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Team Interactive Decision Exercise for Teams
Incorporating Distributed Expertise (TIDE²):
A Program and Paradigm for Team Research

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Effective Team Performance Under Stress and Normal Conditions

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| 13. ABSTRACT (Maximum 200 words) This report describes a networked software program called TIDE ² and shows how this program can be used in scientific studies in the area of team decision making. The relationship between this program and the existing groups literature, as well as the theoretical framework driving the current research program are described. Although the initial scenario includes hierachically arranged teams operating under stressful conditions, the programs flexibility allows for different scenarios and non-team applications, and the procedures for manipulating these are laid out. TIDE ² also has sub-programs for collecting, sorting and analyzing data, and these are described, along with the systems requirements needed to run the program. | | | |
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Executive Summary

Recent trends in business, medical, aerospace, and military contexts has pushed issues associated with teams and teamwork to the forefront of the social science research agenda. This report describes a networked software program called TIDE² and shows how this program can be used in scientific studies in the area of team decision making. This report lays out the relationship between TIDE² and the existing literature on groups, and then describes the theoretical framework associated with the research program for which TIDE² was developed. The paradigm associated with this computer program and the program of research for which it was developed involves hierarchically arranged decision making teams where expertise is differentially distributed among various team members. At the core of this paradigm is a team-based multiple cue probability learning task with feedforward instruction. The initial scenario for the TIDE², involves naval Command and Control. This scenario is described, along with the procedures that can be used to manipulate this task in order to achieve specific psychological or contextual effects, such as stress, uncertainty, task complexity and group conflict. The report also describes how this initial scenario can be changed from naval Command and Control to virtually any other type of decision making scenario (e.g., investment banking or personnel selection), so long as the underlying paradigm remains the same. It also describes how the program can be manipulated to create "single-person" versions of the task, in order to facilitate team versus individual comparisons. TIDE² not only provides a stimulus material for research participants, it also contains sophisticated sub-programs for collecting, sorting and storing data. These sub-programs are described, along with the procedures one can execute in order to accomplish traditional groups or decision making analyses such as sociograms, communication networks, policy capturing, or process tracing. The final section of this report lays out the hardware and software requirements needed to run TIDE², which are quite minimal concerning the scope, complexity and flexibility of the program.

Table of Contents

| | |
|---|----|
| Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise (TIDE ²): A Program and Paradigm for Team Research | 7 |
| Traditional Studies of Groups and the Need for TIDE ² | 8 |
| Theoretical Background and Conceptual Framework | 11 |
| Initial Scenario, Task and Targets | 15 |
| Information Available and Threat Determination | 15 |
| Mathematical Structure Underlying the Task | 15 |
| Areas of Expertise | 17 |
| Patrol Sessions and the Mechanics of Making Decisions | 18 |
| The Measure Function | 18 |
| The Query Function | 19 |
| The Transmit Function | 19 |
| The Receive Function | 20 |
| The Judgment Function | 21 |
| Decision Outcome and Feedback | 22 |
| Establishing Sets of Targets with TEAMSET. | 24 |
| Creating Target Files: TEAM??.INI | 24 |
| Naming TEAM??.INI Files | 24 |
| Setting Goals | 24 |
| Selecting One Player or Team Versions | 25 |
| Setting the Game Time | 25 |
| Setting the Feedback Time | 25 |
| Setting Target Attributes | 26 |
| Creating targets with Randomized Cues | 26 |
| Creating Targets with Randomized Outcomes | 27 |
| Manually Specifying Cue Values | 27 |
| Manually Specifying Raw Attribute Values | 27 |
| Sample Configurations of Targets | 28 |
| Establishing Context Effects with Targets in TEAMSET | 30 |
| Manipulating Base Rate | 30 |
| Creating Group Conflict | 30 |
| Creating Ambiguity in Targets | 31 |
| Manipulating Stress Through Time Pressure | 31 |
| Manipulating Task Complexity | 32 |
| Manipulating Tempo | 32 |
| Establishing Prototypes | 33 |
| Creating Trends, Cycles and Seasonality | 33 |
| Changing the Task and Scenario | 35 |
| Changing the Task with TEAMSET | 35 |
| The Measures Screen | 35 |
| # Measures | 35 |

| | |
|---|----|
| # Interactions | 35 |
| # Judgments | 36 |
| # Outcomes | 36 |
| # Icons | 36 |
| Message wait time | 36 |
| Cue weights | 37 |
| Attribute Labels | 37 |
| "Hot" letter key | 38 |
| Raw Scale for Cues | 38 |
| Raw Value Ranges | 39 |
| Interaction Weights | 40 |
| NxNxNxNxN (Interaction Components) | 40 |
| The Communications Screen | 41 |
| Name of Judgments | 41 |
| Values for Criterion | 41 |
| Names of Outcomes | 42 |
| Judgment Hot Keys | 42 |
| Feedback Type | 42 |
| Number of Trials Delayed/Summarized | 42 |
| Feedback Access | 42 |
| Who Can Query Whom | 44 |
| Who Can Transmit Raw Values to Whom | 45 |
| Who Can Send Text Messages to Whom | 45 |
| Writing to Personal Logs | 45 |
| The Icon Screen | 46 |
| Establishing Context Effects with Task Changes | 47 |
| Task Complexity | 47 |
| Required Interdependence | 48 |
| Base Rate for Ambiguous Targets | 48 |
| Required Precision | 48 |
| Group Size | 48 |
| Communication Networks | 49 |
| Speed of Communications | 49 |
| Feedback Variations | 49 |
| Goal and Projection Variations | 50 |
| Changing the Scenario with TEAMSET | 50 |
| Non-Research Uses of TIDE ² with TEAMSET | 51 |
| De-Grouping TIDE ² | 51 |
| One Player - One Role | 51 |
| One Player - Multiple Roles | 52 |
| Output from TIDE ² | 53 |
| Overview of Output Files | 53 |
| Choosing an Output File From TEAMSTAT | 53 |
| xxxyyzzz.SUM: Objective Measures of Group Outcomes and Processes | 54 |
| xxxyyzzz.MSG: Flow and Content of Text Messages | 57 |
| xxxyyzzz.SPS: Data Analysis Output File | 60 |
| Types of Analyses Available From xxxyyzzz.SPS | 61 |
| Judgment Accuracy | 61 |
| Policy Capturing of Raw Data | 62 |

Process Tracing of Information Search 62
 Sociograms of Communication Flows 62
 System Requirements for TIDE² 63
 Hardware 63
 Software 63
 Access to Software 65
 References 67
 Exhibits 69



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Team Interactive Decision Exercise for Teams Incorporating
Distributed Expertise (TIDE²): A Program
and Paradigm for Team Research

Although there is a long standing interest in group dynamics, recent trends in business, medical, aerospace, and military contexts have pushed group oriented issues to the forefront of the social science research agenda. In particular, the emergence of work teams that bring together people with differential areas of expertise who must make decisions under conditions of uncertainty and time pressure are of increasing interest in for many different kinds of social organizations.

For example, manufacturers traditionally separated the functions of market research, product design, production and sales, and then had these differentiated groups performing sequentially. This kind of practice is less suitable to meet today's competition. In order to speed the product development cycle, many manufacturers now bring experts in these four divergent areas together and have them work together in teams. In the medical community, the complexity of modern medicine has created a large number of medical specialists who often have to work together in teams to manage the health care of a single patient. In the aerospace industry, the functioning of aircrews under conditions of stress has also emerged as a critical problem. In several cases, large scale human tragedies like the Tenifere accident have been traced to communication breakdowns among pilots, co-pilots, navigators, air controllers and ground controllers (Foushee, 1987).

Finally, in the military context, events like those of the U.S.S. Stark and U.S.S. Vincennes have highlighted the importance of group process issues and the difficulty of addressing these through policy changes alone. In the U.S.S. Stark incident, air patrol teams that included the frigate itself, AWACs reconnaissance planes and land based radar units allowed an approaching Iraqi jet to position itself and then launch an attack that led to the death of 37 servicemen. Policy changes in the wake of this incident loosened the "rules of engagement" for American vessels operating in the gulf. These measures then backfired thirteen months later when air patrol teams working on and around the Aegis Cruiser U.S.S. Vincennes mistakenly shot down an Iranian Airbus killing over 150 innocent civilians. Thus, the need for research addressing issues associated with teams of experts making decisions under time pressure in uncertain situations has never been greater.

Traditional Studies of Groups and the Need for TIDE²

Groups have been defined as configurations of more than two interdependent individuals who interact over time (McGrath, 1984). Teams are special cases of groups where, in addition to meeting all the definitional rules of groups, teams are also performing some task where success or failure has important consequences for all team members (Ilgen, Major, Hollenbeck, and Segoe, 1991a). Ilgen, et al. have argued that the existing group literature is limited in its ability to answer questions about the kinds of teams that we have just described. Little existing research focuses on decision making accuracy. Much of it fails to pay sufficient attention to issues of external validity along the dimensions which are critical to ongoing teams.

In many cases, this latter step is not at issue because the groups being studied are not pursuing any specific, objectively verifiable goal, where there are clear right and wrong decisions. Moreover, many real-world work teams, unlike their laboratory counterparts, are comprised of members with heterogeneous skills and differentiated expertise. Research that focuses on individuals with homogeneous skills and expertise cannot deal with the source from which many of the problems confronting current work teams emerge.

Finally, one last feature of current work teams that is not well addressed by the current groups literature is the distributed nature of team members. Most group research deals with face-to-face interactions. Members of many current work teams, however, are often physically separated and communicate through technologically mediated methods (fax, electronic mail, conference calls, etc.) which greatly complicates and changes the nature of team processes. The degree to which research on face-to-face interactions that are rich in information redundancy, verbal and non-verbal feedback will generalize to more confined technological media is an open question.

In this report we describe a simulation called TIDE². TIDE² is a series of computer programs that constitute a vehicle for conducting team research. TIDE² stands for Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise. It was developed to provide a paradigm for studying team decision making in the kinds of contexts that confront many existing and developing work teams. These contexts can be characterized as complex, uncertain, ambiguous, and fast tempo. In addition, confronting problems in these contexts requires differentiated expertise embodied in persons who are often geographically distributed and working under tight time pressures where decision quality is important.

Despite being targeted for these kinds of contexts, however, TIDE²

is a flexible system that is adaptable to many different kinds of decision making contexts -- including non-group research where the focus is on a single decision-maker. As a set, the programs (a) provide a standardized decision making stimulus for people who communicate with each other over dedicated lines, (b) support programs for manipulating cues associated with decision alternatives, (c) support programs for radically changing the decision making context confronting participants, (d) support programs for sorting, summarizing, and analyzing quantitative data generated by teams working on the task, and (e) support programs for aiding the content analysis of qualitative data generated by teams working on the task.

The purpose of this report is to familiarize the reader with TIDE². The report is laid out in eight sections. This section discusses the rationale for the development of TIDE². The next section presents an overview of the theoretical background for the research program for which TIDE² was specifically developed. Although researchers interested in these kinds of constructs and relationships will find TIDE² particularly useful, the flexible nature of the program makes it suitable for many programs of research that are only tangentially interested in the constructs discussed here.

The third section describes the initial version of TIDE² that accompanies this document and describes the naval Command and Control (C²) scenario. This section describes the task from the participants' point of view as well as the experimenter's point of view. As such, it describes how to manipulate and measure a number of constructs commonly of interest to decision making researchers or researchers working with teams.

The fourth section of this report discusses how to radically change the scenario or frame placed around the paradigm in order to create a context more suitable for other types of research. For example, one can move from a naval command and control scenario to an investment banking scenario, or a scenario involving a personnel selection decision, or a scenario involving the prediction of real world events (e.g., horse races, stock prices, jury decisions, etc). This section also explores non-research uses of TIDE² such as team and individual assessment, training and development. The fifth section discusses two ways of transforming TIDE² into an individual exercise.

Section six discusses the output that is generated when participants work on TIDE². This section details the quantitative and qualitative data that are automatically recorded. It also documents how files are generated that summarize, sort and prepare these data for analysis with SPSS, SAS or other data analytic software.

Section seven shows how to analyze the data collected and arrayed by TIDE² to conduct common types of team or decision making analyses. These include (a) policy capturing of individual judgments from raw data, (b) policy capturing team decisions from raw data or summary judgments of individual team members, (c) process tracing the timing and sequence of information search, (d) priming and recency analyses focusing on the effects of timing and sequence on decisions, and (e) sociometric analyses focusing on who communicates with whom, when, how and about what. Finally, the section, presents hardware and software requirements associated with using TIDE².

Theoretical Background and Conceptual Framework

The theory and conceptual framework that underlie the program of research for which TIDE² was developed have been described in detail by Ilgen, Major, Hollenbeck, and Seago (1991b). Exhibits 1a through 1c will be used to briefly explain the theory and conceptual framework.

Exhibit 1a illustrates a hierarchical decision making team with four members. Such teams have three primary characteristics. The first of these is that of hierarchy; team members are not all of equal status. In the illustration, member D is of higher status with the other three members reporting to him or her. As drawn, the other three members do not differ in formal status. The second feature is that the primary task of the team is to make decisions. In the case illustrated, each of the subordinate members reaches a decision or judgment (d_A-d_C), and the subordinate's recommendation is passed to the leader who also makes a decision (d_D). Typically, and as is the case in Exhibit 1a, the leader's decision represents the decision of the team.

Insert Exhibit 1a

Exhibit 1b builds upon the hierarchy of Exhibit 1a by introducing distributed expertise. According to the model of Ilgen, et al. (1991b), the distribution of expertise in a team is represented by the allocation of critical information regarding the decision to individuals in the team. The pattern of distribution represents the expertise system. On the far left of Exhibit 1b is a column of Xs representing dimensions of information. If, for example, the team were responsible for purchasing a new robot for a manufacturing unit, the Xs would represent such characteristics as price, system reliability, vender service capability, and capacity. Each X is a vector of elements where the elements represent specific values on the dimension for each of the decisions.

Insert Exhibit 1b

Using the robot purchase as an example and assuming that price is represented by X_1 , the price of a particular robot would be the entry on the vector for that robot. Expertise is represented in the exhibit by the association of information with individuals. Individuals' areas of expertise are construed to be described by the pieces of information to which each person has access. In Exhibit 1b, Person A is an expert in the knowledge domain represented by X_1 and X_2 , Person B by X_2 , X_3 , and X_4 , Person C by X_5 and X_6 , and the leader by X_1 and X_6 . Note that it is not necessary

for information to be the unique property of one person. In the exhibit, information on Dimension 2 is available to both Persons A and B, and the leader has direct knowledge about both 1 and 6 even though those dimensions are known by Persons A and C, respectively. Thus, although the distribution of expertise is represented by the way in which information is allocated to every member of the group, it is not necessary that all of the information be available to only one of the team members. On the other hand, it is also not acceptable to have all members of the team have direct access to all of the relevant information if the expertise in the group is to be distributed. In other words, when everyone knows all information without getting some of it from other team members, the level and nature of expertise in that group is not considered to be distributed within the group as a matter of definition.

Exhibit 1b introduces one other important feature of teams -- a communication structure. By definition, communication structures exist among persons. The one illustrated in the exhibit shows Person A being able to communicate directly only with the leader, Person D. Persons B and C can communicate directly with the leader and with each other. Finally, the leader communicates directly with each of the subordinates A, B, and C. In this team, it is still possible for all persons on the team to communicate with all others, but, for Person A, the communication with Persons B and C is indirect. That is, A must go through D to get messages to and from the other two subordinates. The same is true for B and C.

The combination of the communication system with the expertise system provides the structure within a team for potential access to information by each team member. Take, for example, Person B in Exhibit 1b. This person may access information on X_2 , X_3 and X_4 directly. The person is one step removed from information on X_5 and X_6 ; he or she can ask Person C for that information, assuming that Person C honors Person B's request, and, for X_6 , the same could be done through the leader. Finally, Person B can access information on X_1 indirectly by going through two persons, first the leader who could then go through Person A to get the information and relay it back to B. A similar two step indirect path exists from B through the leader and Person C to information on X_5 . In most cases, however, it would appear to be more efficient to get that information by going directly to Person C.

With Exhibit 1b, we have incorporated distributed expertise into a team hierarchy in such a way as to provide a structure for describing how information becomes available to team members for making decisions. The availability of information relevant to a team decision represents a necessary but not sufficient condition for reaching a decision. The remainder of the process involves the decision itself. In particular, the concern is with how the information is used by the team to reach a decision and with the quality of the decision. In order to evaluate the latter, decision

making research typically has used decisions for which the quality of decisions can be evaluated against criteria established a priori.

The model of Ilgen et al (1991b) is an adaptation of the Brunswick Lens model frequently used to model decisions of individuals (see Stevenson, Busmeyer and Naylor (1991) for an excellent description of the model and its use for individual decisions.). At the individual level, a problem is defined in terms of a finite set of dimensions of information for which the decision to be reached can be described as a function of the cues, and the function can be established a priori. In this way, the functional relationship of the cues to the decision becomes the standard to which the actual decision made by the decision maker can be compared.

Exhibit 1c introduces the decision process to the combination of the hierarchy of Exhibit 1a and the expertise and communication systems of Exhibit 1b. As was the case in the first two exhibits, six dimensions of information are used to reach a decision ($X_1 - X_6$). Working left from the X_i s, the a priori or "correct" decision is represented by Y_d . The lines between the dimensions of information and the decision represent the extent to which each one of the dimensions is related (contributes) to the decision. In the individual decision making literature using the Brunswick Lens model, a linear regression model is used to relate dimensions to decisions. Regression weights are chosen a priori, and then sets of cues and decisions are generated to match the chosen model. The team construal of the decision model represented in Exhibit 1c is exactly analogous to this. Here, a set of cue values are generated along with a set of decisions in order to fit an a priori model, and the model generated from the sample of cues presented to the group is represented in the left hand portion of Exhibit 1c. The Y_d is the "correct" decision to which the team's decision can be compared.

Insert Exhibit 1c

The right hand portion of Exhibit 1c represents decisions made in the team. As illustrated, there are two sets of decisions. The first of these includes the decisions made by Persons A, B and C, symbolized by Y_{dA} , Y_{dB} and Y_{dC} . The exhibit illustrates the case where all six sets of information are used by each team member to make a decision. Each team member's decision can be represented or captured by regressing the individual's decisions on the cues presented to him or her. The second decision is that of the leader. This decision has the potential for being a little more involved than the subordinate decisions in a group structured in the hierarchical fashion illustrated. One way for the leader to make a decision is exactly the same as that of the subordinates.

That is to say, the leader can base his or her decision upon a linear combination of the six cues. However, unlike the subordinates, in the configuration illustrated in Exhibit 1c the leader has access to the decisions of each of the subordinates. Thus, the subordinate decisions are analogous to cue dimensions for a decision by the leader based on three cues. Therefore, the leader's decision can be modeled as a function of the three subordinates' decisions by regressing onto the leader's decision, the subordinates' decisions. Within this framework, one way to evaluate the accuracy of either the leader's/team's decision and/or those of the team members is to compare them to the decisions judged a priori to be most appropriate, specifically, to compare Y_{dA} , Y_{dB} , Y_{dC} , or Y_{dD} to Y_d .

The three exhibits just described complete the conceptual framework to be used here regarding decision making in hierarchical teams with distributed expertise. Onto this framework can be mapped a large number of team and individual constructs that are likely to play a major role in team decision making. At the individual level, for example, it can be argued that team members' abilities will affect the decisions of both the persons and the team. At the team level constructs such as conflict, coordination, cooperation and climate have been shown to be important. The research on teams from the perspective developed here will incorporate these and other individual and team constructs to study team decision making when the decision making task is modeled by the structures introduced in Exhibits 1a, 1b, and 1c.

Initial Scenario, Task and Targets

The initial scenario associated with TIDE² is that of a four-person naval Command and Control team assigned the task of monitoring the airspace in the vicinity of an aircraft carrier battle group. Exhibit 2 shows a one page description of the scenario provided to participants that introduces them to the team's mission. Exhibit 3 shows an overview description of the roles assigned to the four players as well as the types of judgments they need to make.

Insert Exhibits 2 and 3 here

Information Available and Threat Determination

The team can measure each incoming target on nine attributes. The names and descriptions of all the attributes are shown in Exhibit 4. This exhibit also shows the scale associated with each characteristic as well as its possible range. The degree of threat represented by the target can be ascertained by knowing (a) the target's standing on these nine attributes and (b) the five rules that describe how target characteristics combine to determine the level of threat. The five rules associated with the initial scenario are shown in Exhibit 5. The last four rules are called "combination rules" because the degree of threat associated with knowledge of one attribute can only truly be ascertained if one also has knowledge of the attribute with which it combines.

Insert Exhibit 4 and 5 here

Mathematical Structure Underlying the Task

At the core of this simulation is a mathematic linear combination of the form shown below in Equation 1, where W is a cue weight and B is a cue value.

$$[1] \text{ True Score} = W_1 B_1 + W_2 B_2 + W_3 B_3 + W_4 B_4 + W_5 B_5$$

The resulting value attained by assigning weights and inserting cue values into this linear combination determines the "true score" for each target. Each "rule" that was described to participants in the instructions coincides with one term in the equation that gives the true score for each target.

The linear combination associated with the initial version of TIDE² therefore has five components, four of which are combinations of

multiple cues to match the four combination rules. The exact linear combination used in the initial version of TIDE² is shown in Equation 2 below, where the parenthetic value is the cue weight, and the # indicates the number of the attribute described previously in Exhibit 4 (i.e., #1 is speed, #2 is altitude, #9 is range, etc.)

$$[2] \text{ TS} = (2)(\#5) + (1)(\#1)(\#6) + (1)(\#2)(\#7) + (1)(\#3)(\#8) + (1)(\#4)(\#9)$$

The cues can take on values of 0 (i.e., non threatening), 1 (i.e., somewhat threatening) or 2 (i.e., very threatening). So for example, the first rule deals with the attribute IFF (i.e., #5). This attribute, from Equation 2 has a weight of 2. Thus, if the cue value takes on a value of zero, this component of the overall linear combination becomes zero. If the cue takes on a value of one, this component of the linear combination takes on a value of two. If this cue takes on a value of two, this component of the linear combination takes on a value of four.

As an additional example, the second rule is a combination rule involving Speed and Direction (i.e., Cues #1 and #6) where the combination of these two cues is weighted 1. Thus, if both cues take on a value of two, then this component of the linear combination takes on a value of four. If they both took on a value of one, this component of the overall linear combination is one. If either one of the cues took on a value of zero, this component of the linear combination would become zero, regardless of the value associated with the other cue (i.e., since one of the components becomes zero, the product of all three components becomes zero).

Exhibit 6 shows how raw data on each of the nine cues translates into "non-threatening," "somewhat threatening" and "very threatening" cue values.

Insert Exhibit 6 here

Thus, in the initial version of TIDE², the true score for each target ranges from 0 (i.e., a completely non-threatening target where all cue values equal 0) to 20 (i.e., a very threatening target where all cue values equal 2). Verbally, a very threatening target would appear similar to the target described in the first paragraph in the section "How Rules Combine..." back in Exhibit 5. Verbally, a completely non-threatening target would appear similar to the target described in the second paragraph of that section.

Intermediate values between 0 and 20 call for decisions that are more aggressive than IGNORE and less aggressive than DEFEND. Exhibit 6 shows how true scores on targets are translated into the

"Correct Decisions" that serve as the criterion against which team decisions are evaluated. The target described in the third paragraph of the section on "How Rules Combine" in Exhibit 5 has a true score of 10. This score comes about as shown in Equation 3 below.

$$[3] \text{ TS} = (2)(2) + (1)(0)(0) + (1)(2)(2) + (1)(0)(0) + (1)(1)(2)$$

$$10 = 4 + 0 + 4 + 0 + 2$$

For researchers familiar with Multiple Cue Probability Learning (MCPL) tasks, the core of this simulation can be construed as an MCPL task with feedforward (Hammond and Summers, 1972). Feedforward simply refers to the fact that participants perform the task after being instructed in the weights assigned to cues.

Areas of Expertise

One feature of TIDE² that makes it unique relative to other MCPL tasks is that the task is performed in a team context where individual members have different areas of expertise. In the naval Command and Control scenario, the participant playing the role of the Commanding Officer (CO) of the Carrier is the team leader and the person who ultimately decides what stance should be taken toward each target. Each of the other team members makes recommendations to the leader.

Each team member has expertise that is unique to his or her role. That expertise comes in three forms, (a) the ability to measure attributes of the target, (b) the ability to translate raw data on target attributes into judgments regarding how threatening the target is on that attribute and (c) the knowledge of rules.

For example, although all team members know that military aircraft are more threatening than non-military aircraft, only two people in the team can actually measure IFF (i.e., Attribute #5). These two team members are the only ones trained in how to translate raw data on IFF (i.e., 0.0 to 1.6 Mhz) into judgments about threat (i.e., non-threatening, somewhat threatening or very threatening).

Also, each team member has to memorize one of the four combination rules (e.g., one member must memorize how speed and direction go together). Thus, at least one member of every team will be an expert on one of the combination rules.

Like all the other team members, the CO of the Carrier memorizes one combination rule. Relative to his or her teammates, however, the Carrier can only measure a relatively small number of target attributes. The distinctive competency of the Carrier is that this

person is an expert in terms of knowing the expertise of all the other team members.

Exhibit 7 shows the specific role instructions provided to the Carrier position. Exhibits 8, 9 and 10 show the corresponding specific instructions given to participants occupying the Coastal Air Defense (CAD), AWACs, and Cruiser positions.

Insert Exhibits 7, 8, 9 and 10 here

Patrol Sessions and the Mechanics of Making Decisions

Patrol sessions refer to the time that teams are responsible for monitoring air traffic in their designated area. While teams are monitoring traffic, they are stationed at a computer monitor that displays the screen shown in Exhibit 11. This screen, referred to as the "sea screen," has four icons on it, to remind team members that there are four members of the team; the Carrier (i.e., the team leader), the AWACS (i.e., plane), the Coastal Air Defense unit (i.e., the land mass) and the Aegis Cruiser (i.e., the ship). A red asterisk in the middle of the screen indicates the presence of a target in the teams airspace. A countdown clock on the screen tells how long before the team must render a decision. The target will begin to beep when there is 30 seconds remaining. The frequency of the beeping will increase as time winds down. This gives a clear impression that the time available for making a decision is running out. In order to give the carrier time to review the judgments of the other team members, the outlying stations should begin rendering their judgments at this time. If the Carrier position (i.e., the leader) fails to register the team's decision with respect to the target in the prescribed time, this is treated as if the team decided to IGNORE the target. This could result in a positive outcome if the team should have ignored the target, but could lead to a disaster if the target called for a more aggressive response.

Inset Exhibit 11 here

The bar at the top of the screen indicates what the team can do while on patrol. There are basically five things that teams can do when trying to decide what to do with a target.

The Measure Function. If a team member hits the ALT key, the menu will highlight Measure. This option allows each participant to take measurements of the target on attributes that he or she can measure. The option is chosen by hitting RETURN (or hitting the down arrow key) when Measure is highlighted. If they choose this

option, they will get a menu listing the attributes they can measure. They then use the arrow keys to move to the attribute they wish to measure. When the appropriate attribute is highlighted, they hit RETURN. They can also measure the desired attribute by simply typing the letter indicated in red on the menu (we will refer to these throughout as "hot keys"). For example, if they just type "s", they will learn the "Speed" of the target. The value of the target on the attribute selected will appear at the bottom left portion of the screen. Hitting RETURN again will remove this information from the screen. If participants do not hit return, this information will go away on its own after 5 seconds.

The **Measure** menu also has two entries called "Summary" and "Log." If they highlight "Summary" and then hit RETURN, a summary of everything they know about this specific target will appear on the screen (this includes what was measured and what has been received from others via transmissions). Participants can also get this summary by just hitting the F2 function key. If they highlight "Log" and then hit return, they will get a summary of all text messages that have ever been sent to them and recorded into their "Log." The purpose of the "Log" will become clearer after we discuss the "Receive" option.

The Query Function. If the participant hits the ALT key and then hits "Q," **Query** will be highlighted. **Query** allows team members to ask other players for information on the target. If the participant hits RETURN (or presses the down arrow key) while **Query** is highlighted, another menu will be called up that presents all nine attributes. Participants can use the arrow keys to move up or down to the attribute on which they would like information and then hit RETURN (here too participants could also simply use the hot keys). This will lead to another menu at the bottom right portion of the screen that asks from whom the participant wants to get this information. Again, participants can use the arrow keys to highlight who they want to ask. The highlighted position will have white brackets surrounding the name. When the right person is highlighted, they hit RETURN. Another box will appear telling them that the query was sent. If they hit RETURN again, this message will disappear.

The Transmit Function. If participants press the ALT key and then hit "T," **Transmit** will be highlighted. **Transmit** allows a team member to send information to other team members. If RETURN (or the down arrow key) is hit while **Transmit** is highlighted, another menu will be called up that asks them what they want to send. Team members can send two kinds of information. First, they can send data on any attribute that they have measured. To do this, they can simply use the arrow keys to move up or down to the attribute they want to send, and then hit RETURN (again they could also simply use the hot keys). This will lead to another menu at the

bottom right portion of the screen that asks them where they want to send this information. Using the arrow keys, they highlight to whom they want to send the information as indicated by white brackets surrounding the position name. When the correct position is highlighted, they hit RETURN. Another box then appears telling them that the transmission was sent. If they hit RETURN again, this message will disappear.

It is important to stress that in order to Transmit data on an attribute, the participants must have measured the attribute first.

The Transmit menu includes a selection called "Text." Choosing this option allows the participant to send a text message to another player or to themselves. If they hit RETURN when the "Text" box is highlighted, they will get another menu asking them where they want to send this text message. They can use the arrow keys to highlight where they want to send the message and then hit RETURN. They will then be presented with a long thin rectangular box, into which they can type their message. Messages can only be 60 characters long. After participants have typed their message, they should hit return, which ends and sends the text transmission. An indicator will appear telling them that the transmission was sent. Hitting RETURN again removes this message.

Participants can also send text messages to themselves using these same procedures. This creates a running log of personal notes that can be reviewed at any time during the experimental sessions. Messages send to oneself are automatically received and saved.

The Receive Function. If participants press the ALT key and then hit "R" the menu will highlight Receive. This option allows the receipt of messages from other team members. Three kinds of messages can be received. First, other team members may have a question about data associated with the target. As we have seen already, this is called a "Query." Second the team members may wish to tell the participant something. Team members can tell each other things in two ways. First, they may want to give each other raw data on the target, which we saw earlier was called a "Transmission." Second, they may wish to send a text message, which we referred to as a "Message."

Participants are made aware of the fact that they have something to Receive from others by indicators that appear at the bottom left portion of the screen. If they see a "Qry" this means someone is asking for information. If they see a "Trn" it means someone is sending them a transmission. If they see a "Msg" someone is sending them a text message. Hitting Receive when none of these indicators are off accomplishes nothing, since when they are all off, there is nothing to receive.

When there is something to receive, hitting Receive will call up

another menu that will show what there is to receive and from whom it came. Participants can use the up and down arrow keys to highlight what message they would like to Receive. When the desired communication is highlighted, they just hit RETURN and the query, transmission or message highlighted will appear in a box at the bottom left side of the screen.

If participants choose to receive a transmission, that data will automatically be included in the summary box. If they choose to receive a message, another menu will come up asking you whether they want to "Log" this message. If they "Log" the message, the message will be written into their "Log File" and will always be available to them to read by choosing the "Log" option on the "Measure" menu. If they do not want a permanent record of this message, they can use the arrow key to highlight "Don't Log," hit RETURN and the message will disappear. If participants make no response to this message, the computer will automatically not Log the message after ten seconds.

There are no hot keys available within the receive function.

The Judgment Function. If the participant presses the ALT key and then hits "J," Judgment will be highlighted. If the participant then hits RETURN (or the down arrow key) a menu will come up that gives the seven possible responses to make toward the target (i.e., Ignore, Review, Monitor, Warn, Ready, Lock-On, or Defend). For all but the CO of the Carrier, this option allows them to tell the team leader (i.e., the Carrier) what they think the team should do regarding this target. If a participant wants to send a judgment, he or she can use the arrow keys or the hot keys to highlight the decision he or she thinks is right and then hits RETURN. A message will appear in the bottom right portion of the screen asking the participant if he or she is sure that this is the recommendation they want to make. If they are sure, they hit RETURN. The leader will immediately receive this information. In fact, the icon representing the team member sending the recommendation will turn red on the leader's screen and the recommendation will be typed in the icon). Team members can only send one recommendation, so they should wait until they are sure before they make a judgment.

When the leader (i.e., the Carrier) sends his or her judgment this is the team's official decision, and this ends the trial. The team leader can make a decision even if all the other members have not registered their recommendations, and the leader is free to use or disregard these recommendations as he or she sees fit. If the leader fails to render a decision before time runs out, the team's decision is treated as an IGNORE.

Decision Outcome and Feedback

When the trial is over, all team members will receive an immediate report telling them how well the team performed. This will appear on the "feedback screen," that will come up right after the trial. The Feedback Screen is shown in Exhibit 12.

Insert Exhibit 12 here

The feedback screen informs team members of their decision, as well as the "correct decision." There are five possible outcomes from an encounter, and the team's total effectiveness will be expressed in terms of points associated with each outcome. The five possible outcomes are:

HIT - A hit means that the groups decision was exactly correct, so for example, the target should have been "warned" and that was exactly what the team decided. A hit is worth 2 points to the team's overall score. The color bars at the top and bottom of the screen will be green when this occurs.

NEAR MISS -- A near miss means that the team was off by one place in terms of their aggressiveness level. For example, if the team decision was "warn," when it should have been "monitor," this would be a near miss (a little too aggressive). It would also be a near miss if the team decision was "warn" when they should have been "ready" (a little too passive). Participants are told that a near miss is a pretty good outcome. A near miss is worth 1 point. The color bars at the top and bottom of the screen will be aquamarine when this occurs.

MISS -- A miss means that the team decision was off by two places. This is worth 0 points. The color bars will be purple when this occurs.

INCIDENT -- An incident means that the team was off by three places in their response to the target. An incident means that the team just narrowly avoided disaster (e.g., being hit itself or mistakenly shooting down a friendly target). This outcome results in a loss of 1 point. The color bars will be red when this occurs.

DISASTER -- A disaster means that the team decision was off by four places. This outcome results in a loss of 2 points. The color bars will be black in this case.

The feedback screen provides information on the judgments rendered by the other team members, as well as information on the team's performance history. The teams goal is also displayed here, where

the goal is expressed in terms of total points to accumulate over the entire session. The screen also provides a projection of what the team's total score will be at the end of a session, if they continue to perform at their current level of proficiency.

This concludes our description of the task as it looks from the perspective of the participants. The next two sections will focus on the task from the point of view of the experimenter. The first section will focus on how to construct the targets.

Establishing Sets of Targets with TEAMSET.

TEAMSET.EXE is a support program in TIDE². One function of TEAMSET.EXE allows the experimenter to create targets. The targets created are stored in a file called TEAM??.INI, where the ?? refer to the number of the session being created or edited. TIDE² looks for a TEAM??.INI file every time it is initiated, and this is the means by which experimenters can control the sets of targets that are seen by participants.

Creating Target Files: TEAM??.INI

To create a TEAM??.INI file, one needs to be in the TIDE² directory and then type TEAMSET, and hit RETURN. If this is done, the experimenter is presented with a prompt. This prompt will ask for the "Parameter File" desired. If the experimenter wants to use the default version of the simulation, then type in "TDWGT1" and hit RETURN. "TDWGT1 is the default Parameter File which can be changed if desired. We will discuss why and how one might change Parameter Files in a later section of this report.

After one has entered "TDWGT1", a new screen will appear presenting the information displayed in Exhibit 13. To create targets select "number of session to maintain" and hit RETURN. If this is done, the screen will then appear as shown in Exhibit 14. There are several features of this screen that need to be described.

Insert Exhibit 13 and 14 here

Naming TEAM??.INI Files. At the top left portion of the screen you see "Games set title." This allows the experimenter to place a verbal label on that INI file (e.g., "Experiment I," "All Ambiguous Targets," "June 12, 1992," etc.). This is optional and the program will function if this is left blank. To change or create a label type "41" and hit RETURN. Then, at the prompt enter the name you wish and hit RETURN. The name entered will then appear in the top left corner of the screen.

Setting Goals. At the top right hand portion of the screen, you see "Goal." This option can be used to set a quantitative goal for each team member's performance. For example, if there are to be 20 targets, a goal of 20 (given the scoring system described in the previous section), implies that the individual or team needs, on average, a near miss every trial. Since the carrier's decision is synonymous with the team's decision, the goal for the carrier, is in fact, the team's goal. A goal of 30 would be more difficult and imply that participants need to be getting near misses half the time and hits all the rest of the time. The goal is optional and

the program will function if it is set to 0 or left blank. If the experimenter wants to set a goal, he or she should type "42" and then hit RETURN. Then, at the prompt, type in the goal desired for each player and hit RETURN. When entering the goal for each player you should keep two things in mind. First, there are only two spaces allowed for the goal for each player (thus you cannot assign a goal of 120). Second, the goals need to be entered without spaces between the values. So for example, if we wanted the Team's goal (i.e., the Carrier's goal) to be 30, while the other team members' goals to be 27, at the prompt we would enter "30272727." This goal will appear in the upper right hand corner of the screen (see Exhibit 14). It will also appear on the participant's feedback screen every time that screen comes up, next to the word "Goal."

Selecting One Player or Team Versions. Also in the upper right hand corner is the word "Single." If the researcher is dealing with individual decision making, then he or she should type in "43" hit RETURN, and then enter "Y" and hit RETURN. This will invoke the default "Single Player" version of the simulation. We will have more to say about the "Single Player" version of TIDE² in a later section of this report. If the researcher is dealing with teams or groups, he or she should type "43," hit RETURN, and then enter "N," and hit RETURN again. This will invoke the default "Team" version of the simulation. For purposes of description here, we will assume that the researcher is conducting studies on teams.

Setting the Game Time. Straight below the "Single" option is the "Game Time" function. This allows the experimenter to manipulate the time teams will have to respond to the target being created. To set the time, type "11" and hit return. At this point, the experimenter simply types in the number of seconds that participants will have to make a decision about the target being created. For example, 120 seconds is a relatively short time. On the other hand, 360 seconds gives participants a long time to make decisions in this simulation.

Setting the Feedback Time. Immediately below the "Game Time" function is the "Feedback" function. This controls how long the feedback screen will be visible between trials. Participants in TIDE² sessions are always in one of two states -- engaged with targets or receiving feedback. Thus, manipulating feedback time is a way of controlling the tempo of the simulation. Very short durations of feedback mean that targets are coming one right after another. Long periods of feedback break up targets and give participants time to rest, communicate with each other through text messages, or peruse their log file.

Setting Target Attributes

All the remaining parts of the screen deal with the actual construction of targets. There are many different ways to create targets depending upon the need of the particular study being conducted. We will describe four different ways. Before we do this, however, we need to make the important distinction between "Raw Values" and "Cue Values."

"Raw Values are in the scale of the attribute and vary in range for each attribute. That is, in raw values, Speed ranges from 200 to 800 and is described in a scale of miles per hour (mph). Altitude, in raw values ranges from 5,000 to 30,000, and is described in a scale of feet. "Cue Values," on the other hand, refer to translations of raw values into their respective degrees of threat. "Cue Values" all have the same range and scale, taking on values of 0, 1 or 2 (for non-threatening, somewhat threatening, and very threatening respectively). In some instances, the experimenter may wish to create targets by entering "Raw Values," and in other cases, the experimenter may wish to create targets using "Cue Values." With this distinction in place, we will now describe the four means of creating targets.

Creating targets with Randomized Cues. First, there may be conditions when the experimenter wishes to create targets where the cues values associated with these targets are orthogonal (i.e., the nine target dimensions are all unrelated). To do this, at the "Your Choice" prompt, type "10R" and hit RETURN two times. The program will generate values itself, drawing from a random population of values for each of the nine cues. Over a large number of targets, this process will generate a context where the cues are orthogonal.

There is one important point to note about creating targets made up of orthogonal cues; the resulting targets will not be randomly or rectangularly distributed, but rather skewed toward higher values. In other words, employing this method in creating targets will lead to a large number of "safe targets" (i.e., Ignore, Review and Monitor) and very few "threatening targets" (i.e., Ready, Lock-on or Defend). This occurs because of the interactive nature of the cues associated with the initial version of the simulation. If any cues that are components of combination rules take on a value of 0, the value attributable to that combination goes to 0, regardless of the value for the other cue. For example, if speed is low (e.g. raw value of 290 mph and cue value of 0), the target is non-threatening according to the "Speed-Direction" combination rule regardless of the value for direction (i.e., even if the target is coming straight in at 0 degrees -- a cue value of 2 -- the Speed-Direction interaction is 0).

Creating Targets with Randomized Outcomes. Since random cues do not generate random outcomes, there is also an option available to create targets that are randomly distributed in terms of "True Score." To do this, at the "Your Choice" prompt type "10" and then hit RETURN twice. This creates a set of targets whose true scores are randomly distributed.

It should be stressed here, that if the targets are randomly distributed, the cues associated with these targets will not be orthogonal. Experimenters need to carefully think through whether they want independent cues or independent outcomes.

Manually Specifying Cue Values. In other cases, experimenters may be interested in neither randomly generated cues or randomly generated targets, and instead may wish to create specific targets. Thus a third way to create targets is to directly enter cue values. To do this, at the prompt "Your Choice," type "10" and RETURN once. Then just enter the nine cue values (either 0, 1 or 2) that you want for this target, where the first number represents the first cue (i.e., Speed), and the second number represents the second cue (i.e., Altitude) and so on.

Thus, entering "222222222" will create a target that is very threatening, and participants should choose "Defend." Entering "000000000" will create a target that is very non-threatening, and participants should choose "Ignore." Entering "111111111" will generate an intermediate target that participants should "Monitor." By playing with different patterns of cue values, the experimenter can create any kind of target he or she wishes.

Manually Specifying Raw Attribute Values. A fourth and final way of creating targets is to specify the exact raw values that are desired for every cue. For example, at the "Your Choice" prompt, if the experimenter wants a specific speed for this target, (e.g. 800 mph) type "1" and RETURN. The program will ask for the value desired, at which point the experimenter types "800" and then RETURN. That raw value will appear on the screen immediately, along with the appropriate cue value (i.e., 2). If the experimenter then wants to specify the raw value for Direction, he or she could type "6" and hit RETURN at the "Your Choice" prompt. The experimenter then enters the raw value for direction desired (e.g., 02 degrees) and then hits RETURN. The cue value associated with this raw value (i.e., 2) then appears on the screen.

The program will not allow the experimenter to plug in a raw value that is out of range (e.g., Speed of 2,000 mph, Direction of 90 degrees, etc.).

It is important to note that the screen that the experimenter manipulates displays both the raw data in the scale associated with the cue (e.g., mph, meters, ft., etc.) and the cue value. Only the

raw values are seen by participants when they are engaged in the simulation. The cue values are never seen by the participants. This is the value they need to infer based upon the raw value they see and the expertise that they have obtained through training.

Returning to the TEAMSET screen, just below the ninth cue is the "Correct Decision" (i.e., Ignore, Warn, Defend, etc.). This serves as the criterion against which the team's decision will be compared. This is computed automatically by the program. Experimenters do not type in the "Correct Decision" directly. This can only be set in one of the four ways just described. In other words, there is no option for an experimenter to request a "Defend" and then have the computer generate it.

Experimenters can mix and match targets creating processes to come up with a single target. For example, at the "Your Choice" prompt, one could type in "10R" and hit RETURN twice and get a target with randomly generated cues. Then the researcher could type "1" and hit RETURN to change the randomly generated Speed value to some other desired value.

Sample Configurations of Targets. Exhibit 15 shows the configuration for several different types of targets that may be of interest to decision making researchers. Some of these like (a) a sure Defend and (b) a sure Ignore have been discussed already. Targets (c) and (d) show two different ways of getting to a "Warn." In (c) the target is somewhat threatening on most dimensions, and it is this feature of the configuration that results in a "Warn." The configuration in (d) also generates a target that should be warned, but in this case, the target is very threatening on some attributes but not threatening at all on other attributes.

Insert Exhibit 15 here

Often experimenters are interested in reactions to targets that are ambiguous on one or more dimensions. In the initial version of this simulation, the participants training on cues leaves a range of values that are somewhat indeterminate as to their degree of threat. For example, if you turn back to Exhibit 7, 8, 9, and 10, you can see that there are "grey zones" associated with all cues. For example a speed of 500 falls in a grey zone between "somewhat threatening" and "very threatening." Similarly, 25,000 ft falls somewhere between "non-threatening" and "somewhat threatening" on altitude. Thus, although it is clear to the program at what point the cue goes from one state to another (e.g., non-threatening to somewhat threatening), this is not always clear to the participants because of their instructions. Thus, by specifying the exact raw value for each cue, and placing this in a grey zone, the

experimenter can create a relatively ambiguous target, such as that depicted in (e). Both (a) and (e) call for the exact same decision (i.e., Defend), but (e) is much more ambiguous relative to (a).

Experimenters can also use these grey zones to create targets that are "deceiving." An example of this is shown in (f). Here the target is obviously very threatening on the first four dimensions. On the last four dimensions, however, the target is non-threatening, but in a relatively ambiguous manner (i.e., cue values of 0 but raw values in grey zones). Thus, all combination rules go to 0, giving the target a value of 2 (due to IFF) and thus an "Ignore." This will not look like an "Ignore" to most participants. Instead, it will appear to be much more threatening than it truly is.

Experimenters can also generate "conflict generating" targets that look one way to some team members, but look entirely different to other team members. For example, the target shown in (g) appears to the CAD, based on what he or she can measure, to be very threatening. On the other hand, the target as it appears to the AWAC is much less threatening. Under these kinds of conditions, it would not be unusual to find the CAD making recommendations that look overly aggressive to the AWACs, and recommendations from the AWACs that look overly passive to the CAD. These are just a sample of the kinds of experimental variables that can be manipulated with targets via TEAMSET.

One feature of TIDE² that may limit some researchers is the inability to make targets change during a trial. Dynamic targets can be simulated via TIDE² through instructions and manipulation of the feedback screen, however. So for example, participants could be told that an overall trial for a specific target is actually 5 sub-trials, where the participants need to make preliminary judgments at each sub-trial. The experimenter can then go into TEAMSET and create targets in blocks of 5. In doing so, the experimenter may want to follow a rule that a target can only change on some dimensions (e.g., speed, altitude, angle, direction, corridor status, and range), and that the target can only go from one state (e.g., threatening) to an adjacent state (somewhat threatening) between sub-trials. Thus, through a series of sub-trials, the experimenter can create a target that starts out non-threatening, and then slowly turns threatening, or vice versa.

Establishing Context Effects with Targets in TEAMSET

By manipulating a set of targets created via TEAMSET, an experimenter can create several contextual effects that are often relevant to researchers in decision-making or team behavior. We will specifically examine nine of these.

Manipulating Base Rate

In the decision making literature, base rate refers to the a priori probability that the criterion will be of one type versus another. In this context, a set of targets can be generated so that the field is dominated by almost all "threatening" or all "non-threatening" targets. In this overall field, one can then introduce "ambiguous" or "deceiving" targets and see how participants reactions are affected by the base rate.

For example, Hollenbeck, Segó, Ilgen, and Major (1991) randomly assigned participants to either a threatening base rate or rectangular base rate conditions. In the threatening base rate condition all but four of 21 targets were Defends or Lock-ons. In the rectangular base rate condition there was an equal number of all seven possible outcomes. They then studied how the exact same four "non-threatening targets" were responded to by teams that varied in their base rate for targets. Decision making theory would suggest that the same four targets would prove much more difficult for participants in the threatening base rate condition than in the rectangular condition.

Creating Group Conflict

Group conflict is a condition where there are multiple instances of different team members coming to different opinions. By generating "conflicting targets" in the manner described in the previous section, it is possible to generate a context where two team members are often likely to disagree. Researchers can then examine what effect this has on team outcomes and processes.

For example, in Hollenbeck et al. (1991), participants were randomly assigned to two conditions where the outcomes associated with targets were identical, but where the nature of cues leading up to those outcomes was varied. In the conflict condition, the CAD and AWACs participants were provided with information that was as conflicting as possible given the constraints inherent in keeping the overall criterion matched with control participants. They then examined how these individuals rated each other, the communication patterns they displayed with each other, and how other members (e.g., the leader) reacted to both.

Creating Ambiguity in Targets

In the previous section we described a process to generate targets that will appear ambiguous to participants. By employing only ambiguous targets, one can see how ambiguity in the task affects team outcomes and processes. For example, in Hollenbeck et al. (1991) participants were randomly assigned to two conditions, where the cue values and criterion values were equal for each, but where the raw values for targets either (a) all fell in "grey zones" for teams in one condition, or (b) all fell within established ranges for teams in the other condition. They then examined what impact this had on perceptions of uncertainty, stress, communication patterns, and outcomes.

Manipulating Stress Through Time Pressure

Stress is typically conceived as a negative emotional reaction and concomitant physiological change in a person that occurs when someone is confronted with a challenge or problem. Stress is particularly acute under conditions where there is uncertainty regarding one's capacity to alleviate or meet the demand imposed by the threatening stimulus (McGrath, 1976). In this simulation, stress is manipulated by varying the amount of time pressure associated with specific targets. Thus, by decreasing the amount of time associated with a given trial, stress levels for participants should be higher.

For example, Hollenbeck et al. (1991) ran teams in six conditions where the amount of time that they had to respond to targets was varied, but where the targets themselves were a constant. In one condition participants experienced little time pressure throughout the experiment (i.e., they had five minutes to respond to each target), whereas in another, participants experienced a great deal of time pressure (i.e., they were given two minutes with each target). In the third and fourth conditions, participants experienced either increasing or decreasing time pressure throughout the experiment. Finally, in the two remaining conditions participants were given high or low time pressure but under conditions where all targets were ambiguous on all dimensions.

This design allowed Hollenbeck et al. (1991) to test the effects of time pressure on stress both within and across teams. It also allowed an exploration of the effects of ambiguity on stress independent of time pressure. Stress was measured in terms of participants' perceptions, as well as through physiological measures of stress taken with robotic vital signs monitors attached to participants. Hollenbeck et al. (1991) also examined the degree to which time pressure affected group outcomes and processes.

Manipulating Task Complexity

In his conceptual treatment of task complexity, Wood (1986) identified three primary dimensions of task complexity: component complexity, coordinative complexity and dynamic complexity. The first two of these can be manipulated through the judicious use of target creation in TEAMSET program.

Component complexity in Wood's system deals with the sheer number of pieces of information that need to be processed to perform the task. This type of complexity can be manipulated by yoking the values of separate dimensions, so that knowledge on one gives precise knowledge about the value of another. By yoking cues, one can take the initial version of the simulation which has nine attributes and convert it into a system that really has only 5 unique attributes (since knowledge on four gives precise knowledge on four others).

For example, Hollenbeck et al. (1991) randomly assigned teams to two conditions, one where there were nine orthogonal dimensions, and another where the "combination cues" were yoked. Specifically, the targets were created in the yoked condition in such a manner that if the target was threatening on one dimension, it was equally threatening on whatever dimension worked in combination with the first dimension (e.g. if it was threatening on Speed, it was also threatening on Direction). Participants were informed of this and thus the nine cue task was effectively turned into a five cue task (i.e., IFF and the four combination rules).

A second type of complexity identified by Wood is coordinative complexity. This deals with the complexity in how the various pieces of information interact. Yoking cues impacts this dimension of complexity since perfect confounding of the combination cues destroys the interactive nature of these cues (i.e., within an interaction, one "non-threatening" cue cannot cancel out a "threatening" cue).

Manipulating Tempo

There are two kinds of pressure created by time in this simulation. One deals with the time available to respond to targets, and the other deals with tempo, that is, the time between targets (i.e., the time the Feedback Screen is displayed). In fast tempo environments, one target follows another in quick succession. There is little time to rest or reflect between trials. This can be manipulated in this simulation by varying the time available to examine feedback. Short duration (e.g., ten seconds) feedback screens create a fast tempo, whereas long duration (e.g., 30 seconds) feedback screens create a slow tempo.

Establishing Prototypes

In cognitive psychology, a "prototype" is a simplistic frame used to interpret and make sense of more complex information (Lord, 1985). So for example, if someone suggests that another person is a "yuppie," this conjures up an image in the listener's mind about what the person will probably be like on a number of dimensions such as "profession," "political attitudes," "dress and demeanor," "purchasing preferences," etc. In the TIDE² simulation, one can create prototypes by generating targets that are categorical in nature.

For example, the environment that a participant encounters may be made up of only four kinds of targets (fighters, bombers, airliners and corporate jets) each of which can assume only two states (e.g., an attacking fighter vs. an innocent fighter flyover or a lost corporate jet vs. a kamikaze corporate jet, etc.). In this kind of context, the participant's task is to sort targets into categories depending upon critical attributes of the target. Some of the attributes may overlap across categories (e.g., an innocent fighter flyover and kamikaze corporate jet are similar on some dimensions such as Size and Speed), but differ on others (e.g., Radar and IFF). The development and use of these kinds of prototypes often separates experts from novices and may be of interest to researchers in team decision-making.

Creating Trends, Cycles and Seasonality

"Trends" refer to relationships within experimental sessions between adjacent targets. "Trends" can be established by creating targets that steadily increase or decrease in terms of their threat level during the duration of the experiment.

"Cycles" can be established by creating and then changing the direction of trends systematically. Thus, targets can increase in their level of threat up to some point, then begin to decrease up to some point and then start up again.

"Seasonality" can also be established by having the degree of threat covary with some unit of time. For example, trials can be described as seasons, in that the first ten are summer, the next 10 are fall, etc. Scenarios can be written around these to suggest that hostility levels are always low in winter.

In summary, this section has described and shown a number of ways to use the initial version of TIDE² for various kinds of team research, where the task and scenario are as described above. That is, the context is a naval air patrol context where there are these specific nine cues, that combine in these specific five ways to generate one of these seven criterion decisions. In all cases,

four players, measure these specific cues, and communicate in specific fashions to reach one of seven possible decisions.

TIDE² is a much more flexible program than is implied so far. We will focus on its flexibility in the next section. First we will show how to change the nature of the task while maintaining the naval air patrol scenario. In the next sub-section we will show how to change the nature of the scenario so that it has nothing to do with air patrol.

Changing the Task and Scenario

Recall from Exhibit 13 that the menu screen in TEAMSET comes with two primary options:

"W to modify weights and values" -- which makes desired changes in the "initial version" of the simulation, and

"## of session to create or maintain" -- which creates or changes targets.

Up until this point, we have been only dealing with the option for creating and changing targets. If one wishes to change the initial version of the simulation, the first option shown in Exhibit 13 should be selected.

Changing the Task with TEAMSET

For a moment, assume you are indifferent to the naval Command and Control scenario but wish to modify the underlying task in some manner that differs from the initial version of the simulation. We will use a running example to show how many different changes can be made and accumulated in TIDE², so that when finished, the researcher has a personally tailored simulation that differs from the "initial version." Enter TEAMSET, and at the prompt choose "W" for "modify weights and values." When this is accomplished, you will see the screen shown in Exhibit 16a and 16b. These screens will be referred to as the "Measures Screen," and the "Communications Screen" respectively.

Insert Exhibit 16a and 16b here

The Measures Screen. Each bracketed number in that screen corresponds to an aspect of TIDE² that can be manipulated. We will discuss each of these in turn, focusing on the goal of keeping the air patrol scenario but changing specific facets of the task.

[1] # Measures -- This feature allows the experimenter to change the number of cues that comprise that simulation. The initial version has 9, which is the maximum, but an experimenter can opt for less than this. For example, if you type "1", then hit RETURN, and then type "6", and hit RETURN. This creates a six cue task.

[2] # Interactions -- There are four interactions or combination rules in the initial version of the simulation (i.e., Attribute 1 combines with Attribute 6, etc.). This is the maximum allowed, however, this number can be reduced to 0 interactions. For example, if you type "2", then hit RETURN, and then type "0", and hit

RETURN. Now, we have created a version of the simulation where there are no interaction or combinations of attributes.

[3] # Judgments -- In the initial version of the simulation, there are 8 possible judgments that can be made. Seven of these have been described already (i.e., Ignore, Review, Monitor, Warn, Ready, Lock-on, Defend). In addition to these, the program also generates a "No Call" for participants who fail to make a recommendation or decision in the time allowed. This is treated as an "Ignore" by the computer in determining decision accuracy, but for informational reasons, it is differentiated from Ignore when participants get their feedback. Eight is the maximum number of decisions allowed, but an experimenter can use fewer. For example, typing "3", hitting RETURN, and then typing "2", and hitting RETURN, will lead to a simulation where the decision is a dichotomy.

[4] # Outcomes -- In the initial version of TIDE² there are 5 decision outcomes (Hit, Near Miss, Miss, Incident, and Disaster). This is the maximum number of discrete outcomes. This number can be reduced as low as 2, however. For example, typing 4, hitting return, and then 2 will lead to this many outcomes.

[5] # Icons -- There are four icons on that appear on the screen in the initial version of TIDE². This is the maximum, although it can be reduced. Typing 5, then hitting RETURN, and then 3 would create a screen with space for only three icons.

[6] Message wait time -- The CPU of the computers running TIDE² needs to do two major tasks. First, it needs to interact with the Team??INI files that contain the targets so participants can measure and record target attributes. However, the CPU also has to leave this aspect of the simulation to search for messages from other players that reside on the network. The message wait time function allows the experimenter to determine how often the CPU goes looking for messages. This has some non-trivial implications for the simulation.

If the message time is set very low, for example .10 seconds, then the CPU is often "not home" at the instant the participants hit the ALT key to activate the Menu Bar. If this occurs, the Menu Bar is not highlighted, and participants cannot measure target attributes. This is frustrating for participants who seem to expect immediate action from their response (even when informed otherwise) especially in high pressure trials. The advantage of short wait times is that messages are received virtually the moment they are sent.

If the message wait time is set very high, for example 10.0 seconds, then just the opposite problem results. Participants can get immediate access to the Menu Bar following their ALT key input.

However, the time between sending a message and receiving one gets inordinately long. For example, it could take ten seconds to send a message, and then another ten seconds to receive one's answer, which, in a 150 second trial, may be too slow to be useful. This too can be frustrating for participants.

In pilot tests, we have found that three seconds provides a good balance between these two sources of frustration. Other experimenters may have reasons for making different decisions (e.g., vary the delay or cost associated with communication) so this can be modified. For example, if you type "6", hit RETURN, and then type "8", and hit RETURN. Now, the CPU will look to the network for messages every eight seconds. We will talk about this again when we discuss hardware requirements for TIDE².

[7] Cue weights -- Although no label is provided, option 7 exists to manipulate the weights assigned to cues. For example, if you turn back to Exhibit 16a, you can see that, in the initial version of the simulation, only one cue (i.e., IFF, Cue #5) gets a non-zero weight (it gets a weight of 2). This can be seen in the initial "Modify Weights and Values" screen where down the column under [7], all values but #5 are set to 0. This can be changed, however, if the experimenter is interested in having a large number of "main effect" cues. For example, the task we are currently modifying has six cues, with no interactions used to make a dichotomous decision. If the experimenter types "7", hits RETURN, and then enters "111111", all six cues created will be unit-weighted in generating the criterion value. That is, the mathematical expression for generating criterion values will become:

$$[4] \quad Y = (1)X_1 + (1)X_2 + (1)X_3 + (1)X_4 + (1)X_5 + (1)X_6$$

It is important to note that whenever the experimenter wishes to change any weight, all weights must be entered after the [7] prompt. That is, if we now wanted to go back and double the weights on the first three attributes, we would need to enter "222111."

[8] Attribute Labels -- Although no label is provided, option 8 refers to the label attached to the Attribute numbered #1, #2, etc. If an experimenter wanted to change the name of an attribute, this could be accomplished with this option. For example, if the experimenter disliked Attribute #5's current label (i.e., IFF) he or she could change it to something else. As with option [7], if the researcher wishes to change any attribute label, all must be re-entered.

For example, if one wishes to only change IFF, then one must do the following. First, type "8", and then hit RETURN. This will invoke the screen shown in Exhibit 17a. Since Speed is not to be changed, simply type Speed and then hit RETURN. Exhibit 17b will then be

presented. Since it is also desired to keep Altitude, simply type Altitude, and then hit RETURN. Continue to type in the labels you wish to leave unchanged, until you get to IFF. At this point, the screen will appear as it does in Exhibit 17c. Now type in the new label you wish to replace IFF with. For example, type in "Emissions" if that is the new label desired, and then hit RETURN. At this point, the screen will appear as shown in Exhibit 17d. All one needs to do now, is enter the label for the last attribute, Direction. Since this is to be unchanged, follow the procedure discussed above for re-typing attribute names. Hitting return after entering "Direction," since this is the last cue, returns you to the Measures Screen, which now reveals the new label for Attribute #5.

Insert Exhibit 17a, 17b, 17c, and 17d here

[9] "Hot" letter key -- Earlier we discussed two ways of selecting attributes to be measured. First, moving up and down in the Measurement box using the arrow keys, highlighting the desired attribute and then hitting RETURN. Second, one can also simply type in the "hot key," associated with a given attribute (i.e., the red letter within each attribute label). For example, typing "z" for a quick measure of Size.

Option 9 allows you to determine which letter will be hot wired in this fashion. As with other options, if you wish to change one "hot key," you must re-enter all of them. TO change it, enter the number representing the location of the letter in the word. So for example if you wanted to make it so that "s" was the hot letter for "Size" (rather than for "Speed") you would change the third hot key (which made "z" the hot letter for "Size") to 1. At the same time, you would need to go back and change the hot letter for speed to something other than "s," perhaps 2 to pick up "p" as its hot letter. Therefore, at the prompt, you would type "211211".

[10] Raw Scale for Cues -- The raw scale associated with each cue is determined by Option 10. Thus, Speed is described in miles per hour (mph), Altitude described in terms of feet, etc. These can be changed. For example, earlier we changed IFF to Emissions. Since megahertz (Mhz) is not a scale in which Emissions is measured, this will need to be changed. The number of letter available for a label is limited to 8.

To change the raw scale values type in "10" and then hit RETURN. You will be presented with the screen shown in Exhibit 18a. This screen tells you the old scale value, and then asks you to enter the new scale value. In our running example, since you do not wish to change the scaling associated with Speed, you would type in "mph." After this hit RETURN, and repeat this for all the scales

you do not wish to change. When you come to IFF, whose scale you do wish to change, the screen will appear as shown in Exhibit 18b. Now, after being presented with the old scale (Mhz), you would enter the new scale you wish to use. So for example, if you wanted to measure "Emissions" in terms of temperature, you would type in "C" to reflect degrees Centigrade. Continue this process until all attributes have their scales redefined. When all of these are entered, you will automatically go back to the Measures Screen that displays weights and values.

Insert Exhibits 18a and 18b here

[11] Raw Value Ranges -- This portion of the TEAMSET screen determines both the range of raw score values associated with each attribute and the manner in which raw scale values are converted into cue values. In the initial version of the simulation, for example, with the Attribute "Speed," this table shows that the slowest speed is 100 mph and the fastest is 800 mph. The table also shows how raw score ranges convert into cue values. So for example, in this table, a speed of 100 to 300 converts to a cue value of 0 (i.e., "non-threatening"). A speed of 301 to 550 converts to a cue value of 1 (i.e., "somewhat threatening"). A speed of 551 to 800 converts to a cue value of 2 ("very threatening").

If one wanted to change these, it can be accomplished by typing "11," and then hitting RETURN. The program will then ask you for the number of the attribute that you wish to change. So, in our example, after adding Emissions as measured in degrees centigrade, the old scale ranges (.2 to 1.6) available for this new variable are no longer appropriate. Therefore, we would type "5" and then hit RETURN. You will be presented with a screen that looks like that depicted in Exhibit 19. You will be prompted with the old raw score value of the "non-threatening" endpoint of the cue value continuum. In our example, this would be .2 (i.e., the lowest value when the attribute was expressed in Mhz). At this point, type in the temperature that will be the low end (in terms of threat), such as 500 and then hit RETURN. The program now reads 500 degrees centigrade as the lowest possible temperature for "Emissions."

Insert Exhibit 19 here

You would then enter the other end of the "non-threatening" value on temperature. So for example, if we wanted temperatures of 751 to become "somewhat threatening," we would type "750," and then hit RETURN, to indicate that temperature moves from "non-threatening"

to "somewhat threatening" as one moves from 750 to 751 degrees centigrade. You now enter "751" and hit RETURN, to make 751 degrees centigrade as the low point value for the "somewhat threatening" range. Continue this procedure until you have entered all the inflection points for the three levels of threat.

It should be stressed, that when "grey zones" are created, they are created via instructions to participants, not the program. That is, instructions to participants may say that 500C to 700C is "non-threatening," and that 800C to 1,000C is "somewhat threatening." This creates a grey zone for participants in the 701 to 799 range. No such ambiguity can exist for the program. You need not put the inflection point for the cue in the center of the grey zone. Instructions to participants could state that 500C to 750C is non-threatening. This implies that 751C to 800C is a grey zone. In reality, however, all values that fall in the grey zone reflect cue values that are in fact "somewhat threatening."

[12] Interaction Weights -- The initial version of the TIDE² simulation contains four interactions or combination rules, and this is the maximum number allowed. Each of these interactions, as is apparent from Equation 2, was weighted 1. The weight attributed to the interactions among cues can be modified by Option 12. For example, if the experimenter wanted only one interaction present, but wanted to make that critical, he or she could type in "12," and then hit RETURN. Then enter "2000" which means that the first interaction is given a weight of 2, and that there are no interactions other than this.

[13] NxNxNxNxN (Interaction Components) -- Option 13 allows the experimenter to define which two or more cues he or she would like to combine in an interactive fashion. Sticking with our running example, rather than Speed and Direction going together, the experimenter may wish to have Speed and Altitude go together, so that low targets that are flying fast are especially threatening. To do this, type in "13" and then hit RETURN. Type in "12" and then hit RETURN to indicate that you want the first two cues to interact. (Option 12 was already used to give this interaction a weight of 2). The other interactions are given weights of 0, so these in effect are inoperable, although the experimenter could erase these if that was desired. This makes the new linear combination for generating the "true score" associated with our running example:

$$[5] \quad Y = (1)X_1 + (1)X_2 + (1)X_3 + (1)X_4 + (1)X_5 + (1)X_6 + (2)X_1X_2$$

TIDE² can support triple, quadruple and quintuple interactions. These can be used for generating what are basically stochastic elements to the equation. This stochastic element will appear to participants as "noise."

This completes the discussion of the "Measures Screen" of the "modify weights and values" option in TEAMSET. Many other changes can be introduced in the "Communications Screen." To get to the Communications Screen from the Measures Screen, type "B" and hit RETURN.

The Communications Screen. The Communications Screen contains Options numbered 14 through 26, and this screen is depicted in Exhibit 16b.

[14] Role Name -- Although unlabeled, Option 14 deals with the names of the positions that make up the stations in TIDE². If the experimenter wanted to have all four stations at sea, and eliminate the CAD station, he or she would type in "14" and then hit RETURN. You will be prompted with the old names of the stations and then asked to enter the new names. When presented with CAD relabel this role as "Submarine." After all four names have been entered, hit RETURN, and you will be returned to Communications Screen.

[15] Who Measures What -- In the initial version of TIDE² each of the outlying stations (i.e., CAD, AWACs, and Cruiser) can measure 5 attributes and the carrier can measure 3. Option 15 determines which attributes the person in each position can measure. If we wanted to construct a simulation where every player could measure every attribute, we could do this employing this option. To do this, type "15," and hit RETURN. You will be prompted with the role name and a list of the attributes that this role can currently measure. In our running example, we have six cues for each station, so type in "123456" and then hit RETURN. After you do this for the last station, you will be returned to the Communications Screen. In our running example, we have a six cue system. If we want to make it so that each position can measure every attribute, we would type in "123456" under 15.

[16] Name of Judgments -- Earlier we noted that there are eight possible judgments that can be accommodated by TIDE². Option 16 allows one to change the name associated with these judgments. So for example, in an earlier example of changing Option 3, we showed how to go from a eight judgment system, to a dichotomous decision. At this point in TEAMSET we would need to relabel these two options. For example, we may relabel them "Standby" and "Fire." To do this, type in "16" and then hit RETURN. You will be prompted with the old name for the first decision (Ignore), and will then change this by entering "Standby," and then RETURN. You will then be prompted with the old name for the second decision (Review), which you would then change to "Fire."

[17] Values for Criterion -- Exhibit 6 showed how scores on the linear combination that aggregated the cue values was converted into the eight possible criterion judgments. Option 17 is used to set the cut-offs for these criteria. For example, in the default

version of the simulation, 0-2 is an "Ignore," 3-5 is a "Review," etc. In our running example, we have turned the decision into a dichotomy, and changed the linear combination from that shown in Equation 3 with that now shown in Equation 5. We might draw the cut-offs of a "Standby" from 0 to 10, and the cut-off for a "Fire" from 11 to 20.

[18] Names of Outcomes -- Option 18 allows the experimenter to change the number of outcomes associated with any decision -- criterion combination. In the initial version of TIDE², there are five possible outcomes. This is the maximum allowed. This number can be reduced, however. In our running example, where we have reduced the criterion and judgment to a dichotomy, we may simply label the outcomes "Hit" and "Miss". To do this, type in "18" and then hit RETURN. You will be prompted with the old outcome names, and you should replace these with the new names in the same manner as was done with attribute names, scale ranges, and so on.

[19] Judgment Hot Keys -- Just as one can identify hot keys for measuring attributes, querying attributes or transmitting data, one can also use hot keys to register judgments. These are specified in a manner identical to that previously discussed for Option 9.

[20] Feedback Type -- As mentioned earlier there are three options for providing feedback in TIDE², immediate, delayed and summarized. Option 20 allows you to choose which of these forms you would like. The default form of feedback is immediate "F". If you want to delay the feedback so that participants get feedback from Trial 1, three trials later, you would type "20" and then hit RETURN. Type in "D" and then hit RETURN again. This turns on the delayed feedback version of the simulation. To determine the length of the delay you would need to employ Option [21] which is discussed next. If you wanted to provide summarized feedback after three trials, you would follow the same steps, except, choose "S" rather than "D".

[21] Number of Trials Delayed/Summarized -- If one opts to use delayed or summarized feedback in Option [20], one should then use Option [21] to specify the number of trials that feedback will be delayed or summarized across. In our running example, we wish to delay feedback three trials, so that feedback on Trial 1 is presented after Trial 4, Trial 2 after Trial 5, and so on. The same procedure would be used to summarize feedback after every three trials. So for example, if the experimenter wanted to provide participants with summarized feedback after every three trials, he or she would type "21", and then hit RETURN. Type "3" and then hit RETURN, and now feedback will be summarized rather than delayed.

[22] Feedback Access -- In the default version of the simulation, each team member gets detailed feedback for the team between

trials. Since the Carrier registers the team's decision, this is the Carrier's individual feedback as well. Non-carriers get no such detailed feedback regarding their recommendations in the default version of the simulation. However, this can be changed.

There are basically five different decisions to be made for each team member when it comes to configuring feedback. These five decisions are:

- (1) Will the person have access to feedback for the Carrier (i.e., the team)?
- (2) Will the person have access to feedback for the CAD?
- (3) Will the person have access to feedback for the AWACs?
- (4) Will the person have access to feedback for the Cruiser?
- (5) Will the person have access to feedback for all four positions simultaneously on a single screen?

These decisions are registered by entering either "Y" for yes or "N" for No, in answer to each of the questions numbered (1) through (5) above for each of four players. That is, every time one wishes to change feedback access, one must register 20 decisions (five questions for four team members).

Refer to Exhibit 20 to see how the answers to these questions are registered in TIDE². One registers these decisions by inserting a Y or N above the pair of vertical numbers that identify the question and the team member for whom the question is being answered. The structure is made up of 3 rows and 20 columns. The first row is where one enters the answer to the 5 questions posed above. The second row specifies the terminal for which the question is being answered. The third row specifies whose feedback will or will not be made available.

Insert Exhibit 20 here

So for example, assume that we would like to generate a simulation where the Carrier can get individual feedback on every team member's performance, but that the other team members can only get feedback on their own individual performance and the team's performance. To accomplish this, type in "22" and then hit RETURN. The cursor will move up to the "View Feedback" line, two spaces left of the colon. To make it so the Carrier can have access to all feedback, we need to answer questions (1) through (5) above "yes" for the Carrier. Therefore, we would type in "YYYYY" as the

first five entries. Since we want the CAD (i.e., the second position) to get feedback on his or her own and the team, we would then type in "YNNNN" to indicate that CAD can access feedback on the Carrier (i.e., the team) and himself or herself. For the AWACS, we would answer the five questions "YNYNN", and for the Cruiser, we would answer the questions "YNNYN." Thus, the entire line, which represents the answers to the 20 questions, would read:

YYYYYYNNNNYNNYNNYNNYN

For team members engaged in the simulation to evoke these options they need to hit certain function keys. F4 provides Carrier feedback, F5 provides access to CAD feedback, F6 provides access to AWACS feedback, F7 provides access to Cruiser feedback, and F8 provides access to all four simultaneously on one screen. If a team member does not have access to a specific feedback source, then hitting the function key associated with that source will have no effect. The instructions about the feedback must be provided by the experimenter to the participants. There is no menu driven source for participants to access feedback.

[23] Who Can Query Whom -- Communication channels in the default version of TIDE² are set up so that each player can query, transmit, send and receive text from every other player. This can be changed. Option [23] controls the query function, and determines who can query whom. Exhibit 21 shows an expanded view of this section of the Communications Screen with descriptions of functions inserted. The top line of this screen contains the numbers 1111222233334444 where 1 refers to the Carrier, 2 the CAD, 3 the AWACS and 4 the Cruiser. This line indicates the source of the query (that is where it originates). Just below this line is another line that contains the numbers 2341 3412 4123 where the numbers refer to the team members in the same manner described previously. This line indicates the destination of the query. The top line, and the line below it form vertical pairs. The vertical pairs set up the question "can x query y," where x refers to the source (on the top line) and y the destination (the bottom line). Thus, the first vertical pair is 12 and therefore asks can the Carrier (i.e., Position 1) query the CAD (Position 2). The rest of the pairs complete all possible alternatives for query sources-destinations. The blanks in the second line are there to reflect the fact that a team member cannot query himself or herself.

Insert Exhibit 21 here

Just below the "From:" and "To:" lines is a string of Y's or N's that provide the answer to the question set by the vertical pair above it. Thus, a "Y" below the first vertical pair, 12, means that the Carrier can send a query to the CAD. In fact, as we said

already, in the default version, everyone can query everyone else, so all the entries in this line are Y by default. A vertical pair that contains a blank (i.e., the vertical pair that asks can x query x, a meaningless question) will always have a Y below it and this cannot be changed.

Let's assume that we wanted to restrict queries and set up a "wheel," network, where the Carrier can query everyone, but the other stations could only query the Carrier. To do this, type in "23" and then hit RETURN. The cursor will move up to the line labeled "Query to:" in the Communications Screen (the right of [23]). At this point you would enter: YYYYYNNNNYNNNNYNNN

[24] Who Can Transmit Raw Values to Whom -- Option [24] follows the exact same format as Option [23], except in this case, the question posed by the vertical pair is "can x send a transmission to y?" Changes are made in the same manner described in [23], and thus if we wanted to extend our wheel network to transmissions we would type "24", then hit RETURN, and then enter: YYYYYNNNNYNNNNYNNN.

[25] Who Can Send Text Messages to Whom -- This option follows the exact same format as [23] and [24] but now a vertical pair sets up the question, "can x send a text message to y?" Changes are made here the same way as described above. Thus, to convert the default communication network to a wheel, one would type in "25", then hit RETURN, and then enter: YYYYYNNNNYNNNNYNNN.

[26] Writing to Personal Logs -- Recall that team members have the option of saving any text message sent to them from another player by using the log option that comes up after receipt of a text message. You can use Option [26] to allow players to send text messages to themselves. Thus, the log can become a personal notebook for the player where he or she can store information on roles, rules or characteristics of other players. This option takes the place of giving participants paper to keep notes on, and has the advantage over paper in that the timing and content of the notes are captured by the simulation program.

The initial version allows personal logs, but this can be turned off. For example, if we wanted to make it so that the Carrier could keep a log, but the other players could not, we would type in "26" and then hit RETURN. The cursor will move up to the line labeled "Trn To Log:" (i.e., Option [26]). At this point, you would type "YNNN".

There is one last aspect of the simulation that can be changed with TEAMSET, and this deals with the icons. The icons have their own screen. To get to the Icon Screen from either the Measures Screen or the Communication Screen, type "I" and then hit RETURN.

The Icon Screen. By this time you may have noted the rudimentary form of the icons that come with TIDE². Because menus have to be pulled down on top of Icons, the program will not allow screen space to be sectioned off for sophisticated graphics. Despite this, experimenters who wish to do so can substitute their own rudimentary icons for those provided.

To make this kind of change by first typing "I" and hitting RETURN. This will call up the third screen under "modify weights and values" option of TEAMSET. This screen shows you the icons that are currently being used by the simulation. In the default version of the simulation they are the Carrier (position 1), CAD (position 2), AWAC (position 3) and Cruiser (position 4). Inside each icon is the label associated with the icon.

To change an icon, (i.e., change the CAD to a Submarine), you would type "2W", and then hit RETURN. The 2 selects the CAD icon and the "W" clears the old icon so that a new one can be created. The number pad on the keyboard is used to draw the new icon. The four directional arrows will create a line one space in length in the direction of the arrow. To make corners you would use the following keys:

- end key makes a lower left corner,
- home key makes an upper left corner,
- PgDn key makes a lower right corner,
- PgUp key makes an upper right corner.

It should be noted that this is not a simple task at first but in time icon drawing can be mastered.

If you wanted to move the Submarine icon down the screen a little you would type "2D" and then hit RETURN. This will move the icon down one space. If you want the Submarine lower you would continue to type "2D" until the icon is where you want it. It is important to note at this time that you have to use CAPITAL LETTERS to move the icons. Lower case letters move the icon label as will be explained next. To move the icons you use the following letters with the appropriate icon number:

- D moves the icon down one space,
- U moves the icon up one space,
- L moves the icon to the left one space,
- R move the icon to the right one space.

After the icon is moved to its new place you will need to move the icon label. To move the Submarine label down you would type "2d" and this would move the label down one space. Note that to move the icon labels you use lower case letters. The same letters result in the same moves they did when moving the icon.

For example, assume we eliminated the CAD station in our running example, and replaced it with a submarine. A rudimentary icon for a submarine could be developed and added to the screen so that when completed, the new sea screen would look like that shown in Exhibit 22.

Insert Exhibit 22 here

To save the changes made in this session, type "W" and hit RETURN to execute the modifications. The new simulation looks like that displayed in Exhibit 23, and can be contrasted with that displayed in Exhibit 11, which is the initial version of the simulation. If we did not wish to save the changes, type "C" to cancel them.

Insert Exhibit 23 here

Establishing Context Effects with Task Changes

There are many different context effects of interest to researchers in the area of teams and decision making that can be manipulated by changes in the task. We give several examples of these below, along with the corresponding number in TEAMSET (shown within brackets) that was described above.

Task Complexity. Earlier we discussed, Wood's (1986) three primary dimensions of task complexity: component complexity, coordinative complexity, and dynamic complexity. We also showed how the first two of these can be manipulated with TEAMSET by creating targets that are yoked on the attributes that form the combination rules. These two type of complexity can also be manipulated by changing parameters in the "Modify Weights and Values" section of TEAMSET.

Again, component complexity refers to the number of pieces of information that have to be processed to perform the task. This is readily manipulated in TIDE² by simply altering the number of attributes that can be measured (see [1] above). The coordinative aspect of task complexity can also be handled by setting all the interactions to zero (see [12] above). Placing large weights on the interactions, and raising the order of these (creating three or four way interactions - see [13] above) will have just the opposite effect on coordinative complexity.

There is no necessity that an attribute that can be measured have any ecological validity with respect to predicting the criterion. For example, one could create a nine attribute system where three of the attributes are weighted 0 (see [7] or [12] above) and

therefore simply create noise on the predictor side. The inclusion of fifth order interaction terms also have the psychological effect of adding noise to the criterion side (see [13] above).

Required Interdependence. The initial version of TIDE² uses combination rules, and then nests dimensions within roles such that no one role can get all the information on any combination rule. This forces interdependence among players. Interdependence can be manipulated, however, by adjusting who can measure what (see [15]). High redundancy, where many roles can measure all the same attributes, leads to low interdependence. Taken to an extreme, this could mean that all players can measure all attributes by themselves. Low redundancy, on the other hand, means everyone measures unique attributes, and this creates high interdependence. Taken to an extreme, one could employ an eight attribute system where each of four roles can measure two unique attributes.

Base Rate for Ambiguous Targets. Earlier we noted that through the use of "grey zones" presented in the instructions, one can create targets that are ambiguous to participants. In the initial version of TIDE² the so called "grey zones" are in reality demarcated so that values in the lower half of the range fall on one side of the cut-off. For example, the grey zone on speed runs from 275 - 325 mph, but in reality, a speed of 300 mph is non-threatening whereas 301 is somewhat threatening. One can create "biased" grey zones, however, where almost all values within the "grey zone" fall one way or the other. Thus, with speed, the grey zone of 275 - 325, could, in reality, relate to a system where 275 is non-threatening, but 276 through 325 is somewhat threatening. Thus, when in doubt, participants in this kind of context should lean toward aggressive responses. Of course, a biased grey zone of just the opposite nature could also be created.

Required Precision. The initial version of TIDE² uses seven judgment categories and allows for the possibility of five different outcomes. This could be considered a precise decision making context. The system we replaced it with, however, requires much less precision (see [3] and [4] above). It has only two types of judgments (Standby and Fire), and two types of outcomes (Hit or Miss). One may wish to require less precise decisions in highly speeded contexts, where there might be one or two decisions made a minute. In this context, the number of trials for a team within a specified time period could be increased relative to the number that might be possible for teams making more finely graded judgments.

Group Size. The initial version of TIDE² uses four players, but this number can be reduced to triads and dyads (see [5] and [14] above). It can even be reduced to one, however we will discuss single person versions of TIDE² in detail in a later section.

Communication Networks. Many of the conventional communication networks studied in the groups literature, such as "wheels," "lines," "circles," "comcons," etc. can be invoked in TIDE². These can be created by manipulating the options on who can query, transmit, or send text messages to whom (see [22], [24], [25], and [26]).

Speed of Communications. Communications in the initial version of TIDE² move relatively quickly and efficiently between players, with a maximum transmission time of 3 seconds. Communications can be made much slower, and therefore become more costly and less helpful to players by manipulations of the "Message wait time" (see [#6] above).

Feedback Variations. In the initial version of TIDE² the team receives feedback of team performance and the performance history for the team is displayed. Individuals get to see their respective decisions but are not given specific feedback on their performance, nor are their personal performance histories presented with the feedback screen. These can be made available to participants by manipulating Option [22].

In addition, the initial version of TIDE² gives feedback immediately with respect to the target that the players just encountered. Feedback on targets can be delivered in two other ways, however. First, one can obtain trial-delayed feedback, where the feedback coming up on the screen actually refers to a target experienced a specified number of trials prior to the target just encountered. In other words, participants act on a target at Time 1, but do not receive feedback until Time 4, after acting on perhaps three other targets in the meantime. This can be accomplished as described above in Option [20] and [21].

Second, feedback can also be summative over many trials rather than provided after every single trial. That is, participants could act on five targets in a row before receiving any feedback. Then, the feedback they do receive would just be for the five targets as a

whole (e.g., three hits, a near miss and a miss), with no way of tying specific decisions to specific outcomes. This can be accomplished through Options [20] and [21].

Finally, the feedback screen can be turned off altogether. There are two ways of doing this. First, as previously described in the "session to maintain" part of TEAMSET, one can set the feedback time to zero. If one does this, then targets come up one after another with no break in between them. If one wished to eliminate feedback, but not increase tempo, then a second means of eliminating feedback should be used. Specifically, one could use the "modify weights and values" part of TEAMSET to delay feedback

over x trials where x equals the total number of trials. This method allows one to create rest periods (where players get a blank orange screen) where feedback screens used to appear.

Goal and Projection Variations. The initial version of TIDE² has a team goal option, that comes with a projection that tells participants where they will be at the end of the trial if they continue to perform at the same rate experienced to that point. One can also create individual goals and projections for team members. This can be accomplished as described above in the "session to maintain" part of TEAMSET.

Changing the Scenario with TEAMSET

Up to this point we have been changing the various aspects of the task with TEAMSET, but we have retained the scenario of naval air patrol. The "Modify weights and values" portion of TEAMSET allows much more radical changes in the context, and one can even create different scenarios. For example, by changing cue names, cue values, ranges, player names, judgments and outcomes entirely different scenarios can be developed.

For example, TIDE² could be turned into a personnel selection task where there are four team members; an interviewer, a testing specialist, a recruiter, and a plant manager (the leader). The applicant becomes the "target" that might be assessed on eight dimensions; interpersonal skills and experience (measured by the interviewer); verbal and quantitative ability (measured by the testing specialist); strength of academic program and GPA (measured by the recruiter); fit with current employees and fit with future organizational strategy (measured by the plant manager). These four could then pool their judgments and come up with a team decision either graded (the desirability of hiring the individual) or dichotomous (hire or not hire), which then can be evaluated against some criterion developed for the scenario.

TIDE² could also be turned into an investment banking scenario where the four players might be a CEO (the leader), a production specialist, a financial specialist and a marketing specialist that have to come together to make recommendations about investment opportunities (e.g., whether to purchase another company). "Targets" are then potential takeover targets and decisions can be based on measures of: interest rate projections, capital availability projections, company ledgers, company performance history, company technology, industry analysis, analysis of competitor with the industry, etc. TIDE² could in the same manner be turned into a medical scenario where medical specialists like a cardiologist, an anaesthetist, an admitting emergency physician, and a nurse make decisions regarding the treatment of a patient based on information dealing with initial onset of symptoms, test

results, behavioral monitoring, etc.

Scenarios described so far, have typically involved simulations where the criterion was an invention of the experimenter, but studies in ecological prediction could also be conducted with TIDE². For example, teams of participants could be asked to handicap horse races. Members could be given "live" information taken from actual racing forms and presented in the form of nine attributes via TIDE². Members could exchange information and then make predictions about which horse would win. These could then be contrasted with real outcomes from the races. Thus, users of TIDE² are not limited to hypothetical decision contexts and researchers can take advantage of the many archival sources available to come up with real and interesting contexts where teams might come together to make decisions.

Non-Research Uses of TIDE² with TEAMSET

Although TIDE² was designed as a research vehicle, it may also have certain non-research uses. For example, it could be employed as a group development or team building exercise. It could be used as a work simulation for a group or an individual for tasks with a large number of decision-making components. It could be used as an assessment device, much like a "hard wired" Leaderless Group Discussion exercise. It could also be used in individual assessment as a perceptual and judgment measure of personality characteristics and decision style (see Nunnally, 1978; Hollenbeck & Whitener, 1988).

De-Grouping TIDE²

Although designed as a team simulation, TIDE² can also be used as an individual task where there is a single person making decisions. This would be useful for comparing teams versus individuals on the same task, or for strict individually-oriented decision-making research that used no teams at all. There are two means of eliminating the team aspect of TIDE².

One Player - One Role. The TEAMSET program allows the researcher to change many of the parameters associated with the simulation, and this program can be used to convert TIDE² into an individual task.

The researcher simply needs to specify that the team will have only one member (see [5] and [14] in the "modify weights and values program), and set up the "who can measure what" parameter (see [15]) so that the one person can measure all attributes. If the computers are shut off the network, the four computers used to run one team can be used to run four individual decision makers

simultaneously.

Hollenbeck, Sego, Ilgen and Major (1991) compared the effectiveness of teams versus individuals on the initial version of TIDE². The reader is referred to that manuscript for the results of that comparison.

One Player - Multiple Roles. The TEAMSET program also allows one to run an individually-oriented version of the simulation, where there are multiple roles. The One Player-Multiple Role version differs from that describe above in that the player can move back and forth from one role to another using the F4 through F7 keys. In this version of the single player simulation, the researcher could still impose a hierarchical knowledge base where the single person has to access different stations to learn different things about the target. Thus, to get information on speed, the participant would have to recall that speed can only be measured by the AWACs, and then transfer into that station using the F5 key. He or she may even feel the need to transmit this information back to the carrier position so that the information will be available in the summary box. Thus, the One Player-Multiple Role version of the individually-oriented simulation is much more complex than the One Player-One Role version.

Output from TIDE²

One of the advantages of using TIDE² in research is that large amounts of information are automatically collected during the simulation sessions. This simplifies the transition in going from data collection to data analysis.

Overview of Output Files

As an overview, TIDE² can be used to produce three types of output files at the end of every session. The first file provides a summary of several important objective measures of group outcomes and processes. The second file provides a written record of every text message sent during the session. This includes the trial number, the source, the destination and time of every message. The third file converts almost every keystroke made during the sessions into a quantitative file in SPSS format.

The output data are stored and compiled on a number of different files, each of which will be described in detail below. As an overview, each team produces four raw data files, one for each station. Before using TEAMSTAT to create the three files described above, these four raw data files need to be merged into one file, and sorted. The files are combined via a program called RENLOG2, and they are sorted via a program called TEAMSORT. Both RENLOG2 and TEAMSORT are run automatically at the end of an experimental session (i.e., they do not need to be invoked explicitly by the experimenter). At this point, the file has the name:

xxxyyzzz.CS

where xxx refers to the group number, yy refers to the session number, and zzz refers to the experiment number. CS is a designation that indicates that the file has been combined and sorted. Once the output from the simulation is in this form, TEAMSTAT can be used to generate the summary file (i.e., xxxyyzzz.SUM), the message file (i.e., xxxyyzzz.MSG), and the data analysis file (i.e., xxxyyzzz.SPS). These are all described below.

Choosing an Output File From TEAMSTAT

When an experimental session is over, an autoexec file automatically creates the xxxyyzzz.CS file. To create the xxxyyzzz.SUM, xxxyyzzz.MSG, xxxyyzzz.SPS files you need to run TEAMSTAT. To invoke this program type "TEAMSTAT" and hit RETURN. You will be prompted with the screen shown in Exhibit 24. At this point, you simply enter the hot key associated with the type of file that you would like to create with TEAMSTAT (i.e., .SUM, .MSG, .SPS), and then hit RETURN. Another screen appears prompting you for the input file. Enter the input file name (i.e., xxxyyzzz.CS)

and then hit RETURN. A third screen appears during processing of the data which confirms which file is being created, and where the program is in the process. When this program is completed, you are returned to the screen shown in Exhibit 24.

Insert Exhibit 24 here

xxxzyzzz.SUM: Objective Measures of Group Outcomes and Processes. Exhibit 25 shows a portion of the typical output file derived from TEAMSTAT program after generating a xxxzyzzz.SUM file. This file provides a quick overview of the major outcomes and processes associated with that team's experience during the experimental session. We will walk through each section of the file highlighting the meaning of the information provided.

Insert Exhibit 25 here

At the top left portion of the screen, one can see the number of the trial that is being summarized. So in Exhibit 25, we see summaries for specific Trials #18 and #19, as well as one total summary for all 19 games that made up that experimental session.

Let's first examine the output associated with the 18th trial, that is printed on the top portion of the exhibit. Just under the Trial number, information is provided on how much time the team had during that trial, in this case, 210 seconds. Just under this is the "Correct Decision" for the target, which in this case was 1, which stands for Ignore (2 is Review, 3 is Monitor, etc.). Just to the right of this is the team's outcome associated with this target, which happened to be a Near Miss.

In the next section of the screen, information is provided for each of the four team members. This information is arrayed in four major columns, each of which has several sub-columns. The major columns are for the Carrier, CAD, AWACs and Cruiser roles.

Looking first at the Carrier, one sees that his or her judgment (which is the Team's official judgment) was a "2" (i.e., a Review). Since we know already that the "Correct Decision" for this target was a "1" (i.e., an Ignore) we see that the team was 1 point off in their judgment, which is why the outcome was a NEAR MISS. Just below the judgment line, we can also see the time at which this judgment was rendered -- 205 seconds. Since we know already that there was 210 seconds in the total trial, this means that the Carrier rendered its decision with only five seconds remaining in the trial.

Moving across the columns, we see the same types of information arrayed for the other three team members. The CAD, for example, also made a Review judgment, but the AWACs and Cruiser both said Ignore. The Cruiser got his or her recommendation in first (at 153 seconds), well ahead of the other stations which came in roughly 20 seconds prior to the end of the trial.

Below this information, we are provided with four tables where the communications between stations are quantified. To understand the information provided in these tables we must first describe the meaning attached to the labels on the rows. The first four of these will be self-evident, but the last 5 require some explanation.

The first row is labeled "Query," and the number in this cell tells how many times the person being reported on queried the person referred to by the number (where 1 is the Carrier, 2 is the CAD, 3 is the AWACs and 4 is the Cruiser). This table shows that the Carrier did not "Query" anyone during this trial, nor did the CAD or the Cruiser. In fact, the only "Query" sent during this trial was from the AWACs who sent this to "2," that is, the CAD.

The second row is labeled "Receive" and this number tells how many different queries, transmissions or messages the person being described received during the trial. Thus, in Trial 18, the Carrier received 9 messages, 3 from the CAD (i.e., Person 2), 5 from the AWACs (i.e., Person 3), and 1 from the Cruiser (i.e., Person 4). During the same trial, the CAD received 4 messages, 3 of which came from the Carrier, and 1 of which came from the AWACs.

The third row provides the number of transmissions that the person being described sent to various other team members. Thus, in Trial 18, the Carrier transmitted three times, one to each of the other team members. The CAD transmitted 4 pieces of information, 3 to the Carrier and 1 to the AWACs.

The fourth row gives the number of text messages sent between players. Thus, in Trial 18, the Carrier sent 7 text messages, 2 to CAD and AWACs and 3 to Cruiser. Moving over to the AWACs we see that he sent four messages, all of which went to the Carrier.

To understand the meaning attached to the remaining five rows, we must first depict the stages associated with a successful instance of communication between team members. Exhibit 26 depicts the behaviors that are required to have a question asked and then answered in this simulation. In the sequence depicted in Exhibit 26, the AWACs wants to find out the Speed of the target from the CAD unit. The first step (a) is to send a query from AWACs to CAD. In the second step, (b) this query must be received by CAD. In the third step, (c), the CAD must transmit the requested data on Speed to the AWACs. Finally, in the fourth step (d), the AWACs must then

receive this transmission from the CAD. This four step process thus completes the communication, and AWACs now knows the Speed of the target.

Insert Exhibit 26 here

TIDE² combines many of the behaviors reflected in this sequence into objective measures of team process. Returning back to Exhibit 25, for example, the fifth row refers to the number of "Slightings." A "Slighting," in terms of Exhibit 26 occurs when there is a step (a) but no step (b). For example, AWACs is slighted if he or she sends a query to CAD and CAD never bothers to look at it. There were no "Slightings" in Trial 18, but if one looks at Trial 19, one sees that the AWACs was slighted twice, once by the CAD and once by the Cruiser.

Row six in the table displayed in Exhibit 25 reports the number of "Unresponsives." In terms of Exhibit 26, an "Unresponsive" behavior occurs when there is a step (a) and (b), but no step (c). For example, the CAD is unresponsive if he or she receives a query from the AWACs but then never bothers to send the AWACs the information requested. In Trial 19 there were a couple of instances of unresponsive behavior. On one occasion, the AWACs was unresponsive to the Carrier, and on a different occasion, the CAD was unresponsive to the AWACs.

Row seven of the table displayed in Exhibit 25 reports the number of "Forgets." In terms of Exhibit 26, a "Forget" occurs when there is a step (a), (b), and (c), but no step (d). For example, the CAD would register a "Forget" if he or she asked for Speed from the AWACs, and then the AWACs sent Speed to him or her, but the CAD never bothered to receive it. As is apparent in Exhibit 25. There were no "Forgets" in either Trial 18 or 19.

If the four step sequence is completed successfully, this is referred to as a "Learn," and the number of "Learns" that take place in the trial is recorded in the seventh row of the table shown in Exhibit 25. A "Learn" means that the person involved asked for and received the information that he or she requested. There were no actual "Learns" in Trials 18 and 19. It is worth noting that this is not atypical near the end of the trial. We often find that with experience and increased coordination, the teams make less use of this as a means of exchange and frequently use "Lectures" (described below) or text messages in the place of the less efficient, four step "Learn-ing" process.

In the eighth row, we also see the term "Lecture." In terms of Exhibit 26, a "Lecture" means that there was no Step (a) or (b) -- just steps (c) and (d). In other words, the AWACs might have never

requested Speed from the CAD, however, the CAD transmitted this information to the AWACs anyway, and the AWACs received it. Well-coordinated teams often use "Lectures" (for example, the AWACs might tell the CAD in a text message to 'Send me speed every time') as a means of moving information around quickly and efficiently. It is critical to note that the number in the table refers to the number of times the person being described "Lectured" others. It does not refer to the number of times he or she was "Lectured to." In Trial 18 we see that the Carrier gave three "Lectures," one to each member of the team. The CAD also gave 3 "Lectures," but all three of the lectures were directed at the Carrier.

Finally, the last row of the Table shown in Exhibit 25 is labeled "Summary." This portion of the table documents the attributes that the person knew at the time he or she rendered a judgement. As such, it is literally a snapshot of what this person's summary box looked like just prior to the decision. Thus, we can see that at the end of Trial 18 that the Carrier had information on seven attributes: IFF, Speed, Angle, Altitude, Size, Direction, and Corridor Status. At the end of Trial 19, the Carrier only had information on six attributes, all of those that he or she had in Trial 18, minus Direction.

Along with trial by trial results, the xxxyyzzz.SUM program provides a summary table, shown at the bottom of Exhibit 25, which totals up the results associated with outcomes and processes across the whole experiment. Thus, we see that across the 19 trials, this team had 7 hits, 10 near misses, and 2 misses. We can see that across the whole experiment, the Carrier queried other team members 42 times, and that these were relatively evenly distributed (14, 13, and 15 to CAD, AWACs and Cruiser respectively). In terms of "Receiving" we can see from the next row that the CAD, received 73 messages, the bulk of which (52) came from the Carrier. In the next row we can see that the Cruiser sent 14 transmissions, most of which were sent to the Carrier (11). These quick, "eyeball" analyses of the sessions can be made for all the rows contained in the tables. This type of quick-read analysis is the purpose of xxxyyzzz.SUM. All the information presented here (and much more) is written, in a different format into xxxyyzzz.SPS where more fine grained data-analytic techniques can be brought to bear. The data analytic file, xxxyyzzz.SPS, will be discussed later.

xxxyyzzz.MSG: Flow and Content of Text Messages. A second type of output from TIDE² provides an avenue for examining the nature and content of the text message flow between group members. When team members are allowed to exchange text messages, a great deal of information that might otherwise have traveled through (and hence be captured by xxxyyzzz.SUM or xxxyyzzz.SPS) the query, transmit and receive functions are instead sent through the text function. If this happens a great deal, then the information provided in the Summary tables of xxxyyzzz.SUM can be somewhat

misleading.

The reason for this is that information on target attributes sent through the "Text message" function will not be picked up in the summary boxes associated with xxxyyzzz.SUM. Thus, if the Carrier asks AWACs for Speed and then the AWACs responds via a text message (saying verbally that Speed is "723 mph" or "speed is very fast" or "speed -- bad" this text message is not recognized as a transmission. Therefore, xxxyyzzz.SUM will not indicate that the carrier knew Speed, when in fact he or she might have either known it precisely or had a general idea of its degree of threat on this attribute. The xxxyyzzz.SUM file might also record this as "unresponsive" on AWACs' part for lack of an explicit transmission on Speed, when in fact AWACs did fulfill the Carrier's request.

Thus, one must either turn off the text message option in TIDE², or be ready to content analyze text messages that are sent via this mode. Sample output from xxxyyzzz.MSG is shown in Exhibit 27.

Insert Exhibit 27 about here

The M merely indicates that a message was documented. The first number to the right of this indicates the trial during which the message was sent. Thus, from Exhibit 27 we see that there were 24 total messages, 4 of which came in the first trial, 0 during the second, 1 during the third, and so on. After the Trial number are two numbers that specify where the text originated and where it was sent. Thus, the first message went from Carrier to CAD, the second message went from AWAC to the Carrier, the third message went from Cruiser to the AWAC, and so on. The number to the right of this tells how much time was remaining in the trial when the message was sent. Thus, the first message occurred with 140 seconds left, the second message occurred with 139 seconds left, the third message was sent with 130 seconds left, and so on. Finally, the text string printed at the end reiterates the sender's name, and provides the full text message.

One means for content analyzing these messages is provided below. This is not the only way, but it is one method that we find useful. In this method, each message is coded using the decision tree shown in Exhibit 28.

Insert Exhibit 28 here

As an overview, the researcher using this method of content analysis needs to make several determinations (i.e., answer several questions) regarding each text message. The first determination to

be made in coding text messages with this decision tree deals with whether the message is "task-related OR socio-emotional" in nature. If it is socio-emotional, the message is coded as 1. If the message is judged to be task oriented, a determination is then made as to whether the person was "seeking OR providing" task-related information. After this, one then asks whether the message dealt with the "specific target at hand OR generic roles/rules" type of information. If the message deals with rules/roles then it is coded 2 if it was seeking information and coded 3 if it was providing information.

If the message dealt with information on a specific target, then one asks whether the information was "transmittable OR not transmittable". In this context, "transmittable" simply means whether this specific text message could have been handled via either the query or transmit function. For example, the text message "what is the speed of this one," might be sent by someone seeking information on the target. This question could have been handled with a query, and was therefore "transmittable." Information-seeking requests that are transmittable are coded 4. If someone answered this by sending the text message "speed is 725 mph," this too was transmittable. Information-providing text messages that were transmittable are coded 6. In general, transmittable target information is distinguished by the fact that it deals with raw data, and therefore could be handled with the query and transmission functions.

On the other hand, text messages could deal with characteristics of the target that are non-transmittable, in that they request an interpretation concerning the raw data, rather than a simple relay of the raw data. So for example, the information-seeking text message "Is this one threatening on Speed?" and the corresponding information-providing text message, "This one is very threatening on Speed" represents "non-transmittable" target specific information. Information-seeking text messages that are non-transmittable are coded 5. Information-providing text messages that are non-transmittable are coded 7.

Thus, in summary, a message is coded 1 if it is non-task related. Codes 2 and 3 are reserved for text messages that are either seeking or providing information on generic rules/roles. Codes 4 through 7 are reserved for text messages that either seek or provide information on the specific target being evaluated at that time. Codes 4 and 6 are for transmittable type exchanges, whereas 5 and 7 are for non-transmittable type exchanges.

In some cases it might be useful to extend the coding of 4 through 7 one more step. Specifically, it might be useful to code the number of the attribute on which information was exchanged. So for example, a message coded 6, might be extended and coded 6-1 if it dealt with Speed, 6-2 if it dealt with Altitude, 6-3 if it dealt

with Size, and so on. Extending the coding in this manner will allow the researcher to accurately augment the summary information provided in the xxxyyzzz.SUM output file. That is, the summary indicates what the person learned about the target through the Measure, Query and Transmission functions, and extended text message coding indicates what the person knew about the target through text messages. Since these are all the means of collecting information on the target, this provides a complete picture of what information the person had at the end of the trial.

Exhibit 29 shows how this coding scheme could be applied to ten different messages. The purpose of this explanation is not to advocate the particular coding scheme. Clearly, many other coding schemes could be developed for many purposes. Rather, our purpose was to show the richness of the text data and the fact that these

data can then be coded into variables that have some theoretical relevance. How this coding is done depends on the particular investigation.

Insert Exhibit 29 here

xxxyyzzz.SPS: Data Analysis Output File. The third and final output file from TIDE² is the data file that is prepared to be processed using SPSS. This file has a generic form so that there are five lines per trial. The first line provides data on the target. The remaining four lines provide data for each subject, (i.e., Carrier, CAD, AWACs and Cruiser). The last four lines are 537 characters long, and include almost everything that the person did in the trial, and when he or she did it.

Thus, there are five lines of data for each trial. Since there are almost always multiple trials in experiments, for each experiment, there are usually x lines of data where x equals the number of trials times five. So for example, a team with 20 trials will have a data set that is 100 lines long where each line has 537 characters.

In addition, since there are almost always multiple groups in an experiment, there are typically y lines of data for the entire experiment, where y equals the number of groups times the number of trials times five. Thus, a study where 40 groups engage in 20 trials generates a data file that is 4,000 lines long, with each line having 537 characters.

Any single experimenter will probably be interested in a only portion of the variables captured in the 537 character line. TIDE² was developed to be as flexible as possible, however. Thus, this data file creation program errs on the side of over-inclusion

so that it will fit the needs of most users.

Exhibit 30 shows how the data from the simulation is arrayed. Line 1 contains information on the groups identification, the trial and the true score, and the target attributes. The remaining four lines are devoted to individual players, and all have a parallel structure. In this structure, the data is arrayed in the following blocks:

Insert Exhibit 30 here

- (a) what the subject measured (and when),
- (b) who asked whom what (and when),
- (c) who transmitted what to whom (and when),
- (d) who sent text messages to whom (and when),
- (e) who received queries about what from whom (and when),
- (f) who received what transmissions from whom (and when),
- (g) who received messages from who (and when),
- (h) what the subject knew about the target at three different times in the trial (as indexed through the Summary box)
- (i) what the subject's decision was (and when it was registered)
- (j) the number of slights, unresponsives, forgets, learns and lectures experienced by the subject
- (k) whether the subject knew both parts of any or all of the possible combination rules

Types of Analyses Available From xxxyyzzz.SPS

There are many conventional analyses in the groups and decision making literatures that are easily run off the xxxyyzzz.SPS file. We will quickly list some of the major ones below.

Judgment Accuracy

One of the critical dependent variables in either individual decision-making or team decision-making is the accuracy of judgments. Accuracy is typically operationalized as the absolute difference between the team/individual decision and the true score. This can be calculated by combining the measures from line 1 with those from (i) above. Accuracy is also sometimes operationalized by the correlation over multiple trials between the decision and the true score. This too can be calculated with information from line 1 and (i) correlated over multiple trials. Other variables can then be related to accuracy to test theories about the effects of various kinds of independent variables or process variables on decision-making accuracy.

Policy Capturing of Raw Data

Another widespread practice in the decision-making literature is to conduct policy-capturing research. In policy capturing studies, the influence of various aspects of the target are regressed on actual decisions to determine empirically what information is driving decisions. This can be accomplished off of xxxyyzzz.SPS in a variety of ways.

First, one can policy capture the decisions of team members by regressing their judgments on raw target attributes. Therefore, one would regress the decisions provided in (i) on the attribute information given in line 1, or the known characteristics of the target given in (h).

Second, one could policy capture the decision of the leader in terms of the summary recommendations of the other players. Here, one regresses the leaders decision, given in (i) on the second line, with the recommendations of other team members given in section (i) of lines 3, 4 and 5.

Process Tracing of Information Search

Another common analysis in the decision-making literature deals with process tracing. In process tracing, the experimenter attempts to capture the information seeking processes of participants, in terms of what information was sought, from whom, and at what time (e.g., Ford, Schmitt, Schechtman, Hults, & Doherty, 1989). This can be accomplished by examining the timing of various information requests and transitions. Specifically, this calls for an analysis of (a), (b), and (d).

Process tracing and policy capturing come together in studies that examine primacy and recency effects. That is, priming and recency studies look at the differential impact of various pieces of information on decisions, as affected by the order or timing of information acquisition. Primacy studies focus on the effects of early information, and recency studies focus on the effects of information that comes in late. Here, one would examine the relationship between the information received in (a), (e), (f), and (g) with (i).

Sociograms of Communication Flows

In the groups literature, sociograms are used to provide a picture of the communication channels that develop in groups. That is, they attempt to generate quantitative indices of who talks to whom with what frequency. These can also be generated from xxxyyzzz.SPS through an examination of the data in section (b), (c), and (d).

System Requirements for TIDE²

TIDE² requires a minimal amount of hardware and software. Almost any IBM compatible system can run TIDE² and almost any networking system can be employed. All of the software can reside on a single double density 5 1/4 inch floppy disk.

Hardware

TIDE² can be run on 1 to 4 IBM compatible computers. If one is using the One Player only version of TIDE² one can use almost any IBM compatible computer. On the other hand, if one is going to use a team version of TIDE², we strongly recommend that at least one of the computers in the four person configuration have a 386 processor. In reality, the team version of TIDE² actually resides on only one computer in the dedicated network, which acts as a server to the other computers. The team version of the program places a high demand on the server, and lesser processors will react too slowly when participants are engaged in the simulation. This slowness in response is of such a magnitude, that it significantly influences participants behaviors and attitudes. The other machines can have a 286 processor with no significant loss of access time.

Software

There are two sets of required software for running TIDE². The first set is generic software that deals with the basic operating environment and the network. In terms of the basic operating environment, TIDE² requires DOS 4.01 or higher. In terms of networking software, almost any microcomputing network software will work, although LANTASTIC was the specific software used in developing the program.

The second set of required software is TIDE² specific. TIDE² is basically a set of programs that generate the simulation and captures the data. There are 10 files which include:

- (a) TERM.INI -- This identifies each computer terminal with a role in the simulation (i.e., Carrier, CAD, etc.).
- (b) TEAM??.INI -- This file contains the targets created in the "session to create or maintain targets" part of TEAMSET (see Exhibit 13). The question marks represent the number of the session being created and saved. Thus, in an experiment that has participants return for three sessions, the three sets of targets they respond to might be labeled TEAM01.INI, TEAM02.INI, and TEAM03.INI.

(c) TEAMDEMO.EXE -- This program constitutes the simulation itself. In the default version of the simulation, typing in TEAMDEMO and then hitting return initiates the simulation.

(d) TEAMDEMO.WGT -- This program contains the basic parameters for TEAMDEMO.EXE. These are set in the "modify weights and values" part of TEAMSET (see Exhibit 16a and 16b). In the default version of TIDE² the specific file labeled TEAMDEMO.WGT contains the parameters associated with the default version of the simulation. If you wish to generate a different set of parameters you can label this new set anything you would like, so long as you conform to the .WGT suffix. For example, you could label the first variation of the default as "VARIANT1.WGT."

(e) TEAMSET.EXE -- This program is used to either "create and maintain targets" and "modify weights and values." In other words, this is the file to execute if one wishes to create a TEAM??.INI file or a ????????.WGT file.

(f) SETCLCK.BAT -- This BAT file synchronizes the computer clocks between trials to insure accurate recording of time in the output file. Without this file, clocks drift apart over time, that is, one computer's clock may read 55 seconds left, while another's might read 65 seconds left. This creates significant problems for both the experimenter (in sorting files) and the participants (in coordinating their actions).

(g) RENLOG2 -- The immediate output of the simulation is four raw data files. These raw data files are labeled TEAM1.LOG, TEAM2.LOG, TEAM3.LOG and TEAM4.LOG where the number refers to the position (i.e., 1 for Carrier, 2 for CAD, etc). RENLOG2 merges these into a single file organized by position. When finished, RENLOG2 automatically initiates TEAMSORT.EXE, which is discussed next.

(h) TEAMSORT.EXE -- TEAMSORT.EXE takes the files merged by RENLOG2 and then sorts them by game and time remaining within the game. When TEAMSORT.EXE is finished, a new file called xxxyyzzz.CS is created. The CS stands for combined and sorted, and the xxx refers to the group number, yy refers to the session number, and zzz refers to the experiment number. This CS file is then ready for data-analytic processing by TEAMSTAT.EXE, which is discussed below.

(i) TEAMSTAT.EXE -- This is a program that converts the xxxyyzzz.CS file into xxxyyzzz.MSG, xxxyyzzz.SUM, and xxxyyzzz.SPS files. The three latter files are discussed in detail in an earlier section "Output from TIDE²."

(j) T.BAT -- This program creates a prompt that states "Type

t to start TEAMDEMO." When t is then typed, this initiates TEAMDEMO. The experimenter then enters ???????.WGT, Group Number, Session Number, and Experiment Number, then hits return, and then the TIDE² Logo Screen appears. From here, all one needs to do is hit RETURN to start the simulation.

This is entered only at the server computer (i.e., the default is the Carrier). The other computers, simply require the "t" to be entered.

If the server goes down (i.e., the Carrier), the experimenter needs to hit "SHIFT F1" on the other computers. SHIFT F1 turns off the simulation and returns the computers to the C prompt. At the server, the experimenter should type in "T2" and then hit RETURN. Here the experimenter needs to re-enter the ???????.WGT, Group Number, Session Number, and Experiment Number and then hit RETURN. This takes you back to the TIDE² Logo Screen. When the server is back to the Logo Screen, the experimenter should then type "T" on each of the other computers and then hit RETURN. When all of the computers are at the TIDE² Logo Screen, you are ready to re-enter the simulation. This program allows you to enter a session at a specific game. To do this, type "G" (note that this must be a CAPITAL G -- a lower case g will not work) and then hit RETURN. The program will prompt you with "What trial number." At this point, enter the trial number immediately after the trial number where the simulation crashed and then hit return. All four computers will re-enter the simulation at the specified trial. Unfortunately, the data from the trial where the computer crashed will probably not be complete (because the trial was cut short by the crash). This should be recoded as "missing data" when analyzing xxxyyzzz.SPS.

If one of the outlying position crashes, the procedure is much simpler. Just type "T" and then hit RETURN. The person at this position will be taken back to the TIDE² Logo Screen. The person will remain at this screen, until the current trial is finished. When the next trial starts, the person on the crashed computer will then re-enter at the same point where his or her teammates are. Again, the trial where the program crashed will have to be treated as "missing data" for this one subject (not the whole team).

Access to Software

The software for TIDE² was written by Anders Johanson of the Applications Services at Michigan State University according to the requirements generated by the authors. Version 1.0 of TIDE² is as described in this report. Copies of the disk containing the TIDE² software as described here are available for a small fee from the

authors (this excludes DOS and the network software). At the time of this printing the fee was \$25.00 to cover the costs of the report, disk, shipping, and handling. This fee can be waived in some instances.

References to this task in future work should cite this report.

Finally, we cannot take responsibility for the use of the task by others or guarantee the programs performance on other systems.

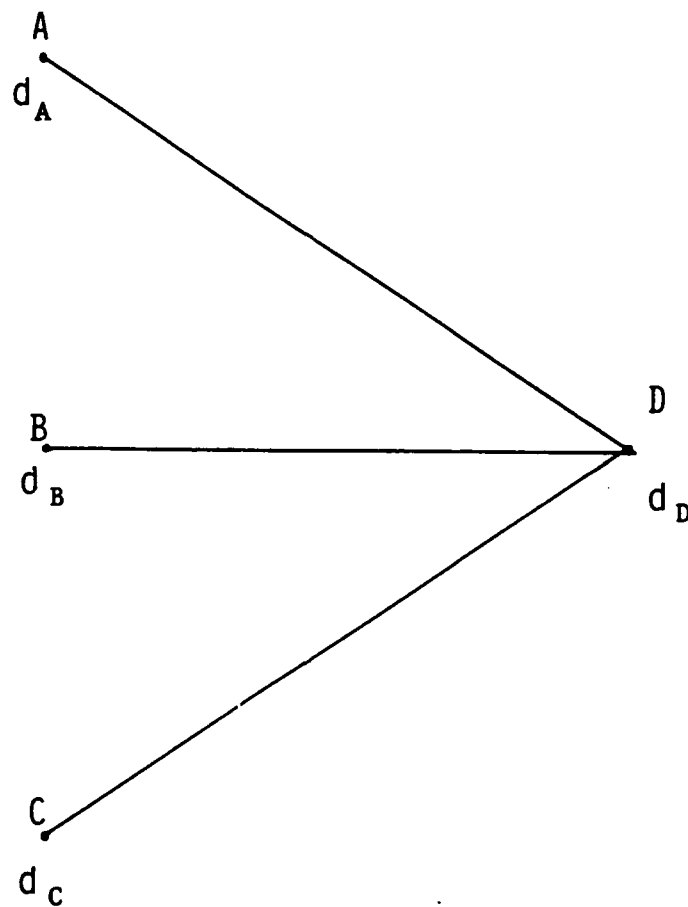
References

- Ford, J.K., Schmitt, N., Schechtman, S.L., Hults, B.M., & Doherty, M.L. (1989). Process tracing methods: Contributions, problems and neglected research questions. Organizational Behavior and Human Decision Processes, 43, 58-74.
- Foushee, H.C. (1987). Dyads and triads at 35,000. American Psychologist, 37, 85-94.
- Hammond, K.R. & Summers, D.A. (1972). Cognitive control. Psychological Review, 79, 58-67.
- Hollenbeck, J.R., Segó, D., Ilgen, D.R. & Major, D.A. (1991). Construct validation of objective measures of team performance and process derived from a networked simulation. Unpublished manuscript.
- Hollenbeck, J.R. & Whitener, E.M. (1988). Reclaiming personality traits for personnel selection: Self-esteem as an illustrative case. Journal of Management, 14, 81-91.
- Ilgen, D.R., Major, D.A., Hollenbeck, J.R. & Segó, D. (1991a). Team research in the 1990's. In M. Chemers and R. Ayman (Eds.), Leadership and Organizational Effectiveness. New York: Academic Press.
- Ilgen, D.R., Major, D.A., Hollenbeck, J.R., & Segó, D. (1991b). Decision making in teams: A levels perspective on an individual decision making analog. In R. Guzzo and E. Salas (Eds.), Team Decision Making in Organizations. San Francisco: Jossey Bass.
- Lord, R.G. (1985). An information processing approach to social perceptions, leadership and behavioral measurement in organizations. In B.M. Staw & L.L. Cummings (Eds.), Research in organizational behavior (Volume 7, pp. 87-128. Greenwich, CT: JAI Press.
- McGrath, J.E. (1976). Stress and behavior in organizations. In M.D. Dunnette (Ed.), Handbook of Industrial/Organizational Psychology. Chicago: Rand McNally.
- McGrath, J.E. (1984). Groups: Interaction and Performance. Englewood Cliffs, NJ: Prentice Hall.
- Nunnally, J. (1978). Psychometric Theory. New York: McGraw Hill.

Stevenson, M.K., Busemeyer, J.R., & Naylor, J.C. (1990). Judgment and decision-making. In M.D. Dunnette and L.M. Hough (Eds.) Handbook of Industrial/Organizational Psychology, Second Edition, (Volume 2, pp. 283-382). Palo Alto, CA.: Consulting Psychologist Press.

Wood, R. (1986). Task complexity: Definition of a construct. Organizational Behavior and Human Decision Processes, 37, 60-82.

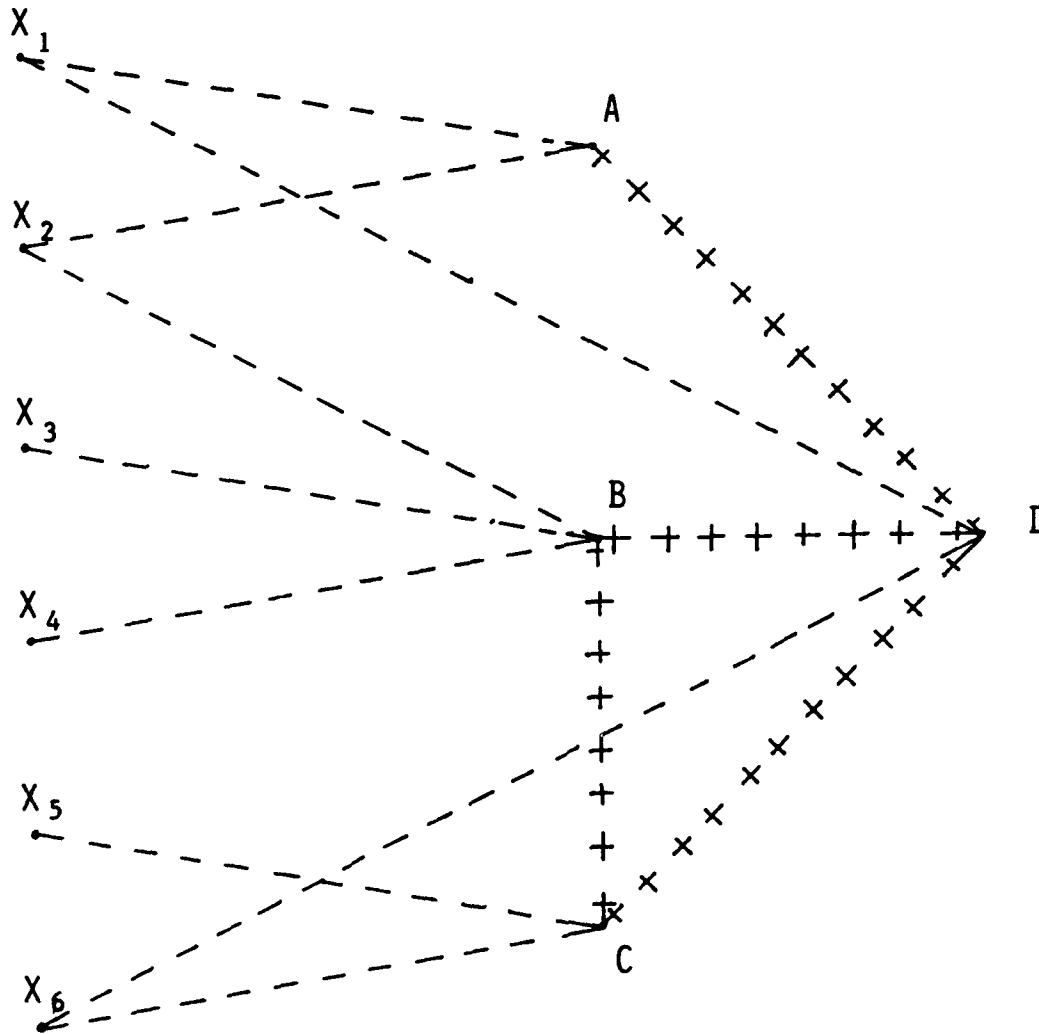
Exhibit 1a. Illustration of a Hierarchical Decision Making Team.



A, B, C, & D are Team Members

d_A , d_B , d_C , and d_D are Team Member Decisions

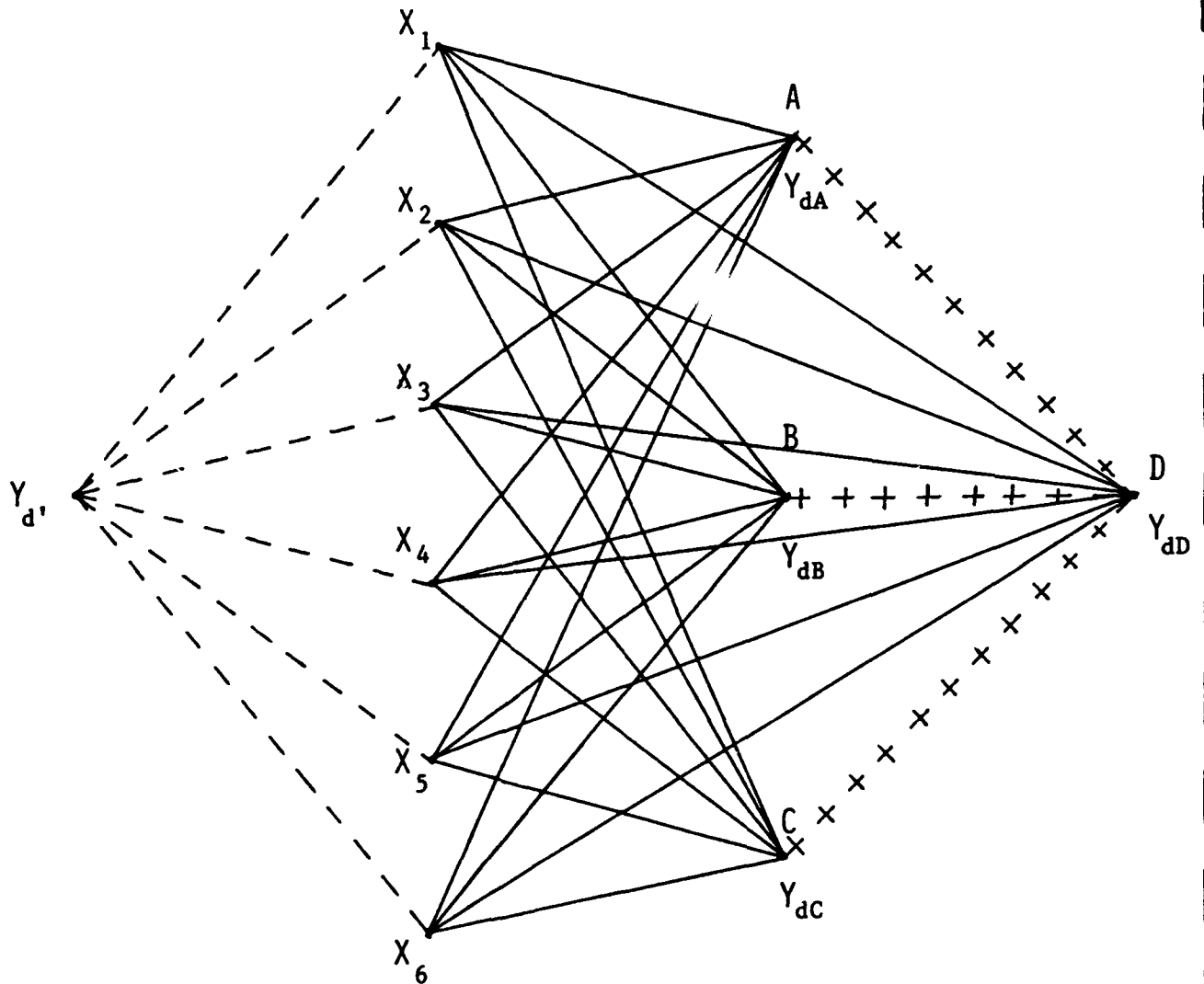
Exhibit 1b. Illustrative Information Distribution and Communication Structure in a Hierarchical Decision Making Team with Distributed Expertise.



Key

- X_i = Cues (Units of Information)
- A, B, C & D = Persons (Team Members)
- = Direct Links to Cues
- +++++++ = Interpersonal Communication Paths

Exhibit 1c. The Utilization of Information and Team Member Recommendations in the Hierarchical Decision Making Team with Distributed Expertise.



Key

- $Y_{d'}$ = Decision Based on a priori Model
- X_i = Cues (Units of Information)
- A, B, C & D = Persons (Team Members)
- Y_{dA} , Y_{dB} , Y_{dC} = Recommendations of Subordinate Team Members
- Y_{dD} = Team Leader Decision
- = Cue Validities in a priori Model
- = Cue Utilization by Team Members in Arriving at Recommendations
- +++++++ = Leaders Utilization of Team Members Recommendations in Leaders Decision

Exhibit 2. Initial TIDE² Scenario

INTRODUCTION

The year is 1994 and you are a part of a U.S. naval carrier groups's command and control team stationed in the Middle East. A regional conflict between two nations in this area has recently broken out, and your mission is to protect seagoing commercial traffic in the area from accidental or intentional attacks. As history indicates, this is a highly sensitive task. For example, in 1987, an Iraqi jet accidentally fired two Exocet missiles into the Frigate U.S.S. Stark, killing 37 American servicemen and crippling the vessel. One year later, the U.S.S. Cruiser Vincennes accidentally shot down an Iranian passenger plane killing 290 innocent civilians. Any repeat of mistakes of this kind will probably lead to a withdrawal of American forces from the area. Such a withdrawal would have disastrous economic and political ramifications that would spread well beyond this region.

THE TASK FORCE

A naval carrier battle group team is an awesome array of ships and support units. As shown on the cover of this handbook, it has a concentric ring of missile firing warships which protect the aircraft carrier at its center. The aircraft carrier, in return provides an overall umbrella of air protection for the entire task force. The carrier's 90 planes can unleash air strikes against targets at land, sea and even under water. A carrier group can dominate up to 196,000 square miles of Ocean. A standard carrier group consists of six ships; the Carrier itself, two Ticonderoga class Aegis Cruisers, two anti-air Destroyers, and a submarine.

A carrier group is also supported by AWACs reconnaissance planes and a land based Coastal Air Defense (CAD) unit. Although the Carrier itself is equipped with some air patrol capacities, the Cruisers, AWACs and CAD units provide the bulk of air traffic patrol. Taken together, the air patrol groups on the Carrier, the Cruiser, the AWACs and the CAD unit make up the command and control team.

Exhibit 2 continued

TEAM MISSION

The team of which you are a part, will role play the Commnading Officers of various units in the carrier group. Your mission is to monitor the air space surrounding the carrier group, making sure that neutral ships are not attacked. In performing this role, you must make certain that you do not allow loss of life resulting from accidental or intentional attacks on ships in the task force. At the same time, it is also of paramount importance that you do not inadvertently shoot down friendly military aircraft or any civilian aircraft. Many passenger flights move in and out of the region, and friendly military aircraft from nations not involved in the conflict also patrol the area. The navy can ill-afford any mistakes of either the Stark or Vincennes variety.

Exhibit 3. Overview of Roles in TIDE²

OVERVIEW OF ROLES

There are four roles in this simulation, one for each member of a four person team. The leader is the Commanding Officer (CO) of the Aircraft Carrier. The other team members include the CO of an AWACs air reconnaissance plane; the CO of an Aegis Cruiser, and the CO of a Coastal Air Defense (CAD) unit located on the mainland. The team's task is to decide what response the carrier group should make toward incoming air targets. Teams base their decisions on data they collect by measuring characteristics of aircraft that enter the group's airspace. These measures are obtained from sophisticated radar equipment. Aircraft that are being tracked on radar are called targets. There are seven possible choices to make for each incoming target. These responses are graded in terms of their aggressiveness. Each of these is described below, moving from least to most aggressive:

(1) **IGNORE:** This means that the carrier group should devote no further attention to the target, but instead should focus on other possible targets in the area. The group should never ignore a target that might possibly attack, for obvious reasons.

(2) **REVIEW.** This means to leave this target momentarily, so that the team can monitor other targets, but to return to this target after a short period of time to update its status. A carrier group can review a number of targets, but not an infinite number of targets.

(3) **MONITOR:** Here the carrier group should continuously track the target on radar. A carrier group can monitor fewer targets than it can review, and thus monitoring diminishes the groups overall patrol capacity.

(4) **WARN:** In this case the carrier group sends a message to the target identifying the group and alerting the target to steer clear. Warning targets that should be ignored detracts from the salience of legitimate warnings. Warning targets that intend to attack is also bad, since the warning makes it easier for the attacker to locate the ship.

(5) **READY:** This means to steer the ship into a defensive posture and to set defensive weapons on automatic. A ship in a readied position is rarely vulnerable to attack. This stance should not be taken to non-threatening targets since weapons set to automatic can fire mistakenly at innocent targets that fly too close to the carrier group. A ship in this position cannot readily use offensive weapons on the target.

Exhibit 3 continued

(6) **LOCK-ON:** This synchronizes the ship's radar and attack weapons so that the weapons fix themselves on the target. A ship at Lock-On position can use offensive weapons at a moments notice. A ship's capacity to track other targets is severely constrained once it has Locked-On a single target, however. Thus, this should be reserved for targets that are almost certain to be threatening.

(7) **DEFEND:** Defend is "weapons away." A defend decision cannot be aborted once initiated and thus must only be used when the group feels attack is imminent.

Exhibit 4. Target Attributes, Scales and Ranges

Characteristics of Targets

- (1) **Speed:** 150 to 800 mile per hour (mph)
- (2) **Altitude:** 5,000 to 35,000 feet
- (3) **Size:** 15 to 50 meters
- (4) **Angle:** -15 degrees (rapid descent) to +15 degrees (rapid ascent)
- (5) **IFF:** "Identification Friend or Foe." This is a radio signal that identifies whether an aircraft is civilian, para-military or military, ranging from .2 Mhz (an airliner) to 1.6Mhz (a fighter aircraft)
- (6) **Direction:** from +40 degrees (passing far to the east or west of the carrier) to 00 degrees (coming straight in to the carrier)
- (7) **Corridor Status:** a corridor is a 20 mile wide lane open to commercial air traffic, and this is expressed in terms of miles from the center of the corridor, ranging from 1 mile (in the middle of the corridor) to 50 miles (way outside the corridor)
- (8) **Radar Type:** the kind of radar possessed by the aircraft ranging from Class 1 (weather radar only) to Class 9 (weapons radar)
- (9) **Range:** distance of the aircraft from the carrier ranging anywhere from 20 to 200 miles

Exhibit 5. Determining Levels of Threat and Forming Judgments

DETERMINING THE LEVEL OF THREAT

In general, the degree to which an incoming target is threatening depends on its standing on the nine attributes. There are five simple rules to remember in determining the danger associated with any target:

- (a) all else equal, in terms of IFF, military targets are more threatening than civilian targets (see attribute #5)
- (b) SPEED and DIRECTION go together, so that fast targets coming straight in are most threatening (see #1 and #6 above). Speed alone and direction alone mean nothing. There is nothing to fear if fast targets are not headed toward the group. There is nothing to fear from slow objects headed directly for the group.
- (c) ANGLE and RANGE go together, so that descending targets that are close are especially threatening (see #4 and #9 above). Angle alone and range alone mean nothing. Descending targets that are far away, or close targets that are on the way up are not threatening.
- (d) ALTITUDE and CORRIDOR STATUS go together, so that low flying targets that are way outside the corridor are especially threatening (see #2 and #7 above). Altitude alone and corridor status alone mean nothing. There is nothing to fear from high flying targets well outside the corridor or low flying targets in the middle of the corridor.
- (e) SIZE and RADAR go together, so that small objects with weapons radar are especially threatening (see #3 and #8 above). There is nothing to fear from small targets with weather radar only or from large targets with weapons radar.

HOW RULES COMBINE TO DETERMINE JUDGMENTS

The five rules combine to determine the overall threat represented by the target. So for example, if the team detected a (a) military aircraft that is (b) flying in straight and fast, (c) was close and descending, (d) was flying low and way outside the corridor, and (e) was small and had weapons radar; the ship is being attacked and should DEFEND.

If the team detected (a) a civilian aircraft, that is (b) passing slow at an angle, (c) was far away and ascending, (d) was flying high and in the middle of the corridor and (e) was large and had weather radar; this is a passenger plane that should be IGNORED.

Exhibit 5 continued

Intermediate responses like MONITOR, WARN, or READY are to be used when the target is threatening according to some of the rules but not all. For example, a military aircraft that is close and descending (see rule c), small and with weapons radar (see rule e), but is traveling slowly at an angle to the group (see rule b), and is high and in the middle of the corridor (see rule d) might need to be WARNED. It should not be IGNORED, but neither should it be shot down.

Exhibit 6. Converting True Score Criterion Values to Correct Response Categories

| <u>CRITERION VALUES</u> | | <u>RESPONSE CATEGORIES</u> |
|-------------------------|-------|----------------------------|
| 00 - 02 | ----> | IGNORE |
| 03 - 05 | ----> | REVIEW |
| 06 - 08 | ----> | MONITOR |
| 09 - 11 | ----> | WARN |
| 12 - 14 | ----> | READY |
| 15 - 17 | ----> | LOCK-ON |
| 18 - 20 | ----> | DEFEND |

Exhibit 7. The Carrier's Specific Role

Role of Leader (Carrier). The Carrier is the leader who makes the team's final decision. The carrier can only measure and interpret three things: (1) Speed, (2) Angle, (3) Corridor Status. The range of values and degree of threat associated with each are shown below.

| | Degree of Threat | | |
|-----------------|------------------|----------------------|------------------|
| | Non-Threatening | Somewhat Threatening | Very Threatening |
| Speed | 100 - 275mph | 325 - 500mph | 600 - 800mph |
| Angle | +15 to +8 dgs | +3 to -3 dgs | -8 to -15 dgs |
| Corridor Status | 0 to 8 mi | 12 to 18 mi | 22 to 30 mi |

The leader is unique in knowing what the other units are experts in, however. The area of others' expertise is listed below:

| Unit Mbr / | Speed | Altit | Size | Angle | IFF | Direct | Corr.St. | Radar | Range |
|------------|-------|-------|------|-------|-----|--------|----------|-------|-------|
| Carrier | X | X | X | X | X | | | | |
| Members | | | | X | X | X | X | X | X |
| Observer | X | X | | | | | X | X | X |

Summary of How to Determine Threat Levels

all else equal, in terms of IFF, military targets are more threatening than civilian targets (see attribute #5)

SPEED and DIRECTION go together, so that fast targets coming straight are most threatening (see #1--#6 above). Speed alone and direction alone mean nothing. There is nothing to fear if fast targets are not headed toward the team. There is nothing to fear from objects headed directly for the team that are moving slowly.

ANGLE and RANGE go together, so that descending targets that are close especially threatening (see #4--#9) above. Angle alone and range alone mean nothing. Descending targets that are far away, or close gets that are on the way up are not threatening.

ALTITUDE and CORRIDOR STATUS go together, so that low flying targets that are way outside the corridor are especially threatening (see #2--#7 above). Altitude alone and corridor status alone mean nothing. There is nothing to fear from high flying targets well outside the corridor or low flying targets in the middle of the corridor. ***

Exhibit 7 continued

(e) SIZE and RADAR go together, so that small objects with weapons radar are especially threatening (see #3--#8 above). There is nothing to fear from small targets with weather radar only or from large targets with weapons radar.

*** Carrier must memorize this rule!!

hibit 8. The CAD's Specific Role

Our Specific Role

Role of Land Platform (CAD). The Coastal Air Defense (CAD) unit is a specialist in the measurement and interpretation of five target attributes: (1) speed, (2) altitude, (3) size, (4) angle, and (5) IFF.

The range of values and degree of threat associated with each are shown below.

| | Degree of Threat | | |
|----------|------------------|----------------------|------------------|
| | Non-Threatening | Somewhat Threatening | Very Threatening |
| Speed | 100 - 275mph | 325 - 500mph | 600 - 800mph |
| Altitude | 35,000-27,000ft | 23,000ft-17,000ft | 13,000ft-5,000ft |
| Size | 65 - 43 mtr | 37 - 23 mtr | 17 - 10 mtr |
| Angle | +15 to +8 dgs | +3 to -3 dgs | -8 to -15 dgs |
| IFF | .2 to .6Mhz | .9 to 1.1Mhz | 1.4 to 1.8Mhz |

Summary of How to Determine Threat Levels

If all else equal, in terms of IFF, military targets are more threatening than civilian targets (see attribute #5)

(b) SPEED and DIRECTION go together, so that fast targets coming straight in are most threatening (see #1--#6 above). Speed alone and direction alone mean nothing. There is nothing to fear if fast targets are not headed toward the teams. There is nothing to fear from objects headed directly for the teams that are moving slowly.

ANGLE and RANGE go together, so that descending targets that are close are especially threatening (see #4--#9) above. Angle alone and range alone mean nothing. Descending targets that are far away, or close targets that are on the way up are not threatening.

ALTITUDE and CORRIDOR STATUS go together, so that low flying targets that are way outside the corridor are especially threatening (see #2--#7 above). Altitude alone and corridor status alone mean nothing. There is nothing to fear from high flying targets well outside the corridor or low flying targets in the middle of the corridor.

SIZE and RADAR go together, so that small objects with weapons radar are especially threatening (see #3--#8 above). There is nothing to fear from small targets with weather radar only or from large targets with weapons radar.

CAD must memorize this rule!!

Exhibit 9. The AWAC's Specific Role

Role of Air Platform (AWACs). The AWACs unit is a specialist in the measurement and interpretation of five target attributes: (1) angle, (2) IFF, (3) direction, (4) Corridor status, and Radar Type

The range of values and degree of threat associated with each are shown below.

| | Degree of Threat | | |
|-------------|------------------|----------------------|------------------|
| | Non-Threatening | Somewhat Threatening | Very Threatening |
| Angle | +8 to +15 dgs | +3 to -3 dgs | -8 to -15 dgs |
| IFF | .2 to .6Mhz | .9 to 1.1Mhz | 1.4 to 1.8Mhz |
| Direction | 30 to 22 dgs | 18 to 12 dgs | 08 to 00 dgs |
| Corridor St | 0 to 8 mi | 12 to 18 mi | 22 to 30 mi |
| Radar Type | Class 1 & 2 | Class 5 | Class 8 & 9 |

Summary of How to Determine Threat Levels

(a) all else equal, in terms of IFF, military targets are more threatening than civilian targets (see attribute #5)

(b) SPEED and DIRECTION go together, so that fast targets coming straight in are most threatening (see #1--#6 above). Speed alone and direction alone mean nothing. There is nothing to fear if fast targets are not headed toward the teams. There is nothing to fear from objects headed directly for the teams that are moving slowly.

*** (c) ANGLE and RANGE go together, so that descending targets that are close are especially threatening (see #4--#9) above. Angle alone and range alone mean nothing. Descending targets that are far away, or close targets that are on the way up are not threatening.

(d) ALTITUDE and CORRIDOR STATUS go together, so that low flying targets that are way outside the corridor are especially threatening (see #2--#7 above). Altitude alone and corridor status alone mean nothing. There is nothing to fear from high flying targets well outside the corridor or low flying targets in the middle of the corridor.

(e) SIZE and RADAR go together, so that small objects with weapons radar are especially threatening (see #3--#8 above). There is nothing to fear from small targets with weather radar only or from large targets with weapons radar.

*** AWACs must memorize this rule!!

bit 10. The Cruiser's Specific Role

of Sea Platform (Cruiser). The Aegis Cruiser is a specialist in the measurement and interpretation of five target attributes: (1) Corridor Status, (2) Radar Type, (3) Range, (4) Speed, and (5) Altitude.

range of values and degree of threat associated with each are shown below.

| | Degree of Threat | | |
|-----------------|------------------------|-----------------------------|-------------------------|
| | <u>Non-Threatening</u> | <u>Somewhat Threatening</u> | <u>Very Threatening</u> |
| Corridor Status | 0 to 8 mi | 12 to 18 mi | 22 to 30 mi |
| Radar Type | Class 1 & 2 | Class 5 | Class 8 & 9 |
| Range | 200 to 110 mi | 90 - 60 mi | 40 to 1 mi |
| Speed | 100 - 275mph | 325 - 500mph | 600 - 800mph |
| Altitude | 27,000-35,000ft | 17,000ft-23,000ft | 5,000ft-13,000ft |

Summary of How to Determine Threat Levels

all else equal, in terms of IFF, military targets are more threatening than civilian targets (see attribute #5)

SPEED and DIRECTION go together, so that fast targets coming straight are most threatening (see #1--#6 above). Speed alone and direction alone mean nothing. There is nothing to fear if fast targets are not headed toward the teams. There is nothing to fear from objects headed directly for the teams that are moving slowly.

ANGLE and RANGE go together, so that descending targets that are close are especially threatening (see #4--#9) above. Angle alone and range alone mean nothing. Descending targets that are far away, or close targets that are on the way up are not threatening.

ALTITUDE and CORRIDOR STATUS go together, so that low flying targets that are way outside the corridor are especially threatening (see #2--#7) above. Altitude alone and corridor status alone mean nothing. There is nothing to fear from high flying targets well outside the corridor or low flying targets in the middle of the corridor.

(e) SIZE and RADAR go together, so that small objects with weapons are especially threatening (see #3--#8 above). There is nothing to fear from small targets with weather radar only or from large targets with weapons radar.

Cruiser must memorize this rule!!

Exhibit 11. The Sea Screen

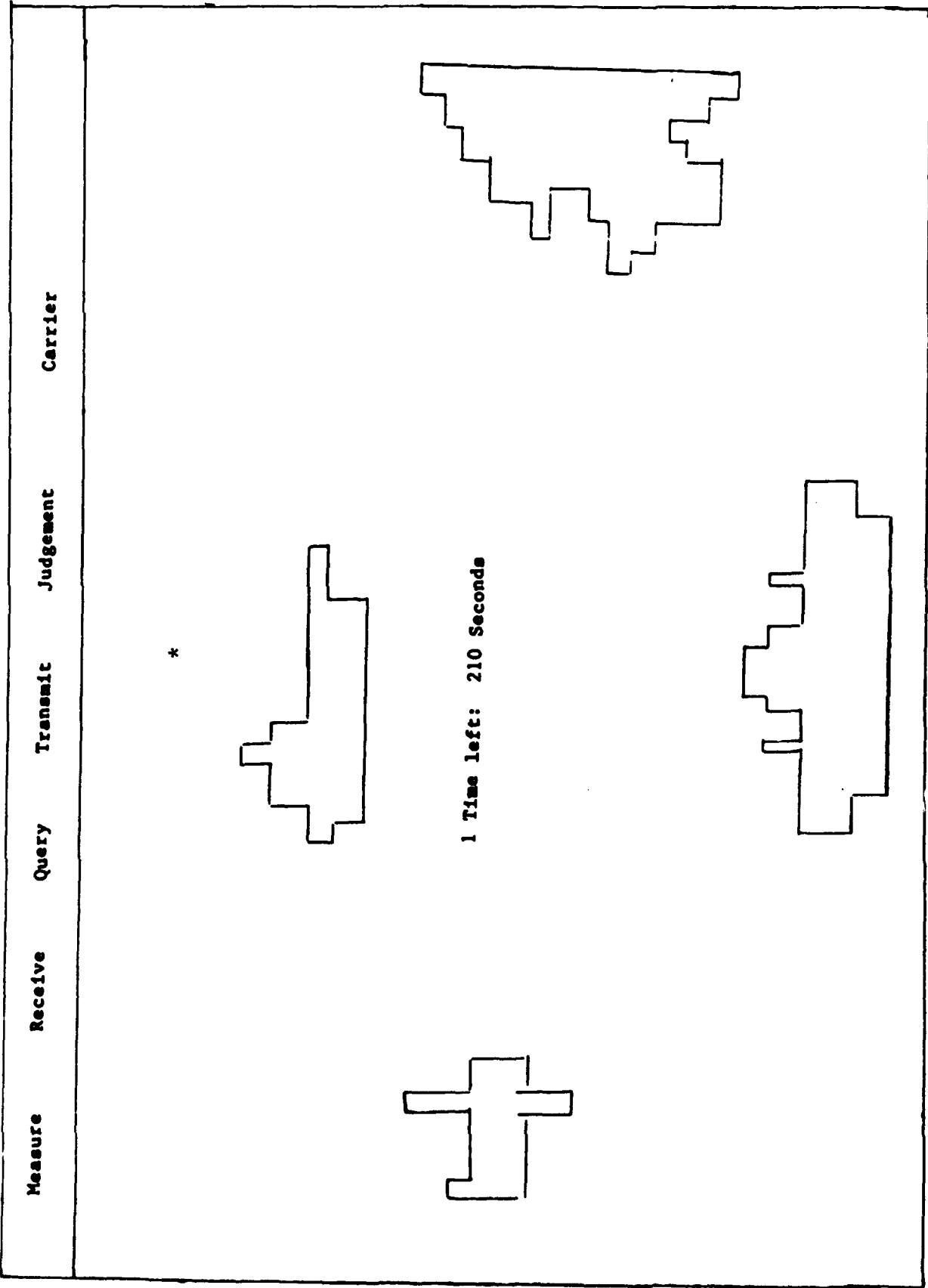


Exhibit 12. The Feedback Screen

| Measure | Receive | Query | Transmit | Judgement | Carrier |
|---------------------------------------|---------|-------|----------|--------------------------|---------|
| TEAM DECISION | Ignore | --- | --- | | |
| CORRECT DECISION | Monitor | ---/ | MISS | | |
| Station Judgements | | | | | |
| Performance History | | | | | |
| Cruiser | No Call | | | Number of Encounters = 5 | |
| AWACS | Ignore | | | Hits = 3 | |
| CAD | Warn | | | Near Misses = 1 | |
| | | | | Misses = 1 | |
| | | | | Incidents = 0 | |
| | | | | Disasters = 0 | |
| Goal = 20, Total = 7, Projection = 28 | | | | | |

Exhibit 13. The TEAMSET Initial Menu Screen

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TEAMSET V011791 TEAMDEMO Modify Weights & Values or Sessions

W to modify Weights & Values

of Session to maintain

E to end program

Your choice?

Exhibit 15. Sample Configurations of Targets

| | (a) | (b) | (c) | (d) | (e) | (f) | (g) |
|----------------|---------|----------|----------|---------|----------|---------|---------|
| 1 -- Speed | 743mph | 155mph | 425mph | 735mph | 575mph | 743mph | 735mph |
| 2 -- Altitude | 5,100ft | 29,000ft | 20,000ft | 6,200ft | 14,000ft | 5,100ft | 6,200ft |
| 3 -- Size | 17m | 49m | 30m | 50m | 18m | 17m | 15m |
| 4 -- Angle | -11deg | +13deg | -13deg | +10deg | -07deg | -11deg | -01deg |
| 5 -- IFF | 1.5Mhz | .4Mhz | 1.7Mhz | .9Mhz | 1.3Mhz | 1.5Mhz | .7Mhz |
| 6 -- Direction | 03deg | 29deg | 15deg | 02deg | 09deg | 21deg | 29deg |
| 7 -- Corr Stat | 29mi | 02mi | 15mi | 27mi | 21mi | 10mi | 2mi |
| 8 -- Radar | 8C1 | 1C1 | 5C1 | 2C1 | 7C1 | 3C1 | 1C1 |
| 9 -- Range | 12mi | 185mi | 75mi | 170mi | 47mi | 100mi | 185mi |

Exhibit 14. The TEAMSET Target Creation Screen

Team Decision - Update TEAM99.INI file

[41] Game set title = Experiment 1

[42] Goals: 20 18 19 21

[43] Single(Y): N

Game 1 of 20 Games

[1] 0 Speed 2 555 mph
[2] 0 Altitude 2 7103 ftt
[3] 0 Size 2 10 m
[4] 0 Angle 1 -3 degg
[5] 2 IFF 2 1.3 Mhz
[6] 0 Direction 2 1 degg
[7] 0 Corr Status 2 21 mi out
[8] 0 Radar 2 8 Class
[9] 0 Range 2 32 mm
1 1 1 1 Defend

[11] Game Time: 120

[12] Feedback : 30

Your choice?

Enter [##] to change, G## to show game ##, D to Delete or S to Stop
Use [10]R to Randomly assign all 9 values. New Value is
up to 9 (0-2) leave blank/null for 0-2 also Random.

Exhibit 16a. The Measures Screen in TEAMSET

Modify tdwgt1.WGT Weights & Values

1] # Measures = 9 [2] # Interactions = 4 [3] # Judgements = 8
4] # Outcomes = 5 [5] # Icons = 4 [6] Message wit time = 1

| [7] | [8] | [9] | [10] | [11] | | | | | |
|-----|-------------|-----|--------|-------|-------|-------|-------|------|-------|
| 0 | Speed | 1 | mph | 100 | 300 | 301 | 550 | 551 | 800 |
| 0 | Altitude | 1 | ft | 25001 | 35000 | 15001 | 25000 | 5000 | 15000 |
| 0 | Size | 3 | m | 41 | 65 | 21 | 40 | 10 | 20 |
| 0 | Angle | 2 | deg | 6 | 15 | -5 | 5 | -15 | -6 |
| 2 | IFF | 1 | Mhz | .2 | .7 | .8 | 1.2 | 1.3 | 1.8 |
| 0 | Direction | 1 | deg | 21 | 30 | 11 | 20 | 0 | 10 |
| 0 | Corr Status | 1 | mi out | 0 | 10 | 11 | 20 | 21 | 30 |
| 0 | Radar | 1 | Class | 1 | 3 | 4 | 6 | 7 | 9 |
| 0 | Range | 4 | m | 100 | 200 | 50 | 99 | 0 | 49 |

Interactions: Weight[12] 1 1 1 1 NxNxNxNxN[13] 16 49 38 27

Use [19] to View/Mod Icons, A for Measures+, B for Comm+
Enter: [#] to change, C to Cancel changes, or W to Write Mods?

Exhibit 16b. The Communications Screen in TEAMSET

Modify tdgwt1.WGT Weights & Values

| | | | | | | |
|---------|-------|---------|------|------------|-----------|----------|
| [14] | [15] | [16] | [17] | [18] | | |
| Carrier | 147 | No Call | 0 | Warn 11 | HIT | |
| CAD | 12345 | Ignore | 2 | Ready 14 | NEAR MISS | |
| AWACS | 45678 | Review | 5 | Lock-on 17 | MISS | |
| Cruiser | 12789 | Monitor | 8 | Defend 20 | INCIDENT | DISASTER |

[20] Feedback Type (F/D/S): D [21] D/S #: 3
[22] Feedback to: YYYYYYYYYY YYYY YYYY

Type 1111222233334444 allowed Queries/Transmits
[23] Query :YYYYYYYYYYYYYYYY
[24] Trn value:YYYYYYYYYYYYYYYY
[25] Trn Text :YYYYYYYYYYYYYYYY
[26] Trn Log :YYYY

Use [19] to View/Mod Icons, A for Measures+, B for Comm+
Enter: [##] to change, C to Cancel changes, or W to Write Mods?

Exhibit 17a-d. Changing Attribute Names

Exhibit 17a

Enter new Name or [CR] only to keep same
for 1 Speed ?

Exhibit 17b

Enter new Name or [CR] only to keep same
for 1 Speed ? Speed
for 2 Altitude ?

Exhibit 17c

Enter new Name or [CR] only to keep same
for 1 Speed ? Speed
for 2 Altitude ? Altitude
for 3 Size ? Size
for 4 Angle ? Angle
for 5 IFF ?

Exhibit 17d

Enter new Name or [CR] only to keep same
for 1 Speed ? Speed
for 2 Altitude ? Altitude
for 3 Size ? Size
for 4 Angle ? Angle
for 5 IFF ? Emissions
for 6 Direction ?

Exhibit 18a-b. Changing the Attribute Scale Abbreviation

Exhibit 18a

Enter new Measure suffix or [CR] only to keep same
for 1 mph ?

Exhibit 18b

Enter new Measure suffix or [CR] only to keep same
for 1 mph ? mph
for 2 ft? ft
for 3 m? m
for 4 deg? deg
for 5 Mhz?

xhibit 19. Recalibrating the Attribute Scale

Enter Measure #? 5
How enter value for its
D
Low , old = .2 new?

Exhibit 20. Establishing Access to Feedback

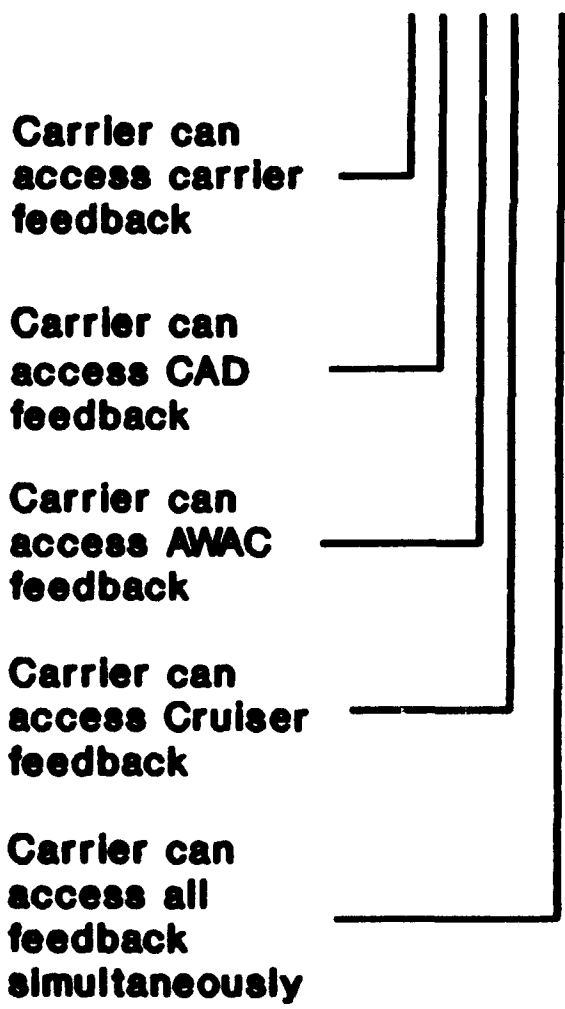
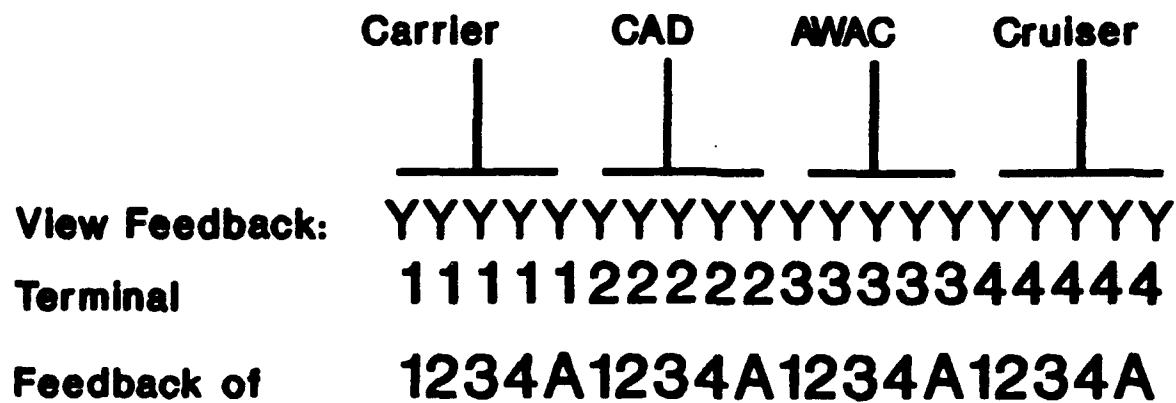


Exhibit 21. Establishing Query Communication Linkages

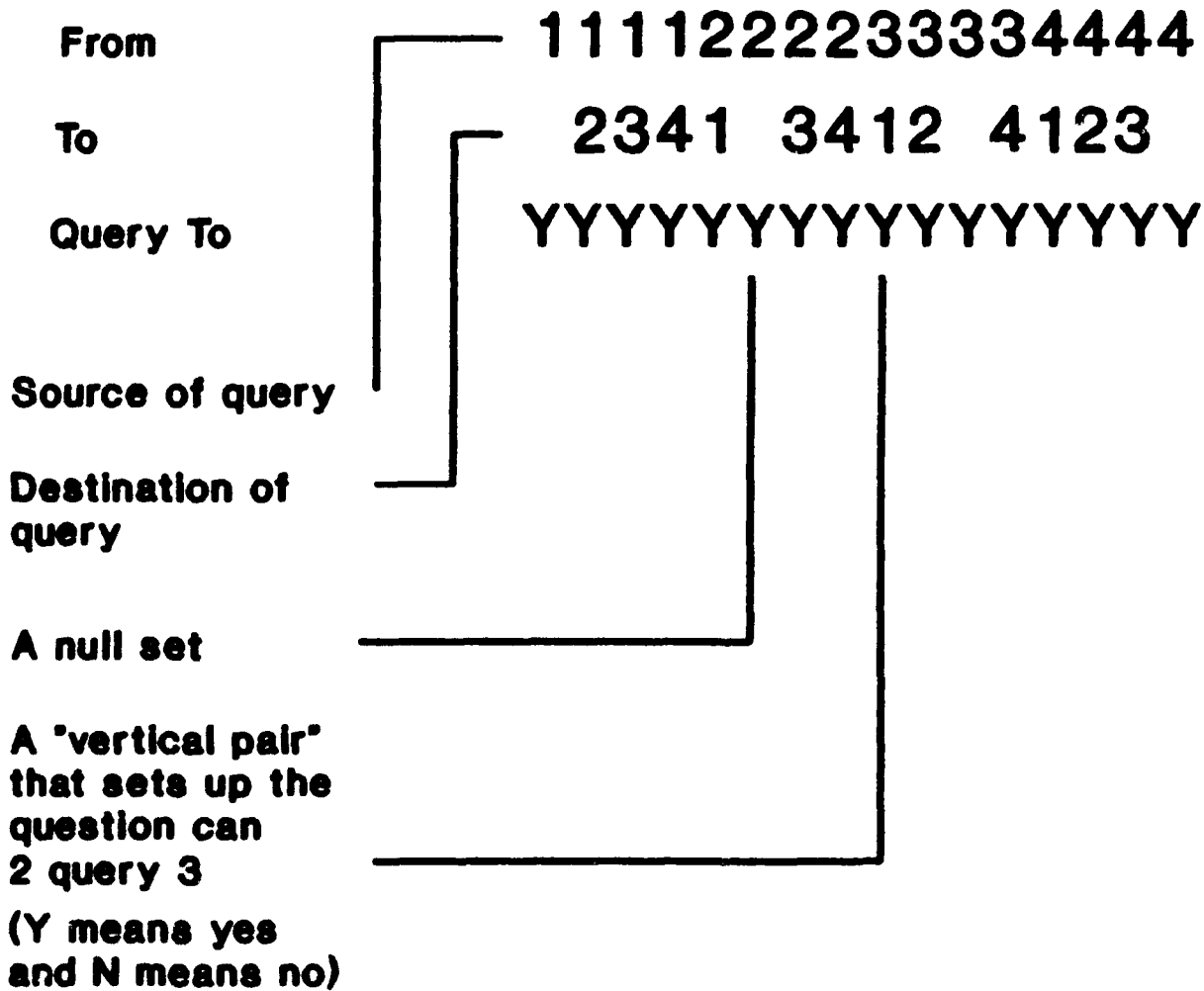
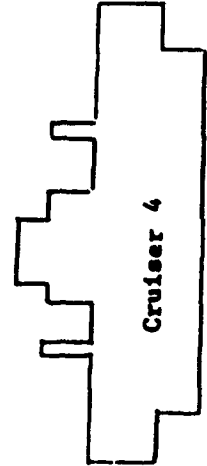
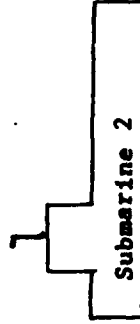
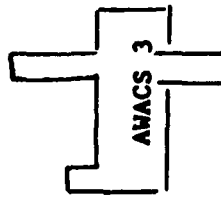
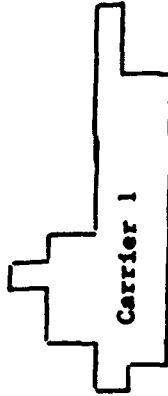


Exhibit 22. Edited Icon Screen

... Menu ... Modify file: tdvgt1.WGT



TIDE²
97

Exhibit 23. Edited Sea Screen

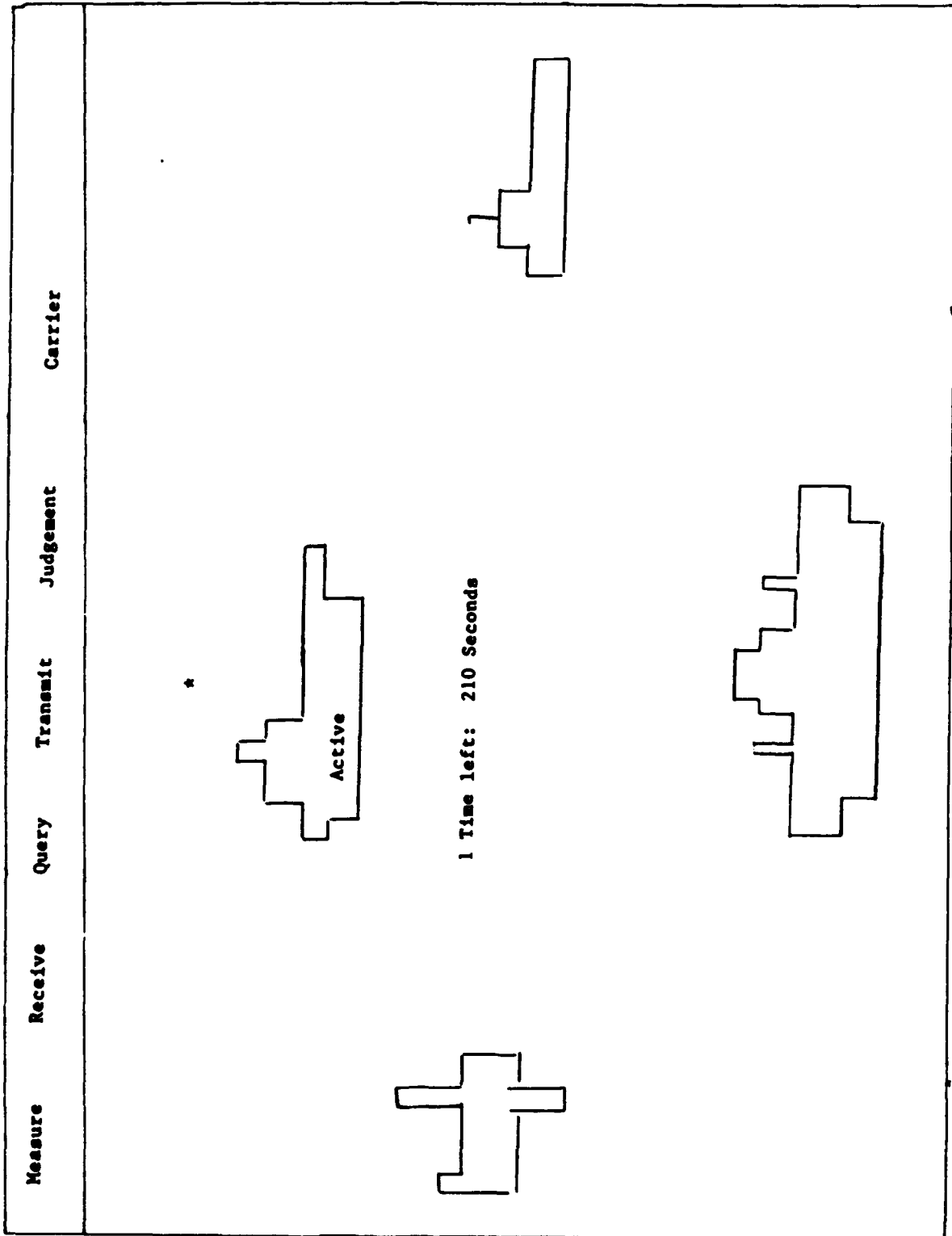


Exhibit 24. The TEAMSTAT Master Menu

| | |
|--|---------|
| TEAMSTAT Master Menu | VO61891 |
| <p>Message File</p> <p>SPSS File</p> <p>Summary Report File</p> <p>Quit</p> | |
| <p>Press the highlighted letter(s) of the report(s) you want produced, then press ENTER.</p> | |

Exhibit 25. A Sample of the xxxyyzzz.SUM Output File

Game 18
Time Allowed - 210
Proper Judgement - 1 NEAR MISS

| | Carrier Judgement - 2 Time - 205 | | | | CAD Judgement - 2 Time - 188 | | | | AWACS Judgement - 1 Time - 192 | | | | Cruiser Judgement - 1 Time - 153 | | | |
|--------------|-------------------------------------|-----|-----|---|---------------------------------|-----|-----|---|-----------------------------------|-----|-----|---|-------------------------------------|-----|-----|---|
| | TOTAL | 2 | 3 | 4 | TOTAL | 1 | 3 | 4 | TOTAL | 1 | 2 | 4 | TOTAL | 1 | 2 | 3 |
| Query | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Receive | 9 | 3 | 5 | 1 | 4 | 3 | 1 | 0 | 6 | 3 | 1 | 2 | 5 | 4 | 0 | 1 |
| Transmit | 3 | 1 | 1 | 1 | 4 | 3 | 1 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Message | 7 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 2 | 1 | 0 | 1 |
| Slight | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unresponsive | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Forgets | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Learns | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Lecture | 3 | 1 | 1 | 1 | 3 | 3 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Summary | IFF | Spe | Ang | | IFF | Spe | Siz | | Ang | Cor | Spe | | Ang | Ran | Cor | |
| | Alt | Siz | Dir | | Cor | Ang | Alt | | Siz | Dir | IFF | | Alt | Spe | IFF | |
| | Cor | | | | | | | | Rad | | | | | | | |

Game 19
Time Allowed - 210
Proper Judgement - 1 MISS

| | Carrier Judgement - 3 Time - 207 | | | | CAD Judgement - 0 Time - 188 | | | | AWACS Judgement - 2 Time - 185 | | | | Cruiser Judgement - 4 Time - 200 | | | |
|--------------|-------------------------------------|-----|-----|---|---------------------------------|-----|-----|---|-----------------------------------|-----|-----|---|-------------------------------------|-----|-----|---|
| | TOTAL | 2 | 3 | 4 | TOTAL | 1 | 3 | 4 | TOTAL | 1 | 2 | 4 | TOTAL | 1 | 2 | 3 |
| Query | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Receive | 8 | 5 | 2 | 1 | 4 | 3 | 1 | 0 | 4 | 4 | 0 | 0 | 3 | 2 | 0 | 1 |
| Transmit | 3 | 1 | 1 | 1 | 3 | 3 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Message | 5 | 2 | 2 | 1 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 1 | 0 | 0 |
| Slight | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Unresponsive | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Forgets | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Learns | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lecture | 2 | 0 | 1 | 1 | 3 | 3 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Summary | IFF | Alt | Spe | | IFF | Cor | Ang | | Cor | Spe | Rad | | Ang | Ran | IFF | |
| | Ang | Cor | Siz | | Alt | Siz | | | Dir | IFF | Ang | | Cor | Spe | Alt | |

Totals For All Games

| | NEAR MISS- 10 Carrier | | | | MISS- 2 CAD | | | | INCIDENT- 0 AWACS | | | | DISASTER- 0 Cruiser | | | | BD- 0 | | | |
|--------------|--------------------------|----|----|----|----------------|----|----|---|----------------------|----|----|---|------------------------|----|---|---|-------|---|---|---|
| | TOTAL | 2 | 3 | 4 | TOTAL | 1 | 3 | 4 | TOTAL | 1 | 2 | 4 | TOTAL | 1 | 2 | 3 | TOTAL | 1 | 2 | 3 |
| Query | 42 | 14 | 13 | 15 | 12 | 3 | 5 | 4 | 22 | 6 | 11 | 5 | 5 | 1 | 2 | 2 | | | | |
| Receive | 117 | 35 | 50 | 32 | 73 | 50 | 16 | 7 | 74 | 52 | 15 | 7 | 63 | 47 | 7 | 9 | | | | |
| Transmit | 32 | 11 | 13 | 8 | 32 | 24 | 7 | 1 | 12 | 7 | 1 | 4 | 14 | 11 | 1 | 2 | | | | |
| Message | 76 | 26 | 26 | 24 | 17 | 9 | 5 | 3 | 43 | 37 | 4 | 2 | 30 | 20 | 4 | 6 | | | | |
| Slight | 1 | 0 | 0 | 1 | 3 | 1 | 2 | 0 | 5 | 0 | 2 | 3 | 2 | 0 | 0 | 2 | | | | |
| Unresponsive | 21 | 5 | 8 | 8 | 7 | 2 | 2 | 3 | 6 | 1 | 4 | 1 | 2 | 1 | 1 | 0 | | | | |
| Forgets | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | | | | |
| Learns | 21 | 9 | 5 | 7 | 1 | 0 | 0 | 1 | 13 | 5 | 7 | 1 | 0 | 0 | 0 | 0 | | | | |
| Lecture | 25 | 9 | 8 | 8 | 15 | 15 | 0 | 0 | 6 | 2 | 0 | 4 | 4 | 4 | 0 | 0 | | | | |

Exhibit 26. Objective Measures from TIDE² Communications

Some Objective Measures From TIDE²

| a | b | c | d |
|------------------------------|---------------|-----------------|--------------------------|
| QUERY -----> | RECEIVE-----> | TRANSMIT -----> | RECEIVE |
| (AWAC to CAD) (Re: Speed) | (CAD to AWAC) | (CAD to AWAC) | (AWAC to CAD) (Speed) |

Raw Indices

| | |
|----------------|---------------------------|
| "Slight" | -- a but no b |
| "Unresponsive" | -- a and b, but no c |
| "Learn" | -- a, b, c, and d |
| "Lectures" | -- c and d, but no a or b |
| "Forget" | -- a, b and c, but no d |

Composite Indices

| | |
|--------------------|---|
| Learned + Lectured | = Taught |
| Taught + Measured | = Known (special case of known interactions) |
| Uncooperative Acts | = Slight + Unresponsives |
| Wasted Motions | = Forgets + Rehash (where Rehash = "Known" but Lectured) |
| Inefficiencies | = Uncooperative Acts + Wasted Motions |
| Coordination | = Known/Inefficiencies |

Exhibit 27. A Sample of the xxxyyzzz.MSG Output File

M 1 4 3 140M Cruiser Hi,dude.
M 1 3 1 139M AWACS send money
M 1 2 4 138M CAD i do not know
M 1 1 2 138M Carrier help whatever
M 3 2 1 146M CAD the awak knowsw direction it is a possible threat
M 4 4 1 72M Cruiser I received a -1 angle from AWAC and -14 from you.
M 5 1 4 167M Carrier i dont know size
M 6 3 1 223M AWACS havent measured
M 6 1 4 157M Carrier dont know direction
M 6 1 3 96M Carrier dont know size
M 6 1 4 56M Carrier dont know size
M 7 4 2 281M Cruiser Do you know size?
M 7 3 1 231M AWACS dont have size
M 7 4 3 205M Cruiser Do you know size?
M 7 4 1 81M Cruiser don't have IFF
M 8 1 3 242M Carrier dont know size
M 8 4 1 211M Cruiser what did you want?
M 8 1 4 141M Carrier dont know altitude
M 8 3 4 96M AWACS dont know size
M 8 4 2 40M Cruiser You need to send me size as soon as you get it,
OK?
M 9 4 1 217M Cruiser What things can you measure?
M 9 1 4 179M Carrier speed angle and corridor
M 9 3 1 162M AWACS dont know #\$\$&***@!\$\$ altitude
M 9 4 2 95M Cruiser Thank you. ,

Exhibit 28. Content Analysis Coding Scheme for xxxyyzzz.MSG

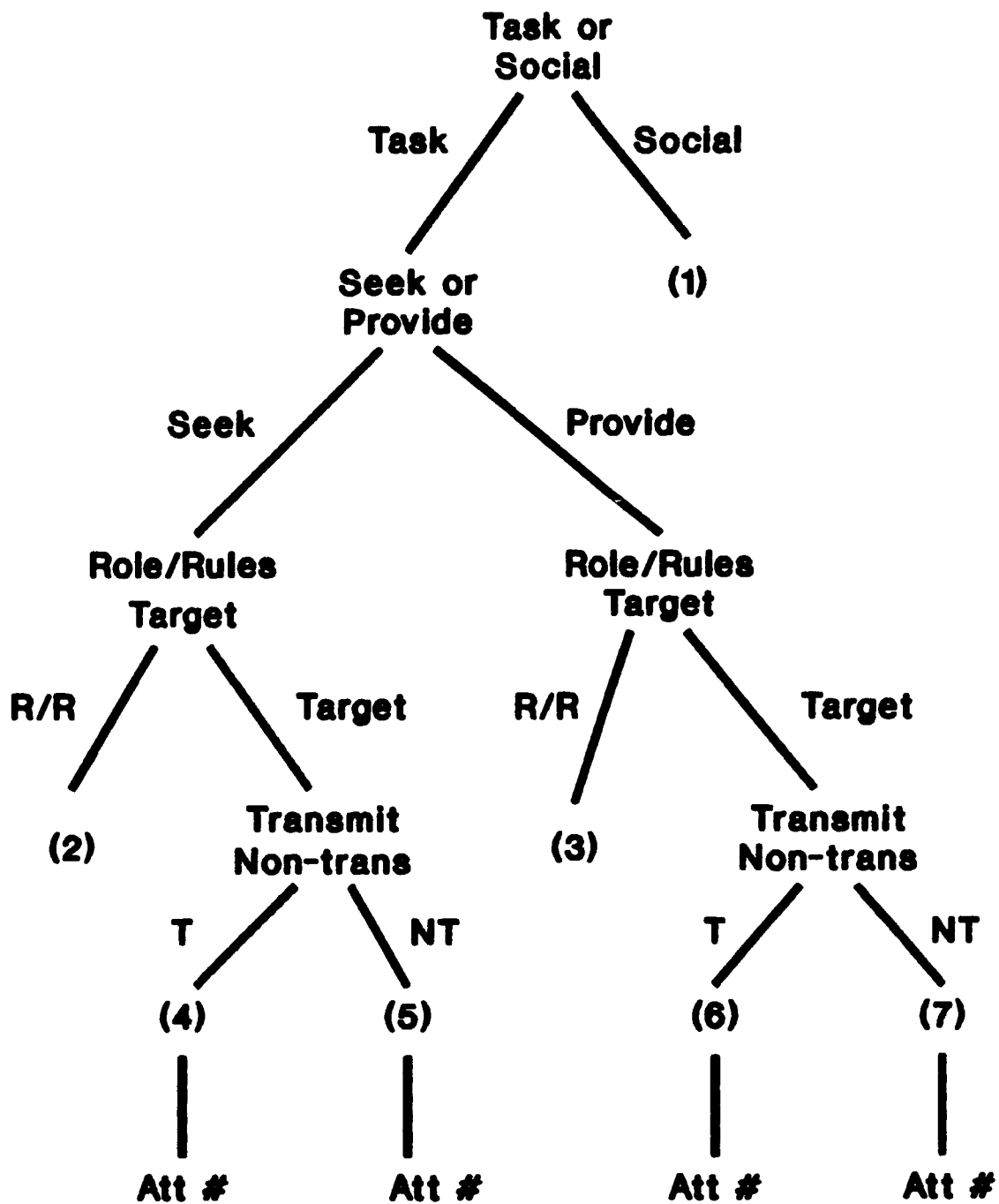


Exhibit 29. Examples of Coded Text Messages

| | | |
|----|---|---|
| 1 | I dont know size | 3 |
| 2 | I received a -1 angle from AWAC and -14 from you. | 7 |
| 3 | The speed is 540mhp | 6 |
| 4 | is this target bad on speed? | 5 |
| 5 | Can you send me size as soon as you get it every time | 2 |
| 6 | What is the IFF? | 4 |
| 7 | What things can you measure? | 2 |
| 8 | I can measure speed IFF and direction | 3 |
| 9 | This target is very very bad!!!! | 7 |
| 10 | Thank you. | 1 |

Exhibit 30. Format for xxxyyzzz.SPS Output File

The layout of the fixed format data analysis output file.

| Line/Column | Description | Vaules |
|-------------|--|---|
| 1 | 1-3 Group number: | 000-999 |
| | 4-5 Session number: | 00-99 |
| | 6-8 Experiment number: | 000-999 |
| | 9-10 Game number: | 1-99 |
| | 11 Correct judgement for game: | 1-7 |
| 2-5* 1-36 | Measurement data: 9 blocks of 4 digits in the form MTTT. M is each of 9 attributes: | 1=measured 0=not measured 9=can't measure |
| | TTT is time left in game: | 001-999 |
| 37-126 | Query data: 18 blocks of 5 digits in the form WwTTT. W is who was queried: w is which attribute: TTT is time left in game: | 1-4 1-9 001-999 |
| 127-216 | Transmission data: 18 blocks of 5 digits in the form WwTTT. W is where the transmission was sent: w is what attribute was sent: TTT is time left in the game: | 1-4 1-9 001-999 |
| 217-256 | Message data: 10 blocks of 4 digits in the form WTTT. W is who was sent the message: TTT is time left in game: | 1-4 001-999 |
| 257-346 | Receive query data: 18 blocks of 5 digits in the form WwTTT. W is who the query was from: w is what attribute was asked for: TTT is time left in game: | 1-4 1-9 001-999 |
| 347-436 | Received transmission data: 18 blocks of 5 digits in the from WwTTT. W is who the trans was from: w is what attribute was sent: TTT is time left in game: | 1-4 1-9 001-999 |

Exhibit 30 continued

| | | |
|---------|--|---|
| 437-476 | <p>Received message data: 10 blocks of 4 digits in the form WTTT. W is who sent the message: TTT is time left in game:</p> | <p>1-4 001-999</p> |
| 477-478 | <p>Number of time the summary box was accessed:</p> | <p>00-99</p> |
| 479-490 | <p>Summary data second to last time viewed in the form abcdefghiTTT. a is the first attribute: b through i are in the same format: TTT is time left in game:</p> | <p>1=available 0=not available 001-999</p> |
| 491-502 | <p>Summary data next to last time viewed in the form abcdefghiTTT. (same as above)</p> | |
| 503-514 | <p>Summary data last time viewed in the form abcdefghiTTT. (same as above)</p> | |
| 515-518 | <p>Judgment data: 4 digits in the form JTTT. J is the judgment: TTT time left in game:</p> | <p>0-7 001-999</p> |
| 519-523 | <p>Communication summary data with station number 2 in the form SUFLl. S is the number of slights: U is the number of non-responses: F is the number of forgets: L is the number of learns: l is the number of lectures:</p> | <p>1-9 1-9 1-9 1-9 1-9</p> |
| 524-528 | <p>Communication summary data with station number 3 in the form SUFLl. S is the number of slights: U is the number of non-responses: F is the number of forgets: L is the number of learns: l is the number of lectures:</p> | <p>1-9 1-9 1-9 1-9 1-9</p> |

Exhibit 30 continued

529-533 Communication summary data with
 station number 4 in the form
 SUFL1.
 S is the number of slights: 1-9
 U is the number of non-responses: 1-9
 F is the number of forgets: 1-9
 L is the number of learns: 1-9
 l is the number of lectures: 1-9

534-537 Interaction data: 4 digits in the
 form ABCD.
 A, was the first interaction
 available: 1=yes
 0=no

 B, was the second interaction
 available: 1=yes
 0=no

 C, was the third interaction
 available: 1=yes
 0=no

 D, was the forth interaction
 available: 1=yes
 0=no

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