SYSTEMATIC ASSESSMENT OF C2 EFFECTIVENESS AND ITS DETERMINANTS

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1 INTRODUCTION*

1.1 BACKGROUND

Between 1985 and 1993 the Fort Leavenworth Field Unit of the Army Research Institute sponsored the development and application of the Army Command and Control Assessment Tool (ACCES). Original ACCES was developed by a team from Defense Systems, Inc. (DSI) under the leadership of Dr. Richard E. Hayes as an adaptation of HEAT (the Headquarters Effectiveness Assessment Tool). HEAT, in turn was originally developed by the Defense Information Systems Agency (DISA, then Defense Communications Agency) with support from the Basic Research Group BRG) for Command and Control of the Joint Directors of Laboratories.

In 1990 a team from Evidence Based Research, Inc. (EBR), also led by Dr. Hayes, was awarded a competitive contract for Enhancements to ACCES under which they worked with ARI to improve the ACCES methodology, provide consistency and quality control in ACCES applications, and develop the Army Command and Control (ACCE) Model based on what was learned from the ACCES program.

The two tools, HEAT and ACCES, represent the most broadly applied systematic assessment of Command and Control processes. As Figure 1-1 indicates, nearly fifty different applications have been made, ranging from laboratory experiments to field exercises. In all, more than 200 different headquarters have been observed in settings ranging from joint exercises to operational tests.

FIGURE 1-1: PAST EXERCISE APPLICATIONS

JOINT:	BOLD EAGLE 84 (83)	ABLE ARCHER (NOV 84)	GRENADA (83)
AIRFORCE:	MAC (84)	ABLE ARCHER (84)	
ARMY:	OTEA/OPTEC	ARMY RESEARCH INSTITUTE / BCTP	
	1ST INFANTRY DIVISION (86)	4TH INFANTRY DIVISION (87)	1ST INFANTRY DIVISION (90)
	1ST ARMORED DIVISION (87)	24TH INFANTRY DIVISION (88)	10TH MOUNTAIN DIVISION (90)
	ASAS (89)	7TH INFANTRY DIVISION (88)	6TH INFANTRY DIVISION (LT) (91)
	III CORPS (91)	3RD ARMORED DIVISION (88)	7TH INFANTRY DIVISION (LT) (91)
	III CORPS (92)	III CORPS (89)	4TH INFANTRY DIVISION (JUN 91)
	III CORPS (93)	82ND AIRBORNE DIVISION (92)	34TH INFANTRY DIVISION (NG) (91)
	ARMY OTHER	10TH MOUNTAIN DIVISION (LT) (92)	5TH INFANTRY DIVISION (92)
	GRENADA (83)	6TH INFANTRY DIVISION (LT) (93)	1ST INFANTRY DIVISION (92)
	LOGEX (JUN 89)		
	COSTA RICA (91)		
	PANAMA (91)		
	BOLIVIA (91)		
NAVY:	BFIT 2-85 (85)	BFIT 2-86 (86)	BFIT 3-87 (87)
	BFIT 1-86 (86)	FLEETEX 1-86 (86)	BFIT 3-86 (86)
		WARGAME POM-87, NWC (85)	
USMC:	PARTICIPATION IN ALL BFIT EXERCISES		BOLD EAGLE (83)
	POM-87 WARGAME (85)		GRENADA (83)

1.2 FOCUS

This paper focuses on recent Army exercises where ACCES was applied and on the prototype ACCE Model, delivered late in 1993. ACCES is an objective data collection and

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* Sponsored By U.S. Army Research Institute, Ft. Leavenworth, Kansas.

analysis system for monitoring the performance of staffs and the overall quality of the C2 (command and control) systems that support commanders and staffs. The ACCES system uses quantitative indicators of (a) the effectiveness of C2, as well as (b) the speed and (c) quality of the C2 processes that are observed.

Section II of the paper presents data from ten division-level command post exercises, nine WARFIGHTER exercises from the Battle Command Training Program (BCTP) and one independent division exercise, all observed between 1990 and 1993. One of the divisions on which data were collected was National Guard. These data are unique in that they deal with Post-Cold War situations where Army divisions were employed in situations characterized by relatively high uncertainty (terrain, enemy forces and friendly forces were much less familiar than those during the Cold War).

The patterns of C2 identified in US Army Post-Cold War situations are discussed in Section III. This discussion takes the highly descriptive materials in Section II and organizes across time, relative success and functional relationships. The key driver in the analysis turns out to be the level of stress on the C2 system.

Finally, Section IV of the paper describes the ACCE model prototype developed by EBR with the support of the Center for Excellence in Command and Control at the George Mason University. This prototype arose from ARI's perception that existing combat models do not represent C2, while those that do have little or no behavioral content. Many of them focus primarily on communications. At the same time, ARI believed that the ACCES program would benefit from the technical challenge of moving beyond the empirical, descriptive orientation to a more rigorous analytical perspective. The ACCE model is designed to permit systematic assessment of changes in C2 personnel, procedures, organization, and equipment.

The working prototype of the ACCE Model has limited scope: it focuses on the Commander, G-2 (Intelligence), G-3 (Plans and Operations), and DTAC (Division Tactical Command Post) of an Army Division, with supporting data from those brigade and corps head-quarters that are directly linked to those division cells. The prototype runs in MicroSaint on a Macintosh computer. Its parameters are based on a combination of relevant data from past ACCES applications and a system of rules and relationships elicited from C2 experts on the ACCES Enhancements project team. It has been applied to an example problem, increasing the experience of selected staff officers within a division.

2 ARMY COMMAND AND CONTROL AS DESCRIBED BY ACCES DATA

2.1 BACKGROUND

This section reports detailed empirical results for ACCES measures collected in ten different division level exercises between 1990 and 1993. Hence, they provide one of the broadest looks at Post-Cold War Army C2 available.

These exercises lasted between three and five days, with ACCES data collection always occurring at the Division Main (DMAIN) command center (with observers in G-3 Operations, G-3 Plans and the G-2, Intelligence, cells and attending major division level briefings and meetings in the Command Section) and the Division Tactical Command Post (DTAC). Depending on the number of data collectors available and the geographic dispersion of the command centers, data was sometimes also collected in Brigade headquarters (maneuver and aviation) as well as the Division Rear (DREAR) command center.

Data were collected on the processes of command and control (C2), with particular emphasis on C2 effectiveness, the quality of the C2 processes observed (particularly information processing and decision making), and the speed with which they were carried out. The resulting information base is unique. Virtually no other team has had the opportunity or tools to collect comparable information, using a systematic method, on Army C2 performance across this range of exercises. Because all of these exercises occurred between 1990 and 1992, they represent insight into Army C2 in the context of Post-Cold War exercise scenarios. Army force planners, modelers, and designers of C2 systems should look upon this data as a rich resource that can support requirements analysis, systems design, development of model parameters, and baseline assessments of C2 performance.

These exercises have generated massive amounts of data, nearly 45,000 individual items. Analysis has been organized functionally, beginning with measures of effectiveness and the overall process, then working backwards around the decision cycle that is used to organize the ACCES data from Preparation of Directives to Course of Action Analysis, Situation Assessment, Information Consistency (Information Seeking, Coordination, and Consistency of Data at Different Command Centers), and Information Handling (Incoming Reports, Outgoing Reports, and Queries About Them). These analyses only scratch the surface of the large database. Moreover, they must be seen as preliminary since ACCES collection continues.

In general, data analysis has been organized both over time and across command centers. Typical exercises lasted 4 or 5 days and were preceded by an extended period of planning for the initial exercise phase. In the case of Battle Command Training Program (BCTP) exercises, the initiation scenario was always known weeks, and often months, in advance. Day 1 of the exercises was largely spent on movement to contact, passage of lines, or similar slowly developing events. Day 2 typically involved heavy contact and the rapid development of the battlefield. By Day 3 both sides had often lost significant proportions of their combat power and were reconstituting and launching new initiatives, which usually continued until the end of the exercise (ENDEX). The data from Days 4 and 5 have been combined. Only a few exercises lasted five days, so the total number of observations for Day 5 would be very low on most variables. Moreover, Day 4 was often the last day of the Battle Command Training Program (BCTP) exercise, so "ENDEX" effects (the tendency to plan less rigorously because you know the exercise will end before you have to implement the new plans, focusing some energy on ending the exercise smoothly and thinking ahead to exercise debriefings and other post-exercise activities) are often represented in those data as well as being present in all Day 5 data.

Because of the focus on division level and the positioning of data collectors, DMAIN often accounts for the bulk of the information available. The analyses contrast data from DMAIN with those from any other command center for which at least fifteen valid data points exist on the same variables. Those with lower frequencies were either not analyzed or were included in a data category that was labeled "ELSE."

The raw data supporting these analyses are contained in the Army Research Institute's ACCES database and can be acquired through them. Appendix 2 of this report shows the information analyzed in graphic form, plotting values CP by CP over the exercise days. Rather than seek to report on the large number of ACCES measures (up to 258 depending on the measure set selected, this discussion focuses on primary measures for which a hundred or more data points are available.

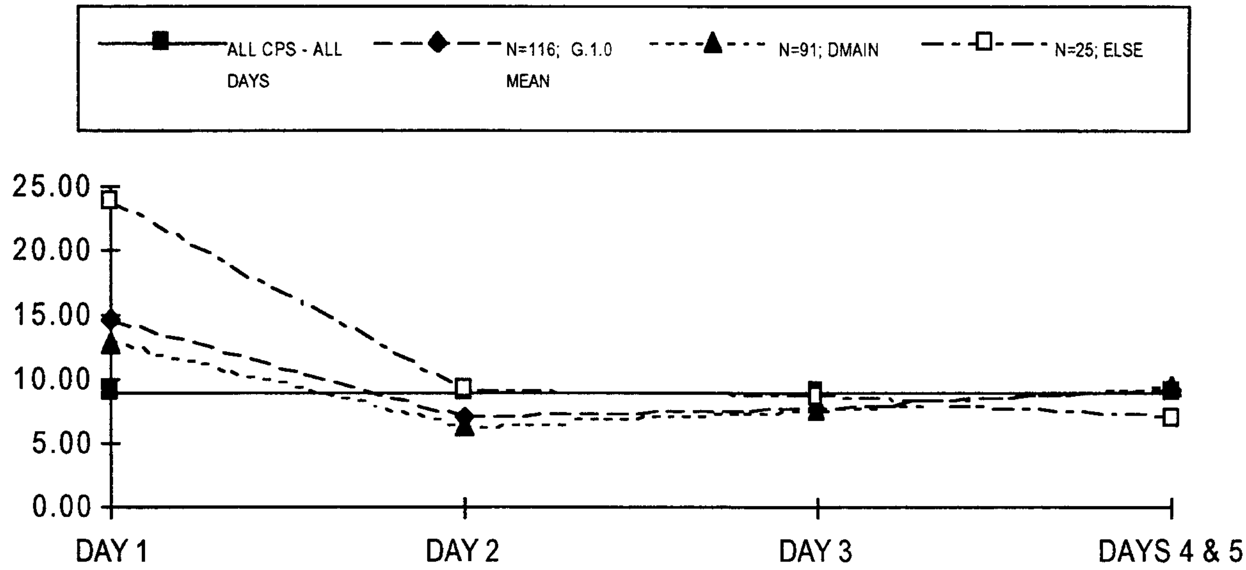
2.2 GENERAL MEASURES: EFFECTIVENESS AND OVERALL DECISION CYCLES

There are six primary general measures: Plan Duration, Plan Stability, Plan Execution, Planning Success, Planning Initiative, and Planning Cycle Time. Each of them reflects different ways to measure overall C2 performance, ranging from the speed of the process to the ability of the C2 system to generate plans that (a) achieve their intended missions and (b) can be carried out within the contingencies foreseen by the planners. They reflect the ACCES assumption that command centers do not fight the enemy, but rather produce plans (combinations of missions, assets [task organizations as well as supplies and equipment], boundaries and schedules) that should enable successful military operations.

2.2.1 Plan Duration

The average plan (most commonly a Division Fragmentary Order or FRAGO) observed in ACCES applications was in effect 8.9 hours, with the longest of the 116 plans scored surviving for more than 43 hours and the shortest about 20 minutes. The median (typical) plan lasted just over 5 hours, indicating that the mean was pulled up by a few relatively long plan durations. As Figure 2-1 shows, however, Plan Duration varies considerably depending on the day of the exercise when it was issued and the command post (CP) where it originated.

Figure 2-1: Plan Duration



* Plans issued on exercise Day 1, when the divisions were (a) implementing plans they had developed over time based on a scenario and (b) not yet fully engaged, lasted (p = .01 based on a t-Test) longer (14.6 hours) than plans issued on other days (7.8).

* Plan Duration was lowest (7 hours) on Day 2, which typically includes the period when the division engaged well organized enemy forces. A gradual improvement then ensues, apparently as the two sides exhaust their initial combat power and the division gains an improved understanding of the battlefield dynamics and how to better conduct its C2 processes.

* Plans originating in Division Main had longer Plan Duration, on every day, than plans originating in other command centers. However, they also account for the great bulk of the available data (91 of 116 observations, or 78 percent).

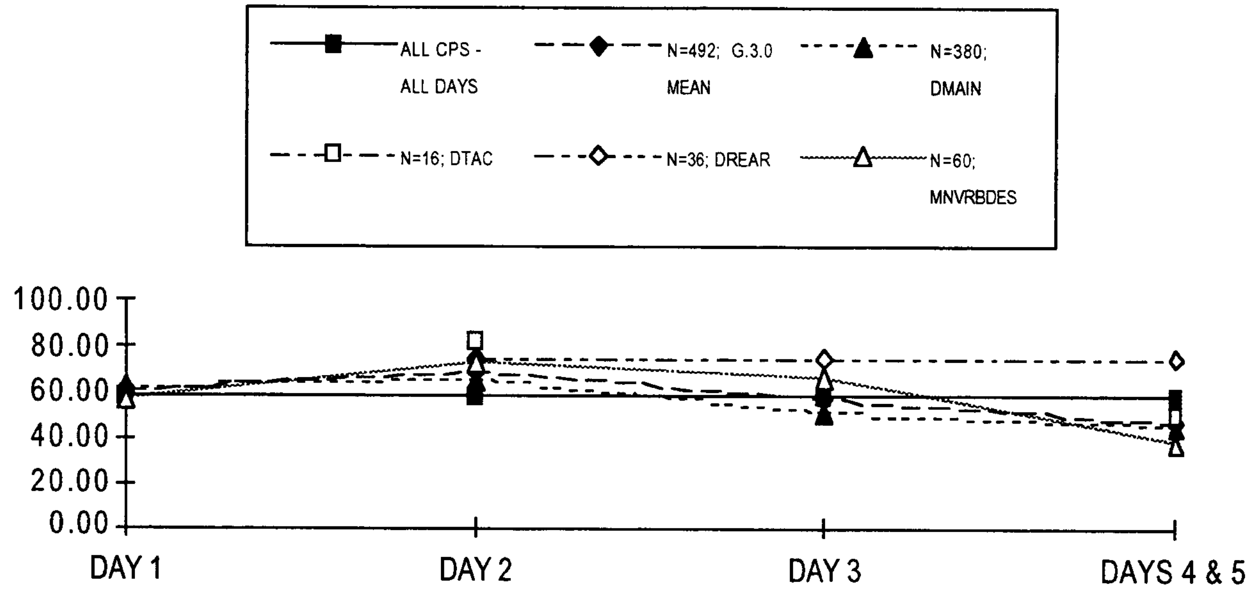
This pattern indicates that "command and control on the fly" became the norm as soon as division exercises began to focus on Post-Cold War scenarios. It also shows the effect of combat on formal plans (they disintegrate rapidly). The improvement following Day 2 also appears to reflect learning during the exercises.

Interpretation of findings on this variable need to be constrained by an understanding that long plan durations are not an end in themselves. Long plan durations provide more consistent guidance to subordinate units and permit more time to develop new plans. There is also be some minimum plan duration necessary to permit subordinate units to execute one plan before receiving a new one. However, these lead times are a function of battlefield dynamics and the speed of the C2 process. Hence, there is no ideal plan duration, only acceptable ones for a given situation.

2.2.2 Plan Stability

Because of collection problems, only a small number of observations were available on this measure. The data indicate that plans last about 65% of the time they are intended to last. The basis for this calculation is the elapsed time from the implementation of the first element of the plan until it is altered (by changing the missions, task organization, boundaries or schedules) beyond those contingencies included in the plan, divided by the intended life of the plan. The fact that plans tend to need updating after about two-thirds of their expected life, is important both for those who are training planners and for analysts

Figure 2-2: Plan Execution



seeking to understand the dynamics of command and control processes.

2.2.3 Plan Execution

Collection here was much more successful (492 observations) with the DMAIN providing more than three-quarters of the data (380). This measure looks at the percentage of the plan elements that survive the intended plan life. Hence, a plan in which the task organization, missions assigned, and boundaries survived (were not modified beyond the contingencies built into them) for the full intended life of the plan, but the schedule had to be modified before then would receive a score of .75 (3/4).

* Overall, 57.6 percent of the plan elements survived.

* The pattern over time is considerably different from that for Plan Duration (See Figure 2-2). Day 1's mean is 61%, rising on Day 2 to 69%, then declining to 56 and 46 percent respectively on Day 3 and Day 4 & 5.

* DMAIN is not the best command center at issuing plans that can be implemented without changes. DREAR, DTAC, and the Maneuver Brigades all appear to do somewhat better, although the number of data points for them limits confidence in this pattern.

The shorter Plan Durations of Day 2 appear to help CPs create plan elements that can be executed, but the dynamics (or entropy) of the battlefield continue to increase over time.

2.2.4 Planning Success

This same trend is obvious in the data for Planning Success, which indicates the percentage of plans where the command center was able to foresee battlefield dynamics correctly (issue either a dominant plan or one that generated adaptive control of the battlefield). On average, only 38% of plans met this goal, with steady decline in the mean over the four time periods of interest (54%, 46%, 36%, and 19%). Even when the ENDEX phenomenon is recognized, this indicator shows continuous entropy in the command and control system over time. DMAIN does not perform better on this indicator. This measure has a rather low frequency (N = 117), dominated by DMAIN (N = 93). Many of the same plans are present in the data for this measure and plan execution.

2.2.5 Planning Initiative

Proactive and contingent directives, those in which the initiative is understood to be with friendly forces (as opposed to reactive plans) were developed for 61% of the 322 scorable cases observed. DMAIN's performance declined over the four time periods measured (78%, 73%, 66%, and 54.5%, respectively). The maneuver brigades showed the same trend (81%, 61%, 60%, and 43%) on a much smaller number of cases. However, the other command centers (DTAC, DREAR and aviation brigades) show a temporary recovery on Day 3 of the typical exercise. This, combined with the relatively flat middle period for the DTAC suggests that the C2 systems were able to gain some respite from the battlefield's entropy following the major clashes of Day 2 (as the Plan Duration figures suggest), but could not recover adequately before the next round of simulated combat interactions was initiated.

2.2.6 Planning Cycle Time

Overall Planning Cycle Time was scored for 138 plans and averaged 3.6 hours. The time required rose over the first three days (2.5 hours, 3.2 hours, 5.3 hours) before declining to 3.1 during Days 4 & 5 of the exercise. This last value appears to be a function of "ENDEX" being close and the knowledge that these plans will not be subjected to the rigors of the exercise. DMAIN, which produces by far the most complex plans of the CPs observed, has the longest Planning Cycle Time.

Planning cycle times are also sorted on the basis of the degree of time pressure (or stress) under which they are generated. This is established by looking at the degree of success in implementing the prior plan. Because of the short typical Plan Duration and the low values for Plan Stability, only a small number of "low stress" planning cycles (those with little time pressure) were recorded.

* Moderate Stress Planning Cycles required nearly 4 hours each, with a tendency to decline over time (from 7.4 hours on Day 1 to 0.4 hours on Days 4 and 5, with a range of 4 to 5 hours on Days 2 and 3.
* High Stress Planning Cycles had the opposite trend, with an average value of 3 hours that rose every day except the last one (1.6 hours, 3.3 hours, 4.5 hours and 2.8 hours). These values are less than or equal to those for moderate stress cycles (for which more time should be available).

The finding of increased planning time under high stress and low time availability appears to fly in the face of the conventional literature that is based largely on crisis decision making. Note however, that the level of stress is constant across the four days and the Moderate Stress times remain higher through Day 3. Despite the perceived urgency, Army command centers clearly found they needed more and more time to develop a coherent battlefield picture and plan of action.

2.2.7 Insights from General Measures of C2 Performance

While certainly not as great as those arising from combat, the pressures built into the exercises observed (pressures to succeed on key professional tasks, pressures to defeat the simulated enemy, and so forth) and the "fog of war" resulting from the interaction of simulated units combine, when viewed through the lens of ACCES measurement to provide a coherent and important picture of typical Army C2 in the early 1990s.

1. Planning cycles are typically quite short, less than four hours.
2. Planning "on the fly" has become the norm, with division level plans lasting only about 9 hours, and those created after combat has been initiated last even less time.
3. Measured in two quite different ways, division level planning achieves between 58 and 65 percent of the success (effectiveness) that is theoretically possible.
4. Considerable evidence exists that, in the exercises observed, the "fog of war" tends to wear down the quality of C2 over time. Two measures of the tone of overall C2, Planning Initiative and Planning Success, both decline over time under the pressures of simulated combat. Despite the opportunity for learning inherent in the training exercises observed, the amount of time needed to

complete a planning cycle tends to increase as time passes.

5. Plan Duration declines significantly when divisions are forced to replan on the fly, but there is evidence that they improve at this process as the exercise proceeds.

2.3 PREPARATION OF DIRECTIVES

Directive Preparation measures focus on the process by which decisions are converted into guidance for subordinate units. They focus on the articulation of plans. Data are gathered on the number and variety of participants in the process, the time spent, clarity and fidelity of the directive to the decision made, and the lead time provided to the subordinate units.

2.3.1 Number and Variety of Participants

The number individuals and viewpoints (staff sections) involved in the preparation of directives are both recorded by the observers. 3.5 people representing 2.8 staff sections were involved in the average directive preparation process. Both numbers are lowest on Day 1 (2.5 and 1.9, respectively), then virtually stable for the rest of the exercise (3.6, 3.5 and 3.8 for number; 2.9, 2.8 and 2.9 for variety). This suggests that the bulk of Day 1 activity focuses on relatively minor changes from the original OPLAN, which begins to need serious changes later in the exercise. DMAIN (which has the largest staff conducting this function) is higher than the other CPs for both variables, although the average DTAC values hover around 3.5 and 2.3.

2.3.2 Directive Preparation Time

The 147 observed directives required an average of 1.6 hours to prepare, with DMAIN being the slowest command center (averaging about 2.5 hours). Since they produce the most complex directives of the CPs observed, this pattern is not surprising.

The pattern over time is less common. The slowest day tends to be Day 3 (in order, 1.9 hours, 0.8 hours, 2.7 hours, and 1.3 hours), and this difference is significant. While the number of observations is very small, the same pattern also applies to the time needed to prepare warning orders. Apparently the complexity of directive needed for the "reconstitution and replanning" phase that typically follows the first intense combat on Day 2 exceeds that of the other days. An alternative explanation might be that the fatigue resulting from the first two days becomes a factor on the third day, but that explanation also requires an explanation for the shorter period on Day 4 (perhaps ENDEX or recovery of the sleep cycle). The complexity argument is more compelling.

2.3.3 Directive Consistency With Decision

Not surprisingly, very few differences were recorded between the elements of decisions made and the corresponding elements of the directives implementing them. Overall, fidelity was rated as 96% of elements. However, even small error rates in this arena are potentially important. Moreover, none of the errors recorded were on Day 1 and those observed tended to be on Day 3 (92 percent fidelity compared with 98 percent on Days 2, 4 & 5. This is the same day when directive preparation slowed perceptibly. Again, the related complexity issue is an attractive explanation.

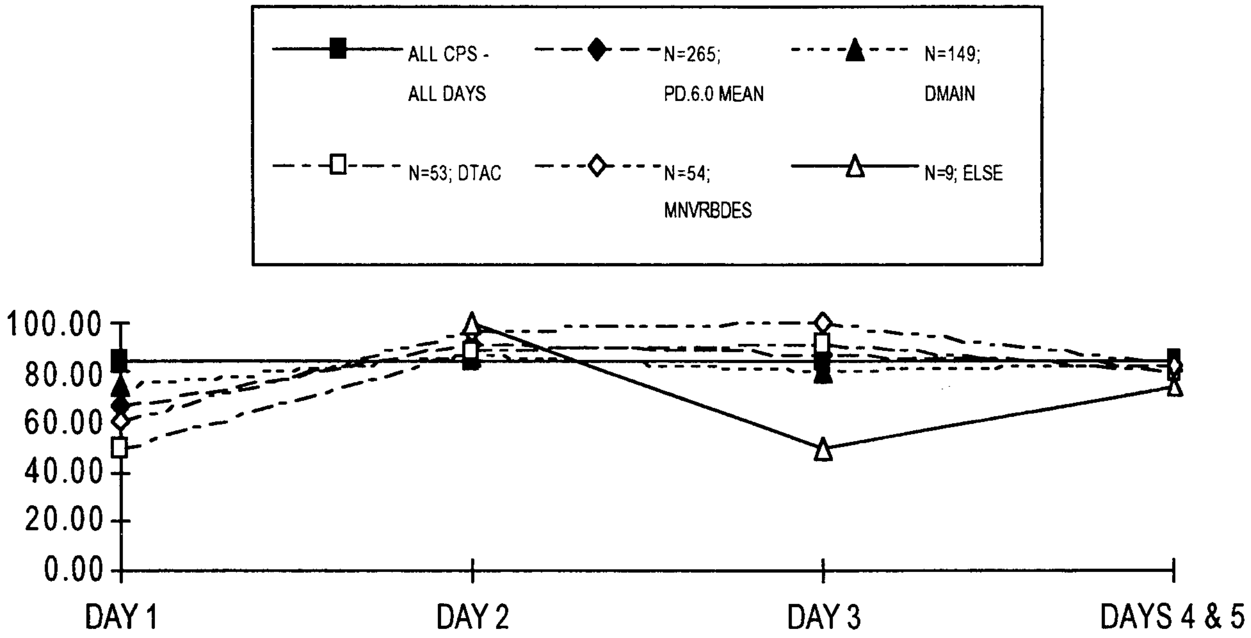
2.3.4 Directive Clarity

Clarity is measured by exception -- if no recipient queries a directive it is assumed to be clear. By this criterion, 85% of the directives observed were scored as clear. However, the patterns over time and across command centers are far from consistent as Figure 2-3 demonstrates.

Day 1 was the worst for all command centers, averaging 66 percent clarity. Day 2 showed improvement everywhere, and rose to 92 percent clarity (which is a significant gain, $p=.02$), despite the fact that this is a period in which plans are constantly being changed. Days 3 and the combination of Days 4 & 5 decline steadily to 87 and 83 percent, respectively. Day 1 involves the largest and most complex directives issued, which is one possible explanation for this pattern. It is also the day when command centers get their first practical experience at working with one another in the field setting.

Maneuver Brigades, which tend to issue simple directives, generally had the highest clarity scores. DMAIN, which issues the most complex ones tended to have the lowest scores. DTAC tends to fall between them. However, on Day 1, DMAIN has the highest clarity rating,

Figure 2-3: Clarity Of Directives



approximately 75%. Unlike the other command centers, DMAIN is largely occupied during this period with implementing plans that were developed over several weeks and have often been reviewed with their recipients throughout the division.

2.3.5 Directive Lead Time

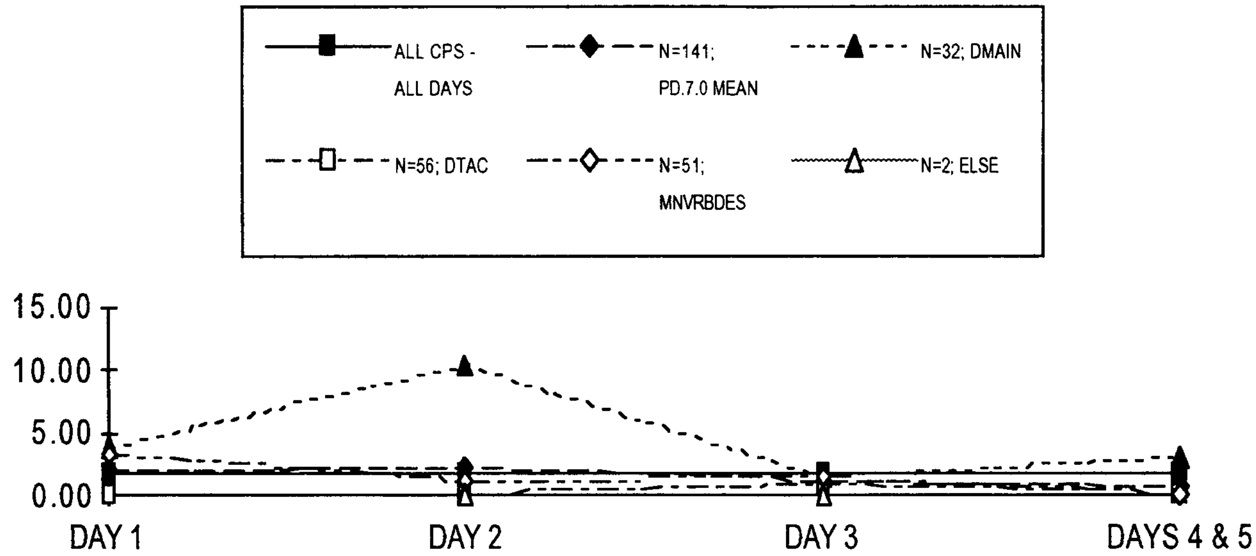
The data collected about the lead time provided to subordinate units was distributed more evenly across command centers than most of the directive preparation variables (see Figure 2-4), with the DTAC (56 cases) and Maneuver Brigades (51 cases) each outnumbering DMAIN (31 cases). Hence, the directives involved are a somewhat different set from those reported on other measures. Overall lead time provided was scored as averaging 1.7 hours and declining after the Day 2 (2.1 hours, 2.3 hours, 1.7 hours, and 0.6 hours, respectively). DMAIN was longer than either DTAC or the Maneuver Brigades, which reflects their more tactical orientation. The pattern over time, however, reflects the entropy and loss of control that was detected in the Overall C2 Performance Measures.

2.3.6 Insights About the Preparation of Directives

Directive preparation is the last, and one of the most important of the C2 functional processes that ACCES reports. While sometimes considered a mechanical step, observers emphasize that it is a very creative process, often involving considerable analysis as well as decisions (choices among options) within the broad framework of a larger decision. The evidence emphasizes the importance of this insight.

1. Directive preparation is typically team work, involving both several people and individuals with different responsibilities, points of view, information, and expertise.
2. At 1.6 hours, the average directive preparation consumes almost half of the typical total planning cycle time (3.6 hours). Indeed, the amount of planning included in this C2 process is reflected in this statistic. If this were a simple mechanical process, much less time would be required.

Figure 2-4: Lead Time For Subordinate Unit's Planning



3. The complexity of the process is further reflected in the fact that both errors in translating decisions into directives and problems with directive clarity cluster on Day 3 of the exercises, apparently because fatigue impacts during that time period.

4. Directive lead times and clarity decline after Day 2, two more indicators of the deteriorating C2 process under the pressure of simulated combat.

2.4 COURSE OF ACTION ANALYSES

Course of action analyses are completed before a decision is made. This process includes developing alternatives as well as assessing them. In a sense, this is the highest order cognitive C2 activity. ACCES looks at the number and variety of participants, the number of alternatives analyzed, the completeness and accuracy of the COA analysis, and how far the analysis looks into the future.

2.4.1 Number and Variety of Participants

The average of the 258 COA analyses scored involved 3.8 people, who were drawn from 3.5 different staff sections. About half the data are taken from DMAIN, where both values rise over time, with the largest rise between Day 2 and Day 3 (Number of Participants 3.5, 3.6, 4.5, 4.6; Number of Staff Sections Represented 2.7, 3.1, 4.2, 4.1). The other command centers were more irregular. Perhaps more important, there is no significant difference between the number and variety of participants in DMAIN COA analyses and those in other command centers, despite the larger staff available in DMAIN.

2.4.2 Number of Courses of Action Considered

On the 133 COA analyses reported, the average number of courses of action considered was only 2.1. Over time, this is a very stable value (2.05, 2.06, 2.11, and 1.93 over the four days). DMAIN does tend to consider the most alternatives, but the difference is only large on Day 2, when the average value rises to 2.8 COAs. This small mean indicates a potential vulnerability and is very different from current Army doctrine and training. Its stability over time and across CPs suggests a thoroughly entrenched practice.

2.4.3 Completeness of COA Analyses

ACCES establishes a list of topics that should be addressed when a COA analysis is carried out: enemy intentions, friendly force capabilities, timing, consequences of success, and potential enemy reactions. A score of 100 means all were explicitly addressed. If one were left out, the score would be 80 (4/5 x 100).

The average score for the 307 COA analyses reported was 38 percent, just less than two of the five elements. Over time there was some tendency for improvement (33%, 34%, 39%, and 43%). The maneuver brigades tend to make more complete COA analyses than other CPs after Day 1, but even they do not average more than 63 percent. DTAC looks particularly weak, hovering near one-third. Like the small number of alternatives considered, the narrow focus of COA analyses suggests a vulnerability in the C2 process.

2.4.4 Accuracy of COA Analyses

The accuracy of the elements included in the COA analysis averaged an impressive 80 percent. However, to be assessed an element had to be (a) in the course of action chosen for implementation, and (b) reported by the observers based on exercise ground truth. That limited the data to 56 total observations, which is marginal. Based on this limited data, however, COA analysis appears least accurate on Day 1 and most accurate on Day 2 (69%, 90%, 79%, and 77%). This pattern is reasonable. On Day 1 most exercise units have a relatively poor idea of the enemy's true disposition and intentions. During Day 2 these usually become much clearer. Beyond that, both sides typically must deal with more uncertainty as the reconstitute their forces and undertake new missions.

2.4.5 Temporal Vision of COA Analyses

The average COA analyses seeks to look almost 20 hours into the future. This value is stable over the first two days (19.0 and 19.5 hours), rises on Day 3 (22.7 hours), then declines on Day 4 & 5 (17.7). The increase on Day 3 can largely be traced to a few cases in the maneuver brigades, but is also visible at DMAIN. The Day 4 decline is almost certainly an ENDEX effect.

DMAIN has the longest temporal vision after Day 1 (16.5 hours, 27.6 hours, 28.8 hours, and 23.7 hours). This appears to confirm the idea that DMAIN spends most of Day 1 making minor adjustments to its original plan because it has not yet been subjected to the stress of simulated combat. In addition, the overall average around 20 hours provides a comfortable cushion for a command and control process that generates plans that average 8 hours after Day 1. However, the Day 1 value of 16 hours is very close to the average 14.6 hour plan duration for that exercise day. There is no cushion implied there, which is almost certainly one source of the pressure on Day 2 planning.

2.4.6 Insights About Course of Action Analyses

While course of action analysis is widely recognized as one of the vital C2 functions, the ACCES data suggests that Army doctrine is not being followed and vulnerabilities are being created.

1. A stable average of only two alternatives being considered and less than half the relevant elements are being examined suggests that the typical Army C2 process observed is narrowly focused.
2. The COA analyses typically involve only slightly more people than directive preparation. DMAIN uses about the same number as other command centers, which implies this process is not being given the rich attention doctrine specifies. This phenomenon could be related to the narrow focus of the COA analyses.
3. COA analyses tend to be much more narrow than would be ideal. Despite improvement as the exercise unit gains experience, the typical analyses never covers half of the elements that should be addressed.
4. Contact with the enemy improves the accuracy of COA analysis and may be a factor in its broadening over time.
5. During Day 1, COA analyses barely focus beyond the typical plan duration. This may be one factor in the pressure on the planning process observed on Day 2.

6. After Day 1, COA analyses tend to focus almost a full day into the future, while typical plans are about eight hours. This should be adequate to permit effective planning and may be one reason plan duration begins to grow after Day 2.

2.5 TRACKING OR SITUATION ASSESSMENT

Throughout exercises, the participants make statements about their perceptions of the battlefield. These statements go beyond issues of fact (such as, "The 4th Independent Tank Regiment is at 50% strength") to include inferences about the military situation (for example, "the enemy is positioned to launch an attack in the North"). These are situation assessments or efforts to track the battlefield. ACCES collects data on the completeness of those assessments, the accuracy of situation assessment items, and the temporal vision of situation assessments.

Because tracking the friendly situation is primarily a task for the Operations sections of a headquarters and tracking the enemy is primarily a task for the Intelligence sections; and because very different systems are used to gather and move information about friendly and enemy forces; ACCES separates data about the quality of C2 Tracking performance into perception of the friendly situation and perceptions of the enemy situation. In practice, the two are closely linked, particularly in the command function where they must be brought together. However, diagnosis of the quality of situation assessment and which systems are performing well or badly is facilitated by this independent collection.

Past research using ACCES data has shown that the quality of situation assessment is a key determinant of overall C2 success. Hence, ACCES observers are encouraged to capture this information whenever possible. In a sense, this set of inferences is always the beginning of the higher order processes in an ACCES decision cycle.

2.5.1 Completeness of Situation Assessment

Not all situation assessments should be complete. Many of them deal with only a single aspect of the battlefield; such as force composition, disposition, activities, capabilities or enemy intentions. These incomplete assessments tend to arise as the commander and staff review the on-going flow of information that is reported to them and seek to understand it. ACCES does not attempt to measure the completeness of these assessments. On the other hand, there are a number of occasions when a conscious effort is made to provide a complete situation assessment. These include formal update briefings to commanders or senior visiting officers, shift change briefings within a staff, written reports to higher headquarters, and so forth. When these occur, ACCES observers record their contents and measure them against a preset standard for items to be covered.

Over 3000 situations assessments were evaluated for completeness. The average assessment contained only about two-thirds of the items (65%) called for in ACCES. However, these values are not stable over time. Day 1 averages 71%, Day 2 falls to 62%, Day 3 recovers to 68%, and the combined Day 4 & 5 averages only 59%. The initial decline corresponds with the first serious simulated combat and would be consistent with the literature on groups under pressure tending to narrow their focus. The Day 3 recovery corresponds to the recovery period when both sides typically slow the battle as they reconstitute their forces and organize for a new battle phase. The decline during the last period may reflect that second round of intense simulated combat, and ENDEX effect, or both.

DMAIN, which provides more than 1300 of the data points, has a somewhat different pattern than the overall C2 system, stability during the first two days, an improvement on the third, and a return to its normal range at the end of the exercise (64%, 65%, 71%, 65%). DTAC, with more than 800 observations, does follow the general pattern (75%, 67%, 72%, 61%), but is above the typical vale for every single day. The maneuver brigades, which has a large set of 927 observations on this measure, are lower than the norm after the first day, but also follow the general pattern over time (73%, 61%, 65%, 53%).

These data support the hypothesis about the effect of stress and the assumed combat densities. DMAIN has the largest staff by far and the source of the hypotheses about breadth of attention is the small group and crisis management literatures, which derive their data from isolated groups. Moreover, this is apparently neither a doctrine or initial training problem. The smaller headquarters at DTAC and in maneuver brigade CPs actually provide broader formal assessments during Day 1, when the stress is lower and more time is available.

Because the information for friendly assessments is generated by the operations personnel and systems while that for assessing the enemy situation is largely the product of the intelligence system, ACCES also looks at these two groups of data independently.

Friendly assessments have a similar overall mean (66% compared with 65%) when compared with total assessments, but follow a very different pattern over time. Their most complete day is Day 2, with their worst being Day 3 (62%, 83%, 50%, 61%). The variation is not coming from DMAIN, which is pretty stable (65%, 66%, 68%, and 64%), as is DTAC (75%, 74%, 75%, 61%). Maneuver brigades are therefore very unstable, with major declines in Day 3.

Not surprisingly, therefore, the "saw tooth" in the overall data proved to be based largely on situation assessments focused on the enemy. The mean value across all command centers and time periods was again close to the overall value (63.5% versus 65%). Day 1 was 71%, declining to 60% on Day 2, rising to 68% on Day 3, and falling to 58% on the combined Day 4 & 5. As in the overall variable, the DMAIN values were generally stable except for a high completeness index on Day 3 (63.5%, 64%, 73.5%, 66%). Both the DTAC (74%, 58%, 68%, 61%) and the maneuver brigades (75%, 56%, 79%, 45%) show the dominant pattern.

When friendly assessments are reported, the combat service support situation is the element most likely to be left out. For estimates of the enemy situation, statements of enemy alternative courses of action are the subject most likely to be omitted.

Completeness of situation assessments show two important patterns. First, under pressure the smaller headquarters tend to narrow their focus. Second, the narrowing is actually a tendency to focus on the familiar and easy to get information (friendly forces) and not on the enemy situation.

2.5.2 Accuracy of Situation Assessments

Each of the elements in a situation assessment can be checked against ground truth and scored for accuracy or correctness. This process makes major demands on the data collectors and analysts because they must know both the contents of the assessment, the time it was made, and enough "ground truth" to enable them to score the item. On most exercises, well under half of the assessments collected can be scored for accuracy.

Overall 81 percent of the 1258 assessment elements that could be checked were found to be accurate. The worst day tended to be the first (73.5%, significantly lower p=.04), with stable, better values thereafter (82%, 84%, 82%). DMAIN, which has the most complex situation to track, shows steady improvement over time (74%, 77%, 79%, 85%), as does the DTAC (68%, 78%, 79%. 81%). However, the DTAC is below the average level of performance on all four days. Maneuver brigades do this quite well (85%, 89%, 92%, 85%), but the fact that they tend to be less complete than the other command centers must be remembered. It appears that they only make assessments about relatively obvious questions.

The units observed were correct in their assessments of friendly forces an average of 82% of the time, slightly above the overall value of 81%. However, performance on this measure is unstable over time, with Day 2 well above the others (80%, 88% which is significantly higher [p=.05], 79%, 80%). DMAIN shows improvement over time here, as it does on the overall value (76%, 78%, 80%, 90%). DTAC, on the other hand, starts very strong and declines in the middle of the typical exercise (90.5%, 90.5%, 75%, 75%). Maneuver brigades account for the improvement on Day 2 (79%, 91%, 86%, 80%).

Elements of situation assessments focused on the enemy were only slightly worse overall (80%) and provided the observations that pulled down the first days performance in the overall measure (64%, 77%, 88%, 83%). As in friendly assessments, DMAIN was able to improve performance over time (71%, 76%, 78%, 81%), as was the DTAC (42%, 68%, 83%, 87%). However, the very low value for the DTAC on the first day is worth noting. Maneuver brigades again have high scores on the few assessments they make (95%, 87%, 96%, 88%).

Accuracy of assessments are an arena where learning appears to take place over time. The scores tend to rise as the command centers become familiar with the battlefield, its dynamics, and their own command and control systems. Smaller command centers, which we know focus on fewer items, tend to assess the situation better.

2.5.3 Temporal Focus of Situation Assessments

When estimates of the situation are expressed they can focus at any point in time from now into the future. Better command and control systems are able to look beyond the immediate situation, so ACCES also collects information about the temporal focus of assessment situations. Since some statements are made in terms of event sequence (For example, "after we cross the river, the enemy will have to retreat.") and some assessments contain a number of very different elements, not all of which can be assigned a time value. Total available observations was only 288 data items.

The mean for temporal assessments was 13 hours into the future and was not stable over time (15 hours, 12 hours, 16 hours, and 9 hours). This pattern conforms to the simulated combat scenarios on most of the exercises observed with Day 2 shortening its time horizon under the pressure of increased combat intensity, Day 3 looking ahead to the next phase and Day 4 & 5 declining as a result of renewed intense combat and ENDEX.

Friendly situation assessments are actually shorter than the norm (11 hours), making enemy assessments above the norm (14 hours). Friendly assessments suffer a major shrinkage of focus on Day 4 & 5 (13.7 hours, 10.7 hours, 14.4 hours, and 4.8 hours), which is almost certainly an ENDEX effect. This tendency is less pronounced in enemy assessments (16 hours, 13.5 hours, 17 hours, 13 hours).

In keeping with its longer term planning responsibilities, DMAIN consistently has a longer time horizon for the situation tracking than do the other command centers, but the enemy assessments at DMAIN explain most of this difference. The consistent pattern of looking further ahead in time when considering the enemy than the friendly situation suggested a planning vulnerability.

2.5.4 Insights From Tracking and Situation Assessment

Situation assessment is the beginning of the higher order cognitive processes by which a commander and his staff carry out planning cycles. When a complete, accurate, and forward looking estimate of the situation is available effective planning and directive preparation are greatly facilitated. Hence this is an important segment of the ACCES data describing Army command and control processes. Several important insights emerge from its analysis.

1. Overall, situation assessments that were intended to be complete only covered about two-thirds of the items that doctrine indicates should be considered. For friendly forces combat service support elements tended to be left out. For enemy forces, enemy courses of action were the most common omission.

2. During periods of high stress the smaller, more tactical command centers (DTAC and maneuver brigades) tended to narrow their focus an perform less complete estimates of the situation, which focused more heavily on what is known about friendly forces than on the enemy situation.

3. While they make the least complete assessments, the maneuver brigades tend to make more accurate assessments than other command centers observed. Since theirs tend to be immediate and tactical, this pattern is not surprising.

4. DTAC, which also tends to deal with the tactical situation, also tends to be more accurate than the DMAIN when it makes a situation assessment. DMAIN, which has to handle the widest range and looks further into the future than the more tactical command centers, has the lowest accuracy rate.

5. Temporal horizons for the friendly situation tend to be shorter than those for the enemy situation. Coupled with the fact that they tend to leave out information on the combat service support situation (which is a long lead time item), this pattern suggests a

vulnerability in planning. Shorter time horizons are also associated with days of intense simulated conflict.

6. Completeness and temporal focus of situation assessments clearly trade off with their accuracy. The more narrow the scope of tracking and the closer the issue is to contemporary, the higher the accuracy achieved.

7. On Day 1 of the exercises observed, the 15 hour temporal focus of situation assessments is just barely equal to the observed plan duration (14.6 hours). On later days, the relationship between these variables improve somewhat, particularly for assessments of the enemy situation. However, remembering that the situation assessment normally triggers a planning cycle, which includes between 2 and 6 hours), the temporal focus of situation assessments is generally quite marginal to support effective planning.

2.6 INFORMATION CONSISTENCY AND COORDINATION

Excellent C3I is characterized by consistency of information both within the cells of a given command center (primarily DMAIN and DTAC in these exercises) and across different command centers. At the same time, excellent C3I also involves constant coordination of actions on the battlefield and gathering of information about the battlefield that is not available from routine reports. ACCES collects data on a variety of these activities that are outside the regular reporting system and not always central to a particular decision cycle.

The relevant variables include consistency of situation assessments within and across command posts (CPs), coordination completion rates and coordination delays within and across CPs, consistency of directives within and across CPs, and information seeking cycle times and success rates within and across CPs.

2.6.1 Agreement on Situation Assessments

These data are often difficult to collect because they require observers at two different locations to record information about current estimates of the situation at the same time and to compare their substantive content later, often after the exercise. Over 800 valid observations were recorded, however, so the variable can be reported with some confidence.

Agreement on situation assessment elements is a measure of whether different command posts "see the same battlefield." However, that is not the same issue as whether they see the battlefield well or accurately. A common battlefield picture should facilitate both the quality of communications between staff sections and CPs and the ease with which plans are produced. However, sharing the same poor quality picture of the battlefield would only speed and ease the processes of poor planning.

Some 86 percent of the 590 situation assessment elements that could be compared within command centers were rated as consistent. A saw tooth pattern was traced over time, with Day 2 and the combined Day 4 & 5 having the better performance (78%, 91%, 83%, 93%).

Situation assessments were somewhat less consistent across command posts (79.5% agreement) for the 382 observations available. While relatively constant on the first two days, consistency improved significantly over the last two (75%, 73%, 84%, 92%).

Finding that agreement on the military situation within command centers is higher than agreement across them is not surprising. However, these data also indicate that only part of the tendency for accuracy of situation assessments to improve over time at both DMAIN and DTAC is benefiting the larger system. Moreover, since the completeness of situation assessments tends to narrow on Days 2 and 4, when the consistency is highest, this pattern appears to be another reflection of the tendency to focus on the familiar and limit their search to easily acquired information during intense combat periods.

2.6.2 Quality of Coordination

In the best of all possible worlds, battlefield actions could be coordinated completely and instantaneously. However, coordinations compete for attention with other C2 activities. Moreover, sources of delay abound and, when enough delay occurs the subject is often overtaken by events. Hence, ACCES records both the completion rate of coordination actions and the time required to complete them.

2.6.3 Coordinations Within Command Centers

Overall, 82.5% of the 460 coordination actions observed within CPs on ACCES exercises were successfully completed. DMAIN, with the most observations, drives the dominant pattern, a saw tooth with its highest values on Day 2 and Day 4 (79%, 84%, 80%, 86%). The DMAIN version is more exaggerated (65%, 93%, 69%, 95%). The over time pattern suggests that when the division is heavily engaged it pays more attention to battlefield coordination. The time spent on these activities may detract from that available for other C2 processes such as situation assessment, which become more narrow. If this pattern is correct, the observed CPs are heavily burdened and shifting resources among activities rather than conducting all C3I functions on a continuous basis. Moreover, the slowed times for directive preparation for Days 2 and 4 & 5 (reported earlier) appear to be reflections of greater concentration on, and need for, coordination during these periods of intense simulated combat.

Time delays in completing coordinations average 1.1 hours within CPs, with 343 valid observations. However, these delays vary widely over time, from 1.4 hours on Day 1 to 1.2 on Day 2, 0.6 on Day 3, and 1.1 again on Days 4 & 5. DMAIN, which provides about half the data, is very quick on Day 1 and 3, much slower on Days 2 and 4 (0.1, 1.7, 0.4, 1.8). Typically Day 1 is spent executing a detailed plan DMAIN has been working for weeks, so its need for internal coordination should be minimal, while other CPs, which are in the midst of executing that basic plan, need time to synchronize their activities. The intense combat simulated on Days 2 and 4 also appear to force more complex coordination at DMAIN. The fact that the higher completion rates occur on the same days as the slower coordination cycles provides further evidence of this pattern.

2.6.4 Coordinations Between Command Centers

While apparently more difficult, the 741 coordinations observed between CPs were actually more successful than those within the same CPs (85% versus 82.5%). Some deterioration occurs over the four days of a typical exercise (87%, 87%, 85%, 83%), but all the values are near the overall mean. DMAIN and DTAC, however, both have their lowest day (86% and 83%, respectively) on Day 2, when combat is typically most intense. However, their lowest days are not far from the overall mean.

Surprisingly, coordinations between CPs averaged less time than those within CPs (0.7 hours versus 1.1 hours) Clearly the Army communications system was not a barrier to rapid coordination and face to face opportunities did not save very much time. Learning was also apparently present on coordinations between CPs because the time required declined for those coordinations completed (1.0 hours, 0.8 hours, 0.4 hours, 0.5 hours). The one-half hour time may represent a practical minimum for typical coordinations.

2.6.5 Summary of Patterns for Quality of Coordination

One possible explanation for both the higher completion rate and greater speed of coordinations between CPs than within them is the hierarchy of command centers. Coordinations almost always involve a superior and a subordinate. The subordinate is typically highly motivated for rapid and successful actions.

The saw tooth effect on coordinations within CPs and the fact that DMAIN and DTAC have their lowest coordination completion rates and longest coordination times on Day 2 argue for the fact that intense combat complicates the coordination process. This corresponds with the longer directive preparation times on Days 2 and 4 & 5.

The quality of communications between command centers was more than adequate to support the coordination processes observed.

2.6.6 Consistency of Directives

No problems with directive consistency were observed within any Army command center during any of the exercises. This is an improvement over past applications of ACCES. Directive consistency between CPs, however, was a far from perfect 84 percent. The only notable difference over time was that Day 1, when the unit was implementing its relatively detailed plan prepared before the exercise, was significantly better (90% consistency) on between CP consistency than the other days.

2.6.7 Information Seeking

By definition, information seeking is a proactive effort by a command center to acquire C2 information that would not be reported to it routinely or is not supposed to be reported to it at the time its is desired. The information seeking issue was added to ACCES for the last three applications in order to provide insight into different styles in C2, so the number of relevant observations is relatively low. However, the issue is potentially important and is handled in the same general way as coordination attempts. ACCES looks at both the completion (or success) rate and the time required to complete an information seeking cycle.

Only 85 data points are available on the success rate for information seeking within a single CP. The completion rate is quite high, 95%. The delays observed are also quite short, less than 0.1 hours.

The 123 observations for information seeking across CPs have a success rate of almost 87%, somewhat lower than that for the same function within CPs. Delays average 0.3 hours. In an absolute sense, obtaining information across CPs is less successful and requires more time than the same function within a command center.

2.6.8 Insights Based on Information Consistency and Coordination

1. Situation assessments are more consistent within than across command centers.

2. During periods of more intense combat, consistency of situation assessments rises, particularly within command centers. However, this is also the period when they become more narrow and tend to focus on the more readily understood friendly forces.

3. Coordinations are more rapid across command centers than within them, which appears to be the result of the unequal status of the different command centers. This finding also indicates that the quality of communications between command centers is at least good enough to support effective coordination.

4. Periods of intense simulated combat are associated with slower, but more successful, coordination processes. This coordination appears to slow the directive preparation process.

5. Consistency of directives between command centers is higher when working off a detailed, fully coordinated plan than when following a rapidly developed or "hasty" plan.

6. Information seeking is slowed and the success rate lower, when conducted between CPs rather than within them.

7. Coordinations are considerably slower and less successful than information seeking efforts.

2.7 REPORTING (INCOMING AND OUTGOING INFORMATION)

The reporting system underlies the higher order processes by which the estimate of the situation is developed, options are generated, decisions made, and directives promulgated. ACCES contains dozens of measures about the quality of information handling, many of them designed to support the test community (OPTEC, or the Operational and Test Command of the Army, for example) during periods when ARI was working closely with them. However, ACCES observers on most ARI sponsored exercises are instructed to emphasize the higher order C3I processes and collect reporting data only when it does not conflict with their efforts to obtain information on those higher order processes. This fact and the relatively modest relationship between these variables and ARI's primary focus on human behavior have led the study team to focus the analysis on a selected subset of these measures.

ACCES scores incoming and outgoing reports. This analysis stresses the outgoing reports except for those few incoming information variables that only apply to incoming information, delays before a report is <u>perceived</u> after it has been <u>received</u>.

2.7.1 Clarity of Outgoing Reports

A report is considered clear by ACCES unless one or more recipients makes an inquiry after receiving it. This measurement by exception is the same approach used to judge clarity of directives. Data for 145 reports showed a mean score of 95 percent clarity. However, this included a significant decline on Day 4 (100%, 100%, 99%, 82%) which can be seen either as an ENDEX effect (carelessness) or the cumulative effect of pressures on the C2 system over time from loss of adaptive control to fatigue. Since the exercises observed were not only for training purposes, but also evaluations of the commanders and their staffs, carelessness seems like the weaker hypothesis.

2.7.2 Report Completeness

Formal reports, particularly SITREPS (Situation Reports) and INTSUMS (Intelligence Summaries) can be judged against a list of topics they should cover. Outgoing SITREPS, largely from brigades, were found to contain an average of 87 percent of the appropriate information, with considerable improvement after Day 1. G-3 Operations, within the DMAIN, which produces the bulk of these reports, appears to benefit from the exercise experience. However, incoming SITREPS, largely received at DMAIN and DTAC, were found to contain an average of only about 61 percent of the same items and tended to deteriorate over time.

INTSUMS going out (almost always from DMAIN) were found to be much more complete (93%), with only a single low period, Day 2 (73%). Incoming INTSUMS were also high (88%), but tended to decline after Day 1, with no real recovery. The intelligence process, therefore, looks very much like the overall C3I process over time and is being "ground down" by the entropy of simulated combat.

2.7.3 Report Punctuality

Only scheduled reports can be punctual or late. Both outgoing and incoming SITREPS tended to become more punctual as the exercises went on, but the outgoing ones were typically more punctual than those being received (65% versus 35%). INTSUMS tended to be late. Punctuality of outgoing INTSUMS averaged 29% and tended to decline as the exercise proceeded. Incoming INTSUMS were ignored because they are often produced by the corps exercise cell, which is well insulated from the pressures of the exercise. Overall, entropy appears to impact report punctuality.

2.7.4 Report Accuracy

SITREPS tended to be very accurate (98.5% for substantive in out-going reports and 96% for incoming reports). INTSUM information could not be verified against ground truth often enough to provide a meaningful measure. However, unscheduled reports from the field (spot reports about the enemy and operational updates on friendly forces) were also highly accurate (98% for outgoing reports, 95% for incoming reports). Since these deal with reports about both friendly and enemy forces, the quality of factual information in the C2 system appears to be quite high.

2.7.5 Speed of Reporting

Spot reports and friendly situation updates are unscheduled and usually have some urgency. Incoming operations reports were found to cover information an average of 0.4 hours old while spot reports on the enemy were about 0.7 hours old when received. When necessary, these were very rapidly retransmitted (in a matter of minutes) from the brigade and division level headquarters who received them. Moreover transmission times between command centers were extremely short.

2.7.6 Speed of Report Perception

ACCES also collects data about the time elapsed between when a CP has received a report and the time that someone with the authority to review or act on the report is aware of it (has perceived it). These perception times proved to be quite short, but still several minutes. Perception time for friendly operations report updates averaged 0.17 hours (about 10 minutes). Spot reports for enemy forces had an average perception time of 0.23 hours (about 14 minutes). Not all these reports are urgent and quite a few of them actually had zero perception time (the received had the authority), so these values are not a cause for concern. However, these average delays are another piece of evidence that CPs are busy places and must defer some tasks in order to accomplish others.

2.7.7 Insights From Data on Reporting

Reporting, as seen from the limited ACCES data collected, is a process quite apart from the efforts of the commander and staff to manage the battle. However, some relevant conclusions emerge.

1. The quality of reporting was high on the observed exercises.

2. The communications systems generally made it possible to move the reports rapidly.

3. Both the pressure of simulated combat and the entropy inherent in continuous C3I exercise processes were reflected in reporting measures. Punctuality, completeness, and clarity all show the impact of these pressures.

2.8 CONCLUSIONS

ACCES measures paint a rich and coherent picture of Army command, control, communications, and intelligence effectiveness, processes, and speed on the ten exercises observed between 1990 and 1992. The data are uniquely valuable in their own right, providing a baseline of C3I performance on Post-Cold War scenarios that does not exist in any other form. These data also suggest a pattern of strengths and weaknesses from which important lessons learned can be readily inferred. Finally, they provide a basis for reexamining the way Army C3I is conceptualized, both in ACCES and in larger US Army doctrine and practice. The last chapter of this report focuses beyond the data on these larger patterns.

3 PATTERNS IN ARMY COMMAND AND CONTROL

3.1 PURPOSE

Integrating the information from the full range Army C3I functions assessed by ACCES is perhaps the best way to understand how that process works. While three to five day exercises with simulated combat do not create all the pressures of real combat or all of the problems inherent in the fog of war, they do place considerable stress on the people and systems the Army will rely on during real combat and crises. Since we know that these simulations fall short of the stresses expected in the field, we should expect that those C3I functions, systems, procedures, and tasks that do not score well in the exercise environment are not robust enough.

At the same time, the purpose of assessment is not only to learn what goes badly, but also what goes well. Those elements of the C3I system that do function effectively in BCTP and division training environments should be strength areas in combat and crises and provide the basis for improving the others.

The ten ACCES applications analyzed in this report represent a unique opportunity to gain insight into the patterns of C3I performance in Post-Cold War scenarios.

3.2 OVERALL PATTERNS

Three dominant patterns emerge when the individual measures and families of related measures are examined. Several measures, particularly those in the General or Overall Effectiveness arena decline over time during the exercises. A few improve over time. A substantial number, however, look like a saw tooth over time, suggesting meaningful differences between exercise Days 1 and 3 and the alternatives Days 2 and (composite Day) 4 & 5. Since these alternating days generally have a pattern related to the BCTP scenarios and the pattern is present in a number of indicators, EBR's analysis assumes that they are a reflection of the changing battlefield dynamics.

* Day 1 is a low stress day in which most divisions are in the process of implementing a plan they had several weeks to prepare and coordinate and involves modest combat activity. Most typically, Day 1 is dominated by movement to contact, passage of lines or similar activities.

* Day 2 is usually dominated by intense combat with both the red and blue sides near full strength. Stresses and large consequences for delay or poor decision making are strongly perceived.

* Day 3 is typically a slower combat day because both sides have spent considerable combat power, the battlefield has been transformed and they are in the process of transitioning to new missions as well as reconstituting their forces.

* Day 4, and when it occurs, Day 5, include renewed combat as both sides seek to implement the plans to achieve their new missions. The last few hours of exercises are also subject to an "ENDEX" effect in which performance may deteriorate. On most ACCES

applications the senior analyst attempts to cut off data collection before this phenomenon becomes a problem.

Understanding what has been learned about Army command and control requires that all three of these patterns be examined.

3.3 AREAS OF DECLINING PERFORMANCE

Four of the overall performance and C3I effectiveness measures tend to decline across the four days of the exercise (See Table 3-1). A smaller and smaller percentage of the plans generated achieve adaptive control of the battlefield as the typical exercise moves through time. More and more of the plans become reactive rather than proactive or contingent. After the second exercise day, fewer and fewer of the plan elements can be executed within the set of contingencies originally envisioned. Moreover, as the exercise goes on the command and control cycle time increases for those situations where speed is the most important -- cases in which the previous plan has failed and a new one is urgently needed.

TABLE 3-1 ACCES MEASURES THAT DECLINE OVER TIME
Plan Execution
Plan Success
Plan Initiative
C2 Cycle Time (High)
Directive Lead Time
Clarity of Outgoing Reports

Two other measures also tend to deteriorate over time, the lead time provided to subordinate commands for implementing directives and the clarity of outgoing reports. Shortening lead times are potentially devastating to successful combat. Each time they decline the ability of subordinate organizations to develop and implement their own plans becomes more constrained. This could, in turn, contribute to the deteriorating overall success of Division-level planning.

Clarity of outgoing reports is not a major variable in the ACCES system. Moreover, its deterioration occurs late in the exercise, so it could simply be a function of ENDEX. However the decline is substantial and follows three days of very high scores on the same measure across all command centers. Hence, EBR believes this decline is one more sign of the deterioration of the C3I system over time.

While far from perfect, the training exercises observed appear to have created enough pressure on the units to demonstrate the cumulative effects of the "fog of war" and the entropy inherent in sustained efforts to perform C3I functions. The ACCES findings suggest that:

* There is ample room for improvement in overall C3I performance and the effectiveness of C3I. The existing system can be improved.
* Extension of the exercises would drive home the lessons learned and demonstrate the importance of improved C3I training and systems.

3.4 AREAS OF IMPROVING PERFORMANCE

A half dozen other ACCES measures showed stable patterns of improvement (Table 3-2). The only overall measure improving is the C2 cycle time when the system is under moderate stress. This is in direct contrast to the slower cycle times when the C2 process is under major stress and time pressure. Apparently these more modest stress cycles become routinized as the command centers gain experience with them during the exercise. The high stress cycles, however, apparently take increasing time precisely because they occur when the situation is out of hand.

TABLE 3-2 ACCES MEASURES THAT IMPROVE OVER TIME
C2 Cycle Time (Moderate)
COA Number
COA Variety
COA Completeness
Tracking Accuracy
Speed of Coordination Between CPs

Measures with improving scores cluster in the Course of Action (COA) function. The number and variety of personnel participating in COAs tends to rise over time. Small group research and Army doctrine both argue that broader participation will lead to better decision making, particularly in complex arenas. Concomitant with that trend, the completeness of COA analyses also rises over time. This is also consistent with the small group literature which notes that the larger number of participants will allow the group to perform richer explorations of the problem.

Accuracy of tracking or situation assessments also tends to improve as the exercise moves through time. This may be partly a function of learning how to interpret the information from the simulated wargame, but it is also probably related to becoming familiar with the dynamics of the battlefield. Past research has also shown that this factor is a crucial determinant of success, so improving performance on it can be important. However, the fact that the completeness of situation assessments does not also increase limits the value of this pattern.

Finally, the speed with which coordinations are accomplished across command centers decreases over time. This indicates that the unit is learning to conduct business successfully across space.

All of these areas reflect improved performance and learning from the training exercises. However, they represent only a small part of the overall C3I system. While two crucial C3I functions (COA Analysis and Tracking) are present only the COA function is represented in any depth. Progress appears to be made primarily on procedural functions where time in the field introduces the staffs to interactive functions and the learning occurs as a natural part of the exercise.

3.5 SAW TOOTH UNDER PRESSURE: THE PREDOMINANT PATTERN

Most of the meaningful variables with a strong pattern follow the saw tooth outline described above. Three variables are better during periods of intense combat, situation assessment consistency (both within and across command centers), time spent on preparation of directives, and the success rate for coordinations. Not all of this information is, however, positive.

Considerably less time is spent after each decision and before issuing directives during intense combat. This pattern plays an important role in fitting the whole puzzle together because it indicates the haste with which directives are prepared under pressure. Since the directive preparation times on intense combat days (2 and 4) are considerably shorter than the coordination times for those days, this pattern also indicates that coordinations are being done "on the fly" to determine the feasibility of alternative COAs rather than after decisions have been made.

Consistent situation assessments are generally considered good, but in this case the consistency is based on less complete assessments that focus in more closely to the present. Hence, they represent a pattern in which "groupthink" is possible and the narrowed focus may be a source of vulnerability. In essence, by concentrating on fewer aspects of the battle, particularly those for which good information is available (largely data on friendly forces), the staff become more correct about a more narrow portion of the battlefield dynamics.

All of the other variables listed in Table 3-3 had weaker performance under pressure. Note that accuracy of COA analysis is subject to stress from battlefield dynamics. As noted above, the completeness of situation assessments declines when the pace of battle increases and the temporal focus of those assessments moves in closer to the present. This is another well understood small group phenomenon: under pressure people tend to focus on the familiar (limiting their search for new information) and to shorted their time horizon.

TABLE 3-3
ACCES MEASURES THAT SAW-TOOTH OVER TIME

<u>Better Under Pressure (Days 2 and 4)</u>
Directive Preparation Time
Consistency of Situation Assessment Wthin CPs
Successful Completion of Coordination

<u>Worse Under Pressure (Days 2 and 4)</u>
COA Accuracy
Completeness of Situation Assessments
Temporal Focus of Situation Assessments
Consistency of Situation Assessment Between CPs
Speed of Coordination Within CPs

Two coordination measures also follow the saw tooth pattern. The speed of coordination cycles slows considerably. At the same time, as noted earlier, their success rate increases. Under pressure of simulated combat, therefore, coordination becomes more important and requires more time. This is consistent with the pattern noted above of coordination activities becoming substitutes for formal COA analyses during intense combat. This increased attention results in greater coordination success, but at the expense of the time and energy to conduct other, more deliberate C3I processes.

3.6 ARMY COMMAND AND CONTROL RECONCEPTUALIZED

Looking not only at the patterns presented here, but also the rich set of information available from the past three years of ACCES applications and the experienced obtained in supporting them, the EBR team working ACCES to Enhancements has developed a figure to reconceptualize the Army command and control process. This figure is intended to replace the relatively simple, single decision cycle loop that ACCES has used to describe command and control while, at the same time, provide meaningful feedback to those responsible for designing Army doctrine, systems, and training.

Army command and control is best understood as a set of connected functions and activities. Each element is important to a proper understanding of the whole.

All C3I occurs in the context of an operating environment, which includes the enemy, friendly forces, missions assigned, the physical and social environment, and higher headquarters intent. Data on C3I systems must be collected with enough of this information associated to allow sorting into meaningful groups of operations and exercises. However, the same C3I functions must be performed regardless of the environment. The speed and quality necessary for success will vary by environment (for example, the quality of the threat may change the performance needed for mission accomplishment), but not the basic C3I functions themselves.

Commanders and their staffs are engaged in five distinct activities worth monitoring. Three of these are complex functional arenas that are supported by elaborate processes and systems: information management, decision management, and battlefield management. The other two are very simple human activities, but are the keys to successful C3I: situation assessment and making decisions.

As Figure 3-1 illustrates, the three major management systems are composed of a number of procedures that can be monitored and measured in detail. The next generation of ACCES, for example, should include detailed measures that track the frequency, quality, and speed of these functions.

The key insights, however, revolve around the activities and functions that connect these management activities.

* Situation assessment does not belong to either information processing or decision management. Rather it is a unique function that helps Division commander's and their staffs to decide whether they have the time necessary to conduct a doctrinal COA analysis (conduct "deliberate planning") or whether they need to exercise the "Commander's Shortcut" which leads more directly to a decision,
* The Commander's Shortcut is an established part of the Army's Battle Command process, but not well recognized in doctrine, particularly for complex echelon's such as division. However, the dynamics of the modern battlefield have made this high speed process (now often referred to as "command and control on the fly") a necessity. BCTP units were driven to it on their intense combat days, just as Desert Storm units found it necessary.
* The Commander's Shortcut is not a blind leap from simple recognition that a novel or threatening situation has arisen to a decision. Rather it is an intense process involving commanders directly and extensive coordination (which often involves selected staff) to ensure that the new guidance can be implemented. This "pre-decision command coordination" reduces the complexity of directives and allows rapid implementation once a decision is made.

When time pressure permits, the more traditional (and doctrinal) decision management process occurs. Because this process is designed to avoid the problems of groupthink, narrow focus and foreshortened time horizons, it reduces the risks inherent in all new plans. However, because this process is being taught as "the" solution, there is some evidence of a tendency to execute it in a truncated way, which achieves neither the benefits of proper decision

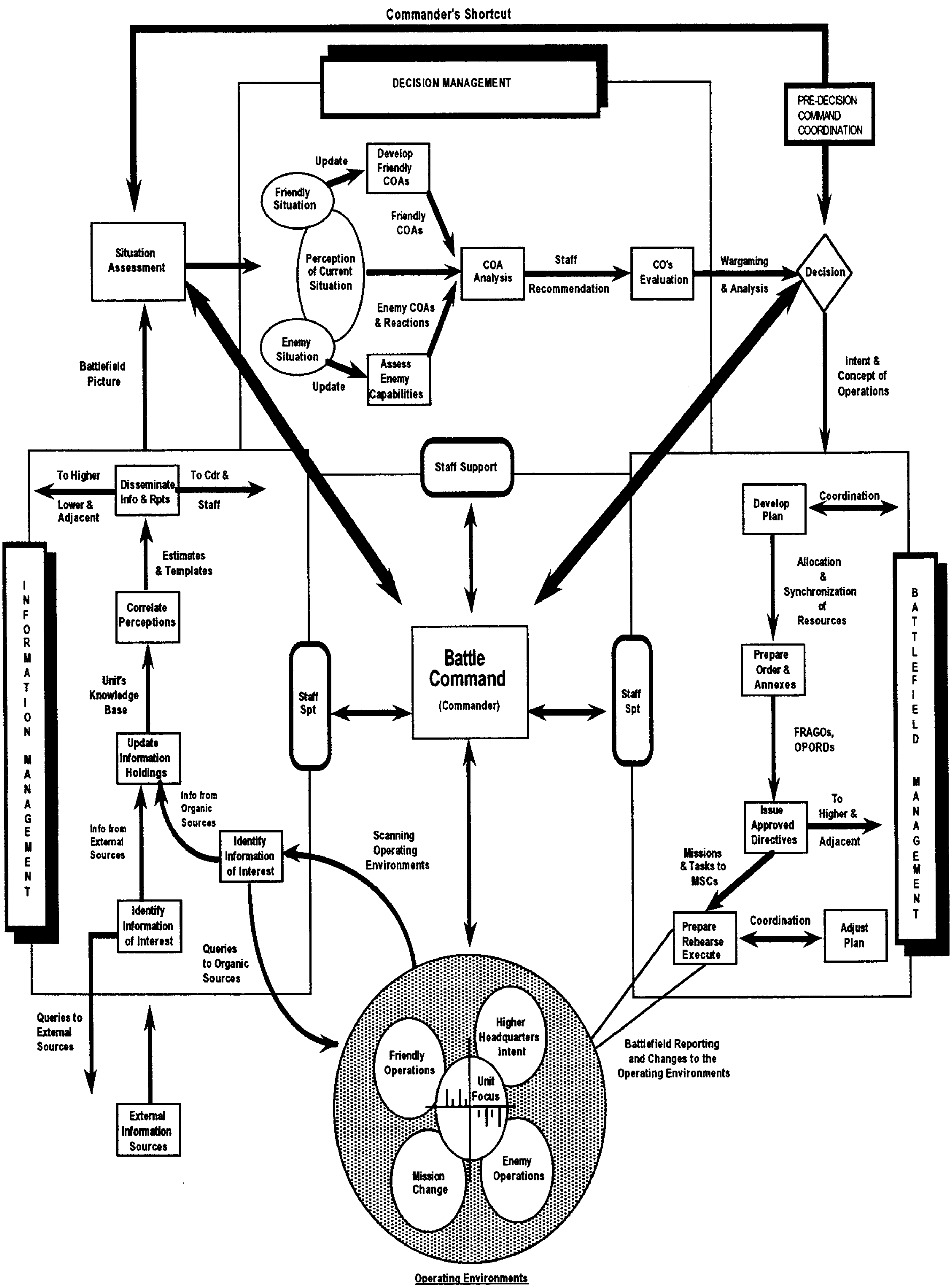


Figure 3-1: DECISION MANAGEMENT

management nor those of the properly executed Commander's shortcut. Poorly done, it comes to look like "dithering" in which partial COA analyses and constantly being scrapped as their focus is destroyed by the battlefield dynamics.

As this new style of command and control becomes more common, the Army needs to collect both information on how well it performs and insights from those who practice it well so that it can be taught to those preparing for command. ACCES can be adapted to play a significant role supporting that process.

4 THE ARMY COMMAND AND CONTROL EVALUATION (ACCE) MODEL

4.1 PURPOSE

The Army Command and Control Evaluation model (ACCE) was developed under contract to the Ft. Leavenworth Field Unit of the Army Research Institute (ARI) as a part of the Enhancements to the Army Command and Control Evaluation System (ACCES) project. ACCES is an objective system for monitoring the performance of staffs and the command and control systems that support by creating quantitative indicators of (a) the effectiveness of the command and control (C2) systems as well as (b) the speed and (c) quality of the C2 processes observed in exercises. ACCES has been used to collect C2 data for ARI from Battle Command Training Program (BCTP) exercises and to derive baseline information about command and control systems for the Operational Test Command (OPTEC).

ARI requested that Evidence Based Research, Incorporated (EBR) and its subcontractor, the George Mason University Center for Command Control and Communications (GMU) undertake the development of an analytic model of C2, drawing where possible from the philosophy, data, and experience generated from ACCES. The model should (a) permit assessment of changes in personnel, equipment, procedures, or organization and (b) focus on the behavioral aspects of C2.

The need for such a model arose from ARI's perceptions that most combat models do not represent C2, while those that do have little or no behavioral content. ARI also perceived that most C2 models focus more heavily on communication than on C2 and also tend to minimize behavioral issues. At the same time, ARI anticipated that the ACCES program would benefit from the technical challenge of moving beyond the descriptive conception of C2 developed in the early 1980s to a more rigorous analytical perspective. Finally, the Ft. Leavenworth Field Unit noted that issues related to changes in C2 personnel, procedures, organization, and equipment arise frequently and are difficult to answer systematically. Progress toward an ACCES-based analytical model would improve the Army's capability to deal with these issues in a timely and cost-effective manner.

4.2 STATUS

Progress toward a valid model has, as was expected by all those involved, been slow and difficult. However, there has been substantial progress; a working prototype of the ACCE Model is available and has been applied to an example problem: the increased experience of selected staff officers within a division. The prototype has a limited scope; it focuses on the Commander, G-2 (Intelligence), G-3 (Plans and Operations), and DTAC (Division Tactical Command Post) of an Army division, with supporting data from those brigade and corps headquarters that are directly linked to the depicted cells. The prototype runs in MicroSaint on a Macintosh computer. It contains parameters based on relevant data from prior ACCES applications and a system of judgmental rules and relationships elicited from C2 experts on the ACCES Enhancements project team.

4.3 STRUCTURE AND APPROACH

ACCES views C2 as an adaptive control system that obtains knowledge from its environment and that seeks to establish control over its environment through the development and implementation of plans (plans being defined as coherent combinations of missions, assets [implementing organizations and their equipment], schedules, and boundaries). Control is achieved when the plans can be carried out successfully, either in their original form or through the activation of contingencies that are contained in the plan or issued as separate guidance.

FIGURE 4-1: OVERALL STRUCTURE OF THE ARMY COMMAND AND CONTROL EVALUATION (ACCE) MODEL

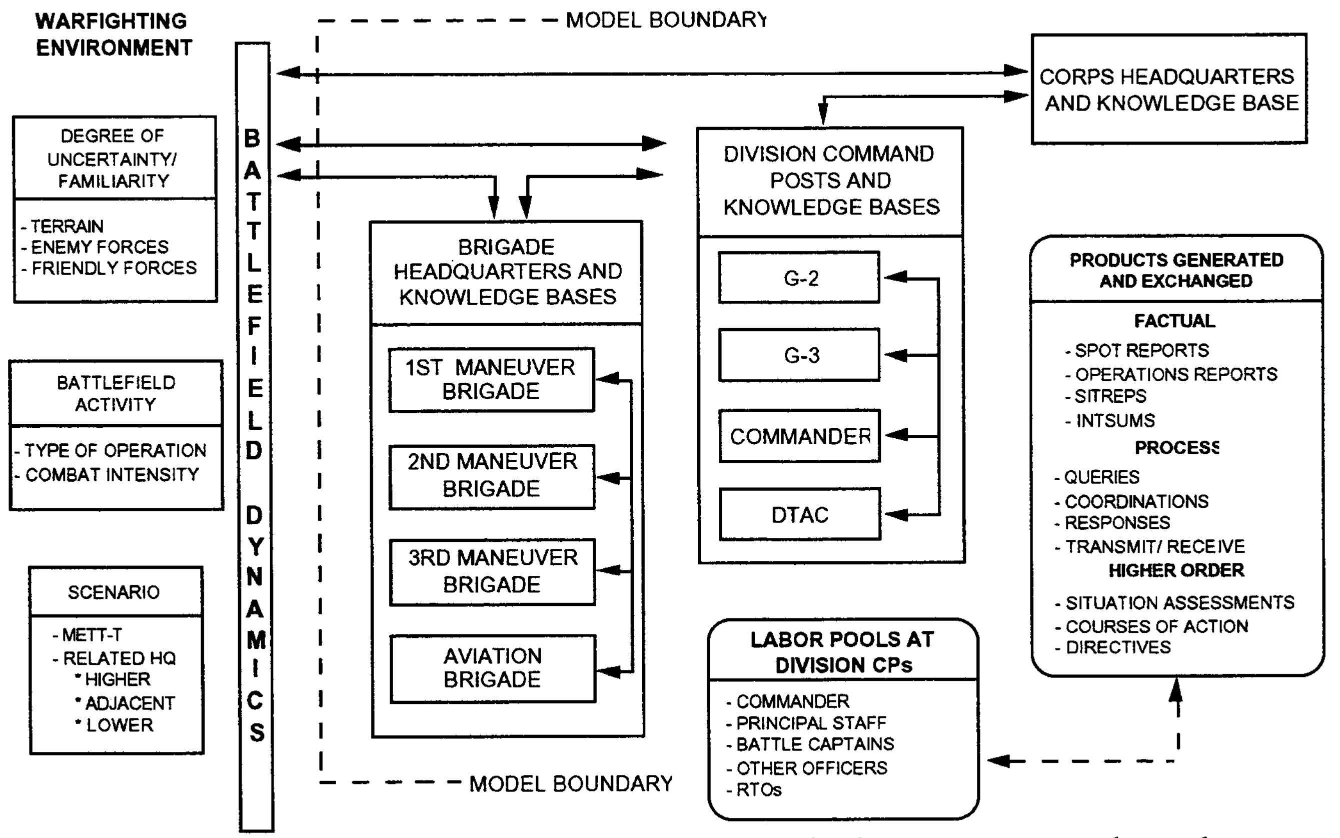


Figure 4-1 shows the overall structure of the prototype Army Command and Control Evaluation (ACCE) model. The ACCE model assumes that the nature of the C2 process (its pace, the way the process works, and the key parameters that determine the quality of the processes) vary across warfighting environments, of which the three most important features are: familiarity/uncertainty, type of operation/intensity of combat, and specific scenario.

At the topmost level, the ACCE model assumes that the effectiveness of the C2 processes depends on the degree of familiarity or uncertainty the headquarters has with the war-fighting environment. This is reflected in its knowledge (or ignorance) of the terrain where the operations occur (broadly defined to include weather and demographics), its knowledge of the enemy forces, and its knowledge of the friendly forces with whom it is operating or on whom it must depend.

The C2 processes at work are also assumed to depend on the type of operation being conducted and the intensity of the combat environment. Clearly the message flow and pace of decisions are different during movement to contact than during offensive operations, and different in clashes with irregular forces than in combat with conventional military formations.

Finally, the specific scenario is important. Clearly the elements of METT-T (Mission, Enemy, Troops, Terrain over Time) make a difference, not only because they reflect the concrete embodiment of the uncertainty/ familiarity and battlefield activity, but also because they provide the details of how many forces must be tracked and directed. For C2 modeling, assumptions about the number and variety of higher, adjacent, and subordinate headquarters that are active also provide a basis for communications and decision-making workload. Variations in the scenario are not anticipated to alter the parameters of the model in the way differences in the uncertainty present and nature of the battlefield activity will, but they will affect the workload on the C2 system.

Taken together, these three major features of the war-fighting environment establish the "Battlefield Dynamics" which form the exogenous environment for the model and the C2 system. Everything that goes on inside the ACCE model is related to the efforts made to achieve adaptive control over this environment and feedback information about the degree of success achieved toward that goal.

For the working prototype, a specific war-fighting environment was selected and parameters and processes typical of that environment modeled. The focus selected was the middle period of a typical BCTP/ WARFIGHTER exercise, a period characterized by intense combat in a moderately uncertain combat environment and combined offensive and defensive operations. Both the parameters and processes were drawn from data available at the time each model segment was developed. For the most part, these were data from the second, third, and fourth days of six or seven ACCES applications. Because more ACCES data are now available, different parameters would be built-in if the model were being revised or extended, but the processes would remain the same.

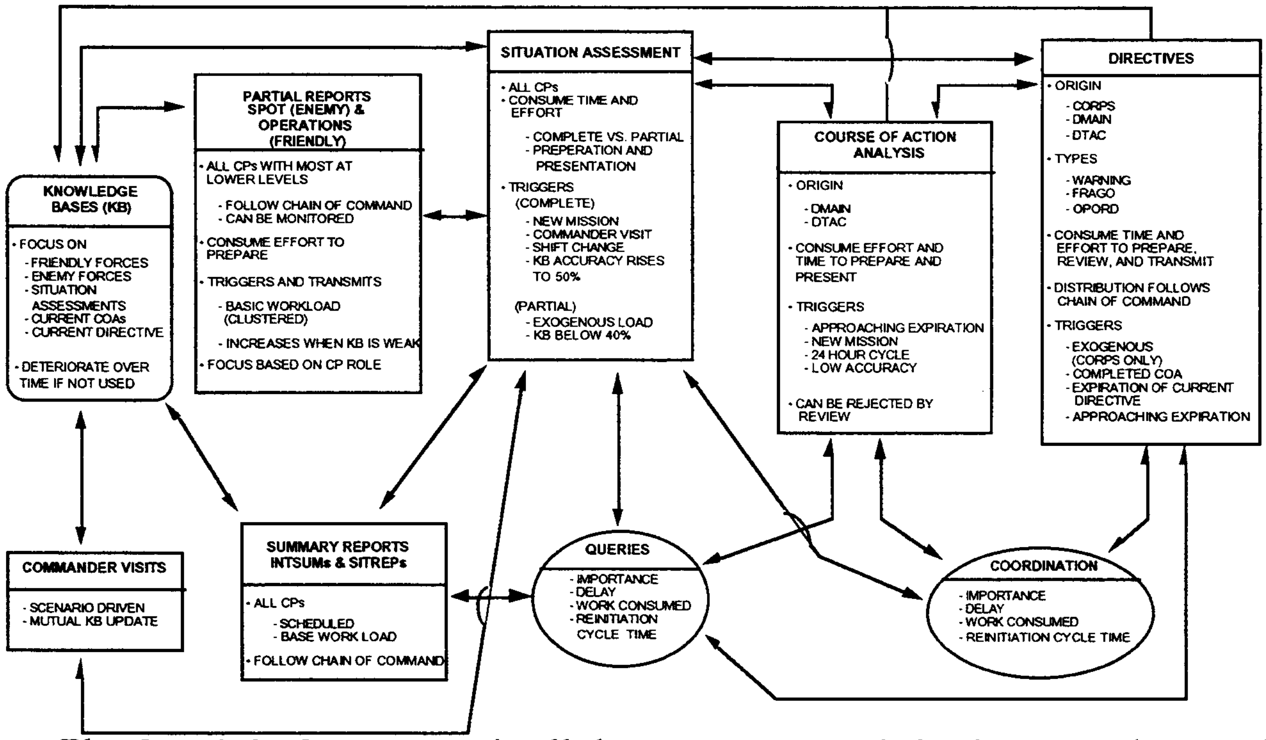
As Figure 4-1 indicates, the model focuses on the four C2 nodes of interest at the division level, but provides for their interaction not only with one another, but also the brigade and corps C2 nodes and "knowledge bases," as well as the environment in terms of battlefield dynamics. Information is received from the battlefield, and from exchanges among the C2 nodes, in the form of C2 products that can be factual, process-oriented, or higher order. Factual products include information about entities and can be narrowly focused and unscheduled (spot reports about the enemy or operations reports about friendly units) or scheduled and broadly focused (situation reports on friendly units and intelligence summaries on enemy forces). Some products are primarily the result of processes such as inquiry, coordination, responding to inquiries or coordination attempts, or transmit/receive activities. Others embody higher-order processes such as situation assessments, course of action analyses, or directives.

The ACCE model focuses on the C2 processes of generating and exchanging these products and on the effect of their content. Each effort (generation, transmittal, receipt, processing, etc.) consumes labor and time within the division C2 nodes of interest. The rules in the model deal with the creation, transmittal, receipt, processing, and quality of these products. Each C2 node of interest has a knowledge base in which it stores all its current information and the attributes of that information. Work pools have been created for the commander, principal staff, battle captains at each C2 node, other officers (which includes senior non-commissioned officers and warrant officers who play significant roles), and radio-telephone operators (RTOs). Rules exist on shift change, sleep, the overlap of shifts when workload is high, and the impact of fatigue on performance if excessive shifts are worked. Moreover, some work (processing some kinds of products or completing specific tasks, such as approving directives for dissemination) requires particular types of personnel.

The system of products and their "drivers" in the prototype ACCE model is portrayed in Figure 4-2. The overall system consists of hundreds of specific rules. However, the figure represents the primary causal linkages and processes that have been incorporated.

The flow of information between nodes and among the nodes' respective knowledge bases is modeled by moving products according to rules designed to replicate both the "background work" that is a constant in Army C2 and the surges that result either from battlefield dynamics or other events exogenous to the model. Figure 4-2 shows the major linkages built into the ACCE model, but does not show their ties to the battlefield or the movement of products between C2 nodes. While the bulk of the products are reports, the more important deal with the higher-order processes required for successful C2. Hence, this discussion describes the central concept, the knowledge base, and then works backwards, from the directives issued to the reports. The ACCE model represents a system, so all of its parts are interconnected and any can be used as the beginning.

FIGURE 4-2: PRODUCTS AND THEIR "DRIVERS" IN THE PROTOTYPE ACCE MODEL



The **knowledge bases** contain all the elements necessary for understanding the battlefield:

1. information on each friendly force of interest, which is assigned values for each entity as present/absent, accurate/ inaccurate and time of origin,
2. information on enemy forces of interest (with the same attributes),
3. a current situation assessment, which has an accuracy attribute and a time completed,
4. a current course of action assessment, which has attributes of completeness, time the current course of action was selected, and a time period for which it is valid,
5. a current directive, including its intended life and complexity (the number of contingencies incorporated).

Knowledge bases deteriorate over time unless they are updated. Different elements deteriorate at different rates depending on the dynamics of the battlefield and the quality of the information and processes that generated them.

Knowledge bases can be set with any desired levels of completeness, accuracy, and other attributes (such as intended life of the current directive) at the beginning of a model "run". The prototype uses the mean value for each type of information and has also been "exercised" by setting the friendly and enemy information to zero to determine how long it takes them to enter the "normal" region and stabilize.

Knowledge bases are updated whenever new information arrives in the form of a product and when the commander visits the C2 node (bringing his personal knowledge base). The updates require time and labor for processing. Work flow is based on a hierarchy among product types and levels of importance that cut across product types. These follow a preset distribution reflecting the nature of the product and the C2 node where it originates. Information flows also focus on particular subsets of the forces. For example, spot reports from engaged brigades deal with a segment of the enemy forces "assigned" to their area of operations, while spot reports from corps may deal with any part of the enemy forces.

In the case of a **commander's visit**, the commander's knowledge base is compared with the one at the C2 node and random draws are used to determine which value will be maintained in the cell. The commander moves between C2 nodes based on scenario information (e.g., going forward to brigades when low information quality is present, which is presumed to mean the engaged brigades will be having a difficult time) and preset rules (e.g., he receives a daily briefing at the division main CP [DMAIN]). The commander was included in the prototype in order to demonstrate the ability to model the movement of key personnel. He is the only single-person knowledge base in the current version, but others can be added for particular applications or in the more general model.

In the prototype ACCE model, **directives** can originate at corps, division, or the brigades, though the focus is on the preparation, dissemination, and quality of those generated at division. Division directives will be generated at DMAIN, except under extreme pressure (DMAIN work overload, or the failure of plans and very poor information on which to base a new one). Under such circumstances the DTAC may issue directives.

Three types of directives are present in the model: warning orders, fragmentary orders (FRAGOs, which modify operations orders) and operations orders (OPORDs). These are increasingly large and require increasing amounts of time and effort to prepare, review and issue. Their distribution in the model follows the chain of command.

New directives are triggered in four different ways. First, corps may issue a new directive to the division at any time based on a random draw. Division will develop a directive whenever (a) it has completed a new course of action analysis, or (b) its current directive expires. In addition, the model carries information about the actual duration of the current directive and assumes that the C2 node will recognize the true ending time for the current directive at 75% of its actual life and therefore initiate efforts to replace it with a new one at that point. Note that the ACCE model does not assume a course of action (COA) analysis. If the current directive either expires or is expected to expire, a directive may be initiated without prior COA. When this occurs, however, the quality of the resulting directive is reduced and work to replace it will have to be initiated more quickly.

Directives cause **queries and coordinations**, as do the other types of products. These queries and coordinations vary in importance, in the work required to issue and respond to them, in the delays they impose, and in the time before they are reinitiated if no response is received. Larger, more complex products require more supporting information from these processes of inquiry and coordination. Products are delayed until adequate coordination has been undertaken and sufficient information has been gathered.

COA analyses include completeness, a time when a specific COA was selected (the initiation point for directive preparation) and a duration for which they are valid. Analyses are triggered by (a) approaching expiration of the existing COA or the directive, (b) receipt of a new mission, (c) low accuracy in the knowledge base, or (d) the expiration of a 24 hour cycle that has been built into the prototype. Trigger thresholds for the accuracy of the knowledge base have been selected, based on expert judgment and the data from past ACCES exercises, to represent the level of information at which the environment (battlefield dynamic) is so different from the current knowledge at the C2 node that the inconsistency becomes apparent to those following the battle. Although this initiates work in the C2 node, it represents feedback from the environment.

The ACCE model also assumes that the commander may (a) modify or combine COAs offered to him, (b) develop a new one, or (c) reject the analysis he is presented and order a new COA analysis. It further assumes that the COA analysis improves across iterations (the chances the commander accepts the results increase) as a result of the interaction that occurs when the COAs are reviewed.

Situation assessment products occur in all nodes and can be complete (involving all elements of the friendly or enemy situations) or partial (involving only portions of them). Time and labor are consumed both to develop situation assessments and to present them.

Partial situation assessments are part of the on-going workload in all nodes, with their frequency and breadth established based on the scenario. In addition, when the quality of the knowledge base falls below a threshold value (set at 40% in the prototype), an increase in situation assessments occurs, on the premise that the anomalies between the battlefield picture present at the command post (CP) and the reports received will cause the staff to recognize meaningful new developments more often than they do when their information is better.

Complete situation assessments are prepared and presented whenever a new mission is received or when the knowledge base, which has been below the quality threshold (40%) rises into the "comfort zone" (set at 50% in the prototype). Complete assessments are presented each time the CP is visited by the commander and during shift changes, but no new preparation effort is expended for these presentations.

Situation assessments can also trigger COA analyses and directives, as well as being triggered by them when the current directives of COAs expire or are seen as about to expire.

The flow of information among the C2 nodes is largely modeled as a flow of **partial and summary reports**, which provide factual updates about the battlefield. The partial reports deal with information about unit identifications, locations, status, and activities. Spot reports cover enemy forces and operations reports cover the friendly elements. Partial reports flow along the chain of command, but have some probability of being monitored at C2 nodes that are not their direct addressee if the communication link is an open one, such as a radio network.

Partial reports have a basic frequency that is established based on the scenario. This frequency is clustered in time (rather than randomly or uniformly distributed) to better reflect typical real world flows. It also reflect the different assets and responsibilities of the C2 nodes being modeled. When the knowledge base is weak (falls below a threshold), the flow of partial reports increases, on the assumption that the operating units will "discover" more discrepancies between the "real world" and their current knowledge bases, and increase their reporting substantially.

Summary reports cover whole areas. Intelligence summaries (INTSUMs) deal with enemy information, and situation reports (SITREPs) cover friendly forces. These summary reports are scheduled as they would be in an exercising unit's field standard operating procedures (SOP). They require for time and labor. They are also reported along the chain of command.

4.6 CONCLUSION

The ACCE model is designed to capture the human aspects of Army C2 processes and to translate what is known about them into an analytic tool capable of answering crucial "what if" questions regarding changes in personnel, equipment, procedures, and organization. These are inherently complicated behavioral processes and, although the ACCES data and experience provide considerable insight into them, only a model of this complexity can capture the "state of the art" knowledge concerning them. The details of the ACCE model are contained in the concept articulation paper that supports the model, the rules and parameters created as part of the modeling process, and the MicroSaint code in the working prototype. This summary document is intended to facilitate understanding of the model structure and underlying philosophy.

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