A Strategic Assessment of Infrastructure Asset-Management Modeling

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Budget constraints and scarce resources have sparked agencies to maximize efficiency when operating and maintaining aging infrastructure. For example, in 2007 Air Force civil engineers introduced a formalized approach for maintaining infrastructure, labeling it asset management in order to optimize the performance of the 139,556 infrastructure assets (facilities, runways, utility lines, and roadways) valued at $263.43 billion.[1] Along with introducing asset management, the Air Force's senior leadership restructured civil engineer organizations and incorporated an asset-management function at all vertical levels to address such issues as a shrinking budget, deterioration of infrastructure, significant demand for infrastructure projects, and infrastructure challenges. Specifically, these leaders intended to balance resources across asset types, reduce the stock of infrastructure assets, and decrease the maintenance and repair budget—all the while maintaining a constant level of service and operations.[2] The incorporation of asset-management functions at all vertical organizational levels (unit, major command, and headquarters) emphasized planning and implementing asset-management principles in daily decision making. Air Force leaders introduced the culture change of this type of management into its organizations to handle infrastructure assets efficiently and maximize limited resources.[3]

The comprehensive framework necessary to provide guidance for asset-management business principles drove the need to restructure civil engineer units further and, under transformation, established the Air Force Civil Engineer Center, headquartered at Joint Base San Antonio, Texas. The next step calls for implementing a comprehensive asset-management framework that offers guidance for agencies with large, varying infrastructure sets and limited resources, such as the Air Force. This framework would illustrate relationships among the components of asset management and integrate them into a useful decision-support system. It would also optimize the performance of infrastructure assets and give decision makers the appropriate information to develop viable approaches and alternatives.[4] Thus, this article introduces a comprehensive asset-management framework for the agencies mentioned above—one that would allow them to conduct effective management of infrastructure assets. Such a framework would translate common and well-established asset-management philosophies into an implementable solution. Next-generation technology enables senior leadership to apply this asset-management framework as well as align the strategic-, operational-, and tactical-level data into an efficient decision-support system. To illustrate implementation of the comprehensive framework, its validity, and relationships among the components of asset management, this article uses a representative sample of Air Force infrastructure.[5]

Infrastructure Challenges

Four issues sparked the need for a comprehensive asset-management framework: financial factors as opposed to technical factors, short-term as opposed to long-term planning, a network as opposed to individual projects, and allocation of resources across asset types.[6] When implementing a solution, one weighs financial factors, such as cost of maintenance and repair projects, against technical factors, such as structural quality of roofs and foundations. A shrinking budget and the monetary cost of necessary projects exceeding the funds available for these projects exacerbate the constant problem of financial constraints. Under these circumstances, "asset managers must allocate funds among competing, yet deserving requirements."[7] Additionally, short-term remedies are evaluated against long-term goals. A short-term fix may not be the most economical solution, and a long-term strategy may not be the timeliest solution.[8] The difficulty in balancing short- and long-term factors significantly increases with rapidly changing targets and goals. These issues hinder the ability to assess and delineate short- and long-term budgets and priorities, creating an increasingly difficult task.

Infrastructure is an integrated system with individual components that function both independently and in conjunction with other systems.[9] The interconnectedness of infrastructure links assets into a complex system of interrelated elements.[10] This concept of infrastructure coupling correlates the state of one infrastructure asset to the state of another, creating an interdependency between the two; however, most maintenance management systems (MMS) assess only individual components or isolated projects instead of accounting for individual projects, network goals, and coupling effects.[11] These individual projects are weighed against networks in which infrastructure is constrained by the weakest link or networks whose parts demand simultaneous replacement in neighboring systems.

Last, budget constraints for maintenance and repair projects require decision makers to allocate and balance resources across asset types as they consider an asset's value to an agency's operations and the current condition of the infrastructure. The difficulty in allocating resources across numerous types of infrastructure encompasses objective comparison among these assets of their worth and importance. Rapidly evolving leadership drives altered goals along with these issues, producing an increasingly arduous task of delineating among assets and determining which ones need resource allocation. The contending factors of financial as opposed to technical; short-term as opposed to long-term planning; a network as opposed to individual projects; and allocation of resources across asset types represent challenges as well as opportunities for decision makers, bringing about the necessity of a comprehensive asset-management framework for numerous infrastructure types that properly balances these aspects and guides the analytical process of asset management.

Data-Modeling Process

Several strategic asset-management models exist (e.g., the Transportation Asset Management Guide); however, turning these frameworks into a useful decision-making tool for Air Force asset management demanded a comprehensive data model capable of implementing the service's specific requirements. Thus, the researchers used a data-modeling process developed by Paul Longley, Mike Goodchild, David Maguire, and David Rhind to build a comprehensive framework that incorporates well-understood components of asset management.[12] The method of data modeling is a type of systems modeling that defines and analyzes data requirements to support an agency's business practices.[13] Specifically, "a data model is a set of constructs for representing objects and processes in the digital environment."[14] A data model also involves ontologies, which define the components of a system and associate them in classes, relationships, or functions.[15] Data modeling consists of four levels (listed in order of increasing abstraction): reality, conceptual model, logical model, and physical model.[16]

Reality

Reality establishes an understanding of the system and the interactions of its components.[17] Furthermore, it includes aspects deemed applicable to the real-world construct.

Conceptual Model

The conceptual model, oriented toward its human users, consists of selected objects and processes relevant to the problem domain.[18] It identifies objects of significance, collects information, and describes associations between components.

Logical Model

Depicted in diagrams and lists, a logical model is an implementation-oriented representation of reality.[19] It depicts the entities, attributes, and relationships among the components of a system. The development of a logical model includes matching organizational functions with specific data necessary to support each function as well as illustrating influential strategic components.[20] This type of model assists agencies in engendering a common understanding of the business processes of asset management, data requisites, and maintenance and repair requirements across both vertical and horizontal boundaries.

Physical Model

A computer-oriented physical model portrays the actual implementation and demonstrates the digital application of objects.[21] It describes the databases and identifies the information needed for the process.[22] This type of model assists agencies in attaining efficient access to data across the enterprise as well as integrity of data and security measures.[23]

For the scope of this article, data modeling focuses on asset-management processes for agencies with large, varying infrastructure sets and the information necessary to make decisions based upon the strategic components of these infrastructure systems. Ultimately, the article seeks to evaluate the Air Force's asset management and guide the execution of next-generation information technology as a means of creating a decision-support system for agencies with substantial, assorted infrastructure inventories and limited resources.

Results: Logical Model

Development of the logical asset-management model produced a comprehensive framework of an operational infrastructure system with numerous types of assets. This logical model consists of components—defined and described in the reality-model and conceptual-model phases—prevalent to the business practices of asset management. Figure 1 presents the logical model, graphically depicting influential strategic components as well as relationships vital to the asset-management process. It also illustrates the ontologies and associations among the asset-management components and identifies the data required to promote analysis of infrastructure operations.

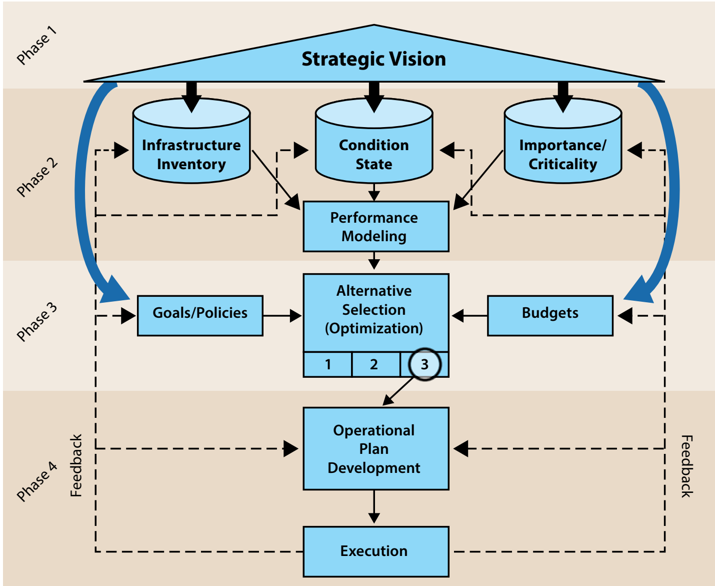
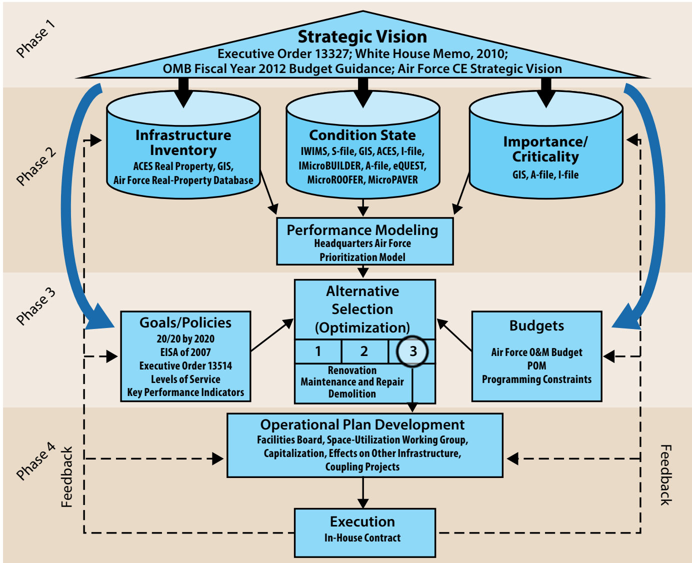


Figure 1. Logical asset-management model

The strategic components illustrated in this logical model formulate the process of asset management. Although relationships may differ according to organization, the basic artifacts of the asset-management system are considered, defined, and discussed below.

The researchers tailored this logical model specifically to the Air Force's infrastructure operations, using a representative sample of the service's infrastructure to demonstrate the model's application and validity. Figure 2 shows the general logical model (fig. 1) specifically implemented for the US Air Force. One could apply this same process to any agency with a large, varying infrastructure inventory and limited resources. In particular, figure 2 presents the Air Force case study of the logical model, which modifies the general logical model to the service's asset-management process, depicts the components as they pertain to this specific organization, incorporates Air Force entities prevalent to each component, and identifies the data needed for analysis of its infrastructure systems.



ACES – Automated Civil Engineer System
CE – Civil Engineer
EISA – Energy Independence and Security Act
GIS – Geographic Information System
IWIMS – Interim Work Information Management System
O&M – Operation and Maintenance
OMB – Office of Management and Budget
POM – Program Objective Memorandum

Figure 2. Logical asset-management model for the Air Force

The strategic asset-management components depicted in the logical model (fig. 2) comprise the process of asset management for the Air Force. To illustrate the specific Air Force application, the sections below further define and discuss each asset-management artifact.

Phase 1

Strategic vision. The strategic vision creates an umbrella under which one can align the operational aspects of data collection, budgets, policies, and goals to utilize the latest asset-management techniques.[24] Knowledge of the desired end state allows decision makers to prudently dedicate resources to the operation, maintenance, and repair of infrastructure assets.

Air Force strategic vision. National leaders and policy makers establish the overarching strategic vision. Specifically, the White House and Congress influence the strategic visions of all federal agencies, including the Department of Defense and the Air Force. The Department of Defense's strategic-level documents provide overarching guidance that the Air Force implements through its own strategic vision and operations. According to the strategic vision of the Air Force's civil engineer career field, the Office of the Air Force Civil Engineer seeks to "provide . . . efficient, sustainable installations by using transformational business practices and innovative technologies."[25] This strategic vision highlights the use of asset-management principles in daily operations and currently guides data collection, budgets, policies, and goals for the service.

Phase 2

Infrastructure inventory. By maintaining an infrastructure inventory, one can determine assets owned and their location.[26]

Air Force infrastructure inventory. The Air Force possesses an incredibly diverse set of constructed facilities and infrastructure assets, ranging from dormitories to aircraft hangars to warehouses.[27] This infrastructure, which supports a myriad of government functions, is located on numerous continents. The age of the 139,556 infrastructure assets in the Air Force's inventory spans decades—sometimes centuries—of building design and construction technologies.[28] The service collects and maintains data for its infrastructure inventory with a valid set of data-management systems in order to generate a snapshot of its assets; however, considerable information-technology issues exist because current systems do not effectively communicate with each other and data are entered numerous times into multiple data-management systems.[29] For example, the Air Force's Automated Civil Engineer System, which contains data regarding infrastructure operations such as maintenance and repair projects, hinders information flow because of its incompatibility with other MMSs, such as the Geographic Information System.

Condition state. Because infrastructure systems are in a constant state of decay, the condition state of an asset represents a snapshot of dynamic infrastructure assets.[30] Collecting condition-state data allows one to understand the current maintenance and repair necessary for infrastructure and to predict the future state of assets.[31]

Air Force condition state. The Air Force collects condition-state data in an MMS—the Interim Work Information Management System, tailored specifically for military operations. The service also utilizes MicroROOFER for the condition state of roofs and MicroPAVER for that of pavements, to name just a few. Moreover, the Air Force carries over approximately $9.3 billion of maintenance-and-repair backlog each year, which amounts to 3.5 percent of its current replacement value.[32] This quantity of deferred maintenance and repair is above the recommended industry standard of 1 to 2 percent residual from year to year.[33]

Importance and criticality. An infrastructure asset's criticality characterizes its importance or business value to an agency's operations. Agencies collect data on importance and criticality to fulfill two objectives: to understand the effect that incapacity or destruction of infrastructure assets would have on operations and to establish a relative order of significance among assets for the purpose of allocating limited resources.[34]

Air Force importance and criticality. The Air Force captures importance and criticality data to accurately assess (1) the relative significance of assets for the purpose of allocating and balancing limited resources and (2) the effect of inoperable assets on operations. The service utilizes the mission dependency index, an infrastructure metric, to link the importance and criticality of infrastructure assets to the mission of an installation. Information about importance and criticality enables decision makers to understand the link between infrastructure assets and mission accomplishment.

Performance Modeling. Performance modeling serves as the primary tool for understanding the maintenance and repair needs of infrastructure systems.[35] Decisions about maintenance and repair seek to choose the most economical (from a life-cycle standpoint) approach to determining what one should fix first.[36] In essence, such a tool relies on accurate data to guide decisions related to the established strategic vision. Thus, a dependency exists between the performance modeling tool and the strategic vision to ensure that measureable components of the tool give decision makers the necessary information to align viable approaches with the strategic vision. Ultimately, the goal is to enable them to make informed, performance-based decisions that link the goals, policies, and budget to known aspects of a system's attributes (inventory, condition state, and importance and criticality) and performance (metrics and modeling tools).

Air Force performance modeling. Performance modeling for the Air Force serves as the primary tool for prioritizing maintenance and repair requirements; toward that end, it utilizes an equation with infrastructure metrics to rank-order projects. Headquarters Air Force developed the current performance modeling tool and recently adopted an updated tool, which was implemented in 2013.

Phase 3

Goals and policies. Goals and policies arise from and align with the strategic vision to convey how an agency manages its assets; they also translate an organization's strategic vision into specific, relevant targets.[37] The latter, together with focus items, represent benchmarks that propel agencies toward realizing their desired long-term objectives. Typically, agencies define their levels of service in their goals and policies, which assist in shaping targets and constraints of the system.

Air Force goals and policies. To align with the strategic vision of providing sustainable installations by using transformational business practices, the Air Force coined the term *20/20 by 2020* to represent its goal of reducing both the physical square footage of its infrastructure as well as maintenance and repair costs by 20 percent by the year 2020.[38] The Energy Independence and Security Act of 2007, which aims to reduce energy usage by 30 percent by the year 2015; Executive Order 13514, which seeks to reduce potable water usage by 26 percent as well as nonpotable water usage by 20 percent by the year 2020; and the 20/20 by 2020 goal align with the Air Force's strategic-level vision.[39] These objectives intend to reduce the Air Force's real-property footprint to the most desirable size and incorporate energy and water conservation methods in the interest of optimizing the performance of infrastructure assets that support the war-fighting mission.[40] Ultimately, the Air Force reduces the stock of infrastructure assets as well as the maintenance and repair budget while maintaining a constant level of service and operations. This concern with the Air Force's infrastructure, which also applies to any agency with similar intiatives, reinforces the demand for a comprehensive framework to accommodate numerous infrastructure types and limited resources to inform asset-management decisions.

Budget. Budgets, which dictate the availability of resources for infrastructure projects, constitute the preeminent constraint that shapes practically every decision about asset management.

Air Force budget. Currently, the Air Force allocates $2.5 billion annually to maintenance and repair projects.[41] This budget amounts to 0.95 percent of its current replacement value, which remains significantly lower than the recommended industry standard of 2 to 4 percent.[42] Air Force regulations dictate the maximum amount available for various project types, such as $750,000 for minor construction, which imposes additional financial constraints. Allocating resources across asset types causes another budget issue for the service. Given the limited resources available, decision makers compare the worth and importance of infrastructure assets to determine which ones require resource allocation.

Alternative selection. Alternative selection explores options associated with infrastructure assets to determine which approach is in the agency's best interest. It entails examining and analyzing information from the performance modeling tool, goals, and policies as well as an understanding of financial constraints to determine the most advantageous solution. At this step in the comprehensive framework, decision makers determine the preferred resolution from the data provided.[43]

Air Force alternative selection. Under the operations and maintenance (O&M) budget, the Air Force examines four options for its infrastructure: demolish, maintain and repair, renovate, or construct an asset with capitalization.[44] The O&M budget funds demolition, maintenance and repair, and renovation projects. Capitalization, otherwise known as military construction, creates a new infrastructure asset that improves capability and corrects infrastructure issues. However, such construction falls under a separate budget with direct congressional oversight and approval; it does not compete with O&M funds.

Phase 4

Operational plan development. The purpose of operational plan development involves examining the impact of the preferred course of action on an agency's infrastructure from the perspective of second- and third-order effects. After one determines an optimal solution, operational plan development considers ways of leveraging efficiency from infrastructure networks and the effect of the proposed course of action on other aspects of these assets.[45]

Air Force operational plan development. Along with addressing how the optimal solution affects current maintenance and repair projects, planning for future endeavors (e.g., space utilization as well as future maintenance and repair projects) occurs as a part of operational plan development. The preferred course of action entails consideration for bundling projects together to gain time and cost efficiencies. One can carry out projects on connected, neighboring infrastructure systems and replace parts simultaneously—for example, completing an airfield lighting project while executing a pavement project on a runway.[46]

Execution. Preventive maintenance, reactive maintenance, project implementation, and demolition occur during execution, which involves synchronizing the previously discussed components as a means of completing projects.[47]

Air Force execution. In the case of the Air Force, execution entails coordinating the labor and funding to carry out demolition, maintenance and repair projects, and/or renovation. Execution implements the optimal solution to utilize limited resources in the most effective manner and thereby optimize the performance of infrastructure assets.

Feedback. Because asset-management frameworks are iterative, the feedback loop allows this cyclic process to reflect upon past efforts and start again.[48] The initial cycle through this comprehensive framework serves as the basis for subsequent cycles and influences future decisions.[49] Upon execution of a project, decision makers analyze the results, address any issues, and work through the framework again at the appropriate phase.

Air Force feedback. The iterative process of asset management for the Air Force requires a feedback loop. The continual movement of personnel and commanders on the headquarters staff keeps the strategic vision, goals, and policies in constant flux. Additionally, the O&M budget varies from year to year.[50] Thus, the service's decision makers examine results and address changes during feedback, prior to resuming the iterative process of asset management.

The logical asset-management model (fig. 1) establishes a comprehensive framework that offers guidance for the asset-management process. It acts as a useful decision-making tool applicable to agencies with a substantial, varied infrastructure inventory and limited resources. This framework enables decision makers to formulate viable approaches and alternatives to infrastructure management and facilitates efficient use of the annual O&M budget in order to optimize the performance of infrastructure assets.

The logical Air Force asset-management model (fig. 2) creates a decision-making framework for the service that directs the analytical process of asset management and addresses infrastructure issues specifically for this organization. This comprehensive asset-management framework confirms its general applicability to agencies with a large, varying infrastructure inventory and limited resources. It also affirms that agencies can tailor the general logical model to infrastructure systems of a particular organization, thus establishing the framework's usability and utility for agencies with similar infrastructure characteristics and budget constraints. The final step in the data-modeling process consists of developing a physical model that employs the relationships among asset-management components and their ontologies. Physical models are tailored to the specific infrastructure operations of individual agencies and their data requirements as a means of compiling information for the performance modeling tools. This article purposefully excludes the Air Force physical model that guides the implementation of next-generation information technology because it lacks applicability to other agencies with similar infrastructure characteristics and budget constraints.

Key Findings

The analysis conducted during this research effort offers two key findings that pertain not only to the Air Force but also to agencies with similar infrastructure characteristics and budget constraints. First, a discontinuity exists between the service's established strategic vision, goals, and policies and the current (equation 1) as well as recently adopted (equation 2) performance modeling tools. The logical model accentuates this disconnect, demonstrating the need for an improved tool that aligns with the Air Force's strategic vision, goals, and policies. At present, the service uses equation 1 to prioritize maintenance and repair projects:[51]

Equation 1

$$\text{Priority} = (\textit{Facility Condition Index} \times \textit{Mission Dependency Index}) +/- \textit{Commander Adjustment}$$

During alternative development, the Air Force encounters a primary limitation caused by discontinuity between the measureable metrics of its goals (the 20/20 by 2020 objective, the Energy Independence and Security Act of 2007, and Executive Order 13514) and the infrastructure metrics of the current performance modeling tool.[52] To reiterate, the 20/20 by 2020 goal wishes to reduce both the physical square footage of Air Force infrastructure as well as maintenance and repair costs by 20 percent by the year 2020; the Energy Independence and Security Act aims to decrease energy usage by 30 percent by the year 2015; and Executive Order 13514 seeks to lessen the use of potable water usage by 26 percent and nonpotable water by 20 percent by the year 2020. However, the current priority equation—equation 1 (performance modeling tool)—prioritizes projects with condition-state and infrastructure-inventory information based on each infrastructure's economic health and importance to operations (facility condition index and mission dependency index). This equation neither considers nor accounts for the objectives of 20/20 by 2020, the Energy Independence and Security Act of 2007, or Executive Order 13514 (reduction in square footage, energy usage, and water usage, respectively); it does not include energy, water, or square-footage infrastructure metrics sought by the Air Force's goals. This disconnect between the current performance modeling tool (equation 1) and goals causes decision makers to select an optimal solution based upon either the goals or the priority equation—but not both. It also produces competing interests and a lack of synergy between the goals and current performance modeling tool (equation 1). Thus, the priority order generated by the current tool does not align with established Air Force goals, creating a disconnect from the comprehensive framework and the relationships among asset-management components depicted in the framework. Additionally, decision makers will utilize the current Air Force performance modeling tool (equation 1) to prioritize maintenance and repair projects until implementation of the recently adopted performance modeling tool (equation 2) in 2013:[53]

Equation 2

$$\text{Priority} = 0.15(\textit{Health, Safety and Compliance}) + 0.10(\textit{Facility Condition Index} \times 100) + 0.15(\textit{Standardized Mission Dependency Index}) + 0.20(\textit{Local Mission Impact}) + 0.15(\textit{Cost Efficiency}) + 0.25(\textit{Service Quality})$$

The recently adopted performance modeling tool (equation 2) also accounts for the asset-management components of infrastructure inventory and condition state, as well as importance and criticality, by including the infrastructure metrics of the facility condition index, standardized mission dependency index, and local mission impact. Nevertheless, the Air Force encounters a limitation with the recently adopted performance modeling (equation 2) tool during alternative development because the latter combines goals for energy and space utilization into one infrastructure metric—cost efficiency—and does not include a water-usage metric. Although the cost-efficiency metric aligns with established goals for utilizing energy and space, it does not balance these objectives to ensure their realization. Once again, the priority order generated by the recently adopted performance modeling tool (equation 2) does not align with all of the Air Force's established goals, also generating a disconnect from the comprehensive asset-management framework and the relationships among asset-management components depicted in the framework. Thus, the Air Force needs an improved performance modeling tool that incorporates infrastructure metrics for utilizing energy, water, and space if it wishes to objectively prioritize maintenance and repair projects, compare various types of infrastructure at different locations, and produce master priority lists for its infrastructure assets.

The second key finding establishes that the data and MMS necessary for strategic-level asset management do not align with those needed for tactical-level asset management because of a lack of enterprise-wide data and an enterprise-level MMS to manage the information. The strategic level forecasts, requests, and justifies a long-term budget for demolition, renovation, capitalization, and maintenance and repair projects with a 10- to 12-year outlook. But the tactical level allocates the O&M budget and advocates for short-term requirements with a one- to two-year outlook. The tactical level (Air Force installations) funnels data—usually in an MMS—up to the strategic level, based on its own outlook. Similarly, the strategic level (Headquarters Air Force) funnels data—usually in an MMS—down to the tactical level, based on its own outlook. The top-down data transfer does not consider the tactical-level outlook, and the bottom-up data transfer does not consider the strategic-level outlook. This disparity stems from differences in operations between the two levels. Long-term planning is not a concern of the tactical level because it concentrates on short-term execution, but a lack of information regarding long-term requirements results in a dearth of requests for and justification of future budgets. Consequently, an adequate amount of O&M funds will not be available for projects in 10 years, when the long term becomes the short term. Moreover, the strategic level does not concern itself with short-term execution because it focuses on long-term planning and because funds for short-term execution have already been allocated to installations across various asset types.

Additionally, the Air Force's civil engineer community collects data for, utilizes, and maintains more than 10 MMSs. At times, the system utilized by the strategic level is not the same MMS employed by the tactical level. In these instances, the lack of compatibility between data formats hinders the top-down, bottom-up flow of information. Air Force efforts should align the data and MMS required for strategic-level asset management with those necessary for asset management at the tactical level—precisely what the comprehensive asset-management framework does. The latter streamlines communication, aligns data requirements between vertical as well as horizontal levels, and formulates resolutions in the best interest of all levels. Aligning the needed data and MMS enables transparency of information and streamlines its collection and maintenance for efficient, effective database management. The comprehensive asset-management framework for numerous infrastructure types fulfills the ultimate goal of data management—to align the MMS and necessary information for asset management so that decision makers can conceive of approaches and alternatives in the best interest of all vertical (tactical, operational, and strategic) levels of the Air Force. The discontinuity that exists between the performance modeling tools (equation 1 and equation 2) and the Air Force's strategic vision, goals, and policies—as well as the differences in MMS and data required between the strategic and tactical levels—causes misaligned data management at both horizontal and vertical levels (fig. 3).

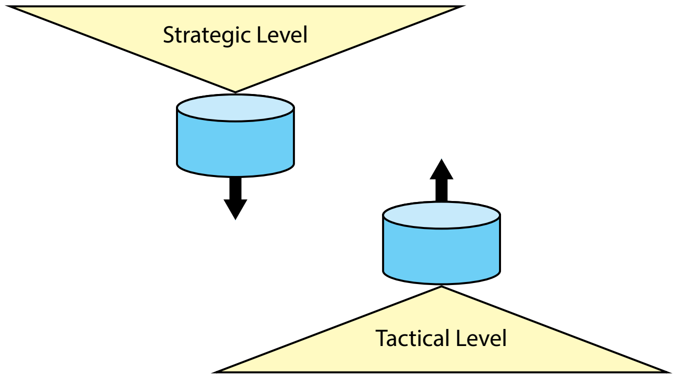


Figure 3. Data disparity between the strategic and tactical levels

Thus, creation of a single enterprise-level database for the Air Force will further the implementation of asset-management business practices. Next-generation technology would both enable implementation of the asset-management framework and provide enterprise-wide data access at all levels (strategic, operational, and tactical). A streamlined top-down, bottom-up approach with a single enterprise-level database (e.g., oracle and structured query language) and common data that aligns the strategic and tactical levels both vertically and horizontally would effectively manage and allocate resources across numerous types of infrastructure assets—the premise of next-generation technology. This approach toward integration of information technology would allow the tactical level to provide the strategic level with data applicable to its focus area and vice versa—unlike the current situation, in which the tactical and strategic levels supply the other with information that applies to their own outlook.

Conclusion

This article has identified two requirements fulfilled by developing a comprehensive asset-management framework that offers guidance for numerous infrastructure types and satisfies asset-management business principles—specifically, for agencies with a large, varying infrastructure inventory and limited resources. The utility of this research lies in its product, which contributes to asset management's body of knowledge and optimizes the performance of numerous infrastructure types at various locations. The article discussed two key findings: data disparities at both the horizontal and vertical levels as well as performance modeling tools that do not account for Air Force goals. It utilized a representative sample of Air Force infrastructure to illustrate implementation of the comprehensive asset-management framework and to demonstrate the proposed framework's utility in identifying the two key findings. Thus, agencies with constrained resources and a substantial, disparate inventory of infrastructure can conduct holistic management of infrastructure assets by applying this framework to their specific infrastructure operations. ✪

Notes

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