



## **ACCESS BASED COST ESTIMATION FOR BEDDOWN ANALYSIS**

### **THESIS**

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THESIS

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### **Abstract**

The purpose of this research is to develop an automated web-enabled beddown estimation application for Air Mobility Command in order to increase the effectiveness and enhance the robustness of beddown estimates. This includes generating rough order of magnitude cost estimates for the potential beddown of air mobility assets as well as serving as a centralized data warehouse for current and future scenarios. The application developed is intended to provide the analyst with the maximum amount of both quantitative and qualitative input for any potential decision to quickly identify infrastructure requirement shortfalls and associated costs to satisfy those shortfalls. The application can also be used to train office personnel on actual beddown procedures.

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Jasper E. Pennington

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# ACCESS COST ESTIMATION FOR BEDDOWN ANALYSIS

## I. Introduction

### General Issues

In the Air Force, the *permanent* basing of units and aircraft is referred to as a beddown. According to AFI 10-503, *Base Unit Beddown Program*, a beddown specifically refers to:

“... 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 DoD, non-DoD federal, state and local governmental, and/or private agencies requesting the use of Air Force real property.”

This process encompasses a myriad of tasks to include assessing the actual site selection, environmental impacts, as well as geopolitical impacts of the proposed beddown. The actual beddown may, based on location, include existing facility analysis, airspace availability, site access (for foreign locations), as well as service and support contract requirements.

Exploring the basing options for current and future weapon systems has become more common and critical as all services strain to comply with directives from the Base Realignment and Closure (BRAC) commission. In fact, the BRAC process relies on accurate and timely data for beddown scenarios from the

services in order to generate accurate recommendations to realign units in a manner that saves money for those services.

Key to the beddown analysis is the site survey. As a minimum, a site survey will address the costs and benefits of the proposed beddown and assess potential impacts to existing missions, housing, infrastructure, manpower, and any other applicable base operating support. Site surveys should briefly address potential environmental impacts, proposed method of transaction, or any additional interest areas as required.

Air Mobility Command Planning and Programs Requirements Division (AMC/A75R) is the agency responsible to conduct the infrastructure analysis of any proposed beddown within AMC. Whenever AMC considers a potential unit move or new weapon system beddown, AMC/A75R initiates an infrastructure requirements scrub of existing facilities to identify potential shortfalls based on the new systems demand. These shortfalls are then compared to historical construction cost data to calculate a rough order of magnitude cost requirement to meet the demand of the proposed beddown.

Some specific factors effecting facility infrastructure demand are the total number of personnel, individual aircraft characteristics (runway length, hangar size, etc.), training requirements, and alert mission status. Each of these and other factors together drive specific facility requirements as outlined in AFH 32-1084, *Facility Requirements*. Historically, AMC/A75R has had to rely on professional knowledge and individual research ability to gather the necessary data for proposed beddown scenarios. Aircraft “cheat sheets” and facility real estate

binders are kept to speed up the lookup process but generally, the process is still manual at best.

This process has been habitually problematic since the department must regularly produce cost estimates with turn around suspenses as little as two hours. There is currently no data system that contains all the relevant data to conduct these types of infrastructure analysis. Several researchers have developed tools to assist in the process. As mentioned earlier, the A75R department maintains aircraft cheat sheets and retail facility binders for reference. Additionally, the staff has developed and maintains basic requirements reference charts for a handful of aircraft that are common to many of the scenarios. Still, these reference charts are far from complete and are prone to error or simply becoming outdated from aircraft or facility modification.

An earlier researcher (Salmond, 2005) examined the use of spreadsheets to incorporate the existing facility requirements matrix data into an active workbook. This showed promise in removing human calculation error but still required extensive data to be researched and added to the worksheet. As before, this data would be in danger of becoming 'stale' if there were any changes from the proponent. Consequently, planners would still have to regularly verify the data used in this tool.

By the request of A75R, further research was conducted (Kitchens, 2005) into the possibility of a similar application under Microsoft Access to facilitate ease of use. This research showed the ability of Access to conduct the

calculations as well as the spreadsheet tool but again faced the problem of ‘stale’ data.

Currently, there is no single beddown automation tool that can conduct the necessary calculation as well as facilitate the “look-up” requirements necessary to ensure that the relevant data is current.

### **Problem Statement**

The purpose of this research is to develop an automated beddown estimation application for Air Mobility Command in order to increase the effectiveness and enhance the robustness of beddown estimates. This application will make use of any available on-line resources to research the data necessary and, with that data, identify the infrastructure shortfalls and estimate cost requirements based on those shortfalls.

### **Research Objectives**

The first objective is to fully understand the complete process that AMC/A75R uses to conduct infrastructure analysis. A thorough examination of all “cheat sheets” and other references must be made to identify all sources of data and determine what assumptions, if any have been made. Whenever other sources cannot be found, it will be necessary to use existing A75R references. These references must be validated.

The second objective will be to investigate available on-line sources of data and other existing databases. The necessary protocols and network access authorizations must be understood in order to allow the application to interface as needed without violating Air Force or DoD policy.

The third objective is to develop a Microsoft Access database that conducts the necessary calculations for the economic analysis based on the data obtainable through the

on-line databases identified. And finally, the fourth objective is to verify and validate the application.

### **Research Questions**

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

1. What are the key cost driving factors to facility beddown analysis?
2. What existing databases are in use to automate the data collection process?
3. How can these different sources be brought together?
4. What security requirements must be met for the data collection process?
5. What are potential obstacles and how can they be overcome?

### **Methodology**

This research begins with detailed analysis of the existing research and automation efforts as applied to AMC/A75R beddown scenarios. Decomposition of the existing process and discussions with A75R personnel will detail the procedures and current references used for the manual beddown analysis as currently conducted by AMC.

As literature review, we will examine existing automation systems in order to determine if methods are useful for this type of application or whether data may be used or imported as necessary. Specifically, we will examine the Automated Civil Engineer System-Real Property (ACES-RP), the Parametric Cost Engineering System (PACES), the Core Automated Maintenance System For Mobility (CAMS FM - G081), the Airfield Suitability and Restrictions Report (ASRR) and the Pavement-Transportation Computer Assisted Structural Engineering (PCASE) software.

In accordance with existing AFI, the cost analysis portion of the analysis application will utilize data obtained from the Air Force Civil Engineer Support Agency (AFCESA) Historical Air Force Construction Cost Handbook.

### **Assumptions and Limitations**

Any automation software or on-line tool will have been specifically developed for some other purpose than the application we are developing. These sources will be used for raw data sources only. No underlying calculations from other software will be linked to or included in this application development.

Whenever possible, information obtained via on-line sources will be obtained from the proponent agencies for that data. As the proponent agency, we will assume that data obtained will be the most current available.

This research does not attempt to address the historical costing methods of AFCESA. The factors from the handbook will be used where applicable in any cost estimate.

### **Summary**

This chapter describes the beddown cost estimation process and AMC/A75R's responsibility in that process. This research will attempt to develop a Microsoft Access-based cost estimation application for the beddown process that eliminates much of the human error and speeds up the process by accessing existing on-line sources. To this end we will examine any existing tools as well as potential on-line sources of data and conduct discussions with A75R personnel in order to thoroughly understand and validate the internal processes and determine how best to construct the application and facilitate their needs. Last, we discussed the methodology that will be used to meet the research

objectives and the specific research questions that will reveal that objective as well as the research assumptions and limitations.

The following chapters will explore the steps necessary to answer the problem addressed by this research. Chapter II will discuss the current beddown scenario process, current tools available, and review the relevant literature. Chapter III will outline the methodology for meeting the objective and research questions of this research. Chapter IV will discuss the results and analysis of the application developed by this research. As conclusion, Chapter V will synthesize the research, discuss the implications for AMC, and recommend future research possibilities.

## **II. Literature Review**

### **Chapter Overview**

Contingency and deployment planning is the common state of affairs with the Air Force and all other services in today's global environment. Planners are regularly seeking the optimum mix of combat forces and support units to achieve the Nation's objectives in current and the various possible future operations. To support the continuing planning process, the Air Force has established basic tactics, techniques, and procedures (TTPs) to address hasty planning using pre-positioned war reserve stocks, unit capability packages, and pre-developed time-phased force deployment data (TPFDD). Very simply, we have become very good at developing and projecting these short-term unit movements to support our global operations. However, we have failed to develop similar tools and TTPs for the permanent positioning of forces under the beddown process. Ultimately, the planners conducting the beddown analysis must repeatedly begin anew with each scenario and negotiate the maze of requirements and publications for each scenario (Salmond, 2005).

Currently we are a nation at war and so our primary focus of resources is to prosecuting and ultimately, winning the battles currently underway and setting the conditions for any that may follow. We now find ourselves more than ever straining to make our defense budgets go as far as possible to maintain operations and develop the weapon systems needed for the future. Because of this, we cannot ignore cost saving initiatives such as BRAC in the current environment. Though we may *want* the Air Force

to hold up on these alignment issues, we cannot assume that the environment will stabilize any time in the immediate future. We have to continue to act now to conserve our resources and position existing and future weapon systems in a manner that is smart, supportive of the current fight, and gets the most “bang for the buck” as possible.

These initiatives are in fact more important in the current environment. As stated by Secretary Rumsfeld in the current Quadrennial Defense Review:

“We also have been adjusting the U.S. global military force posture, making long overdue adjustments to U.S. basing by moving away from a static defense in obsolete Cold War garrisons. . . . BRAC, now being implemented, will support overseas restructuring and the imperative of rapid power projection, with domestic basing that provides needed training infrastructure. BRAC changes will also promote joint and multi-Service basing in order to achieve economies of scale.” (Rumsfeld, 2006)

It is evident that the current administration is not only actively pushing to accomplish those previously planned realignments but, with the current emphasis on joint capabilities based forces, more will be coming in the future.

As mentioned in Chapter I, the Air Force has very detailed directives outlining the infrastructure requirements to support the various aircraft in the forces inventory.

Primary sources are: Air Force Handbook (AFH) 32-1084, *Civil Engineering: Facility Requirements*; Unified Facility Criteria (UFC) 3-260-1, *Airfield and Heliport Planning and Design*; aircraft specific Technical Orders (TOs); and various other design guides, Engineering Technical Letters (ETL), and Air Force Instructions (AFIs). The number of

hard copy sources needed to identify the requirements and characteristics relevant to any particular beddown scenario can quickly become daunting.

To combat some of the mystery and minimize the amount of “sleuthing” a beddown analyst must undertake, AMC/A75R has developed quick reference “trip books”. These books contain tabulated data based on excerpts from *Facility Requirements, Airfield and Heliport Planning and Design*, aircraft technical orders, and other sources that have proven useful in past analyses. For the most common airframes the division developed facility category code reference tables that equate a specific number of a type of aircraft to basic area of facility space required. Using this type of data, the analyst can develop an approximation of the amount of facility required and compare that to the real property records containing space currently available. Then, with this data and the existing mission facility demand, the analyst can identify facility shortfalls and generate a rough order of magnitude cost estimate for construction to meet the new demand from the proposed beddown.

The current beddown scenario analysis process is entirely manual. There is no existing information system that facilitates the type of analysis conducted during these beddown scenarios or one that links the necessary information together at one source. In fact, some of the pre-calculated facility category code values used in the AMC/A75R trip book cannot be validated using the existing publications. Either they were in error when they were first calculated or they were based on data that has changed and has since become ‘stale’ since then. Consequently, the validity of information based on these calculations is in question.

## **Information Systems**

This research will investigate two stand-alone and several web based applications to determine if the data, structure, or interface methods can provide insights to the application development. First we will discuss the Pavement-Transportation Computer Assisted Structural Engineering (PCASE) software and its usefulness as a centralized repository for aircraft characteristic data. Next, we will examine the Parametric Cost Engineering System (PACES) software as a possible source for cost and inflation data. Third, we will examine the Automated Civil Engineer System-Real Property (ACES-RP) application as a source for existing base infrastructure data. Fourth, we will look at the Airfield Suitability and Restrictions Report (ASRR) as a source document for existing pavements data. Fifth, we will look at various web-based resources related to the logistics G081 database regarding current mission demands at bases. And finally, we will discuss the Air Force GeoBase installation visualization tool as well as several available web-based imagery tools that are available.

### ***Pavement-Transportation Computer Assisted Structural Engineering (PCASE)***

The Pavement-Transportation Computer Assisted Structural Engineering software program is a program that incorporates all transportation design and evaluation criteria into a stand-alone software package. The PCASE computer programs include rigid and flexible airfield design by conventional and layered elastic methodologies, rigid and flexible road design, as well as railroad evaluation. (Walker and Adolf, 2005:4-5)

As described above, the PCASE software primarily focuses on pavement design for roads and airfields. Much of the capability of the software is irrelevant to AMC/A75R initial infrastructure analysis and, in fact, is used for more detailed

analysis from other departments' personnel during site visits. However, in order to develop the analysis of the pavement in question, the PCASE software has built into it the most comprehensive aircraft characteristics database to date. Manually, analysts must refer to either the specific airframe technical order or the cumbersome ETL 1110-3-394, *Engineering and Design - Aircraft Characteristics for Airfield-Heliport Design and Evaluation*, for this information. The ETL, though thorough, consists of over 1000 pages of scanned data and does not have a simple online reference. Fortunately, this data was incorporated into the PCASE software and is available for use through its interface.

### ***Parametric Cost Engineering System (PACES)***

In the early 1980s, the U.S. Air Force began funding the development of a parametric cost-estimating tool for construction projects. PACES was originally developed for military construction projects and was intended to support the certification and estimating needs of the military engineering community. Current Air Force, Army Corps of Engineers, and Navy policy is to use parametric cost estimating systems to the maximum extent possible for programming and budgeting military construction projects. (Earth Tech, 2005)

The PACES software is updated annually with unit cost data and local area cost factors. Additionally, since this program is specifically designed for construction estimates, inflation indices are included as well. The software is distributed free as a stand-alone PC application to Air Force agencies. The base data files are Microsoft Access compatible and could be used as export sources to another application. However, because the construction scenario options are so

robust in the PACES software, it may be more desirable to export data in a format that could be imported into PACES for final analysis. At the time of this thesis the author has not obtained permission to access the data tables included with the PACES software. Therefore, integration with this program will be limited to data table structure emulation in order to facilitate import if approval can be obtained.

### **On-Line Data Sources**

#### ***Automated Civil Engineer System-Real Property (ACES-RP)***

The ACES-RP application tracks real property, housing, fire department, government provided furnishings, facility maintenance and scheduling, personnel and training, military construction, environmental impact and energy utilization data. The system is used at base, major command (MAJCOM), and Air Force-level activities for the management of Air Force Civil Engineer assets. (AFCESA/CEOI, 2005)

This real property database is where the AMC/A75R personnel generate the real property reports that are used during the beddown analysis. Of the many reports available in ACES-RP are aggregate facility rollups by CAT Code as well as detail reports by CAT Code. With this information the analyst has a pretty good picture of what currently exists at a particular location. Users must have an ACES-RP specific login and password to access the database. Although the data cannot be accessed directly via a web-style query, the program does allow exporting in Microsoft Excel format.

#### ***Global Decision Support System (GDSS)/ Airfield Suitability and Restrictions Report (ASRR)***

The ASRR is a published and online database maintained by the AMC Airspace and Airfields Operation Branch (AMC/A36A). Due to the type of aircraft and missions

flown by AMC, it became evident over time that it needed to gather and publish its own data regarding airfield suitability. Though this type of data was available through civilian channels, it was not directly transferable to the specific needs of the Air Force and were often lacking. The final product of AMC's efforts became the Airfield Suitability and Restrictions Report, or ASRR (Klingler, 2005).

Though the ASRR is distributed quarterly as an actual printed document, the preferred method of access is via the on-line interface. Figure 1 shows the on-line version of the ASRR, the "Giant Report", accessible through the AMC/A36AS airfield lookup interface (A36AS, 2006). AFI 11-202, Vol 3, *General Flight Rules*, mandates MAJCOMs develop their own procedures for using this document. All commands flying AMC-type aircraft require crews to review the ASRR before flight. The ASRR is also available to all AMC-contracted air as well as select foreign governments.

The screenshot displays a web browser window with the address bar showing a URL from the Air Force Database (afd.scott.af.mil). The main content area is titled "Giant Report | KBLV - SCOTT AFB MIDAMERICA". Below this, there is a "Basic Information" section with various fields for airfield data. The "Survey Date" is 20-DEC-1993, "Review By" is KLINGLER, and "Review Date" is 26-JAN-2006. At the bottom, there is a "Suitability Codes" section with a list of codes: ABCDEFGHQ.

| Basic Information            |                      |                          |
|------------------------------|----------------------|--------------------------|
| Name: SCOTT AFB MIDAMERICA   | ICAO: KBLV           | Alternate ICAO:          |
| Alternate Names: BELLEVILLE  | WAC INNR: 0359-00182 | Category ID:             |
| Airfield Type: JOINT (J)     |                      |                          |
| Latitude: 38 32.7N           | Longitude: 089 50.1W | Elevation: 459           |
| Country: ILLINOIS            | Country Code: 17     |                          |
| STIF information exists for: |                      |                          |
| Other Links: [NOTAMS]        |                      |                          |
| Survey Date: 20-DEC-1993     | Review By: KLINGLER  | Review Date: 26-JAN-2006 |
| Suitability Codes            |                      |                          |
| Codes: ABCDEFGHQ             |                      |                          |

**Figure 1 Giant Report (A36AS, 2006)**

The AMC Airspace and Airfields Operation Branch maintain a computer database of over 3,200 airfields worldwide, accessible through the Global Decision Support System (GDSS). This data is accessible through any ".mil" computer and provides

specific information on runways, taxiways, parking aprons, etc. The Airfield Suitability personnel receive feedback regarding conditions from personnel at the locations as well as through official hazard notifications. Also, the staff is proactive to contact the specific airfields occasionally to verify/validate existing and update the report as necessary.

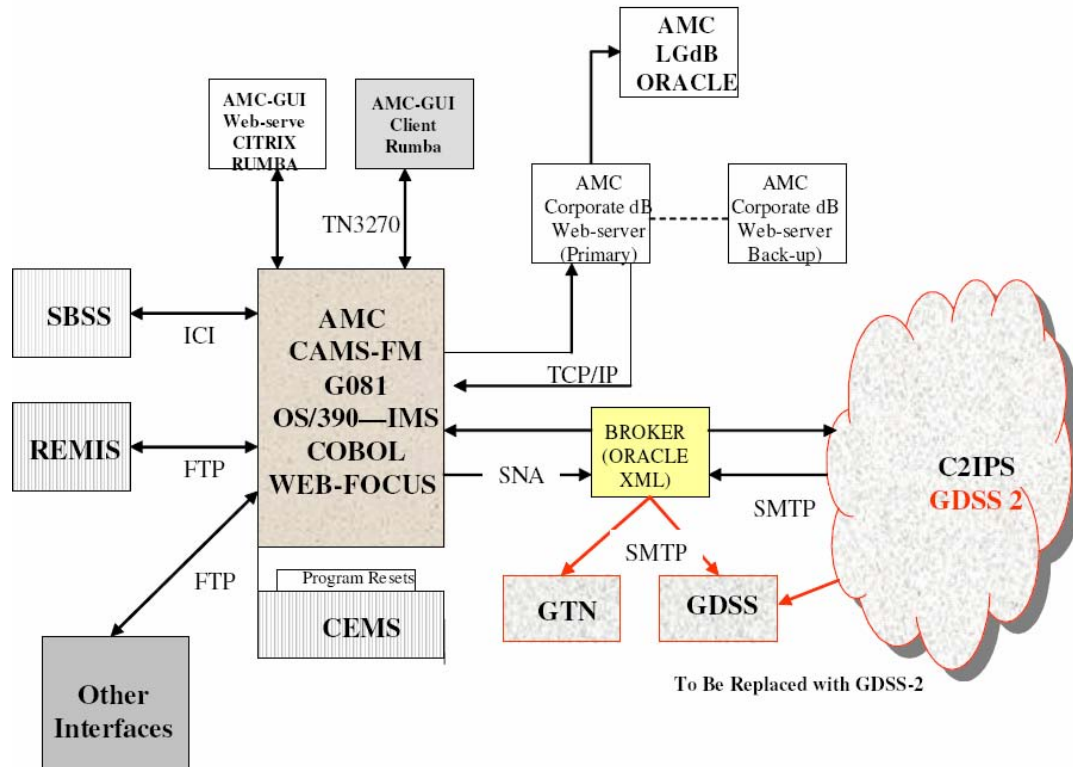
As applicable to this research, the Giant Report provides the detailed pavements data for runways, aprons, and taxiways. This report contains length, width, and pavement classification numbers (PCN) for all pavements at a given location.

### ***Core Automated Maintenance System for Mobility (CAMS FM - G081)***

The CAMS For Mobility (CAMS FM/G081) Maintenance Information System supports the Mobility Air Forces of Air Mobility Command (AMC), Air National Guard, Air Force Reserve Command, and Air Education and Training Command.

G081 integrates information from several existing systems such as the Reliability & Maintainability Information System (REMIS), Comprehensive Engine Management System (CEMS), Command & Control Information Processing System (C2IPS), and Standard Base Supply System (SBSS), etc.

Figure 2 outlines the basic architecture and interface protocols. The system provides management functional capabilities such as equipment inventory, status, and utilization data used to support command and AF level flying hour programs, budgeting for spares, and weapon system reliability analyses (Liggett, 2004). For the purpose of our research, the system includes a web-based interface that users may use to access selected information.



**Figure 2 G081 Interface (Liggett, 2004)**

Within the context of the G081 web enabled query are numerous reports regarding aircraft maintenance status. With respect to this research, the G081 reports provide a summary view of aircraft assigned to a particular installation. This information is directly applicable to calculating the existing facility requirements in order to determine what remains for beddown issues.

The information is available via web-query to the G081 database. Figure 3 shows how the interface can be used to produce an aircraft availability report for all aircraft assigned to the bases:

**Aircraft Availability Report for All Aircraft Assigned to All Bases**  
as of: February 20, 2006 17:45Z  
(Updated every 15 minutes)

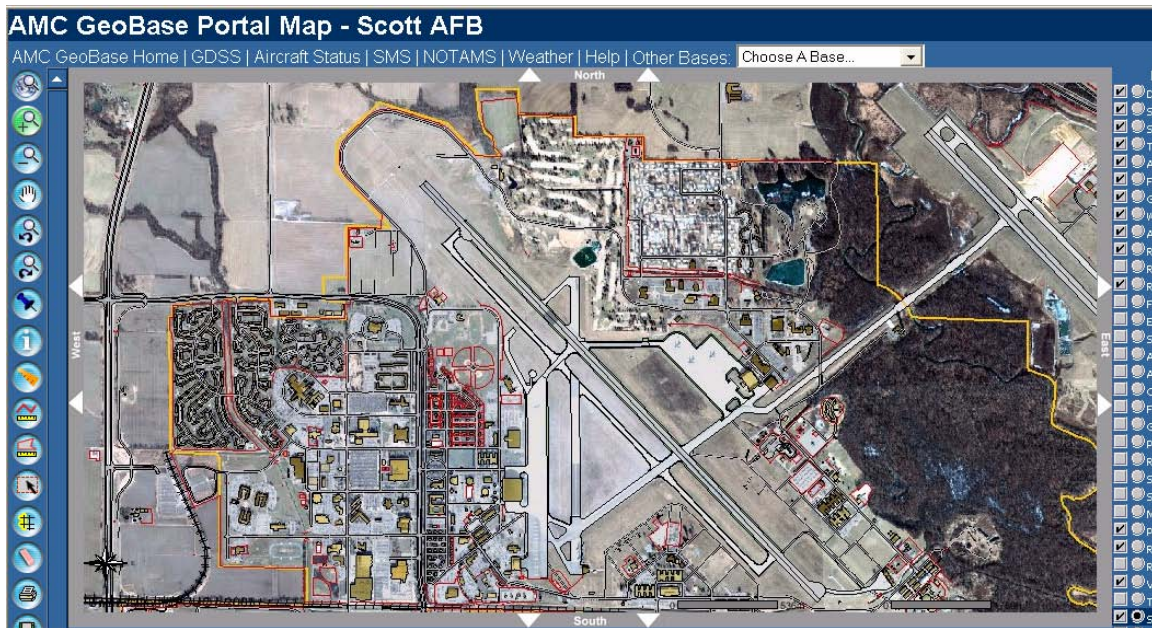
| BASE                          | MDS | ACFT<br>ASGN | LOANED     |     | DEPOT<br>IN<br>(+) | ACFT OFF |     | ON<br>POS<br>(=) | TRAN<br>(+) | RAMP<br>(=) | NDT<br>AVAIL | MC  | 6HR<br>ETIC | 12HR<br>ETIC | 24HR<br>ETIC | >24HR<br>ETIC | MSN | SPR | ALRT | MSN | LCL<br>DS/GT | STATIC |
|-------------------------------|-----|--------------|------------|-----|--------------------|----------|-----|------------------|-------------|-------------|--------------|-----|-------------|--------------|--------------|---------------|-----|-----|------|-----|--------------|--------|
|                               |     |              | OUT<br>(-) | (-) |                    | (-)      | (-) |                  |             |             |              |     |             |              |              |               |     |     |      |     |              |        |
| Air Mobility Command Bases    |     |              |            |     |                    |          |     |                  |             |             |              |     |             |              |              |               |     |     |      |     |              |        |
| Charleston AFB (DKFX) [AMC]   |     | C017A        | 53         | 1   |                    | 8        | 44  | 23               |             | 21          | 1            | 16  | 2           | 1            |              | 2             |     |     |      | 7   | 2            |        |
| Dover AFB (FJKT) [AMC]        |     | C005A        | 2          |     |                    | 1        | 1   | 1                | 1           |             |              |     |             |              |              | 1             |     |     |      |     |              |        |
|                               |     | C005B        | 26         | 1   | 1                  | 8        | 18  | 2                |             | 15          | 5            | 5   | 2           | 2            | 1            | 2             |     |     |      |     |              |        |
| Dyess AFB (FNWZ) [AMC]        |     | C130E        | 4          |     | 5                  | 1        | 8   | 5                |             | 3           | 2            |     |             |              |              | 1             |     |     |      |     |              |        |
|                               |     | C130H        | 22         |     |                    | 7        | 22  | 5                |             | 17          | 14           |     |             |              |              | 4             |     |     |      |     | 8            |        |
| Fairchild AFB (GJKZ) [AMC]    |     | KC135R       | 21         |     |                    | 6        | 15  | 7                |             | 8           | 7            |     |             |              |              | 1             | 1   |     |      | 1   | 4            |        |
|                               |     | KC135T       | 13         |     |                    | 1        | 12  | 4                |             | 8           | 2            | 7   |             |              |              |               |     |     |      | 1   | 4            |        |
| Grand Forks AFB (JFSD) [AMC]  |     | KC135R       | 36         | 1   |                    | 2        | 26  | 12               | 1           | 15          | 14           | 1   |             |              |              |               |     |     |      |     | 8            |        |
|                               |     | KC135T       | 7          |     |                    | 3        | 4   | 2                |             | 2           | 2            |     |             |              |              |               |     |     |      |     | 1            |        |
| Little Rock AFB (NKAKA) [AMC] |     | C130E        | 16         | 8   |                    | 1        | 7   |                  |             | 7           | 5            | 2   |             |              |              | 5             |     |     |      |     |              |        |
|                               |     | C130H        | 14         |     |                    | 1        | 13  | 7                |             | 6           | 4            |     |             |              |              | 2             |     |     |      |     |              |        |
| MacDill AFB (NVZR) [AMC]      |     | KC135R       | 12         |     |                    | 1        | 11  | 4                |             | 7           | 1            | 4   |             |              |              | 3             |     |     |      |     | 4            |        |
| McChord AFB (PQWY) [AMC]      |     | C017A        | 50         |     |                    | 3        | 47  | 26               |             | 21          | 18           | 1   | 1           | 1            |              |               |     |     |      |     |              |        |
| McConnell AFB (PRQE) [AMC]    |     | KC135R       | 33         |     |                    | 6        | 27  | 9                |             | 18          | 16           |     | 2           |              |              |               |     |     |      |     | 4            |        |
|                               |     | KC135T       | 6          |     |                    | 2        | 4   | 2                |             | 2           | 2            |     |             |              |              |               |     |     |      |     |              | 1      |
| McGuire AFB (PTFL) [AMC]      |     | C017A        | 13         |     |                    |          | 13  | 8                | 4           | 9           | 9            |     |             |              |              |               | 1   | 1   |      |     |              |        |
|                               |     | KC010A       | 32         |     |                    | 3        | 29  | 15               |             | 14          | 1            | 12  | 1           | 1            |              |               |     |     |      |     |              |        |
| Pope AFB (TMKH) [AMC]         |     | C130E        | 27         |     | 6                  | 1        | 32  | 10               |             | 22          | 10           | 2   |             |              |              | 13            |     |     |      |     |              |        |
| Robins AFB (UHJD) [AMC]       |     | KC135R       | 11         |     |                    | 1        | 10  | 5                |             | 5           | 5            |     |             |              |              |               |     |     |      |     | 2            |        |
|                               |     | KC135T       | 2          |     |                    | 2        | 1   |                  |             | 1           | 1            |     |             |              |              |               |     |     |      |     | 1            |        |
| Travis AFB (XDAT) [AMC]       |     | C005B        | 24         | 1   | 1                  | 4        | 20  | 11               |             | 9           | 3            | 6   |             |              |              | 3             |     |     |      |     | 1            |        |
|                               |     | C005C        | 2          |     |                    |          | 2   |                  |             | 2           | 1            | 1   |             |              |              |               |     |     |      |     |              |        |
|                               |     | KC010A       | 27         |     |                    | 5        | 22  | 11               |             | 11          | 9            | 1   |             |              |              | 1             |     |     |      |     | 1            |        |
| Subtotal:                     |     |              | 460        | 12  | 13                 | 72       | 389 | 170              | 6           | 224         | 28           | 165 | 9           | 7            | 2            | 38            | 2   | 1   | 9    | 40  | 1            |        |

**Figure 3 Availability Report (DISA OKC, 2005)**

### *GeoBase*

The GeoBase web application is an evolving standard that presents geospatial information through a common installation picture (CIP). Figure 4 displays a typical GeoBase output screen. The GeoBase installation picture is developed by combining detailed (1m and 5m) satellite imagery and overlay data. Overlay data is generated and submitted via the respective data proponent (i.e. CE, SC, TRANS, etc...) to ensure that the data is as accurate as possible (Rathbun, 2006).

Additionally, the GeoBase application is not the data server for much of the data presented. It is constructed in order to pull the data from the necessary sources so that redundant data repositories are not created. Thus, when a user selects a specific building detail he is not pulling data that is contained within GeoBase but instead, GeoBase is displaying the respective data that it pulls from ACES.



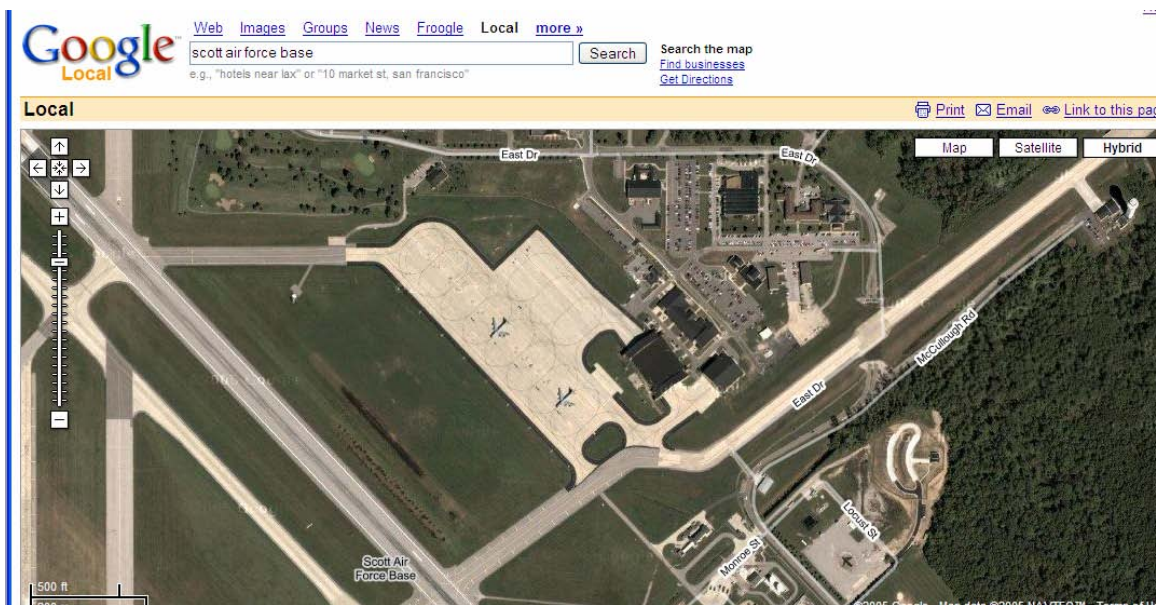
**Figure 4 GeoBase CIP (Updike, 2006)**

Currently, there are several Air Force GeoBase servers that can be accessed with an Air Force Portal login account. As of the time of this research, there was no central site for all the Air Force GeoBase links and many were accessible only through private servers; thus, if a user were not logged on to an AMC server he would not be able to link to the AMC sites. This access limitation is still developing and evolving. Currently, many of the sites are available through the Air Combat Command Geobase console (McKercher, 2006) or the Air Mobility Command GeoBase consol (Updike, 2006).

#### ***Other Web-Based Imagery Tools***

Over the past several years the internet has evolved several on-line mapping tools that may prove useful for base planning. Several of these such as Google Local (Page et. al., 2005), Yahoo Maps Beta (Filo and Yang, 2005), and Windows Live Local Beta (Thota, 2005) now provide detailed satellite or over flight imagery views that rival the GeoBase imagery.

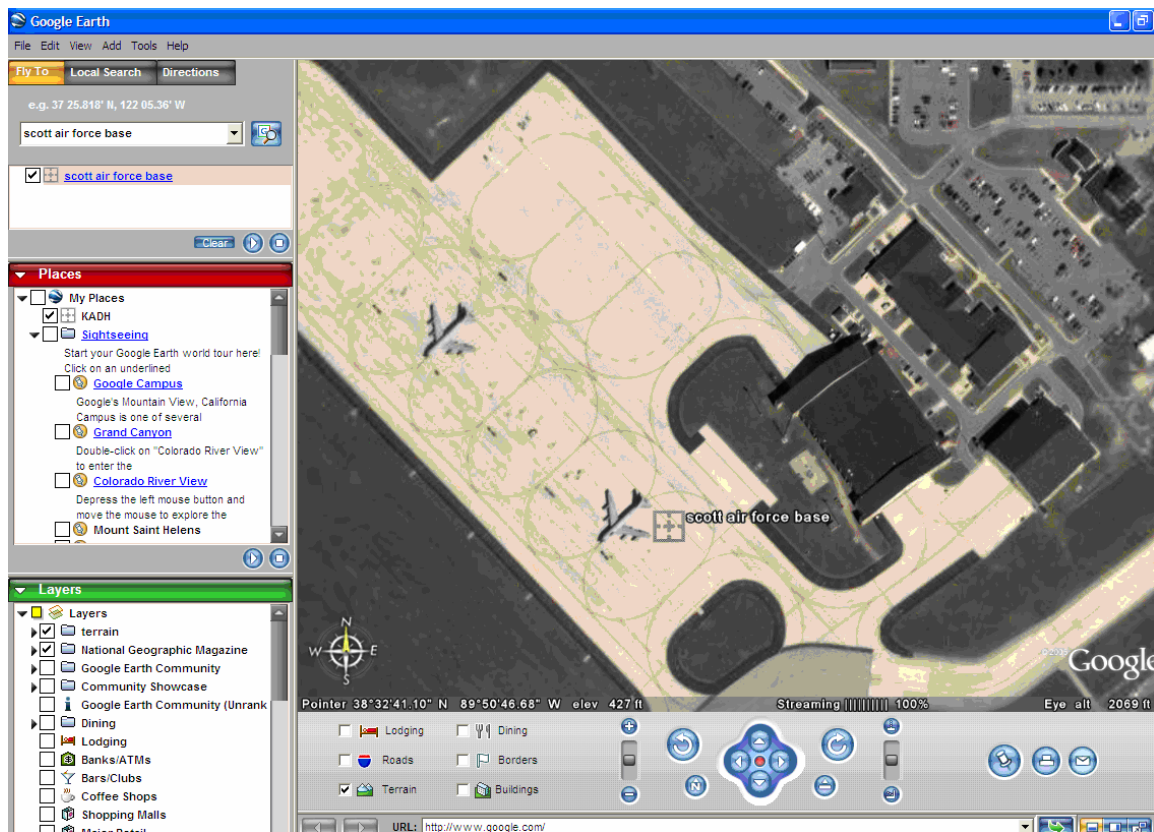
As the older and now non-Beta web application available, Google Local (formerly Google Maps) was examined for possible integration into the tool. Useful features of this application include its availability through non-secure networks and live scrollable and zoomable windows. The level of detail and clarity common in CONUS locations can be seen in Figure 5. The application features quick loading frames that overlay basic landmarks and features for the user. Additionally, the web application facilitates latitude and longitude search and zoom capabilities. This feature makes it possible for a user with specific latitude-longitude coordinates to open a window directly to the satellite imagery of the desired location.



**Figure 5 Google Local Satellite Imagery (Page et. al., 2005)**

A further expansion of the Google Maps environment resulted in the development of the Google Earth stand alone application. Figure 6 shows an example screen shot of the Google earth application. This application is a free program that is downloadable to the user computer which is capable of accessing the same imagery as the web-based

browser. However, users of the Google Earth software now have expanded and much more detailed open source overlay information as well as the ability to create custom overlays, landmarks, and comments that may either be kept on the local machine or made available to other users.



**Figure 6 Google Earth Imagery**

As with the web-based version, this software has keyword and latitude-longitude search capabilities. The image in Figure 6 was obtained by inputting “scott air force base” into the search window. Once a location has been loaded, users may then use the provided tools to generate overlays, measure straight line and areas, or add overlays.

## **Summary**

As the Air Force continues to do its part in the Global War on Terrorism, it must also continue to structure its forces in the most efficient and manner for the current and future missions. Consequently, basing of existing units and beddown of future weapon systems to maintain our position of superiority demand that we continue to move ahead in search of those 'optimum' configurations where our resources are allocated to our greatest advantage.

With beddown analysis as a continuous process in the modern force, we must develop the tools to facilitate the accurate and timely analysis needed. In this chapter we have examined several information systems, stand-alone and web-based, that manage the data necessary to conduct these beddown analysis. It becomes apparent that the tools are available to develop an application as proposed in this research. Once integration issues are addressed, it should be possible to develop an application that collects data as the GeoBase application does and conduct the beddown scenario.

### **III. Methodology**

#### **Chapter Overview**

The methodology for developing a Microsoft Access based beddown planning application has roots in two previous research efforts and builds upon each of these. Initial research (Salmond, 2005) made use of a spreadsheet platform in order to capitalize on the spreadsheets ability to organize information and conduct multiple calculations. Follow-on research (Kitchens, 2005) recognized the relational database as a natural extension and allowed the development and customization of user forms and interfaces for the data. The database methods kept the underlying data hidden from the user so they would not become distracted by or potentially damage the underlying base logic.

This research expands upon the existing research by using Visual Basic for Applications (VBA) to further customize and streamline the application process as well as develop external interface routines. Conceptually, the application is scenario centered and accomplishes the beddown analysis by the following logic: Identifying facility CAT Code requirements for the proposed aircraft; recognizing existing infrastructure and mission demands at the desired location; and finally, generating a construction cost estimate based on the historical cost indices.

#### **Program Base for Application Development**

A thorough examination of the AMC/A75R “trip book” resources, AFH 32-1084, and existing spreadsheet tools led to the identification of the most relevant data for the beddown analysis. Discussions with the A75R personnel further refined the resource list to those they have found to be the greatest cost drivers in the beddown process.

Required data was examined against available data sources and categorized as either external or internal only to the proposed beddown application's database. External data sources were those that actually had usable digital interfaces (web or LAN based) that allow the application to query and import the information without the user as an interface. This is the preferred method to reduce human error in the beddown process. Internal only data were those data sets that did not facilitate electronic query and import actions. Examples of this type of data are the various factor tables in the AFH 32-1084. Existing spreadsheet data (Salmond, 2005) and tabular data from the AFH 32-1084 that was developed during earlier research (Kitchens, 2005) were then formatted for and entered into the database.

Though the spreadsheet tool made use of cross sheet cell reference for complicated calculations, the Access application also has the capability of robust calculation methods with the use of VBA. Calculations are completed in either underlying Form VBA code or through global modules accessible throughout the application. In order to facilitate multiple scenarios and variations, the interim calculations and final estimates are generated in scenario specific tabular data that are separate from the source data. In this way, the 'building blocks' of the scenario are never changed and other scenarios may use the same data.

In creating the application, we will be designing four distinct types of data tables to gather, hold, or calculate data. For the purpose of this research we will refer to tables that are updated electronically through external sources as *active tables*. We will refer to those data tables that must be edited or updated manually (such as AFH 32-1084 tables) as *static tables*. Tables that primarily contain information prompted for by the

application and entered by the user are *user tables*, and tables that contain only calculated data are *calculated tables*.

The interface for the application will be specifically designed to restrict the user to the portions of the underlying data sets that are relevant. All inputs and other actions are conducted through a series of forms that lead the user through the beddown process. In this way, the necessary questions are asked when needed and the user remains oblivious to the underlying calculations (and unable to inadvertently change them).

### **Conceptual Application Development**

The key driving factors to any particular beddown scenario are the number and type of aircraft involved, the proposed beddown location, and the time frame for the beddown (Salmond, 2005). Cost estimates are derived from the calculated facility requirements based on the specific aircraft, location characteristics and the additional inflation indices from the proposed timeline. The references for the calculation are the AFH 32-1084 and the Unified Facilities Criteria.

### **Gathering External Data**

It is not the intent to turn this database into some great repository of information. Whenever possible, data will be pulled from outside sources with the responsibility to maintain that data. By doing this we can avoid our data becoming ‘stale’. We have already researched and identified potential data sources and will be working to incorporate interfaces to those sources as the application is developed. Since the specific information for a particular beddown must exist locally, the application will, when necessary, prompt the user to import current data or conduct a requery in order to validate existing data.

## Initial Application Development

The initial application development consisted of organizing the quantitative data that would be used for calculations into tables that lend themselves to query and SQL referencing. Attempts were made where possible to align data structures with possible external sources to minimize import errors and unnecessary data transformations.

Figure 7 displays the layout of the aircraft characteristics data table developed for the application. This data table (tblACChar) contains essential information about particular aircraft necessary to calculate facility requirements. This table is used to calculate runway, hangar, and parking requirements as well as to various maintenance and munitions facility requirements. This is an active table that pulls data from the Pavement-Transportation Computer Assisted Structural Engineering (PCASE) database (Walker and Adolf, 2005).

| tblACChar : Table |     |                   |              |          |   |       |          |   |   |   |          |           |          |   |   |   |   |   |     |     |      |    |     |        |       |       |         |        |         |
|-------------------|-----|-------------------|--------------|----------|---|-------|----------|---|---|---|----------|-----------|----------|---|---|---|---|---|-----|-----|------|----|-----|--------|-------|-------|---------|--------|---------|
|                   | ACC | VehicleId         | Name         | LandGear | T | H     | TurningR | V | V | V | WingSpan | OverallLg | OverallH | V | V | S | F | T | Min | Cer | Nose | Fo | Min | MinTak | MinTa | MinTa | MaxTake | MaxTak | MinTake |
| ▶                 | 60  | WES(621)-A-10     | Single, Tric | 0        | 0 | 0     | 0        | 0 | 0 | 0 | 57.5     | 53.3      | 14.7     | 0 | 0 | 0 | 0 | 0 | 9.1 | 0   | 27.4 | 0  | 0   | 20000  | 1000  | 2000  | 50000   | 50000  | 5000    |
|                   | 61  | WESW>% B-1B       | Twin Tand    | 0        | 0 | 10    | 0        | 0 | 0 | 0 | 136.7    | 151.1     | 33.6     | 0 | 0 | 0 | 0 | 0 | 8   | 0   | 0    | 0  | 0   | 189000 | 1500  | 1800  | 4440000 | 477000 | 10200   |
|                   | 62  | WES#ZC C-17       | Dual Tand    | 0        | 0 | 114   | 0        | 0 | 0 | 0 | 170      | 174       | 55.1     | 0 | 0 | 0 | 0 | 0 | 14  | 0   | 0    | 0  | 0   | 331400 | 3000  | 0     | 580000  | 580000 | 7600    |
|                   | 63  | WES-J19C C-5A     | Tricycle Tw  | 0        | 0 | 72.5  | 0        | 0 | 0 | 0 | 222.7    | 247.8     | 65.1     | 0 | 0 | 0 | 0 | 0 | 14  | 62  | 117  | 0  | 0   | 375000 | 1580  | 2300  | 769000  | 837000 | 10000   |
|                   | 64  | WESOX H KC-10     |              | 0        | 0 | 0     | 0        | 0 | 0 | 0 | 0        | 0         | 0        | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 0    | 0  | 0   | 0      | 0     | 0     | 0       | 0      | 0       |
|                   | 65  | WESR%R KC-135     |              | 0        | 0 | 0     | 0        | 0 | 0 | 0 | 0        | 0         | 0        | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 0    | 0  | 0   | 0      | 0     | 0     | 0       | 0      | 0       |
|                   | 66  | WES VXA C-130H    | Single Tan   | 0        | 0 | 122   | 0        | 0 | 0 | 0 | 132.6    | 99.5      | 38.4     | 0 | 0 | 0 | 0 | 0 | 15  | 33  | 43.6 | 0  | 0   | 70000  | 750   | 1900  | 155000  | 175000 | 4100    |
|                   | 67  | WES3T S C-141     | Dual Tand    | 0        | 0 | 120.4 | 0        | 0 | 0 | 0 | 160      | 168.3     | 39.3     | 0 | 0 | 0 | 0 | 0 | 11  | 38  | 85.5 | 0  | 0   | 144500 | 1300  | 1800  | 325000  | 344900 | 5900    |
|                   | 68  | WES*?L A-6 INTRUD | Single, Tric | 0        | 0 | 0     | 0        | 0 | 0 | 0 | 53       | 54.67     | 15.5     | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 0    | 0  | 0   | 26600  | 4820  | 4560  | 0       | 60400  | 3890    |
|                   | 69  | WES=E8L S3-B      |              | 0        | 0 | 0     | 0        | 0 | 0 | 0 | 0        | 0         | 0        | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 0    | 0  | 0   | 0      | 0     | 0     | 0       | 0      | 0       |
|                   | 70  | WES=+9J T-37      |              | 0        | 0 | 0     | 0        | 0 | 0 | 0 | 0        | 0         | 0        | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 0    | 0  | 0   | 0      | 0     | 0     | 0       | 0      | 0       |
| * tber)           |     |                   |              |          |   |       |          |   |   |   |          |           |          |   |   |   |   |   |     |     |      |    |     |        |       |       |         |        |         |

**Figure 7 Aircraft Characteristic Data**

The aircraft classification number (ACN) table (tblACNs), shown in Figure 8, is also an active table that contains data pulled from PACES. This data contains values used to calculate aircraft ACN values for the four different categories if rigid and flexible pavement sub grades. Relationships are in the linear form  $ACN = (slope) * WT + (intercept)$ .

| tblACNs : Table |          |           |           |           |           |           |            |            |            |            |         |
|-----------------|----------|-----------|-----------|-----------|-----------|-----------|------------|------------|------------|------------|---------|
|                 | ACCharID | VehicleID | SlopeA    | SlopeB    | SlopeC    | SlopeD    | InterceptA | InterceptB | InterceptC | InterceptD | Flexibl |
| ▶               | 60       | WES(6Z    | 0.405149  | 0.405149  | 0.405149  | 0.405149  | 0          | 0          | 0          | 0          | -1      |
|                 | 60       | WES(6Z    | 0.4080106 | 0.4080106 | 0.4080106 | 0.4080106 | -0.06804   | -0.06804   | -0.068037  | -0.06804   | 0       |
|                 | 68       | WES*?I    | 0.4337740 | 0.4337740 | 0.4337740 | 0.4337740 | 0          | 0          | 0          | 0          | -1      |
|                 | 68       | WES*?I    | 0.4437486 | 0.4437486 | 0.4437486 | 0.4437486 | -0.11658   | -0.11658   | -0.116580  | -0.11658   | 0       |
|                 | 66       | WES-V>    | 0.1651079 | 0.1931763 | 0.2119118 | 0.2543028 | -1.47132   | -1.81779   | -2.333367  | -3.86343   | -1      |
|                 | 66       | WES-V>    | 0.185053  | 0.2072239 | 0.2299702 | 0.2435076 | -1.48683   | -2.15313   | -2.947331  | -3.14734   | 0       |
|                 | 70       | WES=+     | 0.3655422 | 0.3655422 | 0.3655422 | 0.3655422 | 0          | 0          | 0          | 0          | -1      |
|                 | 70       | WES=+     | 0.350828  | 0.350828  | 0.350828  | 0.350828  | -0.01229   | -0.01229   | -0.012285  | -0.01229   | 0       |
|                 | 69       | WES=E     | 0.3851385 | 0.3851385 | 0.3851385 | 0.3851385 | 0          | 0          | 0          | 0          | -1      |

**Figure 8 Aircraft Pavements Classification Data**

Several data tables are needed to store various facilities requirements factor data from the *Facility Requirements* handbook (AFH 32-1084). These are tables where the underlying logic was not explained and therefore could not be calculated based solely on the aircraft data. An example of this type of table is the covered aircraft maintenance space requirements. Figure 9 shows how the factors to calculate the required amount of covered aircraft maintenance space are contained in the application database. These factors are taken from Table 7.1 of the *Facility Requirements* handbook. Using these factors we can determine that, on average, 10 B-1 bombers would require three covered maintenance spaces ( $PAAXFactor = 10 \times 0.3 = 3$ ).

| tbl7_1 : Table |   |    |          |        |
|----------------|---|----|----------|--------|
|                |   | ID | Aircraft | Factor |
| ▶              | + | 1  | B-1      | 0.3    |
|                | + | 2  | B-52     | 0.15   |
|                | + | 3  | C-5      | 0.16   |
|                | + | 4  | C-9      | 0.18   |
|                | + | 5  | C-12F    | 0.1    |
|                | + | 6  | C-17     | 0.2    |
|                | + | 7  | C-21     | 0.25   |
|                | + | 8  | C/KC-135 | 0.15   |
|                | + | 9  | C-130    | 0.15   |
|                | + | 10 | C-141    | 0.16   |

**Figure 9 AFH 32-1084 Table 7-1**

Each beddown analysis in the application will assigned a distinct scenario identifier. Under this scenario ID the user will provide the information pertaining to the scenario. The first data needed is the type and number of aircraft that are being considered in the scenario. Figure 10 displays the new mission data table (tblNMdata). This table is a user table that holds the specific aircraft details as well as interim data holders for calculations. These calculations were included to maintain consistency with the AMC beddown flowcharts. These interim fields are not visible to the user and are modified only through the Visual Basic code of the respective input form.

| ID     | SCEN | Model  | PAA | Alert                               | Num | Crew | DPA | DPB | DPC    | DPD | DPE | DPF | DPG | DPH | DPI | DPJ | DPK | DPL  | DPM | DPN |
|--------|------|--------|-----|-------------------------------------|-----|------|-----|-----|--------|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|
| 22     | 20   | C-141  | 20  | <input checked="" type="checkbox"/> | 6   | 12   | 0   | 0   | 0      | 20  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0   |
| 23     | 20   | C-17   | 10  | <input type="checkbox"/>            | 0   | 0    | 2   | 6   | 935238 | 10  | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 0    | 0   | 0   |
| 24     | 20   | C-5A   | 10  | <input checked="" type="checkbox"/> | 8   | 80   | 0   | 0   | 0      | 10  | 0   | 0   | 0   | 1   | 0   | 0   | 0   | 304  | 0   | 0   |
| 29     | 22   | C-130H | 10  | <input type="checkbox"/>            | 0   | 0    | 2   | 6   | 422940 | 10  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0   |
| 30     | 20   | C-130H | 30  | <input checked="" type="checkbox"/> | 5   | 30   | 0   | 0   | 0      | 30  | 2   | 18  | 0   | 0   | 0   | 0   | 0   | 4332 | 0   | 0   |
| 36     | 31   | A-10   | 2   | <input type="checkbox"/>            | 0   | 0    | 0   | 0   | 0      | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0   |
| * ber) | 0    |        | 0   | <input type="checkbox"/>            | 0   | 0    | 0   | 0   | 0      | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0    | 0   | 0   |

**Figure 10 New Mission Data**

The next group of tables relate to details regarding the chosen beddown location. Figure 11 shows the facility category code data. This is a list of available category codes for facility usage identifying each by name and designating the measurement units. A selection box is included for the user to select if the particular category code will be used in the beddown analysis. Category codes not selected will be ignored and not included in the cost summary.

| CATCODES : Table |         |                    |    |       |     |      |                                     |
|------------------|---------|--------------------|----|-------|-----|------|-------------------------------------|
|                  | CatCode | Name               | UM | Other | UM2 | Type | Select                              |
| +                | 179475  | RG SM ARMS SYS     |    | 8     | FP  | E    | <input type="checkbox"/>            |
| +                | 179511  | FIREMAN TNG FCLTY  |    | 1     | EA  | E    | <input type="checkbox"/>            |
| +                | 211111  | HG MAINT           | SF |       |     | D    | <input checked="" type="checkbox"/> |
| +                | 211152  | SHP ACFT GEN PURP  | SF |       |     | D    | <input checked="" type="checkbox"/> |
| +                | 211153  | SHP NON-DESTR INSP | SF |       |     | D    | <input checked="" type="checkbox"/> |
| +                | 211154  | SHP A/M ORGL       | SF |       |     | A    | <input checked="" type="checkbox"/> |
| +                | 211157  | SHP JET ENG I/MNT  | SF |       |     | A    | <input checked="" type="checkbox"/> |
| +                | 211159  | ACFT COR CON       | SF |       |     | D    | <input checked="" type="checkbox"/> |

Record: 1 of 332

**Figure 11 Facility Category Code Data**

The Airfield suitability header data table (GDSS table), shown in Figure 12, is an active table that pulls data from the on-line Airfield Suitability and Restrictions Report (ASRR). The header table contains the restrictions information as well as latitude-longitude position data for imagery data selection.

| GDSS : Table |                  |      |      |                |            |    |               |          |           |       |          |     |    |    |    |      |        |      |
|--------------|------------------|------|------|----------------|------------|----|---------------|----------|-----------|-------|----------|-----|----|----|----|------|--------|------|
| ID           | NAME             | ICAO | Alte | Alternate Name | WAC INNR   | Ce | Airfield Type | Latitude | Longitude | Eleva | Country  | Cou | Su | Re | Rd | Code | Geoloc | Area |
| 11           | SCOTT AFB MIDAME | KBLV |      | BELLEVILLE     | 0359-00182 |    | JOINT (J)     | 38 32.7N | 089 50.1W | 459   | ILLINOIS | 17  | 12 | KL | 17 | ABC  | VDYD   | 018  |
| 11           | AFONSOS          | SBAF |      | CAMPO DOS A    | 1263-08003 |    | MILITARY (M)  | 22 52.5S | 043 23.1W | 112   | BRAZIL   | BR  |    | Wh | 15 | ACF  | ACLP   | 018  |
| 12           | BEMIDJI BELTRAMI | KBJI |      |                | GDSSTMKBJI |    | CIVILIAN (C)  | 47 30.6N | 094 56.0W | 1390  | MINNESC  | 27  | 05 | KL | 29 | BCF  | BGCW   | 018  |
| 13           | YUCCA AIRSTRI    | KL74 |      |                | GDSSTMKL74 |    | CIVILIAN (C)  | 36 56.7N | 116 02.3W | 3919  | NEVADA   | 32  | 09 | Wh | 10 | QRS  | ZQSZ   | 018  |
| 14           | WRIGHT PATTERSO  | KFFO |      |                | 0358-00138 |    | MILITARY (M)  | 39 49.6N | 084 02.9W | 823   | OHIO     | 39  | 22 | KL | 11 | ABC  | ZHTV   | 018  |

\* (number) 0

Record: 1 of 5

**Figure 12 Airfield Suitability Header Data**

Figure 13 displays the airfield suitability runway data (Runways table). This table contains detailed length, width and rating information for all runways at a particular location. This is another active table that imports data from the online ASRR. This table and the airfield suitability header table are linked by the ICAO fields.

| Runways : Table |      |      |      |        |       |       |         |           |             |         |   |     |     |     |      |     |     |
|-----------------|------|------|------|--------|-------|-------|---------|-----------|-------------|---------|---|-----|-----|-----|------|-----|-----|
| Runway\         | ICAO | Name | Prim | Length | LDA   | Width | Surface | Condition | Raw WBC     | PCN     | S | T   | ST  | TT  | SBTT | TDT | TRT |
| 38              | KBLV | 14L  | *    | 10000  | 10000 | 150   | CON     | GOOD      | PCN 67RCWT  | 67RCWT  | 0 | 111 | 175 | 345 | 593  | 840 | 585 |
| 39              | KBLV | 14R  |      | 8001   | 8001  | 150   | PEM     | GOOD      | PCN 90RBWT  | 90RBWT  | 0 | 111 | 175 | 345 | 593  | 840 | 585 |
| 40              | SBAF | 08   | *    | 6562   | 6562  | 171   | CON     | GOOD      | PCN 14RCYT  |         | 0 | 0   | 80  | 118 | 0    | 375 | 0   |
| 41              | KBJI | 07   |      | 5699   | 4999  | 150   | ASP     | GOOD      | T 55        | 13FC    | 0 | 55  | 75  | 116 | 0    | 314 | 0   |
| 42              | KBJI | 13   | *    | 6598   | 6598  | 150   | ASP     | GOOD      | T 55        | 13FC    | 0 | 55  | 75  | 116 | 0    | 314 | 0   |
| 44              | KL74 | 14   | *    | 9000   | 9000  | 200   | GRE     | FAIR      | LCN 30      |         | 0 | 0   | 0   | 0   | 0    | 0   | 0   |
| 45              | KFFO | 05L  | *    | 12601  | 12601 | 300   | PEM     | GOOD      | PCN 67RBWT  | 67RBWT  | 0 | 111 | 175 | 345 | 593  | 840 | 585 |
| 46              | KFFO | 05R  |      | 7000   | 7000  | 150   | ASP     | GOOD      | PCN 118RBWT | 118RBWT | 0 | 111 | 175 | 345 | 593  | 840 | 585 |
| * (Number)      |      |      |      | 0      | 0     | 0     |         |           |             |         | 0 | 0   | 0   | 0   | 0    | 0   | 0   |

Record: 1 of 8

**Figure 13 Airfield Suitability Runway Data**

The airfield suitability taxiway data table (Taxiways table), shown in Figure 14, is the second sub-table linked to the airfield suitability header table. As with the runway data table, this table contains dimension and specific classification information on each taxiway at the location.

| Taxiways : Table |      |          |       |         |           |          |      |              |  |
|------------------|------|----------|-------|---------|-----------|----------|------|--------------|--|
| TaxiwayID        | ICAO | Name     | Width | Surface | Condition | WBC      | PCN  | Has Lighting |  |
| 43               | KBLV | A        | 75    | CON     | GOOD      | PCN 67RC | 67RC | ✓            |  |
| 44               | KBLV | E        | 75    | BIT     | GOOD      | PCN 67RC | 67RC | ✓            |  |
| 45               | KBLV | G        | 75    | ASP     | GOOD      | PCN 67RC | 67RC | ✓            |  |
| 46               | KBLV | H        | 25    | ASP     | GOOD      | S 12     | XXXX | ✓            |  |
| 47               | KBLV | K - M, P | 75    | CON     | GOOD      | TT 209   | 31RC | ✓            |  |
| 48               | SBAF | LINK     | 65    | CON     | GOOD      | LCN 41   |      | ✓            |  |
| 49               | SBAF | LINK-2   | 50    | CON     | GOOD      | LCN 41   |      | ✓            |  |
| 50               | SBAF | LINK 3   | 35    | CON     | GOOD      | LCN 41   |      | ✓            |  |

**Figure 14 Airfield Suitability Taxiway Data**

Figure 15 shows the final table linked to the airfield suitability header table is the airfield suitability apron data table. Again, like the runway and taxiway tables, it contains information regarding the dimensions and ratings of all apron pavements at the location.

| Aprons : Table |      |            |        |       |         |           |          |      |                                     |  |
|----------------|------|------------|--------|-------|---------|-----------|----------|------|-------------------------------------|--|
| AprID          | ICAO | Apron ID   | Length | Width | Surface | Condition | WBC      | PCN  | Has Lighting                        |  |
| 14             | KBLV | CARGO      | 600    | 500   | CON     | GOOD      | TT 209   | 31RC | <input checked="" type="checkbox"/> |  |
| 15             | KBLV | F          | 3000   | 150   | ASP     | FAIR      | PCN 67RC | 67RC | <input checked="" type="checkbox"/> |  |
| 16             | KBLV | GUARD      | 1000   | 425   | CON     | GOOD      | PCN 67RC | 67RC | <input checked="" type="checkbox"/> |  |
| 17             | KBLV | NORTH RAMP | 338    | 2200  | CON     | FAIR      | PCN 67RC | 67RC | <input type="checkbox"/>            |  |
| 18             | KBLV | PAX        | 1000   | 400   | CON     | GOOD      | TT 209   | 31RC | <input checked="" type="checkbox"/> |  |
| 19             | KBLV | SOUTH RAMP | 338    | 1050  | ASP     | FAIR      | PCN 67RC | 67RC | <input type="checkbox"/>            |  |
| 20             | SBAF | HANGAR     | 165    | 100   | CON     | GOOD      | UNKN     |      | <input type="checkbox"/>            |  |
| 21             | SBAF | HANGAR     | 600    | 100   | ASP     | GOOD      | UNKN     |      | <input type="checkbox"/>            |  |

**Figure 15 Airfield Suitability Apron Data**

The last table that focuses on location specific information is the Base Detail table shown in Figure 16. This is an active table that imports data from files generated by the Automated Civil Engineer System-Real Property (ACES-RP) program. This file contains the by-building category code details for all category codes selected for analysis in the beddown scenario. This detail file is used to calculate aggregate rollups by category code for comparison in the beddown process.

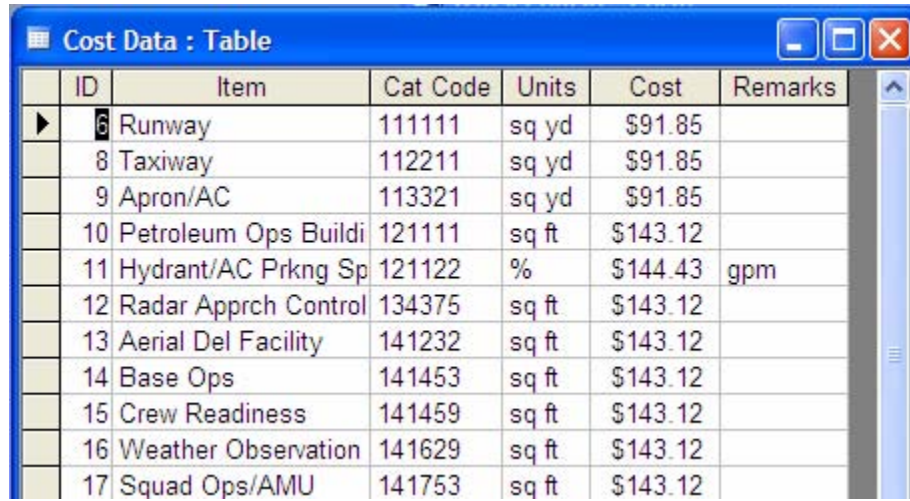
| BASE DETAIL : Table |      |      |       |         |                   |         |    |       |     |      |  |
|---------------------|------|------|-------|---------|-------------------|---------|----|-------|-----|------|--|
| ID                  | BASE | ICAO | Fac # | CatCode | Name              | Area    | UM | Other | UM2 | Type |  |
| 3347                | 1    | KBLV | 7114  | 112211  | TAXIWAY           | 12,970  | SY |       |     | E    |  |
| 3348                | 1    | KBLV | 7116  | 112211  | TAXIWAY           | 52,261  | SY |       |     | E    |  |
| 3349                | 1    | KBLV | 7200  | 113321  | APRON             | 163,501 | SY |       |     | E    |  |
| 3350                | 1    | KBLV | 7202  | 113321  | APRON             | 52,090  | SY |       |     | E    |  |
| 3351                | 1    | KBLV | 7204  | 113321  | APRON             | 63,166  | SY |       |     | E    |  |
| 3352                | 1    | KBLV | 7205  | 116642  | SHLDR.PAVED       | 14,761  | SY |       |     | E    |  |
| 3339                | 1    | KBLV | 7050  | 116663  | PAD.HELICOPTER    | 3,467   | SY |       |     | E    |  |
| 3313                | 1    | KBLV | 6730  | 116667  | PAD.CALIBRATION   | 2,061   | SY |       |     | E    |  |
| 3262                | 1    | KBLV | 6250  | 116672  | PAD, ACFT WASH RK | 2,494   | SY | 1     | EA  | E    |  |
| 3263                | 1    | KBLV | 6270  | 116672  | PAD, ACFT WASH RK | 711     | SY | 1     | EA  | E    |  |

**Figure 16 Base Detail by Category Code**

The last three data tables relate to the historic and projected cost of construction for the scenario. Each of these tables contains data that is derived from the *Historical Air Force Construction Cost Handbook*. These tables require updating once a year with the

publication of the latest cost handbook. Though they are currently static tables, it is possible to eventually develop a module to import the data from the latest version of the Parametric Cost Engineering System (PACES) program.

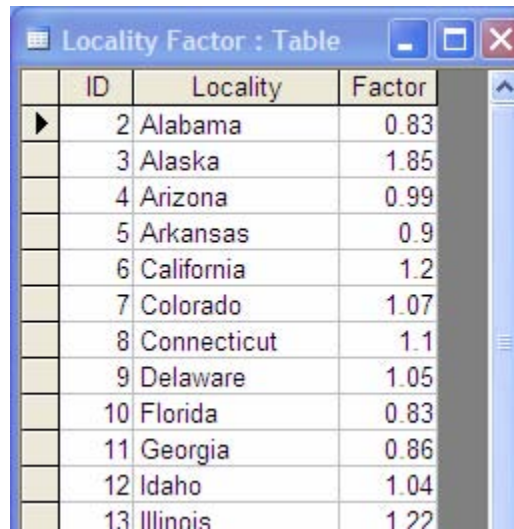
The first of these tables, shown in Figure 17, is the historical cost data table. This table contains the historic cost per unit data for the various category codes.



| ID | Item                 | Cat Code | Units | Cost     | Remarks |
|----|----------------------|----------|-------|----------|---------|
| 6  | Runway               | 111111   | sq yd | \$91.85  |         |
| 8  | Taxiway              | 112211   | sq yd | \$91.85  |         |
| 9  | Apron/AC             | 113321   | sq yd | \$91.85  |         |
| 10 | Petroleum Ops Buildi | 121111   | sq ft | \$143.12 |         |
| 11 | Hydrant/AC Prkng Sp  | 121122   | %     | \$144.43 | gpm     |
| 12 | Radar Apprch Control | 134375   | sq ft | \$143.12 |         |
| 13 | Aerial Del Facility  | 141232   | sq ft | \$143.12 |         |
| 14 | Base Ops             | 141453   | sq ft | \$143.12 |         |
| 15 | Crew Readiness       | 141459   | sq ft | \$143.12 |         |
| 16 | Weather Observation  | 141629   | sq ft | \$143.12 |         |
| 17 | Squad Ops/AMU        | 141753   | sq ft | \$143.12 |         |

**Figure 17 Historical Cost Data by Category Code**

Figure 18 shows the next cost data table which is the locality factor table. This is another static table that holds the state specific location multiplicative modifier. Data from this table is used with the estimated construction cost to approximate the true cost based on the particular state. Thus, a \$10,000 construction estimate would result in an approximated cost of \$8,300 in Alabama ( $\$10,000 \times 0.83$ ). The same construction would cost approximately \$12,000 in California ( $\$10,000 \times 1.2$ ).

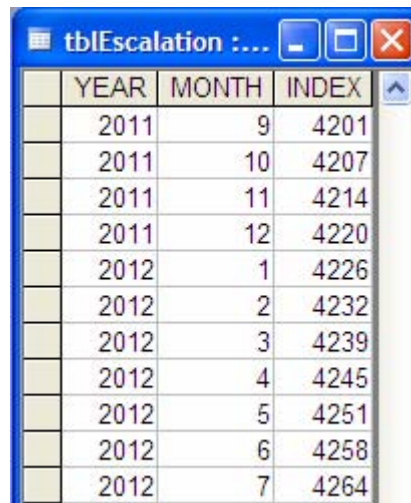


| ID | Locality    | Factor |
|----|-------------|--------|
| 2  | Alabama     | 0.83   |
| 3  | Alaska      | 1.85   |
| 4  | Arizona     | 0.99   |
| 5  | Arkansas    | 0.9    |
| 6  | California  | 1.2    |
| 7  | Colorado    | 1.07   |
| 8  | Connecticut | 1.1    |
| 9  | Delaware    | 1.05   |
| 10 | Florida     | 0.83   |
| 11 | Georgia     | 0.86   |
| 12 | Idaho       | 1.04   |
| 13 | Illinois    | 1.22   |

**Figure 18 Locality Cost Factors**

The final cost related table is the economic inflation data table (tblEscalation) shown in Figure 19. This table contains the Engineering News Record Building (ENR) Construction Index (BCI) for months up to the cost handbook publication data and the ENR BCI adjusted by the current Office of Management and Budget escalation indices for dates beyond February 2005.

Data from this table is used to calculate the inflation adjustment indices for proposed construction timelines.



| YEAR | MONTH | INDEX |
|------|-------|-------|
| 2011 | 9     | 4201  |
| 2011 | 10    | 4207  |
| 2011 | 11    | 4214  |
| 2011 | 12    | 4220  |
| 2012 | 1     | 4226  |
| 2012 | 2     | 4232  |
| 2012 | 3     | 4239  |
| 2012 | 4     | 4245  |
| 2012 | 5     | 4251  |
| 2012 | 6     | 4258  |
| 2012 | 7     | 4264  |

## **Figure 19 Economic Inflation Data**

### **Summary**

This chapter discussed the initial development and organization of the Access application. Tables were defined for data required for the beddown analysis and external sources were identified where applicable. Some basic logic regarding the generation of the category code aggregate values were discussed as well as the preferred method of generating cost estimates through these tables. The following chapter will address interface methods and the results and analysis of the final application.

## **IV. Results and Analysis**

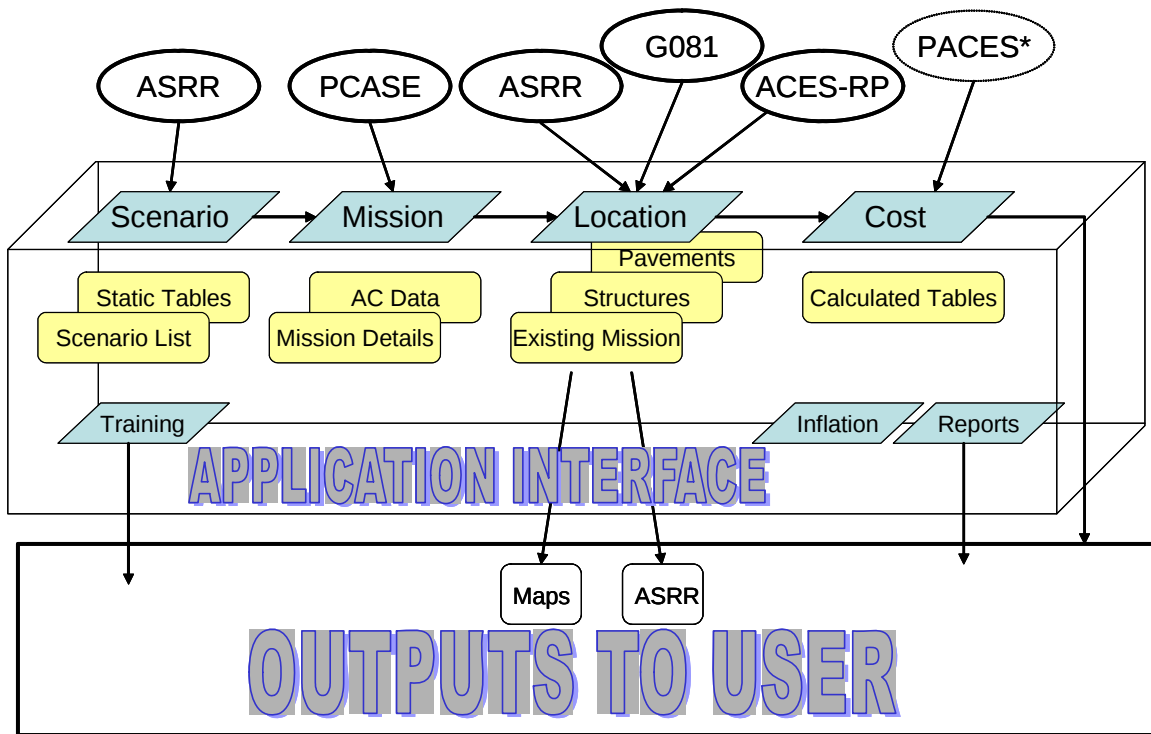
### **Chapter Overview**

This chapter details the research findings revealed through the development of the AMC/A75R beddown analysis application. These finding will be examined through discussion of the final application development, construction and flow. Afterwards we will discuss the significant findings based on the research objectives detailed in Chapter I and the research design outlined in Chapter III.

### **Final Application Development**

Figure 20 displays the graphical relationship between the external sources, interaction forms, data table types, and the user. The application is controlled by the minimum number of user forms as possible to maintain simplicity and still retain capability. Starting on the left, the user will initiate a scenario, define the beddown mission load, gather the relevant data regarding the location of the beddown, and finally examine the calculated costs and generate outputs.

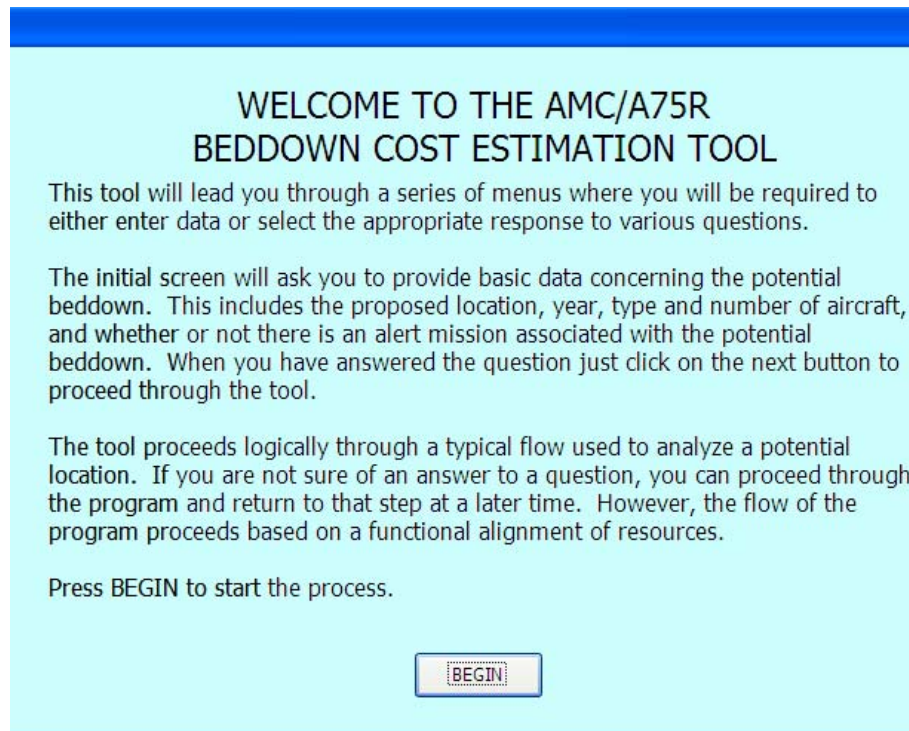
This is a very simplified explanation of what is going on inside of the application. In fact, to accomplish these tasks, the application currently uses 57 Access tables, 52 Access forms and sub forms, 21 Access queries, and 3438 lines of Visual Basic code. In the following sections we will go through the application in more detail and discuss some of the interactions and underlying data.



\*Not Currently incorporated

**Figure 20 Application Relationships to External Sources and User**

After the initial splash screen, the user is directed to the welcome screen shown in Figure 21. This form simply explains some initial information regarding the type of data need from the user before continuing with the application.

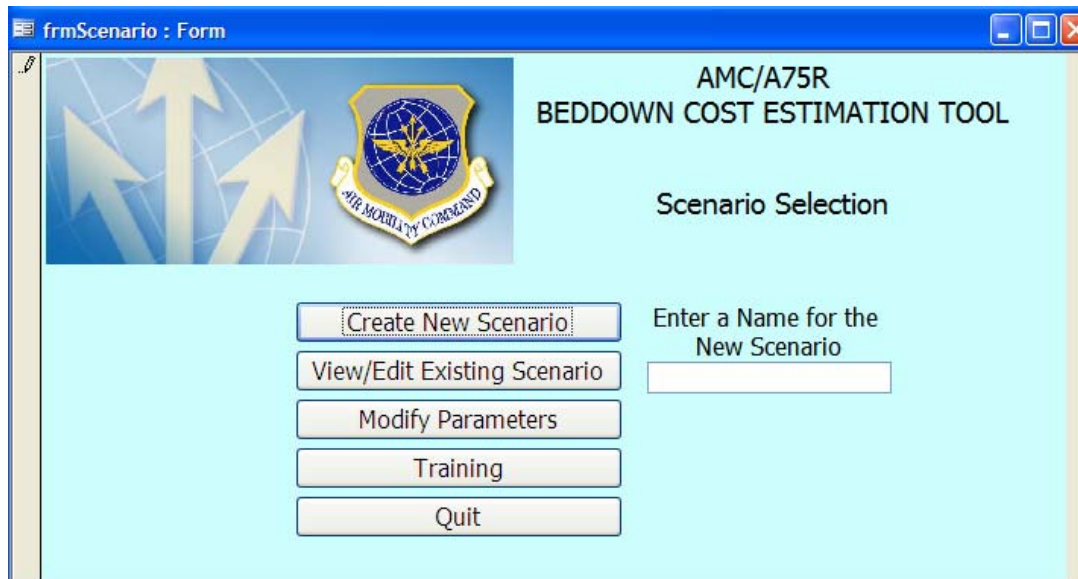


**Figure 21 Initial Screen**

Figure 22 displays the first input form the user will see is the Scenario Selection form. As evident by the captions on the command buttons, here the user may start a new scenario from scratch by entering a new name, select an existing scenario to view, modify parameters, or view training.

Each scenario generated by the application is identified by an application generated unique code. It is possible for the user to use the same name as a previously generated scenario. Users should use a descriptive name in order to distinguish their scenario from others.

The training module has not been fully developed yet and is currently inactive. By request of the AMC/A75R personnel, it has been added as a means to orient new personnel to the beddown process. In that module, the user will have references to the application user manual, pre and post beddown checklists, the AMC graphical beddown flowcharts, as well as links to external web-based reference materials.



**Figure 22 Scenario Selection**

The most important action available through the *Scenario Selection* form is parameter maintenance which is accessed by selecting the “Modify Parameters” command button. Figure 23 displays the form opened by this command button. This form allows access to all the ‘static’ data tables in the database that do not have any means to be updated electronically.

These tables consist primarily of the tables derived from the *Facility Requirements* handbook and the *Airfield and Heliport Planning and Design* manual.

Also included in this category are the cost data tables derived from the DoD *Facilities Pricing Guide* and the *Historical Air Force Construction Cost Handbook*.

The data contained in these cost tables can also be obtained electronically through interface with the PACES software data tables. However, since the PACES software is proprietary, we did not develop the interface during this research.

| 7.1 | Covered Aircraft Maintenance Space       | tbl7_1 |
|-----|------------------------------------------|--------|
| 7.2 | Separation Dimensions Inside Hangars     | tbl7_2 |
| 7.3 | General Purpose Maintenance Shops        | tbl7_3 |
| 7.4 | AMU/Maintenance Shops                    | tbl7_4 |
| 7.5 | Jet Engine Intermediate Maintenance Shop | tbl7_5 |
| 7.6 | Maintenance Support                      | tbl7_6 |
| 7.7 | Space Requirements for Avionics Shops    | tbl7_7 |

**Figure 23 Static Table Edit Screen**

After selecting or entering a scenario name, the user will be directed to the New Mission Data form shown in Figure 24. This form emulates the logic on flow chart 1 of the AMC beddown logic flowcharts and hence references that source in its name. At this point, the user will enter the particular information regarding the beddown he/she is working on. As with the AMC flowcharts, data entered in this form generate interim calculation that are used to calculate various facility requirements. In this application, those interim requirements are done via Visual Basic and are not visible to the user.

The key driving factors to many of the facility requirements are the specific aircraft characteristics such as length, width, and tail height. The user can only select

aircraft from the dropdown menu that have already been input into the database and consequently have the required information.

The aircraft information is managed in the scenario by type of aircraft and consequently, an aircraft that has been already selected will not be available for additional selections. The application maintains the data for each of the aircraft types in the scenario as well as an aggregate rollup for the combined scenario. The aggregate data is what will be compared to existing facility later. The application determines how aircraft data will be combined in the aggregate table. For example, the determining factors for runways are the length and width. When information from more than one aircraft is added into the aggregate record, we are only interested in the greatest requirement. On the other hand, apron area must be considered for all aircraft and the total sum of requirements will be entered into the aggregate record.

If a required aircraft is not available from the drop down list or the user simply wishes to modify an existing aircraft they will select the Edit/Import Aircraft Data command button. This opens the Edit/Import Module we will discuss next.

Another key consideration for the cost estimate in the beddown process is the location of the specific beddown. This determines what existing facilities are present and the adjusted construction costs based on the geographic region. Since we are using this application primarily for CONUS base planning, and are generally looking at locations with pre-existing airfields, we will use the ASRR database to select locations. As with the aircraft information, if the particular location is not available from the drop down list then a command button can be used to manually create or look for the location. Since the

on-line ASRR database is continually maintained the possibility exists that locations may be added or, on rare occasions, removed.

**AMC/A75R  
BEDDOWN COST ESTIMATION TOOL**

**Form 1  
New Mission Data**

Scenario Name:  Location:

| Aircraft | Number | Alert Mission                       | Number of Alert Aircraft: | Number of Alert Crew: |
|----------|--------|-------------------------------------|---------------------------|-----------------------|
| S3-B     | 20     | <input checked="" type="checkbox"/> | 6                         | 12                    |
| C-17     | 10     | <input type="checkbox"/>            | 0                         | 0                     |
| C-5A     | 10     | <input checked="" type="checkbox"/> | 8                         | 80                    |
| C-130H   | 30     | <input checked="" type="checkbox"/> | 5                         | 30                    |
|          | 0      | <input type="checkbox"/>            | 0                         | 0                     |

View Bare Base Requirements

Edit/Import Aircraft Data

Manage Locations

Continue >>

**Figure 24 New Mission Data Collection Form**

The Edit/Import Module for aircraft provides the user with the ability to import aircraft data from the PACES program and manipulate aircraft already loaded in the database. Figure 25 displays this module. Initiating an import action generates dynamic requeries for the underling data in both this form and the New Mission Data form. These dynamic requery actions permit the user to immediately access the information imported without having to close and reload the forms. This also avoids database errors by preventing users from importing aircraft that have already been entered into the system before they have been cleared. The underlying query essentially filters already selected aircraft from the list of possible aircraft from PACES.

**Figure 25 Aircraft Edit/Import Module**

Choosing to view or edit the aircraft data opens the Aircraft Characteristic Data form. This form, shown in Figure 26, is designed to roughly emulate enclosure 1 to ETL 1110-3-394, *Engineering and Design Characteristics for Airfield-Heliport Design and Evaluation*. This manual, produced by the Army Corps of Engineers, is the most comprehensive book regarding aircraft characteristics for all the services.

In this form, copying and editing data are very similar actions. Since the PCASE data is from ‘published’ sources we do not want to lose that information until the source makes the changes needed. Consequently, choosing to edit a PCASE data aircraft creates a copy of the aircraft with a designation (u) as a user modified aircraft. Choosing to copy the record performs a similar action.

**Aircraft Characteristic Data**

Aircraft  Engine Rating

Min. T/O Wt.  \*Min. T/O Dist. @ Min. T/O Wt.

\* Min. T/O Dist. @ Min. T/O Wt. With Abort Dist.

Max. T/O Wt. Peace-Time  Max. T/O Wt. War-Time

\* Min. T/O Dist. @ Max. T/O Wt. War-Time

\* Min. T/O Dist. @ Max. T/O Wt. War-Time With Abort Dist.

Min. Ldg. Wt.  Max. Ldg. Wt.

\* Min. Ldg. Dist. @ Min. Ldg. Wt.

\* Min. Ldg. Dist. @ Max. Ldg. Wt.

|   | SlopeA   | SlopeB    | SlopeC   | SlopeD   | InterceptA | InterceptB | InterceptC | InterceptD | Flexible |
|---|----------|-----------|----------|----------|------------|------------|------------|------------|----------|
| ▶ | 0.405149 | 0.405149  | 0.405149 | 0.405149 | 0          | 0          | 0          | 0          | -1       |
|   | 0.408011 | 0.4080106 | 0.408011 | 0.408011 | -0.06804   | -0.068037  | -0.068037  | -0.06804   | 0        |

**Figure 26 Aircraft Edit Detail Form**

Once the user has completed entering the aircraft for the scenario the “Continue” command button initiates the visual basic code that validates the data and performs the aggregate analysis. The module called receives the aircraft data as an editable ‘recordset’ from the form and processes it record by record. Using the recordset data object allows for easy manipulation of varying numbers of aircraft.

During the analysis, if the user has entered something wrong (selecting and alert mission without designating the number of aircraft) he will be prompted to resolve them before being allowed to continue. Once any errors have been eliminated, the user is directed to the Existing Facility Data form as displayed in Figure 27.

This form allows access to the location specific information regarding existing pavements data, building and other structure data, and already based aircraft information.

These three categories naturally present themselves in the beddown analysis process and they were one of the initial considerations when designing the organization of the data tables. Consequently, each category has its own tab that is linked to the underlying tables to present the information in an organized manner for user access. The ‘AIRCRAFT’ tab allows the user to generate a query to the G081 database and retrieve the aggregate count of aircraft based at the location by type. With this information, the application can conduct the same calculations as on the new mission form to generate the facility requirements for the aircraft already based at the location.

The ‘PAVEMENTS’ tab provides the user with an abbreviated rollup of the existing pavements data based on the ASRR Giant Report format. This report is the same web-based report that the application accesses to gather this data when the user selects the ‘Import’ command button.

Also available from this form are the web links to the ‘Giant Report’ and Google satellite map based on the longitude/latitude information from the ASRR data. If the user has installed the GoogleEarth application, the Google Earth command button will create a Google Earth reference file based on the ASRR data and start the Google Earth application zooming in to the satellite view of the designated location.



AMC/A75R  
BEDDOWN COST ESTIMATION TOOL

Form 2  
Existing Facility Data

Beddown Location:

[Continue >>](#)

PAVEMENTS   STRUCTURES   AIRCRAFT

| Runways |         |        |       |       |         |           |            |        |   |     |     |     |      |     |     |
|---------|---------|--------|-------|-------|---------|-----------|------------|--------|---|-----|-----|-----|------|-----|-----|
| Name    | Primary | Length | LDA   | Width | Surface | Condition | Raw WBC    | PCN    | S | T   | ST  | TT  | SBTT | TDI | TRT |
| ▶ 14L   | *       | 10000  | 10000 | 150   | CON     | GOOD      | PCN 67RCWT | 67RCWT | 0 | 111 | 175 | 345 | 593  | 840 | 585 |
| 14R     |         | 8001   | 8001  | 150   | PEM     | GOOD      | PCN 90RBWT | 90RBWT | 0 | 111 | 175 | 345 | 593  | 840 | 585 |

| Taxiways |       |         |           |          |      |                                     |
|----------|-------|---------|-----------|----------|------|-------------------------------------|
| Name     | Width | Surface | Condition | WBC      | PCN  | Has Lighting                        |
| ▶ A      | 75    | CON     | GOOD      | PCN 67RC | 67RC | <input checked="" type="checkbox"/> |
| E        | 75    | BIT     | GOOD      | PCN 67RC | 67RC | <input checked="" type="checkbox"/> |
| G        | 75    | ASP     | GOOD      | PCN 67RC | 67RC | <input checked="" type="checkbox"/> |
| H        | 25    | ASP     | GOOD      | S 12     | XXXX | <input checked="" type="checkbox"/> |
| K - M, P | 75    | CON     | GOOD      | TT 209   | 31RC | <input checked="" type="checkbox"/> |

| Aprons     |        |       |         |           |          |      |                                     |
|------------|--------|-------|---------|-----------|----------|------|-------------------------------------|
| Apron ID   | Length | Width | Surface | Condition | WBC      | PCN  | Has Lighting                        |
| ▶ CARGO    | 600    | 500   | CON     | GOOD      | TT 209   | 31RC | <input checked="" type="checkbox"/> |
| F          | 3000   | 150   | ASP     | FAIR      | PCN 67RC | 67RC | <input checked="" type="checkbox"/> |
| GUARD      | 1000   | 425   | CON     | GOOD      | PCN 67RC | 67RC | <input checked="" type="checkbox"/> |
| NORTH RAMP | 338    | 2200  | CON     | FAIR      | PCN 67RC | 67RC | <input type="checkbox"/>            |
| PAX        | 1000   | 400   | CON     | GOOD      | TT 209   | 31RC | <input checked="" type="checkbox"/> |

[Edit](#)

[Import](#)

[Google Earth](#)

[Google Map](#)

[View ASRR](#)

**Figure 27 Existing Facility - Pavements**

In some cases, as in our example, the user may need to edit the information loaded from the ASRR. In this case, notice that the last entry under Taxiways refers to four separate taxiways in one. The application needs each taxiway to be entered in a separate record in order to recognize them all. Selecting the ‘Edit’ command pulls up the application’s “MiniGiant” form to edit the information loaded from the ASRR. Figure 28 displays the pavements data as seen in the edit mode.

| Basic Information          |         |                     |           |                      |          |                                     |            |                      |   |           |     |     |      |
|----------------------------|---------|---------------------|-----------|----------------------|----------|-------------------------------------|------------|----------------------|---|-----------|-----|-----|------|
| NAME: SCOTT AFB MIDAMERICA |         | ICAO: KBLV          |           | Alternate ICAO:      |          | Alternate Names: BELLEVILLE         |            | WAC INNR: 0359-00182 |   |           |     |     |      |
| Airfield Type: JOINT (J)   |         | Latitude: 38 32.7N  |           | Longitude: 089 50.1W |          | Elevation: 459                      |            | Country: ILLINOIS    |   | Country C |     |     |      |
| Survey Date: 12/20/1993    |         | Review By: KLINGLEH |           | Codes: ABCDEFGH      |          | Geoloc: VDYD                        |            | Area ID: 018         |   | FAA: BLV  |     |     |      |
| Runway Information         |         |                     |           |                      |          |                                     |            |                      |   |           |     |     |      |
| Name                       | Primary | Length              | LDA       | Width                | Surface  | Condition                           | Raw WBC    | PCN                  | S | T         | ST  | TT  | SBTT |
| ▶ 14L                      | *       | 10000               | 10000     | 150                  | CON      | GOOD                                | PCN 67RCWT | 67RCWT               | 0 | 111       | 175 | 345 | 59   |
| 14R                        |         | 8001                | 8001      | 150                  | PEM      | GOOD                                | PCN 90RBWT | 90RBWT               | 0 | 111       | 175 | 345 | 59   |
| *                          |         | 0                   | 0         | 0                    |          |                                     |            |                      | 0 | 0         | 0   | 0   |      |
| Taxiway Information        |         |                     |           |                      |          |                                     |            |                      |   |           |     |     |      |
| Name                       | Width   | Surface             | Condition | WBC                  | PCN      | Has Lighting                        |            |                      |   |           |     |     |      |
| ▶ A                        | 75      | CON                 | GOOD      | PCN 67RC             | 67RC     | <input checked="" type="checkbox"/> |            |                      |   |           |     |     |      |
| E                          | 75      | BIT                 | GOOD      | PCN 67RC             | 67RC     | <input checked="" type="checkbox"/> |            |                      |   |           |     |     |      |
| G                          | 75      | ASP                 | GOOD      | PCN 67RC             | 67RC     | <input checked="" type="checkbox"/> |            |                      |   |           |     |     |      |
| H                          | 25      | ASP                 | GOOD      | S 12                 | XXXX     | <input checked="" type="checkbox"/> |            |                      |   |           |     |     |      |
| K - M, P                   | 75      | CON                 | GOOD      | TT 209               | 31RC     | <input checked="" type="checkbox"/> |            |                      |   |           |     |     |      |
| Parking Apron Information  |         |                     |           |                      |          |                                     |            |                      |   |           |     |     |      |
| Apron ID                   | Length  | Width               | Surface   | Condition            | WBC      | PCN                                 |            |                      |   |           |     |     |      |
| ▶ CARGO                    | 600     | 500                 | CON       | GOOD                 | TT 209   | 31RC                                |            |                      |   |           |     |     |      |
| F                          | 3000    | 150                 | ASP       | FAIR                 | PCN 67RC | 67RC                                |            |                      |   |           |     |     |      |

**Figure 28 Pavements “MiniGiant” Edit Form**

If the specific location has never been loaded into the database before, the user selects the 'Import' command to open ASSR Import form shown in Figure 29. This form uses the International Civil Aviation Organization (ICAO) reference number from the abbreviated list referenced in the Scenario form to reference the full ASRR for the location. Locations the user has input manually will not have an ICAO and would not be on the ASRR database. If a user attempts to import data from one of these types of locations he will be advised through a pop-up message and the ASRR import form will not open.

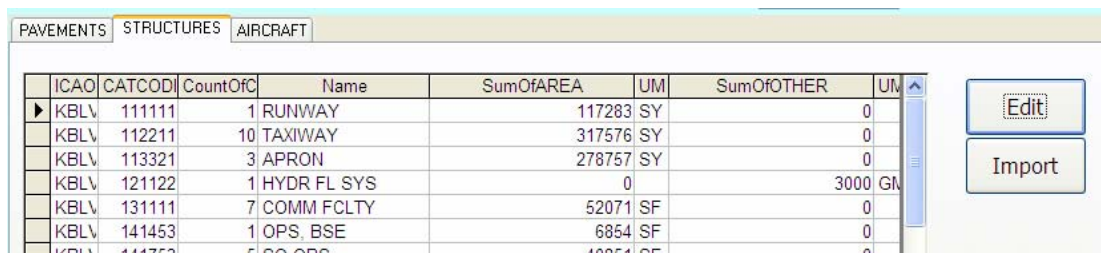
The screenshot shows a Windows-style application window titled "frmASRRImport : Form". The main content area has a light blue background and is titled "Import Pavements Data from ASRR". It contains four labeled text input fields: "NAME:" with the value "WILLIAM P GWINN", "ICAO:" with "06FA", "LOCATION:" with "FLORIDA", and "COORD:" with "2654N:08019W". Below these fields are three buttons: "Google Earth", "Import", and "Close". At the bottom of the form area are two underlined blue hyperlinks: "Google Map" and "View ASRR". The bottom of the window features a status bar with the text "Record: 1 of 2848" and navigation icons.

**Figure 29 ASRR Import Form**

The last tab we will discuss on this form is the 'STRUCTURES' tab as seen in Figure 30. This tab displays the aggregate rollup of existing facilities at the location as imported from ACES-RP. This data is obtained from an ACES-RP export disk containing the facility category code rollup by individual facility on the installation.

Selecting 'Import' opens a Windows file open dialog box that the user uses to select the file on his computer or via LAN. The 'Edit' command button opens up the detailed facility information where the user can modify the individual records as necessary. If needed, the user may modify the aggregate numbers later on the calculated rollups form. These data records, however, will not be changed.

After all importing and editing has been accomplished, the user selects the 'Continue >>' button. This initiates the Visual Basic routine that performs the final calculations to generate and combine all the aggregate requirements by facility category code and directs user to the 'Calculated Rollup' form.



| ICAO | CATCOD | CountOfC | Name        | SumOfAREA | UM | SumOfOTHER | UM |
|------|--------|----------|-------------|-----------|----|------------|----|
| KBLV | 111111 | 1        | RUNWAY      | 117283    | SY | 0          |    |
| KBLV | 112211 | 10       | TAXIWAY     | 317576    | SY | 0          |    |
| KBLV | 113321 | 3        | APRON       | 278757    | SY | 0          |    |
| KBLV | 121122 | 1        | HYDR FL SYS | 0         |    | 3000       | GN |
| KBLV | 131111 | 7        | COMM FCLTY  | 52071     | SF | 0          |    |
| KBLV | 141453 | 1        | OPS. BSE    | 6854      | SF | 0          |    |

**Figure 30 Existing Facility - Structures**

Figure 31 shows the 'Calculated Rollup' form which displays the availability and requirements of each facility category code and the shortage or excess generated using the equation:

$$\text{Needed} - (\text{Available} - \text{Used}) = \text{Short}$$

In this equation, 'Needed' is the total needed to support the beddown package, 'Available' is the total quantity of that particular category, and 'Used' is the requirements from existing aircraft already based at the location. Since we are looking at shortages, a negative number means there is an excess at the location and a positive number indicates a true capacity shortfall.

The second window shows the subtotal construction cost for each shortfall identified. This data is summed to produce the “Grand Total” estimate at the top of the form. Both of the tables in the form are dynamic and, like a spreadsheet, all calculations are automatically updated when changes are made. Changes made to the values in this section do not affect the calculated values from earlier sections. If the user needs to get the original values back, clicking the ‘ReCalc’ button over the respective column will load the calculated values back into the form.

AMC/A75R  
BEDDOWN COST ESTIMATION TOOL

Form 3  
Calculated Rollup

Beddown Location:  
SCOTT AFB MIDAMERICA  
ILLINOIS  
ICAO: KBLV

Grand Total: \$18,634,288.54

ReCalc ReCalc ReCalc

| CatCode | Needed | Available | Used | Short   |
|---------|--------|-----------|------|---------|
| 111111  | 8000   | 8000      |      |         |
| 112211  | 0      | 317576    | 0    | -317576 |
| 113321  | 0      | 278757    | 0    | -278757 |
| 116116  | 500    | 0         | 0    | 500     |
| 121122  | 0      | 0         | 0    | 0       |
| 131111  | 10627  | 52071     | 0    | -41444  |
| 141232  | 0      | 0         | 0    | 0       |
| 141453  | 23000  | 6854      | 0    | 16146   |
| 141459  | 0      | 0         | 0    | 0       |
| 141629  | 0      | 0         | 0    | 0       |
| 141753  | 64000  | 40851     | 0    | 23149   |
| 141782  | 0      | 0         | 0    | 0       |
| 141783  | 0      | 0         | 0    | 0       |

| CatCode | Unit Cost | SubTotal       |
|---------|-----------|----------------|
| 116116  |           |                |
| 141453  | \$143.12  | \$2,310,815.52 |
| 141753  | \$143.12  | \$3,313,084.88 |
| 211111  | \$191.47  | \$9,573,882.94 |
| 211152  | \$147.95  | \$953,833.65   |
| 211153  | \$147.95  | \$676,279.45   |
| 211157  | \$147.95  | \$314,393.75   |
| 211179  | \$191.47  | \$237,422.80   |
| 214425  | \$145.05  | \$943,695.30   |
| 214467  | \$145.05  | \$51,202.65    |
| 217712  | \$142.68  | \$259,677.60   |
| 721312  |           |                |
| 730835  |           |                |

Toggle Locality Index On

Reports Google Map  
Save Output View ASRR  
Inflation Analyzer Google Earth  
Edit

**Figure 31 Calculated Rollup Form**

Also referenced in this form are the location specific economic multipliers. By clicking the ‘Locality Index’ toggle button, the adjusted facility construction estimate based on the beddown location is displayed in place of the generic estimate. Figure 32 shows the Calculated Rollup form with the Locality Index activated. These estimates can be compared directly in the Inflation Effects Analyzer.

Form 3  
Calculated Rollup

Grand Total: \$22,733,832.02

Multiplier: 1.22

Beddown Location:  
SCOTT AFB MIDAMERICA  
ILLINOIS  
ICAO: KBLV

ReCalc ReCalc ReCalc

Toggle Locality Index Off

| SetCode | Needed | Available | Head | Short | CostCode | Unit Cost | SubTotal |
|---------|--------|-----------|------|-------|----------|-----------|----------|
|         |        |           |      |       |          |           |          |

**Figure 32 Calculated Rollup Form w/Multiplier**

Selecting 'Inflation Analyzer' from the Calculated Rollup form opens the Inflation Effects Analyzer shown in Figure 33. This form allows the user to take into account the local adjusted economic factor as well as the projected effects of inflation. As per the Air Force Construction guide, cost estimates taking into effect inflation are based on the inflation index from the mid point of construction. The user is prompted to input the projected start and completion date for the construction to calculate the effects of inflation. This form is specifically designed to deactivate the 'Calculate' button until the dates have been entered.

Inflation Effects Analyzer

Construction Cost

Generic \$18,634,288.54

By Location \$22,733,832.02

Start Construction: Dec

Construction Complete: 2006

Adjusted for Inflation

Inf Index

Calculate

**Figure 33 Inflation Effects Start**

Once the start and end construction dates are entered the application retrieves the applicable projected inflation multiplier and generates a cost comparison summary.

Figure 34 shows a completed Inflation Effects form.

The screenshot displays the 'Inflation Effects Analyzer' form. It is divided into two main sections: 'Construction Cost' and 'Adjusted for Inflation'. The 'Construction Cost' section has two input fields: 'Generic' with the value '\$18,634,288.54' and 'By Location' with the value '\$22,733,832.02'. Below these are two date pickers: 'Start Construction' set to 'Dec 2006' and 'Construction Complete' set to 'Feb 2008'. The 'Adjusted for Inflation' section, which is highlighted with a black border, contains two output fields: '\$19,092,616.09' and '\$23,292,991.63'. Below these is an 'Inf Index' field with the value '1.02459592' and a 'Calculate' button.

| Inflation Effects Analyzer      |                                          |
|---------------------------------|------------------------------------------|
| <b>Construction Cost</b>        | <b>Adjusted for Inflation</b>            |
| Generic \$18,634,288.54         | \$19,092,616.09                          |
| By Location \$22,733,832.02     | \$23,292,991.63                          |
| Start Construction: Dec 2006    | Inf Index 1.02459592                     |
| Construction Complete: Feb 2008 | <input type="button" value="Calculate"/> |

**Figure 34 Inflation Effects Calculated**

At this point, the basic beddown analysis is essentially complete. The analyst may now examine alternate variations of the scenario in order to see the effects. Moving on to the reports screen, the user may then generate preexisting or custom reports that may be used in the beddown scenario report.

## **Research Findings**

### ***Objective 1 – Understand the complete process that AMC/A75R uses to conduct infrastructure analysis***

Previous research (Salmond, 2005) examined the beddown process in order to isolate the primary cost driving factors. This initial study was verified again during this research through discussions with AMC/A75R personnel and analysis of the applicable facility guidelines. Where locality and projected timeframe of the beddown affect the beddown cost by a multiplicative factor, this factor generally does not contribute more than a small

percent in the cost (only five states have average factors in excess of 1.15). In roughly half of the continental United States (24 states), the locality multiplier results in a decrease in the projected cost from the national average. Similarly, the projected increase due to interest is generally less than five percent. Understanding this, it is apparent that the primary cost drivers are number and type of aircraft in the beddown scenario.

Gathering the individual aircraft data, the beddown analyst references the applicable facility requirements from AFH 32-1084 to generate the rough by-aircraft infrastructure requirements to support the specific airframe.

Once the demand for the beddown is understood, an existing facility study is completed that identifies the amount of space by facility category code that is available at the location. Particular attention must be given to the use of facilities by tenant units. Units already on the ground may use larger areas of certain facilities simply because they are currently underutilized. Additionally, aggregate rollups do not necessarily tell of an area is adequate for a new mission. An aggregate rollup that reveals 250 square feet of available space may consist of five separate locations. Consequently, the analyst must delve into the by-building-number details of the real property records.

With the demand and free space calculations, a basic cost estimate can then be completed based on historic cost factors, published facility-type costs, area cost factors, and future cost factors. The application accomplishes this using the most common formats used by the AMC/A75R team. Once calculations are complete for the scenario, preexisting or custom reports can be used as feeder documents for the beddown planning documents.

***Objective 2 – Investigate available on-line sources of data and other existing databases***

Digital databases are the preferred sources for data collection for the application. This enables the analyst to focus on the scenario instead of having to continually verify information currency. Additionally, using the digital means of data transfer limits the opportunity for human error when entering information and allows the data to be managed and updated by the proponent of that data.

Open source data is limited to the open source mapping tools such as Google Local, Google Earth and Yahoo Maps. Though the data from these sources are not used directly in calculating cost, they are useful for the analyst attempting to visualize the facilities in question. The Google Earth application additionally supports rudimentary measurement functions that are useful to validate information from the real property database.

Stand alone software sources include the PACES and PCASE software. Both of these applications use an access style database that is directly compatible with the application we have built. Both are produced by data proponents and are periodically updated. Both are available free of charge to military units. The PACES software, however, has some very basic protection intended to prevent unwanted access to the raw data files. Access to this data is delayed until official approval can be obtained.

On-line secure sources include the ACES-RP, G081, ASRR, and GeoBase applications. Currently, all but the ACES-RP programs are accessible with an Air Force Portal login password. The ACES-RP program would still require an application specific password for each user. Consequently, access to the ACES-RP data will be conducted

through file transfer. The other programs have web based access that can provide the needed information for pavements, existing units, and visualization of the installation.

To minimize the number of accounts and passwords an analyst would have to juggle, the beddown application makes use of Visual Basic routines that make web browser calls to the relevant web-based application and then imports that data into the application database. By doing this we do not increase the sensitivity of the application beyond that of any individual application. This technique is a take-off of methods used in the GeoBase applications.

***Objective 3 – Develop a Microsoft Access database that conducts the necessary beddown calculations***

Though the application database can now be used as a dynamically-updatable reference for beddown analysis, the goal for this research is to complete an application that can actually complete the calculations. Earlier models have made use of the spreadsheet format due to the ability to perform multiple simultaneous calculations and cascade changes throughout the spreadsheet.

Examining options for calculating the demands, facilities, and cost totals in the application included the use of an embedded spreadsheet and the use of Visual Basic. Ultimately we settled on a form format that summarized the relevant data in a spreadsheet-like format and employed visual basic and dynamic-queries to perform the calculations.

***Objective 4 – Verify and Validate the Application***

Verification is the task of ensuring that the model behaves as you intended (Kelton et. al., 2004:540). This is essentially debugging the program. Verification was

completed as the application was built by using historic beddown scenarios and conducting manual calculations. Several procedural problems were identified in the historic methods during this verification process. Several times, incorrect lengths were used (human error) and in one case, an incorrect formula was being used. These discrepancies were researched with the appropriate references and the application was observed to generate the correct results.

Validation is the task of ensuring that the model behaves the same as the real system (Kelton et. al., 2004:540). This is a more complicated process in the context of this application. The first issue in question is what is the real system that we are dealing with? Is this referring to the cost estimation process itself or to what the process should be?

If we are referring to the estimation process itself then we cannot effectively validate the application with the historic cost estimates. The application conducts the estimates consistently each time based on detailed facility requirement calculations. Most of the historic cost estimates either have errors as discussed in the previous section or are of such broad (lower) detail that they cannot be accurately compared to the application analysis. In this case, the application cannot be validated against the historic data as it does not reproduce these errors.

However, if we are referring to what the cost estimation process *should be* then we can deduce through manual calculation that the application does indeed generate the estimates the historical estimates should have.

## **Summary**

This chapter details the research findings revealed through the development of the AMC/A75R beddown analysis application. Research findings were examined through discussion of the final application development, construction and flow and the previously stated research questions were addressed in the context of the application construction. The following chapter will present conclusions based on the application research and recommendations for future research.

## **V. Conclusions and Recommendations**

### **Recommendation**

We recommend that the AMC/A75R adopt the beddown analysis application developed during this research for use in their beddown cost infrastructure analysis. Currently, the application can perform initial facility requirements calculations with minimal user input thereby greatly reducing the chance of human error.

These calculations are performed consistently across multiple scenarios and thus establish an excellent baseline for the detailed analysis. The ability to access external data sources directly further reduces the opportunity to introduce user error and increases the fidelity of the application.

The remainder of this chapter will discuss the application's contributions and shortfalls as well as propose directions for future research. The chapter concludes with a summary of the research.

### **Conclusion**

#### ***Contribution***

Previous research had made considerable progress in gathering the AMC/A75R “corporate knowledge” on beddown estimates, reducing analysis time, ensuring consistency in the analysis (Salmond, 2005), and investigating initial portability into an Access database (Kitchens, 2005). Continuing this research line, the application developed during this most current research incorporates on-line data sources wherever possible, establishes connectivity to cost and existing infrastructure data, includes

construction time inflation factors, and allows for multiple aircraft analysis. The next few paragraphs will go into more detail on each positive impact that has developed.

One of the goals when initiating this research was to free the beddown analyst from the burden of continually researching and verifying baseline data for the estimates. Although AMC/A75R had compiled useful manual references for estimates, these were poorly documented and had to be checked regularly to insure that they were actually up to date. Examining possible sources of data revealed that the aircraft characteristics, location-specific pavements, infrastructure, and mission data, as well as historic cost data were all available through either preexisting stand-alone software or through on-line web based queries. Interfaces to these sources were coded into the application using Visual Basic allowing transparent access to the respective sources. This implementation gives the analyst access to the most current data and facilitates import directly into the application without the advent of human error and reduces input time from hours to minutes.

In the beddown process, cost factors are derived from the *Historical Air Force Construction Cost Handbook* and the *DoD Facilities Pricing Guide*. These two books provide the data necessary to determine realistic cost estimates based on actual construction costs and summary rollups by facility category code. Though the manuals are effective, the technique is cumbersome when having to consider the implications of multiple category codes. Consequently, under normal practices, the beddown analyst would endure additional hours of referencing and cross-referencing with calculator in hand in order to develop the estimate.

During source research, we found that the sources mentioned are also the base sources for the PACES software. Examining the PACES data structure revealed that it could be used as another source for input directly into our application. Because of the proprietary nature of the PACES software and the fact that the databases are password protected we only went so far as to mimic the table format in our own database and input the initial data manually. Maintaining the data within the application allows the use of Visual Basic again to play the part of the calculator for the analyst and conduct the same calculations seamlessly within the computer without tying up the analyst. The data within the application is current based on the 2005 cost handbook and will remain current through the year. If approval is obtained for the PACES data access then the updates for these tables will be automated as we have already done for the PCASE software.

Included within the PACES software are the raw Engineering News Record (ENR) Building Construction Indices (BCI) and inflation multipliers based upon Project Budget Document (PBD) 604 published by the Under Secretary of Defense (Comptroller). These indices allow the analyst to investigate the inflation effects over various construction time periods.

A significant improvement over earlier models is the ability to examine multiple aircraft scenarios and the increase in types of aircraft available for analysis. Under earlier tools, the analyst was limited to generating the bare base requirements for only six models of aircraft, one at a time. With the enhanced data sources, the current application already contains 119 various military and civilian aircraft that the user has the ability to use or modify as necessary. With the use of Visual Basic, facility category codes can be

calculated for multiple aircraft and aggregate requirements are rolled up for each scenario.

### ***Limitations***

The following paragraphs discuss the current limitations and areas for improvement to the developed application.

Every attempt was made to incorporate current on-line data sources where possible. However, there are still many areas in the application where user input is required. Additionally, during this research we found that we still had to verify the aircraft data imported from PACES. The data imported was correct but we observed that in some cases, there was simply no detail data. In these cases we referred back to the *Engineering and Design Characteristics for Airfield-Heliport Design and Evaluation* manual to fill in the blanks.

The Visual Basic routines used to access data from browser based queries were designed to import data from those web pages exactly as the data is currently formatted. Thus the routines are not very robust. Major changes in the source web design would render the import utilities incompatible and they would have to be rewritten. Additionally, moving the links to other servers would create similar, though easier to fix, problems.

These import problems could be overcome by gaining direct account access to the respective databases. That course of action was considered initially during development but was discarded because of the additional security requirements. This would also limit the number of users for the application since multiple users could not share account access to the external databases.

An additional concern is the possibility of outside sources gathering information on DoD plans by analysis of commercial web-site accesses from the military domains. The use of the Google Local web sites generates site queries based on specific latitude-longitude coordinates. With the current political and community social strains associated with BRAC or other unit alignments there could be negative repercussions from having the targeted areas of consideration revealed in an untimely manner. However, there currently exist means to defeat intelligence gathering efforts of this nature such as IP-spoofing and the generation of false queries to mask the relevant information.

### **Future Research**

There are abundant areas for future research that may expand upon the existing application structure or by additional interfaces with external applications. Among these possible areas of enhancement is the inclusion of a multiple location analysis heuristic, the addition of indirect support facilities into the infrastructure analyzed, and an export utility to take advantage of the capabilities of PACES.

With the beddown details loaded into the application it should be possible to construct a Visual Basic subroutine to compare the aggregate demands to the existing infrastructure of several locations at once. Users could categorize beddown scenarios as most favorable to least favorable based on the projected comparison of construction costs generated. Further investigation into this course of action should lead to an optimization routine where proposed aircraft force packages could be distributed (or realigned) over geographic locations in order to minimize cost.

The addition of secondary support facilities analysis may prove valuable insight as to the long term cost impact of these beddown actions. Whereas the facilities

examined in this research apply directly to the performance of the unit missions, there are other facilities that will naturally warrant construction as a natural expansion of the beddown. Such things as gyms, elementary schools, chapels, and theaters do not immediately impact whether a beddown is feasible but long term additions of personnel and families will naturally warrant these types of construction and/or improvements. According to the Congressional Budget Office analysis of long-term implications of defense plans from January 2003, “up-front funding for the fifth BRAC round would increase DoD's military construction costs by a total of \$8 billion between 2006 and 2008.” Projected future savings from these realignments could be considerably impacted by numerous secondary supporting facility costs.

A third area for improvement would be the final development of an interface with PACES that allows the user to pull necessary cost and inflation data from the application. In a similar manner, examining the PACES file structure may make it possible to develop an export utility to send beddown construction data directly to PACES. This way, analysts could take advantage of PACES full capabilities for project management to develop an even more detailed analysis.

## **Summary**

This chapter discussed the contributions and limitations of the developed application to AMC/A75R. Recommendations for future research were discussed and explained in brief. The purpose of this research is to develop an automated web-enabled beddown estimation application for Air Mobility Command in order to increase the effectiveness and enhance the robustness of beddown estimates. This was accomplished by determining the key cost driving factors to facility beddown analysis, identifying

existing databases for data collection, linking these sources together in an Access database application and examining how potential obstacles could be overcome.

This research was sponsored by AMC/A75R to further the understanding of the decision analysis process that occurs during beddown planning scenarios and to identify means to reduce the beddown planning timeframe.

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## **Vita**

Captain Jasper E. “Jak” Pennington graduated from Junction City Senior High School in Junction City, Kansas. He entered undergraduate studies at the University of Central Oklahoma in Edmond, Oklahoma where he graduated with a Bachelor of Science degree in Physics Engineering in May 1996. He was commissioned through the Army ROTC where he was recognized as a Distinguished Graduate and nominated for a Regular Commission.

His first assignment was at Aberdeen Proving Grounds, Maryland as a student in the Ordnance Officer’s Basic Course. He attended Airborne training at Fort Benning, Georgia and in March 1997 was assigned to the 123<sup>rd</sup> Main Support Battalion, 1<sup>st</sup> Armored Division, Baumholder, Germany where he served as a Platoon Leader, Maintenance Shop Officer and the Battalion Support Operations Maintenance Officer.

In July 2000, CPT Pennington returned to the states where he attended the Combined Logistic Officer’s Career Course and the Combined Arms Service and Staff School. He was then assigned as the S3 Operations officer for the 64<sup>th</sup> Corps Support Group at Fort Hood, Texas and in January 2001 he took command of Bravo Forward Support Company, 240<sup>th</sup> Forward Support Battalion, 4<sup>th</sup> Infantry Division (Mechanized) where he served for the next two and a half years. During his command, CPT Pennington deployed his Company to Baqubah, Iraq in support of Operation Iraqi Freedom. In August 2004, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned as the Team Chief of the M1A1 Technical Assistance Field Team (M1A1 TAFT) in Cairo, Egypt.

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| 14. ABSTRACT<br>The purpose of this research is to develop an automated web-enabled beddown estimation application for Air Mobility Command in order to increase the effectiveness and enhance the robustness of beddown estimates. This includes generating rough order of magnitude cost estimates for the potential beddown of air mobility assets as well as serving as a centralized data warehouse for current and future scenarios. The application developed is intended to provide the analyst with the maximum amount of both quantitative and qualitative input for any potential decision to quickly identify infrastructure requirement shortfalls and associated costs to satisfy those shortfalls. The application can also be used to train office personnel on actual beddown procedures.                                                                                                                                                              |             |                                          |                               |                                                                        |                                                                                                      |
| 15. SUBJECT TERMS<br>Beddown Planning, Infrastructure, Microsoft Access, Database, Air Mobility, Planning Tool                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |             |                                          |                               |                                                                        |                                                                                                      |
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| U                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | U           | U                                        | UU                            | 77                                                                     | 19b. TELEPHONE NUMBER (Include area code)<br>(937) 255-3636, ext 4703; e-mail: Alan.Johnson@afit.edu |