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C2 Agility: Evaluating a new Brigade Standard Operating Procedure for Information Management and Coordination

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Abstract

In this study we experimented with two command and control (C2) concepts for Edge Force operations called Non-Hierarchical Information Management (NHIM) and Non-Hierarchical Coordination (NHC). The concepts were translated into a Standard Operating Procedure (SOP) for a Brigade C2 structure. The purpose of NHIM is to share information necessary to enable horizontal coordination among units of equal standing within the same C2 structure. The purpose of NHC is to speed up the decision loop and to free mental capacity for forward planning on subsequent phases of operations at higher head quarters (HQ) level. This experiment attempted to validate the Brigade SOP in a realistic military C2 context. Thirty-four Swedish and Singaporean army officers participated as staff either in the Brigade or subordinated Battalions. The use of the NHIM/NHC SOP resulted in timely and accurate decisions and self-coordinating actions at the Battalion level, and the participants found the NHC process easy to apply. The technical C2 systems provided participants with easy access to all documents and situation map (sitmap) information for self-coordination. This study demonstrated the potential usefulness of the NHIM and NHC SOP in peace support/peace enforcement (PS/PE) operations. The criteria for NHC were tested and proven as useful guidelines for selecting the appropriate type of coordination during execution.

Introduction

As in other military armed forces, there are two important trends affecting current C2 development in the Swedish and the Singapore Armed Forces. The first trend is the growing complexity of the operational environment (e.g., Rudd, Bayley & Petruczynik, 2006; Smith, 2006), with heterogeneous make-up of participants such as military, non government organizations (NGOs), government agencies, local authorities, tribal leaders, etc. This in turn has an impact on military operations resulting in dynamic changes to missions given to military forces. Afghanistan and Iraq are two such examples. The second trend has to do with the increasing capacity of emerging information technology (sensors, network and computers) that has the enabling potential of allowing war fighters at the edge to be connected in real-time during operations (e.g., Alberts, Garstka & Stein, 1999). Sweden and Singapore have an ongoing collaboration aimed at developing and experimenting new C2 concepts and methods. In 2009 we started exploring two such C2 concepts for Edge Force operations called Non-Hierarchical Information Management (NHIM) and Non-Hierarchical Coordination (NHC), (Tan, Thunholm, Lee, Wikberg, Ng, Chng, Tan, Tey, Hallberg & Larsson, 2009). In the present study, we further developed these concepts for information sharing and self-coordination into a Standard Operating Procedure (SOP) for a Brigade (Bde), with four subordinated Battalions (Bns). The purpose of this study was to validate this Bde – Bn SOP in a realistic military C2 experimentation context and setting.

The complex operational environment

Military commanders are increasingly finding themselves operating in a complex environment (e.g., Smith, 2006). Compounding the problem is the need to operate against an opponent acting as an irregular force, dispersed over large areas, and yet living and hiding among civilian structures. Such an enemy has no clear force structure that can be localized easily for attacks and they have no qualms about using irregular warfare techniques and weapons such as improvised explosive devices (IEDs) and suicide bombers (Smith, 2006).

This complex environment has several implications on military operations. Apart from the need to operate over a much greater area than before, decision rights must also be

distributed to the edge (i.e., tactical) units in order to facilitate the speed of actions and counter-actions. Increasingly, military commanders must also exhibit characteristics such as flexibility and adaptivity to the changing circumstances both in terms of their ability to detect changes and the agility to mount quick responses. This means delegating authorities and having clear but robust Rules of Engagement (ROE).

Whilst allowing freedom to improvise at the lowest echelon, Commanders (Cdrs) at all levels must be fully aware of the implications of each action such that with delegation of decision rights, it will not result in that Cdrs at higher levels have to deal with unintended consequences. Local commanders who have insights must be aware of developments beyond their area of operations and understanding how their decisions will and could contribute to attainment of higher echelon's objectives and how one's actions may impact on other stakeholders' objectives. Information sharing that leads to understanding therefore is of central importance.

C2 Theory on information sharing and coordination

One basic assumption from current C2 literature (e.g. Alberts & Hayes, 2005; Alberts, Huber & Moffat 2010) is that an increase in information sharing among the entities in the Area of Operations (AO) will result in an increase in Shared Situation Awareness (SSA), for example among different sub-units of a deployed Brigade. A high level of SSA will enable faster and more (self-) synchronized actions taken in the AO in order for Cdr and forces to deal with rapidly unfolding events. Faster and more coordinated responses are beneficial in increasing the overall mission effectiveness in the AO whilst compressing the Observe-Orient-Decide-Act loop cycle. This hypothesis is sometimes called the "tenets of Network Centric Operations (NCO)" or "the value chain of NCO" (Alberts and Hayes, 2005; 2006; cf. Figure 1).

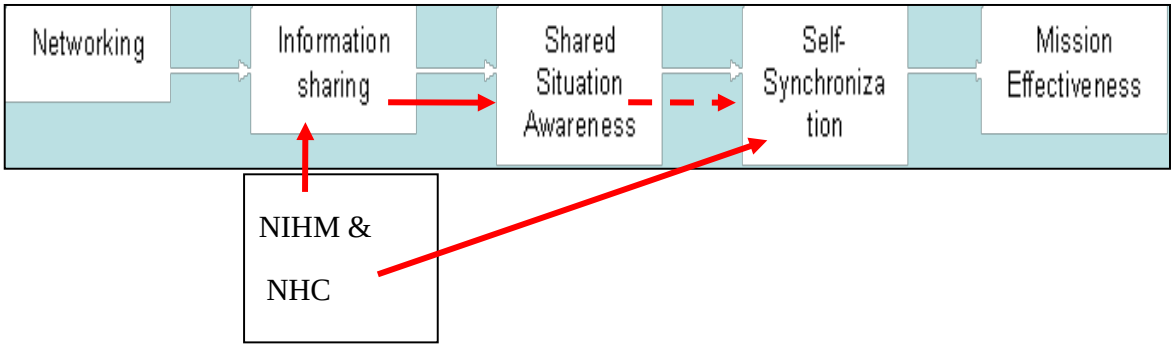

Figure 1. *The NHIM /NHC concepts in relation to the Value Chain of NCO*

Self-synchronization as a C2 concept is not yet fully understood (Alberts & Hayes, 2005). In its purest form it suggests a completely flat organization, but this is not how we define it in the context of our experiments. Instead of *total* self-synchronization, we used *increased self-coordination* as comparison to the traditional hierarchical system where all coordinations in principle had to be done through or approved by a higher HQ. Thus we encouraged self-coordination between and among units at the same level with guidance from Higher HQ (HHQ) such as Cdr's Intent and tasking to the subordinated units. Earlier findings on self-synchronization in micro-world C2 of fire-fighting (Brehmer, 2009; Brehmer & Svenmarck, 1995) indicated that (1) in order for self-synchronization to take place, there must be a learned procedure on how to do it. It is not enough to provide (relevant) battlefield information such as blue force tracking and a common operational picture. The staff must also

be trained in the new self-synchronization procedure. (2) Self-synchronization occurs along the seams of physical boundaries between units with overlapping tasks. (3) For self-synchronization to be effective, the synchronizing parties must have a shared opinion regarding the common goal and intentions as issued from a higher commander.

Defining NHIM and NHC

NHIM is a concept co-developed by the Swedish Armed Forces (SwAF) Joint Concept Development & Experimentation Center (JCDEC) and the Singapore Armed Forces Centre for Military Experimentation (SCME). The NHIM concept is connected to the value chain of NCO. In Figure 1 NHIM and NHC's connection to the Value Chain of NCO is presented. The core conceptual thinking of the NHIM part is that the information available within a C2 structure in principle should be made accessible to all members of the organization. All members (units) in a C2 structure should also be enabled to update information, and a common reference situation picture should be made accessible. (However this does not preclude exception to the rule such as when mission security and originality of source needs to be protected). A Common Reference Picture (CRP) as opposed to a strict dictate of a Common Operating Picture (COP) is preferred, as NHIM recognizes that different levels may have different needs for details of the situation as well as geographical needs. Differences in opinion between units regarding map objects should be resolved at the level where they occurred, but a higher hierarchical level with a better overview of the whole situation should be able to give guidance regarding how to interpret ambiguous information (i.e., higher staff must still conduct situation analysis and provide intelligence summaries, and estimates of the enemies to subordinates).

NHIM is also in line with the idea that the operational environment is highly dynamic and hence, the need for operating units to ensure synchronization of local objectives with higher strategic goals. In addition, a CRP as provided through the NHIM procedure is supposed to reduce ambiguity as well as preventing fratricides and possibly avoiding any unintended consequence from freedom of actions. Building a CRP will thus reduce ambiguity and improve sharing and understanding across the organization. This could result in deeper collaboration and NHC between and among units without unnecessarily involving HHQ in every line decisions. This means enhanced performance in terms of coordinated and effective actions, desired effects, improved agility and avoiding fratricide.

As shown in Figure 1, NHIM and NHC deal directly with the way information is being managed in the C2 chain. The direct purpose of NHIM/NHC is to increase the level of SSA of members whilst enabling horizontal coordination among same-level of units within the same C2 structure. NHIM does not replace or preclude the need to do planning. Planning is still important much like what is being advocated by traditional practices. However, during executions, NHIM SOP encourages and allows sub-units (in this case Bns) to adopt non-hierarchical information sharing and self coordination (NHC) even as situations change and new threats emerge. This means that during operations, local problems or obstacles encountered at the Bn level should be solved unilaterally and possibly without involvement of the HHQ (in this case a Bde). One key aspect of NHIM/NHC is that self-coordination presupposes the Bde having visibility of the NHC process through C2 system enablers with the Bde to exercise "veto" power in the NHC process among the Bns. The purpose of adopting NHC is to speed up the decision loop and to free mental capacity for forward planning on subsequent phases of operation at the Bde.

In our first evaluation of the NHIM concept during experimentation, (Tan, et. al., 2009) a formal comparison was done between the NHIM concept and a traditional hierarchical concept, i.e., Hierarchical Information Management, (HIM), and in that study the NHC concept was not fully operationalized yet. Our discovery indicated that NHIM was

perceived by the participants as a more effective C2 procedure than the traditional hierarchical (HIM) process. The main result of the study was that the NHIM procedure resulted in a faster decision-loop for the Bde/Bn system as manifested in a faster issuance of Fragmentary Orders (FragOs). As mentioned in the introduction and in many other C2 literatures (e.g., Alberts & Hayes, 2003; Hanlon, 2004), the ability to respond quickly to threats and seizing opportunities on the battlefield is often seen as crucial for success. In essence, the speed of developing and issuance of new FragOs was one such testament of an effective response.

Purpose and expectations

The Standard Operating Procedure (SOP) that was evaluated in this study consisted of two parts, *information management* and *coordination*. The SOP prescribed routines as a default for *non-hierarchical information management*. It also included a criteria-based routine for *coordination during execution*, with *NHC* as a default. If these criteria for non-hierarchical coordination between Bns were not met, the SOP also included routines for *hierarchical coordination (HC)* to be facilitated. The criteria and processes for NHC and HC are presented in Appendix 1.

Given that NHIM/NHC is prescribed as a default mode in the SOP with clear conditions for reverting to HC, the experiment therefore was not focused on experimentally comparing hierarchical (HC) versus non-hierarchical coordination (NHC). Instead, based on the results of our previous study (Tan et. Al., 2009); a set of expectations was developed as presented in the following:

- The participants should be able to apply the coordination criteria and consistently decide on which process to follow (NHC or HC), although a choice between NHC or HC would ultimately be dependent on the individual Cdr's perception of each unique and contextual situation. This means that if two Cdrs can agree on which type of situation they are subjected to in a given scenario, they would be able to select consistently which C2 procedure to follow (NHC or HC), notwithstanding that there is always a possibility that the situation will be interpreted differently between two Cdrs.
- The NHIM SOP would be perceived as an effective procedure for execution of operations in realistic field settings as compared to a traditional, more hierarchically designed procedure. NHIM SOP would also be perceived as an improvement, because it makes the C2 chain to respond more adaptively in terms of the quality and timeliness of decisions made (i.e., problems are allowed to be solved at an appropriate level rather than routinely being brought up to the Bde level for resolution).
- The quality of Bn orders issued as a result of a NHC process would be of at least the same quality as Bn orders issued as a result of a HC process.
- Bn FragOs would be issued faster after a NHC process as compared to the HC process, because in the NHC process the Bn Cdrs can make decisions and produce orders without having to wait for coordination from the Bde.

Although we expected the NHIM SOP to be an effective procedure, we also identified a set of potentially *unintended consequences*, developed by Subject Matter Experts (SME) as an attempt to try and anticipate what might result from the introduction of NHIM and NHC processes into a C2 environment, where the staff members and commanders are traditionally used to HC. Several possible unintended consequences were identified:

- Bn activities that do not reflect thoughtful conformance of Bde Cdr's intention.
- Loss of freedom of action (primary at the Bde level) due to wrong commitment of Bn resources. This unintended consequence could result in jeopardising the Bde's mission.

- Mindset problems (i.e. problems to switch between HC and NHC, and abdication of responsibility by both the Bde Cdr and staff). It must be possible to switch between HC and NHC without confusing the C2 process.
- High and non-sustainable overload in term of works at the Bn level. The SOP for NHC must therefore ensure that Bn Cdrs can cope with the workload and not be in an overload situation.
- Information management problems, for example regarding how to keep the Bde staff in the loop and updated regarding coordination among the Bns. Information must be regularly updated in order for it to be adequate. Local agreements between Bn Cdrs must not lead to loss of information.

We designed the SOP in order to mitigate these identified possible unintended consequences when NHIM/NHC was adopted. Thus, our expectations were that these unintended consequences would not occur during the scenario-based validation runs of this study.

Method

Participants, Task and Scenario

Thirty-four male Swedish and Singaporean army officers participated in this study and formed part of staff across a Mechanized Bde, three Mechanized Bns and a Fire Support Bn. The descriptive statistics of the participating teams are presented in Table 1. The participants played key roles representing Commander (Cdr), Chief of Staff (COS), Short term planning (G3 Plans), Execution (G3 Tactical Operations Center, TOC), and Intelligence (G2).

Table 1. *Descriptive Statistics of the participants*

Descriptives		**6th Bde**	**61st Mech Bn**	**62nd Mech Bn**	**63rd Mech Bn**	**92nd FS Bn**
Mean Age		38.5 (SD 4.2)	32.5 (SD 2.9)	39.0 (SD 6.1)	42.3 (SD 7.7)	46.8 (SD 9.2)
Ranks	CPT	4	4	3	2	
	MAJ	4	2	2	2	4
	LTC	1				
	COL	1				
Mean No of Years in Service		16.3 (SD 4.4)	11.0 (SD 3.0)	18.2 (SD 5.8)	21.0 (SD 8.6)	26.5 (SD 9.3)
Experience in Peace-Keeping Operations		40%	0%	40%	0%	50%

The task given to the participants was to act in their assigned roles and to the best of their ability *execute* the Orders received from the higher Cdr. They were also instructed to follow the SOP closely. The execution process included continuous assessment of the development of the situation, production and distribution of situation reports (sitreps) through the C2 systems, activity coordination and development and issuing of FragO in response to events that were judged by the participants themselves to require FragOs. One part of the SOP that was of specific importance was the criteria for deciding whether to select NHC or HC. The rules and criteria for selection of NHC or HC are presented in Appendix 1. The participants role-played in key functions over five half-day runs in a peace-enforcement scenario previously developed by SwAF and refined by SMEs in the Experimenters Team.

We used a PS/PE scenario because this could be the kind of scenario and tasks that both our countries and armed forces may be called upon to participate in the foreseeable

future. The key events in the scenario included establishment of a *Zone of Separation* through a large city, between two regular forces and also irregulars and warlords on both sides. Another key feature of the scenario was the need to handle ethnic enclaves. The complexity of the scenario was increased on an incremental level during five half-day runs included in this study. The C2 context was that the Bde was subordinated to a Land Component Command role played by the Experiment Control (ExCon), and at the lower end of the chain of command, Companies subordinated to the Bns, were also role played by ExCon.

Design and measurements

The experiment was designed as a mixed design case study. Figure 2 presents all variables that we were interested to include in this study. They have been put together in a measurement model, defining the different categories of variables and how they relate to each other. Our "independent variable", presented to the left side of Figure 2, was *Scenario Inject Type*, in two different categories: 1) Injects are supposed to violate criteria for NHC, and 2) Injects are supposed to be in line with criteria for NHC.

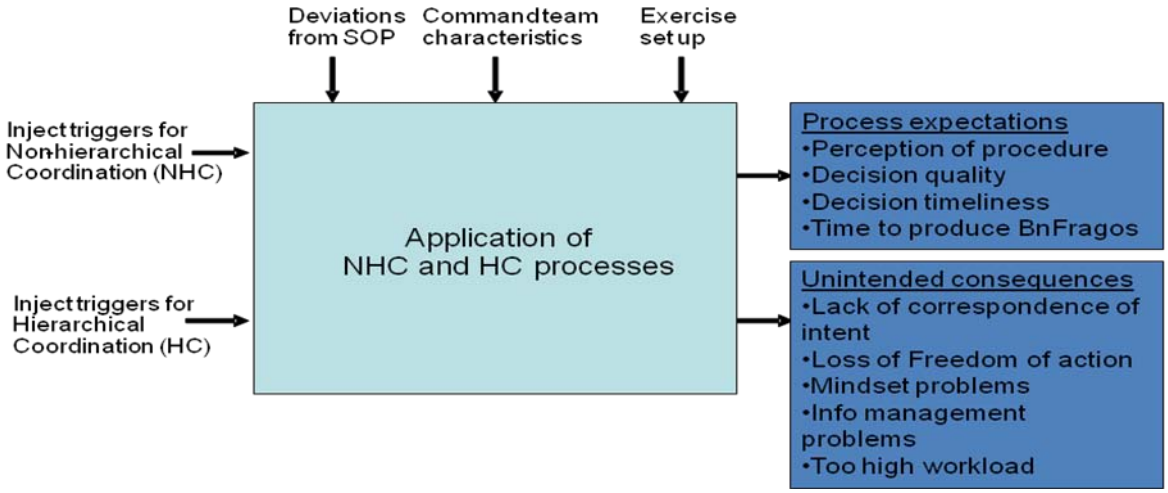

Figure 2. *The Measurement Model*

The dependent variables presented in the two right side boxes in Figure 2 were based on the expectations presented in the final part of the introduction. The upper right box consists of positive expectations and the lower right box consists of some possible unintended consequences previously mentioned. Finally, we also identified three areas of possible confounding variables to control for and these areas are presented on the upper side of Figure 2. Details on how these variables were operationalized and measured will be presented in the result section.

Technical C2 systems

The technical base for the experiment was the Swedish C2 system called "SWECCIS 2.0" (Swedish Command & Control Information System), completed with some additional functions. At the Bde level an application (SITAWARE) was used to provide a situation map. At the Bn level another application (SLB) was used to provide a sitmap function. As the SITAWARE and the SLB systems cannot transfer any data directly between each other, a third application called the "TRACK SERVER" was used. The TRACK SERVER could merge situation information from both systems and automatically provide a "Blue force

tracking" tool, whilst replicating red and green sitmap information from both SLB and SITAWARE. The TRACKSERVER was provided to both Bde and Bns. To simplify the NHC procedure in terms of letting the Bde to have visibility into the Bn SLB system, (where the Bns partly coordinated their activities) the Bde Tactical Operations Center (TOC) was also provided with an SLB client. Two other systems that were provided in order to enable coordination activities was a simulated radio system called "TVS" (which also included a telephone function) and a chat module called "SPARK". For handling of documents, both the Bns and the Bde used the same system called the "PORTAL". All units also had access to Microsoft Outlook for transmission of emails.

Procedure

Prior to the experiment, a one-week training session on the SOP and on the systems was provided. All observers also participated in the training program and the final version of the observer protocols were tested on the final applied scenario based training run.

The experiment week was initiated by a final rehearsal run in which, besides SOP procedures and C2 system, all data collection procedures were rehearsed. The actual experiment was undertaken in three days and divided into five half day runs (only one run was executed on the last day). During each run, a number of injects were introduced. The response in terms of executed SOP procedure from each staff during each run was documented by observers as well as participants. Data was collected using questionnaires and observer protocols. All data was collected, compiled and analyzed during, or directly after, the exercise. At the end of the experiment, there was a 3-hour session for the participants to re-group and provide their insights on how to further develop the SOP documents. Finally, on the next day after the exercise, a presentation and discussion of the preliminary data characteristics was undertaken with all participants. The purpose of the discussion was to further analyze and, if possible, explain the obtained results.

Results

Application of the Standard Operating Procedure (SOP)

Initially it was important to establish whether the participants were able to follow the SOP as expected, and especially, if they were able to apply, to each specific situation, the NHC and HC criteria included in the SOP (as presented in Appendix 1). Deviations from the SOP was captured mainly by the observers and reported after each run. In addition, the participants also self-reported on this after each run. Deviation from SOP was presented as a possible confounding variable in the measurement model presented in the Method section, but because of its importance it will be presented before all other variables.

Observer ratings for the statement "*The team I observed did not deviate from the SOP"* (see Table 2) showed that, in general, the observers' ratings indicated no substantial deviations from the SOP and no observer commented on any specific deviation. In Run 3, all the teams had the highest ratings by all observers signifying that there was minimal deviation from SOP in this run.

Table 2. *Mean Ratings for Both Teams and Runs on Deviation from SOP*

Teams	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Mean Ratings for Each Team**
6th Bde	3.0	5.0	5.0	4.0	4.0	4.2
61st Bn	5.0	5.0	5.0	3.0	4.0	4.4
62nd Bn	5.0	5.0	5.0	3.0	5.0	4.6
63rd Bn	4.0	4.0	5.0	4.0	5.0	4.4
92nd Bn	3.0	4.0	5.0	4.0	5.0	4.2
Mean Ratings for Each Run	4.0	4.6	5.0	3.6	4.6	

1 = Strongly Disagree,
2 = Disagree,
3 = Neither Disagree Nor Agree,
4 = Agree,
5 =Strongly Agree

Regarding the application of the NHC and HC processes, the two different processes were supposed to be triggered by the characteristics of injects. In general the scenario was designed to start with low intensity and smaller events injected to the participating staffs both through subordinated and higher levels (i. e., through Companies and LCC), and then the scenario gradually escalated to have more intense and difficult situations in the final runs.

There were a number of injects that were followed by the observers, and each inject was supposed to trigger either NHC or HC. However, there was an imbalance towards NHC, because this was the new process, but some HC injects were also necessary in order to evaluate if HC could work in parallel with NHC. Each scenario could include up to three separate injects to follow-up for each Bn and the Bde. Table 3 presents a summary of how intended injects were actually handled by the participating staff.

Table 3. *Summary of compliance with conducted injects (based on observers registration during each run).*

		Actually Executed (AE)		Sum of played injects	Total
		HC	NHC		
Intended inject response	HC	4	0	4 (12,5 %)	32
	NHC	4	24	28 (87,5 %)	
	Sum of AE injects	8 (25 %)	24 (75%)		
	Total	32			

As can be seen from the table, the result was that all four HC triggering injects were handled by the HC process. Similarly, there were also four out of a total of 28 NHC triggering injects being handled by participants thru adoption of the HC process. When we looked at the content of these four situations in order to understand why they were not handled as expected, it was evident that two of the situations were the results of misunderstandings and they were thus of less interest. The other two situations resulting in HC instead of the anticipated NHC process were more interesting because they actually suggested that the process prescribed in the SOP worked as intended. One of these situations will be presented as an example.

This situation occurred because the Bde staff interpreted the situation differently than anticipated. As presented in the SOP, the Bde can always “veto” a self-coordination between

Bns if the Bde had thought that the solution developed by the coordinating Bns was not in line with the Bde Cdr's intent. In this case, one of the Bns wanted to coordinate with another Bn in order to use a resource (a mine clearing unit) that the Bde wanted to keep for an upcoming task. Thus, the Bde did "veto" the ongoing self-coordination between the two Bns and issued directives to the Bn to use another resource (i.e., use of the HC process). This was in line with the criteria for HC as presented in the SOP. On hindsight, all four deviations registered in Table 3 indicated that the participants had a good understanding of the criteria for NHC and HC stated in the SOP. The deviations resulted because the scenario developers could not fully anticipate how the situation could be perceived by the participants at the time of the inject.

The overall result from these measurements was thus within expectations as the participants did follow the SOP and they also managed to apply the criteria for coordination in a way that made it clear to them concerning when to use non-hierarchical coordination (NHC) and when to switch to hierarchical coordination (HC).

Perception of the SOP

Our main expectation, based on our previous study (Tan et. al., 2009) was that the SOP would be perceived as an effective procedure for execution of operations in realistic field settings, and it would be perceived as an improvement compared to a traditional, more hierarchically designed procedure, because it made the C2 chain to respond more adaptively in terms of decision timeliness (i.e., problems are allowed to be solved at an appropriate level and not routinely being brought to the brigade level for resolution).

These aspects were evaluated after all runs had been performed and the results on the different items posed to the participants as statements are presented in Table 4. The rating scale was: Strongly disagree = 1, Disagree = 2, Neither Disagree nor Agree = 3, Agree = 4, and Strongly Agree = 5.

Table 4. *Mean values and standard deviations on four aspects of the SOP evaluation.*

Statements	**All N =23 Mean (SD)**	**6th Bde, N = 9 Mean (SD)**	**61st Bn N = 6 Mean (SD)**	**62nd Bn N = 1 Mean (SD)**	**63rd Bn N = 4 Mean (SD)**	**92nd Bn N = 3 Mean (SD)**
1. "The SOP used in this experiment represents an efficient procedure for doing C2 in a realistic field setting".	2.93 (.83)	2.89 (1.1)	**2.33** (.52)	3.0 (.0)	3.5 (.58)	3.33 (1.15)
2. "The criteria list included in the SOP for selecting between HC and NHC is clear and provides realistic guidelines for selecting between the two different C2 coordination processes".	3.67 (1.18)	3.33 (1.0)	2.83 (.98)	4.0 (.0)	4.5 (.58)	3.33 (1.15)
3. "The ability to do NHC in certain situations according to the SOP is an improvement to C2 coordination in realistic field settings compared to traditional hierarchical coordination".	3.67 (.96)	3.44 (.75)	3.83 (.41)	4.0 (.0)	4.25 (.96)	3.0 (1.7)
4. "NHC saves time in the coordination process and contributes to actions being implemented more timely in realistic field settings".	3.74 (.71)	3.44 (.73)	4.17 (.41)	4.0 (.0)	4.25 (.5)	3.33 (1.15)

As can be seen from Table 4, the results were not on the positive side for all four aspects. A mean value close to 4 or above indicates an average agreement, which is positive. Mean values close to 2 or below indicates an average disagreement which was negative regarding our expectations. There was only one evaluation from one Bn that was clearly negative. However, none of the other Bns or the Brigade are enthusiastic over the new SOP as their ratings are close to 3 (= undecided). However, the overall mean value on evaluation items 2-4 (Table 4) indicated an average agreement (mean values close to 4) on all these items, but if we look at the specific mean values from each unit, it was obvious that some units were closer to undecided (rating 3) on some items. So how can the negative or undecided ratings of the SOP and the NHC procedure be interpreted? After all runs had been completed we arranged a SOP workshop to gain a better understanding of some of the verbal comments and explicit suggestions that were made to improve on the SOP. Some comments provided by the participants during the workshop were useful in order to understand the negative ratings.

There were two main areas of improvements that were requested by some of the Bns or the Bde. One area concerned the criteria for NHC and HC and the other was on the details of the instructions on how to utilize the systems. Regarding the criteria three of the Bns had added minor remarks pertaining to the clarity of the details. All the remarks from the Bns regarding the criteria can be viewed as minor and could easily be clarified. One remark from the Bde was that they perceived a risk (in general) that if Bns were not properly manned to do self-coordination to a large extent, they risked being overloaded. However, in the continuing presentation of the results, it was obvious that the Bns did not have a feeling of an overwhelming workload.

The other main area for criticism of the SOP was the perceived need for more clarity regarding when to use a specific system and for what purpose? For example, how many overlays should be used and how they should be named. This was something that had to be tailor-made to each specific C2 situation, depending on organization, and should not be a big problem.

However on the positive side, the free text comments made frequently by the participants after each run had confirmed the observation fact that the ability to have visibility (through the SLB system) of the lateral Bns sitmaps, and the ability to coordinate over chat (the SPARK system) had indeed reduced information management problems and allowed the Bns and the Bde to be adequately updated in order to make easy usage of NHC procedure. Initially the Bde decided that NHC should be done over the (voice) radio net on the Bde channel. But as experienced during Run 1, it became obvious that this did not work well, mostly due to too much “clutters” and delay. For Run 2 the decision from the Bde (i.e., the participants themselves) was to use the chat system for NHC, and from Run 2 onwards, several participants reported the adjustment to had worked very well and have created a traceable line of communications that could be followed by all Bns and the Bde in the network. One problem however, reported by some participants was that the sitmap info in SLB did not always reflect the current situation as it was developed over the chat system. Some delays in the SLB compared to the actual situation were perceived although not specified by the reporting participant.

The overall results from the evaluation of the SOP indicated that the participants perceived that there were some areas for improvements regarding the level of details needed in order to implement the SOP for field use. However, it was also clear that a large number of participants perceived the new SOP with the NHIM procedure, the NHC criteria and process as an improvement compared to the traditional HC process and as having saved time in the coordination process leading to actions being implemented more timely on the ground. Most participants could see the advantages with both types of coordination in different

circumstances and those advantages were in line with the criteria for NHC and HC implemented in the new SOP.

Decision quality and timeliness of decisions

As the bearing thoughts in NHIM and in NHC, as presented in the introduction, were related to *decision quality* and *decision timeliness* of actions/reactions, we measured both *quality* of the actions (as manifested in orders issued from the staffs) and the *timeliness* of these orders. We measured whether the NHC decisions (made by the Bn Cdrs) met the *quality* and *timeliness* criteria of the person who should have made those decisions if the NHC procedure was not in place, i.e., the Bde Cdr. Thus, after each run we had the Bde Cdr and the TOC Director of the 6 Bde to rate the quality and timeliness of the actions taken and orders issued at the Bn level.

The Bde Cdr and the TOC director rated on the same five-step rating scale as previously described and made an agreement on the rating for each Bn after each of the four first runs. During Run 5, the Bde was cut off from the communication for a long period and subsequently could not do the evaluation. The rating scale was: Strongly disagree = 1, Disagree = 2, Neither Disagree nor Agree = 3, Agree = 4, and Strongly Agree = 5.

Regarding the decision quality and timeliness, the following two statements were presented to the Bde Cdr and the TOC director: (1) For each Bn, rate how agreeable you are to the statement: "*The quality of the FragO and other information produced by the Bn during the last run was adequate*". The mean value of the ratings from all runs and for all Bns was 5 (SD = 0.0, Min 5, Max = 5); and for the second statement, (2) For each Bn, rate how agreeable you are to the statement: "*During the latest run, the Bn produced FragOs in a timely manner*". The mean value of the ratings from all runs and for all Bns was 4.25 (SD = 0.5, Min = 4, Max = 5). Also, all the observers to the Bns made quality and timeliness ratings on the same rating scale and their corresponding mean values (and SD) were 4.4 (SD = 0.71) for Quality and 4.6 (SD = 0.81) for Timeliness.

Thus, the results show that the quality, timing of actions and orders made by the Bn Cdrs during NHC met the standard expected from the perspective of the Bde and from the observers. This means that both the Bn team members and the observers agreed that the Bns had made appropriate decisions and implemented those decisions (and actions) in a timely manner during all runs.

Time to produce battalion fragmentary orders

Regarding the time to produce Bn FragOs, the original idea was to be able to compare results between Bns when they did NHC and when they coordinated through the Bde (HC). However, this approach was not feasible, partly because there was no balance between HC and NHC runs, and partly because it was difficult to define what should be included as a "Bn FragO". We had marked a number of specific scenario injects to be followed up by the observers, but as indicated earlier, we could never be sure how these injects would be perceived by the participants. Nevertheless, the mean response time to make a decision on how to handle an inject at the Bn level over all five runs was 21.6 minutes (SD =18.2; Min = 1, Max = 93 minutes). Twelve of these decisions and orders were made in less than 10 minutes; only two of them took more than an hour. This result supports and complements the previous result that FragOs where produced in a timely manner.

Potentially unintended consequences with NHIM and NHC SOP

Although we expected the SOP to be an effective procedure and the default routine for *information management,* we also identified a set of potentially unintended consequences

when the NHIM and NHC process was introduced, and these were previously presented in the final part of the introduction, and also in the measurement model (Figure 2, bottom right square). We took several different measures on all of these variables but due to limited space and to the fact that only one of them was partly observed, we will only report briefly on that variable.

In order to measure if the Bns self-coordination had resulted in any activities not in line with the Bde Cdr intent the Bde cdr and TOC director after each run rated four different statements on the same 5-step likert-scale presented above. The four statements was as follows:

(1) Rate how agreeable you are to the statement: "*The correspondence of the plan and execution of the observed team was in line with the Bde commander's intent*".
(2) For each Bn, rate how agreeable you are to the statement: "*During the latest run, the Bn has made the correct decisions and taken the correct actions from the Bde CO perspective*",
(3) For each Bn, rate how agreeable you are to the statement: "*Decisions made by the Bns as a result of NHC did not result in any unintended consequences for the Bde*".
(4) For each Bn, rate how agreeable you are to the statement: "*Bde CO and staff accountability to superior commanders is not blurred as a consequence of NHC between Bns, and the Bde CO and staff is prepared to take responsibility for decisions made and actions taken at the Bn level*".

All mean values on these ratings from all runs, except for run 5, were above 4. Ratings close to 4 or above means agreement with the statements, and it is interesting to note that the only values lower than 4 resulted from the last run, when the Bde was cut off from communications and the Bns had to self-coordinate without the ability from the Bde to use a "veto" in the Bns planning phase. This resulted in a Bns plan to set up a task force to protect the Airport of Debarcation (APOD) when it was threatened during Run 5. Although the protection of the APOD was first priority of the Bde, the Bde still did not approve of the way the task force was composed. Instead, the Bde had another solution and as soon as the communication was re-established the Bde changed the Bns plan and performed hierarchical coordination regarding the protection of the APOD.

Together these results indicate that implementation of the NHIM and NHC procedure *per se* did not result in Bn activities not in line with the Bde cdr's Intent, but when the Bde was cut off from its ability to "veto" (by an arranged communication break-down), then some problems arised.

Possible Confounding Variables

In order to fully understand and explain the results, we also included a set of possible confounding variables that were presented in the measurement model (see Figure 2). We took several different measures on these variables but due to limited space we will only report briefly on those two confounders that seemed to have affected the results. These variables were *Scenario Realism* and *System Failures* and they were both sub-variables to the variable Exercise Set-up (see Figure 2).

In order to measure perceived scenario realism, participants were asked, after all runs had been completed, to agree or disagree with the following statement: "*The realism of the scenario was sufficient to play/act my role in a serious way*". A five-step rating scale was used: (1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree). The mean rating for the 63 Mech Bn was indicated agreement but for units other than the 63 Mech Bn it fell below 4. For 6 Bde and 62 Bn their average rating indicated "undecided" (around 3) but for 61 Bn and 92 Bn, the rating was close to 2, indicating a clear position that the scenario was not realistic enough for them to be able to act seriously in their

roles. In their verbal comments to ratings some participants mainly provided feedback that the pace at which injects were presented mainly in the final run was unrealistic.

In order to measure the impact of system failures, we used the following measurement: After each of the five runs the participants individually responded (Yes/No) to the following statement: "*Did any technical failures or issues occur during the run which affected your personal performance?*" The result was that there were frequent reports of system failures, especially for one of the systems (SLB) during the entire experiment and participants reflected in the survey that this had affected their performance and limited what they could do for missions in the experiment.

In summary, the *scenario realism* as a confounding variable could have played a significant role in affecting the results of the experiment as the realism was perceived to be low, at least after Run 5, by a significant number of participants. *System failures* also seemed to be a major cause for concern as a potential confounder to the experiment. The influence of these confounding variables will be discussed in the final section of this report.

Discussion

The purpose of this experiment was to *validate* a Bde-Bn SOP, including a detailed information management procedure called NHIM, and a rule- or criteria based self-coordinating procedure for coordination among the battalions, called NHC. The result from the different measurements indicated that the SOP worked rather well, resulting in timely and accurate decisions and actions at the self-coordinating Bn level. The positive expectations we had from an earlier experiment (Tan, et. al., 2009) were generally met. The new self-coordination procedure (NHC) based on sets of criteria was also seen as an improvement by most Bn staff members for realistic field settings as compared to traditional hierarchical coordination. NHC was also perceived as a time saver by the Bns, contributing to more timely actions, although these views were not so clearly shared by the Bde staff members. However, the participants and the observers had found it easy to select between the two coordination processes. Generally, participants were receptive to the new SOP, i.e., that NHIM and NHC SOP, with their conditions were a good entry level for edge force concept and operations. However, both SwAF and Singapore Armed Forces teams acknowledged that individual armed forces would have to further customize the new SOP to their unique cultural context and organizational appetite for greater empowerment.

It was also clear that the technical C2 systems (when they worked), had provided participants with easy access to all documents and sitmap information for self-coordination. The systems had successfully facilitated self-coordination procedure among units. Bns were able to follow in real-time the development of the situation in neighboring Bn areas and anticipated when to offer assistance to a lateral Bn Cdr, or who to turn to for request of assistance. The chat function was a very useful tool in allowing units to keep track of the situation development and results of NHC between different Bns, and this was in line with previous findings, (e.g., Simpson, 2006). One important reason for this was that chat left a useful trail of decisions made. Operators therefore do not need to take notes as chat helps keep track of what other units are doing even if the operator had to leave his position for a while.

The possible unintended consequences with the new NMIM and NHC procedures that we identified in advance of the study did not materialize, and this was something we tried to prevent already in the design of the SOP. The Bn Cdrs were in most cases able to act in line with the Bde Cdr's intent, and only in one occasion, when the Bde was cut off from communications, did the Bn Cdrs come up with a plan that was not perceived to be in line with the Bde Cdr's intentions, and that, of course, could not be the fault of NHC procedure. In all other cases and according to the SOP, the Bde was able to monitor the Bn self-

coordination process, and in a few cases they used their ability to "veto" the self-coordination process in an early stage, and in a way that was fully in line with the NHC criteria.

How about the validity and reliability of these results? First, regarding reliability, we took several different measurements on many of the dependent variables. We did not depend solely on self-evaluation by the participants, but we also used military observers (and we also took measures to increase their inter-rater reliability by scoring and comparing scores during the training run). As the differences between different types of measurements on the dependent variables were generally small and unsubstantial, we conclude that the reliability in the measurements was acceptable.

Regarding the validity, or the ability to generalize our results to other and more realistic situations, we have at least two confounding variables that seemed to have affected the experiment and thus possibly also affected the validity of the results. One area was the low confidence in the scenario realism; the other was the frequent system failures. However, as the main criticism of the scenario was that it was too intense and unrealistic in the sense that too many things happened too fast, we thought that this was not a threat to the validity of the results. The reason was that although we sometimes exposed the participants to a very high paced scenario, the NHIM and NHC procedure still worked well, which means that it should probably work well in a real environment where the pace is often slower. Also, the overall sentiment that the speed was unrealistic could have stemmed solely from Run 5 being higher in intensity coupled with the loss of communication. This could be due to the evaluation question regarding the scenario realism being placed in the Post-Experiment Participant Survey which was done after that particular run. If this was such, perception of realism would not have affected the results or on how the participants performed for the other runs.

Regarding the system failures, the same reasoning as for scenario realism could be used. Although there were frequent system failures, to a level that sometimes made it difficult for the participants to act properly, the NHIM and NHC procedure still worked, due to systems redundancy. This means that the procedure should work also in a more stable system environment. However, one possible negative result of the rather frequent system failures in some runs could be that it affected negatively the evaluation of the SOP.

A third area of importance for the ability to generalize the results is also related to the scenario, but even more to the specific type of operation that was conducted. We conducted a PS/PE scenario that for most runs (with the possible exception for Run 5) included only activities related to that kind of low intensity operation. Therefore we found it difficult to generalize our results to more traditional force-on-force scenarios as they were in many important ways different, especially regarding operational tempo, severity of the activities and the need for coordinated actions.

To conclude this discussion on validity and reliability, we opined that our results should be fairly valid for realistic field settings and specifically for PS/PE type of operations. For more traditional operations we opined that the SOP must be adapted and tested further.

Final conclusion

This study demonstrated the potential usefulness of the NHIM and NHC SOP in PS/PE operations. The criteria for NHC and HC that were painstakingly developed between Sweden and Singapore proved to be useful guidelines for selecting the appropriate type of coordination during execution. We also think that in the current environment where PS/PE is the rule rather than the exception for our troops, the NHC criteria can be valuable. As observed, current phenomena such as the so called CNN effect (in combination with better technology and lower operational tempo) has shown the limitations of traditional "mission tactics" or "mission command" because of the undesired effects of our actions. Our NHC/HC criteria can actually be seen as a means to guide command in a way that will make it more

flexible or agile. Instead of using the concept of "mission command" which tends to be rather unspecific, our criteria developed for use with the NHC concept (which can be viewed as a kind of mission command) and HC concept (which can be viewed as more centralized command) could provide clearer and hence more effective guidelines on when NHC or HC should be adopted in an operational context.

Finally, in the next step it would be interesting to make at least some of the improvements to the SOP that have become obvious to us from the results of this study, and then to test the SOP in a traditional force-on-force scenario. Based on earlier result from studies on self-coordination, there is reason to believe that the advantages of a NHC and NHIM procedure should be even greater in a time-pressured and highly complex scenario (c.f., Brehmer, 2009; Dekker, 2006).

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Appendix 1

This is an excerpt from the Brigade SOP presenting the rules and criteria for both NHC and HC and also presenting the guidelines for Commander's Intent statement.

1. Non Hierarchical Coordination (NHC) Guidelines

1.1 Basic Rule

Non-hierarchical coordination (NHC) is mainly applied during execution and should not prevent the Bde HQ from coordinating between Bns in the OPPLAN. However, during planning, the Bde HQ should prepare the plan in such a way that NHC between Bns during execution of the plan is facilitated. This is primarily done by providing a clear intent (see section 1.7) for the mission. It is also possible for the Bde HQ to task the Bns (through FRAGOs) without completing the detailed coordination, instead of regulating all the details, and hence require the Bns to conduct certain degree of self-coordination. NHC is most likely to occur at the boundaries of adjacent units operating next to each other, which require more detailed coordination in terms of time and space, sharing of information pertaining to the threats and potentially resources to accomplish the missions. Should NHC likely be required, this should be identified by the Bde HQ or highlighted by the Bn HQs during planning.

Non hierarchical coordination (NHC) between Bns during *execution* is the rule and hierarchical coordination (HC) is the exception. This is based on the assumption that the Bde HQ has the ability to intervene in the coordination process if his subordinated units coordinate in a way that is not in line with Bde Commander's intent. The ability for the Bde HQ to intervene presupposes that the Bde HQ is informed of the Bn –Bn coordination through the communication channels of the C2 system. It is the responsibility of the Bn who initiates the NHC with a lateral Bn to make sure that the Bde is informed of the NHC process. Should the communication with the Bde HQ fail, the Bns can also proceed with NHC if it meets a set of criteria.

Although NHC is the default mode for coordination, the selected mode of coordination in each specific situation is determined by whether the criteria for NHC are met in the specific situation. The following paragraphs described the criteria as to when coordination should be done by non-hierarchical self-coordination (NHC). If the criteria are not met, then the Bn should seek coordination from the Bde HQ (i.e., Hierarchical coordination) or clear with the Bde HQ before initiating any bilateral coordination.

The following provides the Criteria list that is supposed to give guidelines for:

1. When a Bn can offer assistance directly to another Bn
2. When a Bn can ask a lateral Bn for assistance (instead of asking the Bde)
3. What must be specified when a Bn asks another Bn for assistance (instead of asking the Bde HQ)
4. When the Bde HQ should be involved in the coordination between Bns during execution of a mission

1.2 When can a Bn offer assistance to another Bn?

A Bn can offer assistance to a lateral Bn if he realizes that the other Bn needs assistance, or if he realizes that there is an opportunity to exploit that will shape the outcome of the overall mission if assistance is offered in a proactive way.

If the Bde HQ has visibility (through the C2 system), then the following criteria for NHC apply:

1. My intended action is clearly within the HCdr intent.
2. My intended action can be taken without 18eopardizing my mission.
3. The consequences of intended actions (making a wrong decision) are not severe.

If these criteria are not met, the Bn should ask the Bde HQ for Hierarchical Coordination or clarify the situation with the Bde HQ before initiating any bilateral coordination. In the event that the Bde HQ does not have visibility over the Bns, NHC should still occur if the following circumstances apply:

1. It is time critical (need rapid reaction)
   - No time to await a decision from Bde HQ or no way to contact Bde HQ
   - Severe consequences to lateral battalion if I do not assist
   - Bn has spare/available assets or a reserve that he does not need to use
   - Lateral Bn will fail his mission if I don't assist
   - No other assistance is available to lateral Bn or if others are available, they cannot assist immediately.

2. My intended action will clearly assist the overall mission of the Bde
   - Lateral Bns mission is more important than my own mission

1.3 When can a Bn ask a lateral Bn for assistance?

A Bn can ask for assistance from a lateral Bn if he realizes that his own Bn needs assistance, or if he realizes that there is an opportunity to accomplish something fundamental that will shape the outcome if assistance is received in a proactive way.

If the Bde HQ has visibility (contact through the C2 system), then the following criteria for NHC apply:

1. My intended action is clearly within HCdr intent.
2. My intended request for assistance is necessary to fulfil my mission.
3. The consequences of intended actions (making a wrong decision) are not severe.

If these criteria are not met, the Bn should ask the Bde HQ for Hierarchical Coordination or clarify the situation with the Bde HQ before initiating any bilateral coordination. In the event that the Bde HQ does not have visibility over the Bns, NHC should still occur if the following circumstances apply:

1. It is time critical (need for rapid reaction)
   - No time to await a decision from Bde HQ or no way to contact Bde HQ
   - Severe consequences to own battalion if I do not get assistance
   - Own Bn will fail the mission if I don't get assistance
   - No other assistance is available to own Bn or if others are available, they cannot assist immediately.

2. My intended action will clearly assist the overall mission of the Bde
   - Lateral Bns mission is less important than my own mission

1.4 What must be specified when a Bn asks for assistance from another Bn?

If a Bn asks for assistance, it must specify the following information to the lateral Bn when asking for assistance:

- Who/What are the force/resources you are asking for?
- What is the task that the assisting unit is to help up?
- Where is the place you want the assistance to go to (link up point and location to execute the tasks)?
- When should the task be completed?
- Why are we doing this (should be in line w Hcdr intent)?
- How is the assisting unit supposed to solve the task (only necessary coordinating instructions)?

1.5 Hierarchical Coordination (HC) Guidelines

Hierarchical coordination between subordinated Bns during execution should be done by the Bde HQ when it is requested from a Bn, if the criteria for NHC under 1.2-3 are not met. This means that HC should be done under the following circumstances:

1. The situation calls for an action/response involving two or more subordinated units, and that action is not clearly within the provided Bde Cdr's intent?
2. The situation calls for a coordinated action that might jeopardize a current task given to a subordinated Cdr
3. The situation calls for coordination between two or more subordinated units and the consequences of making a wrong decision (by the subordinated Cdrs´) or taking the wrong action could be severe to the Bde or the whole force mission.

1.6 Bn Self Coordination Procedure

When the Bns go into NHC, the following procedure should be followed;

1. Identification of a need for assistance or opportunity to assist another Bn
2. Coordinate within own staff
3. Radio conference with lateral Bn to establish preliminary agreement
4. Notify the Bde Staff about preliminary agreement
5. Follow up with coordination agreement on SLB

N.B.: As stated in the SOP, a clear Commander's Intent is a very important tool for conducting effective NHC, and although we did not test new ways to formulate NHC we still provided some suggested guidelines in the SOP and they were as follows (excerpt from the SOP):

1.7 Commander's Intent

For Non-hierarchical coordination to work, it is important to have a common understanding of the Commander's Intent through the chain of command, all the way down to squad leader level. For Flexible Integrated Theaterwide Experiment (FITX) 2, we are only testing two hierarchical levels (Bde HQ-Bn) and hence the focus will be on creating a common understanding between the Bde HQ and Bns. FITX-2 is not testing new ways to formulate or convey commander's intent, but there is still a need (based on observations from FITX-1 and other studies) to highlight some suggested routines for communicating commander's intent from Bde HQ to Bns, and for Bns to ensure that they understand the commander's intent. In addition to providing a written intent, as normally provided in an orders including FRAGO, the following measures could be taken:

1. Provide intent in both writing and voice communication over the radio
2. Elaborate the criteria for success
3. Elaborate not only what is intended to accomplish, and how, but also what is important to be avoided.

4. Elaborate what could be the minimum requirements, if the intent cannot be met to 100%
5. Encourage clarifications from the Bn Cdrs so they can have a deeper understanding, e.g., “what if...” questions from the Bn Cdrs.
6. Request back-brief of the commander’s intent so that the Bde Cdr can be sure that the Bn Cdr has understood the intent.