

**Data Analysis Tool for Air Force Facility Maintenance and Repair**

THESIS

Jim H. Daniels III, Captain, USAF

AFIT/GEM/ENV/17M

**DEPARTMENT OF THE AIR FORCE**

**AIR UNIVERSITY**

***AIR FORCE INSTITUTE OF TECHNOLOGY***

**Wright-Patterson Air Force Base, Ohio**

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# LITERATURE REVIEW

## Overview

The USAF has a robust infrastructure dictating a robust facility maintenance and repair (M&R) program. The goal of this literature review is to understand how the USAF manages its facility M&R and find areas that could benefit from advanced technologies or improvement. In order to find areas that need improvement, USAF FM systems and techniques are compared to those of industry leaders. First, this research explores how USAF currently manages its facility infrastructure and explains the future vision of USAF FM. Then, leading industry techniques are examined. Any key differences or potential improvements are extracted from the academic conversation.

The goal is to find an area that needs improvement but is not being improved.

Based on the differences between the current USAF applications of FM techniques, it is apparent the USAF can improve through a combination of improved analysis of consolidated data from their many data collection systems and the analysis of personnel productivity within the facility maintenance and repair teams.

The act of managing facility M&R is referred to as facility management (FM) in this research. USAF FM uses several computer based systems to facilitate M&R. Most of the systems are referred to by its acronym in all capital letters. Each acronym is defined and explained as each computer system’s role in the FM process is explained. However, TRIRIGA and BUILDER are two systems that are not acronyms and simply the name of the computer system, but the name is written in all caps.

## FM in the USAF

The United States was established as its own branch of the military in 1947. As a part of this, the newly created Air Force developed a need to build and maintain permanent bases of its own. Air Force Civil Engineering began to develop a facility maintenance program to manage its airfields and supporting facilities with a maintenance and repair branch, real property inventory, and master planning (Hartzer, Walker, Gatewood, Grandine, & Kuranda, 2012). Over time, Air Force Civil Engineering has developed several programs and underwent several organizational transformations in order to efficiently manage USAF property.

Currently, the USAF uses several different computer based systems to collect and store data. First, the Interim Work Information Management System (IWIMS) is used collect and store all maintenance and repair activities. It is used in conjunction with the Automated Civil Engineer System (ACES) split into ACES-Project Management (ACES-PM) and ACES-Real Property (ACES-RP). ACES-PM collects and stores new construction data and ACES-RP stores basic information about the facilities that the Air Force Civil Engineers are responsible for maintaining (\*CE Portal 1).

The Architecture Geographic Information System (ArcGIS) database is a system that the USAF uses mainly for emergency response and building location information. It is updated and maintained but vastly underutilized. It is also managed by a separate division of USAF CE from the section that manages the maintenance and repair (\*CE Portal 2).

BUILDER is a sustainment management system adopted by the Air Force through the United States Army Corps of Engineers (USACE). It is a facility condition assessment system that holds facility data and condition assessment data for the components of a facility. BUILDER uses this data and uses a formula based model to predict facility lifecycle and overall building condition (\*CE Portal 3).

Recently, they USAF Civil Engineering underwent an organization structure transformation. With this transformation, it introduced new information collection systems that manage facility information more quickly and efficiently. This is referred to as next generation information technologies (NextGen IT). NextGen IT mainly consists of the introduction of TRIRIGA. TRIRIGA is a replacement system built by International Business Machine (IBM) to replace IWIMS. TRIRIGA and NextGen IT are commonly used interchangeably in USAF playbooks and instructions. TRIRIGA stores maintenance and repair data, but it uses an updated priority system and a more user-friendly interface. However, one of the main problems with NextGen IT is that it takes so long to implement that by the time a new system is introduced, it is already becoming obsolete (\*CE Portal 4).

## FM in Industry

Improving facility maintenance and repair is not a new topic in literature. Optimization, efficiency, and cost reduction have always been an integral basis for facility maintenance and repair improvement. FM in industry is constantly evolving and improving. Some of the main areas of improvement are: building information modeling (BIM), geographic information systems (GIS), budget projecting, and personnel productivity.

Construction industry leaders now implement BIM as an integral part of FM. BIM is three-dimensional modeling software that contains building rendering and stores building information. BIM aids in building design, construction, maintenance, and operation of facilities by showing how different facility components work together and the exact location in three-dimensions. This new medium creates a better cognitive understanding than traditional two-dimensional blueprints or drawings can articulate. BIM, when implemented properly, also has the potential to encompass a large number of data sources for facility maintenance. Since BIM is used for design, construction, and maintenance, the initial data is not lost through miscommunication, or transfer error between multiple fragmented systems. Its unique capabilities even allow for maintainability considerations during the design process (Becerik-Gerber, Jazizadeh, Li, & Calis, 2012).

BIM has also shown to improve safety within FM processes. On a day to day basis, maintenance and repair technicians are repeatedly in high risk situations. Even with proper Occupational Safety and Health Administration (OSHA) practices, inaccurate, out-of-date drawings often put technicians in the way of unnecessary risk. Safety is currently relayed through training, pamphlets, and meetings. Very few of these are actually site specific. Research has shown that the more time required retrieving safety information, the less likely the worker is to retrieve that information (Wetzel & Thabet, 2015). Using a BIM based framework, the safety will not only be easier to retrieve, but it will also be accurate to that specific maintenance or repair situation. This study shows that not only can BIM based FM processes increase productivity, but they can also increase the safety of the workers when they are performing their maintenance and repair tasks (Wetzel & Thabet, 2015).

Out of its many system databases, the USAF does not have BIM capability. Beyond the three-dimensional modeling, the main benefit is the use of one main system for all data collection. Not only is all the facility maintenance data stored in the same location instead of several different systems, but the data from the original design and construction is also encompassed. This eliminates the issue of mismanagement or transfer of data between systems. The ease of access can also deliver more accurate and reliable safety information keeping the technicians safe. System compatibility and accurate data are essential in efficient FM.

Industry leaders are also using GIS in conjunction with BIM databases. The integration of these two technologies is very important because GIS contains key data in location. Location is a helpful aid in the management of utilities, where many are hidden underground and often difficult to locate. While both GIS and BIM display spatial information, GIS is the outdoor modeling aspect. Any unnecessary data can cause confusion, and simple access to location from GIS in combination with the accurate data from BIM allow these two information databases to offer invaluable insight into facility issues (Kang & Hong, 2015).

The USAF currently ArcGIS, but it does not use it for the application shown in the above research. It is not integrated or adapted into any of the facility maintenance systems. Integration of these two systems could potentially decrease facility maintenance and repair process times. This is another example of how multiple programs that are not coordinated create issues with data accuracy and usability. Industry research shows that GIS data is helpful in FM, the USAF has GIS data, but the USAF does not use GIS data to help FM.

Budgeting for facility maintenance and repair is an area where the USAF is improving with the introduction of BUILDER. Industry leaders developed numerous ways to budget for facility maintenance ranging from an antiquated basic estimate based on initial cost/replacement value to the current leading industry standard of assessment based on the facility’s current/projected facility condition. Decreasing budgets and competing priorities necessitate that the USAF use the newest, most accurate techniques.

The USAF currently bases the money needed for maintenance and repair on 1% of the plant replacement value (PRV) for all maintenance and repair annually. However, multiple other models represent a better budget for maintenance and repair such as: estimates based on quantifiable attributes of the plant, life-cycle cost analysis of individual facility systems, and assessment of facility system physical condition. Industry leaders use many criteria stemming from these approaches in a formula budgeting approach to look long-term. These models not only take into account the current status of the facility infrastructure and help model the most cost-effective repairs, but they also project budgets into the future so they can be planned for, reducing the risk of failure (Ottoman, Nixon, & Lofgren, 1999).

More recently industry leaders focus on minimizing the fluctuation within the budget for maintaining facilities. Industry leaders are continually revising and improving formula budgeting models. Building components and building materials each have different life expectancies or usable lives. Conversely, because it is easier to budget for a more consistent maintenance and repair cost annually, it is best to adjust budget projection formulas to regulate or minimize fluctuation in maintenance and repair. If the budget is not high enough to cover the required maintenance and repair, that maintenance and repair is likely differed or postponed. Failing to perform adequate, timely maintenance and repair has negative effects on the life cycle and performance of the facility leading to increased costs in the future. Adapting the models to stabilize the yearly cost of the facility maintenance and in effect preventing the postponement of maintenance and repair activities and increasing the life expectancy of a building (Kim, Han, & Hyun, 2015).

Updated budgeting techniques are important for the USAF to increase its efficiency, and they are making progress through the implementation of BUILDER. BUILDER uses the facility conditions and predicts future failure. Once the USAF fully implements and cleans the data within BUILDER, it will be working toward efficient FM budgeting. Once this is accomplished, it is important to take steps to minimize fluctuation between annual budgets in order to minimize postponed maintenance and repair to continually improve the life expectancy of its facilities and decrease overall facility life cycle costs (Kim, Han, & Hyun, 2015).

The final tool utilized by industry leaders is assessment of personnel productivity. The construction industry did not start tracking personnel productivity until the early 2000s. When analyzed, between the 1970s and the late 1990s personnel productivity increased, generally due to advancements in technology. Studying direct work rate, labor cost, and construction output, researchers drew conclusions on how changes in equipment costs or implementation of new technology affected the daily construction output. Using this analysis, project managers were finally able to quantify how daily output affected labor cost over time and how spikes in daily equipment cost affected the daily output (Allmon, Haas, Borcherding, & Goodrum, 2000).

With a properly constructed model, the USAF will be able to analyze how installation exercises or deployments affect the direct work, and daily output for each unit within the USAF Civil Engineering maintenance and repair sections. Currently the labor costs are not easily compared to direct work rate or construction output. The USAF needs a system to take advantage of the data they collected on these subjects. Then, they would be able to at least set benchmarks to see how implementing the NextGen IT systems or participating in installation exercises affect their maintenance and repair output.

Currently, the most common approach to increase construction productivity is by using models. These models use input and output factors to help facilitate decision makers to draw accurate conclusions based on productivity analysis. Construction related models are based on factors of individual performance and/or process based views. Models are then adapted to pull out the most advantageous traits and benchmarked to set a basis for productivity. Two common models are set up where productivity is based in terms of value and then again or where productivity is based in terms of quantity (Becker et al., 2012).

The key takeaway from the analysis of personnel productivity is that given the correct data, it is possible to create models and set benchmarks for the analysis of personnel productivity. With this data, it is possible to direct changes to personnel support or processes that will improve the facility maintenance process external to the condition or status of the facilities being managed.

## Where USAF FM Falls Short

The USAF Civil Engineering falls short in the data analyzation and data communication aspects of facility maintenance. The USAF has several systems and large amounts of data collected, but it is still difficult to interpret that data even though the program interfaces are vastly improving with the introduction of NextGen IT. Because of delays in implementation of improved data collection systems, over time the USAF has fallen behind leading industry tactics.

The retrieval of information is making improvements toward industry standard with the introduction of TRIRIGA and BUILDER but still do not meet the utility of BIM modeling. The use of multiple systems that are unrelated with information mixed across several platforms hinders the USAF Civil Engineering performance in terms of FM. On the other hand, the implementation of barcode scanning on maintenance items is a vast improvement over IWIMS and ACES-RP. If this was included in with GIS location references, it has potential for major system efficiency improvement. However, the antiquated facility number system leads to delayed process times compared to GIS referenced systems. USAF Civil Engineering does very little to assess, benchmark, or improve personnel performance. Understanding the personnel benchmarks in terms of value or output could greatly help personnel decisions and improve the organization.

Overall, the two main areas where the USAF can improve are through a combination of the analysis of consolidated data from their many data collection systems and the analysis of personnel productivity within the facility maintenance and repair teams. This could be included in one platform that consolidates the data from the various databases, then using the large amount of data, and a focus on personal productivity, benchmarks can be set and the user can draw meaningful conclusions based on actual facility maintenance and repair data.

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\*CE Portal – CE Portal is a website with a collection of Air Force Civil Engineering papers, articles, slideshows, and playbooks. Exact reference/citation to be determined. 4 separate sources that need to be extracted and cited.

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