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Decision Analysis Method for Air Mobility Beddown Planning Scenarios

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DECISION ANALYSIS METHOD FOR AIR MOBILITY BEDDOWN PLANNING SCENARIOS

THESIS

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Abstract

Currently at Air Mobility Command, Plans and Programming, Requirements Division (AMC/A75R), infrastructure requirements for a proposed permanent beddown location are accomplished through corporate knowledge and manual lookup. With the loss of corporate knowledge in the foreseeable future, AMC/A75R is would like to capture this knowledge base in an information system. This research developed a spreadsheet analysis tool that takes hard requirements and compares them with existing capabilities at a given location. Through gap analysis, the tool produced infrastructure requirement shortfalls and associated costs to satisfy the shortfalls.

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Jacob M. Salmond

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DECISION ANALYSIS METHOD FOR AIR MOBILITY BEDDOWN PLANNING SCENARIOS

I. Introduction

General Issues

Beddown is the process and act of placing a unit, mission or activity on real property for longer than one year. This applies to activities of all military branches, other Department of Defense (DoD), non-DoD federal, state and local governmental, and/or private agencies requesting the use of Air Force real property (AFI 10-503). Actions are taken to position Air Force units worldwide, which include selecting sites and resolving political, airspace, environmental, and beddown issues. Such actions may range from establishing and maintaining units in permanent facilities (beddown) to arranging access, transit, and service agreements for contingencies, exercises, and visits (AFPD 10-5).

The planning of weapons systems beddown is a typical occurrence in today's Air Force. Requirements are developed for global peacetime and wartime planning, Base Realignment and Closure (BRAC), and introduction of new weapon systems. Specifically, Air Mobility Command Planning and Programs Requirements Division (AMC/A75R) develops the infrastructure portion of beddown proposals for the movement of weapon systems, typically aircraft, in support of the requirements above, as well as the European and Pacific En Route Infrastructure Steering Committees (EERISC and PERISC respectively).

For each what-if scenario that is analyzed within AMC, AMC/A75R is tasked with investigating base infrastructure and sizing locations to support a wide range of weapon systems. What-if scenarios are constantly being analyzed for the movement of aircraft within the command. Infrastructure shortfalls and a rough order of magnitude cost are the main requirements for each scenario. At times, the timeline required for the completion of these scenarios is as little as two hours.

A typical scenario begins with any combination of what, where, when, and how many -- type of aircraft, location of beddown, time frame for the decision, and the number of aircraft involved. Currently, infrastructure requirements for a proposed location are accomplished through corporate knowledge, electronic inquiries, and manual lookup. Corporate knowledge is dependent on the individual, their level of experience, and their knowledge of Air Force systems. The electronic inquiries consist of telephone calls to community planners from installations in question, electronic mail back and forth to different areas of expertise, and investigations into databases. The manual lookups are accomplished via as-built drawings on record, air field evaluations, and real estate records.

A simple table matrix along with Air Force Instructions (AFI), Unified Facilities Criteria (UFC), and other directives are used to retrieve numbers for infrastructure requirements. These numbers are compared to what is currently available and a list of shortfalls is developed. The list of needs drives a rough order of magnitude cost estimate via the historic cost handbook developed by Air Force Civil Engineer Support Agency (AFCESA).

This current process is lacking because of the reliance on individual experts, lack of consistency across analyses, slowness and difficulty, and integration problems. The corporate knowledge of beddown analysis has not satisfactorily been captured in a management information system. No single decision analysis tool exits that can promote fast, consistent beddown analyses.

Problem Statement

Currently, infrastructure requirements for a proposed beddown location are accomplished through corporate knowledge and manual lookup. The purpose of this research is to develop a decision analysis tool that compares hard requirements versus existing capabilities and through gap analysis identifies infrastructure requirement shortfalls and associated costs to satisfy these shortfalls.

Research Objectives

This thesis will be based on three objectives through which the research problem will be addressed. Each objective is not independent of the other, but each may not necessarily be fully accomplished before looking at the next.

The first objective is to understand the current what-if scenario process. This includes identifying the controlling factors, quantification of those factors, and relative importance of each. These factors will be identified through current directive for infrastructure requirements, as well as discussion with subject matter experts.

The second objective will be to link the controlling factors together. The objective will begin with deciding what decision analysis tool is best suited for this problem and it will then be implemented. This is where the “black box” will begin to take shape.

The third objective will be an investigation of implementation issues that may arise with the introduction of a new tool. There are many "lessons learned" articles available that discuss implementation of new technology.

The final objective will be to validate the tool using historic scenarios as well as current day scenarios. A historic scenario will be analyzed and the results will be compared to the actual historic results. Also a current day scenario will be analyzed and the results will be compared to a current day manual lookup exercise.

Research Questions

To meet the objectives of this research, the following questions were developed:

1. What are the key factors to consider when conducting beddown planning?
2. How are these factors quantified?
3. What is their relative importance?
4. What relationships link these factors together?
5. What potential issues might arise with implementation and how might they be addressed?

Methodology

This research will begin with an extensive review of literature, current tools, and discussion with subject matter experts. From the information gathered, the key factors will be identified, quantified, and relationships will be connected. From this, a spreadsheet based decision analysis tool will be distilled, tested, and validated. Limiting factors and shortfalls will be investigated from lessons learned and expert input.

The literature available for this application is limited mostly to tools developed by the military and military contractors. The two tools that will be investigated by this research are Logistics Analysis to Improve Deployability (LOG-AID) and Aerial Port of Debarkation Model (APOD). LOG-AID contains a tool, Beddown Capability Assessment Tool (BCAT), which assesses a particular location's capabilities for bare base beddown. APOD also contains a tool, Airfield Throughput Tool (ATT), which analyzes a location's maximum throughput and limiting factors. These tools will be investigated for the possibility of being applied to this problem.

Controlling factors and their relationships will be distilled by using BCAT and ATT, coupled with the current what-if process used by AMC/A75R. BCAT and ATT will also be used as a beginning point for the development of a spreadsheet tool which will then be refined to fit this research.

The cost analysis portion of this application will be developed through the use of AFCESA's Historical Air Force Construction Cost Handbook.

Assumptions and Limitations

The current tools that are being used as a part of this research were developed for the military and for different types of missions. The BCAT tool is used in a bare base situation and the ATT tool is used in a cargo/throughput situation. There will be inherent differences between those tools and the mobility/tanker situation this research is addressing. This research will be limited by these compatibility issues as well as the ability to glean pertinent information and/or alter these tools to fit this application.

Another limitation is within the cost portion of the final product of this research. AFCESA reviews the Cost Handbook every fiscal year and includes additional information from the last fiscal year. When this is done, line item costs and projected cost factors are updated. To maintain any level of accuracy, the cost portion of this new tool will need to be updated with any updates made to the Cost Handbook.

A major assumption being made is that the research driving this methodology is purely a Headquarters perspective. Individual installation's detailed base support plans will not considered in the analysis accomplished by this research. Any similar base-level infrastructure investment that has been previously programmed will not be considered through the use of the tool developed by this research.

Lastly, this research will not take any political climates into consideration. Because the BRAC process can be political in nature, this research will limit itself to analysis of infrastructure only and not possibilities due to a location's political connectivity.

Summary

This chapter describes AMC/A75R's involvement in what-if beddown scenarios within the command and how they currently analyze infrastructure requirements and costs. This research will attempt to synthesize a spreadsheet based decision analysis tool that will do away with the manual lookup method that is currently being used to accomplish this task. To do this, subject matter experts and the BCAT and ATT tools will be used to develop key factors, relationships between them, how they are quantified, their relative importance, and the basis of this new tool. Finally, the methodology to meet the objectives and answer the research questions was discussed as well as the assumptions and limitations of this research.

The following chapters explain the steps taken to address the problem being addressed by this research. Chapter II will discuss the current what-if scenario process and tools being used, and review the relevant literature. Chapter III will provide our methodology for meeting the objective and research questions of this research. Chapter IV will discuss the results and analysis of the tool developed by this research. Finally, Chapter V will synthesize this research, discuss implications for AMC, and recommend future research possibilities.

II. Literature Review

Chapter Overview

The use of the term beddown encompasses many aspects of military operations, planning, and maneuvers. Currently the Air Force is in high operations tempo and has been for many years. As a corporation, we are very good at contingency preparation, deployment, employment, and recovery. This type of beddown is done quickly with very little permanent infrastructure. Deployment beddowns are accomplished through war ready materials (WRM), unit type codes (UTC), time-phase force deployment data (TPFDD), and pre-developed tool kits. Multiple deployment operation beddown tools are already available in today's Air Force; however, there is a general lack of permanent movement type beddown analysis systems.

Technology and innovation have dramatically shaped things over the years changing the use of slide rules to computers that fit in the hand for difficult calculations. The same calculations that took minutes now take seconds. The Air Force has been bedding down people, missions, and weapon systems before 1947. More specifically Air Mobility Command has been planning tanker and air lift beddown from way back with its roots in Strategic Air Command. In today's Air Force those beddowns are still being planned but with different requirements and quicker turn around times. These requirements are developed for changes in threat or strategy, i.e. global peacetime and wartime planning, Base Realignment and Closure (BRAC), and the introduction of new weapon systems.

The Air Force has several directives that spell out exactly what is required for each aircraft type. This can be seen in Air Force Handbook (AFH) 32-1084, *Civil Engineering: Facility Requirements*; Unified Facility Criteria (UFC) 3-260-1, *Airfield and Helioport Planning and Design*; as well as many other Design Guides, Technical Orders (TO), Engineering Technical Letters (ETL), and Air Force Instructions (AFI). A predicament occurs when individuals synthesize these directives into a base of corporate knowledge that they can use to make recommendations to leadership. When leadership has a question about moving X number of aircraft to Y location (what-if scenarios), these individuals must either work from memory or turn directly to the corresponding directive, chapter, and page to develop a solution. To further complicate this issue, this corporate knowledge is not satisfactorily captured to be passed on to others.

AMC/A75R has developed a table matrix using AFH 32-1084, UFC 3-260-1, and other AMC design guides as a starting point for aircraft beddown infrastructure requirements. The table contains aircraft types and their respective infrastructure requirements by category codes. Category codes are used by the Air Force as numerical identifiers for different types of facilities. For example, the category code 111-111 represents runway pavements. The numbers extracted from this table are compared to what is currently available and a list of shortfalls is developed. The list of needs drives a rough order of magnitude cost estimate via the historic cost handbook developed by Air Force Civil Engineer Support Agency (AFCESA). AMC/A75R has a process with a normalized method to accomplish Air Mobility Beddown Planning but there is no insurance of consistency or an established technological information system to aid them. This research is not a case of having a smart piece of technology and trying to find a problem to apply it to, but rather a case of having a problem and developing a system to apply as a solution.

Information Systems

This research will investigate three deployment type operation tools as a means to gain an understanding of their information organization, connection of controlling factor relationships, and attempts in overcoming the resistance to technology acceptance. The first tool discussed is the Strategic Tool for the Analysis of Required Transportation (START) which was developed through a RAND study and implements the methodology for determining manpower and equipment deployment requirements. The next tool discussed is the Aerial Port of Debarkation (APOD) Model developed by US Transportation Command to determine and model throughput and TPFDD requirements for cargo and passengers through an airfield. The final tool discussed is the Logistics Analysis to Improve Deployment (LOG-AID) tool suite which was developed by the Air Force Research Laboratory to improve Air Expeditionary Force.

Strategic Tool for the Analysis of Required Transportation (START)

START is a tool that was developed through research by the Resource Management Program of RAND Project AIR FORCE and was jointly sponsored by the USAF Deputy Chief of Staff of Installations and Logistics (USAF/IL) and the USAF Directorate of Operational Plans and Joint Matters (USAF/XOX). The research was based on defining a methodology for determining manpower and equipment deployment requirements and was summarized by the prototype research tool START which illustrates the methodology.

The Air Force is transitioning from a threat-based planning posture to a capabilities-based planning posture (Rumsfeld, 2001). Snyder & Mills (2004) discussed this transformation in regards to deployment planning:

> Adopting a planning strategy based on a portfolio of capabilities suggests the need to develop a means to calculate swiftly the manpower and equipment required to generate each of the capabilities in that portfolio. This need, in combination with the current expeditionary posture of the Air Force, highlights the value of expediting deployment-planning timelines.

Time-phased force deployment data (TPFDD) is generated order for the planning of the logistical component of Air Force deployments. A TPFDD is a breakdown of what units of resources need to be deployed in order to support the mission objectives, who supplies the resources, and the timing and routing of the resource's transport. Tabletop plans and war plans can take years to develop. This process gives planners valuable experience that translates into better deployment plans when real world crisis occurs. In some instances the planners use the tabletops as templates. With the ability to use pre-made plans, the amount of time it takes to develop a TPFDD can be reduced to weeks and months rather than years.

An information system that can analyze and automate this planning work would greatly accelerate the planning process and hence would help to guide the transition to a capabilities-based, expeditionary Air Force (Snyder & Mills, 2004). START illustrates how the methodology of this process can be implemented into an analysis tool for this capability. It was developed with two objectives in mind: to demonstrate the feasibility of a tool to generate a parameterized list of unit type codes (UTC) necessary to support a specified mission based on a limited number of inputs, and to estimate the movement requirements to achieve initial operating capability at all deployed locations (Snyder & Mills, 2004).

Knowledge of what material is needed at a base to attain capabilities given the state of the base, the type and mission of the aircraft and other parameters exists organically within each functional area of the Air Force. There is no model available that compiles a comprehensive list of UTC needed in order to achieve initial operating capabilities because no set of rules exists that reach across more than one functional area (Galway, Amouzegar, Hillestad, & Snyder, 2002).

In the development of the START model, rules developed by functional areas as well as information collected from various sources where incorporated. The information necessary to devise these rules was collected primarily through interviews with senior noncommissioned officers at Headquarters (HQ) Air Combat Command (ACC) and HQ Air Mobility Command (AMC). The functional responses provided the core of the logic and critical inputs that were implemented. Air Force documents acted as a supplement to the interviews. In some cases, functional areas have already formalized their requirements as rules (e.g., fuels equipment) and have published them in Air Force documents. In other cases, the documents were used to fill in gaps and ambiguities that arose from the interviews. (Snyder & Mills, 2004)

Figure 1 displays the relationships of the model inputs to the functional outputs. This flow diagram along with the original narrative discussion gives the reader the basic understanding of how the Air Force deploys and the power of developing these types of analysis tools. This model will not be applied directly to our research but supplies the understanding of organizing inputs, outputs, and data flow within the model.

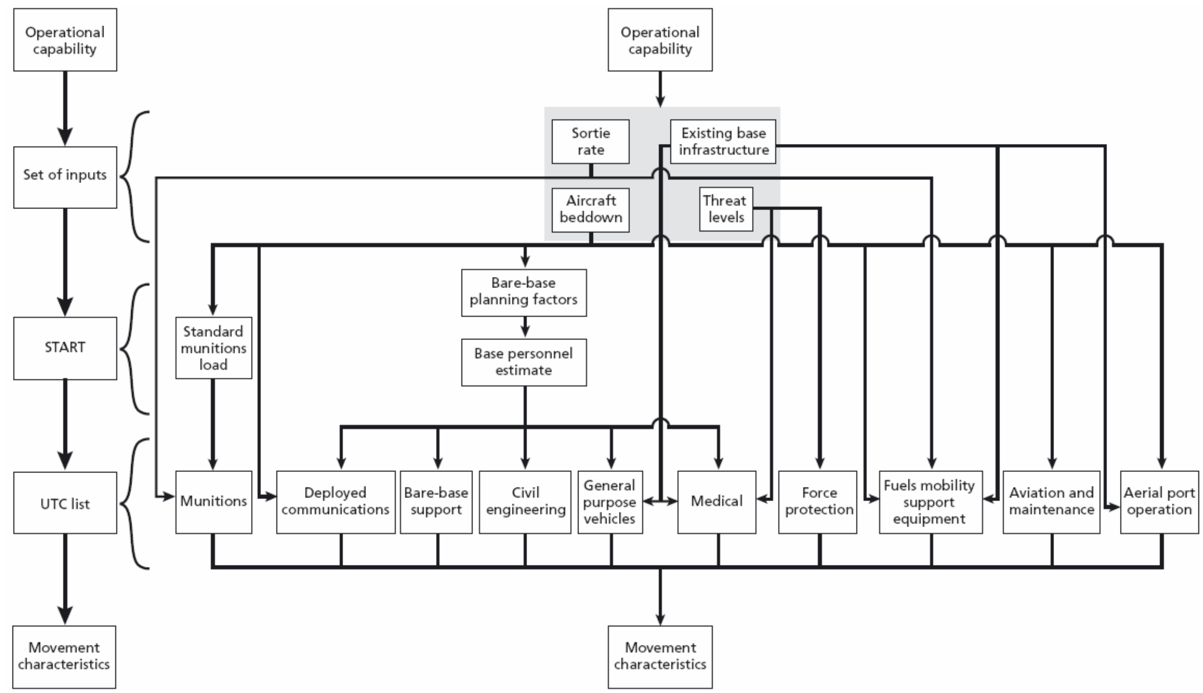

Figure 1 Relationships of Model Inputs to Functional Outputs (Snyder & Mills, 2004)

Aerial Port of Debarkation (APOD) Model

The APOD Model is an integrated group of analysis and decision support tools that provide airfield requirements and capability analysis for deployment planning. Its primary purpose is to assist Department of Defense planners and analysts in refining the Joint Reception, Staging, Onward Movement, and Integration enabler requirements during a Crisis-Action or TPFDD development process (US TRANSCOM, 2003). This model aids in identifying limiting factors, optimizing throughput, and simulating resources and process on an airfield. The tools included in this model investigate the enablers and processes at an airfield from reception to onward movement and is evaluated at four points in the flow at the airfield. Figure 2 graphically displays these evaluation points.

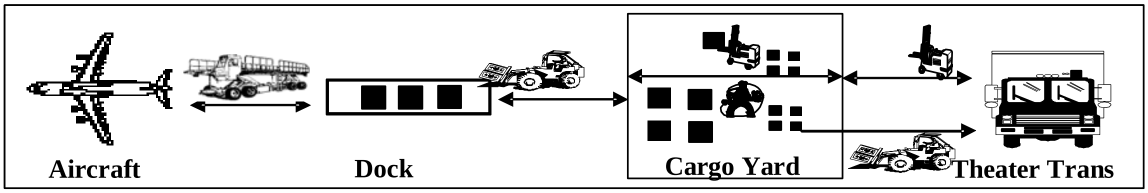

Figure 2 Airfield Cargo Throughput Evaluation Points (APOD Users Manual, 2003)

The APOD model consists of three tools: Airfield Throughput Tool (ATT), Rapid Analysis Tool (RAT), and the Airfield Simulation Tool (AST). The ATT is a vigorous, crisis-action planning tool featuring throughput, maximum-on-ground (MOG), and transportation enabler analysis of airfield requirements and capabilities. The ATT provides a quick-look analysis of an Airport's maximum throughput and limiting factors. The RAT is a TPFDD refinement tool featuring a time-phased look at requirements versus capabilities and sequencing of transportation enablers to mitigate shortfalls. The RAT provides a quick-look evaluation of the capability of airport transportation enablers to meet the TPFDD reception and onward movement of cargo and passengers. The AST is a stochastic, discrete-event driven simulation of airfield transportation resources and processes. Aircraft, cargo, parking spots, fuel, material handling equipment, cargo processing personnel are examples of the resources being modeled. (US TRANSCOM, 2003)

The methodology behind the construction of this model is not being investigated and will not be articulated in this document because of the logistic analysis being done by the tools within the model. What is being reviewed is the construction of user interfaces and the development of user inputs and outputs received. How the data connections are made, what the relational interactions are used, and how the information is organized is also part of the knowledge gained.

Logistics Analysis to Improve Deployability (LOG-AID)

The LOG-AID program was designed as a two-phase effort. Phase I focused on understanding and documenting the current wing-level deployment process, analyzing the process to identify strengths and weaknesses, and developing an improved processing concept supported by a set of software tools. Phase I identified 18 deployment process improvements, five conceptualized tools, and the process description concept for the improved process. The information was distilled from interviewing 427 users at 23 sites throughout the Air Force, observing deployment operations, and reviewing current Air Force directives. (LOG-AID Final Tech Report, 1998).

Phase II focused on taking the Phase I results into a field experiment to evaluate the improvement potential using a more realistic operational environment. The factors for the benefit analysis included the factors of reducing deployment footprint, reduced deployment time, and improved use of deployment support resources, especially the augmentee workforce.

A tool of particular interest that was developed to support the implementation of the deployment process improvements is the Beddown Capability Assessment Tool (BCAT). BCAT is a program that aids a planner in the identification of reception base capabilities and TPFDD capabilities to support a given scenario (BCAT CONOPS, 2001). BCAT uses a partial rule-based approach to allow the planner to adjust the planning factors for a given scenario. Not every element of the assessment is rule-base, and the software will only recognize specific types of rules for each area. This approach maximizes flexibility in assessing capabilities while minimizing the number of parameters that the user must enter. The key groups of information used by BCAT are the TPFDD, air tasking order data, assessment database, and the rules. The user has complete control over the assessment database, limited control over the knowledge base, and no direct control over the site survey data.

Technology Integration Issues

Organizations have recognized the importance of information technology (IT) and have dramatically increased IT investments (Venkatesh et al., 2003). Performance gains resulting from such investments have been low. Davis et al. (1989) attribute such low performance gains to users' non-acceptance of IT systems and developed the Technology Acceptance Model (TAM) in response to this condition.

The TAM maintains its position by realizing that performance gains for an organization will not be realized if employees do not make use of the purchased technology. The users of the system must accept it on a behavioral level in order for the IT systems to be used (Davis et al., 1989). Given an ideal situation where a system is early in the design process, discovering and understanding the factors that contribute to user acceptance can help developers create systems that are more likely to be accepted and used by organizational members. Also, a system that is already in use can be better redesigned and more accepted if there is an understanding of the user acceptance factors involved. Davis et al. (1989) identified two major user acceptance factors that have consistently been included in further studied validating the TAM. These factors are perceived usefulness and perceived ease of use. In all of the TAM studies, perceived usefulness and perceived ease of use were found to have a significant positive relationship with actual system use.

The TAM model defines perceived usefulness as a subjective factor describing the perception of a user that a particular IT system will increase job performance as a result of the IT system's use. Perceived ease of use is also a subjective factor, this factor describing the user's perception that using a particular IT system will be free from effort. The model also defines three other factors contributing to technology acceptance: external variables, user attitudes, and behavioral intention. The user attitudes factor describes the positive or negative feelings a user has toward the technology. Behavioral intention describes how strong a user's intentions are to actually use the system.

A graphical configuration of the TAM is shown in Figure 3. Perceived ease of use affects perceived usefulness and user attitudes. Perceived usefulness affects user attitudes and behavioral intention. User attitudes affect behavioral intention and behavioral intention affects actual system use.

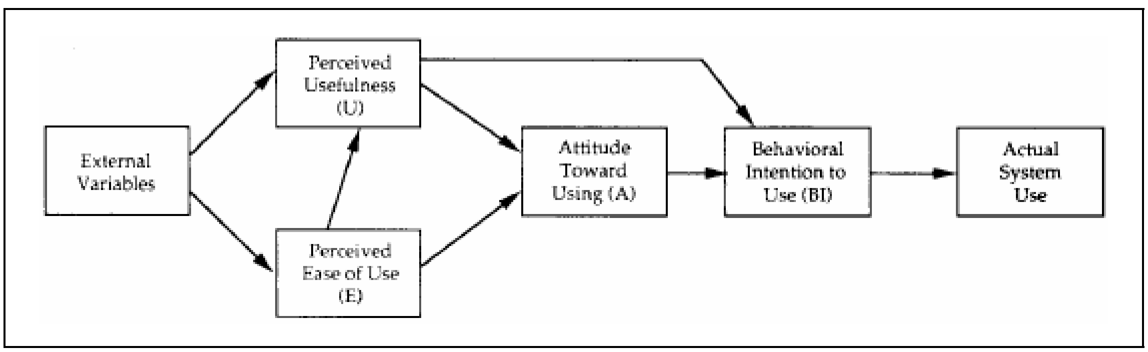

Figure 3 Technology Acceptance Model Relationships (Davis et al., 1989)

Included in the 1989 Davis et al. study was validation of the interaction between the different factors in the TAM. Business administration master's degree students were surveyed on their usage of a word processing software package. The results verified that all the listed factors had positive correlations with the proposed affected factors. The two most significant factors affecting technology acceptance were found to be perceived usefulness and perceived ease of use.

Summary

The Air Force is changing. Everything has to be done quicker, more accurately, and with less and less resources. This paper identifies three tools that attempt to take knowledge management systems and turn them into user friendly information systems. These knowledge management systems come in the form of personnel and their expertise, Air Force directives, and many years of experience. The resulting information systems have all been developed in similar ways. Each effort has been completed through a compilation of interviews with experts and references to Air Force directives. All of them end up in different forms but their basic structures are the same. The two most important factors in technology acceptance were also discussed and are key points in this research. By following the lead of experts and concentrating on technology acceptance, an attempt will be made to take the knowledge of Air Mobility Beddown Planning and develop a tool that captures that knowledge.

III. Methodology

Chapter Overview

The methodologies for building an air mobility beddown planning model is based on a spreadsheet's ability to functionally organize information, run multiple calculations, and fluently organize model results in a spreadsheet according to the users' desires. This design focuses user friendly interfaces, straight forward processes, and minimal user inputs required to calculate the rough order of magnitude (ROM) and develop a list of shortfalls.

The rationale for this model is based on developing a spreadsheet based tool that quantitatively represents the process for an analyst when developing their response to a "what-if" scenario, BRAC consideration, or a new weapons system beddown and their use of infrastructure requirements according to Air Force directives. This spreadsheet based, quantitative analysis should accomplish three goals: First, it should identify the infrastructure requirements for the desired aircraft type. Second, it should compare the requirements to the existing infrastructure to produce a list of shortfalls. Third, the tool's shortfall calculations should drive the production of a rough order of magnitude cost estimate.

Program Base for Tool Development

The instruments for this study include Air Force Handbook 32-1084, recent historic beddown scenarios, and discussions with analysts in AMC/A75R. Data was collected from all of these sources and amalgamated it into useful information for planning the organization and function of this tool.

The most popular spreadsheet and database packages were investigated as the base for the tool being developed. We chose a spreadsheet environment because it is already widely available and familiar to the intended users. Infrastructure requirements can be easily organized into tables. Organization is easy to accomplish in a spreadsheet as well. Equations can easily transverse different sheets and can be easily copied down an entire column. References can be made throughout an individual file using a single cell without have to repeat similar things in different sheets. Finally, the Visual Basic language for running a macro within the spreadsheet give the designer much more versatility with the development and flow of information throughout the tool.

The tool was built with three major goals in mind: easy upgradeability, easy to read and understand, and user friendly. The information will be organized by aircraft type, facility type, and what function it serves. All the calculations are planned to be done on calculation sheets while unchanging resident information will stay on static hidden sheets. User interfaces will be kept to a minimum and as simple as possible.

Conceptual Tool Development

To begin building the model, there must be an understanding of the current beddown process at AMC. A typical scenario begins with any combination of what type of aircraft, the location of the planned beddown, the time frame for the beddown, and the total number of aircraft involved in the movement.

The initial estimates are then taken on a site survey of the proposed location(s). At this point there are iterations between the what-if scenarios and what is available on the ground. When a satisfactory site has been selected and an estimate agreed on, the next step is the Site Activation Task Force (SATAF). During this step more iterations are made, projected are planned and programmed, and funding is scheduled.

This research will focus on the what-if scenario analysis prior to any site surveys and develop a decision analysis tool taking hard requirements compared with existing capabilities and through gap analysis produce infrastructure requirement shortfalls and associated costs to satisfy these shortfalls.

AMC/A75R uses a simple table matrix, Table 1, along with Air Force Instructions (AFI), Unified Facilities Criteria (UFC), and other directives are used to retrieve numbers for infrastructure requirements.

Table 1 Current Table Matrix

	(BRAC Capacity) AMC Facilities Matrix										
	Draft Deliberative Document - For Discussion Purposes Only - Not Releasable Under FOIA										
	Sqdn Size	**Tail Height**	**Aircraft Wingspan**	**Aircraft Length**	**Runway Length**	**Runway Width**	**Taxiway Width**	**Apron per AC**	**Shortfield Length**	**Shortfield Width**	**Hydrant per AC Prkng Spc**
					111-111	**111-111W**	**112-211**	**113-321**	**116-116**	**116-116**	**121-122**
					See note 1						See note 2
Air Force 1	2	64.3	195.7	231.8	8,000	150	75	23031	NA	NA	NA
C-130	14	38.5	132.6	99.5	8,000	150	75	7,770	3,500	60	0.75
C-130J	14	38.4	132.6	112.8	8,000	150	75	8,550	3,500	60	0.75
C-141	16	39.3	160	168.4	9,000	150	75	15,867	NA	NA	0.75
C-17	12	55.1	170	173	9,000	150	75	17,319	3,500	90	0.75
C-21	6	12.3	39.5	48.7	6,600	150	75	899	NA	NA	NA
C-5	16	65.1	222.7	247.8	11,000	150	75	32,497	NA	NA	0.75
C-9	NA	27.5	93.4	119.3	7,000	150	75	8,086	NA	NA	NA
C-20 (G-III)	NA	24.4	77.8	83.1	5,000	150	75	5635	NA	NA	NA
C-32 (B-757)	NA	44.5	124.8	155.3	6,000	150	75	11914	NA	NA	NA
C-37 (G-V)	NA	25.8	93.5	96.4	5,000	150	75	6981	NA	NA	NA
C-40 (B-737)	NA	41.2	117.5	110.3	6,000	150	75	6549	NA	NA	NA
KC-10	12	58.1	165.3	182.1	12,000	150	75	17,726	NA	NA	0.75
KC-135	12	41.7	130.8	136.2	12,000	150	75	10,491	NA	NA	0.75
UH-1	15	12.8	9.5 (48.0 - rotor diameter)	57.3	NA	150	NA	3837	NA	NA	NA
Unit of Measure		feet	feet	feet	feet	feet	feet	sq yd	feet	feet	factor
Source		AC Flt Man 1	AC Flt Man 1	AC Flt Man 1	AC Flt Man 1-1	AF Joint Man 32-1013	AF Joint Man 32-1013	AFH 32-1084	AFH 32-1084	AF Joint Man 32-1013	AFH 32-1084

AMC's inquiry for a location's existing infrastructure is accomplished through discussions with community planners, drawings on file, airfield evaluations, and real estate records. Required infrastructure is then compared with available infrastructure and a list of shortfalls is developed. The time frame and beddown location define the cost factors. The list of needs, cost factors, and number of aircraft drives a rough order of magnitude (ROM) cost estimate. These relationship connections are represented in Figure 4, and represent the basis for the conceptual air mobility beddown planning tool.

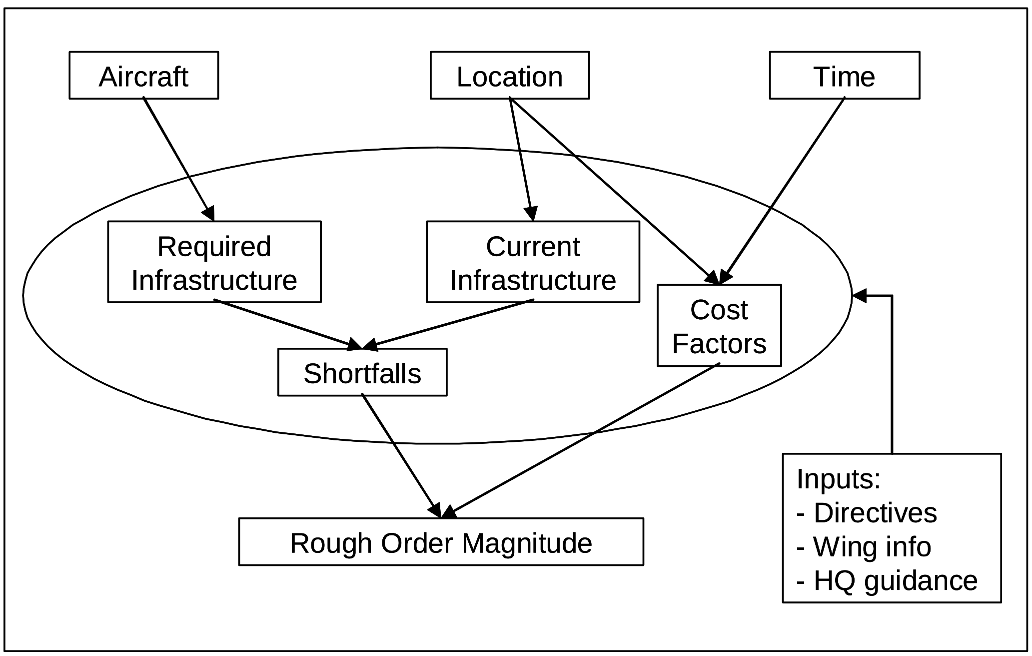

Figure 4 Air Mobility Beddown Planning Relationships

The key factors in scenario analysis have been identified as being the aircraft type, costs, and existing and required infrastructure. This research will be focused on six aircraft types in AMC's inventory: C-130, C-17, C-5, KC-10, KC-135, and a generic widebody aircraft. The cost factors vary across the United States and must consider inflation increases. Infrastructure requirements are driven by *AFH* 32-1084 and AMC design guides and, the existing infrastructure comes from command controlled real property records. These key factors will be used to develop a spreadsheet based decision analysis tool.

Initial Tool Development

The initial development of the air mobility beddown planning tool, started with six sheets. The first sheet begins by requesting user inputs for the type and number of aircraft and a request for information relating to work schedule. The *Start* page can be seen in Figure 5 below. Notice the other tabs at the bottom of the sheet.

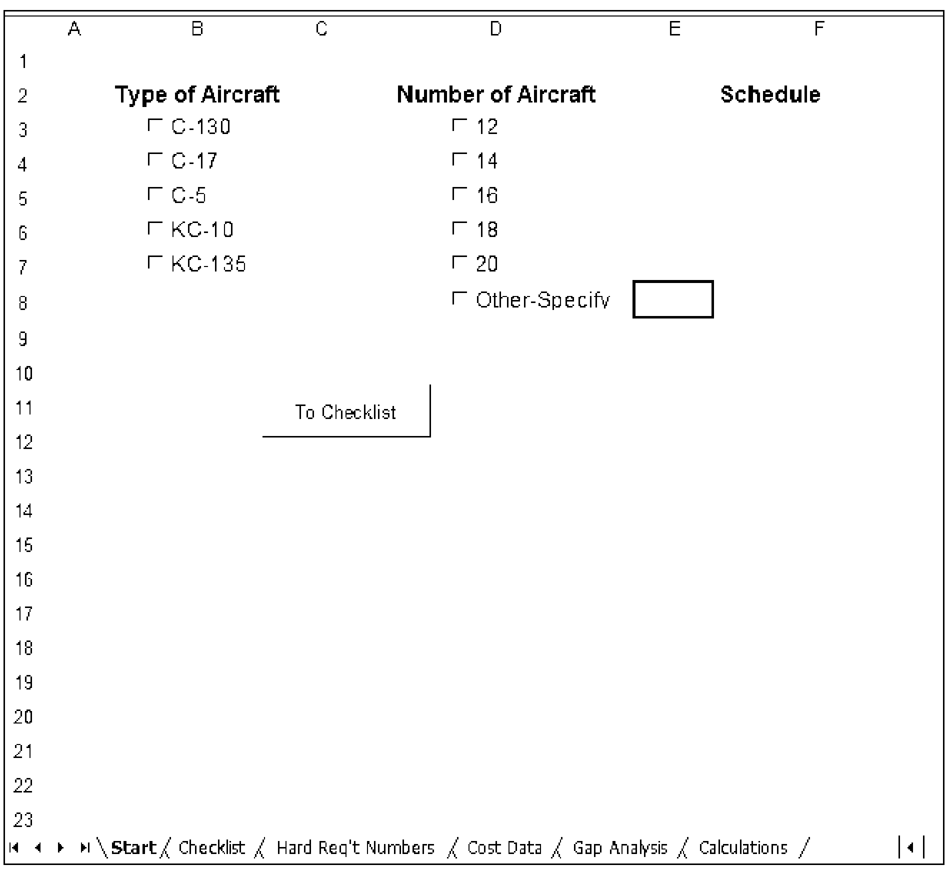

Figure 5 Initial tool development *Start* sheet

The next sheet in the initial development is the *Checklist* sheet, Figure 6. Here the user would check all infrastructure items that pertained to the scenario being analyzed. This sheet is organized by Air Force Category Code. Checking a box would ensure that infrastructure item is considered in the calculation. Any box not checked would not be considered in the calculations.

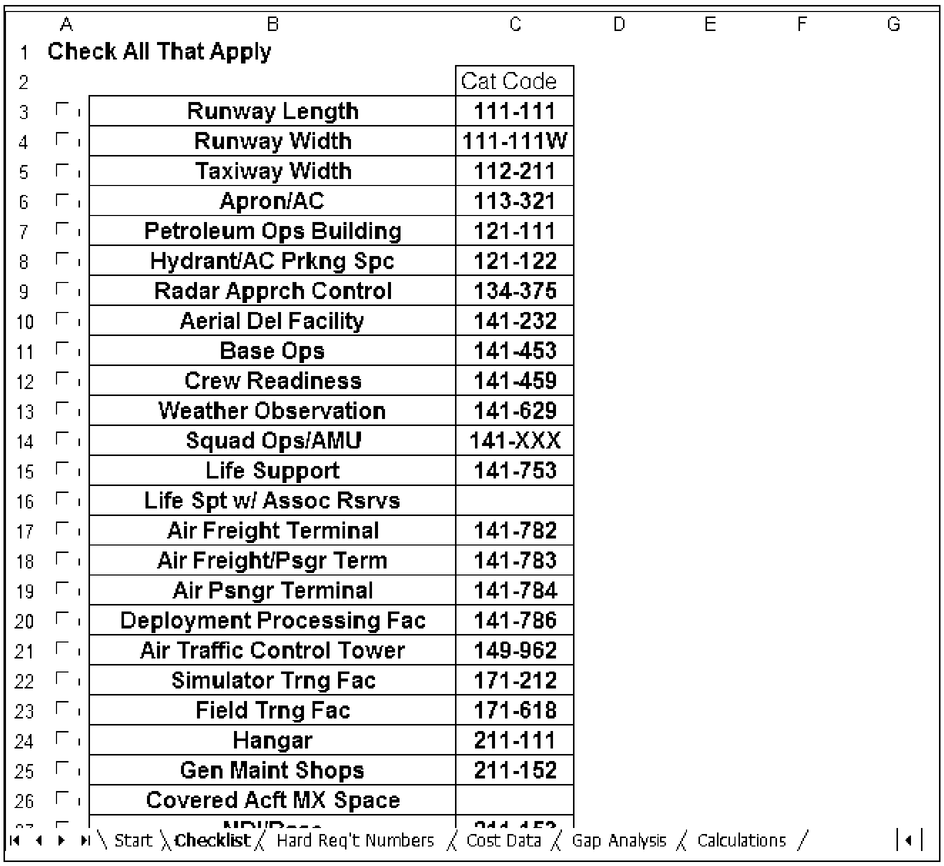

Figure 6 Initial tool development *Checklist* sheet

The *Hard Req't Numbers* sheet, Figure 7, would contain the infrastructure requirements from *AFH* 32-1084 organized by category code in the left column and aircraft type in the top column. This data would be resident information for the tool and would require limited access by the user. This sheet would eventually be hidden from the user's view and used only as a function of the macros and equations within the tool.

	A	B	C	D	E	F	
1		Cat Code	Units	C-130J	C-17	C-5	K
2	Sqdn Size		ft	14	12	16	
3	Tail Height		ft	38.4	55.1	65.1	
4	Aircraft Wingspan		ft	132.6	170	222.7	
5	Aircraft Length		ft	99.5	173	247.8	
6	Min dist btw wings (prkd)		ft	20	25-50	25-51	
7	Runway Length	111-111	ft	8.000	9.000	11.000	
8	Runway Width	111-111W	ft	150	150	150	
9	Taxiway Width	112-211	ft	75	75	75	
10	Apron/AC	113-321	sq yd	8.550	17.319	32.497	
11	Petroleum Ops Building	121-111					
12	Hydrant/AC Prkng Spc	121-122	%	0.75	0.75	0.75	
13	Radar Apprch Control	134-375	sq ft	8000	8000	8000	
14	Aerial Del Facility	141-232	sq ft	33.400	33.400	33.400	
15	Base Ops	141-453	sq ft	11815	11815	11815	
16	Crew Readiness	141-459				AFH 32-10	
17	Weather Observation	141-629	sq ft	400	400	400	
18	Squad Ops/AMU	141-XXX	sq ft	39978 (w/Life Spt)	41.929	42.303	
19	Life Support	141-753	sq ft	NA	14.388	14.388	
20	Life Spt w/ Assoc Rsrvs		sq ft	NA	17.988	17.988	
21	Air Freight Terminal	141-782	sq ft	AFH 32-1084 para 5.20	249.000	227.000	A
22	Air Freight/Psgr Term	141-783	sq ft			AFH 32-1084	
23	Air Psngr Terminal	141-784	sq ft	AFH 32-1084 Table 5.9	35.000	35.000	A
24	Deployment Processing Fac	141-786	sq ft				
25	Air Traffic Control Tower	149-962	sq ft	4955	4955	4955	
26	Simulator Trng Fac	171-212	sq ft			AFH 32-10	
27	Field Trng Fac	171-618	sq ft	39.600			
28	Hangar	211-111	sq ft	26.555	48.760	81.000	
29	Gen Maint Shops	211-152	sq ft	39.000	80.000	80.000	
30	Covered Acft MX Space		sq ft	0.15	0.20	0.16	
31	COMBS	442-758	sq ft	NA	NA	NA	
32	NDI/Base	211-153	sq ft	5000	5000	5.000	
33	Arcrft Org MX Shop	211-154	sq ft	10.000	2.000	7.000	

Start / Checklist / **Hard Req't Numbers** / Cost Data / Gap Analysis / Calculations

Figure 7 Initial tool development *Hard Req't Numbers* sheet

The next sheet is the *Cost Data* sheet, Figure 8. This data would be resident information to the tool but would require occasional access by the user. Cost information is expected to change from year to year. Plans include integration/interaction of this tool with an Air Force cost estimation tool call Parametric Cost Estimation System (PACES). This tool is developed through a government contract and contains cost information according to AFCESA's Historic Cost Guide Book as well as UFC 3-701-3.

	A	B	C	D	E	F	G
1		Cat Code	Units				
2	Sqdn Size		ft				
3	Tail Height		ft				
4	Aircraft Wingspan		ft				
5	Aircraft Length		ft				
6	Runway	111-111	sq yd	$91.85			
7							
8	Taxiway	112-211	sq yd	$91.85			
9	Apron/AC	113-321	sq yd	$91.85			
10	Shortfield Length	116-116	sq yd	$91.85			
11	Shortfield Width	116-116					
12	Hydrant/AC Prkng Spc	121-122	%	$144.43	gpm		
13	Aerial Del Facility	141-232	sq ft	$143.12			
14	Base Ops	141-453	sq ft	$143.12			
15	Crew Readiness	141-459	sq ft	$143.12			
16	Weather Observation	141-629	sq ft	$143.12			
17	Squad Ops/AMU	141-753	sq ft	$143.12			
18	Life Support	141-753	sq ft	$143.12			
19	Life Spt w/ Assoc Rsrvs		sq ft	$143.12			
20	Air Freight Terminal	141-782	sq ft	$143.12			
21	Air Freight Psgr Term	141-783	sq ft	$143.12			
22	Air Psngr Terminal	141-784	sq ft	$143.12			
23	Deployment Processing Fac	141-786	sq ft	$143.12			
24	Air Traffic Control Twoer	149-962	sq ft	$557.93			
25	Radar Apprch Control						
26	Simulator Trng Fac	171-212	sq ft	$164.39			
27	Field Trng Fac	171-618	sq ft	$143.12			
28	Hangar	211-111	sq ft	$191.47			
29	Gen Maint Shops	211-152	sq ft	$147.95			
30	Composite Shop	211-152	sq ft	$147.95			
31	Covered Acft MX Space						
32	NDI/Base	211-153	sq ft	$147.95			
33	Arcrft Org MX Shop	211-154	sq ft	$147.95			

Start / Checklist / Hard Req't Numbers / Cost Data / Gap Analysis / Calculations

Figure 8 Initial tool development *Cost Data* sheet

The following sheet is the *Gap Analysis* sheet, Figure 9. This sheet would be the output the user would see and use for final analysis. This sheet contains the amount of each infrastructure item need for the beddown. This page is organized by category code in the left column and would also give the analyst the total cost or rough order of magnitude.

	A	B	C	D	E	F	G
1		Cat Code	Shortfall	$$$$			
2	Sqdn Size					ROM =	$###K
3	Tail Height						
4	Aircraft Wingspan						
5	Aircraft Length						
6	Runway Length	111-111					
7	Runway Width	111-111W					
8	Taxiway Width	112-211					
9	Apron/AC	113-321					
10	Shortfield Length	116-116					
11	Shortfield Width	116-116					
12	Hydrant/AC Prkng Spc	121-122					
13	Aerial Del Facility	141-232					
14	Access to Drop Zone						
15	Access to Refueling Tracks						
16	Base Ops	141-453					
17	Crew Readiness	141-459					
18	Weather Observation	141-629					
19	Squad Ops/AMU	141-XXX					
20	Life Support	141-753					
21	Life Spt w/ Assoc Rsrvs						
22	Air Freight Terminal	141-782					
23	Air Freight Psgr Term	141-783					
24	Air Psngr Terminal	141-784					
25	Deployment Processing Fac	141-786					
26	Air Traffic Control Twoer	141-962					
27	Radar Apprch Control						
28	Simulator Trng Fac	171-212					
29	Field Trng Fac	171-618					
30	Hangar	211-111					
31	Gen Maint Shops	211-152					
32	Covered Acft MX Space						
33	COMBS	442-758					

Start / Checklist / Hard Req't Numbers / Cost Data / **Gap Analysis** / Calculations /

Figure 9 Initial tool development *Gap Analysis* sheet

The last sheet is the *Calculations* sheet, Figure 10. This sheet will capture all information pertinent to the analysis and dealing with calculations. This sheet will be populated via macros that run as a part of the tool. This sheet doesn't contain any resident information for analysis but will change for each scenario. This sheet will be hidden from user's view, only to be accessed if there is a change in the operation of calculations or the logic behind the calculations.

	A	B	C	D	E	F	G
1		Cat Code	Hard Req't	Existing	Shortfall	Line Cost	Total Cost
2	Sqdn Size						
3	Tail Height						
4	Aircraft Wingspan						
5	Aircraft Length						
6	Runway Length	111-111					
7	Runway Width	111-111W					
8	Taxiway Width	112-211					
9	Apron/AC	113-321					
10	Shortfield Length	116-116					
11	Shortfield Width	116-116					
12	Hydrant/AC Prkng Spc	121-122					
13	Aerial Del Facility	141-232					
14	Access to Drop Zone						
15	Access to Refueling Tracks						
16	Base Ops	141-453					
17	Crew Readiness	141-459					
18	Weather Observation	141-629					
19	Squad Ops/AMU	141-XXX					
20	Life Support	141-753					
21	Life Spt w/ Assoc Rsrvs						
22	Air Freight Terminal	141-782					
23	Air Freight Psgr Term	141-783					
24	Air Psngr Terminal	141-784					
25	Deployment Processing Fac	141-786					
26	Air Traffic Control Twoer	141-962					
27	Radar Apprch Control						
28	Simulator Trng Fac	171-212					
29	Field Trng Fac	171-618					
30	Hangar	211-111					
31	Gen Maint Shops	211-152					
32	Covered Acft MX Space						
33	COMBS	442-758					

Start / Checklist / Hard Req't Numbers / Cost Data / Gap Analysis / **Calculations**

Figure 10 Initial tool development *Calculations* sheet

Summary

This chapter discussed the use of a spreadsheet program as the base for the development of the tool. The conceptual development of the tool was then addressed by discussing the current process and the relationship connections developed through initial research. Finally the chapter concluded with a display of the initial development of the tool and the organization of individual sheets within the tool. The following chapter will address the results and analysis of the final tool developed through this research.

IV. Results and Analysis

Chapter Overview

This chapter provides a synopsis of the research findings realized through the development of the Air Mobility Beddown Planning Tool. This will be accomplished through discussions of the final tool construction, user interfaces, macros, flow and connections within the tool. This will be followed by an analysis and report of significant findings according to the research objectives laid out in Chapter I and the research design laid out in Chapter III. Within the analysis portion of this chapter there will be an investigation into the current validation accomplished on this tool.

Final Tool Development

The controlling factors have been identified as the type and number of aircraft, location, time frame for decision, infrastructure requirements, available infrastructure, and ROM cost, the quantification of these factors was fairly straightforward. The type of aircraft was limited to AMC's major airframes. The location and timeframe depend on the scenario being analyzed. The number of aircraft is related to the primary assigned aircraft. Infrastructure requirements are laid out in AFH 32-1084 and the available infrastructure is location dependent. The ROM is driven by the shortfall amounts and the line item costs listed in UFC 3-701-3. All of these factors have been implemented into the spreadsheet based tool in various methods, and the following discussion will describe the interactions and connections of these factors.

Figure 11 displays the relationships between the various sheets within the Air Mobility Beddown Planning tool. All of the diamond shaped boxes are user interaction sheets. Here the user either makes a selection or inputs pertinent information. All of the rectangular boxes are resident information type sheets. This means that the information does not change or is related to a specific scenario and is not visible to the user. Information is transferred to and from these sheets as well as performing calculations. The circles represent the output that the user can view. Arrow connectors represent the flow from the users' perspective and the circle connectors represent the flow of information in the background of the tool. The final tool contains a total of 25 sheets, to include four user interaction sheets, six calculation sheets, four resident information sheets, and six gap analysis and graphical output sheets. To perform all of the data transfer and chart development tasks, there are over 250 lines of code. The following discussion will detail function of each sheet within the tool starting with the user interface sheets and finishing with the resident and calculation sheets.

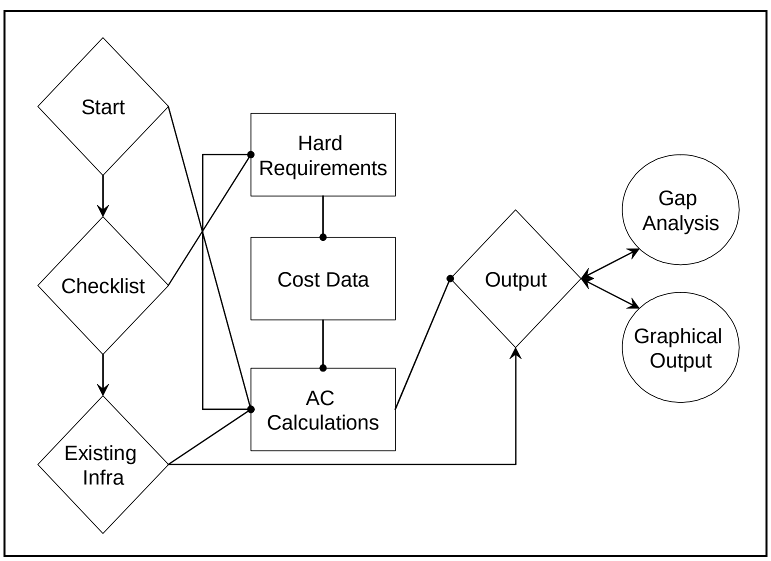

Figure 11 Air Mobility Beddown Planning Tool Relationships

The first sheet that appears when the tool is opened is the *Instruction* sheet, Figure 12. This sheet gives the user a quick overview of how to proceed through the tool and what information is needed to perform the analysis. Also provided on this sheet are some short recommendations on what not to do, for example, the user should not turn the sheet tabs back on and use them to proceed through the tool. This will override the macros and the code operations; therefore, all of the data transfer and calculations will not be completed as originally intended. To begin scenario analysis, the user clicks the Start button to proceed to the *Start* sheet.

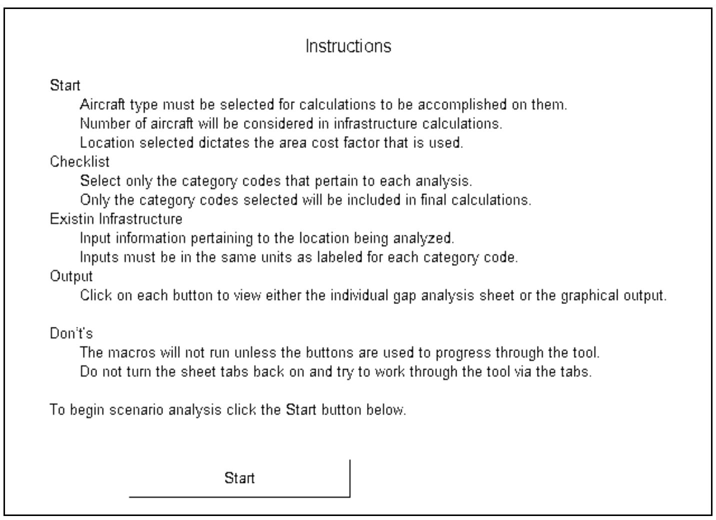

Figure 12 Air Mobility Beddown Planning Tool *Instruction* sheet

On the *Start* sheet, Figure 13, the user will select the aircraft type, number, and location as per the scenario being analyzed. The selections made by the user will be the basis of the calculations and by clicking the To "Checklist" button a macro will transfer the information to a calculation sheet. The aircraft type must be selected for the tool to perform any calculations. The user may also use the Reset button to start over and make a new selection.

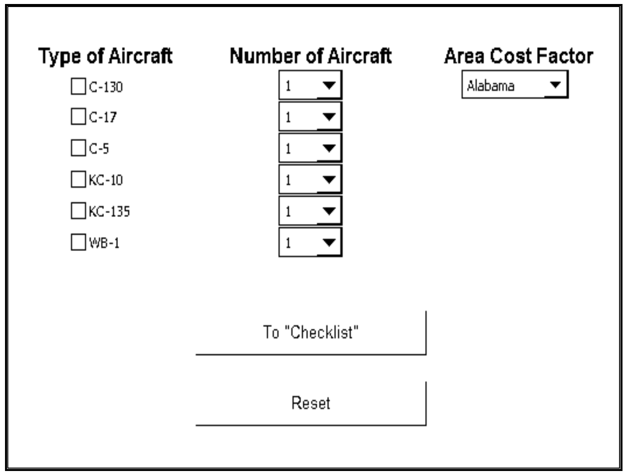

Figure 13 Air Mobility Beddown Planning Tool *Start* sheet

Once the user has made their selection on the *Start* sheet, they can then proceed onto the *Checklist* sheet, Figure 14. This sheet contains all direct mission support infrastructure that could be considered when planning a permanent aircraft beddown. On this sheet the user has the ability to select any and all category codes that pertain to the analysis being conducted. An item must be selected if it is to be considered in the gap analysis calculations. Any item not selected will return a zero when the output is produced. By clicking on the To “Existing Infrastructure” button the user proceeds on to the next interaction sheet and the macro runs a code to transfer each item selected.

Check All That Apply		
☑	**CHECK HERE IF ALL APPLY**	Clear All
☑	Runway Length	111-111
☑	Runway Width	111-111W
☑	Taxiway Width	112-211
☑	Apron/AC	113-321
☑	Petroleum Ops Building	121-111
☑	Hydrant/AC Prkng Spc	121-122
☑	Radar Apprch Control	134-375
☑	Aerial Del Facility	141-232
☑	Base Ops	141-453
☑	Crew Readiness	141-459
☑	Weather Observation	141-629
☑	Squad Ops/AMU	141-XXX
☑	Life Support	141-753
☑	Life Spt w/ Assoc Rsrvs	
☐	Air Freight Terminal	141-782

Figure 14 Air Mobility Beddown Planning Tool *Checklist* sheet

Now that the user has selected the aircraft type and number, location, and pertinent category codes, they will proceed on to the *Existing Infrastructure* sheet, Figure 15. Here the user will input any information that is known about the location being analyzed. The information must be in the same units as is labeled on the sheet and must be input in the column of the aircraft type that is being analyzed. If the worst-case-scenario is the desired analysis then the user will not input any information on this sheet and will proceed on to the final user interface by clicking the Calculate button.

	Cat Code	Units	C-130J	C-17	C-5	KC-10	KC-135	WB-1
Runway Length	111-111	ft						
Runway Width	111-111W	ft						
Taxiway Width	112-211	ft						
Apron/AC	113-321	sq yd						
Petroleum Ops Building	121-111							
Hydrant/AC Prkng Spc	121-122	%						
Radar Apprch Control	134-375	sq ft						
Aerial Del Facility	141-232	sq ft						
Base Ops	141-453	sq ft						
Crew Readiness	141-459							
Weather Observation	141-629	sq ft						
Squad Ops/AMU	141-XXX	sq ft						
Life Support	141-753	sq ft						
Life Spt w/ Assoc Rsrvs		sq ft						
Air Freight Terminal	141-782	sq ft						
Air Freight/Psgr Term	141-783	sq ft						
Air Psngr Terminal	141-784	sq ft						

Figure 15 Air Mobility Beddown Planning Tool *Existing Infrastructure* sheet

The final user interface is the *Output* sheet, Figure 16. This sheet does not show any actual output but gives the user the option of how the output is to be viewed. Each aircraft type has its own *Gap Analysis* sheet, Figure 17, and its own *Graph* sheets, Figure 18. The user selects the view by clicking on the button corresponding to either the gap analysis or graphical outputs which are all arranged according to aircraft type.

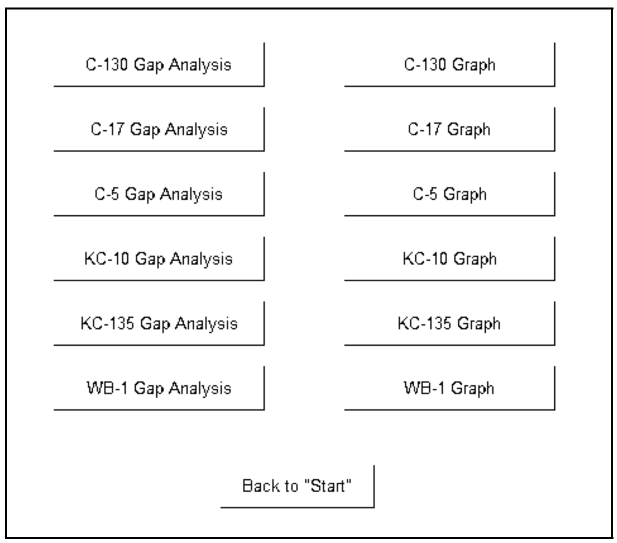

Figure 16 Air Mobility Beddown Planning Tool *Output* sheet

The *Gap Analysis* sheet, Figure 4-7, is aircraft specific and organized by category code. The output displays the facility type, category code, shortfall amount in English and Metric units, and cost in thousands of dollars. At the bottom of the sheet is a ROM total for that aircraft type. This is the output requested by AMC/A75R and it enables simple and speedy transfer of the data to planning documents that are used by AMC as well as the installation considered for the beddown.

		C-130 Shortfall				Cost
	Cat Code	English	Units	Metric	Units	($K)
Number of Aircraft		12.00	ft	12.00		
Tail Height		38.40	ft	12.80	m	
Aircraft Wingspan		132.60	ft	44.20	m	
Aircraft Length		99.50	ft	33.17	m	
Min dist btw wings (prkd)		Req't Met	ft		m	
Runway Length	**111-111**	8,000.00	ft	2,666.67	m	$12,247
Runway Width	**111-111W**	150.00	ft	50.00	m	
Taxiway Width	**112-211**	75.00	ft	25.00	m	$2
Apron/AC	**113-321**	8,550.00	sq yd	7,182.00	sq m	$785
Petroleum Ops Building	**121-111**	Req't Met	sq ft	Req't Met	sq m	n/a
Hydrant/AC Prkng Spc	**121-122**	0.75	%	0.75	%	$1
Radar Apprch Control	**134-375**	8,000.00	sq ft	746.40	sq m	$1,145
Aerial Del Facility	**141-232**	33,400.00	sq ft	3,116.22	sq m	$4,780
Base Ops	**141-453**	11,815.00	sq ft	1,102.34	sq m	$1,691
Crew Readiness	**141-459**	Req't Met	sq ft	Req't Met	sq m	n/a
Weather Observation	**141-629**	400.00	sq ft	37.32	sq m	$57
Squad Ops/AMU	**141-XXX**	39,978.00	sq ft	3,729.95	sq m	$5,722
Life Support	**141-753**	Req't Met	sq ft	Req't Met	sq m	n/a
Life Spt w/ Assoc Rsrvs		Req't Met	sq ft	Req't Met	sq m	n/a
Air Freight Terminal	**141-782**	Req't Met	sq ft	Req't Met	sq m	n/a
Air Freight/Psgr Term	**141-783**	Req't Met	sq ft	Req't Met	sq m	n/a
Air Psngr Terminal	**141-784**	Req't Met	sq ft	Req't Met	sq m	n/a
Deployment Processing Fac	**141-786**	Req't Met	sq ft	Req't Met	sq m	n/a
Air Traffic Control Tower	**149-962**	4,955.00	sq ft	462.30	sq m	$2,765
Simulator Trng Fac	**171-212**	Req't Met	sq ft	Req't Met	sq m	n/a
Field Trng Fac	**171-618**	39,600.00	sq ft	3,694.68	sq m	$5,668
Hangar	**211-111**	26,555.00	sq ft	2,477.58	sq m	$5,084
Gen Maint Shops	**211-152**	39,000.00	sq ft	3,638.70	sq m	$5,770
Covered Acft MX Space		0.15	sq ft	0.01	sq m	$0

Figure 17 Air Mobility Beddown Planning Tool *Gap Analysis* sheet

The graphical output is displayed on the same sheet but has varying capability. The graph on the left in Figure 18 is sample combined output for one aircraft type. This graph has major facility groups as the X-axis and cost as the Y-axis. The left cost axis is facility group total cost in millions of dollars and the right cost axis is a running cumulative total cost in millions of dollars. The graph on the right is a representative sample of the drill-down capability of the tool. This graph represents the facility group from the graph on the left broken down into specific category codes and their individual cost in thousands of dollars.

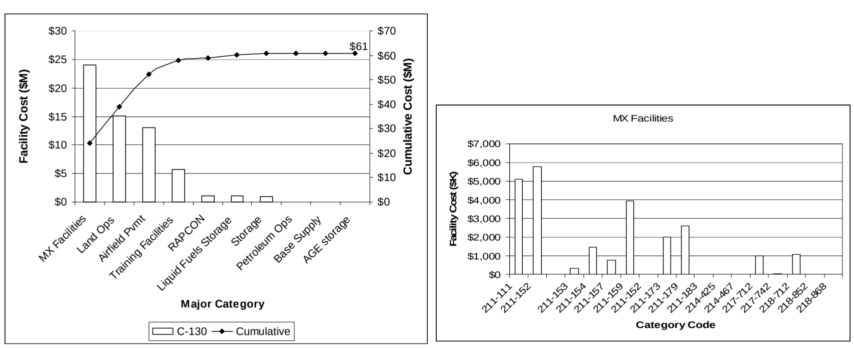

Figure 18 Air Mobility Beddown Planning Tool *Graph* sheets

With all of the user interface sheets and their functions discussed, we must progress onto the sheets of the tool that the user will not interact with. The first sheet to be discussed contains the hard requirements for each aircraft type and is organized by category code. This sheet remains hidden from the users view to keep the data safe from tampering. All numbers were extracted directly from AFH 32-1084. There are a few infrastructure requirements that require the use of tabled information from the regulation. For this research the worse-case-scenario has been chosen. Figure 19 below, displays a sample of this sheet.

	Cat Code	Units	C-130J	C-17	C-5	KC-10	KC-135	WB-1
Number of Aircraft		ft	14	12	16	12	12	12
Tail Height		ft	38 4	55.1	65 1	58.1	41 7	58 1
Aircraft Wingspan		ft	132.6	170	222.7	165 3	130.8	170
Aircraft Length		ft	99 5	173	247 8	182.1	136 2	182 1
Min dist btw wings (prkd)		ft	20	25-50	25-51	50	50	50
Runway Length	**111-111**	ft	8 000	9.000	11 000	12.000	12 000	12000
Runway Width	**111-111W**	ft	150	150	150	150	150	150
Taxiway Width	**112-211**	ft	75	75	75	75	75	75
Apron/AC	**113-321**	sq yd	8.550	17 319	32.497	17 726	10.491	17726
Petroleum Ops Building	**121-111**							0
Hydrant/AC Prkng Spc	**121-122**	%	0 75	0.75	0 75	0.75	0 75	0 75
Radar Apprch Control	**134-375**	sq ft	8000	8000	8000	8000	8000	8000
Aerial Del Facility	**141-232**	sq ft	33.400	33 400	33.400	0	0	33400
Base Ops	**141-453**	sq ft	11815	11815	11815	11815	11815	11815
Crew Readiness	**141-459**							0
Weather Observation	**141-629**	sq ft	400	400	400	400	400	400
Squad Ops/AMU	**141-XXX**	sq ft	39.978	41 929	42.303	41 475	40.860	41929
Life Support	**141-753**	sq ft		14.388	14 388			14388
Life Spt w/ Assoc Rsrvs		sq ft		17 988	17.988			17988
Air Freight Terminal	**141-782**	sq ft		249.000	227 000			249000
Air Freight/Psgr Term	**141-783**	sq ft						0
Air Psngr Terminal	**141-784**	sq ft		35.000	35 000			35000
Deployment Processing Fac	**141-786**	sq ft						0
Air Traffic Control Tower	**149-962**	sq ft	4955	4955	4955	4955	4955	4955
Simulator Trng Fac	**171-212**	sq ft						0
Field Trng Fac	**171-618**	sq ft	39 600					0
Hangar	**211-111**	sq ft	26.555	48 760	81.000	48 760	48.760	48760
Gen Maint Shops	**211-152**	sq ft	39 000	80.000	80 000	48.000	48 000	80000
Covered Acft MX Space		sq ft	0 15	0.20	0 16	0.25	0 15	0 25
NDI/Base	**211-153**	sq ft	5000	5000	5 000	5.000	5 000	5000
Arcrft Org MX Shop	**211-154**	sq ft	10.000	2 000	7.000		4.000	2000
Eng I&R/Squad	**211-157**	sq ft	5 200	10 000	10 000	10 000	10 000	10000

Instructions / Start / Checklist / **Hard Req't Numbers** / Existing Infrastructure / Output / Cost Data / C-130

Figure 19 Air Mobility Beddown Planning Tool *Hard Requirement* sheet

The next resident information sheet is the *Cost Data* sheet. This sheet contains the average cost data for facility types using prior year construction throughout the Department of Defense (UFC 3-701-3 & Historical Air Force Construction Cost

Handbook). Also included in this sheet are the area cost factors organized by state. Figure 20 displays a sample of this sheet. These factors will be included in the calculations according to the users input at the start of the analysis. AMC/A75R requested that the user maintain the ability to choose the area cost factor or change the line item average cost at their will. These types of changes will be done on an individual analyst basis and will be done through instructions in the users' manual.

	Cat Code	Units		Area
				Alabama
				Alaska
				Arizona
				Arkansas
				California
Runway	**111-111**	sq yd	$92	Colorado
				Connecticut
Taxiway	**112-211**	sq yd	$92	Delaware
Apron/AC	**113-321**	sq yd	$92	Florida
Petroleum Ops Building	**121-111**	sq ft	$143	Georgia
Hydrant/AC Prkng Spc	**121-122**	%	$144 gpm	Idaho
Radar Apprch Control	**134-375**	sq ft	$143	Illinois
Aerial Del Facility	**141-232**	sq ft	$143	Indiana
Base Ops	**141-453**	sq ft	$143	Iowa
Crew Readiness	**141-459**	sq ft	$143	Kansas
Weather Observation	**141-629**	sq ft	$143	Kentucky
Squad Ops/AMU	**141-753**	sq ft	$143	Louisiana
Life Support	**141-753**	sq ft	$143	Maine
Life Spt w/ Assoc Rsrvs		sq ft	$143	Maryland
Air Freight Terminal	**141-782**	sq ft	$143	Massachusetts
Air Freight Psgr Term	**141-783**	sq ft	$143	Michigan
Air Psngr Terminal	**141-784**	sq ft	$143	Minnesota
Deployment Processing Fac	**141-786**	sq ft	$143	Mississippi
Air Traffic Control Twoer	**149-962**	sq ft	$558	Missouri
Simulator Trng Fac	**171-212**	sq ft	$164	Montana
Field Trng Fac	**171-618**	sq ft	$143	Nebraska
Hangar	**211-111**	sq ft	$191	Nevada
Gen Maint Shops	**211-152**	sq ft	$148	New Hampshir
Covered Acft MX Space		sq ft		New Jersey
COMBS	**442-758**	sq ft	$70	New Mexico
NDI/Base	**211-153**	sq ft	$148	New York
Arcrft Org MX Shop	**211-154**	sq ft	$148	North Carolina

Instructions / Start / Checklist / Hard Req't Numbers / Existing Infrastructure / Output / **Cost Data** / C-130 G

Figure 20 Air Mobility Beddown Planning Tool *Cost Data* sheet

Finally, each aircraft type has a sheet dedicated to calculations. These sheets are filled with data from the *Hard Requirements*, *Existing Infrastructure*, and *Cost Data* sheets and combine all calculations onto one sheet. These sheets are hidden from the users view only to be operational in the background. Computer code operates macros that transfer data to and from these sheets and equations are maintained here. Figure 21 shows a sample *Calculations* sheet from the tool.

C-130	Cat Code	Hard Req't	Existing	Shortfall/Overage	Line Cost	Total Cost	Metric untis
Number of Aircraft		12	0	12			
Tail Height		0	0	38			13
Aircraft Wingspan		0	0	133			44
Aircraft Length		0	0	100			33
Min dist btw wings (prkd)		0	0	Req't Met	$0		
Runway Length	**111-111**	8000		8.000	$92	$12.246.667	2.667
Runway Width	**111-111W**	150		150			50
Taxiway Width	**112-211**	75		75	$92	$2.296	25
Apron/AC	**113-321**	8550		8.550	$92	$785.318	7.182
Petroleum Ops Building	**121-111**			Req't Met	$143	n/a	Req't Met
Hydrant/AC Prkng Spc	**121-122**	0.75		1	$144	$1.300	0.75
Radar Apprch Control	**134-375**	8000		8.000	$143	$1.144.960	746
Aerial Del Facility	**141-232**	33400		33.400	$143	$4.780.208	3.116
Base Ops	**141-453**	11815		11.815	$143	$1.690.963	1.102
Crew Readiness	**141-459**			Req't Met	$143	n/a	Req't Met
Weather Observation	**141-629**	400		400	$143	$57.240	37
Squad Ops/AMU	**141-XXX**	39978		39.978	$143	$5.721.651	3.730
Life Support	**141-753**			Req't Met	$143	n/a	Req't Met
Life Spt w/ Assoc Rsrvs				Req't Met	$143	n/a	Req't Met
Air Freight Terminal	**141-782**			Req't Met	$143	n/a	Req't Met
Air Freight/Psgr Term	**141-783**			Req't Met	$143	n/a	Req't Met
Air Psngr Terminal	**141-784**			Req't Met	$143	n/a	Req't Met
Deployment Processing Fac	**141-786**			Req't Met	$143	n/a	Req't Met
Air Traffic Control Tower	**149-962**	4955		4.955	$558	$2.764.543	462
Simulator Trng Fac	**171-212**			Req't Met	$164	n/a	Req't Met
Field Trng Fac	**171-618**	39600		39.600	$143	$5.667.552	3.695
Hangar	**211-111**	26555		26.555	$191	$5.084.486	2.478
Gen Maint Shops	**211-152**	39000		39.000	$148	$5.770.050	3.639
Covered Acft MX Space		0.15		0		$0	0
COMBS	**442-758**	5000		5.000	$70	$348.100	467
NDI/Base	**211-153**	10000		10.000	$148	$1.479.500	933
Arcrft Org MX Shop	**211-154**	5200		5.200	$148	$769.340	485

C-5 Graph / KC-10 Graph / KC-135 Graph / WB-1 Graph \ **C-130 Calc** / C-17 Calc / C-5 Calc / KC-10 Calc / KC-135 Calc / W

Figure 21 Air Mobility Beddown Planning Tool *Calculation* sheet

Research Findings

Objective 1 - Understand the Current What-if Scenario Process

In order to develop this tool, there had to be an understanding of the current what-if analysis process being used at AMC/A75R. This includes identifying the controlling factors, quantifying those factors, and the relative importance of each. The four key factors are: type and quantity of aircraft, the planned beddown location, and the time constraints. These factors were identified through current directives for infrastructure requirements, as well as discussions with current analysts. The planned beddown location for each scenario is limited to AMC installations. The “when” factor for each scenario translates into a cost factor increase for future year’s work. Each aircraft type has a specific squadron size that will be included as the standard and is also known as the primary assigned aircraft (PAA); however, there will be an option to go outside that standard.

With the four factors addressed above, the analysts use a simple table matrix of requirements that has been developed for these scenarios. This table includes the aircraft type on the left axis and the infrastructure items according to category code across the top axis. This matrix gives a per aircraft estimate for each infrastructure category code as listed in AFH 32-1084. This estimated amount is used to calculate through various iterations the amount of each infrastructure item needed.

Next, there is a compilation of available infrastructure at the location in question. The current infrastructure available is compared to the hard requirements in the directives. Depending on how far along in the analysis is in the beddown process, there begins a kind of bargaining process between AMC and the installation in question. The tool developed from this research is intended for use very early in the planning process, before extensive bargaining occurs.

Finally, with the list of shortfalls, a cost estimate is developed using historic cost factors, published facility-type costs, area cost factors, and future cost factors (UFC 3-701-3 & Historical Air Force Construction Cost Handbook). The only typically requested number is the final total cost or the rough order of magnitude (ROM); however, to aid the staff at AMC/A75R, the tool provides a breakdown of the final gap analysis in a format similar to what is required for planning documents.

Objective 2 - Link the Controlling Factors Together

The second objective was to link the controlling factors together. Figure 4 displays the conceptual linkage and Figure 11 displays the linkage as implemented into the tool. Aircraft type drives the required infrastructure from the directives. The location being analyzed fills the current infrastructure availability and drives the location cost factors. The time frame for the beddown process also drives the future cost factors. The difference between the required and current infrastructure generates the list of shortfalls. These shortfalls and their related cost factors drive the ROM. Inputs that do not change with the analysis are the directives and headquarters' guidance via AMC design guides.

This objective continued to resolution with deciding which decision analysis tool is best suited for this problem and how to implement it. After investigation of the directives used for these scenarios and discussing the process with the analysts at AMC/A75R, a spreadsheet was chosen as the basis for this tool. Spreadsheets are well suited for tables of information, its uses of references for equations, and the simple transfer of information from one sheet to the next. The requirements laid out in AFH 32-1084 were easily extracted and organized into tables in a worksheet. This is where the tool began to take shape.

Objective 3 - Investigation of Implementation Issue That May Arise

The third objective was to investigate the implementation issues that may arise with the introduction of the new tool. There are many published articles available discussing implementation issues with new technology; matter of fact, there are complete research areas in technology acceptance. As addressed in the literature review, the two most significant factors affecting technology acceptance were found to be perceived usefulness and perceived ease of use (Davis et al., 1989).

This research began because of perceived usefulness in trying to codify corporate knowledge pertaining to beddown planning. This does not however, affect the perceived usefulness to the analysts after the research has been done and the tool has been constructed. To alleviate this implementation issue, we demonstrated to A75R analysts that this tool saves the analyst time and energy by eliminating the need to use and maintain separate copies of the regulations. The required information has been consolidated into one centralized location and even if the information is flawed the analysts have the ability to correct it. This tool will be perceived useful to the new analysts that come into the office because of their lack of scenario analysis and familiarity with the regulations. The more senior analysts may hesitate in their commitment to using this tool because of their vast knowledge of the regulations.

The implementation issue dealing with perceived ease of use has been attacked in multiple ways. The first mitigating item is the introduction sheet, *Instructions*, that has been implemented as the starting point for any new scenario analysis. This sheet gives the user a quick overview of the tool with instructions for using the tool as well as cautions for what not to do. The next line of defense is the limitation of user inputs needed. The controlling factors for analysis have been laid out on the Start sheet with simple check boxes and list choices. Also at this point, the user can only use buttons that go forward through the tool or back to the instructions. This limits the chance that the user will go to different sheets without using the buttons. Finally the tabs at the bottom of the page have been removed to keep the user from jumping to other sheets and not activating the macros in the background.

Objective 4 - Validate the Tool Using a Historic Scenario

The final objective was to validate the tool using a historic scenarios as well as a current day scenario. Due to inaccurate logic developed in the original Air Mobility Beddown Planning Tool, the originally planned validation was not accomplished; however, there has been an extensive amount of face validation accomplished. The following discussion will detail the validation accomplished through user analysis and exercising the tool to ensure calculations are working. Chapter V will discuss future work to validate this tool using a suitable historic and current day scenario.

The tool developed through this research went through many iterations of design via the inputs from the analysts at AMC/A75R and the C-17 System Program Office (SPO). The introduction to AMC/A75R occurred in April of 2004 at the European En-Route Infrastructure Steering Committee conference. AMC had a foreseeable loss of a longtime analyst and the individual's corporate knowledge. In June 2004 this researcher visited AMC to collect information and data to begin developing the methodology and basis for the research. The initially developed tool was taken to the C-17 Site Activation Task Force III at Altus AFB, Oklahoma in December 2004. Here the tool was investigated by individuals from Air Education and Training Command, Altus AFB, and AMC. Inputs were given for more detailed information and tool refinements. A meeting was conducted with the C-17 SPO in January 2005. Again and with a more refined tool, the tool's progress was inspected and additional inputs where given. Finally the completed tool was taken to AMC in February 2005 for a final examination. The analysts thoroughly investigated the tool for any incomplete areas, information, and processes. Final adjustments were made to include the addition of a generic widebody aircraft type, English and metric units, and the desired view of outputs. This research created a movement in their office to investigate more deeply the thought process and mental checklist that is used when analyzing a scenario and the tool developed through this research acted as a catalyst to this process.

By making additional infrastructure available for analysis, the Air Mobility Beddown Planning Tool will calculate those differences and report them to the user. Figure 22 displays the graphical output of C-130 beddown analysis with no known existing infrastructure. By including available infrastructure in the analysis, Figure 23, the tool will show a change in the highest major cost areas. Total maintenance facility cost will decrease slightly but airfield pavements, land ops, and radar facilities will decrease in cost as well as the overall rough order of magnitude.

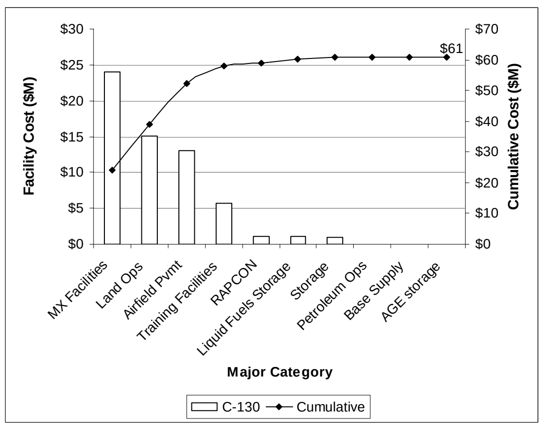

Figure 22 *C-130 Graph* sheet (no existing infrastructure)

	A	B	C	D	E
1		Cat Code	Units	C-130	C-17
7	Runway Length	111-111	ft	10,000	
8	Runway Width	111-111W	ft	150	
9	Taxiway Width	112-211	ft	75	
10	Apron/AC	113-321	sq yd		
11	Petroleum Ops Building	121-111			
12	Hydrant/AC Prkng Spc	121-122	%	0.75	
13	Radar Apprch Control	134-375	sq ft	8000	
14	Aerial Del Facility	141-232	sq ft	33,400	
15	Base Ops	141-453	sq ft	11815	
16	Crew Readiness	141-459			
17	Weather Observation	141-629	sq ft	400	
18	Squad Ops/AMU	141-XXX	sq ft	39,978	
19	Life Support	141-753	sq ft		
20	Life Spt w/ Assoc Rsrvs		sq ft		
21	Air Freight Terminal	141-782	sq ft		
22	Air Freight/Psgr Term	141-783	sq ft		
23	Air Psngr Terminal	141-784	sq ft		
24	Deployment Processing Fac	141-786	sq ft		
25	Air Traffic Control Tower	149-962	sq ft	2000	
26	Simulator Trng Fac	171-212	sq ft		
27	Field Trng Fac	171-618	sq ft	10,000	
28	Hangar	211-111	sq ft	5,000	
29	Gen Maint Shops	211-152	sq ft	0	
30	Covered Acft MX Space		sq ft	0.15	
31	NDI/Base	211-153	sq ft	1000	
32	Arcrft Org MX Shop	211-154	sq ft	2,000	
33	Eng I&R/Squad	211-157	sq ft	5,200	

Figure 23 *Existing Infrastructure* sheet (including additional infrastructure)

Figure 24 displays the predicted change in requirements and total cost by including existing available infrastructure in the analysis. The graphical output maintains a set scale to give the user a comparable view in the changes.

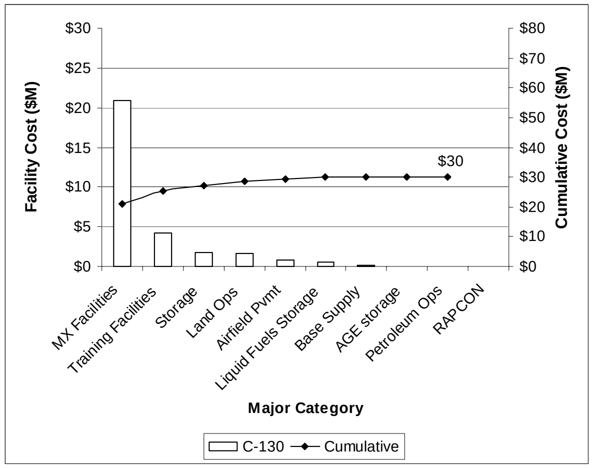

Figure 24 *C-130 Graph* sheet (additional existing infrastructure)

Summary

This chapter detailed the findings realized through the final development of the Air Mobility Beddown Planning Tool via the implementation of the research design specified in Chapter III. The controlling factors were identified and linked in their relationships. The tool's flow through user inputs as well as computer coded macros was discussed in detail to understand its function and logic. The research findings were discussed in order of the each research objectives and analyzed as implemented in the beddown planning tool. The implementation issues and validation process were then discussed. The next chapter will present observations on the tool developed by this research as well as conclusions and recommendations for future research.

V. Conclusions and Recommendations

Recommendation

We recommend that AMC/A75R use the Air Mobility Beddown Planning Tool developed by this research for rough cut analysis. At this stage of development, the tool is ready for worst case scenario use and will give accurate outputs for such analysis. The outputs developed stand as excellent checklists for beddown planning requirements. This tool stands as contribution in the right direction and shows the added benefit of a correctly designed information technology system. The remainder of the chapter discussed the specific contributions and shortfalls of this research as well as information for future research areas.

The investigation into the air mobility beddown planning process concludes in this chapter by discussing the researcher's observations about the tool developed and recommendations for future research. Observations on the tool are detailed by the positives and negatives it may bring to AMC/A75R's beddown scenario analysis. This chapter concludes with a summary of the research project.

As a completed deliverable of this research, this tool stands only as a good start in the air mobility beddown planning process. At this time the tool will operate only as a worse-case-scenario tool without consideration of existing infrastructure. This will limit AMC/A75R's use but will be a good starting point for any analysis they must accomplish.

Conclusion

Contribution

The development of this air mobility beddown planning tool has ended with many positive outcomes. Corporate knowledge within the AMC/A75R office has been codified, analysis time has been decreased, analysis results are repeatable, the tool is extremely portable, and it will provide a quick training tool for quick spin up of analysts. The next few paragraphs will go into more detail on each positive impact that has developed.

An original principle from the birth of this research was to capture the corporate knowledge of longtime analysts in the AMC/A75R office. It is the opinion of this researcher that this has been accomplished, although not to its fullest extent. This research project has acted as a catalyst for the analysts in AMC/A75R office. They have begun to take deep long looks at how they do business and how they can codify corporate knowledge and process that are taken for granted on a daily basis.

The biggest benefit as perceived by this researcher and AMC/A75R is the amount of time is takes to complete the analysis. All of the infrastructure requirements are compiled into one place and organized in a way that makes sense to the analysts. By organizing the information by aircraft type and category code, the gap analysis output is in a format that is easily transferred to planning documents. The amount of time it takes to compile the necessary information and make the calculations has been drastically reduced.

In the past a scenario would be given to five individual analysts for their analysis and it could result in five different results. With the development of this tool the gap analysis and beddown planning will consistently be the same. Given the tool developed by this research and the same scenario, the same five analysts will develop the same gap analysis output. This will reduce the disparity between analysts and ensure repeatable analysis for the same scenario.

With the mobile environment that the Air Force and AMC/A75R live in today, the tool developed by this research is a perfect fit. The tool is very portable and can quickly and easily be loaded onto a laptop. The total file size and computer processing requirements to run this tool are very minimal. The last look by the researcher showed that the tool was fewer than 400 KB in file size.

An unintended positive benefit of this research is the training potential that has developed from the construction of this tool and the thought process behind the planning process. This research created a movement in their office to investigate the thought process and mental checklist that is used when analyzing a scenario and the tool developed through this research acted as a catalyst to this process. AMC/A75R is ramping up for the year 2005 round of Base Re-alignment and Closure process. By developing their thought process and using the tool that has already been developed by this research, there is now an ability to quickly train a new analyst as more work and analysts enter their office.

Limitations

The following discussion addresses the Air Mobility Beddown Planning Tool's limitations in its current state of development. This section will address improvements need for model fidelity through the following actions: accomplish validation through historic scenario, incorporate recent AMC clarifications, establish connectivity to cost and existing infrastructure data, add indirect operations support infrastructure, time factors, multiple aircraft analysis. Each item will be discussed in further detail below.

The first additional requirement to be addressed is accomplishing validation through a historic scenario. The tool went through many iterations of design via the inputs from the analysts at AMC/A75R. It was thoroughly investigated by their office; however, it was never checked for accuracy using a suitable historic scenario. This limits the immediate usability of the tool when it is delivered too them, but gives them an excellent start point to refine what has already been accomplished.

The next area for improvement is the need to incorporate recent AMC clarifications. As discussed in Chapter IV, there were multiple assumptions made about the decision logic that was implemented into the analysis tool. AMC/A75R has had the chance to lay out their process more completely and continue to refine their process. The new decision logic is now available and could easily be incorporated into this tool. This logic is most directly related to existing infrastructure at a location being analyzed.

A third area for improvement is related to the benefit added by establishing electronic connectivity to cost information. The original concept of the tool included an interface with PACES so that the cost portion of the tool did not have to be manually updated whenever there is a change in average prices. The user was not fully enamored with this type of interaction and wanted a more user interactive/user specific type of cost estimating portion. This limits the durability of the tool developed. By making the cost updates manual, there has been no added efficiency over the original process.

Along with the cost is a parallel need to establish electronic connectivity with existing infrastructure data. The originally concept of the tool included an electronic connection to a database containing installation infrastructure. Due to inaccuracies in the existing infrastructure database and time constraints in the educational process, interaction between this tool and an infrastructure database was not implemented. Because of the inability to implement this portion the methodology, the calculation logic lays out a worse-case-scenario situation. User benefits would included reduced research time for locations being analyzed and confidence in the existing infrastructure model inputs.

Finally, the lack of the tool's ability to analyze multiple aircraft type scenarios is the greatest limitation. Today's Air Force is no longer a one wing installation but a multiple flying operation installation. This is especially true with the newest round of Base Realignment and Closure proceedings looming in the near future. As a corporation the Air Force is going to have to deal with multiple missions at single locations. The ability of the tool to consider multiple aircraft types in one analysis would greatly benefit AMC/A75R.

Future Research

There are almost limitless possibilities for future work on this type of research and decision analysis tool. This research focused on facility infrastructure, but this type of research could stretch into the logistics side of business to deal with manpower needs, equipment needs, training needs, etc. This could even possibly stretch into the operations and maintenance side of Air Force business. For the near term research there are a few specific areas that must be investigated further.

First would be the completion and addition of corrected AMC/A75R logic into the currently developed tool. AMC/A75R has continued to investigate and upgrade logic in the beddown process. Updates with them and their work will enhance the outcome of this tool. Their logic charts display detailed thought and operations in a computer programming type of thought with distinctive requirements for user inputs and displayed output reports.

The next major area for future work would be the integration of the existing infrastructure and cost factors electronically into the tool. The data is there and in electronic form, but the difficulty is in the science behind communication between different information technologies. ACES RP and PACES are good information systems and could be implemented into the tool by someone with higher understanding of technological interactions. Along the same lines as the items above, would be the addition and implementation of pavement condition index (PCI) information into this tool. This information is readily available from AFCESA and is never more than five years old. The corrected logic provided by AMC/A75R includes the consideration of PCI ratings when calculating the shortfalls for the runways, taxiways, and aprons.

Two final areas of added benefit would be the implementation of a bi-directional analysis for beddown planning and an incorporation of a decision analysis framework for qualitative issue assessment. The bi-directionality of the tool would allow the user to pick a location and give an analysis of what type and how many aircraft could be added to the location without increasing infrastructure needs. The decision analysis framework for qualitative issue could be implemented to handle the vast amount of environmental issues that go along with new mission beddown and even take the tool to the level of giving a rank order of beddown locations to include not only cost but environmental issues, noise issues, and encroachment issues to list a few.

Summary

This chapter discussed the positive and negative impact for AMC/A75R by the researcher's observations. Also the recommendations for future research were discussed and explained in short detail. The purpose of this research is to develop a decision analysis tool that takes hard requirements and compares them with existing capabilities, and through gap analysis produce infrastructure requirement shortfalls and associated costs to satisfy these shortfalls. This was accomplished by identifying the key factors to when conducting beddown planning, quantifying those factors, linking those factors together according to their relationships, and investigating the potential issues that could arise with implementation and how those issues might they be addressed.

This research was sponsored by AMC/A75R to provide an understanding of the decision analysis process that occurs during beddown planning scenarios. This researcher is confident that the full understanding has not been accomplished but that an excellent start in the right direction has been made. This research and the tool developed by it will benefit the office of AMC/A75R in both training and analysis, and will initiate their office to continue to refine the logic they develop.

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14. ABSTRACT

Currently at Air Mobility Command, Plans and Programming, Requirements Division (AMC/A75R), infrastructure requirements for a proposed permanent beddown location are accomplished through corporate knowledge and manual lookup. With the loss of corporate knowledge in the foreseeable future, AMC/A75R is would like to capture this knowledge base in an information system. This research developed a spreadsheet analysis tool that takes hard requirements and compares them with existing capabilities at a given location. Through gap analysis, the tool produced infrastructure requirement shortfalls and associated costs to satisfy the shortfalls.

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