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SIMULATION OF AN ARMY DEEP OPERATIONS COMBAT DECISIONMAKING PROCESS

By

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A model of an Army Deep Operations Coordination Cell (DOCC) Combat Decisionmaking process (CDP) is presented. The model was developed from U.S. Army doctrine and current U.S. Army Corps Command Centers. Each of the functions of the DOCC CDP were identified and linked together in a functional flow chart. The distribution for each of these individual functions' durations were identified, and personnel requirements for each of the functions were assigned. This model was then tested through a simulation built by the author. The simulation was designed for use in analysis of the DOCC and other Command and Control organizations. The DOCC CDP then was tested using the performance characteristics of mission completion times. Once our baseline analysis was completed, we experimented with selective manpower reductions. We show that the overall manning of the DOCC CDP would be reduced from 100 percent of authorized levels to less than one third of the authorized levels without degrading baseline completion rates.

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SIMULATION OF AN ARMY DEEP OPERATIONS COMBAT DECISIONMAKING PROCESS

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ABSTRACT

This paper presents a model of an Army Deep Operations Coordination Cell (DOCC) Combat Decisionmaking Process (CDP). The model was developed from U.S. Army doctrine and current U.S. Army Corps Command Centers. Each of the functions of the DOCC CDP were identified and linked together in a functional flow chart. The distributions for each of these individual functions' durations were identified, and personnel requirements for each of the functions were assigned. This model was then tested through a simulation built by the author. The simulation was designed for use in analysis of the DOCC and other Command and Control organizations. The DOCC CDP then was tested using the performance characteristics of mission completion times. Once our baseline analysis was completed, we experimented with selective manpower reductions. This thesis shows that the overall manning of the DOCC CDP could be reduced from 100 percent of authorized levels to less than one third of the authorized levels without degrading baseline completion rates.

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EXECUTIVE SUMMARY

This paper presents a model of an Army Deep Operations Coordination Cell (DOCC) Combat Decisionmaking Process (CDP). The model was developed from U.S. Army doctrine and current U.S. Army Corps Command Centers. Each of the functions of the DOCC CDP were identified and linked together in a functional flow chart. The resulting flow chart was a network where a mission would enter the system and before it could be completed, several functions would have to be performed on it. Once a function was completed, other functions would act on the mission. At some points a function would be held up awaiting the completion of another function on that mission. Once all functions were finished acting on the mission, the mission was finished. The distributions for each of these individual functions' durations were identified and personnel requirements for each of the functions were assigned.

The author first considered using an off-the-shelf simulation to test this model. Several simulations were considered, such as the Intelligence and Electronic Warfare Network (IEWNET) and Command and Control Network (C2NET). These simulations proved helpful in verifying certain aspects of the DOCC CDP model but were not adequate for the testing of the DOCC CDP model. These simulations lacked several of the tasks in the DOCC CDP: their network structure required re-routing and their documentation did not readily support modifications. Thus, the DOCC CDP model was tested through a simulation built by the author. The simulation is written in MODSIM, an

object-oriented simulation language. The simulation was designed for use in analysis of the DOCC and other Command and Control organizations.

The DOCC CDP then was tested using the performance characteristics of mission completion times. This analysis was conducted using a standard for throughput (mission completion times) in a network where missions arrive and are acted on in the order that they arrive. Missions that arrive in the network when there are no personnel available must wait in a line (queue) for available personnel. This type of network is referred to as a common queuing network. This analysis, called steady-state simulation output analysis, typically has two stages. The initial stage consists of a period of time the simulation takes to "warm up" to the mean or baseline level. The second stage is the analysis conducted at this baseline level.

The DOCC CDP had no "warm up" stage and operated without any backlog of work when using the authorized personnel level of 310. Once the baseline analysis was completed, experimentations were conducted with selective manpower reductions. This thesis shows that the overall manning of the DOCC CDP could be reduced from 100 percent of authorized levels to less than one third of the authorized levels (100 personnel) without degrading baseline completion rates. This leaves 210 personnel to work the other part of the DOCC, the Deliberate Decisionmaking Process (DDP). However, TRAC-SAC, the agency tasked with overall analysis responsibility of the DOCC, estimated the CDP would only consume 20 percent of the authorized personnel. At 20 percent of the authorized personnel (62 people), the CDP would have a backlog of missions causing increased mission completion times and an eventual breakdown of its operation.

ACKNOWLEDGMENT

This thesis was written in conjunction and in parallel with the ongoing work on the DOCC model by TRAC-SAC. This thesis includes work done by the author during her experience tour with TRAC-SAC and her work conducted after that experience tour. Significant contributions in building the DOCC model were made by TRAC-SAC and used by the author in this thesis. Thanks and appreciation are extended to the TRAC-SAC team of "Larry, Darryl and Daryl".

I. INTRODUCTION

A. BACKGROUND

Since the Gulf War, the U.S. Army has been focusing on the time it takes senior headquarters to generate changes to missions and promulgate them to subordinates. Particular attention is being paid to the Deep Operations Coordination Cell of the Corps Tactical Headquarters.

Army command and control systems have been undergoing continuous automation for many years and will probably continue to do so for the foreseeable future. [Ref. 1] Automated systems that are currently under development that will impact the DOCC include the Maneuver Control System (MCS), Army Battle Command System (ABCS), All Source Analysis System (ASAS), Forward Area Air Defense Command and Control and Information (FAADC2I), and many others. Some of these are addressed in the Key C2 (Command and Control) Systems (Appendix A). Most of these systems are not scheduled to be fielded until close to the year 2000.

Two years ago, the Commander, V U.S. Army Corps decided that the potential gains from the automation of DOCC functions were too great to wait until the year 2000. V Corps let a contract that would have an interim automated DOCC fielded prior to 1994. This resulted in the design and development of the Automated Deep Operations Coordination System (ADOCS).

The ADOCS automates several functions of the DOCC. In exercises and tests, this automation has reduced the time and number of personnel required to perform these functions. In some cases, the overall mission time has also been reduced. Based on this success, both III and XVIII Corps are now interested in purchasing and fielding similar systems.

This desire for additional ADOCS systems caused the Depth and Simultaneous Attack Battle Lab (D&SA BL), Fort Sill, Oklahoma to initiate a comprehensive study of the effectiveness and efficiency of both the DOCC and the ADOCS. The Training and Research Analysis Command - Studies Analysis Center (TRAC-SAC), Fort Leavenworth, Kansas, is working in support of the D&SA BL in this study.

Part of the TRAC-SAC effort is to build a functional process model of the operational tasks that are performed in the DOCC. This model will be used to examine the operations in the current DOCC and establish a baseline prior to assessing the improvements that will result from fielding the ADOCS.

B. PURPOSE OF THESIS

This thesis supports the Depth and Simultaneous Attack Battle Lab and the TRAC-SAC effort by assisting TRAC-SAC in the development of the conceptual model of the Combat Decisionmaking Process (CDP) portion of the DOCC and by developing an object-oriented simulation that is used to assess the optimal mission completion times and personnel requirements of the CDP. [Ref. 2]

There are two distinct Decisionmaking Processes within a command and control structure. The Deliberate Decisionmaking Process (DDP) is the process of making the initial decision. The CDP is the portion that reacts to changes in previous decisions. The CDP portion of the DOCC was specifically chosen as the focus of analysis by D&SA BL after initial analysis by TRAC-SAC and this author. This analysis identified the CDP as the portion of the DOCC that incorporated most of the ADOCS enhancements. [Ref. 3]

C. METHODOLOGY

As a first step toward modeling and analyzing an Army Corps DOCC CDP, a review of the current and future automated command and control systems was conducted, both to learn what was being automated elsewhere in the Corps, and to ensure that no duplication of effort was occurring in the Corps. Next, a model of the Corps DOCC functions was developed, based on Army Field Manuals and other sources (see Chapter II). This model was sent to D&SA BL (the sponsor) for confirmation of its validity. With the functional model approved, the distribution for the time required to complete each function was obtained from a previous Corps command and control simulation and verified by V Corps for accuracy. [Ref. 4] Based on this data, and keeping Measures of Effectiveness (MOEs) obtained from TRAC-SAC in mind, an object-oriented simulation was built to analyze the DOCC CDP prior to the implementation of ADOCS. This simulation was used to determine optimal mission completion times and to assess the personnel requirements of the DOCC CDP.

D. DEFINITIONS

Definitions of key terms and organizations are given in the paragraphs that follow to facilitate reading the rest of the thesis. These may be skipped by those familiar with U.S. Army command and control terminology.

1. Command and Control

a. Command

Command - Authority that a commander in the military service exercises over subordinates by virtue of rank or assignment. Command includes this authority and responsibility for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel. [Ref. 5]

b. Control

Control - Authority which may be less than full command exercised by a commander over part of the activities of subordinate or other organizations. [Ref. 5]

c. Command and Control (C2)

C2 is command authority combined with the ability to control an origination. The process is carried out "through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander." [Ref. 5] Effective and efficient use of the C2 relationship will lead to more effective mission accomplishment of the organization.

2. Decision Making Process

a. Deliberate Decisionmaking Process (DDP)

The DDP provides the most thorough approach to decisionmaking available in unconstrained environments. It is used before operations commence to plan and coordinate the operations. [Ref. 2]

b. Combat Decisionmaking Process (CDP)

The CDP is the decisionmaking process used once operations have commenced. These decisions are not as thoroughly planned or coordinated, but are executed in a timely fashion and allow the commander to decide, move and execute in the limited time available. During this phase, the command may be planning up to three operations simultaneously: the current battle, the future battle and a sequel to future operations. [Ref. 2]

c. Measures of Effectiveness (MOEs)

The criteria against which the DOCC CDP is to be tested. The simulation and or model must perform sufficiently well against this criteria to be considered successful. The better the performance in these areas, the more effective and efficient the subject in question is. The DOCC CDP MOEs are addressed later in this thesis.

3. Organizations

a. Training Resource Analysis Center's Studies and Analysis Center

The Training Resource Analysis Center's Studies and Analysis Center (TRAC-SAC) located at Fort Leavenworth, Kansas, focuses their studies on the assessment of Corps sized units.

b. Depth and Simultaneous Attack Battle Lab (D&SA BL)

The D&SA BL located at Fort Sill, Oklahoma, focuses on deep operations. Their description of deep encompasses both physical distance and time. Deep operations may be those operations beyond the forward edge of friendly forces (distance) or those operations occurring beyond the current battle (time).

c. Deep Operations Coordination Cell (DOCC)

The Deep Operations Coordination Cell is a portion of the U.S. Army Corps Tactical Headquarters (TAC). Its exact organization differs from Corps to Corps, but it always consists of an organizing, coordinating, and planning staff made up of personnel from several disciplines and organizations tasked to support both the DDP and CDP portions of the deep operations of the Corps. (see Appendix B) This staff is divided into four sections: Intelligence, Fire Support Coordinator, Current Operations and Plans. [Ref. 6]

E. OUTLINE OF CHAPTERS

In Chapter II, the Deep Operations Coordination Cell Combat Decisionmaking Process (DOCC CDP) conceptual model development is presented in detail. This chapter discusses the evolution from model concept to sponsor's approval of the model.

Chapter III lays out the DOCC CDP simulation building. From the conceptual model and the Measures of Effectiveness (MOE's), a simulation is presented and built using MODSIM.

The results of the DOCC CDP simulation are compiled and analyzed in Chapter IV. The results of the analysis are presented and graphs of the data and analysis are provided. From the model and the simulation results, conclusions about the DOCC CDP optimal mission completion times and manning requirements are presented in Chapter V. Recommendations for further analysis are also presented.

II. DEEP OPERATIONS COORDINATION CELL CONCEPTUAL MODEL

A. INTRODUCTION

The DOCC CDP conceptual model was developed in five steps: (1) identification of the organizational tasks performed within the DOCC and the sections responsible for performing them, (2) definition of the processes (task flows) used to perform the operational tasks, (3) refinement of the scope and focus of the model, (4) identification of appropriate measures of effectiveness, and (5) selection and verification of distributions to be used to model the operational tasks' durations. These steps are discussed in Section B below. Section C explains the procedure that was used to obtain the sponsor's approval throughout the development process.

B. BUILDING THE DOCC CDP MODEL

1. Organizational task identification

Information from four primary sources was combined to develop a list of operational tasks performed in the DOCC and specify which DOCC section performs each task. They are discussed in the sections that follow.

a. Student Text 100-9

This text is provided to students at the Command and General Staff College, Ft Leavenworth. It discusses the tactical decisionmaking process and outlines how the actions of a Corps DOCC can be divided into the Deliberate and Combat Decisionmaking elements. Since the sponsor (D&SA BL) wanted to focus on the ability of a Corps DOCC to react to changes in missions, this model needed to focus on the Combat Decisionmaking Process of a Corps DOCC. [Ref. 7]

b. Corps ARTEP Manuals

A thorough search of doctrinal reference materials revealed that the specific functions of a Corps are not defined in the Army Field Manual system. These functional definitions are left to each individual Corps Commander. This discovery, coupled with the desire to find documented assignment of operational functions to organizational entities, lead to a review of the Corps Army Readiness Test and Evaluation Program (Corps ARTEP) Manuals. These manuals describe the Corps missions that can be evaluated and suggest which elements of the Corps should perform them. However, the Corps ARTEP Manuals were written before the DOCC was established as a separate entity, so the deep operations portions of these missions were extracted from the Main and Tactical Command Post functions and combined to define a DOCC.

c. Comparison with Other Systems

Information about other C2 systems obtained from the literature was used to amend the DOCC model. Some tasks were combined, and others were assigned to different sections, but very few tasks were added to those obtained from the Corps ARTEP.

d. Observation of V Corps Exercise

Finally, two persons from TRAC-SAC observed a V Corps exercise in Germany in July 1994. Their observations lent face validity to the DOCC model. The sections described were correct, and only slight changes were required in the tasks assigned to the sections. [Ref. 8]

e. Obtaining Approval of the Task Identification

Approval of the tasks and assignment was continuously requested from the sponsor during model development. Changes were made and the sponsor continued to provide encouragement. Comments were also obtained from other agencies that were working on elements of the ADOCS study and were taken into consideration. The final task list was provided to the sponsor in June 1994 and approved. [Ref. 9]

2. Task Flow Model

Four primary sources were used to define the task flows that accomplish the operational tasks. They are discussed in the sections that follow.

a. Comparison with C2NET

C2NET is a Command and Control network simulation designed to represent the information flow in a Corps (1992). [Ref. 4] It proved to be the most useful resource for defining task flows. All the tasks needed to model DOCC were not in C2NET. Although some tasks in C2NET were close but not exactly the same as ones in DOCC, over 90 percent of the flow descriptions for DOCC were easily extracted from C2NET. The network paths in C2NET were not very well documented and attempts to trace this network have taken TRAC-SAC over one year. Thus, due to poor documentation and dissimliar tasks, C2NET was not used for this analysis. However, it was the closest simulation this author and the TRAC-SAC team could find to the DOCC model.

b. Student Text 100-9

This text was used to refine the task flows extracted from C2NET to more accurately reflect the DOCC network model. It also helped identify the concurrency of several situation updates and the proper places and times for fragmentary order generation. [Ref. 7]

c. Corps ARTEP Manuals

The ARTEP Manuals assisted in defining precedence relationships in the staff coordination decisions, specifically in determining which tasks must proceed any other specific task and which tasks were a product of a specific task.

d. Personal Experience

Some of the information obtained tended to conflict with this author's experience at a Corps headquarters. The changes identified by this author were presented to TRAC-SAC for approval and included in the DOCC CDP Model.

e. Obtaining Approval of the Task Flow Model

The DOCC model, including both the Deliberate Decisionmaking Process (DDP) and the Combat Decisionmaking Process (CDP), was presented to the sponsor for approval. This included the complete task lists and the functional flows for the DDP and

CDP [Appendix C]. Model acceptance and approval to continue the analysis were obtained.

3. Narrowing the Model's Scope

a. Bounding the Corps DOCC (DDP vs CDP)

As information on the ADOCS was obtained through discussions with the sponsor and other agencies working on the DOCC study, it became evident that while the ADOCS automates several aspects of the DOCC, the primary focus is on the CDP portion. Since verification of the ADOCS improvements is the primary purpose of the study, the focus of the analysis shifted to the CDP portion of the DOCC. The model was divided by splitting it into a DOCC CDP and a DOCC DDP, with TRAC-SAC focusing on the DOCC CDP portion. An assumption that 20 percent of the DOCC personnel would be available for the CDP portion was made at this juncture by TRAC-SAC. The viability of this assumption is an issue examined in this thesis.

b. Sponsors Approval

The decision to focus on the DOCC CDP portion alone was presented to the sponsor and approved. The sponsor indicated that they were interested in this exact area. Prior to this, all responses from the sponsor were in the form of not rejecting the progress. This response was an obvious approval.

4. MOEs

Once the model was designed and the scope of the model fully established, the focus of the analysis was refined. Since the DOCC involved personnel and their actions, and the improvements the ADOCS offered were reduced mission completion times and manpower usage, these became the subjects of the MOEs. The first MOE is mission completion time. It is measured from the introduction of a mission into the DOCC CDP until the last task of the mission is complete and it leaves the DOCC CDP. The second MOE is the number of personnel required to operate the DOCC CDP without increasing mission completion time.

These MOEs were coordinated with, and forwarded through, TRAC-SAC to the sponsor, who concurred that these MOEs would satisfy this portion of their study. No further MOEs were identified.

5. Time Distributions of Individual Functions

To analyze the operations of the DOCC, and obtain values for the MOEs, a distribution for the time required to complete each function was required. These are discussed below.

a. Obtaining Time Distributions of Functions Already Established

Through the literature review and study of the C2NET model, this author was able to obtain triangular distribution parameters for over 80 percent of the individual Corps Staff functions.

b. Obtaining Distributions for Function Not Yet Established

Of the remaining functions, all but two were included in the C2NET model; these were listed by their sub-functions. These sub-functions were each assigned triangular distributions, however none was listed for the composite function in the DOCC CDP model. To obtain a triangular distribution for the composite function, the triangular distributions for the sub-functions were combined. The parameters (maximum, median and minimum) of the triangular distributions of the sub-functions were multiplied by the man-hours and then averaged back down to the man-hour most prevalent in the sub-functions' listing of man-hours. The parameter, man-hours, was used to determine the time it took to perform a function and how many people it required to perform that function, and were thus unavailable to perform other functions during that time period.

$$Min = \frac{\sum \text{(each sub-function min)} \times \text{(man hours for each sub-function min)}}{\text{Total number of sub-functions}}$$

$$Median = \frac{\sum \text{(each sub-function median)} \times \text{(man hours for each sub-function median)}}{\text{Total number of sub-functions}}$$

$$Max = \frac{\sum \text{(each sub-function max)} \times \text{(man hours for each sub-function max)}}{\text{Total number of sub-functions}}$$

Figure 1 Time Distributions

The remaining two functions were not listed in the C2NET model, but similar functions were listed. Distributions for the two remaining functions were derived from those given for the similar function . While it is clear that a sum of triangular random variables is not triangular, the sponsoring organization, and the Army C2 community in general, is comfortable with triangular distributions specified for task durations. Rather than presenting probabilistic arguments for the few tasks not in the C2NET database, the intuitive parameter specification approach was used.

*c. **Obtaining Approval of Individual Time Distributions***

The listing of each of these functions with their distributions and man-hours was confirmed with TRAC-SAC. They, in turn, consulted the staff at the Command and General Staff College on those functions not contained in C2NET for accuracy. The function distributions and man-hours were then forwarded to the sponsor for approval. This was the second instance where the sponsor indicated that the model supports their desired interests. [Ref. 9]

III. DEEP OPERATIONS COORDINATION CELL SIMULATION

A. INTRODUCTION

With the functional process flow model of the DOCC CDP completed, the remaining objective of the thesis is to examine the processes within the DOCC CDP to determine the effect of selective personnel reductions.

B. CHOOSING A SIMULATION

1. Deciding to Use Simulation

It was not possible to examine the process within a DOCC CDP as represented in this model, or to assess the impact of personnel reductions on those processes, since the hybrid DOCC CDP does not actually exist. Therefore, it was decided to use a simulation for the analysis.

2. Decision to Build a New Simulation

None of the current simulations available fully represented the DOCC CDP model. The closest was the C2NET, but major changes needed to be made to C2NET in order for it to be useful such as: re-designing network flows, asigning tasks to specific staff sections, modifying existing tasks, and incorporating new tasks. C2NET was completed in 1992 and the personnel involved in its construction and design were no longer available for assistance. Moreover, the reasons for specific design and construction decisions were not given in the available documentation or code comments.

3. Using Object-Oriented Programming (OOP)

Object-oriented programming (OOP) is a relatively new programming style and has yet to enjoy widespread use for Command and Control simulations. EAGLE is the only Command and Control simulation found in use by the Army that is based on OOP. [Ref. 10] The main reasons this author chose OOP were to reduce coding through the use of inheritance and to provide a simulation that could be easily modified to support additional analysis.

The simulation was specifically designed to provide a computer program that could be easily modified to support additional analysis. The simulation code itself is written to take all its model parameter definitions from two different input files. The simulation performs all the required tasks in the order designated by the input files in the time specified by the input files. These files are the only things that should require modification when conducting future analyses with similar fidelity requirements.

C. THE DOCC CDP SIMULATION DEVELOPMENT

1. Input Data Files

Two input data files were designed for the model. The input data files needed to be designed in such a manner that one could change structure and function parameters to analyze reduced manning and automation. One file contained the information that bounded the responsibilities and abilities of each of the four sections of the DOCC. It represents the organizational staff structure. In the organizational sections, the personnel authorizations and responsibilities are listed. These include the functions that they are responsible for performing.

The other file contained the specific information about each of the functions and processing parameters. These functions are listed individually and include the distributions parameters, personnel required, functions required to be performed first (required functions), and the functions that will be required to be performed upon conclusion of this function (spawned functions).

2. Multiple Queues

The principal components of the simulation create a network of priority queues. The simulation processes the mission following actual task flows and precedence relationships as it proceeds through the DOCC CDP. Upon initiation, every mission is processed in the first section (Intelligence). There, the function "Disseminate Combat Information and Intelligence" is performed on the mission. When this function is complete, seven other tasks are requested to be performed on the mission. This process, creating requests for other functions upon completion of processing of one function, is referred to as *spawning*.

Each spawned function request is immediately routed to a check of its status. The simulation checks each request to see if all the prerequisite functions have been completed (required tasks). If they have not, the request is placed into a waiting queue.

If all the prerequisite tasks have been completed, the simulation attempts to find enough personnel to perform the function. If the people are unavailable, this request enters a pool of eligible requests that are awaiting personnel. This queue is filled with a priority system. First all requests are placed in the order of their mission priority and then in order of their mission initiation time.

If the request was able to obtain the personnel to perform the function, those personnel are made unavailable to other functions. The simulation then draws a time from the appropriate distribution and waits for that time to elapse. Once the time has elapsed, the personnel are released from the function and made available. The simulation then simultaneously spawns requests from this function and searches in the eligible queue for the next request awaiting people.

This cyclic process continues until the final function, "Develop FRAG Orders 2", is performed in section four (Current Operations and Plans). This function terminates the simulation of the mission and a request for output of mission completion times.

Also, included in the simulation are some functions this author has termed "people wasters". These functions are initiated either on a random basis or by another function. These functions include things such as updating a map board. These functions are necessary, but they do not spawn other functions and they are not necessarily initiated by another function. The other type of people waster is a function that is spawned, but when it is completed does not spawn other functions. It needs to be performed, but does not interrupt the mission flow if it is delayed.

IV. SIMULATION RESULTS AND ANALYSIS

A. MISSION COMPLETION TIMES

The analysis of system mission completion times should coincide with the standard analysis for throughput in a common queuing network. This analysis, commonly referred to as steady-state simulation output analysis, typically has two stages. The first stage is the discovery and truncation of the initial transient period. The second stage is the estimation of the mean of the resulting identically distributed, autocorrelated sample. [Ref. 10]

In this model, when manpower of the DOCC CDP is at specified levels, the system has no problem handling the input workload expected. This workload of one CDP mission every 300 minutes (five hours) produced the output trace shown in Figure 2.

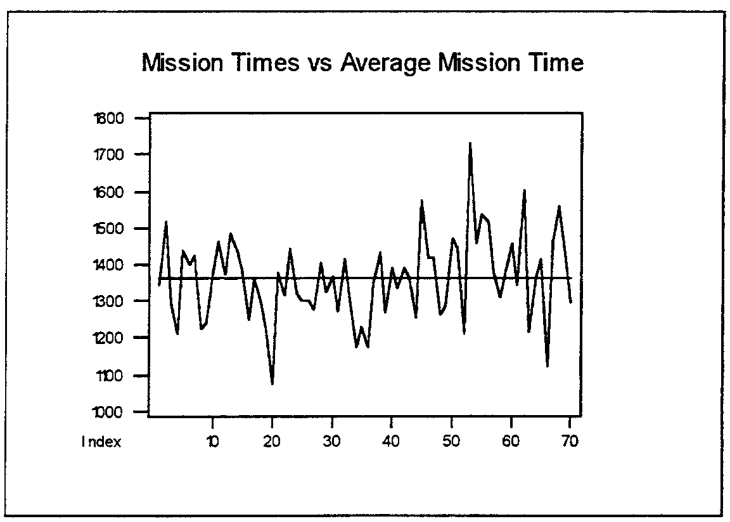

Figure 2 Steady State Mission Times

This trace shows how the DOCC, with authorized manpower, handles missions at this input rate as a network with light traffic: no mission backlog was evident and no visible initial transient period exists.

This author chose to use a simple replicative scheme to address possible autocorrelation problems. Since there was no need to truncate the beginning of the data stream, the simulation was restarted after collecting the data for a one-week cycle. Thirty weeks were collected and each week was treated as a single independent batch. Using these batches, the descriptive statistics given in Table 1 were calculated.

TABLE 1 AVERAGE MISSION TIMES

Mean	1379.67
Median	1377.3
Minimum	1361.7
Maximum	1381.1
First Quartile	1371.2
Third Quartile	1378.9
Standard Deviation	4.7

B. REDUCING MANPOWER

Because the DOCC CDP had no problem handling the input workload, it was apparent that it was over staffed. It was straightforward to determine the staffing levels where some mission completion rate degradation became evident. By reducing the staffs for each section in an across-the-board manner, no loss in performance was observed until the DOCC staff was reduced below one third of the original staffing. Reducing the staffs beyond this level caused backlogs to become frequent and persistent. Figure 3 depicts slightly higher mission completion times when the system becomes backlogged.

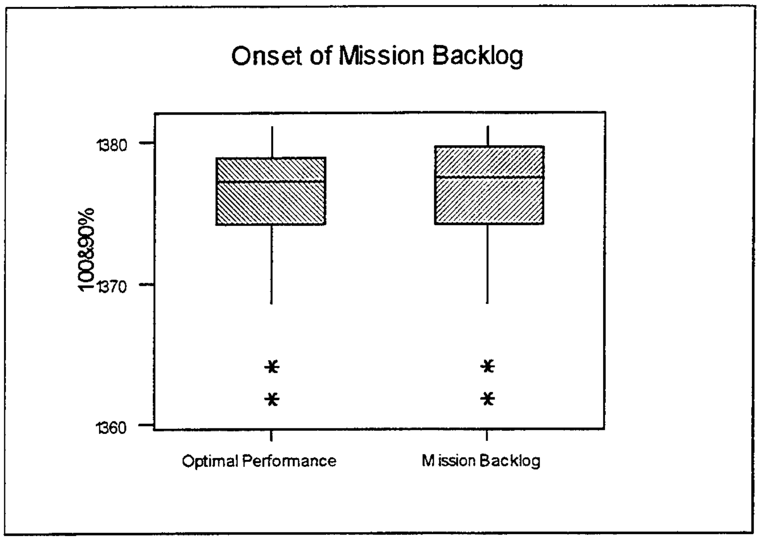

Figure 3 Onset of Mission Backlogs

Of the 310 personnel authorized for the DOCC, only 100 were needed for the CDP (Table 2). Hence, two thirds of the DOCC staff can be available for the DDP, or for other duties. TRAC-SAC anticipated that only twenty percent of the DOCC staff would be required for the CDP. Based on this model, staffing according to the anticipated TRAC-SAC levels will result in growing backlogs of critical CDP missions in the DOCC and cause the eventual breakdown of the DOCC mission effectiveness.

TABLE 2 DOCC PERSONNEL

	Authorized Personnel	Required for CDP	Available for DDP
Section 1	120	16	104
Section 2	41	36	5
Section 3	84	18	66
Section 4	65	30	35
TOTAL:	**310**	**00**	**210**

C. LIMITATIONS

Although the data used in this study were approved by sponsors within the Army, mention must be made of the limitations of results based on this data. In particular, one must note the deterministic rate of CDP missions into the DOCC structure. Well known results in queuing theory show that deterministic inputs produce lower bounds on queue lengths and system residence times. Hence, while the above results indicate that the TRAC-SAC estimates of manning requirements are too low, this author did not model the anticipated surges in input rates which should arise in real combat. These surges can and should be analyzed using this model. Supporting data on surge input rates and surge durations would be the only additional requirements for this analysis.

V. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

A model of an Army Corps DOCC CDP was developed. The individual functions were identified and the required number of personnel to perform each function and time distribution for completion were established for each of these functions. These functions were carried out by an organization of four sections where the authorized number of personnel for each section was assigned.

A simulation of this model was developed to determine the baseline mission completion times and to analyze the effects of reduced manning. The simulation was written in MODSIM, an object-oriented simulation language. The simulation was specifically written to be useable in future C2 and/or organizational analyses concerned with mission completion times, including the impact of ADOCS.

The simulation was exercised and baseline mission completion times and parameters were established. Using these times as a standard, the number of personnel in each section was reduced to the point of mission time degradation. The minimum number of personnel required to perform the DOCC CDP function without compromising mission completion time optimality was established at less than one third of authorized DOCC strength.

B. CONCLUSIONS

The purpose of this thesis was to model a Deep Operations Coordination Cell (DOCC) Combat Decisionmaking Process (CDP) for an Army Corps and assist TRAC-SAC and D&SA BL in assessing the effectiveness and efficiency of the DOCC CDP under varying manning levels.

Each of the functions performed in the DOCC CDP were examined, and established function time parameters and personnel requirements were established. The functions were combined into a DOCC CDP model and an analysis of the model was conducted from a simulation this author wrote to analyze C2 and/or organizational structures. The mean baseline mission completion time was just under 23 hours. The minimum required personnel was established at 100.

C. RECOMMENDATIONS

1. Model the DOCC Deliberate Decisionmaking Process

From the conclusions of this thesis, a minimum number of personnel required for the DOCC CDP was established. The remaining number of personnel are available for the DOCC DDP. The DOCC DDP may or may not be able to perform at baseline levels with the available number of personnel remaining. If the DOCC DDP requires more personnel than available, both the DOCC DDP and the DOCC CDP need to be analyzed for balanced capabilities with the personnel limitations of the DOCC.

2. Presentation to TRAC-SAC

The results of this thesis will be presented to TRAC-SAC for inclusion into the study sponsored by the D&SA BL. The simulation will also be made available to TRAC-SAC for use in further analysis.

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APPENDIX A

KEY C2 SYSTEMS

1. The Advanced Field Artillery Tactical Data System (AFATDS) is an integrated fire support Command and Control (C2) system. It is designated to process fire missions and to coordinate and maximize fire support assets including mortars, field artillery, cannon, missile, attack helicopters, air support, naval gunfire and offensive electronic warfare. Its capabilities are designed for Corps and lower echelon use.

2. The Maneuver Control System (MCS) is a C2 system designed to exchange information and synchronize the Air Land Battle. This system is a tool for the commander allowing the commander to receive and transmit battlefield information such as mission information, courses of action, schemes of maneuver, warnings, operations orders, priorities, intelligence requests, fire requests, supply status requests and air operations requests. This system is currently under development in its twelfth revision.

3. The All Source Analysis System (ASAS) is an automated intelligence processing and dissemination system designed to give timely intelligence and targeting support to the commanders. The system was designed to be used at organizations Echelons Above Corps down to Brigade level. It produces ground battle situation displays, disseminates intelligence information provided target nominations, helps manage organic IEW assets, assists in providing operations security support and assists in deception and counterintelligence operations.

4. The Combat Service Support Control System (CSSCS) provides timely data on critical supplies and services to the strategic and tactical commanders. The critical supplies and services that CSSCS reports on are ammunition and fuel supplies, medical and personnel status, transportation, maintenance services, general supply and field services. It will be interoperable with the other C2 systems currently in design and will incorporate a C2 ability for the CSS commander's own units.

5. The Forward Area Air Defense Command and Control and Information (FAADC2I) System has been undergoing revision to be come more inclusive. In its initial stages, this was the Air Defense Command and Control System (ADOCCS). It is being built to integrate the battlefield with the airspace above it. FAADC2I integrates weapons, sensors and C2 to protect maneuver forces, critical command posts, and combat support and combat service support elements from low-altitude air attack. FAADC2I is designed for primary use at the battalion level.

6. The Army Command and Control System (ACCS) was formerly referred to as the Army Battle Command System (ABCS). It is an interoperable system of systems which provide information throughout the command layers enabling the functional commanders the means to synchronize the forces. It uses existing systems and links information from these systems in a stove pipe fashion from the supporting staffs to subordinate and superior units and their staffs.

7. The Intelligence and Electronic Warfare Network is a simulation model of an Army Corps intelligence and electronic warfare processing. It was written to incorporate the

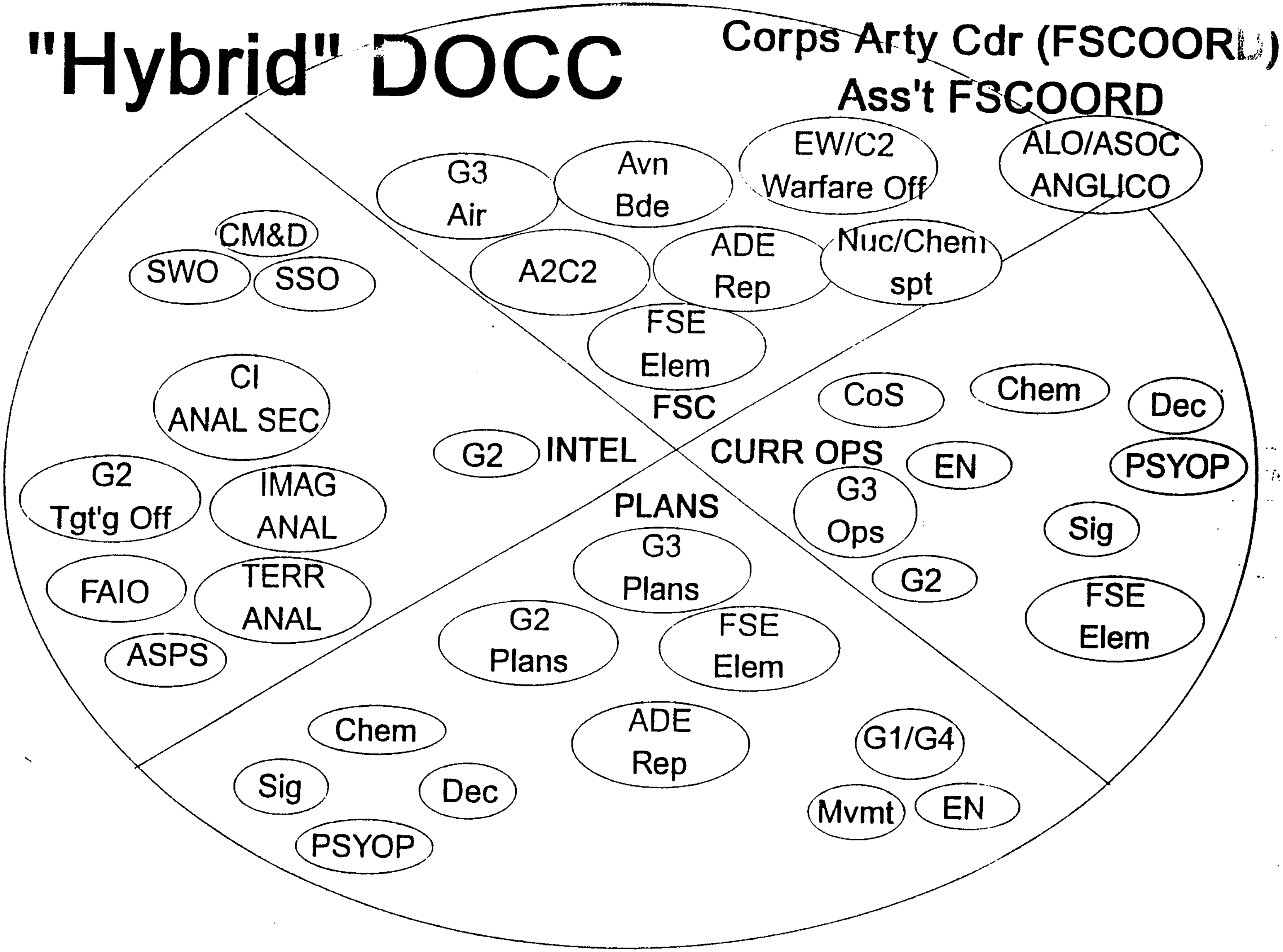
existing systems and systems under design and their use in the process. It includes capabilities of MCS and ASAS in the links with brigade and higher organizations. IEWNET focuses on information flow to and from unit organizations and no the internal organizational processing of that information.

8. The Modular Command and Control Evaluation Structure (MCES) was developed to provide a generic approach to the evaluation of C2 systems. It provides a model to follow in evaluating C2 systems and describes Measures of Effectiveness (MOEs) characteristics for C2 systems.

APPENDIX B

HYBRID DOCC

"Hybrid" DOCC



Corps Arty Cdr (FSCOORD)
Ass't FSCOORD
G3 Air
Avn Bde
EW/C2 Warfare Off
ALO/ASOC ANGLICO
CM&D
SWO
SSO
A2C2
ADE Rep
Nuc/Chem spt
FSE Elem
FSC
CI ANAL SEC
G2
INTEL
CoS
Chem
Dec
CURR OPS
EN
PSYOP
G3 Ops
G2 Tgt'g Off
IMAG ANAL
PLANS
G3 Plans
Sig
FAIO
TERR ANAL
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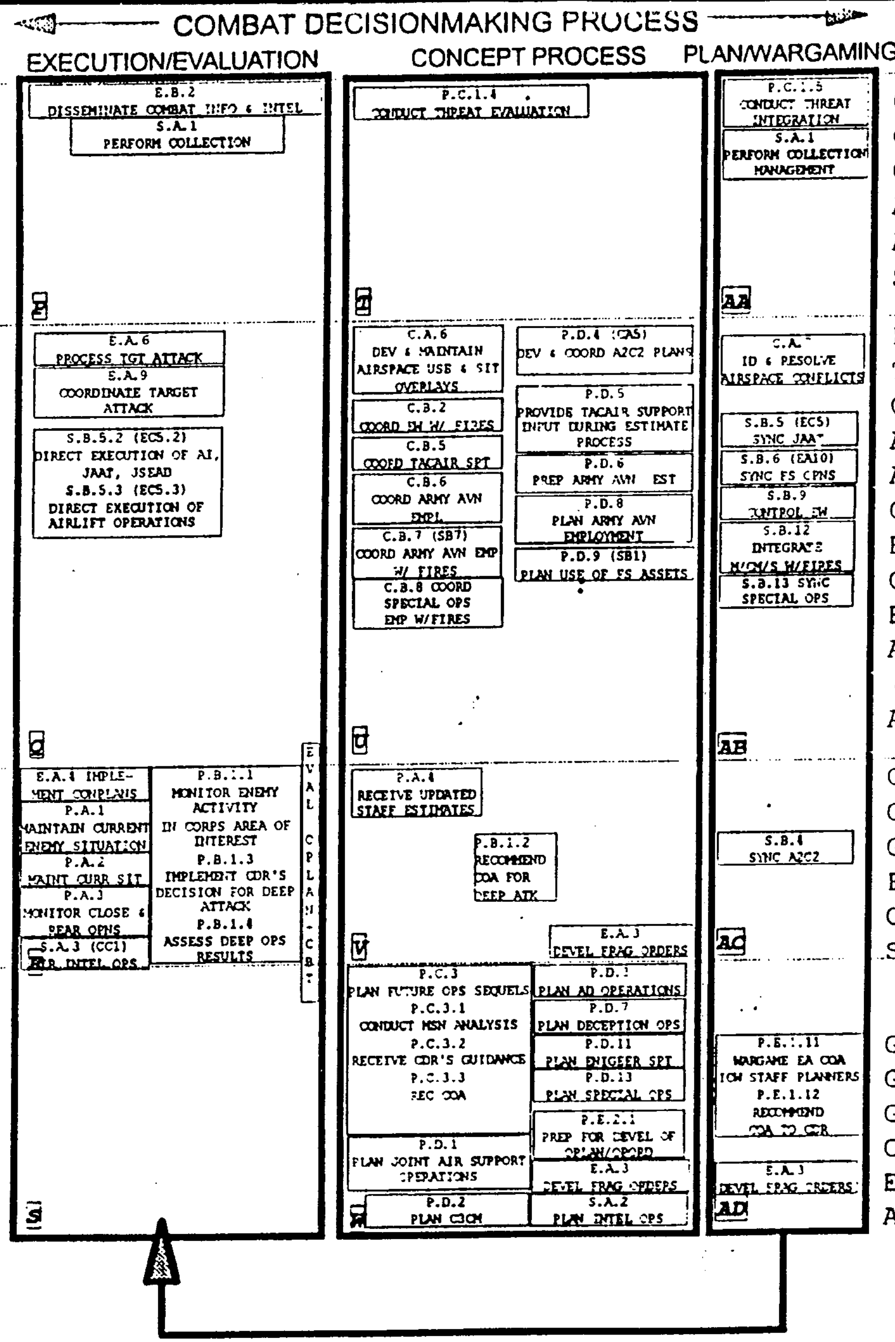
Dec
Mvmt
EN
PSYOP



MANNING CHART

G2	15	FAIO	3
CM&D	16	IMAGERY ANALYSIS	12
COUNTERINTELLIGENCE ANALYSIS SECTION	10	STAFF WEATHER OFFICER (SWO)	10
ALL SOURCE PRODUCTION SECTION (ASPS)	41	TERRAIN ANALYSIS TM	9
		SSO	4

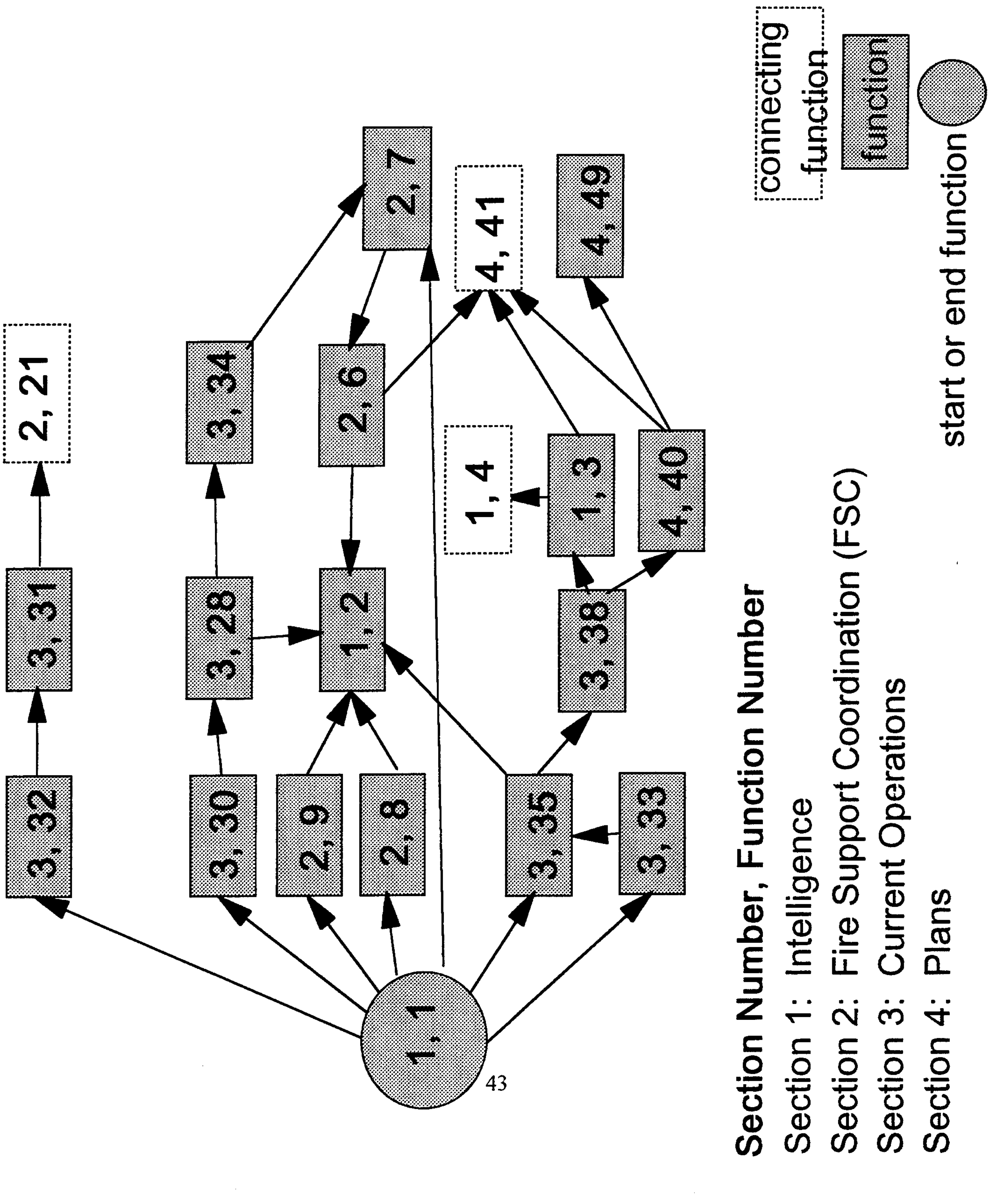
FSE	9	NUC/CHEM SPT	6
TACTICAL AIR CONTROL PARTY (TACP)		NGLO	
AVN BDE	7		
AD	7		
G2			
EW SEC	6		
G3 AIR/A2C2	6		
ENGINEER			
AIR SUPPORT OPS CNTR (ASOC)			
ALO			

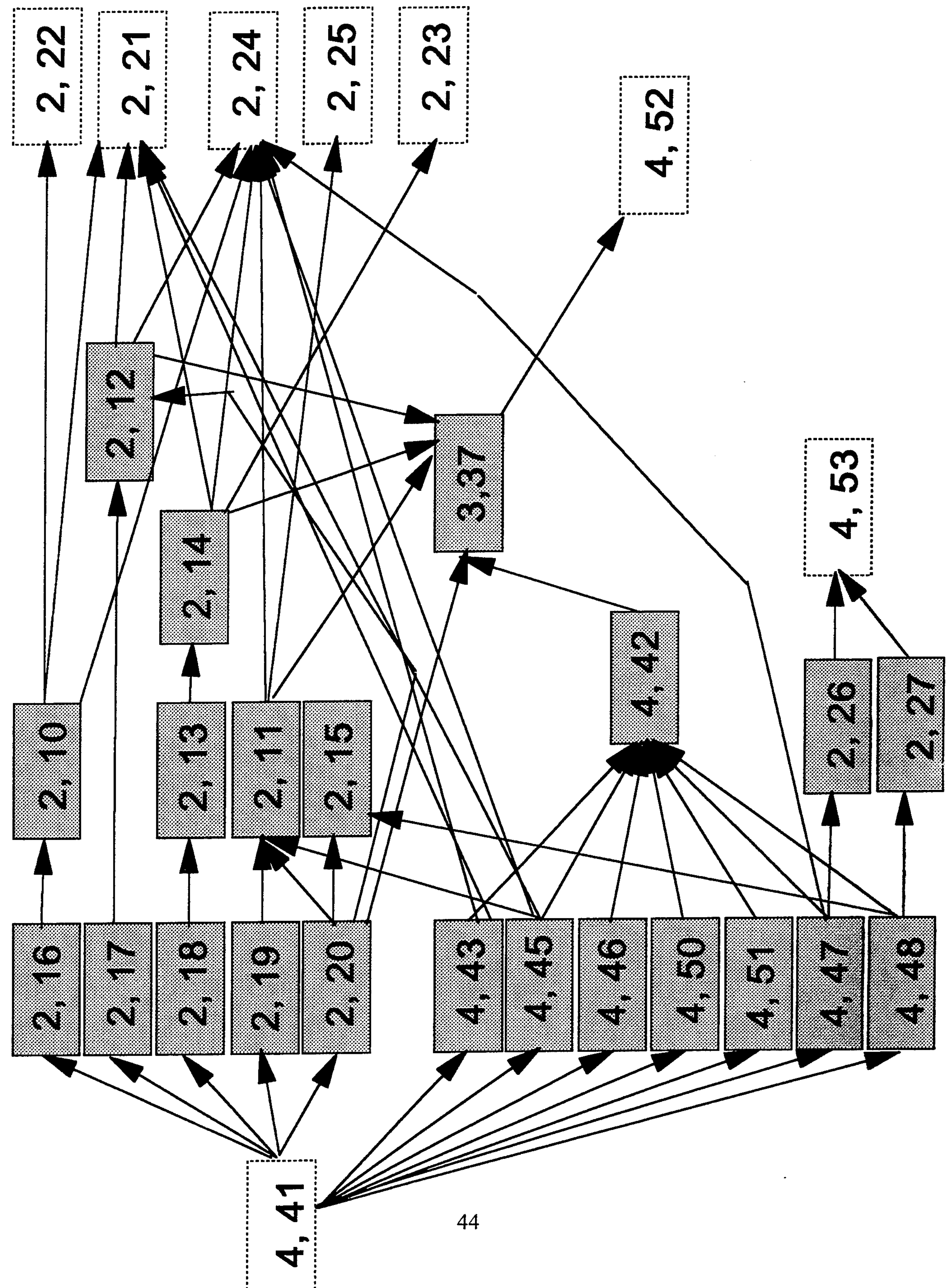
CoS	15	ENG	9
G2	9	AD	
G3	28	AVN	
FS	2	PSYOP	4
CHEM	10	DECEP	2
SIG	5		

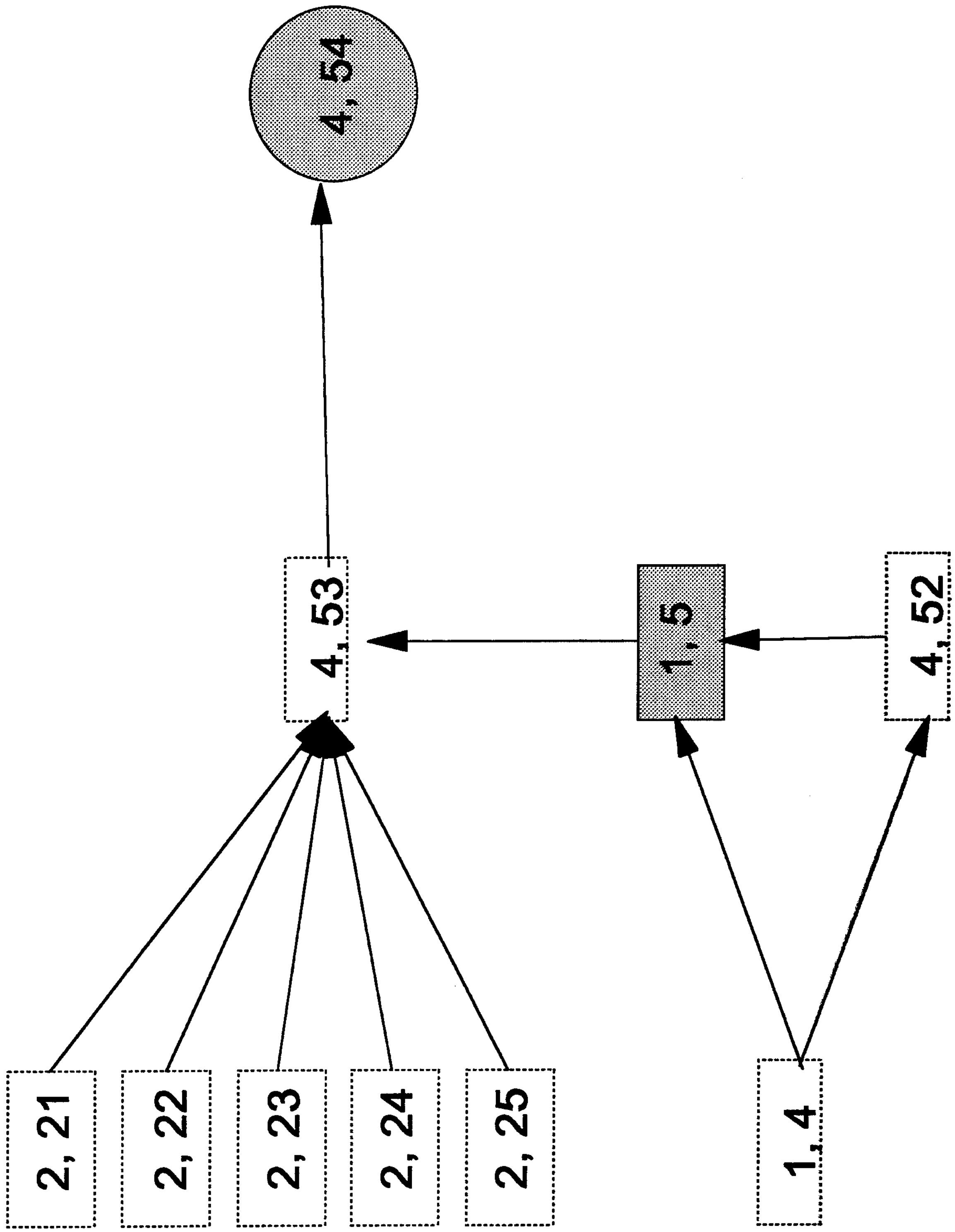
G1/G4	14	AD	2
G2	4	FSE	3
G3	16	DECEPTION	8
CML	1	PSYOP	3
ENG	5	SIG	2
AVN		MVMT	7

APPENDIX C

DOCC CDP MODEL FUNCTIONAL FLOW CHARTS




2, 22
2, 21
2, 24
2, 25
2, 23
4, 52
2, 12
3,37
4, 53
2, 14
4, 42
2, 10
2, 13
2, 11
2, 15
2, 26
2, 27
2, 16
2, 17
2, 18
2, 19
2, 20
4, 43
4, 45
4, 46
4, 50
4, 51
4, 47
4, 48
4, 41


4, 54
4, 53
1, 5
4, 52
2, 21
2, 22
2, 23
2, 24
2, 25
1, 4

APPENDIX D

INDIVIDUAL MISSION COMPLETION TIMES

	70 Missions	
1341.6	1317.15	1417.27
1520.56	1300.92	1264.65
1294.4	1301.13	1284.96
1210.05	1278.95	1469.63
1436.95	1406.81	1441.39
1401.57	1322.93	1209.08
1422.17	1366.53	1731.59
1224.48	1274.01	1457.04
1239.29	1416.20	1537.85
1379.70	1304.60	1518.50
1460.20	1170.78	1382.03
1369.61	1231.04	1308.00
1485.15	1172.68	1377.54
1438.38	1346.80	1458.55
1381.15	1433.18	1341.51
1247.33	1265.29	1603.92
1362.41	1388.59	1213.08
1296.58	1332.73	1362.96
1226.17	1389.74	1412.99
1074.91	1364.29	1120.73
1375.30	1255.12	1460.69
1313.08	1574.17	1558.88
1444.72	1417.27	1443.52
		1296.64

Results	
n	70.0
Mean	1360.7
Median	1365.4
StDev	116.2
Min	1074.9
Max	1731.6
Q1	1283.5
Q3	1437.3

APPENDIX E

INPUT DATA

DESK INPUT DATA

4
Number of Records
1 -> # The Desk Number
16 # The Number of People available to this desk 120
5 # The Number of Tasks this desk can do
DisseminateCombatInfoIntel
MonitorCollectionEffort
ConductThreatEvaluation
ConductThreatIntegration
PerformCollectionManagement \\
2 -> # 41
36
22 + 3
ProcessTargetAttack
CoordinateTargetAttack
DirectExecutionOfAJJ
DirectExecutionOfAirliftOpns
DevelopMaintainAirspaceUse
CoordinateElectronicWarfarewithFires
CoordinateTACAIRSupport
CoordinateArmyAvaitionEmployment
CoordinateArmyAviationEmploymentWithFires
CoordinateSpecialOperationsEmploymentWithFires
DevelopCoordinateA2C2Plans
PlanTACAIRSupport
PlanArmyAvaitionEmployment
PlanEWSupport
PlanUseOfFireSupportAssets
IdentifyResolveAirspaceConflicts
SynchronizeA2C2
SynchronizeJAAT
SynchronizeFireSupportOperations
ControlEW
IntegrateMCSWithFires
SynchronizeSpOps \\

3 -> # 84
18
12
ImplementContingencyPlans
Direc IntelligenceOperations
MaintainCurrentEnemySituation
MaintainCurrentSituation
MonitorClosRearOperations
MonitorEnemyActivityInCAI
ImplementCommandersDecisionForDA
AssessDeepOperationsResults
SynchronizeCombatOperations
ReceiveUpdatedStaffEstimates
RecommendCOAForDeepAttack
DevelopFRAGOrders3
4 -> # 65
30
15
ConductMissionAanalysis
ReceiveCommandersGuidance
ProduceStaffEstimate
PlanJointAirSupportOperations
PlanC3CM
PlanAirDefenseOperations
PlanDeceptionOperations
PlanEngineerSupport
PlanSpecia Operations
PrepareForDevelopementOfOPLAN
DevelopFRAGOrders1
PlanIntelligenceOperations
WargameEnemyActivityCOAIAWStaffPlanners
RecommendCOAToCommander
DevelopFRAGOrders2 \\

TASK INPUT DATA

54 # INTELLIGENCE CELL
Disseminate Combat Info and Intel ->
2 # Number of People to Do this Task
1 # Priority
0 # Number of Required Tasks Bean Starts Here
7 # Number of Spawned Tasks
MonitorCloseRearOperations 3
DirectExecutionOfAirliftOpns 2
DirectExecutionOfAJJ 2
CoordinateTargetAttack 2
MaintainCurrentEnemySituation 3
MonitorEnemyActivityInCAI 3
AssessDeepOperationsResults 3
17.5 32.5 50 \\
Monitor Collection Effort ->
4
1
0
0
2.5 4.0 15.0 \\
Conduct Threat Evaluation ->
2
1
1
RecommendCOAForDeepAttack
2
ReceiveCommandersGuidance 4
ConductThreatIntegration 1
56.5 71.7 111.8 \\
Conduct Threat Integration ->
2
1
1
ConductThreatEvaluation
2
WargameEnemyActivityCOA AWStaffPlanners 4
PerformCollectionManagement 1
56.5 71.7 111.8 \\

```
PerformCollectionManagement        ->
4
1
2
ConductThreatIntegration
WargameEnemyActivityCOAIAWStaffPlanners
1
RecommendCOAToCommander  4
2.5  4.0  15.0  \\
Process Target Attack->                        #        FIRE SUPPORT CELL
2
1
2
CoordinateTargetAttack
ImplementContingencyPlans
2
ReceiveCommandersGuidance  4
MonitorCollectionEffort  1
0.5  3.0  10.0  \\
Coordinate Target Attack     ->
4
1
2
DisseminateCombatInfoIntel
ImplementCommandersDecisionForDA
1
ProcessTargetAttack  2
5.0  27.5  55.0  \\
Direc ExecutionOfAJJ->
1
1
1
DisseminateCOmbatInfoIntel
1
MonitorCollectionEffort  1
29.5  50.8  113.7  \\
```

DirectExecutionOfAirliftOpns->
1
1
1
DisseminateCombatInfoIntel
1
MonitorColletionEffort 1
29.5 50.8 113.7 \\
DevelopMaintainAirspaceUse->
2
1
1
DevelopCoordinateA2C2Plans
3
IdentifyResolveAirspaceConflicts 2
SynchronizeA2C2 2
SynchronizeFireSupportOperations 2
75 165 240 \\
CoordinateElectronicWarfareWithFires ->
1
1
3
PlanC3CM
PlanUseOfFireSupportAssets
PlanEWSupport
3
ReceiveUpdatedStaffEstimates 3
SynchronizeFireSupportOperations 2
ControlEW 2
21 48 93 \\
CoordinateTACAIRSupport ->
1
1
2
PlanUseOfFireSupportAssets
PlanTACAIRSupport
3
ReceiveUpdatedStaffEstimates 3
IdentifyResolveAirspaceConflicts 2
SynchronizeFireSupportOperations 2
29.5 50.8 113.7 \\

CoordinateArmyAvaitionEmployment ->
1
1
1
PlanArmyAviationEmployment
1
CoordinateArmyAviationEmploymentWithFires
60 120 270 \\
CoordinateArmyAviationEmploymentWithFires ->
3
1
2
CoordinateArmyAviationEmployment
PlanUseOfFireSupportAssets
4
ReceiveUpdatedStaffEstimates 3
IdentifyResolveAirspaceConflicts 2
SynchronizeJAAT 2
SynchronizeFireSupportOperations 2
40 150 220 \\
CoordinateSpecialOperationsEmploymentWithFires ->
5
1
2
PlanSpecialOperations
PlanUseOfFireSupportAssets
1
ReceiveUpdatedStaffEstimates 3
60 82.5 120 \\
DevelopCoordinateA2C2Plans ->
3
1
1
ReceiveCommandersGuidance
1
DevelopMaintainAirspaceUse 2
85 117.7 261.7 \\

PlanTACAIR Support ->
5
1
1
ReceiveCommandersGuidance
1
CoordinateTACAIRSupport 2
66 92.6 142.7 \\
PlanArmyAvaitionEmployment ->
1
1
1
ReceiveCommandersGuidance
1
CoordinateArmyAviationEmployment 2
90 135 240 \\
PlanEWSupport ->
1
1
1
ReceiveCommandersGuidance
1
CoordinateElectronicWarfareWithFires 2
83.3 126.7 210 \\
PlanUseOfFireSupportAssets ->
2
1
1
ReceiveCommandersGuidance
6
CoordinateElectronicWarfareWithFires 2
CoordinateTACAIRSupport 2
CoordinateArmyAviationEmploymentWithFires 2
CoordinateSpOpsEmploymentWithFires 2
ReceiveUpdatedStaffEstimates 3
IntegrateMCSWithFires 2
30 60 100 \\

IdentifyResolveAirspaceConflicts ->
3
1
7
MaintainCurrentSituation
SynchronizeFireSupportOperations
DevelopMaintainAirspaceUse
CoordinateTACAIRSupport
CoordinateArmyAviationEmploymentWithFires
PlanJointAirSupportOperations
PlanAirDefenseOperations
1
RecommendCOAToCommander 4
32 80 252 \\
SynchronizeA2C2 ->
3
1
2
SynchronizeFireSupportOperations
DevelopMaintain irspaceUse
1
RecommendCOAToCommander 4
85 171.7 261.7 \\
SynchronizeJAAT ->
1
1
3
CoordinateArmyAviationEmploymentWithFires
SynchronizeFireSupportOperations
PlanJointAirSupportOperations
1
RecommendCOAToCommander 4
29.5 50.8 113.7 \\

SynchronizeFireSupportOperations ->
2
1
7
CoordinateTACAIRSupport
PlanJointAirSupportOperations
PlanAirDefenseOperations
PlanEngineerSupport
DevelopMaintainAirspaceUse
CoordinateElectronicWarfareWithFires
CoordinateArmyAviationEmploymentWithFires
6
IdentifyResolveAirspaceConflicts 2
SynchronizeA2C2 2
SynchronizeJAAT 2
ControlEW 2
IntegrateMCSWithFires 2
SynchronizeSpOps 2
30 60 120 \\
ControlEW ->
1
1
2
SynchronizeFireSupportOperations
CoordinateElectronicWarfareWithFires
1
RecommendCOAToCommander 4
21 48 93 \\
IntegrateMCSWithFires ->
2
1
3
SynchronizeFireSupportOperations
PlanEngineeringSupport
PlanUseOfFireSupportAssets
1
RecommendCOAToCommander 4
40 80 100 \\

SynchronizeSpecialOperations ->
2
1
2
SynchronizeFireSupportOperations
PlanSpecialOperations
1
RecommendCOAToCommander 4
22.5 52.5 116.3 \\
ImplementContingencyPlans -> # HQ AND CURRENT OPERATIONS CELL
5
1
2
MaintainCurrentSituation
MaintainCurrentEnemySituation
4
MonitorCollectionEffort 1
ProcessTargetAttack 2
ImplementCommandersDecisionForDA 3
SynchronizeCombatOperations 3
60 82.5 120 \\
DirectIntelligenceOperations ->
2
1
0
0
51.3 81.4 118.33 \\
MaintainCurrentEnemySituation ->
1
1
1
DisseminateCombatInfoIntel
1
ImplementCOntingencyPlans 3
30.3 45.5 76 \\

MaintainCurrentSituation ->
3
1
1
MonitorCloseRearOperations
2
IdentofyResolveAirspaceConflicts 2
ImplementCOntingencyPlans 3
45 63.8 86.3 \\
Monitor CloseRearOperations ->
2
1
1
DisseminateCombatInfoIntel
1
MaintainCurrentSituation 3
31.3 60.0 127.5 \\
MonitorEnemyActivityInCAI ->
2
1
1
DisseminateCombatInfoIntel
1
AssessDeepOperationsResults 3
28 46 87 \\
ImplementCommandersDecisionForDA ->
2
1
1
ImplementContingencyPlans
1
CoordinateTargetAttack 2
28 46 87 \\
AssessDeepOperationsResults ->
2
1
2
MonitorEnemyActivityInCAI
DisseminateCombatInfoIntel
2
MonitorCollectionEffort 1
RecommendCOAForDeepAttack 3
28 46 87 \\

SynchronizeCombatOperations ->
1
1
1
ImplementCOntingencyPlans
0
60 90 120 \\
ReceiveUpdatedStaffEstimates ->
2
1
7
CoordinateElectronicWarfareWithFires
CoordinateTACAIRSupport
CoordinateArmyAviationEmploymentWithFires
CoordinateSpOpsEmploymentWithFires
PlanUseOfFireSupportAssets
ProduceStaffEstimate
1
WargameEnemyActivityCOAIAWStaff Planners 4
23 39 55 \\
RecommendCOAForDeepAttack ->
2
1
1
AssessDeepOperationsResults
2
ConductThreatEvaluation 1
ConductMissionAnalysis 4
28 46 87 \\
DevelopFRAGOrders3 ->
3
1
0
0
28.8 66 390 \\

Conduct Mission Analysis -> # PLANS & COMBAT SERVICE SUPPORT (CSS) CELL
1
1
1
RecommendCOAForDeepAttack
2
ReceiveCommandersGuidance 4
PrepareForDevelopmentOfOPLAN 4
56.25 105 166.25 \\
ReceiveCommandersGuidance ->
1
1
3
ConductThreatEvaluation
ConductMissionAnalysis
ProcessTargetAttack
14
DevelopCoordinateA2C2Plans 2
PlanTACAIRSupport 2
PlanArmyAviationEmployment 2
PlanEWSupport 2
PlanUseOfFireSupportAssets 2
ProduceStaffEstimate 4
PlanJointAirSupportOperaitons 4
PlanC3CM 4
PlanAirDefenseOperations 4
PlanDeceptionOperations 4
PlanEngineerSupport 4
PlanSpecialOperations 4
DevelopFRAGOrders1 4
PlanIntelligenceOperations 4
56.25 105 166.25 \\

ProduceStaf Estimate ->
1
1
9
ReceiveCommandersGuidance
PlanJointAirSupportOperations
PlanC3CM
PlanAirDefenseOperations
PlanDeceptionOperations
PlanEngineerSupport
PlanSpecialOperations
DevelopFRAGOrders1
PlanIntelligenceOperations
3
ReceiveUpdatedStaffEstimates 3
56.25 105 166.25 \\
PlanJointAirSupportOperations ->
3
1
1
ReceiveCommandersGuidance
4
SynchronizeJAAT 2
ProduceStaffEstimates 4
IdentifyResolveAirspaceConflicts 2
SynchronizeFireSupportOperations 2
30 60 105 \\
PlanC3CM ->
1
1
1
ReceiveCommandersGuidance
2
ProduceStaffEstimate 4
CoordinateElectronicWarfareWithFires 2
30 270 465 \\

PlanAirDefenseOperations ->
2
1
1
ReceiveCommandersGuidance
3
ProduceStaffEstimate 4
IdentifyResolveAirspaceConflicts 2
SynchronizeFireSupportOperations 2
92.5 192.5 370 \\
PlanDeceptionOperations ->
2
1
1
ReceiveCommandersGuidance
2
ProduceStaffEstimate 4
ReceiveUpdatedStaffEstimates 3
56.3 112.5 180 \\
PlanEngineerSupport ->
2
1
1
ReceiveCommandersGuidance
3
ProduceStaffEstimate 4
SynchronizeFireSuppartOperations 2
IntegrateMCSWithFires 2
30 60 100 \\

PlanSpecialOperations->
5
1
1
ReceiveCommandersGuidance
3
ProduceStaffEstimate 4
SynchronizeSpOps 2
CoordinateSpOpsEmploymentWithFires 2
60.0 82.5 120 \\

```
PrepareForDevelopementOfOPLAN ->
2
1
1
ConductMissionAnalysis
0
210 405 600 \\                    #     No Spawn Tasks
DevelopFRAGOrders1        ->
3
1
1
ReceiveCommandersGuidance
1
ProduceStaffEstimate 4
28.8 66.0 390.0 \\
PlanIntelligenceOperations    ->
1
1
1
ReceiveCommandersGuidance
1
ProduceStaffEstimate 4
30.3 45.5 76.0 \\
WargameEnemyActiviCOIAWStaff Planners ->
2
1
2
ReceiveUpdatedStaffEstimates
ConductThreatIntegration
1
PerformCollectionManagement 1
37.5 52.5 75 \\
```

```
RecommendCOAToCommander        ->
2
1
7
IdentifyResolveAirspaceConflicts
SynchronizeA2C2
SynchronizeJAAT
PerformCollectionManagement
ControlEW
IntegratMCSWithFires
SynchronizeSpOps
1
DevelopFRAGOrders2  4
37.5  52.5  75.0  \\
Develop FRAG Orders 2      ->
3
1
1
RecommendCOAToCommander
0
28.8  66.0  390.0  \\                    #        No Spawn Tasks, print elapsed time
```

APPENDIX F

WEEKLY MISSION DATA

I am at the beginning of Mission File (30) Replications (30)

REP #	MEAN	VAR	SAMPLE	CI
30	1368.55	9770.24	1366.33	70.74
60	1361.73	11723.40	1384.98	54.79
90	1363.98	11263.18	1244.01	43.85
120	1370.67	11579.97	1404.12	38.51
150	1369.46	11687.36	1249.48	34.60
180	1373.04	11485.53	1397.37	31.31
210	1374.35	11937.07	1361.12	29.55
240	1373.78	11982.15	1261.61	27.70
270	1375.08	12271.94	1225.74	26.43
300	1375.52	12573.71	1521.13	25.38
330	1375.69	12493.95	1548.74	24.12
360	1377.07	12453.68	1408.04	23.06
390	1380.49	12737.27	1325.49	22.40
420	1381.09	12562.53	1449.13	21.44
450	1380.47	12147.44	1320.25	20.37
480	1379.67	12182.17	1222.82	19.75
510	1378.91	12079.19	1280.75	19.08
540	1379.08	11875.20	1477.18	18.38
570	1377.80	11979.39	1338.72	17.97
600	1377.14	12287.93	1488.71	17.73
630	1377.66	12425.14	1248.86	17.41
660	1377.62	12425.47	1214.72	17.01
690	1377.41	12423.19	1436.82	16.63
720	1377.49	12515.06	1630.85	16.34
750	1378.72	12691.58	1370.03	16.12
780	1378.59	12691.24	1313.01	15.81
810	1379.62	12718.15	1425.05	15.53
840	1378.99	12867.41	1468.15	15.34
870	1376.76	12886.06	1222.00	15.09
900	1376.94	12982.63	1324.31	14.89

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