

Perception and handling of complex problems in dynamic settings – three cases of relevance to military command and crisis management

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Abstract

Command of military operations requires leaders and teams who are able to make decisions and respond in an appropriate, timely manner even in highly uncertain situations. The degree of situational uncertainty has continued to increase as military requirements have evolved in response to changing conditions around the world and advances in information systems that have made more information available. To provide a basis for better understanding of the dynamics of operations, we suggest an approach linking Effects Based Operations (EBO) modelling and analysis with System Dynamics (SD) principles, yielding valuable insights in the complexity of modern warfare and conflict resolution. To illustrate our approach, we present the following dynamic cases: 1) operational logistics, 2) strategic investments, and 3) crisis management.

Introduction

Command of military operations requires leaders and teams who are able to make decisions and respond in an appropriate, timely manner even in highly uncertain situations. The degree of situational uncertainty has continued to increase as military requirements have evolved in

response to changing conditions around the world and advances in information systems that have made more information available, faster than ever before (NATO, 2003).

To respond to the terrorist threat, for example, military forces must “anticipate the unexpected and be prepared for the unimaginable” (NATO, 2003). The people and organizations of the military must be adaptable and technology must enable their adaptability. Adaptability is both a proactive and reactive process and can be seen in what military forces do and how they operate.

Information systems are a critical component of adaptable performance – especially of distributed, decentralized, yet highly interdependent military forces required to deftly transition between modes of operation and levels of intensity (e.g., from high-intensity war-fighting to low intensity peacekeeping, or vice versa) in collaboration with joint and coalition forces.

As Horn (2003) makes clear: “Commanders will be required to operate in, and be comfortable with, ambiguous and uncertain surroundings. Their options for using force will often be restricted. In addition, of necessity, they will require the capability of adapting physically and theoretically to changes in the immediate operational area as well as in the larger international security environment. These sorts of uncertain situations will also demand that individuals, units and formations be agile, flexible and capable of responding to the unforeseen and unexpected.” The future conflict will first and foremost be of an asymmetric¹ nature.

Network Centric Warfare (NCW) and Effects Based Operations (EBO)

The development of concepts such as Network Centric Warfare (NCW) and Effects Based Operations (EBO) are attempts to structure, understand and take advantage of the opportunities that are now exposed in the transformation processes involving technology, organisation, doctrine, training, leadership and culture. NCW essentially encompasses the idea of interconnecting a heterogeneous range of actors and objects (typically called effectors, sensors, decision makers etc) in the battle-space through telecommunication and computer networks. The advantages of NCW are (Diesen, 2004):

- The most ideally located decision maker may engage any target within range of the networked sensors, and may employ the best-suited effector for the engagement mission (self-synchronisation).
- Multi-role objects allow interchange of information and flexible usage of all resources (multi-functionality).
- All levels of the command organisation may receive and utilise the available information, at no incremental cost (information “overlying”).

The above benefits not only provide solutions and opportunities, but also pose central dilemmas. As an example, consider the self-synchronisation and overlaying aspects of NCW. In effect, these will lead to a “collapse” of the traditional command hierarchy (tactical, operational and strategic levels). When all actors receive all information, there is a high risk of information overload, let alone potential confusion when it comes to who is going to

¹ An asymmetric threat is a concept used to describe attempts to circumvent or undermine an opponent’s strengths while exploiting his weaknesses, and using methods that differ significantly from the opponent’s usual mode of operation.

implement what decision. Will it be the strategic command or rather the individual soldier in the battlefield (the paradox of the “strategic corporal”)?

EBO may in many ways be regarded as the defence analyst’s attempt to turn the multi-faceted implications of NCW into analysable and well-structured problems, in that it provides a modified and fruitful perspective on *operational dynamics*. That is, it offers insight into the “driving forces” governing modern warfare and conflict resolution. Davis (2001) defines EBO as “operations conceived and planned in a *systems framework* [emphasis made by this author] that considers the full range of direct, indirect, and cascading effects—effects that may, with different degrees of probability, be achieved by the application of military, diplomatic, psychological, and economic instruments.”

Instead of the established force structure and procedures providing a more or less given effect in relatively well-known settings (*platform centric warfare*), the problem is reformulated to being one of determining what combination of assets may yield a desired effect (*network centric warfare*). The advantage to the latter approach is that it is more appropriate for handling a wider range (even a priori unknown) circumstances.

As pointed out by Davis (2001), the main challenge is that current methods of analysis and modelling appear to be inadequate for representing EBO. Davis proposes the following principles as a guide for defining and conducting analyses, in order to take the “broad view” on defence (force and operations) planning:

- Defence planning should focus on mission-system capability, which refers to the ability to accomplish missions under a wide range of operational circumstances.
- Analysis dealing with EBO should fully confront the scope and magnitude of uncertainty and should deal explicitly with probability and randomness. E.g., assessments of capability should refer specifically to most-likely, best-case, and worst-case outcomes.
- Dealing with uncertainty will require low-resolution exploratory analysis for breadth, as well as more-detailed modelling and gaming for both depth and insight into underlying phenomena. This suggests a “family-of-models-and-games” approach in which information obtained from different members of the “family” is used to inform and cross-calibrate the whole body of knowledge.
- A key element of analytical work should be qualitative modelling, including cognitive modelling of the decision making and behaviour of commanders, political leaders, and even societies. Such modelling should be undertaken in an “uncertainty-sensitive” framework.
- Much of the related modelling should be organized around adaptive systems for command and control and other matters, rather than around the mass and physical characteristics of forces (focus on decisions and behaviours of people and organizations. This implies emphasis on the concepts and technology of agent-based modelling, as well as on system engineering.
- Analysts should vigorously pursue a new base of empirical information—including information obtainable from history and from a combination of gaming, man-in-the-loop simulation, and experiments in battle laboratories and the field. This information should

be collected and framed in ways that illuminate complex and subtle relationships and that support uncertainty analysis.

Cognitive models of operations = Command concepts

Essential to the successful conduct of a military operation is that the commander, his/her supporting staff, and subordinate units together have a “shared” mental conception of the tasks to be accomplished, the goal(s) to be reached, and the methods to employ. Builder et al (1999) have developed a concept called “Command Concepts”, which in essence constitute the commander’s mental visualisation of the course of the operation, including desired end state(s). At the most general (cognitive) level, it is required that the commander has the ability to create, disseminate and update/maintain a “command concept” for the planned operation.

Closely linked to command concepts is the Situational Awareness (SA). Endsley (1988) defines SA like this: “Situational awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future”. The SA concept is therefore essential to accomplish rapid and “correct” decision making in operations. According to Brewster (2002), many studies within military and scientific communities conclude that (military) commanders actually rely more heavily on an intuitive versus an analytic approach when in a field environment. The intuitive approach to decision making appears to be chosen when facing: ill-structured problems; uncertain or dynamic environments; time stress; and/or high stakes. The intuitive approach is based on pattern recognition and experience, and goes within the military profession under terms such as “fingerspitzengefühl” and “coup d’oeil”.

The contribution from System Dynamics (SD)

A military operation or campaign presents the commander with a dynamic decision problem. During the campaign, the commander continuously receives status information, and on the basis of this information he will manage his resources (by issuing directives to his staff and subordinate commanders). As the directives are acted upon, subordinates will report back on outcome and new status (updated situation assessment). This cyclic procedure will repeat for the duration of the campaign.

As a practical example to illustrate, consider this general description of crisis management, taken from the NATO/PfP “Generic Crisis Management Handbook” (1997 interim version): *“Procedures and activities in crisis management range across; information acquisition and assessment; the analysis of the situation; the establishment of goals to be achieved; the development of options for actions and their comparison; the implementation of chosen options, to (finally, as feedback to close the loop) the analysis of the reaction of the parties involved.”*

According to Brehmer and Allard (1991), a dynamic decision problem has the following characteristics:

- It requires a series of decisions
- The decisions are interdependent.

- The state of the problem changes, both autonomously, and as a consequence of the decision maker's actions
- Decisions must be made in real time

Following Brehmer (2000, 2002) this kind of task can be seen as a problem of finding a way to use one process to control another process, and it is the relation between the processes that determines what strategies are possible. It also means that the time scales of the task are important. The decision maker thus has two essential tasks:

- To control the system
- To control his workload and avoid being overwhelmed by the task

That a series of *interdependent* decisions is required means that the decision maker must learn to allocate (in time and space) his resources in a way that provides for the best possible overall outcome. That the task changes both autonomously and as a consequence of the decision maker's action means that he must be able to distinguish between the effects of his own actions from autonomous effects.

That the decisions must be made in *real time* means that the decision maker must be able to find a strategy that protects him from being overwhelmed (according to Brehmer (2002) expert decision makers are recognized by their capability to adapt their work strategies to control their work load); he must learn not only about the task, but also about his own abilities. He must understand how to use a process for controlling another process, find ways to handle the delays, and possess an understanding of the time scales.

Intuition vs. analysis?

Intuition and analysis represent the end points of the "cognitive continuum" (Dunwoody et al 2000), but the cognitive mode is rarely purely intuitive or analytical. More often, it is a mixture of both. This is referred to as "quasi-rationality" (Brunswik 1956, Hammond 1996). This "middle course" is characterized by a robust and adaptive decision making/problem solving process, and is closely associated with "common sense". Tasks that contain uncertainty, dynamics and many (redundant) perceptual cues (thereby making the task hard to analyse) will benefit from a largely intuitive approach (Dunwoody et al 2000). Intuitive decision making is quick (almost instantaneous), and happens with low cognitive control and low conscious awareness. Perhaps paradoxically, good intuition is not commonplace, and in constant need of improvement!

That people have problems when applying common sense (or intuition) to static situations involving simple probability judgment is well known (see Kagel and Roth (1995), for a comprehensive review). Several authors now point to decision makers' failure to consider feedback in complex, dynamic systems. Let two recent studies illustrate the magnitude of this problem: In his studies of management of renewable resources, Moxnes (1998) observes that experienced decision makers over-invest and over-utilize their resources. He attributes this behavior to systematic misperceptions of stocks and flows, and of non-linearities. Sweeny and Sterman (2000) took a different approach when they gave system dynamics case problems to students at an elite business school. The students, who were highly educated in mathematics and science (but had received no prior schooling in system dynamics concepts), were found to

have a poor level of understanding of the basic system dynamics concepts: stock and flow relationships, and time delays.

Inspired by the Sweeny and Sterman (2000) study, Ossimitz (2002) has conducted an investigation where 154 subjects were given different tasks in dynamic thinking in general, and in the interpretation of stock-flow related graphs in particular. The results were alarming, in that the mean performance of the subjects was approximately at the level of tossing a coin for each answer. He suspects that the lacking ability is to grasp that a positive net-flow results in an increase in the corresponding stock. In a related study, Kainz and Ossimitz (2002) finds that a 90-minute crash course introducing basic stock-flow concepts between pre- and posttest was suitable to bring about an improvement in performance.

Jensen and Brehmer (2003) let a collection of laypeople attempt to establish equilibrium in a simple predator-and-prey simulation. They find that even though the task was structurally simple, it was still perceived as difficult. They conclude that subjects may have a low ability to apply indirect reasoning, at the same time as they resort to thinking in terms of discrete time steps rather than in terms of continuous time.

It is thus a general observation that people perform quite poorly in systems with even modest levels of complexity. Sterman (2000) labels this kind of cognitive dysfunction “misperceptions of feedback”. The solution would be to develop “systems thinking” abilities.

Tversky & Kahneman (1987) recognized early the shortcomings of a static, one-shot approach to learning. They describe the prospects for learning in dynamic environments like this: “Effective learning takes place only under certain conditions: it requires accurate and immediate feedback about the relation between the situational conditions and the appropriate response. The necessary feedback is often lacking for the decisions faced by managers, entrepreneurs, and politicians because:

- Outcomes are commonly delayed and not attributable to a particular action
- Variability in the environment degrades the reliability of the feedback, especially where outcomes of low probability are involved
- There is often no information about what the outcome would have been if another decision had been taken
- Most important decisions are unique and therefore provide little opportunity for learning (see Einhorn and Hogarth 1978)”

Though decision-making errors may disappear with guided experience and reflection, little research has focused on the improvement in decision strategies – in particular, changes in decision making with experience have not been revealed to any extent. Notable exceptions exist, however. Bakken (1989) finds that in a simulated economy, subject’s performance improves over trials. Paich & Sterman (1993), in their investigation of human performance in a product lifecycle task, finds that performance suffers as dynamic complexity increases. Brehmer (1988) finds that action lags decrease performance in a simulated forest fire, and at the same time conditions for learning get worse.

Three dynamic cases

The aim of presenting the following cases is to demonstrate how structurally simple, deterministic tasks may induce complex dynamic behaviour, and that this behaviour is not

fully perceived even by fairly competent decision makers. The importance and generality of the tasks (within a defence organization) makes strong cases for improvement, for example through simulation based training.

Case 1 – Operational logistics

The following case employs a model simulating a humanitarian task, where decision makers were either in command of an operational supply chain; a supporting supply chain; or had to control both in combination. Practice on the simulation model was organized at two levels of complexity: Practice on each of the single supply lines in turn, before embarking on the combined task (simplified approach); and as practice on the combined task from the start (full-scale approach). Similarly the cover stories existed in two versions – a very brief one – and a more verbose one (more than twice the number of words compared to the former).

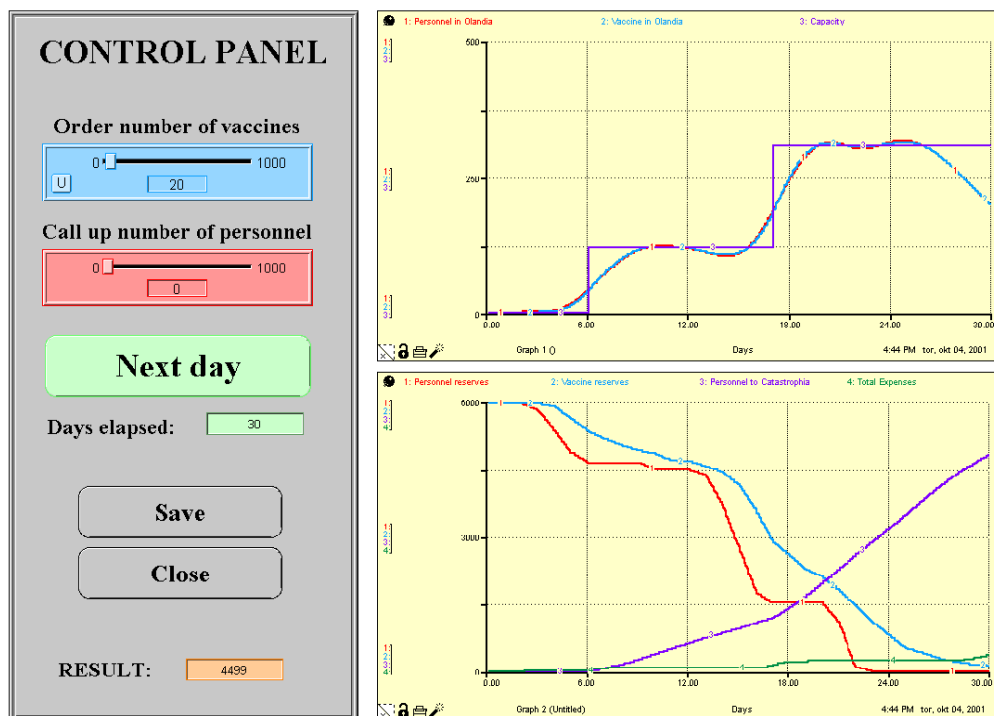


Diagram 1: User interface of the simulation model

When practicing, the decision makers were instructed to complete as many trials as they could manage within a limited time – 100 minutes. The time limit was equal across all treatments. The effect of practicing was measured as performance on a subsequent evaluation task – similar to the full-scale task with verbose cover story, but with slightly adjusted contextual information. The best participants would get monetary rewards.

In addition to the fundamental problem of matching supply with capacity, good decisions in the simulation model are characterized by three capabilities:

- “Ordering ahead”, taking into account transportation lags in the supply chains

- “Cut-off” in ordering – when capacity utilization approaches its maximum
- Near perfect balance between the two supply chains

The problem of matching supply with capacity is present in sub-models (a sub-model represents either one of the standalone supply chains) as well as in the full model, except on a smaller scale. Moving from sub-models to the full model requires merely recognition of the fact that the two supply chains that previously were separated now have to move in synchronization, and that different time lags between the chains make this a non-trivial effort.

The experimental results indicate that learning does occur from training, and that the number of practice trials explains performance, not the treatments as such (Bakken and Gilljam 2003). A key training issue then becomes how such increased training frequency can be obtained in practice. The experiment indicates that a simpler cover story, and a simpler simulation model will not in itself be sufficient. Our results suggest that participants may have employed a certain “style” or “rhythm” when making decisions in the experimental environment. If the cognitive complexity is decreased through a simpler cover story or a decomposed model structure, participants probably to some extent compensate by creating and reflecting on additional hypotheses about cause and effect relationships. The continued research attention within training improvement should therefore be a divided one: on how to facilitate and guide participants’ mental processes, as well as on techniques and technology for environment compression.

Case 2 – Strategic investments

The following case is an extremely simplified model of the logistics chain in a “Peace Support Operation”, and focuses on the dynamic interrelations between budget allocations and cost of operations (initial purchases and running sustenance), and the short- and long-term consequences of a limited time budget expansion. The paradox encountered is that a one-time budget increase may lead not only to a performance boost in the short term (primary effect), but also to a significant penalty in the longer term (unintended side-effect). The primary cause of this behaviour is the “chaining” and thus preservation of discrete age classes (cohorts) in the model, which through time lag and negative feedback conserves an imbalance of structure from the one-time increased purchases and throughout the lifetime of the resources. In fact, the one-time perturbation sets off a pattern of oscillations in performance, which, though dampened, could continue for the whole duration of the operation. Note that the task is fully deterministic, and complete information is contained on an A4 page. Based on the task description alone, subjects will be asked to depict the performance curve as a function of the budget input.

The task was first tested on N=7 defence analysts (Bakken et al 2004). When prompted, the subjects did not manage to reproduce the cyclic performance resulting from the one-time budget increase. Instead, graphs sketched (by hand) resembled more the “plain” budget profile, but stretched out in time. Only one subject correctly perceived and rendered the “unintended” performance penalty, but he had also a background in system dynamics (SD). Detailed inspections of the graphs reveal that subjects stipulated an accumulated performance boost of more than three times the actual increase.

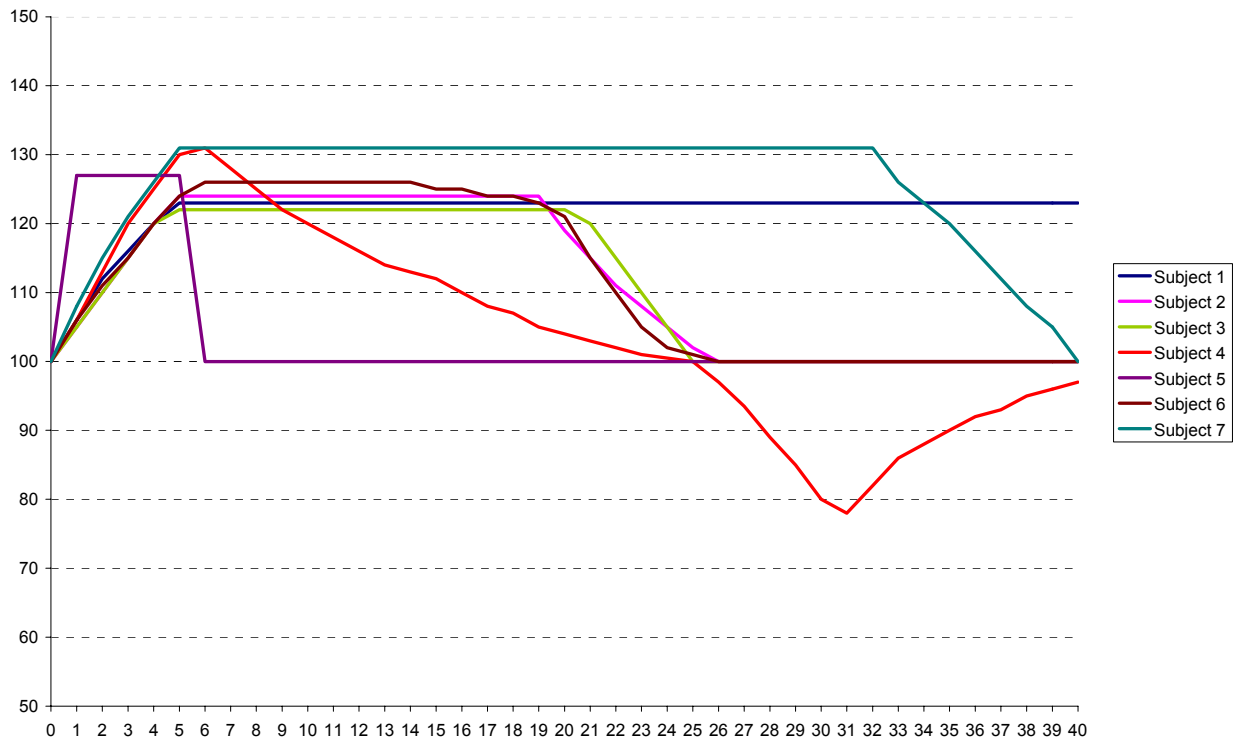


Diagram 2: Estimated Total Effects sketched by subjects #1-7. The sketch by subject 4 is the only one closely resembling the analytic solution.

The second study involved N=10 military college cadets. The task was repeated as in study 1, but this time with a debrief session immediately following the task itself. The subjects were also presented with four questions aimed at assessing subjects' confidence in own judgment as well as their understanding of the problem at hand. To simplify, subjects were this time presented with six template graphs (diagram 3), and instructed to choose individually the one that in their opinion best resembled the actual performance profile. None of the subjects managed to pick the best one (graph E).

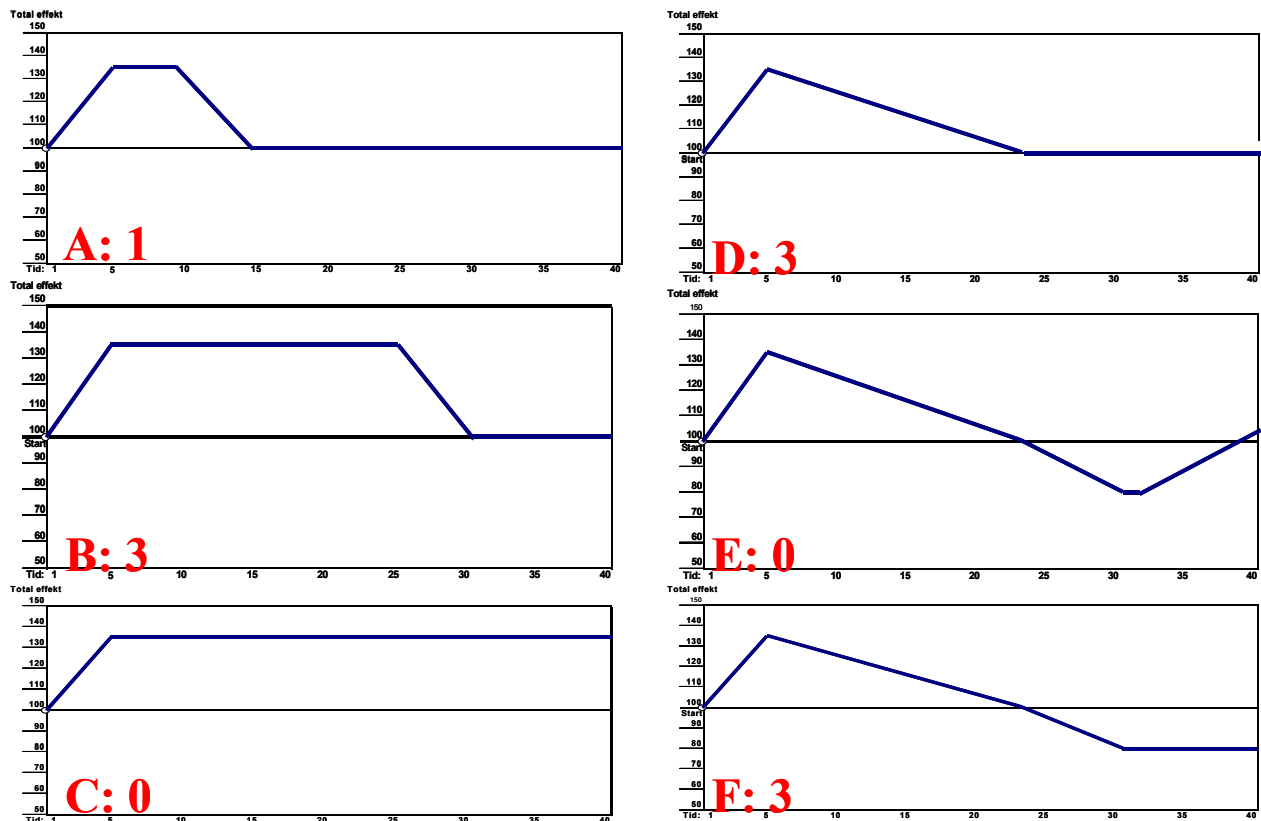


Diagram 3: Selection of template graphs to choose from (number of subjects choosing the actual graph is indicated)

Despite the low number of experimental subjects, the obvious conclusion is that intuition is a poor judge of dynamic (feedback) processes. The subjects appear to use the first order intuitive judgment as an “anchor” to which subsequent adjustments may be made (processing in spreadsheet or SD modelling software might reveal the analytic solution, but this approach usually takes valuable time which otherwise might be spent on environment monitoring and other management/executive activities). When the necessary SD insight is lacking, in this case the ability to recognise that a significant time lag coupled with negative feedback tends to produce oscillations around a baseline, such adjustments rarely happen. This kind of misperception results in over-optimism when it comes to estimate the performance of the system, because over-shoots are perceived as extended for a longer time than appropriate, and “under-shoots” are not detected at all.

Case 3 – Crisis management

Rudolph and Repenning (2002) use a fairly simple system dynamics model to study how organizations react to an ongoing stream of interruptions to normal activities. The key assumption in the model is that stress is linked to the resolution rate through a relationship known as the Yerkes–Dodson curve (Yerkes and Dodson 1908). The Yerkes–Dodson Curve depicts a curvilinear relationship between stress and performance. Initially, stress improves performance, but, as it continues to increase, performance eventually declines. When people are under stress, autonomic arousal, which manifests as faster breathing and a higher heart rate, heightens awareness and focuses attention on the sources of stress. For modest levels of

stress, this reaction improves task performance in most contexts. However, as stress grows, autonomic arousal also rises and consumes scarce cognitive resources. That is, people become distracted by the physical sensations and, consequently, performance declines (Repenning, 2003).

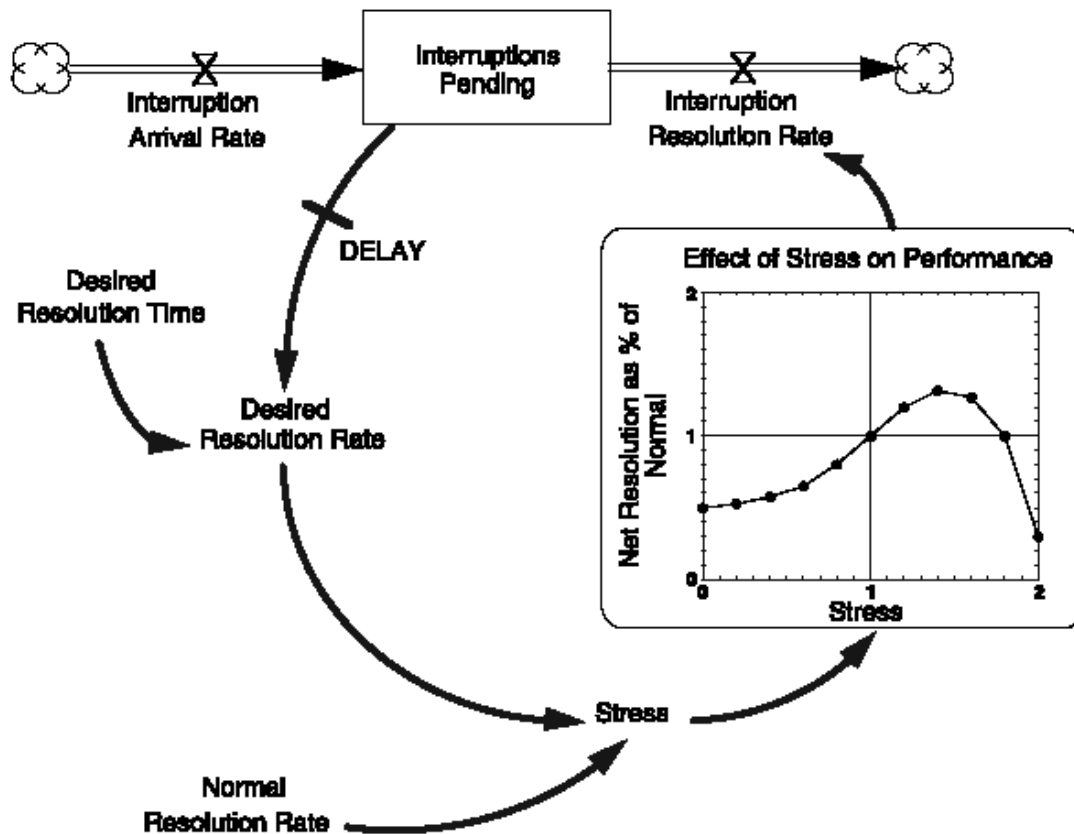


Diagram 4: Structure of disaster model. Facsimile from Repenning (2003).

The system has two equilibria, one stable and one unstable. If the level of interruptions pending, and therefore the amount of stress, stays below the unstable equilibrium, the system will tend to return to the stable equilibrium. If, however, the level of stress pushes the system beyond the unstable equilibrium, then performance quickly collapses in a vicious cycle of accumulating unresolved interruptions, mounting stress, and declining performance.

Rudolph and Repenning (2002) effectively used system dynamics to outline a new crisis archetype, the quantity-induced crisis. While the existing literature focused on how novel events could precipitate a crisis, their simple model suggested that disaster could also result from a stream of more routine interruptions. Distinguishing between two types of organizational crises, novelty-induced and quantity-induced, and their associated dynamics has several implications for both practice and research. Most notably, their analysis suggests that the strategies often proposed for mitigating novelty-induced crises – stepping back and reframing the situation – can be counterproductive when confronting a potential quantity-induced crisis. Any action that temporarily slows the interruption resolution rate can push the system closer to the unstable equilibrium, making collapse more likely.

In his research framework from 1967, Perrow reasons along the same lines when he classifies tasks to be solved in organisations.

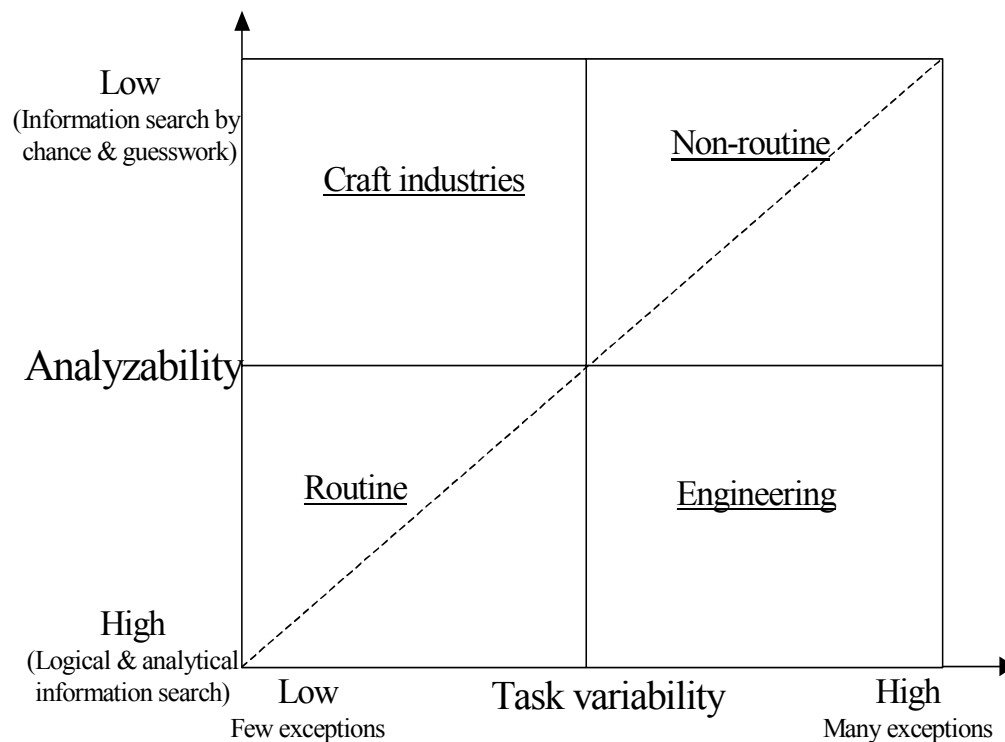


Diagram 5: Perrow's complexity framework

The framework consists of two dimensions: The task's variability, defined as the number of exceptions encountered in the task resolution, ranging from few to many. The other dimension is the analysability of the exception encountered. The exceptions may be analysable, which means that the search process triggered by the exception is systematic and predictable. The exceptions may also be un-analysable, which means that one does not know how the exception should be handled. The search process is characterized by guesswork and a more elaborate problem solving is required. This framework has been the source of much of the research on the relationship between technology and organizational structure (see Haerem 2002).

Contrary to how the framework was originally used, it is not so that a task always belongs in one of the quadrants. Organizations are more or less good at learning. Learning in organizations is often defined as changes in routines (Argyris og Schon 1978) and learning in this framework can be analysed as changes in the analysability and variability dimensions. From the framework it is also clear that it is the exceptions in the tasks and the analysability of these that make the task resolution processes challenging to handle. Good models for exception handling provides those managing work processes necessary tools to handle the processes more efficient.

Integrating CC, SA and SD

Brehmer (2000) points to two main principles when it comes to interpret people's problems in handling dynamic settings:

- Overemphasis on the present: Decision makers tend to attend to only the information currently at hand, and as a result experience difficulties in accommodating feedback delays. The world is perceived "here and now", and the information is not processed any further.
- Lack of systems thinking: the tendency to think linearly, that is, to believe that actions and results are directly related and ignore the side effects of actions. This tendency can also be viewed as an over-reliance on information that is readily available, along with a tendency to ignore what must be inferred – such as side effects.

When discussing "command concepts", Brehmer (2002) issues a warning against relying solely on (direct) feedback control of a command process. Without taking into account inherent delays, the command system would inevitably become reactive and lagging, resulting in loss of initiative and subsequently loss of personnel and equipment. A (mental) model needs to be able to produce reliable predictions of future events if it is to provide the basis for a functional command concept.

Therefore, systems thinking imply first and foremost striking a balance between the feed-forward and feedback modes of information processing. The feedback mode involves perceiving the outcome of an (single or series of) action or event, in order to interpret its causes ("meaning"). Feed-forward, on the other hand, is about being proactive – using interpretations to generate possible future causes of events (mental simulation). The quality of mental simulation will generally be dependent on the experience ("expertise") of the decision maker, as well as the complexity of the situation.

The table below is an attempt to integrate command concepts (CC), situational awareness (SA), and system dynamics/thinking (SD/ST) abilities. The leftmost column summarises the requirements posed by CC and SA. The remaining columns exemplify challenges found in the categories of time lags, feedback and non-linearities, respectively.

SD/ST challenges CC/SA requirements	Time lags	Feedback (positive/negative)	Non-linearities
<p>1: Perception Detect and classify relevant objects (static and dynamic) and “features” in text and on map.</p>	<p>The “Common Operational Picture” (COP) may be outdated, i.e., reflects a previous state rather than the current.</p>	<p>Misperception of the “age” of a given COP may inadvertently accelerate feedback processes.</p>	<p>A broad range of heterogeneous objects requires that mental models be more elaborate and complex.</p>
<p>2: Understanding Mental model (picture) of the current situation, including events and causes leading up to it. Assessment of forces “at play”, their traits, capabilities and command (personalities).</p>	<p>Different types of objects may have different times to target and effect (the difference being several orders of magnitude at the extreme).</p>	<p>Consider feedback processes when analysing possible causes of events leading up the current situation. (e.g. questioning the “true” motivation of the enemy).</p>	<p>“Force multipliers”: is the idea that two or more effectors engaging a target simultaneously yield a higher total effect than if the same effectors was employed sequentially.</p>
<p>3: Projection Mental visualisation of probable future developments of the situation. Assess congruence between plan and resources. Structure adapted to desired effect. CCIR including confirming and refuting signs. Enemy development. Evaluate C2 criticalities. Contingency plans.</p>	<p>Mental models need to incorporate the effect of delays resulting from e.g. congestion along lines of transportation; the time it takes to disseminate orders and intentions through the chain of command; the time from engagement and to results.</p>	<p><i>Positive</i> (accelerating) feedback may dominate when the operation is on a “winning course”, i.e., gaining a foothold on enemy land may accelerate the progress. <i>Negative</i> (stabilising) feedback is dominant in the traditional attrition situation; when left undisturbed, forces will wear each other down to extinction.</p>	<p>Plans should incorporate the possibility that while forces engage and are interconnected in complex ways, a “chaotic” state may occur. While appearing to be uncontrollable, it is still important to understand what determines the seemingly “chaotic” condition.</p>

Table 1: Examples of dynamic challenges in military operations and crisis management

Further work - A training solution for commanders and staff

Experimentation is required to define the training requirements, organizational design, and information system requirements for adaptable performance of military coalitions (NATO, 2003). In connection with the development of NCW concept(s), it is necessary to create a range of arenas for exercising and testing, where one can get experiences with both technical and human aspects of the NCW concept. We suggest the development of a Minimalist Decision Trainer², or “learning lab”, for NCW with focus on the human aspects.

The training solution will have as its main ambition to expose and point to challenges, dilemmas and opportunities inherent in the NCW concept. By providing personnel with a foundation for reflection on these aspects, it is possible to contribute to both individual understanding and organisational development. As a prerequisite for NCW lies the development of a technology infrastructure, facilitating information gathering, sharing and presentation. In a “learning lab” setting for NCW, we assume the required technical infrastructure to be in place and fully operative, and will emulate³ the most essential features of this infrastructure. The solution will on the basis of this assumption provide a “practice arena” for organising, information gathering, communicating and decision making (within certain boundaries).

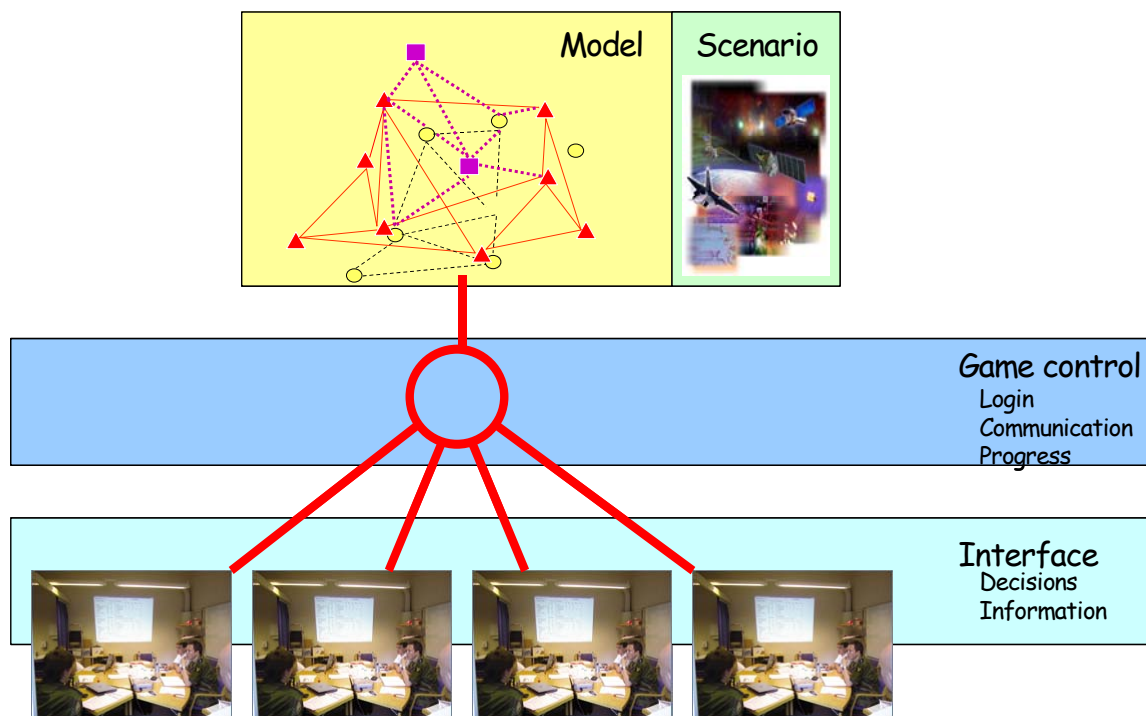


Diagram 6: Organisation layout of Learning Lab for NCW

² A Minimalist Decision Trainer (MDT) provides a solution for simplifying and compressing the training environment. MDT is designed to be a very simple and pedagogically focused simulation-supported system (i.e., microworld) for use in the training of General-level commanders (both existing and to-be). MDT is aimed at putting a commander or the command group in charge of own logistics and operations resources in a scenario. The scenario may contain any implied or explicit mission. The resources reflect a combined joint operation; typically there will be less than a hundred units representing land, sea, air and other resources (Bakken and Gilljam, 2003).

³ Thus, in gaming mode we operate some time into the future.

The “learning lab” provides the arena where two (or more) teams, consisting of different units (a unit may in turn be a single person or a team), can meet to solve problems subject to a scenario. Every unit will have access to a networked personal computer. A simulation game will be run over the network, where participating units receive information and submit decisions. Together, the units’ decisions will have consequences for the progress of the game. By developing a broad spectrum of scenarios, and enforcing restrictions on information access before and during the game (while allowing communication within team and between commander and team), it is possible to create valid experiences for participating players.

Conclusions

In this paper we have suggested a new approach to learning and understanding within the concepts of Network Centric Operations and Effects Based Operations. To arrive at a solution rooted in theories of both modern military leadership as well as dynamic decision making, we have linked the principles of “best practice” EBO modelling and analysis with System Dynamic insights.

Experimental results from case #1, Operational logistics, indicate that learning does occur from training, and that the number of practice trials explains performance, not the treatments as such. A key training issue then becomes how such increased training frequency can be obtained in practice. Training improvement research should have a divided focus: on how to facilitate and guide participants’ mental processes, as well as on techniques and technology for environment compression.

Case #2, Strategic investments, shows us (as expected) that intuition may be a poor judge of dynamic feedback processes. When the necessary insight is lacking, decision makers rarely arrive at correct conclusions. The consequences may be (as in this case) overly optimistic estimates of cost and effect.

Case #3, Crisis management, draws on Repenning’s (2003) work in formulating a dynamic model of a crisis archetype. Most notably, he shows that the strategies often proposed for mitigating novelty-induced crises – stepping back and reframing the situation – can be counterproductive when confronting a potential quantity-induced crisis. Any action that temporarily slows the interruption resolution rate can push the system closer to the unstable equilibrium, making collapse more likely. Interestingly, this approach is also consistent with Perrow’s (1967) framework for classifying task complexity in organisations.

The cases have (among others) exposed a need for a “learning lab” for NCW. The purpose of the learning lab would be, through man-machine and inter-team interaction, to improve mental models of commanders and teams, and thus improved outcomes of future operations.

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