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Modeling interpersonal trust in distributed command and control teams

Topic

Topic 3: Information Sharing and Collaboration Processes and Behaviors

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Title: Modeling Interpersonal Trust in Distributed Command and Control Teams[1]

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Abstract

In command and control (C2), team agility is the currency of mission success and it depends on trust between team members. Recent emphasis on joint, interagency, intergovernmental, and multinational operations introduces new barriers to trust formation, as parties with no prior contact and dissimilar backgrounds judge trustworthiness from limited information and communicate through media that challenge the timeliness and security of exchanges. To foster an environment of mutual trust in such settings, military teams must understand how trust is influenced by personal and situational factors. Based on current literature, interviews, and observations of C2 simulations, we are developing a conceptual model of trust that responds to current C2 challenges of distributed communications, mission uncertainty, and team diversity. We propose that trust reflects two basic, interrelated processes: trust in individual team members and trust in the networked collective. For both processes, characteristics of the trustor, trustee, and environment influence expectations about the trustee, and situational factors moderate the relationship between these expectations and the trustor's behavior. Our efforts support C2 future concepts experimentation by emphasizing the human dimension of C2, and will be leveraged to assess and establish trust in networked teams.

1. Background

The military's adoption of advanced information technology has allowed networked forces to become the dominant mechanism for maintaining information superiority and agility at all levels of command (Alberts, Garstka, & Stein, 2000). Networking capabilities hold promise for improving the ability of distributed teams to exchange information and establish shared situational awareness (Alberts, 2002; TRADOC PAM 525-3-7, 2008), but technology alone cannot ensure success. As one example, the Iraq Reconstruction Management System (IRMS) was designed to coordinate and monitor the many reconstruction efforts funded by the U.S. in Iraq (McDermott, Haigler, & Keays, 2006). In theory, all agencies conducting U.S.-funded reconstruction would update this networked database with current cost and status information, thus facilitating the allocation and management of funds, and promoting synchronization of efforts. In reality, only a subset of funding recipients regularly updated the IRMS, rendering its information outdated and incomplete (McDermott et al., 2006). The system's common operational picture was therefore underutilized and distrusted, and reports furnished from its output were considered unreliable (Warren, Brooks, et al., 2009). Information on the IRMS was also distrusted due to inconsistent reporting procedures and an unclear interface that gave the illusion of excessive data entry errors (Warren, Buhaissi, Haigler, Keays, & Needham, 2009). The various struggles of the IRMS highlight the importance of considering the human factor in

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C2: the success of network-enabled operations can be limited by the actions of human operators and by low trust in the other members of the networked collective.

Researchers have long touted the ability of mutual trust to promote information sharing, cooperation, and collaboration among teammates (e.g., Avery, Auvine, Streibel, & Weiss, 1981; Mathieu, Marks, & Zaccaro, 2001; Salas, Sims, & Burke, 2005; Staples & Webster, 2008), but the uncertainty that characterizes network-enabled, full-spectrum operations seems to make trust *essential* for effective information exchange. These novel and dynamic team structures lack prescribed, doctrinal standards to guide the patterns and channels of information exchange. Uncertain of any 'correct' behavior, team members in such situations are more likely to base communications on personal judgments, such as decisions about who they can trust (Dirks & Ferrin, 2001). Trust-based communications risk excluding the diverse team members included in joint, interagency, intergovernmental, and multinational (JIIM) operations, because their apparent dissimilarities impede trust development (Adams, Waldherr, Sartori, & Thomson, 2007; Robert, Dennis, & Hung, 2009). Team diversity and distribution also introduce different reporting structures, functional independence, and a lack of visibility over each other's actions; as these factors combine to reduce accountability, the potential for trust to promote cooperation becomes more critical (Adams & Webb, 2003; Jarvenpaa & Shaw, 1998).

Changes to the structure, process, and operational objectives of C2 thus heighten the need for trust in individual teammates and also the larger collective using the network. At the same time, these changes might threaten the ability to build trust by uniting diverse members who primarily communicate through technical media. This requires that tests of future C2 concepts account for trust in order to fully simulate the impact of such changes on information sharing, interpersonal networking, sense-making, decision-making, and, ultimately, mission effectiveness. In turn, accounting for trust in C2 requires an in-depth understanding of how trust in people functions, both at an individual and at a collective level. This paper describes initial development of a model of trust, which seeks to anticipate the challenges that operational and structural changes to C2 may impose on trust development and, by extension, mission effectiveness.

This work supports a larger initiative aimed at enhancing collaboration and decision making in complex, network-enabled C2 environments (ATO R.ARL.2009.05/Tactical Human Integration of Networked Knowledge; THINK ATO). In a four-year investigation, now nearing completion of its first year, we will build and test a conceptual model that will be used to assess trust, to account for its impact on mission effectiveness in network-enabled C2, and to help ensure that the human dimension of trust is taken into account during C2 future concepts experiments. In later years, our research will be applied to the design of interventions that facilitate the calibration of trust in distributed C2 teams. In this paper, we describe our initial findings and present our planned way ahead for the remaining years of our research program.

2. **Trust Definition and Approach**

Consistent with other researchers (e.g., Mayer, Davis, & Schoorman, 1995), we define trust as a willingness to be vulnerable to the actions of an object of trust (or *trustee*) in the absence of external control or visibility on those actions. In contrast to most existing work, our model posits that the willingness to be vulnerable can be defined and reliably measured as *both* a

cognitive/affective judgment and a behavioral manifestation. The judgment is based on characteristics of the trustee and the person making the judgment (or *trustor*), and can be operationally defined as general expectations about the trustee's behavior (e.g., “The logistics officer will provide information that supports mission success”). The behavioral component reflects the joint influence of these expectations and of environmental conditions (e.g., “Given time constraints, I will accept the logistics officer's estimates without double-checking them”), and can be measured through communication patterns between the trustor and trustee.

Previous work has cautioned against the use of behavior-based measures (e.g., Mayer et al., 1995; Rousseau, Sitkin, Burt, & Camerer, 1998), because behaviors can be sensitive to many factors other than trust. During information exchange in C2 for example, communication patterns often follow procedural requirements rather than personal judgments. In order to isolate the impact of trust on behavior, we must comprehensively analyze the trust process so that other influences can be separated. This approach also requires specification of precise trust-related behaviors, because the number of intervening variables necessary to link affect to behavior can be reduced by more targeted definitions of trust-related behavior. Past work examining the relationship between trust judgments and global behavioral characteristics such as 'performance' have found only weak correlations (reviewed in Colquitt, Scott, & LePine, 2007; Dirks & Ferrin, 2001), but the relationship between judgments and more concrete, micro-level behaviors (e.g., frequency of double-checking behaviors) has not been tested in a comprehensive model and may prove more amenable to such an analysis. Accounting for behavior is thus tractable, provided that we identify the precise behaviors that need to be captured, and that we account for the relevant situational conditions that might obscure the behavioral manifestation of trust.

Focusing on behavior enables our research to address the fact that self-reported feelings of trust are not perfect predictors of behavior, and to generate assessments of trust that relate directly to data captured during large-scale C2 simulations. The particular behavioral targets of interest to our research are patterns of information exchange and communications aggregated over the course of a simulated C2 exercise. Our focus is on the patterns that emerge among the key members of the command group and personnel in the operations and intelligence cells, as well as between echelons, services, multinational units, and interagency actors. The ultimate question we seek to answer is: how does trust in individuals and in the collective team account for differences in these patterns? Our research design is founded on the assumptions that:

- The strength of the relation between trusting feelings and trusting behavior is reliably influenced by situational conditions;
- There are elements of information exchange and communications that can be uniquely accounted for by trust; and
- Studying the objects of trust (i.e., individuals and the networked collective) separately will provide information useful for modeling their collective impact on behavior.

Over the course of four years, we will build and test separate conceptual models for both objects of trust, and then integrate our findings into a full model. The models will link elements of the environment (i.e., the trustee's behaviors) to expectations regarding the trustee's performance (i.e., the trustor's judgment) and – based on environmental conditions – to trust-

related behavior (i.e., the trustor's behavior). In the remainder of this paper, we will discuss the evidence we have collected so far to build our foundational models of trust. Although designed to be consistent with the current literature and our data on trust in C2 teams, these models are still under development and will undergo more rigorous and quantitative refinement in later stages of our research.

3. Overview of the Current Research

The objectives of the first year of our research have been to characterize the trust process and to gather an exhaustive list of variables for both of our foundational models. We are building these models using a combined top-down / bottom-up approach, exploring a wide range of scholarly and professional literature and then refining our findings with insights from subject matter experts and simulated C2 exercises. We began with a comprehensive literature review that included research investigating trust in civilian work groups, military units, and close personal relationships. Our literature review also covered examinations of trust in automation and information technology and trust in organizations and widely distributed knowledge networks (e.g., online communities of practice). Our readings enabled development of preliminary models for both trust objects, each of which specified characteristics of the trustee and trustor that influence trustworthiness judgments, and situational factors that influence behaviors (directly or interactively with trustworthiness judgments).

Testing within the application environment was necessary in order to identify C2-relevant trustee behaviors that convey trustworthiness (i.e., the cues that provide information about the relevant trustee characteristics) and trustor behaviors that are associated with more or less trust (i.e., risk management behaviors). We therefore supplemented our literature review with information gathered from subject matter experts and observations of simulated division-level C2 exercises. These data also allowed us to begin pruning our lists to those variables that are most likely to account for trust-related behavior in networked communications and information sharing, although more extensive model testing and reduction will occur in later stages of our research.

We first conducted one-on-one interviews with eight active duty or recently retired Army personnel who had served either as a commander or as a key staff member of a combined arms command group (battalion- or brigade-level). During these semi-structured interviews, we told each respondent about the goals of our work and the objects of trust we wanted to examine, and asked them to discuss the issues to which their experience seemed most applicable. We also observed a division-level C2 exercise conducted with students at the Command and General Staff College (CGSC), who worked in teams of approximately 60 students to form a skeletal division headquarters as well as subordinate units (US and multinational). Most students had served on brigade or division staffs, and occupied exercise roles that were consistent with their deployment experience. We buttressed these observations with the documented observations (reported by trained analysts) from two division-level, multinational C2 exercises (Omni Fusion 2008 and 2009) conducted at the Battle Command Battle Lab. In the coming months, we plan to survey additional CGSC students in order to ensure that our findings are based on a representative sample of Army personnel who have command group experience, and we plan to conduct additional interview sessions with members of a division staff.

4. Interpersonal Trust

Understanding interpersonal trust is necessary for modeling C2 communication patterns because it partially accounts for who is communicating with whom, and for the content of those communications. In our model, interpersonal trust refers to dyadic relationships in which the trustor knows some information about the trustee, which accrues through a combination of direct interactions, reputation, or stereotypes. This model is intended to accommodate a variety of relationships, with expectations about new individuals being based on different cues than the expectations for established, close relationships. In what follows, we present a conceptual model of interpersonal trust (Figure 1), and describe how it was built from our readings, interviews, and research on C2 simulations. We begin by discussing the characteristics of the trustee and trustor that contribute to judgments of trustworthiness, and the precise trustee behaviors that convey these characteristics in C2 (Table 1). We then address the ways in which judgments, in combination with certain environmental conditions, can influence behavior, and we provide specific behaviors that were identified from our research (Table 2).

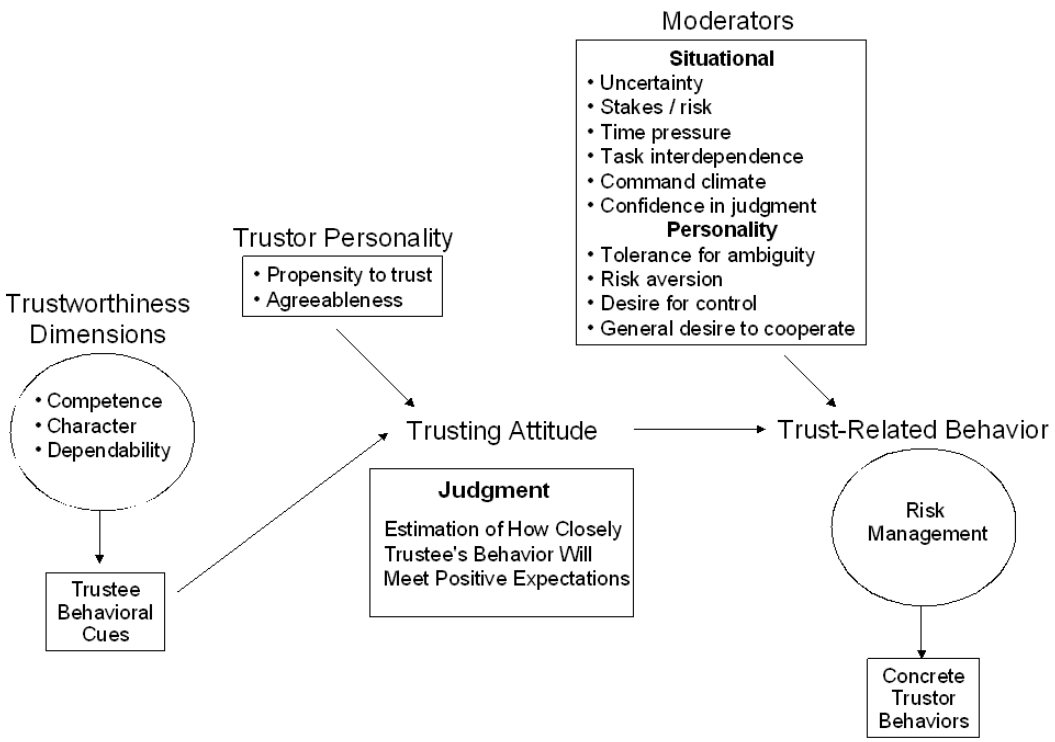

Figure 1. Interpersonal trust in C2 teams

4.1. Determinants of Trust

Trustworthiness Dimensions

Research on interpersonal trust has identified several key dimensions of the trustee's personality that figure heavily into trust judgments. A prominent dimension of trustworthiness

identified in previous work (e.g., Adams & Webb, 2003; Colquitt et al., 2007; Mayer et al., 1995; Ruark, Orvis, Horn, & Langkamer, 2009; Sweeney, 2007) and reiterated by most of our interviewees is *competence*. Competence refers to the trustee's knowledge or performance in a domain of interest, and is thus highly context-dependent, and supports expectations that the trustee is *able* do what is needed (Colquitt et al., 2007; Falcone & Castelfranchi, 2004; Serva, Fuller, & Mayer, 2005). As shown in Table 1, our observations and interviews revealed that cues conveying competence are generally gathered from information-sharing behaviors, problem solving and planning actions, and – in the case of newer relationships – assumptions about the trustee's training or background. However, several of our interviewees noted that in diverse C2 teams, competence is sometimes hard to recognize because not all valuable skills are readily observable, and those that reflect expertise in an unfamiliar area are hard to evaluate. Aware of this challenge, another interviewee mentioned that knowing how to communicate knowledge is a component of being seen as competent, because it is often necessary to balance the need to simplify concepts enough that everyone can understand with the need to demonstrate specialized knowledge. Our research thus concurs with extant literature in highlighting the contribution of competence to positive expectations concerning other team members, and further suggests that competence cues might be difficult to evaluate in diverse, JIIM operations.

Just as important as the ability to perform is the expectation that the trustee is *willing* to do what is needed (Colquitt et al., 2007; Falcone & Castelfranchi, 2004; Serva et al., 2005), which stems from the trustee having the *character* to perform as desired. The importance of character has been highlighted in several studies of military personnel (Adams & Webb, 2003; Ruark et al., 2009; Sweeney, 2007), and reinforced through our own findings. Our research revealed that trustees convey character cues by being accountable for their own actions, engaging in citizenship behaviors, exchanging information honestly and discreetly, and also indirectly through their group membership (Table 1). Character cues gleaned from information sharing behaviors seem to be especially important in C2: data collected during the 2009 Omni Fusion exercise found that at the start of a new relationship, trustors share more information with those teammates who are seen as honest and/or responsible, and our interviewees mentioned only sharing sensitive information with trustees seen as discreet. However, several of our interviewees said that they assume all Army personnel possess strong character, due to the Army's organizational values and tendency to weed out individuals with poor character early in their careers. In contrast, our interviewees reported that the lack of common experiences, conflicting goals, and even competition for resources results in negative assumptions about the character of personnel from JIIM organizations. Character is therefore likely to be an important trust dimension, though our research suggests that group membership provides a very strong starting cue against which future interactions are evaluated.

A third trustee dimension that contributes to trust judgments is *dependability*, which refers to the trustee's *readiness* to do what is needed and an ability to do so *consistently*. Dependability allows the trustor to develop predictions of how the trustee will behave, and this seems to be especially important for trust in military teams (Adams & Webb, 2003; Ruark et al., 2009). Our research suggests that dependability cues are found in information-sharing behaviors, and in the degree of preparedness and follow-through that the trustee exhibits across all actions (Table 1). Our interviewees indicated that dependability is especially important during information sharing in C2 because subordinates need to know what the commander wants (i.e.,

the content and format of shared information, etc.), and the commander needs to count on subordinates to meet these expectations. Based on these finding, cues about the trustee's dependability are expected to influence trust judgments and behaviors.

Table 1.
Trustee behavioral cues informing interpersonal trust in C2 teams

Dimension	Cue Category / Source	Cues
Competence	Information-sharing behaviors	Accuracy and usefulness of shared information; Whether shared information is actionable bottom-line or 'data-dump'
	Planning and problem-solving behaviors	Breaking down problems to core issues; Mentioning second- and third-order effects during planning meetings; Adapting current plans with environmental changes; Calling on other teammates whose roles and expertise are relevant
	Indirect sources	Training and experience; Group membership
Character	Accountability	Acceptance of blame for errors; Acceptance of help and advice
	Citizenship behaviors	Offering help or advice to others; Consideration of morale of others; Whether focus is on work or own career
	Information-sharing behaviors	Honesty in information exchange; Respect for secrecy of information
	Indirect sources	Group membership
Dependability	Information-sharing behaviors	Timeliness of shared information; Consistency of information format; Adherence to SOPs
	Preparedness	Accessibility; Readiness to contribute to decision making process
	Follow-through	Meeting commitments; Compliance with requests; Prioritizing mission tasks over social chat

Trustor Personality

Personality characteristics of the trustor also influence trust judgments, because certain individuals will make more favorable projections than others on the basis of a *trusting disposition* (Colquitt et al., 2007; Kiffin-Peterson & Cordery, 2003; Mayer et al., 1995) and perhaps even characteristics such as high agreeableness and low neuroticism (Dirks & Skarlicki, 2004). Personal characteristics seem to have a greater influence in new relationships, when the nature of the trustee is unknown. Research has found that the influence of dispositional trust on trust judgments is weakened, or fully mediated, as trustors gather new information about the trustee (Colquitt et al., 2007; Kiffin-Peterson & Cordery, 2003; Robert et al., 2009), and that more trusting individuals evaluate these cues in a way that is no different from less trusting individuals (Rotter, 1980). However, this reduction in the importance of trustor factors requires visibility of the cues listed above. Trustworthiness cues are often revealed more slowly in technology-mediated communications (e.g., Riegelsberger, Sasse, & McCarthy, 2003; Wilson, Straus, & McEvily, 2006), suggesting that trust judgments about distributed C2 team members would be more dependent on trustor factors (Hung, Dennis, & Robert, 2004). Our model

includes the propensity to trust as a determinant of expectations about individuals, but in keeping with the existing evidence, we predict that this will have a greater effect in new relationships and in the context of distributed communications.

4.2. Trust-Related Behaviors

Trusting behaviors are those that demonstrate a willingness to make oneself vulnerable to the actions of others. Where trust is low, interacting with the trustee entails risk, and so trustor behaviors generally seek to reduce vulnerability by mitigating this risk. Behavioral manifestations of trust are rarely a focus in empirical studies (though see Jarvenpaa & Shaw, 1998; Serva et al., 2005; Zand, 1972), and have not been examined in a C2 context. Specifying trust-related behaviors was therefore a key objective from our interviews and observations. These data collection opportunities yielded a set of risk management behaviors, detailed in Table 2.

Table 2.
Concrete trustor behaviors reflecting interpersonal trust in C2 teams

Risk Management Type	Category	Behavior
Accept Risk: Trusting Behaviors	General	Accept information from trustee with minimal (or no) checking; Prioritize exchanges with trustee
	Trustor is subordinate	Accept orders from trustee without challenging them
	Trustor is superior	Assign more important tasks to trustee
Mitigate Risk: Distrusting Behaviors	General	Communicate that there is a problem
	Competency-based distrust	Demonstrate how to do the task correctly, or work with the trustee to find a solution
	Character-based distrust	Avoid
	Information management	Double-check information from trustee; Monitor completion of ongoing tasks
	Trustor is superior	Replace trustee or reassign tasks; Assign simpler or lower-importance tasks to trustee
Distrusting Behavior	Affective response	Complain

In general, we found that trustors manage risk by modulating the frequency of their interactions (e.g., becoming less accessible for untrusted individuals, and more accessible for trusted individuals), the content of these interactions (e.g., offering guidance to untrusted teammates, but requesting information from those who are trusted), and their responses to information (e.g., how closely they double-check incoming materials). However, our research revealed that the nature of risk mitigation is likely to depend upon the value of specific trustworthiness dimensions. If a trustee is seen as good-intentioned and dependable, but not particularly competent, trustors usually respond by either demonstrating how something should be done, or working with the trustee to find a solution. In contrast, if a trustee is believed to be competent but lazy or self-serving, the trustor is likely to keep a distance from this person. Our

interviewees also mentioned that the options for risk mitigation depend upon the hierarchical position of the trustee (e.g., only a subordinate can be disciplined). Additionally, our interviewees said that extreme responses such as fully replacing a staff member are a last resort, given the shortage of trained staff members and the Army's emphasis on leader training and development. We observed that risk management behaviors towards co-located versus distributed trustees were generally similar, though guidance and monitoring were mostly limited to face-to-face interactions. In addition to behaviors that serve to manage risk, we found that distrust often elicits complaint; although this does not effectively mitigate risk, it may prove to be a reliable indicator of low trust.

4.3. Situational and Personal Factors

As discussed earlier, aspects of the current environment and characteristics of the trustor moderate the degree to which behaviors correspond to trust judgments. A clear understanding of these factors is thus essential in order for a comprehensive trust model to make behavioral predictions based on trustworthiness cues. Previous work has identified risk – which is sensitive to task complexity, task importance, and the importance of the information that is shared – as being especially important in moderating the relationship between judgment and behavior (Adams & Webb, 2003; Mayer et al., 1995). Our interviewees reiterated the significance of risk, noting that, during a training exercise, giving an untrustworthy staff member an important task might be a good learning opportunity, but in theater there is too much at stake and only the most qualified individuals are given important tasks. Risk must therefore be included in our model as a factor that influences the relationship between expectations and trusting behaviors.

Although risk is consistently mentioned as being an important moderator, other situational conditions also constrain behavior in ways that influence this relationship. For example, reassigning a difficult task to a more trusted individual or double-checking someone's work would require the availability of alternatives and time, respectively; in the absence of such options, risk management behaviors are limited, and may not reflect trust judgments accurately. Empirically, researchers have found that interactions that occur within a formalized protocol (Jarvenpaa, Shaw, & Staples, 2004), are contractually-constrained (Butler, 1999), or involve highly interdependent tasks (Staples & Webster, 2008) can produce trusting behaviors regardless of trustworthiness assessments, thus weakening the statistical relationship between judgment and behavior. For example, analyses conducted within a division-level C2 exercise (Omni Fusion) found that participants differed in how strongly they perceived their tasks to be interdependent with those of their teammates. For participants who reported low task interdependence, judgments of their teammates' trustworthiness were predictive of their tendency to share information with the team. In contrast, participants who reported high task interdependence frequently shared information with their team regardless of trust, suggesting that this behavior reflected the interdependent nature of the task rather than personal judgments. This finding emphasizes that trustors must be aware of task factors in order for them to influence behavior. In diverse JIIM teams, uncertainty about role requirements and information-exchange procedures might limit the opportunity for situational factors to influence behavior. Our model must therefore include task variables that constrain behavior, and must also consider the trustor's *awareness* of these conditions.

Finally, some researchers have theorized that personality traits of the trustor also influence the relationship between trust judgments and trust behaviors. For example, individuals whose personal or cultural values hold trusting behaviors in high esteem (e.g., thinking that cooperating with others is good) might be more likely to engage in such behaviors even if trust is low (Whitener, Brodt, Korsgaard, & Werner, 1998). Confidence in the trust judgment may also play a role, and could perhaps be moderated by factors such as tolerance for ambiguity. Though these factors are all plausible, none has been empirically investigated, and so further testing of our model will need to reveal whether the trustor's personality has a reliable influence on the relationship between judgment and behavior.

4.4. Summary

The model from Figure 1 reflects extensive reading on interpersonal trust and preliminary research in C2 environments. Our model specifies the behavioral instantiations of latent dimensions of the trustee's trustworthiness, which trustors use in combination with their own biases to form a projection of positive outcomes. The figure also shows the current comprehensive list of situational conditions (moderators) that our research suggests should be accounted for when exploring the link between trusting attitudes and risk management behaviors. Few of the situational conditions we presented have been quantitatively tested, and their collective impact on the relationship between affect and behavior remains unknown. Having collected only qualitative data so far, we have not been able to reduce the sets of variables listed here to those that are most important in C2. A priority is thus to make the model more parsimonious (and, by extension, more statistically tractable).

5. Trust in the Networked Collective

Trust in the networked collective as a whole is relevant because there are times when communications occur with the full command group or across JIIM partners, and participants must trust that the collective will respond appropriately. Trust in the collective goes beyond the average trust in individual teammates, since many members are unknown and even among those who are known, one must learn to trust their ability to interact with the networking technology and with each other. Expecting that interacting with the collective will be favorable to the mission has implications for whether an individual will retrieve or share information on the group network versus with individually selected participants. Below, we discuss a preliminary model of trust in a networked collective (Figure 2). We first present the relevant trustworthiness dimensions and the behavioral cues that convey these properties (Table 3); because we are dealing with a collective, the dimensions reflect both aggregate characteristics that are derivable from trust in individual teammates, and systemic properties that emerge through the interactive properties of these individuals. We then present candidate trustor biases that combine with these cues to form trust judgments and to influence the specific risk management behaviors identified in our research (Table 4). Finally, we discuss the situational conditions that moderate the behavioral manifestation of trust.

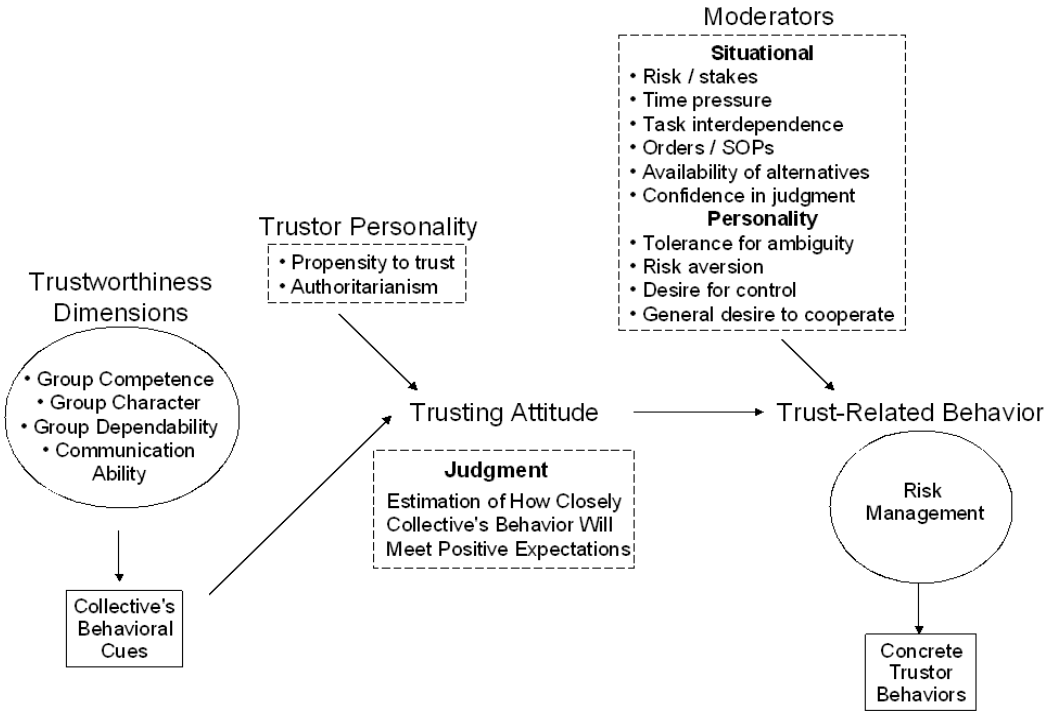

Figure 2. Trust in the networked collective in C2 teams

5.1. Determinants of Trust

Trustworthiness Dimensions

Most of the literature investigating group-level trust has examined trustworthiness dimensions that parallel those found to predict trust in individuals (i.e., competence, character, and dependability: Adams & Webb, 2003; Jarvenpaa, Knoll, & Leidner, 1998; Usoro, Sharratt, Tsui, & Shekhar, 2007). For instance, research on online learning communities has found that trust in a networked collective is sensitive to the expertise that members possess (e.g., Ardichvili, Page, & Wentling, 2003; Usoro et al., 2007). Although only one of our interviewees mentioned using group competence to inform his expectations, observations of C2 exercises (both Omni Fusion and the CGSC simulation) have shown that when operators perceive little competence in network operators, they are reluctant to use the network's human-entered data. Cues of group competence are primarily gleaned from information-sharing behaviors on the group network and assumptions based on the training or staffing of the group (Table 3). Our interviewees mentioned the importance of group character, but we saw no cues related to group character in the exercises we observed, and several students said that character is not an issue because the network is restricted to military personnel who are assumed to be trustworthy in character. Further testing may reveal that group character becomes an issue in larger JIIM operations where group diversity (which was low in the CGSC exercise) might influence judgments about group interactions. The group's dependability, which has implications for whether network operators can assume consistency in the information they receive from the network and in the responsiveness to information they post on the network, has been shown to compromise trust in

military simulations. Cues of group dependability are mostly found in information-sharing behaviors (Table 3).

Our research found that the group's communication ability is also important, and that this is assessed independently of the above dimensions. Group communication ability is a systemic property resulting from the interactions between group members, which can be distorted by a single poor communicator. Communication ability was an important dimension in the CGSC exercise, because even when members were tactically competent and well-meaning, the accuracy of the information they shared was compromised by difficulties with the networking technology and general reporting procedures. It is imperative that network operators be able to communicate with all members of the collective through a common language and through SOPs that dictate what should be shared, as well as how, where, and when to share. Finding a common language was even a problem in the Omni Fusion exercise, which featured multinational partners from Anglophone nations that have worked together before (American, Canadian, British, and Australian officers). Despite their similarities and history of collaboration, the officers' national differences in procedures, terms, acronyms, and even rules of engagement prevented fluid integration. The quality of group communications also depends in part upon the networking technology through which the collective is united and its ability to transmit information faithfully. Our analysis revealed that the performance and usability of the networking technology influence trust judgments, as do personal differences in the readiness to try new technologies. Overall, cues of communication ability are found in information sharing behaviors, group diversity, and properties that build trust in the technology such as the system performance, usability, and user training (Table 3).

Table 3.
Trustee behavioral cues informing trust in the networked collective in C2 teams

Dimension	Cue Category / Source	Cues
Group Competence	Information-sharing	Frequency of data errors on network
	Environment	Whether collective is understaffed / overworked; Training of group
Group Character	Indirect sources	Group membership
Group Dependability	Environment	Presence of SOPs; Use of shared C2 system
	Information-sharing	Consistency of information sharing
	Third-party sources	Group diversity
Communication Ability	Information-sharing	Accuracy of the common operating picture
	Indirect sources	Group membership
	System performance	Frequency of system errors; Interoperability of networks
	System usability	Ease of organization and data entry; Ambiguity in interface
	User knowledge of system	Technical training; Frequency of data-entry errors on network

Trustor Personality

The role of trustor biases on group-level trust judgments has not been investigated thoroughly. It is therefore uncertain whether the propensity to trust, or other personality variables such as authoritarianism will influence expectations about the group. Use of technology has often been found to be influenced by a propensity to trust technology (Dzindolet, Dawe, Beck, & Pierce, 2001; Lee & See, 2004; Merritt & Ilgen, 2008), and so behaviors on the network that connects the collective may be influenced by this bias. The role of these trustor personality characteristics will need to be investigated quantitatively in our later research.

5.2. Trust-Related Behaviors

During our interviews and observations, we identified behaviors that are related to the trustor's expectations about the group's performance. Our research revealed the trust-related information sharing and receiving behaviors listed in Table 4. In general, members of C2 teams mitigate the risk of an untrusted C2 collective by reducing or even avoiding group-level interactions (often replacing them with individual-level interactions) or by strengthening these interactions through double-checking. One of our interviewees said that he would check all new information for plausibility and its consistency with other information, regardless of trust. This underscores the importance of carefully distinguishing between conscientious information processing versus risk mitigation when assessing trust-related behavior, and we will need to consider this factor in our later modeling.

Table 4.
Concrete trustor behaviors reflecting trust in the networked collective in C2 teams

Risk Management Type	Category	Behavior
Accept Risk: Trusting Behaviors	Information receiving	Accept information; Little need to double-check or identify source of information
	Information sharing	Place new information on group network
Mitigate Risk: Distrusting Behaviors	Information receiving	Double-check information (e.g., ask trusted colleague, seek additional confirmation from the source, assign a team to verify the information, determine whether the poster had sufficient visibility or physical proximity to report accurately, examine the currency of the event); Ignore
	Information sharing	Communicate off-network with known, trusted individuals
	Prevent future problems	Establish SOPs; Provide technical training

Note that some of the risk mitigation behaviors identified for the networked collective are similar to the behaviors we identified for interactions with individuals (Table 2), such as avoiding interactions or double-checking information received from the untrusted source. A key difference between risk management during individual versus group interactions is that opportunities to retrain the trustee are more limited when engaging with a collective. We

observed that these instructive behaviors were very common when an *individual* was not trusted due to low competence; in fact, trustors generally increased their interactions with such individuals in order to offer help and instruction, and almost never ignored a less competent performer. In contrast, when cues of low competence were found at a collective level, trustors usually reduced group-level interactions and treated all information on the network with extreme caution. These differences suggest that the complexity and abstract nature of a collective might obscure an understanding of why errors are occurring (and thus how to fix them), whereas such troubleshooting is more straightforward when working with an individual. Although we did not observe any attempts to retrain a less competent collective, trustors sometimes developed and distributed information-sharing standards that were intended to address challenges with information flow and technology use (i.e., low communication ability). Together, these findings suggest that trustors only initiate preventative risk-management behaviors towards a collective when trust is lowered by systemic group properties, and this is an issue we will need to examine further as our research continues.

5.3. Situational and Personal Factors

In general, we found that the situational and personal characteristics that moderate the relationship between judgments about the collective and trust-related behaviors mirror those identified for our model of trust in individuals. Specifically, our interviewees noted that risk influences how willing operators are to engage with a group or on a network in which they lack confidence; as the cost of error increases, interaction with a networked collective judged to be less trustworthy will decrease. Our interviewees additionally reported that information overload and time pressure can influence whether expectations for the network are predictive of behavior, because these parameters may limit risk management behaviors such as double-checking. Another important situational condition identified by our interviewees is whether staff members are required to communicate through the network. If everyone is required to use the network, then trust judgments about the collective will have little opportunity to influence communication patterns. As mentioned earlier, some operators double check *all* information coming from the network (whereas some rarely check it), regardless of trust. During our observations, we saw that individuals vary in this tendency, suggesting that personality factors such as conscientiousness or tolerance for ambiguity might account for these differences.

5.4. Summary

As depicted in Figure 2, the determinants of trust in the networked collective constitute a combination of aggregate and systemic group characteristics, and these dimensions are evaluated primarily through cues of information-sharing behaviors, network performance and usability, and group diversity. Projecting that communications with the group will be useful stimulates interactions on the network, but these behaviors are also sensitive to situational variables and personal characteristics. If these factors combine to encourage risk mitigation, then system operators are likely to replace or verify group-level communications with interactions with specific, trusted individuals. Further pilot testing will be needed in order to revise this model to a more parsimonious framework, and also to identify how trust in the collective – which is partly understood through trust in individuals – combines with interpersonal trust to influence communications behaviors.

6. Future Work and Implications

With its focus on behavior, our work presents a promising new approach for studying, measuring, and predicting trust. In our observations and interviews, we identified discrete behavioral cues of the trustee that could be used to objectively measure trustworthiness, and also to manipulate the trustworthiness of role-players or computerized agents during trust experiments. We also have begun to specify the behavioral manifestations of trust, which will ultimately allow future concepts C2 testing to simulate the role of trust on mission effectiveness. Following extensive iterations of model testing, we hope to be able to use a refined list of risk management behaviors as a trust measure that could replace the need for surveys. This would not only avoid concerns about the accuracy of self-reporting subjective processes, but could significantly advance the use of interactive trust exercises by providing a measure that can be sampled continuously across the exercise and without disrupting interactions. We acknowledge that this is an ambitious endeavor, and that its success rests on the development of an accurate and reliable model that links trustee behaviors to trustor behaviors.

In the remaining three years of this research effort, we will further prune and systematically test our conceptual models of trust using data from a combination of laboratory and field studies. The primary goal of these quantitative analyses is to identify the most parsimonious combination of trustee behavioral cues, trustor personality factors, and situational variables that can account for trust-related behavior observed in C2 communications and information exchange patterns. Further testing will also allow us to create and test a single, integrated model of trust in networked C2 teams (Figure 3 presents a high-level, conceptual model). Ultimately, this model will be used to predict the impact of trust on situation awareness and team adaptability, and also to guide the creation of interventions for calibrating trust judgments and behaviors. By fostering better calibrated trust in distributed teams and accounting for how this trust "looks" in C2 exercise data, we can optimally account for the human factor of trust in networked C2 and its relation to mission effectiveness.

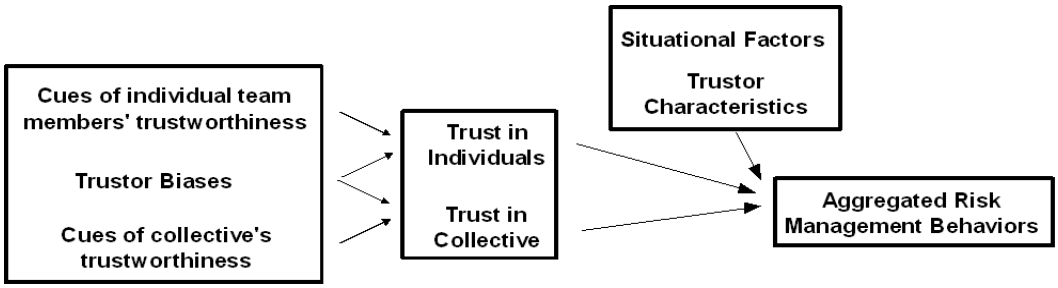

Figure 3. Integrated model of trust in distributed C2 teams

In conclusion, although trust is generally accepted to be critical to successful military operations, relatively little is known about how trust functions in networked C2 teams. Trust may be essential for achieving the ambitious goals of network-enabled operations, but it is unknown what trust "looks like" in this context, how it is fostered, and how it enhances situational

awareness and team adaptability above and beyond other factors such as teamwork skills and organizational design. Conceptualizing and quantitatively modeling trust in this context is complicated, requiring consideration of multiple objects of trust, integration of diverse behavioral research findings, and application of multivariate statistical analysis to aggregated field data. The work presented in this paper represents an initial step in clarifying the role of trust in networked C2, with much work remaining.

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