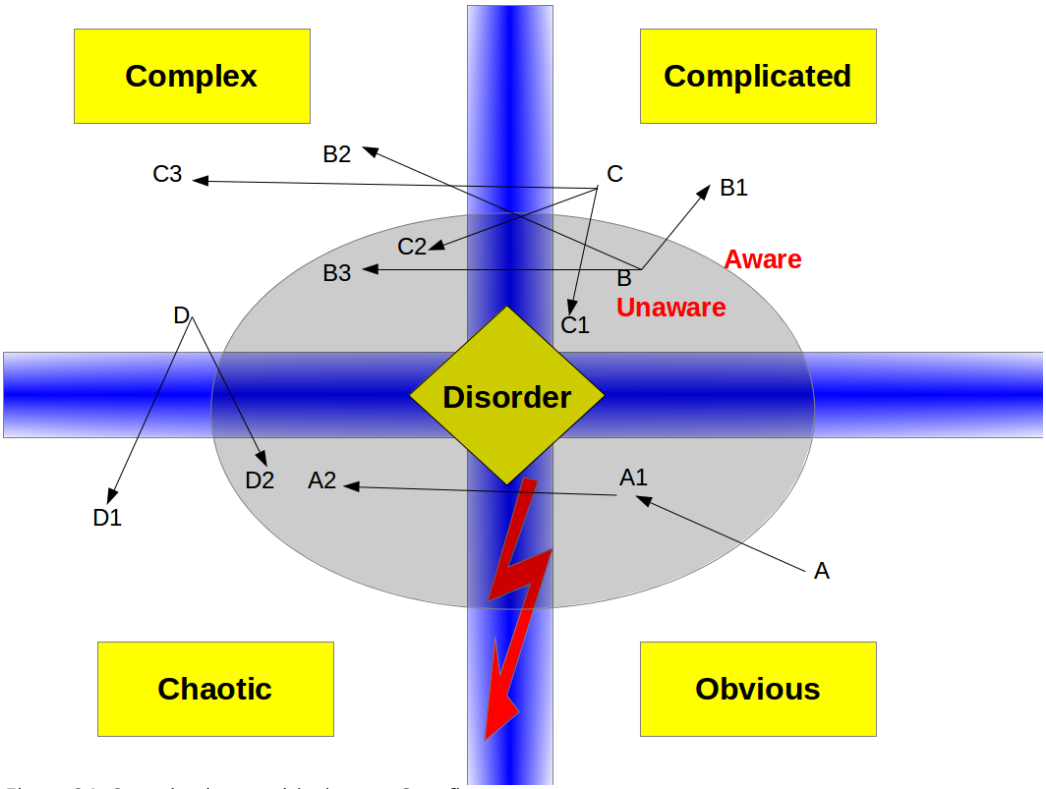

Figure 24: Organizations and (un)aware Cynefin

In the figures below we are using following notation:

$$_{\{P,R\}}A^{DS}_{Time}$$

A is the name of the organization. The left subscript represents if the organization is perceiving (P) the situation, which can be different from reality (R). The superscript DS represents the (intelligence) data set at time Time (the right subscript).

4.3.2. Evolution over Time

Figure 25 depicts the evolution of an organization over time. It may concern the organization itself or its position in its environment. We will discuss the evolution of organization A in its environment.

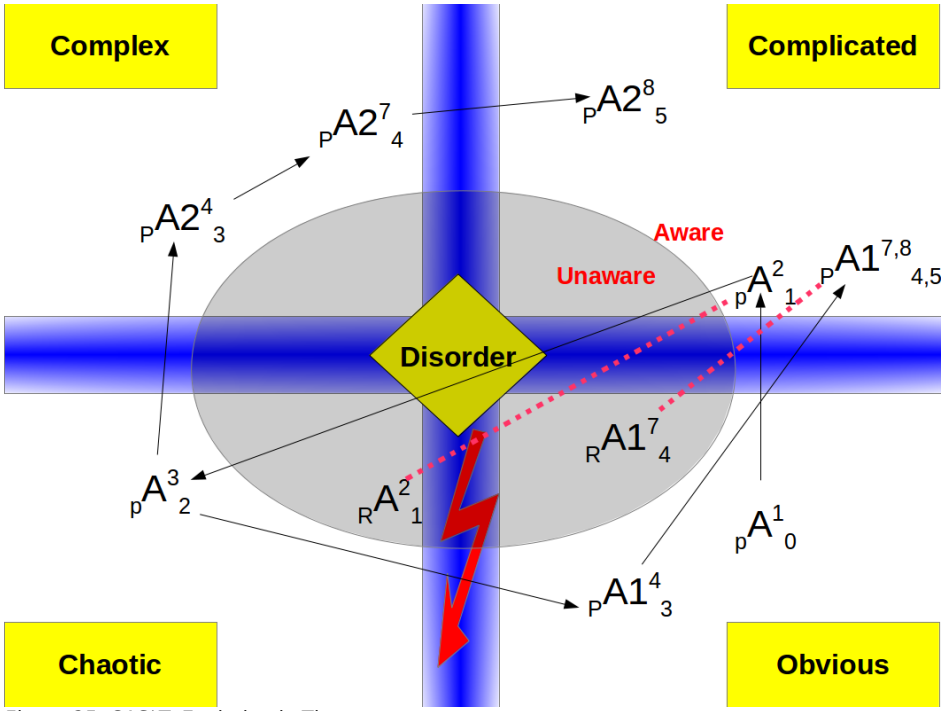

*Figure 25: CAS*T: Evolution in Time*

Organization A starts at time 0 (t_0) with the intelligence data set 1 (DS1) ${}_{P}A^{1}_{0}$ in the obvious space. At t_1 it perceives to be in the complicated space based on DS2: ${}_{P}A^{2}_{1}$. Unfortunately it is a *Mind the Cliff* situation: ${}_{R}A^{2}_{1.}$ Due to the unexpected effects, the organization A is collecting new information DS3 and realizes that it is in the chaotic space: ${}_{P}A^{3}_{2}$. The decision is made to split up the organization A into A1 (for the activities in the obvious space ${}_{P}A1^{4}_{3}$) and A2 for an exploration of new opportunities in the complex space: ${}_{P}A2^{4}_{3}$. The latter evolves with its new products at t_5 into the complicated space ${}_{P}A2^{8}_{5.}$. Eventually the former will also evolve into the complicated, not at t_4 (${}_{R}A1^{7}_{4}$) but at t_5 (${}_{P}A1^{8}_{5}$).

The reason to split up A, is that its culture is not compatible for handling complex situations. Only a part went over to A2 and new people have been recruited.

Besides the history essential for understanding a (per definition) evolving CAS, figure 25 shows also the accuracy of the intelligence (data sets), which is crucial for its situational awareness and/or the quality of decision making.

It illustrates as well that an organization can be confronted at the same time with different management needs and therefore different management tools thus different investment techniques. In this case, management of the original organization A opted to split up A but another solution could have been to restructure A -not the least to change the culture- with two subunits A1 and A2. Here the new mother organization A must be flexible enough to manage A1 (with a detailed C2) and to guide A2 (with a mission C2).

4.3.3. Market

Figure 26 shows how organization A observes its environment (market) over time. At t_0 A was not aware that organization E was already in its environment ($_RE^1_0$) although influencing the interactions. Only at t_1 $_PA^3_1$ is aware of $_PE^4_1$.

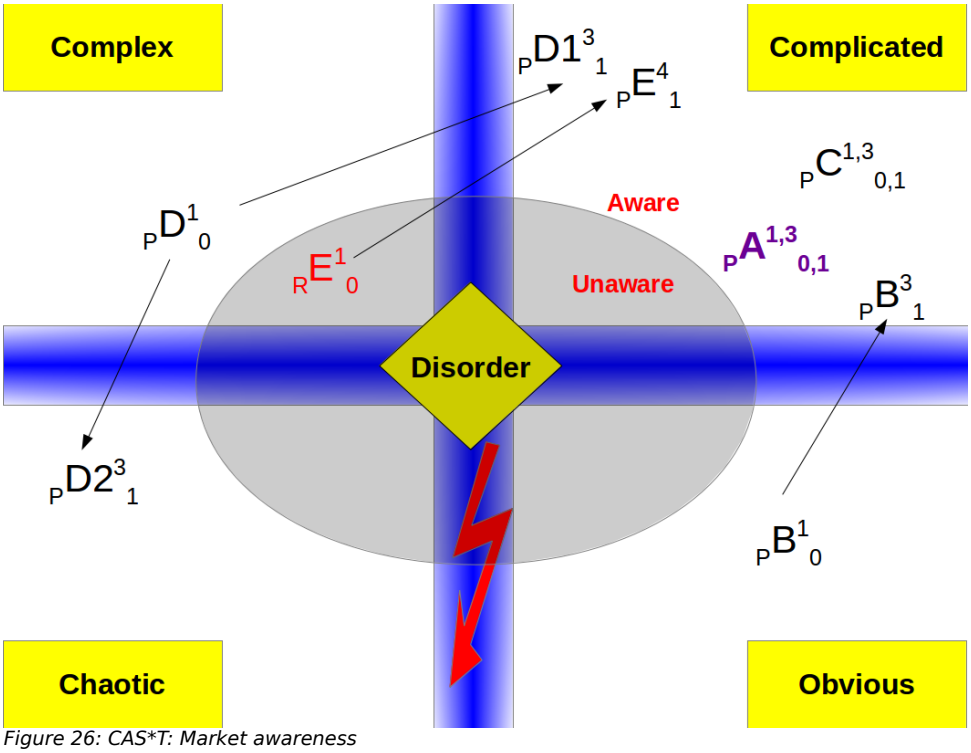

*Figure 26: CAS*T: Market awareness*

Organization B has moved from obvious to complicated, C stayed in complicated and D has transformed itself into D1 and D2, comparable to A in previous example

.

4.3.4. Organization and Market

Although the whole is more than the sum of its parts, it might be interesting to know how an organization composed of different types of organizations and thus its subunits are interacting with the environment. So the structure of an organization can also be mapped.

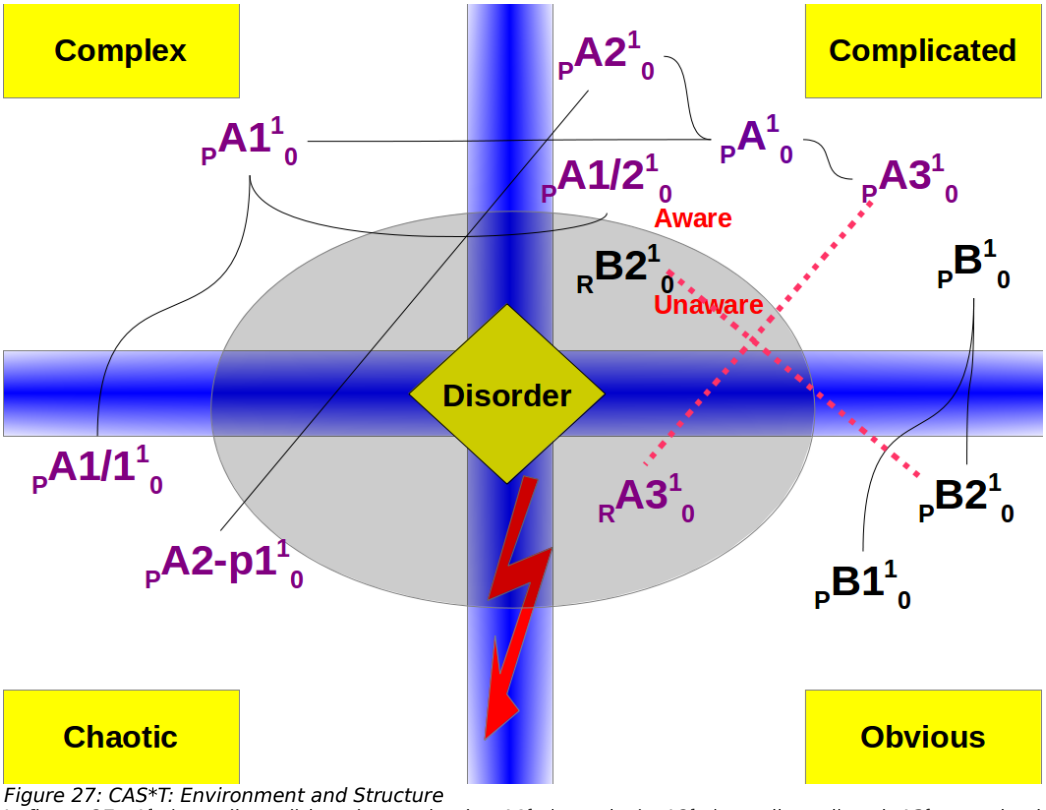

*Figure 27: CAS*T: Environment and Structure*

In figure 27 ${}_{P}A1^{1}_{0}$ (complicated) has three subunits ${}_{P}A1^{1}_{0}$ (complex), ${}_{P}A2^{1}_{0}$ (complicated) and ${}_{P}A3^{1}_{0}$ perceived to be in a complicated space but actually it is the obvious space (${}_{R}A3^{1}_{0}$).

Of course further underlying subunits and projects can also be pictured. In this case A1 has two subunits (${}_{P}A1/1^{1}_{0}$ and ${}_{P}A1/2^{1}_{0}$); A2 has a project ${}_{P}A2\text{-}p1^{1}_{0}$ in the chaotic space. Other organizations can also be pictured (like organization B). This type of presentation can be used for snapshot or evolution.

4.3.5. Type of Organization and Market

Figure 28 adds the type of organization to each element. This can be ST (mindless, uni-minded, multi-minded) or Cynefin (obvious, complicated, complex, chaotic). In this figure we have taken Cynefin.

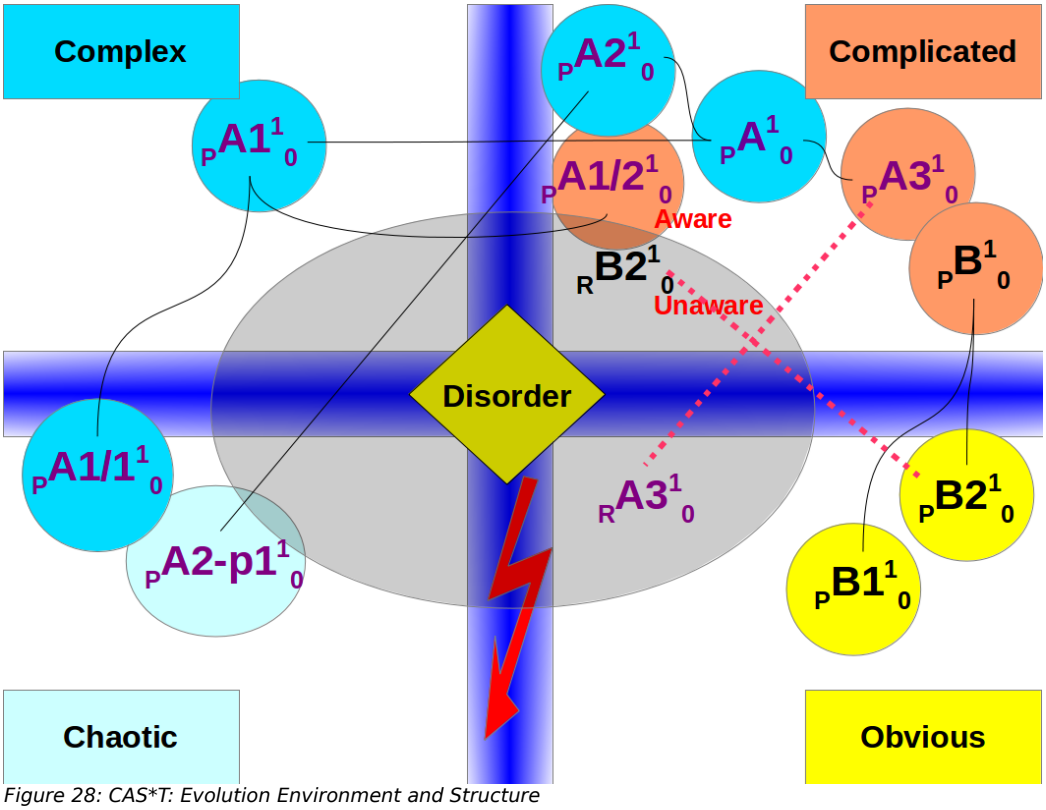

*Figure 28: CAS*T: Evolution Environment and Structure*

Organization A is complex in a complicated space as its subunit A2 is. Many reasons can be the cause of this situation:

- A moved previously from complex to complicated, and needs reconfiguration (investment);
- A has reconfigured (invested) so that it can move into a complex market;
- the subunits are significant important complex organizations;
- or a combination of the previous situations.

Logically the type of organization should correspond with the type of environment in which it is situated. It can though be different but levels exist. A complex organization can manage more easy a complicated or a an obvious organization. The same for a complicated over an obvious: Nevertheless a complex organization that has to run a chemical plant (with a lot of necessary security restrictions) might not have the right mindset to handle it.

According figure 28, organization A has a wrong perception of B2 which may have negative consequences (approaching the complicated market). Furthermore, it positions its subunit A3 in the wrong space and it is running A3 as being complicated.

Before discussing investment techniques in the different Cynefin spaces, we need first to discuss the risks and drivers of strategy.

4.4. Risks and Drivers of Strategy

4.4.1. Focus on Risks

Reducing uncertainty in the context of a detailed C2 gives the subjective feeling of mitigating risks. Opportunities are of second order, because the commander has not much freedom of action. In the context of mission C2, the commander is more inclined to accept a certain degree of uncertainty. In this case he is taking into account both risks and opportunities.

Mitigating risk is the domain of ordered Cynefin spaces, but these spaces are only a part of the reality. The importance of unordered spaces is growing, meaning that organizations are confronted with CAS (environment), and most likely they are operating themselves as CAS (organizations). The characteristics of CAS make that linear thinking about risks (and for that matter opportunities) is not adequate anymore.

We will discuss also the systemic risks, so that we can better assess investments (organizational changes) in the ordered and unordered spaces.

4.4.2. Risks and innovations

O'Donnell (2005) defines “risk as the likelihood that the outcome from a process will not meet expectations”, and in the business context this means that “[b]usiness risks represent threats to the ability of an enterprise to execute business processes effectively and to create customer value in accordance with strategic objectives”.

White (1995) writes that “[a]lthough there is little agreement over a definition of 'risk' the notion of probability is central to all risk assessment techniques identified in the literature, although the interpretation of probability depends on whether it is viewed objectively or subjectively.” White (1995), Arena et al.(2010), O'Donnell (2005) and Gordon et al. (2009) state that the interpretation of risks is more subjectively done than objectively.

Concerning subjectively, White (1995) enumerates following weaknesses of experts (p. 39), experts essential in the complicated space, but less in the unordered spaces:

- experts may differ in their judgment of safety;
- experts could be influenced by political power;
- empirical data suggests that experts and lay people have quite different perceptions about the riskiness of various technologies;
- expert assessments are susceptible to bias;
- it is difficult to transplant a deduction from one context to another.

As a matter of fact, expert systems usually present information in a simplified, unidimensional format, which often hides the complexity of the subject matter under consideration (p. 30).

Holland (2008) describes the not so obvious characteristics of CAS. As already mentioned above John Holland sees CAS more in a competitive (external) environment, although a collaborative (internal) environment also exist as in the form of an organization. So, CAS is an evolving, perpetually changing set of agents where

- there is no global competitor or global optimum;
- there is great diversity, as in a tropical forest ([89]), with many niches occupied by different kinds of agents;
- Innovation is a regular feature – equilibrium is rare and temporary;
- Anticipations change the course of the system.

These anticipations can be right or wrong, but in any case it changes the course of the system, so therefore also the system itself.

More crucial to this section are the innovations. Holland (2008) has observed CAS that have regularly produced innovations. These observations suggest changes in the way we usually conduct research:

- Risk-taking: Allow for high failure rates in funding. Because of the exponential growth of the successful “spin-offs”, the return from “home-runs” greatly exceeds the losses incurred by the failures. As such, these projects are essential for the investments in complex spaces.
- Diversity and parallelisms. Exploring several paths simultaneously in exploring a given question.

89 One tree in a rainforest can have more than one thousand different species on it.

- Credit assignment. Provide ways of rewarding stage-setting activities.

So a big corporation is not required to go into one direction, it does not have to stick to one project but can launch different projects (probes) at the same time, even to solve one single problem or to grasp one single opportunity. Every project has its own kind of risk. Normally these investments are rather limited. The home-runs long after the initial investments (also of the failures) allow the corporation to survive. Unfortunately in this economy these CAS (corporations) are always judged on their short time bottom line, thus net earnings, net income or earnings per share (EPS) (Investopedia BL, n.d.). Holland (2008) rightly states that this is a fundamental problem for the companies. He gives the US motor industry as an example of what can happen if the companies are not looking ahead. His question is ([90]) how do we find ways that we can "do" risky projects that do not pay off right away? Most important to him are the early moves in a project not so much the obvious last steps. Therefore it is important to keep track of the evolution of the CAS.

4.4.3. A Need for a Holistic Approach

So, risk management is the identification, assessment, and prioritization of risks (based on uncertainties) followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities (Funston, 2010, p. xxiii). This may be the case in ordered spaces, the question is, what about the unordered spaces?

White (1995) writes in her abstract: "Systems thinking is holistic, that is it deals with wholes rather than parts and is relevant to tackling ill-structured 'messy' problems." She reviews the literature on risk to identify the techniques and concepts used in the management of risk and the identification of potential failures. The majority of these concepts are systematic and reductionist. As risk is associated with uncertainty and ill-structured problems, she suggests that ST could be a valuable aid to risk management.

4.4.4. Types of Risks

4.4.4.1. Emergent risks

According to Bowser (2011) traditional business frameworks tend to be reductionist in nature. Therefore in CS some of the emergent properties (risks) are missed. Business has become increasingly very complex and fast moving and the globalization of markets and economies make that the outside influence on the companies is significant.

So classic frameworks may miss emergent properties and by using approaches which implicitly assume that equilibriums have to be reached, a poor approximation of the business under these conditions can be a consequence, thus leading to poor decision making. CAS*T takes into account the emergent properties and is not equilibrium-seeking. Concerning the classic frameworks, most of the tools are focused on outcomes rather than on the drivers and this makes it difficult to embed them where people specialized in risk management are thinking more in term of drivers.

Cantle et al. (2011) add that although business has become increasingly complex, the techniques are still about linear behaviors and "normal" distributions, thus belonging to the obvious and complicated domains of Cynefin.

An enterprise is a CAS with a purpose to attain the business objectives as they have been specified. According to Cantle et al. (2011), if the CAS doesn't and it is a downside then that is a risk. If it is due to the internal interactions between agents (components), then Cantle et al. (2011) conclude that emergent behavior brings significant new systemic risks. Risk is thus an unintended emergent property of a CAS. Since risk is an emergent property, aggregating the behavior of components will not say anything about the whole.

Risks are treated as events which happen at a point of time. However risks are processes which emerge over time from the complex interactions of many nodes. Risks do not necessarily come suddenly. Most of the time they are evolving and become visible at a later moment, meaning they have reached the tipping point. The credit bubble is such an example. Although the indications were there, the enterprises were not immediately (willing to be) aware of it. Another aspect of the evolution is that an emerging risk is a function of the past system performance.

In most cases a risk receives only one label so that the aggregation of risks in one functional domain goes smoothly. However risks happen through the interaction of different risk factors. Moreover a dynamic exists between these risks (from different so called original functional domains), so that most of these risks must have more than one label. Therefore risks have multiple characteristics.

4.4.4.2. Risk Appetite

Risk appetite is the risk that an organization is willing to take in the pursuit of its strategy, therefore it is a known risk, an aware systemic risk while emergent risk is an unaware systemic risk. Other risks are non-

90 Holland (2008) compares the risk-taking with the lever points.

systemic (aware and unaware).

Allan et al. (2011) state that risk appetite is a concept that many practitioners find confusing and hard to implement because there is no common measure for all risks. “By thinking holistically, risk appetite can be viewed as 'our comfort and preference for accepting a series of interconnected uncertainties related to achieving our strategic goals'. By making those uncertainties and the connectivity of the underlying drivers explicit, it is possible for decision makers to define their risk appetite and monitor performance against it more effectively. […] Similarly, the identification and assessment of emerging risks can become more robust by using a systems approach that enables a clearer understanding of the underlying dynamics that exist between the key factors of the risks themselves. It is possible to identify interactions in a system that may propagate hitherto unseen risks. Emerging risks can be viewed as evolving risks from a complex system. It is also known that such systems exhibit signals in advance of an observable change in overall performance. Knowing how to spot and interpret those signs is the key to building a scientific and robust emerging risk process. Also it is becoming increasingly clear that risk appetite and emerging risks are interconnected in many ways.” This confirms the findings of Cantle et al. (2011)([91]).

Risk appetite is situated in four different contexts: financial, insurance, regulatory and management behavior.

4.4.5. Strategy Drivers

SWOT analysis is about **S**trength/**W**eakness and **O**pportunities/**T**hreats. Risks bring the realization of the strategy in danger; drivers give impulses to the realization of the strategy.

Drivers can be divided into systemic and non-systemic categories. Each category has drivers and risks of which the organization is aware or unaware. So in analogy with systemic risks we have emergent drivers and known drivers.

Assessing drivers and risks in a transdisciplinary way will help the organization to create environments and experiments to allow patterns to emerge if the organization is in a complex space. And in general, it will help the situational awareness in adapting the strategy and eventually changing the organization.

4.5. Investment techniques

So the future is not stable and is unknown (or known) to a certain degree because of the elements described above. Different kinds of investment techniques exist and just like in the Cynefin framework, the range goes from simple to very complex techniques.

It is not the subject of the investment that determines the technique, but rather the context. The introduction of a new technology can be simple or complicated for company A, while for company B it can be complex and even chaotic (due to a competitive disadvantage that can cause the downfall of the company).

The discussion of all possible investment techniques is out of the scope of this section. Only a few will be handled to show the necessary balance between the investment techniques and the contexts being organization (introspection, internal examination) and domains (extrospection, external observation).

4.5.1. CAS: Trade-off between robustness and optimization

Lowe et al. (2006, p. 7) show that optimal investments are not likely with CAS. There is a trade-off between robustness and optimization. “Real CAS are often sub-optimal, meaning that their effectiveness is not maximized, just good enough to continue to survive [as a whole].

This has a couple of consequences. Firstly, any optimality is transient. Since change is never-ending and uncertainty is unavoidable, any optimization is true only briefly. Thus, it is rarely worth the effort to create maximum efficiency. Secondly, sub-optimality permits robustness and adaptability. Being sub-optimal and just good enough means that the system can allocate resources to maintaining reserves and variety so that the system can be more robust, resilient and adaptive. However, greater variety tends to generate greater complexity and less efficiency, so that an appropriate balance must be found. As a result, there is no optimum state or perfect design, and designers should not attempt to chase the mirage of maximum efficiency too far.”

Above we have shown that a CAS (organization) is balancing between (temporary) stability and the edge of chaos, with emergent strategies as result. Flexibility and agility are needed, the organization may have to adapt quickly to changes requiring to increase/decrease performance, or to stop old systems, or to start new systems, or a combination of above mentioned needs.

4.5.2. Obvious Space

Capital budgeting methods based on the discounted cash flow (DCF) have been the primary instruments for investment decision making. The most commonly used DCF-based method is the net present value (NPV). NPV discounts all cash flows (incoming and outgoing) related to the project or process to the

91 That should be no surprise because Neil Cantle is in both groups.

present value (PV). If the sum of discounted cash flows is positive then the project is a candidate to invest in. This technique is suited to a simple context (everything is known). “Under static circumstances, DCF-based methods provide reliable results. However, the real world situations are seldom static. Especially in cases of large investments with long economic lives the static DCF-based methods fail to present a highly reliable picture of the profitability” (Wang and Lee, 2010, p. 696).

In this context EA will also be simple, therefore EA can support the investment decision-makers.

If business is in a more complex context then it is hard to predict the future, so what about the future cash flows? “[In] a rapidly changing environment, we don’t really know how things are going to unfold, so it’s difficult to make forecasts or budgets going many years into the future.” (Mauboussin, 2011, p. 92). Even tougher mathematical models cannot predict the future: *“Complexity theory predicts that we cannot rely on predictions.”* (Matthews, 2012a).

Shen (2009) and Huang, Kao and Li (2007) write that firstly the evaluation of investments are not trivial, because the costs and benefits may involve uncertainty and vagueness, which make computation of return on investments difficult. Secondly, projects are assessed from various dimensions and criteria, which need advanced decision tools to aid. Thirdly, solutions may be bundled with some special constraints about the system architecture, budgets, decision preferences, and so on. The authors are proposing a fuzzy multi-objective decision approach for evaluating IT-projects. Fuzzy sets are used because the expertise of specialized people from different domains has to be combined together along with their level of expertise, which situates this technique more in the complicated context.

4.5.3. Complicated Space

In the complicated context management needs more flexibility so that it can postpone, delay, start, and abandon projects. Cobb and Charnes (2007) state that managerial flexibility has value. “The assumption that all investments are irreversible is a fundamental weakness of most DCF methods. […] The ability of their managers to make smart decisions in the face of volatile market and technological conditions is essential for firms in any competitive industry.”(p. 173). Real Option Analysis (ROA) or Real Option Valuation (ROV) gives management this flexibility and it tackles the problem of uncertainty and risk related to each investment (Trigeorgis, 2002; Fichman, 2004; Brach, 2003; Mun, 2006). Options are the right but not the obligation to execute an action (sell or buy). Translated to real option, it means that management can decide to postpone, stop, start, increase, decrease, reorient, restart or put on hold a project. The reasons may be because of the lack of relevant information, or to wait for results of some pilot projects, or to wait for better conditions in the environment (market).

Table 3 gives an overview of possible real options.

Option	Description
Postpone	Wait to determine whether to implement certain modules (hardware, software, network,...) without imperiling the potential benefits.
Abandon	Abandon the project (terminate at the current stage) (exit)
Switch	Re-arrange the sequence of installing/updating/finishing modules
Scope up	Add new modules not scheduled previously or increase quality
Scope down	Remove already installed modules or reduce quality
Explore	Investing in a prototype to explore the possibilities
Stage	Flexibility to stop and resume modules in progress

Table 3: Types of Real Options

Weeds (2006) warns that certain urgent events force the organization to act immediately, indicating that an organization must permanently screen its environment, and therefore implement an intelligence system. It must be stressed that even organizations that are not using ROV must implement a similar system; otherwise it will miss opportunities and be warned too late for eventual threats.

To be useful for ROV, EA-projects must be linked to risk management and simulation programs and especially the impact analysis of projects on the overall architectures (different layers).

In her study, von Helfenstein (2009) advocates the use of ROV when complexity and risks are involved. Since most of the business has shifted towards complex contexts, it is surprising that ROV is not used more in investment appraisals.

However as General Helmuth von Moltke once said: “No plan survives contact with the enemy.” As a

matter of fact ROV shares a common drawback with the classic investment techniques, being that it does not take into account the interaction of the organization with its environment (market, government, etc.) (Grenadier, 2000; Smit et al., 2009; Fereira et al., 2009). A solution could be to combine ROV with game theory, which results in the theory of option games. However option games demand a lot of intelligence and computing power and can only be justified in some cases. The organization can play different games (game theory) at the same time in different domains and/or different levels. Besides, the underlying organizational elements (agents) can themselves play different games regarding the mother organization (the whole) and regarding each other, even for a same project. Finance can collaborate with third parties, while human resources are in competition with these parties. If there is no superstructure (like project management or business unit), then contradictory signals are sent to the market (a complicated space in this case). So, there is no such thing as a unique strategic game to play. Thus if game options are used, in every node more than two (solution) paths may exist, which may quickly lead into a Chaos system (Glenn, 1996; Rabaey, 2011). Moreover, game option is too limited to grasp the whole context of the opponents (Rabaey, 2011) to represent nonlinear situations.

Collan et al. (2009) remark another disadvantage of (probabilistic) ROV by stating that real options are commonly valued with the same methods that have been used to value financial options, that is, with Black-Scholes option pricing formula, with the binomial option valuation method, or with Monte-Carlo-based methods. Most of the methods are complex and demand a good understanding of the underlying mathematics, which make their use difficult in practice. On top of that the pure (probabilistic) real option rule characterizes the present value of expected cash flows by a single number, which is not realistic in many cases (Lee and Lee, 2011). In addition these models are based on the assumption that they can quite accurately mimic the underlying markets as a process, an assumption that may hold for some quite efficiently traded financial securities, but not for investments of a 'singular' organization where every investment is intimately linked to the organization and not to a market.

Still, if ROV is not widely used, classic investment techniques are, and their integration with flexibility and risk is more complex than with ROV (example see Misra et al. (2011)).

To overcome the above mentioned problems different authors (Collan, 2008; Collan et al., 2009; Lee et al., 2011; Wang et al., 2010; Tolga et al., 2008) are proposing fuzzy sets. (See also Wikipedia Fuzzy Pay-Off Method for Real Option Valuation, n.d.), (Bednyagin et al., n.d.)).

So if enough statistical data is available then ROV can be used, most of the time in complicated contexts. If not, then fuzzy ROV is preferred (complicated and complex contexts). Although in a complex context the relevance of experts is not that big, Fuzzy ROV is better suited for making decisions in groups (Tao, Jinlong, Benhai and Shan, 2007) which is certainly useful for complicated spaces.

In this case of fuzzy ROV, the knowledge layer of EA is very important. Experts have to feed the knowledge-base linked to the concerning processes and information systems. However ROV is not suited for complex and chaos domain projects. Here EA must be fully integrated with CAS*T. Since projects and/or organizations are moving quickly towards the unordered domains, EA and investment techniques suited for these domains are preferably used from the beginning because changing methods during projects can be very time and energy consuming. As opposed to the ordered domains, EA cannot be used directly to support investments in the unordered domains. Only through the integration with CAS*T, EA can indirectly support these investments.

4.5.4. Complex Space

One of the characteristics of a CAS is emergence, but also for the complex space where one should *probe-sense-respond*. Launching multiple projects and wait at a reasonable cost for successful projects to emerge is a way to invest in a complex space. This is also what capital venture is about. Of course an organization can simulate the behaviors of agents to determine which projects could be interesting.

Intelligence is even more important than in the ordered spaces. Organizations should continuously observe phenomena in complex environments for opportunities (and threats). Not only the organizations which are in complex spaces, but also the organizations in the ordered spaces should. For the latter organizations, if an opportunity is detected, the organization or parts of it could be restructured to adapt to a complex environment (possibly with some restrictions). That is why changes to an organization (adapting C2, means and goals) are investments. However not all investments are organizational changes. Some will be outside the organization like funding an external project.

4.5.5. Chaotic space

If a chaotic space is entered on purpose, then the objective of the organization is to explore new markets or opportunities. What can an explorer hope to have as return?

4.5.6. Pendulum effect and Organizational Interfaces

We stated that CAS are constantly moving between a state of stability and a situation of being at the edge of chaos. This pendulum effect swings the CAS into and out of the different Cynefin spaces over time. This has severe consequences on how investments have to be assessed and thus how decisions have to be

made.

However more difficult for individuals and especially leaders and managers is how they should behave. The USMC have adopted a policy so that decision makers (commanders at every level) know how to behave (USMC C2 spectrum), that is also the reason why they can excel in so many different situations.

As a matter of fact, the biggest difference between USMC C2 spectrum and Cynefin framework is that the former not only contains a real system of sense-making (and situational awareness) but it contains also a real C2-system. Cynefin is an abstract framework. We believe CAS*T helps the organization to build real systems.

Less obvious is the change of commanding (leading) in mostly uni-minded structural organization, this is the internal side of the CAS (organization). There is also an external side that on which governments, public, actual and potential investors and/or partners, and other organizations are looking at the CAS (organization). This is due to the legal (and economic) entity of the CAS (organization).

It is very confusing for these parties to see a CAS continuously shape-shifting when it is moving from one space to another. Our original idea is to present a public interface to the outer-world ([92]), which is in line with OODA:

- show a self-managed view of our CAS (organization) to our enemies (conflict);
- have an official interaction with governmental bodies (neutral, conflict, synergy);
- attract potential allies (partners) and keep or reject actual allies (synergy).

So we need to design interfaces, especially for the outer-world of our CAS (organization), this is another reason to use ST in combination of CAS, thus CAS*T.

Our first thought was to have an interface based on extra-muros (outside the walls of our CAS (organization)) and intra-muros (inside) ([93]), but due to the alliances we are proposing the IT-version of collaborating with allies based on an extranet:

- InterOrg: as the public interface of an organization seen by the whole internet;
- ExtraOrg: extranet is a more secured part of the network of an organization, in which it can collaborate with partners (like suppliers and customers);
- IntraOrg: intranet only accessible to members of the CAS (organization).

From our discussions with Gert De Beuckelaer (personal communication, 2014) (see 4.6 Case BASF: R&D and IT) on the chemical industries, especially big internationals, we have concluded that InterOrg is best situated in the complicated Cynefin space:

- It is the less simple of the ordered spaces;
- The board represents the organization and has still a hierarchal role to play;
- Advice has been given to have as much possible sub-units in the complex and complicated spaces (not obvious (“Mind the Cliff”) and only for opportunities exploration in the chaotic);
- Psychological reason for the so-called leaders of the organization;
- Big investments are made in function of the economic cycles: investments in new technology in boom period and disinvestments of old technology in economic downturn.

The last reason is of course typical for the complicated space, but investments in new plants based on new technology are spread over several years (physical reasons and financial reasons).

92 This is based on our experience with Object-Oriented programming and Web Services.

93 Intra-muros and extra-muros students.

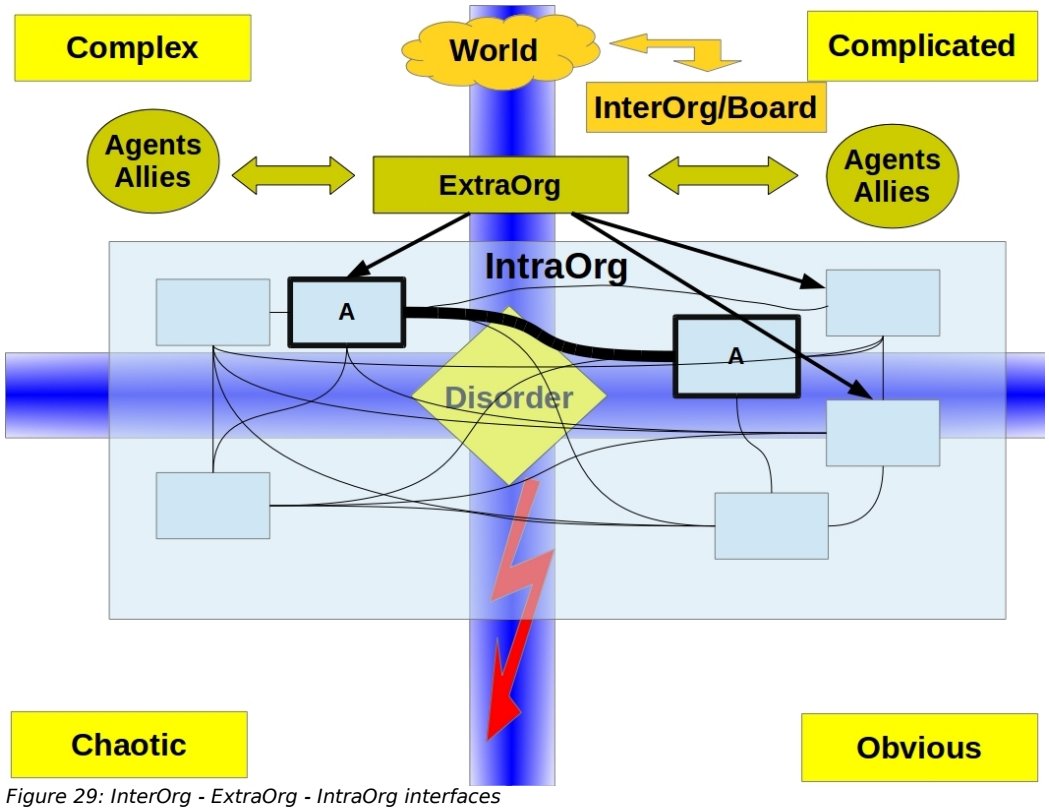

Figure 29: InterOrg - ExtraOrg - IntraOrg interfaces

Figure 29 shows the different types of interfaces. For the CAS (organization) the IntraOrg is the real structural organization. This can have any form but it should reflect the reality (or at least its own perception).

ExtraOrg is how the partners (agents in CAS (environment) that are allies of our CAS (organization)). In function of the necessity of the relationship of the CAS (organization) with its allies, it can reflect reality or it can shows how the sub-unit of the CAS (organization) should perceived. In the figure sub-unit A is at one time in the complex space and at another time in the complicated space.

InterOrg is how the CAS (organization) would like to be perceived by the world.

These interfaces are important for ST because they determine the context in which the organization should be designed. Of course, the IntraOrg is the realm of self-organization.

4.5.7. The whole prevails

The discussion of the USMC C2 spectrum and the Cynefin framework revealed the influence of emergent behavior. If people are choosing for alternatives for projects, they may (unconsciously) decide to optimize the processes and the use of resources, however the aim should be that the whole is optimized.

Figure 30.a shows the obvious context where it is quite straight forward (DCF) and if at the beginning they thought about the whole, it will be fine, however there is always a change of events that might provoke a change in strategy for the project. The complicated context (figure 30.b) with real option thinking should keep the whole in mind at every node decision. As mentioned above regarding processes in a complicated context, blindly improving the processes without looking at the organization as a whole can be counterproductive.

In the unordered contexts (figure 30.c), because of the exogenous unawareness, projects can go in any direction, if there is no shared vision (grand strategy). So emergent strategies (figure 15) should always fit in the shared vision (figure 30.d). If the shared vision is not anymore in tune with the reality then it will need to be changed (double loop).

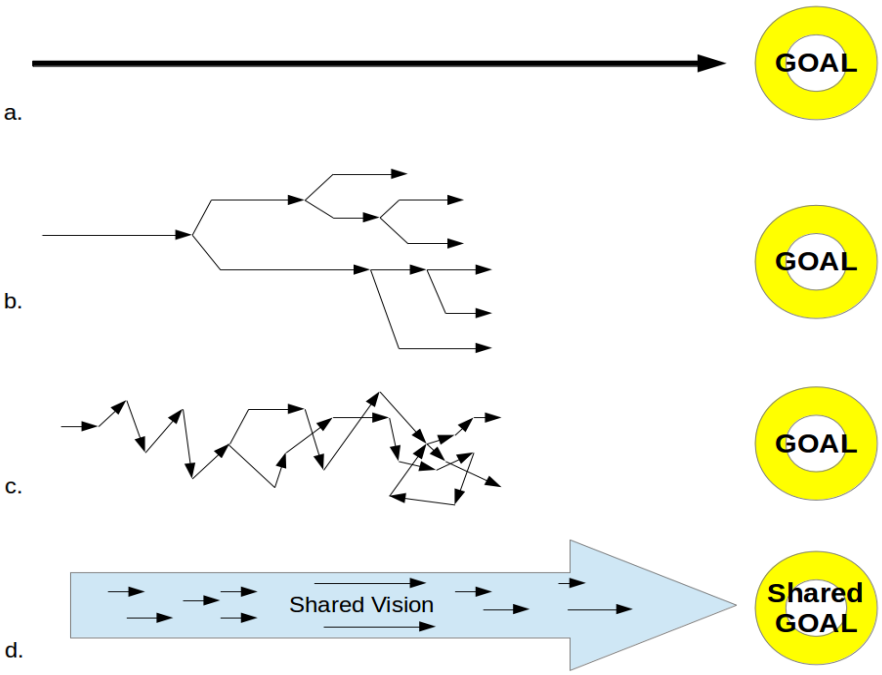

Figure 30: Importance of Shared Vision

Figure 31 gives an overview of the different investment techniques for the ordered and unordered spaces.

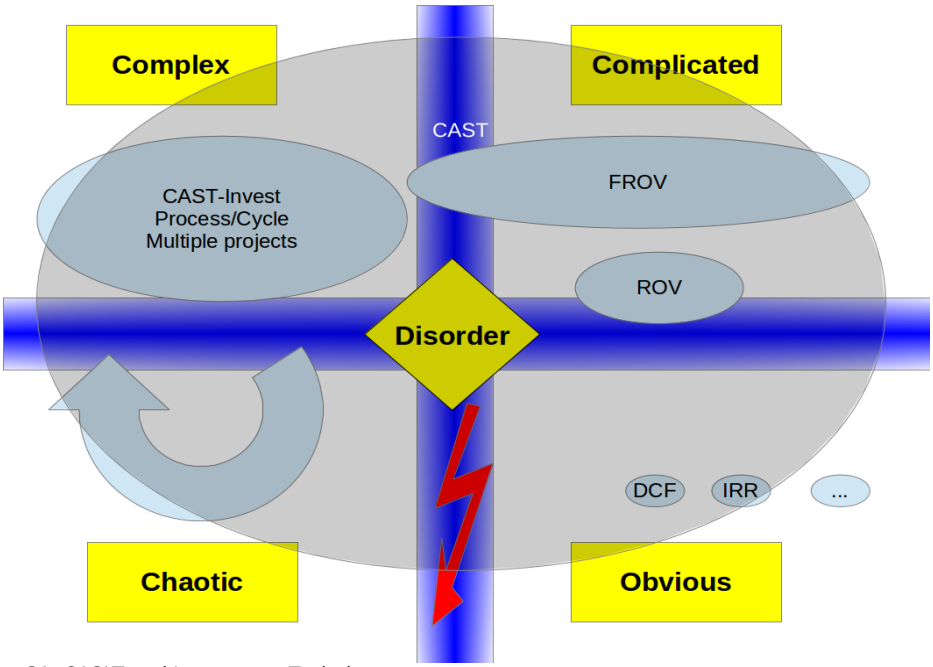

*Figure 31: CAS*T and Investment Techniques*

4.5.8. Intractability and Path Dependence

A characteristic of CAS that we have not fully discussed yet but that is relevant to investments, is the intractability (element of the computational CT).

Wikipedia Intractability (n.d.) states that problems that can be solved in theory but which in practice take too long for their solutions to be useful, are known as intractable problems.

Nikolic (2010) makes the link with CAS. Intractability is something that all evolving systems do, including CAS. In this context, complex [adaptive] systems do have a history (Cilliers 2005). The system memory and history is captured at both the micro- (personal experience, personal opinions, worldview) and macroscopic (cultural, ritual, value system) levels. Therefore, system history plays an important role in defining the state of the system as well as affecting system evolution (Holmdahl, 2006) (See also Jones (2003).

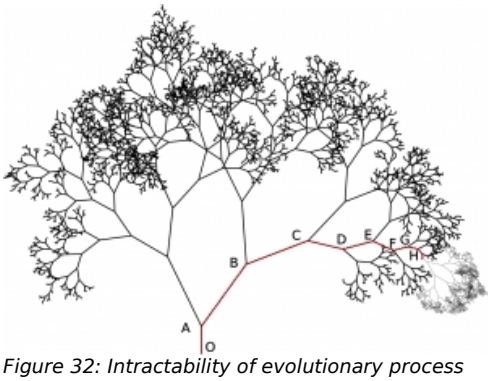

Figure 32: Intractability of evolutionary process and CAS

Figure 32 depicts the intractability of (an evolutionary process of) a CAS. The red line is the way a system has evolved (O-A-B-C-D-E-F-G-H-…). The other branches are the other (possible) futures that could have happened but which the CAS has not evolved on, and therefore never existed. The splits occur when the CAS make decisions or that some important events are happening (environment). Therefore, to Nikolic (2010), there is no faster way of predicting the future. A CAS cannot jump into the future, it has to go through the steps of evolution.

Another related concept, more known in evolutionary economics, strategy and social sciences is path dependence (Schneider et al., 2006) which means that current and future states, actions, or decisions depend on the path of previous states, actions, or decisions (Page, 2006). Importantly path dependence indicates that the characteristic of equifinality ([94]) might not apply to nonlinear systems, certainly to CAS, for their initial conditions might create paths that lead to unique states (Schneider et al., 2006).

In all instances that path dependence is asserted, the assertion amounts to some version of "history matters." So, where we are today is a result of what has happened in the past. An example of path dependence could be: "we saved and invested last year and therefore we have assets today" might be more fashionably expressed as, "the capital stock is path dependent." (Margolis et al., n.d.).

Although we cannot predict the future, we can however study possible futures. Professor Najam (2008) confirms that the prediction of the future cannot be done, rather we should study (project) possible long term futures based on the realities of today with a focus on interdisciplinary work. Levin (2008) points out that people discount the future (its value) in different ways because they have different backgrounds or perspectives (certainly the intangible ones like aesthetics and ethics). All the more reasons to work in an interdisciplinary way. Yet *trans*disciplinary for CAS is better (Ackoff, 1999).

To simulate possible futures or scenarios, we may also use agents-based modeling. For instance, a government agent can have in each simulation a different policy on which the other agents will also act differently. We may assume that most of the interacting CAS will happen in the complex and chaos Cynefin spaces, thus scenario planning should at least also be in the complex domain and not only in the complicated domain (see figure 20, p.73).

To be noted is that models of evolving CAS must themselves be evolving complex systems. As a consequence, these models cannot be created from scratch but must be grown from simple to complex models (Nikolic & Dijkema, 2010) ([95]).

From an organizational point of view, it is obvious that due to the number of interdependent but mostly autonomous agents, a top-down approach is not the best way: the brains in the uni-minded system cannot foresee and command everything (detailed C2). Therefore it will be a bottom-up approach in a multi-minded system-of-systems (mission C2).

The impossibility to predict the future due to intractability makes classic investment techniques as overall techniques irrelevant. In addition the irreversibility of most investments is rendering them “risky”. Consequently if a CAS is investing then it has to base it on scenarios where a lot of attention will be spent to “how to fail gracefully?” as Nikolic (2010) stated. CAS would start with pilot projects and decide go/no go after an evaluation time or special event or it would start full ahead when a positive leverage point has been reached. One can rightly say that this is very similar to real options thinking, or rather real options thinking leans very closely with the philosophy based on CAS and the sense-making frameworks (thus CAS*T).

So, a CAS has to evolve step-by-step: observing, learning, adapting. According to Cantle et al. (2011), it is crucial that a CAS keeps track of its evolution, thus knowing its evolutionary process (figure 32 Intractability of evolutionary process and CAS).

4.6. Case BASF: R&D and IT

4.6.1. General

BASF, founded in 1865, is the largest chemical producer in the world and is headquartered in Ludwigshafen (Germany). It has plants on every continent, nevertheless about half of its 112,000 employees is based in Germany. So, BASF has branches in several countries, countries that have their own culture and customs. BASF is a company with many agents (agents in a complex system) between which there are many interactions.

BASF consists of different divisions (more than 30 related to products, four laboratory divisions and a

94 Schneider et al. (2006) have compared open systems from General Systems Theory (GST) with CAS. Thus in this case they are referring to the equifinality of open systems.

95 The paper of Nikolic et al. (2010) “presents a sociotechnical evolutionary modeling process for creating evolving and complex Agent-Based Models (ABMs) for understanding the evolution of large-scale sociotechnical systems such as infrastructures. It involves the continuous co-evolution and improvement of a social process for model specification, the technical design of a modular simulation engine, the encoding of formalized knowledge and the collection of relevant facts. In the paper, [the authors] introduce the process design, the requirements for guiding the evolution of the modeling process and illustrate the process for ABM development by showing a series of ever more complex models.”

logistic division) and many smaller units.

A product division has production plants, product laboratories (quality, testing), marketing and other services. The research for the products is done by one or more laboratory divisions, which is 70% of the total R&D efforts. The other 30% is for basic research. The total R&D budget is around 10% of the revenues.

To avoid unwanted overlapping research and to stimulate synergies, the head of R&D (Vorstand ([96]) member Research) is organizing monthly meetings with the R&D Division heads and some specific researchers.

BASF has various types of IT (both core, core support, administrative support).

Mr. De Beuckelaer had his career in BASF. He worked in various areas of BASF (most of the time research), and this in several different positions and in different countries; each with their own (sub) culture and habits. He ended in a very high position (VP US).

Mr. De Beuckelaer has taught at MIT, UCL, TU Munich, mainly in the field of thermodynamics. He also taught at the Belgian Royal High Institute of Defense. He has read *On War* in German. He was a reserve officer in the military engineering.

He also worked for the NSA and the French Ecole Polytechnique.

He is author of the books "It's broken, let's fix it", "Flanders Dies" and "Always Trouble with the Computers".

I have met Mr. De Beuckelaer at meetings. He was willing to speak in an open discussion on various topics (thus open questions). Mr. De Beuckelaer explained the structure of BASF and the situation of the IT. Afterward I asked him some additional questions by email, which Mr. De Beuckelaer in some cases responded punctually, and in other cases he responded in form of articles to place questions and answers better in the context.

The reason why I have asked him to give more information on his company and its IT is because Mr De Beuckelaer knows very well BASF; he acknowledges the importance of mental models and he knows the mental models of BASF. In addition, he has a considerable knowledge of the military world.

4.6.2. Simple Rules

BASF has simple rules (guidelines) culturally:

- Our first and foremost concern is the survival of the firm. We take no chances that brings this goal at risk.
- We will deceive no one (our owners, our employees, our customers, our suppliers), on the contrary, we will actively defend their interests and this in a fair proportion.
- We behave in society as good and loyal citizens.

Economically:

- 50% of our products should not be older than 10 years.

Everything is assessed against these simple rules.

4.6.3. Holistic: Verbund

Verbund is a German word which in this context we could translate as “bringing together (in different ways)”. The concept allows to form new processes by using products coming from different divisions to combine into new products, and to use byproducts from one process as an input in one or more other processes.

This needs a holistic approach of the whole (like ST), which cannot be obtained by a reductionist approach.

It is also in line with our capability approach, which shows the emergent synergistic properties of systems. Although the relationship with customers and other stakeholders is important, the internal relationships between the components of an organization (capability) are equally important.

Here we see also the importance of the design process in ST next to analysis and synthesis. By taking the whole into consideration and knowing the components and especially their interactions, processes can be reshaped or added or deleted, improving in this way the whole.

4.6.4. Cynefin – Organization and IT

Figure 33 is an example of our CAS*T extended Cynefin framework. This is a strong simplification of the BASF organization. We have only mentioned generic divisions, production units, projects and laboratories. We have focused on the use of the different IT applications.

96 Vorstand is German for Board of Directors

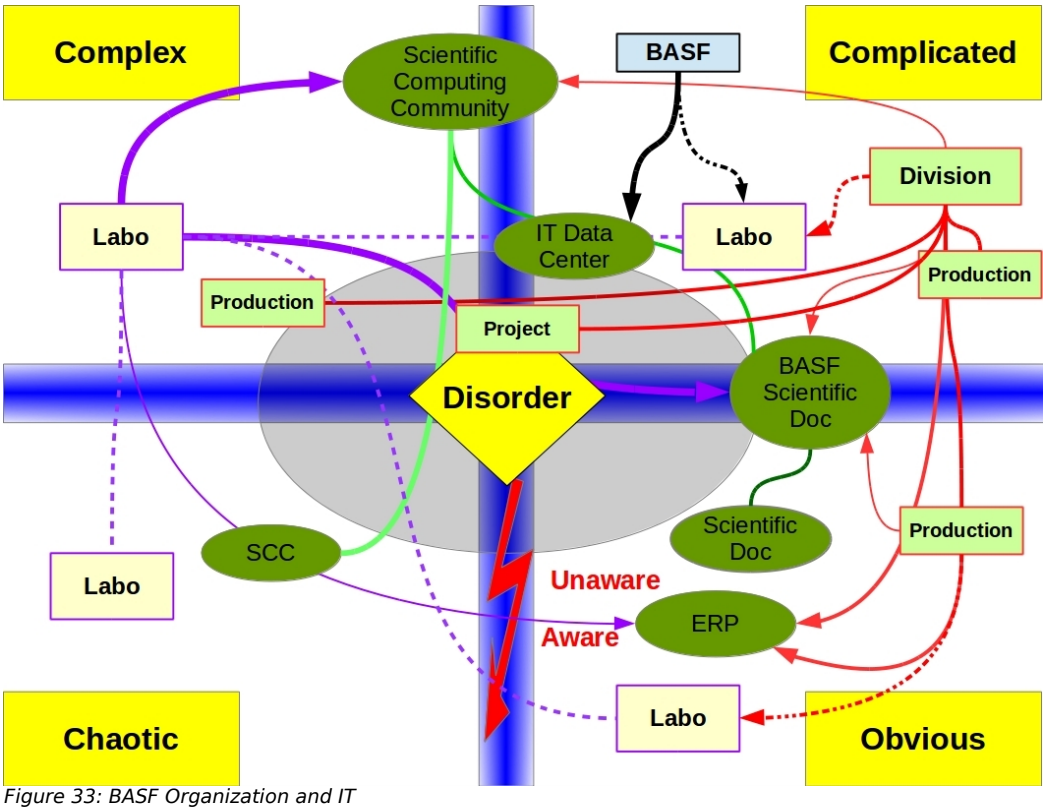

Figure 33: BASF Organization and IT

4.6.4.1. BASF IT Domains

BASF has more than one IT domain. *ERP* is one domain and it is situated in the obvious space. The *IT data center* is the classic IT center (like infrastructure, network, distributed computing, databases). Although mostly situated in complicated, Mr De Beuckelaer positions it on the border between complex and complicated, because of some R&D needs.

Scientific Computing Community (SCC) is spread over complicated, complex and chaotic: Molecular Modeling, Molecular Mechanics, Quantum Chemistry, Crystal Graphics, Solid State Physics, Prediction of Substance properties, Genetics, Image Processing, Statistics, Experimental Planning, Laboratory Automation, etc. The teams are divided over the laboratories because the techniques are very specific for different scientific disciplines.

There is a very small central group which is responsible for the cohesion in the "community". This group must discover and exploit synergies and keep the 'information flow' into motion. They also represent the community. They do so by structured intensive information exchange. Thus, among others a monthly presentation of a current topic on which all members of the concerned departments are invited, which are located in Complex / Complicated.

A subunit of SCC is *Scientific Documentation (SciDoc)*, originally evolved from the former library. Its task is to publish (if possible immediately) scientific information in any form on-line. To this end it has contracts with the major information providers: CAS (Chemical Abstracts) Stanford Research, Elsevier, etc.

But there is also *BASF document base (BASFdoc)*, which is quite impressive. It contains documents in the form of reports, monographs, laboratory journals etc. The information is stored in databases, and from a central engine stunningly effective accessible. It is also a interface layer for the different sources of SciDoc. The BASF search engines are different; very often people are looking for a chemical (sub)structure or even a chemistry reaction. This unit is on the border between obvious and complicated.

BASFdoc and SciDoc are conceived as knowledge bases not as an intelligence system.

4.6.4.2. Generic BASF Units

The box *BASF* represents at the same time the Vorstand as the whole organization (which is in the

complicated space) and it uses the IT data center responsible for the infrastructure, databases, software packages (non-scientific and no ERP).

The production units are not only in the obvious and complicated spaces but also in the complex. Polymer production is already complicated by itself but it becomes complex because an intensive coordination with the customer and the manufacturer of the processing equipment is needed. The feedback loops may provide the necessary surprises (emergent practices). And of course there is a the same time a race with competitors.

For some products BASF has a monopoly, but in one case BASF made losses but not the client. Mr De Beuckelaer wrote a program so that BASF could model the economics of BASF and its clients for that product. The results were that BASF and its clients were making profits. This is an example of defining borders of a system in function of the problem to be solved without damaging the overall performance of BASF, because Mr De Beuckelaer kept the bigger picture in mind.

The obvious production units don't have much freedom mostly because of strict security regulations or best practices (processes), which is in line with the Cynefin “obvious”: no degree of freedom. The production units are using ERP, SCC, SciDoc and BASFdoc, but more intensively ERP (thicker connection-line).

The laboratories of the four laboratory divisions are present in one of the four Cynefin spaces. Some laboratories are in chaotic and are trying to move to complex. Examples in the obvious are analytical chemistry and routine measurement of material properties. Extreme microscopy is an example in the complicated space.

Mr De Beuckelaer points out that the leadership style is different from unit to unit, as a matter of fact it is different from Cynefin space to space. When he was the head of production plant with severe security governance, he was a Frederick the Great (Prussian king). An example is giving by Mr. De Beuckelaer. The production of vinyl chloride is very dangerous (annual killing rate of 3%). To reduce the accident risks accidents everything must be executed in a strict and precise way to prevent a higher annual killing rate and preferably to reduce this rate to zero. This was case for the plant of De Beuckelaer, but he was ruling as a Prussian king, which the people understood for their own sake.

In the case of a unit that needed to work with the client and a third party manufacturer then he was a Talleyrand type ([97]) (complicated, complex). At the head of a laboratory in complex space, he was guiding the other people. In a chaotic space, he was acting as a dictator (act-sense-respond).

Using (adapting to) the right type of leadership is essential for the success of the organization and requires a (very) good situational awareness of the leader and the recognition of culture and the structure-processes in the orient-phase of OODA. Of course this has to do with capabilities of Mr De Beuckelaer to adapt (intuitively) to the Cynefin spaces, but was BASF acting accordingly the Cynefin framework?

4.6.5. Investments BASF

The budget process is an iterative process with a bottom-up and a top-down approach.

The divisions are informing the Vorstand about their need for big investments, that decides the total investment amount. That amount is divided over the divisions according the BASF strategic plan (which mentions what has to grow, what has to be kept at the same level, and what has shrink/abandon).

The divisions are then proposing a more detailed list to the Central Planning (iterative process between Central Planning and the divisions. All the investments are put in the context of BASF (harmonization). The Central Planning submits eventually a proposition of budget to the Vorstand that decides (approves).

Regarding R&D, the Vorstand decides the guidelines for R&D investments which is approximately 10% of the revenues. The R&D budget is divided into basic research (30%) and the division-related research (70%).

So the divisions are proposing how much they would like to spend (zero based budgeting) on improvements in production processes and / or products. Basically it follows the same process as described above. The research projects are done by laboratories of the four laboratory divisions.

Remarkably is that everything is decided based on ROI. Mr De Beuckelaer had proposed to use DCF, but this has not been accepted (too complicated). The reasons are that for a big chemical company investment projects take about three years and the amount of money involved is huge. A pilot project can be implemented to use a new technology. The pilot project can produce 10.000 tons of a product and costs hundred millions Euro, while the final plant should produce yearly millions of tons of that product and costs more than a billion Euro.

So, for example, the Vorstand has to decide whether or not to issue a billion Euro for a new Ethylene Cracker. The conditions to invest right away are mostly not favorable. Nevertheless, between decision and launch are three years. BASF has to decide on the investment when the new factory seems totally not

97 Charles Maurice de Talleyrand-Périgord (1754–1838). He was Napoleon's chief diplomatic aide in the conquest of Europe. Most of the time, however, he worked for peace so as to consolidate France's gains. (Wikipedia, last accessed on August 25, 2014 from http://en.wikipedia.org/wiki/Charles_Maurice_de_Talleyrand-P%C3%A9rigord).

profitable. But BASF knows from experience that if there is too little ethylene, the prices are high. Everyone builds and within three years, there is an over-capacity and thus very low prices (analogous to the pork cycle).

In some cases, BASF will invest anti-cyclically: in a boom invest in the new technology, in recession divestment of the old technology.

Some failures are due to this long process. This is acceptable for building factories but not for IT-products like hard disks, computer and operating systems. In these cases, the cycle is much shorter. This is an example of using the wrong management techniques.

Another reason is a too rapid upscale of a laboratory process to a production process (without pilot project). ARCO (Atlantic Richfield) is an example, a plant of 1 billion dollar did never go into production. Problems included poor material balance and corrosion.

4.6.6. Learning Organization

If you have a rule that only 50% of your products may be more than ten years old, then you need to have innovative people when you are in the unordered Cynefin spaces. BASF recruits people and they need to start at a lower level than their original qualifications; before giving orders you need first to learn to obey is the principle of Mr De Beuckelaer.

Similar to the armed forces, one can only make career by switching from one “vertical functional” column to another (production, research, marketing, product manager, division manager). The purpose is to bring new fresh ideas into a unit coming from other domains (functional, subject matters), but they all share the same BASF-culture (mental models).

Mr De Beuckelaer beliefs in quality reserve, meaning that if an employee has his position, he still needs to continue to learn not only to be up-to-date in his domain but also to get a bigger picture.

4.6.7. Conclusions BASF

BASF exists already for 150 years and it is the largest chemical producer in the world so it has big impact on the chemical market. In this market the time to market is on average three years. However products that are not part of its core business are faster on their market (for instance BASF has produced pc's). So in this case the situational awareness is not adequate, neither are the related investment techniques. An introduction of Cynefin could avoid these mistakes. Nevertheless BASF uses real options thinking combined with ROI for its big projects, not just ROI.

Because of its products policy, BASF is with a lot of its laboratories in the unordered Cynefin spaces, while the production divisions are in the ordered spaces. Here the leadership is adapted to the circumstances.

The holistic view with *Verbund* is a move towards a multi-minded organization, where communication and coordination will increase. In this context, the knowledge-bases should be extended to a more dynamic intelligence management system in support of decision-making and knowledge management. Figure 33 BASF Organization and IT shows that information systems should not be in the same space as their users. Important is that all the agents have access to the different resources and above all can collaborate with each other.

Last but not least, shared mental models in all BASF units and the challenge to have 50% of its products not older than ten years, make that BASF is continuously innovating and that it has to avoid stagnating mental models.

4.7. Conclusions on Cynefin Framework

The Cynefin framework (Figure 20) is an analytical framework designed to help decision makers—organizational leaders and system managers—understand where their system stands in the external environment. The Cynefin framework is used for knowledge management, for IT design, for project management, etc. because it recognizes the causal differences that exist between different types of systems and gives people a very quick and easy way to fit between them so they can use the appropriate method for the appropriate domain (Snowden, n.d.).

It provides knowledge about the general characteristics of the five domains in which leaders could find their systems. It helps decision makers understand what kinds of methods and tools will be likely to work in their particular organizations, and which ones won’t.

The Cynefin concept provides key insights that most leaders have likely been ignorant about:

- The boundaries between simple, complicated, complex and chaotic are indistinct. Consequently, changes in external conditions or internal system modifications may push a given system from one domain to another without being aware of it, if its leaders aren’t paying attention (have good intelligence).
- A particular system may inhabit more than one domain simultaneously. For example, a vertically integrated manufacturing company may find its production subsystem in the complicated domain, but its sales and marketing may be in the complex domain.

- The spatial relationship among the domains emphasizes how easily (or insidiously) an organization might slip from one domain into another, possibly without noticing it. The boundary between complicated and complex is less extreme than the boundary between the simple and the chaotic. Consequently, the failure of management to recognize a shift from complicated to complex, while problematic, is not likely to be as catastrophic as the failure to recognize a shift from simple to chaotic. But all domains are directly exposed to the zone of disorder, which should prompt leaders to heightened awareness of their system's relationship with its external environment.
- Obvious (or simple) and complicated domains assume an ordered universe, where cause-and-effect relationships are perceptible, and right answers can be determined based on facts.
- Complex and chaotic domains are unordered, meaning that there is no apparent relationship between cause and effect. This doesn’t mean that there is no cause and effect, just that it’s not apparent or obvious. While the ordered part of the continuum (obvious and complicated) can be managed based on facts, the unordered part requires intuition and recognition of patterns. Consequently, the tools and methods that work well in the obvious and complicated domains tend to be less effective (or completely ineffective) in the complex and chaotic domains.

Regarding our subject of investments, we have noted that in the ordered domains there is a fail-safe design. In a complex space there are fail-safe experiments: succeeding experiments will be amplified, failing experiments will be abandoned.

Figure 33 BASF Organization and IT shows that information systems should not be in the same space as their users. Important is that all the agents have access to the different resources and above all can collaborate with each other.

We have extended the Cynefin framework by introducing (un)awareness, so that we can make a difference between the perceived and the real situation. If the perceived and real situation are the same then only the real situation is shown.

The aim is to assess not only the quality of the situational awareness capabilities, but also to construct the history of the CAS (organization) in its context (CAS (environment)) and the history of the CAS (environment) itself.

We can combine structure, functions and eventually processes in the extended version of the Cynefin framework (snapshot or evolution). Also we have concluded that risks are threats for the execution of the dynamic strategy but the other side of the coin are the opportunities. Both should be assessed (being aware of at least) at the same time.

In the next chapters we will discuss CAS*T tools and concepts that can be used to define the situational awareness (internal and external) and the strategy and thus organizational changes.

5. The consequences of CAS*T for EA

In previous chapters we have discussed CAS*T in the context of the organization (CAS) in a CAS environment. We will now examine IT of an organization in our CAS*T context, especially the enterprise architecture (EA), which we have already been discussing.

In this chapter, we go deeper in the subject because of the importance of structure, and in CAS*T structures are dynamic. This is important for an organization to be aware of and of course to take this into account, if it wants to survive in the ever changing environment. We will propose the concept of CAS*T-EA, as an element of the original concepts presented in this thesis

Further we will propose tools for modeling in CAS*T Tools. The purpose is not only to describe systems (CAS (Organizations and Environment)) but also to make the mental models more explicit (figure 37), so that we can find easier the leverage points . The proposed tools are phylogenetic trees, cognitive mapping, ST modeling (Causal Loop Diagrams (CLD) and Stock Flow Diagrams (SFD)), Bayesian networks, and Agents Based Modeling (ABM). We will discuss only ABM in this chapter, the other tools are discussed in appendix 1

In addition to these tools, using introspection and extrospection (Cynefin), the organization can adapt its (emergent) strategy. It can redesign itself (self-organization) and try to influence the environment to create a better context for its strategy. In both cases the hierarchy of leverage points should be used to determine at which level the organization should intervene.

5.1. CAS*T and EA

5.1.1. Introduction

5.1.1.1. Cynefin and EA

The Cynefin framework illustrates the principle of bounded diversity; different tools and methods apply in different contexts. So if EA is to be successful as a discipline, its practitioners must recognize this phenomenon and adapt their practice accordingly (Bean, 2011).

However even when the EA practitioners are aware of this then the projects can still fail, because they are confronted with a bigger problem: knowing the whole (enterprise) is not possible. Senge (2006) and CT (Flood, 1999) begin both by acknowledging the interrelated nature of things as well as emergence, where the whole is experienced as being greater than the sum of its parts. A special form is the spontaneous self-organization. For a human being it is impossible to know all the existing interconnections of a complex system. EA therefore cannot fully represent the enterprise. This is based on the incompressibility concept (darkness principle) (Independence Partners, 2011) which states that no complex system can be known completely. The best representation of a complex system is the system itself; because any representation other than the system itself will necessarily misrepresent certain aspects of the original system.

Each individual element in the system is ignorant of the behavior of the system as a whole and can only respond to the information that is available to it locally, that is why we will propose the concept of BPEIS (Business Process Embedded Information System) (Rabaey et al., 2006; 2007). If each element would know what is happening to the system as a whole, all of the complexity of the larger system should be present in that specific element. Related to its environment, it is nearly impossible to know how the system's environment will affect that system.

Flood (1999) states that people have to work local in space and time. Space are the things that one is immediately involved in and time means the not very future. If we look at EA frameworks like TOGAF (n.d.) the purpose of EA is to optimize across the enterprise the often fragmented legacy of processes (both manual and automated) into an integrated environment that is responsive to change and supportive of the delivery of the business strategy.

This purpose corresponds to the biological view of an enterprise for which EA is seen as the link between strategy and execution. It addresses all facets of the enterprise in order to coherently execute the strategy.

As a matter of fact, TOGAF (n.d.) defines the enterprise as any collection of organizations (system-of-systems) that has a common set of goals. We would say shared goals and vision. The term enterprise in the context of EA can be used to denote both an entire enterprise - encompassing all of its information and technology services, processes, and infrastructure - and a specific domain within the enterprise. In both cases, the architecture crosses multiple systems, and multiple functional groups within the enterprise. One can question the effectiveness of such (non-systemic) frameworks. Moreover they extend the enterprise nowadays frequently to partners, suppliers, and customers. If the goal is to integrate an extended enterprise, then the enterprise comprises the partners, suppliers, and customers, as well as internal business units. However for successful projects, bounded action areas (BAA) have to be defined so that the focused part of the enterprise and its external collaborating agents can easily be served. BAA

are temporarily and partially (Flood, 1999).

Obviously in addition the unordered domains and the CAS are not taken into consideration. This implies that changes (and optimizations) are driven by cause-and-effect chains, which have no or few utility in the unordered domains. Moreover the fact that a system can inhabit more than one system simultaneously and that an organization can shift from one domain to another unnoticed, makes this approach to EA a disadvantage rather than an advantage in this fast changing world.

The Enterprise Architecture Research Forum (EARF, n.d.) defines Enterprise Architecture as “the continuous practice of describing the essential elements of a socio-technical organization, their relationships to each other and to the environment, in order to understand complexity and manage change.” This definition matches the approach of CAS, however we have not found a framework that supports the definition.

The definition of the IT Analysis company Gartner also stresses the need for responsiveness. “Enterprise architecture (EA) is a discipline for proactively and holistically leading enterprise responses to disruptive forces by identifying and analyzing the execution of change toward desired business vision and outcomes. EA delivers value by presenting business and IT leaders with signature-ready recommendations for adjusting policies and projects to achieve target business outcomes that capitalize on relevant business disruptions. EA is used to steer decision making toward the evolution of the future state architecture.” (Gartner, n.d.)

5.1.1.2. CAS and EA

Janssen et al. (2006, p. 2) relate EA in the context of CAS: “The term “enterprise” refers to the scope of the architecture, dealing with the organization as a whole or multiple agencies rather than with a certain organizational part or individual components and/or projects. The architecture is based on statements of how an enterprise wants to use IT, not on what and how information has to be made available. The strategic aspects of IT systems provide the contexts for the architectural design choices and decisions. Enterprise architecture models provide ways to deal with the complexity including work (who, where), function (how), information (what) and infrastructure (how to)”.

Therefore EA should consist of distinguished levels. The naming of the distinguished levels may differ. The well-known TOGAF (Open Group Architecture Framework) uses four levels: Business Architecture, Application Architecture, Data Architecture and Technical Architecture. We choose to substitute Information for Data and Infrastructure for Technical.

Conforming to the Cynefin framework which states that to avoid disorder limits/boundaries must be set to CAS, Janssen et al. (2006, p. 2) write that “[t]he idea of enterprise architecture is that it can be used to guide design decisions and limits the solution space by setting constraints. Architectural principles are textual statements that describe the constraints imposed upon the organization, and/or the decisions taken in support of realizing the business strategies. Principles restrict architectures and set the direction for the future. Architectural descriptions can form the basis for the implementation and transformation of existing structure into the desired architecture.”

That is why ST is so important to CAS because besides analyzing and synthesizing, the third function is also designing.

5.1.1.3. Strands of Activity

Bean (2011) defines three strands to EA activity, each of which may have business, information and technology elements. The first strand is a prescriptive strand that is determining, agreeing and promulgating fundamental design principles, policies and standards in support of organizational strategies, risk reduction and key performance characteristics. These can then be applied to relevant decision-making in business/IT development projects.

The second strand is descriptive. It is creating an aligned set of formal models that define key elements of the business, its information systems and its technologies and managing these in such a way that the relationships between these different elements can be clearly understood. These facilitate understanding of what is involved in business or IT change and can provide a common starting point for new business or IT development projects.

Thirdly, a programmatic strand is designing a target state architecture and identifying and coordinating the significant projects, commitments, and milestones to move towards it, including the development of core ‘building blocks’ that can be shared across different projects.

EA teams typically carry out blends of these three strands of activity with varying emphasis on business, knowledge, information, applications and technology architecture (the five layers). However because of the dynamic environment (internally and externally) EA need to be continuously updated. Moreover a BAA can overlap with one or more other BAA's. Therefore it is advisable to implement different systems capable of interfacing with each other and/or other more classic conceived information systems. The blend however will be in function of the Cynefin spaces in which the organization and its parts are.

5.1.2. Business Process Embedded Information System (BPEIS)

5.1.2.1. Overview

EA is a discipline that aspires to improve enterprise coherence, yet it is itself often rather incoherent, mainly due to the fact that it is still relatively immature. There is confusion over its meaning, purpose and scope, and also the role of the EA function. It is often unclear from reading current literature on EA whether an author is referring to a knowledge base, a process/practice or a team of people (Bean, 2011, p.1). So lots of different interpretations of the term EA exist (Rabaey et al., 2007). Some hold long lists of technological choices that an organization should make concerning infrastructure and application design. Others put these technological decisions into sets of guidelines to information architecture and business architecture.

We are proposing a holistic and original framework based on our original concept of CAS*T ([98]). Therefore EA should be put in a broader context than merely infrastructure architecture and application architecture, because applications are built to support business processes and operate on information gathered through these business processes, but also outside these processes. Hence, architecture only concerned with infrastructure and application design is insufficient to support a business. The architecture of a building is based on the function that this building will have (store, house, manufacturing, etc.). In the same way an EA should consider the business and its dynamics so that it can take precautions for changing business requirements or the reuse of certain artifacts in other business domains (Rabaey, 2012).

5.1.2.2. Stages

Ross (2003) defines four stages of EA:

- Application Silo Stage,
- Technology Standardization Stage,
- Data Rationalization Stage and
- Modular Architecture.

We will define and illustrate them on the basis of our experience as an IT professional of Belgian Defense.

Application Silo Stage can be seen as an archipelago. An enterprise needs an information system to manage its functions and responsibilities, but a common characteristic in the beginning of IT was that these information systems were isolated. They look more like an archipelago with a deep sea in-between than (inter)connected parts of the enterprise. And although EA has already been on the scene for many years, the smooth interfacing of all the different parts and their information systems remains a problematic area in need of further attention. In this stage EA is just the collection of the architectures of isolated applications, most of them implemented in different technologies.

In 1984, this was the case when we arrived in the IT-center of the Medical Service. As a matter of fact, it was the same situation for the IT in whole Belgian Defense. The Technology Standardization Stage is the first step towards an EA in which technology gets standardized, and unfortunately often centralization is put in place. The deployment of resources shifts from application development into the development of a shared infrastructure. This phase is further often characterized by the introduction of business intelligence and a first attempt to manage business processes.

The Data Rationalization Stage consists of process and data standardization. The deployment of resources shifts from application development into data management and infrastructure development. The involvement of senior business managers becomes institutionalized by a common forum of IT and business managers. In this phase we also see a shift of data ownership from IT towards the business.

For this reason , we (Rabaey et al., 2004) were introducing the Interdisciplinary Forum (IF) based on the exploring of the different perspectives (business, resources) in a detailed C2-structure (uni-minded view).

In this phase we also see a shift of data ownership from IT towards the business.

The modular architecture - characterized by enterprise-wide global standards with loosely coupled applications -makes that information and technology components continue to meet the global standards, while local differences in the core processes can be implemented through modules.

5.1.2.3. A fifth Stage: BPEIS

In Rabaey et al., (2006; 2007) we have added a fifth stage: business process embedded information systems (BPEIS). As the name implies, the business process has its own information system and moreover it is embedded in the business process.

In the case of CAS (organization) BPEIS could also be called Agent Information System.

Cloud computing (CC) is a technology which puts whole or partial parts of the Information Technology (IT) infrastructure and services in a virtualized environment inside and/or outside the traditional IT center

98 While the classic EA is based on reductionist thinking, CAS*T-EA is based on holistic thinking.

perimeter. It touches every level of the IT architecture and thus has a big influence on the way the internal and external users via their business processes are interacting with this architecture. Security is a big issue in this context. Besides the security, business and architectural issues may increase the risks and create more uncertainties for these kinds of projects (Rabaey, 2012a) (See appendix 3).

Due to the ever faster changing environment of an organization and increasing interactions with it, a global and central “steering” becomes quite impossible if the organization aims to have a flexible and rapid response. So the organization delegates to the business units and their processes. Therefore IT must be federated to obtain the necessary autonomy for the IT-applications. That is why we (Rabaey et al., 2006; 2007) are proposing to embed information systems into business processes. CC in combination with SOA makes BPEIS technically possible. In the context of cloud computing BPEIS can be considered as Business Process as a Service (BPaaS).

All aspects of the information system can be federated without losing the consistency of the information system in the enterprise.

From the point of view of ST, business processes are far more than a flow of activities performed by members of the enterprise. As a matter of fact, all agents who are involved in the business process must be included in its domain. Boundaries are drawn creating a BAA ([99]) which will be most of the time partially (thus not the whole) and temporarily (thus limited in time) (Flood, 1999). This is even not exceptionally for EA because most definitions of EA take enterprise to be an organization or business unit. So in practice, EA techniques are often applied to the implementation of an endeavor as a large programme, project (Bean, 2011) or processes. The temporarily and partially aspects of a BAA demands a dynamic approach of EA, which implies a continuously updating of models. In this case, the interactions between the agents within the whole and the agents outside the CAS (organization) must be taken into account. Methods like CLD are very useful to study these interactions.

5.1.3. Knowledge and Information Layer

We believe that before going to the fifth stage, an enterprise has to create a knowledge and information model, and that is why we add a fifth layer to EA: knowledge.

Level Architecture	Description
Business Architecture	Is about the description of the business processes as viewed from a business perspective. It should focus on the strategic environment and the business processes, which should attain the objectives.
Knowledge Architecture	Charts the knowledge asset.
Information Architecture	Describes the information the business is dependent on. This description must pay attention to where information enters the business processes, how this information enters the process, electronically or by other means, who is the owner of the information, and by whom it is to be used.
Application Architecture	Is about how to implement the applications or IT systems in all of its aspects (programming, development environment, quality book of software, etc.).
Infrastructure Architecture	Deals with guidelines concerning hardware platforms, network infrastructure, operating systems.

Table 4: Levels of Enterprise Architecture

If CC will come up to the expectations of the market then IT will become a utility (commodity) and competitive/collaborative advantage will become almost fully dependent on the capability of producing intelligence for decision-making and knowledge management (in systems, processes and human resources). So the differentiation will be made on the level of knowledge assets and therefore knowledge has to be addressed in a specific architecture. That is why we are proposing that extra level.

In this context Korhonen (2012) writes that the traditional notion of EA assumes information systems as underlying operative resources rather than as core value assets and true business enablers. Actually business-IT alignment exacerbates the business-IT divide. Therefore IT is seen as a separate, value-adding function, relegated to a subordinate role of a mere service and cost center, whose focus is on operational quality and reliability - on producing predictable outcomes on a consistent basis.

However the knowledge economy forces enterprises to compete at the level of knowledge and not anymore at the level of information. So the differentiation will be made on the level of knowledge assets and therefore knowledge has to be addressed in a specific architecture. We concluded that EA should be put in a broader context than merely infrastructure architecture and application architecture, because

99 However due to legal reasons an artificial but official border is made.

applications are built to support business processes and operate on information gathered through these business processes from the environment, therefore EA must cover the business and especially its dynamics so that it can take precautions for changing business requirements or the reuse of certain artifacts in other business domains.

Modeling knowledge brings us to epistemological and ontological models. Bean (2011, p.6) states that "[t]here is an important distinction between ontological models of a reasonably well-understood domain that purport to represent parts of the 'real world'" (mostly developed by subject matters experts)", and epistemological models that are used to explore perceptions of the real world. Epistemological models are not necessarily models of reality but are designed to support discussion, debate and argument about people's perceptions of reality, where the real nature of the problems to be tackled is unclear." Senge (2006) advocates dialogue and discussion to tackle problems. The use of epistemological models will certainly bring implicit mental models to the surface during the processes of dialogue and discussion, for which we are proposing tools (see next section)..

In the context of the Cynefin framework epistemological models will certainly be used in the complex and chaotic Cynefin spaces, while in the complicated and simple spaces we will find ontological and epistemological models.

Intelligence creates and updates knowledge and in some cases the mental models and strategy. Merging or separating processes (or structures) should be assessed to determine if the cultures of the new and old parties fit the organization (see Rabaey et al. (2007) for more details). Thus at the same time, the structure of the organization has to be defined, and the business processes have to be modeled in the BPM tool, which is obviously managed at the level business level of EA.

Once the business model, knowledge model and the conceptual information model are defined, then they need to be merged into a global model (information, knowledge mapping and business processes), where the BAA or business process should manage their own (embedded) information system. But as already mentioned, it has to start with a conceptual information model to solve the problems of information management. Following, the knowledge model should test the cultural compatibilities of the applications with the business.

Since the environment of the organization is permanently changing and thus the organization also, the information system of the organization has to be adapted to the new situation, especially the knowledge infrastructure (via the CAS*T Int B). So, if a business process could be fully automated and it holds itself the information, then a consistent part of the producible and needed information will be embedded in the business process, in accordance with the culture (customization based on culture and knowledge).

This is confirmed by Bean (2011) who considers the major goal of EA to be coherency management. EA is evolving from Foundation Architecture (Aligning IT with Business Goals) through 'Extended Architecture' (Co-designing Business and IT change simultaneously in projects) to 'Embedded Architecture', where generically 'architectural' methods and ways of working are embedded in the normal processes of the organization and a level of coherence that is appropriate to the organization's culture and operating model is achieved and maintained organically.

Of course, the concept of embedding is not new, Object-Oriented programming (OOP) e.g. keeps methods and data private in objects. Those objects are interfacing with their environment through public functions and data.

*5.1.4. Conclusions on CAS*T and EA*

The effects of CAS*T for EA are manifold:

- EA must be dynamic because of the continuously changing environment and therefore continuously changing the organization (=investments). Managing EA should be included in the processes of the Intelligence Base;
- Knowledge-management must be reflected in EA,
- EA must keep track of the reasons why it has been used, why the models had to be changed during the project. So the (changing) contexts are at least equally important as the models themselves, therefore EA should be a part of the systemic models, rather than being outside ST tools and models.
- Links between feedback loops and EA are essential to understand the EA.

Before discussing the hierarchy of leverage points in a CAS (organization) and relate this to EA, we first discuss how we can model a CAS, in particular to make the mental models more explicit.

5.2. Creating Systemic Models

Without a sense-making framework such as Cynefin or USMC C2 spectrum, decisions about which methods or tools to use in a particular situation become a trial-and-error, hit-and-miss proposition. How

many times has a management team embraced a philosophy or methodology promoted by a particular expert or consulting company, sometimes as a panacea, only to be disappointed with the results? There are obviously other factors instrumental to success, such as organizational psychology and change management. But with an effective foundational understanding of where a particular system resides “in the firmament,” the choice of appropriate methods can dramatically enhance the probability of success of the system’s improvement efforts, making the jobs of organizational psychologists and change agents much easier (Dettmer, 2011, pp. 28-29).

We are proposing the following tools used in Enterprise Risk Management (ERM) ([100]) solutions, which are compatible with ST and CAS: phylogenetic trees, cognitive mapping, ST modeling (CLD and SFD), Bayesian networks and ABM. At this moment, these tools are not integrated into a single framework. In further research we would like to build interfaces to connect theses tools into CAS*T. The existing information sources (coming from applications, databases, texts and so on) should be accessible for the Intelligence Base, the results of the ST processes of analysis, synthesis and design are stored in the Intelligence Base for dissemination. The Intelligence Base is discussed in the next chapter.

5.2.1. Agent-based Modeling (ABM)

Holland (2008) discusses ABM in his talk “Modeling Complex Adaptive Systems”. ABM is not only to study the many interactions amongst agents ([101]), it shows also how the system as a whole will behave.

“Agent Based Modeling (also sometimes related to the term multi-agent system) is an essentially decentralized, individual-centric (as opposed to system level) approach to model design. When designing an agent based model the modeler identifies the active entities, the agents (which can be people, companies, projects, assets, vehicles, cities, animals, ships, products, etc.), defines their behavior (main drivers, reactions, memory, states, ...), puts them in a certain environment, establishes connections, and runs the simulation. The global behavior then emerges as a result of interactions of many individual behaviors. It combines elements of game theory, complex systems, emergence, computational sociology, multi-agent systems, and evolutionary programming.” (Csala, 2012).

So, the agents are essentially decentralized. Compared to SFD, in ABM the global system behavior (dynamics) is not defined. On the contrary, the modeler defines behavior at an individual level, and the global behavior emerges as a result of many individual agents, each following its own behavior rules, living together in some environment and communicating with each other and with the environment, as in a CAS. So ABM is a bottom-up modeling (Borshchev et al., 2004; Scholl, n.d.; Teose et al., 2011, Csala, 2012).

Allan et al. (2011) warns that whilst ABM is a very powerful modeling technique it has to be used with care if precise values are required and is often best used to explore system behaviors rather than specific values (p. 37).

SFD uses stock, flows, loops and delays to represent the real world, but due to the way of modeling it gives an aggregate view with strong explanatory power (reflecting mental models). In essence it is a top-down approach, while ABM is a bottom-up approach (Csala, 2012) (figures 34 and 35).

100 The main sources are Cantle et al. (2011) and Allan et al. (2011).

101 Agents in a CAS can be many things or persons, like people acting at the stock exchange or cells in a immune system (Holland, 2008).

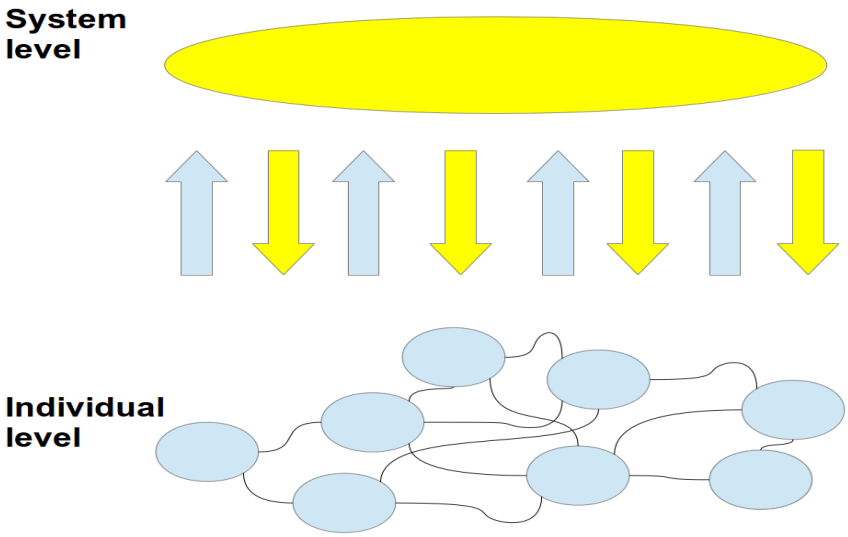

Figure 34: SFD (aggregate) and ABM (individual)

	SFD	ABM
Perspective	Top-down	Bottom-up
Main Building Block	Causal loops	Agent entities
Unit of Analysis	System structure	Rules of Agents behavior
Level of modeling	Aggregate system behavior	Individual agent behavior
System structure	Pre-determined	Evolvable
Time handling	Continuous	Continuous or discrete

Table 5: Comparison SFD and ABM

Table 5 compares SFD with ABM (based on Csala (2012)). It is remarkable that for a long time there was no common literature, thus mono-technical literature instead of multi-technical, Scholl (n.d.) was calling for cross study and joint research. More recently authors like Csala (2012), Teose et al. (2011) (Embedding System Dynamics in Agent Based Models for Complex Adaptive Systems) and Borshchev et al. (2004) are proposing to embed one technique in the other.

Figure 36 shows how SFD and ABM can be embedded. Of course the whole (light green) as a CAS (organization) will interact with other entities in its environment which can be a CAS like a market system. Although ABM is a bottom-up approach it can also be used to represent the whole (Teose et al., 2011). Each agent can be described with its rules or as a SFD or as another ABM. Note that these SFD or ABM can have other embedded SFD or ABM, thus a system-of-systems.

At the moment of the publication of their paper (Borshchev et al., 2004), Borshchev and Filippov were working at XJ Technologies, nowadays Anylogic, which has a product also called Anylogic. It integrates the three modeling methods for simulation: ABM, System Dynamics (SD) or SFD and Discrete Events (DE).

“How modeling approaches correspond to the abstraction levels. System dynamics dealing with aggregates is obviously used at the highest abstraction level. Discrete event modeling is used at low to middle abstraction. As for agent based modeling, this technology is used across all abstraction levels, and agent may model objects of very diverse nature and scale: at the "physical" level agents may be e.g. pedestrians or cars or robots, at the middle level – customers, at the highest level – competing

companies."(Wikipedia AnyLogic, n.d.) (figure 35)([102])([103]).

We have not chosen DE because ABM can handle the three levels mostly discrete while SD with SFD mostly continuous. Since ST studies the organization in its environment both ABM and SFD (or CLD in a simplified way) can be used.

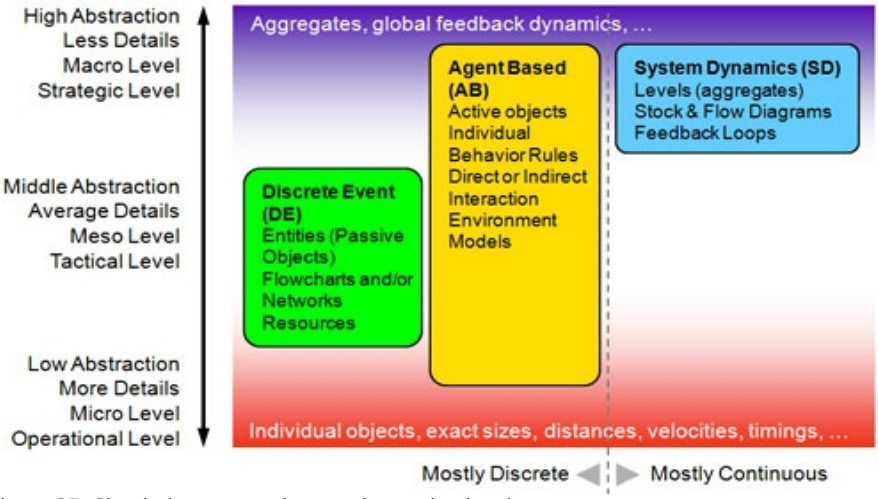

Figure 35: Simulation approaches vs abstraction levels

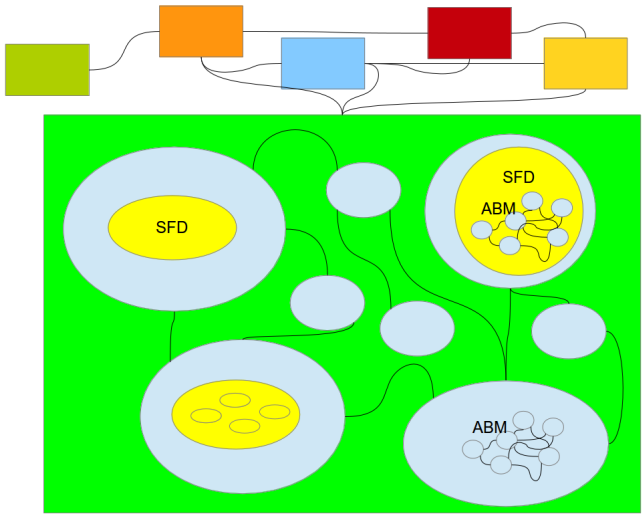

Figure 36: Embedded use of SFD and ABM

102 We do not agree with the use of tactical and operational level in figure 35.

103 *Figure 35*. Simulation approaches vs abstraction levels. In *Wikipedia AnyLogic (n.d.)*

5.2.2. Overview

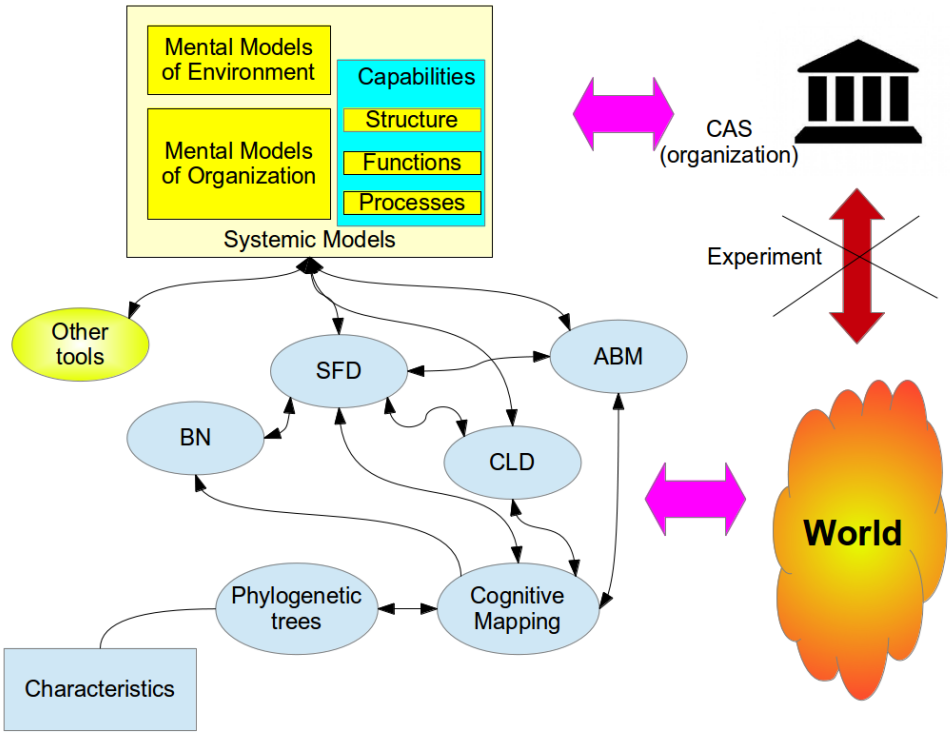

*Figure 37: CAS*T-tools*

Figure 37 shows the possible connections between the CAS*T-tools. One of our points in further research is to conceive a workable combination of tools to support the systemic models in our framework. It is not necessary to use all tools but at least one of them interacting directly with the systemic models should be used. As suggested by Scholl (n.d) regarding ABM and SD, we also state that the combination (interconnection) of CAS*T-tools should have emerging properties beneficial for the organization('s models).

Gharajedaghi (2011), Sterman (2010), Csala (2012) and Borshchev et al. (2004) state that models should be used to study the possible effects of organizational changes (= investments), thus not to experiment directly in the real-world (Csala, 2012). Of course, when an organization is in the chaotic Cynefin space, then that can be necessary to do it anyway (act, sense, respond).

Remark that we have mentioned *Other tools* because the nature of the CAS (organization) may require specific tools.

Models are a simplification of the reality (of the world), but they can become very complex, as a matter of fact, the models themselves are CS. Therefore models are built in an iterative process, where each iteration should enrich or correct the models, or in the case of one or more significant changes in the environment or the way of thinking (double loop) of the CAS (organization) to adapt the models.

The OODA-cycle is also respected. The transdisciplinary forum observes the world and these observations are interpreted and integrated in the systemic models. Hypotheses are formulated (decide) and tested (act) which generates new observations. After one or more iterations the organization can decide to change its behavior (act) by implementing organizational (capabilities) changes (= investments), which can have effects (nonlinear or not) in the real world. The fuel of this process is intelligence (see next chapter).

5.3. Leverage Points in a CAS

5.3.1. Counterintuitive

In the context of investments and organizational optimization, despite the characteristics of a CAS, people want “to fix things”. The questions are where to start and what are the most effective ways to improve. Most innovations occur at the edge of chaos, however not all organizations or parts of them are constantly at the edge of chaos or in chaos.

Yet an organization may also want to change its strategy or tactics. These may happen at different levels (grand strategy, operational strategy, grand tactics, etc.). If an organization changes tactics then it is more likely that this may have less consequences than changing the grand strategy, though nonlinear effects are still possible.

Donella Meadows (1997) proposed a hierarchy of twelve places to intervene in a system, which we believe are the same for a CAS. To Jay W. Forrester (1971) social complex systems are behaving counterintuitively. As a consequence, leverage points (LP) are also counterintuitive; the tendency is to push the leverage point in the wrong direction what causes the opposite effects (Meadows, 1997). It is therefore necessary to use ST on CAS (thus CAS*T) to avoid undesired effects.

5.3.2. State of a system

Basically a system (process) of a CAS can be described as follows (figure 38)([104])

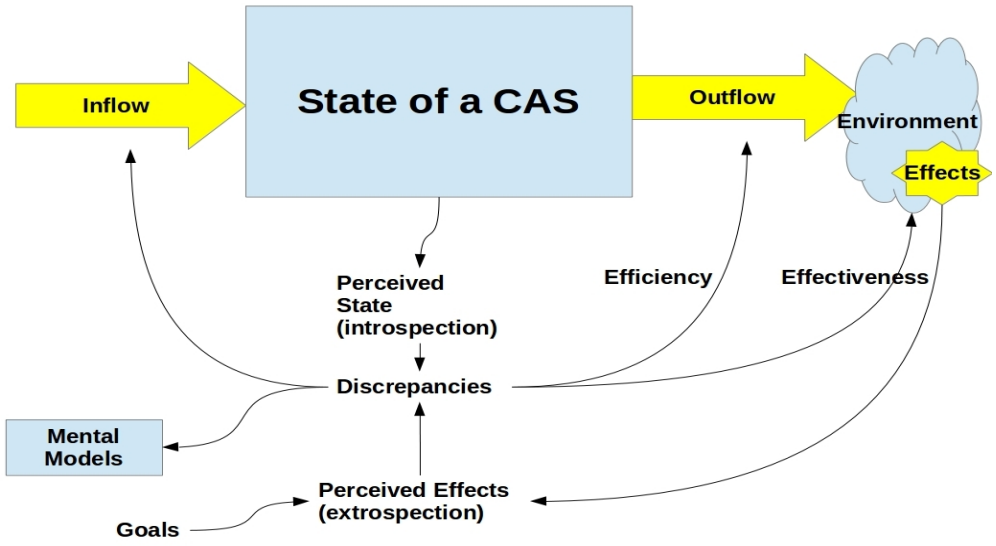

Figure 38: State of a CAS

The system is in a specific state at t_0. inflows are increasing the stock, while outflows are decreasing the stock. The state of the system is determined by the relationship between inflows and outflows. If the inflows are bigger than the outflows, then logically the stock increases, and vice verse decreases. System states can be physical (water in bathtub) or non-physical (level of knowledge).

The difference between a complex system and a CAS is that the organization as a CAS can change its goals, even its mental models. Based on our definition of organization and strategy the inflows may not only change in quantity but also in nature, due to a change in the strategy. For our CAS*T discussion this is very relevant and it will make the twelve different leverage points of Meadows more understandable. Meadows (1997) did not place the environment, although very important for a CAS, in the picture.

104 The figure in Meadows (1997) handles only the perceived state of a complex system and its discrepancies. Since we are discussing organization as CAS we have added its environment and the observed (perceived) effects. Certainly the efficiency is the first loop, effectiveness can be the first loop and the second loop. For the latter mental models can be adapted.

In the example of filling a bathtub (perceived state), you should open the inflow faucet until the water has the desired level (goal). That is, the discrepancy between the desired level and the state of the system at t_i is zero. At that time you stop the inflow (closing the inflowing faucet). If for a reason there is too much water then the outflow faucet is opened until the discrepancy (desired, actual level) is zero.

A bit more complicated is when you want to have the water at a certain (desired) temperature and at a certain (desired) level. So you dispose of a hot water tap and a cold water tap. If the boiler is far away then a delay in delivering hot water may implicate that you have to evacuate water and try again with adding hot and cold water (oscillation). Certainly when the temperature and level has to be kept stable during a certain (desired) time.

We can replace the bathtub by a bank account. The person will take actions to keep its bank account at a desired level, which can of course change over time according his will, his evolving needs (goals) and his income (resources).

This is at a personal level. At the level of a bank with a huge amounts of accounts, the system becomes more complex (not only by the details) and even more at the levels of national and world economies.

5.3.3. Meadows' Twelve Levels of LP

Table 6 gives an overview of the twelve levels of LP in increasing order of effectiveness, which we will discuss ([105]).

Level	LP - Intervention Places
12	Constants, parameters, numbers (such as subsidies, taxes, standards).
11	The sizes of buffers and other stabilizing stocks, relative to their flows.
10	The structure of material stocks and flows (such as transport networks, population age structures)
9	The lengths of delays, relative to the rate of system change.
8	The strength of negative feedback loops, relative to the impacts they are trying to correct against.
7	The gain around driving positive feedback loops.
6	The structure of information flows (who does and does not have access to information).
5	The rules of the system (such as incentives, punishments, constraints).
4	The power to add, change, evolve, or self-organize system structure.
3	The goals of the system.
2	The mindset or paradigm out of which the system — its goals, structure, rules, delays, parameters — arises.
1	The power to transcend paradigms.

Table 6: The Twelve Leverage Points (Donella Meadows)

LP 12. Constants, parameters, numbers (subsidies, taxes, standards)

“Parameters in systems jargon means the numbers that determine how much of a discrepancy turns which faucet how fast, most of which are popular intervention points.”

LP 11. The sizes of buffers and other stabilizing stocks, relative to their flows

Buffers are created by increasing stocks. Although increasing outflows or inflows will not destabilize the buffer (over a short period of time), buffers cost money and if they are too big then the system becomes too inflexible. Of course when there is no buffer, as in Six Sigma tuned processes (Snowden, 2013), then a system becomes very vulnerable to changes in the environment.

LP 10. The structure of material stocks and flows and nodes of intersection (such as transport networks, population age structures, flow of nitrogen through soil)

In Belgium most trains are passing through Brussels (central hub). Even the highways are in the same situation, if you want to go from one side of the country to the other side, chances are very high that you will drive on the ring round Brussels, traffic congestion and enormous delays as a result (Vermeersch, 2014).

Although the physical structure is crucial in a system, it is rarely a LP “because changing it is rarely quick

105 Quoted texts are taken from Meadows (1997).

or simple. The leverage point is in proper design in the first place. After the structure is built, the leverage is in understanding its limitations and bottlenecks, using it with maximum efficiency, and refraining from fluctuations or expansions that strain its capacity."

Taking into account that CAS are not predictable, it is essential for man-made, thus sociocultural organization to "design" flexibility. So in the conception it is not only analysis and synthesis, but also design.

LP 9. The lengths of delays, relative to the rate of system changes.

Delays in feedback loops may dramatically influence system behavior and may cause oscillations. "If you're trying to adjust a system state to your goal, but you only receive delayed information about what the system state is, you will overshoot and undershoot. Same if your information is timely, but your response isn't." Which is also essential in decision-making (OODA-cycle).

Delays are caused by the characteristics of some elements in the system. Quick changes are mostly not possible, things take as long as they take. Therefore slowing down the change rate may be preferred. For this reason growth rates are higher up on the leverage-point hierarchy than delay times.

LP 8. The strength of negative feedback loops, relative to the impacts they are trying to correct against.

Until now we discussed physical parts of the system. The higher ranked LPs are related to the information and control parts.

A CAS usually has numerous negative feedback loops to self-correct under different conditions and impacts. Not all of them are always active but they are fail-safe procedures to protect the long-term welfare of the system.

One of the big mistakes we make is to strip away these 'emergency' response mechanisms because they aren't often used and they appear to be costly. In the short term we see no effect from doing this. In the long term, we drastically narrow the range of conditions over which the system can survive." Snowden (2013) refers amongst others to Six Sigma and BPR when they strip off these mechanisms in the name of efficiency and cost-savings.

The quality of a negative loop (reducing discrepancies between the desired and actual state) depends on the combination of all its parameters and links. The quality of the decision to adjust to the observed level is function of the observation (accuracy, rapidity), the orientation (interpretation of the observation) in the context of the organization and taking into account the capability of acting (speed, power, capability).

LP 7. The gain around driving positive feedback loops

"Positive feedback loops are sources of growth, explosion, erosion, and collapse in systems. A system with an unchecked positive loop ultimately will destroy itself. That's why there are so few of them. Usually a negative loop will kick in sooner or later."

If rapidly turning positive loops are not slowed down or not balanced enough by negative feedback loops then chaos could be the result.

LP 6. The structure of information flows (who does and does not have access to information)

Some people think that information is power. That is why they are holding back information. Therefore some crucial feed-back may be missing with a system malfunction as a result. Moreover a systematic tendency of people to avoid accountability for their own decisions and actions is also a reason for missing feedback.

LP 5. The rules of the system (incentives, punishments, constraints)

Most CAS are driven by simple rules (Eisenhardt et al., 2001). They define the scope of the CAS, its boundaries and its degrees of freedom. Restructuring rules are "high leverage points. Power over the rules is real power [more than holding information]."

Colonel Reed (2006) warns however that thoughtless application of rules and procedures can stifle innovation, hamper adaptivity and dash creativity.

LP 4. The power to add, change, evolve, or self-organize system structure

Self-organization is in biology evolution and in human sciences technical advances or social revolution. "Self-organization means changing any aspect of a system lower on this list — adding completely new physical structures, […] adding new negative or positive loops, or new rules. The ability to self-organize is the strongest form of system resilience." That is why in CAS*T organizational changes are seen as investments (self-organize).

Unfortunately these LP are unpopular, namely to encourage variability and diversity which implies "losing control", certainly in uni-minded organizations with detailed C2.

LP 3. The goals of the system

When we look at our definition of strategy and the fact that a CAS should be purposeful, then it is logic that the goals of a system are ranked high in the list of LP. Changing the whole-system goals has a repercussion on "everything further down the list, physical stocks and flows, feedback loops, information flows, even self-organizing behavior." All that "will be twisted to conform to that goal."

LP 2. The mindset or paradigm out of which the system — its goals, structure, rules, delays, parameters

— arises

Mental models are the source of organizations. They explain how these organizations behave, based on the “shared idea in the minds of society, the great big unstated assumptions — unstated because unnecessary to state; everyone already knows them — constitute that society’s paradigm, or deepest set of beliefs about how the world works.” Moreover mental models are harder to change than anything else about a system., Therefore mental models are highly ranked. “But there’s nothing physical or expensive or even slow in the process of paradigm change. In a single individual it can happen in a millisecond. All it takes is a click in the mind, a falling of scales from eyes, a new way of seeing.”

LP 1. The power to transcend paradigms

Shifting a paradigm or changing mental models demands an open-mindness of the people or the CAS. People should keep themselves “unattached in the arena of paradigms, to stay flexible, to realize that NO paradigm is 'true', that every one, including the one that sweetly shapes your own worldview, is a tremendously limited understanding of an immense and amazing universe that is far beyond human comprehension.”

*5.3.4. CAS*T Twelve Levels of LP*

We will now adapt the twelve levels of Meadows to CAS*T.

For open systems (CAS (organizations)) open-mindedness is an essential element. That is why we are putting open-mindedness as level 0 to stress the conditio sine qua non for this type of organizations, and as a matter of fact for all sociocultural, man-made organizations.

Conform our model of single and double loop we are placing the mental models as level 1 (mindset or paradigm in the Meadows' table) and culture as level 2. However it is possible for organizations that through (previous) successes and/or by accepting dogma's, culture comes above the mental models, indicating that the culture is defining the contents of the mental models. In this case, we cannot talk anymore of open-mindedness.

As a matter of fact, the whole organization becomes frozen with so-called stable parts, “so that virtually all forces yield, at most, only minor system changes, resulting in too much buffering and low adaptability and evolutability” (Schneider et al., 2006, p. 355).

Our definition of strategy is the dynamic behavior of the organization and its agents as a result to interact or not with its environment by using the means/capabilities to attain its self-chosen goals (level 3) in that environment.

These means are situated in the lowest parts of the leverage points (12 to 9), therefore investing in means could be useless or less beneficial than adapting the organization by intervening in higher ranked leverage points.

The problem is that with reductionist thinking in contrast to the lower leverage points, the higher ranked leverage points are not obviously to detect, never mind to change them effectively (in the right direction). With holistic thinking chances are higher to change the right leverage points in the right direction. In that context we have proposed our CAS*T tools. CLD and SFD are very useful, certainly to represent the positive (level 7) and negative (level 8) feedback loops. That is why these two levels are part of the CAS*T-EA because otherwise chances are high that it will become again reductionist.

We note as Schneider et al. (2006, p. 360) that “[c]omplexity in a system occurs from the interaction of system variables (in general) over time. Major factors that influence complexity include positive or self-reinforcing feedback loops that generate growth and amplify deviations; negative or self-correcting feedback loops that counteract change; and single and double loop learning, the former in which existing mental models are maintained and the latter which involve the reframing of mental models. Other factors that also influence complexity include path dependence, as previously described; delays in outputs relative to inputs; aging of the system; and possible oscillation, amplification, and phase lags (Sterman, 2000). In summary, complexity is complex, meaning that it is difficult if not impossible for humans, given their cognitive processing limitations, to comprehend–albeit predict–phenomena under this condition.”

In CAS*T changing the organization ([106]) through leverage points demands time, energy and relocating or changing resources (means), which as a matter of fact is a definition of investments. Therefore organizational changes are investments and vice verse.

Long term planning is also difficult because of the unknown future. The main direction (shared vision) is known, but emergent strategy is the rule. Otherwise, today's solutions become tomorrow's problems created by linear thinking in a nonlinear complex world (Reed, 2006). Colonel Reed suggests to use concepts of ST (in our case CAS*T) that should be applied by leaders at all levels, but especially those within the acquisition community, so that an organization can have success in the contemporary operating environment.

106 Not just the processes or structure, but the whole.

Level	LP - Intervention Places	CAS*T EA	CAS*T Framework
0	Open-mindedness	X	X
1	Mental Models		X
2	Culture		X
3	The goals of the system		X
4	The power to add, change, evolve, or self-organize system structure		X
5	The rules of the system		X
6	The structure of information flows (who does and does not have access to information).	X	X
7	The gain around driving positive feedback loops.	X	X
8	The strength of negative feedback loops, relative to the impacts they are trying to correct against.	X	X
9	The lengths of delays, relative to the rate of system change.	X	X
10	The structure of material stocks and flows	X	X
11	The sizes of buffers and other stabilizing stocks, relative to their flows.	X	X
12	Constants, parameters, numbers	X	X

*Table 7: Leverage Points and CAS*T*

5.4. Cases

5.4.1. Case Migration Mainframe

This migration is an an example of technology standardization (EA).

In 1989, we had to establish a Request for Proposal (RFP) to SIEMENS BS2000 mainframes, networks, terminals and COBOL (also assembler) programs in a transaction and batch processing environment of the Medical Service in Belgium and (West-)Germany. The RFP was a technical shopping list with a minimum technical requirement for each item. The only somewhat global requirement was the overall performance requirement of the desired ICT-infrastructure and architecture.

When assessing the different proposals, we had to deal with two different architectures, both answering the requirements but where one has more added value (Unix servers, RDBMS, TCP-IP network, X11-terminals) than the other which was the mainframe provider. Luckily the solution with the most added value was also the cheapest one. The result was an architecture based on Unix (SUN), RDBMS (Sybase), X11-displays, all integrated in a TCP-IP and X25 based network.

The migration of the monolithic mainframe configuration to a client/server SUN/Sybase configuration had to be done in 9 months. The migration was a success, but we were left with a solution of old wine in new bottles. Although, technically it was a big change and we had a better performing infrastructure and equipment, on the business side, there was no improvement nor a fundamental change in the way people were working (effectively). It must be said that the time period of nine months was too short to rethink the business side and write the right applications for it ([107]).

The improvements in effectiveness were in the domain of referential integrity and reporting. The gained standardization was more on the level of programming (and techniques) and managing projects (change and new requests).

At the level of Defense, there was indeed an attempt to have a shared infrastructure. However this was not sufficient for our needs, due to the fact that we moved into a client/server architecture with more demanding services. So we decided to build a private network to improve the performance of our

107 We did however anticipate in 1990 the Y2K problem, introduced multi-currency (so no Euro problem) and we created a unique id-number for the whole medical service, which reduced a lot of duplicate records and improved the quality of exchanging data between the different applications for global reporting.

applications.

With the introduction of RDBMS, our reporting capabilities increased and the concept of Business Intelligence (BI) was adopted, which is an example of data rationalization.

In a later phase we have introduced Business Process Management (BPM), because we wanted to know where and how we were supporting the business processes with our IT-system. At that moment we were not aware of the fact that self-organization is very strong in the shadow system, which brings us to the next case, in which we were focusing too much on BPM in the formal structure of the organization.

5.4.2. Case TBT

A big project, called TBT ([108]), of automating the medical reimbursement for defense personnel is a good example of this. We had problems to implement the first idea to digitize all documents and invoices, which were triggering work flow instances. We came with the *best solution* (efficiency and effectiveness), however we had neglect to co-learn with the personnel to solve the problem. Some interviews with the direction and section leaders of the formal structure and the project goals were not enough to conceive a workable but more important acceptable solution for the personnel.

Worse, every personnel member was a specialist and the section leaders were not always aware of the functioning of the service. Problems were most of the time solved in the shadow system, only legal problems could not be solved internally.

The project goals were first defined by MST (Medical Staff Section Medical Techniques) and transmitted to us. We interviewed the “formal” leaders of the service TBT and started afterwards a market study to determine the budget. Then a RFP was published and the *best affordable* solution was chosen.

However with the implementation more practical problems came at the surface, and especially the social resistance (due to the lack of co-learning and collaboration in the shadow system) made that the concept of work flow and imaging system was changed to an archiving system, hence the whole acquired system was an overkill.

The main reasons of failure were:

- underestimation of the power of the shadow system (specialists)
- poor capability of abstract thinking of the head of service TBT;
- no digital signature allowed because payment orders had to be signed manually;
- the head of MST retired during the project, and his successor had other priorities, so no sponsor anymore;
- our functional analysis without co-learning.

So we changed our approach to BPM to understand better the context (including the shadow system) of the entity to be automated and we started a BPR project for the Medical Service with IBM.

During the project, the new structure of Defense split the Medical Service into ACOS Well Being and Command of Operations of the Medical Component and I moved to ACOS Eval to start up the new ACOS as Chief of Division Information Management. Unfortunately the scope of the BPR-project had then been changed to build use cases for IT-projects. So instead of extending towards a business concept, it was reduced to IT matters without a decent context of medical-military business, thus the opposite of the EA evolution. The same mistakes as we had done before, were then repeated.

5.4.3. Case Fedict

The Federal Public Service for Information and Communication Technology (Fedict) ([109]) is a federal public service, that defines and implements the federal e-government strategy. It uses innovative ICT to help the various federal public services to improve their service portfolios and tailor them to meet the needs of the general public, businesses and civil servants.

For example, Fedict is involved in building and developing the software for the electronic identity card (eID). Fedict also develops new online services aimed at the general public, businesses and civil servants, and made available through the federal portal.

We had interviews with Mr. Peter Strickx on March 23, 2011 and July 1, 2014. Being the CTO of Fedict he could give me the general picture of CC in the Belgian federal government, and answer more technical questions. He was at that time managing the RFP for DataCenter-as-a-Service (DcaaS).

The purposes were:

- To know more about the CC-projects of the federal government (Rabaey, 2012)
- To exchange information on CC (Rabaey, 2012a; 2012b)
- and at the end giving feedback to make a case (July 1, 2014).

108 TBT abbreviation for TerugBeTaling: Dutch for reimbursement.

109 From the website Fedict www.fedict.belgium.be

There was no questionnaire.

5.4.3.1. Cloud Computing (CC)

The main characteristic of CC ([110]) is standardization (of services). Through this standardization on every level, management becomes easier. Another advantage of standardization is the efficiency and therefore the reduction of costs in setting up and maintaining services. Mr. Peter Strickx said that not the CC on itself will make IT more efficient but the way to get into the Cloud, the preparation, like standardization and virtualization makes IT more efficient (personal communication, March 23th, 2011).

This standardization permits a better virtualization because it provides a whole set of processes, activities and tools to support the virtualization and the on-demand-self-service, by providing standardized approval cycles, and even pre-approved services with special rules. Paradoxically, this is again a technology standardization (second stage) and at the same time a modular architecture.

To enable the move to the Cloud for the Belgian federal departments, Fedict intended to implement a DCaaS: Data Center as a Service. It is a community cloud with external and internal infrastructure. The main reason for keeping an internal infrastructure is security. More specifically the databases (with confidential information) will stay in hands of Fedict.

5.4.3.2. Elections 2014

The RFP has been released but the Belgian federal government (Elio Di Rupo I (EDR I)) was in budget problems and in 2014 there were federal elections. From our experiences as IT-responsible for the Medical Service, ACOS Eval and DG Education (Royal Military Academy) mostly the projects are not stopped but the delays to finalize the RFP are shortened so that from the moment there is even a small problem, this can cause the RFP to pass its delays. Due to the rigid procurement legislation in most cases that is the end of that version of the RFP because of other scheduled projects or in the case of Fedict CC procurement no new investment budgets have been planned ([111]). The old infrastructure can still function of course, however with less capabilities, less agility and less flexibility, thus less service for the citizens (taxpayers).

5.4.3.3. Legislation and Leverage Points

The Belgian and European laws regarding government CC procurement should be simplified, however the opposite is happening. In an attempt to standardize the CC market the European Commission (EC) is restricting more and more the CC market (EC, 2012;2014; 2015) while there are still emergent practices surfacing. Apparently the EC wants to move the CC market from a complex Cynefin space towards a complicated space through standardization rules aiming a bigger efficiency, by consequence less robustness. Moreover the European Cloud Partnership (ECP) Steering Board is certainly not a model for a transdisciplinary forum.

To Donella Meadows (1997) this would have been an example of how to turn the button of a leverage point in the wrong direction. In this context, changing the procurement legislation (rules LP 5) and/or to give the governmental organizations as Fedict the space to self-organize (LP 4) ([112]) could be solutions.

However EDR I was looking for a CC solution outside the federal government, namely SMALS ([113]). Although SMALS delivers anno 2014 IaaS (clients need to manage themselves the virtual servers), thus this solution is not what Fedict was aiming at for the federal governmental organizations.

5.4.3.4. Autonomy

The more the CC layers come closer to the business processes, the more chance for a complex behavior, thus the more chance to be in the complex Cynefin space (for investments). Certainly for the agents that are quasi-independent to invest, CC should be bottom up (BPEIS). Therefore organizations should implement ESB and SOA.

On the other hand, IaaS and PaaS are more IT-agent related CC layers. In any case, CC needs a mission C2 approach and not a detailed. The ESB and SOA are at the same time the capabilities (means) to give that flexibility to any agents (also IT-agents), but are also the restrictions in chosing CC solutions.

5.5. Conclusions from consequences of CAS*T for EA

5.5.1. Our extensions for EA

The world grows smaller and the environment (CAS) changes quickly and continuously. A CAS (organization) has to survive in this context. Emergent properties of the whole cannot be explained by

110 See appendix 3 Investments in Cloud computing (CC) p.169.

111 In the Belgian government procurement system there are budgets to order, and budgets to pay the invoices.

112 Both LP 4 and LP 5 are outside CAS*T-EA.

113 Website of SMALS: https://www.smals.be/nl

analyzing the parts of the whole and the whole cannot be detached from its environment. Therefore EA must take CAS*T into consideration. An essential element is a sense-making framework as the Cynefin Framework. We have shown that this framework not only determines in which context an organization is, but also that dynamics can damage the organization if it is not aware of the shift from one context to another.

We have discussed EA in the CAS*T framework to solve this issue and to support an agile organization. It covers the LP from 12 to 6 (table 7, p.116), including the negative and positive feedback loops. The different layers have been redefined so that not only IT systems but all systems are taken into account, so a whole EA.

We have firstly introduced BPEIS, which gives agents the flexibility and agility to self-organize, though in the context of a shared vision (grand strategy). An implication of BPEIS for the IT-function is that an ESB (with SOA) should be used (Appendix 2). Secondly, we have extended the EA-layers with a Knowledge layer, essential for a learning organization (reactive and generative) which a CAS (organization) is and certainly for a multi-minded, networked CAS.

CAS*T-EA is a concept and has to be instantiated for every enterprise separately. Copy-and-paste of a configuration of organization A onto organization B can be catastrophic, not only because of the different possible contexts in which organization B and/or its parts are, but also because of the mental models and the culture that can and will be significantly different.

5.5.2. Cases

In our cases we have given example of technology standardization (migration mainframe, Fedict CC), data rationalization (migration mainframe) and modular architecture (Fedict CC).

TBT was not a full success because the business process automatization (business architecture of the formal structure) was not accepted by the shadow system of the organization.

CC project fedict is an illustration of the utility of CAS*T LP (simplifying procurement legislation) and the need for greater autonomy on the one hand for the user regarding CC (BPEIS) and on the other hand for Fedict to take advantage of the emergent practices of CC (complex Cynefin space).

5.5.3. Systemic Models and Leverage Points

We have discussed tools that help the organization to evaluate its situation. Especially CLD, SFD and ABM are bringing a more holistic image of the CAS (organization) in its CAS (environment) and give shape to the mental models.

That these mental models are very important to the survival of an organization has been shown by the twelve leverage points of Donella Meadows (1997). We have adapted these LP to the CAS*T framework resulting in our proposal table 7 Leverage Points and CAS*T.

In CAS*T changing the organization through leverage points demands time, energy and relocating or changing resources (means), which as a matter of fact is a definition of investment. Therefore organizational changes are investments and vice verse.

5.5.4. Transdisciplinary Forum

So discussing the results of the CAS*T tools with the situational awareness (Cynefin) via intelligence (see next chapter) in a transdisciplinary forum could better define the LP to intervene in the CAS (organization) (means, reorganizing capabilities) to attain the self-chosen goals and hence putting investments in the right perspective.

CAS*T is as a matter of fact at the same time a (conceptual) framework and a communication (and coordination) system. Organizations (CAS) need to cope with uncertainty. The purpose of developing a conceptual framework is to simplify (without oversimplifying) and to handle the complexities and dynamics of their environments (CAS).

Linked to this conceptual framework is the vision, which is emerging from the mental models confronted with the situational awareness to define goals to attain in the CAS (environment). New intelligence can lead to a new cycle of *Destruction and Construction* of mental models (for decision making and knowledge).

Regarding the communication part, Walters (1994) states that the commander's vision is a shared framework that attempts to provide order and direction to and in what we would otherwise refer to as the fog, friction, and chaos of war. This vision becomes the framework from which the commander and other organizational leaders determine objectives and upon which they subsequently base decisions (pp.19-20). In a multi-minded organization, the shared vision emerges from the interactions of the different agents (polyarchy) and becomes the main message for all agents to direct their actions and thinking, thus the intent and concept of operation.

In the next chapter we are introducing our concept of CAS*T Intelligence Base, so crucial for sense-making situational awareness, thus decision making and knowledge creation.

6. CAS*T Intelligence Base

In chapter 2 *Organizations as Complex Adaptive Systems* we have seen that intelligence is necessary to update the mental models and for a CAS to co-evolve with its environment. In chapter 3 *War as Complex Adaptive System* we have focused on the role of intelligence in the process of decision-making (fuel). In this chapter we will not only discuss the second function of intelligence namely to increase and update our knowledge but also the intelligence base, after which we will discuss the Evaluation Information System (failure) and the triple loop learning.

6.1. Permanent collection of intelligence

Our original concept of Intelligence Base (Int B) is based on our study of the Art of War (Rabaey, 1997; 2003; Rabaey et al., 2004) and was the first time presented at the NATO IST-055 Specialist meeting in The Hague (Netherlands) (Rabaey et al., 2006).

Many Western versions of Art of War exist, but basically the version of Professor Bernard (1976) gives the essence. The first principle is the balance between goals and means. This principle has only one rule: the permanent collection of intelligence, which is essential for a good situational awareness.

The second principle is the liberty of action, the third is the economy of forces. In the context of CAS (organization and environment), and since the Art of War is based on reductionist thinking (confronted with *On War* of Karl von Clausewitz) we believe the principles and rules are obsolete (Rabaey, forthcoming1), except for the rule of permanent collection of intelligence (as a matter of fact, it should be a principle) and partially the first principle itself.

Relevant to our discussion, is that according to Karl von Clausewitz war is neither art nor science (another military thinking) because war is an act of human intercourse. Though he did tell that "art of war" is more appropriate than "science of war," he denied war the category of art because of an essential difference (Walters, 1994): “[W]ar is not an exercise of the will directed at inanimate matter, as is the case with the mechanical arts, or at matter which is animate but passive and yielding, as is the case with the human mind and emotions in the fine arts. In war, the will is directed at an animate object that reacts. It must be obvious that the intellectual codification used in the arts and sciences is inappropriate to such an activity.” (Clausewiz, 1993, p.173-174).

Not only is the speed of delivery of information increasing in this ever faster changing world, but also the amount of information.

This chapter introduces the concept of the CAS*T Intelligence Base, which meets the needs of an efficient and effective intelligence system. The Intelligence Base is composed of a Fact Base (storing information), an Interpreted Information Base (storing intelligence), an Unknown Base (to manage the requested information) and an Intelligence Bus (communication system). The underlying architecture is based on Service-Oriented Architecture (SOA), already adopted by the business world to integrate business processes and their applications.

6.2. Intelligence

6.2.1. Why discuss intelligence

A CAS must be aware of its environment (context) and its own structure, processes and outcomes to be able to survive. Everything can change at any time so the CAS has to observe in a continuous way. In this context, Savigny et al. (2009a, p. 42) state that “ST places high value on understanding context and looking for connections between the parts, actors and processes of the system. [...] They make deliberate attempts to anticipate, rather than to react to, the downstream consequences of changes in the [complex adaptive] system, and to identify upstream points of leverage.”

Intelligence is mostly linked to reducing uncertainty and thus to reduce or at least mitigate risks. We have already referred to O'Donnell (2005) who states that to “manage risk on an enterprise-wide basis, organizations must expand their focus beyond traditional concepts of risk to include economic and political factors along with risks related to reputation, ethics, and data integrity.” (p. 178). This can only be the case if the organization is continuously screening its environment and itself, and it must be capable of interpreting these observations (in the Orient phase of OODA).

6.2.2. Intelligence-Cycle

We will discuss now some types of intelligence cycle.

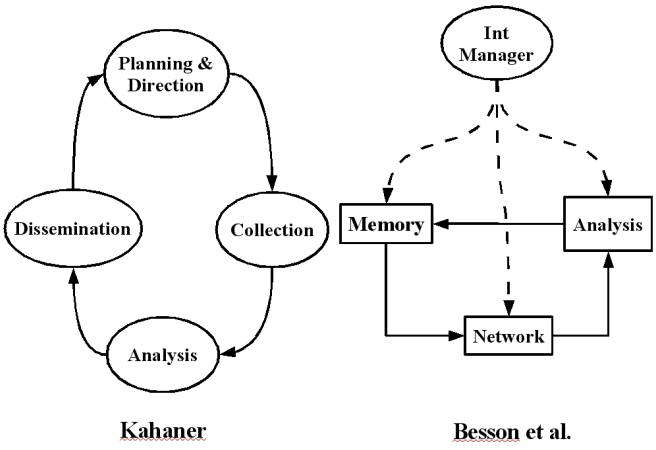

Figure 39 Intelligence Cycles

The intelligence manager has following resources in the so-called intelligence cycle: the memory (where all acquired information is stored), the network (of sensors) and the analysis capability. The latter analyses all incoming information and processes it into intelligence that will be stored into the memory. In the scheme of Besson et al. (2001) in figure 39, the 'unknown' drives actively the intelligence cycle, however sensors collect on a permanent base also information, which can be useful for the organization.

The most difficult task is to formulate and translate the question into clear language, which leads the organization to the pertinent and relevant information. In other words, it gives the knowledge about opportunities and threats, which the organization would otherwise ignore (Besson et al., 2001, p. 22).

Larry Kahaner (1997) sees the intelligence cycle as a process instead of a function. “Therefore it should appear in all aspects of your business as one seamless, continuous activity not relegated to one area, division or unit” (p. 23). This process has four steps: Planning & Direction, Collection, Analysis and Dissemination (p. 43).

The step “Planning & Direction” starts with a clear understanding of the user’s needs and includes his time constraints. Once well understood, further intelligence actions are planned. The “Collection” involves obtaining raw information that can be turned into usable intelligence for the decision making of an organization ([114]). “Analysis” is the process of taking information and integrating it with other information so that intelligence is created. “Dissemination” is distribution of the intelligence towards the client and other organizations that may also be concerned by this intelligence.

We will first discuss more in depth the relationship between information and knowledge.

6.2.3. Information and knowledge

The term 'information' means any communication or representation of knowledge such as facts, data, or opinions in any medium or form, including textual, numerical, graphic, cartographic, narrative, or audiovisual forms (Whitehouse, 1996). So information is not knowledge but a representation of knowledge.

Sanchez et al. (2000) define “knowledge as the set of beliefs held by an individual about causal relationships among phenomena”. As such, knowledge is part of the mental models and by consequence knowledge is in the orient-phase of OODA.

Causal relationships in this definition are cause and effect relationships between imaginable events or actions and likely consequences of those events or actions. Organizational knowledge is then defined as the shared set of beliefs about causal relationships held by individuals within a group.” Both definitions are products of reductionist thinking. In the domain of ST emergent perspectives are noted in the domain of knowledge management.

114 Mainly two types of information exist: primary and secondary. Primary information comes directly from the information sources. Secondary information is coming from other sources then primary sources, which have altered the “raw facts”.

Based on the idea that the whole is greater than the sum of its parts, on the website of systems-thinking (n.d.) they start by saying what information and related concepts are not:

- A collection of data is not information.
- A collection of information is not knowledge.
- A collection of knowledge is not wisdom.
- A collection of wisdom is not truth.

Data, which is just a meaningless point in space and time, without reference to either space or time is a fact out of context, therefore it is without a meaningful relation to anything else. It only becomes useful when placed in a context. So, a collection of data is not on its own information. The pieces of data may represent information, yet whether or not it is information depends on the understanding of the one perceiving the data in his context. Therefore information is subjective: context of the person and the perception of associations between a collection of data and/or the association between data and other information.

“While information entails an understanding of the relations between data, it generally does not provide a foundation for why the data is what it is, nor an indication as to how the data is likely to change over time. Information has a tendency to be relatively static in time and linear in nature. Information is a relationship between data and, quite simply, is what it is, with great dependence on context for its meaning and with little implication for the future.

Beyond relation there is pattern, where pattern is more than simply a relation of relations. Pattern embodies both a consistency and completeness of relations which, to an extent, creates its own context. Pattern also serves as an Archetype with both an implied repeatability and predictability.” (systems-thinking, n.d.).

A pattern has the potential to represent knowledge, when a person is able to realize and understand the patterns and their implications. Humans are pattern based intelligent beings (carbon), although they need to interpret data (silicon). The patterns representing knowledge have a tendency to be more self-contextualizing which means that a pattern creates its own context rather than being context dependent to the same extent that information is. “A pattern which represents knowledge also provides, when the pattern is understood, a high level of reliability or predictability as to how the pattern will evolve over time, for patterns are seldom static.” (systems-thinking, n.d.)

Keeping only the last version of a pattern is thus not enough. The history of a pattern is also a part of the history of the learning organization (CAS). As a consequence, our proposal contains also the versioning of information and patterns, so inference rules if any need also to be stored.

“Patterns which represent knowledge have a completeness to them that information simply does not contain. Wisdom arises when one understands the foundational principles responsible for the patterns representing knowledge being what they are. And wisdom, even more so than knowledge, tends to create its own context.” (systems-thinking, n.d.).

They summarize as follows:

- Information relates to description, definition, or perspective (what, who, when, where).
- Knowledge comprises strategy, practice, method, or approach (how).
- Wisdom embodies principle, insight, moral, or archetype (why).

Gharajedaghi (2011, p. 33) defines in the same way these concepts. He states that the way of doing business also has evolved regarding the usefulness of information and knowledge. There was once a time when having information about clients was a competitive advantage. Nowadays knowing how clients are thinking 'what they want to do' gives a company a competitive advantage.

Wisdom should be found in the mental models. They are the guidelines *why* a CAS (organization) is doing *what* it does. Mental models are also related to the power of self-organization.

6.3. Coherent Knowledge-based Operations

We have already shown the importance of the situational awareness for the evolution of the mental models. USAF Lieutenant-Colonel Perry Luzwick (2000) makes the link between information, knowledge and situational awareness. Leaders at all levels have to make decisions in the absence of complete information – which is anyway impossible (Artigani, 2005). Three actions will help: taking full advantage of employees’ knowledge, improving situational awareness, and using the OODA-model. These elements are important core functions of Coherent Knowledge-based Operations (CKO).

“Coherent Knowledge-based Operations (CKO) combines the three powerful concepts of KM, information warfare, and network-centric business (NCB) to control IE [Information Environment]. This control enables an organization to attain and maintain a competitive advantage while at the same time preventing, or at least complicating, the competition from reducing your advantage and increasing their own.” (Solstad,

2013) ([115]) Figure 40 depicts CKO ([116]). NCB is an operation model that departs from a hierarchical structure to a network structure, with an all-to-all communication, which connects resources and different departments within the organization together, to a more effective entity (Solstad, 2013).

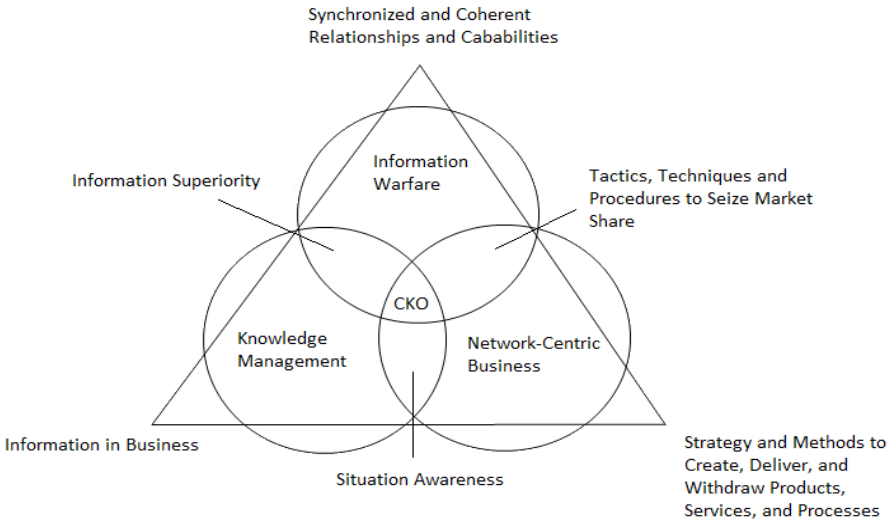

Figure 40: CKO

In figure 40, information superiority means the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same (Solstad, 2013).

To Luzwick (2000) situational awareness and the OODA model are woven synergistically through knowledge management (KM), information operations (IO) and network centric business (NCB) – similar to NCW. KM is the fuel for the OODA furnace. Here we disagree with Luzwick, informations coming from the observe-phase is the fuel of OODA. However knowledge is one of the components of OODA (and of our CAS*T Int B).

KM supports NCB and IO, which are the tools that will help an organization to control its information environment (IE)([117]), have better KM, and perform NCB in the face of information warfare (IW) attacks. As we will discuss later in this chapter, CAS*T Int B is managing also the effort to collect information (pulling and pushing). IO must be seen as the mechanism to collect information.

Luzwick (2000) continues: "KM and IO synergistically raise situational awareness. [NCB] is the use of the IE, supported by KM and IO, to execute business processes more effectively and efficiently." He warns that "[IW] is real and the attacks will only become more sophisticated and damaging. [CKO] is a powerful construct that will contribute to controlling your [IE] and making your business more successful. It's a sound, unifying model to synergistically link functions in order to attain and maintain a competitive advantage."

Figure 41 ([118]) is regarding the chain data-information-knowledge not conform the philosophy of OODA. Orient uses and creates knowledge. As in the case of mental models the process of *Destruction and Construction* is applied.

115 He is referring to Jones, A., Kovacich, G.& Luzwick, P. (2002). *Global Information Warfare: How Businesses, Governments, and Others Achieve Objectives and Attain Competitive Advantages.* Auerbach Publications.

116 *Figure 40* Figure *A visual representation of the parts which together forms CKO* from http://dsolstad.com/

117 IE is the composition of humans, organizations and processes that gather, manage and conveys information. The information itself is also included (Solstad, 2013). This is conform with our intelligence process, and thus CAS*T Int B.

118 *Figure 41* Figure Coherent Knowledge-based Operations Applied from http://obromley.deoss.net/web/content/situational_awareness_4.htm.

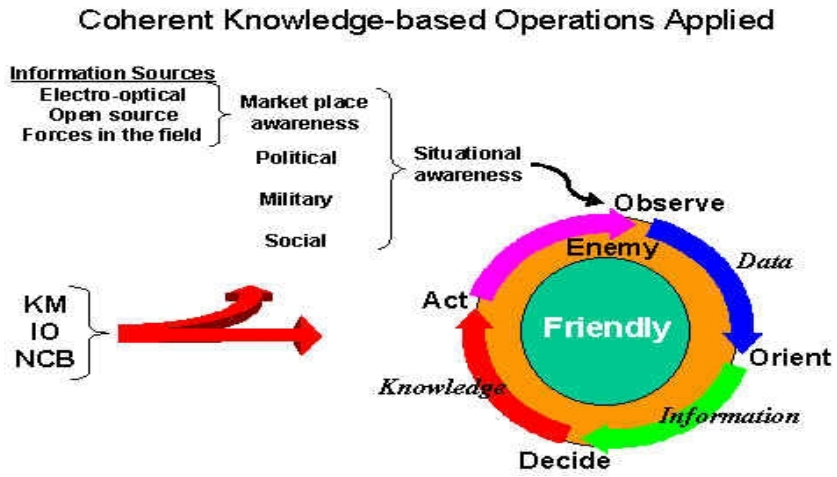

Figure 41: CKO and OODA

“Islands of knowledge and stove piped functional areas are the wrong construct in the Knowledge Age. The government, industry and the public are becoming network centric.” (p15). It is obvious that the different organizations are all moving into a CAS (environment).

6.4. It is all about known and unknown

Unfortunately, mental models do not represent the unknown. We quote Deming: "The most important things are unknown or unknowable." - "The most important things cannot be measured." The future is full of unexpected events and issues that are most important, long term, cannot be measured in advance.” (Rabaey, 2014).

It is however up to the organization to define its strategy to act in the future. Flood (1999) discusses the interactive planning of Ackoff, which is nothing else but an execution of a dynamic (emergent) strategy. Of course, strategy and objectives without planning are only wishes (OODA). Interactive planning asks what can be done now to create the (desired) future, not what will be the future independently of what an organization is doing now. The main aim of interactive planning is to assist members of an organization to “design” a desirable future and to invent ways of realizing it (see also Gharajedaghi, 2011). This reflects Ackoff's firm belief in the maxim “*plan or be planned.”*

Therefore an organization will collect and transform information into intelligence to enrich its knowledge and/or to support the decision-makers by reducing their uncertainties (to an acceptable level), so that a better awareness and interactive planning are achieved.

We discussed the (un)awareness and stated that awareness was the accepted knowledge and intuition. However in the context of Intelligence base, we will use the (un)known.

To better understand intelligence base we need to relate information and knowledge to what is known and unknown, in other words their respective states.

		State of our information	
		Known	Unknown
State of our knowledge	Known	**Known-known** The information is available and we have it. (Asked and answered)	**Known-unknown** We know the information we need but we don't have the answers” (Asked and but not answered)
	Unknown	**Unknown-known** The information we need is out there somewhere, but we don't know what we are looking for. (Not asked but the answer is out there)	**Unknown-unknown** We don't know what we don't know. (Not asked and not answered)

Table 8: States of Knowledge and information

6.4.1.1. Known-known

Known-known is a situation where the knowledge and the information are available to decide what to do or not do (behavior). This is typical for systems which are simple and/or in a simple domain. Cause-and-effects are obvious and feed-backs are bringing the systems easily back to the desired state.

6.4.1.2. Unknown-unknown

Unknown-unknown is when an organization is not aware of a situation, therefore it cannot ask to have more information to increase the knowledge or to make (better) decisions in that particular domain. It can be that it is not directly related to the interest of the organization. However the actual knowledge, culture or belief patterns may cause the sensors of the organization to reject the information, meaning it does not match in its context.

USAF Colonel John Boyd depicts this very clearly in his concept of OODA-loop (Observe-Orient-Decide-Act). OODA (Figure 42) is an important concept on decision-making at the strategic, operational and tactical level. The organization observes the environment, then it considers the new information and orients its thinking (based on its mental models) into a direction based on cultural traditions, existing knowledge, genetic heritage and the process of analysis-synthesis. In the next step it will decide which will result in an action. The organization will observe the effects, and the cycle starts all over again. Rabaey & Mercken (2012) have adapted the OODA-cycle to the context of an organization. Although used in a holistic framework, they did not include the design thinking because it was not fully adapted to ST. So in the picture below (Figure 42) design thinking (in the context of restricting CAS) has been added as described by Gharajedaghi (2011). The term act has been replaced by behavior because a decision can be not to act at all.

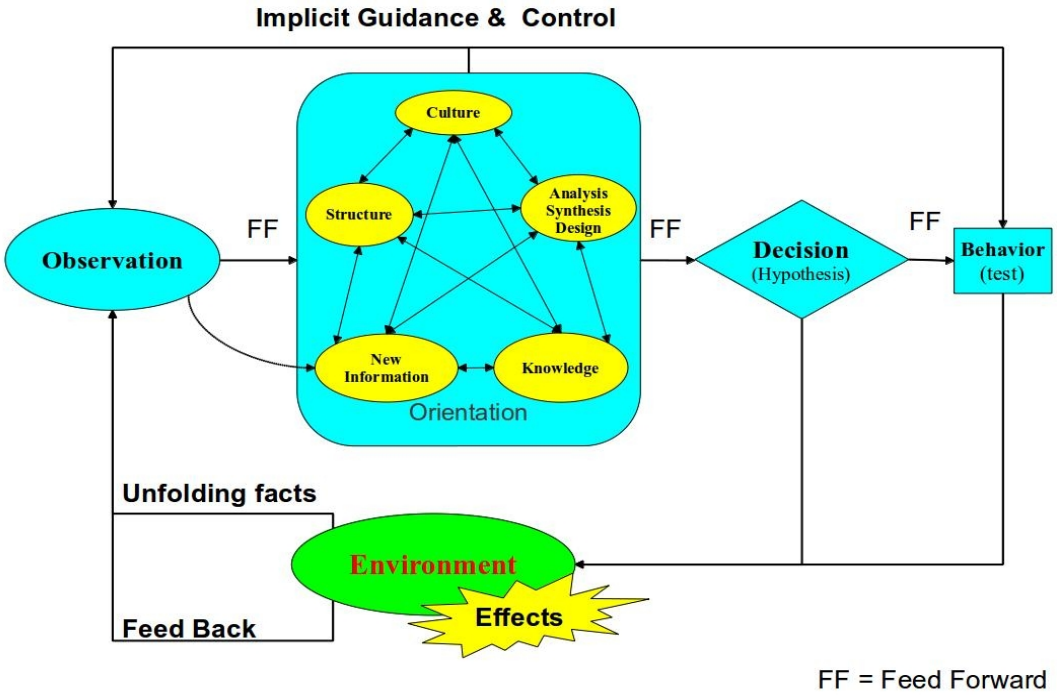

Figure 42: OODA-loop (adapted from Rabaey & Mercken (2012)

Dettmer (2011) writes in his outstanding paper "Systems Thinking and the Cynefin Framework: A Strategic Approach to Managing Complex Systems": "Like the Logical Thinking Process [LTP], the OODA loop is a qualitative tool. Though it accepts quantitative data in the observation step, it ultimately depends on intuitive knowledge to capitalize on any such data [(figure 42)]. And like the thinking process, the OODA loop is effective in multiple domains. In fact, it is even more broadly applicable than the LTP." (p. 26). Therefore mental models are very important. So through the whole OODA-cycle the mental models are active. Reason the more to frequently evaluate these mental models (via the Double learning loop).

6.4.1.3. Known-unknown

This is more related to the complicated spaces, because for one problem there may be more than one answer possible. Although it is more complicated than the known-known, the relationship between cause and effect still pertains, though such relationships may not be obvious. Whether or not they are obvious depends of the depth of people's knowledge about the environment and the system. Variability and uncertainty increase in a complicated environment, increasing the potential range of problems as well as the number of possible right answers. […] We know the questions to ask, but we don't know the answers. Thus, cause-and-effect analysis is only as good as the knowledge of system or environment that one has available. […] information is usually available somewhere. It's usually just a matter of research to find it." (Dettmer, 2011, p.11).

6.4.1.4. Unknown-known

The built knowledge is not sufficient because the environment is changing too fast. However, the information is out there but the organization does not know what exactly it is looking for. This is the domain of complex systems which typically have multiple agents in the organization.

Dettmer (2011) is quoting Kurtz and Snowden: "... there are cause and effect relationships between the agents, but both the number of agents and the number of relationships defy categorization or analytic techniques. Emergent patterns can be perceived but not predicted; we call this phenomenon retrospective coherence. In this space, structured methods that seize upon such retrospectively coherent patterns and codify them into procedures will confront only new and different patterns for which they are ill prepared. Once a pattern has stabilized, its path appears logical, but it is only one of many that could have stabilized, each of which also would have appeared logical in retrospect. Patterns may indeed repeat for a time in this space, but we cannot be sure that they will continue to repeat, because the underlying sources of the patterns are not open to inspection (and observation of the system may itself disrupt the patterns). Thus, relying on expert opinions based on historically stable patterns of meaning will insufficiently prepare us to recognize and act upon unexpected patterns." (p.14).

6.5. Intelligence Base Concept

6.5.1. Application domain

Just as the Boyd theory (OODA), the concept of Intelligence Base was primarily conceived for military conflicts and politics (national and international), but as warfare is a CAS (environment), so are the actual world society and its economy. Moreover military troops are CAS (organizations), therefore we can apply this concept for organizations (CAS).

6.5.2. Harnessing the intelligence of the organization

Gifford (n.d.) writes that "the organization as a whole knows more than the leadership and is a huge resource of energy and ideas. Some modern organizations allow colleagues to influence the direction of the organization by showing their preferences for different projects, thereby allowing them to 'vote with their feet'. Others encourage and reward entrepreneurial ideas from any colleague, and set up small ad hoc teams to explore these."

However we need a system to provide these functions and processes. That is why we are proposing the Intelligence Base.

6.5.3. Components

Intelligence Base is a system to manage in essence the unknown and the knowledge (Rabaey & Mercken, 2012; 2013). It is composed of (Figure 43):

- Planning and Directing: this cell receives and manages the intelligence needs.
- Collecting cell is responsible for the managing of the network of sensors.
- Network of sensors will collect data on demand or ad hoc
- Knowledge Base is a software system capable of supporting the explicit representation of knowledge in some specific competence domain and of exploiting it through appropriate reasoning mechanisms in order to provide high-level problem-solving performance. The knowledge base, a part of the Intelligence base, stores available knowledge concerning the domain at hand, represented in appropriate explicit form and ready to be used by the reasoning mechanism (Guida & Tasso, 1994)
- Facts Base is the collection of all raw information. This makes a later interpretation of facts ([119]) possible with new inference rules and/or knowledge.
- Unknown Base supports the management of all requests that are still active.
- Analysis, Synthesis and Design: the intellectual interpretation of the collected data in a context relevant to the user and/or organization.

119 Boone (2011) states that 'facts' never exist independently from the thinking framework that has made that fact thinkable (p. 245), thus this should also be taken into account.

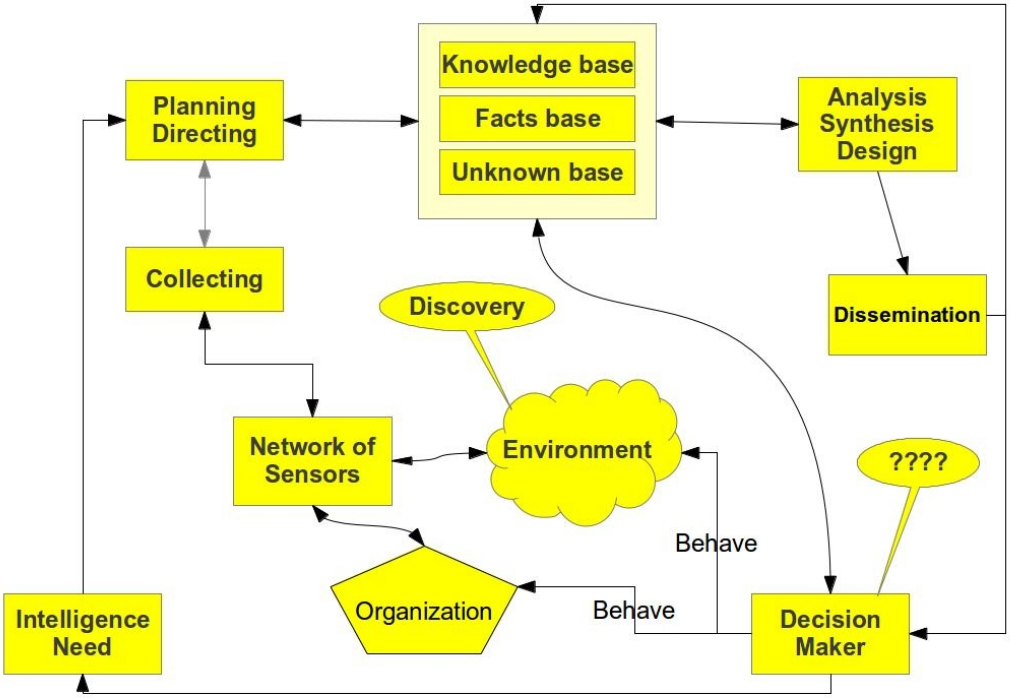

Figure 43: Intelligence Base (internal and external sensing)

The “Planning and Directing” cell will look in the knowledge base to see if the intelligence need can be satisfied. If so it will transmit the need to the “Analysis, Synthesis and Design” which will disseminate to the client. If not, the “Planning and Directing” cell will send a request for search to the manager of the sensors “Collecting cell”.

Regarding the network of sensors, two events can trigger an interaction between the decision making process and the intelligence process. Firstly, the decision maker expresses an intelligence need (pull). The second trigger is the spontaneous transmission of newly detected facts by the sensors (push).

The case of “Information Pull” is when the decision maker does not find the necessary intelligence (in the Intelligence Base or outside of it), he expresses his need to the “Planning & Direction”. As mentioned above, the latter will then define the needed intelligence actions. The needed information may not be in the Intelligence Base in which case the network has to be instructed (push). The resulting information (if any) is then interpreted (“Analysis, Synthesis and Design”). Additional information may be required if there is not enough information to be integrated into intelligence. Once the intelligence is acquired, then it will be disseminated to the intelligence client. The information and intelligence are stored respectively in the Facts Base and the Interpreted Information Base, and the Unknown Base is updated.

In the case of “Information Push” the sensors are injecting information in the network (push). The transmitted information is then analyzed. If the information can be integrated, then the resulting intelligence is pushed to the concerned people and/or organizations. The information and intelligence (if any) are stored respectively in the Facts Base and the Knowledge Base.

Just like a fighting pilot and his OODA, the whole intelligence process can be made by one person only: the decision-maker (compatible with OODA).

Snowden (2002) distinguishes three ages in KM. The first (prior to 1995) was information for decision support. The second age was about content management, knowledge was seen as a thing. However knowledge can only be volunteered (thus it cannot be conscripted) and moreover a person only knows what he knows when he needs to know it, so human knowledge is deeply contextual. In the third age of KM knowledge must be seen as a paradox: it is both thing and a flow, just like light can be a wave or

particles.

In this context Snowden conceived the Cynefin framework. Knowledge can be created in different ways following the space one is in. Our concept of CAS*T Int B reflects the two characteristics of knowledge in the third age:

- It is a thing: knowledge base, even more facts base and unknown base;
- It is a flow: the whole intelligence process in CAS*T Int B.

And related to the two previous ages, CAS*T Int B supports decision making and the creation of knowledge and content. The Cynefin framework guides the organization in its situational awareness not only related to itself (Cynefin is about self-awareness) but also to explore the space and time continuum outside its own environment (based on our definition of strategy and NCW concept).

6.5.4. Communication

Regarding the organization of the intelligence process, different types can be used: hierarchical or networked. However in an interconnected whole a networked structure is preferable. Ackoff has a hybrid solution: the circular organization (Flood, 1999), which of course can also be used for decision making. A circular organization is a democratic hierarchy which has as purpose a more active contribution of people in co-defining their involvement in the organization.

The main structural characteristic is the board, thus more likely an uni-minded organization. It is a body of people from a local department of an organization. Each person in a position of authority is automatically member of the board. If a higher hierarchy exists then he is also member of the board of the higher hierarchy, idem dito if a lower hierarchy exists. Another example is the system of operation order in the Belgian Defense. An operation order contains in general the mission of the higher level, in detail the own level and in general the missions of the subordinated units.

Regarding the multi-minded, in essence it is a whole of interdependent agents where a detailed C2 does not exist, but a mission C2 exists. As a consequence, another type of organizing has to be defined.

6.5.4.1. Bus-structure

A process consists of a logical set of activities organized to attain one or more goals. These activities can be clustered in sub-processes, which can be considered as services for the main process. The communication in these sub-processes (services) is hidden from the main process; however, the communication between these sub-processes is not.

This configuration can be represented as a communication-bus (Linthicum, 2000) which connects all services (sub-processes). These services communicate with each other via an interface to the communication-bus.

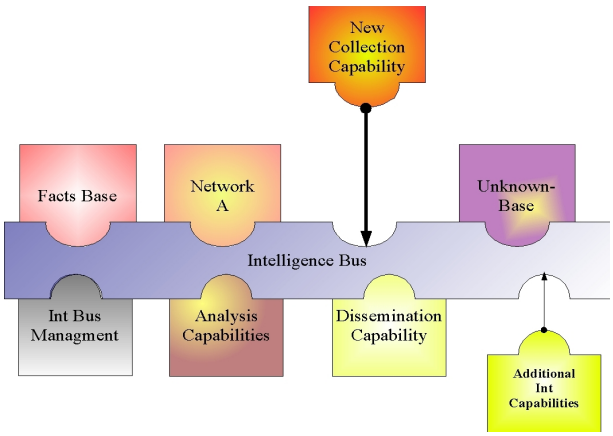

Figure 44 Logical Bus-structure

Regarding the Intelligence Process, the services are those sub-processes described by Kahaner (1997) (Planning & Direction, Collection, Analysis, Dissemination), the network management (Besson et al., 2001) and the components of the Intelligence Base (Fact Base, Interpreted Information Base and Unknown Base).

A special Management module manages the intelligence bus. Its responsibility is the good functioning of the Intelligence bus (like security, availability, interconnectivity). Additional services can be plugged into

the bus, as long as they respect the rules of interfacing with the Intelligence bus (Figure 44 Logical Bus-structure).

The connection with the C2 system is of great importance. The intelligence base is at the service of the commander of the (supported) organization, so both systems should be tightly (but in a secure way) connected with each other.

6.5.4.2. Multi-level and Collaboration

An intelligence bus should be capable of communicating with other intelligence buses and even with other systems. In that way, pulling and pushing information or intelligence can be done throughout the whole organization and even outside the organization with trusted, auditable relations and connections.

Nowadays technically all this is feasible; however competition between intelligence services (national and international) makes it difficult to implement such interconnectivity. “No rivalries are more intense than those between intelligence services working, by different means, on the same side.” (Keegan, 2003, p.385).

In 2006 this was the greatest challenge instead of the technical issues. Anno 2014, the US Intelligence Community (IC) is moving away from a (stovepipe) agency-centric IT-model to a shared-service model. The main reason was the political pressure to reduce the budget of IC (Slabodkin, 2014) without losing intelligence capabilities.

Figure 45 represents a multi-level organization where each level disposes of its own Intelligence Base. It is in function of the command structure and connections, how the capabilities and resources will be organized and deployed.

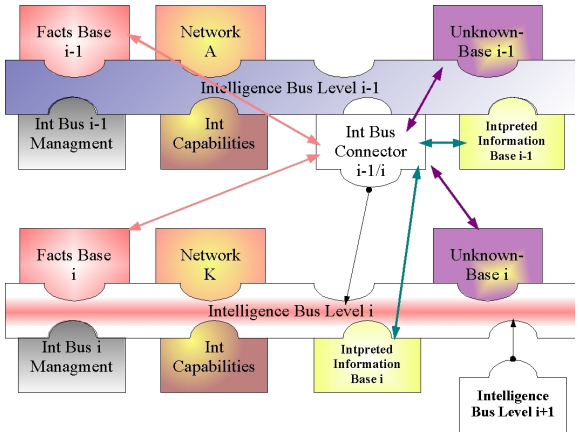

Figure 45 Connection of cascaded Intelligence Buses

6.5.4.3. SOA

For the ICT of an organization, the biggest challenge is the integration of different information systems inside and outside that organization, mostly called Enterprise Application Integration (EAI) (Linthicum, 2000; Rabaey et al., 2005). The most recent IT, which handles this problem, is SOA, together with Cloud Computing. SOA organizes the discrete functions contained in enterprise applications into interoperable services communicating via standardized connections, called web services.

Because intelligence is a process (Kahaner, 1997), SOA is a suitable solution for the working of the intelligence base and the connection between several intelligence bases. Since a C2 system has also many processes, we may even consider interconnecting both systems via SOA (Rabaey et al., 2003), which is the case in NCW.

The technologies used in SOA are suited to give the local intelligent base its autonomy. During the period of disconnection, messages are queued. Once the connection is re-established, messages are exchanged on priority-based criteria (Barry, 2003).

Other intelligence capabilities (services) can replace the existing capabilities without changing the interface. The intelligence bus manager can easily plug additional capabilities into the intelligence bus, so SOA improves the flexibility, the agility and the productivity of the intelligence base (server) and thus its client, the C2 system.

The intelligence client may have a need for information coming from external applications (legacy systems). In that case, components of the SOA may interface and query those applications without the intervention of a human.

6.5.5. Strategic Level

6.5.5.1. Political level

The government has many sources (national and foreign) from which it receives intelligence to determine the politics and strategy of the nation (Bernard, 1976). Therefore, the political power of a nation (or alliance of nations) should enable the communication (in a secure way) between its own intelligence services and their sources (Figure 46 Strategic view).

So national Intelligence is the "integrated departmental intelligence that covers the broad aspects of national policy and national security, is of concern to more than one department or agency, and transcends the exclusive competence of the intelligence community [IC]" (DOD, 1999, p.258). Of course, this does not imply that every department or agency can have free access to the sources of the others. The grand strategy and policy of the nation will determine the priorities, the hierarchy and the conventions of collaboration between the intelligence capabilities of the different departments.

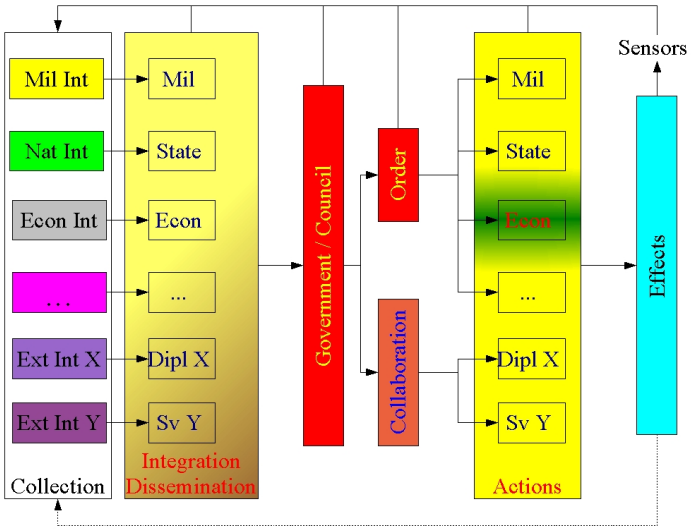

Figure 46 Strategic view

6.5.5.2. Military Strategic Level

a) Strategic Intelligence

"War is simply a continuation of political intercourse, with the addition of other means." (Clausewitz, 1993, p.731) Therefore, the government of a nation (or alliance of nations) determines war or any activity in this domain. Strategic Intelligence is the "intelligence that is required for the formulation of military strategy, policy, and military plans and operations at national and theater levels" (DOD, 1999, p.361). The reasoning for the strategic political level can be maintained for the level of military strategy. In fact, this system can be cascaded throughout the whole (military) organization or put at the service of a networked organization. Mainly this is possible because intelligence is in fact a process.

Since 9/11 national security is confronted with a special form of violence: international terrorism. "Intelligence superiority, we are constantly told, is the key to success in war, particularly the war against terrorism" (Keegan, 2003, p. 383). Collaboration between national or international Intelligence services is not enough. Some subsets of the different Intelligence Bases should be clustered into one special, logical Intelligence Base to respond to international terrorism. Besson et al. (2001) even show that economical intelligence can be used against terrorism (p. 318), and therefore collaboration and/or integration are necessary.

b) Military Intelligence

Military Intelligence is "[i]ntelligence on any foreign military or military-related situation or activity which is significant to military policy-making or the planning and conduct of military operations and activities

(DOD, 1999, p. 244).

In this context, US DOD has its Military Intelligence Integrated Data System / Integrated Data Base (MIIDS/IDB). The purpose of MIIDS/IDB is “an architecture for improving the manner in which military intelligence is analyzed ([120]), stored and disseminated” (DOD, 1999, p244). It is the intelligence repository of worldwide order-of-battle and installation data (see also FAS (2014)).

However, the Intelligence Base goes further and supports the whole intelligence process and intelligence management. In Figure 47 a central bus connects every level of the military organization and interfaces with the Government Intelligence Bus.

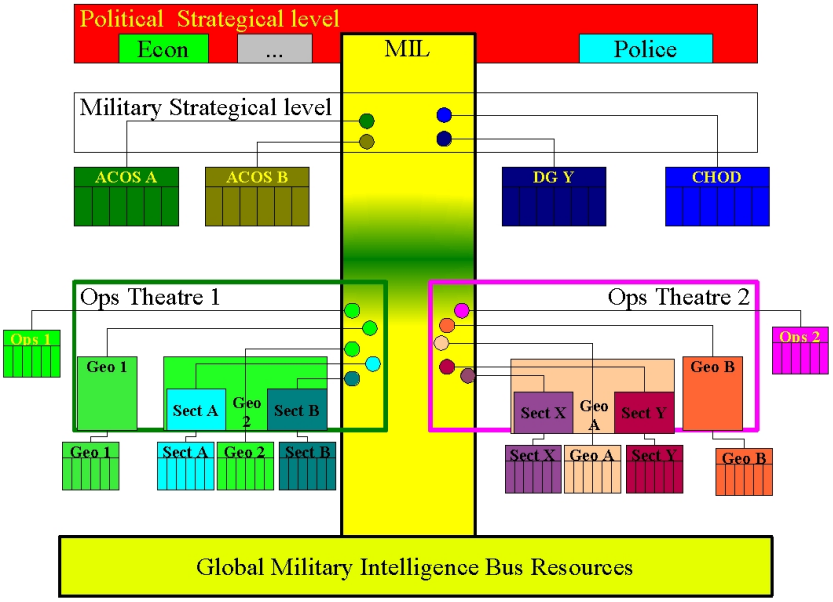

Figure 47 Logical Military Intelligence Bus

The global Military Intelligence Bus Resources hold at least the same information and intelligence as all the local Intelligence Bases together. By analogy with the data warehouse of the ICT, we can call it the Intelligence Warehouse. Such an Intelligence Warehouse should be capable of creating more intelligence because of the vaster amount of information it has in comparison with the local intelligence bases. Possibly, this is the place where the domain knowledge bases can be integrated with the global intelligence base.

6.5.5.3. Operational level

Operational intelligence is “Intelligence that is required for planning and conducting campaigns and major operations to accomplish strategic objectives within theaters or areas of operations” (DOD, 1999, p.278).

From the higher level, the operational level receives supplementary information and intelligence to execute the mission. Tactical information is coming from the tactical systems or from the higher level (collected by tactical systems from other units). The unit itself transmits also its collected or received information or intelligence to the higher level and/or lower levels (NCW).

The different intelligence bases are not permanently connected to the central bus; p.e. for the projected units. The possibility to communicate with the higher or lower levels does not always exist; therefore just like the C2 system it supports, an intelligence base must be able to function autonomously from the rest. At the moment of reconnection, the exchange of information and intelligence will not be First-In, First-Out (FIFO), but prioritized (time-critical, mission-critical).

The process supporting the creation of intelligence and knowledge should be in the single loop (assessing and expanding knowledge areas). Observations are leading to a decision (and planning) of a certain behavior (act or not act), which will have a certain effect on the environment (Figure 48)

120 In the case of CAS*T also synthesized.

Since the end of the Cold War new types of operations saw the light; examples are Peace Keeping Operations and humanitarian operations. These new types of operations cause also new types of intelligence, or extend the focus onto intelligence that was less important for classical military actions (social, economical, ethical, cultural, religious and so on). Moreover, economical activities with the environment are increasing, which improves the collection of information. As Fuld writes, “Wherever money is exchanged, so is information” (Fuld, 1995, p. 28).

6.5.6. Intelligence and Double Loop Learning

The process supporting the creation of intelligence and knowledge should be in the single loop (assessing and expanding knowledge areas). Observations are leading to a decision (and planning) of a certain behavior (act or not act), which will have a certain effect on the environment (Figure 48).

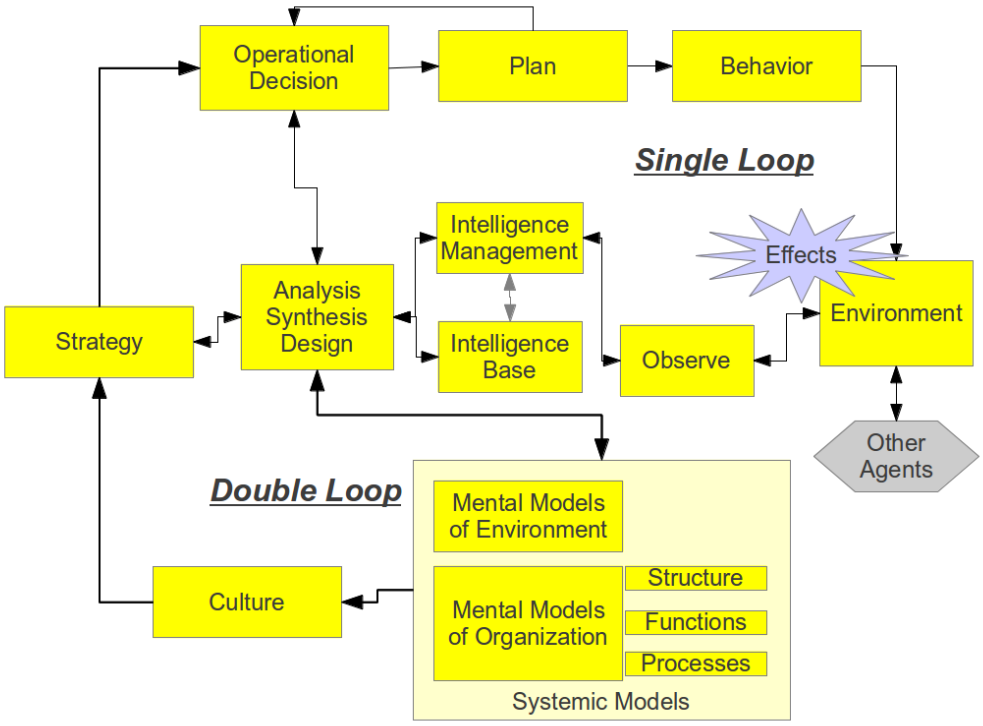

Figure 48: Double Loop and Intelligence Base

During the analysis-synthesis-design step, intelligence can be generated which may cause an update of the mental models of the environment and/or the organization. These changes of the models may imply that culture may have to change and certainly that the strategy has to be adapted which will influence all activities in the single loop.

6.5.7. Conclusion for Int B

The intelligence capability consists of processes. It may not be limited to one part of an organization, on the contrary. We are proposing the Intelligence Base to support the intelligence capability. It consists of:

- A “Facts Base”: to store the information;
- An “Interpreted Information Base”: to store the intelligence;
- An “Unknown Base”: to manage the unknown, which the organization would like to have information about it;

- An “Intelligence Bus”: to connect the different services of the intelligence capabilities;

The architecture chosen are SOA and Cloud Computing (Slabodkin, 2014), which gives the organization the flexibility and the agility to respond quickly to changes and to connect with systems. Thanks to Cloud Computing and under pressure of economy of scale, IC of the USA is moving to a shared service model (Slabodkin, 2014).

This architecture provides the technologies to integrate the Int B with its C2 system, so that the quality and quantity of information (and intelligence) fusion is improved. It fulfills also the needs of projected units, which have to operate autonomously.

Regarding the interconnectivity with other national and international Intelligence Services, a cultural change has to take place (rivalry). With the adoption of the Intelligence Base philosophy, intelligence services can enter into clear agreements, so that among others, governments can effectively fight international terrorism.

As a conclusion, the CAS*T Int B is a strategic ([121]) instrument for the CAS (organization).

For a more in depth discussion we refer to the work of Rabaey and Mercken (2012) for the general concept and Rabaey and Mercken (2013) for a complex adaptive systems-thinking approach.

6.6. CAS*T-loop

With the ACOS Eval example of EIS and Balanced Scorecard (BSC), to be discussed at the end of this chapter, and our discussion on NCW we have shown that technology and culture – and more in general the mental models – must be compatible. This implies firstly that implementing the concept of CAS*T Int B needs to be adopted (and CAS*T in general also) and secondly the new technology must be compatible with the mindset. The mindset has first to change from reductionist thinking to a holistic thinking (CAS*T).

In this context, we will now discuss the CAS*T loop, starting by repeating that CAS (CT) and ST concepts are complementary for open, social (human-made) organizations.

Figure 49 “CAS*T-loop“ is based on single/double loop model (figure 3), OODA, (Figure 42) and the Intelligence Base (Figure 43: Intelligence Base (internal and external sensing), Figure 48: Double Loop and Intelligence Base) and on what follows.

In the single loop an organization makes changes to improve immediate outcomes. In the double loop changes are made either to prevent a problem or to embed a solution. The third loop is focused on ethics (Cram, 2011).

In her paper “Mechanisms to support organizational learning: the integration of action learning tools into multidisciplinary design team practice”, Evers (2004) writes that triple loop learning involves three types of management of the learning process: design management (How?), debate management (What?) and might-right management (Why?). These questions correspond to what Gharajedaghi (2011, p. 33) writes on purposefulness of a system: “To influence the actors in our transactional environment we have to understand why they do what they do.” Of course an organization also must understand why it does what it does. Teams need to become aware of and use all three centers of learning, continually looping among these three questions and functions intelligently and responsibly. Evers (2004) makes reference to Argyris who calls this continuous process ‘multiloop’ learning.

Romme et al. (1999) also reference Argyris: “Double loop learning appears to facilitate the adaptive potential of an organization, but most organizations seem to have great difficulties in actually learning in a double loop manner.” They continue “[T]riple loop learning is about increasing the fullness and deepness of learning about the diversity of issues and dilemmas faced, by linking together all local units of learning in one overall learning infrastructure as well as developing the competences and skills to use this infrastructure. […] Triple loop learning manifests itself in the form of 'collective mindfulness'': members discover how they and their predecessors have facilitated or inhibited learning, and produce new structures and strategies for learning.” (p. 440).([122])

The role of the infrastructure which they mention and which is needed for the triple loop is fulfilled by the Intelligence Base, which facilitates learning and increases the knowledge.

As already mentioned above, Sterman (2010) added mental models to the double loop ([123]). Although he defined a double loopback between (information) feedback and the mental models, Rabaey (2012b) esteems that this double loopback can be the cause of an (increasing) gap between the models and the awareness (culture, strategy) of the organization, so that loopback is not drawn (figure 3) ([124]). This is however not the case in figure 49, because the connection is not made between feedback and the mental

121 Here in the meaning of essential for the survival of the CAS (organization).

122 Tosey et al. (2012) note that this type of third learning loop has little theoretical rooting.

123 Even more confusing, Romme et al. (1999, p. 440) write that triple loop learning is more concerned with structural patterns (mental maps, facilitating structures, etc.), thus mental models, which in our case based on OODA and Sterman (2010) is double loop learning

124 Based on the one hand on the philosophy of OODA, where hypotheses are tested and the feedback comes as observation back into the system, and on the other hand on the fact that mental models are the highest ranked in the hierarchy of leverage points.

models, but feed forward and feedback exist between the “Analysis-Synthesis-Design” function and the mental models. So, if necessary the culture and/or the (grand) strategy will be adapted. The (grand) strategy can be directly adapted without having to change the culture and/or fundamentally change the mental models. Therefore a new allocation of resources is possible without changing fundamentally the structure (mental models of the organization).

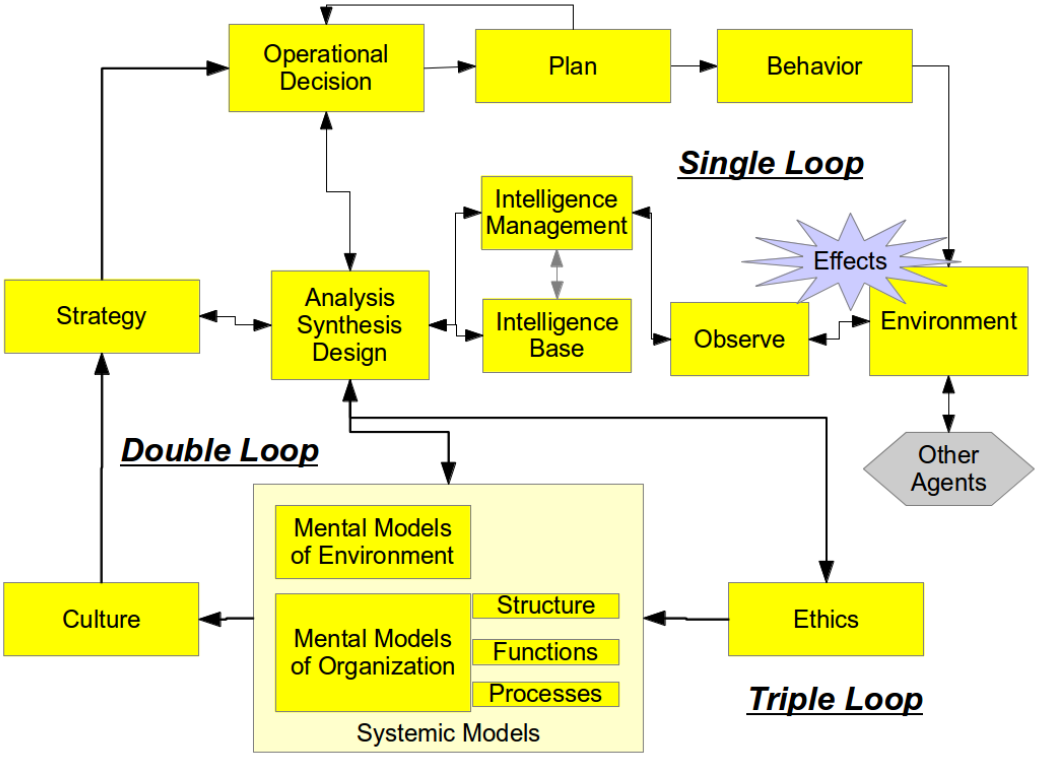

Figure 49: Triple Loop

For the above mentioned reasons a triple-loop (figure 49) is not necessary, so figure 48 will be the representation of the CAS*T-loop. Moreover the domains mentioned in the Cynefin framework will be monitored and will be used in both mental models (environment / external observation) and organization (internal introspection)) so that the organization can use the right set of management tools. Of course, by using the OODA of John Boyd, the organization will always use the right management method and related tools.

Snowden (2014) reminds us to the origin of the word “management” by referring Williams ([125]) in his foreword in the book “A Systemic Perspective to Managing Complexity with Enterprise Architecture” in which Rabaey (2014) proposed his original approach to EA, namely CAS*T-EA (see below): “*The English verb “to manage” was originally derived from the Italian maneggiare, meaning to handle and train horses.* [...] *The emphasis is on learning with, abiding with, adapting to, respecting, and working with another complex entity: the horse and rider as co-evolving brambles in a wider thicket of social traditions surrounding beauty and form. Around the early 18th century, this original meaning merged with the French term ménage, or household, making it easier to adapt the meaning of the combined term manage to the metaphor of the obedient machine, to the corridors of power, and to the actions of controlling and directing* ” Regarding organizations he states “A complex system is nonlinear in nature; it has dispositions, but is not causal in the conventional sense of that word; the same thing only happens again the same way twice by accident. Such systems are modulated by constraints and interventions as a result of which patterns of meaning emerge over time. The metaphor is that of ecology not a machine . [...] We cannot afford the high level of constraint that has characterized the last few decades, but neither can we

125 Williams, R. (1983). Keywords: A vocabulary of culture and society. London: Fontanta Press.

descend into anarchy. We need to think of management and by implication design in the context of the original maneggiare not the command and control capabilities of a machine."

With this thought, we may conclude that a new way of managing organizations, thus CAS, is needed. A non-prescriptive ST can provide managers and leaders more correct insights and emergent strategies to evolve and grow rather than survive in this constantly changing environment.

6.7. Case: Evaluation Information System (EIS)

In what follows we will show in which context Int B could have been implemented, and how the culture has been the reason why it has never been implemented.

6.7.1. New Defense structure

In 2002 the Ministry of Defense of Belgium was transformed so that all the resource managers (like human resources (HR)) of every staff unit of the armed force and the Joint Staff were transferred to the respective resource domains (in the case of human resources to General Direction Human Resources (HR)). The Army has changed into Land Component, Air Force into Air Component, Navy into Naval Component and the Medical Service into Medical Component (figure 50).

Since there was no EA, the transformation took longer than foreseen, and in 2015 the applications are still in transformation or ready to be replaced by another software. If an EA had existed, this could have been prevented.

Another issue was the culture change of the personnel working in the processes of the resources and of those who needed to leave his/her armed force to go to a newly formed resource domain. Although there is no explicit link between (the conventional) EA and the culture of an organization, every change should take the resistance into account (Change management).

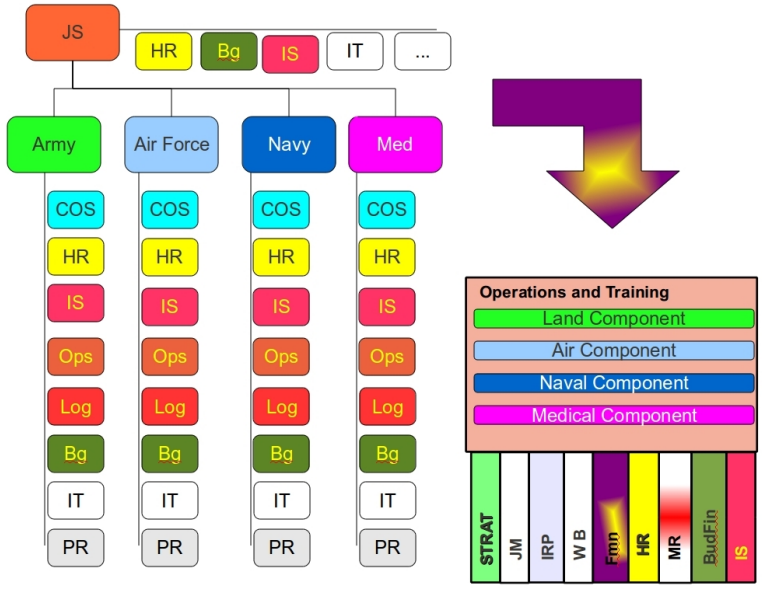

Figure 50: Belgian Ministry of Defense

6.7.2. An integrated framework

The Assistant Chief of Staff Evaluation (ACOS Eval) was a new staff department responsible for the evaluation of the functioning of the Belgian Defense. Its main missions were to measure the performance of the other departments and to help them improve their functioning. I was chief of the Division Information Management and System Manager of ACOS Eval.

A set of management tools was selected (Balanced Scorecard (BSC)([126]), Self-assessment (European Foundation for Quality Management (EFQM)), Business Process Management (BPM)) and introduced in the other departments.

Originally BPM was not one of the tools, but we could convince ACOS Eval to adopt BPM, based on the fact

126 In the next case we discuss why the BSC was not a success due to cultural differences.

that we needed

- to know where we could place indicators (BSC);
- to detect bottle-necks and leverage points (optimizing);
- to know where data of the information systems are used in the business processes;
- BPM as input for EFQM, which in turn could lead to optimization of these processes.

Our proposal was to have a top-down and bottom-up approach.

To support the functioning of ACOS Eval, we conceived as system manager of ACOS Eval the Evaluation Information System (EIS). Figure 51 depicts EIS which has mainly three big components:

- Management Intelligence
- Business Management tools (as mentioned above) in the portal
- Social Network Portal for knowledge sharing and homologation of systems

The clients are the Chief of Defense (CHOD), other departments and the lower level management for their decision making and functioning, thus a typical uni-minded view with a detailed C2 structure.

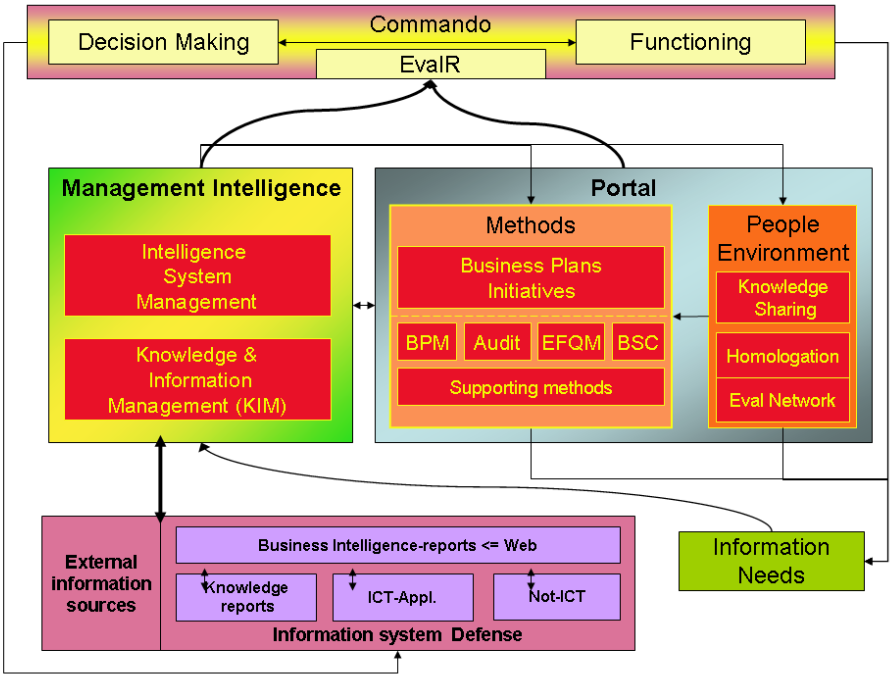

Figure 51: ACOS Eval Information System - Concept

The sources of the EIS are:

- External information sources (open source, NATO, EU, etc.)
- Internal information systems of the Belgian Defense with above a business intelligence layer.

The Management Intelligence provided management with intelligence and/or knowledge to improve decision making and functioning of their departments.

6.7.3. No need for Knowledge Management (KM)

So intelligence has two outputs, one is for decision making and the other is to create knowledge. However there was no concept of knowledge management. For that reason we became member of the KM community of the Federal Public Service Personnel & Organization (KM-net). Although reports and documentation on knowledge management have been transmitted to the other ACOS and DG (General Directors), there was no interest for KM, mainly because the different ACOS and DG were still struggling with the integration of the information systems in the different functional (thus not business) domains.

6.7.4. No need for EA

The integration of these different information systems had a fundamental problem: the tower of Babel. Every force had another vocabulary, way of working, culture etc. It was not a merge of strategy so that the whole would be optimized despite the sub-optimization of some forces transformed into components, but it was a battle between mainly the two biggest forces: the Army and the Air Force. This was the driver of our two publications on *Business Integration*: Classification of IT-integration Based on Business Collaboration (Rabaey et al., 2005a), Holistic Approach to Align ICT Capabilities with Business Integration (Rabaey et al., 2007) and Business Process Embedded Information Systems (BPEIS) For Flexibility and Adaptability (Rabaey et al., 2006a).

We are referring to the tower of Babel because there was not even a consensus on terms. Moreover the business context was very different. For instance ILIAS was the logistic information system of the Belgian Air Force (BAF). If BAF had projected units like in Italy for the Yugoslavian wars then a data communication is permanently available. This was and is not the case for the projected units of the Army and the Medical Service and this for tactical and operational reasons. We had a logistic information system that could work without a permanent connection with the main server in Belgium. In this context, although we were not really focusing on CAS and ST but on NCW, we proposed to have more decentralized, autonomous but interdependent information systems to give (business) units more flexibility and agility to cope with local issues. Of course there had to be a shared vision (grand strategy), that would be translated into EA (added with KM and BPEIS) in a SOA technology context.

A second problem was that ILIAS was conceived for aircrafts. Every item of an aircraft like the F-16 was cataloged, and did never change (although different roles could be attributed to the F-16, the configurations were in the tree-structure). For the Medical Service we had different sets of medication and medical equipment that was changing over time, so here again ILIAS at its stage of 2002 could not help us. Nevertheless ILIAS was “chosen” to be the logistic information system for all defense.

At that time, a column in a table of ILIAS could contain more than one item at the same time, so the normalization and adaptation of the application still had to start. An internal report of Defense showed that the SAP defense-implementation would be cheaper and be quicker available for whole of Belgian Defense, and exchange/collaboration with NATO member-states would be more efficient.

In the context of EIS we needed a blueprint of all information systems and the context in which these information systems were operating (BPM), the obvious solution was EA, but that would have shown the inefficiency and lack of effective use of resources. So the answer was “No Time”.

We are not an advocate of ERP systems, certainly not in the CAS*T-philosophy were organizations are in the complex Cynefin space, but it was better to adopt to SAP than having to develop an own BAF version of ERP. SAP could solve a lot of problems because it was a working system even on submarines. Not that we have any submarines in Belgian Defense, but it is a very good example of a projected unit that have to work autonomously from the main server.

Later, due to the many problems, other ACOS and DG were questioning the relevancy of ILIAS. A workgroup was formed to study other possibilities. The result was the advice to implement an Enterprise Service Bus (ESB) (based on our research) so that particular solutions (as a matter of fact BPEIS) could continue to exist and that these applications would be wrapped in web services. The study has been transmitted via the CHOD to the Minister of Defense (MOD), however the report has never reached MOD ([127]).

Of course there is the trade-off between adapting SAP to the own organization, or adapting the organization to SAP, but anyway the whole defense had to adapt to the BAF logistic.

6.7.5. Big Brother is watching you

In the period of 2002 – 2003 we had launched requests for information on the EVAL framework (later EIS). Our architecture was composed in layers

- BPM framework
- Assessment framework (BSC and EFQM)
- Data warehouse for Defense
- An ESB preferably based on middleware (java and web services) thus a SOA-like concept ([128])

Big consultancy companies as PWC, IBM, KPMG, CSC amongst others were very much interested and could give working solutions for the budget we had. The average implementation and roll-out (Self-

127 Meanwhile the previous Director General Material became CHOD. He was the former Head of the Air Force Logistics and the sponsor of ILIAS.

128 The term “Service Oriented Architecture” or “SOA” was first coined by Gartner analyst Yefim V. Natis in his research paper published on April 12, 1996. In it, he defined SOA as “a software architecture that starts with an interface definition and builds the entire application topology as a topology of interfaces, interface implementations and interface calls”. SOA didn’t get much traction until 2001 when web services technology became widely adopted. In many respects, web services gave SOA the foundation it needed to become widely accepted (Safari SOA, n.d.).

assessment, BPM, BSC, data warehouse, infrastructure ESB) would have taken two and a half years.

Representatives of all ACOS and DG were present at the information sessions, however it was the General Director Material Resources – Communication and Information Systems (MR CIS) who had a problem that another ACOS or DG would be the functional boss of the data warehouse. MR CIS would implement with his team his own Defense data warehouse. When I left Defense in 2012 there was no data warehouse or ESB.

MR CIS used the budget of EIS to buy and implement Oracle and ILIAS on an IBM mainframe, although every specialist warned that it would not work. It did not work and EIS has never been implemented. Not surprisingly, for (internal) political reasons the concept of ACOS Eval has been changed into an Internal Audit Department in 2007.

6.8. Case: Tableau de bord is not BSC

6.8.1. Problem Statement

As the system manager of the Assistant Chief of Staff Evaluation, I have noticed that the introduction of the BSC in Defense was not completely a success due to cultural reasons. In some areas there was success but in others, there was not.

Central to a good understanding of the situation is that at that moment the new Chief Of Defense (CHOD) General August Van Daele asked for a French *Tableau de bord* (Dashboard) system and not for our Anglo-Saxon BSC ([129]) as conceived by the workgroup Evaluation and implemented by ACOS Eval.

General Van Daele was a Flemish engineer though -Flemish (Dutch) has the same roots as English- and he made his career in logistics of the F16 aircraft, so he was constantly in contact with Anglo-Saxon (US) business, technical and logistic people.

So our fundamental question was: “Does the Balanced Scorecard fit the culture of the organization?” Or put more generally, “Does a management technique fit the culture of the organization?”

6.8.2. The Techniques

6.8.2.1. BSC

“A Balanced Scorecard monitors the performance of all or part of an organization, towards strategic or operational goals. It uses financial and non-financial performance measures […] to highlight areas where the organization is failing to do what is required or was expected.” (2GC, 2014).

Anno 2002 we were using the second generation of BSC (four perspectives and strategy map). The strategic objectives were assessed or monitored through Key Performance Indicators (KPI).

There was a cascade of KPI: lower units (BSC) could well create their own KPIs, but they were also required to provide data to the higher levels (KPI).

Some levels had problems to determine whether to find accurate and right data for KPI and / or other levels had problems to establish the BSC itself (utility or concept). The latter was mostly due to the feeling of "Big Brother is watching you", certainly if generals or colonels had to deliver data or information to the higher level where the responsible officer was a lower in rank.

Otherwise stated, there were, respectively, information-technical problems and cultural issues.

In addition, Corporater (n.d.) states that the challenge lays in the implementation of the BSC, and is of a cultural nature. Kaplan and Norton pay little attention to the cultural challenges of implementing a BSC. Both being engineers, they are much less au fait with the cultural building blocks of an organization than they are the structural. Most BSC programmes fail during the implementation phase, which to Corporater (n.d.) is typically the result of cultural factors. More than anything else, a BSC programme is about creating the right mindset. Creating a strategic mindset is not a structural or process challenge, it is a cultural challenge ([130]).

6.8.2.2. Tableau de bord

Tableau de bord is a dashboard. Its functions are (Expert-Comptable, 2014):

- measuring performance against objectives: it highlights the physical results (quantity manufactured, sold, etc.) or financial (revenue, margin result) compared to the goals and it highlights differences;
- Supporting the decisions on corrective actions to address the identified gaps;
- Informing and motivating management. It is used to communicate internally on the performance obtained, it stimulates teams in attaining their goals.

129 His predecessor Admiral Willy Herteleer had no problems with the Anglo-Saxon BSC. Just like me, Admiral Herteleer holds a degree in Social and Military Sciences, while General Van Daele holds a degree of *polytechnicien*.

130 We would like to stress that culture is a derivate of the mental models.

At the level of the CHOD, there is not that much difference between BSC and tableau de bord. Nevertheless General Van Daele rejected the BSC for the tableau de bord.

6.8.3. France is not the USA

6.8.3.1. Political and philosophical differences

We discusses the underlying political and philosophical principles of the American and French revolutions Rabaey (2013). Basically it is John Locke versus Jean-Jacques Rousseau.

The state philosophy of John Locke is based on the fact that the State receives its power from the people to serve the people. If the State abuses this power then the people have the right to take back that power. The people have the full sovereignty and for that reason the people have the right to revolt against that State (The Right of Revolution). In his work "Two Treatises of Government" Locke states that people basically have the right to live their lives freely and undisturbed , and that the only limitation of this freedom is the obligation to give others the same freedom, which in fact amounts to the basis of the Enlightenment. This philosophy was taken over by Thomas Jefferson in the American Revolution and Declaration of Independence: the free man can not be forced by the will of another.

Very different was the situation with Rousseau, although he was influenced by Locke (Social Contract). He found that the importance of the individual was entirely subordinate to the interests of the whole group. The "General Will" was the will of the State, not the will of the people and every citizen should abide by the general interest, otherwise he would be forced to do so. The result was that the undercurrent of the French Revolution was not based on the self-determination of free citizens, but on the collective will of the State. Whereas Locke emphasized the free man (without coercion), this was just the opposite for Rousseau: the coercion of the State was an essential element of society, which in fact amounted to the totalitarian power of the State. It is the same State who determines the public interest (General Will) who also ensures compliance.

Both revolutions gave birth to democracy, however the approaches to the citizens are completely different. This is a good example of the implicit mental models. Making them explicit, give people insights in the different approaches of the same “term”.

This difference of philosophies are also shedding a better light on the business (education) system in both countries.

6.8.3.2. A difference in ideology

Bourguignon et al. (2001; 2004) show that culture plays an important role in the acceptance or non-acceptance of the BSC. Their study is about the “non-success” of the BSC in France([131]), while the French CEO's and managers are more in favor of their “own” French “tableau de bord”. The Belgian CHOD asked explicitly for a “*tableau de bord opérationnel*”. The question of course is: *Can there be a relationship between the French culture and the Belgian Defense culture?*

Bourguignon et al. (2004) suggest that the BSC and the *tableau de bord*, respectively, bear the marks of the respective ideologies of these two countries. By ideology Bourguignon et al. (2004) understand beliefs, knowledge and ideas serving to maintain social order, i.e., to construct hierarchies, to make people obey as well as to cope with uncertainty ([132]). They claim that any society has its own distinctive ideology, i.e., ideologies differ among capitalist societies, and that the distinctive ideology of a society is embedded in the rules and methods used for the purposes of that society’s collective action. So Locke's philosophy will generate other rules and implement another social order than Rousseau's philosophy.

Bourguignon et al. (2004) argue that management methods are tools contributing to constructing hierarchies, making people obey and coping with uncertainty. Furthermore these management tools rely on implicit ideas about how to create social order([133]). It is logic that the unique ideology of a given society is embedded in the management methods created and developed in local organizations, which implies that the ideological assumptions of a management method transferred from one place to another may be more or less coherent with the ideology of the new place, but the transferred method may subvert the existing social order, which may explain local resistance to the technique.

This explains not only why the BSC in general was not a success in the Belgian Defense, but are there any reasons why the culture of the Belgian Defense (at least the top) would be similar to the French culture?

131 In French it is called “Tableau de bord prospectif”

132 “Implicitly it relies on individual, more or less conscious, cognitive models which are socially learned. Similarly to language, however, the ideology of a society can only be imperfectly represented within the mind of any given individual and will be represented in different ways in different individuals. We do not assume ideology to have any external objective reality like the physical world; growing up in a society, however, people accommodate their cognitive schemas in accordance with the social knowledge, beliefs and ideas of that society: the local ideology shapes their individual cognitive models in a powerful way. Consequently, we may assume that the ideology underlying a social order differs from place to place and, hence, that societies, organizations and social groups may have different ideologies. Thus, beliefs regarding social order, i.e., ideology, are locally anchored” ([Bourguignon 2004], p. 111)

133 Which Bourguignon et al. (2004) refer to as the ideological assumptions of management methods.

Regarding the American system, Bourguignon et al. (2004) note that fair treatment of the individual is generally associated with

- appropriate rewards of a person's contribution at work;
- the idea of everybody being treated equally.

So in the US, people who contribute are supposed to be fairly rewarded and therefore judgment should be based on well-established facts and not on the opinions of authorities.

"Where the fair contract rules American society, the principle of honor rules in France: everyone belongs to a social group with specific obligations and privileges distinct from those of other groups. [...] In ancient France, a person's place in the hierarchical social structure was a question of birth. Today it is a question of education." The new nobilities are created through the education system i.e. the "Grandes Ecoles" (Bourguignon et al., 2004, p. 123).

Three types of grandes écoles exist:

- École Nationale d'Aministration (ENA) for public administration;
- Grandes Écoles de Commerce;
- Grandes Écoles d'Ingénieurs.

In the last type, the most highly ranked is the "Ecole Polytechnique (which dates back to 1794 and still has military status although almost none of the students goes on to a military career)".

The reason of this phenomenon is that after the French Revolution, the ancient aristocracy by birth has been replaced by an aristocracy of talents. This educational system leads to a title which only a select group of institutions is allowed to confer and, consequently, to a social membership and the career is guaranteed. So, for anyone graduating from a Grande École, a good professional position is generally guaranteed and the career will generally depend on the ranking and fame of the institution ([134])([135]).

6.8.3.3. BSC is ideological not correct in France

As a consequence, "[t]his low emphasis on management education and the fact that French companies are managed by engineers with little or no education in management implies a relative lack of a management profession driving the diffusion of management methods. The lack of interest in management methods seems understandable when one considers that, in France, the role which management devices play in the United States is handled by the social hierarchy, which is based on honor and reinforced by the education and recruitment systems. In France, social hierarchies and power depend on education rather than on performance, and the way in which social hierarchies are created in that country explains why decentralization and subsequent financial control have not gained the strong position there which they enjoy in the United States." (Bourguignon et al., 2004, p.127).

In this context, BSC is not consistent with French ideology. It creates a hierarchy through performance measurements and rewards, which is atypical in France with a society based on honor, rank and privilege. "It should also be noted that implementing the routines of the balanced scorecard in a French company will probably not reduce the feeling of uncertainty as it reduces self-determination. Thus the generic assumption of causality made in the balanced scorecard, the rational deployment process and the existence of an underlying strategic concept may create a defensive attitude among French employees, which would lead them not to obey. In addition, the limited institutional support of the balanced scorecard in France means that its implementation does not legitimate French managers." (Bourguignon et al., 2004, pp. 127-128)

6.8.4. Belgian Royal Military Academy (RMA)

Regarding the system of Belgian military education (of officers), RMA has its roots in the French Polytechnique educational system ([136]). The first Belgian King Leopold I, asked the French Lieutenant-Colonel, later Lieutenant-General J. Chapelié to found a military academy (Koninklijke Militaire School – Ecole Royale Militaire). General Chapelié graduated from the Ecole Polytechnique, which stood model for the Belgian Military Academy (February 7th, 1834). The first sessions were only for engineers (Artillery, Genie). In 1841 came the first promotion of "A*rmes Simples*" to form officers of the Infantry and Cavalry ([137]). The name already of simple weapons shows the difference in esteem between "Armes Simples" and

134 In 1993, 50% of the 200 most influential French managers came from ENA or Ecole Polytechnique while only 10% came from business schools, 70% of the latter having been educated at HEC. Graduates from business schools mostly hold jobs at the level just below the top management. It is remarkable that most top managers have not received a management-oriented education and that, instead, they come from the most prestigious educational institutions." (Bourguinon et al., 2004, p. 125).

135 To be noted, a virtual circle of the "status" of management an management methods exists in the USA. A MBA degree from prestigious business schools may lead directly to high-ranking management positions, but must of the new management techniques taught in these business schools are coming from business people holding these degrees of MBA. (Bourguinon et al. 2004, p 121). This may also be the case in some military environments.

136 Source: RMA(1984)

137 This is now called "Master in Social and Military Sciences" (SSMW). In the numbering of the sessions , for the same

“Polytechnique” although the most important fighting capabilities were Infantry and Cavalry.

The influence of General Chapelié on the culture of the Belgian Armed Forces was and still is very important. He introduced the French educational nobilities (Ecole Polytechnique) during his command of the Royal Military Academy from 1834 until 1863, thus during 29 years ([138]).

Since RMA was a relatively closed educational system, there has been not much external influence to change this culture. Polytechniciens have a higher status by their studies ([139]) and therefore have relatively more top functions than the rest of the officers (certainly in the non-technical domains). Thus the Belgian military education of officers has the same characteristics as the French educational system in general.

Since the BSC is not accepted in the French culture, because BSC is not coherent with the French ideology, chances are high that BSC will neither be accepted by people graduating from French educational influenced institutes.

Based on findings of the research of Bourguignon et al. (2001; 2004), we can conclude that French roots of the Royal Military Academy, and thus the military thinking and ideology, is not favorable for implementing the (American) BSC in Defense, as such. That is why a Flemish engineer specialist in F-16 logistics (USA) but studied in the Belgian Royal Military Academy had chosen to employ French management techniques over typical Anglo-Saxon.

So, mental models and culture are the causes why culturally management techniques are accepted or rejected (See also 3.2 Network-Centric Warfare (NCW) and 5.3.4 CAS*T Twelve Levels of LP).This example of BSC shows that it is not only essential to know the mental models but also the evolution of these mental models (similar to path dependence) which we have shown in our discussions on CAS and the OODA-loop of John Boyd, especially in the Orient phase of OODA (section 3.3).

6.9. Conclusions on CAS*T Int B

6.9.1. NCB and CKO

Operations need nowadays more and more knowledge to be successful. We can call them Coherent Knowledge-bound Operations (CKO). CKO do not only have their application in the military (NCW) but also in business (NCB).

Three important functions are:

- improving and using knowledge of the members;
- improving situational awareness (Cynefin);
- OODA-cycle (complex decision-making).

In the context of adaptability, self-organization is a conditio sine qua non for an organization to evolve, to survive. The situational awareness is the driver of the intelligence cycle. The organization needs information about its environment so that it can learn (improve knowledge) and decide to adapt (its strategy) and if necessary its mental models.

We have discussed the different states of knowledge and information (known/unknown). Remark that we used awareness and unawareness in the case of Cynefin.

*6.9.2. CAS*T Int B*

The next topic was our concept of CAS*T Intelligence Base. It is an information system supporting the intelligence cycle. It takes a central place in the single and double loop learning of the CAS (organization) (figure 48 *Double Loop and Intelligence Base*).

Originally conceived for military and political conflicts, we have shown how multiple Int B can be connected to each other and to C2-systems (certainly in the context of NCW). Int B can also be used in business. But as with the implementation of each concept, it must be compatible with the culture of the organization (thus mental models). We have discussed the Belgian Defense EIS as an example of an IS that was supporting culturally not accepted management techniques and concepts.

The triple-loop learning has been discussed. We came to the conclusion that ethics is derived from the mental models, so the triple-loop learning is not needed.

We have also concluded that a new way of managing organizations is needed. A non-prescriptive ST can provide managers and leaders more correct insights and emergent strategies to evolve and grow rather

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academical year, the promotion number of the polytechnicians (POL) is 15 higher than the for the SSMW, so 140 promotion SSMW corresponds to 155 promotion POL.

138 RMA (1984, p. 427) lists the commanders of the Military Academy from 1834 until 1984. From the 25 commanders, only one general graduated from the promotion “Infantry and Cavalry”: Lieutenant-General Van Emelen was commander of the Royal Military Academy (1926-1927). The successor of Lieutenant-General Chapelié , Lieutenant-General Nerenburger was neither a polytechnician, he graduated form the French Ecole Spéciale Militaire de Saint Cyr, but still he was French.

139 Except for the medical doctors.

than survive in this constantly changing environment, which is the aim of CAS*T.

The main conclusion is the conceptual symbiosis between Snowden's Cynefin framework and CAS*T Int B. Knowledge can be created in different ways following the space one is in. Our original concept of CAS*T Int B reflects the two characteristics of knowledge in the third age:

- It is a thing: knowledge base, even more facts base and unknown base;
- It is a flow: the whole intelligence process in CAS*T Int B.

And related to the two previous ages, CAS*T Int B supports decision making and the creation of knowledge and content. The Cynefin framework guides the organization in its situational awareness not only related to itself (Cynefin is about self-awareness) but also to explore the space and time continuum outside its own environment (based on our definition of strategy and NCW concept).

6.9.3. Findings from the cases EIS and BSC

6.9.3.1. The right philosophy

EIS was based on a holistic approach of the Military business, but in particular the resources managers (Material Resources DG MR, Human Resources DG HR and Budget-Finances DG BudFin) were only interested in the optimization of their resources accompanied with tons of regulations and procedures. The architect (in contradiction to the one of Ackoff (1994a)) has to optimize the rooms, not the house. CT and ST would have been of great value to show that all these uncoordinated rules were increasing unnecessarily the (detail) complexity of the military business.

Moreover, a captain of a ship had to consult one or more information systems in every stovepipe (resources) domain to check if he could leave with his ship and crew. Since these stovepipes were a fact, and by definition there was no operational integration (see Rabaey et al,. 2007), we proposed an ESB. However due to a lack of shared vision (ACOS Eval had to ask CHOD to harmonize at least the sectoral (stovepipe) plans) the agents were confronted with contradicting rules, resulting in a very slow working CAS. The whole was certainly not more than the sum of its parts, on the contrary.

The choice of management tools like the BSC has been made without a thorough study of the impact of the culture on the implementation of these tools. We were definitely not in the simple Cynefin space in which we have the best practice. Moreover because the restructuring was more based on the results of battles between the different forces, and since there was no single winner, Defense was certainly in the unordered Cynefin domains, if not in the disordered ([140]).

6.9.3.2. Legal entities and multi-minded view

For an organization as Defense, we do not see the realization a fully multi-minded organization, rather an in-between form, where the shared vision is coming from a nation's politics (democratically elected) and where the soldiers are citizens of that nation. So the objectives (attained by operations) and restrictions are set by the government and the armed forces will operate in a multi-minded way (NCW). Here we can make an analogy with entities like companies.

As a matter of fact, there are two ways of evolution. The first type of evolution is that an existing company is shifting from a uni-minded form towards a multi-minded form, where the company is a whole in the sense of CAS*T. In this case there will still be a part of the whole that is directing the activities of the whole and its parts thus imposing a shared vision.

The second type of evolution is that entities are forming a new entity, a new whole. The shared vision is a consensus of all agents/parts of the new whole.

140 Defense was working on basis of the informal human relations (the shadow system).

7. Conclusions and Further Research

7.1 Overview

7.1.1 Main idea

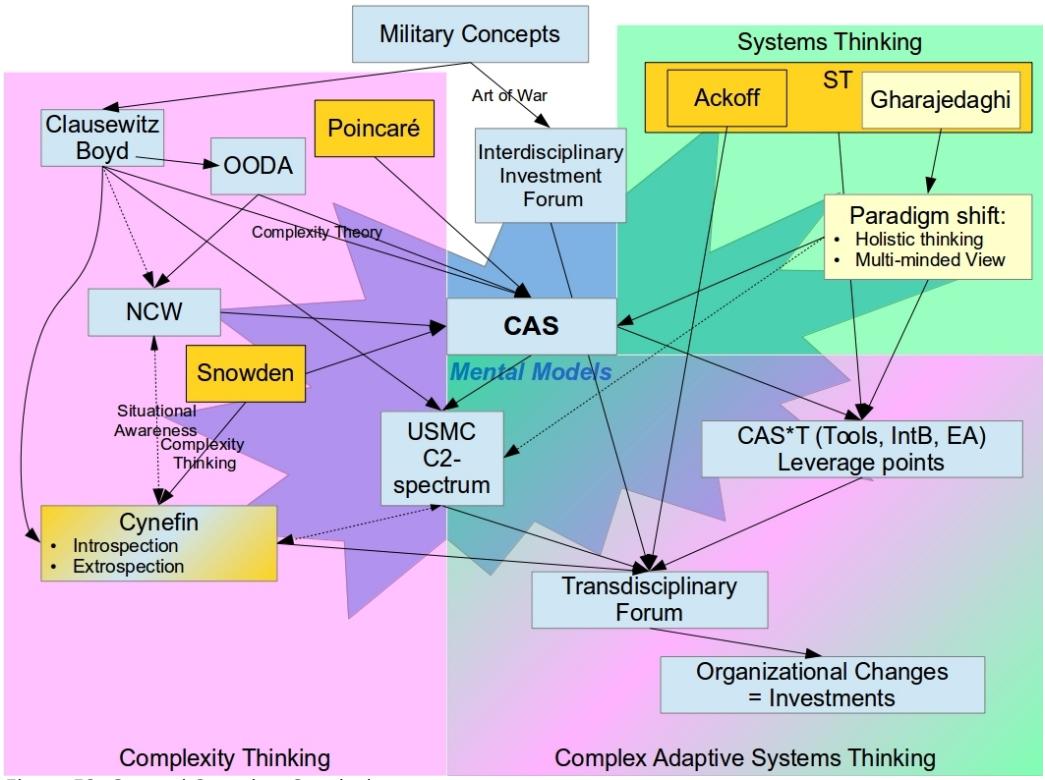

Figure 52: General Overview Conclusions

Our original research objective was to apply military concepts and way of thinking (like von Clausewitz, Boyd, NCW, Art of War) to develop a general framework for strategic IT-investments for all kinds of organizations. In our previous work experience we developed an interdisciplinary investment forum based on the Belgian Art of War (Rabaey, et al., 2004), but it brought us quickly in the domain of complex systems (Poincaré) and CAS, because war is a CAS, and the fighting parties are CAS (von Clausewitz, Boyd) (figure Figure). In an almost unrestricted context of war, everything can happen and the future is unpredictable, but this is also the case in our hypercompetitive world of today, characterized by the compression of time and space, resulting in an increased number of agents interacting with each other. Hence we must be aware of the complex environment in which investments in general, and IT-investments in particular have to be decided and executed (long term and medium term).

7.1.2 Research questions

The first group of research questions dealt with the relevance of military theories (von Clausewitz, Boyd's OODA, USMC C2 spectrum and NCW) for a contemporary company. We believe we have shown the answer to these questions is clearly affirmative.

The second major research question was whether it is good idea to combine Complexity Thinking (CxT) (the left, pink side of figure Figure) and Systems Thinking (ST)(the green, right upper part) to study CAS. We believe ST is necessary in addition to CxT because ST focuses also on the design of human-made CAS (based on restrictions imposed by humans in the organization and in the environment) and hence proposed a CAS*T-framework (the pink-green, right lower part).

In what follows we will answer these questions more in detail.

7.2 Organizations as CAS

7.2.1 Organization

Humans are social beings, so they will form socio-groups, in which a human will interact with other humans in a CAS (environment). When they have a shared vision they can form an organization. A man-made organization is a set of:

- agents;
- an environment;
- interactions – formal as well as informal – within and between the two above categories;
- one or more purposes (shared goals);
- and that is capable of learning (thus adapting).

An organization may consist of other organizations (recursion, system-of-systems). An organization will behave in its environment following its strategy. We have defined strategy as the dynamic behavior of the organization and its agents as a result of the will to act with its means to attain its self-chosen goals in its environment.

To execute this strategy, the organization may choose amongst different forms (Gharajedaghi, 2011):

- mindless (it cannot evolve from itself, so we do not consider this in this dissertation);
- uni-minded (a hierarchal organization with the top deciding everything – biological with deciding head and executing body);
- multi-minded (a networked organization; sociocultural).

7.2.2 CAS

All CAS have common characteristics, the most important are:

- Emergence: Interactions among agents in CAS may lead to emerging global (or system-wide) properties that are very different from the behavior of individual agents.
- Adaptive Self-Organization: CAS tend to adapt to their environments and to self-organize. Rather than tending toward disorder or entropy, CAS spontaneously crystallize into more highly ordered states.
- Nonlinear: disproportional consequences.
- Lack of an Equilibrium: CAS adjust and readjust at many interactive time scales. A consequence is that due to the internal and external dynamics (changes), a CAS operates under conditions far from equilibrium, which means that there is continual change and response to the constant flow of energy in the system.
- Large number of elements with rich interactions: the large number of elements is more related to CAS as an environment. CAS (organization) may have internally less agents, but if the interactions amongst them are rich (feedback, feedforward) and many then it can be very complex.

7.3 Research Results

7.3.1 CAS*T

Complexity Thinking (CxT) and Systems Thinking (ST) handle CAS. Is ST necessary in addition to CxT because ST focuses also on the design of human-made CAS (based on restrictions imposed by humans in the organization and in the environment). Hence CAS*T-framework?

An obstacle to solve problems is reductionist thinking, certainly in the case of a CAS where the whole is more than the sum of its parts. Systems Thinking (ST) (Gharajedaghi, Ackoff)(figure Figure) and Complexity Thinking (CxT) (Snowden) are more appropriate to handle complex situations (organization and/or environment). Since we focus on men-made organizations, we deal with two types of CAS, the CAS (organization) as a legal entity imposed by CAS (environment), the second type. Therefore we are using ST to design (restrictions for) CAS (organization). The idea of CAS*T (Complex Adaptive Systems Thinking) is making the bridge between two distinct concepts: CxT and ST.

Since complexity is due to the inability of one language or perspective to describe all the properties of the system an organization is observing, an organization should use more than one language and/or perspective to solve its issues. Therefore a transdisciplinary approach is needed because transdisciplinary inquiry tends to focus on the inquiry or issue itself. A transdisciplinary approach focuses on an issue within and beyond discipline boundaries with the possibility of new perspectives (Ackoff, 1999).

7.3.2 Karl von Clausewitz: relevance

Karl von Clausewitz wrote *On War* in the beginning of the 19th century. Since he is still influencing, which elements are timeless and are still relevant for contemporary organizations (strategy, investments)?

Based on the theories of Henri Poincaré (la.te 19th century), Beyerchen (1992) shows that already in the beginning of the 19th century Karl von Clausewitz was describing war as a CAS, though using a contemporary vocabulary.

In the discussion on *Eine wunderliche Dreifaltigkeit* that proved the unpredictability of war, we noted also that due to the (always scarce financial and other) resources and the anticipative interactions, it is appropriate to decide on investments (=organizational changes) in shorter, but "inter-coherent" cycles. This corresponds to emergent strategy.

Another point is that the engineering (scientific management) approach is prescriptive (Jomini) and therefore it is not suited for CAS (organization), for which the past explains the actual configuration of the CAS (organization). A descriptive (von Clausewitz) ecological approach is ideal to learn from the past. In this case, human ecology is the relationship between human groups and their physical and socio-economical environment. Descriptive approaches support organic evolution in a constantly changing environment, which is hardly feasible with prescriptive approaches.

7.3.3 John Boyd: OODA for organizations

John Boyd developed an individual complex decision-making framework OODA (Observe-Orient-Decide-Act). Can this OODA be used in an organizational decision-making framework for IT, especially CAS organizations?

John Boyd developed the OODA-loop which represents an individual decision-making process. We observe, and we place the observations in its context and evaluate what the implications for us are (orient). Then we make decisions (decide) how we will behave (act). Our behavior will have effects in our environment which we will observe (the circle is closed).

For a CAS (organization) to survive in a CAS (environment), it needs to be aware constantly of its situation. It needs to observe and interpret the (observed) signals coming from the environment (pulled and/or pushed) to create intelligence, which it will use to make decisions and to increase and update its knowledge.

However OODA is not just a cycle. It has a lot of feedbacks and feedforwards and it is suited to handle complex situations (it even includes intuition). The most important phase is "Orient" which – although not mentioned explicitly by Boyd – holds the mental models. They determine not only how we decide but also how we observe and act (implicit guidance and control), thus also how we are making decisions on investments, thus also IT-investments.

But people see it only through the components of the orient-phase: genetic heritage (CAS->structure), analysis-synthesis (extended with design because of ST), previous experience (CAS->knowledge), cultural tradition (CAS->culture) and of course the new information. Here we see also the importance of the past (evolution) because culture, knowledge and structure are results of past decisions (intractability and path dependence) and even how we think (analysis-synthesis-design) is also based on the past.

7.3.4 USMC C2-spectrum

7.3.4.1 Sense-making framework

Based on the theories and concepts of Karl von Clausewitz and John Boyd, the United States Marines Corps (USMC) has developed a flexible, adaptive command-and-control (C2) system capable to be deployed in different situations: USMC C2-spectrum. Should civilian organizations adopt also this philosophy or concepts? Different types of C2 imply different types of leadership and organizational forms, how can a civilian organization determine when what to use. We believe the well-known Cynefin framework can be extended in this respect.

The USMC has developed an adaptable C2 system to handle different situations determined by the degree of complexity and influenced by the compression of time and space. Time should not be seen as absolute time, rather as the relative speed to go through the OODA-loop: the time to observe something and the time to act can be long in absolute time, but very short to have an effective action.

Key in this all are the situational awareness and its input: intelligence. This is similar to the business world, even though there are no violent physical interactions, the compression of time and space is a fact, creating extreme conditions (CAS (environment)) in which CAS (organizations) have to (inter)act.

So the configuration of the C2-system (leadership, organizational structure, freedom of action (restrictions)) is in function of the situation. USMC can change from one type of C2 to another because of the shared vision, the shared knowledge of the commander's intention and the training. However all these and other elements are derived from the shared mental models (Orient-phase in OODA). Therefore other CAS (organization) cannot copy-and-paste this system. The Cynefin framework (see below), a generic

sense-making framework, should be considered as a base and be extended to create a similar system.

7.3.4.2 CAS*T Intelligence Base

Related to this is the universal rule of the Art of War: Continuously Seeking Intelligence. To continuously gather intelligence is an important rule in the theories and concepts of Karl von Clausewitz, John Boyd and USMC C2-spectrum. Can a civilian organization implement this rule by using a concept like CAS*T Intelligence Base and use it for the situational awareness?

The transdisciplinary forum observes the world and these observations are interpreted and integrated in the systemic models. Hypotheses are formulated (decide) and tested (act) which generates new observations. After one or more iterations the organization can decide to change its behavior (act) by implementing organizational (capabilities) changes (= investments), which can have effects (nonlinear or not) in the real world. The driving force of this process is the need for intelligence. Without intelligence there is no situational awareness (introspection, extrospection), so a CAS (organization) would fly blind.

If open-mindedness exists to accept observations (**O**ODA) that do not fit the mental models and the will ([141]) exists to update these models (O**O**DA) then the organization may co-evolve (OOD**A**) with its environment. Moreover the intelligence supports the organizational and individual decision-making (OO**D**A) and increases and updates the knowledge (O**O**DA). Luzwick (2000) makes the link between information, knowledge and situational awareness. Leaders at all levels have to make decisions in the absence of complete information – which is anyway impossible (Artigani, 2005).

Three actions will help: taking full advantage of employees' knowledge, improving situational awareness, and using the OODA-model. These elements are important core functions of Coherent Knowledge-based Operations (CKO) which combine the three concepts of KM, information warfare, and network-centric business (NCB) to control the Information Environment (IE). Therefore the intelligence-cycle must be a continuous process. Our concept of Intelligence Base is to support this process. The Intelligence Base is a system to manage in essence the unknown and the knowledge (Rabaey & Mercken, 2012; 2013). It is composed of (figure 53):

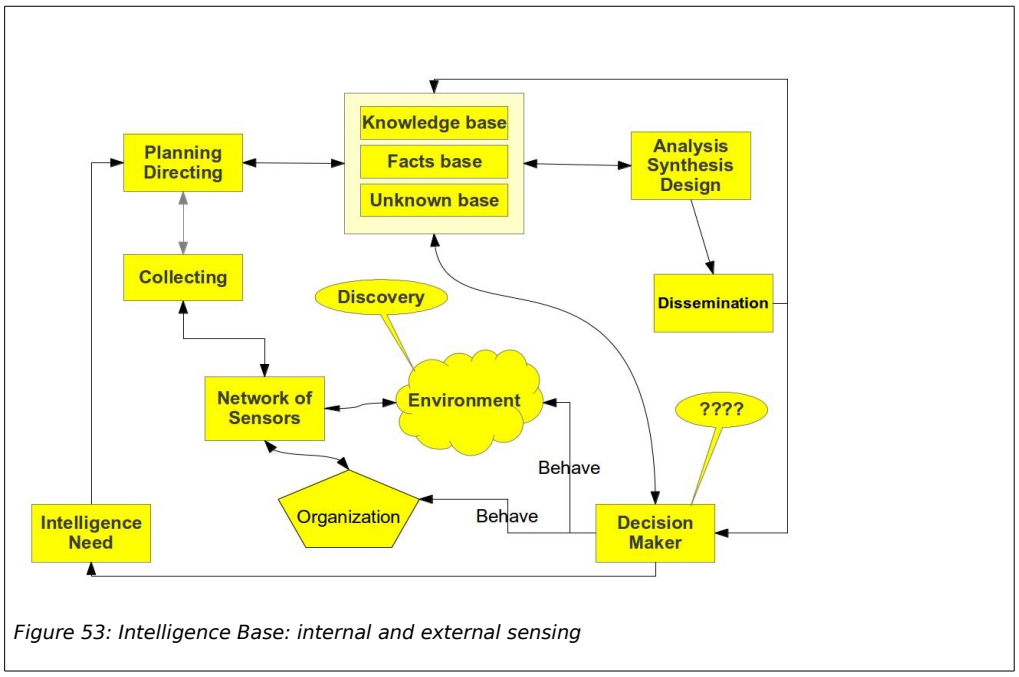

Figure 53: Intelligence Base: internal and external sensing

- Planning and Directing: this cell receives and manages the intelligence needs.
- Collecting cell is responsible for the managing of the network of sensors.
- Network of sensors will collect data on demand or ad hoc
- Knowledge Base is a software system capable of supporting the explicit representation of knowledge in some specific competence domain and of exploiting it through appropriate

141 The will is a very important factor (also in our definition of strategy).

reasoning mechanisms in order to provide high-level problem-solving performance. The knowledge base, a part of the Intelligence base, stores available knowledge concerning the domain at hand, represented in appropriate explicit form and ready to be used by the reasoning mechanism (Guida & Tasso, 1994)

- Facts Base is the collection of all raw information. This made a later interpretation of facts ([142]) possible with new inference rules and/or knowledge.
- Unknown Base supports the management of all requests that are still active.
- Analysis, Synthesis and Design: the intellectual (ST) interpretation of the collected data in a context relevant to the user and/or organization.

The “Planning and Directing” cell will look in the knowledge base to see if the intelligence need can be satisfied. If so it will transmit the need to the “Analysis, Synthesis and Design” which will disseminate to the client. If not, the “Planning and Directing” cell will send a request for search to the manager of the sensors “Collecting cell”. Two events can trigger an interaction between the decision making process and the intelligence process: pull (the decision maker expresses an intelligence need) and push (the spontaneous transmission of newly detected facts by the sensors).

The chosen architecture is SOA and Cloud Computing which gives the organization the flexibility and the agility to respond quickly to changes and to connect with systems. This architecture provides the technologies to integrate the Int B with its C2 system, so that the quality and quantity of information (and intelligence) fusion is improved. It fulfills also the needs of projected units, which have to operate autonomously. So the CAS*T Int B is a strategic ([143]) instrument for the CAS (organization) -civilian and military - and it supports the single and double learning with the integration of mental models (figure 54):

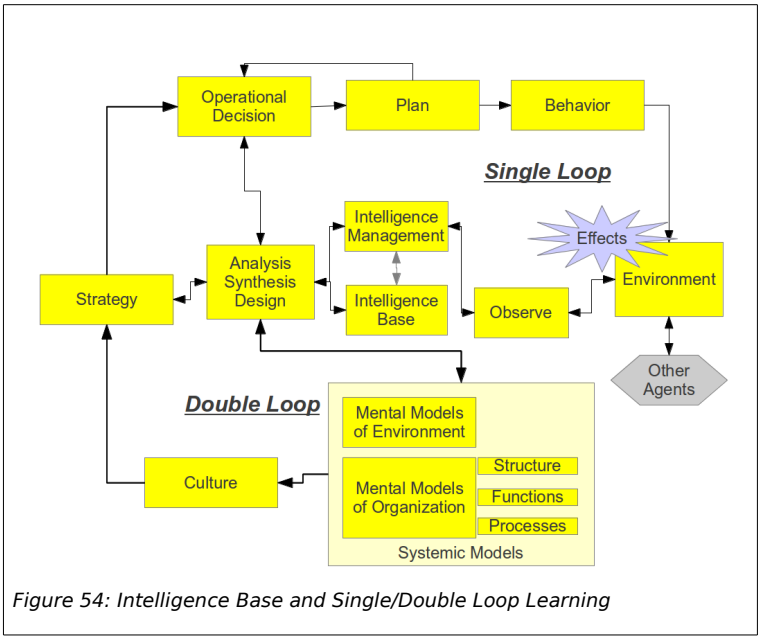

Figure 54: Intelligence Base and Single/Double Loop Learning

We see clearly that during the analysis-synthesis-design step, intelligence can be generated which may cause an update of the mental models of the environment and/or the organization. These changes of the models may imply that culture may have to change and certainly that the strategy has to be adapted which will influence all activities in the single loop.

7.3.5 Mental Models

The Orient-phase of the OODA-loop is the seat of the mental models which determine how an organization is structured, how it is operating and thus is relevant for investing. How can these mental models and the underlying concepts be used to invest in the organization in

142 Boone (2011) states that 'facts' never exist independently from the thinking framework that has made that fact thinkable (p. 245), thus this should also be taken into account.

143 Here in the meaning of essential for the survival of the CAS (organization).

general, and in IT in general (EA)?

Which tools can be used to construct these mental models (CAS*T-tools)?

7.3.5.1 CAS*T and EA

In general EA includes the following architectures: information, application and infrastructure. Nowadays knowledge is a much more powerful asset than information (because the latter became ubiquitous). Knowledge (created and maintained by a performing situational awareness and intelligence system like CAS*T Int B) is a driver for competitive advantage of the organization, or more appropriate in the context of CAS: an adapting advantage. That is why we are proposing an additional layer namely the knowledge layer. Our approach on the CAS (organization) based on the capabilities can use our proposed CAS*T tools to view structure, functions and processes in a more dynamic way. In table Table the leverage points from six to twelve are also related to EA. Since multi-minded organizations can be loosely coupled (complex Cynefin space), agents or clusters of agents must have autonomy over their own information systems, that is why we have proposed another stage in the evolution of information systems in an organization: we called it Business Process Embedded Information System (BPEIS) or in the context of CAS an Agent Information System (AIS).

The earlier stages of EA are Application Silo Stage, Technology Standardization Stage (Case Migration Mainframe), Data Rationalization Stage (Case Migration Mainframe) and a Modular Architecture (Case Fedict).

Although the modular architecture - characterized by enterprise-wide global standards with loosely coupled applications -makes that information and technology components continue to meet the global standards, while local differences in the core processes can be implemented through modules, the agents have not the full autonomy over their IS yet. BPEIS/AIS goes a step further, agents have the autonomy over their own IS. The only restrictions are the Enterprise Service Bus and its underlaying infrastructure which is in line with a mission C2 of a multi-minded CAS (organization). SOA and CC are IT enablers of BPEIS/AIS.

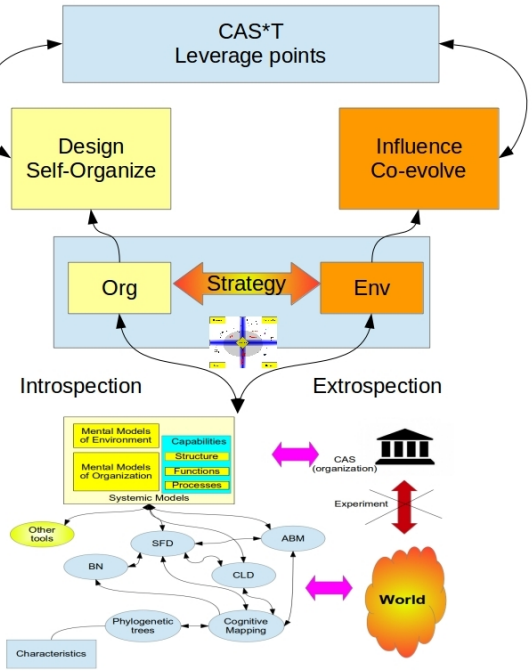

*Figure 55: CAS*T Tools and Leverage Points*

7.3.5.2 Hierarchy of Leverage Points

7.3.5.2.1 Tools

The purpose of the CAS*T tools is not only to describe systems (CAS (Organizations and Environment)) by systemic models but also to make the mental models more explicit, so that we can find easier the right leverage points. The proposed tools are phylogenetic trees, cognitive mapping, Bayesian networks, Causal Loop Diagrams, Stock Flow Diagrams and Agents Based Modeling (Figure 55).

Gharajedaghi (2011), Sterman (2010), Csala (2012) and Borshchev et al. (2004) state that models should be used to study the possible effects of organizational changes (= investments), thus not to experiment directly in the real-world (Csala, 2012). Of course, when an organization is in the chaotic Cynefin space, then action is necessary (act, sense, respond).

7.3.5.2.2 Leverage Points

By using the Cynefin framework for the introspection and extrospection, the organization can adapt its (emergent) strategy. It can redesign itself (self-organization) and try to influence the environment to create a better context for its strategy. In both cases the hierarchy of leverage points should be used (table 9).

Level	LP - Intervention Places	CAS*T EA	CAS*T Framework
0	Open-mindedness	X	X
1	Mental Models		X
2	Culture		X
3	The goals of the system		X
4	The power to add, change, evolve, or self-organize system structure		X
5	The rules of the system		X
6	The structure of information flows (who does and does not have access to information).	X	X
7	The gain around driving positive feedback loops.	X	X
8	The strength of negative feedback loops, relative to the impacts they are trying to correct against.	X	X
9	The lengths of delays, relative to the rate of system change.	X	X
10	The structure of material stocks and flows	X	X
11	The sizes of buffers and other stabilizing stocks, relative to their flows.	X	X
12	Constants, parameters, numbers	X	X

*Table 9: Leverage Points for CAS*T-EA and CAS*T Framework*

Donella Meadows (1997) proposed twelve places to intervene in a system, which are the same for a CAS. We have adapted this list to CAS*T, the higher on the list, the more effect the leverage point may have on the whole system. For open systems open-mindedness to adapt their own mental models is an essential element (level 0)(table Table). Conform the model of single and double learning, mental models are level 1 and culture is level 2. However it is possible for organizations that through (previous) successes and/or by accepting dogma's, culture comes above the mental models, indicating that the culture is defining the contents of the mental models, so there is no open-mindedness possible.

As a matter of fact, the whole organization becomes frozen with so-called stable parts, “so that virtually all forces yield, at most, only minor system changes, resulting in too much buffering and low adaptability and evolutability” (Schneider et al., 2006, p. 355). Our case of the BSC failure in Belgian Defense has

shown that these mental models can be very strong and organizations may reject worthy solutions.

Our definition of strategy is the dynamic behavior of the organization and its agents as a result to interact or not with its environment by using the means/capabilities to attain its self-chosen goals (level 3) in that environment. These means are situated in the lowest parts of the leverage points (12 to 9), therefore investing in means could be useless or less beneficial than adapting the organization by intervening in higher ranked leverage points. Three cases illustrate this point. The case of migration from Siemens to a Unix-based solutions is an example of a low ranked project (ranging from 12 to 10) that was only old wine in new bottles. More benefits and performance could have been gained by changing the structure of information flows. The new technology permitted more flexibility to have more diversity in the products of the Medical Service.

The case of Fedict is an example of how simplifying rules (LP5) could improve the agility of an organization. The case of TBT is showing the power of self-organization (LP4) of the shadow system. The problem was also that with reductionist thinking in contrast to the lower leverage points, the higher ranked leverage points were not obvious to detect, let alone change them effectively in the right direction. With holistic thinking chances are higher to change the right leverage points in the right direction. In that context the proposed ST tools CLD and SFD are very useful, certainly to represent the positive (level 7) and negative (level 8) feedback loops. That is why these two levels are part of the CAS*T-EA.

We note with Schneider et al. (2006, p. 360) that "[c]omplexity in a system occurs from the interaction of system variables (in general) over time. Major factors that influence complexity include positive or self-reinforcing feedback loops that generate growth and amplify deviations; negative or self-correcting feedback loops that counteract change; and single and double loop learning, the former in which existing mental models are maintained and the latter which involve the reframing of mental models. Other factors that also influence complexity include path dependence, delays in outputs relative to inputs; aging of the system; and possible oscillation, amplification, and phase lags (Sterman, 2000). In summary, complexity is complex, meaning that it is difficult if not impossible for humans, given their cognitive processing limitations, to comprehend–albeit predict–phenomena under this condition."

Long time planning is difficult because of the unknown future. The main direction (shared vision) is known, but emergent strategy is the rule. Otherwise, today's solutions become tomorrow's problems created by linear thinking in a nonlinear complex world (Reed, 2006). Colonel Reed suggests to use concepts of ST (in our case CAS*T) that should be applied by leaders at all levels, but especially those within the acquisition community, so that an organization can have success in the contemporary operating environment.

7.3.6 Cynefin Framework

Mental models are a cognitive representation of the environment and so they indicate how much an organization is aware of its situation. The Cynefin framework is a sense-making framework, how can the Cynefin framework be used to assess the situational awareness and its own perception?

The Cynefin framework defines different spaces each with specific characteristics. What consequences have these characteristics for management and leadership in general and IT-investments in particular?

One of the most important topics is the situational awareness, by analogy with holistic military thinking (an example is NCW). In this context, we extend the well-known Cynefin sense-making framework for both CAS (organization) (introspection) and CAS (environment) (extrospection) to exploit the situational awareness.

7.3.6.1 Spaces

The Cynefin framework, which originates from Snowden's work in knowledge management is based on complexity science and is also applicable to strategy formulation. It provides a means of exploring different organizational contexts and selecting approaches accordingly. Thus Cynefin allows people and organizations to better understand the contexts within which they are operating (Snowden, n.d.; Bean, 2011). The Cynefin framework helps the organization to assess the necessary knowledge, the cause-and-effect relationships and the role (degree) of uncertainty. This has consequences for the volatility of knowledge; the higher the volatility, the more important the intelligence (process) is. Since dynamics are very important in CAS*T, we can speak of dynamic knowledge.

The ordered spaces consist of Obvious and Complicated space. The former has clear cause-and-effects, fitted for standard operating procedures and best practices, therefore "Sense-Categorize-Respond". In the CAS (environment) everything is transparent. The complicated CAS has cause-and-effects separated in time and space but still detectable in an acceptable time. The knowledge is known, but the information isn't always (known-unknown). Experts and analysis are needed so more than one solutions are possible (good practices, and scenario planning), thus Sense-Analyze-Respond. The unordered spaces consist of Complex an Chaotic spaces. The complex space is the domain of barely restricted CAS (organization or environment).

7.3.6.2 Cynefin and organizational structure

The obvious space (tightly constrained, no degrees of freedom) holds the mindless and uni-minded organizations. The latter is also in the complicated space (governing constraints, tightly coupled). The multi-minded organizations are in the complex space (enabling constraints, loosely coupled).

The chaotic space (lacking constraint, de-coupled) is the domain of the organization that was not aware of the fact that it moved from obvious (mind the “cliff”) or from complex space. CAS (organization) may deliberately be going into the chaotic space to explore new opportunities (at the edge of chaos).

Of course, other transitions are possible, so hybrid organizations may be situated on the borders between the different spaces.

The Cynefin framework is also relevant to determine the needed leadership and structure and therefore C2 system of the organization. We have extended the Cynefin framework with (un)awareness and the different forms to describe a CAS (organization) in its CAS (environment): evolution over time, market, environment and structure and a combination namely evolution environment and structure.

From the BASF-case we have concluded that the IS or IT-architecture does not necessarily need to be in the same Cynefin space as the units of their users. Regarding the link between mental models and situational awareness, we know that awareness is the knowledge or perception of a situation or fact. Relevant is that external stimuli (thus from the environment) are observed, understood and interpreted based on our mental models (Orient in OODA).

7.3.6.3 Cynefin and management techniques

As a consequence we can determine which combination of types of leadership, C2 and organizational form should be used in the five Cynefin spaces, therefore also determining the most appropriate management techniques like investment techniques. The more restrictions and organizational rigidity management is implementing, the simpler investment techniques will be. However in a CAS an investment is always a trade-off between robustness (capability to adapt and to create variety) and efficiency (cost reduction). Too much variety makes investments more complicated, even complex and less efficient. So a harmony must be found as a function of the context of the environment and the organization (situational awareness), for which we propose the Cynefin framework and CAS*T Int B within a transdisciplinary forum.
Since organizations or parts of it may move between Cynefin spaces, the respective spatial investment techniques should be used. Overall, OODA should be used to support (complex) decision-making so that at least in every Cynefin space we have the same, coherent decision-making process. Essential to both OODA and Cynefin is intelligence, therefore we have proposed the CAS*T Int B to support transdisciplinary decision-making and knowledge management. The case discussed about the Cloud Computing project of Fedict is an example of how an investment failed due to the wrong decision framework and because Cloud Computing had still properties emerging so that putting restrictions was counterproductive.

7.3.6.4 CAS*T Int B and Cynefin

The main conclusion is the conceptual symbiosis between Snowden's Cynefin framework and CAS*T Int B. Knowledge can be created in different ways following the space an organization is in. Our concept of CAS*T Int B reflects the two characteristics of knowledge in the third age:

- It is a thing: knowledge base, even more facts base and unknown base;
- It is a flow: the whole intelligence process in CAS*T Int B.

And related to the two previous ages, CAS*T Int B supports decision making and the creation of knowledge and content. The Cynefin framework guides the organization in its situational awareness not only related to itself (Cynefin is about self-awareness) but also to explore the space and the time continuum outside its own environment.

7.3.7 Network-Centric Warfare (NCW): centralization and decentralization

ICT made NCW possible (compression time/space) and the NCW philosophy itself made decentralized execution possible. However the organizational form types needed to be adapted, how can ST help with this and what are the consequences to build IT-systems (Enterprise Architecture, EA)?

Before answering this research question we have to place NCW in our context.

7.3.7.1 Paradigm shift

NCW is a paradigm shift from platform-centric warfare to a more networked collaborative system. NCW enables a shift from attrition-style warfare to a much faster and more effective war fighting style characterized by the new concepts of speed of command and self-synchronization. Speed of command is the transformation of information-superiority into decision-superiority to gain a competitive advantage. This is of course in line with OODA. Self-Synchronization is the ability of a well-informed force to organize

and synchronize complex warfare activities from bottom up (Roberts et al., 2003, p. 14), which is in line with the characteristics of CAS.

7.3.7.2 Tacticization of Strategy

As a consequence NCW is a shift from a uni-minded to a multi-minded organization, though Gharajedaghi (personal communication, 2011) has admitted that hybrid forms may exist, which is the case of NCW. The decision for the goals and the general maneuver idea are given by the higher command (thus centralized), while the execution is decentralized.

Tacticization of the strategy is about the fact that high level strategy is influenced by lower strategy and even by tactics because the high level strategy is 'distracted' from the global view by wanting to do micromanagement.

7.3.7.3 CAS*T EA avoids Tacticization of Strategy

So in NCW danger for tacticization of strategy may happen because of ICT (everybody is potentially connected to everybody, from the government to the strategic corporal) and since there is still a form of hierarchal power structure, the danger exists that higher level command (in particular political) is intervening in the local definition of goals and execution, especially to obtain quick wins. To avoid tacticization of the strategy Handel (2001) is recommending to approach war and politics in a holistic way, which is the same for NCB.

This is certainly the case for uni-minded organizations and organizations on their way of evolving from uni-minded towards multi-minded (like NCW and NCB). Here ST can help designing the organization to avoid tacticization of strategy by ICT (CAS*T EA).

The fundamental distinction with multi-minded organizations is that the multi-minded organizations work already holistically, otherwise they cannot function (shared vision and shared mental models, thus shared perceptions (second-degree agreements)).

7.3.8 Investment Techniques

7.3.8.1 Option Games

Besides the investment question related to Cynefin framework, are option games a useful extension of Real Option Valuation (ROV) to integrate interactions with the environment?

In her study, von Helfenstein (2009) advocates the use of ROV when complexity and risks are involved. Since most of the business has shifted towards complex contexts, it is surprising that ROV is not used more in investment appraisals.

However ROV shares a common drawback with the classic investment techniques, being that it does not take into account the interaction of the organization with its environment (market, government, etc.) (Grenadier, 2000; Smit et al., 2009; Fereira et al., 2009).

A solution could be to combine ROV with game theory, which results in the theory of option games. The organization can play different games (game theory) at the same time in different domains and/or different levels. Due to the emergent strategy typical for a CAS, in every node may exist more than two (solution) paths, which going further in the future may quickly lead into a Chaos system (Glenn, 1996; Rabaey, 2011). Above all, we believe that the theory of option games is too limited to grasp the whole context of the opponents to represent nonlinear situations (Rabaey, 2011).

7.3.8.2 Transdisciplinary Forum

Can the leverage points hierarchy be used to know where and how to invest (organizational changes) so that investments are more effective and efficient?

How can a transdisciplinary approach contribute more to assess investments in general and in IT in particular?

Our aim was to bring together CxT, ST and the transdisciplinary approach in our CAS*T framework. The purpose of CAS*T is to guide an organization to adopt the best possible disposition with the appropriate C2, so that the organization can adapt (organizational changes = investments) as good as possible to its (changing) environment in function of its (probably changing) goals.

The transdisciplinary forum is the place where IT-investments are decided on. It can have different shapes depending on the space the CAS (organization) and/or its sub-units are in:

- leader (ordered spaces, chaotic space);
- formal groups (complicated spaces);
- informal (emergent) groups or leaders (complex space).

The leverage points for investments (organization changes) with particular attention to IT are assessed in CAS*T-EA. The bottom-line is that investments in general and IT in particular need a holistic (CAS*T) approach to find the best possible trade-off in the respective Cynefin spaces. Unfortunately no uniform,

unique investment technique for all these spaces exists. Useful techniques are one topic for further research.

7.4 Suggestions for Further Research

Figure 56 depicts holistically the different subjects of further research and their principal connections.

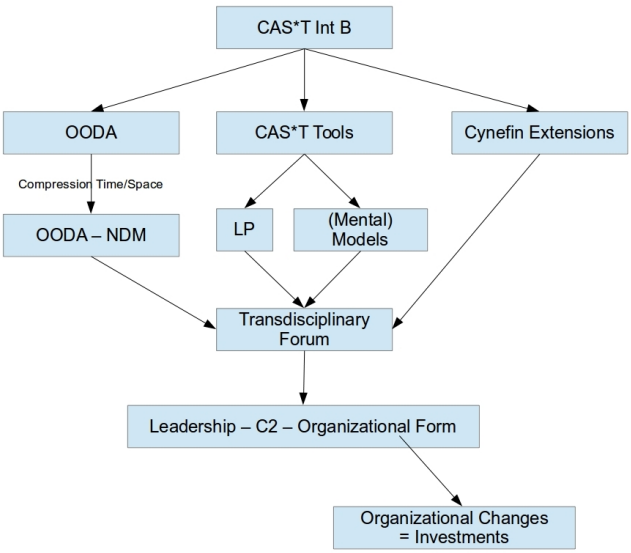

Figure 56: Further Research

CAS*T Int B drives the process of intelligence. A generic model should be developed so that an organization can instantiate a real-life system adapted to its needs and culture.

Elements of the CAS*T Int B are also parts of the OODA-cycle (like intelligence cycle (OODA), knowledge base (OODA)). Research should determine whether both can be integrated into an adaptive C2-system (from detailed to mission) or at least how they can interface with each other, taken into account that temporary disconnections can be possible due to operational issues.

Because of the compression of time and space, the integration of OODA and NDM could be of great value to organizations. The NDM approach emphasizes the role of experience in enabling people to rapidly categorize and/or sense situations to make effective decisions, in casu a chaotic space where no real defined goals exist or a complex space. So NDM is limited to individuals in dangerous crisis situations, but since organizations (as living beings) are evolving towards multi-minded forms, crisis situations for the organization should be handled by the whole organization and not only by a crisis management unit. Situational awareness is certainly critical, therefore Cynefin should also be considered.

CAS*T tools (or other tools) should be more integrated (or better interfaced) so that the organization can dispose over the relevant models.

In this context, research should be done how to detect and to use leverage points in a correct way. Further research is needed to organize the TF and to determine where a TF should be formed and which configuration should be chosen for. Further the above mentioned methods and the (outputs of the) tools should be integrated and interfaced).

Appendices

1. CAS*T Tools except ABM

In chapter 5 The consequences of CAS*T for EA (p.103) we have introduced the tools we can use in CAS*T. In this appendix we will discuss these tools except for ABM which is discussed in chapter 5.

1.1. Phylogenetic Trees

A phylogenetic tree or evolutionary tree is a branching diagram or 'tree' showing the inferred evolutionary relationships among various biological species or other entities—their phylogeny—based upon similarities and differences in their physical and/or genetic characteristics. The taxa joined together in the tree are implied to have descended from a common ancestor." (Wikipedia Phylogenetic tree, n.d.). Allan et al. (2011) ([144]) state it is also applicable to any entity that has complex adaptive behaviors. "By applying phylogenetic analysis evolutionary relationships of entities can be inferred from which people can obtain classifications of entities, predict emerging entities and hypothesize the properties of those emerging entities." (p. 34). The difficulty in applying phylogenetic analysis lies in its philosophical aspects.

The basic idea is that risk profiles continue to evolve, therefore lots of short branches exist. Due to the evolutionary aspects (path-dependency), phylogenetic analysis is used for unaware systemic risks and drivers.

1.2. Cognitive mapping

Cognitive mapping is a form of causal mapping developed by Colin Eden and Fran Ackermann. The cognitive maps are related to concept maps or mind maps. However in mind maps, the links can have any meaning, while in cognitive maps, links are only causal. It is been used for strategic planning and decision making about organizational strategies (Venable, n.d.). Since investments are organizational changes based on emergent strategies, cognitive mappings could be used. However Allan et al. (2011) do not propose it to use for systemic unaware risks (and drivers). In this context, it looks pretty much like a Balanced Scorecard (figure 57 ([145])), a reductionist tool. It takes a snapshot of a part of the interconnected activities in a CAS. So they use it for risk appetite, which is a known systemic risk and thus not an emergent risk. A problem is broken into its constituent elements, which are then treated as distinct concepts. Afterward the different concepts are reconnected to represent in a graphical format.

144 Cantle et al. (2011) are referring to cladistic tree.

145 *Figure 57*. Cognitive Strategy Map Reprinted form SODA (Journey-making methodology) using Decision Explorer software. In *University of Bolton - Coeducate Project*. Retrieved February 28, 2014 from http://coeducate.bolton.ac.uk/2009/06/29/soda-journey-making-methodology-using-decision-explorer-software/

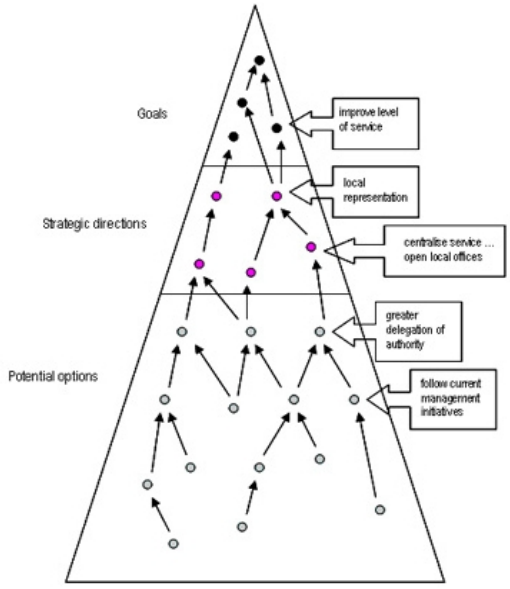

Figure 57: Cognitive Strategy Map

This can only work, if the new nodes are added in the overall picture, the impact of the deleted being studied as the changed nodes, thus starting then a new overall assessment of the whole CAS. Here again it must be an iterative process, which Allan et al. (2011) are ignoring, or otherwise they did not explicitly mention it.

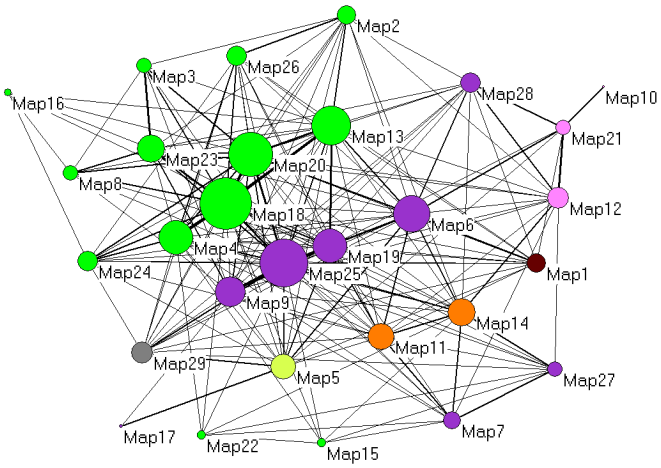

Figure 58: Fuzzy Cognitive Mapping

Cognitive mapping can also be used to bring all stories together. Everybody is adding nodes and the

relationships between these nodes, which can result in a map as shown in figure 58([146]). This can also be used as input for ST modeling but only if the drivers are also included.

Regarding cognitive mapping, Cantle et al. (2011) warn that the most dangerous issue is not really what you do not know, but that what you know ain't wrong.

1.3. ST Modeling

All models are wrong, some models are useful. - *George Box*

Allan et al. (2011) advise not to use systems dynamic modeling because it requires considerable programming and mathematical knowledge from users, and worse it is time consuming (p. 38). This may be correct if no other persons in the organization is using ST modeling. But with CAS*T we are proposing to use ST modeling in the whole CAS (organization). Moreover cognitive mapping can be an input for ST modeling and vice verse.

John D. Sterman (2002) in his internal MIT-paper *System Dynamics: Systems Thinking and Modeling for a Complex World* writes that social systems (CAS organizations) have the tendency for well-intentioned interventions to be defeated by the response of the system to the intervention itself. Therefore the field of system dynamics is designed to help organizations to learn about the structure and dynamics of the CAS in which they are embedded (and can embed themselves other systems), design high-leverage policies for sustained improvement, and catalyze successful implementation and change.

Probably the most important reason why systems dynamics modeling is not popular in business management is because it demands knowledge of engineering control theory and the theory of nonlinear dynamical systems which involves the development of formal models to capture complex dynamics, and to create an environment for co-learning and policy design.

The two most used ST modeling tools are the Causal Loop Diagram (CLD) and Stock and Flow Diagram (SFD). SFD along with the mathematical expressions that specify each construct, provides a technique that enables an organization to create a (business) prototype of a system to explore the system's behavior and to test the effect of changes to the system's structure and the policies governing its behavior (Stock & Flow Diagram, n.d.). In other words, SFD gives a dynamic view on the organization's systems which makes simulation possible.

The elements are ([147]):

- A stock represents a part of a system whose value at any given instant in time depends on the systems past behavior. Thus the value of the stocks at a particular instant in time cannot simply be determined by measuring the value of the other parts of the system at that instant in time. Therefore the only way a stock is calculated is how it changes at every instant and adding up all these changes.
- Flows represent the rate at which the stock is changing at any given instant, they either flow into a stock (causing it to increase) or flow out of a stock (causing it to decrease).
- Converters either represent parts at the boundary of the system (i.e. parts whose value is not determined by the behavior of the system itself) or they represent parts of a system whose value can be derived from other parts of the system at any time through some computational procedure.
- Much like in CLD the connectors of a system show how the parts of a system influence each other. Stocks can only be influenced by flows (i.e. there can be no connector that connects into a stock), flows can be influenced by stocks, other flows, and by converters. Converters either are not influenced at all (i.e. they are at the systems boundary) or are influenced by stocks, flows and other converters.
- Sources and sinks are stocks that lie outside of the models boundary – they are used to show that a stock is flowing from a source or into a sink that lies outside of the models boundary. On diagrams, sources and sinks are represented by small clouds.

Figure 59 ([148]) is a simple representation of the evolution of a population. Children are born (birth) which is

146 *Figure 58*. Fuzzy Cognitive Mapping Reprinted from Fuzzy Cognitive Mapping 2009 ALTER-Net Summer School. In *FCMappers.* Retrieved February 28, 2014 from http://www.fcmappers.net/joomla/index.php?option=com_content&view=article&id=72:peyresq-2009-alter-net-summer-school&catid=38:past-projects&Itemid=37

147 The definitions of stock, flow, converters, sources and sinks are taken from Stock & Flow Diagram (n.d.)

148 Figure 59 CLD of Population. Reprinted from Causal Loop Diagram (CLD). In *Systems Dynamics Tutorial,* http://people.revoledu.com/kardi/tutorial/SystemDynamic/

a reinforcing (or positive) loop. The bigger the population, the more chance of having births. People are dying which decreases the number of people. This is a balancing (or negative) loop. This CLD shows only the logic, but we can not make simulations with it.

However a SFD is suited for simulation as shown in figure 60 ([149]), which is the SFD representation of the CLD of figure 59. We have an initial number of people and over time the birth rate and death rate will determine the evolution of the number of people. The different rates can be percentages and/or functions.

Of course this is an oversimplification of the reality, but the method is to let evolve the different diagrams by adding stocks, flows and other elements in the diagram (versioning).

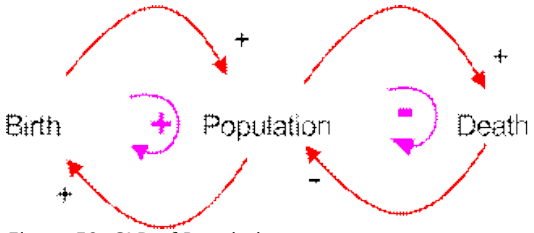

Figure 59: CLD of Population

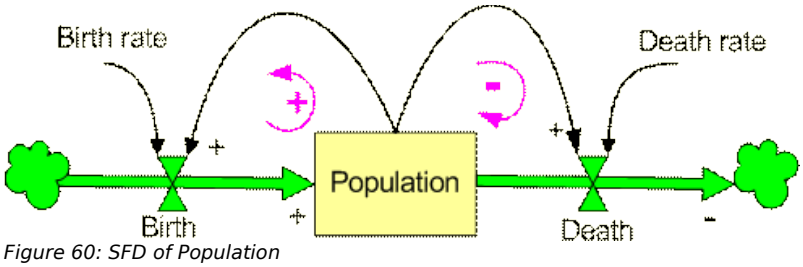

Figure 60: SFD of Population

1.4. Bayesian Networks

Until now we have seen that CLD are useful to discover leverage points and the two main loops, reinforcing and balancing. Bayesian networks (BN) are acyclic, meaning there may not be any loop in the diagram or Directed Acyclic Graph (DAG).

In general, “[p]robabilistic graphical models are graphs in which nodes represent random variables, and the (lack of) arcs represent conditional independence assumptions. Hence they provide a compact representation of joint probability distributions. Undirected graphical models, also called Markov Random Fields (MRFs) or Markov networks, have a simple definition of independence: two (sets of) nodes A and B are conditionally independent given a third set, C, if all paths between the nodes in A and B are separated by a node in C. By contrast, directed graphical models also called Bayesian Networks or Belief Networks (BNs), have a more complicated notion of independence, which takes into account the directionality of the arcs, as we explain below.

[…]

Although directed models have a more complicated notion of independence than undirected models, they do have several advantages. The most important one is that one can regard an arc from A to B as indicating that A 'causes' B. … This can be used as a guide to construct the graph structure. In addition, directed models can encode deterministic relationships, and are easier to learn (fit to data).

[…]

In addition to the graph structure, it is necessary to specify the parameters of the model. For a directed model, we must specify the Conditional Probability Distribution (CPD) at each node. If the variables are discrete, this can be represented as a table (Conditional Probability Table: CPT), which lists the probability that the child node takes on each of its different values for each combination of values of its parents. Consider the following example, in which all nodes are binary, i.e., have two possible values, which we will

149 Figure 60 SFD of Population. Reprinted from Stock and Flow Diagram (SFD). In *Systems Dynamics Tutorial*,http://people.revoledu.com/kardi/tutorial/SystemDynamic/

denote by T (true) and F (false).” (Murphy, 1998).

Figure 61 ([150]) represents how rain is influencing whether the sprinkler is activated or not. If it rains then the sprinklers should not be active (link from *Rain* to *Sprinkler)*. So the CPT of sprinkler contains the impact (influence) of rain on it. Both rain and the sprinkler influence whether the grass is wet.

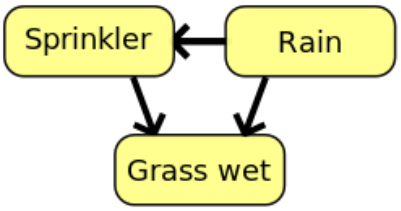

Figure 61: Nodes-only picture (without the CPTs) of a Simple Bayesian Network

Figure 62 ([151]) has the CPTs. Here we can see that some other elements are missing which would make the model more dynamic, namely the season for instance in Belgium. It will have another behavior in summer than in winter, spring or autumn. The CPT for the rain is taken over a whole year.

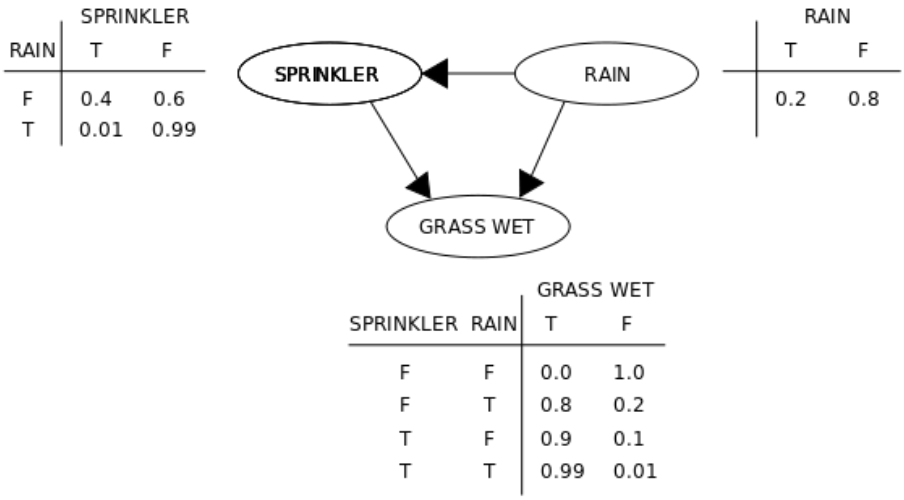

Figure 62: A simple Bayesian network

An enrichment of the model is given by Murphy (1998), when he expands the model with the fact if the sky is cloudy or not (figure 63)([152]). So the CPT of Cloudy as level one has one (2^0) probability set, while rain and sprinkler as second level have two (2^1)and *grass is wet* has now 4 (2^2). Notice that if he would only have put a link between *Cloudy* and *Rain* then there would have been four levels instead of three.

150 *Figure 61*. Nodes-only picture (without the CPTs) of a Simple Bayesian Network. Reprinted from Bayesian network. In *Wikipedia.* Retrieved March 8, 2014 from http://en.wikipedia.org/wiki/Bayesian_network

151 *Figure 62*. A simple Bayesian network. Reprinted from Bayesian network. In *Wikipedia.* Retrieved March 8, 2014 from http://en.wikipedia.org/wiki/Bayesian_network

152 Figure 63. Influence of Clouds on Sprinkler model. Reprinted from Representation. In *A Brief Introduction to Graphical Models and Bayesian Networks*. Retrieved March 8, 2014 from http://www.cs.ubc.ca/~murphyk/Bayes/bnintro.html

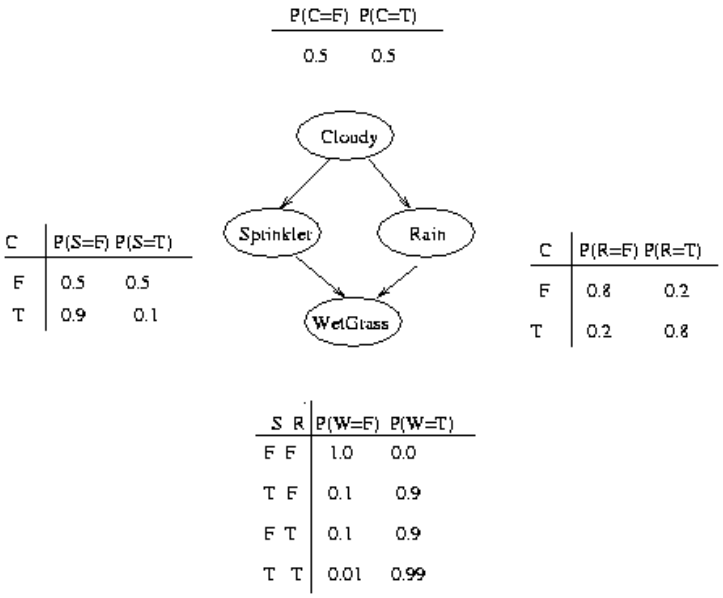

Figure 63: Influence of Clouds on Sprinkler model

Just like CLD and SFD with BN we have causal links between nodes in the model, thus a form of causality only it is acyclic. Since CAS are full of feedback (and feedforward) loops which cause complexity, one may ask if DAG are not unnatural in CAS*T. Allan et al. (2011): “Visually, a BN is in a hierarchy structure with nodes cascading in layers, allowing users to visually understand the logic relationships among variables.” (p. 35). “Normally, a [BN] has a clear directed hierarchical structure where the nodes on a higher level are the parents of those next to them. The relationship between parent(s) and a child is represented as a joint conditional probability and thus enables information to be propagated in both directions. Furthermore, the construction of BN follows one’s instinct and common sense as descriptive information and qualitative knowledge would be sufficient. Yet, domain expert knowledge can improve the quality of a BN.

The analytical power of Bayesian Networks lies in their ability to enable inference and learning. With regards to inference, BN techniques allow one to make predictions as well as diagnose. That is, if the parents’ information is available, the states of a child can be obtained using Bayes’ theorem, whilst if the evidence of child’s state is observed or observable, the states of parent nodes can be reasoned in a posterior manner.” (p. 40).

So, Allan et al. (2011) may write that their approach is holistic, they ignore the characteristics of CAS (organization). Therefore, because of the acyclic characteristic of BN, we can conclude that BN - and for the same reason the cognitive strategy map - can only be used as a tool to refine the variables, stocks and flows in SFD where a chain of acyclic dependencies exist or at least to be aware of the lack of reciprocal interdependencies of BN.

2. Architectural Considerations

2.1. CAS*T Effects on EA

The effects of CAS*T for EA are manifold:

- EA must be dynamic because of the continuously changing environment and therefore continuously changing the organization (=investments). Managing EA should be included in the processes of Intelligence Base;
- Knowledge-management must be reflected in EA;
- EA must keep track of the reasons why it has been used, why the models had to be changed during the project, …. So the (changing) contexts are at least equally important as the models themselves, therefore EA should be a part of the systemic models, rather than being outside ST tools and models;
- Links between feedback loops and EA are essential to understand the EA.

Last but not least, EA must have a holistic approach.

2.2. Knowledge Layer

As mentioned above, lots of different interpretations of the term EA exist (Rabaey, 2012). In this context Korhonen (2012) writes that the traditional notion of EA assumes information systems as underlying operative resources rather than as core value assets and true business enablers. Actually business-IT alignment exacerbates the business-IT divide. Therefore IT is seen as a separate, value-adding function, relegated to a subordinate role of a mere service and cost center, whose focus is on operational quality and reliability -- on producing predictable outcomes on a consistent basis.

However the knowledge economy forces enterprises to compete at the level of knowledge and not anymore at the level of information. So the differentiation will be made on the level of knowledge assets and therefore knowledge has to be addressed in a specific architecture. We concluded that EA should be put in a broader context than merely infrastructure architecture and application architecture, because applications are built to support business processes and operate on information gathered through these business processes from the environment, therefore EA must cover the business and especially its dynamics so that it can take precautions for changing business requirements or the reuse of certain artifacts in other business domains.

Modeling knowledge brings us to epistemological and ontological models. Bean (2011, p.6) states that “[t]here is an important distinction between ontological models of a reasonably well-understood domain that purport to represent parts of the ‘real world’” (mostly developed by subject matters experts)”, and epistemological models that are used to explore perceptions of the real world. Epistemological models are not necessarily models of reality but are designed to support discussion, debate and argument about people’s perceptions of reality, where the real nature of the problems to be tackled is unclear.” Senge (2006) advocates dialogue and discussion to tackle problems. The use of epistemological models will certainly bring implicit mental models to the surface during the processes of dialogue and discussion.

In the context of the Cynefin framework epistemological models will certainly be used in the complex and chaotic Cynefin spaces, while in the complicated and simple spaces we will find ontological and epistemological models.

2.3. Capability Approach

The capability approach shows the emergent synergistic properties of systems: the whole is indeed greater than the sum of its (collaborating) parts. Although the relationship with customers and other stakeholders is important, the internal relationships between the components of an organization (capability) are equally important.

In Figure 64 the different layers have been redefined so that not only IT systems but all systems are taken into account, so it is a whole EA. The knowledge and information layers are managed in the Intelligence Base. Agents of the enterprise are interconnected and have to share the elements of the Intelligence Base. The sensors are detecting the environment. Of course, KIM can be mapped into different layers.

The capabilities form another layer. It represents the functions that are performed outside of the defined enterprise. Defined in this case means from the point of view of the observer. For example the defined enterprise can be a system in a bigger whole, therefore to the bigger whole the enterprise is a system, and for the enterprise the environment can be the bigger whole alone or a combination of the whole with other agents (and conditions).

As such, the underlying layer of systems is partially explained. Systems can be nested, thus a system can be composed of other systems, which then also can be composed of other systems (System-of-systems). It is essential that the interactions are also caught.

Systems are using resources and that is the last layer “Resources”.

We included also the “Other Agents” because of the possibilities of mutual outsourcing and/or collaboration. If it is on the level of capabilities then the collaboration should be seen as a new enterprise (whole). If it is in the layer of systems then it is more outsourcing, cosourcing or insourcing. Regarding the resources, the other agents are suppliers.

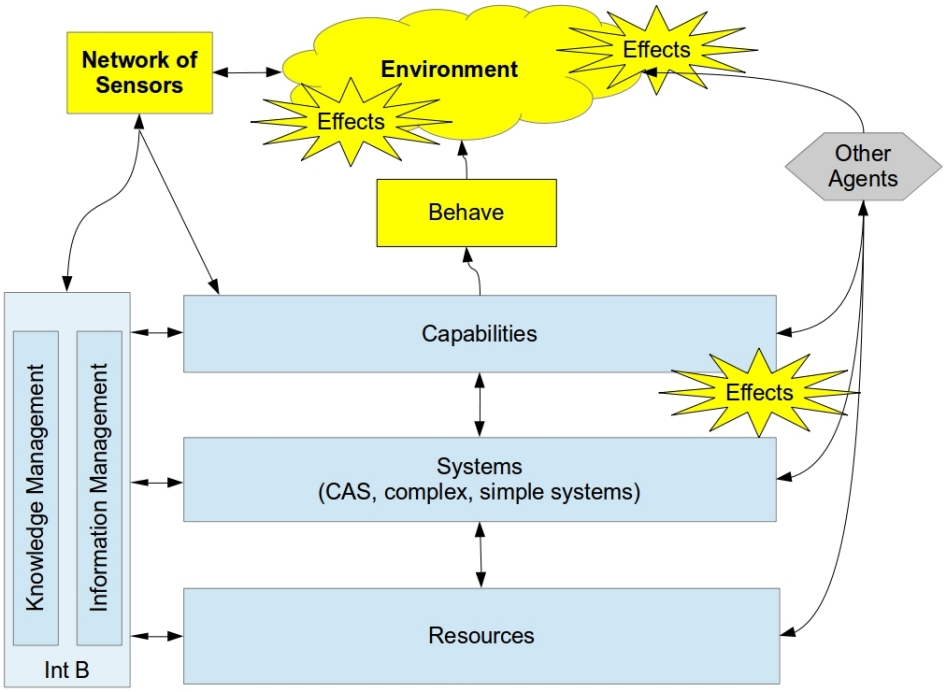

*Figure 64: CAS*T EA*

2.4. Information systems

With the evolution of intelligent agents and/or networks software is not anymore only a set of pre-programmed algorithms. As a matter of fact, intelligent agents became CAS and they are effectively used in processes and/or systems and may even be a capability or a system used with other agents.

CAS*T EA corresponds also to the traditional layers of EA for IT: business, information, applications, infrastructure. Here also it will depend on who is “observing” the IT. If the observer is the enterprise which owns the IT, then probably the IT will be in the layers of systems and resources. If the IT department is the observer then it will cover the layers from resources to capabilities (and KIM).

So because of the CAS*T’s approach flexibility and interacting and/or integrating models are possible. We would like to stress that the Cynefin framework may not be forgotten so that the IT department (as with any other department) or the whole are aware in which domain they are.

We are referring Bean (2011) and Johnston (2005) for more details.

2.5. Bus Structure

All agents (CAS, complex systems, external agents) are interconnected. A hub is not efficient for a sociocultural entity. We are making an analogy with Enterprise Service Bus and to visualize the nested and interrelated agents we use also a bus structure.

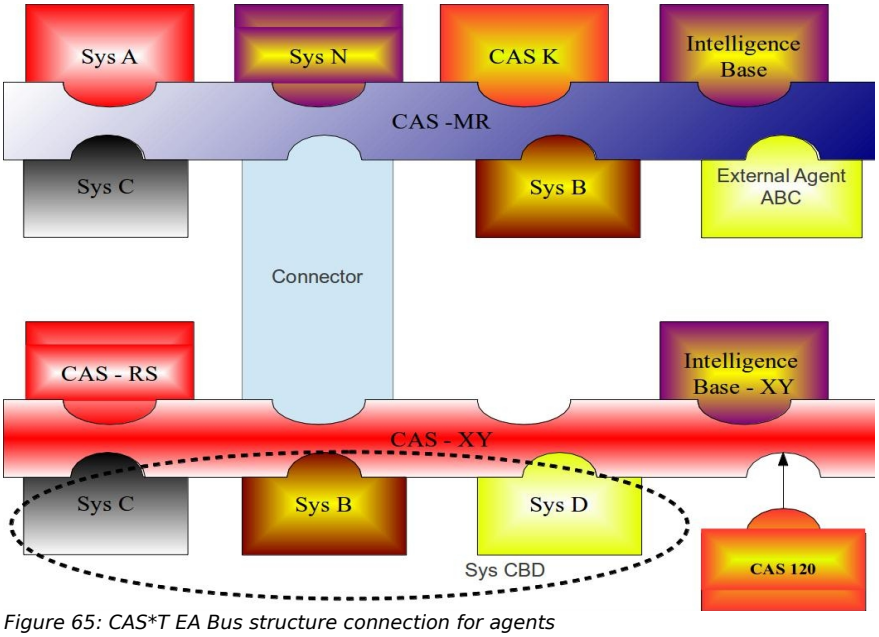

*Figure 65: CAS*T EA Bus structure connection for agents*

An enterprise forms capabilities with CAS MR and XY. These CAS are composed themselves of other agents. CAS XY has its own Intelligence Base (connected to the other one) and uses CAS -RS, a new CAS 120 and a complex system CBD (composed of Sys C, Sys B and Sys D) (dotted line); the Sys C ens Sys B however are also used in CAS-MR. CAS-MR has an external agent ABC.

Sys CBD can be a SOA IT-application that supports the logistics of the whole organization. Sys B is the inventory, while Sys C is the invoice and Sys D is the distribution management. This IT application uses IT-infrastructure (network, servers, device) which can also be represented.

2.6. Meta Service Bus and EA Models

The principle of recursion can also be implemented at the IT-level. Holland (2008) does not only find models based on building blocks important, but also models of the formation of boundaries and signals, relevant in the hierarchy of a system. Both are co-evolving, meaning that hierarchy can change as the components and that the purpose can change. He refers to Adam Smith where the work of a single craftsman has been distributed over a chain of workers doing a simple action. The costs dropped with a factor ten. In our case of IT the same can be said, but what is more relevant, is how boundaries are made and how signals are created to pass work from one step to another step. Holland (2008) states that since Adam Smith we do not have any good computer model for this transition. He claims that studying “things” like signals and boundaries and how they form or how they co-evolve are essential in understanding hierarchy/recursion (in a CAS).

So even though we are connecting (independent) modules in an IT-system through interfaces, somehow a structure is formed (with boundaries) where interfacing (signals) are crucial. Nested modules (aggregates) are built into a complex system (hierarchy/recursion). Different ways of recombining of existing modules are possible and no best solution/practice (obvious Cynefin space) and probably no good solutions/practices (complicated) exist but an emerging solution/practice (complex), because of the perpetually evolving needs and thus functions of the IT-system.

Nevertheless, since communication in a multi-minded organization is very important, we will focus on the service bus. As we have seen before at the enterprise level the concept of ESB is well known. The concept of service bus can be used for the embedded information system of the business processes (BPEIS). Programs (modules) of the BPEIS are interacting through Business Process Service Bus (BPSB) with other modules of the own BPEIS or with other applications (can be other BPEIS) inside or outside the enterprise (most likely via the ESB).

Figure 66 depicts the concept of recurrent service bus. It has to be noted that more than four levels are indeed possible, In addition it does not matter for ST if a business process is partially automated or not

automated at all.

To be consistent with the concept of recursion, the programs should also have a (program) service bus with similar management functions of the ESB, which should of course be compatible. The advantage of such service bus is that a program can adapt its version to the request of the client through the business logic management module (multiple versions of a module can reside on the same program service bus). This technique can also be used with service buses at higher levels.

A BPEIS does not necessary have to stay in the physical boundaries of the enterprise. This will be more the exception than the rule. The control can even be outside the main users' enterprise. So an ESB limited to the physical boundaries of an enterprise may cause organizational and/or management problems. Virtual ESB implemented (VESB) in the cloud, the cloud service bus (CSB), is the way ahead (see also Rabaey 2012, 2012a, 2012b; Rabaey et al., 2013).

Separate bodies like authentication agents are controlling the traffic (communication) between the different BPEIS (be it in the CSB, (V)ESB or any other service bus, and other types of information system management). Standardization is a must, the web services and SOA combined with CC are realizing this standardization. In the same context, semantic web (Rabaey et al. 2007a) and intelligent agents (Rabaey, Vandyck and Tromp, 2003) need to have a standardized platform to communicate and collaborate.

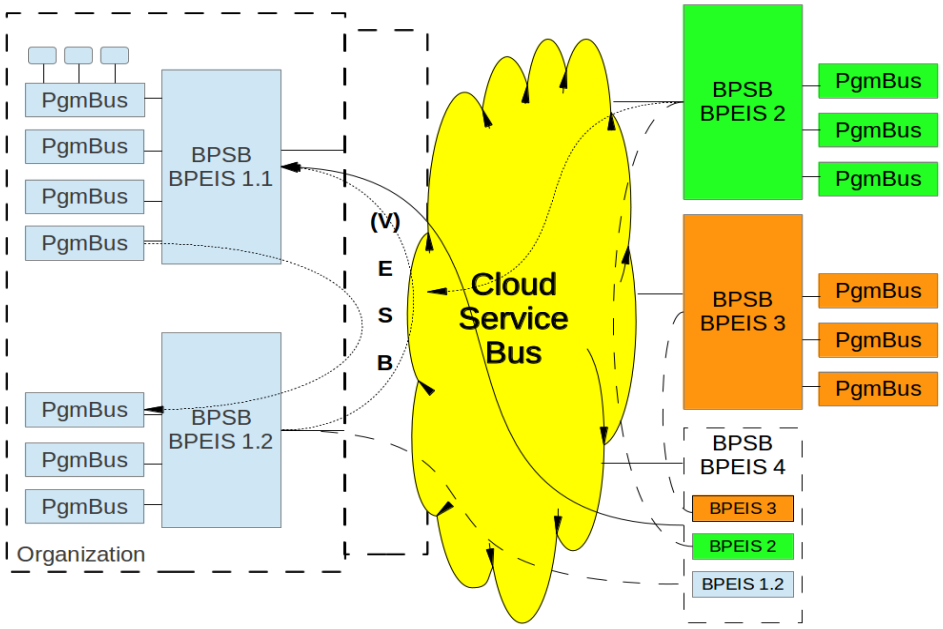

Figure 66: Cloud Service Bus

Figure 66 shows that the information system of the organization consists of two BPEIS (1.1 and 1.2). They communicate through the (V)ESB which is virtualized in the Cloud Service Bus (CSB). BPEIS 2 and 3 are directly connected to the CSB. BPEIS 4 is composed of the three other BPEIS: BPEIS 1.2, 2 and 3. Analogous to the capability approach, BPEIS 4 without any programs has a management module.

So service buses can be recurrent (recursive-system theorem, modularity and hierarchy principle). The consequence for a CAS*T EA is that models of the BPEIS in particular and BP in general should also be recurrent.

2.7. Summary

The knowledge and information layers are managed by the CAS*T Int B. The capabilities form another layer. It represents the functions that are performed outside of the defined enterprise. The underlying layer of systems contains nested systems, thus a system can be composed of other systems, which can then also be composed of other systems. Systems are using resources and that is the last layer “Resources”.

“Other Agents” have also been defined because of the possibilities of mutual outsourcing and/or collaboration. If it is on the level of capabilities then the collaboration should be seen as a new enterprise (whole). If it is connected to the layer of systems then we can talk of outsourcing, cosourcing or inslourcing. Regarding the resources, the other agents are suppliers.

The fact of having nested systems (system-of-systems) and the sociocultural form, a bus structure has been proposed to represent the interconnection of the systems (figure 66).

3. Investments in Cloud computing (CC)

3.1. General Overview

In what follows, we will discuss how CC investments ([153]) can be assessed by CAS*T.

CC is a new IT which puts whole or partial parts of the IT-infrastructure and services ([154]) (IaaS, PaaS, SaaS, BPaaS) in a virtualized environment inside and/or outside the traditional IT center perimeter (private, public, hybrid Cloud).

CC gives agility and flexibility to the organization especially in the case of AIS, and SaaS and BPaaS will be of more interest for business agents, but in general the CC investments should be decentralized in the context of Network-Centric Business (NCB). Of course in accordance with the guidelines on the ESB. This is an example of a complex system based on simple rules for the CAS (organization), although the ESB itself can be complicated or complex, but the whole is directed by the shared vision (in analogy with NCW).

The TF will look holistically at the investments beyond the boundaries of the different disciplines especially beyond the IT. Depending on the situation, the TF as decision-maker can be a leader, an (emergent) informal or a formal group. In the case of a formal group (highly probable in a uni-minded organization) the TF must be aware that a shadow system may exist (the realm of self-organization) (Holmdahl, 2006).

The CC investments as for any investments in a CAS are a trade-off between robustness and optimization (Lowe et al., 2006). Robustness is a potential for adaptability which may lead to variety. Snowden (2002) warns nevertheless for the law of requisite variety, if diversity falls below a certain level then the system stagnates and stops. A common investment appraisal process was one of the examples of ways in which organizations can destroy requisite variety. However too much variety makes investments more complicated, even complex and less efficient. So a harmony must be found as a function of the context of environment and organization (situational awareness), thus Cynefin framework and CAS*T Int B.

Regarding our case Fedict, we conclude that the Belgian and European procurement laws for governments are not adequate enough indeed too rigid to handle IT more in particular CC in complex situations. Moreover CC with its many service models touches every aspect of the CAS*T EA (architectures), so the consequences (of feedback loops) cannot be foreseen (emergent patterns) thus we are in a complex Cynefin space (already the future of CAS (environment) is unpredictable).

So, the Request For Proposal (RFP) is a complex system itself (just like the model of a CAS), meaning it has to evolve over time, but as such it stays theoretical so there are no implementations, thus different pilot projects (with different emerging results) must be launched t detect the emergent practices.

So the Belgian and European laws regarding government CC procurement should be simplified, however the opposite is happening. In an attempt to standardize the CC market the European Commission (EC) is restricting more and more the CC market (EC, 2012;2014; 2015). Apparently the EC wants to move the CC market from a complex Cynefin space towards a complicated space through standardization rules aiming a bigger efficiency, by consequence less robustness. To Donella Meadows (1997) this would have been an example of how to turn the button of a leverage point in the wrong direction. Moreover the European Cloud Partnership (ECP) Steering Board is certainly not a model for a transdisciplinary forum.

It cannot be neither the case to use CC as a *tool* in a conventional IT-center. CC is then not a IT paradigm shift, but merely a way to virtualize and standardize IT-components in mostly private clouds (CAPEX issues, thus rigidity).

3.2. Problem Posing CC

3.2.1. IT as commodity

CC is a new technology which puts whole or partial parts of the IT-infrastructure and services in a virtualized environment inside and/or outside the traditional IT center perimeter. It touches every level of the IT architecture and thus has a big influence on the way the internal and external users via their business processes are interacting with this architecture.

CC is a hot topic not to say a hype, amongst business and IT leaders today for its potential to transform IT service delivery and to galvanize service-oriented architecture (SOA). Some people even state that just like electricity and telephone, IT will be transformed into a commodity or the fifth form of utility.

With CC, applications and data can be stored all over the world. Thus trust becomes a very important issue. Trust is already en important issue in SOA but CC has brought it to the forefront. There has to be a trade-off between cost and confidentiality, which is culturally influenced.

153 Based on Rabaey (2014; 2013; 2012; 2011).

154 Iaas: Infrastructure as a Service; PaaS: Platform as a Service; SaaS: Software as a Service; BPaaS: Business Process as a Service.

3.2.2. CC changes even more the way of approaching IT

But more important is the strategic context of the CAS (organization). Nowadays the business has moved from a “safe and slow” market toward a complex even chaotic fast moving society (not only the markets have changed). The theory of CAS which describes the internal and external connections of the organization in such a CAS (environment) will help leaders and managers in companies, governments and non-profit organizations to evolve in this context, therefore CC is part of that system and in some cases, CC can become a CAS.

As a consequence, a new Business Thinking Model is needed. But as for must business, the tools may be important, but the vision and the strategy to use these tools are much more important. So it may not be solely technology driven (otherwise hype) but also business driven. A combination of both should already be implemented in the development of the Grand Strategy (Shared Vision). Only in this way the new technology paradigm can be proliferated into different strategylevels, resulting in an awareness at the operational level (business processes and projects). Consequently the investment methodology has to follow this new concept

The technology of CC forces the top management of uni-minded organizations to think (even more carefully) about competition and collaboration, be it now in relation to the customers, suppliers, government or “traditional” competitors. Brandenburger et al. (1995) talk about “Co-opetition” a combination of Cooperation and Competition in the evolution of Game Theory, which through strategic games can be applied in the investment decision process in general and in IT in particular.

3.2.3. US Government

The US Office of E-Government & Information Technology states that IT advancements have been at the center of a transformation in how the private sector operates - and revolutionized the efficiency, convenience, and effectiveness with which it serves its customers. “The Federal Government largely has missed out on that transformation due to poor management of technology investments, with IT projects too often costing hundreds of millions of dollars more than they should, taking years longer than necessary to deploy, and delivering technologies that are obsolete by the time they are completed. We are working to close the resulting gap between the best performing private sector organizations and the federal government.

The Office of E-Government and Information Technology (E-Gov), headed by the Federal Government’s Chief Information Officer, develops and provides direction in the use of Internet-based technologies to make it easier for citizens and businesses to interact with the Federal Government, save taxpayer dollars, and streamline citizen participation.” (Whitehouse, n.d.).

As a consequence, the Obama administration has enforced that for every new initiative in e-government, CC solutions should be considered first (Spínola, 2009). A good example in our domain is the US Intelligence Community (IC) which has to move away from a (stovepipe) agency-centric IT-model to a shared-service model in the Cloud (Slabodkin, 2014).

3.2.4. Purpose of this Section

The purpose of this section is to place IT and in particular CC into the context of the CAS*T. Possible economies of an implementation or an extension of CC in the organization, along with the risks, are assessed in the business and technology context of that organization.

CC is a very demanding technology regarding the level of maturity (stages) of CAS*T-EA, certainly when the business processes of an organization are directly affected by the implementation of CC. Therefore an extra stage in CAS*T-EA and an extra service model are conceived to better map the opportunities and risks while investing in CC.

The organization is a CAS (with possible desired restrictions) and therefore a transdisciplinary approach (via CAS*T) is needed. We have observed that the IT industry has moved towards a (more) easy integration of technological solutions. This is not caused by an altruistic reflex of those organizations, but by the Internet as the concept of interconnecting everything, everywhere at any time. The question is if CAS*T-EA is a conditio sine qua non to succeed the implementation of CC.

In this framework the move of legacy systems to the Cloud and the overall risks related to the implementation of CC are discussed.

3.3. A short introduction to CC

Although terms related to CC are being defined (National Institute of Standards and Technology (NIST)), some commercial companies are redefining some terms to suite their sales or marketing model. We will give an overview of the definitions and characteristics of CC as defined by NIST. The quoted parts are extracted from NIST (2011).

3.3.1. The characteristics of CC

- “On-demand self-service. A consumer can unilaterally provision computing capabilities, such as

server time and network storage, as needed automatically without requiring human interaction with each service's provider."

- "Broad network access. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and PDAs)."
- "Resource pooling. The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory, network bandwidth, and virtual machines."
- "Rapid elasticity. Capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out, and rapidly released to quickly scale in. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time."
- "Measured Service. Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service." This is necessary for the pay per use business model.

3.3.2. The service models

- "Cloud Software as a Service (SaaS). The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser." It can be considered as a complete outsourcing of an application, but based on pay-per-use.
- "Cloud Platform as a Service (PaaS). The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations."
- "Cloud Infrastructure as a Service (IaaS). The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications." This reduces the upfront capital cost and it enables companies to start small and quick, without having to invest in possible future capacity performance (CAPEX becomes OPEX).
- We consider also Business Process -as-a-Service (BPaaS). BPaaS is pre-assembled business processes which are provided via cloud application platforms to the consumers (Marks et al., 2010).

Figure 67 ([155]) depicts the CC services.

155 *Figure 67* Wikipedia (2012) *Cloud Computing Layers* [Illustration]. Retrieved January 23, 2014 from http://en.wikipedia.org/wiki/File:Cloud_computing_layers.png

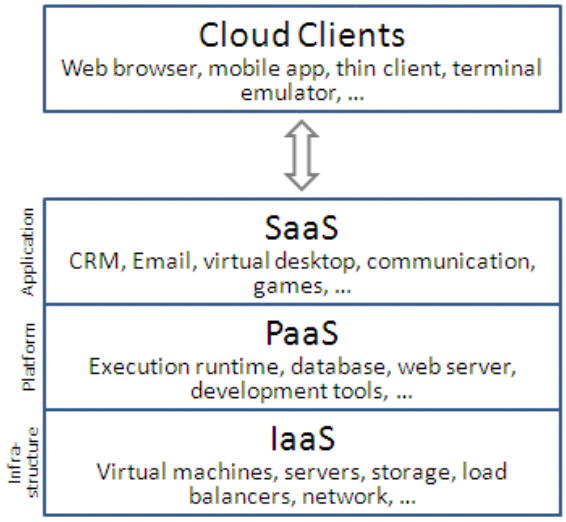

Figure 67: CC Services

3.3.3. The deployment models

- "Private cloud. The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise. "
- "Community cloud. The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise. "
  An example is the USA IC, discussed in CAS*T Int B, where all intelligence agencies are gathered into one community cloud.
- "Public cloud. The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services."
- "Hybrid cloud. The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds). "

Figure 68 ([156]) shows the concepts of the different deployment models. The community cloud is not shown because it can be on or off premise, respectively private and public.

156 *Figure 68* Wikipedia (2009) *Cloud Computing Types* [Illustration]. Retrieved January 23, 2014 from http://en.wikipedia.org/wiki/File:Cloud_computing_types.svg

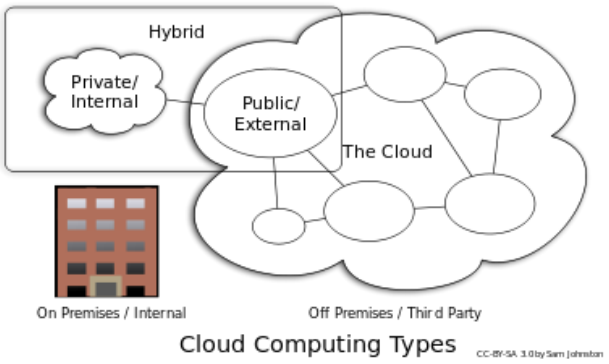

Figure 68: CC deployment models

3.3.4. Evolution, not revolution

Whereas the NIST's definition is quite strict, CC is usually used as a "catch all" concept. The term became a buzz word, referring also to existing techniques like virtualization: old wine in new bottles.

However the term seems to be evolving in the minds of people toward the mutualization of computing resources thanks to remote transfer and access techniques on a "on demand" and instantaneous access basis (Laurent, 2011).

3.4. Fedict

3.4.1. Standardization and Virtualization

The main characteristic of CC is standardization (of services). Through this standardization on every level, management becomes easier. Another advantage of standardization is the efficiency and therefore the reduction of costs in setting up and maintaining services. Mr. Peter Strickx, CTO of Federal ICT Agency (Fedict) ([157]) said that not the CC on itself will make IT more efficient but the way to get into the Cloud, the preparation, like standardization and virtualization makes IT more efficient (personal communication, March 23th, 2011).

This standardization permits a better virtualization because it provides a whole set of processes, activities and tools to support the virtualization and the on-demand-self-service, by providing standardized approval cycles, and even pre-approved services with special rules.

To enable the move to the Cloud for the Belgian federal departments, Fedict intended to implement a DCaaS: Data Center as a Service. It is a community cloud with external and internal infrastructure. The main reason for keeping an internal infrastructure is security. More specifically the databases (with confidential information) will stay in hands of Fedict.

3.4.2. General considerations

The government can play three roles in investing in CC. It can itself be a cloud service-provider, or it is a cloud customer (cloud service-consumer) or the government can be a mixture of both (hybrid situation). We make the assumption that the IT-resources are managed by one governmental organization, that we call GovIT. In Belgium the Fedict does not fulfill completely this role, but is instead an enabler and coordinator at federal level. As such, every federal public service also has an IT-department. However in the context of CC, Fedict is fulfilling the role.

The GovIT is the interface between the other governmental organizations, which are always cloud service consumers, and the cloud service-provider (itself or a third party).

CC gives the possibility to optimize the use of IT-resources, only the efficiency makes it such that IT-resources are delivered in a just-in-time philosophy. As a matter of fact the IT-resources are kept scarce. Therefore even as a cloud service consumer a capacity planning is in any case needed. This capacity planning is linked to the strategic planning (long term vision) and the business operational planning (short term vision, and present), formalized through the CAS*T-EA, taken the characteristic of emergence into account.

157 In the text we are interchanging Government IT (GovIT) and Fedict.

In both cases, GovIT will probably always have to acquire software from third party. The fact that GovIT represents the whole government, it can negotiate very good prices for the use of software. Since CC is about standardization, the government has all interest to offer Open Source Software (OSS) as part of the services. Some examples in the infrastructure are Linux, MariaDB, in the platform eclipse, in the software Alfresco, openoffice, and Intalio and Bonita for BPaaS. The costs of ownership can be reduced to the professional maintenance and consultancy for these OSS. By avoiding acquiring costs, GovIT can eventually invest in the OSS development in order to direct it more to the needs of the governmental organizations.

An example is the Public Federal Service Personnel and Organization in Belgium. It implemented Alfresco as content and community platform. Other public federal services can join the projects by adding (standardized) hardware (disks) in the IT-infrastructure.

3.4.3. Government as Cloud Provider

Unlike a commercial Cloud Data Center (CDC), the GovIT has a planning of the needed resources, if possible through budgeting. A commercial CDC has to invest in infrastructure, hardware and people for customers it does not know yet. They can't wait for the customer to be known, because due to the short service delivery time demanded by the customer, it would be too late for the commercial CDC to acquire new resources.

As already mentioned a CDC has to make a trade-off between the number of offered standard services and the manageability of that number of services.

Besides the number of services (in the service catalog), it has to agree the service level for every offered service with the different governmental organizations (SLA) regarding Recovery Time and Recovery Point Objectives.

The GovIT needs to foresee a backup site, it has the choice to keep a backup site alive, or itself can negotiate with a third party for a backup site. One may not forget that when the backup site has to take over from the main site, the backup site itself has no other backup site. So in the case that GovIT has its (second) own backup site, it will still have to negotiate a backup of that second CDC. Of course, GovIT can always keep a third CDC alive, but this becomes very expensive, unless it sells its Cloud capacity to others. This is a typical growth option.

3.4.4. Government as Cloud Customer

It is possible that GovIT is abandoning the idea to be a CDC or to continue to be a CDC. This is only possible if all five levels of architecture in CAS*T-EA are well defined and understood. In general, GovIT will opt for a hybrid solution. Hybrid in two ways: integrating legacy systems with the Cloud and hybrid deployment model (public-private combination).

3.4.5. Elections 2014

The Request For Proposal (RFP) has been released but the Belgian federal government (Elio Di Rupo I (EDR I)) was in budget problems and in 2014 there were federal elections. From our experiences as IT-responsible for the Medical Service, ACOS Eval and DG Education (Royal Military Academy) mostly the projects are not stopped but the delays to finalize the RFP are shortened so that even a single problem can cause the RFP to pass its delays. Due to the rigid procurement legislation in most cases that is the end of that version of the RFP because of other scheduled projects or in the case of Fedict CC procurement no new investment budgets have been planned ([158]). The old infrastructure can still function of course, however with less capabilities, less agility and less flexibility, thus less service for the citizens (taxpayers).

In this context, changing the procurement legislation (rules LP 5) and/or to give the governmental organizations as Fedict the space to self-organize (LP 4) ([159]) could be solutions. However EDR I was looking for a CC solution outside the federal government, namely SMALS ([160]). Although SMALS delivers anno 2014 IaaS (clients need to manage themselves the virtual servers), thus this solution is not what Fedict was aiming at for the federal governmental organizations.

158 In the Belgian government procurement system there are budgets to order, and budgets to pay the invoices.

159 Both LP 4 and LP 5 are outside CAS*T-EA.

160 Website of SMALS: https://www.smals.be/nl

3.5. ST and CC-projects

3.5.1. Holistic approach CC

This new IT-mindset, especially in the domain of SaaS and BPaaS, is influencing the approach of assessing "IT investments". IT-systems which use CC touch every aspect of the organization: business and resources, thus we are encouraged to have a more holistic approach.

The fact that a company's data (or part of it) can be stored anywhere on the internet makes confidentiality and security an important topic (CSA, 2010; Abrams, 2011; Laurent, 2011; Soenen and Palante, 2011). The laws applying to the data will differ from country to country (legal aspects).

Judicial risks (due to the CAS (environment)), lie in the domain of confidentiality of the data, especially with reference to the customers of the organization. For instance, if the cloud service provider has a cloud data center in China (primary storage or backup storage), then the organization should be aware that data has to cross unencrypted the Chinese border.

Putting data and/or processes in the Cloud is one aspect, getting them out again, or even deleting them and being sure that they are really deleted, is another (security of data). Moreover, integrating Cloud data (off-premise) with data in the company (on-premise) may present difficulties (IT-technical issues, business inefficiency). Certainly the "easy" access to CC services is resulting in quick solutions that can be "difficult" to integrate later with other CC services and/or legacy systems. We have seen these same problems with Enterprise Application Integration (EAI), but finding solutions now with the Cloud is proving even more challenging. It was a similar problem in the 80's with the introduction of the pc in companies. People were buying stand alone systems that later needed to be integrated into the existing company's applications: here 'bad' wine in new bottles.

The employees and collaborators of a company are confronted more and more with the situation that they are working less on-premise, and more at home (legal aspects, insurance, human resources) and are thus themselves on the internet. Therefore their IT-environment (pc, mobile, devices) should be secure and as such share the responsibility of the IT-security (off-premise).

So the acquisition (here also the financial question of CAPEX and OPEX) of Cloud Computer services cannot and may not be solely assessed from the perspective of the IT-department of a company or organization, but must employ a transdisciplinary approach: legal, human resources, material resources, IT, financial, logistics, business, etc. Even in the calculation of the Total Cost of Ownership (TCO) Abrams, Kirwin, Guptill and Odell (2011) state that a holistic approach is necessary because TCO is not a formal financial model but is a holistic view of IT costs across enterprise boundaries over time. Therefore a holistic framework called Transdisciplinary Forum (as a part of CAS*T) is being proposed ([161]) for the cases when investments concern the whole organization or significant clusters of agents, otherwise for BPEIS in a multi-minded structure the agents can decide themselves. Moreover to CAS (organization), investments are organizational changes, which have to be done step-by-step (emergent strategies).

3.5.2. From Strategy to Service

If the organization is now profit or non-profit, CC has considerable advantages, not only for the organization but also for its partners, customers and service providers. These advantages along with challenges and opportunities (risks) of CC are being brought into frame and placed in the context of S2IF. From a business perspective, a resource or service provider will be evaluated on the delivery of the service (SLA) and the quality of service (QoS), which is defined scalability, availability and reliability.

During our discussion on transdisciplinary approach, we stated that we do not have to know all the parts of a car to drive it. We referred to the Chaos theory (Glenn, 1996) where a Chaos system (as a whole) can be controlled by parameters ("control knobs") although the system is not fully described. So even for an uni-minded organization with a detailed C2, if that organization has more than one parameter to control the system (functioning) then it should coordinate the parametrization in the system, otherwise one or more parameters may destabilize its functioning.

This can be seen in Figure 69. In the left part of the picture, the controlling parameters X and Y are separately managed respectively by components A and B. In the right part, S2IF will monitor the whole and harmonize the input of both parameters, so that no instability a priori is attained. However since organizations are CAS, emergence exists. Later in the section, we will discuss how the responsible agents should react.

Related to the "Edge of Chaos"; systems exist on a spectrum ranging from equilibrium to chaos. The most productive state to be in is at the edge of chaos where diversity, variety and creativity are at the maximum, leading to new possibilities. Controls, such as simple rules (Esienhardt et al., 2001) and regulations or institutional and budgetary restrictions, ensure that an agent's behaviors are limited, thus changing the aggregate behavior and forcing the CAS to behave in a predictable way (Janssen et al., 2006).

161 In Rabaey (2013) it was called Strategic Interdisciplinary Investment Forum (S2IF)

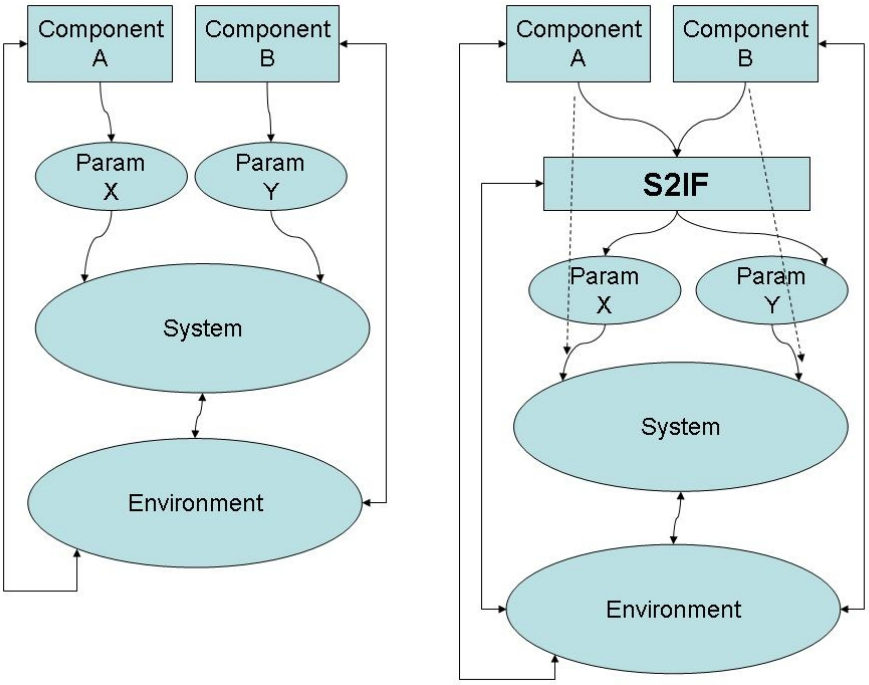

Figure 69 S2IF as Coordination (Harmonizing)

So or the organization or some of its sub-units are in the ordered spaces, or they are obliged to move from the complex space to the ordered spaces.

However in order to be able to operate in all Cynefin spaces, S2IF, which we can rename to Transdisciplinary Forum (TF) may be the leaders in a CAS (organization) who are more “enablers” or “facilitators” than commanders. As already mentioned, their role in C2 changes from command-and-control to communicate-and-coordinate. As a matter of fact, the TF can be institutionalized (ordered spaces) or can be emergent (complex space). Thus depending on the Cynefin spaces the CAS (organization) or its sub-units are in, TF can be formal or informal (emergent).

3.5.3. C2 and projects

We have already discussed C2, but we would like to focus here more on the project side of the story. The concept of CAS is important for the C2 of an organization (military or civilian). Lowe et al. (2006) state that good military commanders have intuitively understood the nature of complexity and nonlinearity on the battlefield. In turn, the science of complexity may reveal the underlying basis of these intuitive truths, which we have proved.

Classic “formal” management philosophy does not cope with these issues related to CAS. That’s why Lowe et al. (2006, p.9) write: “Continuous change means people, structures and processes need to be able to adapt appropriately. Study of CAS indicates that an agile organization can be built on the basis of individuals with a simple but effective set of rules and the ability to communicate and adapt. A study […] showed that the *[organization]* has functioned effectively in the past through the use of informal networks. […] Organizational rigidity has been seen by those within the system as a restriction that reduces effectiveness to some extent. Rather than attempting to address this by finding the perfect C2 structure, CAS ideas promote the use of individual initiative through informal networks as part of our C2 culture and not just as a tolerated ‘work-around’”.

Regarding CC projects, we are referring to John Seddon (2003) who describes the characteristics of detailed C2 project management. Detailed C2 projects are typical top-down and hierarchy based. The design is functional (based on functional analysis. The measurements for the progress and efficiency are output, targets or indicators, thus management by numbers and this is exactly the basis and the means of the decision-making. So, the decision-making is separated from work.

These numbers are largely financial and activity-related (what people do). Which brings us to the next

characteristic: the typical role of management is to manage people and budgets. This is in contrast with ST, where the role of management is to act on the system. So it is logical that detailed C2 projects approach problems via reductionist thinking. Most of the time the same standards are used for all projects of any kind. The relationship between the company and the customers or suppliers are based on contracts. The ethos of detailed C2 management is to control, while in ST it will be learning so that changes are adaptive and integral (CAS*T, mission C2), instead of reactive.

Projects exist because some aspect of the organization has to be changed, removed or added. Savigny et al. (2009) are calling projects interventions in the system (CAS*T: organizational changes). They remark in their work on ST for health system strengthening that most organizations don't understand systems capacity, therefore the research and development communities struggle to design specific interventions that optimize a system's ability to deliver essential functions. And all to often there is another poorly appreciated phenomenon that every intervention, from the simplest to the most complex, has an effect on the "overall system": "Presumably simple interventions targeting one health system entry point have multiple and sometimes counterintuitive effects elsewhere in the system. […] It is increasingly clear that no intervention – with a particular emphasis on system-level or system-wide interventions- ought to be considered 'simple'" (p. 30).

They continue to state that it is imperative that an organization understands the complex effects, synergies ([162]) and emergent behavior of system interventions to assess investments. Not only it is fundamental for investments to know what works but for whom, and under what circumstances (p. 30).

So the context and the boundaries of an investment intervention are equally important in the decision-making process of investments. However we do not know everything of the context, nor our own organization, so risks exist as we have discussed.

3.6. Investment process CC

3.6.1. Investments CC and Cynefin

During the sense-making framework discussions, we have given an overview of the different investment techniques in the different Cynefin framework spaces.

A topic for CC investments is the CAPEX/OPEX ([163]). For fiscal and accounting these are two different expenditures that are treated differently. However related to DCF, CAPEX is a cost which cannot be deducted in the (tax) year in which it is paid or incurred and must be capitalized. The capital expenditure costs are then amortized or depreciated over the life of the asset which has been acquired. From the point of view of cash flow, the yearly amortized or deprecated amounts are incoming cash flows. As such, CAPEX and OPEX can be used in the same context and be compared to each other.

If business is in a more complex context then it is hard to predict the future, so what about the future cash flows? "[In] a rapidly changing environment, we don't really know how things are going to unfold, so it's difficult to make forecasts or budgets going many years into the future." (Mauboussin, 2011, p. 92)

Shen (2009, p. 712) and Huang, Kao and Li (2007, p. 688) write that indeed the evaluation of (IT-) investments are not trivial, because the costs and benefits may involve uncertainty and vagueness, which make return on investments difficult. Further (IT-)projects are assessed from various dimensions and criteria, which need advanced decision tools to aid. Thirdly, (IT-)solutions may be bundled with some special constraints about the system architecture, budgets, decision preferences, and so on (see also S2IF). The authors are proposing a fuzzy multi-objective decision approach for evaluating IT-projects. Fuzzy sets are used because the expertise of specialized people from different domains has to be combined together along with their level of expertise (see also fuzzy Real Options Valuation below and Tolga and Kahraman (2008)). We refer to Thomaidis, Nikitakos and Dounias (2006) for the theory and case studies based on Fuzzy Sets and Lauria and Duchessi (2006) based on Bayesian Belief Network (BBN).

We recapitulate the investments in the different Cynefin spaces.

Simple techniques as DCF or IRR can only be used in the simple Cynefin space (Sense – Categorize – Respond) because the cause-and-effect are well known and the relative future is stable (known), thus the best solution exists.

In the complicated Cynefin space (Sense – Analyze - Respond) more expertise is required to understand the cause-and-effect, however the best solution does not exist, only good solutions exist. Management needs to be able to stop, start, put on hold, restart, expand, etc. projects. This flexibility can be obtained by using ROV, however we have argued that FROV are more suited for this Cynefin space. For these reasons, we have placed ROV on the boundary between simple and complicated Cynefin space.

162 Synergy is a situation where different entities combine advantageously – where the whole becomes greater than the sum of the individual parts (Savigny et al., 2009, p.30).

163 See also OG (2010) and Abrams (2011)

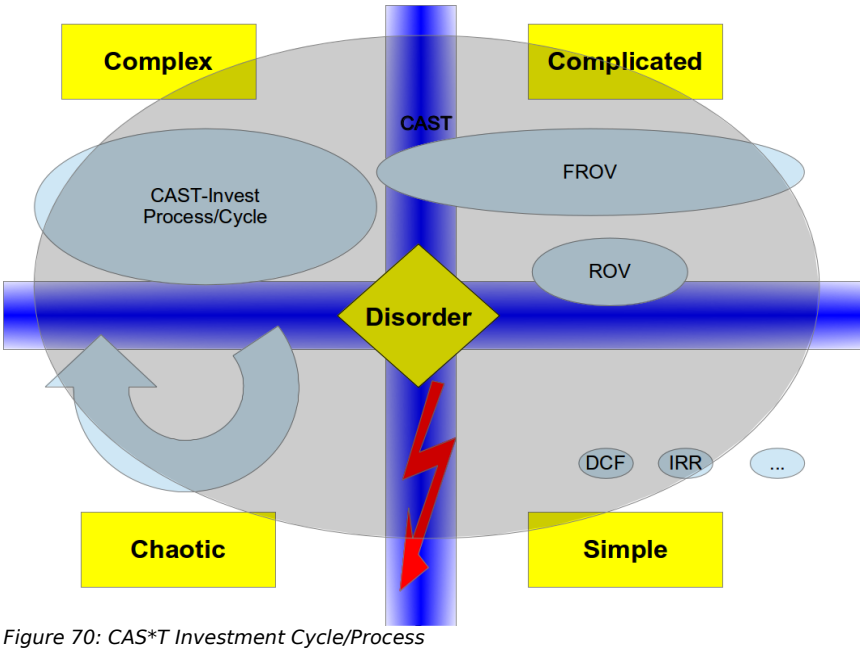

*Figure 70: CAS*T Investment Cycle/Process*

We have proposed a set of tools to help the organization to be aware of the situation in the complex Cynefin space (situational awareness as in NCW; Probe – Sense - Respond) and therefore support the decision-making (emergent strategies and solution). The methodologies and/or the family of tools are subject for further research.

Snowden (n.d.) recommends to go only into the chaotic Cynefin to innovate (innovating at the edge of chaos). If an organization went in there by accident, he suggests to leave it immediately. A very dangerous case is when the organization fell of the cliff (see section 4.2.7 Mind the "Cliff"). The management attitude is as Snowden ([164]) states, more fascist: Act – Sense – Respond.

CC will be situated in the complex and complicated Cynefin spaces.

The ultimate goal of the further research could be to develop a framework in which the same family of tools could be used in all Cynefin spaces.

3.6.2. Risk Management Aspects

3.6.2.1. Cloud Cube Model

The Jericho Forum of the Open Group are proposing the Cloud Cube Model (CCM) (Figure 71) as a framework to investigate the secure collaboration in cloud formations (models) (OG, 2009), (Chang, 2010) and to define the best model for the business needs (Chang, 2010a), but it can also be used to assess the risks for the different service models and/or deployment models.

Following questions are examples of what can be assessed by the organization with CCM, as long with issues around some possible solutions: "What are the risks (security) for Private and Public Clouds?", "How do you couple Public with Private (hybrid thus), and what are the right reasons for it?", "A private cloud application using the corporate e-mail system in the public cloud." and "A public cloud application using resources from the private cloud."

As discussed above, the main issue to opt for a global CC strategy in an organization is certainly the interoperability of applications inside the organization (private cloud, legacy systems) and outside the organization (public cloud, non-cloud third party systems). This is more complex than implementing a hybrid cloud, or for that matter a community cloud. The cloud cube model gives a good framework to determine the risks, but also the opportunities.

164 Snowden (2013) discusses the two extremes: fascist (likes rules) and anarchy (does not like rules). At a certain moment fascism will always win from the anarchy.

Dimension	Description	Remarks
Internal and External	the type of deployment model (internal: private; external: public; both: hybrid)	
Open and Proprietary	defines the state of ownership of the cloud technology and indicates the degree of interoperability, as well as enabling “data/application transportability” between providers. It also indicates any constraints on being able to share applications.	the 'lock-in' with a provider
Perimeterised (Per) / De-perimeterised (D-p)	represents the architectural mindset if one is operating inside the traditional IT perimeter (with firewall) or outside	De-perimeterisation (OG, 2009, 2010) has always been related to the gradual failure / removal / shrinking / collapse of the traditional silo-based IT perimeter. It is about the way data can be accessed from a private cloud (like VPN) or from a public cloud (like data segregation, privileged user access).
Insourced and Outsourced	is about respectively in-house development of clouds and the services provided by cloud service providers.	

Table 10: Dimensions of Cloud Cube Model

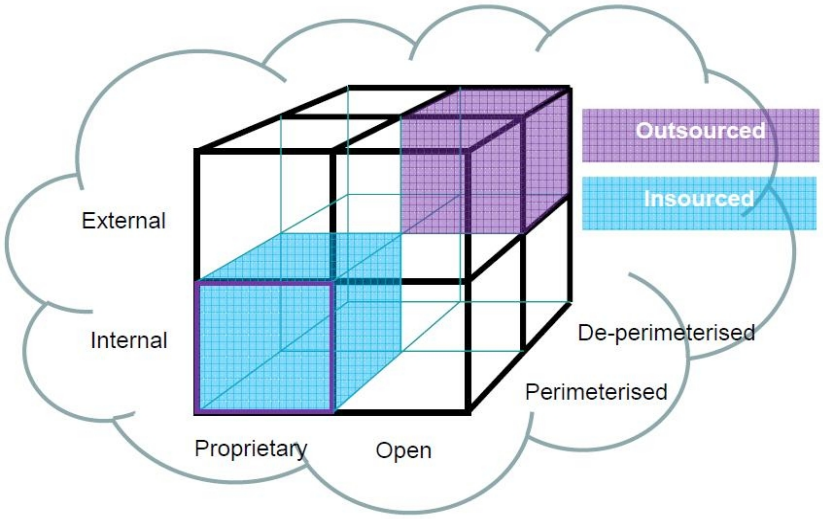

Figure 71: Cloud Cube Model (CCM)

3.6.2.2. Risk Categories

While CCM gives a good insight in how the cloud should be approached in the architectural domain, other kind of risks should also be considered. Triantis (2000) in his discussion on real option valuation gives a general classification of risks. For each risk category (first column) in the following table, some examples can be found in the second column.

Risk Category	Example
Technological	Implementing new technology Production breakdown, operational risks
Economical	Material cost Macroeconomic conditions

Risk Category	Example
Financial	CAPEX (Investment budget) OPEX (Budgets for Operational costs)
Legal/Regulatory	Political regime and legislation Environmental change
Performance	Subcontractor Judicial risk

Table 11: Types of Risks of Cloud Computing

The technological risk category is fully covered by the CCM, but an additional point of interest is “Disaster and Recovery”(D&R) Two parameters are important to define the SLA of D&R:

- Recovery Time Objectives (RTO): what's the maximum downtime (for an application)
- Recovery Point Objectives (RPO): the amount of loss of data, or transactions

In function of these two parameters and the cost of each solution, two ways of D&R are possible: active-active and active-passive. Active-active means that the second site is receiving every change of state of the applications and their data (transactions), and vice verse. The benefits of active-active are quick recovery and take over, while the costs are keeping two CDC alive and of course the bandwidth use. With Active-Passive, the second site is receiving everything but it is not put on line. The benefits of active-passive are less demanding service to back up (so cheaper), but it takes more time to come back on line in the Cloud.

The technological risks are for a first implementation a considerable issue, particularly for the private cloud because all of the risks stays in the organization and it remains a capital investment (CAPEX), and not an operational cost (OPEX) (Marks et al., 2010). Due to this, the private cloud is also more sensitive for economical fluctuations (negative). On the other hand, since public cloud is another form of outsourcing, the performance of the cloud service provider is something that the organization does not control except through SLA and penalties (Spínola, 2009).

So, the economical risks are for a government very important. Although it can have an impact on the macroeconomics conditions, some issues like the latest financial crisis are not under control. As a consequence, the economical risks may have an influence in the financial domain in casu the budgets for investments (CAPEX) and operational costs (OPEX), and vice verse. CC in a public or hybrid cloud gives flexibility.

One may ask if a pure private cloud can really save money (except for the operational cost savings due to standardization and virtualization). In this context cloud service providers as IBM are proposing shared private cloud (computing) which is a public cloud but located in countries that GovIT agreed on. The term private indicates that the servers or services for one organization are protected from the rest of the servers in that particular cloud (this is a security issue, some cloud service providers can’t guarantee this security service).

The fact that cloud service providers are giving choices where the data and/or applications are hosted is also linked with the legal and/or regulatory risk category. The legislation of the country where the cloud service provider has data centers or service centers, is applicable, not the legislation of the country of the customer or cloud service provider. The political or cultural environment at the possible locations of one or more components of service management (see figure 72) may influence the decision about where to implement components.

China demands that every IT-communication crossing its border is unencrypted; therefore for touchy information the CDC in a location in China, while interacting with customers outside China, may have a No-Go light.

Other issues that have to be taken into account are the tax regulation and the culture (attitude) of the local service managers to follow procedures (discipline, care, etc.).

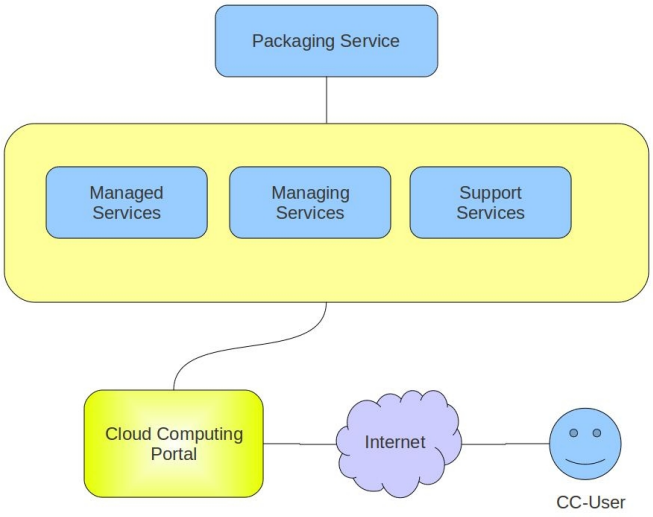

Figure 72: Service management model

Judicial risks lies more in the domain of confidentiality of the data, especially towards the customers of the organization (also linked with previous category) and the quality of service of the cloud service provider. Questions about the latter are: “What if the Cloud provider cannot fulfill his SLA?”, “If the government ICT is itself responsible as Cloud provider then what are the risks and legal aspects of this failure?”

3.6.2.3. Systemic risks

We could not obtain relevant cases about CC investments nor CC implementations to discuss the systemic risks (risk appetite, emergent risks). In any case it would have requested to know also the mental models.

3.7. Cloud Computing and TF

3.7.1. Positioning of IT in an organization

Transdisciplinary Forum can have different shapes depending on the space the CAS (organization) and/or its sub-units are in:

- leader (ordered spaces, chaotic space);
- formal groups (complicated spaces);
- informal (emergent) groups or leaders (complex space).

As already mentioned IT does not exist just for itself; it must serve a purpose of facilitating the working and managing of an organization. This organization and its environment, both CAS, are characterized by complexity and IT itself does not escape this phenomenon, on the contrary. This complexity drives organizational shifts in systems, processes, culture and value (Lowe et al., 2006). The challenges that IT with CC is facing are “not simple”. Formal structures coexist with and are supporting informal structures.

The non-Cloud IT has trouble supporting these informal structures, because security policies and user management are quite strict and do not permit informal structures. Even virtual groups are still subject to these rules. As a matter of fact, handling complexity in an efficient way encourages culture and processes of devolving control. Moreover the diversity in processes and capabilities is increasing. Through CC, business users are able to define and use “Services” in a flexible way. IT-strategy should only give simple rules for acquiring and using this flexibility. So, IT indeed becomes a commodity and utility.

The private Cloud and hybrid Cloud are just a transitional phase towards a global public Cloud. The early adopters are now facing issues like confidentiality and security, however in a CAS every agent has to adapt very quickly to the changes external to the organization (market, government, customers) and internal to the organization (changing relationships, changing structure, etc.) so that even if data is stolen the information will be passé. Knowledge on the contrary is very sensitive. This does not imply that security can be non-existent, but security may not be a reason to slow down the co-evolution of the (whole) organization and its (heterogeneous) components (agents).

TF should reflect this concern and force IT to shift from a centrally controlling information system manager (although systems can be decentralized) to a facilitator/coach of Cloud services for the whole organization (expertise).

On the level of the individual (user, employee, manager, etc.) complexity drives individual demands on knowledge, approach and interactions (Lowe et al., 2006). The IT with CC must enable the individual in CAS to operate in a dynamic and uncertain environment. So not only a group of people (forming an agent) but also an individual must be quickly served. All of these individuals have a diversity of knowledge, skills and experience. This implies that the traditional service delivery and programming in IT can not be used anymore, because it has to serve every individual in the most efficient way. Although investments in CAS are suboptimal (for reason of robustness) this diversity is too big to be served in a centralized way. A consequence for TF is that it may not only handle agents' requests but it should also satisfy individual needs in the formal and informal structure. How these needs are expressed is in function of the culture and the structure (ad hoc) of the organization and will therefore be unique (just like the strategy is unique in complex context).

In the domain of CC it is impossible for the IT or even the TF to foresee everything for everybody. Initiatives will be bottom up, so the general strategy (and its derived resources strategy and business strategy) will only be able to give the general directions by determining the boundaries.

Is this typical for CC? For Janssen et al. (2006) it is not, because in their CAS perspective on EA in e-Government, they state that (IT) system architectures should emerge from the local level, instead of trying to define them at a national level. These authors are discussing classic but nevertheless CAS IT-systems and come to the same conclusion, so that one can state that CC has the characteristics of a CAS, and therefore the investments in CC should be handled on every level with respect to the characteristics of CAS, which TF does in a holistic way.

3.7.2. Service Models

CC can be an investment in relation to resources (IT) strategy, be it widespread (all levels of CC services) or more related to the infrastructure (IaaS, PaaS). In other cases, CC can be situated on the operational level (SaaS or BPaaS). These services can be stand alone, or can be built upon IaaS or PaaS (acquired or to be acquired). It is however very important that the investment decision of CC be located in the right domain (IT-strategy or operational strategy). This will determine on the one hand if the CIO (or the TF) has more or less freedom of action in making decisions on CC and on the other hand which financial (investment) techniques can be used to assess these investments. In the case of SaaS and BpaaS, it is possible that (as mentioned above) the CIO has no say in the matter other than of how it should be assessed or integrated, but the TF has.

Abrams et al. (2011) see three possible ways to implement SaaS. The first one is "Rip-and-Replace". The conditions are that at least 20% cost benefit should be attained and that minimal operational changes are required. "New SaaS" is the second case where the company has a new business model or is exploring new markets, new customers. Or perhaps another reason may be that the existing solutions suffer from technological obsolescence. The third way is the hybrid solution (from the first two ways). Reasons may be:

- Reliance on existing software/solutions/systems;
- New capabilities unaffordable with traditional solutions;
- Extension of business;
- Filling functional or operational gaps

This implies a lot of business assessment and (business and technological) risk mitigation before choosing the best possible solution. Although Rabaey (2012) treats the implementation of a Government Cloud (GovCloud), the proposed method is also applicable for profit and other non-profit. The condition sine qua non is to have a form of Enterprise Architecture, in casu CAS*T-EA.

There is no "logical" path to move into the Cloud like the sequence of IaaS, PaaS and SaaS. One organization can move from SaaS to PaaS when it has developed (or acquired) a software that yields a competitive advantage.

So, it sounds like a paradox but with the introduction of such a technological concept as CC in an organization, business gains more freedom in relation to IT, because IT is indeed becoming a commodity.

3.7.3. Classic IT-View

Is Private Cloud really a Cloud deployment model? A characteristic of CC is an "On demand Self Service" where a consumer pays as he uses services. However if the private cloud is fully bought and maintained by a company then the employee (consumer) does not pay as he uses.

In a fully private cloud the company is the owner (CAPEX) of all hardware, operating systems, system software, applications, network, personnel, etc. As a matter of fact there is no difference between a fully private cloud and a static data center, only the organization of the services is different. The company however can still chose between "buy it or lease it" for one or more components. But the whole management including for example capacity planning and management is the sole responsibility of the

company.

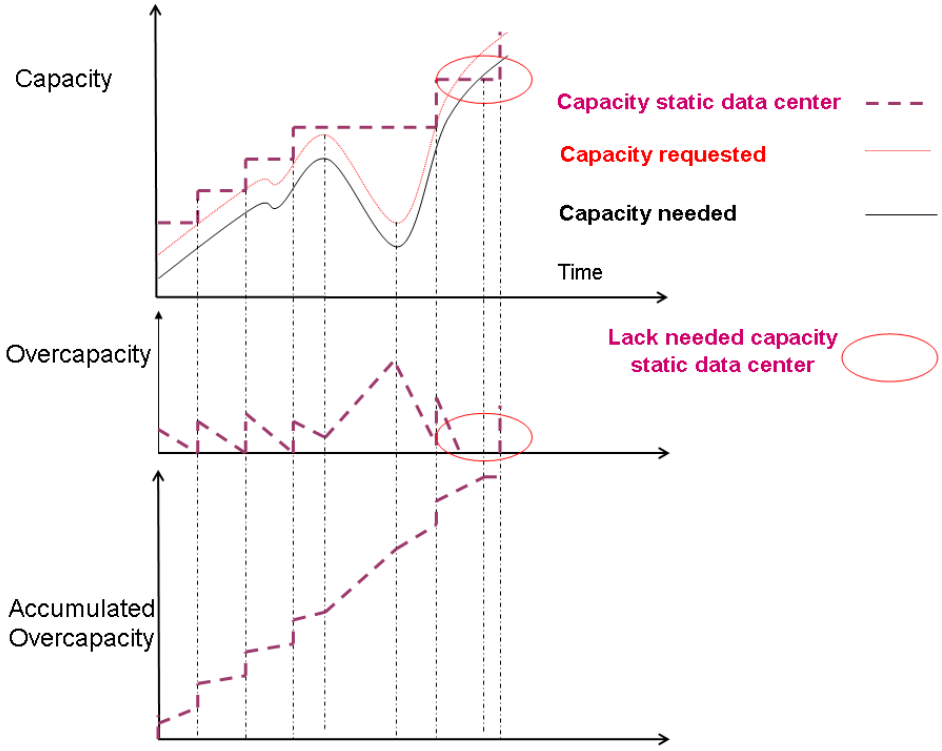

Figure 73: Capacity Problem Full Private Cloud

Figure 73 shows that a company with a fully private cloud may encounter serious problems (like a static data center). The technological risks for a first implementation are a considerable issue, particularly for the private cloud because all of the risks stays in the organization and it remains a capital investment (CAPEX), and not an operational cost (OPEX) (Marks et al., 2010). Due to this, the private cloud is also more sensitive to economical fluctuations (negative). In addition, since public cloud is another form of outsourcing, the performance of the cloud service provider is something that the organization does not control except through SLA and penalties (Spínola, 2009).

So, the investments of private clouds in relation to capacity are discrete which means that for a certain period the data center has an overcapacity of resources. In the case that the needed capacity drops then this overcapacity increases. So a part of the CPU-cycles, disks and software licenses are not used and it is a loss for the company. This lost money could have been used for other purposes (opportunity costs). The accumulated overcapacity figure gives an impression of how this may evolve over time (accumulated loss in cash flow also).

Another, far more dangerous situation is that there is not enough capacity (due to wrong business estimates or problems with the supplier of hardware and/or software), which may results in clients of the companies moving away. If the policy of the company permits it, then a solution can be to (pay as you) use extra capacity off-premise for a certain period, meaning hybrid cloud solution.

As a matter of fact, the only advantage of a “private cloud managed” data center is that it is more efficiently run than a non-cloud datacenter.

A first move towards the real cloud philosophy is the “Shared Infrastructure Private Cloud”. It is IaaS but the infrastructure is completely (virtualized) separated from the other customers of the Cloud Service Provider. This solves the hardware capacity problem and only licenses (system software and applications) have to be managed by the company itself, which can also be partly reduced with PaaS.

Big Cloud Service Providers like IBM offer contracts for a “Shared Private Cloud”. It is a SLA-driven solution which gives security and flexibility to the customers.

If a company moves directly towards public cloud then this can be cheap (for example credit card clouds)

but as already mentioned, it can be very unsafe. For this reason companies are asking more security, confidentiality what means that they are asking for SLA which must be compatible with their policies.

In the near future both deployment models, shared private cloud (with SLA) and public cloud (with SLA), will join into one Cloud deployment SLA-model. At that point, IT as commodity will be a fact.

3.7.4. CAS IT-view

In previous point the classic IT-view states implicitly that a centrally managed IT does not give enough flexibility in a fast changing and complex environment and may cause opportunity costs (since alternatives exist now with public and/or shared private cloud). However if the organization is large enough (like a government), where advantages of scale can be attained then it may be worthwhile to have a private cloud. As a matter of fact, a part of the organization becomes a Cloud Service Provider, in which case another dynamic business model is applicable. Another example is Defense (operations), where not only IT but also energy, transport, etc. are provided by Defense itself (reason of autonomy and freedom of action).

From the point of view of CAS-theory, the heterogeneous agents need a lot of flexibility and autonomy (within well defined and simple boundaries). So a centralized management IT is out of the question. The IT-management is rather an enabler of interoperability (processes) and interconnectivity (network, security, access management). IT management is the advisor in accordance with the EA of the different agents in the (mother) organization. Therefore the solution of the public cloud (with SLA) and the solution of the shared private cloud (with SLA) will be the same and is the way to go.

3.7.5. IT-governance for Cloud Computing

Soenen and Palante (2011) in their work “Cloud Governance is … more than Security” presented at the conference “Cloud Law or Legal Cloud” warn that the main issue with CC is not security (and the related legal aspects). Governance indeed is more than security. So, can TF in the context of CC be used to integrate IT/Cloud Governance?

The authors’ concept of Cloud Governance is based on the IT-governance methodologies like COBIT. The general points of attention are the following ones. “Cloud Context” which defines the managing and the monitoring processes with the roles and responsibilities in the IT-domain. Through CAS, TF broadens this set of roles and responsibilities to the whole business.

- “Strategic alignment” is embedded in TF.
- “Value creation” in TF is implemented by discussing the contribution to the business by examining the services (immediacy, availability), the SLA, cost (pay for use), scalability and mobility.
- “Risk mitigation” for CC a holistic version CCM could be used.
- “Resources Optimization” is not possible in CAS because of the trade-off between optimization and robustness.
- “Communication and Information”: all concerned agents are present and should therefore be capable of communicating with and informing all stakeholders. Moreover the interconnectivity of all agents in a CAS demands a sharing of information and intelligence.
- “Monitoring and Evaluation” is equally embedded in TF, but attention should be giving to the influence of feedback loops in CAS (and other leverage points).

Thus TF supports the concept of Cloud Governance, even in the complex context of a CAS. However, it can not be stressed enough that the existence of CAS*T-EA is a condition sine qua non for governing CC.

3.8. Bringing the pieces together: Transdisciplinary Approach

CAS*T-EA can be the blueprint of the organization's business and IT organization in the ordered spaces, and estimate in the complex space. Many stages (of maturity) are possible, but it is a conditio sine qua non, if the organization and its sub-units wants to implement SaaS on a large scale, that it has reached at least the level of modular architecture, and for BPaaS the level of BPEIS. For IaaS and PaaS, respectively Technology Standardization and Data Rationalization should be implemented.

If the agents want to move the functionality of legacy systems to the Cloud, then they may use the migration system proposed in this chapter. Here also CAS*T-EA is important, because it will determine which processes will be affected and which applications should be focused on to move to the Cloud. They have three choices: PaaS, SaaS and BPaaS. The stage levels of CAS*T-EA will determine the ambition level of the migration (see figure below).

If the ambition level for the Cloud is not in balance with the stage level of CAS*T-EA, then the organization should put first effort in EA. However it is possible that it can acquire a more demanding service model, if and only if it can acquire the corresponding CAS*T-EA. Examples are ERP-packages, in this case ported to the Cloud. This is not without any risk, because of the knowledge architecture, which does not only

represent the knowledge mapping but it is also a reflection of the mental models, phrased otherwise danger for “the cultural shock” may occur.

All this is discussed and evaluated in the TF at the appropriate level. Since TF is holistic (therefore also other investment in resources than IT), the IT is capable to handle CAS*T-EA as reference for the investment proposals. Itself produces and updates SLA and Steering Plans which should be integrated into CAS*T-EA.

TF will evaluate the investment proposals and projects on a continuous base, so that no opportunities are missed or no risk appears or increases without being noticed. Investments are organizational changes requiring energy, time and resources. The fact that they are continuously followed up is very normal (even necessary) for a CAS (organization) thanks to the processes of CAS*T Int B. It is a continuous cyclic process and because of the holistic character of TF, all competences (thus also IT) are continuously informed about the progress (and of course the changes in the environment). This will encourage the agents to keep CAS*T-EA also up-to-date (certainly in ordered spaces).

3.9. Scenario's

3.9.1. Legacy system

Regarding mainframes, the people who can work with them are retiring. However there are still a lot of applications running on mainframes. The purpose is to virtualize these mainframes in a CDC. The maintenance of these is then outsourced to specialized groups of people ([165]).

Clearly we are in the situation of complicated Cynefin space. Besides economic or technical reasons, flexibility can be a driver to move to CC, because it may allow the CAS (organization) or its sub-units to move quicker from one Cynefin space to another, especially complex space.

In general, the goal is to connect parts of those applications in the cloud. Different strategies are possible like Enterprise Application Integration (EAI), but with the introduction of SOA, legacy systems can be wrapped into web services. The next step is to wrap modules in web services (SOA-components) and to migrate the different SOA-components to the Cloud (See figure 74).

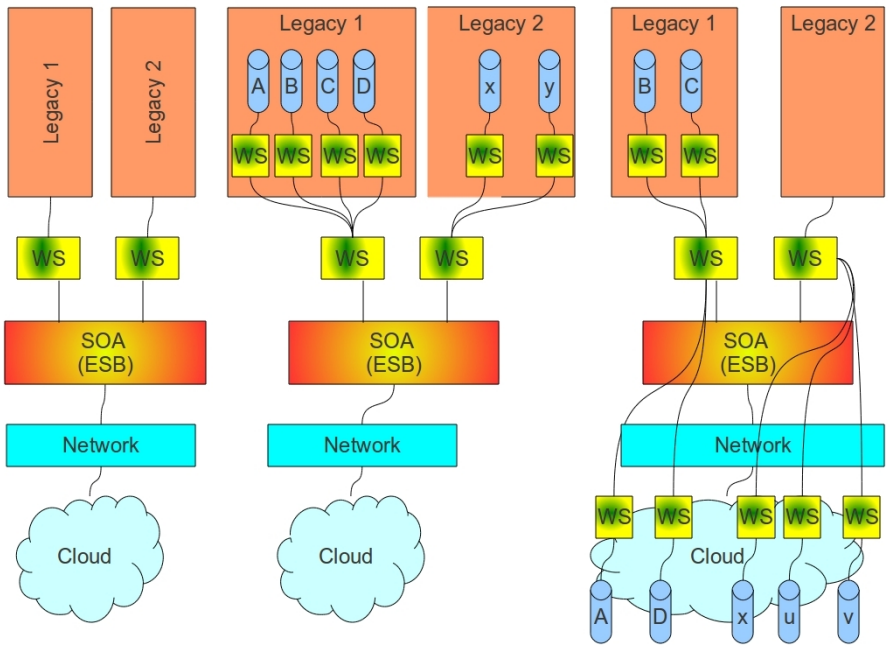

Figure 74: Legacy system, SOA and Cloud Computing

The message is not to convert all legacy systems into Cloud or SOA-components. If the legacy system performs well and at a reasonable price and acceptable service, these systems can stay (until signs of

165 This based on Rabaey (2012) on Government Cloud and EA with the RFP of Fedict in mind.

functional or technical obsolescence are spotted).

The reasons for moving towards the Cloud and/or SOA is that the legacy system is becoming economically, functionally or technically obsolete. Moving from legacy systems towards SaaS has to be carefully planned and for an organization having only legacy systems, moving to the cloud is as a matter of fact a real option on itself (Spínola, 2009) because it has the characteristics of an organization in a complicated spaces. It gives flexibility to the organizations and if successful the operational costs are reduced. In a growth scenario, pay per use becomes pay-as-you-grow.

Rabaey (2004a, et al. 2005a, 2007) are proposing an assessment system for Enterprise Application Integration (EAI) based on the interdisciplinary forum (IF)([166]), which can also be used for CC.

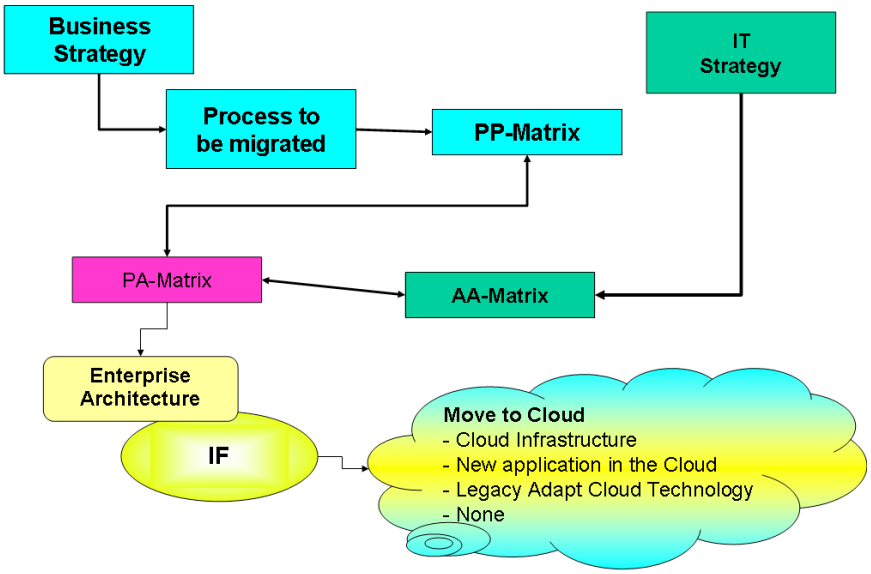

Figure 75: EA-IF decision process for legacay-2-Cloud

Figure 75 ([167]) shows the process to move applications to the cloud. First the department decides which processes should be migrated. The interdependency of all processes is mapped in the Process-Process (PP-) matrix, where in the rows and the columns the processes are listed. In the corresponding cell is mentioned what the relationships and relative relations are. The IT does a similar exercise but for the application-application (AA-) matrix. By merging both matrices into the PA-matrix, the IF/TF can detect which processes are affected and which applications (or part of them) should be moved to the Cloud.

This is the domain of CAS*T-EA, however certainly in the case of a move to a more flexible and adaptive environment (CAS (environment)), the CAS (organization) and its sub-units should consider to look for LP outside CAS*T-EA that can create more added value. But in general, the proposed migration decision process can be used in any case.

The following figure 76 ([168])([169]) depicts the concept of a possible architecture combing legacy systems, SOA (ESB) and CC.

166 In the context of CAS*T: TF.

167 *Figure 75* Adopted from Figure EA-IF in Rabaey et al. (2007)

168 *Figure 76* Figure SOA and Cloud Computing from Rabaey (2012).

169 FW: Firewall; DMZ: Demilitarized Zone; C2G: Citizen-to-Government; G2G: Government-to-Government.

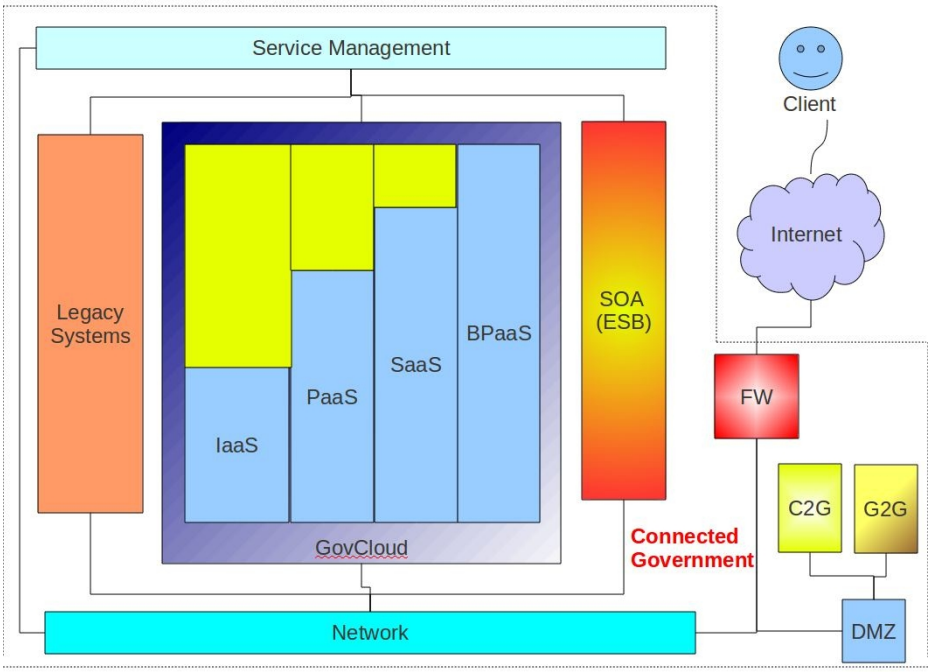

Figure 76: SOA and Cloud Computing

Although SaaS can be directly presented to the agents some softwares are better contained in web services. Most of them are based on business processes which use confidential data.

If business oriented services would fail or be too risky, the department should consider moving the infrastructure of the legacy system anyway to the cloud technology (private, public, hybrid cloud). It will be at least flexible regarding security (disaster and recovery) and/or cost reduction (pay-per-use) and/or create the option to move faster from one service provider to another.

Based on the assessment, the agents will decide to move or not to move one or more applications to the cloud, and if so then in which deployment and/or service models. The go-decision will always be built on a SLA be it in the case of GovIT or a commercial cloud service provider. The choice of which financial technique to be used depends on the target Cynefin space.

3.9.2. ERP-Systems

ERP-based systems are the so-called “best practices” solutions. However referring to the Cynefin framework, these systems correspond to the obvious context and are far from supporting agility.

If a government wants to have more agile systems then it should consider SOA and/or CC. Here also, the ESB is a very important component. Nowadays ERP’s have Application Program Interfaces (API) that are web services, thus the communication (by preference) goes through the ESB. Otherwise these API’s can be wrapped in web services to enable the ERP to communicate anyway through web services.

These web services have the advantage that an ERP (which can be a legacy system, see previous point) can be gradually migrated (modules) to SOA- and/or CC based solutions.

ERP-products are sometimes branded as SaaS, but SaaS does not guarantee more agility. As we have seen in the discussion on CAS, the interrelationships are very important. A SaaS should interact with other systems to exchange data or to receive a workflow object and after treating it, send it to another node in the workflow (business process). This is in some cases not possible or it is limited. A higher level system must coordinate (orchestrate) the different processes. It is this higher level system that can make the whole (CAS) agile or not. Due to its flexibility (which implies also complexity) SOA is the best candidate orchestrator.

3.9.3. Examples

In section 2.6 Meta Service Bus and EA Models we have proposed to use ESB inside an organization or CSB outside the organization to communicate between applications. The peer-to-peer connections are replaced with a communication bus.

In this example A, B, C, D, E and F are providers of software services (SaaS). These can be delivered on servers (physical platforms or virtual machines) or by datacenters or hybrid configurations. (see also previous case).

This is certainly not a project in the simple Cynefin space. In the case of our migration from SIEMENS mainframes to a SUN/SYBASE/X11/TCP-IP ([170]) configuration we were putting old wine in new bottles. At the level of the applications and underlying databases it was more a manually executed reverse engineering of the COBOL and assembler programs. At the application level, the complexity came more from the number of programs (to be converted) and at the network level the switching from sequential polling of block terminals to a TCP-IP network with servers and X11 terminals.

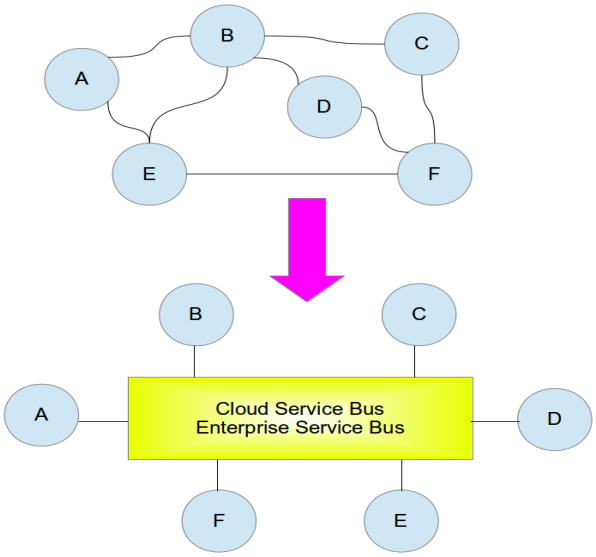

Figure 77: Connecting to ESB

So it is rather a complicated Cynefin space. In figure 77 it can be similar if physical serves are moved to virtual machines (IaaS and/or PaaS) and the communication is serviced by a ESB. As already mentioned, this is more happening in the sole domain of the IT-manager, unless the users may pay-for-use for servers (machines or services) and manage themselves the servers. This will be the case of BPEIS with the underlying infrastructure.

However from the moment the user has decision making responsibilities of how his business processes are supported by the IT thus information systems, the issues are moved from technical domain to the social domain. Different people are interacting and the organization itself is interacting with its environment that is constantly changing.

170 SUN: Unix hardware and software vendor; Sybase: RDBMS; X1: Graphical Display protocol and terminals; TCP-IP: network protocol.

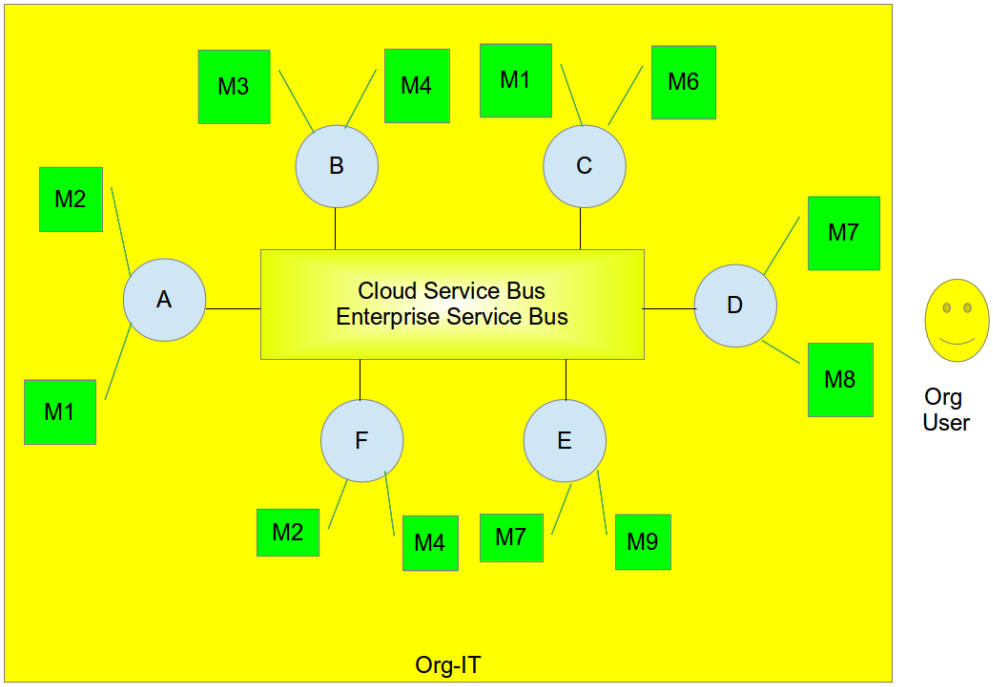

Figure 78: Private Cloud

Figure 78 shows the above mentioned ESB with (internal) SaaS providers, in other words a private cloud. The actual configuration consists of the servers (A-F). Each server is providing two modules of softwares, some are redundant due to capacity issues or because they are critical. The organization has designed different business processes (BP) to deliver one or more functions:

- BP 1 uses M1 and M2;
- BP 2 uses M3, M6, M8 and M9;
- BP 3 uses M4, M8 and M2;
- ...

Due to an unexpected change in the legislation the process BP 2 must adapt M6 and BP 3 must adapt M4 and BP3 needs a new software N5, and all this before the end of the next month. The own IT cannot satisfy all needs within time.

Different scenario's are possible:

- own IT adapts the existing modules M6 and M4, and outsources N5 and it becomes M5;
- own IT adapts the existing modules and the N5 is delivered as a SaaS outside the organization;
- own IT develops N5 and outsources the adapting of M4 and M6;
- outsourcing the adapting of M4, replaces M6 by an external N6 (SaaS) because it was anyway obsolete; and N5 is also an external SaaS
- ...

The risks and drivers may be different for each scenario. Due to the impact of each scenario on the organization, a scenario can be in the complex, complicated or chaotic Cynefin space, thus the organization must be aware to use the right management tools, techniques and philosophy for each scenario.

If the organization does not have any experience with public cloud then it must explore the risks and

drivers of that solution together with the hybrid cloud. Thus a phylogenetic tree of the risks and drivers will be necessary so that the cognitive maps can be updated and so on. The eventual simulation of the organizational changes and the related costs and benefits can determine the way to go. Although in the ordered Cynefin spaces, classic investment techniques can be used, it is recommended to follow the simulations because of the possible interactions with other agents and/or projects. *How?* is an element for future research.

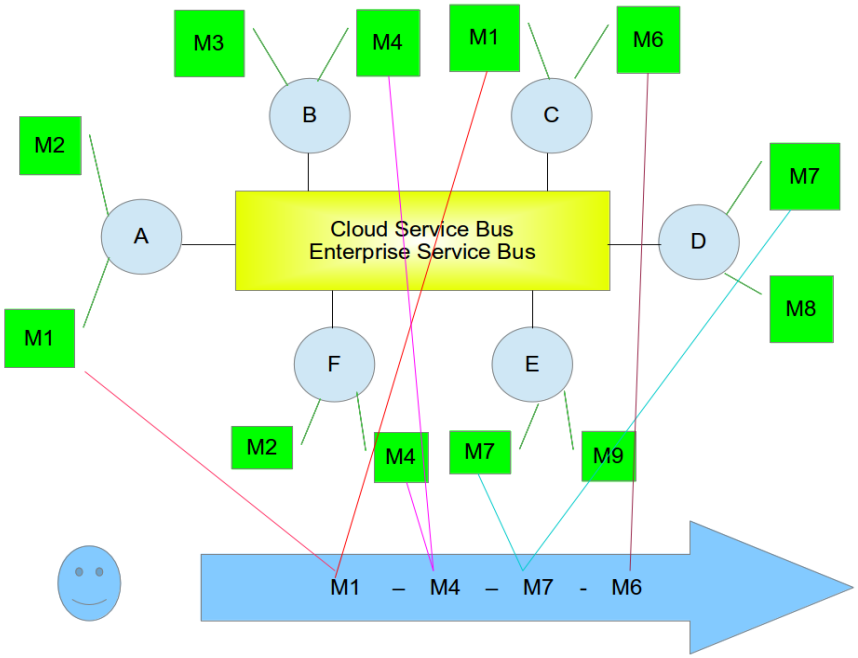

Figure 79: Public Cloud

Figure 79 is the same as the previous only the SaaS providers are from the point of view of the organization in the public cloud. The figure depicts the choice an organization has to make for its business process composed of the modules M1, M4, M7 and M6. None of the providers can deliver all deliver so via the CSB the organization has to assemble a BP based on these four modules. Each provider can have different SLA and quality of service. Although the configuration is technically the same the context is completely different and thus the case (risks, drivers). Even if we take BP2 and BP3 of the previous, then the issues are significantly different. The used CAS*T-tools can be the same but the mental models are not and therefore *copy-paste* is not advisable.

3.10. Conclusions from Investment in CC

The classic approach of investments via C2 projects is top-down and hierarchy based and pernicious in a fast perpetually changing environment. Since most IT-systems which use CC touch every aspect of the organization, a holistic approach is recommended. Moreover investments are organizational changes, however this is not very well understood, thus the different views on organizational structures as discussed by Gharajedaghi (2011) should be brought under the attention of the organization.

CC itself is a CAS; what implies that the CAS (organization) is not only confronted with a non-linear external phenomenon but also an internal (Systems-of-systems). To guide investments in CC CAS*T-EA is needed, but other leverage points outside CAS*T-EA must also be examined.

Thus the evaluation of CC must be placed on the one hand in the context of the CAS (organization) and the allocation of its resources or of its sub-units, and on the other hand the CAS (environment). For this, we have proposed the Transdisciplinary Forum (based on Strategic Interdisciplinary Investment Forum), where the allocation of inter alia IT-resources (like CC) in business processes (operational strategy) is decided in function of the business goals (business strategy) of the shared vision or the strategies of its agents

In the case of IaaS and PaaS, the investments are more likely in the resources (IT) strategy, while SaaS and BPaaS which are interacting directly with the agents (business processes) and are therefore mostly situated in the operational strategy. Anyway, since both (operational and IT-strategy) are derived respectively indirectly and directly from the Grand Strategy (shared vision), the CC investments are completely placed into the context of the organization.

The transdisciplinary forum observes the world and these observations are interpreted and integrated in the systemic models. Hypotheses are formulated (decide) and tested (act) which generates new observations. After one or more iterations the organization can decide to change its behavior (act) by implementing organizational (capabilities) changes (= investments), which can have effects (nonlinear or not) in the real world (OODA). The fuel of this process is supplied by the CAS*T Int B.

These investments are a trade-off between robustness and optimization. Lowe et al. (2006, p. 7): “This has a couple of consequences. Firstly, any optimality is transient. Since change is never-ending and uncertainty is unavoidable, any optimization is true only briefly. Thus, it is rarely worth the effort to create maximum efficiency. Secondly, sub-optimality permits robustness and adaptability. Being sub-optimal and just good enough means that the system can allocate resources to maintaining reserves and variety so that the system can be more robust, resilient and adaptive. However, greater variety tends to generate greater complexity and less efficiency, so that an appropriate balance must be found. As a result, there is no optimum state or perfect design, and designers should not attempt to chase the mirage of maximum efficiency too far.”

We have discussed investment techniques in the context of the Cynefin framework. However we have not yet found investment techniques for the unordered spaces. The ultimate goal of the further research could be to develop a framework in which the same family of tools could be used in all Cynefin spaces.

The framework of CC is still in movement and by taken CAS into account, this framework will produce a model which will combine a public cloud (with SLA) with a shared private (with SLA).

Our conclusive remark is that CAS (organization) should not be afraid to move to the “Cloud”, as long as they prepare and execute it carefully. In this chapter we have proposed a generic framework of TF to support these decisions and planning. The organization can instantiate its own framework in function of its capabilities and culture.

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