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21a NAME OF RESPONSIBLE INDIVIDUAL L. T. Duffy	21b TELEPHONE (include Area Code) (619) 553-9222	21c OFFICE SYMBOL Code 442
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TEAM DECISION MAKING AND TECHNOLOGY*

LorRaine Duffy

Naval Command Control and Ocean Surveillance Center,
San Diego, CA

In 1990, Martin Marietta deployed a satellite into the wrong orbit when engineers instructed the computer programmers to open the bay door to the hatch containing the satellite. The programmers opened the "wrong door," although they had followed the instructions correctly (Associated Press, 1990). Today, \$150 million sits dead in orbit around the earth. The total cost of the miscommunication: \$500 million. In 1989, an Avianca airliner crashed in New York awaiting clearance for landing, while critically low on fuel. Ground control misinterpreted the Colombian pilot's urgent message regarding his fuel shortage and assumed that a fuel emergency had not been reached. More than 270 people died. The captain aboard the USS Vincennes had approximately 180 seconds in which to process information from several of his support staff and make the decision as to whether to shoot the (then misidentified) Iranian airbus and protect his crew. Although the decision was militarily correct, 290 civilians died and questions were raised regarding the inadequacy of our scientific knowledge concerning team decision making and decision support systems in this "real life" setting.

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*The views expressed in this chapter are solely those of the author and should not be construed as an official position of the United States government.

when these multiple-expert parties attempted to reach a resolution. What factors are important in predicting team effectiveness and what is the impact of technologically sophisticated systems on these teams? We know a great deal about the answer when discussing individual decision makers (Abelson & Levi, 1985), but very little when discussing technologically supported multiple decision makers (Duffy, 1990; Galegher, 1990).

A DEFINITION OF COMPUTER-SUPPORTED TEAM DECISION MAKING

Although I refer to groups and teams interchangeably, a distinction should be drawn between "real" teams and groups created in laboratory settings for the purposes of research, because they operate under different assumptions and constraints. The study of laboratory-created groups has led to valuable theoretical insight into the group decision-making process; however, whether these insights generalize outside the laboratory is not clear (Michaelson, Watson, & Black, 1989; Michaelson, Watson, Schwartzkopf, & Black, 1992; Tindale & Larson, 1992). Seeger (1983) and Tetlock (1985) noted that the academic literature on group decision making is based on data drawn from artificially created groups in a laboratory setting, working on arbitrary tasks. This has led to questionable conclusions regarding the processes that are undertaken by real teams to reach decisions in organizational and political contexts (Janis, 1989). However, descriptive studies of real teams have been unable to systematically test theories regarding process that would be generalizable (Hackman, 1990). Laboratory research and descriptive studies together may provide us with some insight into the nature of team decision making in a technological context.

Team decision making is further complicated when it is supported by technology, such as decision support systems that are comprised of decision aids, informational data bases, computers, intercoms, telephones, video, and so forth (Johansen et al., 1991). Decision making, as a term, no longer adequately fits the expanded activities that the team undertakes to solve a problem or reach an intended goal. *Intellectual teamwork* is possibly a better term to describe team decision making in technologically supported environments, because according to Galegher (1990), it assumes "... individuals working together (often across long periods of time) to manipulate information or to create information intensive products" (p. 195). For example, products can include strategic planning documents, integrated engineering designs, or comprehensive medical diagnoses. It does not focus on the manual movements that characterize assembly line work, or restrict itself to the coordination of physical activities among team members. It is much broader than the conventional decision making that is characteristic of much of the management

literature on group decision making. The focus is on the implicit cognitive and coordination strategies and information use that are undertaken by a team to make a decision, reach an intended goal, or solve a problem (Bushnell, Serfaty, & Kleinman, 1987; Kleinman & Serfaty, 1989).

Assume, then, that team and group decision making involves co-acting members with specialized knowledge, interacting to arrive at some valued decision(s) or outcomes. (See Duffy, 1990, for a more complete definition.) Teams have accountable membership (Tetlock, 1985), often work in unpredictable ambiguous environments, and process information (or enact various functions) for variable lengths of time. As McGrath (1990) noted, "temporal patterns are not fixed in time in the sense that a given set of actions does not always last a certain number of minutes" (p. 26). Team actions can occur iteratively, nonsequentially, and redundantly.

To keep in line with what we see in real teams, Galegher's definition is expanded here to include the following requirements: (a) team members who have different and specialized expertise, (b) the interaction of individual and group problem-solving activities, as well as (c) substantial interpersonal communication in "nonsequential" task time frames (as defined before by McGrath). Given this definition, the team task is more intellectually intensive than the coordinated manual activities typically associated with, for example, industrial teams and command and control teams (Morgan, Glickman, Woodward, Blaiwes, & Salas, 1986; Sundstrom, DeMuese, & Futrell, 1990).

Given that teams engage in our expanded definition of intellectual teamwork, what kinds of problems beset teams and can technology address these problems? First, though, what types of problems are there?

TEAM DECISION-MAKING PROBLEMS

What kinds of biases affect the decision making of teams engaged in intellectual teamwork? Two broad categories are process "problems" and content "problems." These problems occur as a function of errors, such as slips and mistakes (Norman, 1988), and cognitive biases (Kahneman, Tversky, & Slovic, 1982). Before a description can be given, a caveat is in order. The point of commission of an error or bias may be undefinable for teamwork. When an individual commits an error or succumbs to a bias, it is usually definable at the moment of behavioral commission, because we cannot see "inside a person's head." When the team commits an error or succumbs to a bias, it is difficult to define the point of commission, because teams can explicitly self-correct behaviors before the end of a team work sequence of behaviors and correct verbal reasoning. This is, in effect, like "seeing inside the team's head." Error, then, can only be reliably defined after the fact (Sticha & Gribben, 1992). Researchers must be very clear of their definition of team error and at what

level of analysis they are working in order to determine the nature and effects of these errors and biases. It is one thing to assume an error or bias on the part of one team member, based on notions of what would be considered logical behavior or intended action. But, when one has a team of decision makers, that assumption is stretched to the limit. Any individual can assume a different perspective on the problem or intention of action and act according to the logic of that perspective or intention, not the logic of the experimenter. The experimenter's definition of the team error or bias is a substantial research issue.

Errors/Bias Due to Process

The team decision-making process, in general, may itself serve as a source of error or bias. One categorization of process includes the following four dimensions (McDonald, 1990): rational, consensual, empirical, and political. Rational decision processes are goal centered, logical, and efficient and include many of the processes characterized by multiattribute utility theory (Keeney & Raiffa, 1976). Unfortunately, rational decision processes rely on the assumption that knowledge of all attributes and consequences of the problem are definable by the team members or can be derived, and that imagination can be used to define one's knowledge of "future events," making them predictable. Consensual processes demand participation and general agreement on an outcome by all team members. They highlight a strong bias to democratic processes. Support of this process has been the focus of much of the development of technological support for group decision making in the business community. Empirical processes are based on the use of information or evidence and demand accountability or credibility. These processes might be subsumed under rational processes; one can be rational without being empirical, but one cannot be empirical without being rational. Political decision processes rely heavily on adaptability and external legitimacy. "Satisficing" (Simon, 1955), a decision strategy of choosing the first "acceptable" solution generated as opposed to an optimal solution, for individuals could be generalized to team decision making. Whether these different processes are unique to particular types of teams or to particular points in the decision-making process remains unanswered. It does appear that they are not mutually exclusive, and any decision situation can be described as consisting of each process in varying degrees.

Emphasizing one process over another may cause a predilection to error. For example, I would assert that the Martin Marietta team was engaged in rational decision making, when consensual decision making should have been the focus because of the high demand for coordination among the team members (even though it was in a rational and empirical context). The Avianca incident seemed to reflect a focus on political and consensual decision

making; the air ground controller was making the quickest satisfying decision possible under his very heavy task load and trying to reach concurrence with the pilot despite language differences. However, there should have been more credence given to the empirical processes—the determination of actual facts on fuel load. The Vincennes incident was heavily enmeshed in empirical decision making (determining the identification of the unknown aircraft by correlating different sources of tactical information about the aircraft), as well as in the more obvious political decision making, and was overloaded by the demands of both. The overload on human processing may have been unavoidable in this case. We must improve the technological support of the appropriate process when a change in the process type is unfeasible. (Of course, research is needed to empirically support these assertions. We discuss this later.)

Errors/Bias Due to Content

The current literature on content-related errors and biases that is the most useful for teams engaged in intellectual teamwork seems to fall into three general categories: informational, normative, and structural. These categories are derived from a mix of individual and group decision-making literature. How well the transfer of the terminology from an individual perspective to the team perspective occurs is a major research issue. As Tindale (this volume) notes, the effects can be quite different for the individual and the group, depending on the bias under investigation.

Informational Errors/Biases. Informational errors/biases are most closely associated with Kahneman et al.'s (1982) description of the types of individual cognitive heuristics and biases. Examples of these would be representativeness, availability, and the base-rate fallacy. Informational errors are similar to Janis' (1989) depiction of cognitive effects in team decision making. The error occurs at a cognitive level, rather than at a social/interpersonal level. Eekhout and Rouse (1981), Rasmussen (1986), Norman (1988), Reason (1990), and Rouse and Rouse (1983) all provided classification schemes for individual cognitive errors. They range from Norman's *slips* (resulting from automatic behavior) and *mistakes* (resulting from conscious deliberation) to Reason's *slips*, *rule-based mistakes*, and *knowledge-based mistakes*. Many of these errors seem to result from erroneous or hidden assumptions raised when an inappropriate "context" (or frame) is used to delineate the information needed for a particular decision. This may relate to the use of schemata, heuristics, scripts, assumptions, and so forth.

Most of the research on informational error and bias has been conducted in laboratories on individuals. Do these often laboratory-induced individual errors transfer to nonlaboratory, often irrational, teams? The illusory corre-

lation effect studied in the laboratory (Chapman & Chapman, 1969) is one area of research that has transferred well from the laboratory to the applied setting: from the individual to the team. The Chapman's research found just such effects with individuals on a clinical categorization task. Tolcott, Marvin, and Bresnick (1989) found a similar effect, discussed as confirmation bias, with teams of military planners. Base rate fallacy has also made the transition; from Kahneman and Tversky's (1973) study of individuals to Hinsz, Tindale, Nagao, Davis, and Robertson's (1988) study of the group's susceptibility to base-rate fallacy. Satisficing (Simon, 1955) as a strategy can lead to good and bad expert-like decisions for the individual decision maker. This concept has been reworked (with modifications) to depict expert-like team decision making in time-constrained situations, as "recognition-primed" decision making (Klein & Thordsen, 1989).

Informational errors and biases are based on how information is processed and transferred. This suggests that an information-processing perspective of team interaction may be an appropriate model (Hinsz, 1990a; Lord, 1985; Taylor & Crocker, 1981; Wegner, 1987). This perspective can provide a rich source of predictions regarding intellectual teamwork. For example, the engineers and programmers in the Martin Marietta problem may have been victim to a simple case of miscommunication. When the engineers told the programmers to "Open bay door one," they did not know that their referents were different—engineers were referring to the upper bay, the programmers were referring to the lower bay. At the critical moment, they were both thinking of "bay door one." This does not give us much insight into resolving the problem to inhibit its future occurrence. But if one were to think of the incident as two teams working with different "mental models" or "schemas" of the problem, it provides software designers with an idea of potential correctives/aids in the decision support systems used by engineers and programmers. (Simply editing a procedural manual cannot solve the problem of one team member not knowing he/she is using the wrong referent at the time of execution.) This is a recent area of development with respect to understanding team interaction (Cannon-Bowers & Salas, 1990; Hinsz, 1990b; Rentsch & Duffy, 1990). If mental models are the appropriate unit of cognitive analysis, encoding as an information-processing function would be an appropriate unit of functional analysis. It also would be interesting to see if software designers could encourage consensual decision processes in this highly rational context, as discussed earlier. Knowing which mental models are represented in individual team members and how to communicate them to the other team members would move us far in the direction of preventing potential "miscommunications" and \$150 million mistakes.

Another perspective on mental models would be to study the way the information is stored and then retrieved from group memory (Wegner, 1987), which can be affected by coding information in a format congruent to the

"story told" format, as in the use of analogies (Janis, 1989); or in a similar vein, as depicted by Pennington and Hastie's (1992) explanation-based reasoning. If different team members choose different storing strategies, team errors could occur in retrieving and combining the needed information. Surfacing important information from group memory (Wegner, 1987) for group decision making is not as straightforward as with individual retrieval. Stasser (1992) and Stasser and Titus (1985) found that in a laboratory study based on an information sampling model, groups have a tendency to share commonly known information, not uniquely held information. (*Unique information* is that known only by an individual group member, not by other group members.) Technology in the form of software support for "surfacing" uniquely held information should be the focus of development in group support systems.

Normative Errors/Biases. A second category of error/bias is more socially based; it includes normative influences or affiliating influences (Janis, 1989) and is a derivative of more traditional social psychological variables. They are influences specific to social interaction processes or expectation of interaction with others. Included is the "groupthink" effect (Janis, 1972; Janis & Mann, 1977), where small group consensus occurs due to pressure from group members to preserve group harmony. The *Abilene paradox* (Harvey, 1974, 1988) is the "flip" side of this process, wherein there is outward group acceptance of a solution, although each member internally does not agree with the socially accepted solution, much along the lines of the false consensus effect (Sanders & Mullen, 1983). This push to agreement may have been the operative social mechanism that drove the decision making for the harried air controller in trying to understand the fuel situation on the Avianca airliner. Rather than lose valuable time querying whether the pilot understood his request for information, the controller assumed that the pilot had understood the request. The pilot in turn assumed the air controller was "handling" the situation and did not query the understanding of the air controller. One could hypothesize that both agreed to the solution (to wait) but internally were not "happy" about it. (Note, too, that from a human factors' standpoint, I am not denying the overwhelming criticality of the pilot's lack of knowledge of his own airliner's fuel reserves.)

Incremental decision making is a socially induced bias in the team process as described by Janis (1989), where the latest decision is the "smallest" possible incremental change from the last decision made in the same area. The underlying reason is to "cover one's rear flank." Tetlock (1985) described an "avoid punishment" strategy similar in description to incremental decision making. In other words, a group makes numerous small decisions that are less likely to erupt into trouble or create dissent than one large course-changing decision. Another bias is a group preference for sequential process-

ing in group interaction (such as turn-taking), noted by Galegher (1990), specifically in computer-mediated interacting groups. Other more commonly known process variables are related to personality and ideological conflicts occurring among team members, which may cause difficulty or misunderstanding in reaching consensus. The most popular is the domination of group interaction by one member, which has been a ripe area of research in computer-mediated group decision making because it is relatively easy to observe the dominant member as he/she is reduced to using only verbal skills to influence the group, rather than much richer behavioral influences, such as posturing, glowering, or selectively attending to favored group members (Kiesler, Siegel, & McGuire, 1984; Nunamaker, Applegate, & Kosynski, 1988).

Structural Errors/Biases. Finally, structural variables that influence the type of error or bias that may appear are derived from the organizational or environmental context in which they occur. Cohen, March, and Olsen (1972) were among the first to note that group decision making was heavily influenced by the organizational context in which it occurred. Mismatches in the more global, systems-theoretic variables, such as organizational hierarchy, led to poor group decision making, particularly in real-life settings (March & Weisinger-Baylor, 1986). For example, inappropriate lines of authority (e.g., by rank and not by skill) could lead to errors in team decision making (Rochlin, La Porte, & Roberts, 1987), as well as a failure to coordinate uniquely held expert information (Cicourel, 1990; Hutchins, 1990); that is, "valued" information is not distributed among team members. Think of a surgical team of doctors consulting on the health care of a patient. The "worth" or "value" of a recommendation for a course of health care is couched in the socially based reputation and perceived competence of the member making the recommendation. Information gains value by how that doctor is perceived by his/her colleagues in knowledge, ranking, and expertise. This is quite evident in teams that are engaged in consensual decision making—where democratic processes tend to be followed. In military teams, the same influences may be occurring but are less evident, because the rigid authority structure forces the members to accept a member's information as valid, despite personal feelings about that member's competence or expertise. (However, it is known that a particular member's view is worked around or ignored due to the perceived incompetence of that member.)

Errors (or poor performance) also can occur because of the effects of task characteristics (such as noted by Hammond, Hamm, Grassia, & Pearson, 1987; Stammers & Hallum, 1985), spatial arrangement of team members in organizations, the degree of technological support, and so on, all of which have little or no research evidence but much anecdotal evidence. The crew of the USS Vincennes was ultimately following organizational doctrine (based on the type of technological support they had, such as the configuration of

weapon systems), which left little room for negotiation in attempting to correctly define the problem in a situation with little time, high risk, high uncertainty, and great stress.

Given that we know that team decision making can succumb to any of these errors, what can we do technologically to ensure accuracy? What is the current state of technological support in this area?

TEAM DECISION MAKING AND TECHNOLOGY

Technology is now a fact of life, not only in complex systems exemplified at the beginning of this chapter, but in our everyday lives. We see it in the computers we use, the appliances we have trouble manipulating, and the transportation systems that we take for granted. Interestingly, decision technologists have only recently begun to pay attention to group support systems and collaborative work. Group support systems encompass a wide range of technology (hardware, software, and network) that support group processes and functions. *Collaborative work* implies any task that requires the multiple inputs of more than one person or machine to reach an intended goal. Getting one piece of needed information from another person or source is not, by definition, collaborative work. Nor does it necessarily imply consensus among team members. Collaborative work implies working jointly, especially on an intellectual endeavor (Webster's New Collegiate Dictionary, 1980). The variety of hardware and software suites that comprise group support systems is growing daily. Their main purpose is to function as quantitative and qualitative group decision aids for the purposes of five functions: communication, group memory/information access, coordination, development, and collaboration, such as brainstorming, group drawing, and group authoring (Nunamaker, 1992). Mechanically, support systems vary along two dimensions: time and place. They support group processes that occur at the same time and place, same time-different place, different time-same place, and different time and place (Johansen et al., 1991). Philosophically, there is another dimension that must be addressed: the time dimension that is the focus of the group decision making itself, or *strategic versus tactical* focus, to borrow language from the military. Strategic decision making incorporates the most important or overriding goals for military action. In business, the concept is referenced in long range, five year plans and in company's purpose and goals. Strategic planning meetings are a common occurrence in almost any business, as well as in military environments. Tactical decision making involves the actions or means of less magnitude or that involve actions and objects that are a short distance from the base of operations (especially in the U.S. Air Force), as opposed to those of strategy. It tends to be used in business operations to refer to "everyday functioning" or those deci-

sions that a business makes with an immediate end or goal in view. It is much more time compressed in its goals than strategic decision making. Group support systems, such as meeting room environments, focus heavily on supporting the strategic decision making of an organization. Coordination and communication software focus on the tactical decision making that an organization conducts. There is no software or hardware that focuses on the *transition* from one form to the other.

The assumptions that group support systems make, particularly meeting support software, with regard to group decision making are: rationality among decision makers; decision making as a structured linear process; the need for anonymity or a facilitator as a process controller; and the need to replicate the face-to-face decision-making environment. Each of these assumptions can be questioned given the particular circumstances under investigation, and none has had consistent empirical or anecdotal evidence to support it. Pinsonneault and Kraemer (1990) offered an excellent review of the area and noted that in "eyeballing" the available data, group decision support systems seem to increase: the depth of analysis of groups, the level of participation by individual group members, consensus reaching, the confidence and satisfaction with the group decision, and improvement of the quality of the decision. They also found support for the assertion that these systems reduce domination of the group by a few members and reduce decision time.

Overall, then, the objectives of these group decision support systems are generally supported. The objectives include: (a) provision of available information more accurately, more completely, and in faster accession time; (b) reduction of coordination effort (obviating process loss); (c) reduction of negative group influence effects (moving the decision making from a normative-influenced one to an information-influenced one); (d) and the increase of wider audience view of the same material, under the assumption that this leads to faster common understanding (Kraemer & King, 1988).

However, new problems are associated with the preceding gains in process: (a) team members are no longer interacting in a face-to-face format in "real time" and with no replacement for the loss of nonverbal information that is gained "in situ"; (b) as a result, the process becomes asynchronous with unknown impact; (c) the process becomes democratized without the members' knowledge or consent (Kiesler, et al., 1984); and (d) there are no quick recovery mechanisms for errors and misinterpretations, particularly because "backchannel communication" has been eliminated (Galegher, 1990). (Backchannel communication occurs in the "background" of primary communication and can be used to quickly query and to confirm understanding among team members.)

These group system problems will continue to plague technology supported team decision making unless they are addressed in the early stages of decision support system development. For example, teams like those described

in the satellite incident would continue to suffer from two of the major problems just listed: no face-to-face communication and no quick recovery mechanisms. However, a group system could begin by addressing the two that could impact the type of problem that the Martin Marietta team experienced: asynchronous processing and democratization of the interaction. For example, with a group support system providing an interactive graphic view of the rocket carrying the satellite to be viewed by all members of the satellite deployment team, would the same error have occurred? It would lead to a more synchronous process because the interactive graphics enable them to work on the view simultaneously, such as in group authoring software. (Everyone can "write" on a common document at essentially the same time.) It also would allow for the development of a more consensual decision process between the team members, as they can interact, not simply react.

Could the Avianca disaster have been averted if the two principal participants (the pilot and the air traffic controller) had a system that more specifically queried their assumptions about the level of fuel left on the airliner (within the given time constraints of the decision)? This is a case where the "backchannel" communication support needs to be improved. This situation would continue to suffer from the lack of face-to-face interaction, but one can see that the supports need not have to concentrate so much on the synchronical or democratic processes, because they had less impact. Increasing the richness of information (Daft & Lengel, 1986) by increasing backchannel communication is another possible solution. What type of system "fixes" would have given the crew of the USS Vincennes enough information to realize that their team situation assessment had incorporated incorrect information (e.g., the altitude reading of the incoming plane)? "Human factoring" the display panel is only a partial answer. We need to know more about how information is acquired, processed, and distributed among a team of experts, before we can truly begin to develop system "fixes." This is another question to be resolved by research on team decision making and technology.

RESEARCH ISSUES

What are some of the main issues that we need to address in order to build a program of research that will answer some of the questions posed earlier? And what has been already developed to attempt to answer these questions?

Four major research issues influence the direction of our growing understanding of team decision making in a technological context. The first issue involves simply understanding team/group decision making and cognitive issues in a technological context. Most of the dominant research has been associated with analytical models of decision making by individuals. Less attention has been focused on group/team decision making. Very little research

has been conducted on decision making in a technological context. (See Abelson & Levi, 1985, for a review of individual decision-making issues; Davis & Stasson, 1988, and Levine & Moreland, 1990, for group decision-making issues; and Kraemer & King, 1988, for a review of technologically supported group decision-making issues.) It is heavily influenced by generating decision support systems/aids that give better answers to the queries posed. In fact, a neglected area has been the creation of systems that assist in better identification or assessment of the problem or situation (Moreland & Levine, 1992; Raphael, 1991). Real and expert teams often can resolve a problem quite nicely once it is correctly identified. Errors, as well as process loss (Steiner, 1972, 1976), occur when the problem is erroneously defined, assessed, understood or framed, as in the Martin Marietta and Vincennes examples. There is little research on the process of situation assessment and the cycle of strategic versus tactical decision making that impacts that process.

The second issue revolves around the problems raised by normative factors that effect group decision making (group dynamic variables) in technological context. Research in academic and applied settings has resulted in a large conflicting base of information. The preponderance of studies and system development focus on variables that structure group (specifically, groups in a meeting) process (Galegher, 1990; Kiesler, Siegel, & McGuire, 1984). Pinsonneault and Kraemer (1990) and Kraemer and King (1988) specifically highlight our lack of understanding regarding technologically supported groups and group dynamics variables. We simply know very little of the normative influences that occur in technological settings because there is so little research conducted in this area. The only factors that have received wide consistent attention are the "dominant personality" issue and anonymity as a process controller. The overwhelming result is that group systems cause group processes to democratize (Kiesler et al., 1984).

Communication effectiveness provides the third set of research issues. This is a broadly defined field, with the preponderance of information coming from researchers looking at the effects of social presence across machine mediums (Short, Williams, & Christie, 1976), information richness (Daft & Lengel, 1986), and psychological distance (Wellens, this volume, 1989, 1990), among others (McGrath & Hollingshead, 1993). The evidence runs from linguistic (exactly how do we say it; Kiesler et al., 1984) to mechanical (in what medium is the information presented; Chapanis, Ochsman, Parrish, & Weeks, 1972; Galegher, 1990; Wellens, 1989) to personal (the effects of cognitive and decision styles in technological context; Duffy, 1984; Meshkati, 1991). However, as with normative factors, the evidence is piecemeal and conflicting. The trend promoted by software and hardware developers of increasing social presence is seriously questioned by research conducted by Wellens (1989). His research demonstrates the negative effects of providing too much social presence information between team members. One of the most pressing needs is for a

multidisciplinary approach in answering these questions. Researchers in communication, psychology, anthropology, human factors, business, and systems control theory need to begin cooperative efforts.

Finally, the most applied perspective comes from those interested in broader *organizational and environmental (such as cultural) issues* (Huber, 1990). A promising new organizational theory proposed by Huber, Valacich, and Jessup (1993) outlining group support system impact on organizational effectiveness provides specific proposed relationships among organizational variables and organizational effectiveness. The underlying premise is that group support technology, when correctly applied, will improve an organization's effectiveness. It provides a framework specifically tailored to group decision support systems and is a rich source of research ideas. Meshkati (1991) (along the lines of Rochlin et al.'s 1987 assertions and Rasmussen's 1986 theoretical perspective) has made a strong case that error analysis necessarily requires an analysis at the individual interface level, the job/task analysis level, and the organizational (communication network) level. No one level of analysis will provide possible solutions or preventives for system errors such as those described in the Vincennes incident, the Three Mile Island accident, and the Chernobyl nuclear plant accident. This multilevel perspective can help guide system developers in assessing the appropriate level of intervention when designing "error-free" decision support systems.

Environmental issues are those that involve factors outside the immediate organization. For example, the impact of the culture that provides the context for the organization is poorly understood (Jessup & Valacich, 1993); and as described in the Avianca air disaster, a critically important variable. Multicultural factors in a technological context have little clear research evidence to date, but much anecdotal information. I would assume that, with the continuing proliferation of cellular/video phones, facsimile machines, group meeting systems, improvements in videoteleconferencing and digital technology, coupled with an increasingly global economy, this area will only grow as a research focus. The military is experiencing the same trend, as witnessed in Desert Storm. Future battles will be of a combined force nature (with many different countries playing a part) and collaboration needs to be technologically supported on a second-by-second basis. We must become smart about the effects of culture in the technological context because this information may, at one level, help avert the next military conflict and, at another level, help prevent errors that could lead to fratricide.

The three examples of team decision making presented earlier provide an applied context that can highlight some of the more important areas of research that have the highest potential in improving the process and content of team decision making. Understanding team decision making and cognitive processes in a technological context is relevant to all three, specifically because of its vague and encompassing wording. We know very little about

how groups decide, whether it is in a distributed, technologically supported context (with computer support systems), where members are not face-to-face (as in the satellite and Avianca examples) or in the Vincennes example, where team decision making occurred among members who were co-located (in the same physical location) but were operating in an environment of high uncertainty and time pressure.

As discussed earlier, normative (member influence) and communication effectiveness factors appear to be relevant to the satellite and Avianca incidents. Both incidents were clearly affected by the distributed location of the team members, compounded by the lack of common referents. Therefore, developing an understanding of the types of system components that would replace or enhance communication effectiveness (and secondarily normative influences) would have immediate payoff. This was less an issue (albeit, still an important one) for the Vincennes, because team members were co-located, had common referents to the problem, and had experience working as a team.

Organizational and environmental factors were most evident in two of the three examples. It appears to be least apparent in the satellite example, only because I have assumed that the team members were committed to the same organizational view and brought similar backgrounds to the problem. (Granted, this is a big assumption.) However, these factors seem to be the most obvious in the Avianca and Vincennes incidents and provide a strong focus for possible future research. The cultural context of the Avianca disaster seems self-evident; the military context of the Vincennes provides the organizational perspective that helps explain the types of decisions that would be made in high-uncertainty and high-time-pressure situations. These factors cannot be ignored in trying to build system enhancements to obviate these "errors" in the future. Table 13.1 summarizes this discussion of possible future research areas.

SUMMARY

In this chapter, I have attempted to describe some of the problems that can affect team decision making from a process and content perspective, outlined group decision support system characteristics and their ability to enhance the group decision-making process, and suggested four research areas that encompass the type of issues that should be addressed. To reiterate, team errors/biases fall into two perspectives: process and content. Process errors were defined as the use of the wrong process for the nature of the problem facing the team. Content errors were further subcategorized into informational, normative, and structural "types." Group support systems and collaborative work issues were described by outlining their objectives and looking at research that supported those objectives. Research on team or group

13. TEAM DECISION MAKING

TABLE 13.1
Summary Table of Research Issue Priority
for Three Examples of Team Decision Making

	Decision Making Cognitive Issues	Normative	Communication Effectiveness	Organizational Environmental
Satellite	primary	secondary	primary	secondary
Avianca	primary	secondary	primary	primary
Vincennes	primary	unknown	secondary	primary

decision-making problems is still an embryonic field with little empirical research; this is further compounded in the group support technology area.

With regard to the four research issues, several conclusions can be drawn. Overall, there is great practical potential to increasing our understanding of the group decision-making process in the technological context. The academic literature has provided the practitioner with some salient variables that can be studied to discover their impact on group decision making (Jessup & Valacich, 1993). Good applied evidence is accumulating (Galegher, Kraut, & Egidio, 1990; Hackman, 1990; Jessup & Valacich, 1993). However, normative variables appear to suffer from fragmentation in research. Often, group dynamic variables are experimentally studied independently, when the practitioner knows that their effects are interactive, hence the popularity of anecdotal and experiential evidence (Hackman, 1990; Janis, 1989), rather than the experimental evidence. Future research on team decision making must address this discrepancy in what we know (the anecdotes) versus what we can prove (the experimental evidence).

Communication research, by the nature of its topic, has recently begun to have an impact on computer-mediated group decision making. By focusing on what is communicated through the computer medium, researchers are discovering the most salient variables for the improvement of group support technologies (Galegher, Kraut, & Egidio, 1990). The most impressive practical literature has come from these researchers. Finally, organizational and cultural issues are only recently being addressed from a psychological (versus a management) point of view (Connolly, 1993). Interestingly, there has been comparatively little written on the interactive nature of group decision making and organizational structure (see Sundstrom et al., 1990). How can technology within organizations be structurally "placed" to enhance the group process? I am referring to both physical location (Polley & Stone, 1993) and procedural aspects of incorporating this technology. Huber, Valacich, and Jessup (1993) provided a theory that can guide the development of research on this question. Anecdotally, this could be evidenced by the success of "power down" decision making—lowering authority for decision making to the lowest possible organizational level—with the requisite restructuring of decision-

making responsibility, power, and technological supports (Walter Ulmer, personal communication, January 24, 1990).

The ideal solution, of course, is to combine all these perspectives into a single interdisciplinary research program, because the answers within any given experimental paradigm would have the ability to more completely explain each of the other perspectives. The recent growth in the literature on group decision making in a technologically supported context beyond the settings of meetings (Conference on Computer-Supported Cooperative Work [CSCW], 1990) has proven that this important topic is gaining the attention it deserves; and with a little insight and a lot of hard work, the answers that have eluded us will be uncovered.

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