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C^2 Team Collaboration Experiment – A Joint Research by Sweden and Singapore on Teams in a CPoF environment

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Abstract

Given NCW-enabled capabilities, "how do command teams out-wit the enemy?", "how do command teams best collaborate to achieve effective results?", and "how can teams be continuously creative such that it constantly comes out with plans that surprises and out-smarts the adversaries?" are key questions that Sweden and Singapore Armed Forces are grappling with as they enter the Net-Centric age. A model that enables these outcomes must deal with the realism of war which is characterized by uncertainty, time-pressure, high complexity and dynamics. It must also encourage greater insight and creativity amongst the command team members so that the plans they have designed will out-wit the enemy. So, the Team Insight Model (TIM) was developed as a theoretical model adopting Sweden's knowledge and experience in developing battle procedures in the form of Planning Under Time Pressure (PUT) Model developed by Thunholm (2003), and SCME's studies into Team Insights. The conviction is that TIM will bring about better tempo, situation awareness, plan and preparedness for the team, resulting in better decisions and outcomes.

This paper will explain the theoretical basis of TIM, and the method by which the experiment was carried out. It will report on the results and discuss about the outcomes from the experiment

Key words: Team Insight Model, Knowledge Battle Procedure, MissionMate, Collaboration, TeamSight, MIND, military planning, team creativity, CPoF

Introduction

The progressive move to a technology-enabled military in the new Century has shifted substantially to the way C2 processes are carried out in the tactical command post. In this introduction we will cover areas related to the development of a new distributed tactical army planning and execution process.

Boyd's OODA (Observe-Orient-Decide-Act) loop (Boyd, 1987) provides a theoretical foundation on the cycle and the tempo of Command and Control operations. To out-wit the enemy, the idea is to work inside his OODA loop to render his planned actions ineffective, surprise him, and a ultimately cause his cycle to collapse. 'To work within the OODA cycle' means to have planning processes and C2 information systems augmentation that enables an increase in the speed of decision making, and also result in better and more creative plans and decisions. Firstly, the idea of speed is an important enabler to decisive operations in war and has been emphasized in Clausewitz (1976) and Liddel Hart (1927) and more recent military theorists (e.g. Lind, 1985; Van Creveld, 1985). The idea is to pass the loop quicker than the enemy (enhancing our OODA cycle), and thereby render his actions more and more inappropriate and irrelevant. Modern army regulations (e.g. US Army, 2003; SwAF, 2002) are also in line with this thinking. The OODA loop is not only about making quick decisions. However, in the C2 area the focus is often on decision speed, because making plans and decisions are the main activity for the C2 function. Secondly, creativity in planning will provide the other edge because having more creative ways to exploit terrain and resources could upset enemy's well-thought out plans (breaking-up enemy's OODA cycle). Most literature on warfare does not talk about creativity or insight generation. However, it is common to find expositions on developing surprises (e.g. Clausewitz, 1976) or military problem solving. Nonetheless, research on creativity abounds in the field of psychology and management science and could be applied in the warfare setting. In the Network-Centric era with distributed collaboration technologies, there is an increase in the

opportunities of information and ideas exchange and if these are well exploited will lead to successful planning processes that 'out-OODAs' the enemy. The Team Insight Model (TIM) is a theoretical model developed to address planning methodologies and C2 system design to achieve better decision speed and plans – resulting in *winning* Command Teams.

Planning Under Time Pressure Model

With modern doctrines emphasizing speed, there should therefore be an impetus to develop better doctrinal planning methodologies over current modern army doctrinal planning paradigm (e.g NATO, 1998; US Army, 1997, 2003, Singapore Army, Staff Organisation and Procedures, M-TRADOC-1014-02, Jun 2001) which is based on a decision outcome optimization rationale, with little emphasis on speed of the planning and decision-making process. The basic planning model prescribed in such doctrines is often very time-consuming and cumbersome to follow. Prescriptions how to adapt the process to time-pressure is often incomplete and the planner is warned not to short-cut the process because that will result in a lower quality decision (US Army, 1997). The key moment of the traditional planning process is the development and comparison of several, normally three, detailed courses of action, followed by final selection of the perceived best option by the team.

Recent research on military planning and decision making indicates that traditional planning models are seldom followed in field settings (Fallesen, 2000; Klein, 1989, 1999; Pascual & Henderson, 1997;). The main reason provided by experienced military planners when asked about this is that the traditional process is too time-consuming (Klein, 1999). Instead of trying to find an optimal solution, the military decision maker, working under time-pressure, often goes for a satisficing (good-enough) solution or plan, and draws upon his previous experience and his understanding of the situation in order to find it. This way of making decisions and plans has been observed in many different studies (e.g. Fallesen, 2000; Klein, 1989, 1993; Pascual & Henderson, 1997; Serfaty, MacMillan, Entin, & Entin).

Findings from empirical studies explicitly aimed at exploring the planning and decision-making process in military units have been reported by Klein and Miller (1999), Klein, Schmitt, McCloskey, Heaton, Klinger and Wolf (1996), and Klein, Schmitt, McCloskey and Phillips (2000). Based on the findings from these studies Schmitt and Klein (1999) concluded that there was a need for a military decision-making model that (compared to the traditional models): a) is faster in order to deal with normally present time-pressure, b) involves the commander more into the process, since the commander typically could come up with a better solution than his/her staff and in a fraction of the time they needed, c) involve a small group of experienced planners to develop the initial concept of operations together with the commander, d) allow for a more natural initial problem solving strategy (cf. Klein 1996; Lipshitz & Adar Praz, 2005), allowing for iterations between the sub-steps of the planning process, e) use wargaming (mental or visual simulation) as a means for learning more about the battle and communicate intent, and f) reduce the need for transitions between different teams of planners and executors, since those transitions often resulted in the loss of meaning of the intent of the plan.

Schmitt and Klein (1999) presented a Recognitional Planning Model (RPM) of the military decision-making process that was meant to be both descriptive and prescriptive. Descriptive since it describes how military battle planning is actually done by skilled military commanders and staffs, prescriptive since it provides a strategy that will increase the speed of planning compared to the traditional approach prescribed (e.g. US Army, 1997; US Marine Corps, 1996).

Thunholm (2003, 2005), building on the RPM, presented the Planning Under Time-pressure Model (PUT). The PUT-model was primarily intended for use at the tactical level (Division, Brigade and Battalion) in a battlefield environment characterized by uncertainty, time-pressure, high complexity and dynamics. Thunholm focused not primarily on decision speed but applied a cost-benefit perspective on the military planning process under time-pressure. Only planning events that added something crucial to the quality of the decision up-front were allowed to be a part of the planning process (Thunholm, 2005). The idea was to develop a model well adapted to realistic battle-field conditions, a model that would be used by military planners, and that resulted in faster decisions without any loss in decision- and plan quality. The PUT model is based on a satisficing rationale, that is, the purpose is to find one good-enough option early in the planning process and then refine and corroborate it through wargaming. The planners are supposed to work in a small planning team led by the commander. The first part of the process is to understand the mission given by a higher headquarters and to visualize that mission. The second part of the process is to understand the situation, both the current state and the predicted or possible future situation. This includes generation of simple options for both enemy and own forces but not in the same detailed and time-consuming way prescribed in traditional models. Also, no selection of one option should be made at this stage. The third part of the process is to define situation specific success criteria that need to be a part of the final plan. The fifth part of the process is to develop one plan, based on the best understanding of the goal, the current and possible future situation, and the success criteria. The sixth part of the process is to wargame the plan against one or more enemy possible plans. The seventh part of the process is to make a formal decision and after that, develop and issue operational orders and concurrently make contingency orders in order to speed up the execution phase of the plan. A full description of the PUT-model is provided in Thunholm (2003). Testing with the PUT model (ibid) indicated significantly quicker decisions without loss of decision quality, lower perception of time-pressure and high usability ratings of the model for use in realistic battlefield conditions. The PUT model started to be introduced in the Swedish armed forces as the tactical planning model in 2003.

Team Insights

A key area not often studied in the area of military decision making is the area of Command team insight generation. Yet insights are important because beyond process effectiveness, it is ideas that will help a Command Team out-wit the enemy and win the war. There are two definitions of insights from literature. The first refers to a state of understanding – understanding a principle, a concept, a problem etc (Smith, 1995). In this regard, insight can be achieved by incremental acquisition of knowledge. The second definition is phenomenological and describes insight as an experience involving a sudden emergence of an idea, i.e. the "Aha!" experience. This is the familiar experience of ideation in brainstorming activities. Finke (1995) classifies insight along the same lines albeit from a cognitive psychological angle – Convergent and Divergent Thinking. Convergent Thinking refers to thinking focusing on a single idea or possibility, given a collection of facts, e.g. building up of evidence towards a hypothesis of a crime. Divergent Thinking on the other hand, refers to thinking that flows outwards from a concept, making connection with external ideas that one may not ordinarily consider.

Using Finke's definition, we defined two types of insights: a) *Convergent Insight*, which refers to the discovery of a creative structure or solution derived from making sense of an apparently disconnected set of facts. (form-follows-functions). b) *Divergent Insight* refers to the

generation of ideas based on a pre-defined structure and the discovery of novel use and implications from this starting structure. An example is an explorer moving into new land to see what might be discovered rather than confirming what one suspected (function-follows-form).

Based on research by Mayer (1995), there are several ways by which Convergent Insight could be achieved. These techniques will help us identify C2 system functions and processes that could support creative synthesis: a) *Completing a Schema*. This is a Gestaltist view of creative problem solving as a process to figure out how pieces of information come together according to the givens and goals of a problem, to form a coherent structure. Hence, Insight (a state of understanding) occurs when information is becoming correlated, and causal relations between events are established, such that everything starts falling into place and becoming sensible to the person appreciating the picture. Based on this approach, diversity of views, the source of insight, is based on the diversity of members of the team coming from different background (experiences) as well as their access to different information sources. b) *Reorganizing Visual Information*. Sometimes, a problem is immediately solved when the problem solver looks at a problem situation in a new perspective. New Insights could be formed when we look at the battle from different perspectives – using 2D, 3D or flipping the picture around to look at the situation from the enemy's perspective could offer fresh perspectives. c) *Reformulating a Problem*. One Gestalt psychologist Karl Dunker (1945) found that insight occurs when a problem solver mentally redefines and clarifies the problem. There are two methods for reformulating a problem, firstly by redefining the *goal,* and secondly, by redefining the *givens*. d) *Overcoming a Mental Block*. Another perspective offered by the Gestalt psychologists is that people can be prevented from creative solutions based on their reliance on inappropriate past experience. So processes that deliberately question the past experience and mentally remove them could lead to new insights. e) *Finding a Problem Analog*. On the other hand, as suggested by another Gestalt psychologist Wertheimer (1945/49), certain past experience could in fact spark insight. Wertheimer suggested that insight sometimes involves applying the structural organization of one situation in a new problem.

In the area of Divergent Insights, the process begins by a certain structure and then explore possible uses and implications of that structure – i.e. form first then function. Finke (Finke 1995). The idea is to attempt to achieve divergent insights by laying out the plan first before thinking why such a plan and how the plan could achieve the objectives. Pre-Inventive Artifacts are primitive forms of basic building blocks for a plan. Examples at the strategic level planning could be notions such as flanking, dept-operations, counter-air operations etc. This approach could help break mental blocks, and also useful for the reformulation of the problems.

Planning in Distributed Networks

Network-Centric collaboration capabilities provide new opportunities to increase decision-making speed and ideation. With rich collaboration involving high throughput of ideas and knowledge exchange, parallel planning across organizational hierarchies is possible increasing overall planning speed. In addition, discussions involving multiple parties, previously limited by space and time constraints (e.g. between discussions between Brigade and Battalion is conducted only during the scheduled meetings), is no longer limited by meetings and this, as suggested by Mayer (Mayer, 95), would increase insights generation due to the diversity of views.

Team Collaboration Experiment 1.

The purpose of this study, called Team Collaboration Experiment 1 (TCX 1), was to explore the effects of TIM. For this experiment, TIM is a combination of a naturalistic planning and decision-making model called the Knowledge Battle Procedure (KBP) (inspired by the PUT) and of a C2 System for distributed planning called MissionMate (MM) with TeamSight (TS). The KBP, MM and TS will be described in detail in the method section.

Given the explorative purpose of the TCX 1, no formal hypotheses were formed. The TCX 1 is the first study in a series of several more, and it was done as a part of the overall Swedish Armed Forces (SwAF) and Singapore Armed Forces (SAF) collaboration framework. The results from TCX 1 should form the base for developing testable hypotheses for later experiments. However, some expectations are connected to the use of the TIM. First, there is an expectation of a higher overall planning tempo throughout the chain of command. This expectation is based on increased ability of parallel planning when using the MissionMate and TeamSight system and also on increased planning tempo through the use of a naturalistic planning procedure, allowing for an early identification of a course of action. Second, there is an expectation of higher overall plan and execution quality. This expectation is based on increased shared situation awareness through the use of MissionMate, where all members of the planning staff can have the same view or look at each others view. The expectation of higher plan and execution quality is also based on the ability to listen in to the planning process of a higher (or a lower) echelon, and thereby better understand the will of the higher commander. Given more channels to discuss and share info through MissionMate, better insights and more creative solutions in the plan are expected to be generated. Third, there is an expectation that the TIM should be regarded as a good model for battle planning and execution under realistic battlefield conditions. This expectation is based on the KBP being a naturalistic process better adapted to the way commanders naturally like to deal with real battlefield decision problems.

Method

Participants

Participants were the Battalion Commander (CO) and staff of the 40 Singapore Armoured Regiment (40 SAR). Participating Principal Staff Officers (PSOs) were the Personnel Officer (S1), the Intelligence Officer (S2), the Operations Officer (S3), the Logistics Officer (S4), the Fire Support Officer (FSO), the Battalion Signal Officer (BSO) and the Pioneer Officer (PO), making N = 8. Their ordinary staff support personnel supported the PSOs. All participants were men. The participants mean age was 25.7 years (Min = 19, Max = 34, SD = 5.4). The participants on average reported 4.1 years of job experience as an officer (Min = 1, Max = 14, SD = 4.4) and 6.6 years experience from work in the present role (Min = 0, Max = 14, SD = 5.1). The participants on average reported to have previously participated in 3.7 planning processes (Min = 0, Max = 20, SD = 6.7) and that it was on average 3.6 years since the last time (Min = 0, Max = 9, Sd = 3.6). These figures indicate a substantial span among the participants, both concerning age and experience. The Bn CO, and also to some extent the S2 and S3 could be considered as experienced in their roles while the rest of the PSOs were rather inexperienced. Only the S3 had previous experience using the MissionMate system. As a unit the Battalion was generally young and had only been working together for a couple of weeks. The significance of this is that the participants should be less influenced by the current SAF Battle Procedure (BP) and possibly open to adopt the new KBP. On the other hand, the inexperienced participants should be less knowledgeable about battle planning and less able to contribute significantly to

the process the same way as more experienced officers should have been. The result of the process should be more dependent on the ability of the CO as the most experienced participant.

Design

The study was designed to *explore* the effects of the Team Insight Model (TIM) on (a) decision quality, (b) decision tempo, (c) planning and execution process and (d) team creativity. The measurements taken on these four main dependent variables are described in detail in the measurements section. The TIM is an abstraction for the combination of a new planning model, the KBP, and new tools, the MM and TS.

Some background variables and confounding variables were also included in the design and measurements taken on those are also described in the measurements section.

The study design included (I) a formal training session on the TIM of 1.5 days, (II) an applied scenario-based training session (planning and execution of plan), including pre-measurements on all variables, of 1.5 days, and finally, (III) one test-session (planning and execution of plan) of 1.5 days. This design does not allow for any formal experimental comparison between the TIM and the current SAF BP. Conclusions about the relative efficiency of the TIM compared to SAF BP must be based on the participants and the observers' previous experience from planning according to SAF BP and similar planning models.

Scenario

The scenario was pictured with a Division requiring to capture an enemy Brigade deployed over Temasek land (fictitious) with a width of 20 km and a depth of 35 km. The 8th Singapore Armoured Brigade was playing as part of the Division formation and her role as the Armour Brigade was to punch through to the depth as fast as possible to dislocate the enemy's Reserve forces comprising of a Battalion size but dispersed over several areas. The scenario was realistic as there was a variation in one of the earlier exercises held in Singapore. The Armoured Brigade has 3 mechanised battalions under her command, and the experimental subjects essentially played the role of the mechanized Battalion. The Battalion was to develop a Battalion plan based on the Brigade Orders. The scenario was designed to enforce replanning through a chain of injects given during the execution

Task

The participants acted in their ordinary roles as Battalion CO and principal staff officers aided by ordinary staff support personnel. The battalion was one of several units of the 8th Singapore Armoured Brigade (8 SAB) included in the scenario. The task was to follow the KBP (for details see the KBP section), and to utilize MM and TS tools (see the MM and TS section) in order to produce a complete (written) battalion operational order (OpsO). The time restriction included in the KBP is to use maximum four hours to produce the order, after receiving final Brigade Operations Orders (OpsO). The superior brigade CO and staff (8 SAB) were role played by the real 8 SAB CO and staff officers organized as a White Cell (Scenario High Control). The Battalion team was supposed to interact with their superior HQ and also with subordinate Company units, also role-played by members of 8 SAB staff (Scenario Low Control). The task to produce an OpsO in a scenario like this is common and should be familiar at least to the experienced participants. The task did not differ between the training scenario and the test scenario.

The Mission Mate and Team Operating Picture (TOP) C2 Collaboration Application

The Singapore Armed Force (SAF) Centre for Military Experimentation (SCME), together with the Defence Science and Technology Agency (DSTA) have recently developed a C2 system called MissionMate that was applied at the Brigade level experiment exercise conducted out in Shoalwater Bay, Australia (Cheah, Chew and Teh, 2005). MissionMate is a C2KS system build on a distributed architecture (Cheah, Chew, and Tan, 2004). The system's architecture is built using a thin client and Service-Oriented concept where C2 applications (or services) can be accessed anywhere on the network via a browser. The key applications used to enable TCX are the Team Operating Picture (TOP) and the Ecology Spaces. The TOP is a key application that enables GIS-based whiteboarding collaboration and parallel planning operating. The key feature of TOP is the idea called TeamSight[1] (Team (in)Sight as inspired by TIM), which augmented with other communication tools such as video conferencing and chat, enables the distributed Command Team to co-author a plan together on a virtual map-based whiteboard, allow members to oversee each other's developments in real-time, allow discussions on plans in a distributed mode, and thereby increasing team insight generation. For TIM specifically, each PSO would then construct their personal operational and planning pictures. By having separate operational pictures for each PSO, the total amount of operational pictures gives rise to greater amount of information to be firstly, visually seen and secondly, collaborate on the situational constructs of others in his team.

While the plan is being constructed on the GIS, another collaborative tool within TOP is called the Ecology Space. The Ecology Space is a collaborative mind tree that helps the team to create, share and edit textual information to supplement the GIS overlays being drawn. An analogy to the Ecology Space is to have a collaborative Microsoft Powerpoint where the notes and graphic portions are collaborative. The Ecology Space is being used to track the development of the plans being formed throughout the entire battle procedure, for approval of plans with the higher command as well as for dissemination of Orders to the lower echelon.

The Knowledge Battle Procedure

In early 2004, SCME had several interactions with Gary Klein and Peter Thunholm to sense how to improve the current SAF BP through the use of RPM/PUT together with TeamSight as part of their sensemaking effort to improve tactical command post operations for the land battle. Capitalizing on MissionMate's TeamSight concept and the inspiration of PUT (Thunholm, 2003) and RPM (Schmitt & Klein, 1999), SCME put together a knowledge battle procedure (KBP) in late 2004 that prescribes the ability to conduct distributed and parallel planning with higher and lower echelon of commands. The KBP consists of only 5 stages namely, 1) the preliminary planning stage, 2) receiving of orders 3) mission analysis 4) develop a plan and wargame it and 5) operationalizing the plan. During the preliminary planning stage, the lower echelon is able to listen and possibly interact with the echelon planning the operations through MissionMate. While it is prescribed to only conduct terrain and enemy study of the area of operations at the preliminary planning stage, it does not preclude the lower echelon commander to move on and conduct his preliminary mission analysis and preliminary plans at this stage too since TeamSight readily allows parallel planning. Once the orders are given, the KBP prescribes only 2 meeting sessions namely the mission analysis stage and the wargaming

[1] Future developments of TeamSight includes other applications that improves insight generation. For example, a 3-D visualization tool is being integrated with the current 2-D application to enable the users to see a new perspective of the plan. As discussed earlier, new insights can be garnered by the reorganizing of visual information.

stage for the command team. In between and throughout the battle planning time, time is given for staff interaction through the MissionMate system i.e. parallel planning across the command post team and the staff works off the computer system as opposed to many staff group presentations. The team builds up their ideas and knowledge them down into a collaborative mind space called the ecology space. The idea of the ecology space is to develop a history of how the plans are being conceptualized and finally formed. It is also used as a process of write once many uses i.e. the plans can be used for discussing among the command post staff, subsequently for wargaming among the command team, with the higher echelon wargaming sessions, for orders to the lower echelon, and later for battle management operations since it is part of the TeamSight suite of products.

The KBP is also a step away from the analytical and sequential battle procedure that the SAF currently uses called as the SAF BP. It, like the RPM and PUT, prescribes an early choice of one course of action done at the mission analysis stage, but does not restrict the development of several choices of enemy courses of action. In order to select the best concept at the mission analysis stage, the KBP prescribes the command team to use TeamSight to get a sense and mission ideas of the higher echelon planning products during their mission analysis and wargaming stages, as well as observing the building up of the higher echelon ecology spaces. This is done at the preliminary planning stages using TeamSight. The commander and the team are able to work and conceptualise several concepts prior to the higher echelon orders without having to develop in detail. When orders are given, it is not done in a verbal fashion, but rather it is found in the ecology spaces, where the command team would have already read, clarify among themselves first, confirming their previous understanding and actions done during the preliminary planning stages, prior to clarifying any variations with the higher echelon. The KBP prescribes a detailed mission analysis stage where the command team starts to deliberate their preliminary ideas and concepts done earlier and conducting a pre-mortem (vulnerability analysis) of their concepts before choosing the most appropriate one for the development of the plan.

The other difference from the SAF BP is that all the plans, including the supporting plans, are done concurrently now. The SAF BP advocates the support plans to be developed after the OCA (own course of action) or the Ops Plans are presented. With TeamSight, the plans are drawn in visual sight for all to view, and supporting staff can now conduct concurrent planning or collaborate with the operational plans being developed on-line. While yet to be experimented, the KBP predicts an overall savings of 4 hours in the Brigade command team planning time i.e. a reduction from the usual 12 hours to 8 hours of planning. At the Battalion level, the KBP does not predict any savings in time from the current four-hour cycle, but the ability to generate better quality of plan and anticipating enemy actions earlier.

Measures

The variables were measured by using a battery of observer protocols and questionnaires. The observers were both military and civilians. Out of the military observers two came from Singapore and three from Sweden. All nine civilian observers were from SCME.

Background variables. Before the training run the participants answered a questionnaire on general background factors. The questions were about age, sex, branch, military occupation specialty, job experience as an officer, task experience in current role, rank, and how long it was since last participating in a planning process at Bn level, and finally how many planning processes the participant had conducted in total.

Confounding variables. Two major confounding variables were measured during the exercise. One of them was *realism of the scenario*. All military observers and key personnel (Bn Co and PSOs) from the battalion staff answered questions after each run in order to determine the degree to which the participants believed that the scenario was realistic in every important aspect. A total of four questions concerning (a) the realism of the scenario (the story), (b) whether a realistic amount of information was provided, (c) whether a realistic amount of time given for planning was provided and (d) whether the level of uncertainty was realistic were judged on a six-step Likert scale ranging from 1 (less than satisfactory) to 6 (more than satisfactory). The other confounding variable was *system failure*. In order to detect if there were any major system failures during the exercise all military observers and key personnel from the battalion staff were asked questions on system performance after each run. They stated if they had experienced any problem with the systems during the exercise. If so they were asked to briefly describe the problem.

Dependent variables.

Team Creativity. Team creativity was measured and analyzed as the combined profile of four sub categories.

(1) Communicated ideas. Communicated ideas were measured by participants and observers judging (a) the frequency of generated ideas within the staff compared to normal on a six-step Likert scale ranging from 1 (less than normal) trough 6 (more than normal) and (b) if they found the number of ideas satisfactory on a six-step Likert scale ranging from 1 (less than satisfactory) through 6 (more than satisfactory). The items were answered during the time outs and were to be related to the period between the previous time out and the current time. The number of communicated ideas was also measured by observers counting utterances during the runs. For this purpose one of the classes, exchange of ideas, used in an observer protocol designed to measure communication profile was used. The protocol were used both to classify the battalion staffs internal communication and the staffs communication with external actors such as the bde staff.

Finally, communication of ideas was also measured in the questionnaire for evaluating the mission mate system. The questionnaire had one item were the participants were asked to judge on a four degree scale how MissionMate helped them in the communication of ideas.

(2) Number of communicated ideas by each staff member. This subcategory was measured by participants and observers ranking the order of how much the different staff members generated ideas. The ranking was from the one that generated the largest amount of ideas (score 1) to the one that generated the smallest (score 8). The participants and observers also judged the different staff members level of sharing ideas on a six-step Likert scale ranging from 1 (the staff member that share ideas to a large extent) through 6(the staff member that share ideas very seldom). These items were answered during the time outs and were to be related to the period between the previous time out and the current time.

(3) Openness. Openness was measured by participants and observers in the time outs and was also to be related to the period between the previous time out and the current time. They were asked to judge their perception of the degree of openness within the staff in terms of whether it was satisfactory or not on a six-step Likert scale ranging from 1 (less than satisfactory) through 6 (more than satisfactory). They were also asked to judge whether the level of openness in the staff was normal compared to similar staffs on a six-step Likert scale ranging

from 1(less than normal) through 6 (more than normal). Finally, the battalion staff was asked to compare the level of openness during the exercise with their normal state of openness in similar situations on a Likert scale similar to the previous one mentioned.

(4) Dominance. Dominance was measured by participants and observers ranking the order of how much each staff member dominated the staff's work according to their perception. The ranking was from 1 (the one that dominated the most) to 8 (the one that dominated the least). The participants and observers also judged the different staff members level of domination on a six-step Likert scale ranging from 1(dominates very much) through 6 (dominates very little). These items were answered during the time outs and were to be related to the period between the previous time out and the current time.

Decision quality. Quality of decision was measured and analyzed as the combined profile of two sub categories.

(1) Quality of critical decision and plan. Quality of critical decision and plan was measured by several different means. First, key personnel from the battalion staff completed a questionnaire on their perception of the results of their mission planning. They were asked to judge on a six-step Likert scale how satisfied they were with their team's plan on five factors: (a) how satisfied they were with the Bn plan, (b) how feasible they thought their plan was for accomplishing the mission, (c) how thoroughly worked through it was, (d) how necessary is was to have a plan exactly like the one produced in order to accomplish the mission, and (e) how easy it would be to convince a subordinate company commander about the feasibility of the teams plan.

Second, the staff members completed a questionnaire on how they thought they succeeded in producing a good OpsO. They judged the quality of the OpsO tactical content, clarity and completeness on a six-step Likert scale ranging from (1) much lower than normal through (6) much higher than normal. The battalions OpsO was also judged on the same criteria after the test run independently by the Bde CO, S2 and S3.

(2) Situation awareness. Situation awareness was measured by a number of questionnaires during the execution phase, after the test run and by observer protocols during the whole run.

First the battalion staff were asked to rank order three injects which had occurred during the last hour regarding their threat to prevent the battalion from succeeding in its' task. Then they were asked to briefly describe the consequences from one defined inject. A version of this questionnaire with new injects was distributed at three times during the execution phase.

Second, a similar questionnaire was administered to key brigade staff members about one hour later compared to the Bn staff. As the brigade ranking was done one hour later together with the fact that the brigade staff was a part of the white cell, it was assumed that they would have superior situation understanding. Furthermore they were asked to judge the level of correctness of the Bn staff members individual ranking on a six-step Likert scale ranging from 1(low level of correctness) through 6 (high level of correctness). The eight different predictions by the members of the Bn staff were presented anonymously to the Bde staff judges.

Third, situation awareness was measured by observers counting utterances during the runs. For this purpose two of the classes, building shared understanding and clarification, used in an observer protocol designed to measure communication profile was used. The protocol were used both to classify the battalion staffs internal communication and the staffs communication with external actors such as the bde staff.

Finally, situation awareness was also measured by the mission mate system questionnaire. The questionnaire had three questions were the participants were asked to judge on a four-step scale how MissionMate helped the participant to (a) understand Commanders Intent (b) understand the battlefield situation and (c) anticipate contingencies.

Decision tempo. Decision tempo was measured by observer protocols. Four military observers timed the completion of each sub-process of the KBP and three time measures were computed from the protocols. (1) The time needed for the Bn team from the moment when they received warning orders from the brigade until the Bn CO decided on a concept course of action (COA), (2) the time needed for the Battalion to proceed from a decision on a concept COA until a plan was ready for wargaming with the brigade, and (3) the time needed for the Bn from receiving final OpsO from the Brigade until a complete OpsO were ready to issue to the Company Commanders.

Planning and execution process. Four military observers used observer protocols to document the staffs' performance according to the defined staff process, KBP. In the protocol, the sub processes of KBP were defined. The observers also briefly described how the sub-process was conducted as compared to the detailed process description. The observers where requested to describe whether the staff followed the process exactly or if any deviations from the process occurred and also how many concept COAs that were generated in the planning process. Finally, they were asked on overall comments on each step. Reasons/rationales for the deviations observed could also be included.

Observers also focused on the communication pattern within the staff and between the staff and other actors. Observers counted different classes of utterances during the runs. Communication was divided into six different classes, (1) exchange of ideas, (2) building shared understanding, (3) clarification, (4) team monitoring & self-correction, (5) dissemination and (6) other utterances. 4 civilian observers were used to solve the observation task. The protocol were used both to classify the battalion staffs internal communication and the staffs communication with external actors such as the bgde staff. Altogether the result was supposed to show a profile of the communication content of the staff process. As it is not possible to code the entire communications profile real time over the whole process, 3 selected 1-hour time windows were selected: Bn Wargaming, Bde-Bn Wargaming and Execution Phase.

The planning and execution process was also evaluated by the Technology Measurement Team who devised a set of measures to determine the extent of how technology, in particular, MissionMate, helped the participants to achieve their mission. Observers were assigned to the individual participants to observe them in their usage of the available technology to achieve their mission. They were graded based on the following criteria: (a) Frequency of use of the various tools in MissionMate, (b) ease of use of the various tools in MissionMate, (c) how the tool has contributed to achieving the intended function, and (d) other technical issues encountered.

Observations were made to see how MissionMate facilitated the participants' planning in the individual stages of the Bn planning process, namely: (a) How MM helped the participant to develop Mission plans effectively, (b) how MM helped the participant to wargame his plans with his team members, (c) how MM helped the participant to generate orders, and (d) how MM helped the participant to disseminate orders to lower HQ.

After the exercise a KBP evaluation questionnaire was administered to the participants. They were asked to briefly describe their opinion on (a) what the significance of KBP was, (b) what deviations the staff did from KBP, and (c) why they deviated from the KBP. Finally they were also asked to briefly describe the advantage and disadvantage with TIM (KBP, MM and TS) as compared to the traditional SAF BP.

The Mission Mate system was also analyzed more in depth by a separate questionnaire. The questionnaire, which was completed after the test run and focused on functionality of the mission mate, requested that the participant to express which of the available tools they used. They also were asked to judge on a four degree scale how the tool had contributed to achieving the function, helped them in the communication of ideas, how often they used the tool for different functions and finally their perception on ease of use of the tool.

Procedure

Preparations. The participants were prepared for the experiment through 1.5 days of formal integrated training on the KBP, MM and TS systems. After that applied training took place during 1.5 days, were the participants (both the Bn and Bde staff) went through a complete session of planning and execution with situation updates and execution injects and all measurements, as they were supposed to be conducted during the test run. After that a short after action review was held and the participants received feed-back on the training run. They were then allowed a couple of hours to reconcile and to adjust before the test run started. The test run also took 1.5 days to complete and after that a full after action review was conducted.

The physical set-up of the experiment was according to Figure 1. Run 1 is the training run and run 2 is the test run

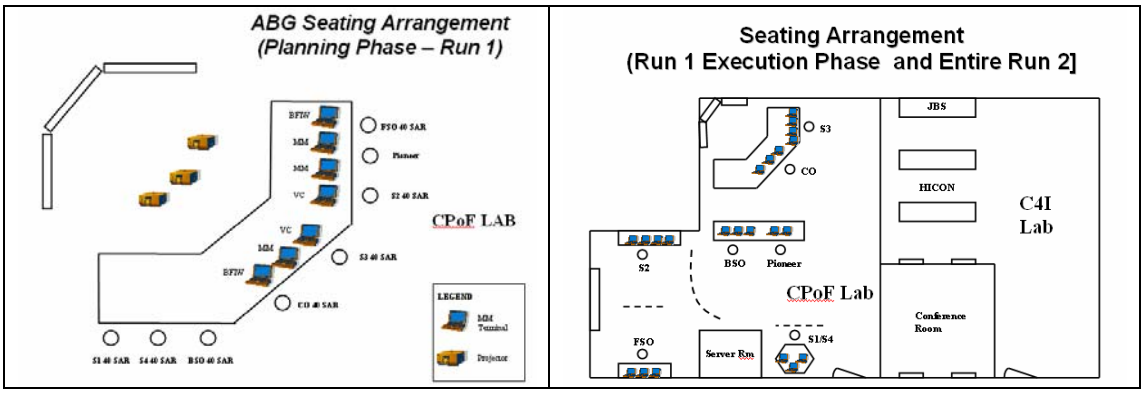

Figure 1: Participants' Seating Arrangement during TCX Experiment

Data collection. Each of the two runs (training and test) were divided into three phases based on how data best should be collected. The first phase was the initial part of the planning until step 4.4 Issue of Commander's Planning Guidance (see Appendix 1). The second phase was the finalizing of the plan and wargaming, until the OpsO was finalized and the final phase was the execution of the mission.

Before the first phase of the training run the key personnel from the battalion staff reported on their background in a specific questionnaire. During each of the three phases observers documented the process according to two different observer protocols, Observer protocol 1 (O1) - on line observation of communication, and observer protocol 4 (O4) - on line observation of process. Protocol O1 was completed by nine civilian observers from SCME and

captured communication pattern among the staff members during a few selected periods of the exercise. All voice communication in all phases was recorded by a system called MIND. Between the first and second, the second and third, and after the third phase the staff answered a questionnaire (questionnaire Q1) to document data on team creativity. A similar questionnaire, denominated observer protocol 2 (O2) was filled in by the observers for the same purpose. In addition questionnaire 5 (Q5) - Judgment on decision quality after planning - was answered by the staff members in order to capture their perception on quality of critical decision and plan.

During the execution phase the battalion staff members answered questions on situation awareness on three occasions. The questionnaire (Q4) was administered in different versions on each occasion. The Q4 was also administered (with one hour delay) to three selected brigade staff members in order to check and rate the battalion staffs' situation awareness.

After the third phase the battalion staff answered another questionnaire (Q2) on quality of decision, completion of process, realism of scenarios and system failure. The observers answered the same questions except for one area in Observer protocol 3 (O3). Quality of decision was excluded from O3 and was instead answered by the brigade CO, S2, and S3 in a separate observer protocol (O5).

After the final phase of the second (test) run the participants finally answered a questionnaire on the MissionMate system (Q6). Q6 contained a more in detail evaluation of the MM but also included questions on idea sharing, quality of decision and completion of process.

Statistical Analyses

The numerical data were scored in two different ways. First, the numerical rating, given by the participants in the questionnaires and by the observers in the observer protocols, was used in the analyses, i.e., if the staff participant responded with a 2 this figure was used. The scale used to give all numerical ratings was a classical six-step Likert scale. In one of the questionnaires a Yes or No answer were used. This specific question was analyzed by a non-parametric chi-two test.

Second, in order to study the agreement among the staff members or observers or observers compared to staff participants a relative analysis perspective was conducted. If staff participant A responded with a 2 and participant B responded with a 5, the relative difference was 3. All participants rankings were compared with all the others participants rankings. Thus, participant A were compared to Participant B,C,D,E,F,G,H,J in the staff (all in all 8 participants in the staff). Second, Participant B was compared to all the others and so forth. Thus, the total degree of agreement was calculated by the total difference for each participant added together. The higher the value described the lower the degree of agreement within the staff.

Results

Manipulation check

Descriptive statistics for the four scenario realism variables (realism of the scenario, realistic amount of information provided, realistic amount of time provided for planning, and realistic level of uncertainty in the scenario) indicated that both participants and observers found the scenario to be satisfactory realistic in every important aspect (M between 3.7 – 4.2 on a six-step scale, SD between .77 - .87). Also, an analysis (2 x 4 split plot ANOVA) with four levels (4 questions) on realism and two groups (observers versus staff members) revealed no significant effects, indicating a high level of agreement between observers and participants. This indicates

that the manipulation worked. Concerning the other confounding variable "system failure" analysis revealed that observers and the staff agreed upon that system failure existed during the run. With regard to hardware, software or network issues, several technical hiccups occurred during both the training and experiment runs of the experiment. Network failures, resulting from network congestion, were encountered. The Joint Battlespace Systems (JBS) server was also down for a short period of time during the first run. In addition, software bugs and application errors were detected in MissionMate. A lag in the VoIP was also detected during the course of the experiment runs. However, these problems were resolved fairly quickly by the engineers upon detection, and the relevant systems were back up quickly for continued use with no major implications to the conduct of the experiment and thus should have no significant effect on the results.

Decision quality

This concept was measured in two aspects "quality of critical decisions and plan" and "team situation awareness". These aspects were measured by observer protocol (O5) and staff questionnaires (Q2, Q4 and Q5).

Quality of critical decision and plan. This aspect was divided in two areas. The first area concerned the quality of the final OpsO and the second area concerned the participants (subjective) perception of the quality of the plan. The items concerning tactical content, clarity, and completeness of the final OpsO were answered both by participants and subject matter experts (SME:s) from the bde. Participants rated the quality of the tactical content of the OpsO as M = 3.4, SD = 1.1 (on a six-step scale), and the SME:s rated it as M = 4.7, SD = 1.5. Participants rated the completeness of the OpsO as M = 3.6, SD = 1.0, and the SME:s rated it as M = 5.0, SD = 1.0. Participants rated the clarity of the OpsO as M = 3.9, SD = 1.1, and the SME:s rated it as M = 5.3, SD = .6. This suggests a slightly higher rating from the SME:s on all aspects of quality. A 2 x 3 split plot ANOVA was computed and it revealed a non-significant tendency that SME:s rated the quality of plan higher than the staff members ($F(1,1)=4.1$, $p=0.078$, $MSe=2.95$). These mean values indicate that SME:s were quite satisfied with the produced plan (mean= 5.0, on a 6 graded scale), but that the participants themselves rated the quality as in between high or low.

Analysis of the five items concerning the staff members' subjective perception of the quality of the plan indicates that the participants on average thought that the plan held reasonably to good quality (M between 4.0 – 4.7, SD between .5 – 1.1, overall M = 4.4). These questions were administered to the participants after the war gaming phase.

The overall conclusion concerning *quality of critical decision and plan* is that it was perceived to be relatively high in all respects studied. There was a tendency for a main effect of participant constellation, i.e., the SME tended to rate plan quality a little bit higher than the staff members.

Team situation awareness Initially, degree of team situational awareness was studied by a 2 x 2 split plot ANOVA. The first factor referred to number of times injects were ranked. The second factor refereed to staff members versus SME:s. The dependent measure was discrepancies. The ANOVA did not reveal significant effects except for an uninteresting effect of injects, i.e., inject 2 were more difficult to agree upon ($F(1,8)=9.5$, $p<0.05$, $MSe= 1.54$). Thus, the staff members agreed to the same extent as SME:s upon how threatening injects were for the mission.

The second analysis was interested in if SME:s and staff members had ranked the injects in the same way. The correlation between SME:s and staff members was strongly positive (r_x=.78). However, the positive correlation was not significant (due to a low n).

The third analysis was interested in how correct each staff member was. The 3 x 2 split plot ANOVA with the same variables were conducted again with SME:s ratings as the dependent measure. The ANOVA did not reveal any significant main or interaction effects. Thus, SME:s rated the answers relatively similar and the staff members received approximately the same values on both inject sessions during the executions. The mean value indicated a high level of shared situation awareness (M = 4.2, on a 6 graded scale).

The conclusion from this is that the empirical pattern suggests that the staff members had a mutual understanding (team situation awareness) of the threatening impact of the injects. Second, they were also consistent with how the SME: s interpreted the injects. Third, the SME also rated the comments for inject consequences (written by the staff members), relatively high.

Planning process

The data collected on the process by the 4 observers were qualitative data. The observers tracked the process and watched for unique and interesting developments in the process. The following are the key observations:

a) For both runs, the battalion staff did not follow the planning process to the letter. Given time pressure, the battalion staff took their initiative to work in parallel with the Brigade planning. Using MissionMate, the battalion was observed to have listened-in to the Brigade's preliminary planning stage where the commander's planning guidance was given. When the Battalion understood the broad directions of the Brigade, it went directly into its own preliminary planning, followed by mission analysis. After which, the staff went further to develop several component plans around key terrain objectives until the time when the orders were issued by the Brigade.

b) After the issue of orders, the Battalion revisited preliminary planning and the mission analysis phases briefly and went directly into the development of a single plan. The team updated the component plans developed earlier and completed key planning components that involved coordination with other Battalions. Although much of the planning was done before the issue of orders, the Battalion did not complete the planning task earlier. Instead, it used up the 4 hours of planning time allocated. When being queried on the reason, the Battalion acknowledged that the "additional time" was used to improve the plan, improve the presentation, and to "fight the system" (particularly during Run 1 when the Battalion was new to the system). In the overall, although the Battalion was able to complete the planning, they did not have the feeling that they have sufficient time for the planning.

c) Having achieved the headstart, the Battalion did not plug into the Brigade planning process very much after the Brigade preliminary planning stage. It spent most of the time working on its own plan. Only on a few occasions did the CO of the Battalion looked at the planning of the Brigade S2 through the TOP.

d). During the initial stages of the planning where there was room for brainstorming, the key contributors of ideas were from the CO, S2 and S3, who were the more senior members of the team. The CO, being the most experienced of the group, is the most articulate. Hardly any contribution of ideas came from the other staff such as S1, S4, Pioneer and FSO except when their area of specialization is concerned. These members are the junior members of the team and

appeared to lack the experience to contribute to generating operational ideas. This is despite the fact that the CO and the senior staff did not appear to be over dominating the discussion.

e). The ideas discussion focused on 'solving the problem', and very little were spent discussing about how to surprise the enemy. This could be due to a lack of time because the Battalion felt that it hardly have time to develop contingency plan.

f). The type of ideas generation by the team is also mainly of the convergent type. '*Completing the schema',* referring the systematic aggregation of available data and information to develop the idea, was the main method used. There was very little divergent thinking.

g). A COA was developed in a sequential way with several subsequent choices between identified smaller options within the frame of a "total" COA. The staff assembled around the map on the electronic knowledge wall, which is a smart board displaying the map, and started to discuss options how to proceed in a chronological way from the starting point to the final target was captured. First the discussion could be about different options to get from the starting point to a suitable river crossing point. When some options how to do this were explored the CO made a decision, and then the team continued to discuss how to get from the river crossing point to target A and so forth. In that way the process can be viewed like a decision tree.

h). From the survey of technology, the MissionMate system was found to be adequate in supporting the collaboration in planning. Many found that the main features for plan drafting is intuitive and this is attested by the fact that the Battalion was able complete the planning time within the 4 hours allocated time despite receiving only 1.5 days of MissionMate system and KBP process training. The participants were found to use of the TOP TeamSight most during the Detailed Planning phases, during Wargaming with the Bde, as well as during the Final-Co-ord and Execution phases. This is consistent, as one would expect most of the interactions to take place during these phases. Several members of the staff were also able to discuss with others using VOIP and TeamSight, or to just observe in the background what other staffs are doing. The CO, for example, was observed to have looked at the S2 working picture and initiated a discussion with him to correct some of his plans using TeamSight. The ability to share the situation awareness pervasively through TeamSight enables the staff to increase the amount of communication and collaborative work then previously possible. The author suspect that this is likely to have increased the plan quality and preparedness, although this was not manifested in the data collected. However, the participants did convey during the After Action Review a sense that they were able to work faster with each other.

Communication Patterns

Communication patterns of the staff collected during different phases of the process, and measured according to the categories of 'exchange of ideas'; 'dissemination of information'; 'building shared understanding'; 'team monitoring and self correction' helps give a profile of the process. The patterns were captured in real time for one hour periods over pre-determined time intervals. The time periods profiled were the Wargaming and Execution phases. To determine the level of agreement among the 4 raters across time, a statistical test (Kendall's W coefficient of concordance) was performed on each set of data. The inter-rater agreement was good at W = 0.761 on a scale of 0-1.00.

The wargaming stage is dominated by the activity of 'building shared understanding' at about 41% and 26% of 'dissemination of information'. The wargaming phase, while being a phase where the plan is tested against the Enemy Course of Action (ECA), was found to be used by the commander more to get his staff or subordinates to understand his intent. The execution

stage has an 30% of communication dealing with 'dissemination of information', 36% on 'building shared understanding' and 21% on 'clarification'. These are principle activities dealing with co-ordination, a key activity during execution.

Of note is the significantly smaller amount of communications dealing with the 'exchange of ideas' and 'team monitoring and self correction'. The proportion of communication in the exchange of ideas are at 4% and 5% respectively for the Wargaming and the Execution Stage and the proportion of communication for 'team monitoring and self correction' is at 2% and 3% respectively for the same stages. This further confirms the observation that very limited amount of idea creation occurs during the process. This is likely to be due to the shortage of time and the limited options space for Battalion operations. Shortage of time is likely to be the cause of the small proportion of team monitoring and self-correction because the staff needs to focus on getting the plan done. Another likely reason is the relative immaturity of the team.

A reflection made by all SME observers was that the voice communications dropped significantly in the second run as compared to the training run and also compared to normal level of communications of a battalion staff. During the training run, much of the activities were co-ordinated by frequent voice communication between the participants. In the planning phase of the second run, however, the participants were observed to be working in their respective areas, and communicated infrequently via voice or using VC/VoIP, or until the CO calls for a group meeting. It was the same during the execution phase, where the level of noise activity was significantly lower as compared to the training run and to normal execution. Voice exchanges revolved largely around a participant telling his colleague to either 'look at such-and-such an overlay for new updates', or for the CO or S3 to broadcast critical updates that have just taken place in the Area of Operations. Coupled with the fact that the participants generally scored well in their Situational Awareness tests, it can be inferred that the participants were able, with the help of the MissionMate tools, to maintain a high level of situation awareness of the battlefield situation.

Planning and decision making tempo

The decision tempo was tracked by 4 military observers. The details of the consolidated timings are shown in Table 1 of Annex A. As highlighted earlier, the Battalion did not follow the process precisely. Part of Battalion level Mission Analysis (Step 4) and Develop a Plan (Step 5) were conducted on the first day in parallel with Brigade planning. Therefore, the Battalion was able to arrive at a concept course of action about 215 mins from the start of the planning, rather than 690 mins as prescribed by the process. However, the Battalion took more time, because they had more time, to arrive at a finalized plan. This is accomplished this in 875 mins compared with 750 mins as prescribed by the process, a difference of 125 mins (about 2 hours)! Although the Battalion made a good headstart on the first day, they continued to use all the time allocated to them to complete the planning. Therefore, from the point of time the Bridage Orders were issued (Step 3), to the Finalization of Plan (Step 5), the Bde took the allotted 240 mins (4 hours) The extra time was used to improve the plan, prepare for the presentation and also to become familiar with the new system.

Based on the process profiling, the Battalion is found to have used more time in during the planning and the wargaming stages. The Battalion used 69 mins (about an hour) more for the planning phase (Step 4), 24 mins more for the Battalion internal wargaming, and 45 mins more

for the Battalion and Brigade Wargaming. These are key stages for refining the plan and achieving shared understanding between the staff and with the superiors.

Team creativity

Team creativity was measured by eight items administered to staff members as well as observers (Q1 and O2) once during the planning phase, once after war gaming, and once after execution. Initially were all measures analyzed separately by a 2 x 3 ANOVA.

Concerning the frequency of the number of ideas shared within the staff compared to normal (in this type of task), no significant effects were obtained. The mean values (M = 4.0 on a 6 graded scale) indicate that the staff believed that they produced a normal amount of ideas. Concerning if the produced number of ideas was perceived as satisfactory or not, no significant effects were obtained. The mean values (M between 4.1 – 4.3, SD between .56 - .71) indicate that the staff believed that they produced a satisfactory number of ideas.

Concerning if the degree of openness within the staff was perceived as satisfactory or not, no significant effects were obtained in the 2 x 3 ANOVA. The mean values (M between 4.0 – 4.2, SD between .6 - .9) indicate that the staff believed that openness was satisfactory. Concerning if this level of openness should be considered as normal for a staff in this type of task, no significant effects were obtained. However, a close to significant effect of observers versus staff members was obtained ($F(1,31)=4.1$, $p=0.052$, $MSe=0.56$). Thus, observers perceived this level of openness as being slightly less normal than the staff members did. The mean value for the observers was 3.8, SD = .7 and for the participants it was 4.4, SD = .7, indicating a normal level of openness.

In order to understand how level of openness was experienced within in this task in comparison to this staffs normal level of openness another question was asked only directed to the staff. “How was degree of openness in this staff compared to this staff’s normal degree of openness?” The ANOVA revealed that participants experienced a normal degree of openness (M = 4.2, SD = .7) during all phases of the excise.

The overall conclusions of these creativity results are first, both observers and staff members were overall relatively satisfied with idea generation and openness. It was perceived as being on a fairly normal level (although a little bit lower for observers than for staff members).

Discussion

The purpose of TCX 1 was to explore the effects of the Team Insight Model (TIM) on a realistic battle planning and execution task. TIM is a modern battle procedure, based on recent research findings from relevant areas, and aided and integrated with a modern computerized collaborative tool. The use of the Team Insight Model (TIM) was expected to result in some improvements (presented in the introduction) compared to traditional ways of conducting C2 processes. Next we will discuss those expectations one by one in the light of the findings of this study. One major difficulty is of course that TCX 1 was not designed to be a comparison between two models. The evaluation of the expectations must therefore be based on logic and previous experience from planning and execution according to traditional models. The first expectation was that the overall planning tempo through the whole chain of command would go up as a result of the increased ability to plan in parallel and of the default prescription in the planning model only to develop one own COA in couple with some other simplifications. This expectation was only partly

supported by the results of this study, and because only one level in the command chain participated fully in the study it is difficult to say anything about total time gains. However there are some important findings that should be discussed. Although the battalion used all of its four hours of planning time, they were able to identify their preferred COA very early in the process compared to a traditional process. And moreover, no participant expressed a need to develop more than one COA to compare with. However, the time saved early in the process was then used to detail and refine the plan instead of releasing it to subordinates earlier. Maybe the explanation is that four hours is very short time to produce a high quality plan and the battalion felt it to be better to invest effort in the plan quality than to release the plan earlier. However, the ability of early identification of a COA should be available at all hierarchical levels of the command chain using the TIM and if there is a strong need for speed then it should be possible to gain a considerable amount of time without loosing anything in plan quality compared to a traditional process. This is of course due to the fact that a COA can be identified earlier in the process when the TIM is used.

The second expectation was that use of the TIM should result in higher overall plan and execution quality. This expectation is based on increased situation awareness through the use of MissionMate, where all members of the planning staff can have the same view or look at each others view. The expectation of higher plan and execution quality is also based on the ability to listen in to the planning process of a higher (or a lower) echelon, and thereby better understand the will of the higher commander. Given more channels to discuss and share info through MissionMate, better insights and more creative solutions in the plan are expected to be generated. This expectation is also partly supported by the results. The quality of the produced plan was considered to be comparably high even though many staff members were junior and inexperienced. The level of shared situation awareness and the insights shown considering the importance of different injects during the execution indicates that TIM was indeed helpful in creating shared situation awareness and this perception is also enhanced by the low need for clarification showed during the execution phase, where the level of verbal communication between the staff members were strikingly low.

The Bn staff members often took the advantage to listen in to the brigade staff and there were quite a lot of communication between the two staffs during the actual planning process. It is however possible to attribute the high level of shared situation awareness showed in the measurements to a strong will from the participants to comply with the demands of the exercise, that is, to do well on the measurements. It is also a risk that the quality ratings were somewhat influenced by the fact that the SME:s were superiors' to the Bn staff members. Also, there was no sense among observers or participants that the level of idea generation or idea sharing was elevated compared to normal. Maybe it is to expect too much? Idea generation is probably more related to experience and other personality and cultural factors than it is to the existence of some tools and models. The training did not specifically highlight the need for divergent thinking. Maybe the results would have been different if this had been done? There is however no doubt that the features of MM and TS together with the KBP working procedure makes it possible for a staff to maintain a high level of shared situation awareness.

Third, there is an expectation that the TIM should be regarded as a good model for battle planning and execution under realistic battlefield conditions. This expectation is based on the KBP being a naturalistic process better adapted to the way commanders naturally like to deal with real battlefield decision problems. This expectation was at least partly supported by the results. When the participants were asked about the advantages and disadvantages of the KBP

almost only advantages were mentioned. And when asked about the significance of the KBP the participants mentioned many of the intended advantages such as increased planning tempo, more time to work out Ops and Support plans and more collaboration among the planners. When queried if they were prepared to exchange the traditional SAF BP with the KBP the participants expressed some caution and wanted more evaluation of the KBP before they felt ready to make that decision. The only important suggestion to improve the KBP was to make a change so that finalization of support plans comes before wargaming and not after as it is now.

Concerning the MM and the TS tools it was surprising to watch how quickly the staff members reached a proficiency level were they could produce a high quality OpsO within the time frame of four hours after only using the system 1.5 + 1.5 days. This indicates that these tools are indeed user friendly.

How valid are these results? TCX 1 is based on a real battalion staff, interacting with a real brigade staff, solving a traditional task in a realistic scenario with a realistic amount of information and uncertainty. Some participants were of low experience but key members, especially the battalion CO were of normal or high experience. The battalion staff was newly organized and not so used to working together. This is probably quite "normal" except for the low amount of training and systems familiarity. Furthermore, most of the findings were in line with expectations and the results should therefore be able to generalize to other army battalion staffs. It should be likely that more training on the TIM should result in further improvement on decision speed and maybe also on decision and execution quality. The claim is that the results suggest that TIM should have some advantages, as discussed above, compared to traditional C2 methods. Such a claim should be valid given the present results! However more research on the TIM is warranted. First it would be interesting to perform an actual comparison between a command chain using the TIM and a command chain using a traditional C2 model. Such a comparison need to involve at least three levels of command in order to fully exploit the possible time gains in the TIM. Second it would be interesting to further exploit if and how TIM enhances team creativity, and also the connection between shared situation awareness in a C2 team and execution quality. Next TCX is planned to take place in Sweden this fall, and maybe that exercise can be reported at CCRTS 2006.

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Appendix I

BDE AND BATTALION KBP AND PROCESS TIME PROFILE

Table 1: Knowledge Battle Procedure

S/n	Outputs	Description	Who develops this?	Est Duration	MM Augmentation
1	**Warning Order**				
2	**Preliminary Planning**				
2.1	Time Schedule for the Planning Process to the point of order release to direct sub-ordinates	Represented by a time-table.	Battalion S3	-	Use of the Time Chart. Use of the InfoHub to publish table of events and necessary agenda.
2.2	Brigade Prelim Planning (this is Step 1 to 3 of the original Brigade BP)	Understand the various factors identified for Terrain Study and how it would affect HHQ mission and goals List the conclusions from Terrain Study. This stage is a truncated process in the experiment.	Bde and Battalion S2	-	KBP Battalion use Team-Sight for working together with the Bde HQ during Bde HQ study of Terrain. Be able to interact with the Bde HQ during conclusions of Terrain Study. Use of VOIP/Video Conferencing and Chat tools for collaboration
2.4	**Mission Analysis (BDE)**			**1.5 hr**	
2.4.1	Understand the Mission	HHQ Goal States HHQ Success Conditions and Contingencies	S2, S3		
2.4.2	Effects of Terrain	To recap and refine the template for EOT for enemy and own forces.	S2 to develop EOT (enemy). S3 to develop EOT (own). FSO to develop EOT (FS).		Use separate Views to draw EOT (Overlays) for Battalion. Battalion to know Bde EOT
2.4.3	Other Factors	Specialists to provide other factors that may influence or limit the mission.	RCP(S2) Adj Unit (S3) FSCM(FSCC) Re-supply (S4) etc		
2.4.4	Issue of CPG	Issue EEI and OIR Issue Various Concept of Operations to meet Bde Goal State. Issue Required Actions and Information to accomplish Bde Mission (possible Success Conditions) Identify Critical Problems that may affect the mission Select 1 Concept of Ops Conduct Pre-Mortem	Comd		List needs for immediate action
2.5	**Develop a Plan**			**4.5 hr**	
2.5.1 2.5.2	Develop ECA Develop Ops Plan and Support Plans	To develop ECAs. This includes enemy concept, enemy deployment, enemy	Battalion listen to Bde selection.	1.5 hr	KBP Battalion use Team-Sight to view the Bde COP discussion. Battalion will be able to know Bde

		reinforcement and conduct of battle. To develop one course of action at Bde level from the EOT. This includes rough concept of ops, own forces units allocation, route of approach (offence), end-state of COA. Bde to develop Success factors. Once Goal State selected, send out Warning Order No. 2. to sub-ordinates.			purpose of the goal state. Preliminary Intelligence Support Plan – EEI and OIR Bn EOT
2.5.3	Wargaming	Conduct Bde level Action-Reaction. This includes support plans. Wargaming procedure sequence is as follows: S3, FSCOORD, BEO, S4 and OC Sig, then S2 react, alternate to S3, FSCOORD, BEO, S4 and OC Sig react. Bde to also conduct Contingency Plans Subsequent actions by other support plans may follow if significant to highlight.	Everyone. KBP Battalion CP listens in and discuss with Bde during Wargaming.	1.5 hr	Bde uses Time-Slider and Ecology Space to conduct Wargaming. KBP Battalion use Team-Sight to view the Bde COP discussion. Battalion will be able to know Bde purpose for the goal state, as well as how the wargaming outcome is. Improve EEI and OIR for Bn AO
2.5.4	Finalisation of Plan	Finalise all the necessary Plans to achieve the desired Goal State. Bde to finalise success factors and Contingency Planning Bde sends out Warning Order No. 3. to sub-ordinates when completed.	Everyone. KBP Battalion can start planning ahead.	1.5 hr	KBP Battalion use Team-Sight to further understand whole Bde plan, their Pre-Mortem state and what it means to them in their specified tasks. KBP Battalion list Specified and Implied Tasks
2.6	**Bde Wargaming with Div**			**1 hr**	
2.7	**Compilation of Orders**			**0.5 hr**	System design to compile Orders automatically from Planning modules thus saving time
3.0	**Bde Issues Orders to Sub-Ordinates CP**	Issues Full Orders to Non-KBP Battalion. Issue Guidance to KBP-Battalion and seek Clarification from KBP Battalion.	Everyone	**0.5 hr**	For KBP-Battalion, issue of guidance and seeking clarification will be through Team-Sight.
4.	**Mission Analysis**			**1 hr**	
4.1	Understand the Mission	HHQ Goal States - Comd Intent, Specified Task and Implied Tasks HHQ Success Conditions and Contingency Plans	S2, S3		KBP Battalion will proceed according to current Battalion Battle Procedure (Aim and Limitation listed out) but list out success criteria from Bde, as well as highlight Pre-Mortem results from Bde in charts.

4.2	Effects of Terrain	To recap and refine the template for EOT for enemy and own forces.	S2 to develop EOT (enemy). S3 to develop EOT (own). FSO to develop EOT (FS).		Use separate Views to draw EOT (Overlays).
4.3	Other Factors	Specialists to provide other factors that may influence or limit the mission.	RCP(S2) Adj Unit (S3) FSCM(FSCC) Re-supply (S4) Etc		
4.4	Issue of CPG	Issue EEI and OIR Issue Various Concept of Operations to meet Battalion Mission and Bde Goal State. Issue Required Actions and Information to accomplish Battalion Mission (Success conditions or Principal Considerations) Identify Critical Problems that may affect the mission Select 1 Concept of Ops Conduct Pre-Mortem (feasibility test)	Comd		KBP Battalion at CPG stage to draw out Bde Goal State affecting Battalion Area of Operations (overlay). KBP Battalion discussed 1 Concept to develop.
5.	**Develop a Plan**			**1.5 hr**	
5.1 5.2	Develop ECA Develop Ops Plan and Support Plans	To develop ECAs. This includes enemy concept, enemy deployment, enemy reinforcement and conduct of battle. To develop the Ops Plan (including Support Plans) at Bn level from the EOT and ECA. This includes rough concept of ops, own forces units allocation, route of approach (offence), end-state of Ops Plan. Bn must also specify desired success conditions.	Everyone	0.5 hr	KBP Battalion use Team-Sight for discussion. Battalion will develop ECAs based on Bde ECAs. Battalion develops their Goal State. Goal state includes success factors and the Ops Plan. It covers Comd Intent, Concept of Ops, Phases and Timings, Success Conditions, Support Plans.
5.3	Wargaming	Conduct Bn level Action-Reaction. This includes support plans. Wargaming procedure sequence is as follows: S3, FSO, Pioneer PC, S4 and BSO, then S2 react, alternate to S3, FSO, Pioneer PC, S4 and BSO react. Developed Reacted ECA and updated Ops Plan Bn to conduct Contingency Planning Subsequent actions by other support plans may follow if	Everyone. Bde CP listens in and discuss with KBP Battalion during Wargaming.	0.5 hr	KBP Battalion uses Time-Slider and Ecology Space to conduct Wargaming. Bde CP listens in to KBP Battalion Wargaming. Bde CP can interact with KBP Battalion if required, as Bde CP is concurrently planning contingencies. Requests for additional support/fires/resources are also ideal at this stage.

		significant to highlight. Prepare Request to HHQ			
5.4	Finalisation of Plan	Finalise all the necessary Plans to achieve the desired Goal State (Comd Intent, Ops Plan, Success Conditions, Critical Events) Bn finalise Contingency Plans Bn sends out Warning Order No. 2. to sub-ordinates when completed.	Everyone.	0.5 hr	Bde listens in to KBP Battalion through Team-Sight. Bde also understands Bn Contingencies. Battalion goes through the Critical Event Chart during Finalisation of Plan and make available on MM. Bde abstract relevant Critical Event List from KBP Battalion.
6.	**Bn Wargaming with Bde**	Present HHQ Intent Present Bn ECAs Present Principal Considerations Present Goal State, success conditions Present Concept of Ops Present Contingency Plans Present Requests Wargaming results in updated documents and plans	Comd	**0.5 hr**	KBP Battalion presents simple brief-back on Goal State, Success Criteria, Concept of Ops and Support Plans using Team-Sight. Bde who has listened in on the KBP Battalion clarifies any issues affecting their mission by switching to KBP Battalion COP. In addition, KBP Battalion wargame Ops Plan with Bde to synchronise with their broader plan, especially for Bde to overview the adjacent units actions. During this action, both Bde and Bn may adjust their plans if necessary for synchronization, since the Bde would have done some contingency planning and further develop their critical event tables.
7.	**Compilation of Orders**		Bn HQ	**0.5 hr**	
8.	**Bn Orders to Coy**	Issue Operational Orders and Issue Orders to the Coy	Bn HQ	**0.5 hr**	
9.	**Bn Wargame with Coy**				
10.	**Final Co-ord**	Bde conducts Final Co-ord.	Everyone	-	Bde finalises critical event list and other information and conveyed to the Cdrs.
11.	**Execution**				

Table 2: KBP Process Profile Captured using Observer Protocol 4

KBP Steps	Event	Allocated Time	Day	Start	End	Duration (mins)	Deviation (mins)	Remarks
Step 1	**Warning Order**	**30**		1112	1157	**45**	**+15**	
Step 2	**Preliminary Planning**		Day 1					
Step 2.1	**Time Schedule**		Day 1					
Step 2.2	**Bde Prelim Planning**	**60**	Day 1	1212	1225	**13**	**- 47**	
	Lunch Break			1225	1350		85	
Step 2.4	**Bde Mission Analysis**	**90**	Day 1	1350	1445	**55**	**-35**	
Step 2.5	**Bde Develop a plan**	**270**	Day 1	1445	2030	**247**	**- 23**	
Step 2.6	**Bde Wargaming with Division**	**60**	Day 1	0	0			
Step 2.7	**Compilation of orders**	**30**	Day 1	0	0			
	Break for next day							
Step 3	**Bde Issue Orders to Sub Ordinates CP**	**30**	**Day 2**	0850	0956	**66**	**+36**	
Step 4	**Bn Mission Analysis**	**60**	Day 1	1424	1520	56	**- 4**	
Step 5	**Bn Develop a Plan**	**90**	*Day 1*	1525	1600	**159**	**+69**	Bn made decision on concept course of action (215 mins from start cf 690 mins according to process)
Step 5	**Bn Develop a Plan**		Day 2	0956	1200			
Step 5.1	**Develop ECA**	30	Day 1	1525	1600	35	+75	
Step 5.2	**Develop Ops Plan and Support Plans**		Day 2	0956	1106	70		
Step 5.3	**Bn Wargaming**	30	Day 2	1106	1200	54	+24	
Step 5.4	**Finalization of Plan**	30		0	0		-30	
Step 6	**Bn Wargaming with Bde**	**30**	Day 2	1420	1535	75	**+45**	Plan finalized (took 875 mins cf with 750 mins according to process. i.e. 125 mins more)
Step 7	**Compilation of orders**	**30**	Not played					
Step 8	**Bn Orders to Coy**	**30**						
Step 9	**Bn Wargame with Coy**	30						
Step 10	**Final Co-ord**	30						
Step 11	**Execution**	-	Day 2	1650	2100	250		