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THESIS

MODEL OF THE US CENTCOM JOINT TARGETING ARCHITECTURE: DEVELOP TARGETS

by

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June 2004

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This thesis was conducted in support of a larger research effort to improve US CENTCOM's joint targeting architecture. The ultimate goal of this research project is to develop a working Extend model, which accurately describes CENTCOM's targeting process, in order to assist the Joint Intelligence Interoperability Board (JIIB) in their JIIB Systems Baseline Assessment (JSBA) for fiscal year 2004, as well as for all subsequent JSBAs. This thesis explains the advantages of using a systems engineering approach to developing a process model, and ultimately an Extend model. It provides a brief description of the entire CENTCOM targeting cycle; however, it focuses on the "Develop Targets" activity. The two major products of this research effort are an accurate and detailed paper model using Microsoft Visio, and a baseline Extend model of the "Develop Targets" activity. The Extend model and its capabilities are described in full detail, and it will serve as the foundation from which the other activities in this targeting process will be modeled. Additionally, recommendations for future improvement of the model are explained.

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This thesis was conducted in support of a larger research effort to improve US CENTCOM's joint targeting architecture. The ultimate goal of this research project was to develop a working Extend model, which accurately describes CENTCOM's targeting process. This model will assist the Joint Intelligence Interoperability Board (JIIB) in their JIIB Systems Baseline Assessment (JSBA) for fiscal year 2004, as well as for all subsequent JSBAs. This thesis explains the advantages of using a systems engineering approach to developing a process model, and ultimately an Extend model. It provides a brief description of the entire CENTCOM targeting cycle; however, it focuses on the "Develop Targets" activity. The two major products of this research effort are an accurate and detailed paper model using Microsoft Visio, and a baseline Extend model of the "Develop Targets" activity. The Extend model and its capabilities are described in full detail, and it will serve as the foundation from which the other activities in this targeting process will be modeled. Additionally, recommendations for future improvement of the model are explained.

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ACRONYM LIST

ABCS	Army Battle Command System
ACE	Analysis and Control Element
ADOCS	Advanced Deep Operations Coordination System
AFATDS	Advanced Field Artillery Tactical Data System
AOC	Air Operations Center
ASAS-L	All Source Analysis System Light
ASAS-RM	All Source Analysis System Remote Workstation
ATO	Air Tasking Order
BCD	Battlefield Coordination Detachment
C4ISR	Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance
CDL	Collateral Damage List
CENTCOM	Central Command
CID	Combat Intelligence Division
CMA	Collection Management Authority
COE	Common Operating Environment
COID	Combat Operations Intelligence Division
CONOPS	Concept of Operations
CONUS	Continental United States
COTS	Commercial off the Shelf
CTL	Candidate Target List
DARS	Daily Aerial Reconnaissance and Surveillance
DB	Database
DBS	Data Broadcast System
DCAP	Data Collection and Analysis Plan
DCCC	Defense Collection Coordination Center
DIICOE	Defense Information Infrastructure Common Operating Environment
DIN	Defense Intelligence Network
DISA	Defense Information Systems Agency
DJFLCC	Deputy Joint Forces Land Component Commander
DMS	Defense Message System
DOCC	Deep Operations Coordination Cell
DOD	Department of Defense
DODAF	Department of Defense Architectural Framework
F2C2	Friendly Forces Coordination Center
FDDI	Fiber Distributed Data Interface
FIFO	First In First Out
FSCL	Fire Support Coordination Line
GALE	Generic Area Limitation Environment
GBS	Global Broadcast System
GCCS-A	Global Command and Control System - Army
GCCS-I3	Global Command and Control System - Integrated Imagery and Intelligence

GCCS-M	Global Command and Control System - Maritime
HPSCI	House Permanent Select Committee on Intelligence
HUMINT	Human Intelligence
IER	Information Exchange Requirement
IMINT	Imagery Intelligence
IOS	Intelligence Operations Server
IPA	Image Product Achieve
IS	Information System
ISR	Intelligence, Surveillance, and Reconnaissance
JBC	Joint Battle Center
JCMT	Joint Collection Management Tools
JDISS	Joint Deployable Intelligence Support System
JFACC	Joint Forces Air Component Commander
JFC	Joint Forces Command
JFMCC	Joint Forces Maritime Component Commander
JFSOCC	Joint Forces Special Operations Component Commander
JGAT	Joint Guidance, Apportionment, and Targeting
JICCENT	Joint Intelligence Center CENTCOM
JIIB	Joint Intelligence Interoperability Board
JIIWG	Joint Intelligence Interoperability Working Group
JITC	Joint Interoperability Test Center
JMCIS	Joint Maritime Command Information System
JOC	Joint Operations Center
JQRR	Joint Quarterly Readiness Review
JSBA	JIIB Systems Baseline Assessment
JTCB	Joint Target Coordination Board
JTF	Joint Task Force
JTL	Joint Target List
JTT	Joint Targeting Toolbox
JWICS	Joint Worldwide Intelligence Communications System
MASINT	Measurement and Signature Intelligence
MAW	Marine Aircraft Wing
MIDB	Modern Integrated Database
MP&BF	Maps, Plots, and Briefing Folders
NCA	National Command Authority
NGA	National Geospacial Intelligence Agency
NIMA	National Imagery and Mapping Agency
NITF	News Industry Text Format
NMJIC	National Military Joint Intelligence Center
NPS	Naval Postgraduate School
OIF	Operation Iraqi Freedom
OPLAN	Operation Plan
OPORD	Operation Order
FRAGO	Fragmentary Order
PM	Program Manager

PSYOP	Psychological Operations
ROE	Rules of Engagement
RSS	Remote Replication System
S&R	Surveillance and Reconnaissance
SCI	Sensitive Compartmentalized Information
SIGINT	Signals Intelligence
SIPRNET	Secret Internet Protocol Routing Network
SJA	Staff Judge Advocate
SOF	Special Operations Forces
SOR	System of Record
TACLAN	Tactical Local Area Network
TARCHECK	Target Check
TBMCS	Theater Battle Management Corps System
TIFF	Tagged Image File Format
UML	Unified Modeling Language
VTCS	Video Tele-conference
WMD	Weapons of Mass Destruction
WOC	Wing Operations Center

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We would like to extend our appreciation to Professor Rich Kimmel and the NPS JIIB team for involving us so heavily in this project, and arranging for the opportunity to present our work at the Joint Battle Center in Suffolk, VA. We also offer a special thanks to Dr. John Osmundson and Dr. William Kemple for their expertise in scoping, guiding and critically reviewing our work throughout this research effort. Elizabeth Jaskowiak proved to be a great help in revising this document. Finally, we sincerely appreciate our classmates in CC4103 who assisted us in getting this project off the ground by beginning to develop the paper model.

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I. INTRODUCTION

This thesis was conducted in support of a much larger research effort to improve US CENTCOM's joint targeting architecture. The ultimate goal of this research project is to develop a working Extend model, which accurately describes CENTCOM's targeting process, in order to assist the Joint Intelligence Interoperability Board (JIIB) in their JIIB Systems Baseline Assessment (JSBA) for fiscal year 2004, as well as for all subsequent JSBAs. This project was initiated to address interoperability problems during Operation Iraqi Freedom (OIF), which are highlighted in CENTCOM's joint quarterly readiness review (JQRR). However, in order to determine potential solutions and process improvement methods for CENTCOM in the form of both alternate architectural structures and cost-to-benefit analyses, it was essential that the process, including all information exchanges and systems, be fully understood.

The necessary understanding of CENTCOM's joint targeting process was achieved by studying a set of three documents, *US CENTCOM Objective Architecture Concerning Targeting, Volume I – Volume III.* These documents were created in 1997. They are quite outdated, and do a poor job of describing the architecture by leaving many gaps and holes in the process. However, due to the fact that these are the most current documents that exist, they are what had to be used to begin this effort. This substantiates the need for a current, accurate and well-described model. The approach, as will be discussed later, will use these 1997 documents as a starting point. Through an iterative process of talking with operators actually involved in the process, the model will be refined to better represent the current architecture being employed.

The overall targeting cycle includes the following six primary activities:

- Establish Guidance and Assign Resources
- Develop Targets
- Prioritize Targets
- Publish ATO
- Manage Targets
- Conduct Combat Assessment

This thesis will provide a brief description of the entire cycle; however, it will focus on the "Develop Targets" activity. The two major products of this research effort are an accurate and detailed paper model using Microsoft Visio, and a working extend model. Both of these models can be found at the Internet site <http://library.nps.navy.mil/uhtbin/hyperion/04Jun_Germakian>. The Visio paper model (400 KB) is listed as "Develop Targets Paper Model in Visio." The Extend model is available at this site in two forms. To view and run the Extend model in Extend, Extend version 6.0 or higher is required. This is a 10MB file and is listed as "Develop Targets Extend Model." If Extend is unavailable, then the model can be viewed in Power Point (400 KB). Power Point serves merely as a visual representation of the Extend model's architecture, and not as working simulation. The link to this file is "CENTCOM Targeting Architecture develop targets extend model."

This written document will provide the reader an understanding of the project's importance, what process modeling is and why it is useful, what the Extend simulation and modeling tool is and why that is useful. It will also provide a detailed understanding of what is transpiring during the "Develop Targets" activity, and ultimately a summary of results and conclusions leading to potential methods for model and process improvement.

A. THESIS STATEMENT

The goal of this thesis is to support a research effort being conducted at the Naval Postgraduate School to develop a working Extend model of CENTCOM's joint targeting architecture. After research and analysis, an accurate paper model and working Extend model were created for the "Develop Targets" activity. The primary measure of effectiveness was time to complete each activity.

B. THESIS APPROACH

The approach taken to develop a working Extend model of the "Develop Targets" activity was as follows. Initially, a thorough study of the entire targeting architecture was conducted using information from the document set: *US CENTCOM Objective Architecture Concerning Targeting, Volume I – Volume III*. Through a careful reading of the process description, graphics and charts, and information exchanges, a paper model was created in Microsoft Visio. This paper model contained numerous holes, or gaps in the flow of information, and multiple iterations were required in order to fill these in to the best of our ability. Once complete, the Visio paper model drove the creation of the Extend model.

We attended an intensive course in modeling and simulation using Extend, and used this tool to create a working model of the "Develop Targets" activity. Again, this involved an iterative process of building many paper models and "throwaway" Extend prototype models before generating a final version in Extend.

In parallel, the other major activities in the targeting architecture were being modeled using the same process. Bi-monthly group meetings were conducted to assure the overall model would link together properly. These meetings were important to ensure that this model would address the issues and concerns that the JIIB had about the joint targeting architecture. In order to do this properly, it was necessary to make sure the model was analyzing the most effective measures and contained the appropriate level of detail.

The "Develop Targets" activity was the first completed, and all results discussed in this thesis pertain strictly to this activity. The capabilities of the "Develop Targets" model were briefed at the Joint Battle Center (JBC) located in Suffolk, VA on May 17, 2004. The model received many positive reviews and demonstrated NPS student involvement on the project. However, it is important to note that the JIIB project will not stop here. In fact, once all six activities of the Extend model are combined and functioning properly, there will still be a significant amount of work required. Recall that this model is based off of an outdated document, with the gaps filled in to the best of our ability. The primary purpose of this initial, baseline model is to make the JIIB aware of the tools that exist to help them refine the targeting architecture. The baseline model will provide a taste of how effectively this process can be altered and analyzed once a detailed and accurate model is developed. The next step would be to update the model by talking to the operators. This will allow the intricacies of the current process to be understood. From this information, the baseline Extend model can be further refined to include these exact details.

C. THESIS RELEVANCE

The development of an accurate paper and Extend model of the joint targeting process would be of enormous benefit because currently no accurate and easily understood documentation exists. The accompanying written material will allow for further understanding of the models by those needing the information. The relevance of this research effort will become more apparent as one becomes more familiar with the power of process modeling and Extend, which is described later in this document.

The Goldwater-Nichols Act of 1986 has driven the DoD to operate as a joint force (*NDU*). However, the realization of a smooth and effective joint force requires an ongoing effort as described in *Joint Vision 2020*. The joint force has become and will remain the key to operational success long into the future because of its flexibility and responsiveness (*Joint Vision* 2). The effectiveness of joint warfare is undeniable, which is why we have seen joint efforts in the past three major conflicts.

> …the employment of the capabilities of the Total Force (active, reserve, guard, and civilian members) increases the options for the commander and complicates the choices of our opponents. To build the most effective force for 2020, we must be fully joint: intellectually, operationally, organizationally, doctrinally, and technically (*Joint Vision* 2).

The movement toward a joint force has become a reality, but in order to do so effectively, it is important to have sound doctrine. A second key aspect needed to optimize joint warfighting capabilities is to ensure interoperability.

> Interoperability is the foundation of effective joint, multinational, and interagency operations. The joint force has made significant progress toward achieving an optimum level of interoperability, but there must be a concerted effort toward continued improvement. Such improvements will include the refinement of joint doctrine as well as further development of common technologies and processes. (*Joint Vision* 15)

Due to the three recent major conflicts occurring within US CENTCOM's area of responsibility, it is clear why they have stated a need to refine their joint targeting process. However, the implications of the development and documentation of such a process will be of use to nearly all US Unified Commands, as they will inevitably be tasked with an increasing number of joint operations requiring a targeting process.

Furthermore, the effort associated with taking the detailed paper model and description to the next level by building a working Extend model will be of incredible value to US CENTCOM and the JIIB. It will allow them to understand exactly how their process functions so that they can determine the best method for improvement; whether it be by restructuring the process, or investing in system upgrades to solve interoperability issues. Adjustments and changes to the process can be made using the model, and the effects can be analyzed. This will, in turn, result in the most efficient and cost-effective means of determining how to improve their process in the future. For example, rather than just thinking that by investing millions of dollars to increase the bandwidth of a certain system they can reduce the length of the targeting cycle dramatically, only to find out later that it actually had no significant effect, they could easily test this scenario in the model and observe the results. As long as the model is updated it will always be useful as a process analysis tool.

D. SUMMARY OF RESULTS

The creation of this model was of great benefit to the NPS JIIB team by serving as a foundation from which the other activities could be modeled in a similar fashion. Many of the kinks with Extend were worked out, which will make the future modeling effort for the other activities smoother.

Also, this model demonstrates its ability to track one of the key metrics, time to complete tasks, throughout the process. The baseline Extend model of "Develop Targets" generates the time it takes for information to flow to different parts of the model. Ultimately, this demonstrates the capabilities that exist for a model of this sort. Once additional research is conducted to produce more accurate parameters within the model, the practical utility of the model will be evident.

E. ORGANIZATION OF THE REMAINDER OF THE THESIS

Chapter II: JIIB

- Discusses the history, purpose, and organization of the JIIB
- Specifies the objective required of the Naval Postgraduate school in the JSBA FY 04

Chapter III: Process Modeling

- Lends insight into the benefits of process modeling and current lack of process modeling efforts with respect to C4ISR architectures
- Explains the value of using a systems engineering approach to develop a process model
- Discusses the advantages of evolving the paper model into a computer simulation model using the Extend environment

Chapter IV: CENTCOM Targeting Process

- Provides a brief overview of CENTCOM’s joint targeting process
- Details the specifics of the “Develop Targets” activity
- Describes the organizations, systems, and communication methods involved throughout this activity

Chapter V: Extend Model of Develop Targets

- Demonstrates the method through which the Extend model was constructed
- Explains the overall model architecture
- Provides a more detailed look at how functions are performed in the model
- Discusses how we used the Extend software to create this model

Chapter VI: Results and Conclusions

- Explains the usefulness of the baseline “Develop Targets” model
- Discusses the results generated from varying bandwidth in the model
- Highlights the importance of further research to make communication and process delay parameters as accurate as possible
- Mentions the future capability of the model to track alternate metrics

II. JIIB

The Joint Intelligence Interoperability Board (JIIB) is charted to promote intelligence systems interoperability to enhance intelligence support of the warfighter (*Joint Intelligence*).

A. HISTORY AND ORGANIZATION OF JIIB

The JIIB enforcement of interoperability is based solely on the language in the FY98 Authorization Bill of the House Permanent Select Committee on Intelligence (HPSCI). This bill directed the creation of a C4I interoperability management focal point. The JIIB charter recognizes the Joint C4I Battle Center (JBC) as an advisory member to perform system interoperability and functional assessment of identified intelligence systems (*JSBA FY04 Project*).

The JIIB is chaired by the Deputy Director for Intelligence Assessments, Doctrine, Requirements and Capabilities (J2P). It consists of planner-level representatives from the Services, advisors from various agencies, and the Program Managers (PMs) of Joint and Service related intelligence systems. The board meets quarterly to provide a venue for direct PM-to-PM liaison and convenes the Joint Intelligence Interoperability Working Group (JIIWG) as required to address specific JIIB tasks (*JSBA FY04 Project*).

To satisfy its task of identifying interoperability shortfalls among Service and Joint systems, the JIIB Systems Baseline Assessment (JSBA) was developed. The first JSBA was published in 1999 to provide a baseline to compare future intelligence interoperability assessments. A few years later, the JIIB requested that the JBC determine the status of interoperability and document changes since the previous baseline in 1999. The JBC responded with the JSBA FY02. The results of JSBA FY02 were delivered to the JIIB in March 2003. During that same period of time, the JIIB decided to conduct a JSBA every two years. Currently, JSBA FY04 is being assembled (*Joint Intelligence*).

B. JSBA FY02

The JIIB requested the JBC conduct a baseline assessment of the current Joint and Service intelligence systems to determine the existing status of interoperability and document changes since the baseline set in 1999. In response, the JBC executed the JSBA FY02. The JSBA FY02 assessed the technical interoperability of current Joint and Service intelligence systems of record (SOR) to exchange critical intelligence information in a Joint Task Force (JTF) environment. It successfully appraised interoperability progress made by the JIIB SOR since the JBC initial JSBA in 1998 and 1999. It also extended the assessment's scope to include Sensitive Compartmented Information (SCI) level intelligence systems and Multi-Level Security (MLS) systems (*Joint Intelligence*)

The JSBA FY02 project assessed the following Joint and Service C4I systems as directed by the JIIB:

Service Systems (U.S. Secret level)

- Navy Global Command and Control System-Maritime (GCCS-M)
- Army All Source Analysis System Remote Work Station (ASAS RWS)
- Army All Source Analysis System-Light (ASAS-L)
- Air Force Theater Battle Management Core System (TBMCS)
- Marine Corps Intelligence Operations Server (IOS)
- Global Command and Control System-Army (GCCS-A)
- Joint Systems (U.S. Secret level)
- Global Command and Control System-Integrated Imagery and Intelligence (GCCS-I^3)
- Special Operations Forces Tactical Local Area Network (TACLAN)
- Joint Deployable Intelligence Support System (JDISS)
- Advanced Deep Operations Coordination System (ADOCS)
- Joint Systems (U.S. Top Secret/SCI level)
- Global Command and Control System-Integrated Imagery and Intelligence (SCI GCCS-I^3)
- Joint Deployable Intelligence Support System (JDISS-UNIX) (*Joint Intelligence*)

These systems are considered vital for intelligence exchange at the JTF level. The systems transfer e-mail, message traffic, overlays, imagery, and other standard intelligence products used to conduct intelligence support operations (*Joint Intelligence*).

The major finding of the JSBA FY02 was a large improvement in technical interoperability between intelligence systems since the 1999 JSBA project. This is largely due to the creation of a common set of hardware and software for the Navy, Air Force, Marines, and the Joint Force Headquarters. This software and hardware allowed GCCS-I^3, JDISS, GCCS-M, IOS, and TBMCS to transfer information almost seamlessly. It is important to note that while the potential for interoperability has been demonstrated, most of the successes cannot currently be easily duplicated during field operations (*Joint Intelligence*).

Despite the interoperability advances, there remain limitations. The first limitation to interoperability is a critical shortage of system experts who are knowledgeable of both required intelligence functions and the complex technical configuration of the different intelligence systems needed for the Joint environment. Current intelligence training and system documentation tends to be oriented heavily towards Service applications and lacks sufficient focus on Joint operations. A second inadequacy is the divergent Army doctrine identified during the 1999 JSBA. While other Service and Joint systems have tended to consolidate functions on common suites of hardware and Defense Information Infrastructure Common Operating Environment (DII COE) compliant software, the Army battle command systems (ABCS) concept currently utilizes eight separate systems. The final considerable interoperability shortcoming is the significant expansion of interoperability requirements. Combatant Commands have identified several new intelligence interoperability requirements since the 1999 assessment. The most noteworthy of these requirements are the need to exchange information across security domains, the replication of key data sharing, and targeting functions between the Joint headquarters and components. Additionally, there exists the continued problem of dealing with mobile targets and unconventional forces, which may require major revisions to the Modernized Integrated Database (MIDB), and other army databases to support the war on terror. The greatest future challenge identified by the JSBA FY02 will be building a consensus between the Combatant Commanders and the Services regarding the selection and prioritization of technological improvements to the SORs (*Joint Intelligence*).

C. JSBA FY04

While still maintaining its goal to identify interoperability shortfalls among Service and Joint systems, the JSBA FY04 has a different focus than the previous JSBAs. It will focus on two CENTCOM initiated Joint Quarterly Readiness Reviews (JQRRs). The first identifies several interoperability deficiencies between systems that comprise the joint targeting architecture. The second highlights interoperability deficiencies in the Intelligence, Surveillance, and Reconnaissance (ISR) collection management applications across the joint spectrum. Two other areas of focus are potential interoperability problems introduced by fielding multiple versions of the Global Command and Control System (GCCS) and fielding multiple versions of the MIDB (*JSBA FY04 Project*).

JSBA FY04 will be worked on by several different organizations. Both the Meyer Institute of Systems Engineering and the Information Sciences (IS) Department from the Naval Postgraduate School (NPS) are participating. Also contributing to the JSAB FY04 is Joint Forces Command (JFC), Joint Battle Center (JBC), and Joint Interoperability Test Center (JITC) (*JSBA FY04 Project*).

The JSBA FY04 will be conducted in six phases over FY04-05.

Phase 1:	Operational Context
Phase 2:	Modeling & Simulation
Phase 3:	Technical Assessment
Phase 4:	Operational Field Study
Phase 5:	Analysis and Reporting
Phase 6:	Planning for JSBA 06 (*JSBA FY04 Project*)

The first phase, Operational Context, defines the context, systems capabilities, documentations requirements, data collection and analysis plan (DCAP), scope, scenarios, and field studies. The next phase, Modeling and Simulation, will create and populate the necessary process, technical, and data models needed to characterize system behavior, based on the results from the first phase. Technical Assessment is the third phase. This phase will be conducted at the JBC. The program offices will assist the JIIB in conducting a controlled assessment of the JIIB systems. This phase also includes a series of functional tasks in a simulated JTF communications environment to address the specific technical interoperability issues identified in phases one and two (*JSBA FY04 Project*)

Phase four, Operational Field Test/Operational Field Study, will use pre-existing joint exercises to validate the findings from previous phases. The primary exercise will be Exercise Unified Endeavor 2004. The fifth phase, Analysis and Reporting, will produce a "Quick look" report, which will combine the interim reports completed at the end of each phase. The final report will be delivered to the JIIB in March of 2005. The final phase, planning, will take place in Apr-May 05. A JIIWG will be convened to produce a plan for JSBA FY06 (*JSBA FY04 Project*).

D. ROLE OF NPS IN JSBA FY04

The Naval Postgraduate School will use a systems engineering approach that will elucidate key joint intelligence issues, examine and trade alternate approaches, and provide a direct connection to select, on-going joint intelligence processes and activities in order to satisfy the JIIB's requirements (JSBA FY04 Project). The JQRRs highlight interoperability deficiencies in ISR collection management applications across the joint spectrum and deficiencies between systems that comprise the joint targeting architecture. Both targeting and collection management processes will be the focus of the NPS modeling effort for JSBA 04. However, targeting is the initial operational process to be researched and modeled (*JIIB Activity Report*). The task of researching and modeling the CENTCOM targeting architecture was broken down into smaller sections. This thesis is responsible for successfully researching and modeling one of these segments. NPS will develop process models in an Extend environment to support an assessment of the targeting architecture and technical interoperability of current Joint and Service intelligence SOR to exchange critical intelligence information in a JTF environment (*JIIB Activity Report*).

III. PROCESS MODELING

Current documents that exist for a vast majority of DoD systems, and information systems in particular, are deficient in describing their processes in a manner that is easily understood, or dissected. Furthermore, with no standard architecture for developing and describing C4ISR systems, each Military Service, major command, and Defense Agency resorts to using different methodologies. This has resulted in system architectures that cannot be readily shared and understood, leading to problems with defining information exchanges and even joint interoperability issues (*All-DoD* 1).

A. HISTORY/BENEFITS

Process modeling can be thought of as a systems engineering approach to understanding the flow of information through a system or process. An advantage of using the Systems Engineering Process Modeling approach has to do with its "ability to analyze complex systems problems in terms of fundamental parameters, formulate alternate architectural solutions, perform trade-off analyses of the alternate solutions, and select a best solution based on a reasonable set of selection criteria" (Osmundson 68). This trade study methodology has proven to be extremely effective in the aerospace industry, resulting in more informed acquisition decisions (Osmundson 68). However, "application of similar systems engineering principles has been lacking in the area of information systems…especially in the design and analysis of complex, time-critical networked, distributed information systems, including military command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) systems" (Osmundson 68).

The development of detailed process models has several benefits:

- Results in the creation of current and accurate documentation.
- Saves resources (time, money, manpower, etc.) during architecture development and assessments.
- Reduces risk by ability to model changes before capital investment.

- Provides more comprehensive analyses.
- Permits analysis of overall system and individual processes with minimal expense and time.

B. CENTCOM TARGETING ARCHITECTURE

The specific process that will be addressed throughout this paper is US Central Command's Targeting Architecture. *U.S. Central Command's Objective Architecture Concerning Targeting* is a document from 1997, which details the organizations, procedures, information and systems involved in the targeting process. But the architecture that was employed to describe this process is not easily translated into an accurate paper model due to information gaps. Also, important modeling concerns, such as timing, are rarely mentioned. If a standard UML type architecture had been used to describe the targeting process, the paper model would have been much easier to complete.

A common argument for why these architectures are rarely produced for information systems stems from the belief that communication systems infrastructures would be far too expensive to change. This point is refuted by noting the importance of "the systems engineering precept that it is useful to know what an unconstrained solution to a problem is as well as the potential trades in performance and cost from constrained and unconstrained solutions" (Osmundson 69). For example, a process model designed to represent CENTCOM's Targeting Architecture could be extremely useful in highlighting areas that hold up or cause a backlog in the flow of information. Once these areas are revealed, further data from simulations and cost analysis could lead to decisions on whether or not to change processes and/or invest in more advanced systems that can process and distribute the information more quickly. A common misconception when it comes to improving military C4ISR systems is to simply increase bandwidth. However, this solution is costly and has the potential to overload system operators with unnecessary information. Clearly, the development of an accurate process model would be extremely useful in order to optimize the system being analyzed.

C. DODAF

The DoD is attempting to improve the way its systems are described through the implementation of Department of Defense Architectural Framework (DODAF) documents. Information systems are designed to get the correct information to the intended recipient both accurately and within a specified timeline. Current documents that describe most information system architectures make this aspect of process modeling very difficult. However, the DODAF system is based on the unified modeling language (UML) (*All-DoD* 17), which "utilizes use case and sequence diagrams among other constructs to help determine information producers and recipients" (Osmundson 70). From these standardized documents across commands, services, and agencies, the IERs can be translated into a thread-based representation, and subsequently into a paper model. In the case of modeling CENTCOM's Targeting Architecture, these convenient DODAF documents are non-existent. This means that a large effort must ensue just to translate the given architecture into a thread-based representation and eventually a paper model. A push is being made to require compliance in creating DODAF documents for each DoD system or process, but currently no mandate exists (*All-DoD* 17).

D. FUNCTIONAL THREADS

The functional thread sequence, through which an iterative process will eventually become a detailed paper model, shares many similarities with the UML sequence mentioned previously. A thread-based representation of a process not only accurately defines the IERs, but also provides insight into system time behavior, which becomes a key parameter in analyzing the performance of distributed, time-sensitive tasks. An example of a functional thread diagram is shown in Figure 1 (Kimmel 4).

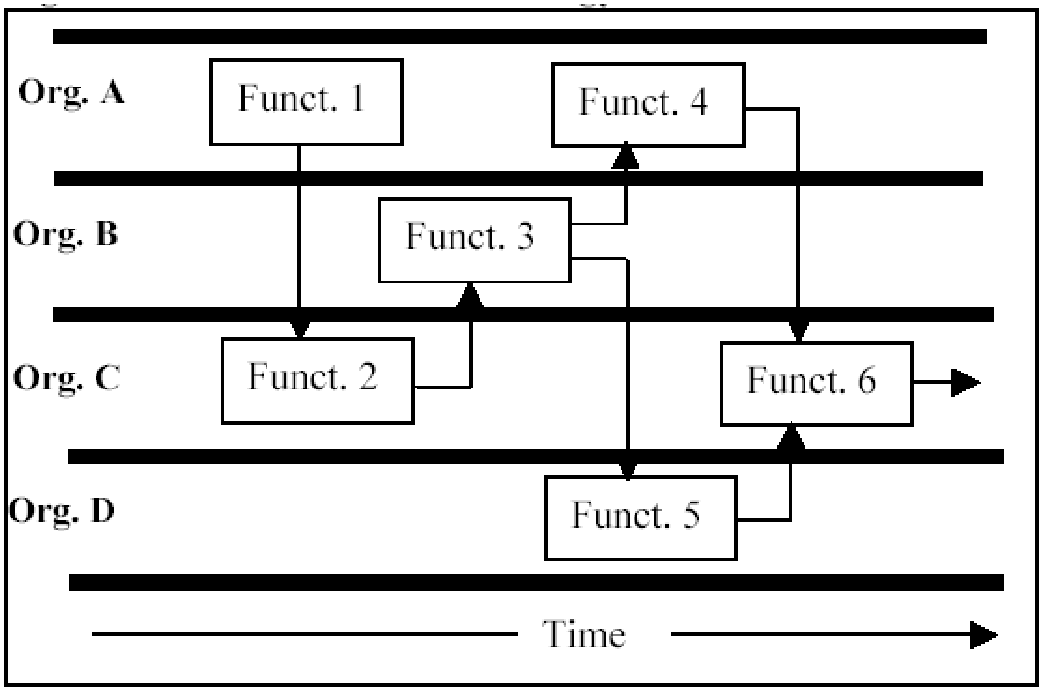

Figure 1. Functional Threads

Organizations that perform tasks and functions are listed on the left. Various functions that are performed are represented as blocks, which are known as processing blocks in the model. The arrows show that information is passed from one function to the next in order to accomplish the overall process. Time intervals are noted, but not quantified. The implementation of this methodology provides a graphical representation of the narrative of the targeting process provided in the CENTCOM CONOPs. This representation will be used to develop the structure of the process model (Kimmel 3).

Figure 1 can be even further annotated to increase its information content by indicating the information exchange requirement (IER) items produced and transmitted at each step of the process, and the systems used to produce, transmit, and receive the IER items. An example of this detail is noted in Figure 2, and is present in all Visio paper models and Extend models (Kimmel 4).

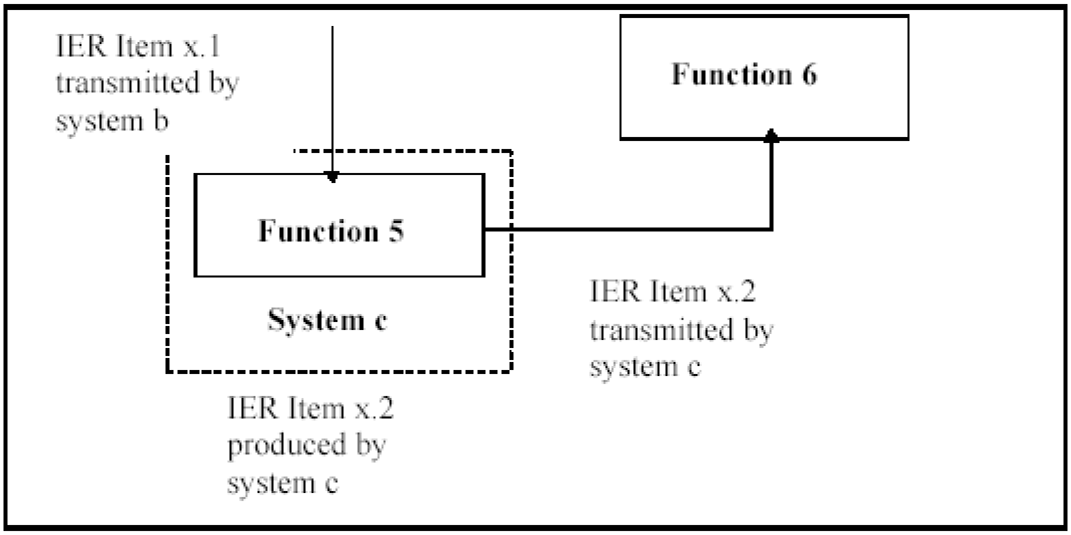

Figure 2. Information Exchange Requirement Template Model

The sequence shown by the arrows in Figures 1 and 2 represent an event thread, which will be extremely useful in highlighting one of the key system parameters; the amount of time necessary to execute the thread. Time delays that are associated with the performance of each function, as well as the delay associated with the necessary communication between functions and systems, can be analyzed in order to optimize the process in question. Perhaps it will determine that certain steps in the process are redundant, and can be eliminated. Or maybe it will highlight areas to invest money so the systems can be upgraded in hopes of reducing data latency due to variables such as:

- network access methods
- message queuing
- processing delays
- decision delays
- network capacity
- propagation path delays (Kimmel 4)

The same modeling approach can be used to address software specific issues and interface issues between software and hardware components. This will establish software requirements to meet criteria specific to software performance or to meeting operational objectives, including information structure and transmission protocols. In summary, this modeling framework establishes the mechanism for examining interoperability effects including:

- Effect of lack of connectivity between input and output systems on process quality and completion times.
- Effect of lack of common formats used for input and output IER items on process quality and completion times.
- Identification of critical processing nodes where interoperability factors are crucial.
- Process/system blocking resulting from lack of interoperability.
- Process synchronization difficulties due to the timing of functions and the production of IER items not being consistent with overall need times, especially under high tempo conditions (Kimmel 4).

Most processes worth analyzing, including CENTCOM's targeting architecture, will include thousands of functional threads. This provides great opportunity to optimize the system and reduce data latency; however, it would be impractical for humans to model these processes and attempt to analytically solve the resulting equations. A far more efficient method for modeling and simulating these processes is through the use of a computer simulation tool.

E. COMPUTER SIMULATION

Simulations involve designing a model of a system and carrying out experiments on it while taking the time domain into consideration. The major advantage of using computer simulation environments to create and run models is to enable hypotheses, such as altering link bandwidth or IERs. These can be tested at a fraction of the cost of actually implementing these changes in the system in question.

Computer simulations are also advantageous due to the ability of the user to easily conduct a "step-wise refinement" of the process (Extend v6 E4). Step-wise refinement often results in accurate approximations to complex problems in a very time efficient manner, and could more effectively communicate how the system really works.

Constructing models in these computer simulation environments facilitates changing the model and quickly testing the effects of these changes. Some examples of changes that can easily be made and tested are:

- Adding, replacing, or deleting activities and delays
- Changing the process flow
- Changing the process and delay times (Extend v6)

Additionally, computer simulations of process models can be constructed in order to take interoperability issues into account. While interoperability tests have not been directly incorporated into this baseline "Develop Targets" model, its framework does facilitate the future addition of these checks. At appropriate locations in the model, tests that are sensitive to interoperability issues can be inserted. The goal is to determine the effect that interoperability deficiencies have on overall or local process performance. Whether or not systems and information formats are interoperable is a technical question that is answered external to the process model, and is an input to the model. The effect such incompatibilities have is a process question that can be answered by process modeling using the following method. Figure 3 illustrates how consideration of interoperability is accomplished (Kimmel 5).

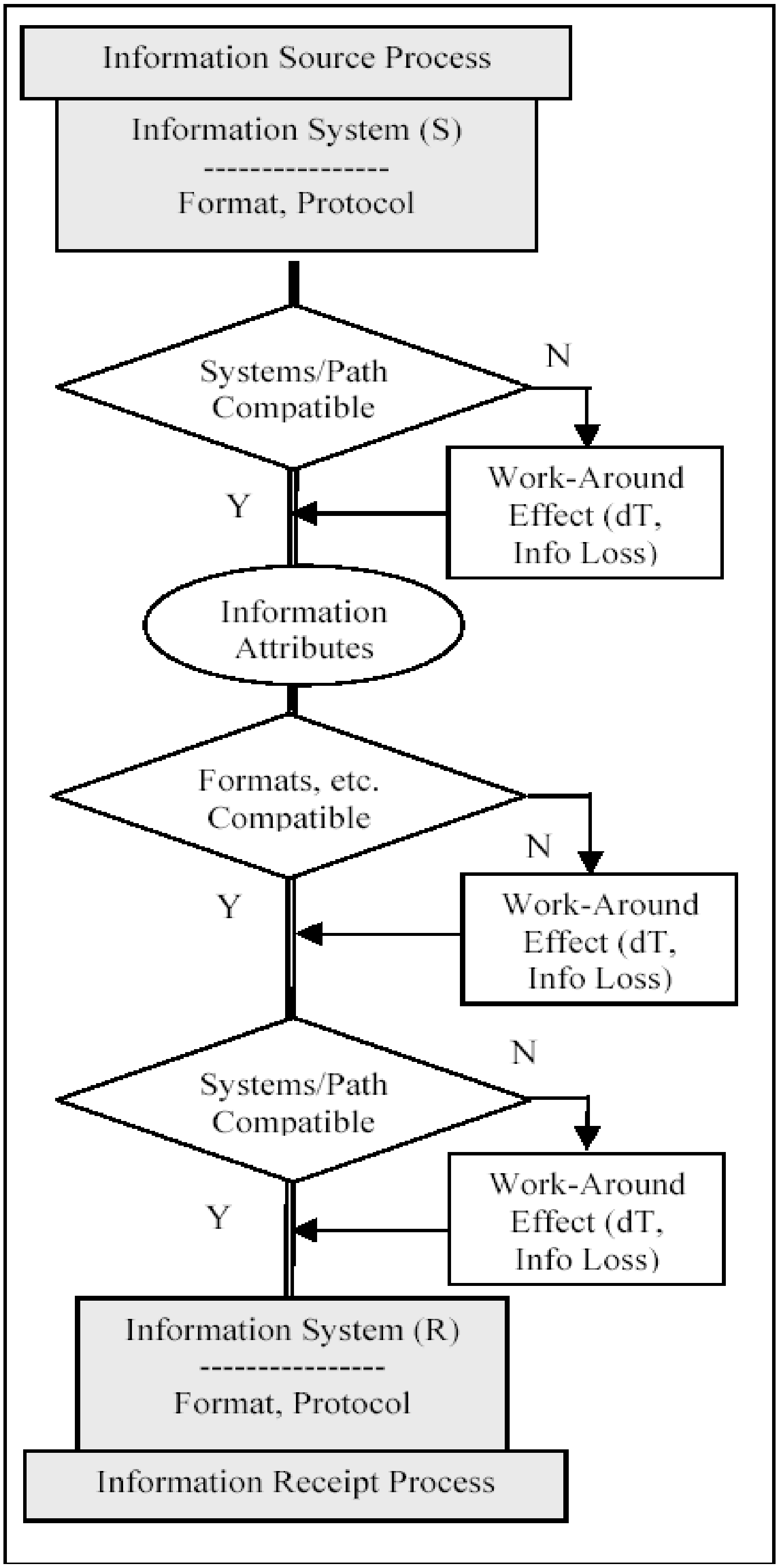

Figure 3. Interoperability Analysis Flow

Information is produced at a source process (S) and is received and used at a receiving process (R), both shown in gray boxes. The source and receipt processes will use information systems (electronic and human) and a transmission path (e-mail, sneaker net, electronic link, etc.), shown as a double solid line. There can be system-to-system or system-to-path interoperability at either end. The information being transmitted will have attributes, such as the format used, or the software used as the information medium (spreadsheet, message format, etc.). Information attribute incompatibilities are also an interoperability problem. Interoperability difficulties can be handled by having tests and branches within the process model, as shown on the diagram. If there is an incompatibility, the program branches to take into account whatever effects occur. Interoperability effects must be programmed into the model, which is done by a branch when interoperability occurs. The effect may be a time delay, or even loss of information. For example, the branch could represent a human interpretation of the information and a manual entry into the next system (R). This programming methodology allows one to investigate various interoperability effects: where critical process breakdowns occur, which fixes are most profitable to make, where to develop adequate workarounds, and the like (Kimmel 5).

1. Extend

The CENTCOM Targeting Architecture modeling effort will be accomplished in the Extend environment. Of all the simulation environments on the market, one of the more effective and user friendly is Extend. Extend is a relatively low cost tool that is easy to learn, easy to work with, and can be run on personal computers. Rather than having to learn to code unique algorithms in order to model items or information flowing throughout a system or process, Extend allows the user to drag and drop pre-coded blocks into the workspace. They can be easily modified to accurately represent the functions of a specific system or process. Alternatively, the ability for the user to code unique blocks to perform a specialized function also exists. In the end, the accuracy of the simulation results generated by Extend models were found to be within 1% of the results generated from using the same parameters in much more expensive and difficult to use analysis tools (Osmundson 72).

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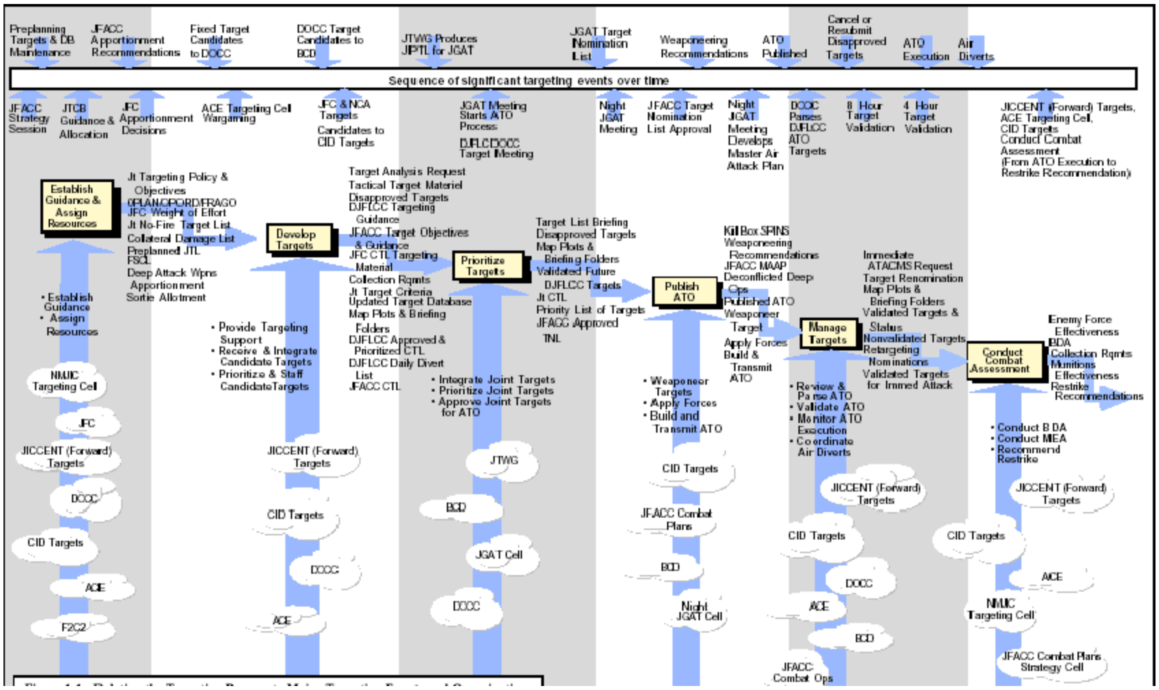
IV. CENTCOM TARGETING PROCESS

This section is intended to provide a broad understanding of what is transpiring throughout the entire joint targeting process. The ultimate goal of this cycle is to produce an air tasking order (ATO) and then conduct a combat assessment of the target to determine if a re-strike is required (*Volume II* 1-1).

A. OVERALL TARGETING ARCHITECTURE

CENTCOM's targeting architecture is broken down into the following six major activities (represented in Figure 4):

- Establish Guidance and Assign Resources
- Develop Targets
- Prioritize Targets
- Publish ATO
- Manage Targets
- Conduct Combat Assessment



Preplanning Targets & DB Maintenance
JFACC Apportionment Recommendations
Fixed Target Candidates to DOCC
DOCC Target Candidates to BCD
JTWG Produces JIPTL for JGAT
JGAT Target Nomination List
Weaponeering Recommendations
ATO Published
Cancel or Resubmit Disapproved Targets
ATO Execution
Air Diverts
Sequence of significant targeting events over time
JFACC Strategy Session
JTCB Guidance & Allocation
JFC Apportionment Decisions
ACE Targeting Cell Wargaming
JFC & NCA Targets
Candidates to CID Targets
JGAT Meeting Starts ATO Process
DJFLCC/DOCC Target Meeting
Night JGAT Meeting
JFACC Target Nomination List Approval
Night JGAT Meeting Develops Master Air Attack Plan
DOCC Parses DJFLCC ATO Targets
8 Hour Target Validation
4 Hour Target Validation
JICCENT (Forward) Targets, ACE Targeting Cell, CID Targets Conduct Combat Assessment (From ATO Execution to Restrike Recommendation)
Establish Guidance & Assign Resources
Jt Targeting Policy & Objectives
OPLAN/OPORD/FRAGO
JFC Weight of Effort
Jt No-Fire Target List
Collateral Damage List
Preplanned JTL
FSCL
Deep Attack Wpns Apportionment
Sortie Allotment
• Establish Guidance
• Assign Resources
Develop Targets
Target Analysis Request
Tactical Target Materiel
Disapproved Targets
DJFLCC Targeting Guidance
JFACC Target Objectives & Guidance
JFC CTL Targeting Material
Collection Rqmts
Jt Target Criteria
Updated Target Database
Map Plots & Briefing Folders
DJFLCC Approved & Prioritized CTL
DJFLCC Daily Divert List
JFACC CTL
• Provide Targeting Support
• Receive & Integrate Candidate Targets
• Prioritize & Staff CandidateTargets
Prioritize Targets
Target List Briefing
Disapproved Targets
Map Plots & Briefing Folders
Validated Future DJFLCC Targets
Jt CTL
Priority List of Targets
JFACC Approved TNL
• Integrate Joint Targets
• Prioritize Joint Targets
• Approve Joint Targets for ATO
Publish ATO
Kill Box SPINS
Weaponeering Recommendations
JFACC MAAP
Deconflicted Deep Ops
Published ATO
Weaponeer Target
Apply Forces
Build & Transmit ATO
• Weaponeer Targets
• Apply Forces
• Build and Transmit ATO
Manage Targets
Immediate ATACMS Request
Target Renomination
Map Plots & Briefing Folders
Validated Targets & Status
Nonvalidated Targets
Retargeting Nominations
Validated Targets for Immed Attack
• Review & Parse ATO
• Validate ATO
• Monitor ATO Execution
• Coordinate Air Diverts
Conduct Combat Assessment
Enemy Force Effectiveness
BDA
Collection Rqmts
Munitions Effectiveness
Restrike Recommendations
• Conduct BDA
• Conduct MEA
• Recommend Restrike
NMJIC Targeting Cell
JFC
JICCENT (Forward) Targets
DOCC
CID Targets
ACE
F2C2
JICCENT (Forward) Targets
CID Targets
DOCC
ACE
JTWG
BCD
JGAT Cell
DOCC
CID Targets
JFACC Combat Plans
BCD
Night JGAT Cell
JICCENT (Forward) Targets
CID Targets
DOCC
ACE
BCD
JFACC Combat Ops
JICCENT (Forward) Targets
CID Targets
ACE
NMJIC Targeting Cell
JFACC Combat Plans Strategy Cell

Figure 4. US CENTCOM Joint Targeting Process

It is important to keep in mind this is not simply an end-to-end process that happens only at the beginning of a conflict. This process must be viewed as an iterative cycle in which it is not uncommon to have three or four air tasking orders in process at any given time (*Volume II* 1-1).

During the "Establish Guidance and Assign Resources" activity the overall guidance and priorities for targets are disseminated and the necessary operational firepower required to satisfy this guidance is obtained (*Volume II* 1-7). The "Develop Targets" activity identifies potential targets, unconstrained by assets needed to destroy them, and begins to build up intelligence information about each target (*Volume II* 1-13). The "Prioritize Targets" activity is necessary to merge the candidate target lists (CTLs) from the component commanders, NCA, and JFC into a single, joint CTL. They are prioritized based on commander's guidance and current battle area situation (*Volume II* 1-24). This prioritized, joint CTL is then used in the "Publish ATO" activity to create an ATO for use the following air tasking day. The ATO is important because it informs the component commanders of the air support they should receive, while coordinating all flying operations for that day (*Volume II* 1-33). While considerable effort goes into producing the ATO, the continuously evolving nature of the tactical environment often makes the ATO's exact execution impossible. The "Manage Targets" activity handles the changes in asset availability, weather conditions, combat losses and emerging targets by ensuring that the objectives of the ATO are satisfied through alternate, yet coordinated, means of execution (*Volume II* 1-42). Finally, the "Conduct Combat Assessment" activity is necessary to determine whether the target was destroyed, and to gauge its effect on the overall campaign. Also, this activity serves to analyze the effectiveness of the weapons, tactics and strategies employed, and makes re-strike recommendations if necessary (*Volume II* 1-53).

A basic understanding of CENTCOM's joint targeting architecture is important when analyzing and modeling any of the six major activities. The remainder of this thesis will focus specifically on the "Develop Targets" activity, which is described in far greater detail in the following section.

B. DEVELOP TARGETS ACTIVITY

The “Develop Targets” activity involves a systematic examination and evaluation of potential enemy military, political, and economic target systems, and identifies their components and interrelationships. Potential military destructive and nondestructive actions are considered. Ultimately, candidate target selection is made based on the target’s contribution to the established campaign and command objectives within the scope of the command guidance. “Develop Targets” is divided into three sub-activities (*Volume II* 1-14):

- Provide Targeting Support
- Receive and Integrate Candidate Targets
- Prioritize and Staff Candidate Targets

The following narrative is best understood in conjunction with the accompanying Visio paper model. This Visio model (400 KB) is available on the Internet site <http://library.nps.navy.mil/uhtbin/hyperion/04Jun_Germakian> under the link “Develop Targets Paper Model in Visio.” The Visio paper model was an important first step in ultimately developing a working model of this activity in Extend. It transformed the written information in CENTCOM’s documentation of the joint targeting architecture into a visual representation of this process in the form of an organizational architecture. In this form, it was easier to understand not only the key organizations involved throughout the process, but also allowed IERs, functional threads, and information gaps to be readily identified. Ultimately, the paper model made the creation of the Extend model more fluid.

Together, the Visio paper model and the following narrative provide a sense of when the processes occur throughout the activity and highlight the data elements that flow between the organizations. This model and process may not be entirely accurate due to information gaps in the documentation, which is why future iterations will be necessary. Furthermore, any assumptions regarding the flow of information between organizations are annotated in the text, and defined by a red information exchange lines in the Visio diagram, as opposed to documented information exchange lines that are blue.

1. Provide Targeting Support

During the "Provide Targeting Support" sub-activity, each member of US CENTCOM's targeting community participates in an early examination of potential theater targets. Their goal is to select those targets that best support the component commander's war effort based on the JFC's strategy, objectives and guidance. Target nominations are selected from a USCENTCOM Preplanned JTL, and intelligence needs are satisfied throughout the target folder development process. JICCENT Targets is the organization that drives "Provide Targeting Support." Throughout this sub-activity existing target databases are updated, collection requirements are both generated and satisfied, and the best employment of available assets is determined (*Volume II* 1-13).

a. Initial Target Selection Process

- This relies heavily upon information that was created and disseminated to component commanders and targeteers during the "Establish Guidance and Assign Resources" activity. The following information, which has been previously disseminated, serves as the basis upon which the initial target lists will be developed: Joint Target Policy and Objectives, Preplanned Joint Target List, FSCL, OPLAN/OPORD/FRAGO, Joint No-Fire Target List, JFC Weight of Effort and Collateral Damage List. This "initial guidance package" is assumed to have already been distributed to all targeteers involved in developing targets and is not depicted in the Visio diagram of "Develop Targets."
- Initial target nominations are produced by JICCENT Targets, CID targets, COID targets, and the ACE upon receipt of the startup target database from the NMJIC. These target nominations do not yet take into consideration the assets needed to destroy them, but rather select a number of targets for which additional information will be gathered. Although not mentioned in the documentation, it was assumed that the JFMCC and JFSOCC also begin their initial target selection process at this time.

b. Acquire Additional Target Intel

- The component commanders and targeteers identify shortfalls in targeting materials and relay this information in the form of target material requests through JICCENT Targets to JICCENT (rear)

Target Materials Branch and NIMA. The information exchange from JICCENT Targets to NIMA is assumed, but likely to occur since it is known that NIMA submits target materials back through JICCENT Targets.

- The requested target material products (Basic Target Graphics and Quick Response Graphics) are processed and disseminated back down to the component commanders, and ultimately the targeteers in the form of graphic, textual, tabular, digital, video and other JICCENT (rear) presentations of target intelligence in support of operations.
- Concurrently, JICCENT Targets reaches back to NMJIC Targets for support on the analysis of specific targets and target systems. The NMJIC serves as the pipeline to CONUS-based intelligence agencies, which can sometimes provide more detailed target analysis. Upon completion these requests are assumed to be pushed forward through JICCENT Targets to deployed targeteers as necessary.
- The targeteers and component commanders review the target materials, and subsequent intelligence shortfalls are submitted to JICCENT DARS, the daily aerial reconnaissance and surveillance conference, in the form of collection requirements. Although documented to flow from the ACE, JFACC and JICCENT Targets to JICCENT DARS, it is assumed that these collection requirements are also generated by the targeteers. JICCENT DARS tasks the SOF and S&R sensors to fulfill organic surveillance and reconnaissance collection requirements. The DCCC is tasked with national asset collection requirements. Completed collection requirements are pushed back through JICCENT DARS to the component commanders. It is assumed that the targeteers also receive the completed collection requirements.
- Concurrently, JICCENT Targets also integrates WMD target information into the evolving target database through information gathered from S&R sensors.

c. Disseminate Appropriate Target Information

- JICCENT Targets compiles and disseminates tactical target material to component commanders and targeteers. This information consists of the targeting systems and materials that a targeteer will have available when deployed.
- Simultaneously, an updated target database and specific criteria regarding the JFC's specific guidance for target categories and

standards on which targeting nominations may be made are distributed to the targeteers. It is assumed that this same information is sent to the maritime and special operations component commanders as well.

2. Receive and Integrate Candidate Targets

During "Receive and Integrate Candidate Targets" sub-activity, the selection of deep operations targets is conducted by Army forces, Marine forces, the Deputy Joint Force Land Component Commander (DJFLCC), JFACC and JFC targeting staffs. JFC guidance and objectives, location of the FSCL, rules of engagement, and target intelligence gathered in the previous sub-activity are all taken into consideration prior to the development of DJFLCC, JFACC and JFC initial candidate target lists (CTLs). These preliminary CTLs are unconstrained by the availability of attack resources. Development of the JFC, JFACC and DJFLCC CTLs should be occurring in parallel, although this is not represented well in the Visio diagram due to the fact that the DJFLCC process is described in the most detail. Also note that JFMCC and JFSOCC targets are incorporated into the JFACC CTL via Liaisons located at the AOC (this information exchange is not modeled).

a. DJFLCC CTL Development

- An updated target database, ROEs, any changes in the FSCL, and JFC guidance and objectives serve as the foundation for the unconstrained nomination of ground targets by the ACE, SJA, and Army and Marine forces. Each of these organizations sends its candidate ground target list to the DOCC.
- The DOCC, which is also aware of ROEs and changes to the FSCL, integrates its own ground target nominations with those received from the aforementioned agencies.
- It is assumed that the initial ground target nominations are passed from the DOCC to the ACE and DJFLCC Staff. Based on a 72 to 96 hour intelligence estimate from the ACE, the DJFLCC staff conducts an operations-intelligence war gaming session to determine the DJFLCC scheme of maneuver and fire support for the next 72 to 96 hours. Accurate targeting guidance and objectives are relayed to the DOCC.
- The DOCC develops an initial DJFLCC CTL based on the targeting guidance and objectives.

- The DOCC also distributes any disapproved targets to the component targeting elements so that they are aware, and can re-submit for approval, if needed.
- The ACE begins its preparation and research of maps, plots and briefing folders to further enhance DJFLCC CTL target intelligence.

b. JFACC CTL

- The BCD cell is notified of any changes to the FSCL.
- The JFACC AOC Combat Plans Target Development Section, consisting of members of the 609 AIS, is responsible for all air component targeting and begins development the JFACC CTL.
- The JGAT cell disseminates JFACC targeting objectives and guidance to the air components; MAW, WOC and JFMCC. It is assumed that these objectives and guidance must have been based on the JFACC CTL, and therefore, the JGAT cell should have received some form of input from AOC Combat Plans.

c. JFC CTL

- The JFC is notified of any changes to the FSCL and integrates its own target nominations list with ground target nominations submitted by JFSOCC and F2C2.
- JICCENT Targets, which has also created an initial list of targets, integrates ground target nominations from the JFC and NMJIC to begin development of the JFC CTL.
- JICCENT Targets prepares and disseminates disapproved targets and target objectives and guidance to the targeting components involved: NMJIC targets, JFC, F2C2 and JFSOCC.
- JICCENT Targets also begins its preparation and research of maps, plots and briefing folders to further enhance JFC CTL target intelligence.

3. Prioritize and Staff Candidate Targets

During this final sub-activity, each component prioritizes and staffs their final CTL before submitting it to the AOC. Again, DJFLCC has the most detailed process, and it was assumed that the JFC and JFACC also prioritize and staff their final CTLs before they are sent to the AOC. In addition to producing a DJFLCC approved and prioritized CTL, a daily divert list is developed and submitted to the AOC to identify high priority ground force targets should JFACC sorties become available. Although neither documented, nor modeled, the JFC and JFACC may also develop a list similar to DJFLCC daily diverts.

a. DJFLCC Approved and Prioritized CTL and Daily Diverts

- The initial DJFLCC CTL compiled by the DOCC is submitted to the DJFLCC staff for recommendations from personnel such as the SJA, engineer, and PSYOPs officer. These recommendations are incorporated, and the CTL is prioritized and re-submitted to the DJFLCC staff for final approval.
- The DOCC also develops the Daily Divert List, which is sent along with the prioritized and staffed CTL to the AOC BCD cell.
- Final maps, plots and briefing folders that were produced by the ACE are received by the DJFLCC.

b. JFACC Prioritized and Staffed CTL

- AOC Combat Plans is assumed to prioritize and staff the JFACC CTL, and send it to CID targets.
- Final maps, plots and briefing folders are produced by CID targets and sent to the AOC.

c. JFC Prioritized and Staffed CTL

- JICCENT Targets is assumed to prioritize and staff the JFC CTL, and send it to CID targets.
- Final maps, plots and briefing folders that were produced by JICCENT Targets are received by the JFC.

The principle outputs at the conclusion of the "Develop Targets" activity are prioritized and staffed CTLs, and current maps, plots and briefing folders. These will serve as the major inputs that drive the following activity, "Prioritize Targets."

C. ORGANIZATIONS WITHIN DEVELOP TARGETS

All of the tasks required to complete "Develop Targets" are not accomplished at a single location or by a single organization. At the top of the chain of command in the area of responsibility is the Joint Force Commander (JFC). The organization is then broken down into the component commands of: Deputy Joint Force Land Component Commander (DJFLCC) (the JFC retains functional responsibility for the joint force land component), Joint Force Air Component Commander (JFACC), Joint Force Maritime Component Commander (JFMCC), and Joint Force Special Operations Component Commander (JFSOCC) (*Volume I* 1-7). Each of the component commanders represents a different area of the joint battlefield. The DJFLCC is in charge of ground operations, the JFACC is in charge of air operations, the JFMCC is in charge operations at sea, and the JFSOCC is in charge of the special operations forces that are in the area of responsibility. These component commands are further divided into numerous organizations to conduct their missions. They also utilize outside organization when they do not have all the information required to accomplish their tasks (*Volume I* 3-2). The following are the organizations that perform a role in "Develop Targets."

1. ACE

The Analysis and Control Element (ACE) is the intelligence node for the DJFLCC (*Volume III* D-3). The ACE performs many roles for the DJFLCC. First, it assists in the development of all intelligence estimate products and special studies for deep operations. Second, it produces target and briefing folders, wargames friendly ground force operational plans, and determines deep attack, high-value, and high-payoff targets. It also coordinates with the ACE intelligence collection manager to satisfy priority intelligence requirements, conducts detailed intelligence analyses of enemy forces, and develops a prioritized candidate target list based on DJFLCC targeting guidance and objectives. Finally, it conducts damage assessments of targets struck, and validates candidate targets 8 and 4 hours before mission strike (*Volume 1* 3-10,11).

The ACE performs several duties during "Develop Targets." The first job for the ACE is conducting operations-intelligence wargaming sessions to determine DJFLCC scheme of maneuver and fire support for next 72-96 hours. Later in "Develop Targets," the ACE, based on DJFLCC approved courses of action, receives guidance from the DOCC and DJFLCC subordinate commands for candidate target development. Finally, it identifies high-value targets, recommends high-payoff targets, and researches, prepares and distributes special studies as part of its target folders. (*Volume II* 13-23).

2. BCD

The Battlefield Coordination Detachment (BCD) is located in Ft. Bragg, North Carolina. Its mission is to facilitate the synchronization of joint air operations with Army ground maneuver and fires, to coordinate joint air support, and to facilitate the exchange of operational and intelligence data (*Volume 1* 3-5). It also conducts extensive coordination during the planning phase of operations (*Volume II* 13-23). The BCD is divided into seven areas of operation. They are Current Intelligence, Future Intelligence, Operations, Air Lift, Plans, Airspace Management, and Air Defense Artillery. It is staffed with 15 officers and 17 enlisted personnel (*Volume 1* 3-5). During the "Develop Target" activity, the BCD receives the DJFLCC approved and prioritized candidate target list via AFATDS (*Volume II* 13-23).

3. CID Targets

The Combat Information Division (CID) Targets is the targeting node within the Air Operations Center (AOC) under the JFACC. It provides target development and conducts battle damage assessment in the targeting cycle (*Volume III* D-3). During the planning phase of operations, CID Targets conducts extensive coordination. (*Volume II* 13-23).

4. COID Targets

The Combat Operations Intelligence Division (COID) Targets is very similar to CID Targets. It is also a targeting node within the AOC under the JFACC. However, instead of planning an operation, COID Targets provides target management during the execution of the ATO (*Volume III* D-3).

5. DCCC

The Defense Collection Coordination Center (DCCC) provides a central node for consolidating requirements for national collection. It is collocated with the NJMIC

(*Volume III* D-4). The DCCC receives integrated component collection requirements that are presented by JICCENT collection manager at the DARS Conference for national asset collection (*Volume II* 13-23).

6. DJFLCC

The Deputy Joint Force Land Component Commander (DJFLCC) is designated the duties, functions, and responsibilities of the Joint Force Land Component Commander (JFLCC). This is because the JFLCC is designated the Joint Forces Commander. The DJFLCC has a staff, and the staff is responsible for providing inputs to targeting recommendations that result in the DJFLCC approved and prioritized candidate target list. The DJFLCC also has a Staff Judge Advocate (SJA) who provides guidance for the legal aspects of targeting, such as collateral damage, the law of armed conflict, and the rules of engagement (*Volume III* D-4).

During "Develop Targets," the DJFLCC has many roles. His guidance and objectives allow for fixed and mobile targets to be nominated, and his targeteers provide coordinates to JFACC targeteers during target nomination. The DJFLCC planners work with ACE intelligence personnel to discuss, dissect, and fuse information concerning friendly operations to develop the best course of action for the ground component forces. Finally, one of the primary products of the "Develop Targets" activity is the production of a DJFLCC approved and prioritized candidate target list (*Volume II* 13-23).

7. DOCC

The Deep Operations Coordination Cell is the division within the DJFLCC staff tasked with planning, coordinating, and executing deep attacks (*Volume III* D-4). Its headquarters are located at Fort McPherson in Atlanta, Georgia. The DOCC coordinates targeting guidance and objectives input into the ATO, ATO execution, and fire support coordination measures. It also maintains the DJFLCC daily divert list. It is divided into the three sections of Target Development, Battle Management, and Fire Support. The DOCC is staffed with 15 officers, 2 warrant officers, 11 noncommissioned officers, 24 Air Force augmenters, along with additional personnel assigned depending on the scope of the operation (*Volume 1* 3-8).

The DOCC serves as a focal point for the DJFLCC to receive Army and Marine CTLs as well as developing its own targets. During "Develop Targets," it consolidates the received targets into a single integrated list of ground targets. The DOCC also coordinates the predicted locations of maneuver forces to counter the targets on the move (*Volume II* 13-23).

8. F2C2

The Friendly Forces Coordination Center (F2C2) passes coalition-nominated deep attack targets to United States target planners at the AOC. It serves as a link between targeting, planners, operators, and coalition forces. During "Develop Targets," the F2C2 sends the coalition target nominations to JICCNET Targets (*Volume II* 13-23).

9. JFACC

The Joint Forces Air Component Commander (JFACC) is responsible for planning, coordinating, allocating, and tasking, as well as recommending to the JFC air sorties to various missions or geographical areas (*Volume III* D-4). Being one of the four component commanders, the JFACC has many activities in "Develop Targets." One of the primary outputs of "Develop Targets" is the JFACC approved CTL. This approval CTL incorporates the targets provided by the JFMCC and JFSOCC. Under the JFACC, the AOC conducts air component targeting, and the JFACC Combats Plans is responsible for the air component targeting regardless of service (*Volume II* 13-23).

10. JFC

The Joint Force Commander (JFC) is the person who is authorized to execute command authority or operational control over a joint force (*Volume III* D-5). The JFC is the person to whom the component commanders (DJLFCC, JFACC, JFSOCC, and JFMCC) report (*Volume I* 3-2). The JFC has a staff that provides targeting recommendations that aid the JFC in guidance, apportionment, and weight of effort. The JFC also has a SJA who provides guidance for the legal aspects of targeting (*Volume III* D-5).

11. JFMCC

The Joint Force Maritime Component Commander is responsible for making recommendations on the proper employment of maritime forces and assets, planning and coordinating maritime operations, or accomplishing similar missions as may be assigned (*Volume III* D-5). In "Develop Targets," the JFMCC sends its target nominations to be incorporated in the JFACC CTL that is sent to the next activity of prioritize targets (*Volume II* 13-23).

12. JFSOCC

The Joint Force Special Operations Component Commander (JFSOCC) is responsible for making recommendations on the proper employment of special operations forces and assets, planning and coordinating special operations, or accomplishing a similar operational mission as assigned by the JFC (*Volume III* D-5). As one of the four component commanders, during "Develop Targets" the JFSOCC sends target nominations to be incorporated into the JFACC CTL (*Volume II* 13-23).

13. JGAT Cell

The Joint Guidance, Apportionment, and Targeting (JGAT) Cell approves the joint integrated prioritized target list (JIPTL) and determines a cut line above which prioritized targets can be serviced by available weapons. Once this list is approved by the JFACC, it become the target nomination list. (Volume III D-5) Organizationally, the JGAT Cell is in the JFACC Air Operations Center (AOC) (*Volume II* 1-64). During the "Develop Targets" activity of the joint targeting architecture, the JGAT Cell sends the JFACC targeting objectives and guidance to JFMCC, WOC, and MAW (*Volume II* 13-23).

14. JICCENT

The Joint Intelligence Center at CENTCOM (JICCENT) refers to the forward-deployed portion of JICCENT that serves as the intelligence center at the joint headquarters. It is responsible for providing and producing intelligence required to support the JFC and staff, components, task forces, elements, and the national intelligence community (*Volume III* D-5). It is organizationally positioned under the JFC and contains Targets, WMD, and DARS branches (*Volume II* 1-66).

15. JICCENT (Rear)

The JICCENT (Rear) is the portion of the JICCENT remaining at MacDill Air Force Base while the joint force is deployed in the theater (*Volume III* D-5). During "Develop Targets," JICCENT (rear) is able to process information it has received from the front, and push results and additional information from its large databases back to assist in mission accomplishment. During "Develop Targets," JICCENT (rear) initially produces target materials, basic target graphics, and quick reaction graphics and sends them to the front over GBS. Its also receives all identified shortfalls in targeting materials to examine whether it has the information needed. A third method JICCENT (rear) supports the targeting process is through a Joint Mapping Coordination Center (JMCC) which provides specialized mapping and imagery support to the Command and ensures NIMA satisfies the Commands imagery and mapping requirements (*Volume II* 13-23).

16. JICCENT DARS

The JICCENT Daily Aerial Reconnaissance and Surveillance (DARS) Conference determines the best use of organic collection resources to satisfy collection requirements (*Volume III* D-5). The DARS Conference is the mechanism JICCENT uses to exercise collection and production management authority throughout the theater. The component commanders' managers use this DARS Conference to consolidate surveillance and reconnaissance requirements. Among those component commanders, the JFACC battlespace managers use the DARS developed collection plan to task organic collection assets using the ATO process (*Volume II* 13-23).

17. JICCENT Targets

The JICCENT Targets branch conducts theater-level targeting and battle damage assessment. It consolidates theater and national level targets and passes them to the JFACC AOC for inclusion in the ATO (*Volume III* D-5). JICCENT Targets is located within JICCENT (forward) along with the WMD Cell and DARS. JICCENT Targets plays a significant role in “Develop Targets.” First, it receives proposed component and national agency target nominations and integrates them into a Preplanned JTL. It then submits target analysis requests to the NJMIC. Based on the tactical environment and intelligence reports, JICCENT Targets provides an updated target database and joint criteria for target selection to the components. One of JICCENT Targets larger roles is to “Develop Targets” for the JFC. It accepts nominations from the JFC, JFSOCC, F2C2, and NMJIC Targeting Cell, while developing its own unconstrained list of targets.

These nominations are combined to form the JFC CTL, which is then ready for JFC staff coordination. Targets not approved are returned to the submitting command or F2C2 to re-enter the cycle and compete again for priority on the CTL. (*Volume II* 13-23).

18. JICCENT WMD Cell

The JICCENT Weapons of Mass Destruction (WMD) Cell provides analytical support for the tracking and identification of WMDs (*Volume III* D-6). During target development, once a S&R Sensor detects a WMD, it is passed to the JICCENT Targets Branch via the SIPRNET or JWICS (*Volume II* 2-30).

19. JOC

The Joint Operations Center (JOC) is responsible for planning, monitoring, and guiding the execution of the JFC’s decisions (*Volume III* D-6). The JOC is a key decision making node in the targeting architecture and is organizationally under the JFC along with JICCENT (forward) (*Volume II* 1-49).

20. JTCB

The Joint Target Coordination Board (JTCB) is a group responsible for targeting oversight that includes coordinating targeting information, providing targeting guidance and priorities, and preparing and refining joint target lists (*Volume III* D-6). To fulfill its oversight role, the JTCB meets daily during crisis and hostilities. The board is chaired by the Deputy Joint Force Commander, with membership comprising the USCENTCOM Director of Intelligence (J2) and Director of Operations (J3), DJFLCC, JFACC, JFMCC, JFSOCC, and other component-level representatives (*Volume II* 1-10).

21. MAW

The Marine Aircraft Wing (MAW) provides aircraft and tactical air control in the amphibious operations area. When they are available, MAW aircraft are tasked to support the JFACC in meeting the JFC's apportionment decisions (*Volume III* D-6).

22. NIMA

The National Imagery and Mapping Agency (NIMA) is a combat support agency that provides timely, relevant and accurate imagery, imagery intelligence, and geospatial information (*Volume III* D-7). NIMA's strategic goals are to provide seamless access to tailorable imagery, make this information available quickly, obtain the best available information, and use private sector services and the best available technologies (*Volume III* C2-145). During "Develop Targets," NIMA sends target materials to JICCENT Targets (*Volume III* E-16). In late 2003, NIMA changed its name to the National Geospatial-Intelligence Agency (NGA). It is headquartered in Bethesda, Maryland, and operates major facilities in the St. Louis, MO. and Washington, D.C. areas. The Agency also fields support teams worldwide (*NGA*).

23. NMJIC Targeting Cell

The National Military Joint Intelligence Center (NMJIC) Targeting Cell responds to requests for information, aids in target list development, and assist with battle damage assessment (*Volume III* D-19). This cell stands up during crisis situations, and can provide specific targets, guidance, and targeting support by way of special studies, analyses and databases. It is CENTCOM's targeting community pipeline to CONUS based intelligence agencies. For the "Develop Targets" activity during the targeting architecture, the NMJIC Targeting Cell distributes the startup target database, and receives, processes, and transmits several key pieces of information (*Volume II* 13-23).

24. S&R Sensors

Surveillance and Reconnaissance (S&R) sensors refer to the many technical means of collecting intelligence data within the battlespace (*Volume III* D-7).

25. SOF

Special Operations Forces (SOF) are specialized military units designed to confront a wide variety of situations ranging from peacetime threats to open warfare. Special Forces main duties include counter-proliferation, counter-terrorism, reconnaissance, small-scale direct action, psychological operations, civil affairs, foreign internal defense, and "unconventional" warfare (*Special*).

A SOF can act as a surveillance and reconnaissance asset that provides near-real-time reporting and allows expeditious adjustments to the ATO. It also plays a critical role as human sensors in identifying emerging high-payoff targets for potential immediate attack (*Volume II* 1-47,61).

26. WOC

The Wing Operations Center (WOC) is the central information node supporting Air Force flying operations (*Volume III* D-7).

D. SYSTEMS UTILIZED DURING DEVELOP TARGETS

In order to better coordinate and communicate, the organizations in "Develop Targets" use many different systems to develop and transmit their information. The four primary types of systems are surveillance and reconnaissance, intelligence data handling, targeting, and command and control (*Volume II* 2-28). The following are system utilized during "Develop Targets."

1. AFATDS

The Advanced Field Artillery Tactical Data System (AFATDS) is a totally integrated fire support C2 system (*AFADTS* 1998). It is a network of computer workstations that processes and exchanges information from the forward observer to the fire support element for all fire support assets. These assets include field artillery, mortars, naval gunfire, attack helicopters, and close air support. The major features of AFATDS are automatic processing of fire requests, generation of multiple tactical fire solutions for missions, monitoring of mission execution, and support for the creation and distribution of fire plans (*AFATDS* 2001).

Through the use of distributed processing capabilities, fire missions will flow through the fire support chain during which target attack criteria will be matched to the most effective weapon systems available at the lowest echelon. The automation provided by AFATDS will enhance the maneuver commander's ability to dominate the battle by providing the right mix of firing platforms and munitions to defeat enemy targets based on the commander's guidance and priorities. During battle, AFATDS will provide up-to-date battlefield information, target analysis, and unit status, while coordinating target damage assessment and sensor operations. AFATDS will also meet field artillery needs by managing critical resources; supporting personnel assignments; collecting and forwarding intelligence information; and controlling supply, maintenance, and other logistical functions (*AFATDS* 1998).

2. JDISS

The Joint Deployable Intelligence Support System (JDISS) program provides a family of hardware and software capabilities that allow connectivity and interoperability with intelligence systems deployed during peace, crisis, and war (Pike *JDISS*). JDISS provides access to imagery, finished intelligence products, and assists in putting together the order of battle. JDISS allows Joint, National, and Coalition users to access databases across the intelligence community. JDISS is not an intelligence system, it is an intelligence support system. It has no intelligence database, no strictly intelligence applications, no map graphics, and no capability to process NRT intelligence (Shannon).

The core software for JDISS is:

- E-mail/chatter
- Word processing/message generator
- Imagery manipulation
- Communications interfaces/map graphics
- Briefing tools/utilities
- Desktop video/voice (Pike *JDISS*)

JDISS is the primary intelligence data handling system used in "Develop Targets." It is utilized by organizations in JICCENT and the NMJIC Targeting Cell. The flexibility to transmit many different types of data and the important role JICCENT plays in "Develop Targets" leads to JDISS being used frequently (*Volume II* 13-23).

3. ASAS

The All-Source Analysis System (ASAS) is a program to automate the processing and analysis of intelligence data from all sources. ASAS is a tactically deployable, ruggedized, and automated information system (Pike *ASAS*). ASAS contributes to attaining information superiority through a network of computer workstations that process and exchange sensor data, fuse multi-source data into a single intelligence picture, and support management of intelligence sensors. ASAS is tactically deployable to support intelligence and electronic warfare operations at battalion through echelons above corps (*ASAS*).

4. JCMT

The Joint Collection Management Tools (JCMT) is a migration system for all-source collection management, combining IMINT, SIGINT, MASINT, and HUMINT tasking. This software-only package provides the tools for gathering, organizing, and tracking intelligence collection. JCMT is used by national, theater, and tactical organizations of all services. JCMT parses over 30 collection management messages into its databases; it can also store any message type for user review. JCMT also accesses numerous technical references and national SIGINT and HUMINT standing requirements (Pike *JCMT*).

JCMT works by collection requirements being generated by war fighters and then allocated to a Collection Management Authority (CMA). The CMA uses the JCMT to provide an overview of the requirements database. JCMT assists the CMA in determining the appropriate collection platform or mix of assets required to perform the mission. Finally, the CMA's collection management system provides the reconnaissance feedback to the war fighters who originated the requests for information (Pike *JCMT*). In

"Develop Targets," JCMT is used very sparingly, only to distribute Collection requirements. The primary intelligence data handling system used in "Develop Targets" is JDISS (*Volume II* 2-28).

5. GCCS

The Global Command and Control System (GCCS) is an integrated, reliable, and secure command and control system linking the National Command Authority down to the Joint Task Force and Component Commanders. It provides seamless battlespace awareness and a fused battlespace picture by exchanging data, imagery, intelligence, status of forces, and planning information. GCCS employs client/server architecture using commercial software and hardware, open systems standards, office automation, government developed military planning software, and worldwide web technology. Also, it rides on the (SIPRNET) communications backbone, or it can be accessed from dial-in remote terminals (*GCCS*). GCCS incorporates the core planning assessment tools required by combatant commanders and their subordinate joint force commanders and meets the readiness support requirements of the Services (*Logistics*).

GCCS is the primary C2 system used in the "Develop Targets" activity in the CENTCOM targeting architecture. In this particular activity, GCCS is used to distribute the FSCL, FSCL changes, joint target policy and objectives, and the rules of engagement. All of the information GCCS distributes is sent over the SIPRNET (*Volume II* 2-28).

GCCS-A is also used in the "Develop Targets" activity. GCCS-A is fundamentally GCCS with additional Army functionality. It will provide a single seamless command and control system and is being integrated with the GCCS.

6. IPA

The Image Product Archive (IPA) supports the storage and dissemination of imagery and imagery products, providing a library of information to imagery customers worldwide. IPA supports both data push and data pull via user profiling and stores imagery in NITF 2.0, TIFF, and other formats. IPA is capable of importing, storing, exporting and managing imagery, and image-based products. It has the capability to retain digital imagery data in on-line, near-line, and off-line storage media. The IPA supports up to 1300 image requests per day and up to 900GB for on-line imagery storage. The IPA should not take longer than eight minutes to transfer a full frame (930MB) national image to any requesting Client, assuming Fiber Distributed Data Interface, FDDI interface(s) and no LAN contention (Pike *IPL*).

At the highest level of abstraction, the imagery production process is similar for all types of imagery. Imagery data is collected and sent to an initial processor; from this processor the data is sent through a dissemination system to a library or database. The imagery files are copied from the database to an exploitation system where intelligence products are generated; the resulting imagery products are returned to the database. Authorized users can access the images they need from this database. This entire process takes place within SCI enclaves for most types of imagery, even though most imagery is at the Secret Collateral level (*Pike IPL*).

7. JMCIS

Joint Maritime Command Information System (JMCIS) was the Navy's primary C2 system afloat. In recent years this system has been replaced by the Navy's version of GCCS. The JMCIS provided a single integrated C4I system that received, processed, displayed, maintained and assessed the unit characteristics, employment scheduling, material condition, combat readiness, warfighting capabilities, positional information and disposition of own and Allied forces. This allowed decision makers to optimize the allocation of resources. JMCIS had state-of-the-art command center support capabilities that kept pace with changing threats and evolving requirements. JMCIS provided current geolocational information on hostile and neutral land, sea and air forces integrated with intelligence and environmental information, and near real time weapons targeting data to submarines (Pike *JMCIS*).

The JMCIS implemented a hardware and software architecture consistent with the Common Operating Environment (COE) specifications defined by the Global Command and Control System (GCCS). The hardware configuration for JMCIS systems were a Navy standard desktop tactical-support computer. Fleet units relied on support from centers ashore for processing high volume data from non-organic sensors, and for the picture of the battle space beyond the range of the afloat force's organic sensors (Pike *JMCIS*). All of these functions of JMCIS are currently handled by Navy's version of GCCS.

8. S&R Systems

Surveillance and reconnaissance (S&R) systems represent all of the S&R assets available to the joint force (*Volume III* D-10).

9. TBMCS

The Theater Battle Management Core Systems (TBMCS) provides Joint and Service Combat Air Forces with automated command, control, communications, computer, and intelligence systems to plan and execute theater-level air campaigns. TBMCS is the theater air module of the GCCS. One of the TBMCS applications provides an integrated air picture updated from a number of theater and strategic sensors and organizations. This integrated air picture, along with the fused intelligence provided by interaction with other Service intelligence systems, supports increased situational awareness (*TBMCS*).

The mission of TBMCS at the force level is to provide the Joint and Combined Air Component Commander with the automated tools necessary to effectively and efficiently plan, monitor, and execute the air campaign. This includes planning and issuing the air tasking and air control orders that ensure the Theater Commander's intent is supported through the application of airpower using the latest intelligence. TBMCS capabilities should also ensure that air operations are de-conflicted. The mission of TBMCS at the unit level is to provide the wing and base commanders and their battle staffs with timely and accurate information for effective decision-making. TBMCS is also supposed to provide the secure, automated, deployable, and distributed Wing-Level Command and Control System with connectivity to force-level TBMCS systems (*TBMCS*).

10. JTT

The Joint Targeting Toolbox (JTT) is part of an intelligence suite that can be integrated onto the TBMCS. The JTT is employed to effectively apply the right weapon on the right target at the right time (Ferens). It is the primary targeting application for the GCCS that allows complete targeting interoperability within the joint community. JTT is a group of software modules that supports the entire targeting cycle, with the goal of leveraging off of current targeting applications by packaging their functionality into a non-duplicative collection of interoperable targeting tools (*Joint Targeting*).

JTT provides a capability to rapidly receive, correlate, manipulate, display and disseminate target intelligence data from multi-discipline sources and apply the resulting information to the battle planning, mission execution and assessment processes. JTT brings all Services', Commands', and government agencies' targeting requirements together in one tool (*Joint Targeting*). JTT can perform all phases of the targeting cycle in near real time. It has a capability that allows users to label data with appropriate classifications, which is important to maintain interoperability and for multi-level database replication from high side to collateral networks in a matter of seconds (Ferens).

11. RRS

The Remote Replication System (RRS) is a large format color printer to produce maps on short notice. The RRS uses copies of existing maps in digital form to print large-format maps and charts. While RRS is far faster than traditional cartographic methods, it is not designed for high-speed, mass printings to support tactical forces. It prints at a rate of approximately one sheet per minute and is suited to analytical work at JICCENT (rear), JICCENT (forward), and the JOC (*Volume II* 2-60). A RSS system located at MacDill can deploy forward to the theater map depot as needed. (*Volume II* 13-23).

12. GALE

The Generic Area Limitation Environment (GALE) has the capability to manipulate and display geospatial and environmental information to predict area limitations for mobile targets (*Volume III* D-8). GALE displays a received image and provides an analytical means to perform area delimitation against types of mobile targets such as theater ballistic missiles (*Volume II* 2-9).

13. TARCHECK

The Target Check (TARCHECK) system is used to examine possible collateral damage from an attack. TARCHECK reads a candidate target list from a flat file downloaded from a targeting system to a disk. It then does a radius comparison around each nominated target to determine the potential collateral damage site. This system then creates a collateral damage report. Mobile targets, special operation force teams, and joint no-fire target lists can also be added to the database for comparison (*Volume II* 13-23).

In "Develop Targets," TARCHECK supports the SJA in his/her targeting role. It is used to enable the DOCC SJA to effectively address legal implications and risks associated with targeting. It is also used to review the candidate target list in the DOCC (*Volume II* 13-23).

E. COMMUNICATION METHODS

The systems previously discussed are how the organizations participating in "Develop Targets" turn the information they receive into usable knowledge. However, these systems need a communication backbone in order to exchange information. The specifications of these various methods of communication are very important for producing an accurate model. The following are the different communications methods employed during "Develop Targets."

1. DMS

The Defense Message System (DMS) is the designated messaging system created by the Defense Information Systems Agency (DISA) for the DoD and supporting agencies. It provides message service to all DoD users, including deployed tactical users, and interfaces to other U.S. government agencies, allied forces and Defense contractors. It is a flexible, commercial off-the-shelf (COTS)-based application providing multi-media messaging and directory (*DISA*). It provides multimedia-messaging services for 270 U.S. military installations around the world.

DMS looks like a typical e-mail application and is designed to feature familiar user-friendly functionality, such as global Directory Service, and transmission support for digital files of any type and size (*DMS* 2001). DMS provides a fully integrated, supportable, secure, and accountable network for E-mail and organizational/official messages for the DoD. It ensures that capability keeps pace with technology for years to come (*DMS* 2004). The scalability of DMS partially depends on the network, with bandwidth being the key issue, and it also depends on the scalability of actual components and the processes on which they reside. A network pipe with infinite capacity, if available, still might be limited by the ability to source the bits rapidly enough (*DMS* 2001).

2. GBS

The Global Broadcast Service (GBS) capitalizes on the popular commercial direct broadcast satellite technology to provide critical information to the nation's war fighters. The GBS system is a space based, high data rate communications link for the asymmetric nature of modern warfare. This system will "push" a high volume of intelligence, weather and other information to widely dispersed, low cost receive terminals, similar to the set-top-box used with commercial data broadcast systems (DBS). One reason GBS is so attractive is the ability to provide high-volume data directly into 18-inch antennas. Mobile force elements are no longer restricted by the requirement for large, fixed antennas to receive information formerly relegated only to command centers. The system will include a capability for the users to request or "pull" specific pieces of information. These requests will be processed by an information management center where each will be prioritized, the desired information requested and then scheduled for transmission. It will interface with other major DoD information systems, such as the Global Command and Control System (GCCS), as well as other theater information management systems (*Global Broadcast*). Overall, GBS provides a highway to move information forward to the theater from rear area support centers at command and national nodes. (*Volume II* 13-23).

3. JWICS

The Joint Worldwide Intelligence Communications System (JWICS) is a network designed to meet the requirements for secure (TS/SCI) multi-media intelligence communications worldwide. It provides DODIIS users a SCI level high-speed multimedia network using high-capacity communications to handle data, voice, imagery, and graphics. It enables point-to-point and multipoint video teleconferences (VTCS), broadcast of the Defense Intelligence Network (DIN), and variable bandwidth packet switched data communications. While most sites have video and data capability on T1 lines, some have strictly data capability (64 kbps lines) (Pike *JWICS*).

In-theater capabilities, as of 1997, have insufficient capacity for immediate support to a major theater war. Connectivity between reach back components has increased to full T1, however in-theater connections are still much smaller. In the event of time-critical targeting information arriving over JWICS, the information must be manually disseminated to a collateral environment. While this is not a difficult process, it takes time that could be saved through increased connectivity. (*Volume II* 2-66,68).

4. SIPRNET

The Secret Internet Protocol Router Network (SIPRNET) is the DoD's secret-level network. As of 2000, the SIPRNET uses smart multiplexers and 512 kilobits per second (kbps) channels. Other transmission services will be acquired or leased as needed. High-speed packet switched service will be provided through the use of IP routers. Since its inception in 1994, the SIPRNET has matured to be the core of our warfighting command and control capability. Many expeditionary commanders ask for SIPRNET ahead of secure voice when deploying their forces (Pike *SIPRNET*). Similar to JWICS, the bandwidth varies between different locations that are connected to the SIPRNET. It has the capability to transmit data, voice, and imagery, as well as support collaborative planning (*Information*).

5. Courier

The use of a courier is to exchange information by physically transferring a copy in some media such as floppy disk or hard copy (*Volume III* D-8).

6. Voice

A voice communication refers to spoken communications, usually telephonic, and the use of facsimile machine over the same telephone lines (*Volume III* D-11).

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V. EXTEND MODEL OF DEVELOP TARGETS

The Visio paper model of the "Develop Targets" activity was a stepping-stone towards completion of our ultimate goal of a model in Extend. As mentioned earlier, Extend is designed to be an easy to use, flexible, extendable simulation tool that can model every aspect of an organization. Extend can be used to create dynamic models from building blocks, explore the processes involved, and see how they relate. Assumptions within the model can be changed to arrive at an optimum solution. By mimicking an organization's operations, Extend allows the user to understand the system better, explore alternative strategies, optimize performance, and train personnel. This is done at a fraction of the cost and time it would take to experiment with the real system (Extend Overview). The Extend model is available in two forms at the Internet site <http://library.nps.navy.mil/uhtbin/hyperion/04Jun_Germakian>. The model (10 MB) is available in Extend version 6.0 or higher at the link "Develop Targets Extend Model." If Extend is unavailable, the model can be viewed, but not run, in Power Point (400 KB) at the link "CENTCOM Targeting Architecture develop targets extend model."

A. MODEL DEVELOPMENT

We had three objectives in converting the Visio paper model to an Extend model. The first objective was to accurately transpose the information from the Visio paper model to the new medium of Extend. Without an accurate transposition, any data pulled from the model would be erroneous. A second objective was to have the ability to accurately monitor the time delay caused by each segment of the model. This allows the user to see where potential bottlenecks are in the targeting process. In the same vein, we wanted the ability to easily modify the model to acquire additional time measurements. The final objective of the Extend model is to highlight interoperability deficiencies between different information nodes and organizations. Interoperability deficiencies are one of the primary focuses of the JQRRs that are driving JSBA FY04.

It is important to note that in this baseline model of the "Develop Targets" activity we have items representative of entire target lists rather than individual targets. This decision was made in order to simplify the model and ensure that our three objectives were met. Our framework will not hinder the other activities that follow “Develop Targets” in which items will be required to represent individual targets. As long as attributes are set up front, through the use of the clone, batch and unbatch functions in Extend, the model will be flexible enough to transition to individual targets in subsequent activities. Even the “Develop Targets” activity, as it is currently designed, can handle individual targets by slightly altering the flow of certain items and modifying activity delay times.

1. Model Architecture

The first step in creating the Extend model involved selecting an overall model architecture. We had to decide what aspects of the Visio paper model to build the Extend model around. After much deliberation, it was decided to choose an activity-based architecture. Extend gives its users the ability to simplify the appearance of its models through the use of Hierarchical blocks (H-blocks). H-blocks nest a group of blocks into a single block. In a model like ours, with hundreds of blocks, you can use H-blocks to simplify the appearance of the model by grouping them together. The Visio paper model revealed seven primary sub-activities within the “Develop Targets” activity. By using an activity-based architecture, the highest level of the “Develop Targets” model would have seven blocks, each representing a sub-activity. However, each of those H-blocks would contain the detailed information allowing the model to accurately represent the actual “Develop Targets” activity.

While developing the architecture of the model, it became clear there were going to be several layers of H-blocks. The use of several layers allows any user to “drill down” into the model and look at specific sections of the model, without having to see all of the detail of the entire model at once. In order for the user to easily know which level he is at, we chose to coordinate the color of all H-blocks at the same level. This model uses three levels and the colors from the highest to lowest layer are purple, blue, and green. The purple blocks represent each of the five major activities in the CENTCOM targeting architecture, where “Develop Targets” is a single block. Once all of the portions of the CENTCOM targeting architecture are complete, this top level will consist of five purple blocks. Currently, in Figure 5, the “Start” block initiates the model. The

"Develop Targets" and "Prioritize Targ" block are the first two major activity blocks within the joint CENTCOM targeting architecture.

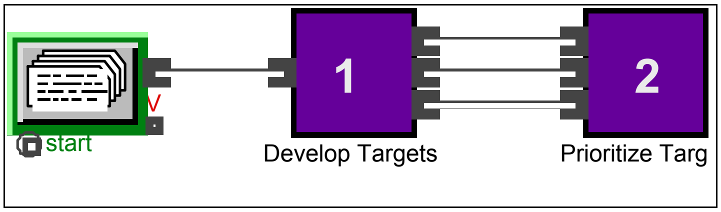


Figure 5. Develop Targets Level 1

If the user drills into the "Develop Targets" purple block, then seven blue blocks will appear (Figure 6). They represent the major activities within the "Develop Targets" activity. Not all of the blue layer activities require additional H-blocks to simplify what occurs in them.

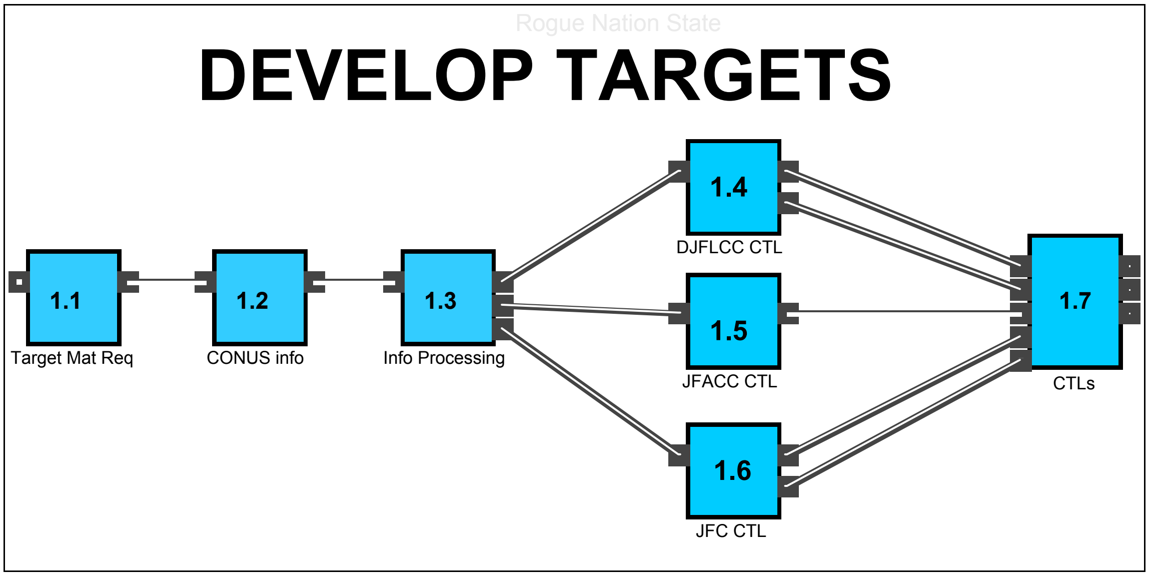


Figure 6. Develop Targets Level 2

Drilling into those H-blocks will lead directly into the Extend blocks where the modeling activity occurs. However, some of the blue level H-blocks do require an additional level of H-blocks within them. This will lead to the third level, which further decomposes the "Develop Targets" activity into green H-block sub-activities. This can be seen in Figure 7 which represents the decomposition of the "Info Processing" block (1.3) into the next level of detail.

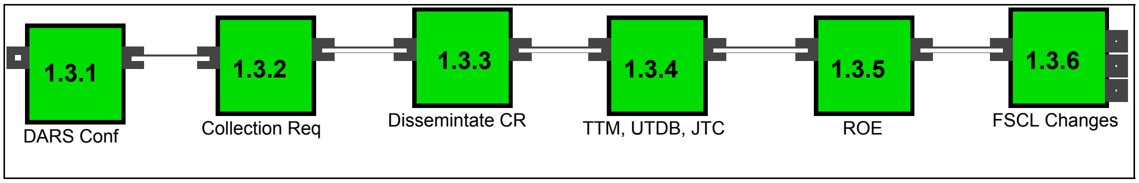


Figure 7. Develop Targets – Information Processing (1.3) Level 3

There were a few instances where we needed additional H-blocks, but did not feel it necessitated the creation of an entire layer. These H-blocks are colored orange. They are located among the Extend blocks and reduce the clutter in those situations.

The different colors allow for the user to easily see what level they are at within the model at any time. However, a need also arose to know the exact location of an H-block and to differentiate it from the other H-blocks at that same level. This dilemma was solved by giving each level H-block (purple, blue, or green) an identifying number. The numbers are roughly in time order, even though certain activities occur in parallel. The "Develop Targets" block in the purple level is "1" because it is the first of the five activities within the CENTCOM targeting architecture being modeled. Note the first activity, "Establish Guidance and Assign Resources," will not be modeled in this baseline Extend simulation. Every H-block contained within the purple "Develop Targets" block will carry that block number, "1," on it as well. The seven blue H-blocks within the "Develop Targets" purple block are numbered 1.1 though 1.7. This numbering system is demonstrated in Figure 6. Within the blue H-block 1.3, are six green H-blocks. They also retain the number attribute from the block they are within and are numbered 1.3.1 through 1.3.6, which can be seen in Figure 7. This allows the users to know where in the model each block is located. It also allows user the ability to communicate clearly to others which block they are focusing on or altering.

Once the activity-based model architecture was chosen, we had to determine how to perform the actions that occur in the paper model in Extend. The most frequently used method was to develop a “throw away” model. A “throw away” model was a small Extend model that could carry out a single function we were investigating. This method allowed us to quickly see the limitations of the Extend software and develop methods to bypass the shortfalls. With every idea that was proved to work in a “throw away” model, we were better able to envision how the overall “Develop Targets” model would function.

2. Cloning Items

Several times throughout the Extend model, an organization will receive inputs from several other organizations, process that information, and produce a new output to be sent elsewhere. We desired items being sent through the model to have the ability to retain individual attributes even after being batched. Our original thought was to activate a new program block to send out new items whenever a new output was produced. This makes sense to a user viewing the model because it is clear that one form of information enters an organization, and a new item is produced. However, after building a few “throw away” models, we discovered that attributes are lost if a program block is used.

We found a solution to this problem by using unbatch blocks. These blocks give the user the ability to make multiple copies, or clones, of items that pass through it. What sets the unbatch block apart from the program block is that cloned items retain their attributes. For example, an item represents a message with an attribute for message size. If this item were cloned using the unbatch block and disseminated to multiple organization, the attribute for message size would be retained in each clone. However, if a program generator were used in this same situation, the attribute of message size would not transfer to the new items. While unbatch blocks are less visually intuitive to the user, proper labeling will allow users to understand what they represent.

3. Standardized Model Procedures

As model development progressed, there rose a need standardize the way several aspects of the model were handled. First, we placed a FIFO Delay block immediately before every Activity Delay block. The Extend software will display an error message if an activity block currently processing one item is sent a second item. The FIFO Delay blocks provide a location for items to wait until the Activity Delay block is ready for them. Second, there are many instances where it is documented that an organization receives a piece of information, but it is not documented what they do with that information. Our solution was to send these items into an Exit block. This allows the model to run without error, even with certain information essentially going to a dead end. It also allows future users who discover a use for that information within that organization to simply remove the exit and send the information where it is needed. Third, information sent between organizations was often documented using more than one communication path, such as voice and courier. For this situation, we set up a hierarchy of communications. In the event of dual communications, the priority from highest to lowest are Net Delay, Courier Delay, and Voice Delay. This hierarchy states a network delay would take precedence over both the voice and courier delays, while the courier delay would take precedence over the voice delay. This allows the model to maintain a consistent interpretation of the paper model.

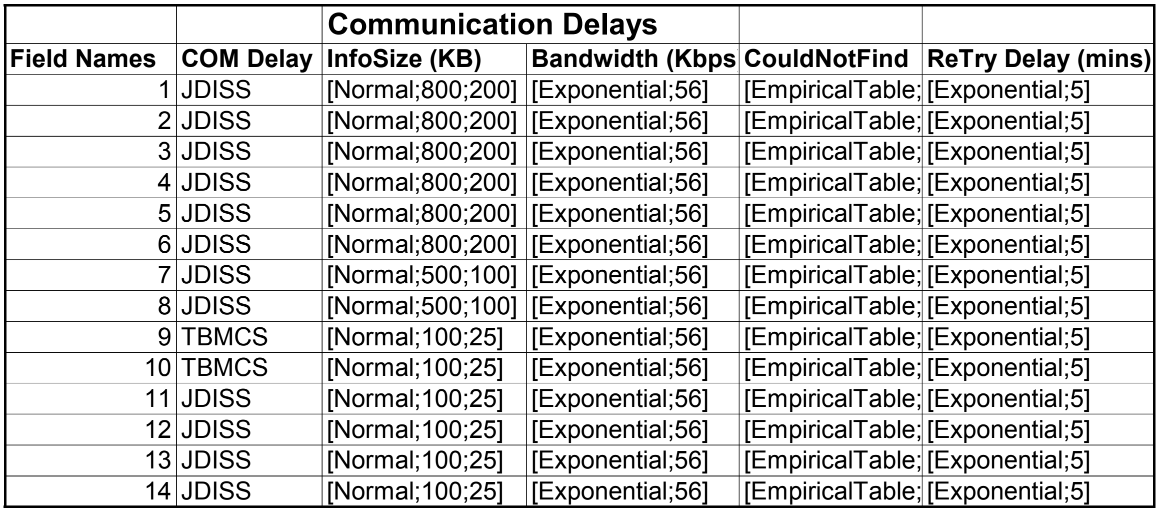
4. Model Database Inputs

In order to enhance the flexibility of our model, we used a database to store information regarding the values and distributions of attributes. A model without a database can still function similarly, however, it is considered to be "hardwired." This means that in order to vary attributes, a user would have to dig down three or four levels in the model. The analysis of the effects of changes on attributes, such as bandwidth and process time, would be an extremely time consuming task for just the "Develop Targets" portion of a hardwired model. Once the entire targeting process is represented, analysis of a hardwired version would be too tedious for anyone to consider it a valuable tool.

To combat the problems associated with hardwiring such a large and variable model, a database was created. This database contains several tables, which store the values and distributions of all the attributes that can be altered throughout the model. In an effort to best create tables that could handle the constantly evolving state of the model, as future activities and delays are incorporated, it was decided to break down the tables so that each one corresponded only to a numbered section of the model at level two. For example, there are seven level two H-blocks in the "Develop Targets" activity (1.1

through 1.7). Each block is associated with two tables; one to represent the attributes for any communication delay and the other represents the attributes for any activity delay. As a result, the communication blocks (network, courier, or voice delays) are numbered from one to n, where n is the total number of communication delay blocks in the section.

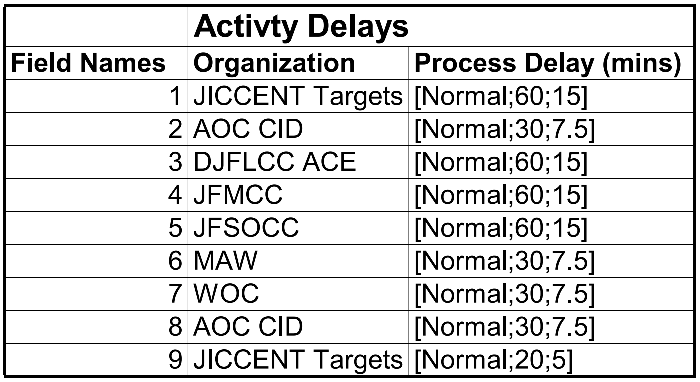
Table 1 is representative of a communication delay database. Under the "Field Names" column is the number that each communication block is assigned in the model. The "COM Delay" column shows what communication system is being used. The next four columns, "InfoSize (KB)," "Bandwidth (Kbps)," "CouldNotFind," and "ReTry Delay (mins), are all attributes that can be changed in the database. Each cell specifies the type of distribution and its key values. For example, in row 1, under "InfoSize (KB) a normal distribution is used with a mean of 800 and a standard deviation of 200. Any attribute with an "EmpiricalTable" distribution is different then the others because the user is able to pick that value explicitly.



		Communication Delays			
Field Names	**COM Delay**	**InfoSize (KB)**	**Bandwidth (Kbps**	**CouldNotFind**	**ReTry Delay (mins)**
1	JDISS	[Normal;800;200]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
2	JDISS	[Normal;800;200]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
3	JDISS	[Normal;800;200]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
4	JDISS	[Normal;800;200]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
5	JDISS	[Normal;800;200]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
6	JDISS	[Normal;800;200]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
7	JDISS	[Normal;500;100]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
8	JDISS	[Normal;500;100]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
9	TBMCS	[Normal;100;25]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
10	TBMCS	[Normal;100;25]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
11	JDISS	[Normal;100;25]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
12	JDISS	[Normal;100;25]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
13	JDISS	[Normal;100;25]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]
14	JDISS	[Normal;100;25]	[Exponential;56]	[EmpiricalTable;	[Exponential;5]

Table 1. Database for Communication Delay Distributions

The activity delay blocks are similarly numbered from one to n. Each number corresponds to a row in the table (i.e., 1.1 COMS, or 1.1 ACT) in which the attributes for that delay are stored. An example activity delay database can be viewed at Table 2. This database is set up similarly to the communication delay database. The values under the column “Field Names” are numbered the same as the activity delay blocks in the model. “Process Delay (mins)” is the only attribute varied in activity delays. The type of distribution and key values are in that column as well.



	Activty Delays	
Field Names	**Organization**	**Process Delay (mins)**
1	JICCENT Targets	[Normal;60;15]
2	AOC CID	[Normal;30;7.5]
3	DJFLCC ACE	[Normal;60;15]
4	JFMCC	[Normal;60;15]
5	JFSOCC	[Normal;60;15]
6	MAW	[Normal;30;7.5]
7	WOC	[Normal;30;7.5]
8	AOC CID	[Normal;30;7.5]
9	JICCENT Targets	[Normal;20;5]

Table 2. Database for Activity Delay Distributions

Having the tables broken out by section, as well as whether they represent communication or activity delay, allows for delays to be added, deleted, or architectural changes to be made easily without impacting the entire model.

To make changes to an attribute, one must still determine which delay block number needs to be altered, open the appropriate table, and change the proper attribute. This is similar to what must be done to make changes in a hardwired model, but there are two key advantages to having a database. First, and perhaps most important, is the ease with which one can look at all attribute distributions at the same time. Without the database, each delay block would have to be opened in order to determine the distribution of the associated attributes. Not only would this make it difficult to compare distributions without creating some form of spreadsheet, but it would also make catching errors in inputting distribution information nearly impossible. Having all of this information in table form makes it much easier for a person to explain, or figure out what is going on in the model without having to dig down into each delay block. Without a database, unless the changes in the attribute were recorded, changing them back, or even keeping track of what they are currently set at, would become an impractical task given the size of the model and the number of delays. This potential scenario, arising from a hardwired model, would in effect render the model useless by making it very difficult for a person to use it as a tool to analyze how changes may affect the process. Secondly, once a person becomes familiar with the numbering system, changes to these distributions can be made extremely quickly and easily so the effect of changes to attributes can be studied.

The only change that had to be made going from the initial "hardwired" model to the final database oriented model involved the units of time that were tracked throughout the process. Initially, seconds were the global time unit for the model; however, the smallest global time unit that a database is compatible with is minutes. Since ultimately the length of the process that is being analyzed is on the order of a few days, it was decided that reporting delay times in minutes rather than seconds would not have much of an effect on the results.

Certain attributes are still input with respect to seconds. An example of this is link bandwidth, which is entered into the table as a distribution around a mean measured in Kbps. The delay block itself has been modified to account for the fact that the model is working in minutes.

One item to be addressed is a glitch associated with the Extend software when implementing the functionality of a database. Each delay is represented by its own record, one through n, within the table. If more than one delay has the same name, which is not uncommon given the nature of this model (i.e., multiple JDISS communications delays could be present in a single section), all the parameters for the attribute will be drawn from the set of parameters defined in the record representing the first delay with the identical string name.

Three methods of combating this problem were devised. The first would involve eliminating the "delay type" field from all the tables thereby deleting the string variable name representative of the type of communication or activity delay from the table. This option was not pursued due to the fact it would require the user to look at the table in conjunction with the model to make any changes to specific blocks, since only a number, as opposed to a number and a name, would now represent these blocks. A second workaround would involve renaming the string variable that represents each delay so that they are all unique. For example there could be JDISS 1, JDISS 2, JDISS 3, and so on.

A final method to solve this issue would involve connecting a constant block to the "input record" value on the database lookup block. This constant block would be configured to correspond with the record number that should be looked up.

Although very similar to the second method, the latter procedure was selected for the following two reasons. First, it makes it slightly easier for the user to check for input errors within the model. Since the constant block sits one level higher than the internal section of the database lookup block, it is quicker to ensure that data is being pulled from the correct record in the table. The constant value being input is displayed on the block itself. The second reason has to do with model flexibility. If delays were added, deleted or rearranged, it is easier to modify the numbers in the constant blocks than to rename all the delays in the table itself.

Even after incorporating the constant block, the database lookup block itself still indicated that the record was reverting back to the record of the first delay with that exact name in the table. However, using information blocks to identify what values for the attributes were actually being assigned, we determined that the appropriate record and corresponding distribution was being associated with the item each time the model was run.

B. EXTEND BLOCKS

The architecture, colors, numbers, standard procedures, and databases all help to better understand what is occurring in the model. However, all of the modeling actions are being performed by blocks from the Extend libraries. With a few exceptions, this model uses a small number of Extend blocks to accomplish the accurate modeling of the "Develop Targets" activity. The blocks most frequently used are:

- Activity Delay
- Batch
- Batch (10)
- Catch
- DB Lookup
- Exit
- Get Attribute

- Input Random Number
- Program
- Queue FIFO
- Select DE Output
- Select DE Output (5)
- Set Attribute
- Throw
- Unbatch
- Unbatch (Variable)

The following 16 sections will describe each of these commonly used Extend blocks in greater detail.

1. Activity Delay

Holds an item for a specified amount of delay time, then releases it. The delay time is the value in the dialog or, if connected, the value at the D connector when the item is received (*Extend v6* A59). Most of the activity delay blocks throughout the model receive either exponentially or normally distributed delay times via a DB Lookup block.

2. Batch

Allows items from several sources to be joined as a single item. This is useful for synchronizing resources and combining various parts of a job. In the dialog, you specify the number of items from each of the inputs that is required to produce one output item. You can also specify that items at one or more inputs will not be brought into the block until one or more of the other inputs has its requirements filled (*Extend v6* A61). The primary use of this block is to collect different inputs at a single organization before that organization processes the information and produces a new item.

3. Batch (10)

Allows items from up to ten sources to be joined into a single item. More than one item may be required at each input before an output is created. In the dialog, you specify the number of items from each of the inputs that is required to produce each output item.

This block is useful when you have many parts that are attached in a process and you want to join them into a single assembly (*Extend v6* 72). This block is used in the same situation as the Batch block.

4. Catch

This block "catches" items sent by Throw blocks even though the blocks aren't connected by connection lines. Any number of Throw blocks can send items to a Catch block. The connection between the blocks is made at the Throw block by specifying in its dialog the label and block number of the Catch block (*Extend v6* 65). Using the Catch block in conjunction with the Throw block is the only way to pass information out of an H-block without using a connector.

5. DB Lookup

The DB Lookup Block can be used to look up a database value. Specify the table, field and record. The record can be accessed directly using its record number, or the table can be searched for a specified value in the first field. This block reads and outputs a value from the database whenever a connector message is received (*Extend Help*). Using these blocks with Databases increases the flexibility of the model by allowing the user to change assumed values quickly.

6. Exit

Passes items out of the simulation. The total number of items absorbed by this block is reported in its dialog and at the # connector (*Extend v6* 66).

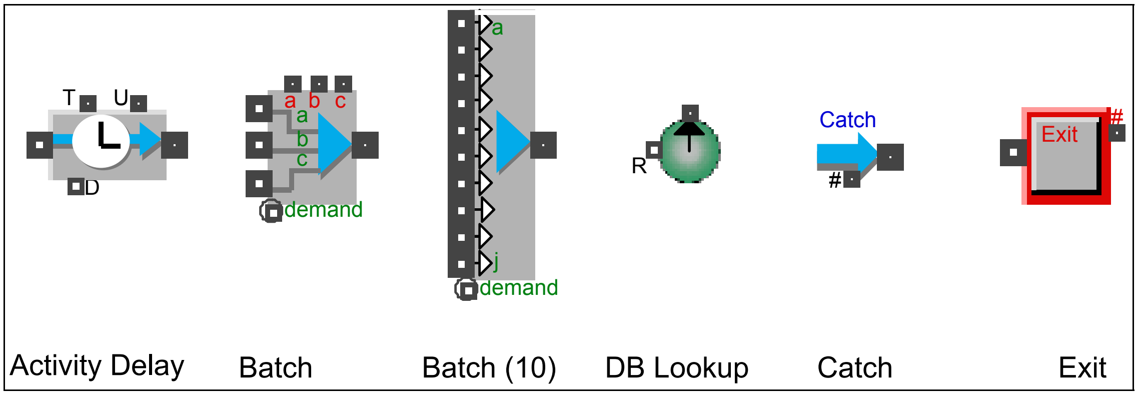


Figure 8. Extend Blocks 1

7. Get Attribute

Removes attributes on items, then passes the items through. The attribute value is shown in the dialog and output at the A connector. You can also use this block to clone the item based on the number in an attribute (*Extend v6* 60).

8. Input Random Number

Generates random integers or real numbers based on the selected distribution. You can use the dialog to specify arguments for the distributions. You can select the type of distribution: Uniform (integer or real), Beta, Binomial, Erlang, Exponential, Gamma, Geometric, HyperExponential, LogLogistic, LogNormal, Negative Binomial, Normal, Pearson type V, Pearson type VI, Poisson, Triangular, Weibull, and Empirical. (*Extend v6* 50). These blocks were used in early versions of the model that did not include DB Lookup blocks. The function they performed in that early version is preformed within the database in current versions.

9. Program

Schedules many items to be output into the model. This is similar to the Generator block, except the arrival times of the items are scheduled rather than random. Also, you can assign a value, priority, and attributes to each item generated. This block is useful for repetitive or timed needs, and is used to initialize the model (*Extend v6* 62).

10. Queue FIFO

A first-in-first-out (FIFO) queue. You can see the average queue length, average wait time, and utilization of the queue in the dialog (*Extend v6* 63). These act as buffers throughout the model to assure smooth runs.

11. Select DE Output

Selects one of two output connectors for the input item based on a decision. The item at the input is passed through the selected output (*Extend v6* 67). These blocks are used when an item needs to be sent to one of two different organizations.

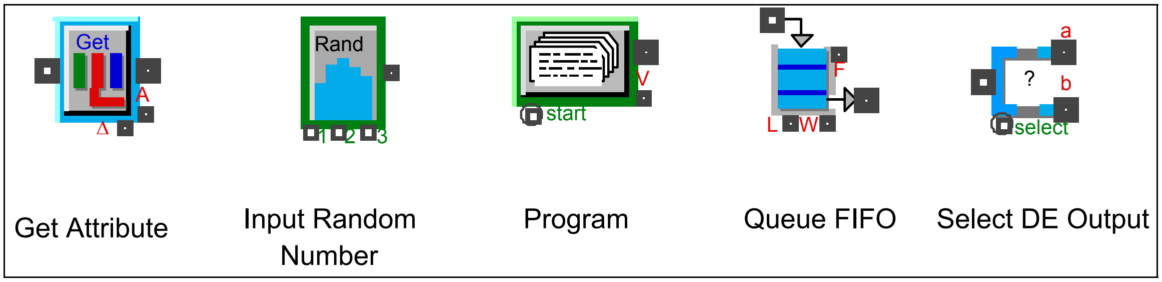


Figure 9. Extend Blocks 2

12. Select DE Output (5)

Selects one output connector out of the five available, based on a decision. The item at the input is passed through the selected output (*Extend v6* 66). These blocks are used to send items to up to five different organizations.

13. Set Attribute

Sets the attributes of items passing through the block. Up to seven attribute names and values may be assigned to an item with each Set Attribute block. The attributes may add to or replace existing item attributes. You can specify the value of one of the attributes with the A connector. The value at the A connector overrides the corresponding value in the dialog (*Extend v6 60*).

14. Throw

This block "throws" items to a Catch block without using an output connector or connection lines. Any number of Throw blocks can send items to a single Catch block. The connection between the blocks is made by specifying the label and block number of the Catch block in the Throw block's dialog (*Extend v6* 67). Using the Throw block in conjunction with the Catch block is the only way to pass information out of an H-block without using a connector.

15. Unbatch

Produces several items from a single input item. The number of items produced at each output is specified in the dialog. The attributes and priorities of the input item are copied to each output. If you selected preserve uniqueness in the Batch block and here, items will be output with their original properties restored (*Extend v6* 61). These blocks are used to clone items when they need to be sent to more than one organization.

16. Unbatch (Variable)

Turns a single item into a stream of identical items. You can specify in the dialog how many copies will be created from each input item (*Extend v6* 72). These blocks are also used to clone items when they need to be sent to more then one organization.

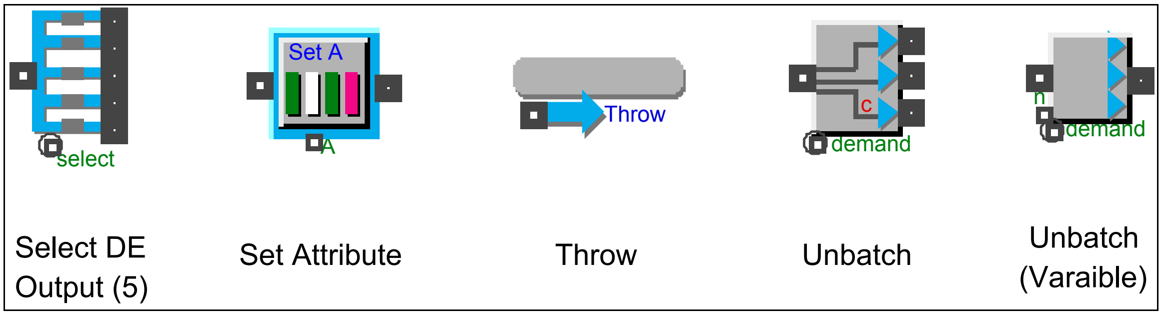


Figure 10. Extend Blocks 3

C. MODULAR BLOCKS

After developing the activity-based architecture, we observed several functions appearing repeatedly throughout the model. This included the transmission of information and the need to monitor time delays. Instead of building the same set of blocks to perform this action again and again, we utilized a modular approach. We created a set of H-blocks that would perform the function of information transmission as well as monitoring time delays. With these modules, whenever one of these functions was required, we simply pasted a block that performed that function into the necessary location. Three information transmission modules were created: net delay, voice delay, and courier delay. To monitor time, two H-blocks were created that work together to perform that function, timer and timer send. In order to be easily identified, these modular blocks are assigned different colors from the blocks at each level of the model. The information transmission delay blocks are yellow with either “Net,” “Courier,” or “Voice” written on them. The timer send blocks are green with “Timer Send” written on them. Even though they are the same color as level three blocks, (see Figure 7) these blocks are completely independent from each other. .

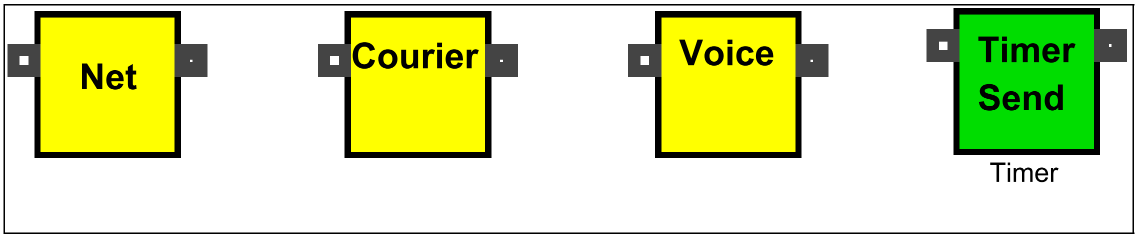


Figure 11. Modular H-blocks

1. Communications Delays

Each of the communication H-blocks contain embedded code that represents an approximate delay for a given means of communication. All delay parameters can easily be modified in the database. The modularity arises as a direct result of being able to simply delete and replace these hierarchical blocks throughout the model so that the effects of different means of communication can be analyzed. The following three sections will describe each of these three communication delays in greater detail.

a. Network Delay

The network delay is used to represent any system that sends information over a network of computers such as SIPRNET, JWICS, DMS, or GBS. Many different intelligence handling, targeting, and command and control systems exist and are used to transmit different types of information over these networks. Some of these overlaying systems utilized in "Develop Targets" are JTT, JDISS, TBMCS, AFATDS, GCCS, and JCMT. Within the network delay H-block exists two additional H-blocks, Message Size and Net. As an item enters the network delay block, it is first assigned a message size (in kilobytes) in the Message Size H-block. An attribute called "InfoSize" is assigned normally around a message size mean and standard deviation. Currently, many of the assigned message size means and standard deviations are estimates. However, given more statistical information about the size of the messages being transmitted, this attribute can be modified to be even more representative.

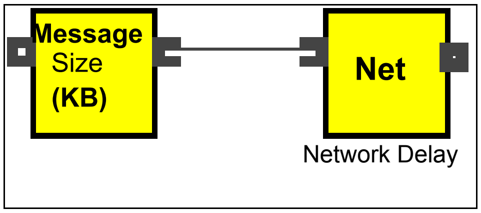
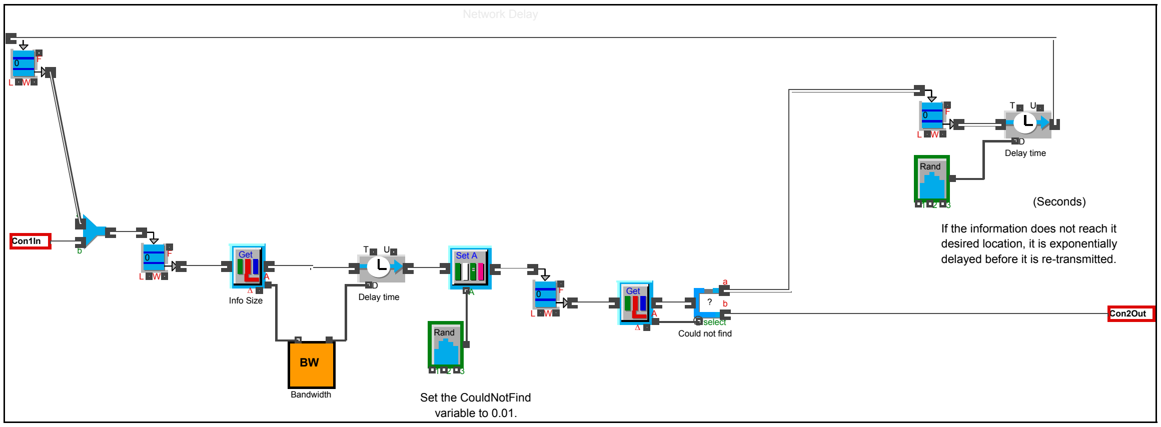


Figure 12. Network Delay H-blocks

Once an item exits the Message Size H-block with its InfoSize attribute, it enters the Net H-block. The Net H-block represents two possible delays that this information can undergo, a bandwidth delay and a possible resend delay. After an initial FIFO queue, the attribute "InfoSize" is obtained and divided by the available system bandwidth, which is currently represented as an exponential distribution with a mean of 56 Kbps, to produce a bandwidth delay. The use of exponential delay models bandwidth particularly well because it can occasionally produce extremely low bandwidths, which simulates a clogged network. Since the model's global time units are minutes, there is a converter within the Bandwidth H-block so that the user may input bandwidth in the conventional standard of kilobits per second. The result delays the item in an activity delay block. An item of note is that InfoSize is measured in Kbytes, while bandwidth is measured in Kbits per second. To compensate, a second conversion is also made within the Bandwidth H-block.

The second delay stems from the possibility that the item did not go through, and therefore has to be retransmitted. This is represented by assigning an attribute called "CouldNotFind." This is currently represented as an empirical table in which the item is deemed to have not gone through 1 percent of the time. Again, this statistic can be changed easily in the input database. If the item did go through, it is routed out of the network delay block. If it did not go through, it must be re-routed back through the network delay block. The top path in Figure13 represents this. Once the determination is made that the information must be re-sent, it is not immediately retransmitted. Instead, it is delayed randomly around an exponential distribution with a mean of 5 minutes. This delay is representative of the time it takes the operators to realize that the message was not received and to actually re-send the information.



Set the CouldNotFind variable to 0.01.

If the information does not reach it desired location, it is exponentially delayed before it is re-transmitted.

Figure 13. Extend Blocks Inside Net H-block

b. Courier Delay

The courier delay block is used to represent any information exchange that requires a person to physically walk information from one place to another. Within a Courier Delay H-block there exist two additional H-blocks: a Dist. Walked H-block and Courier H-Block. As the item enters the Dist. Walked block it is assigned an attribute called “Distance,” which represents the distance, in feet, that the person must walk to deliver the information. In the real world, there are different distances a courier must walk to deliver his information depending on each particular situation. However, in this model, it is assumed the distance a courier must walk is exponentially distributed with a mean of 300 feet.

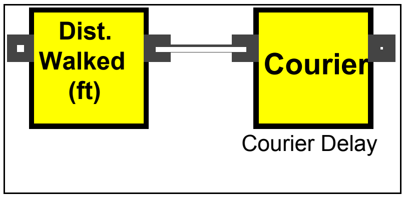
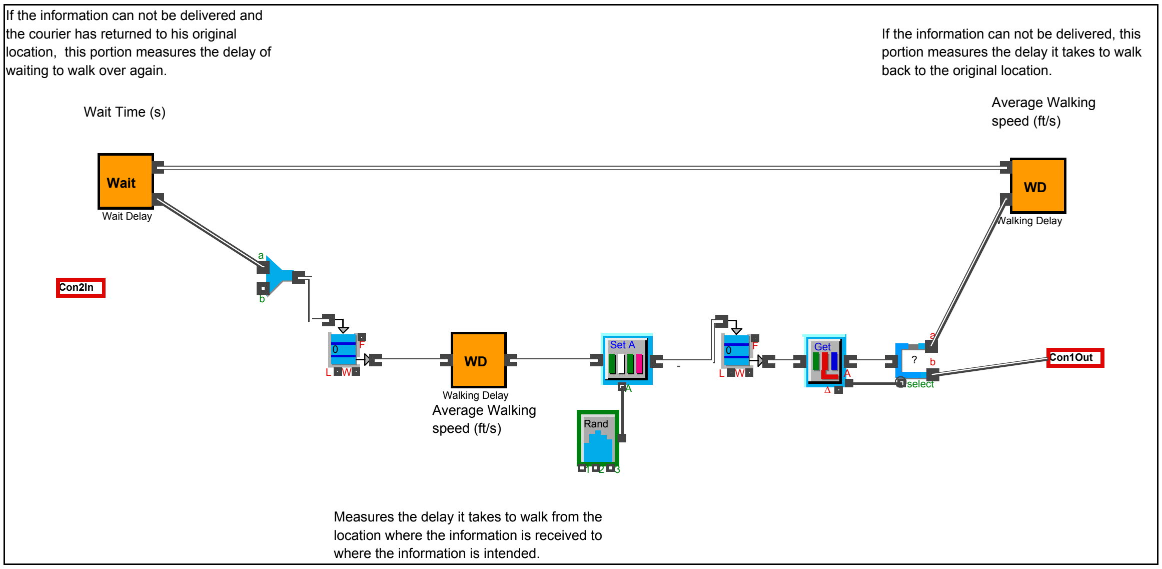


Figure 14. Courier Delay H-block

Once “Distance” is set, this item enters the Courier H-block and can encounter a maximum of three different delays. The item goes immediately into a FIFO queue to prevent it from being lost if the courier delay block is currently busy. If the system is not busy, the item will enter its first delay, at an activity delay block in which it is delayed by an amount of time equal to the distance in feet that must be traveled divided by a random walking speed. The random walking speed is represented as a normal distribution centered around 6 feet per second, with a standard deviation of 1.5 feet. Within the Courier Delay H-block, the walking speed measured in feet per second is converted to feet per minute to correspond to system time being measured in minutes.

As with the network delay block, there is a chance that this information will be walked over and no one will be at the other end to receive it. This is represented by assigning the same attribute as before, "CouldNotFind," to the item. 90 percent of the time, there is someone at the other end to receive the information and the item is routed out of the courier delay block. However, 10 percent of the time, there is nobody to receive the information. This is the second delay represented in the Courier Delay block, where the courier must walk back to his original location. Once the courier returns, he does not turn right back around and try to re-deliver the message. We have the courier exponentially delayed with a mean of five minutes, before he leaves his desk to attempt to re-deliver the information.



If the information can not be delivered and the courier has returned to his original location, this portion measures the delay of waiting to walk over again.

If the information can not be delivered, this portion measures the delay it takes to walk back to the original location.

Measures the delay it takes to walk from the location where the information is received to where the information is intended.

Figure 15. Extend Blocks Within Courier H-Block

c. *Voice Delay*

A Voice Delay block represents any information exchanged verbally over a telephone between organizations. As with the other communication delay blocks, there are two H-blocks within the Voice Delay block. They are Conv Length, short for conversation length, and Voice. An item enters the Voice Delay block and it first goes through the Conv Length H-block. Here, it is assigned an attribute called “ConvLength” which is assigned exponentially around varying means depending on the situation.

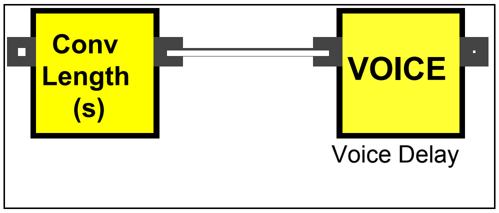
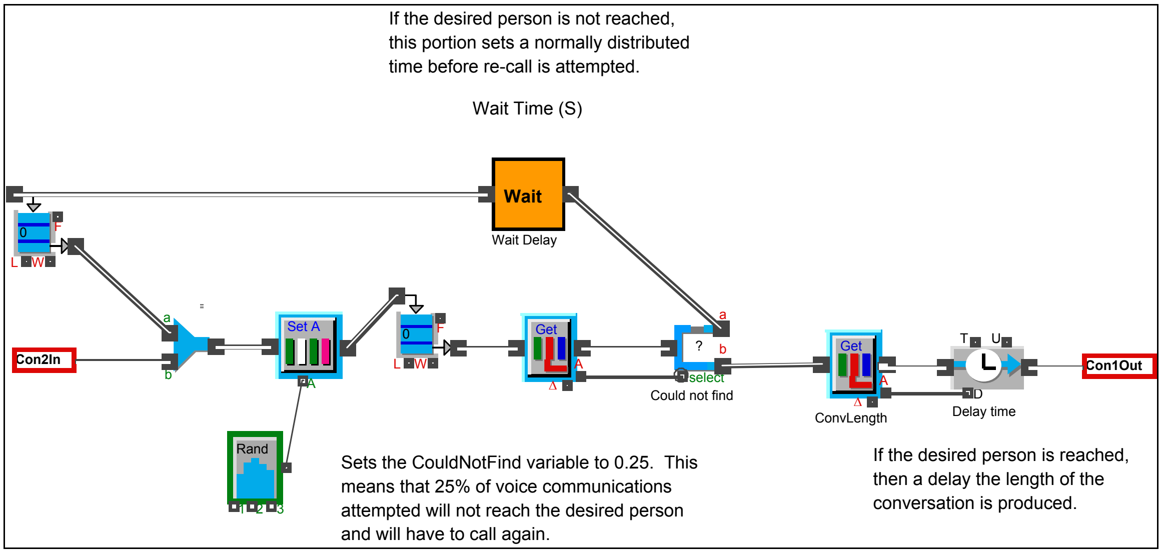


Figure 16. Voice Delay H-blocks

Once the item exits the Conv Length H-block, the item enters the Voice H-block, where it is immediately assigned a second attribute called “CouldNotFind.” This represents a person placing a call and getting no answer from the intended receiver. This attribute is currently set as an empirical table in which 25 percent of the calls do not get answered, and must therefore be placed again. If the call does get answered, which it does 75 percent of the time, the item proceeds to the activity delay block and is delayed by an amount of time equal to the attribute “ConvLength” before it is routed out of the voice delay block. However, if the call is not answered, the item is re-routed back through the voice delay H-block. This H-block represents the time before the call is attempted again. This delay is exponentially distributed with a mean of five minutes.


If the desired person is not reached,
this portion sets a normally distributed
time before re-call is attempted.

Wait Time (S)

Sets the CouldNotFind variable to 0.25. This
means that 25% of voice communications
attempted will not reach the desired person
and will have to call again.

If the desired person is reached,
then a delay the length of the
conversation is produced.

Figure 17. Extend Blocks Within Voice H-block

It is important to emphasize that currently all the delays represented by these three blocks are assumed. They can be changed easily to more accurately represent the process being studied. Upon gathering more data on delay times with different systems, operators, and phone calls, all one has to do is manipulate the random distributions assigned in the input database.

2. Timer Send Block

Timer Send is the last of the modular blocks to be discussed. This H-block works in conjunction with the Timer block in order to measure how long it took for an item to reach that part of the model from the start. What makes the Timer Send block especially useful is that is can be placed at any location of the model and does not disturb it. An item will flow in and out of the Timer Send block with no alteration to the model of "Develop Targets."

Once an item enters the Timer Send block it enters an unbatch (variable) block where two clones are made. The first clone is sent out of the Timer Send block to continue through the targeting architecture. The second clone is sent to a Set Attribute block where it receives an attribute called location. This attribute must be entered into the Timer Send block and should represent the location within the model that the Timer Send block was placed. The item then goes to a Throw block, where it is sent to the Timer H-block for processing. One important note is that a number with more then one decimal point cannot be sent over Throw and Catch blocks. Therefore, when the a third level H-block is referred to, the number "0" is used in place of the second decimal point. This can be observed in Table 3, where block 1.3.1 is represented by 1.301. .

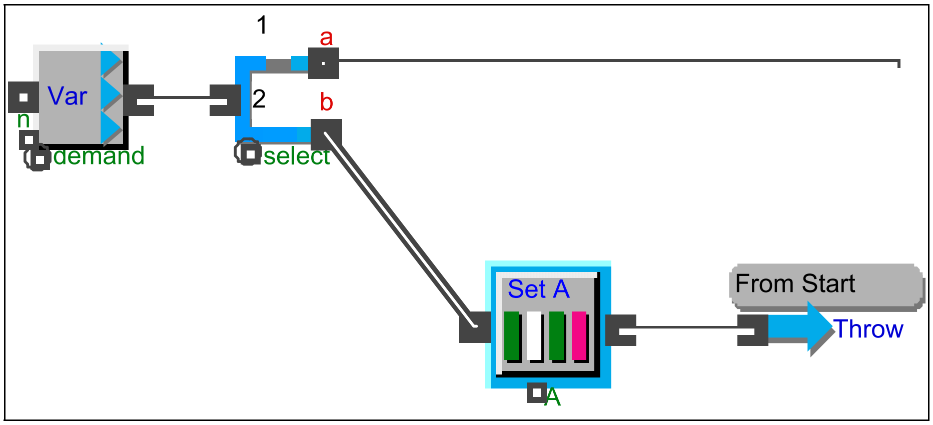


Figure 18. Extend Blocks Within Timer Send H-block

3. Miscellaneous H-blocks

a. Timer

The Timer H-block is used with the Timer Send H-blocks to monitor the time it takes for certain events within the “Develop Targets” activity. The Timer block exists at the top model level, and receives inputs from Timer Send blocks throughout the entire model. An item is “thrown” to the Timer block from a Timer Send block. A Catch block is used to receive the time, at which point it is forwarded to a count block. The Count block counts the items as they arrive. This number will be used to place the data in consecutive rows in an outputted database. The item is then sent to a Get Attribute block that sets the attributes of Row and Time. Row is set by the value sent from the counter, while time is set by the Current Time block that will place the time at which the item was sent to the Timer block on the item. This is followed by three Get Attribute blocks that read the Row, Location, and Time attributes to the File Output block that places the information in a table.

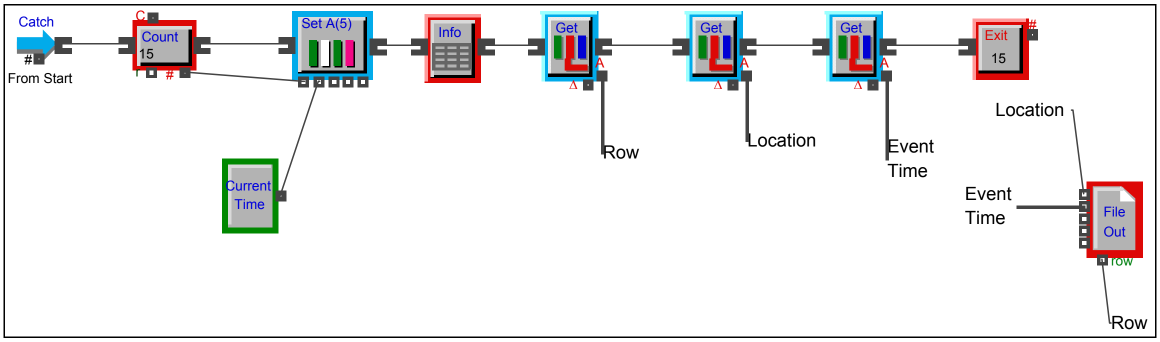


Figure 19. Extend Blocks Within Timer H-block

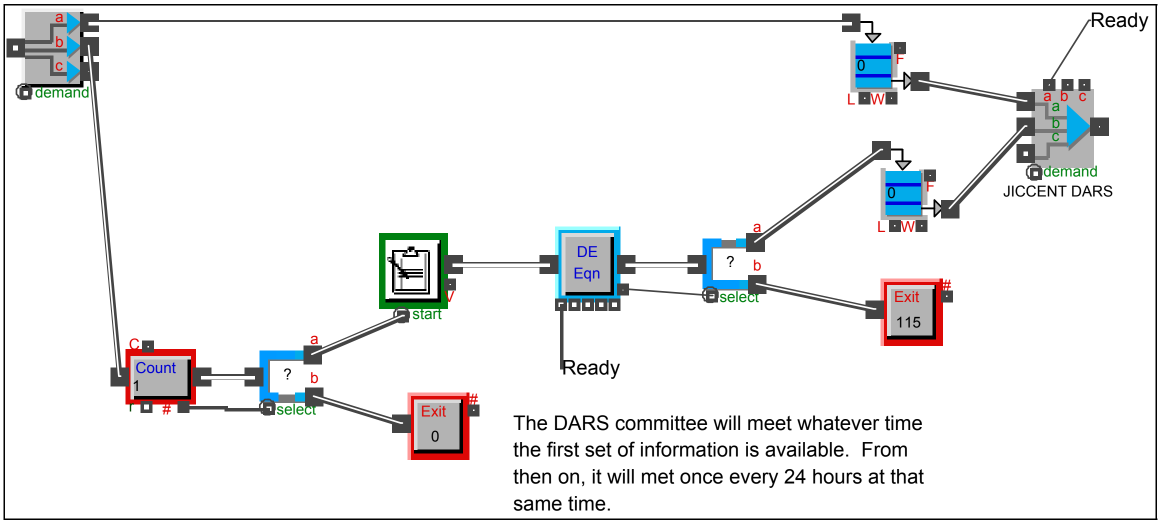
A sample output from the timer appears in Table 3. Note that the activities do not always occur in number order. This can be seen in activities 1.5 and 1.6, which are completed before activity 1.404. This is due to the fact that activities 1.4, 1.5, and 1.6 occur in parallel, rather than in series.

Location	Time (minutes)
1.1	144.5605329
1.2	288.76808
1.301	510.3632915
1.302	931.8590103
1.303	943.672109
1.304	1011.958446
1.305	1036.723901
1.306	1056.631342
1.401	1111.23942
1.5	1254.307462
1.6	1259.310691
1.402	1334.124827
1.403	1422.092764
1.404	1610.569813
1.7	1632.065372

Table 3. Sample Timer Output

b. DARS

The unique situation of the DARS meeting takes place in block 1.3.1. This meeting occurs in the H-block labeled DARS. The item passing into the DARS H-block represents that all the necessary information for the meeting has arrived. This information item is cloned and sent to a batch block. The information waits at this location until the meeting occurs. The meeting will occur when the first set of information passes through. It will then occur every 24 hours from that original time. If the members of the meeting are ready to meet, but the information has not arrived, then the members will not meet and will wait another 24 hours until meeting again.



The DARS committee will meet whatever time the first set of information is available. From then on, it will met once every 24 hours at that same time.

Figure 20. Extend Blocks Within DARS H-block

D. DATA DICTIONARY

"Develop Targets" is the first of the five activities being modeled in the CENTCOM targeting architecture. The other four activities are being modeled by other members of the NPS JIIB team. We have taken several steps to allow these five sections to be joined as seamlessly as possible. First, because "Develop Targets" is the first activity, we were tasked to model our section before the other activities were modeled. After the first draft of our model was finished, we met with the professors on the project and discussed how they could utilize the modeling techniques we used. We also pointed out changes that would be required in the model. Once an overall modeling architecture and technique was chosen, we set standards for the next stage of modeling to follow. In addition to designing the four modular blocks previously mentioned, we were tasked with creating a data dictionary. This states the names and purpose of the attributes, modular blocks, and catch blocks in the model.

1. Attributes

ConvLength (minutes) - Length of a voice communication measured in minutes. Value inputted in Conv. Length block. Utilized in Voice Delay Block.

CouldNotFind (no units) - Percent of messages that are not received by recipient and are sent back into a queue to be re-sent. Utilized in Voice, Courier, and Net Delay Blocks.

Distance (feet) - Distance a courier must walk to deliver a message measured in feet. Value inputted in Dist. Walked block. Utilized in Courier Delay Block.

InfoSize (Kbytes) - Size of information passed over a computer network measured in Kilobytes. Values inputted in Message Size Block. Utilized in Net Delay block.

Row (no units) - Gives each input sent to the Timer block a sequential number. This number is the row in the output table that the time information is assigned.

Time (minutes) - Sets the time as an item is sent to the Timer block. That information is then sent to an output table to be recorded.

Bandwidth (Kbps) - Sets the bandwidth available in a Net Delay block. Value is inputted in the Net Delay block. It is utilized in the Net Delay block as well.

Location (block number) - Identifies the location a Timer Send block sends an item to the Timer block. This value is used in the output table to identify the location in the model a specific time came.

ReTry Delay (minutes) - Amount of time between re-sending messages, or attempting to call or walk information to destination.

Avg Walk Speed (feet/second) - Pace at which courier walks. Utilized in Courier Delay block.

Process Delay (s) - Delay associated with each process/activity.

2. Modular Blocks

Net Delay block - Delays an item based on the size of information being sent, bandwidth available, and chance the message will not be received. The utilized attributes in this H-block are:

- InfoSize
- Bandwidth
- CouldNotFind

Courier Delay block - Delays an item based on the distance a courier must walk to deliver a message, and the chance the message will not be received. The utilized attributes in this H-block are:

- Distance
- CouldNotFind

Voice Delay block - Delays an item based on the length of the conversation needed to transmit the necessary information, and the chance the call will not be answered. The utilized attributes in this H-block are:

- ConvLength
- CouldNotFind

Timer Send - Sends an item to the Timer block to record the time at which the item passed through the Timer Send block. The utilized attributes in this H-block are:

- Location

3. Names of Catch Blocks

Catch blocks have a label (name) and catch items from a "Catch Group." Throw blocks throw items to a Catch Group and also to a specific catch block by label. Therefore, you can send many different items to different locations using a Catch Group, but the "Catch block label" must be unique. The Catch Groups utilized in the "Develop Targets" activity are:

- MP&BFs
- ROE
- Target Database
- Timer
- WMD Targets

The following are unique Catch block labels used in the "Develop Targets" activity. In parentheses is the Catch Group to which the Catch block label belongs.

- From Start (Timer)
- WMD (WMD Targets)
- Maps & Plots (MP&BFs)
- Maps & Plots 2 (MP&BFs)

- Target Database (Target Database)
- ROE (ROE)

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VI. RESULTS AND CONCLUSIONS

A. IMPORTANCE OF EXTEND MODEL

The development of this Extend model was important for two primary reasons. The first is it will serve as a useful foundation from which the other four activities can be modeled in order to represent the entire targeting cycle. The second is it demonstrates the ability of the model to track one of the key metrics, time to complete certain tasks within the cycle.

Creating the Extend model for the "Develop Targets" activity prior to modeling any of the other five activities will save the NPS JIIB group valuable time in the long run. Given the parallel effort of several activities being modeled simultaneously by different people, it is likely that had the effort commenced at the same time, many similar problems would have been encountered. By generating the "Develop Targets" activity roughly two weeks prior to the development of models for the other activities, many ways to work-around certain problems were discovered and briefed to the rest of the NPS JIIB group. Many of these issues have been mentioned in the previous chapter, such as whether or not to implement a database, and, once implemented, how to effectively use it. Ultimately, this baseline model for the "Develop Targets" activity will serve as a valuable skeleton for the development of the overall model of CENTCOM's targeting architecture.

The principle metric tracked by this model is the elapsed time, in minutes. Since this Extend model was developed in an activity-oriented manner, the "Develop Targets" activity was broken down into seven major sub-activities (1.1 through 1.7). By developing a timer block to stamp an item with the current time and throw this value to a table, it is very easy to keep track of the average time it takes to complete any process. As the model is currently configured, this table lists the cumulative time from when the process started to when each major sub-activity was completed. If the user wants to know how much time elapsed during activity 1.3, the cumulative time associated with 1.3 in the output table must be subtracted from the cumulative time associated with 1.2 in the same table. Furthermore, the flexibility of the model will allow for Extend's standard

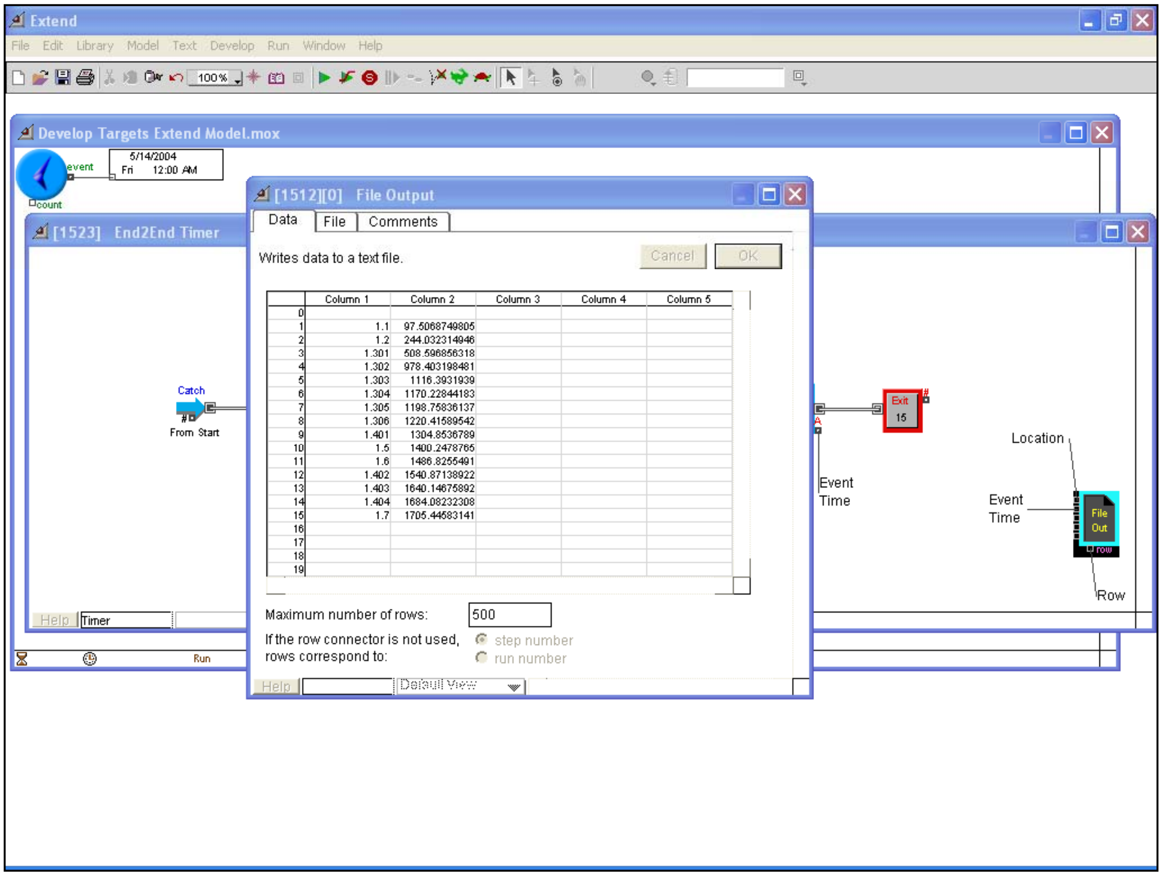
Timer blocks to be placed anywhere in the model. These blocks will measure the amount of time it takes an item to get from any point A to any point B.

The advantage of being able to track time to complete certain sections of this process is that it will hopefully identify chokepoints or bottlenecks in the process. Then, alternate architectures, communication systems, or bandwidths can be tested without incurring any additional cost. This will to help determine which change, if any, would be most cost effective in enhancing the efficiency of the process.

One of the end goals of the Extend model was to determine interoperability shortfalls, or suggest means for process improvement. However, the delay parameters' lack of precision used within the baseline "Develop Targets" model would render a detailed analysis futile. Consequently, the results section discusses the model's ability to demonstrate the effect of changing attributes, such as bandwidth. Future iterations of this model, with improvement to delay parameter accuracy, will better allow the user to identify interoperability shortfalls.

B. EXTEND MODEL RESULTS

The first task in creating the Extend model of the "Develop Targets" activity was to accurately describe the process. The next step was determining a means to generate useful information that would aid decision makers. The primary metric utilized by this Extend model is time. The model outputs quantified time measurements. Each H-block that represents a layer of the model has a Timer Send block embedded within it that records at what time that block finished its portion of the model. These times are collected in the timer block and sent to a File Output block. This records the information in a data table within Extend. Figure 21 shows how the data is recorded. The user can then select the data he wants and paste it into an Excel spreadsheet for data analysis.



Writes data to a text file.

	Column 1	Column 2	Column 3	Column 4	Column 5
0					
1	1.1	97.5068749805			
2	1.2	244.032314946			
3	1.301	508.596856318			
4	1.302	978.403198481			
5	1.303	1116.3931939			
6	1.304	1170.22844183			
7	1.305	1198.75836137			
8	1.306	1220.41589542			
9	1.401	1304.8536789			
10	1.5	1400.2478765			
11	1.6	1486.8255491			
12	1.402	1540.87138922			
13	1.403	1640.14675892			
14	1.404	1684.08232308			
15	1.7	1705.44583141			
16					
17					
18					
19					

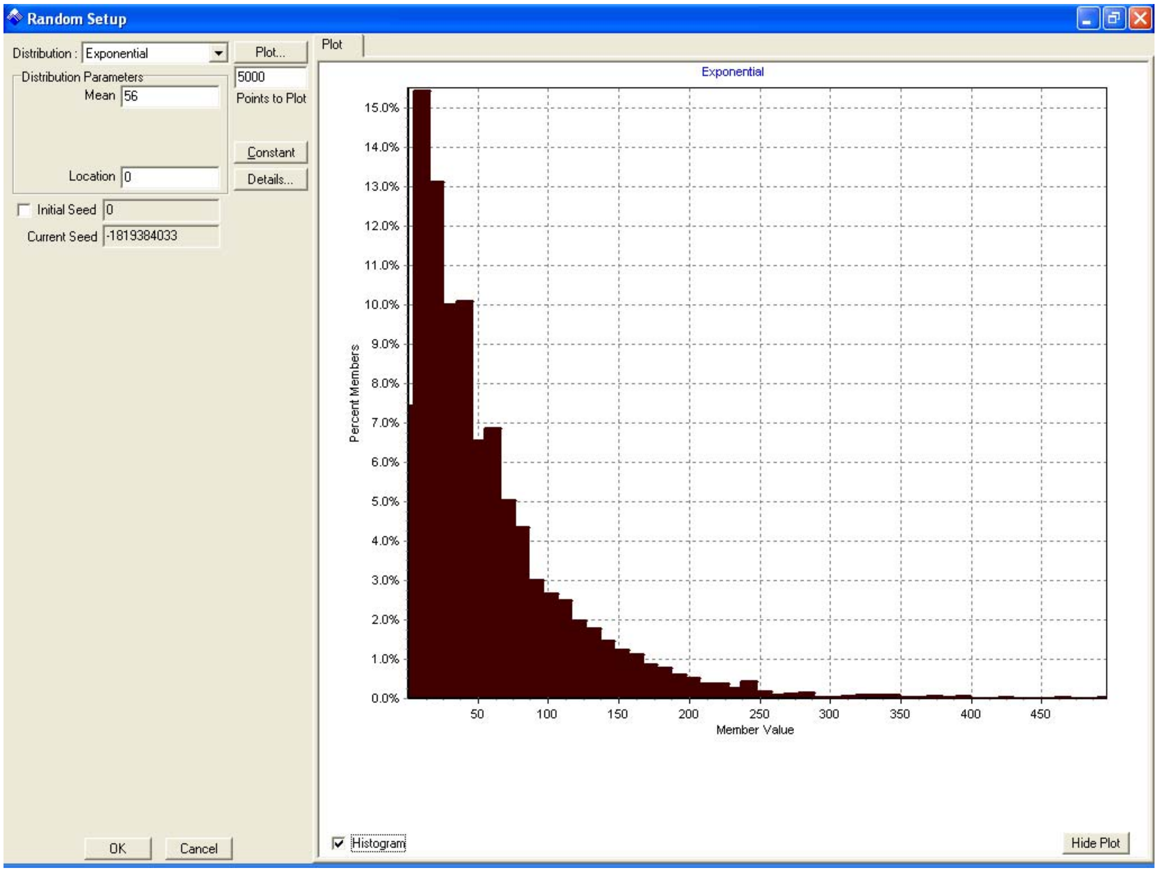
Maximum number of rows: 500

If the row connector is not used, rows correspond to: ● step number ○ run number

Figure 21. Extend File Output Block's Data Table Containing Model Run Time

With assistance of the database, attributes in the "Develop Targets" model can be quickly and easily modified. This offers the user an ability to vary these attributes to see their effect on the overall activity. The model is most suited to measure the metric of time, therefore, we used that to measure the effect of varying an attribute. To demonstrate this potential, we changed the bandwidth attribute and recorded its effects.

The bandwidth attribute is used in every Network Delay H-block to simulate the limited amount of information that can be sent and received from each organization. In the baseline version of the Extend model, we set the bandwidth for all network delays around an exponentially distributed mean of 56 Kbps. Figure 22 shows a histogram of an exponential distribution with a mean of 56. Further research into a more precise bandwidth for each network situation would increase the accuracy of the modeled networks.



Random Setup

Distribution : Exponential

Distribution Parameters

Mean 56

Location 0

5000 Points to Plot

□ Initial Seed 0

Current Seed -1819384033

☑ Histogram

Figure 22. Exponential Distribution

To demonstrate the effect of bandwidth on overall "Develop Targets" run time, we measured the effect of four different bandwidths. Each of the four trials were run 15 times and the time of activity completion was recorded. Due to the fact we are just demonstrating the ability to change attributes and observe a change in the model, we kept all bandwidths the same within each trial. The bandwidth values for each trial were:

- Trial 1:Exponential distribution around a mean of 56 Kbps
- Trial 2:Exponential distribution around a mean of 112 Kbps
- Trial 3:Exponential distribution around a mean of 1554 Kbps
- Trial 4:Constant of 56 Kbps

Trial 1 used a bandwidth of 56 Kbps because they are the model's baseline values. Trial 2 used double the bandwidth that was available in the baseline model. Trial 3 used a bandwidth size of 1554 Kbps because that is the equivalent bandwidth to a T1 line. The final trial switched from an exponential distribution to a constant of 56 Kbps to demonstrate the effect the exponential distribution was having on model time. The results of all four trials can be seen in Table 4, which represents time to complete the "Develop Targets" activity.

Time To Finish Develop Targets Activity (in minutes)

Trial		**1**	**2**	**3**	**4**
		56K exp	**112K exp**	**T1 exp**	**56K constant**
Run #	**1**	1558.962	2227.283	1275.807	1303.812396
	2	1671.324	1840.799	1299.512	1402.230972
	3	19496.98	1371.797	1423.988	1353.164968
	4	2521.763	1913.015	1272.679	1244.381231
	5	1849.807	2463.887	1337.977	1463.628245
	6	2047.672	1606.72	1335.367	1427.128966
	7	1451.646	1450.135	1319.368	1484.544508
	8	2262.725	1527.502	1328.123	1304.997286
	9	1442.189	1461.115	1245.382	1366.741812
	10	1442.189	1286.663	1230.076	1332.458853
	11	13677.55	1776.661	1265.442	1305.28379
	12	7427.729	2352.322	1286.806	1392.019909
	13	1928.626	1919.068	1296.103	1367.740666
	14	2314.496	1348.797	1310.805	1323.082368
	15	2096.378	4686.472	1217.964	1413.906735
Median		2047.672	1776.661	1296.103	1366.741812
Mean		4212.669	1948.816	1296.36	1365.674847
Standard Deviation		5346.802	843.3091	51.03785	65.90332528

Table 4. Varying Bandwidth Extend Model Run Times

By evaluating the median, mean and standard deviation of these four trials, it becomes clear that altering the bandwidth had a large impact on the model. First, looking at trial 1, there is a large difference between the mean and median. This suggests there were some times in the 15 runs that were vastly different from the rest. Examining the standard deviation in this same instance corroborates that point with a value of 5347 minutes (3.7 days). While twelve of the 15 runs took between 1400 and 2600 minutes, the remaining three took over 7000, 13000, and 19000 minutes. Those three represent 20% of the trials and significantly affected the results.

The second trial also used an exponential distribution, but the mean was doubled to 112 Kbps. The median and mean for this trial are still nearly three hours apart, however, that is a much smaller difference than the first trial. The median, 1776 minutes, and the mean, 1948 minutes, are slightly longer than a day. While we do not know the exact length of the "Develop Targets" activity, we estimate it requires around a day; these times are close to what we would expect. The standard deviation is also still very large at 843 minutes (14 hours), but again, this is much smaller than the first trial. While the standard deviation shows there is still a large variation with each run, only one run was particularly different from the others, at 4686 minutes.

The third trial used an exponential distribution with a mean of 1,554 Kbps. This number is significant because it is the bandwidth available on a T1 line. The T1 is one of the more popular standards for digital communication in the United States (Comer 117). The median and mean for this trial were nearly identical at 1296 minutes. Those times are slightly less than a day, which is what the overall time for the "Develop Targets" activity is expected to be. Also, the standard deviation was only 51 minutes, which is what we would expect in an activity that takes about a day to accomplish.

The final trial did not use an exponential distribution, but a constant value of 56 Kbps. This was a way we could see some of the potential consequences of using an exponential distribution. The mean and median for this run were nearly identical with values of 1366 and 1365, respectively. This length is also around the timeframe of a day which we believe the "Develop Targets" activity will require. The standard deviation is a manageable 65 minutes. This indicates most of the run times were similar. It is important to remember that even though we have made the bandwidth constant, all of the other attributes are still either exponentially or normally distributed.

These results reveal several characteristics about the model. First, it is clear that varying an attribute, such as bandwidth, will substantially affect the " Develop Targets" model run time. Second, using an exponential distribution for bandwidth might not be the best distribution. This is especially true when the mean value of the exponential distribution is as low as 56 Kbps. As Figure 22 shows, it produces an available bandwidth that is often too low to support the level of detail in this model. This is discussed further in the Model Improvements section. However, as the mean value of the exponential distribution gets larger, it appears the exponential distribution produces more expected results. This can be seen with the slightly reduced standard deviation in trial 2, and the minimal standard deviation in trial 3. It is important to note that the standard deviation in trial 3 is even smaller than when there is no variance in the bandwidth as shown in trial 4. With a number as large as 1544 kbps set as the mean for the exponential distribution, the chances of a very small bandwidth are minute. Therefore, it appears that exponential distributions can be used to demonstrate the variations that occur in bandwidth, if the mean bandwidth is large enough.

C. MODEL IMPROVEMENTS

It is important to keep in mind that this is just a baseline model, and there is room for significant improvement in future iterations. This section will serve to highlight some of the potential means of upgrading the model.

1. Increase Accuracy

Currently, the model is capable of tracking time to complete activities within the overall process. However, many of the attributes that have been entered into the database, such as link bandwidth, message size, distance, and process delay, are based largely on assumptions. The true value of the timing function of the model will be realized as these parameters are refined and made to be more accurate and representative of what is actually occurring. This can be done as more time and research is spent talking to actual operators and generating tables of statistics for each of the attributes in the model.

One key problem area with the current "Develop Targets" model has to do with the assumption that all communication link bandwidths are exponentially distributed about a mean of 56 Kbps. It was recommended that link bandwidths best fit an exponential distribution; however, at 56 Kbps, it is not uncommon to get several runs where this bandwidth is as low, or less than, 1 Kbps. This means that for a message of 10 MB to be transmitted over a link operating at 1 Kbps would delay the process more than 2.5 hours. This demonstrates the need to increase the detail in the communications delay blocks. The network delay blocks are currently configured to delay the process by over 2.5 hours when a 10 MB file is being sent over a link operating at 1 kbps. This logic may not be entirely accurate since there is the possibility for either the link bandwidth to increase or decrease over this time period, or perhaps alternate means of transmitting the information will be sought out. If through further research it is found that either or both of these scenarios occur, the network delay blocks can be configured to account for this.

Furthermore, activities that occur throughout this process are currently represented by a single activity delay block, which delays the process by a set amount of time. For example, there is currently a single, normal distribution, which represents how long it takes each of the targeteers to develop their initial candidate target lists. While this logic is suitable for the baseline model, there is ample room for improvement by actually studying every task completed by each organization throughout the process. This will ultimately lead to developing hierarchical blocks that contain several activity delay blocks to more accurately represent the activity. Again, this comes down to how detailed a model the user needs to produce in order to answer the questions posed of them.

2. Alternate Metrics

Time is the primary metric that is being tracked by the baseline model. Interoperability checks is another tasking that the final model is capable of handling. Given the labeling system of the model, there are currently ways to notice and test for potential interoperability problems. For example, each network delay is labeled with which system (JDISS, GCCS, AFATDS, etc) is actually being used according to the documentation. By looking at the model it is readily apparent over what systems information is flowing into an organization, and over what systems it is flowing out. By understanding the compatibility of these systems, areas where interoperability problems could exist might be highlighted.

In the future, it is conceivable to implement interoperability checks in the way of message format type checks. For example, before any item is received by a system, it must go through a loop in which it is tested for compatibility. If it is compatible, the item will flow through and there will be no hold-up in the process. However, if it is deemed incompatible, the process can be set to stop and note the error, or continue with some sort of delay associated with reformatting the item to render it compatible. This will enable the model to generate time that more accurately reflect reality.

One final metric that could be added to this model has to do with manpower. Each activity could be assigned a limited number of workers in the form of a resource labor pool. The number of workers, and their tasking situation, could result in additional delays that would be unaccounted for otherwise. The discovery of bottlenecks in the process due to manpower could result in a re-distribution of workers present in the organizations.

3. Enhancing the Timer Block to Process Multiple Runs

The timer block, in its current configuration, will output the time to complete each section to a table for a single run. However, if many runs are desired so that an average can be attained in a monte-carlo type scenario, each run's time outputs will overwrite the previous run's times. Given the purpose of this model, monte-carlo runs will be used quite frequently to generate results. In order to record each run's time statistics to a separate table, an attribute must be set at the very beginning to denote what number run the item is associated with, and each timer throw block will get that attribute and write that time to a column in the table that corresponds to the run number.

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