On How Simulations Can Support Adaptive Thinking in Operations Planning

Jo Erskine Hannay, Karsten Brathen, Jens Inge Hyndøy
FFI – Norwegian Defence Research Establishment
P.O. Box 25, NO-2027 Kjeller
NORWAY

jo.hannay@ffi.no karsten.brathen@ffi.no jens-inge.hyndoy@ffi.no

ABSTRACT
Modern operations planning directives have well-defined stages for developing, testing and rehearsing plans. At the same time, it is acknowledged that warfare is highly unpredictable and hard to plan. However, it is also acknowledged that the planning process in itself gives insights that may prepare for unpredictable situations. We outline how simulations might support and augment operations planning processes by supporting and developing so-called adaptive thinking. In particular, simulation-supported course of action analysis enables multiple trials and analyses, which, (1) enables planners to investigate a larger number of COAs with consequences, thereby broadening the perspective of planners to the possibility of diverse outcomes, (2) may include critical cases generalizable to ranges of COAs, and (3) may include elements targeted to induce adaptive thinking directly. The latter may employ artificial elements to target task processes central to adaptive performance. We conclude that so-called passive decision support systems in a case-driven simulation mode is appropriate for enhancing adaptive thinking.

1.0 INTRODUCTION

The Chief of Staff of the Prussian Army, Field Marshall Helmuth Karl Bernhard Graf von Moltke stated: "No operation extends with any certainty beyond the first encounter with the main hostile force" (translated from [1] in [2]). The statement has since been familiarized to "No plan survives the first bullet" and similar paraphrases. The gist of this statement is that it is unrealistic to create a plan for a military operation with the expectation that events will unfold (even remotely) according to what is foreseen in the plan.

Still, plans are made. To paraphrase a former U.S. President: "In preparing for battle, I have always found that plans are useless, but planning is indispensable". The insights one acquires when devising a plan are crucial to developing an understanding of the factors that will influence the events that will actually happen, likely, counter to plan. In turn, this should benefit the commander in making decisions when events occur that were not foreseen in the plan. Working further along this line of thought, one could say that the purpose of the act of planning military operations is, paradoxically, to prepare for actions for when the plan fails.

This view of the planning process is in line with modern management practices that recognize the futility of too early and too detailed planning in the context of rapidly changing situations [3], [4], [5], [6], [7]. The alternative to planning is not to abstain from doing any preparations at all. Rather, it is to plan and prepare for the right things at the right times. Among other things, this means to postpone planning until there is adequate information, and to plan at a level of detail for which the available information gives grounds. This may be at odds with directives that do not directly support sufficient flexibility.

A process that allows timely planning, would be designed to facilitate continuous learning along the lifespan of the operation. Using the insights about the operation that this learning provides, planners would be free to engage in iterative planning and replanning at the appropriate level of detail without the burden of having to predict the future on questionable grounds.

In line with both modern management practices and research on work performance in unpredictable domains, commanders at all levels need to acquire a capability of *adaptability* to be prepared for rapidly changing situations and chains of events. On the one hand, there must be training programs in place that target the acquirement of adaptive behaviour in the large. On the other hand, the planning process itself must promote adaptive behaviour by priming commanders to prepare for when the plan fails.

Thus, the planning process should be seen as an arena for learning; specifically, for learning and preparation for the operation under planning. In other words, training for acting in a rapidly changing environment on the one hand, and the act of planning on the other hand, are two sides of the same coin.

The objective of the work reported in this paper is to lay the foundation and outline the major design principles for simulation support to operations planning as an arena for learning. We highlight the operational argumentation for the planning process being instrumental to prepare for deviations from the plan, and we underpin this argumentation in a body of research conducted in the field of task analysis and judgement and decision making.

Research has argued convincingly that developing skills for changing and unpredictable situations requires specialized training which employ artificial elements that deviate from on-the job-situations. In the defence domain, the "train as you fight" doctrine may therefore not be sufficient [8]. Our deliberations therefore also respond to the call on us in [9] as authors of [10], to "[...] elaborate on the provocative statement that 'training as you fight is not enough' and their perceived need to introduce artificial events to train decision making and judgment".

In Section 2, we outline the planning process prescribed in NATO. In Section 3, we outline how simulations may support operations planning. We outline relevant notions from research in expertise and learning in Section 4, and in Section 5 we render an inspiring case from the U.S. Army. In Section 6, we suggest more detailed how adaptive thinking can be boosted in and by the planning process. We consolidate the discussion in Section 7 and conclude in Section 8.

2.0 OPERATIONS PLANNING

The NATO Comprehensive Operations Planning Directive (COPD) covers operations planning procedures at the NATO strategic and operational levels, with interactions with the political layer and subordinate layers. The COPD prescribes an incremental process in phases that involve all levels of command. Thus although the COPD explicitly covers planning at higher levels, the structure and phases of the COPD are applicable to lower levels of planning as well. For example, the Norwegian Army Planning and Decision Process [11] prescribes a COPD structure to planning on national brigade and battalion levels.

Roughly, an operations plan evolves through the planning process as follows: The political level perceives indications of a crisis, and underlying levels are subsequently involved in gathering information. If a response to the crisis is called for, draft response options are developed and passed down through levels, which get refined and passed back up. From these, the Concept of Operations (CONOPS) – a high-level outline of the intention and means of the operation – is developed in a similar incremental manner involving all levels of command. As part of developing the CONOPS, different Courses of Action (COA) – foreseen sequences of actions to be performed by BLUEFOR in various situations of the operation – are designed and evaluated, with input from supporting units (intelligence, engineering, logistics, etc.). The CONOPS is then refined incrementally into an Operations Plan (OPLAN), which is then executed. Main actors in the planning process are the planning and intelligence officers at each level who collaborate with other staff at their respective levels in an Operations Planning Group (OPG).

As pointed out in [2], some parts of an operation are easier to plan for than others. For example, mobilization, transport and force deployment is generally easier to plan since there is usually little contact with opposing forces. But Moltke did not prescribe detailed plans after deployment "The higher the headquarters, the shorter and more general will be the orders. The larger the main subordinate units, the more freedom must be left to them" [2]. Dr. Jim Storr, a British Army Officer states a similar view: "Trying to expand the plan into a closely synchronized plan is a fundamental error and a pervasive weakness –

one of attempting to foresee the future rather than impose one's will on the enemy. Commanders on the spot should be allowed to make and execute decisions based on the real situation, not on a closely synchronized plan made in advance or at a higher level [...] [which is] to attempt a precision which the nature of the subject does not admit. [...] A further error is that of trying to plan too far ahead. Combat is unpredictable. [...] If you plan to fight tomorrow, do not plan the next day in anything but the most general detail" [12, p. 142–143].

These remarks point out that planning should be distributed. Indeed, the COPD prescribes a distributed process, so that decisions can be made at the level of detail appropriate to those who both need that detail and have the information to generate it. The remarks also points out that various stages of an operation need different types of planning: Some parts are predictable and can be planned in some detail, while other parts are unpredictable to the degree that the main aim of planning should be to prime oneself for when the plan fails. The important question is how simulation can support this.

3.0 SIMULATION SUPPORT FOR OPERATIONS PLANNING

The concept of simulation support for operations planning sorts under the field of Decision Support Systems (DSS); in particular under *model-driven* DSS in Power's DSS taxonomy [13], by virtue of the simulation models employed.

3.1 Decision Support Systems

An important issue in our discussion is how the user interacts with the DSS. Hättenschwiler [14] characterized DSS as passive, active, and cooperative. A *passive DSS* provides data, visualizations etc. as aids to decision making, but it is up to the user to design solutions and make the final decision. In contrast, an *active DSS* is designed to produce solutions to the user; i.e., performs a large part of the decision process for the user. A *cooperative DSS* combines passive and active characteristics. It will provide users with possible solutions, but the user will make decisions as to which solutions to follow and can modify solutions at will [15].

There is a level of user-interaction in all these modes, although it may be up to the discretion of the user to actually provide that interaction. The important question is how the user actually perceives and uses suggestions and solutions from a DSS, and how suggestions and solutions from a DSS support and build appropriate planning and decision-making skills in the commander.

At the active end of the scale, simulation support for planning may e.g., explore a space of possible outcomes, perhaps to generate the "optimal plan". At the passive end of the scale, simulations may simply animate the plan to show its direct consequences. Advanced techniques include data farming [16], [17] which can be used to search probabilistically through a universe of possible events to generate a range of outcomes to be chosen from according to statistical criteria. Another technique is to use simulations and graph traversal algorithms to generate the optimal sequence of actions for reaching a desired outcome [18], in terms of effects-based planning in the effects-based approach to operations (EBAO) regime. A third technique might use simulation technologies to assess the likelihood of reaching some set of possible future states [19]. These techniques can underlie DSSs along the whole active-passive range, but in general, techniques will provide varying degrees of transparency to the user as to what is being modelled and simulated, as well as user participation in constructing results.

The approach that we focus on in our discussion contrasts to that of generating the optimal plan. Rather, we elaborate on simulation support for boosting the commander's planning and decision skills. In that sense, one would not want a DSS that suggests solutions for the commander. Rather, the DSS should support the commander by showing consequences of the plan in a transparent manner; i.e., we are looking for a passive, rather than an active DSS.

3.2 Notions from Empirical Research Methodology

To further characterize the type of DSS appropriate for various types of planning activity, it is useful to borrow notions from empirical research methodology.

3.2.1 Statistical approach

Simulations in active DSSs are designed to provide statistical measures [20]. By generating and simulating a large number (enough to obtain sufficient statistical significance and power) of events and scenarios, e.g., reflecting different COAs, one can aim to measure differences in efficacy of groups of scenarios.

This is analogous to empirical studies that generate and/or test hypotheses on statistical significance. By design, such studies investigate causal inferences between variations in some variables and the ensuing effects in other variables dependent on the first ones, leaving the internal workings of how these effects come about uncovered [21]. To gain statistically valid results, a very large number of units of analysis must be incorporated. Thus, such studies do usually not give researchers deep insights into underlying mechanisms and processes. The underlying statistical models may embody such insights, but usually not at a level directly accessible to researchers without further analysis, and in particular not to practitioners. Similarly, simulations to generate an optimal plan will investigate the effect that variations in assumed salient parameters will have on reaching a desired outcome (according to EBAO, say), without uncovering the underlying processes as to how these effects come about. By design, then, this does not focus on developing a deeper situational awareness with the commander and does not aim at supporting or building planning and decision making in terms of cognitive ability.

3.2.2 Case-driven approach

In contrast, empirical studies based on case studies [22] rely on investigating a limited number of units of analysis in depth. The objective is to understand underlying mechanisms for observed phenomena, perhaps identified through statistical studies such as those mentioned above. Similarly, simulations used for uncovering the underlying processes that effect the unfolding of an operation, must allow the commander to understand underlying mechanisms that lead to particular outcomes in the field.

3.3 Approaches to simulation support for boosting skills

Needles to say, both analytical and case-driven modes of research are complementary and mutually dependent on each other, and researchers must employ both types of methods to understand whatever it is they are attempting to understand. In principle, the same should be true for simulation support for commanders in understanding operations. However, there is a difference in that commanders must reach decisions quickly in battle, whereas researchers are at liberty to spend time analysing statistical results. This reality has implications for what kind of information is useful for decision making in operations. Thus, an active or collaborative DSS used in a statistical approach might have to implement sophisticated models or rule engines in order to provide timely and relevant information.

All variants of simulation-based decision support along the dimensions of statistical–case driven and active–passive are relevant for planning. However, for the aim to design or use a DSS to boost commanders' decision making skills; in particular as part of the planning process, we focus on a passive, case-driven approach. We now suggest three lines of investigation that further refine the case-driven approach:

1) *Increased exposure to cases*: Simulations enables planners to investigate a larger number of COAs and their possible consequences. This may broaden the perspective of planners to the possibility of diverse outcomes, simply by uncovering sequences of events that may not otherwise have occurred to the planners. This speeds up the rate of experience gain more than real situations will enable, and aims at artificially stimulating the *Extended experience* aspect of the *Expertise* concept (Section 4).

2) *Critical cases*: Construct cases so that the understanding obtained from a case can be generalized to other situations than that case covers. Three principles are useful in designing critical cases [22], [23]. (1) Advantaged case: Negative results obtained from such a case can be generalized to cases that are less advantaged. A simple example is a COA in which a BLUEFOR unit is planned to manoeuvre with flank support. If that unit is defeated in a wargaming simulation, then one can reason that the unit will be defeated with less support in an equivalent situation. (2) Disadvantaged case: Positive results can be generalized to cases less disadvantaged. For example, if a unit succeeds in seizing a target using only a subset of assets available, then one can reason that the unit will succeed with more assets. (3) Essential case: Results obtained from such a case can be generalized to other cases of the same essence. Note that generalization can take place to the degree that one understands the mechanisms behind why events did unfold as they did. The critical cases mode aims at stimulating the *Extended experience* aspect of *Expertise* as above, but may also stimulate the *Superior cognitive representation and organization* aspect of *Expertise* (Section 4) by clustering cases according to ranges of generalizability. Indeed, it requires expertise to define critical cases, but embedding this expertise in cases enables others to benefit from expertise that normally might be present in highly skilled individuals only.
3) *Deliberate practice cases targeted at adaptive thinking*. Such cases would target building the *Superior cognitive representation and organization* aspect of the *Expertise* concept directly. If successful, training programs that implement such cases may aid in building expertise quickly and more efficiently, which may otherwise take a whole career to acquire in on the job learning.

In the next section we recount notions from the fields of of expertise and task analysis that are relevant for adaptive thinking and that underpin the three lines of research above.

4.0 LEARNING AND EXPERTISE

There exists a large body of research on the concept of *Expertise*. Expertise is understood to be specific to tasks within a given domain [24], [25], [26]. It is common to associate several aspects to expertise, which are all related; see Figure 1. For example, in acquiring a skill [27], [28], [29], a person starts by acquiring declarative knowledge from books and tutorials and builds mental models that give appropriate cognitive representation and organization of knowledge. Further, through practice, declarative knowledge is transformed into procedural skill, which at first is slow and error prone [29]. Then, through *extended experience*, performance improves. The high-performing expert has *superior cognitive representation and organization* of knowledge that enables appropriate action with less cognitive effort, compared to novices [24], [30]. In addition, experts should exhibit *consensual agreement*, in that they converge on their understanding of the domain for which they are experts [31]. The expertise concept for given tasks in a domain should also be such that performers are able to determine whether they are experts on those tasks in that domain by *self-assessments*. In the end, the desired effect of expertise is superior *performance on the job tasks* on which one is an expert. In our context, this is performance on real-world warfare tasks. It is, however, unreliable and inefficient to predict future job performance by observing actual job performance [32]. This is why it is desirable to design well-defined tests based on how well an individual reliably performs on *representative tasks* [24] for which there are well-defined measures of performance (MoP) and measures of effectiveness (MoE). There has to be strong theory that allows generalizing from performance on such representative tasks to performance on the job [21], [33].

It is common to emphasise the importance of training on realistic tasks in a realistic environment. However, research has shown that training that simply reflects actual circumstances is not sufficient. For the defence domain, Shadrick and Lussier remark: “The maxim ’Train as you fight’ has risen to such a level of familiarity [...] that the value of the notion goes almost unquestioned. Yet studies of the development of expertise clearly indicate that ‘as you fight’, [...], is neither the most effective nor efficient method of developing expertise” [8, p. 294]. We will discuss this in more detail, but it should be noted that using artificial, rather than realistic, elements in training is common in other domains. For example, an

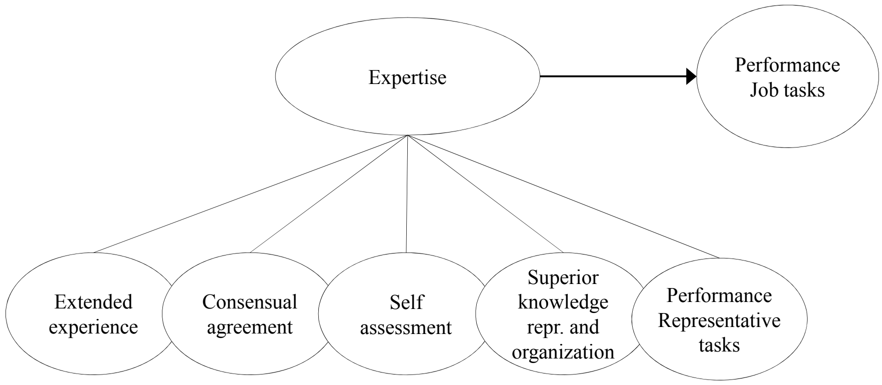

Figure 1: Aspects of Expertise. The desired effect of expertise is superior job performance.

athlete will not spend all her training time practicing the exact sequence of actions she will perform during competition, but will spend considerable time on specific training of muscle groups, on mental preparation, and even on other sport disciplines. A musician will repeatedly focus on difficult passages, thus engaging in artificial behaviour compared to an actual performance, while still using his actual instrument.

For tactical decision making, normal realistic training is, in general, insufficient, because it does not target the development of decision-making skills [8]. Judgement and decision tasks are often so-called inconsistent (different people develop differing successful strategies) [34], [32] or ill-defined (hard even to define successful strategy) [35], [36], [37], [38]. This disrupts the path to expertise described above. For such tasks, teaching any one particular strategy has shown to be futile [39], [8]. Research shows that practitioners on inconsistent and ill-defined tasks may spend half their careers apparently *not* learning and *not* improving performance beyond, perhaps, a very narrow subset of (consistent) tasks. Instead, the idea is to train adaptability; i.e., how to adapt to unknown and surprising situations. In line with this, the notion of *adaptive thinking* has been adopted in the defence domain for tactical decision making [40], [8] based on a concept of adaptive job performance [41]. Adaptive performance is characterized by eight dimensions; one of them being *Dealing with uncertain and unpredictable work situations* in terms of "taking effective action when necessary without having to know the total picture or have all the facts at hand; readily and easily changing gears in response to unpredictable or unexpected events and circumstances, effectively adjusting plans, goals, actions, or priorities to deal with changing situations; imposing structure for self and others that provide as much focus as possible in dynamic situations; not needing things to be black and white; refusing to be paralyzed by uncertainty or ambiguity" [41, p. 617].

Thus, it may be necessary to engage in artificially enhanced tasks to heighten performance. Such tasks are the result of *task analyses* and depend on the actual task at hand. There are many ways to analyse tasks. Particularly relevant for judgement and decision making tasks, *cognitive task analysis* uncovers a range of unconscious processes as well as how decision-makers of varying degrees of proficiency think [42], [43], [39], [44].

Training for adaptive thinking requires artificial tasks (to trigger responses to unfamiliar or unforeseen events) [45], [46] in a deliberate practice setting [40], [8]. Deliberate practice [47] is a framework that addresses the short-comings of "learning on the job", by a strong focus on difficult aspects, immediate and tailored feedback (by a coach or computer-adaptive system), followed by immediate tailored re-trials re-integrated into the larger sequence of tasks. Modelling and simulation is essential for artificial tasks and deliberate practice regimes.

5.0 CASE: U.S. ARMY "THINKING LIKE A COMMANDER" (TLAC) TRAINER

The U.S. Army Research Institute for the Behavioral and Social Sciences conducted a series of studies on tactical performance and training [40], [8], [48]. By observing high-performing officers, they distilled eight themes of tactical thinking behaviours which are characteristic for high performers. They then designed vignettes for training in a deliberate practice framework, together with assessment instruments. The eight themes are [49]:

- *Keep a Focus on the Mission and Higher's Intent*: Commanders must never lose sight of the purpose and results they are directed to achieve - even when unusual and critical events may draw them in a different direction.
- *Model a Thinking Enemy*: Commanders must not forget that the adversaries are reasoning human beings intent on defeating them. It's tempting to simplify the battlefield by treating the enemy as static or simply reactive.
- *Consider Effects of Terrain*: Commanders must not lose sight of the operational effects of the terrain on which they must fight. Every combination of terrain and weather has a significant effect on what can and should be done to accomplish the mission.
- *Use All Assets Available*: Commanders must not lose sight of the synergistic effects of fighting their command as a combined arms team. They consider not only assets under their command, but also those which higher headquarters might bring to bear to assist them.
- *Consider Timing*: Commanders must not lose sight of the time they have available to get things done. Experts have a good sense of how much time it takes to accomplish various battlefield tasks. The proper use of that sense is a vital combat multiplier.
- *See the Big Picture*: Commanders must remain aware of what is happening around them, how it might affect their operations, and how they can affect others' operations. A narrow focus on your own fight can get you or your higher headquarters blind-sided.
- *Visualize the Battlefield*: Commanders must be able to visualize a fluid and dynamic battlefield with some accuracy and use the visualization to their advantage. A commander who develops this difficult skill can reason proactively like no other. "Seeing the battlefield" allows the commander to anticipate and adapt quickly to changing situations.
- *Consider Contingencies and Remain Flexible*: Commanders must never lose sight of the old maxim that "no plan survives the first shot". Flexible plans and well thought out contingencies result in rapid, effective responses under fire.

There is nothing mysterious about these themes; as remarked in [8], the themes are in line with what officers are taught. However, "[...] observations of officers in realistic tactical performances indicate that they typically do not perform according to these norms; the more intense the exercise, the less likely are the officers to exhibit these behaviors" [8, p. 292]. It is therefore unlikely that realistic training will target the building of this desired behaviour, and it does not suffice to merely tell officers that they should exhibit these behaviours. They have to be deliberately trained.

One of the major challenges in learning when it comes to inconsistent or ill-defined tasks is that each new situation radically alters the task and the context in which the task is performed. When addressing the inconsistent situations directly, learning will be poor. With guidance from task analyses, however, the level of task abstraction can be raised to a level that makes tasks consistent over the range of widely inconsistent tactical situations. The eight themes are formulated at an appropriate level of abstraction [8].

In their "Thinking like a Commander" (TLAC) trainer, vignettes for the eight themes are implemented along with performance assessment instruments structured according to the expertise acquirement stages in [28]. The trainer implements deliberate practice principles as follows (abridged from [8, p. 293]):

- *Repetition* – designed tasks, rather than waiting for situations that demand tasks to occur naturally
- *Focused feedback* – timely assessment of critical parts of task performance
- *Immediacy of performance* – immediate repetition of task after feedback
- *Stop and start* – series of short performances, rather than continuous flow of actions
- *Emphasis on difficult aspects* – address hard, crucial tasks that occur infrequently in realistic situations

- *Focus on areas of weakness* – tailored to individual's specific weaknesses, which in realistic setting will be avoided by individual
- *Conscious focus on parts and whole* – zoom in/out of situation to integrate trained tasks in whole
- *Work versus play* – more effortful than casual performance
- *Active coaching* – continuous monitoring of performance and adequacy and structure of training

The training effect of the TLAC trainer was assessed by a repeated measures design, where the number of tactical thinking theme considerations performed by participants per time unit increased significantly over seven trials. Thus, one becomes better at performing trainer tasks by performing more of them. The trainer is as an instrument for performing (artificial) representative tasks (Section 4). That the TLAC trainer actually trains skills in adaptive thinking (construct validity) was assessed by comparing performance between officers who had, and had not, been deployed in combat, crossed with officer rank. The assumption behind this construct validity assessment is that *extended experience* on tactical decision making will increase adaptive thinking. For non-deployed officers, performance increased clearly with higher rank. For deployed officers, performance was generally higher than for non-deployed officers and convergent for higher-ranking officers (another sign of expertise). Construct validity is supported to the degree that the following assumption holds: Deployment is a crucial arena for acquiring adaptive thinking skills. Finally, subjecting non-deployed officers to the TLAC trainer moved performance beyond that of deployed, but not TLAC-trained, officers [8]. This suggest that the TLAC trainer is more effective in building expertise (in the form of *superior cognitive representation and organization* of knowledge) than is *extended experience*. In short, the TLAC trainer validly administers small representative tasks to train and predict performance on the job (Figure 1).

The concept behind adaptive thinking for tactical themes has also been investigated for crisis response training and coordination between military and civilian authorities [50].

The TLAC trainer is intended for acquiring adaptive thinking during training; i.e., not during operations planning. In the next section, we will, however, suggest how concepts behind the TLAC trainer may be used during operations planning to prime commanders for when the plan fails.

6.0 USING THE PLANNING PROCESS FOR ADAPTIVE TRAINING

W. R. Ashby introduced the concept of *double feedback* in a system as a means for adaptive behaviour [51]. This later inspired the *double-loop learning* concept of Argyris and Schön [52], in which an organization may adjust its strategies and methods according to experience (first-loop learning) but may also adjust its underlying values and so-called *theory-in-use* (corporate mental model(s) of the world pertaining to the organization) in light of disruptive events (second-loop learning).

The insight that plans as such are not the most important product of planning, and that commanders must become skilled in adaptive thinking; for example by using a trainer such as the TLAC trainer, is an instance of second-loop learning. This is a revision of why we do what we do. This results in a revision of the planning process itself as an arena for preparing not according to plan, but for events that will happen outside of plan; i.e., a revision of what we do; that is, a revision of the first-loop learning cycle.

This results in two learning arenas. The TLAC trainer is an application of simulation for building adaptive thinking skills as such, out of operational context. But similar to how agile management and development promotes project learning and adaptability during project execution, a particular planning process should be an arena for learning and adaptability for the operation under planning. The process itself must leverage learning about the operation.

Even though commanders may show good results in training repetitions in, say, the TLAC trainer, it is important to support the application of adaptive skills in an operational setting. Viewing the planning process as an operational setting which really should be designed as a learning arena, we suggest the following points for further investigation, with the caveat that further research is required to validate and integrate this into the planning process.

- Dynamic vignettes during simulation: Prompt planner or OPG at critical points in COA simulation, and deploy interaction on tactical thinking themes at those points. Inspired by the TLAC trainer, this interaction can take the form of
  - which themes the planner perceives as particularly relevant at that point
  - what choices (further courses of action) the planners now see that they have
  - why the planner is now choosing a particular choice (further course of action)
- Constructed vignettes deployed during simulation: From the current situational understanding and the commander's intent, generate events that target adaptive thinking. Unlike the approach above, where the OPGs plans and assumptions are played out as such, this is a more invasive approach in which the actions of forces (both OPFOR and other BLUEFOR units than those under planning) and the environment can be manipulated deliberately to trigger adaptive thinking. Vignette interaction can take the same forms as above. Vignettes can be constructed both with and without knowledge of the OPGs plans.

Both these approaches require a coach who is able to provide the focused feedback required in the vignette interactions. To an extent, it may be possible to automate a coach based on events in the simulation and on available plans.

By using validated measures of performance on vignettes (such as in the TLAC trainer), one can assess learning effects due to the planning process. This would allow non-invasive performance monitoring in the work place that would yield a basis for making informed decisions on implementing the ideas put forth here. The vignettes here take the role of representative tasks (Figure 1).

Compared to how planning is done today, the vignettes introduces artificial elements in the planning process. Initially, this artificiality will be perceived as disruptive, but in this case, we argue, disruption is of the better, because only then will commanders be triggered to develop skills they will not otherwise acquire in training or during the planning process. Over time, however, and if planners do believe in the paradox behind "plans are useless but planning is indispensable", the artificial elements will simply become a natural part of the planning process. Then, the TLAC trainer and similar trainers will actually train realistically for planning, and "train as you fight is not enough" eventually becomes "train as you fight is now enough".

Thus, the planning process may have to be modified if one is to address seriously the insight that the prime focus of planning should be learning. But it may also be necessary to adapt how the planning process is distributed to staff. For example, in the Norwegian Army, the OPGs will conduct the plan process and devise a plan. However, the plans will then be handed over to operations officers and commanders who will execute the plan. In other words, those who would learn through the planning process are not those who execute the plan, and the adaptive thinking that was stimulated in the planning process will *not* be inherent in the operations officers and commanders.

To ensure that learning during planning does get transferred to the battle field, one can keep roles as they are, but take measures to transfer learning from planners to executers. This requires more than just a handover of plans. Simulation could be used to illustrate more vividly the main points learned in the planning process. However, generating such a summary, as it were, would require a systematization of the learning that planners acquire when planning. Very likely, this learning, which comes from experiencing the plan through simulation, may have many, so-called, tacit elements [53], which are hard to articulate and convey [54], especially in the time available in operations. If those who plan cannot be exactly those who command the battle, one possible solution may be to have liaison officers who participate in both planning and execution.

7.0 DISCUSSION

In summary, we envision a passive DSS for planning that incorporates case-driven simulation support. Such a DSS will use all three aspects in Section 3.3. Although the focus is on the third aspect (*Deliberate practice targeted at adaptive thinking*), both *Increased exposure to cases* and *Critical cases* are elements in deliberate practice and vignette construction as suggested above.

To determine more clearly how the ideas that are implemented in the TLAC trainer could be transferred to the planning process, a cognitive task analysis of the planning process should be undertaken. Warfare is extremely complex, and according to [12], there has been a tendency to meet this complexity by defining complex processes; including planning processes and process support solutions. "Contemporary problems are coined by a rising complexity. Data Farming is applied in accordance with Ashby's law of requisite variety, postulating that complex problems need complex methods for their solutions" [17]. Ashby's law of requisite variety concerns the minimum number of states necessary for a controller to control a system of a given number of states [55].

The question, however, is to what extent it is desirable and possible to design and support human processes with the aim of control. Storr comments: "[Command posts] should be organized to make decisions that are 'about right but timely' [...] If the underlying decision should be 'about right but very quick', then the plan should not contain much detail" [12, p. 142]. This is in line with the fast and frugal heuristics approach to judgement and decision making [43], to naturalistic decision making [39], and to *sufficing* rather than optimizing [56]. All of these approaches acknowledge the almost impossible task of supplying sufficient reliable information required for predicting accurately how to proceed in inconsistent and ill-defined tasks. Both human decision makers and tools fail to yield good results in uncertain circumstances when using purely analytical processes. Instead, it is argued, human cognitive judgement is geared toward processing unreliable partial information rapidly, and tools should rather be designed to support this mode of decision making rather than a mode geared on analyzing the totality of the situation.

In terms of our discussion, active or collaborative DSS would seem apt for force deployment; i.e., in more predictable situations. The process of force deployment is still highly complex with regards to synchronizing personnel and hardware for deployment at the right time and place according to intelligence on opposing forces' deployment and/or positions. Simulations can aid commanders in generating deployment plans and synchronization matrices for these, by running through various alternatives with desired deployment time and place as desired end state.

However, for planning for once the battle commences, our tenet in this discussion is that passive modes of DSS are appropriate. In the highly unpredictable situation in battle and after initial force deployment, the models and rules that underlie active DSSs would have to be able to deliver reliable and accurate results. In operations planning one may not have the time to validate the results from an active DSS. Human judgement might then be forfeited to reliance on the models in a tool.

According to [57], the requirements foreseen in an active DSS for it to be useful, include that it can develop plans from orders in a wide range of scenarios, that it can identify and prioritize orders, be situationally aware, develop routes, identify threat, identify and select the best COA and react to developments as they occur. The level of sophistication required for an active DSS to achieve this is tremendous. For Deep Green [19], a DSS that compares friendly assumptions and predictions of enemy behavior up against actual events as they unfold, [58] states that obstacles surfaced in terms of the underlying simulation and the availability of the complex information that the simulation requires to yield useful results.

Thus, in the advent of high-performing active and collaborative DSSs that conduct parts of the judgement and decision process for you, it is worth investigating the prospects of passive DSSs for creating high-performing commanders with adaptive skills.

However, it is necessary to conduct task analyses that differentiate tasks for when each type of decision support is suitable. Recently, a consolidated view of judgement and decision making processes has been laid forth [59] that conditions when analytical and heuristic decision making is valid. Also, new ways of modelling work processes may enable us to understand better how to prepare for dealing with various unforeseen alternatives [60].

8.0 CONCLUSION

Although military operations seldom or never unfold as planned, the planning process itself is instrumental to prepare for deviations from the plan. Based on this perspective, it is postulated that the most important aspect of simulation support to operations planning is to nurture and develop so-called adaptive thinking. The question is then how simulations can support adaptive thinking in the planning process. By recounting and synthesizing operational arguments with research on task analysis and expertise, we have arrived at the following general requirements and design principles for simulation support:

- Design a passive decision support system
- Design case-driven simulation support
- Design small representative tasks (e.g., vignettes), for which there are well-defined MoP, and which have been validated to train adaptive thinking.
- Integrate those representative task into the planning process

Artificial elements implemented in simulations can address the particularly hard learning challenges in the inconsistent and ill-defined tasks encountered in operations planning. On the other hand, other parts of operations planning pertain to more predictable situations, and simulations can support the planning process by realistic elements. It is important to conduct task analyses to discern what kind of simulation support is appropriate for various stages of planning.

Although simulations should, at first, (merely) support existing planning processes, the fuller potential of simulations to augment and innovate planning, should be investigated. Elements that may today be perceived as artificial, may later be integrated into the planning process as part of operational procedure.

It is worth noting that the simulation support discussed in this paper can be used as tools to conduct empirical studies giving more insight into planning processes. Simulations also facilitate performance measuring, which is crucial for making sound decisions with regards to process development and acquisitions.

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