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C2 after Contact with the Adversary

Execution of Military Operations as Dynamic Decision Making

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C2 after Contact with the Adversary

Execution of military operations as dynamic decision making

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Abstract

Since the days Napoleon and Moltke military thinkers have made a distinction between planning and execution of a military operation. But whereas there are many models of planning, little has been said about execution, except to point to its chaotic nature and to desirable traits of commanders who must handle this chaos. In this paper, we propose a framework for discussing C2 during execution in a more systematic way. It is based on the view of execution as a form of what decision theorists call dynamic decision making. The framework makes it possible to conceptualize a number of central problems in execution and what is required to handle them. In this paper, we concentrate on two related aspects of dynamic decision making: the need for an adequate model to guide action and develop adequate expectations about what will happen, and the need to make decisions in real time. In the military context, the model is represented by the plan, and we analyze the results of three studies requiring re-planning used concepts from the dynamic decision making framework, concepts relating to the plan and the need for real-time decision making

Introduction

The distinction between planning and execution has been a commonplace in military thinking since Napoleonic times. It finds its classic expression in Moltke's famous dictum: "No plan survives contact with the enemy". But whereas militaries everywhere have devoted considerable effort to develop planning systems, far less seems to have been spent on execution as both doctrines and manuals show (e.g., NATO 2010) Napoleon's words: "One engages, and then one sees" still seem to be the last ones on the subject. One reason for this may be that there has been no general framework for discussing execution. In this paper, we suggest that *dynamic decision making* may serve as such a framework, and we apply it to some results from exercises at our college to illustrate how it can be used.

[1] We are indebted to the track chairmen for their useful comments on an earlier version of the manuscript.

Execution and dynamic decision making

We start with a quote from Brigadier General Richard Simpkin (1985). It provides a useful clue about the differences between planning and execution. Commenting on Moltke, Simpkin had this to say:

> *Moltke maintained that the operational plan should seek to insure that the first contact between the main bodies occurred under the most favourable circumstances possible, and that "no plan survived contact". After this, it was a matter of responsiveness and opportunism.* (Simpkin, 1985, p. 14)

We suggest that this can be understood in terms of a distinction between two modes of control, and that planning and execution represent these two different forms of control. Specifically, we rely on a distinction from control theory, and suggest that before contact, the commander tries to exercise *feedforward control* by means of the plan. After contact, however, he or she has to switch to *feedback control* as the adversary responds to the plan and the commander, in turn, has to respond to this new development, and so on. Exactly what he or she needs to do in execution cannot be predicted, of course, for it depends on what the adversary does in response to his or her initial action. In that sense, Napoleon's words are still valid. This does not, however, mean that execution cannot be understood, or that we cannot identify better (or worse) ways to handle the problems that the commander faces after contact with the adversary.

To make headway, we must first frame the commander's problems in a useful way. We suggest that framing them as a *dynamic decision problem* gives us what we need since dynamic decision making is concerned with the management of interactions in real time of the kind that characterizes execution. The remainder of this paper will be devoted to this concept some applications. We start by describing the characteristics of dynamic decision problems and discuss some of the demands that such problems make on the decision maker. We then briefly review some relevant research results. We go on to discuss the results of three military exercises which present the commander and his or her staff with a need for re-planning, a frequent requirement in dynamic tasks. We use the results from the first two exercises to identify the commander's problems from a dynamic decision making perspective and suggest some ways of handling them. We then test the effects of these suggestions in a third exercise. The results from the third exercise demonstrate that our suggestions actually help the commander cope with some of the problems, indicating that the dynamic decision making perspective is indeed useful.

Dynamic decision problems

Dynamic decision making is not a special form of decision making but decision making under a special set of circumstances. The concept was introduced by Edwards in 1962, and he pointed to three important characteristics of dynamic decision tasks:

1. They require a series of decisions
2. The decisions are not independent
3. The state of the problem changes, both autonomously and as a consequence of the decision maker's actions

Later, Brehmer and Allard (1991) added a forth characteristic:

4. The decisions have to be made in real time

It may seem curious that Edwards omitted time from his list, since time and dynamics are closely related. However, we can easily understand why he did so when we remember that Edwards was working in the traditional probability theory framework for conceptualizing decision making. In probability theory, there is, of course, no place for time.

Dynamic tasks cannot, except under very special circumstances, be handled by a single decision. Instead, they usually require the decision maker to handle an interaction by means of a series of decisions, as described in the first and third statement above. The essence of successful execution of a plan is to bring this interaction to the desired conclusion. This requires the commander to conserve his or her resources to stay the course, so to speak. However, as also noted in the third statement, the adversary is not *only* responsive. He also has a will of his own, and will make plans and take action not only in response to what we do, but also independently in an attempt to make us react. What we observe is actually a mixture of reactions to our own actions and actions that the adversary might have initiated on his own. When evaluating our own tactics and strategies, it is important to be able to distinguish between these two aspects, so as not to misunderstand the effects of what we have done, and, perhaps continue with an ineffectual strategy, or change our approach when we should have continued doing what we were doing. This problem is exacerbated by the various delays in the system, a problem that is further complicated by the fact that the adversary is not only a first-order dynamic system. His current attack may be a response to the attack made three days ago, because it has taken the adversary three days to prepare his counterattack. What we observe must always be seen as a consequence both of autonomous action from the enemy, and as a response to earlier actions by own forces, and, for the aspects that constitute a reaction to what own forces have done, it is often necessary to decide whether it is a response to what has been today, or sometime earlier.

The second characteristics, i.e., that the decisions are interdependent, follows from the fact that the series of decisions has to be handled by limited resources. As a consequence, the resources that we invest in one endeavor are generally not available for another, at least not immediately. This emphasizes the need to have reserves to use if there are new problems to be handled as the situation develops.

Finally, the fourth characteristic points to time as an important concern. When the decision problem is a dynamic one, the decision maker cannot wait and make decisions until he or she feels good and ready to make them. The decisions have to be made when they are required. This is not simply a matter of making quick decisions, as we will explain below. Thus, dynamic decision making is not only about handling interactions and change. They are about handling interactions and change *in time*. As the focus in the studies to be reported below concern time rather than the other three characteristics of dynamic tasks, we will try to clarify how time is problematic in these tasks in some detail and focus on two important aspects.

Temporal aspects of dynamic tasks

We want to point to three aspects of dynamic tasks that have to do with time. The first of these is obvious enough and we have already alluded to it above. It is that the decision maker

cannot wait to make decisions until he or she feels ready to make them. The decisions have to be made when they are required by changes in the state of the decision problem.

To be able to make the decisions when they are required, the decision maker not only has to be able to detect that a decision is required. He or she must also be prepared to actually make the decision. This means that there must be time and resources (information and staff resources) for actually making the decision. Put differently, this means that in dynamic decision making, the decision maker faces two problems: to control the state of the decision task and to make certain that he or she has the time required for making the necessary decisions when they are required – in short to manage the task and to manage his or her working conditions. Empirical studies of expert decision makers show that they learn to manage to perform both these tasks. For example Bainbridge (1979) has shown that process operators in industry control adjust the way that they work with a process so as to be able to stay in control, e.g., by avoid working close to the limits of their equipment so as to avoid having to face difficult problems. Sperandio (1980) has shown that air traffic controllers vary their control methods as their work load changes to be able to manage their control task. The problem is not unknown in military circumstances either. Here the command arrangements are carefully planned so that it will be possible to exercise C2 throughout the operation, albeit perhaps not always with respect to the temporal aspects of the problem, as we will discuss below. It is often limited to distributing decision rights in an appropriate fashion. Another important aspect is to have developed plans for alternative courses of action as appropriate to the situation as it develops.

The second demand is the need to think about the decision problem as one of *handling processes*. Specifically, the problem facing the decision maker is that of finding a way of using one process to control another process (see Brehmer, 2000, for a discussion.).

Another way of formulating this particular problem is to think about it in terms of delays, and the need to handle them. To illustrate this problem we introduce the dynamic decision cycle as a general model of the dynamic decision making, see Fig. 1.

This figure illustrates four important elements of dynamic decision making: *information*, *decision*, *action* and *result.* The result leads to new information, new decisions, and so on. It also points out four important sources of delay that must be handled to master the dynamic task. The first is that between the result and the moment when information about the result reaches the decision maker. This is what is usually called *feedback delay* or *information delay*. Because of this delay, the information that reaches the decision maker will be more or less out of date. If he or she makes a decision on the basis of this information when it arrives, this decision will, of course, also be out of date. In the absence of real time information, the decision maker should make his or her decisions on the basis of some kind of prediction of the results. This requires the decision maker to be fully aware of how long things actually take, and be able to translate this into a prediction of when the expected results have been achieved and the resources are available for other tasks. This is probably an impossible ideal in a field as fraught with friction as the military one. The most usual outcome when there is feedback

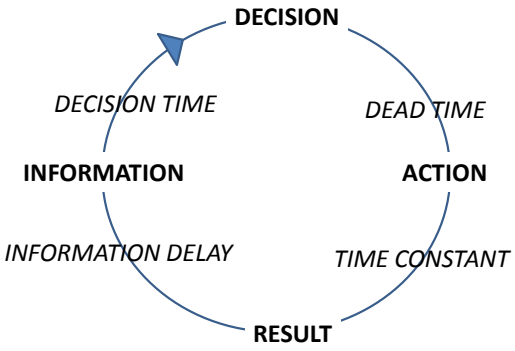

Figure 1. The dynamic decision loop.

delays is, however, that the decision maker, not realizing what has actually been achieved, will continue to commit resources, driving the system into oscillation (see Sterman, 1989). Therefore, even if the decision maker does not want to make decisions on the basis of predictions, he or she should at least wait to commit additional resources until information about the effects of earlier decisions are available. In short, it is important to at least have a model of the time constants of the action undertaken.

The second source of delay is that between the moment when the information has arrived and that when a decision is made – the *decision time*. This is the time required to actually arrive at a decision. This delay has received in inordinate amount of interest, presumably because this is something that can presumably be shortened by modern information technology. The need for a short decision time has been justified by reference to Boyd's OODA loop and the need to make fast decisions to get inside the adversary's OODA loop. This is really not a very sophisticated understanding of what Boyd had to say (see Brehmer, 2009). What Boyd is talking about (although OODA concept as usually employed tends to obscure this) is the need to produce effects quickly, i.e., to get inside the adversary's dynamic decision loop, and here the decision time is often the shortest part (Brehmer, 2005). We will return to this matter below.

The third source of delay is that between the moment when a decision has been made and that when it takes effect. During this time, nothing seems to happen, and control engineers call this form of delay *dead time*, appropriately enough. This is caused by the time required for the decision to reach those who have to execute it and the time they require to get ready to act, e.g., by undertaking the requisite planning. This source of delay is captured in Bateman's (1998) concept of decision making in the military hierarchy as a series of RUDE (Receive-Understand-Decide-Execute) loops.

The fourth and final source of delay is that between the moment when the action has started and that when it takes effect – what control engineers usually call the *time constant* of the process.

Even though the delays are a complex phenomenon, they do not necessarily appear that way to the decision maker. They appear mainly in the form of *one* delay between the moment when a decision has been made and that when information about the results are obtained. However, different forms of delays must be handled in different ways, and it is therefore important that the decision maker understands the nature of the processes that he or she works with in some detail, and is able to actually distinguish between different kinds of delays, something that has proved hard (Brehmer, 1995). The consequences of failing to do so are that the attempts to handle the delays will be ineffective, and may even exacerbate the problem.

Handling decision delays has at least three different aspects. The first is developing efficient staff procedures and decision procedures. These procedures should aim at detecting the need for decisions in time, as well as actually arriving at the decision. The second is that of communicating the decisions quickly and in a form that makes it possible for subordinates to execute them without undue delay. This involves developing effective RUDE cycles as well as issuing orders in a form that facilitates the RUDE cycles at subordinate levels. A third aspect is the need to develop plans for alternative developments that can be put into action quickly if the need should materialize, i.e., to avoid time consuming re-planning by pre-planning.

Handling dead time and time constants is a different matter. Because it takes time for a decision to take effect it should ideally be made before it is required, so that the effect occurs exactly when it is needed. The powers of divination and foresight required for this are usually beyond us. What we can and must do is to adapt our response so that it is adequate when it takes effect. For example, we must try to predict where the adversary will be when we reach him, and the extent to which he has been able to build up his strength at that time so that we can hit him with an adequate force.

The four conditions of control

Using the perspective of control, we can also list four general requirements for successful handling of dynamic tasks. These requirements are completely general, and they apply regardless of whether we are designing an automatic controller or if we consider a military commander who tries to bring a military operation to a successful conclusion. To be specific, there are four conditions that must be met:

1. We must know the goal
2. It must be possible to ascertain the state of the system that we want to control
3. It must be possible to change the state of that system
4. There must be a model of the system, a model that tells us how the system will react when we do things to it, including the case when we do nothing.

The goal of a military operation is usually part of the mission given to the commander. Today, this is usually given as an end state. To be useful for control purposes, this end state must be specific. If it is expressed in very general terms it not very useful for the simple reason that it is hard to know whether it has been achieved or not. As for the second condition, it is usually possible to change at least one's own system as circumstances demand it, subject to the usual friction that is inherent in war. The other two conditions are more problematic. Thus, it is usually not possible to observe the state of the system fully, and as a consequence the models that we can construct to guide our actions will have limited accuracy. The concept of model may seem unfamiliar in the military context. In execution, the model is the *plan*. It is the plan

that tells the commander what to do and what to expect. The final plan is, of course, based on other models: models of the adversary, models of weapons effects, and so on. But these models are no longer interesting once the final plan, which embodies these models, more or less explicitly, has been adopted. It is this final plan that should guide the commander, not the models upon which it has been developed, This plan is, of course, subject to the same problems as modes in any control context. Limited observability makes the plan imperfect just as it makes any model imperfect, and as a consequence it will need frequent updates. It is this understanding that is Moltke expresses when he says that no plan survives contact with the adversary. Because observability is less than perfect, we cannot eliminate all uncertainty, and as a consequence, we need to compensate for imperfections in the original plan on the basis of feedback, In short, surprise is what we should expect, even when we have faith in our plan. a conclusion that is not contradicted by military history. This does not mean that the perspective provided by a control view is useless. On the contrary, it helps us understand what the problems are and what it may be useful to do to improve things, as we hope to show below. Above all, understanding the problems in this way reminds us that there are limits to our understanding and that we therefore should not set our expectations about what we can achieve by planning too high.

Research on dynamic decision making

The discussion above points to what must be included in the commander's model, that is, in the plan. Specifically, the commander's model must include an understanding of processes involved in a way that encompasses the various delays that they produce. It is the quality of the model that decides whether the commander can cope with the problems in execution. A central question, therefore, is whether and under what circumstances, people can develop the models that are needed. As we shall see below, the results from research on dynamic decision making are somewhat discouraging in this respect.

As noted by Builder, Banks and Nordin (1995) cybernetic models of the kind that underpin the concept of dynamic decision making are quite popular in research on C2. Despite their popularity, a dynamic decision making perspective has not been widely used to analyze the execution of military operations, and we cannot find much relevant research on dynamic decision making that has been conducted in military contexts. Indeed, research on dynamic decision making is a relatively new field of research generally, although there is now a growing body of research, but laboratory research and applied research (see, e.g., Brehmer, 1992, for a review, and Osman, 2010, for a more recent one with a slightly different focus).

The ability to develop useful models to handle delays has been a central problem in research on dynamic decision making. The results are uniformly discouraging, regardless of whether they are based on laboratory studies or on observations of process operators (e.g., Hoc, 1989) or military officers in exercises (Worm, 1997), and they can be summarized in one sentence: People ignore delays and treat the information that they have as information about the current state of the system; they simply do not take any account of the delays, regardless of the kind of the delay (see Brehmer, 1995, for a summary of results). When they claim to have discovered delays in the system, they often misinterpret their nature. For example, they may interpret information delays as dead time rather than information delays.

There is, however, one exception, at least in laboratory work. This is when the decision makers can actually *see* the delays happen. In this case, they learn to handle them (Brehmer & Nählinder,, 2007). Such delays are often delays related to the time constants of the system, e.g., the time taken by units to reach their destination. This gives us cause for optimism, for all military officers actually see such delays happen at all levels of the military system during their training as they progress from junior to more senior positions, and one would therefore assume that they learn about them. As we shall see later in this paper, there is some doubt as to whether they actually do.

That it is hard to develop the kind of models that are needed for handling the delays in dynamic systems that cannot be seen to happen is hardly surprising. As the process producing the delay cannot be seen as it develops, the only thing that the decision maker sees is that things do not happen when he or she expected them to happen. It is then difficult to connect what is seen to happen with actions taken quite some time ago with many other actions and events intervening in between. These circumstances would trouble even the best control engineer. In military circumstances, problems to develop the requisite models would mean that it is impossible to be certain about what the effects of one's actions will be and when information about the results will become available. This may well lead a commander to wait for too long before he or she takes action, should things not go as expected. This places him or her outside the adversary's OODA loop, and may well lead to surprising developments that are hard to handle. This may be one reason why re-planning, the need for which is a frequent feature of military operations, is often not done, despite that things are not going as expected. In the remainder of this paper we focus on that phenomenon in three empirical studies.

Empirical observations

In this section we will present some observations regarding difficulties that commanders and their staffs have to handle dynamic decision making. We have made these observations in connection with military staff exercises, where we have been able to set up experiments and quasi-experiments for our purpose. These exercises are concerned with re-planning. This is not because rep-planning is required in all instances of dynamic decision making but because the decision to re-plan tells something about the ability to develop and manage one's model and take various delays into account-

The plan is the model

As noted above, an adequate model is a central requirement for success in dynamic decision making. In execution, the plan is that model. It tells the commander what do and, just as important, what to expect. If the expectations are not met, this is a signal that there is something wrong with plan, and that re-planning is necessary. To be useful for this purpose, the plan must be known in some detail, including the various assumptions upon which it is based, and it must be developed in such a way that expectations based upon it are specific enough to be evaluated in the light of *what* actually happens, and *when* it happens. If the commander has problems detecting when re-planning is required, this may be because he or she is not aware of all aspects of the plan, or that the plan is not formulated in sufficient detail to enable the commander to form relevant expectations. These expectations must be such that they enable the commander, not only to detect that re-planning is necessary, but also to detect this is time

to take action. The latter requirement is often even more difficult to meet than the first. We now turn to this problem.

Making decisions in time

As we have described above, dynamic decision making requires decision making in real time. This means that decisions have to be made when they are required. Because of the delays described above, this often means that they have to be made early, indeed often before there is indication that they are required.

In the military context making decisions in time is difficult due to the complex nature of the military organization. Nevertheless, all the different headquarters in the hierarchical military chain of command must be aware of what this means to them. First, they must keep in mind is that *action on the ground* takes place at the lowest level, which is normally the squad level and that it is at this level that effects are produced. Hence, it is necessary to know how long it will take for all level between own level and the lowest level to go through all RUDE loops that will be necessary down to the squad level That may involve quite a number of levels, e.g., division, brigade, battalion, company and platoon. On each level some planning and tasking of subordinate units must take place before orders can be issued to the subordinated level. These are the RUDE cycles we have referred to above. As a consequence, there is what we have called *dead time* in the system. The higher levels should avoid putting themselves in a position where they have to give orders in a very short time-frame. For example, one rule of thumb used in Swedish Army Doctrine (Swedish Army, 1995) is that it takes 2-3 days after a plan has been initiated at the division level until orders has been transformed through all command levels and finally been issued to the soldiers so the action can start. This in turn means that the planning horizon for a division should always be 2-3 days ahead. Real-time decision making for a division commander and staff is thus making decisions (i.e. *orders* to subordinated units) that do not need to be effectuated on the ground until 2-3 days into the future. If the division staff gets into a situation where they have to implement a new plan and thus issue new orders to the subordinated units in a shorter time frame, the risk is that the orders will be overtaken by the events. This means that by the time that the decision has travelled down the chain of command, from the division down to the platoon, have gone through their respective RUDE cycles, the plan has been rendered irrelevant by the development of the events on the ground. This means that the commander will find him or herself outside the adversary's OODA loop, rather than inside it. Note that this does not only mean that one has to work faster than the adversary, but also that the planning cycle should start earlier than that of the adversary.

There are two ways of coping with this problem and its consequences. The first is try to predict what decisions will be necessary in advance. This is, of course, not always possible, unless there are intelligence reports that reveal the adversary's plans. However, it may be possible to use planning as a tool for investigating the future, and plan for alternative futures so that there, hopefully, will be a plan for what actually happens when it happens. The alternative, once something unexpected has been noticed, is to plan for dealing with the likely development of the situation 2-3 days ahead, so that one at least does not attack where the adversary was three days ago, but where he is likely to be today.

Generally speaking, it is not a simple thing for a division, or higher level units, to move its planning horizon 2-3 days into the unknown future, although the need to do so is recognized in many contemporary C2 doctrines (e.g. NATO, 2010). In addition, the procedures are often

also regulated in a so called "Battle Rhythm". The consequence is that a staff already during planning and preparations needs to plan and prepare for decision making that needs to be done during execution of the plan. When a Division staff is aware that substantial changes to a plan under execution takes 2-3 days to begin to take effect on the ground, it must try to make sure that such a need for substantial change is indicated as early as possible. This means that the staff must define the criteria that can be used as indicators of a substantial change of the situation already during planning and preparation for an operation. That is, they must define concrete and useful expectations, based on their plan. If the situation fulfilling these criteria materializes during execution of the plan, preparations for adjustment of the plan (i.e. the new decision and accompanying orders to subordinates) should ideally already have been made.

The current Swedish Army planning manual (Swedish Army, 2007) includes methods for how to prepare for rapid decision making during execution of a prepared plan (e.g., wargaming and decision support planning), but those preparations are *plan centric*, that is, focused on speeding up the execution of the current plan. This means that those preparations are not focused on defining (and early identifying) criteria indicating that the actual situation deviates from what has been planned for or from the assumptions underlying the plan.

It should be noted that the problems discussed here are not solved by mission command. Mission command will handle unforeseen variation at the lowest level provided that it does not conflict with the commander's intention. When the course of events requires the commander to redirect activity by a new intention, the line of reasoning above applies in a force that relies on mission command in the same way as for a force that uses a more centralized form of command. After all, the commander's intent is a kind of plan in that it guides action, but it differs from a more traditional plan in that it does not tell the subordinates what to expect, only what to achieve. It will therefore not provide very good grounds for how it should be evaluated. This is, however, a problem that requires a paper of its own, and will have to be dropped from the current discussion.

In the first two studies, we focus on what will happen when an initial and well rehearsed battle plan turns out (during execution) to be inadequate it has been based on completely wrong assumptions (see Thunholm, 2007; 2008, for details).

The first study was aimed at the Division level. Participants were eight teams of Swedish Army captains participating in a course in Tactics where they role played the (reduced) head quarters staff for an army division. All eight teams role-played the same "Blue Division" depicted in Figure 2. They used two weeks to plan, reconnoiter the actual terrain, wargame, and issue orders for a conventional military operation at the division level. The "independent variable" was a series of injected reports (scenario information) from which it was possible to infer that the plan was wrong and that was due to the fact that one of the main assumptions regarding the enemy intentions and expected actions was not valid. This, then, is information that their plan, i.e., the model guiding their actions, is incorrect, and that re-planning is necessary. Our question is whether the participants would detect that this is the case. The situation was one involving information delay: the participants have based their plan on information that subsequent events indicates to be wrong in important aspects. Data collection included video recordings of the teams and of the individual commanders during the execution of the plan, individual team member surveys, and analysis of all messages and orders sent and received by the staffs. From the video/audio recordings each teams' execution process was reconstructed and analyzed (see Thunholm, 2007, for details).

The development of the scenario play for the scenario that was used in the study is indicated in Figure 2.

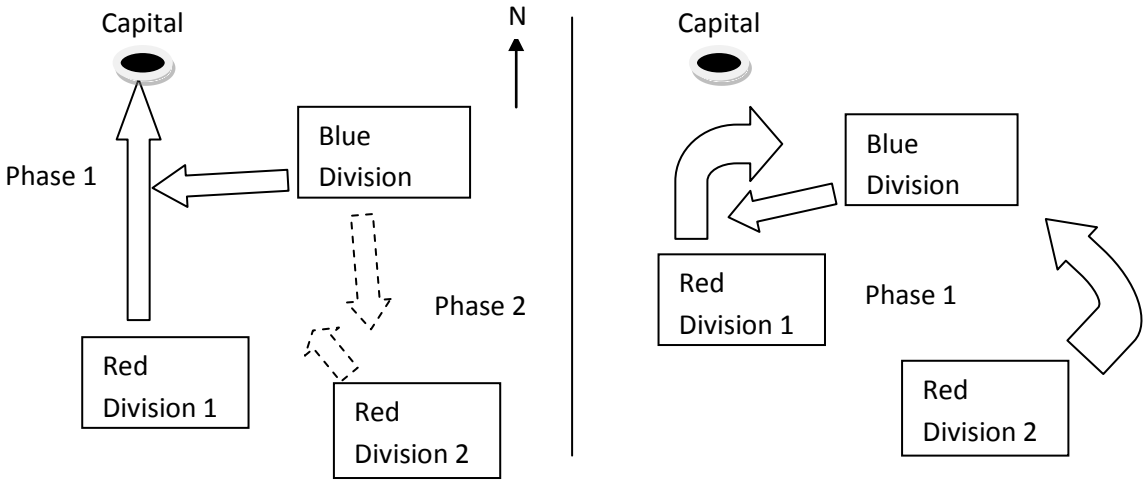

Figure 2. The figure to the left indicates Blue assumptions about Red plan and intentions, and Blue plan. The figure to the right indicates Red plan and what actually happened during the scenario run.

In this scenario, the Blue division was up against two Red (enemy) divisions, but Blue division was better equipped and was fighting on own soil so they had better intelligence. Their orders were to protect the Capital, and they had planned to do so by first attacking and defeating Red division 1 as it was attacking north, heading for the Capital. Then, in Phase 2 (dotted arrows) which was not planned in detail, they should also be prepared to attack the Red division 2.

The assumptions regarding Red, made by the Higher Blue HQ to the Blue division was that Red intended to capture the Capitol and force Blue to give up some important resource areas in the south of Blueland. Another crucial assumption made by higher HQ was that Red Division 2 was very low on supplies and thus not ready to start an attack within the next 72 hours. In our terminology, these assumptions and the plan that rests upon them constitute basis for the model that serves to guide the action of Blue Division in this dynamic context.

The real situation as indicated to the right side of Figure 2 was that Red's intention was to defeat the Blue division in a pincer attack, and Red division 2 was actually prepared to launch an attack immediately. The scenario started with intelligence (information) to Blue division staff that Red division 1 were advancing to the North, exactly as was expected in Blue battle plan. This information is correct but incomplete. Blue does not know this, so they responded by initiating their planned attack to the West. The scenario play went on for five hours and after about one hour intelligence started to come in to the division staff indicating that Red division 2 had started to advance, first to the East and later to the Northwest as indicated in Figure 2. When the scenario play ended, Blue division was fighting Red division 1 to the

West and they were beginning to get in contact with attacking units from Red division 2 in its own rear area. Blue's battle plan (which is the model that guides their action) was obviously based on the crucial assumption made by higher HQ, that Red division 2 would not be able to attack during the first three days of the battle. However, the scenario play demonstrated that this assumption was wrong. The result was that all teams except one failed to counteract the attack of Red division 2 before it could cross the only available natural obstacle (a large river) between Blue Division and Red division 2. These teams, then, had to face a two-front battle against an enemy that outnumbered them about 2-1. Eventually, all teams except one issued new orders to one or two of their subordinated brigades to take action against the enemy attack in the rear. Only one of the teams made the decision in time for the action to be able to be relevant, however. All other teams took this decision too late and were thus overtaken by the events.

Viewing this situation as a dynamic decision making problem it was obvious that the division staffs failed to make a new decision *when* it was required. A probable reason for this was that none of the teams had defined any clear expectations of what to expect, given their plan. Therefore they had no pre-defined indicators of what would constitute an unwanted development of the battlefield situation. Therefore, they did not look actively for indicators of a need for re-planning and they were slow to understand that it was necessary. When they realized that there was a serious threat to their plan they were unable to respond quickly because they had not prepared any options for how to handle such an unexpected situation. It is interesting to note that all team members seemed to be aware of the development of the situation as soon as the new developments were reported to them. That is, they seemed to develop situation awareness, but they failed to make sense of the situation, so they did not understand the need for a very rapid re-planning process. Alternatively, they just did not do what needed to be done about the situation. Many teams did not seem to realize how long it would take to effectuate new orders counteracting the emerging situation in their rear area, i.e., they did not have the requisite understanding of the dead time nor the time constants that would have to be considered in their decisions. In fact, several teams acted for a while as if the emerging threat was not the primary concern that it should have been. This could be due to the fact that the assumption regarding Red Division 2's incapacity to attack within 72 hours was made by the higher HQ. There were clear indications in several teams that when Red Division 2 actually attacked earlier then assumed, it was viewed as a problem of the higher HQ and not for them.

In summary, from a dynamic decision making point of view, the main failure of the participants in this first study was that they failed to use their plan to develop an expectation about what would happen in time, so as to give them the time they needed to for re-planning in time, i.e., re-planning that would take into account the various delays that would have to be handled in their decision to counter the new threat in time. Indeed, the delays did not seem to be part of the participants' models of the problem. Referring back to the discussion earlier about the possibilities for actually learning what these delays are as an officer raises through junior to more senior forms of staff work and command, our results suggest that they do not learn, or at least that they do not learn to compensate for these delays by early decision making.

One possible explanation for this result is that the participants, being Army Captains, were simply not qualified to handle the problem that they encountered in the scenario. The purpose of the second study was to test this explanation in an exercise where the staffs were more adequately manned (see, Thunholm, 2008, for details). Specifically, in this second study there were only three staffs but they were more completely manned, and also with officers with the proper rank to command and staff higher units (two Brigade staffs and a Land Component

Command; LCC). The scenario play was executed over three consecutive days and the same type of video recordings and surveys as in the previously described study were employed to collect data (Details in Thunholm, 2008). As in the first study, the development in this scenario soon indicated that the plan developed by the participants was wrong. As in the first study, this was because a crucial assumption made by the higher HQ regarding the intentions of the opposing force proved to be wrong, an assumption upon which the plan had been based,. The effect was very similar to that observed in the first study. When the information suggesting that basic assumption underlying the plan were wrong was coming in to the staff they took too long to realize the seriousness of the new situation. Re-planning took too long, and as a result their new plans and orders to their subordinates were overtaken by events. Once again, a major problem seemed to extend the own planning horizon the requisite 2-3 days into the future.

In summary, then, the results of this second study suggested that despite more adequate staffing, the participants still failed to handle the dynamics situation because they had not developed expectations about what would happen in the scenario in time for successful re-planning.

How can the ability to execute plans be improved (i.e. how to improve dynamic decision making)?

In this third study, we wanted to test a few ideas, based on a dynamic decision making perspective, regarding how to improve the ability to prepare for execution and re-planning. In this study (see Thunholm, 2009, for details) we had the opportunity to train a few of the key participants in the participating staffs for their task. As we have described above, our interpretation of the failures in the first two studies is that the participants were did not start re-planning early enough to compensate for the various delays that are a necessary part of achieving the necessary action on the lowest levels. That is, the staffs did not set their planning horizon far enough into the future to be able to handle developments that came as a surprise because they had not developed expectations about what could happen. One reason for this is that they did not treat the assumptions upon which their plans were based as what they were, i.e., assumptions, rather than facts, assumptions that may well be wrong, and that there was a need to monitor them. As a consequence, the expectations based on their plans were not as valid as they thought. One possible remedy, therefore, would be to focus the participants' attention on the assumptions, stated and unstated, in the orders they received from higher HQ. Accordingly, in this last study, we first trained the key players to identify the critical assumptions underlying the orders they received from the superior HQ, assumptions about the intentions and probable actions of the adversary that always have to be made by higher echelons to enable the lower echelons to plan, (US Army, 2010). Without these assumptions it would not be possible to make plans at the lower levels, because there would simply be too many unknowns. For example, in the first study (which was used as an example in the training), one of the most critical assumptions and an assumption that was also made explicit in that case, was that the Red Division 2 would not be able to commence an attack within 72 hours.

The second part of the training of participants was to conduct wargaming (action-reaction-counteraction), three days into the future, based on the possibility that this crucial assumption would prove to be wrong. An important purpose of this wargaming was to establish which early signs or criteria to look for once execution of the plan had started, i.e., to make sure that the plan was developed in sufficient detail to provide adequate expectations. Our hypothesis here was that if the staff was prepared to look for early signs that a crucial assumption in the plan was wrong, they would not be overtaken by events so easily and that they would be able

to re-plan and issue orders in time, i.e., as required to handle the delays they faced better. That is, the training was aimed at making the participants more effective dynamic decision-makers.

We realize that a real-life staff will never find the time to prepare and wargame all possible future developments of the situation once execution of a plan has started. They should, however, at the very least wargame and prepare for what they should do if the crucial assumptions underlying their plan should prove to be wrong.

The result of this third study was that the Intelligence cell in the Land Component Command (LCC) actually did manage to alert the Commander LCC at an early stage of the execution of the plan, that one key assumption underlying the plan probably was not correct. They did so based on indicators that they had identified during the preparations phase. The head of the intelligence cell also conducted wargaming 3 days into the future and based on the results he managed to convince the commander of the LCC about the seriousness of the emerging situation. The plan was changed and the situation did not escalate in such a serious way as was the case in the first two studies. However, this conclusion remains a hypothesis; we could not conclude that this was because of the preceding training intervention, because we as experimenters were not in full control of this exercise.

Discussion and conclusions

This paper represents our first attempt to develop a frame of reference based on dynamic decision making for understanding execution and to demonstrate that such a perspective helps us understand the problems that a commander faces during execution, and that it points to what needs to be done to improve things.

A dynamic decision making perspective is quite rich, and here we have only been able to give a very general outline of what it involves. We have concentrated on two central issues: the importance of the model and the requirement to make decisions in real time. This is not to say that dynamic decision making always involves re-planning, only that this focus would enable us to learn something about the nature of the models developed by our participants and how they handled the central problem of making decisions in time.

For C2, the model is the plan. It should both give guidance about what to do and about what to expect. The plan is, of course, based on many other models, such as models of the adversary, models of weapons effects, and so on. But once the plan for the operation has been formulated, it is the important model, and as such it should be developed in sufficient detail to both provide a guide for action and for what to expect. The latter aspect is essential from a dynamic decision making perspective because of the importance of detecting the need for re-planning in time to handle the real-time demands in execution. Specifically, decisions must be made in time to handle the delays that are an inevitable fact in hierarchical organizations like the military organization in which there is a need to go through a number of RUDE cycles to reach the level at which action is actually taken. However, this is not all that needs to be considered. Incorrect assumptions are not the only things that may happen. There can also be more fundamental surprises when the adversary does something that could not have been foreseen at all. Then, the commander may well find him- or herself in the situation where our participants have put themselves unnecessarily. But also in this case, having developed the plan in sufficient detail for it to provide adequate expectations will help the commander dis-

cover when things are not going as planned, and re-planning will be necessary, and that there is a need for new and better intelligence. Identifying and examining the fundamental assumptions upon which the plan is based will always be part of this.

The most general conclusion to be drawn from our observations seems to be that the models developed by our participants were weak with respect to the extent to which they would provide adequate expectations, or, at least, that the participants did not seem to use the models very well for this purpose. As a consequence, it took too long for them to detect that their models were wrong, and that re-planning was needed.

Another general conclusion is that the models were inadequate in that they did not seem to include a representation of the delays, especially the dead time, involves in handling a complex military system.

While our results suggest one way of handling the first of these difficulties, viz., by monitoring the assumptions upon which the plan has been based, we have no suggestion at the present time concerning the second problem. That will have to be left for future studies.

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