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A Model of Advanced Team Decision Making and Performance: Summary Report

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Unit-Collective Training Research Unit

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A MODEL OF ADVANCED TEAM DECISION MAKING AND PERFORMANCE:
SUMMARY REPORT

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**A MODEL OF ADVANCED TEAM DECISION MAKING AND PERFORMANCE:
SUMMARY REPORT**

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Introduction

Select two teams whose individuals are relatively equal in experience, training, skills, and background. Provide these teams with the same training and then observe them perform in their natural environment. Often one team will perform better than the other. Why do these two comparable teams perform differently? Why is one more effective? These are the questions the Army posed to Klein Associates Inc. Answering these questions is the central focus of this research project.

The Army noticed that though various units would go through similar training regimes they might have radically different performance levels during their rotations at the combat training centers (CTCs). This became even more evident as the Army began efforts on their Home Station Determinants Project. The concept behind home station determinants was to look at the relationships between aspects of a unit's home station training (content, sequence, methods, resources expended) and its CTC performance. These training determinants encompass the unit's collective training as well as the individual soldier training issues. What are conspicuously absent are the dynamics of how team members can interact most effectively to accomplish their tasks as a team. There are infinite ways that a collective task can be performed. In addition, every commander has the option of structuring his staff the way he wants to — and new commanders often change the unit's structure in radical ways.

Understanding why some teams perform better than others requires that we look at the dynamic interactions within teams and the way these interactions contribute to the performance of the team. This understanding can form the basis for a descriptive model of teams that can be related to advanced team performance. Once a model is developed, it can be communicated to others and can serve as the basis for developing tools for assessing teams. These assessments can be used as direct feedback for immediate training purposes as well as providing guidelines for future training.

This report describes a Phase II SBIR project conducted by Klein Associates under Army Research Institute (ARI) Contract MDA903-92-C-0098. The overall goal was to address the above questions posed by ARI. The technical objectives for this project were threefold. The first objective involved the identification/development of a model of advanced teams. The second was to develop an assessment instrument based on this model. The third was to evaluate the utility of the model and the instrument using real-world teams.

The work described in this report is a culmination of many years of Klein Associates research on a wide range of teams. The current model of advanced teams that we present here is the result of a series of projects focused specifically on improving our understanding of the nature of teams and the implications of the dynamic interactions of their members. During the Phase I of this work for the U.S. Army Research Institute, we began looking at teams from the perspective of individual cognition and we identified a preliminary set of observable behaviors that appeared indicative to team skills (Thordsen, Klein, Wolf, &

Banks, 1993). In a separately funded SBIR from ARI, we furthered this line of research by producing the original version of the ATDM model (Zsombok, Klein, Kyne, & Klinger, 1993), referred to here as ATDM 1.0. The latest version, ATDM 2.0, was developed during this Phase II project for ARI, and is described in this paper. Development of the model has also been influenced by our work with helicopter crews (Thordsen, Klein, & Wolf, 1990), commercial aviation crews (Klein & Thordsen, 1991; Thordsen & Calderwood, 1989), Army battalion-, brigade-, and division-level planning teams (Thordsen, Galushka, Klein, Young, & Brezovic, 1990; Thordsen, Klein, Michel, & Sullivan, 1988), planning teams at the National Defense University (Calderwood, & Thordsen, 1989; Zsombok, Klein, Kyne, & Klinger, 1993), wildland incident command firefighting teams (Taynor, Klein, & Thordsen, 1987); and Department of Energy emergency operations teams (Klein, Thordsen, & Calderwood, 1989). For clarity, we will always refer to the earlier ATDM model as version 1.0 and to the current model as version 2.0.

The evolution of the current ATDM 2.0 model reflects the lessons we have learned from applying our work in the varied settings mentioned above. The current model incorporates team resources, team identity, team cognition, and team metacognition into a four-tiered framework. The two upper tiers, the Team Components and their Behavioral Dimensions, provide a general description of teams at a domain-independent level. The two lower tiers, specific behaviors and their anchors, allow the descriptive model to be customized for applications with specific domains.

We divided the project into four stages in order to address the technical objectives. In stage one, we conducted an extensive review of the current team literature. In stage two, we developed the team model and an assessment instrument. Stage three included a field test and an evaluation of the model and assessment instrument. And finally, we developed a prototype package of the model and assessment instrument to show that the materials could be transferred to the assessment/training personnel of teams. A report was generated for each of the first three stages. These reports are referenced under Militello, Kyne, Klein, Getchell-Reiter, and Thordsen (1994), Thordsen, Klein, and Kyne (1994), and Kyne, Thordsen, and Kaempf (1994), respectively for the first three stages. The package of materials we used to transfer the information to the domain subject matter experts (SMEs) for the test and evaluation (stage three) constitute the deliverable for stage four. The four stages will be described briefly in the following section but we refer the reader to the full reports for additional description and detail.

Products Delivered

Literature Review

Our primary goal was to create a comprehensive model of team performance that could assess teams in any domain. For this stage of the project, our specific objectives were to review current models of team performance (including ATDM 1.0), identify common themes and patterns among the models, and synthesize the models by classifying the critical

elements of team processes into a common framework (see Militello et al., 1994, for a complete description of the review).

The team performance literature is generally divided into three different fields: social psychology, military science, and industrial/organizational psychology. Because of this, a comprehensive review of team literature would be an overwhelming task under the best of conditions, and to impose any time or financial constraints would make it virtually impossible. Our challenge was to cover a wide range of research and simultaneously complete the task with the resources available. To do this we reviewed 211 team articles from which we identified several lines of research that had integrated previous research and addressed team performance conceptually in operational settings. We further focused our attention on lines of research that contained a theoretical model and a corresponding assessment tool. Working from these assessment tools, we could investigate commonalities across models. These commonalities helped us identify factors to incorporate into a comprehensive model of teams.

Ultimately, the literature review focused on six lines of team research. Each employed different perspectives in their approach to modeling teams. Morgan, Glickman, Woodard, Blaiwes, and Salas (1986) adopted a developmental view of teams. McIntyre and Dickenson (1992) used a control theory metaphor. Fleishman and Zaccaro (1993) prepared an extensive taxonomy of team functions. Olmstead (1992, 1993) worked out the idea of an organization as a homeostatic system that adapts to achieve equilibrium. Helmreich and Foushee (1993) relied on an interpersonal view of teams. Zsombok et al. (1992) relied on a cognitive metaphor.

While these models were similar in many respects, they were unique enough that direct comparisons were difficult. Therefore, a two-stage analysis was adopted for comparison of the models. The initial stage involved extracting the comprehensive set of all the team processes described by the models. The second stage of analysis involved mapping this comprehensive set of processes onto a common framework so we could make comparisons. To borrow a sports metaphor, we put them on the same playing field. This common field allowed us to make several types of comparisons: which specific processes were addressed by which models; the types of processes addressed by the different models (e.g., communication processes, cognitive processes, etc.); and the level of abstraction of the processes each model identified (e.g., abstract construct, behavioral dimension, specific team behavior, or behavioral anchor level).

The review allowed us to make several observations. First, the models generally converged on the processes they identified as critical for team performance. Considering the diversity of the six models and the fact that they were based on very different metaphors, the convergence between them was somewhat unexpected. Second, the models varied in their degree of abstraction. That is, some models provided broad descriptions of team processes while others were tailored for specific teams in specific domains. Third, while we expected to find variation in the terminology used by the models to describe similar

processes, there was also variation in the emphasis the models placed on types of processes. For example, all of the models, either directly or indirectly, addressed the process of leadership, those based on military teams placed more emphasis on it as a process than did the models from other domains. Some models emphasized personalities more than others, some treated communications as processes while others treated communication as a link between processes. Decision making was generally handled as the communication of the results of the decision-making process. In contrast, the ATDM 1.0 model segmented decision making into specific sub-processes.

When all the processes were reduced, they converged on a common set of four components that we loosely classified as team competency, team identity, team planning and decision making, and team self management. Team competency addresses factors that can be viewed as "pre-team." In other words, the "raw materials" that are available from which to build the team. These include things such as the skills and expertise levels that the individuals possess. We considered these "pre-team" since their presence does not guarantee they will be used effectively, or even at all, by the team. The team identity grouping includes the "teamwork" processes identified in the models, such as knowledge of how one's roles and functions affect those of other team members. Planning and decision making captured the cognitive processes described in the models, such as the development of team situation assessment. Finally, all team supervisory processes, such as time management, were included in the team self management category.

The literature review helped guide our revision of the ATDM 1.0 model. One finding in particular caused us to make a major modification. All of the models emphasized team leadership and team resources, except ATDM 1.0, which addressed them only indirectly. Based on this observation, ATDM 2.0 would need to be expanded to cover these processes more directly.

Model Development

Our goal was for the ATDM 2.0 model to cover a full range of team settings including planning and execution for tactical and strategic, novice and experienced teams. As a result, there are four features of ATDM 2.0 that differentiate it from the other models of team performance (e.g., Fleishman & Zaccaro, 1993; Helmreich & Foushee, 1993; McIntyre & Dickenson, 1992; Morgan et al. 1986; Olmstead, 1992, 1993; and Zsombok et al., 1992). First, it is a comprehensive model designed for identifying and describing the key elements that contribute to advanced team performance. Second, ATDM 2.0 is guided by a metaphor that allows one to view a team in much the same manner as you would view any intelligent entity. Third, the model specifically addresses the cognitive functions of teams. Many of the models describe the individuals, resources, and lines of communication, but few wrestle with the team's decision-making and problem-solving processes. Fourth, ATDM 2.0 is designed to be both general and specific. We felt it was important that the model provide a general description of teams and simultaneously be capable of being tailored to specific teams in specific domains. Each model emphasizes at least one of these features, but ATDM 2.0 is the only model that emphasizes all four.

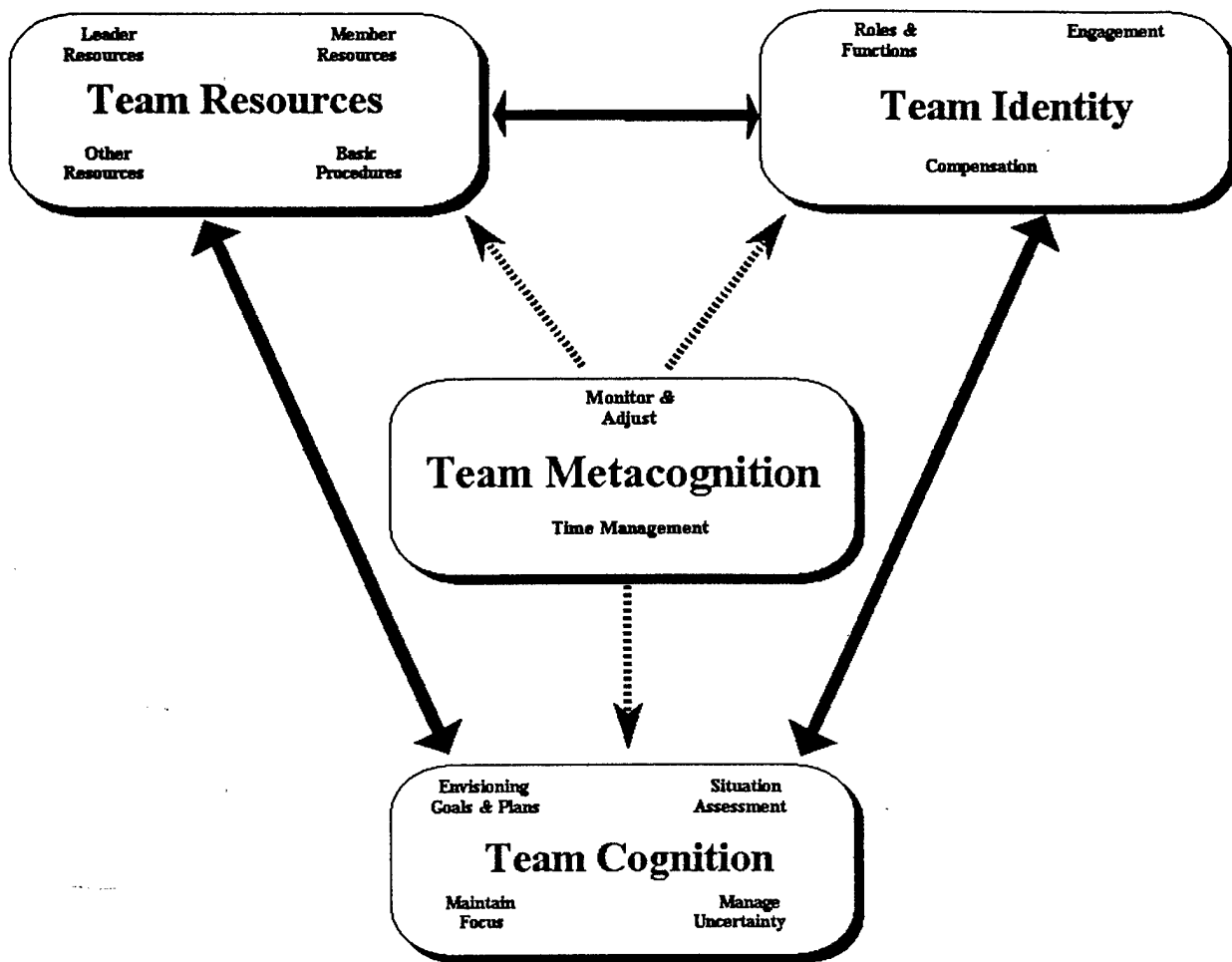


Figure 1: A Model of Advanced Team Decision Making, version 2.0.

To help us accomplish the objective of developing a model that was both general and specific at the same time, we organized the ATDM 2.0 model along four tiers. The two higher tiers (Team Components and Behavioral Dimensions) provide a general description of teams and the factors that contribute to advanced team decision making and performance. This general model of teams, derived from the two upper tiers, is described immediately below and diagramed in Figure 1. The two lower tiers (Specific Behaviors and Behavioral Anchors) allow us to specify observable team behaviors for specific domains. The Specific Behaviors and Behavioral Anchors are discussed in more detail later but cannot be included in Figure 1 since they vary depending upon the domain of interest.

Both versions of the ATDM describe teams as intelligent entities, capable of learning and adapting, making decisions, reacting to surprises, creating plans and executing them, i.e., teams that can demonstrate cognitive capabilities. The upper tier of ATDM 2.0 recognizes four components in describing a team: Team Resources, Team Identity, Team Cognition, and Team Metacognition (see Fig. 1). Team Resources involves recognizing what resources are available to the team. For an individual, these capabilities might involve personality dynamics, intelligence, and experience base. For a team, the cognitive function rests partially on the individual capabilities of the team members and partially on the ability

of the team to recognize and transition these individual resources into resources serving the entire team. Team Identity is the extent to which individuals identify themselves as part of the team. Erikson (1963, 1968) used identity to refer to an individual's establishment of a stable personal identity. One aspect involved selecting a role and knowing that others could clearly identify this role; that, in turn, led to an increased sense of confidence and purpose. Teams also need to develop a sense of identity, clarify the various roles and functions, and develop confidence and purpose. Decentering is a key element of Team Identity (Flavell, 1977; Piaget & Inhelder, 1969). For a young child, identity emerges by differentiating self from the external world. For a team, identity rests on its members to associate themselves with the output of the team, rather than with their own accomplishments. Team Cognition addresses the cognitive maturation of the team to make decisions and solve problems. Many of the "higher mental processes" (Bernstein, Roy, Srull, & Wickens, 1991), such as reasoning and problem solving, would be included under cognition. For both individuals and teams, decision making and problem solving, rely on processes for clarifying intent, forming situation awareness, managing uncertainty, and focusing attention effectively. Team Metacognition is the team's ability to observe itself and adapt. For individuals, metacognition refers to the knowledge and understanding they possess about their cognitive activities and problem solving and their efforts to regulate their ongoing information processing (Borkowski, 1982; Brown, 1975; Flavell, 1980; Santrock, 1983). For the individual, experience leads to metacognitive skills for taking ones' own capabilities into account. Similarly, teams must learn metacognitive or self-management skills to adapt to their own limitations and to the task requirements.

These four components constitute the highest tier of ATDM 2.0 and provide a broad, descriptive model of teams. Just below the Team Components level is the Behavioral Dimensions tier. Behavioral Dimensions are generic team behaviors that can be viewed as the critical dimensions along which each of the Team Components vary. This variation is critical in distinguishing good and poor team performance, opening the doors for assessment and training. While the Behavioral Dimensions are less abstract than the Team Components, they are still domain independent.

The Team Components and Behavioral Dimensions described above are general enough that they can be used to describe any team, regardless of domain. To tailor the model for teams within particular domains, Specific Behaviors for the Behavioral Dimensions and Anchors for these Specific Behaviors must be identified. These constitute the two lower tiers of ATDM 2.0. This structure allows the overarching model of teams, outlined at the Component and Dimension levels (see Fig. 1), to be focused on specific domains. For a detailed description of all levels of the model the reader is referred to Thordsen, Klein, and Kyne (1994).

Development and Evaluation

The goal for this stage of the project was to draft a team assessment instrument based on the ATDM 2.0 model and to evaluate the utility of the instrument in a field setting. The objectives, methods, and results of this initial evaluation study are briefly summarized below. The reader is referred to Kyne et al. (1994) for a full description of the field test.

Four specific objectives were identified for this stage of the project. First, we wanted to test the ATDM 2.0 model's usefulness for describing team performance. We chose urban firefighting as our test domain. Our second objective was to gauge the amount of effort required to identify markers at the Specific Behavior level. Third, we wanted to test the effectiveness of the instrument for helping an observer identify relevant team performance dimensions and rate the quality of performance. The fourth objective was to evaluate the acceptance of the model and instrument by domain experts.

We began this stage of the project by identifying specific behavioral markers for the fireground domain. Earlier we had developed an instrument for military battalion-level battle staffs after interviewing two experienced battalion commanders. This military version of the assessment instrument served as the template for the instrument we would use on the para-military fireground. The military form of the assessment instrument was modified for fire fighting during a pilot study, at which time the specific behavioral markers for the fireground domain were identified. We found that the specific behavioral markers translated easily from military to para-military. In the pilot study, two researchers spent six days with the fire department of a large U.S. city. Using a draft measurement instrument, we accompanied eight Battalion Chiefs (BCs) on 20 incident calls. During this time, we observed firefighting teams in action and interviewed the BCs and other members of the team both during and after incidents. We determined the validity of the instrument's markers and whether it could be used easily in this setting. Based on feedback from team members during the pilot study, we further revised the instrument to the form that we used during the full field test.

Our objectives for the field study were to determine the reliability, useability, and acceptance of the instrument within the constraints of an operational setting. Two researchers accompanied 10 BCs and one company commander to 36 incidents. The incidents were response calls to a variety of emergencies including fires, assist police, and automobile accidents. Some of the teams were comprised of one chief and a single response unit (e.g., one rescue unit) while at other times the teams were made up of multiple companies and, occasionally, more than one battalion.

Our researchers responded to calls with the BCs. We remained with the BC throughout the incident. During each incident, we queried the BC and his aide, monitored radio communications, observed team members' actions, and took comprehensive notes. After each incident, we interviewed team members (including the BC) and completed a rating form. The ratings were arrived at independently.

In addition, we asked five of the BCs to complete a rating form for each incident in which they participated to assess whether the BCs viewed the incidents and applied the assessment instrument in the same way as the researchers. We assessed inter-rater reliability between the two researchers and between the BC and the researchers.

The results indicated that the instrument derived from ATDM 2.0 captured the team processes that were required for successful performance on the urban fireground. The observers and domain SMEs noted examples of each of ATDM 2.0's behavioral dimensions as they assessed their teams. While not every dimension was present in every event, each dimension was critical during at least one of the incidents.

The specific behavioral markers were readily recognized and identified by outside observers and by BCs. Inter-rater reliability for making the categorizations "Present" or "Not Observed" was assessed among researchers and BCs as well as between researchers. Among researchers and BCs reliability was high (81% or above) for the dimensions of member resources, leader resources, nonhuman resources, procedures, roles and functions, engaging, and assessing the situation. Reliability was medium (61% to 80%) for time horizon, range of factors, and monitoring and adjusting. Reliability was low (60% or below) for compensating, envisioning goals, managing uncertainty, and time management. For 29 of the 37 total disagreements between the BCs and the researchers, the BCs indicated that they observed a dimension that the researchers did not. Several possible explanations for these types of disagreements come to mind. First, it may be that the researchers and the BCs did not share a common understanding of the dimensions. Second, it may be that the researchers and the BCs applied the dimensional definitions differently. And third, the BCs, being highly experienced in the domain, may have been able to notice cues and behaviors that were not evident to the researchers.

Our last objective for this stage was to get some indication of whether the BCs would accept the model/instrument and whether they would find it helpful. We found their acceptance high. In many cases, the BCs found the concepts reflected their own thinking about team performance in the domain and they were able to put these concepts into the language of the firefighter. Interviews revealed that many BCs believed they had a need to improve their team training, and that the model and measurement instrument provided them the tools to focus this training on critical team processes.

Handoff Package of Materials for Domain Users

Development of a model of advanced teams does not guarantee that it can be packaged so that domain users can take advantage of this information. One of our objectives was that subject matter experts be able to make use of the model and assessment instrument we developed. Therefore, it was important that we demonstrate that we could convey this information to potential users, such as trainers or commanders. In the domain of firefighting, the potential users are the fireground battalion chiefs. The approach we adopted was to develop a package of materials that would be handed off to the chiefs. This handoff

package included a description of the ATDM 2.0 model, a domain-specific version of an assessment tool derived from the model, and a few other associated materials such as coding sheets and instructions. The handoff package was designed to help BCs understand the specific behaviors critical to advanced team decision making and performance. To be successful, the handoff package needed to help the BCs focus their attention on specific behaviors during task execution in a way that provided them with information to guide intervention. These interventions could take the form of on-line adjustments to the team during an incident, as well as, identifying training needs that could be addressed post-incident.

Our goal was to design the handoff package so it would allow an independent observer or a knowledgeable team member to assess and document how a team performed during a specific incident. The actual assessment instrument requires the observer to provide subjective ratings of team performance at the level of behavior dimensions specified in the ATDM 2.0 model. The observer completes the ratings either as the incident evolves, if time permits, or after the incident when the observer has time to reflect on what occurred. In a military exercise, the observer controllers would be likely users of the instrument. Since there are no observer controllers in the firefighting domain, the BCs who were actively involved in the incident were the users.

The assessment instrument included in the handoff package was divided into two sections. The first was a single sheet on which the observer records his/her ratings for a single incident. It permitted information to be recorded on the Behavioral Dimensions. The observer provides two types of information for each dimension. First, they check whether behavior indicative of the each Dimension was present or not present during the incident. The second type of information was a subjective rating of the quality of team performance for those Dimensions that are present during the incident. These scales are five-point rating scales with a scale value of one anchored to "Very Ineffective," and a scale value of five anchored to "Highly Effective." The observers use their experience and knowledge of the ATDM 2.0 model to arrive at these ratings.

Additional materials included in the package were intended to provide support for the observer as s/he observes team performance and completes the rating scales. The section serves as a quick reference guide for the behavioral dimensions of the ATDM 2.0 model. Grouped by component, each behavioral dimension is allotted one page that is tabbed for easy access. This page provides a definition of the dimension with descriptions of indicators of effective performance and space for the observer to make notes. The observer can refer to these descriptions before, during, or after an incident. This facilitates reliability among observers and for one observer across different incidents. The complete set of handoff materials we provided to the fireground commanders are attached.

Discussion and Applications

Version 1.0 of the ATDM model has been successfully applied in several settings including strategic geopolitical, military operational logistics, and emergency operations teams. The current model (version 2.0) has successfully undergone an initial field test in the firefighting domain. During this 10-day field application, two researchers independently rated each incident along the dimensions of ATDM 2.0. In addition, 16 incidents were rated by the chiefs who were the fireground commanders for each of these incidents. The average inter-rater agreement among researchers was 83% while the average agreement between the researchers and the chiefs was 71%. The reader is referred to Kyne et al. (1994) for a more detailed examination of this field application.

All components and dimensions of the current model have been observed and identified as important in at least one domain during the field applications of the two versions of the ATDM model. Still, while it appears that all components and dimensions merit being part of the descriptive, comprehensive model, not all are equally critical in all domains. This may allow the ATDM 2.0 model, when applied to a specific domain, to be abbreviated to include only the dimensions that describe areas of particular vulnerability for that domain. For initial testing, abridged field versions of the model would have to be developed on a domain-by-domain basis, but heuristics might eventually be identified that could be applied across similar domains. For example, in long standing, stable teams, the dimensions of Member Resources and Roles and Functions might be omitted but need to be retained for teams whose memberships frequently change. So while the comprehensive model needs to include components and dimensions identified across all teams, fielded versions probably can be reduced to make them easier to use and more relevant for particular domains.

How applicable is the ATDM 2.0 model? We feel the model and field instruments derived from the model can be instrumental in improving team assessment, team training, and organizational development.

With ATDM 2.0 tailored for a particular domain, it becomes a tool that can be employed to assess a team's decision making and performance — to identify the strengths and weaknesses of a team along the four components and the 13 dimensions of the model. This assessment can be used to evaluate a team in comparison to a standard or relative to other teams within the same domain.

The knowledge derived from the assessment of the team about its strengths and limitations can also be used for training purposes. Areas where performance is assessed as weak are prime targets for training. This knowledge can focus training where it is needed, rather than letting a team practice what it is already good at and thus wasting valuable, but often limited, training resources. An additional area where use of the ATDM 2.0 model may contribute to training was mentioned by several fire department battalion chiefs who applied the tool to their teams. They said that by using the model to assess their teams, they

simultaneously developed a better understanding of the dynamics and vulnerabilities of teams and of team performance in general.

One other area where the ATDM 2.0 model can be applied is in the area of organizational development. If the critical components and dimensions necessary for a team to perform well are understood, this information can be used in developing an appropriate organizational structure for a particular team, in a particular domain, with particular objectives, responsibilities, and tasks. An understanding of a comprehensive model of teams, such as the one presented here can provide a framework from which specific issues and concerns can be identified and addressed. Some of these questions might be as follows: How can we structure the team to make sure the team members know the strengths and limitations of the other team members, so we take full advantage of these resources? In the context within which our team operates, what can we do to make sure we elicit different perspectives about our situation and ultimately converge on a common assessment? What steps will we need to take to achieve a shared understanding of our objectives? Are there procedures we can implement that will help us, if necessary, communicate changes in our situation assessment and goals to all the members of the team? This list is not intended to capture all the issues that could be considered, however it does provide a glimpse of how a comprehensive model of teams can contribute to the organizational development of a team. A framework for looking at team structure and the performance implications of this structure provides an organization the opportunity to fine-tune its teams to achieve more effective performance that is in line with the overall goals.

While the inter-rater agreement data and the Battalion Chiefs' observations and comments of version 2.0 of the ATDM model are very encouraging, we are anxious to extend the testing and evaluation in several directions. These include additional reliability and validity testing, further study of the generalizability of the descriptive (upper two tiers) portion of the model, closer examination of the psychometric issues involved in adapting the model to specific domains for the application of more rigorous psychometrics. One additional area we would like to investigate is whether the model can be used to differentiate the level of development of a team along the novice-advanced continuum.

Summary

ATDM 2.0 is a comprehensive description of teams that incorporates elements of resources, identity, cognition, and metacognition. In addition, the model is designed to both provide a general description of teams and to be tailored for specific teams. While all of the individual behaviors have been addressed in some fashion in other team models, our objective was to incorporate them into one model. The current version has been successfully applied with advanced execution teams (firefighting). The previous version, which has many structural similarities, has been used successfully with novice teams (emergency operation centers) and strategic, planning teams (the Industrial College for the Armed Forces). These initial field applications have been encouraging although more study is needed for several reasons. First, to more solidly establish reliability, validity, and generalizability of the

model. Second, to identify psychometric principles necessary for tailoring the general, descriptive model to particular domains. And finally, to thoroughly explore the ATDM 2.0 model's potential contribution to the tracking, assessment, and evaluation of a team's development.

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