Journal of Applied Psychology
2005, Vol. 90, No. 5, 964–971


0021-9010/05/$12.00 DOI: 10.1037/0021-9010.90.5.964

RESEARCH REPORTS

# Teamwork in Multiteam Systems

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The authors examined how networks of teams integrate their efforts to succeed collectively. They proposed that integration processes used to align efforts among multiple teams are important predictors of multiteam performance. The authors used a multiteam system (MTS) simulation to assess how both cross-team and within-team processes relate to MTS performance over multiple performance episodes that differed in terms of required interdependence levels. They found that cross-team processes predicted MTS performance beyond that accounted for by within-team processes. Further, cross-team processes were more important for MTS effectiveness when there were high cross-team interdependence demands as compared with situations in which teams could work more independently. Results are discussed in terms of extending theory and applications from teams to multiteam systems.

*Keywords:* teams, multiteam, coordination

The past decade has witnessed a remarkable transformation in work organizations. Gone are formal bureaucratic structures, and team-based designs are becoming the norm (Devine, Clayton, Philips, Dunford, & Melner, 1999; Gully, 2000; Kozlowski & Bell, 2002). However, not all team-based designs are the same. Matrix, subassembly, and cellular designs, along with task forces and virtual organizations, are but a few of the evolving forms. One particular, fairly unique organizational arrangement was recently discussed by Mathieu, Marks, and Zaccaro (2001): multiteam systems (MTSs). They defined MTSs as

> two or more teams that interface directly and interdependently in response to environmental contingencies toward the accomplishment of collective goals. MTS boundaries are defined by virtue of the fact that all teams within the system, while pursuing different proximal goals, share at least one common distal goal; and in so doing exhibit input, process, and outcome interdependence with at least one other team in the system. (p. 290)

Teams within the MTS (hereinafter referred to as *component teams*) may pursue different goals at times, but these goals must somehow come together and be intertwined at a higher level in a goal hierarchy for an MTS to exist (Bateman, O'Neill, & Kenworthy-U'Ren, 2002).

The purpose of this study is to elaborate on the concept of MTSs and to test their underlying processes empirically. We discuss how the relative influence of within-team and cross-team (i.e., MTS) processes relate to overall system effectiveness, as moderated by the interdependencies between teams. We describe how team and MTS processes unfold over time and test our hypotheses in the context of a complex simulated MTS environment. This study makes three unique contributions. First, we focus on MTS phenomena as the unit of inquiry. In so doing, we illustrate how incorporating MTS-level processes provides insight beyond what is apparent at the team level of study. Second, we illustrate how the relative impact of internal versus external team processes drives MTS effectiveness depending on the underlying goal hierarchy that exists between teams. We accomplished this by having MTSs perform comparable missions under varying interdependency conditions. In this sense, we investigate how MTSs adapt to varying conditions in order to be effective. Third, we investigate a unique system in the sense that not only do we have two live teams working together in a simulated environment, but also they must coordinate their efforts with other, computer-controlled "allied teams" to be successful. In other words, whereas our attention is

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This research was funded in part by Air Force Office for Sponsored Research Contract F49620-98-1-0278. The views expressed in this article are those of the authors and do not reflect the official policy or position of the U.S. Air Force, the Department of Defense, or the U.S. Government.

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concentrated on the functioning of the two live teams, they are performing in the context of a much larger network of teams.

## Multiteam Systems

The MTS concept basically describes the functioning of a tightly coupled network of teams. Recent team-focused research has emphasized the point that teams need to well manage interfaces with their external environments if they are to be effective (Ancona & Caldwell, 1992; Choi, 2002; Denison, Hart, & Kahn, 1996; Tesluk & Mathieu, 1999). Yet the focus of even those studies remains the individual team. We submit that an examination of the joint interactions between tightly coupled teams will yield additional insights regarding the effectiveness of the larger system—namely, MTSs. We make the assumption that MTS performance is more than the sum of individual team efforts. Moreover, we argue that effective MTSs are ones in which members can shift attention from within-team activities to cross-team activities as warranted by changes in the performance environment.

MTSs are not simply large teams. Their component teams are distinguishable entities capable of independent actions who may pursue different proximal goals (Arrow & McGrath, 1995). In other words, the relative interdependence of members is higher within component teams than between component teams constituting an MTS. Although these component teams are distinguishable entities, what defines the boundary for inclusion as an MTS is the fact that they share input, process, and outcome interdependence with at least another team in the MTS network (Mathieu et al., 2001). The linking mechanism for these systems is a goal hierarchy—that is, a structure describing how proximal team goals, when accomplished, combine to realize a higher order MTS goal. The goal hierarchy notion prescribes not only *which teams* compose an MTS but *how their contributions* must be synthesized to achieve higher level goals.

Notice that it is the nature of team interdependences that defines MTS membership, not organizational boundaries, such that some configurations may span multiple organizations. For example, Mathieu et al. (2001) described an MTS composed of fire fighters, emergency medical technicians, hospital emergency room teams, and recovery teams, all of whom were involved in saving and treating accident victims. Although the component teams perform markedly different operations, their efforts are tied together by a sequential goal hierarchy demanding quality transitions from one to the other, all in pursuit of the ultimate goal of saving lives. Mohrman, Cohen, and Mohrman (1995) described a host of arrangements that operate within a single organizational setting. The primary advantage of MTSs is their ability to be highly responsive and to reconfigure on the basis of the performance requirements demanded by the work environment (Mathieu et al., 2001). In all instances, however, the nature of the interdependence linking component team goals to the larger system prescribes the relative premium that is on within- versus cross-team teamwork processes for the success of the larger MTS system.

## Teamwork Processes

Marks, Mathieu, and Zaccaro (2001) defined team processes as

> members' interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed towards organizing taskwork to achieve collective goals. . . . Team processes are the means by which members work interdependently to utilize various resources, such as expertise, equipment, and money, to yield meaningful outcomes. (p. 357)

Teamwork processes occur during two phases of team performance episodes: action and transition (Marks et al., 2001). *Action phases* are periods of time when teams conduct task work and rely heavily on coordination and monitoring activities that lead directly to goal accomplishment. In contrast, *transition phases* are periods of time when teams focus primarily on mission analysis, planning, goal setting, and evaluation activities. The underlying rationale of the Marks et al. (2001) framework is that well-executed transition processes facilitate subsequent action processes, which in turn relate significantly to performance. Notably, Marks and her colleagues did not preclude the possibility that transition processes might also relate directly to team performance.

Although the Marks et al. (2001) framework was designed to apply to team-level processes, Mathieu et al. (2001) submitted that it also applies to MTS-level processes. The key distinguishing issue, however, is that in an MTS, the component teams need to synchronize their joint actions so as to facilitate the accomplishment of higher order goals. Ancona and Chong (1999) have discussed the similar notion of *entrainment,* where teams need to temporally align their efforts with those of other systems with which they are tightly coupled. In the case of MTSs, however, the entrainment occurs with respect not only to situational demands but also to the rhythm of the other component team(s). In this sense, it is not simply a matter of teams entraining to some external pacer; it involves synchronizing the efforts of multiple teams in a joint endeavor to handle situational demands. In the current study, this involves the collective coordination of two live teams with computer-controlled teams in a joint effort to deal with hostile ground and air forces. Accordingly, we have MTS members collectively work on transition processes to plan their missions together. We then assess how well they execute action processes, both as individual teams and as an MTS. This enables us to examine how the transition processes facilitate both types of action processes and whether the MTS-level action processes contribute beyond team-level processes in the prediction of MTS performance. Accordingly, as illustrated in Figure 1, we advanced the following hypotheses:

> *Hypothesis 1:* Team action processes will positively predict MTS performance.

> *Hypothesis 2a:* MTS action processes will positively predict MTS performance beyond that accounted for by within-team action processes.

> *Hypothesis 2b:* MTS transition processes will positively predict MTS performance beyond that accounted for by team and MTS action processes.

> *Hypothesis 3a:* MTS transition processes will positively predict team action processes.

> *Hypothesis 3b:* MTS transition processes will positively predict MTS action processes.

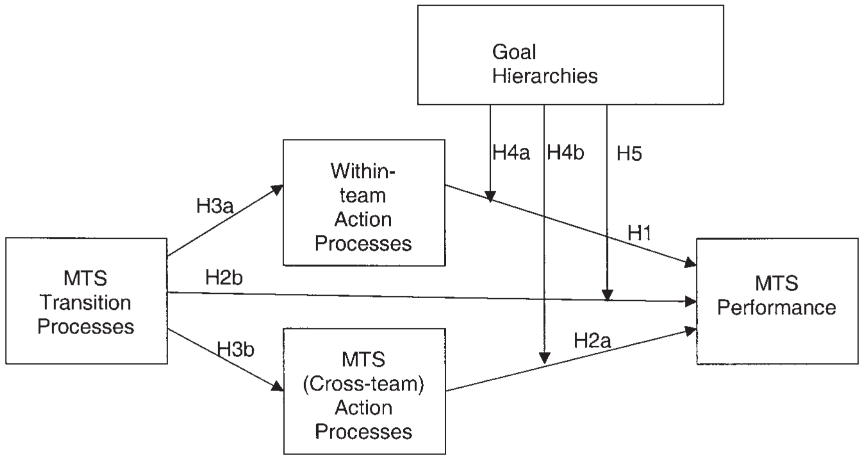


*Figure 1.* Study hypotheses (Hs) depicting the relationships between goal hierarchies, processes, and multiteam performance. MTS = multiteam system.

## MTS Goal Hierarchies

MTS goal hierarchies give rise to multiple types of team interdependencies. Our focus is on process interdependence, defined as the amount of cross-team interaction required for goal accomplishment. Process interdependence is comparable to the concept of task interdependence in teams (Van de Ven & Ferry, 1980), yet the former term is more applicable for present purposes, because we are concerned with the interdependence of team processes as related to the accomplishment of a higher level goal.

Saavedra, Earley, and Van Dyne (1993) and Tesluk, Zaccaro, Marks, and Mathieu (1997) illustrated that teamwork processes are critical when members are highly interdependent and less important as they work more as individual contributors. We extended this logic to the MTS level of inquiry and submit that more complex goal hierarchies generate greater cross-team interdependence and thereby necessitate better executed cross-team processes for system effectiveness. In contrast, less complex goal hierarchies impose fewer demands on cross-team coordination, and system effectiveness would be more a function of the aggregation of individual team efforts. For example, in *pooled arrangements,* the performance of the whole is merely the additive sum of the contributions of the individual component teams, which have no process interdependence or need to synchronize their efforts. In *sequential* or *long-linked arrangements,* one team must successfully perform a task or accomplish a goal in order for another team to successfully perform and achieve its goal. Notice that in a sequential arrangement, not only are the teams' functions interdependent, but a temporal orchestration of activities must unfold in the proper sequence for the MTS to be successful. In an *intensive* arrangement, the accomplishments of the teams' functions are intertwined and must be coordinated simultaneously. In these arrangements, one cannot unequivocally distinguish the performance of one team from that of another, because they are so tightly coupled. Clearly the temporal entrainment of activities is at a premium in these instances as well.

Our basic premise is that when goal hierarchies are less interdependent, MTS performance will be attributable primarily to effective *team* action processes. In contrast, as the goal hierarchy demands greater interdependence between component teams, MTS effectiveness will depend more heavily on effective *MTS* action processes. Choi (2002) presented a similar theoretical argument for a competing relationship between internal and external team activities. He submitted that when teams are highly interdependent with outside constituencies, their effectiveness will be largely attributable to how well they conduct external activities. In contrast, Choi maintained, performance of teams with few external ties will hinge primarily on how well they orchestrate internal activities. Accordingly, we advanced the following hypotheses:

> *Hypothesis 4a:* Team action processes will be more strongly positively related to MTS performance in missions with *less* interdependent goal hierarchies.

> *Hypothesis 4b:* MTS action processes will be more strongly positively related to MTS performance in missions with *more* interdependent goal hierarchies.

> *Hypothesis 5:* MTS transition processes will be more strongly positively related to MTS performance in missions with *more* interdependent goal hierarchies.

## Method

### Participants

We recruited 184 students from psychology courses at a southeastern university to participate in the study in exchange for course credit. The sample was 69% female, had an average age of 21 years, and was 55% Hispanic, 20% Caucasian, 14% African American, and 11% "other." Participants were assigned to 46 four-member MTSs.

### Simulation

A PC-based MTS flight simulation was used as the experimental platform. Participants "flew" two F-22 aircraft as dyads, as part of a larger system that included six other allied aircraft controlled by artificial intelligence (AI). Each live team had a pilot and weapons specialist. The live *air-to-air* team was responsible for destroying enemy aircraft, and the live *air-to-ground* team was responsible for destroying enemy ground-to-air threats. All enemy targets posed a threat to the allied flights and to both live teams. Team members wore microphone-equipped headsets and had a within team "always" on radio channel, along with a second cross-team radio channel that could be activated by a switch.

Members viewed separate monitors, each displaying their own team's cockpit. The pilots flew their aircraft and fired weapons using a joystick and throttle. The weapons specialists used a standard PS2 keyboard to select weapons, add targets to weapon shoot lists, cycle through weapons, and release chaff and flares (defensive "missile decoys"). MTSs performed four parallel missions: one practice and three experimental missions.

## Goal Hierarchy Manipulation

We scripted three base experimental missions that had several important features. First, we placed enemy ground and air threats such that they would attack and destroy the six AI-controlled allied flights. The allied AI flights were programmed to fly a particular route at designated altitudes and speeds. If the live teams failed to accomplish their proximal goals, the allied AI teams would likely be destroyed. Therefore, the AI flights were always sequentially interdependent on the actions of both live teams. Second, the base missions were designed to be parallel, in that although surface characteristics differed (e.g., terrain, flight directions, vehicle types), they were equally difficult, as both computer and live pilot tests confirmed.

The three experimental missions were then modified to alter the live teams' interdependence. In the *pooled goal hierarchy* condition, MTS goals did not require interdependent action between the component teams. Air and ground targets were arranged so that each component team could accomplish its goals without the other team accomplishing its mission. For example, the live air-to-ground team was free to attack its targets without having to wait for the air-to-air team to accomplish its goals. In contrast, in the *sequential goal hierarchy* condition, MTS goals were interdependent, but the focus was on the order and timing of team actions. Targets were arranged throughout the mission so that one team needed to accomplish its goals before the other team could accomplish its goals. For example, the air-to-ground team had to successfully "clear a path" for the air-to-air team to position itself to attack enemy aircraft. The mission was scripted so that the priority of team actions switched between teams throughout the engagement. In the *intensive goal hierarchy* condition, goals were structured so that concurrent, coordinated efforts of both live teams were required. Targets were positioned such that both the air-to-air and the air-to-ground teams needed to simultaneously achieve their goals. Air and ground enemies were located in close proximity and therefore indiscriminately threatened both teams simultaneously. Thus, teams needed to rely on real-time support as they worked both to clear the battle space and to stay alive. Mission presentations were counterbalanced to control for any potential order effects. Subsequent analyses revealed that no significant order effects were evident.

## Procedure

Each experimental session lasted approximately 5 hr and commenced in three general phases. First, background measures were collected, and team assignments were made on the basis of how well participants performed on a multilimb psychomotor task. The member with the highest psychomotor ability score was assigned the role of air team pilot and was formally designated as the MTS leader.

The second phase was a 30-min task-training period that taught participants the task competencies relevant to each position. This phase ended with teams performing a 10-min joint practice mission. The third phase was a 3-hr experimental period where MTSs performed the three missions. Before each 15-min mission, members were provided with blank maps of the battle space, a mission briefing containing goals and the location of enemies, and a situational report that provided information ranging from irrelevant to essential in nature. Teams had 20 min to review the information, develop a mission plan, and write the plan on their mission maps. The teams then flew the performance mission and were debriefed; the cycle then continued for two more missions. The cockpit screens and audio communication of each component team were recorded onto videotapes for later coding of team processes.

## Measures

*Transition phase processes.* The quality of MTS transition processes including planning, mission analysis, and goal specification was assessed through interviews with the designated MTS leader (i.e., the pilot of the air-to-air team) following the mission briefing and planning period. A sample question is, "How do you plan on achieving the objectives you have identified for this mission?" All interviews were audio-recorded and later coded using behaviorally anchored rating scales ratings of each transition process. Two raters independently listened to the interview tapes and rated the quality of process using 1–5 scales with behavioral anchors developed for each dimension indicating low (1), middle (3), and high (5) levels. The correlations among raters for each dimension ranged from .79 to .85, and so we averaged ratings, per dimension, across raters. Although three distinct types of transition process were rated (i.e., goal setting, mission analysis, and strategy formulation), their high intercorrelations suggested that they tapped a single underlying construct. Therefore, we averaged the ratings across dimensions to index MTS transition processes ($\alpha$s = .82, .85, and .85 for Missions 1–3, respectively).

*Action phase processes.* Two subject matter experts observed the behaviors and communications between team members during the experiment and rated MTS-level action processes at the conclusion of each mission. Two other subject matter experts watched the videotapes and rated the intrateam action processes of the two component teams. Four action processes were rated per level of analysis: monitoring progress toward goals, systems monitoring, team monitoring and backup behavior, and coordination. Interrater correlations ranged from .78 to .87. Ratings were averaged first across raters and then across action phase process dimensions to yield one action phase composite rating for each team (i.e., air and ground) and for the overall MTS. Across the three missions, the four process dimensions rated in the pooled, sequential, and intensive conditions, respectively, were $\alpha = .79$, .77, and .77 for the air team; $\alpha = .85$, .75, and .82 for the ground team; and $\alpha = .89$, .87, and .84 for the MTS action processes.

*Multiteam performance.* MTS performance reflects the extent to which the assigned MTS mission goals were accomplished. MTSs earned points in four ways. First, each team could earn points by destroying its primary targets (0–160) and secondary targets (0–30). Second, MTSs earned points on the basis of the status of both live teams. They received 45 points for each undamaged team, 20 if a team was damaged yet alive, and nothing if a team failed to survive (for a score range of 0–90). Third, the MTS received 20 points for each of the six AI flights that survived undamaged, 10 points for each surviving but damaged flight, and nothing for destroyed flights (for a score range of 0–120). Finally, the MTS was penalized if live teams hit ($-20$) or destroyed ($-40$) neutral or allied entities. In total, the potential score range for each mission was $-560$ to 400, whereas the actual scores of the current sample ranged from $-55$ to 280. An automated feature of the simulation calculated the MTS performance score.

It is important to note that all four components of the MTS performance score can be conceptually tied to the MTS level (i.e., to joint actions of the two component teams). Clearly, the AI flights could not survive without the successful efforts of the two live teams. However, even the seemingly individual team scores were sensitive to MTS processes. For example, in many instances the air-to-ground team was the first to perceive the presence of enemy aircraft. In other instances, the air-to-air team noticed allied ground forces near enemy ground targets. To the extent that teams shared information and helped one another, the component teams were better able to perform their designated functions. Moreover, the extent to which, for example, the air-to-ground team incurred damage from enemy aircraft was attributable to both how well they positioned themselves and how well the air-to-air team performed its functions. These relationships were certainly at a premium as the team goals became more interdependent. In sum, the individual team performance scores were in many ways the products of MTS processes such as monitoring one another, gathering and exchanging information, and backing up one another.

### Goal Hierarchy Manipulation Check

We administered two manipulation check items to all MTS members after the transition phase of each mission: "It is important to work closely with the air/ground team to successfully complete the mission" and "For our MTS to succeed, we do not need to work together with the air/ground team" (reverse scored). Participants rated items on a 5-point Likert scale, where 1 = *strongly disagree* and 5 = *strongly agree*. Responses correlated .84 ($p < .01$), and so we averaged them. We expected a pattern of means such that pooled < sequential < intensive conditions. Both pooled and sequential goal hierarchy mission conditions were rated by participants as requiring less team-to-team work to accomplish the mission than did the intensive condition, $F(2, 181) = 20.04$, $p < .05$. However, follow-up tests revealed that there were no perceived differences between the pooled and sequential conditions. This finding is consistent with post hoc evaluations from subject matter experts, who noted that the goal hierarchy manipulation was much more robust between intensive versus sequential and pooled conditions, because the sequential condition essentially forced team interdependence in regard to timing (one team had to perform first, then the other) but did not require the teams to actually engage in coordinated combat during the missions. Thus, owing to the lack of evidence for a valid distinction among pooled versus sequential missions, we chose to combine those conditions. This decision primarily impacts Hypotheses 4 and 5, which we now use in examining how process–performance relationships differ on the basis of interdependency of goal hierarchies.

In all analyses, a dummy code representing goal hierarchies (more interdependent = 1, less interdependent = 0) was entered in the first step of a hierarchical regression. This strategy also controls for differences in scenario difficulty, as such a dummy code captures all of the differences attributable to between-environment factors (Cohen & Cohen, 1983). Correlations among all study variables along with descriptive statistics are reported in Table 1, separately for the more versus less interdependent conditions.

## Results

We tested our hypotheses using repeated measures multiple regression (RMMR). RMMR partitions total variance into that which resides within and between units of analysis—in this case, MTSs (cf. Cohen & Cohen, 1983; Hollenbeck, Ilgen, & Sego, 1994). One then tests the hypothesized relationships using error terms that correspond to within- or between-unit effects. In this application, because all MTSs performed all missions and we measured all variables each time, we are modeling within-MTS variance. This permits a focus on how MTSs must execute different processes in different conditions. As shown in Table 1, the percentage of within-MTS variance amenable for modeling ranged from 16.26 (MTS transition processes) to 43.95 (MTS performance).

### Hypotheses 1–3

We regressed MTS performance first onto the dummy-coded goal hierarchy (to control for any direct effects of the manipulation) and then onto team and MTS action processes. The goal hierarchy code was significant ($R^2_{\Delta\text{within-MTS}} = .12$), $F(1, 91) = 17.52$, $\beta = -.18$, $p < .05$, indicating that MTSs performed worse in the more interdependent mission. Adding the two within-team action processes to the equation yielded a significant $R^2$ increment ($R^2_{\Delta\text{within-MTS}} = .49$), $F(2, 89) = 117.19$, $p < .01$, with both team action processes contributing positively and significantly ($\beta_{\text{air team}} = .27$, $p < .01$; $\beta_{\text{ground team}} = .35$, $p < .01$). Adding the MTS action process variable to the equation yielded an additional significant effect ($R^2_{\Delta\text{within-MTS}} = .04$), $F(1, 88) = 20.02$, $p < .05$, $\beta = .16$, in the hypothesized direction. Finally, adding the MTS transition process variable to the equation also produced a significant $R^2$ increment ($R^2_{\Delta\text{within-MTS}} = .11$), $F(1, 90) = 74.49$, $\beta = .22$, $p < .01$, in the hypothesized direction. All of the predictor variables remained significant in the final equation. As summarized in Table 2, together these results provide support for Hypothesis 1, Hypothesis 2a, and Hypothesis 2b.

Hypothesis 3a predicted that MTS transition processes would positively influence team-level action processes. We tested this by running two hierarchical RMMRs, one regressing air team action processes and the other regressing ground team action processes onto MTS transition processes, after covarying out the goal hier-

Table 1
*Means, Standard Deviations, and Correlations for All Variables by Interdependence*

| Variable | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. MTS transition processes | — | .12 | .06 | −.01 | .27* |
| 2. MTS action processes | .25 | — | .39** | .36** | .34** |
| 3. Air team action processes | .04 | .53** | — | .40** | .47** |
| 4. Ground team action processes | −.08 | .52** | .42** | — | .51** |
| 5. MTS performance | .15 | .58** | .27 | .36* | — |
| Low interdependence | | | | | |
| *M* | 2.16 | 1.35 | 2.51 | 2.23 | 63.52 |
| *SD* | 0.81 | 0.60 | 0.74 | 0.84 | 63.18 |
| High interdependence | | | | | |
| *M* | 2.35 | 1.35 | 2.32 | 2.01 | 31.61 |
| *SD* | 0.86 | 0.69 | 0.64 | 0.70 | 39.20 |
| % variance | | | | | |
| Between MTSs | 83.74 | 68.17 | 75.70 | 80.00 | 56.05 |
| Within MTSs | 16.26 | 31.83 | 24.30 | 20.00 | 43.95 |

*Note.* $N = 46$. Values above the diagonal are low-interdependence correlations; values below the diagonal are high-interdependence correlations. MTS = multiteam system.
* $p < .05$. ** $p < .01$.

Table 2
*Hierarchical Repeated Measures Multiple Regression Analyses Predicting MTS Performance*

| Step | MTS performance | | | |
|---|---|---|---|---|
| | $\beta$ | Total $R^2$ | Incremental $R^2$ | Incremental variance accounted for: within team[a] |
| 1. Goal hierarchy[b] | −.18* | .07 | .07 | .12 |
| 2. Air-to-air within-team action processes | .27** | .34 | .27 | .61 |
| 2. Air-to-ground within-team action processes | .35** | | | |
| 3. Cross-team action processes | .16* | .36 | .02 | .04 |
| 4. MTS transition processes | .22** | .39 | .03 | .11 |

*Note.* $\beta$ is the standardized regression coefficient from the full regression equation. MTS = multiteam system.
[a] $N$ = 138 (3 observations per 46 teams; total within-team degrees of freedom = 92). [b] This variable was dummy-coded: less interdependent = 0, more interdependent = 1.
* $p < .05$. ** $p < .01$.

archy dummy code in both equations. Neither analysis was significant ($R^2_{\Delta\text{within-MTS for air team}} = .01$; $R^2_{\Delta\text{within-MTS for ground team}} = .01$). We found no evidence that MTS transition processes directly influenced team-level action processes, thereby failing to support Hypothesis 3a. We next tested Hypothesis 3b, by regressing MTS transition processes on cross-team action processes, and obtained a significant $R^2$ ($R^2_{\Delta\text{within-MTS}} = .08$), $F(1, 90) = 8.01$, $p < .01$, $\beta = .16$. MTS transition processes predicted MTS action processes but not team action processes. We should note that because Hypotheses 1, 2a, 2b, and 3b were supported, our findings are consistent with the conclusion that MTS action processes (but not team action processes) partially mediate the influence of MTS transition processes on MTS performance (James & Brett, 1984).

### *Hypotheses 4 and 5*

Hypotheses 4 and 5 addressed the extent to which the interdependence levels created by the goal hierarchy moderated the relationships between action processes and MTS performance. We tested these hypotheses by adding cross-product terms representing interactions between the goal hierarchy dummy code and the action processes (i.e., Goal Hierarchy × MTS Action Processes, Goal Hierarchy Vector × Air Team Action Processes, and Goal Hierarchy × Ground Team Action Processes) to the final RMMR equation predicting MTS performance. The set of interaction terms accounted for an additional 11% of the within-MTS variability in MTS performance ($R^2_{\Delta\text{within-MTS}} = .11$), $F(3, 85) = 36.48$, $p < .01$, beyond the direct effects of MTS and team action processes. Standardized beta weights for each interaction term were as follows: ($\beta_{\text{Mission} \times \text{Air Team Action Processes}} = -.798$, $\beta_{\text{Mission} \times \text{Ground Team Action Processes}} = -.257$, $\beta_{\text{Mission} \times \text{MTS Action Processes}} = .284$). To confirm the nature of the interactions, we plotted values representing plus and minus one standard deviation from the means of the continuous variable for each interaction term equation (Cohen & Cohen, 1983). The plots of these interactions are shown in Figure 2. The first graph shows

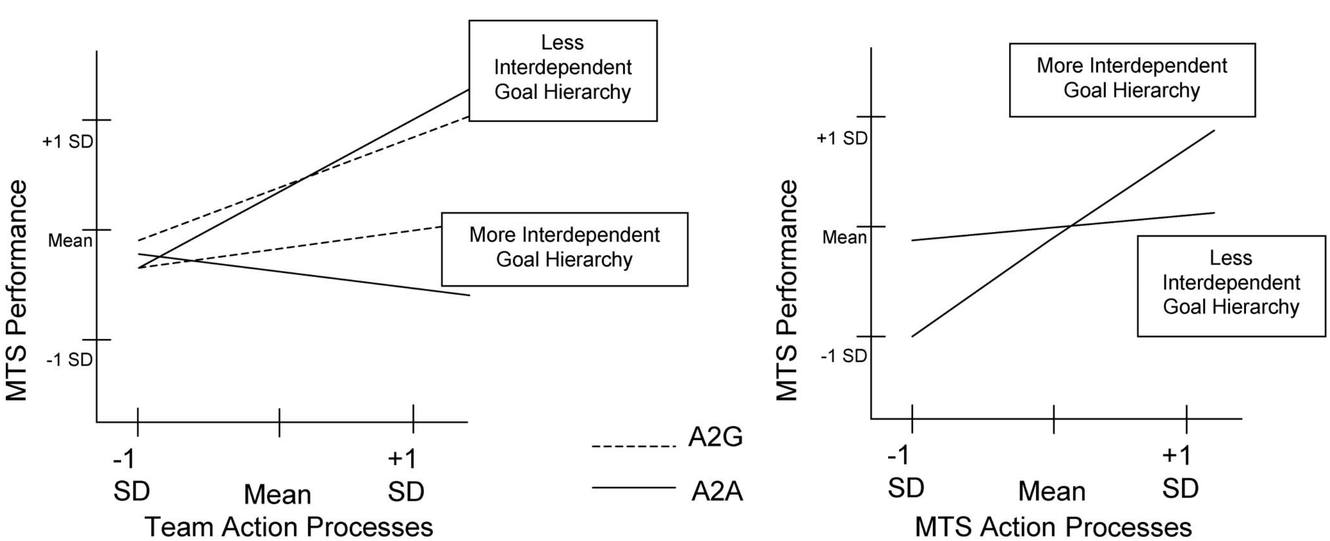


*Figure 2.* Graphs of moderated regression analyses depicting relationship between goal hierarchy, multiteam system (MTS) and within-team processes, and MTS performance. A2G = air to ground; A2A = air to air.

plots of two different moderated regression analyses, one for the air team and one for the ground team. In support of Hypothesis 4a, team action processes were most instrumental in predicting collective success during less interdependent missions, whereas they were not a significant predictor of MTS performance in missions with more interdependent goal hierarchies. This pattern of results was the strongest in the air teams.

The second graph shows that MTS action processes did not significantly influence MTS performance when less interdependent goal hierarchies were present. Conversely, in the more interdependent goal hierarchy mission, there was a positive relationship between MTS action processes and performance. In support of Hypothesis 4b, when MTSs performed intensively interdependent tasks, those that were able to coordinate and monitor *across* component teams were more successful in achieving the collective mission.

We conducted another hierarchical regression to test Hypothesis 5, which predicted that goal hierarchies would moderate the transition process–MTS performance relationship. We first entered the goal hierarchy dummy code, team and MTS action process, and transition process terms, and then entered a multiplicative term representing the interaction of goal hierarchy and transition process. We found that the interaction term accounted for an additional 11% of the within-MTS variability in MTS performance ($R^2_{\Delta\text{within-MTS}} = .11$), $F(1, 86) = 37.87$, $p < .01$. However, a plot of the interaction revealed that it did not conform to the anticipated form. Specifically, transition processes were positively related to MTS performance in less interdependent contexts, whereas they were unrelated to MTS performance in more interdependent circumstances.

## Discussion

This study provides an initial examination of how transition process–action process–performance relationships operate within and between teams in the context of an MTS performing under different goal hierarchies. Consistent with research at the team and organizational levels, we found that cross-team (MTS) action processes were most valuable when working in highly interdependent goal hierarchies. Although component teams were better at executing team action processes than MTS action processes (as evidenced by the lower MTS action process means), the highest performing MTSs exhibited both types of processes. Well-orchestrated MTS transition processes related positively to MTS performance, both directly and as mediated by MTS action processes. The transition processes did not, however, facilitate team-level action processes. These findings underscore the importance of a multilevel focus (Kozlowski & Klein, 2000) for understanding the role of teamwork processes in MTSs. They also suggest that team-focused and MTS-focused process–performance relationships may not be homologous across levels.

Contrary to our expectations, MTS transition processes were more positively related to MTS performance when teams worked in less, as compared with more, interdependent goal hierarchies. We anticipated that MTSs would use transition periods to gain a better understanding of their environments and to develop cross-team strategies for achieving MTS goals. However, in hindsight, we believe that three different phenomena may have occurred. First, some MTSs used the time to generate objectives and strategies that reflected team-level performance goals as opposed to focusing on higher level MTS-level plans, as we had intended. Second, other MTSs appeared to use the time to create well thought out plans for cross-team coordination that were not flexible or adaptive. The rigidity of such MTS plans was not particularly helpful in orchestrating cross-team performance gains in a considerably more challenging performance situation driven by interdependent goal hierarchies. Third, because of the frequency of interaction necessitated by the intensive condition, teams were forced to readily develop plans on the fly (reactive adaptation; Marks et al., 2001) as they were performing the task, and thus transition planning was not related to performance. Conversely, on less interdependent tasks in which teams were not in constant interaction, the quality of the processes they engaged in during transition was predictive of their MTS performance levels.

These findings are consistent with Weingart (1992), who did not find large effects for preplanning processes on team performance. In explaining her results, Weingart argued that the face-to-face interaction among team members enabled planning to run concurrent with task accomplishment. When teams are in constant interaction, preplanning is not as important, whereas when teams operate more independently and their contributions combine in an additive manner, preplanning is the primary means by which their later actions are synchronized.

### *Caveats and Limitations*

One limitation of this study comes from the goal hierarchy manipulation. We intended to establish three levels of interdependence (i.e., pooled, sequential, and intensive), yet our manipulation check suggested that there was no difference between the pooled and sequential conditions. This may well have attenuated some of the results involving the goal hierarchy manipulation. Second, the fact that we sampled undergraduate students performing in a simulated laboratory environment obviously presents some boundary conditions for generalization. We created a situation where teams had distinct proximal goals that related to an overall MTS goal in different ways. The extent to which these goal hierarchies map to those encountered in real-world settings is subject to debate. Nevertheless, our simulation was quite engaging as compared with most laboratory environments. We had the ability to script missions and to embed our live experimental teams into a larger network of allied forces with computer AI controlling the operations of interdependent teams. This scenario offers a powerful blend of experimental control and realism (Marks, 2000). Nevertheless, we acknowledge that researchers will need to examine MTS relationships in field settings to evaluate the generalizability of our findings.

Further, we have examined MTSs consisting of two live dyads. It is certainly true that MTSs composed of more and larger teams may well function differently. On one hand, larger MTSs with more teams of varying sizes might well engender different processes. For example, the decision of which teams are called on to perform which functions may be less clear, social loafing may be more acute, and coordination processes may be more strained. On the other hand, smaller MTSs place greater burdens on individual teams and members and offer less in terms of load balancing, backup behavior, and so forth. In short, the influences of size, design, and operations of different types of MTSs are clearly ripe areas for future investigations. Our results imply that an understanding of the nature of the MTS goal hierarchy is one important factor to be considered in such investigations.

### *Future Research*

In this study, we operated under the assumption that teamwork processes are homologous at the MTS level of inquiry. However, it may be the case that the types of teamwork processes differ at the team and MTS levels. By definition, MTSs are more complex entities because they contain multiple teams that must work cooperatively and interdependently toward a common set of goals. This demands both vertical and horizontal alignment of subgoals and synchronized actions with other teams in the MTS. Depending on the nature of the process interdependencies and the temporal pressures, the sequencing of MTS interactions may be highly complex and require more sophisticated boundary management processes (Kozlowski, Gully, McHugh, Salas, & Cannon-Bowers, 1996). A major leadership challenge is facilitating the optimal balance between team- and MTS-level processes. These challenges also raise questions such as how to best train employees to operate in MTS environments, how to best align reward systems, and how technology might be leveraged to optimize MTS performance (Mathieu et al., 2001).

This study provides a theoretical framework and a preliminary examination of how team and MTS processes combine to influence the performance of a new and evolving type of work arrangement. Our hope is that it motivates others to examine more complex types of MTSs, different goal hierarchy forms, and how these dynamics unfold and develop over time.

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Received October 20, 2003
Revision received April 19, 2004
Accepted May 18, 2004 ■