Adaptive Teams

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Abstract

The goal of research and development in Information Technology for Leader and Team Learning and Operations is to use what we know from cognitive science and cognitive engineering to increase the readiness and adaptive performance of leaders and teams in real-world missions. Special emphasis is given to preparation and functions in Stability and Support Operations (SASO) missions. The government wants to increase the efficiency and the effectiveness with which units prepare for deployment and performance of SASO missions by applying cognitive science to the process.

It is commonplace for organizations to assert that they want to encourage their teams to be adaptive. The military in particular places a high value on having adaptive teams, as opposed to rigid, inflexible teams, because there is so much uncertainty on the battlefield that it is essential to have units that can adjust to changing conditions. In addition, the military organization is taking on new roles in peacekeeping and SASO missions, and there is a significant learning curve involved in preparing to handle these challenges. Yet little has been written about what it means to be an adaptive team.

Introduction

It is commonplace for organizations to assert that they want to encourage their teams to be adaptive. Yet little has been written about what it means to be an adaptive team. This paper describes some of the features of adaptive teams. We describe ways to make teams more adaptive, but we also identify typical practices that discourage adaptability. We believe most teams can become adaptive, but we also believe most teams will not achieve this. It may be more useful for leaders to adopt a lower level of expectations than to persist in unrealistic expectations followed by recriminations when these expectations are not met.

We assert that the primary reason for wanting to have adaptive teams is to cope with uncertainty. In conditions of high uncertainty, where there is a need to initiate action, an adaptive team is

valuable for making the on-site changes that can lead to success in accomplishing the goal, or in appropriately redefining the goal.

There are other ways to manage uncertainty (e.g., Schmitt & Klein, 1996), but these carry penalties. One approach is to generate a set of contingency plans, but this adds to the confusion factor (e.g., which contingency plan are we adopting, and what are the criteria?); assumes that with enough contingency plans the actual circumstances can somehow be captured (unlikely, and the more different contingency plans the greater the confusion); and usually leaves the learning with the planners rather than the executors. A second approach is to wait for the conditions to become more clear, but this is not always possible, and opportunities often slip away. A third approach is to maintain more reserves, but this reduces the impact of the action. Schmitt and Klein discuss other strategies as well. None of these is as effective as having the plan executed by an adaptive team.

We distinguish adaptive teams from adaptive leaders. Ross and Pierce (2000), Ross (2000), Pulakos, Arad, Donovan, and Plamondon (2000), and many others have discussed the importance of adaptivity at the individual level. However, as Pulakos et al. noted, there is a need to identify dimensions of team adaptive performance. Clearly, having adaptive team members will contribute to having an adaptive team. This paper suggests some emergent properties of adaptive teams that go beyond the capabilities of the individual members.

Adaptable teams are prepared to respond to uncertain situations. Recent interest in the concept of adaptability reflects a shift in training philosophy with methods that replace traditional what-to-think training with learning how to think. Uncertainty and the need for adaptability have always been a part of military operations. But to compensate for a lack of adaptability, teams have tended to over-plan, trying to anticipate all the possible situations they are likely to face, to define the appropriate responses in as much detail as possible, and to maintain the resources needed to implement the plans and contingency plans. The rise in uncertainty is due in part to the loss of a defining peer threat in the break-up of the Soviet Union and the emerging more ill-defined asymmetric threats and advances in technology, especially information technology and the data deluge that resulted. U.S. Army transformation and the objective force respond to this uncertainty by creating a force that is more flexible and versatile—able to rapidly respond to missions across the full spectrum from major theater of war to support and stability operations such as peacekeeping and humanitarian assistance. These influences limit the extent to which situations can be anticipated and responses planned. The choice is not whether or not the team should be adaptive, rather it is a choice of how well or quickly the team will adapt.

Another response to uncertainty is delay and the team may choose to delay action until there is less uncertainty in the situation (see Schmitt & Klein, 1996 and Lipshitz & Strauss, 1996 for a review of possible responses to uncertainty). However, waiting to respond until uncertainty is reduced is problematic to Army Transformation on at least two levels. The first is the tendency for inaction to move the team from a proactive to reactive stance, perhaps missing opportunities to influence or control situations.

The second concern is the assumption that uncertainty can be reduced if the team waits long enough and that the necessary cues and patterns will fall into place and be recognized as the

story unfolds. This is not likely in highly ambiguous situations, where uncertainty not only exists in what is happening, but also in how best to respond. Adaptable teams understand that to have an intended consequence, a range of actions is possible and that the direct and indirect impacts of the responses often cannot be measured and may be unknowable. If there were a single best response that could be defined for each set of conditions, then adaptability would be less important. It is not a situation of determining when to be adaptive and when not to: all teams must adapt. The issue is to minimize the cost of the adaptation. Thus, the notion of tactical patience is not appropriate for adaptive teams. Tactical patience may reflect inadequate training (understanding the interactions between the situation and the response) or even an ambiguous mission. Tactical patience assumes a reactive or even an inactive stance. Adaptive teams are proactive and flexible, able to modify internal processes and external actions to achieve their objectives.

Definition of Adaptive Teams

The definition of adaptive teams is straightforward: Teams that are able to make the necessary modifications in order to meet new challenges. This is consistent with the definition of adaptive performance used by Pulakos et al. (2000)—situations in which behavior was modified to meet the demands of a new situation or event or a changed environment. However, the apparent simplicity of the definition is misleading, because the nature of adaptation is complex. It encompasses a number of dimensions. In this section we discuss some of these: external versus internal adaptation, adaptation versus coordination, and planning versus replanning.

We need to distinguish between external and internal adaptation.

Sometimes, a team changes the plans it is carrying out. We can refer to the replanning that takes place during execution as external adaptation because the focus is on altering the way resources are applied to alter the external situation. At other times, a team may need to make changes in its own organization for carrying out any plans. This is internal adaptation. Usually, both types of adaptation may be needed, as in a case where internal reorganization is needed in order to carry out the revised plan. Nevertheless, it is important to understand this distinction. Otherwise, there can be a great deal of confusion about the focus of the adaptation.

For external adaptation, the challenge is to modify a plan in progress. This is much harder than initial planning, because it means re-assigning resources that are already accomplishing tasks. The team has to understand its affordances—what it can achieve, given its current configuration. The status of these units has to be determined, to see if they can be re-programmed on short notice. One of the risks of external adaptation is to create unintended consequences. Another issue of importance in external adaptation is the nature of the plan to be modified. Plans can be modular, or they can be highly interactive. Obviously, the more interactive, the more efficient the plan can be, but also the more difficult to change.

For internal adaptation, we can consider the activity of the team as a form of metacognition. The team needs to observe itself, and the way it is working, to see if it needs to develop new routines or adjust existing routines. Whereas external adaptation can use outcome feedback (e.g., “we

have been trying this, and it isn't having an impact"), internal adaptation often requires process feedback (e.g., "there has to be a better way to do this, one that takes less time and effort").

We Need to Distinguish Between Coordination and Adaptation

We believe it can be useful to build on the work of Bernstein (1996), who studied motor coordination. Bernstein showed how motor coordination depended on building up well-learned routines for accomplishing tasks. Further, the large number of degrees of freedom (for the different joints, muscles, and motor neurons) could not be managed centrally. Self-organizing mechanisms were required to achieve the tight coordination needed for high-level performance. Bernstein provided the example of a skilled blacksmith, who showed virtually the same pattern of hammer movement with each stroke. The face of the hammer described the same arc, but the position of the blacksmith's shoulder, elbow, and wrist would vary. As one joint moved, others would compensate in a self-organizing manner, to result in the low variability of the output. Van Ingen Schenau and van Soest (1996) presented an example of a simple vertical jump, where the timing of the contractions of the major muscle groups have to be very precise in order to achieve the force multiplication needed for high levels of performance.

Bernstein distinguished coordination from dexterity. Coordination was the realization of high levels of efficiency and effectiveness in managing the degrees of freedom to achieve a task. Dexterity was needed when the situation became unpredictable. For dexterity, problem solving was needed. Bernstein used the example of a person running on a smooth track versus a person running over a broken field. The latter required problem solving at every step, as the person had to figure out how much traction was available for thrust versus maintaining balance. Bernstein claimed that motor dexterity was predicated on problem solving. Skilled performers had accumulated coordination routines that could be used for the dynamic reconfigurations, but, even more important, they had developed problem-solving routines for handling the types of challenges they might face.

Klein (in press) has adapted Bernstein's work on motor coordination to describe the coordination of a team. Here, we continue this framework, and describe the adaptability of a team in terms of its dexterity—its capacity for problem solving.

Bernstein described dexterity as the ability to find a [motor] solution for a wide variety of conditions. We will define team adaptation as the ability to find a solution for a wide variety of conditions.

Bernstein described dexterity as having several properties. Dexterity means being able to find a motor solution for an unexpected external challenge, and to do so correctly, quickly, efficiently and resourcefully. Bernstein linked dexterity to the ability to be extemporaneous, rather than pre-programmed. We would refer to this as being able to improvise. (See also Weick's, in press, description of improvisation.) It includes the characteristic of "lightness," which means prepared to change directions rather than being rooted to a prepared sequence. Bernstein further described how dexterity depended on an ability to anticipate what was going to happen, rather than being perpetually surprised.

Bernstein argued that dexterity could be taught by forcing students to encounter deviations and obstacles. In this way, students would develop problem-solving routines that would enable them to find workarounds in the face of future, unexpected challenges. Bernstein believed that transfer of problem-solving routines was more powerful than transfer of specific movements. Thus, a speed skater, with a repertoire of problem-solving routines for balancing over a support that has no width, should find good transfer to bicycle racing, which calls for the same type of problem solving.

We can also speculate that increasing the degrees of freedom should increase the flexibility, and therefore create a potential for more dexterity. At the team level, degrees of freedom could be increased by cross training, to allow more interchangeability of staff. This would be like finding more ways to rotate joints, at the motor coordination level. Degrees of freedom can also be increased by providing more autonomy and decentralization.

We Need to Distinguish Planning Versus Replanning

Klein, Wiggins, and Schmitt (1999) distinguished between these processes. (Note: Some people use "replanning" to refer to changes made during a planning phase, as opposed to changes during execution. Here, we are primarily interested in execution, and we are using the term "replanning" to refer to modifications to a plan made on the fly.) First, for planning, the directions usually come from higher headquarters, but for replanning, the field commander and staff discover the problems and need to react quickly, sometimes before they can get agreement from higher headquarters. So the flow can be reversed. Second, planning begins with a set of resources that can be allocated or held in reserve. For replanning, the activity is to modify a plan in progress. Thus, there is an additional burden to determine the status of the various resources, and to anticipate their status at time (x) which is when the revised directive is issued, and at time (y), which is when the alteration in their actions is needed. Third, planning allows the development of novel courses of action. Replanning usually takes place under such time pressure that a course of action just consists of assemblages of existing, well-understood, and practiced courses of action. It is just too difficult to invent a new approach, and too risky. Even if a new method was invented, it would need to be described and explained to the other team members, and there usually is not enough time.

An example may be useful here. Maclean (1992) described how the supervisor at a forest fire tried to save his crew as they were being overtaken by a huge wall of flames. He invented a new strategy, that of starting a backfire ahead of them to create a burned-out zone in which they could find safety. But there wasn't enough time to explain this. All he could do was tell his crew to follow him. The crew had no idea what he was doing, and no one followed him. Two of the crew were able to outrun the fire, but the rest were burned to death. He survived.

Fourth, during planning, most of the time is taken in building and evaluating the course of action. Dissemination is fairly routine. In replanning, most of the time is spent in preparing the dissemination, and workarounds may be needed to get the word to far-flung sub-teams.

Now that we have explored several distinctions involving team adaptation, we also want to examine some of the problems that can arise during adaptation. There can be dangers when a

team makes modifications. Adaptation is a break with routines, and so it can engender confusion. For example, early research on commercial airline pilots (e.g., Helmreich & Foushee, 1993) showed that some pilots had a very authoritarian personality, and others were democratic. Reasoning that there were some situations calling for each style, the solution seemed to be to train pilots in both styles, so they could be more flexible. The research (Helmreich, Hackman, & Foushee, 1988) showed that these flexible pilots were the least effective of all. The cockpit crews were used to determining the captain's style and adjusting to that. But when captains were flexible, the crews were unable to predict what style the captain would adopt next, and were more confused and frustrated than with either of the more stable styles.

We saw some similar results in an exercise involving the use of information technology for artillery control (Thordsen, 1998). The teams were able to find an adaptation that reduced workload. This worked well during medium level workload periods. But when the workload picked up, the team was unable to cope. They discovered that it was better to retain the inefficient configuration during low workload than to be vulnerable to surge periods. Thus, using an adaptive strategy (i.e., internal adaptation) was counter-productive.

External adaptation can be counter-productive if it emphasizes short-term needs and ignores long-term requirements, or if it addresses a crisis state and ignores the requirements for steady state operations. We see this in teams that overreact to crises and have depleted the resources they need once the crisis is over. Expert performance is often marked by the minimal changes shown, as experts maintain an awareness of future events and demands, and anticipate new challenges. The experts' course corrections are small and smooth, as opposed to the wide deviations shown by novices who are only attending to the crisis at hand.

A classical case of short-term adaptation is the misguided improvisation of J.E.B. Stuart just preceding the battle of Gettysburg. He saw short-term opportunities, and neglected the long-term need to provide intelligence to General Lee about the disposition of the Union forces. As a result, General Lee was deprived of the information he needed. Stuart should have implemented the plan he was given.

We do not have any problems with adaptive teams—teams that can make needed changes. Our concern is with the adaptations themselves. It may not always be wise to make changes in a plan, and adaptive teams need to be careful about when and how they improvise. For example, in one Marine Corps exercise we observed, the battalion commander realized the plan was running into trouble and knew how the plan should be altered. But then he considered how many different units would have to be notified, and how unreliable the communications were, and what could be the consequences if he was unable to let every affected unit know of the change. He decided to continue with the original plan. Thus, one aspect of an effective adaptive team is that it knows when to make adaptations, and when to persist with an adequate plan.

This section has provided some background for considering team adaptation. We have defined adaptation as the ability to make necessary modifications, and we identified the core of that ability as problem solving. Further, we asserted that adaptation can involve a change in the planned use of resources, an internal change in the structure of the team, or both. Finally, while team adaptation is the ability to make necessary modifications, we noted that effective teams do

not always implement these modifications because there are risks incurred every time a team changes its plans. As the saying goes, “wisdom is knowing when.” In the next section we describe the factors that go into effective adaptation.

Factors Contributing to Team Adaptation

We see team adaptation as more than just being prepared to make changes when things go wrong. Effective adaptation depends on a number of factors, listed in Table 1. These include the ability to anticipate, so that attention is being directed in the right places. (We have seen teams that never realized some of their shortcomings and therefore never tried to gather information about them, creating a vicious cycle.) It depends on a mindset of expecting to modify or replace a plan, so that the team is looking for the first signs of trouble to know where they will need to change. It depends on the mindset of expecting to improvise and avoiding a commitment to plans or previous investments (the sunk cost fallacy) that discourages change. It depends on being able to modify both the plan and the internal organization. It depends on having the relevant problem-solving routines in place (along with the routines for carrying out basic actions). It depends on having a big picture to avoid overreacting to short-term crises, and to appreciate the confusions and unintended consequences that might result from making adaptations. (The big picture includes awareness of collateral teams; in many situations we find teams of teams, and this adds additional strain to making adaptations.) It depends on having sufficient skill to be able to control more resources, more degrees of freedom, which confers greater flexibility (this can be accomplished through decentralization and self-organizing adaptations at the lower levels). It depends on having continual awareness of the situation so that the current status of resources is known, and their availability for re-direction is understood. It depends on having an appropriate degree of centralization so that leaders can see the implications of events that happen in different units. It depends on having an organizational structure that provides expertise when needed, provides sufficient degrees of freedom, and has an appropriate degree of centralization.

Table 1
Skills and Abilities Affecting Team Adaptation

- Anticipate problem areas, in order to allocate attention and information-gathering resources
- Mindset of expecting a plan to run into difficulties, and to need modification
- Avoidance of sunk cost fallacy of escalating commitment to a plan as it needs more patches and resources
- Problem detection, to spot signs of trouble early
- Preparation to modify the planned course of action
- Preparation to modify the internal organization for carrying out the plan
- Team competence at routines that are the building blocks of plans
- Experience in solving problems as a team
- Having the big picture so that local goals do not overtake team objectives, and so that unintended consequences can be spotted
- Being able to control more degrees of freedom, or to support self-organizing efforts (decentralization)
- Having a good sense of the situation, including the current affordances

- Maintaining information flow that permits second-order inferences (i.e., inferences built on inputs from different units)
- Availability of expertise as needed

To put the skills listed in Table 1 into some perspective, Figure 1 shows three factors that come into play: The ever-changing situation, the resources available for making adaptations, and the problem solving that is required for adaptation.

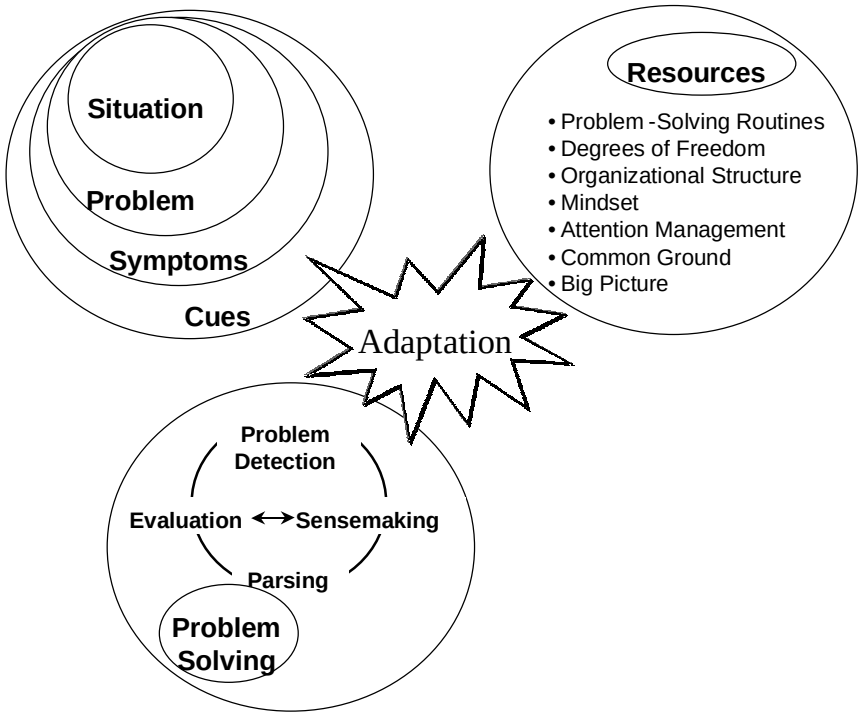

Figure 1. The factors affecting team adaptation.

The Situation

In many cases, the situation is both fluid and uncertain. This makes adaptation difficult, but it is also a reason why adaptive teams are needed. Adaptation is triggered by the belief that the plan is not going well (or by the discovery that there is a unique and important opportunity). Klein, Pliske, Crandall, and Woods (1999) discussed the process of problem detection, particularly the difficulty of understanding the problem itself. The problem does not reveal itself. It is manifested through symptoms, and these are detected through sensors and cues and data elements. An appreciation of team adaptation should begin with the recognition that in many cases a team will not know with confidence that the plan needs to be changed. Or, if the team waits for the uncertainty to diminish, it will also lose the capability to take effective action. Figure 1 shows this as concentric rings, from the problem itself which must be inferred, to the symptoms which also require interpretation, to the cues and data elements.

The Resources

Why are some teams more successful at adapting than others? Figure 1 presents several types of resources that we hypothesize may be critical.

Problem-solving routines. Following Bernstein (1996), we speculate that adaptive teams have had more experience in solving problems, and therefore have built up more routines so that they can rapidly and effectively carry out this process. What sorts of problem-solving routines might these be? We speculate that they might include the following: figuring out how to do communications workarounds; figuring out when common ground has been lost, and how to repair it; figuring out how to decompose a task in a different and better way; visualizing a plan in progress, to see if it is running into trouble; estimating how long it will take to put changes into action; performing a tradeoff between the advantage gained by improving a plan versus the disruption caused; spotting inconsistencies and unintended consequences from making a change; estimating how many resources are needed to accomplish a task so that there isn't overkill or insufficiency; judging when commitment to a plan is a result of sunk cost psychology; estimating the coordination costs of a new team organization; making second-order inferences by synthesizing inputs from different units.

Degrees of freedom. Again, following Bernstein (1996), we speculate that adaptive teams have more degrees of freedom available and are able to control these. The teams are more flexible.

Organizational structure. We speculate that adaptive teams have worked out a good balance of centralization/decentralization. They are able to gather information from different sub-teams and synthesize these data (we can call this an ability to form second-order inferences) and to coordinate the actions of different sub-teams. At the same time, there is enough decentralization to permit self-organizing behaviors that are the hallmark of adaptive teams. If the team is too centralized in its control structure, it will be unable to show the self-organizing behaviors needed for rapid reactions. If the team is too decentralized, then it may have trouble synthesizing the data elements to form an accurate big picture. The boundaries between sub-teams have to be sufficiently permeable that relevant data can get across, and be aggregated and synthesized.

Mindset. We speculate that adaptive teams expect to make adjustments, and are therefore looking for the problems and weaknesses. This stands in contrast to non-adaptive teams that become committed to the planned course of action, and resist having to change it, and are surprised when they realize that it will not work

Attention management. We speculate that, because of this mindset, adaptive teams are actually managing their data-collection resources to detect weaknesses. This stands in contrast to non-adaptive teams that seek to find routines for collecting data, so that data collection does not require much work. Given the problems of acquiring and interpreting data, the team needs to have its collection assets properly configured in order to learn how it is doing, and whether it is making appropriate progress. A common approach is to build a collection plan, and to issue

CCIRs (Commanders Critical Information Requirements) in order to be sure of getting what is needed. (We will discuss the limitations of using CCIRs in a later section.)

Common ground. Adaptive teams realize they may have to make modifications without much time to prepare, so they are careful to calibrate their situational understanding, and to repair breakdowns in common ground (see Klein, Armstrong, Woods, Gokulachandra, & Klein, 2000) for a discussion of common ground in distributed teams). As a result, they are less vulnerable in making changes than non-adaptive teams because they have fewer areas of potential confusion. Common ground depends on the accuracy of assumptions between team members regarding each other's goals, knowledge states, workload, and priorities. The more accurate these assumptions (and the stronger the common ground), the more efficient the communication and the lower the chances for misinterpretations.

Big picture. For the reasons stated above, adaptive teams are more diligent at tracking the big picture, because they know that if they do have to make changes in the planned course of action, these changes are likely to ripple through different aspects of the teams' functioning. This aspect is different than maintaining common ground because it addresses the way the team sees the relationships between different events, whereas common ground is about the accuracy of assumptions needed for communications and interchanges.

Problem Solving

Bernstein (1996) has defined dexterity as problem solving, and so we portray it, in Figure 1, as the set of standard problem-solving processes. These are problem detection, sensemaking (problem identification), parsing (developing a solution), and evaluation.

Problem detection. Klein et al. (1999) described the process of problem detection and why it can be so difficult, both for individuals and teams. In Figure 1, the problem is inferred from the data elements, but that only happens if the data elements are being monitored. Often, there is a "Catch 22" in that you only monitor a data stream if you already think there is a possible problem, but you would not suspect there was a problem unless you were already monitoring the data. We speculate that adaptive teams have an advantage because they have more problem-solving routines available, and have a mindset of expecting to make modifications, so that their attention management is more effective and they are more likely to detect problems early, when they are more tractable.

Adaptation is triggered under conditions described by Klein et al. (1999): An update has been received, changing the interpretation of the situation; an opportunity has arisen; an impasse has been reached; an anomaly has been identified.

Sensemaking. This corresponds to problem identification and diagnosis in most problem-solving models. We use the term "sensemaking" because we believe that the activities discussed by Weick (in press) come into play here, particularly for teams and organizations. Each member will have different types of information, different experiences, different interpretations, and somehow the team must find a way to rapidly construct a workable story of what is going on.

Parsing. The problem solving depends on changing the tasks to be carried out, the way they are to be carried out, or, in many cases, both. We can describe this as making changes in the way the tasks are "parsed." (In this context, parsing means the way tasks are decomposed so that different team members can be working in parallel.) See also Kozlowski, Gully, Nason, and Smith (1999) on the way teams reconfigure their tasks.

For example, if two co-authors need to write a report, and lacking laptop computers they may draft it in longhand on an airline flight (having decided which person writes which sections), and then hand it to a production specialist to do the word processing. But imagine a case where the plane was delayed, so that the report must be produced very soon after the plane lands, but all the production specialists have left for the day. Now the co-authors have to do the word processing themselves. One scheme is for co-author A to enter the first 30 pages, and co-author B to work on the second 30 pages. That is reasonably efficient. Compare it to another scheme, designed to take advantage of the fact that co-author A is left-handed, and co-author B is right-handed. Here, they both work on the entire manuscript, and co-author A uses his left hand, while co-author B uses his right hand (we can call this the 'favored-hand' strategy). This would not be effective means of parsing the task. And even the first strategy might not be useful if there are many references that need to be located. It may be best to have the co-author most familiar with the references do the reference section, while the other co-author enters the text. Or one co-author can work on the graphics, if these are going to be tricky and that co-author has skills in the area. Further, if one co-author does the references and graphics, and the second co-author enters the text, it becomes possible for that second co-author to provide more integration of ideas, and to provide cross-references. In this way, the task itself changes from simple translation of handwritten materials to electronic copy.

For an effective adaptation, the problem of carrying out the mission or pursuing the goal depends on finding a way to break down the task into sub-tasks that can be efficiently performed by the different team members.

We speculate that effective parsing reflects these criteria (shown in Table 2): it reduces the number of handoffs needed (as opposed to having the two co-authors use their favored hands in the example above, which maximized handoffs); reduces the workload (e.g., by having the graphics produced by the co-author with these skills, rather than having the other co-author painfully go through the manual); reduces the reaction time (another reason why the 'favored-hand' method is not suitable); places least strain on common ground (which is why it is not a good idea to have the co-author who is less familiar with the literature prepare the references, because s/he will continually be asking the other co-author which of several possible citations is the correct one); makes best use of expertise (again, the reason for allocating tasks such as preparation of reference section and graphics); and has the lowest coordination costs.

Klein (in press) discussed the coordination costs that are incurred whenever a task is decomposed so that it can be performed by a team. Examples are synchronization costs (the time spent waiting when one sub-task depends on the completion of another, and the second is delayed), diagnosis costs (the additional difficulty of finding problems when sub-tasks are performed in parallel), communications costs (the effort of having the team members keep each other informed) and redirection costs (the time wasted when a task is changed, so that a sub-task

becomes unnecessary, but there is a delay in notifying the person performing that sub-task). The 'favored-hand' strategy for producing the report would incur the highest coordination costs of any of the approaches described.

Table 2
Criteria for Effective Task Parsing

- Handoffs
- Workload
- Reaction time
- Common Ground
- Expertise
- Coordination costs

The activity of parsing a task, particularly under time pressure when a team is trying to adapt, is difficult. It usually involves both external and internal adaptation, an alteration in what is being done and how it is to be done. Thus, while it may be tempting to 'freeze' the task in trying to find better ways of getting it accomplished, or perhaps ways to reduce the number of people needed, this seems to miss the point of team adaptation that the task itself is going to change. Thus, in controlling ships, there was a need for controlling direction, for navigating, and for controlling propulsion. New systems allow all three of these functions to be performed by the same person, at a reduction in workload. In fact, an attempt to separate these functions would be akin to the "favored-hand" strategy. But this new parsing depends on new ways of performing the sub-tasks, e.g., using GPS for navigation rather than relying on sextants.

Evaluation. During adaptations of a plan, teams often have trouble evaluating the new or revised course of action. This is because adaptation involves modifying a plan in progress, so that the status of the different elements is unclear. For example, Mumaw, Swatzler, Roth, and Thomas (1993) in some research involving nuclear power plants, show how hard it is to know what is going on inside the plant. Simply having the schematics and control settings is not enough, because some equipment may be malfunctioning, other pieces of equipment may be shut down for maintenance, and so forth. Only the operator in direct control can appreciate these anomalies and how they will affect the plant's functioning, in case some adaptation is needed. Another reason why evaluation is difficult is that it is difficult to catch unintended consequences. Orasanu (1994) discussed two sorts of aviation accidents, one caused by unwillingness to change a plan, and the other caused by unanticipated consequences when a plan was changed.

Figure 1 shows the three factors that are in operation during team adaptation. Two of these, the resources and the problem-solving activities, interact directly. Figure 2 presents a matrix to highlight some of the strongest areas of interaction.

These are the basic elements of the process of team adaptation. Describing them may produce an impression that adaptation is straightforward. This is not the case. A number of factors, described in the next section, will influence whether a team shows adaptive behavior.

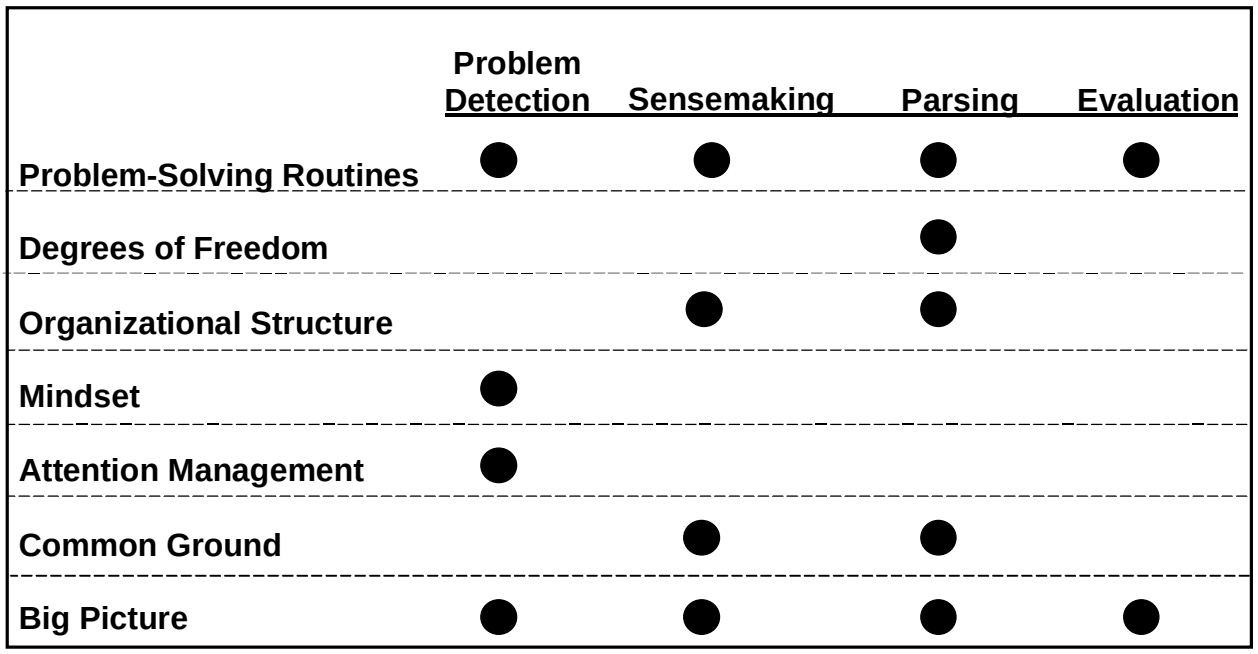

Figure 2. Intersection of adaptation resources and problem-solving activities.

Factors that Reduce Team Adaptivity

We have compiled a list of mistakes that teams and organizations may make, leading to a failure to adapt. Some of these are simply oversights. Some result from inaccurate beliefs. But some are based on organizational culture, and here we think it will be very difficult for teams and organizations to make the changes necessary to become adaptive. We are claiming that there may be inherent barriers to adaptivity in some teams. Even though teams may espouse the goal of being adaptive, they may be unwilling or unable to make the changes necessary. Table 3 lists the practices that will make it difficult or impossible for a team to be adaptive. Table 3 can be treated as a primer of how to create teams that have the wrong stuff. Here is what you would do to create non-adaptive teams.

Table 3
How to Create Non-Adaptive Teams

Training
Train for mastery of task routines
Use the crawl, walk, run method of training
Use part-task training methods

Performance Appraisal
Gauge progress by seeing if the plan is being accomplished
Use outcome feedback methods, and performance standards, and methods such as Management by Objectives.

Organizational structure
Make sure the Command Post is staffed to handle every contingency.
Centralize to provide necessary controls
Rely on collection plans and CCIRs
Use less-skilled personnel to collect data.
Rotate in fresh planners

Plan features
Develop highly detailed plans
Develop highly efficient plans

Training

We can hinder adaptability by the way we train.

Train for mastery of task routines so that they are over-learned to reduce skill decay. Bernstein (1996) cautioned about putting too much emphasis on mastering the routines, rather than building up a problem-solving repertoire. Ideally, as soon as a team achieved an adequate level of performance on routines, they would be put through exercises where things fell apart, forcing them to enter into a problem-solving mode, and preparing them to be on the lookout for problems. However, it is tempting to continue to drill on routines for several reasons. It takes less work. It is easier to gauge level of progress. It provides a feeling of mastery. It satisfies a leader to know that the team can carry out its routines flawlessly. We can refer to this as 'experiosclerosis' (as opposed to flexibility). The teams believe they are experts because they are so good at the routines. They are highly coordinated. Truly dextrous teams never consider themselves experts. Their training always keeps them off-balance, and they are looking for ways to improve on their weaknesses. The routines are best learned in conjunction with the workarounds, not prior to workaround training. As an example, in a SASO training exercise, the teams needed to establish checkpoints. They did so within the traditional framework of maintaining military security, and were so satisfied with carrying out the routines well that they did not realize the routines were inappropriate, and were creating antagonism with the populace that the troops were intended to support.

One reason units like to drill on task routines and procedures is that it allows soldiers to achieve mastery and avoid failure. But what is more important is to force subordinates to develop problem-solving routines, and the way to do that is to confront them with situations and configurations that are unfamiliar. Therefore, they cannot be sure of following the standard steps and procedures to be safe. They have to think things out each time. And a great deal is learned from failure. Nevertheless, many organizations continue to drill on routines rather than require improvisation. The sign of the expert is to know when and how to break the rules.

A related mistake is to make sure everyone masters his/her job before worrying about what others are doing. This is a good way to create negative transfer, because when a team is working well, people are very aware of their interdependencies. By training people to concentrate only on

their own job, the result is that they will have to unlearn these lessons, and unlearn the attentional control strategies, if they ever want to achieve high levels of teamwork.

Adaptive teams worry about the loss of connection between distributed team members, and about the problem of decomposing tasks that will later have to be synthesized. Therefore, adaptive teams encourage their members to be aware of what is going on around them. In contrast, non-adaptive teams take the easier route of using task analyses to figure out the minimum that each person needs to learn (to reduce training costs), and to eliminate those materials that are nice to know, but not necessary. This results in impermeable boundaries, as the different sub-teams know little about the challenges and problems of the others. With impermeable boundaries, it is more difficult if not impossible for these teams to see the bigger picture that crosses over and between the sub-teams. It is more difficult to avoid a parochial attitude that prevents problem detection and adaptation. Further, the more familiar team members are with the jobs of others, the greater chance for role interchange, which adds more flexibility. Finally, the less attention team members pay to each other, the less able they are to calibrate common ground as they go along, or even realize that common ground has been compromised. This creates uncertainty about initiating a workaround without going through the effort of briefing everyone. Because adaptation often demands rapid reactions, the time requirement for re-establishing common ground often is grounds for keeping the original plan.

Use the crawl, walk, run method of training. Sometimes, this strategy is useful, particularly at the level of company and below, where there is a need to learn basic routines. Nevertheless, for training to high levels of competence and for achieving adaptive skills, it may be counterproductive. For complex performance, teams usually have to abandon the strategies that worked when they were just starting out. Riding a bicycle is a different skill than riding a tricycle. Often, individuals and teams will start by limiting the degrees of freedom they have to control, to simplify the task. Examples are darts, hitting a baseball, swinging a golf club. Performance is too variable and chaotic if all the joints and degrees of freedom are open. Therefore, novices reduce degrees of freedom as much as they can, in order to reduce variability and achieve control. As they improve, it is essential that they explore new ways of carrying out the tasks.

Yet trainers often structure a curriculum to build smoothly and to keep errors at a minimum. Perhaps this is to create the impression that those early lessons were not wasted, since they are the building blocks of the future. (Actually, those lessons should be discarded so that the teams can be freed to explore new strategies for managing more degrees of freedom.) The crawl-walk-run approach also fits in with error-free learning, which is relatively painless. It is painless because it is not challenging and threatening. Gopher (1994) showed the importance of flexibility training by preventing people from using their favorite strategies as they learned a computer game, Space Fortress. They were forced to work out alternative strategies, and this gave them richer mental models of how to perform the task. Another example here is the Adaptive Battlefield Thinking training program developed by the Army (Ross, 2000; Ross & Pierce, 2000). This program requires trainees to adopt multiple perspectives, to face unexpected situations, and to learn from failure.

For purposes of structuring a training curriculum, the task should not be oversimplified, but it should not be overwhelming. Bereiter and Scardamalia (1993) discussed the proximal zone of development. The idea is that to achieve excellence, you need to be pushing beyond your comfort zone, but staying short of the point where the task becomes bewildering

Use part-task training methods. Bernstein (1996) criticized these because they isolate different task functions. For dexterity and adaptability, teams will need to see the connections across functions. If the training has used part-task methods, for purposes of efficiency, then it becomes less likely that the teams will be sensitive to the connections and affordances. They will be less likely to achieve problem-solving success by crossing the boundaries of the partial tasks.

Performance Appraisal

We can reduce adaptability by the measures we use to assess performance.

Gauge progress by seeing if the plan is being accomplished. This assumes that the goal is to carry out the plan. However, most plans become obsolete, and should be modified or abandoned. Using the metric of plan accomplishment merely encourages the team to fixate on the plan. Adaptive teams are prepared to engage in rapid replanning, and this should be encouraged.

Unfortunately, many planners do fall in love with their plans. And one of the attractive features of plans is that they provide a basis for measuring progress. The judgment of "how are we doing?" is notoriously difficult. If we can answer this question on the basis of the successful prosecution of the plan, it makes everyone's life easier. So it is tempting to make the plan the basis for progress determinations. But to develop adaptive teams, this temptation should be resisted. Adaptive teams are less worried about formal metrics, and more concerned about the unintended consequences that might arise from the changes they introduce. Adaptive teams understand the purpose of the mission and can modify the plan accordingly. Their focus is on achieving the mission, not carrying out the plan. For non-adaptive teams, it can be the reverse. Thus, in one peacekeeping exercise, little or no mission analysis was done and no attempts were made to describe success criteria. The organization was not prepared to think about progress in carrying out the mission. All they had was the plan.

The deeper mistake here is focusing the effort on carrying out the operations order. One of the keys for adaptive teams is to be able to spot anomalies. The sequence is to recognize the problem, diagnose it, and determine how to make changes. Non-adaptive teams struggle with all three, and very often they never even recognize that something is going wrong. Nothing ever triggers a shift into a problem-solving mode. Latane and Darley (1970) discussed the importance of spotting and reacting to problems, and taking responsibility for initiating action. Non-adaptive teams cannot achieve this. Thus, in a training exercise to prepare for a peacekeeping mission, the trainees were not aware of problems in handling the local populace, problems in carrying out inspections, and so forth. In a nuclear power plant exercise (Klinger & Klein, 1999), the plant managers were simply unaware of ways that performance was breaking down, and they even denied that these breakdowns occurred until confronted with evidence. Therefore, it is essential that teams learn to become more sensitive to what is happening. The danger of focusing on

carrying out the operations order is that this is only one metric of success, and possibly a flawed one. Even if legitimate, it misses other factors that need to be monitored. It simplifies the job of evaluating performance, and that is why it is so tempting—are we carrying out the tasks as scheduled? However, it oversimplifies the evaluation task, and can serve to provide blinders to commanders who need to take a more careful look at how things are progressing.

Truly adaptive teams can sometimes dispense with plans, altogether. Thus, General Horner, the JFACC for Desert Storm, used a reactive planning approach he called "Ready, Fire, Aim." To reduce reaction time, he launched close air support missions without a primary target. They were placed at the immediate disposal of the ground commander. In this way, Horner could evade the restriction of a 72-hour ATO cycle, and provide ready access to air support. If the ground commander didn't need the air support, the aircraft were released to strike secondary targets.

Use outcome feedback methods, and performance standards, and methods such as Management by Objectives. These make good sense if you are drilling a team to achieve better coordination. But if you want an adaptive team, you should encourage it to set its own goals, in accordance with their proximal zone of development. Forcing them to rely on external standards is a step backwards from letting a team become adaptive. The establishment of clear external performance standards can be satisfying. Nevertheless, if teams are being prepared to handle new challenges, it is difficult to imagine how pre-defined performance standards are going to be useful.

Organizational Structure

By preparing an ineffective organization structure, we can impose barriers on adaptability. There are many ways to achieve this.

Make sure the Command Post is staffed to handle every contingency. This is the usual state of affairs, and it results in Command Posts that are so overcrowded that the staff gets in its own way. Klinger and Klein (1999) explained how workload can be reduced by cutting staff, and it is our belief that most Command Posts would function more adaptively with fewer personnel.

In addition to overstaffing the command post, there is also a mistaken organizational practice of trying to plan by getting everyone who is relevant into the room. Because of time pressure, there is a tendency to gather together everyone who needs to be a player. However, rapid replanning seems to work best with cells of perhaps 5-7 people (e.g., Gualtieri, Bergondy, Oser, & Fowlkes, 1998). At some point, the increase in coordination gained by including more people will be cancelled out by the inefficiency of working with too large a group.

Centralize to provide necessary controls. Centralize to provide necessary controls. The reason that adaptive teams centralize is to synthesize data across sub-teams, and see the big picture. Teams that try to impose top-down controls will stifle adaptability. For teams with top-down controls, no one except the commander is confident that he/she has the authority to initiate a workaround.

Rely on collection plans and CCIRs. This is the typical mode of operations for military forces. CCIRs are the Commander's Critical Information Requirements, a list of data elements that the commander believes will be most useful. Unfortunately, it assumes that the important information items can be defined in advance, which is unrealistic in a chaotic environment. Adaptive teams are able to redirect their attention skillfully. They are able to anticipate where to assign attentional resources. Mechanistic processes such as pre-determined collection plans and CCIRs prevent teams from being adaptive, and they are inconsistent with the mindset of exploring the situation. There is a difference between trying to make sense of unexpected types of intelligence, versus processing CCIRs and implementing collection plans. Even worse, in SASO missions, it is often the unexpected, accidental information that may be most important. Collection plans and CCIRs are insensitive to these, and so are the command posts that rely on them. However, even worse than a mechanistic collection plan that is usually hard to modify, is the absence of any preparation for collecting information. In a SASO exercise, we observed a commander instruct his unit "Tell me everything you know until I tell you to stop." The result was a series of time-wasting meetings, because of the failure to prepare for collecting information. The result was also an insensitivity to "found" information that was not expected, but had high value. Weick (in press) noted that an improvisational mindset leads people to be actively looking for anomalies, trying to detect early signs of problems. Thus, adaptability is dependent on the team's mindset at all levels, from detecting the problem, to diagnosing it, to reacting to it.

We recognize that CCIRs and collection plans do serve some useful functions, and therefore, we encourage organizations to find ways of designing flexible strategies for collecting information. Our comments above are based in part on the ineffective practices we have seen regarding the application of collection plans and CCIRs. However, we also want to alert organizations to inherent limitations in trying to build information-gathering routines that can be implemented mindlessly. The purpose of a routine, after all, is to be implemented without high degrees of effort and without having to rethink details each time. This is the opposite of being mindful (e.g., Langer, 1989) and adaptive. The routines of CCIRs and Priority Information Requirements (PIRs) are attractive, but they come with a cost—the reduction of attention.

Adaptive teams are not fixated on CCIRs and collection plans. They can appreciate the significance of context-based information.

Use less-skilled personnel to collect data. Because of the explosion of information, command posts usually establish a procedure whereby the most junior personnel are given the job of sorting through the basic data. This creates several barriers to adaptation. One is that junior personnel are not able to see patterns and implications. They are not able to realize the significance of events that did not happen. So there is a mindless filter imposed on the data. Second, the procedures for sorting out the results of this first filter, and the second, impose time lags and other confusions due to bureaucracies. Third, there is a loss of urgency. Adaptive teams are able to pick up one or two cues and realize their significance, and initiate action right away. Bureaucracies process data elements. Even if a clerk tries to voice urgency, his/her lack of seniority will mute that message. The critical job of being in touch with the situation is delegated to the least able members. It is like driving a high performance car, but using the cheapest tires.

Rotate in fresh planners. One of the inescapable problems the Army faces is the continual disruption of rotating in new decision makers because of injury or death, or even through normal replacement procedures. At the least, the disruption is caused by loss of expertise. There can also be trauma about the reasons for the rotation—the stress of seeing colleagues incapacitated. The average life expectancy of an Infantry 2Lt. in World War II Hurtgen Forest was 26 minutes of combat.

One of the key challenges for decision makers entering into an ongoing operation is to master the assumptions and contextual conditions so that they can gauge progress, identify problems, and understand how to make changes in a plan. It is very difficult to make changes if you don't understand all of the assumptions and interconnections between the elements of an existing plan. This is an easy way to generate unintended consequences that can lead to disaster.

Plan Features

By constructing the wrong type of plans, it is possible to limit adaptation.

Develop highly detailed plans. Planners have difficulty reaching closure. They often learn so much that they want to enshrine their knowledge in more and more branch plans and sequels. They rationalize this tendency by claiming that the details will help those in charge of execution to be more adaptive. All the executors will have to do will be to find the right branch plan, and shift to it. This rationalization is spurious. Executors rarely consult the branch plans and sequels. If anything, the excessive planning discourages adaptation because the executors may be unsure of the implications of making changes. Typically, if they are adaptive, the executors just ignore the plan and proceed with their replanning. They treat plans as platforms for adjustment. They are prepared to handle ill-defined goals and to revise the goals as the situation unfolds (e.g., Klein & Weitzenfeld, 1978).

Another difficulty with highly detailed plans is that they take more time to prepare. Like all plans, they rest on many assumptions. The longer the time gap between the plan preparation and its execution, the greater the likelihood that some of these assumptions will no longer be invalid, and the greater the likelihood that the planning personnel who might have noticed the inconsistency will have rotated. Thus, the more the detail, usually the greater the chance that the plan cannot be trusted, in ways that may be too subtle to detect in advance.

Develop highly efficient plans. The most efficient plans are interactive, so that resources are not wasted. Unfortunately, it is very difficult to modify interactive plans. In contrast, modular plans are usually fairly redundant, but are much easier to modify. Adaptive teams are best served with modular plans.

Summary

We have reviewed some of the barriers to creating adaptive teams because we wanted to describe how difficult this can be. It is one thing to espouse the notion of adaptive teams. It is another to give up some of the practices that get in the way of adaptive teams. For many organizations, it will not be easy, or even feasible, to give up training methods that are systematic and run

smoothly. It will not be easy to give up performance metrics that are clear and easy to apply. It will not be easy to alter organizational practices that are enmeshed in the culture. It will not be easy to change the nature of the plans that are produced.

We are not encouraging these changes. We are simply suggesting that an inability to make the changes may make it harder to build adaptive teams.

Metrics

The question being considered here is how to determine, in advance, whether a team will be capable of adaptive behavior. Are there indicators that can be used? And if we develop metrics, we must also be careful that the metrics do not interfere with effective performance. For example, one metric that can be used to evaluate the goodness of a plan is to see how long the plan stays in place during execution, but this metric can result in a situation where the command post team is discouraged from revising or adapting the plan, because to do so will reflect poorly on them as planners.

Table 4 identifies five types of metrics that could be used to estimate how adaptive a team will be.

Table 4
Metrics for Estimating a Team's Adaptive Capability

• Awareness of mistakes and shortcomings
• Effort spent practicing workarounds
• Ability to calibrate common ground
• Mindset for adaptation
• Balance of centralization/decentralization

Awareness of Mistakes and Shortcomings

Gladwell (1999) suggested that at the level of the individual performers you can determine who is dextrous and who is not by asking people about mistakes they have made recently. Typically, the less competent performers will be unable to remember mistakes, but will be able to talk about poor outcomes that weren't their fault. High-level performers are painfully aware of mistakes because they are skilled at self-evaluation and seek perfection. Applying this to teams, we would ask the leaders about the mistakes the team has been making, to see if they are aware of these or even monitoring for mistakes.

Along the same lines, we would expect that more adaptive teams would be better able to articulate why a plan might fail. This is linked to the ability to take multiple perspectives (Ross, 2000). For a team to be adaptive, we would expect that not only the leaders could perform such analyses, but that subordinates one and two levels down could also identify potential problems, and that these identifications would show a reasonable amount of agreement.

Further, if a team is sensitive to its weaknesses and potential failures, the members should be able to describe internal adaptations they would like to make, or at least frustrations they would like to correct. These internal changes might relate to their use of information-gathering resources. We would also expect to find sensitivity to external adaptation, e.g., potential confusion in carrying out ROE.

Effort Spent Practicing Workarounds

The measure here would be the way the team prepared by having its plan break down, its routines become disabled, and so forth. The key is whether the team is trying to build up relevant problem-solving routines. Can they imagine workarounds if these lose critical resources, such as breakdowns in communications equipment? Can they quickly determine how they would disseminate a fragmentary operations officer (FRAGO) to all the relevant subordinate and collateral units? If there is a need to rapidly disseminate a FRAGO, will the personnel in different units have the same expectations for how the dissemination would occur, or are there inconsistencies? Can the team members identify other means of achieving higher order goals if the plan runs into trouble? Can they anticipate problems with a plan, once it is issued?

Ability to Calibrate Common Ground

This is a specific type of workaround, but a critical one. Does the team practice recognition that it is losing common ground? Does it have practices for recalibrating common ground during low workload periods, rather than waiting for coordination surprises?

Mindset for Adaptation

An adaptive team is one that expects to make changes. It expects to find problems and therefore is looking for them. Does the team show this type of mindset? How does it regard the individuals who first detect the problems—as key assets, or as messengers with unpleasant news? Upon receiving such messages, is the orientation to dismiss the problem or to take it very seriously? Is the team trying to allocate its attentional resources to find problems, or to carry out routines? Does the team try to double-check potential problem areas so that it is not lulled into complacency? When problems do arise, how long does it take before the problem commands the attention of the team? Does the team primarily focus on information it was seeking, or is it also attentive to unexpected information that may be relevant? Can the low-ranking soldiers who encounter unexpected information see the significance, and do they get a hearing for their discoveries? Is the shared mindset one that tries to preserve the interpretation of the situation, or does the team honor the members who try to challenge that interpretation?

Balance of Centralization/Decentralization

Is the team appropriately structured to permit self-organizing behavior (decentralization) and at the same time, synthesis of different inputs (centralization)?

Recommendations

Based on our examination of the factors needed to establish adaptive teams, we have a few recommendations about ways to make teams more adaptive. These involve selection, operational practices, training, and the use of information technology and collaborative technology. We have identified several other factors affecting adaptability, such as organizational structure, the type of plan (modular versus integrated), and the way performance was appraised. These factors are also relevant in this section, but we have little to add beyond what was discussed earlier.

Selection

It should be possible to select for team members who are more adaptive. If so, then it becomes possible to establish adaptive teams through the makeup of the members. Thus, Pulakos et al. (2000) developed a scale, the Job Adaptability Inventory, to measure the degree and type of adaptability required by different types of jobs. They identified a set of eight factors that seem central to adaptability, at an individual level (we will discuss these in the final section). Following this line of research, we would expect to see the development of scales to measure individual differences in adaptability, probably relying on existing scales that differentiate factors such as tolerance for ambiguity.

Operational Practices

There appear to be practices that help teams be more adaptive when necessary. For example, Patterson, Woods, Sarter, and Watts-Perotti (1998) have documented the practice of ground control crews in charge of shuttle launches to use low workload periods for reviewing the plans. This practice allows the ground controllers to discover areas of confusion, and lets them calibrate common ground. Practices such as this can help a team be better prepared to make rapid adaptations. Additional practices would be to have the team meet about disruption to a plan, and also to develop communications routines such as the positive confirmation of messages (to reduce errors during chaotic and time pressured episodes).

Training

There are a number of training interventions that could improve a team's ability to adapt. They include the following:

- Training for both external and internal adaptations
- Developing problem-solving routines
- Training to manage more degrees of freedom
- Developing an "adaptation mindset"
- Blending whole-task training with part-task training
- Training communications workarounds
- Training information-seeking skills
- Training to rapidly "parse" a task
- Training to appreciate the team's affordances

We will not discuss all of these types of skills, because they have been examined earlier. However, it may be useful to expand on a few of these skills. Thus, training to appreciate a team's affordances refers to the need to be continually monitoring the status of resources, and to understand how these resources can be combined in different ways. When a plan breaks down, a team may have limited time to perform such a review, so the more the team is proactively tracking its affordances, the shorter its reaction time.

Another training approach that is relevant here is the work of Gopher, Weil, and Bareket (1994) on the computer game, Space Fortress. They showed that they could train attention management, particularly the reduction of tunneling into cues and the scanning of the big picture. Gopher et al. also showed the value of blocking people from using their favorite strategy to perform a task so that they would have to learn a second way, thereby developing flexibility.

Teams can be taught flexibility by building on the work of Spiro, Feltovich, Jacobson, and Coulson (1992) who used multiple metaphors and other techniques emerging from Cognitive Flexibility Theory to provide cognitive flexibility training. Ross and Pierce (2000) extended Cognitive Flexibility Theory to develop an Adaptive Battlefield Thinking program that combines deliberate practice, multiple perspectives, shifts to stronger mental models through disequilibrium experiences, and scaffolding. The Adaptive Battlefield Thinking program uses Advanced Cognitive Understanding of Military Environments (ACUMEN) to provide training with minimal instructor support. This program addresses issues such as seeing the big picture, and appreciating the unintended consequences of actions so that adaptations are not just short-term reactions.

There are other efforts that could be used to provide training that would help teams become more adaptive. Blickensderfer, Cannon-Bowers, and Salas (1997) have developed a method that could help teams see how well-calibrated they are when faced with challenges. Shattuck (1995) developed a method that could be used to train people to make fewer errors in communicating intent during replanning. Klinger and Klein (1999) have described a situation awareness calibration exercise that has been used to train teams to do a better job of communicating their interpretations of situations.

Pulakos et al. (2000) would suggest the value of training to provide greater facility with new technologies, as well as training that improves interpersonal and cross-cultural skills.

Finally, we would like to consider how one might provide training to result in an "adaptation mindset." This may not be as difficult as it seems. Training curricula can be modified so that exercises and scenarios always include at least one malfunction or breakdown. In this way, the trainee is not simply trying to perform the rudiments of the task. The trainee has to be mindful (as opposed to performing automatically), checking and double-checking everything to see what might go wrong. This may equate with an adaptation mindset. For example, one pilot explained how he was taught to land in a way that assumed a need for a go-around. If the go-around was not required, then he could simply land the airplane. Once, after he received his license, he was landing at a small airport and another pilot took an inappropriate action, necessitating a go-around. He was annoyed, but then he realized that it had been an inconvenience, not a crisis. If

he had not been trained to expect to have to perform a go-around, he might well have been startled, slow to respond, and possibly provoked into an accident.

Information Technology

There are many developments in the fields of information technology and collaboration technology, and it is beyond the scope of this report to review these. One example may suffice. In DARPA's Command Post of the Future project, technology has been developed that allows commanders, staff members, and subordinates to each have their own electronic maps (situated on laptops), and also to have access to each other's maps. In this way each team member was able to have some insight into the thinking of the others. Klein, Armstrong, Woods, Gokulachandra, and Klein (2000) suggested that one of the most useful ways for sustaining common ground is to allow the team members to track the stance of the others—their workload, fatigue level, attentional focus, and so forth. The DARPA technology appears to achieve just that type of outcome.

In contrast, we can warn about the use of information technologies that achieve the reverse. These are technologies that render the team members less aware of the stance of others. For example, one system we observed appeared to produce tunnel vision. It allowed each of the team members to work on his/her section of an operations order, but in isolation, whereas formerly they would be clustered together around a map. The collaboration technology dispensed with the huddles, and the result was that the team members developed tunnel vision. They believed they were collaborating because they were sharing files, but they were less aware of the big picture than before. Hammes (2000) described a similar outcome in a Marine Corps command post. The technology that replaced 3"x5" cards with electronic messages reduced noise, but the result was that the neighboring team members no longer got to see the information, and the noise that was reduced was also a source of team-wide information about the status of resources. The job of the individual became easier, but the performance of the team appeared to suffer.

Conclusions

We have presented some speculations about the nature of team adaptation, the factors contributing to effective adaptation, the way these factors operate, barriers to effective adaptation, along with suggestions for assessing a team's adaptability, and for improving adaptability. Much of what we have written will be familiar to many of the readers, but we believe we have offered some challenging assertions.

We have used Bernstein's (1996) framework to describe adaptation as problem solving, and asserted that excessive drill on task routines can reduce adaptation, rather than improving it. We have asserted that too much part-task training can reduce adaptation. We have described the factors that need to be taken into account in rapidly parsing a task in order to change how it will be performed. We described the ways that organizations actually prevent adaptation because of the way they conduct training, the way they appraise performance, the types of plans they produce, the organizational structure that results in overstaffing, and in mechanistic information-seeking routines. We presented our opinion that most organizations will be unable to give up these practices, and therefore will be limited in how adaptive they can become. We may be

mistaken in some or all of these claims, but we have offered them because we believe they are valid, and because progress is best served by building on falsifiable hypotheses than by rendering bland assertions that cannot be wrong (and therefore have little informational value).

Our model of team adaptation appears to be consistent with the description of individual adaptation provided by Pulakos et al. (2000). These researchers identified eight factors that seemed to be central to adaptation in the workplace: Handling emergencies, handling work stress, solving problems creatively, dealing with uncertainty, learning new work tasks, technologies and procedures, demonstrating interpersonal adaptability, demonstrating cultural adaptability, and demonstrating physically oriented adaptability. We have addressed some, but not all of these factors. The key to our model of team adaptation is the need for problem solving to handle uncertainty. This captures the two of the Pulakos et al. eight factors that received the highest scores across different types of jobs. Several of the other factors seem primarily relevant for individuals, rather than teams (e.g., handling work stress, and demonstrating physically oriented adaptability); these two factors also received very low ratings in the assessment that was conducted by Pulakos et al. Two other factors are inherent in our framework: handling emergency or crisis situations, and learning work tasks, technologies, and procedures. These factors and the remaining two (interpersonal adaptability and cultural adaptability) are about the content of what has to be learned, whereas our intent was to describe the process of team adaptation.

Lastly, we would like to suggest some directions for future research on team adaptation. We hypothesize that teams that are over-trained on routines will be less adaptive than teams that have been practicing workarounds as soon as they reached a minimal level of proficiency on the routines. This should be testable.

We hypothesize that teams can develop problem-solving routines, and we have speculated about the types of problem-solving routines that might exist. This listing can be evaluated and improved. It could be valuable to prepare a more comprehensive set of problem-solving routines that teams should master, in order to become more adaptive.

We hypothesize that task parsing depends on a small set of considerations. This can and should be evaluated and improved. It could be valuable to better understand the variables that contribute to successful parsing.

We hypothesize that teams will benefit from training that provides disruptions and breakdowns, to force the teams to build problem-solving skills. This is testable. Further, if we can learn how to provide useful breakdowns, that would improve scenario development practices. Too often, scenarios simply escalate into Armageddon, which seems to increase stress, but which may not be effective for training, especially if the team needs to learn how to detect problems at early stages when the cues are still subtle.

We hypothesize that it is possible to identify adaptive teams prior to observing them in action. These metrics should be clarified and evaluated.

We have tried to provide some useful ideas for understanding team adaptation. Hopefully, this report can lead to improved practices as well as to continued research. While we would like to see follow-on efforts that build on our analyses, we recognize that future work may take very different directions, because researchers can and should be adaptive.

We hypothesize that the nature of adaptation will change as a team has more experience working together. Kozlowski et al. (1999) suggested some characteristics of these changes.

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