2006 CCRTS
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Towards realising Parallelism for Echelons of Command

Topic: Command & Control, Experimentation

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Towards realising Parallelism for Echelons of Command

ABSTRACT

The concept of Parallelism is to be able to achieve concurrent planning across echelons of command for a single military operation, thus compressing the planning cycle to create additional time resource, which is becoming increasingly precious in today's fast-changing battlefield. The command teams at the various echelons are able to plan collaboratively and in parallel via TeamSight – a virtual collaborative environment, despite being physically separated. This concept was fielded in an experiment conducted from 27 Sept – 6 Oct 2005.

In evaluating the feasibility of Parallelism, several aspects were considered: operational tempo, parallel planning process and output, and achieving common ground. The findings from this exploratory study suggest that Parallelism supported by TeamSight is indeed a viable concept, notwithstanding further refinements to the process and technology.

Key words: Parallelism, parallel planning, Team Insight Model, Team Collaborative Model, Collaboration, TeamSight

INTRODUCTION

The merits of parallel and collaborative planning across echelons of command have long been recognized by many armed forces. The ability of command teams at various echelons to plan for a single operation concurrently will invariably compress the planning cycle, thus creating the increasingly precious resource of time. The creation of more time could, at the commander's discretion, be used to implement any of the winning strategies described by Boyd (1987) – variety, rapidity, harmony, and initiative, all of which are linked to the notion of competition in time. These strategies are effective because they enable the war-fighter to get inside the adversary's Observe-Orient-Decide-Act (OODA) Loop such that they can neither appreciate nor cope with what is really going on.

This paper describes an experiment designed to explore how the network-enabled Integrated Knowledge-based Command and Control (IKC2) environment of the Singapore Armed Forces (SAF) could be leveraged to achieve Parallelism across echelons in planning for a single military operation, thus creating more time resource for our war-fighters.

BACKGROUND

Parallel Planning

Parallel planning may be defined as follows (US Army, 2005):

> Parallel Planning: *Parallel planning is two or more echelons planning for the same operation nearly simultaneously. It is facilitated by continuous information sharing by the higher headquarters with subordinate units concerning future operations. Parallel planning requires significant interaction between echelons. With parallel planning, subordinate units do not wait for their higher headquarters to publish an operations order to begin their own planning and orders development process.*

Despite the well-articulated vision of parallel planning, it has only been implemented to a relatively modest extent in current doctrine. The SAF as well as the US Army prescribe the issuance of warning orders in order to allow subordinate units to start planning and preparing for their operations in parallel before they receive the operations order. However, this only facilitates parallel planning to a limited extent; warning orders guide subordinate units in their conduct of preliminary planning, but the bulk of deliberate planning still occurs after the Higher Headquarters (HHQ) have issued the final operations orders. Figure 1 illustrates the staggered times at which the final orders are issued by the various echelons of command, and bears testament to the largely sequential nature of current planning norms. The proportion of time allocated for planning at each echelon is generalised in Figure 1 as the norm varies across armed forces; the time allocated for planning at the Division level generally falls between an accepted range of one-third to one-half of the total time to execution.

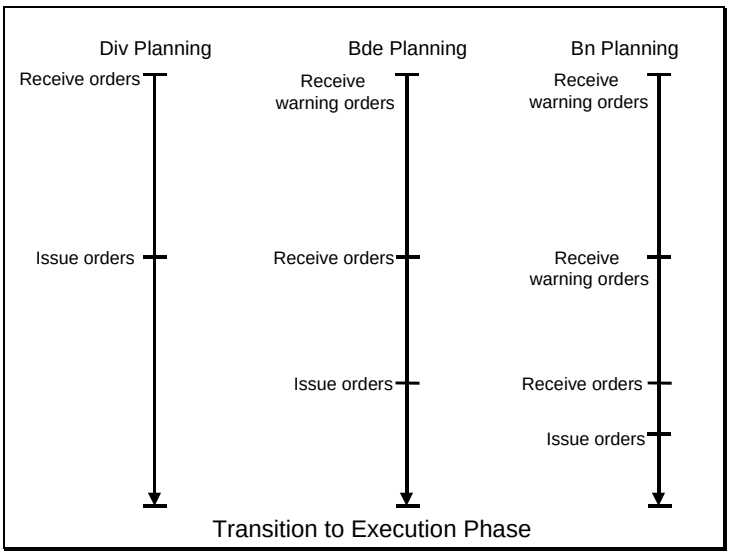


Figure 1. Sequential planning norm in current doctrine.

The concept of Parallelism is an effort to move away from the traditional tenets of what constitutes a hierarchical command structure, of which the major ones are described below.

Physical Co-location for Collaboration. It has long been accepted that individuals need to be physically co-located in order to facilitate collaboration. Currently, the primary means to support the complex and interactive nature of discussions is face-to-face

communication within a physically co-located team. Hence, current planning norms do not call for extensive collaboration between command teams at various echelons since they are located physically apart in order to exert their command presence and discharge their specific command and control responsibilities. However, with modern technology offering greater bandwidths for communication and data throughput, it is possible for individuals separated in space to communicate and collaborate via these tools as if they were physically co-located. The concept of Command Post Anywhere was successfully demonstrated in a field experiment conducted by the SAF Centre for Military Experimentation in October 2004 (Cheah et al, 2005a). In that experiment, an Armoured Brigade command post was able to plan and conduct their operations with no loss in sensemaking ability despite being separated over a distance of 10km, demonstrating that given the right technology, physical co-location no longer becomes a prerequisite for collaboration.

Integrity of Command Team at each Echelon. A conventional command structure is organized hierarchically in order to handle the high complexity of war-fighting by delegation of responsibility to sub-commands – the principle of divide and conquer. This need for delegation is a function of the complexity of the problem space. It is manifested in well-defined roles and responsibilities of the command teams at each echelon, with little cross-pollination of insights and ideas between horizontal domains or vertical command structures. With the advent of networked planning tools that facilitate collaboration between command teams despite them being physically separated, it is timely to explore a more flexible organizational structure that spans across echelons to leverage on the expertise and experiences of individuals to augment HHQ in addressing specific challenges, without detracting from their primary responsibilities.

Sequential Planning. In addition, it is assumed that hierarchical command teams have to work in sequence, that is, higher commands cascade plans down to ensure higher-order intent is met by subordinate units. A process strings together the decision products of these hierarchical command teams. Hence, the operations order developed by a Brigade is handed to the Battalion HQ, which in turn will develop their sub-level intent and plans and so on. However, this process leads to losses in the transfer of command intent during the delivery and receipt of orders, which usually takes place in a short amount of time. While some parallelism is attempted today in order to facilitate early understanding of and alignment to commander's intent, the planning process is still by and large sequential to ensure that coordination points are properly dealt with. This could be a result of current technology not being able to support the high degree of coordination and communication that needs to occur between command teams in order to truly achieve parallel planning.

The concept of Parallelism does not seek to abolish the command hierarchy; instead, it aims to challenge these old paradigms structured by limitations in technology that have long influenced the interaction between echelons of command. With the dawn of network-enabled warfare and the availability of advanced information systems such as TeamSight within the SAF, we are now poised to push the boundaries of parallel and collaborative planning across echelons in order to compress the planning cycle.

TEAMSIGHT

The TeamSight environment comprises the Team Operational Picture (PowerMap), a collaborative information archival tool (PowerMind), and communication tools like video-conferencing and text-chat (PowerVC), which all work together to facilitate the co-ordination and collaboration amongst team members whether physically co-located or distributed, allowing them to draw on the relevant system-level knowledge and expand their individual awareness to support the activities that they perform.

PowerMap is a Geographic Information System (GIS)-based collaborative tool that allows each individual to maintain a workspace for his own situational constructs and also view his team-mates' workspaces to understand and collaborate on their situational constructs. Each user is thus able to monitor the planning products of his counterparts in the command team as well as the current status of maneuver units. Having multiple workspaces available for viewing by any user of the system is also in line with "the established wisdom that commanders and planners must visualize the battle two echelons down and understand it from the perspective of the commander two echelons higher" (de Czege & Biever, 2001) as well as that of adjacent organizations.

PowerMind is a collaborative information archival tool that allows the capture of a snapshot during planning and subsequent annotation by various members of the command team to document the rationale or assumptions behind the plans. One advantage of PowerMind is that it reduces the need to explicitly present and disseminate information during scheduled meetings, as each user is able to pull information from the system even before the conference. Such an environment also allows the command team to quickly fuse their individual pieces of information to generate second-order inference or to obtain a common value for existing information, thus giving rise to "collaboratively generated information" based on information elements either actively shared via PowerVC (text-chat or video conferencing), or simply placed on the network for retrieval when necessary (Kingston & Martell, 2004).

Figure 2 shows the various components of TeamSight which work together to provide command teams at various echelons with the opportunity for continuous information sharing and significant interaction in order to truly achieve Parallelism.

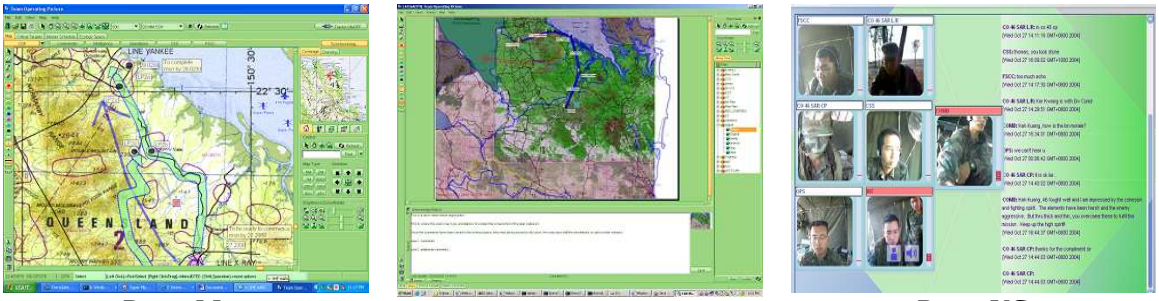


Figure 2. TeamSight comprising PowerMap, PowerMind, and PowerVC.

TWO MODELS OF PARALLELISM

There are two models of parallel planning that the SAF Centre for Military Experimentation (SCME) has developed. These two complementary experimental models are each based on the TeamSight concept as well as the Knowledge Battle Procedure (KBP).

Team Insight Model

The Team Insight Model (TIM) prescribes an implementation of the concept of Parallelism given TeamSight. TIM was jointly developed by the Singapore and Sweden Armed Forces; it was developed as a theoretical model based on Thunholm's Planning Under Time Pressure (PUT) model (2003) and incorporates SCME's research into generating team insights within a command team based on techniques that stem from Finke's (1995) dichotomous classification of convergent versus divergent ideation. The TIM-inspired Knowledge Battle Procedure (KBP) was successfully demonstrated at the Brigade-Battalion level during a joint SAF-SwAF experiment conducted in Singapore in March 2005 (Cheah et al, 2005b).

Figure 3 shows a diagrammatic representation of the TIM model of parallel planning across echelons. In TIM, although the subordinate units are privy to the HHQ planning process via TeamSight, there is no formal participation across echelons. It is believed that the insights into the HHQ planning process will provide the subordinate units with sufficient information for them to start their planning process even before orders are formally issued, thus allowing them to complete planning in a shorter amount of time.

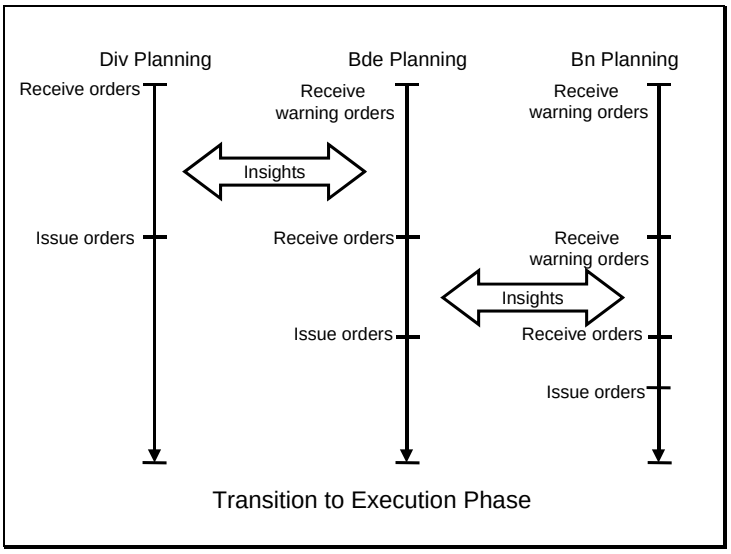


Figure 3. TIM model of Parallelism across echelons of command.

Team Collaborative Model

The Team Collaborative Model (TCM) is an extension of the TIM and considers the interaction between various echelons of command, and how best to harness the

multiplicative effect of having a command team augmented with its subordinate units in order to conduct parallel planning for a single operation such that the lower echelon may complete planning at about the same time as the higher echelon. The motivation for doing so is to compress the overall planning cycle in order to create for our forces a competitive advantage in the time dimension, as well as to facilitate a richness of ideas shared between the echelons. Another advantage of the TCM model over TIM is that it does not require the lower echelon command team to be working over a long period, first gaining insights into the higher echelon planning process and subsequently developing their plans. Instead, the command teams at both echelons work concurrently in analyzing their mission and developing their products such that it is not as drawn out a process and taxing on the lower echelon command teams which may not be structured to work in shifts.

TCM-KBP was developed because it was found that the Division (Div) and Brigade (Bde) levels had some common ground in terms of planning. However, TCM-KBP could potentially also be extended to the higher and lower echelons of command. Figure 4 shows a diagrammatic representation of parallel and collaborative planning between a Div HQ and its subordinate Bdes such that they complete their plans at the same time.

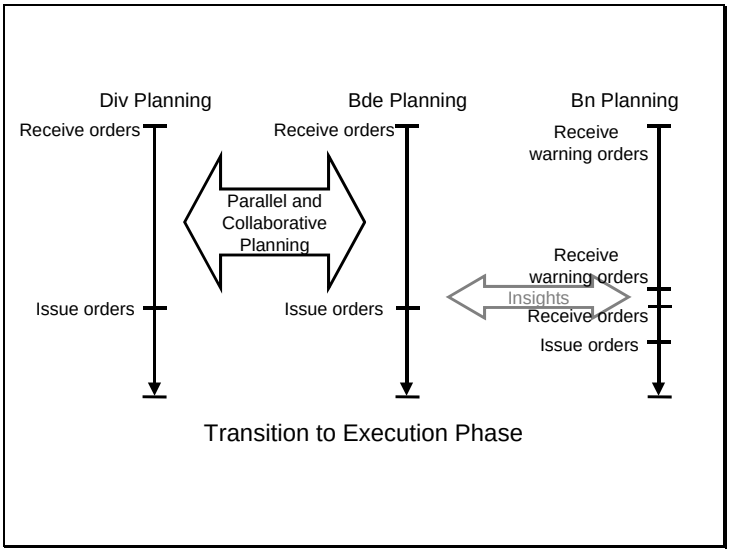


Figure 4. TCM model of Parallelism between Division and Brigade levels.

The TCM model brings with it the possible advantage that a greater degree of alignment of command intent (explicit and implicit) between echelons would arise as a result of the collaborative parallel planning process instead of through the issue of operation orders from HHQ to Lower HQ (LHQ). The underlying assumption is that there is some transfer loss during the short verbal exchange of operations orders and clarification between echelons that could perhaps be mitigated through the collaborative parallel planning process. This experiment sets out to explore if subordinate units do indeed achieve a better understanding of command intent given TCM, and if they are able to develop plans in the absence of firm operations orders from HHQ.

Pigeau and McCann (2000) put forth a model of command intent as comprising an explicit intent along with all its associated connotations latent within the explicit aim. The explicit directive is but the visible apex of the intent hierarchy, built upon a large set of personal, military, and cultural expectations which largely remain uncommunicated, partly for reasons of expediency. Alignment of implicit intent between echelons is just as critical as achieving good understanding of explicit intent, as it not only influences the interpretation of explicit command intent in pervasive and subtle ways, but also serves as a fallback to guide subordinate units' actions should plans fail.

Pigeau and McCann also describe the mechanisms by which implicit and explicit intent may be shared between two individuals: 1) externalization (an individual making explicit his own implicit intent); 2) dialogue (communication of explicit intent between two individuals); 3) internalization (an individual making implicit someone else's explicit intent); 4) socialization (an individual's implicit intent shaping someone else's implicit intent). The challenge in implementing the concept of Parallelism is to trigger increased externalization of implicit intent, as well as to create opportunities for extended dialogue between echelons to share explicit intent such that a common understanding is achieved through the planning process. TCM-KBP identifies the critical junctures of Mission Analysis and Wargaming as periods with an expected high volume of collaborative activity, during which interventions will be introduced to incorporate these mechanisms of achieving common ground.

In essence, TCM-KBP aims to help us break mindsets that were structured by limitations in current technology and archaic ideas. It is the model of a network of command teams, centered on the idea of Parallelism whereby the multiple echelons truly plan in parallel and in collaboration. TCM-KBP is effectively supported by the TeamSight environment, which allows concurrent planning at the different echelons by facilitating the vertical and lateral exchange of data, insights and ideas, such that commanders would not be fixated on one particular mental model.

THE EXPERIMENT

The TIM and TCM models were tested in conjunction with a Division and Brigade level Command Post exercise conducted with SAF officers from the Singapore Command and Staff College (SCSC) from 27 Sept – 6 Oct, 2005.

Participants

The participants were SAF officers who had just completed a course to prepare them for command positions. A total of 128 participants were divided into two groups, with each group participating in one experimental run. Within each group, the participants were assigned to staff the key roles within a Division HQ (23 participants), two subordinate Brigades (each with 11 participants), and a Naval Task Group (3 participants). The rest of the participants were assigned the role of observers. The participants' mean age was 34.9 years (min = 30, max = 39, SD = 1.7). The participants on average reported 14.7 years in

service (min = 10, max = 20, SD = 2.0), but only 34 reported an average of 3.8 years of experience in Division or Brigade level planning (min = 1, max = 10, SD = 2.5).

The bearing of this group of participants on the experiment is that they are less entrenched in current SAF planning doctrine, thus possibly more open to new ideas regarding the TIM or TCM model of parallel planning. However, that the participants were role-playing the various appointments for the purpose of the experiment and the fact that only 34 of them reported some experience with planning at the Division and Brigade levels indicate that there will be some artificiality in the experiment setup. A conscious effort was made to mitigate as much artificiality as possible by assigning roles to participants that closely match their vocation and level of experience.

Design

This experiment was designed to explore the effects of TCM-KBP in comparison with TIM-KBP with regard to operational tempo, the parallel planning process and output, and achieving common ground. Specifically, the hypotheses are as follows:

(a) TCM-KBP augmented with TeamSight would facilitate parallelism across echelons, thereby compressing the planning cycle and increasing operational tempo.

(b) TCM-KBP augmented with TeamSight would result in a greater amount of collaborative communication in the form of idea exchange.

(c) TCM-KBP compared with TIM-KBP would result in no loss in plan quality.

(d) TCM-KBP compared with TIM-KBP would result in a greater level of shared mental models.

The measurements taken on these main dependent variables are described in detail in the section on measures. Some background and confounding variables were also included in the design, and the measurements taken on these are also described in the section on measures.

The study design included a formal training session on the TeamSight tools and scenario training on the new KBP (TIM or TCM) followed by the experimental run proper over a period of four days for each group of participants. This design allows comparison between TIM and TCM but does not include any formal comparison between TIM/TCM and the current SAF Battle Procedure. Prior to this experiment, the participants had already gone through at least four modules of exercises with the current SAF Battle Procedure, therefore any comparisons made to the SAF Battle Procedure are based on participants and observers' prior experience.

Scenario

The scenario was painted as a Div tasked to recapture GOLDLAND (fictitious) from enemy forces and restore the territorial integrity of GOLDLAND. The Div's role was to capture a sector of GOLDLAND in an effort to cut off the enemy's line of communications. The Div was given three Bdes under her command, of which only two were staffed to be played. The Div and Bdes had to develop their respective plans based on the Joint Command HQ Orders.

Task

The participants role-played the key appointments within the Div and Bde command teams. The task was to follow the KBP assigned to them (either TIM-KBP or TCM-KBP), and to utilise the TeamSight suite of tools to conduct planning at their respective echelons. The Higher HQ (Joint Command HQ) was role-played by the Scenario High Control comprising three Directing Staff from SCSC.

Measures

The variables were measured using a battery of observer protocols and questionnaires. The observers comprised both military personnel as well as civilians from SCME.

Background variables. Before the start of the experimental run proper, the participants answered a questionnaire on general background factors. They were asked to provide information regarding their rank, age, sex, vocation, years in service, and years of experience with planning at the Division or Brigade level.

Confounding variables. Two major confounding variables were measured during the experiment. The first was the realism of the scenario. All participants and military observers answered questions after the experimental run regarding the degree to which they thought the scenario was realistic in terms of the story, the amount of information provided, and the amount of time given for planning. These aspects of the scenario were judged on a six-point Likert scale ranging from (1) less than satisfactory through (6) more than satisfactory. The other confounding variable was system failure. All participants and military observers were also asked at the end of each experimental run if they had experienced or observed any problems with the systems during the run. If so, they were asked to briefly describe the problem. A third confounding variable inherent in the experiment design is that the group of participants does not remain constant across the experimental runs.

Dependent variables. A description of how each of the dependent variables are measured is given below:

(a) Operational tempo – Operational tempo was measured by having the Div and Bde Signal Officers record the start and end time of each step of the KBP. Observers were also tasked to note down interesting emergent behaviors, or good practices regarding the use of technology that contributed to an overall compression of the planning cycle.

(b) Parallel planning process – The parallel planning process was measured and analyzed across several dimensions.

1. *Communication profile*. The communication profile was measured by the Key Appointment Holders (KAH) and observers giving a subjective rating of the (i) number of ideas exchanged, (ii) quality of ideas exchanged, (iii) level of ideation by each KAH, (iv) quantity of information shared, (v) predominant mode of information sharing (passive – with little communication overhead incurred vs. active – with much communication overhead), (vi) frequency of use of TeamSight tools (PowerMap, PowerMind, PowerVC – voice, PowerVC – text). Each item was judged on a six-point Likert scale. This questionnaire was answered during time outs called after each period of Mission Analysis and Wargaming and was to be related to the high activity period just concluded.

2. *Workload*. Participants' workload was measured along six elements (mental demand, physical demand, temporal demand, effort, performance, and frustration level) as prescribed by the established NASA-TLX (Hart and Staveland, 1988). Each KAH was required to complete a NASA-TLX survey during the time out after each period of Mission Analysis and Wargaming to provide a subjective self-report of workload.

3. *Team performance*. Team performance was measured across ten elements (aligned, led, stretched, balanced, empowered, effective, focused, harmonious, adaptive, informed) as set out by the Star Performing Team Model (Robinson, 2002). However, in our administration of the survey of team performance, we exercised some liberty in modifying the format of the questionnaire. Our survey of team performance consisted of three (instead of the prescribed ten) statements related to each element of team performance, each cast on a six-point Likert scale ranging from (1) rarely or never through (6) very frequently or always. A sample statement is "The team is aligned internally in terms of having a common mindset." All the participants and observers were required to complete the questionnaire on overall team performance at the end of each experimental run.

4. *Observations*. In addition to the quantitative data collected, observers were also given observation protocols to document the participants' performance according to the prescribed TIM/TCM KBP. The observation template detailed the expected processes and activities of each step of the KBP. The observers were tasked to briefly describe how each step was conducted, and to especially note if there were any deviations from the process description, and to record the rationale for any deviations observed.

(c) Parallel planning output – The output from parallel planning was measured along the single dimension of plan quality. A detailed quality of plan checklist provided by SCSC served as a guide in the development of this questionnaire. The checklist was divided into two categories: fundamental principles of war and attack/advance

(concentration of force, surprise, etc), and tactics (command and control, maneuver and fires, etc). Each SCSC Directing Staff completed one questionnaire for each of the Div and Bde plans developed in each experimental run. They were asked to assess the quality of the plan developed on a six-point Likert scale ranging from (1) lower quality than normal through (6) higher quality than normal.

(d) Achieving common ground – The degree of common ground achieved amongst staff at the Div and Bde levels was measured based on their understanding of command intent. During each time out following Div Mission Analysis/Wargaming during TIM and collective Mission Analysis/Wargaming during TCM, each KAH articulated *in their own words* Div Commander's intent (goals, end state), and further elaborated regarding the supporting activities and limitations. This probe did not assume to capture the respondent's complete understanding of command intent, but instead aimed to elicit what each KAH felt were the salient points about the command intent. A team of three SCME staff assessed the level of common ground by comparing the text responses from the KAHs against the Div Commander's articulation of his intent. In scoring the responses, the SCME staff distilled the themes and sub-goals behind each response, as well as enumerated the activities mentioned. We were especially keen to look out for thematic differences, or even nuances, in the articulation of command intent despite some similarity in activities mentioned.

Procedure

Preparations. A preparatory session for the participants included training on the TeamSight suite of tools as well as an applied scenario-based training session on the TIM or TCM KBP. Figure 5 shows the physical layout of the various command teams within SCME. The Div Command Post (CP) was dispersed according to its operational clusters (Intelligence cell, Operations cell, Fire Support cell, etc.) such that all intra-CP communication had to be channeled through the TeamSight system. The two Bde CPs were each co-located around an info-wall comprising multiple screens that offered a large display of PowerMind, PowerMap, and PowerVC. These large display screens were in addition to the computer terminals that each Bde staff was allocated.

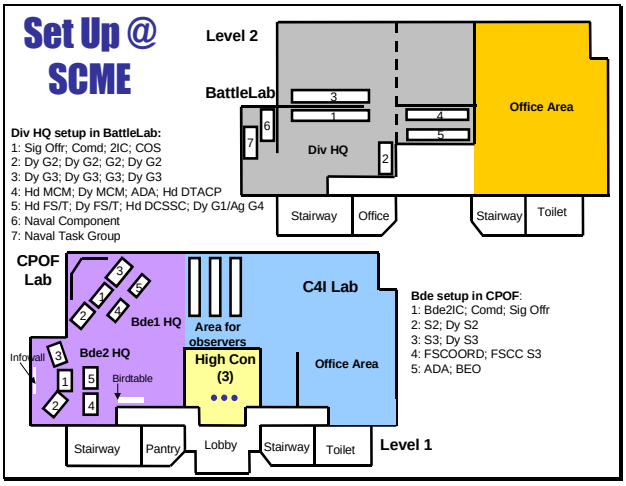


Figure 5. Layout of Div and Bde command teams during the experiment.

Data collection. Before each experimental run commenced, the participants were asked to complete a questionnaire (Q1) that sought to gather information on the background variables. Once the experimental run commenced, the observers were asked to document the process on line according to an observer protocol (O1). The Div and Bde Signal Officers were also tasked to record the start and end time of each step of the KBP. Each experimental run also had several critical periods of high activity identified. These were the Mission Analysis and Wargaming sessions (first conducted at Div level followed by Bde level for TIM; jointly conducted by Div and Bde for TCM). After each of these periods of high activity, a time out was called for the KAHs to complete questionnaires regarding the communication profile (Q2A), their workload (Q2B), and their understanding of the Div Commander's intent (Q2C). All observers were also required to fill in Q2A to give their assessment of the communication that took place over the period of high activity. Logs of the communication during these periods (VOIP, text chat) as well as periodic screen captures of the KAH's computer terminals were also recorded. Following the completion of the planning phase, all the participants and observers were required to answer a final questionnaire that solicited their feedback regarding the TIM/TCM planning process, the scenario, system, and overall team performance (Q3). Finally, the SCSC Directing Staff were also required to complete a plan quality checklist for each of the Div and Bde plans produced. All numerical rating in each of the questionnaires was done on a classical six-point Likert scale.

RESULTS

Manipulation check

Descriptive statistics for the three scenario realism variables (realism of scenario, realistic amount of information provided, and realistic amount of time provided for planning) indicated that both participants and observers found the scenario to be satisfactorily realistic in these important aspects (mean between 3.63-4.31 on a six-point scale; SD between 0.90-1.16).

Concerning the other confounding variable of system failure, 81% (TIM) vs 64% (TCM) of respondents reported some problems encountered with the system. The primary system failure reported by the TIM respondents were bandwidth and latency related issues that hampered the use of PowerVC. The severe lag in the VoIP channeled all communications during Div Mission Analysis through text chat instead. The Div Comd then decided to gather his staff around a large digital display to conduct Div Wargaming. The Bdes were still able to receive audio and video feed of the group discussion in addition to PowerMap, so this change in configuration should not have any significant effect on the experiment results. The problem with PowerVC was solved before the TCM run, and this greatly reduced the number of bandwidth and latency related reports of system failure. The primary system failure reported by the TCM respondents were minor software instability incidents which the engineers were able to resolve fairly quickly upon

detection, and the relevant systems were restored for use with no major implications to the experimental run.

Operational tempo

The time taken for each step of the KBP was tracked by the Div and Bde Signal Officers. The total time taken for Div and Bde planning during the TIM run was 20 hours, rather than 26 hours prescribed by the process. The savings in time may be attributed to various factors. Firstly, the Brigades took the initiative to begin their prelim planning and mission analysis even while the Division was developing their plans, based on the insights they had obtained from the Division mission analysis process. The participants at the Bde level reported that they were able to select their concept of operations and even conduct some contingency planning during Division wargaming when the Division plan had become clearer. As such, the Brigades were able to develop their plans within 1.5 hours of receiving their operations orders and were soon ready to begin wargaming their plans with the Division. Secondly, it should be stated as a caveat that some of the savings in time were due to the fact that that some steps of the KBP were glossed over because the Joint Command HQ and the Battalions were not physically role-played by the experiment participants. Also, not all the support plans were developed in full because of the lean staffing of the Div and Bde command teams, although the major support plans were completed, including the Fire Support, Intelligence Support, Air Defence, Air Support, Naval Task Force, Engineers, Logistics and Communications. There are other smaller support plans such as manpower and medical that were not developed, but they would be inconsequential to the timings.

The total time taken for the collaborative Div and Bde planning during the TCM run was 15.25 hours, rather than the 20 hours prescribed by the process. The step that deviated the most from the expected duration was the joint wargaming of Div and Bde plans. A total of 5 hours were prescribed for this step, but the participants finished this step in an hour with all the major support plans completed as in the TIM.

Parallel planning process

The parallel planning process was characterized along several dimensions: communication profile, participant workload, and team performance. These aspects were measured via numerical ratings obtained from participant and observer questionnaires. In addition, the observers provided a source of anecdotal data that further elucidated the interesting developments in the process.

Communication Profile. The communication patterns of the team collected during the periods of high activity (Mission Analysis and Wargaming) help elucidate the profile of the planning process. Communication transactions were broadly classified into the categories of information sharing or idea exchange. The KAHs and observers rated the number of ideas exchanged as well as quantity of information shared during each period of Mission Analysis (MA) and Wargaming (WG) as satisfactory, with mean ratings falling between 2.88-3.86 for exchange of ideas and 3.21-3.58 for information sharing, on

a six-point scale. The ratings were not significantly different across the different periods of high activity, except for a greater number of ideas exchange reported during collective WG (TCM) compared to Div WG (TIM) ($p = 0.007$). Communication for the purpose of idea exchange was further analyzed by role. Figure 6 charts the relative amount of ideas contributed by each of the Key Appointment Holders during Div MA and WG (TIM) compared to the collective MA and WG (TCM). What is striking is the large degree of similarity of the four profiles. Notably, only the Bde2 Commander contributed significantly more ideas during the collective MA and WG (TCM) than during the Div MA and WG (TIM) ($p = 0.019$, $p = 0.004$ respectively). This quantitative data corroborates with the observations made during collective MA and WG under TCM. The observers noted that there was little evidence of collaboration taking place within staff functions across echelons, with the exception of the intelligence cells (G2/S2) which were collaborating asynchronously over text chat. Most of the collaboration across echelons that took place did so only during scheduled videoconference sessions with only the key Div and Bde staff (namely Div Comd, 2IC, COS, G2, G3, Hd FS/T, Bde1 Comd, and Bde2 Comd) actively participating.

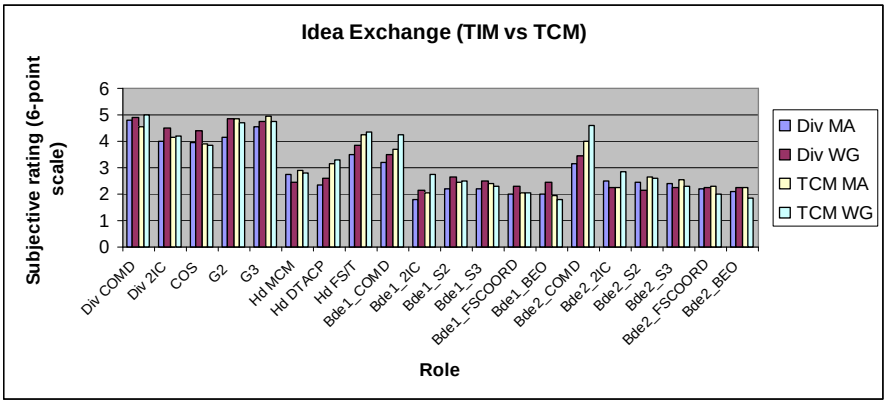
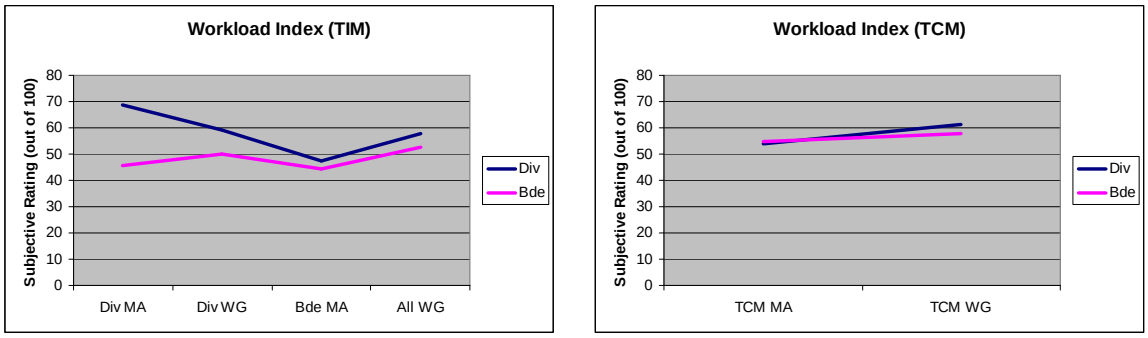


Figure 6. Idea Exchange by Role (Div MA/WG (TIM) vs collective MA/WG (TCM)).

Workload. The workload of the KAHs over each of the high activity periods was assessed by having the KAHs complete a subjective self-rating of six aspects of workload (mental, physical, temporal, effort, performance, frustration level) as prescribed by NASA-TLX (Hart and Staveland, 1988). Figures 7(a) & (b) show the average workload as reported by the Div and Bde staff during TIM and TCM respectively. As expected, during TIM, the workload of Div staff was significantly higher than that of Bde staff during Div MA ($p = 0.018$). The workload difference narrowed during Div WG as the Bdes began their prelim planning and informal mission analysis while the Div firmed up their plans. The difference in workload reported by the Div and Bde staff during Bde MA and Div-Bde WG during TIM was not statistically significant. The measurement of workload during TCM also yielded expected results. There was no statistically significant difference in workload reported by the Div and Bde during the collective MA and WG as staff at both echelons were engaged in similar planning activities albeit at different resolutions at the same time.



(a) **(b)**

Figure 7. Subjective self-rating of workload (out of 100) during **(a)** TIM and **(b)** TCM.

The observers noted that the Div and Bde staff were not able to monitor the multiple channels of communication effectively, such that some of the plans posted on PowerMind and several questions posed via text chat largely went unnoticed. The participants were in fact briefed during the training session that they should work in pairs such that one person could focus on planning and the other could be dedicated to monitor the development of plans by others, and also manage the communication channels. However, this was not observed to have taken place, largely because the lean staffing of the Div and Bdes for this experiment necessitated that each staff had to be actively engaged in developing the plans, leaving little cognitive bandwidth to monitor the multiple channels of communication.

Team performance. The overall assessment of team performance by the participants as well as observers yielded the following results (on a six-point scale): TIM overall mean = 4.41, SD = 0.83; TCM overall mean = 4.40, SD = 0.66. An item-total correlation was also calculated for each of the 30 questions to provide an indication of the contribution that each question had to the overall team performance index. The range of correlation indices (spearman's rho) fell between 0.593-0.889 for TIM and 0.539-0.860 for TCM. These correlation values indicate that the questions are reasonably well correlated. The means of the ten elements of team performance as rated by participants and observers fell within the range of 4.13-4.64 for TIM and 4.09-4.68 for TCM. There were no significant differences between participant and observer ratings for both runs, nor was there a significant difference in team performance between TIM and TCM. It is interesting to note that within each set of data, the element of being *informed* ranked the lowest, while the elements of being *empowered* and *harmonious* ranked at the top of the list. The poorly ranked team behavior of being informed by both the TIM and TCM participants and observers corroborated with the observation that not all the plans posted on PowerMind were accessed by staff members other than the originator of the plans. There are perhaps at least two contributing factors as to why this was so. Firstly, it was noted that the posting of plans on PowerMind did not command other staff members' attention. It would be useful to develop an alert system within PowerMind to allow a user to alert other stakeholders that a plan had been posted. Conversely, it may be useful to have an acknowledgement system such that a user could inform the originator of the plan that his plan had been looked at. Secondly, it was observed that there would need to be a commonly understood method of indexing plans such that every staff member would know exactly where to go to find the specific plan that he was looking for.

Observations. In addition to the quantitative data, the observers provided a source of anecdotal data that further elucidated the interesting developments in TIM/TCM-KBP. The anecdotal observations made about the processes largely corroborate with the quantitative data collected. The following are some key observations, in addition to those already mentioned:

(a) During the TIM run, the Bde Comd and key staff listened in to the Div mission analysis and took the initiative to start their own prelim planning and mission analysis even while the Div was developing their plans. However, the Bde staff reported some frustration experienced when they had to revisit some steps because they were developing their plans based on evolving HHQ plans.
(b) During the TIM run, it was observed that the flow of insights was not just from the Div to the subordinate Bdes. The Div also gleaned insights from listening in on the Bde wargaming process. The Div Comd picked up on several points for further coordination and directed the G3 to work these out with the respective Bde S3 before the final wargaming of Div and Bde plans. However, it was also noted that the Div Comd would need to delegate responsibility to his staff to monitor the various Bdes' wargaming process should they take place simultaneously.
(c) The Div Comd during the TIM run recognized that scheduled briefs could be compressed if all his staff members were conscientious about sharing their annotated plans on PowerMind. He directed his staff to upload their plans, as well as to look at the products of other functional cells before each conference. The conference was reserved for presentation of only the salient points of each plan, and for any clarification sought by other staff members.
(d) During the TCM run, it was observed that the existing hierarchical and centralized C2 structure continued to drive and shape the participants' behavior. Despite the collaborative tools that were in place, there was a fairly low level of collaboration across the various dimensions: within functional groups (Div-Bde), across functional groups, as well as inter Bde.
(e) There was some diversity in the exchange of ideas noted during the TCM run, but the observers generally felt that the options raised were not fully deliberated before the team converged on a solution. This could perhaps be because SAF training and doctrine tend to gear the staff members' thinking towards a small set of possible solutions. The Div Comd acknowledged, however, that it might be useful to have someone take on the role of guarding the team from gravitating towards groupthink.
(f) The TeamSight suite of tools were observed to provide staff members at both the Div and Bde levels with access to a greater level of situation awareness, but achieving shared understanding depended on how clearly the commander was able to articulate his intent as well as the underlying assumptions.

Parallel planning output

Plan quality. Each of the Div and Bde plans developed using TIM-KBP and TCM-KBP were rated by SCSC Directing Staff against a Quality of Plan checklist of considerations under two categories: fundamental principles of war and attack/advance (concentration of

force, surprise, etc), and tactics (command and control, maneuver and fires, etc). Table 1 shows the Directing Staff's ratings of the various Div and Bde plans developed under TIM-KBP and TCM-KBP. There were no significant differences in quality of plans produced under TIM-KBP as compared to TCM-KBP. The figures indicate that the Directing Staff were quite satisfied with the plans produced, with all the mean ratings falling between 4.26 - 4.64 on a six-point scale. It was also observed that both plans developed were largely similar in its approach and scheme of maneuver.

		Div	Bde 1	Bde 2
TIM	Fundamentals	Mean = 4.39 SD = 0.11	Mean = 4.29 SD = 0.22	Mean = 4.47 SD = 0.07
	Tactics	Mean = 4.48 SD = 0.05	Mean = 4.26 SD = 0.52	Mean = 4.28 SD = 0.61
TCM	Fundamentals	Mean = 4.36 SD = 0.21	Mean = 4.35 SD = 0.28	Mean = 4.44 SD = 0.22
	Tactics	Mean = 4.61 SD = 0.19	Mean = 4.46 SD = 0.09	Mean = 4.64 SD = 0.17

Table 1. Directing Staff rating of Div and Bde plans (on six-point scale).

Achieving common ground

The degree of common ground achieved amongst staff at the Div and Bde levels was measured based on their articulation *in their own words* of Div Commander's intent following the critical periods of Mission Analysis and Wargaming. Table 2 shows the results of the analysis of common understanding between Div and Bde staff members:

Phase in KBP		Themes	% respondents	% reported same sub-goals	% reported ≥ 50% of activities	% reported < 50% of activities
TIM	Div Mission Analysis	Reclaim GOLDLAND	76.5%	70%	82% (0% reported 4 out of 4)	16% (2% did not articulate any related activities)
		Destroy / Isolate enemy	23.5%			
	Div Wargaming	Reclaim GOLDLAND	93.8%	87.5%	100% (6% reported 4 out of 4)	0%
		Isolate GOLDLAND	6.2%			
TCM	Collective Mission Analysis	Reclaim GOLDLAND	88.3%	88.2%	88.2% (11.8% reported 4 out of 4)	5.9% (5.9% did not articulate any related activities)
		Destroy enemy	11.7%			
	Collective Wargaming	Reclaim GOLDLAND	92.9%	85.7%	85.7% (21.4% reported 4 out of 4)	7.14% (7.14% did not articulate any related activities)
		Isolate Beachhead	7.1%			

Table 2. Degree of common ground between Div and Bde staff members.

Each of these surveys returned between 14-17 meaningful responses. The void or meaningless responses (e.g. "no change in Commander's intent") were not taken into consideration in computing the statistics.

The statistics on the thematic similarities in command intent articulated by the key staff at the Div and Bdes provide some insights regarding the degree of common ground

achieved by the team. In both experimental runs, the percentage of KAHs who articulate Div Commander's intent with a similar theme (Reclaim GOLDLAND) increases as the KBP progressed from Mission Analysis to Wargaming, as would be expected. However, it is noteworthy that a larger degree of common ground among Div and Bde staff was achieved following collective Mission Analysis during TCM as compared to Div Mission Analysis during TIM. This is reflected by the higher percentages of staff who articulated command intent using a similar theme as well as in the approaches (sub-goals) mentioned.

In the scoring of activities in support of Div Commander's intent as articulated by the Div and Bde staff, it was noted that some respondents who had a different thematic emphasis in their articulation of command intent had nonetheless listed a number of supporting activities in line with those listed by the Div Commander. In addition, it was noted that there were several activities mentioned by several respondents that had in fact been omitted by the Div Commander.

DISCUSSION OF FINDINGS

This experiment set out to explore the effects of TCM-KBP in comparison with TIM-KBP with regard to operational tempo, the parallel planning process and output, and achieving common ground. We will discuss our initial expectations regarding each of these aspects in turn, in the light of the findings from this study:

(a) TCM-KBP augmented with TeamSight would facilitate parallelism across echelons, thereby compressing the planning cycle and increasing operational tempo.

The timings recorded for completion of each of the experimental runs indicate that both TIM-KBP and TCM-KBP can indeed compress the planning cycle. The timesaving measures that were observed in both runs could be attributed to both the processes and technology put in place for this experiment, as well as the initiative displayed by the experiment participants. During the TIM run, the Bdes took the initiative to begin their planning process even while the Div was developing their plans, based on the insights they had obtained from the Div mission analysis process. This behavior was also observed in the joint SAF-SwAF experiment (Cheah et al, 2005b) and perhaps validates the parallel-planning concept, as it shows that given sufficient information and insights into the HHQ planning process, it is natural for the LHQ to get a headstart on their planning process. The Div also adopted a HHQ perspective and developed a culture to ensure that they provided sufficient information to the Bdes during mission analysis for them to start planning in parallel. This was evident when the Div Comd made constant checks with the subordinate Bde Comds over the chat room that they were in a position to start their planning process.

In addition to the parallelism in processes across echelons, there were also some savings in time when the staff members were conscientious about sharing their annotated plans

on PowerMind as well as referring to the products of other functional cells before scheduled briefs. This practice facilitated a reduction in the time required for each staff conference as each KAH only had to highlight the salient points of his plan and clarify any queries raised by other staff members instead of going through the motion of presenting his plan in detail.

(b) TCM-KBP augmented with TeamSight would result in a greater amount of collaborative communication in the form of idea exchange.

The TCM run did not in fact see a marked increase in the amount of collaborative communication (idea exchange) taking place between echelons. Idea generation is in part related to the individual's experience, the culture imposed by operating within a hierarchy of command, as well as the complexity presented by the scenario. The relatively small problem space of the scenario used in the experiment perhaps did not require too much idea exchange as it was rather clear at the onset what each Bde was supposed to do. Despite these possible confounding factors, the findings from this study have nonetheless elucidated some aspects in which stronger interventions could be developed to generate more collaboration in future experiments.

Structure. Despite the TIM-KBP and TCM-KBP formulated prior to this experiment, there was some initial learning on the part of the participants regarding the details of each, largely because not enough time was given to train them on the respective KBP. The participants understood the general intent behind TIM and TCM, but they did not have time to work out their own collaboration structures and processes. In the absence of clearly understood processes for collaboration between the Div and Bde staff, the existing hierarchical and centralized C2 structure continued to drive and shape the participants' behavior, including with whom and when to collaborate. As noted above, much of the collaboration took place only during scheduled videoconference sessions, mainly involving the key appointment holders. The Intelligence Sector seemed to be the only staff function to engage in collaborative discussions across echelons prior to the scheduled briefings although we expected the other staff functions to do the same. Again, this could largely be a training issue that could be resolved fairly easily over time. Future experiments would need to have in place, *a priori*, more defined processes for collaboration.

Mindset. It was observed that during the collective Mission Analysis conducted by the Div during TCM, the participation by the Bde staff was minimal. The Bde staff only started to be more actively involved when the Div was conceptualizing its plan. While the TCM-KBP prescribed that the key Bde staff should be leveraged upon as an extension of the Div HQ during Mission Analysis, it was observed that this change in mindset did not take place during the TCM run. The Bde staff appeared not to recognize their level of stake when the Div was analyzing its mission. Perhaps more time and training would need to be allocated to influence a change in mindset of participants in similar experiments in the future. Once the Bde staff see themselves as primary stakeholders in the Div plans, it is expected that they would collaborate more actively at the Div level till

the Div concept of operation reaches a certain level of maturity before proceeding with fleshing out the details of the Bde level plans.

Technology. It was noted that the technology had room for improvement in terms of facilitating a higher level of information sharing that would in turn lead to more collaboration. The passive posting of plans on PowerMind did not command other staff members' attention as they did not know how the plans were indexed or where to look for the files. PowerMind should be structured in a similar manner to PowerMap for ease of collaboration and access to the information, except that it is based on a non-GIS platform to facilitate collaboration on text, tables, charts and graphs. In addition, it would also be useful to develop features that would provide users with virtual presence awareness, that is, an awareness of the actions of other users at any point in time such that a user would be able to tell who was looking at his plans. It was also raised during the After Action Review that technology could perhaps also have a part to play in encouraging a greater level of idea exchange, in particular, in providing a channel for staff to voice dissent. One suggestion was to set up a message board, or online forum, whereby any staff could post his differing views under the veil of anonymity. This would perhaps address the unwillingness of most people to be seen to be the one raising objections and impeding the progress of the team. Another suggestion was to allow any staff member to set up separate chat rooms with a small audience to allow him to seek feedback on his dissenting views before formally raising it to the commander. While these various technological aids could feature in future experiments to test if they would in fact increase the level of idea exchange, it has to be noted that they would likely succeed only if a greater amount of time was permitted for the planning process. The staff members are likely to focus on their primary roles and tasks if subjected to time pressure, rather than voice dissenting views or even provide feedback to any dissenting views raised by any members of the command team.

(c) TCM-KBP compared with TIM-KBP would result in no loss in plan quality.

The findings from this study indicate that the plans produced by both groups of participants under the TIM-KBP and TCM-KBP did not differ significantly in terms of the overall quality as determined by subject matter experts, as well as in the general approach and scheme of maneuver adopted. As a caveat, it should be noted that the final plan is but one output of a planning process. Indeed, it may be meaningless to rate one plan as better than another plan if they both succeed against the enemy. Perhaps a more telling measure of a planning process is how thoroughly the plan is worked out – that is, how robust is the plan in the face of contingencies? This aspect of plan quality was not measured in this study because the focus was solely on the planning phase. However, it would be instructive to consider this measure of plan quality in future experiments by testing out the plans developed in a two-sided execution play.

(d) TCM-KBP compared with TIM-KBP would result in a greater level of shared mental models.

The results from this study do in fact suggest that a larger degree of common ground among Div and Bde staff was achieved following collective Mission Analysis during TCM as compared to Div Mission Analysis during TIM. This is reflected by the higher percentages of staff who articulated command intent using a similar theme as well as in the approaches (sub-goals) mentioned. One plausible reason why this is so is that the Brigades knew from the onset that they would not be issued with any Orders from the Div HQ, and that they would need to complete their plans at about the same time as the Div. This could have resulted in the Brigade being more engaged in the Div HQ discussions early on in order to quickly achieve shared mental models with the Div. On the other hand, TIM-KBP makes allowance for some of the Bde staff who may have missed the Div Mission Analysis process to eventually align themselves with the HHQ Command Intent through the Orders issued at a later stage in the planning process. Another point of interest in the analysis of completed surveys was that some respondents who had a different thematic emphasis in their articulation of command intent had nonetheless listed a number of supporting activities in line with those listed by the Div Commander. It would be interesting to conduct a follow-on experiment to include two-sided execution play, in order to explore the effects of a team with a common understanding of the activities to be undertaken, but with variations in the understanding of command intent. In addition, it was noted that in the survey responses, there were several activities mentioned by several respondents that had in fact been omitted by the Div Commander. This perhaps points to a need to further improve the administration of the survey, in particular, to prime the experiment participants to be more thorough in completing the survey.

CONCLUSION

This experiment had set out to explore the possibility of exploiting technology and battle procedure techniques towards achieving true parallelism between two echelons of command. TIM-KBP and TCM-KBP were developed to guide the experiment participants in their planning processes and comparisons were made with regard to operational tempo, the parallel planning process and output, and achieving common ground. On the whole, the findings from this study indicate that both the TIM and TCM modes of planning between the Div and Bde levels may be achieved with overall savings in time and no degradation in plan quality. In addition, the TCM mode of planning also appeared to give rise to a higher degree of common understanding of command intent among Div and Bde staff.

The success of this initial experiment raises a whole set of other questions. Under what conditions does TIM or TCM become a preferred mode of planning over the other? How may TIM and TCM co-exist and be employed in a complementary manner across a span of command, as well as across echelons of command? What are the limits of TIM and TCM in terms of their scalability, taking into consideration the cognitive and

technological constraints? These are questions that should be explored in future experiments, as they have bearing on how TIM and TCM could be employed as set pieces that contribute towards building adaptive command teams within the SAF, capable of exercising C2 options to gain a competitive advantage for our war-fighters in the time domain.

In the conduct of follow-on experiments of TIM and TCM, it would be desirable that the participants should ideally be operational Div and Bde command teams with a fair amount of experience with planning at this level such that they would be able to more fully leverage on the infrastructure (processes and systems) put in place to conduct a rich collaborative planning session, supplemented by their experiences. The teams should also be put through the execution phase of their plans in order to test the robustness of the plans developed in the face of contingencies. These follow-on experiments would more fully flesh out the implementation details of both the TIM and the TCM concepts of Parallelism that this exploratory study has shown is indeed viable, notwithstanding further refinements to the process and technology.

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