

MILITARY KNOWLEDGE MANAGEMENT:  
SENSE MAKING,  
DECISION MAKING AND  
KNOWLEDGE CREATION

Author: Juha Mattila,

Colonel (ret), Lead Consultant in Knowledge Point LCC,

Post-graduation student in Aalto University, Helsinki, Finland

Biography: Juha Mattila has served in the Defence Forces of Finland between 1984 and 2012. He was involved two times in transforming the Defence Forces C4I structure. He was also transforming the Land Forces way of fighting 2008-2012. Currently he has been advising in C4I transformation of UAE Armed Forces.

Email: [juhakaimattila24@gmail.com](mailto:juhakaimattila24@gmail.com)

# MILITARY KNOWLEDGE MANAGEMENT: SENSE MAKING, DECISION MAKING AND KNOWLEDGE CREATION

## **Abstract:**

The paper studies evolution of military Knowledge Management from Command and Control perspective to support strategic planning and enterprise architecture of Command, Control, Communications, Computers and Information System of systems.

Military Command and Control is studied in framework of Knowledge Creation through Evolution Theory and Path Creation to find road maps for Military Knowledge Management. Study finds some causalities and dependencies that have effect of Military Enterprise Architecture.

The study finds several ways to support the cognitive level of Information Superiority with C4I systems. The strategy should first diagnose the three dimensions of Sense making, Decision making and Learning with support of defined road map before any solutions are introduced. There should also be room for development in C4I since inflexibility in military structures may end in strategic and operational surprise.

This study is extending the three level Information Superiority Reference Model by Perry 2004. The cognitive layer is further defined with three dimensions: Sense Making, Decision Making and Learning.

Keywords: knowledge creation, sense making, decision making, learning

## **Introduction**

Military Knowledge Management has changed as societies have been evolving and now we are questioning the rules of knowledge

management of industrial era as opposed to information era (Mattila 2013 Feb). In this paper, the military combat operations process called OODA-loop defined by John Boyd (1987) (Osinga 2007:189-200) is studied in the framework of knowing organisation defined by Chun Wei Choo (1998). Framework is tested by the evolution theory (Mokyr 1997) and its path creation (Garud&Karnoe 2000). By combining Boyd and Choo one is able to define three abilities of military command and control process (OODA-loop) from the point of knowledge management as described in figure 1:

1. Sense making, consisting of observation (sensing) and orientation (making sense), is interpreting the equivocal data by passing interpretations.
2. Decision making, which is searching and selecting alternatives according to projected results, preferences and constraints.
3. Knowledge creating, which is creating new knowledge and improving the whole OODA-loop through learning and knowledge acquisition.

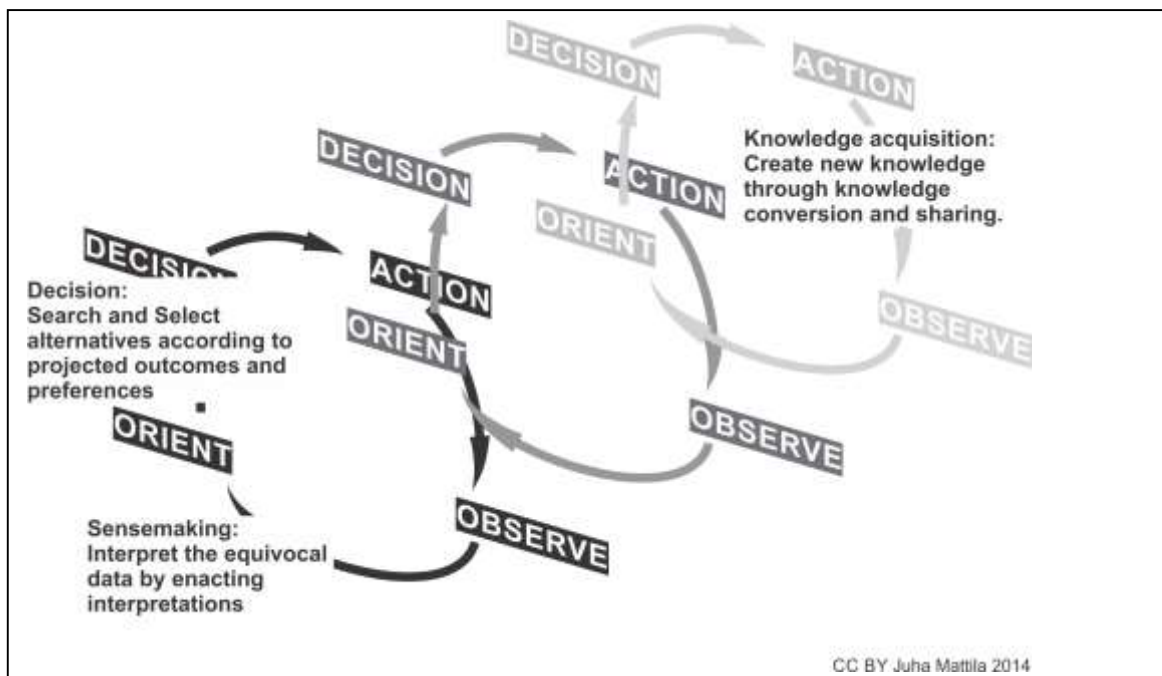


Figure 1: Orientation for military knowledge management from sense making, decision making and knowledge creating approach

This paper defines the major evolutionary paths of each level of Knowledge Management and describes also the short cuts or downshifts that some military organisations have faced when reaching for more revolutionary goals. Paper provides also tools for strategic diagnosis by describing possible paths on both separate and integrated road map where interrelations and challenges may be easier to identify. The goal is to support strategic planning of how Information and Communications Technology, ICT is to enable the knowledge management in military organisation.

## **Description of evolutionary paths in Military Sense making**

Sense making can be projected to observation and orientation of John Boyd's (1987) (Observe, Orient, Decide and Act) OODA loop. OODA loop is analysed in relationship to environment modelled with Kurtz and Snowden (2003) Cynefin framework. Military may face the four different situations defined in this framework: 1. Known, 2. Knowable, 3. Complex and 4. Chaos. Sensing and Sense making is following different process in each of these situations.

Sensing needs to overcome the fog of battlefield (Clausewitz 1832: 217) and egocentricity (Elder & Paul 2011) of human being. Sense making needs to address the attempts of deception (Rothstein and Whaley 2013 p. 39) by adversary, biases of sense making teams and individual mental models. The four different sense making situations are described in following subchapters and in figure 2.

### *Sense – Categorise – Respond in known environment*

In known environment cause and effect relations are repeatable, thus easily perceived and predicable. In this situation military is following their Standard or Standing Operating Procedures, SOP (US Army FM 100-9).

Both individual, team and organisation are observing an event. Event is being sorted with previously defined model like the assumed order of

battle of adversary. Each category has a predetermined type of respond, which is being followed without orientation or decision making (Osinga 2007:192-194). A good example of this is firing based on predetermined targeting list.

Adversary is not normally behaving by the book (Rothstein & Whaley 2013:25-27). It is harmful if surveillance and reconnaissance systems are preprogrammed with assumed standard patterns and fail to detect anything divertive.

This approach is realistic for the lower levels of conscript army, where time to train ISTAR capabilities is short. It is mistakenly followed in forces that believe in Information Superiority gained with sheer volume (Perry et al 2004:14). It is also followed in Armed Forces with access to resources overwhelming to its adversaries (Finkel 2011:58).

### *Sense – Analyse – Decide – Act in knowable environment*

In knowable environment cause and effect are separated over time and space. It needs some scenario playing and systems thinking to create a possible model to describe the knowable environment.

After detection the incoming data needs to be analysed to reveal all effective cause-effect relationships. The analysis needs several experts working together and the challenges of collective sense making will appear: cognitive diversity creates clashes of individual mental models, but in another hand cognitive diversity helps against homogeneity biases like myopia and egocentricity (Smart & Sycara 2013). Sense making is evolving the scenarios as new data is detected. There is a need to create a bigger picture from smaller events and to recognise their interrelationships by systems thinking (Mattila 2014 Oct a).

Current trends in Big Data and Business Intelligence are good example of organisation trying to use all information it controls (Berman 2013:130). By fusing and correlating data differently, organisation may create new knowledge and if succeeding in sharing it, may gain a competitive advantage.

### *Probe - Sense – Analyse – Decide – Act in complex environment*

In complex environment cause and effect are only coherent in retrospect and similar events seldom repeat. Emergent patterns can be perceived but not predicted.

It needs an initiative probe to make possible patterns more visible for observation. Understanding these emergent, new patterns needs multiple perspectives to be involved in sense making. It needs to create stories as base for understanding as they are simple and easy to communicate between team. General McChrystal (2011) has defined this as “Understand the operating environment and your organization while constantly adapting for purpose”.

This is the very base of military professional approach in sense making since situation almost always is at least complex in military environment according to lessons of Emptiness by Miyamoto Musashi (Lahdenpera 2007).

### *Act - Sense – Analyse – Decide in chaotic environment*

No cause and effect relationships are perceivable in chaotic environment. System is turbulent or there is no time to wait patterns to emerge. One might assume there is a potential pattern but it is not visible or reconstruction able. This has been the base in military operations for Douche, Guderian and Swartzkopf (Fuller 1961, Guderian 2001, US Army War College 2004)

It needs a quick and decisive intervention to reduce the turbulence and ability to sense immediately the reaction to the intervention. This deliberate action might create something that is either known or knowable and with effective observing and analysing it might make sense.

Fast and determined action was the main approach for German staff officers and key enabler against Allied officers who tried to approach situations as knowable (Muth 2011 p.191). General Guderian put this as “Es gibt keine verzweifelten Lagen, es gibt nur verzweifelte Menschen”, which roughly means there are no desperate situations only people.

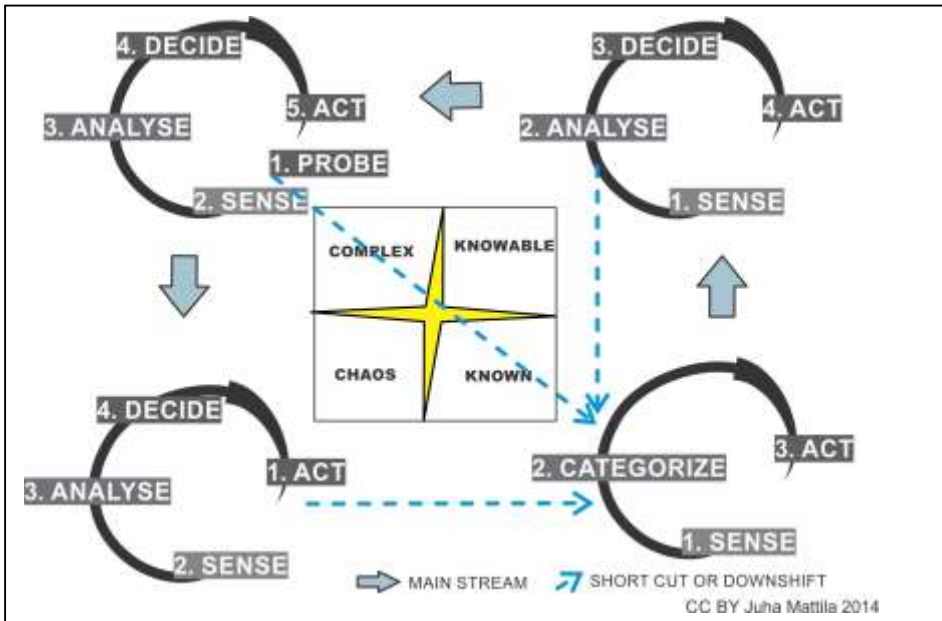


Figure 2: A framework for military sense making from Knowledge Management approach

*Leaps, downshifts and revolutionary paths on sense making map of possible roads*

The sense making ability may collapse and only behavioural routines will continue in crises situation and under extreme stress (Weick 1993). An exercised process should be in place before utilising more agile methods in sense making (Mattila 2014 Oct b).

Sometimes the feeling of having information superiority may cause a downshift. A complex situation is assumed as knowable and collecting more data is expected bring in the clarity. This might have been the case in late ISAF operation, where the collected data reached 40 Exabyte ( $10^{18}$ ) in a month according to General Gartwright (2008).

A need for near real-time recognised operational picture to provide targeting information for target acquisition process may constrain the time and method used for fusion and recognition (JASON 2008). Thus targeting may fall short at basic event categorising and both friendly fire and collateral damage may occur.

## **Description of evolutionary path for Military Decision Making**

Decision is a function of residual uncertainty and the risks associated with the available options as a function of time. This chapter explains one possible road map to military decision making starting from authoritarian commander centric and gradually exploring more unconstrained and shared decision making patterns (Alberts & Nissen 2009). This chapter also discusses why the maturity of decision making is not improving linearly but has seen many revolutionary leaps and downshifts. The entire road map for military decision making is described in following chapters and in figure 3.

### *Authoritarian decision making in classic command and control*

Decisions are made at top, Commander-centric, orders are flowing down and reporting heads upwards by support of hierarchical knowledge management. Decision making is based on individual understanding and any support should be only assertive as De Jomini (1862) puts it: “..., councils of war are a deplorable resource, and can be useful only when concurring in opinion with the commander, in which case they may give him more confidence in his own judgement,...”.

Information flow is following line organisation to enable superiors to understand better situation than their subordinates. The levels of hierarchy and means of communications are delaying situational information which is relayed from bottom up and orders flowing back down. Information is shared “need to know basis only”.



Carrying out tasks is based on pretrained procedures and there is no need to change behaviour during the operation. Knowledge base is following the doctrine and managing issues following standard operating processes.

### *Shared strategic intention with synchronised operational execution*

Unlike his adversaries Napoleon could delegate operational decision making to his generals, who were each heading a Army Corps, bataillon carré. Napoleon shared his battle intent with his commanders (Shamir 2011) and gave them some degree of freedom in execution. This enabled to achieve dominance in volume, time and space, deep strategic penetration or rapid concentration of force superior to more cumbersome adversaries.

Ability to share strategic information by actively collaborating between Corps heads provides good strategic and operational level awareness, alignment and manoeuvrability even if the lower levels in organisation are rigidly following orders and informing superiors through line.

After being outmanoeuvred entirely by Napoleon in Jena 1806, Prussians renewed their officer education and created “auftragstaktik”, which was later translated to mission command (Van Creveld 1985:174).

### *Mission command*

In mission command tactical freedom is delegated to combined arms force level by giving mission to forces including command intent of battle. Forces were expected to fulfil the mission in most suitable way adjusting their tactics as situation was unfolding before the eyes of their commanders. Higher command was controlling execution by defining end states rather than tasking detailed goals.

Mission command needs continual dialogue with higher authorities and mission partners to better understand the changing environment and perspectives (Luck 2013). Collaboration helps in perceiving what shared awareness looks like. It also build trust between commanders. Trust

enables commanders to empower their subordinates to make decisions even creativity as Commander-in-Chief of Reichswehr (Muth 2011) was demanding: “Rules are for fools”.

### *Mission command with peer level collaboration*

New level of awareness enabled by force digitalisation has flattened previously hierarchical organisations because middle level commands are not needed for control and quick reaction. Peer level collaboration lacks strict command relationships and is based more on trust (Mattila 2014 March b).

Whereas the recognised operational picture is presenting the current situation to everyone interested, there is need for continuous dialogue in building and preserving the trust between stakeholders. The shared understanding enables empowerment, cross-domain synergy and eventually improves effectiveness. It will consume time differently compared more line or functional approach. The study of J7 DTD U.S. Armed Forces (2013) proves that “collaboration releases the initiative of subordinates”

### *Self-synchronising with swarming tactics*

Power to the Edge (Alberts&Hayes 2003) principle addresses the shift in relationships required to leverage shared awareness to foster self-synchronisation and achieve major improvements in mission effectiveness. Control is sustained with shared command intent and consciousness instead of tight line control.

Swarming is a way to manoeuvre forces to gain advantage in time and space. It enables asymmetric tactics with agility, focus and convergence. (Mattila 2014 Oct b)

General McChrystal (2013) could improve his Special Operations Task Force capabilities about 30 fold in Iraq Operation 2006. He did this by executing the vision: “If we’re going to win, we need to become a network”. He transformed task force from hierarchical command and control structure to the network of a swarming subunits.

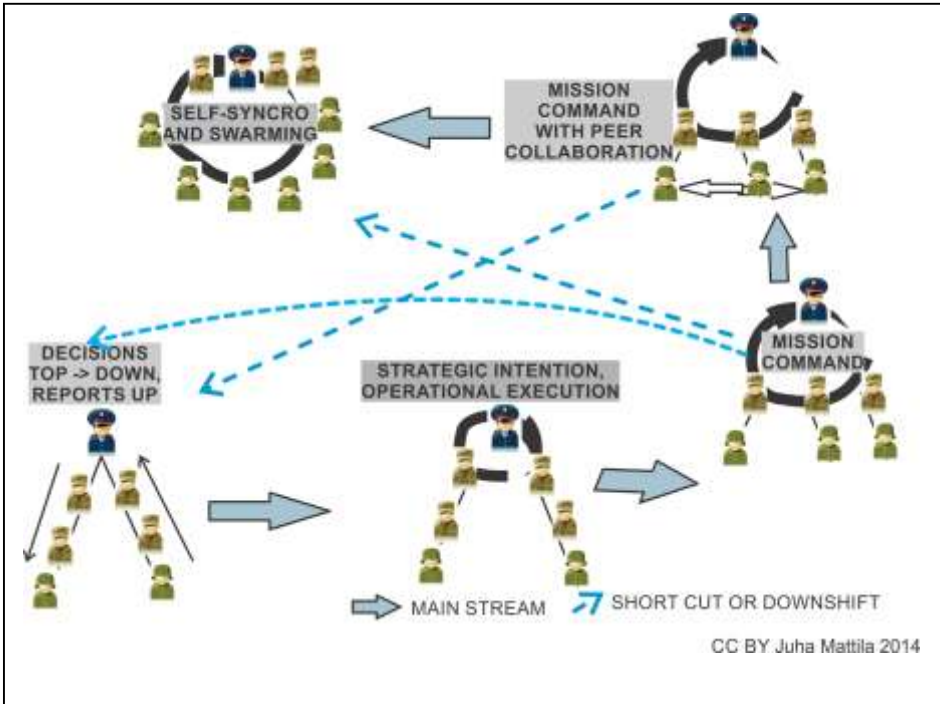


Figure 3: A Road map of Military decision making from Knowledge Management view

*Leaps, downshifts and revolutionary paths on decision making map of possible roads*

Attrition with dominant resources (Boot 2003) has been keeping the command culture centralised and highlighted the linear planning and management more than leadership.

Improved communications and ability to gather up-to-date information from battle is not necessarily leading to mission command or more loosely controlled battle management as described by Van Creveld

(1985: 238-251). The hunger for information at the top may produce an information overload resulting even longer lead times to prepare and launch operation.

It is far easier to return to more centralised command culture when returning to peacetime garrison, tight fiscal constraints, and increased competition for promotion (Hastings 2005). It is also following Taylors (1911) scientific management methods, when higher headquarters centralise the control over myriad of detailed management events during peacetime.

At last there is the human himself as a decision maker in stressful situation. Human decision making has tendency to use pattern recognition. First decision maker is trying to categorise unfolding situation with his previous experience and then utilising the decision used previously. If there is no previous model to be recognised then human goes for most familiar action. As last effort human is trying to lessen undesirable outcomes and maximise his own utility (Alberts 2002:62-66). Thus human being is easily manipulated in stressful situations.

## **Description of evolutionary paths in Military Knowledge acquisition and Learning**

Military training has to prepare individuals and collectives to enter harm's way and perform physically and mentally demanding tasks at the highest possible levels of competence. Military training has the tradition to be more like discipline than a process of creating competence.

This chapter is describing the sub-road map for military learning in more detail. The hypothesis starts by combining the organisational knowledge conversion process by Nonaka and Takeuchi (1995) with classic education ideas of behavioural, cognitive, constructive and social cognitive explained by Hergenbahn and Olson (2008). The model with four different approaches to knowledge acquisition, training, education and learning is described in figure 4. It is tested by explaining existing military training and knowledge creation approaches with it.

Military skills and understanding are learned in different way. Military skills are learned mainly in team training with progressive challenges tailored to each team of arms. Repetition is a disciplined way to establish team's behaviour as part of a bigger system. At battle technical level both individuals, troops and weapon systems are trained to be able to act at level of subconscious habit, motoric memory or preset programming.

Military understanding has several learning approaches. A strong legacy forces military to operate according to the doctrine and thinking by the book. A new request for educating soldiers how to think rather than what to think. This means introducing a combination of three thinking methods: systems thinking, creative thinking and critical thinking. With increasing complexity also need to educate team and organisational learning is arisen. This chapter is focusing on learning military understanding.

### *Drilling what to do and think with behavioural drivers*

Drilling has been a tool for military training as documented vividly in Sun Tzu's Art of War (1910) or in Prussian army (Smith 1998) when soldier was made a standardised, predictable and reliable unit to operate the musket. This is the basic way of socialising tacit skills (Choo 1988) when instructor (master) shows how to do movement to soldiers (apprentices) and then drills it continually supervising proceedings and correcting mistakes.

In behaviourism learner gets positive feedback when his behaviour and learning results are moving in right direction. This is especially effective, when standard of needed performance is gradually increased and award from right behaviour is direct and public.

Soldiers and troops need to exercise as part of bigger fighting system, to gain automation level of skill, to be able to sense cues (Duhigg 2013) of enemy action and to fulfil ones task routinely to be effective under stress.

This industrial (Smith 1998: 45-48) way to educating and training troops may not be the best way to produce sense and decision makers. If the doctrine being educated is not applicable in the situation confronted, then officers do not have means to adapt into it (Harford 2011: 37-79).

### *Understanding how to think with cognitive drivers*

General James Gartwright (2008) called after learning how to think and improving the pace of learning to meet current speed of evolution of business (3 months), technology (18 months) and war fighting (30 days). This requires the ability to create knowledge by bringing together explicit information from several sources. Combining different explicit and tacit ideas (Nonaka et al 2015: 23) needs systems thinking, critical thinking and operational analyses in social space.

The cognitive learning follows more the human way of creating understanding and processing information in his brain. New things are learned within a familiar orientation model. Problem solving is using cognitive approach, where one learns a new way of thinking (schema) and may use this “tool” further in solving for other similar problems. After learning these schemas, there remains a challenge of mapping problem to a right pre-existing schema. This needs logical reasoning like systems thinking (Senge 1990) or operational analyses.

Skills are learned mainly by team training with progressive challenges tailored to each team. Repetition is a discipline as a part of bigger system, but use of skills in different situations and environment is a driver for successful execution in progressively challenging environment.

Understanding is soldiers’ ability to realise their space of operation, teams and systems, other combat supporters, supported and adversary as huge system where different parts interact with one another and with environment (Joint Doctrine Publication 04, 2010). It needs leaders to achieve synthesis of action (Nonaka et al 2015:33) when processing towards understanding of this phenomena. Leaders should reach a certain level of insight and foresight to be able to innovate and create best ways to operate their force as interdependent part of fighting system of systems.

### *Experimenting with constructive drivers*

The knowledge conversion process by Nonaka and Takeuchi (1995) includes: Socialisation – Externalisation – Combination - Internationalisation. Individual shares some experiences of his trials (tacit knowledge) with peers and together they come up (socialisation) with hypothesis for causality model of their analysed experience. They publish (externalisation) their findings in lessons identified (explicit) board. Someone else faces a challenge, finds these lessons together with few more similar, and fuses (combination) these concepts (explicit) to fit into situation in hand. One learns (internalisation) from this successful trial and increases his (tacit) knowledge.

Constructivism means that new information is learned by social and cultural interaction. Information is understood in relation to prior knowledge, experience and skills. Constructivism is using sociocultural dimension to support learning. Interaction with more capable peers, skilful leaders or cognitive tools do create mental constructions that enables students to recall learned things longer. The support is provided according to students' maturity and it is gradually withdrawn as subjects become more internalised. This is a coach or mentor approach, where instructor is supporting enough to have student over first fears, provides safe environment for student to experiment, fail and learn, and gradually allows student to have more room for independent action. This provided an obvious competitive edge to German officers over their allied counterparts during the II WW as analysed by Muth (2011: 190-191).

## *Military as knowledge creating organisation driven by social cognitive learning*

The competitive edge may be gained from continuous organisational knowledge creation and learning by “start talking and get to work” as Weber (1993) says. Conversations are the way knowledge workers discover what they know, share it with their colleagues and in the process create new knowledge for the organisation (Davenport&Prusak 2000: 88-106). This is one way of mitigating the constraint of one man’s understanding.

*“A man has no ears for that to which experience has given him no access.” Nietzsche.*

Knowledge conversion is enforced by social cognitive learning (Denler et al 2014). It means that learner's behaviour changes because of seeing others' behaviour and its effects. There are several factors that decide whether watching a model will result behavioural or cognitive change. These factors include the learner's developmental status, the noticed prestige and competence of the model, the effects received by the model, the relevance of the model's behaviours and consequences to the learner's goals, and the learner's self-efficacy. Self-efficacy refers to the learner's belief in his or her ability to perform according the behaviour.



Machines and men are collaborating, sharing information, creating understanding, learning from experiences and continuing the asymmetric ability over the adversary. This calls for training early to need (Faris 2013). This also needs to include machines in to the process of continuous learning (Mattila 2014).

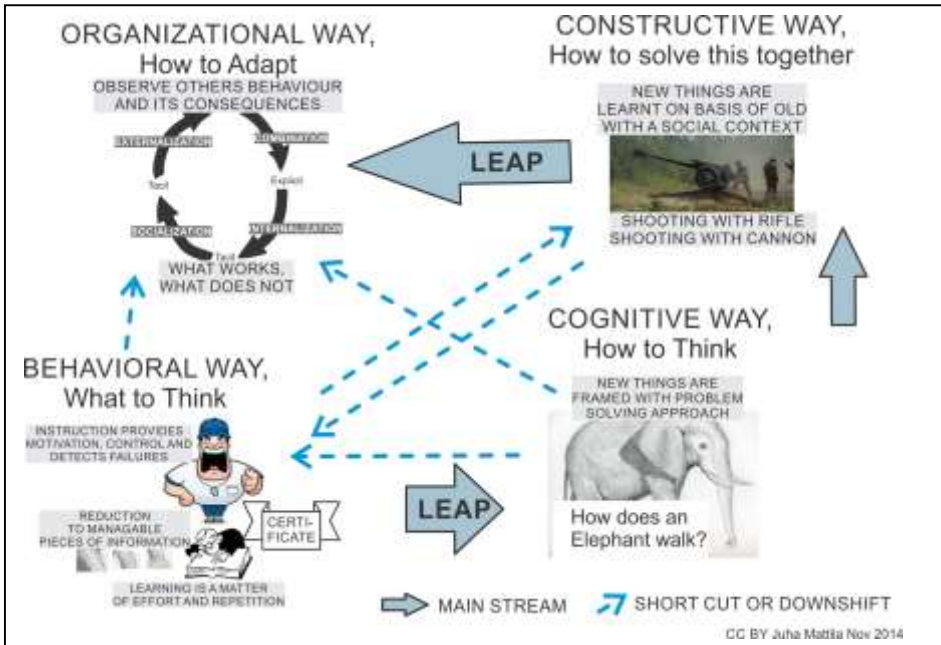


Figure 4: A Road map for military learning from knowledge management approach

*Leaps, downshifts and revolutionary paths on knowledge creation map of possible roads*

When following the evolutionary road on the map of knowledge creation and training, there are two distinct leaps: 1. from what to think to how to think and 2. from team learning to organisational learning (Mattila 2014 Nov).

As described earlier, U.S. Armed Forces have been trying to leap from what to think to how to think for decades, but they have this far

downgraded back to behavioural basics because of the gravity of their doctrine, culture and C2 attitude (Finkel 2007).

Despite of U.S. Armed Forces tradition McChrystal (2014) achieved to take his Special Operations Task force from behavioural level 2003 direct to organisational learning within couple of years.

From team learning to organisational learning there are four obstacles defined as follows:

- First obstacle is the culture of information distribution by need to know basis only. With tactical level information management by push method, military will always face the dilemma of operational security and survivability. Single owner of information does not have full understanding of where information in his possession might be utilised. Military culture needs to be switched to need to share before anything happens (McChrystal 2014).
- Second obstacle is the autocratic culture of command and control if it is featured by “shut your big mouth and stop thinking above your rank” attitude (Harford 2011). This disables the systems thinking, critical thinking and creative thinking needed to try and error with badly needed critique.
- Third obstacle is technology. The building of information technology systems is still defined by the boundaries of a system (Doan et al 2012). Data is constrained by the system because of vendor attempts to preserve market with proprietary solutions. National policy is trying to keep technology dominance (US ITAR) by restraining system integration. Different branches in military are trying to sustain their independency and freedom of movement by abiding interoperability standards.
- Fourth obstacle is information itself. Either information is unstructured so it is not searchable or understandable but by human. Or it is modelled in proprietary way that data transfer always needs interpretation. These problems may be managed with improving semantic structures that frame all pieces of information with standard metadata. Metadata explains data objects and their relationships (Allemang&Hendler 2011). This way information is understandable both to humans and machines.

As military basic skills are trained in very repetition and behavioural way, there is a natural pull to simplify all training delivered in same way. This happens when training and real needs of operation are not linked to one another.

## Consider the way to support knowledge management with information systems and automation

When military command and control is studied from knowledge management view, one recognises major opportunities but also challenges, when combining all three areas of C2 evolution: Sense making, Decision making and Learning as pictured in Figure 5.

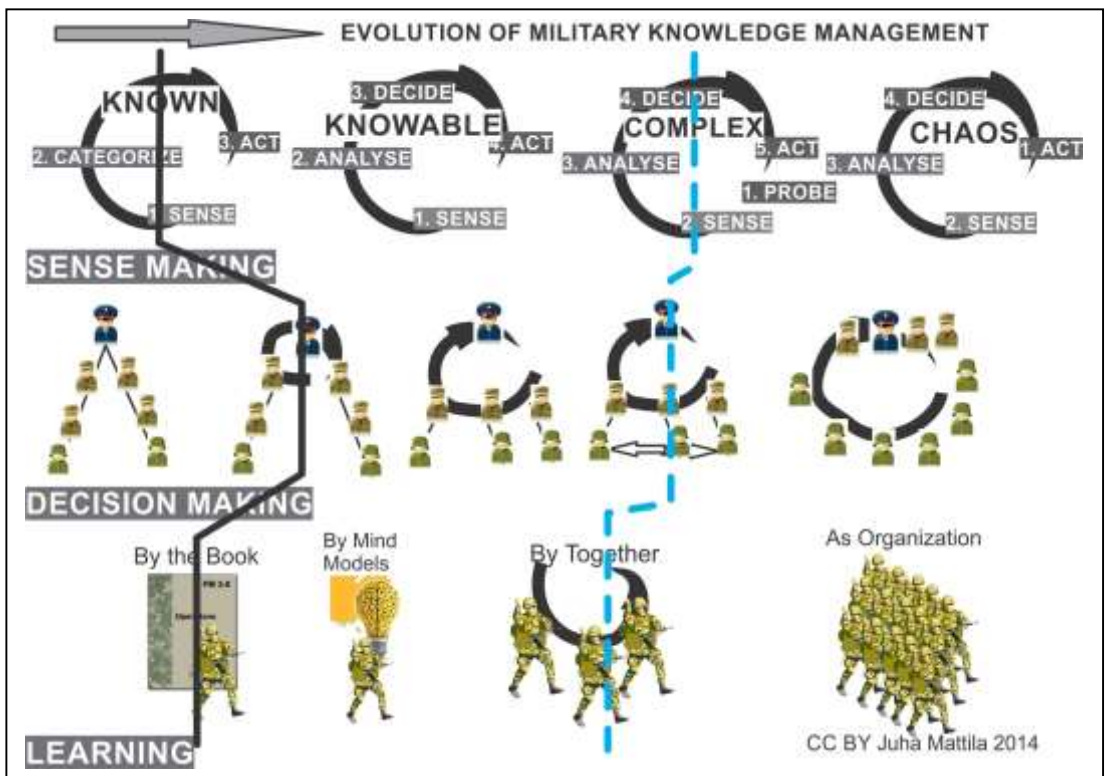


Figure 5: Evolutionary roads of military knowledge management within Command and Control

From evolutionary map of paths in Figure 5 one may conclude that:

- A. There is a possibility to use these maps of possible roads to create a linear strategy to improve C2 capabilities.

1. Define the current C2 situation by admitting the typical features of each stage of C2. (Black even line in figure 5)
  2. Set goal stage for improved command and control in each sub feature. (Blue dotted line in figure 5)
  3. As gap between current and future capability is thus defined, there is possibility to analyse alternative roads leading from current stage towards future capabilities. Strategic courses of action are thus defined.
  4. As these roads are two-way, one should be aware of tendencies that keeps C2 from improving or reverse to starting position.
  5. Create the development programme based on strengths and resources and simulate it with social and cultural variables.
- B. The classic OODA loop and military sense making are more complex than first impression may reveal. Since sense making is always a social event, there is a major impact by the relationships between people. Both individual and team mental models take time to be aligned and it takes even longer to educate whole organisation to follow the same logic. If, in the other hand, organisation is too homogeneous, there is a danger to have too narrow or blind sense making.
- Military situation is normally more diverse than only one dimension of Cynefin framework at time. There might exist all four different stages of dynamics within the same area of operation:
    - Own force and their action might be known or knowable
    - Regular parts of adversary force might fall into knowable category
    - Irregular or militant parts of adversary might fall into complex

- Society, where operation is executed, may seem chaotic.
  - It needs all four means of sensing and sense making processing parallel information from each part of area of interest and more complex orientation and sense making process than any one of above defined.
- C. Military organisations usually improve their culture for decision making with three alternative ways: by copying a successful organisation, by importing new culture, or by fostering a revolution.
1. One might successfully copy new way of behaviour or best practice, but normally organisation needs to create its knowledge by trial and error, since mimicking does not stick for longer term.
  2. Importing new cultures is normal in military force when officers are rotated between different appointments spreading best in-house practices on way. This is possible if officers are provided room for initiative and change to ask WHY.
  3. Revolutionary transformation usually needs both strong outside threat and inside will. Corporate behaviour is slow to change especially within military organisations.
- D. Road map for decision making does not state that swarming and self-synchronised way is better than hierarchical and information constraint way. Organisational culture and situation is dictating also the command and decision making style. Hierarchical culture does not support self-synchronising and conversely.
- E. Most flexible structure of C2 culture is gained, if Sense making in complex situations, Decision making delegated within swarming network and Learning as organisation are combined.
- F. Combining Mission command with Sense making in Chaos situations and learning together made German staff officers way better than their Allied counterparts in the II WW.
- G. U.S. Officers have been struggling in their efforts of improving C2 as their Sense making is heavily fixed with Known approach and

Learning is mainly by the Book. Efforts in delegating Decision making have been bouncing back since their command culture prefers heavy planning and management.

- H. Delegating decision making to swarming level and being able to learn continuously as organisation requires solid base of trust and openness of communication.
- I. If one finds his force to be at first level of sense making, there is need to change knowledge, competence and process before it is implemented heavily in information system. Even if one's own force is known, there may rise challenges in changing the Order of Battle quickly.
- J. It needs more heterogenic team than before to bring up all possible aspects when analysing situation before decision making. Effective teamwork needs building by practice and challengers rather than more information technology. Information technology should be applied first to enable virtual collaboration of ad hoc sense making teams.
- K. Delegating decision making towards mission command needs continual dialogue with higher authorities and mission partners to better understand the changing environment and perspectives and what a shared understanding looks like.
- L. When one reaches towards more agile, focused force that has convergence, there needs to happen a transformation alike McChrystal implemented 2006 in Iraq: McChrystal (2013) explains the transformation strategy of Special Operations Task Force in Iraq as follows: "We began as a network of people, then grew into a network of teams, then a network of organisations, and ultimately a network of nations. Throughout, we evaluated the health of our network by how well each node shared a common but ever-evolving understanding of our organisation, of our battlefield, of our enemy, and of our strategy to defeat them—what we called 'shared consciousness and purpose.'"
- M. There is a tendency (or entropy) in organisation, which does not face pressure from outside, to gain excessive bureaucracy, create narrow

functional silos, simplify skills and competence to be easier trained and withhold most freedom of initiative from lower levels. Command and control culture of this kind does not necessarily survive in situations of complex crises. Especially if information systems are constraining the change to more flexible culture.

- N. Repetition and drilling are essential in learning skills that are needed under stress but building competence that brings advantage in crises situation needs combination of trial, error and social reflection.
1. The powers of human pattern recognition are used when education does create several mind models for possible solutions in future situations.
  2. Since time and resources are constraining instructed learning, there is a need to learn more how to think rather than what. This leads to continuous learning concept that carries over the whole career of military officers.
  3. Skills are usually learnt together within a section or platoon. This should be extended to thinking, understanding and staff working if there is demand for improved situational awareness.
  4. As situation becomes more complex also the learning should change towards social cognitive means over the whole organisation to ensure the flexibility of military doctrine and operations.
- O. There is a heavy cultural, doctrinal, technical and information management opposition for improving learning in military environment. There should be special means of transformation in use when fielding the change in Military Organisations.
- P. One should not expect that C2 strategies are linear, but always approach military C2 system of systems as a complex structure that is constantly in motion.



## Discussion

This paper is extending the Cognitive layer of Perry's (2004) reference model for Information Superiority. The collaboration between individual understanding and shared understanding is replaced with Nonaka's (1995) knowledge creation process. Process is further framed with Coe's (1998) Knowing Organization and Boyd's (1987) Command and Control loop as illustrated in figure 6.

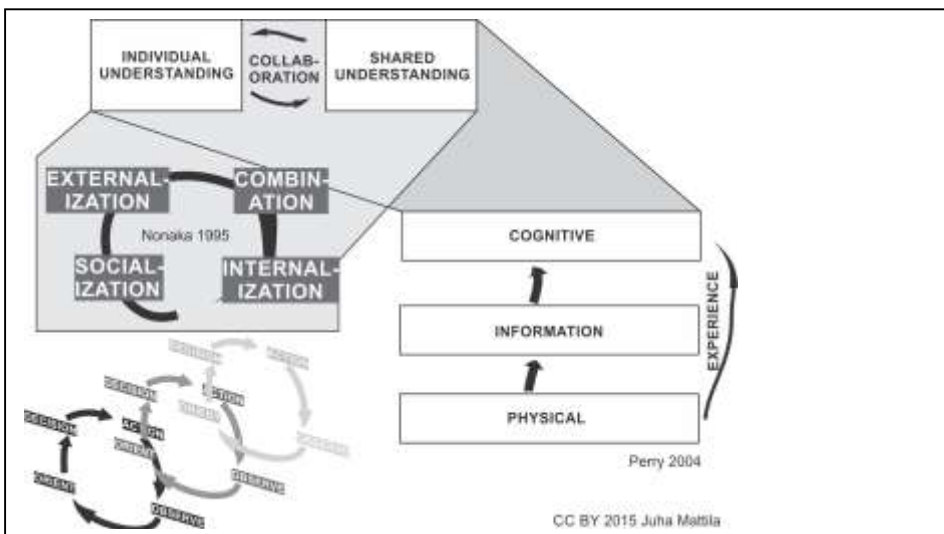


Figure 6: The combination of approaches used in this study

The Combination opens three dimensions of Sense making, Decision making and Learning, where knowledge creation has major effect in military affairs. Evolutionary paths of these three dimensions are defined empirically based on case studies and literature survey. By combining evolutionary paths a Military Knowledge Creation road map of interrelated paths is defined.

The road map for Military Knowledge Creation is used in defining options and constraints for C4I development strategies. These strategies are used further in other studies that try to define model for C4I capabilities development in Military Environment.

## References

- Alberts, David S. (2002): Information Age Transformation. Getting to a 21<sup>st</sup> century Military. CCRP ISBN: 1-893723-062
- Alberts, David S. & Hayes, Richard E. (2003) Power to the Edge: Command and Control in the Information Age. CCRP Publication Series. ISBN 1-893723-13-5
- Alberts, David S. & Nissen, Mark E. (2009): Toward Harmonizing Command and Control with Organization and Management Theory. The international C2 Journal, vol 3, no 2, 2009. CCRP
- Allemang, Dean and Hendler, Jim (2011): Semantic Web for the Working Ontologist. 2nd edition. Waltham, Elsevier inc.
- Berman, Jules J. (2013): Principles of Big Data. Elsevier Inc. 2013. ISBN 978-0-12-404576-7
- Boot, Max (2003): The new American way of War. Foreign Affairs 82:4 (July- August 2003)
- Boyd, John R. (1987): Lecture on Organic Design for Command and Control. March 1987
- Clausewitz, Carl von (1832): Vom Kriege. Edited and translated by Michael Howard and Peter Paret 1976, On War. Princeton University Press. ISBN: 0-691-01854-5
- Choo, Chun Wei (1988): The Knowing Organization. How organization use information to construct meaning, create knowledge and make decisions. Oxford University Press, NY. ISBN 0-19-511012-9
- Davenport, Thomas H. and Prusak, Laurence (2000): Working Knowledge. How Organizations Manage What they Know. Harvard Business School Press.
- De Jomini, Henry (1862): The Art of War. Translated by Mendell & Craighill, Wilder Publications, 2008. ISBN 978-1-60459-358-7

Denler, Heidi & Wolters, Christopher & Benzon Maria (2014): Social Cognitive Theory. Updated on Jan 28, 2014. Downloaded 6. Nov 2014 from <http://www.education.com/reference/article/social-cognitive-theory/>

Doan, AnHai and Halevy, Alon and Ives, Zachary (2012): Principles of Data Integration. Waltham, Elsevier, Inc.

Duhigg, Charles (2013): The Power of Habit. Random House Books. London 2013. ISBN 9781847946249

Elder, Linda & Paul, Richard (2011): Taking Charge of The Human Mind – Thinking, Feeling, Wanting. Foundation of Critical Thinking, 2011. ISBN 0-944583-14-8

Faris, Chris, Command Sergeant Major U.S. SOC: A Case for Changing the Professional Military Education Paradigm. DVIDS news in [http://www.dvidshub.net/news/113386/case-changing-professional-military-education-paradigm?goback=%2Egde\\_3892863\\_member\\_272649445#%2EUi-R0su9KSM](http://www.dvidshub.net/news/113386/case-changing-professional-military-education-paradigm?goback=%2Egde_3892863_member_272649445#%2EUi-R0su9KSM)

Finkel, Meir (2007): On Flexibility. Recovery from technological and doctrinal surprise on the battlefield. Translated by Moshe Tlamim 2011. Stanford University Press. ISBN 978-0-8047-7489-5

Fuller, J.F.C. (1961): The Conduct Of War, 1789-1961: A Study Of The Impact Of The French, Industrial, And Russian Revolutions On War And Its Conduct. Rutgers University Press.

Gartwright, James E.(2008): Leading organizational change to meet new challenges. A presentation given 16 October 2008 as Vice Chairman of Joint Chiefs of Staff

Garud, Raghu and Karnoe, Peter (May 2000): Path Creation as a Process of Mindful Deviation. Published in Path dependence and creation edited by Garud&Karnoe. Lawrence Erlbaum Associates Inc., Mahwah New Jersey 2001

Guderian, Heinz (2001): Panzer leader. Translated by Constantine Fitzgibbon.

Harford, Tim (2011): Adapt. Why Success Always Starts with Failure. Little Brown, London. ISBN 978-1-4087-0152-2

Hastings, Max (2005): Armageddon: The Battle for Germany, 1944-1945. Macmillan, London

Hergenhahn, B.R. & Olson Matthew H. (2008): An Introduction to theories of learning. 7<sup>th</sup> edition. New Delhi, Prentice-Hall of India.

JASON (2008): Data Analysis Challenges, JSR-08-142, MITRE Corporation McLean VA

Joint Doctrine Publication 04 (2010): Understanding. DCDC, MoD, Shrivenham

Liddell Hart, Basil Henry (1954): Strategy 2<sup>nd</sup> revised edition. Meridian Printing 1991. ISBN 0-452-01071-3

Luck, Gary, General (2013): Mission Command and Cross-Domain Synergy. Deployable Training Division, Deputy Director Joint Staff J7, Joint Training.

Mattila, Juha (2013 February): Confrontations, Conflicts and their Management in Postmodern era. Captured from web page <http://c4isys.blogspot.fi/2013/02/confrontations-conflicts-and-their.html>. Published also in Sotilasaikakauslehti 11 and 12 of 2011.

Mattila, Juha (2014 March a): Developing Tactical Communications for Renewed Land Fighting. A Blog writing in <http://c4isys.blogspot.ae/2014/03/developing-tactical-communications-for.html>

Mattila, Juha (2014 March b): Lessons from developing Army Command, Control and Information System for Finnish Land Forces during 2007-2009. Captured from <http://c4isys.blogspot.ae/2014/03/lessons-from-developing-army-command.html>

Mattila, Juha (2014 October a): Evolution of military sense making from knowledge management point of view. A Blog writing in <http://c4isys.blogspot.fi/2014/10/evolution-of-military-sense-making-from.html>

Mattila, Juha (2014 October b): Evolution of military decision making from knowledge management point of view. A Blog writing in <http://c4isys.blogspot.fi/2014/10/evolution-of-military-decision-making.html>

Mattila, Juha (2014 November): Evolution of Military Learning from Knowledge Management point of view. A Blog writing in <http://c4isys.blogspot.fi/2014/11/evolution-of-military-learning-from.html>

McChrystal, Stanley (2013): Lessons from Iraq – It takes a network to defeat a network. Downloaded from Stan McChrystal's blog on 25 June 2013.

McChrystal, Stanley (2014): The Military case for sharing knowledge. March 2014, TED2014. Captured from [http://www.ted.com/talks/stanley\\_mcchrystal\\_the\\_military\\_case\\_for\\_sharing\\_knowledge#t-349456](http://www.ted.com/talks/stanley_mcchrystal_the_military_case_for_sharing_knowledge#t-349456)

Mokyr, Joel (1997): Innovation and selection in Evolutionary Models of Technology – some definitional issues. Conference on Evolutionary Models in Economics Jan. 7-12, 1997 Oxford. England.

Musashi, Miyamoto Go rin no sho. Translated by Samppa Lahdenperä (2007): Maa, vesi, tuuli ja tyhjiys. 7. Edition, Otava 2007

Muth, Jorg (2011): Command Culture. Officer education in the U.S. Army and the German Armed Forces 1901 – 1940 and the consequences for WW II. University of North Texas Press 2011. ISBN 978-1-57441-533-9

Nietzsche: Captured from Nietzsche's quotes <http://www.goodreads.com/quotes/92257-no-one-can-draw-more-out-of-things-books-included>

Nonaka, Ikujiro & Takeuchi, Hirotaka (1995): The Knowledge-Creating Company. How Japanese Companies Create the Dynamics of Innovation. New York, Oxford University Press. ISBN-13 978-0-19-509256-1

Nonaka, Ikujiro & Toyama, Ryoko and Hirata, Toru (2015): Managing Flow. A process theory of the knowledge-based firm. Palgrave Mcmillan, Hampshire. ISBN 978-1-137-49482-5

- Osinga, Frans P.B. (2007): Science, Strategy and War. The strategic theory of John Boyd. Routledge, NY. ISBN:978-0-415-45952-5
- Perry, Walter and Signori, David and Boon, John (2004): Exploring Information Superiority. A Methodology for Measuring the Quality of Information and Its Impact on Shared Awareness. RAND Corporation, Santa Monica CA.
- Rothstein, Hy & Whaley, Barton, Editors (2013): The Art and Science of Military Deception. 2013 Artech House, ISBN 978-60807-551-5
- Senge, Peter (1990): The Fifth Discipline. Currency NY. ISBN 0-385-26095-4
- Shamir, Eitan (2011): Transforming Command. Stanford University Press. ISBN 978-0-8047-7203-7
- Smart, Paul R. and Sycara, Katia P. (2013): Collective sense making and military coalitions. IEEE Intelligent Systems. Downloaded from <http://eprints.soton.ac.uk/344328/1/IS-28-01-Smart.pdf>
- Smith, Frank (1998): The Book of Learning and Forgetting. Teachers College Press. New York. ISBN 0-8077-3750-X
- Taylor, Frederick Winslow (1911): The Principles of Scientific Management. New York, USA, Harper & Brothers. Adopted from Project Gutenberg.
- Tzu, Sun (1910): The Art of War. Translated by Lionel Gilles. Compiled by Barnes & Noble Inc 2014. ISBN: 978-1-4549-1186-9
- U.S. Army Field Manual 100-9, Appendix B: Template for a Standing Operating Procedure. Downloaded from web page [http://www.globalsecurity.org/military/library/policy/army/fm/100-9/fm100\\_7.htm](http://www.globalsecurity.org/military/library/policy/army/fm/100-9/fm100_7.htm)
- U.S. ITAR policy is to safeguard U.S. national security and further U.S. foreign policy objectives. Downloaded from [http://en.wikipedia.org/wiki/International\\_Traffic\\_in\\_Arms\\_Regulations](http://en.wikipedia.org/wiki/International_Traffic_in_Arms_Regulations)
- U.S.Army War College (2014): An Operational Analysis of the Persian Gulf War.

Van Creveld, Martin L.(1985): Command in War. Harvard University Press. ISBN 0-674-1441-4

Weber, Alan M. (1993): What's so New About the New Economy? Harvard Business Review, January – February 1993, p. 28

Weick, Karl E.(1993): Collapse of sensemaking in organizations. Administrative Science Quarterly Volume 38, 1993