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S C I E N C E & T E C H N O L O G Y P O L I C Y I N S T I T U T E

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Executive Summary

Background

BUILDER is a web-based software application used to assess buildings. Developed by the U.S. Army Corps of Engineers Engineering Research and Development Center's Construction Engineering Research Laboratory (CERL), BUILDER helps Federal agencies improve long-term evaluation and maintenance of their building infrastructure. In particular, it provides them with a systematic means of analyzing infrastructure data to improve risk management across building portfolios. The audiences for this report include Federal agency leadership, facility managers, and others involved in shaping national security laboratory research, development, test and evaluation (RDT&E) facility and infrastructure policies, procedures, and investment decisions.

Methods

Researchers from the IDA Science and Technology Policy Institute (STPI) interviewed CERL officials and those involved in the development of BUILDER. From our initial discussions with CERL officials, we identified a list of Federal agencies and sub-agencies using BUILDER as a tool to assess the condition and needs of their Federal facilities. We conducted 25 interviews with Federal agency and laboratory stakeholders, including facility managers, policymakers, and contractors that license or partner with CERL on BUILDER. Note that BUILDER is a tool used for all types of Federal buildings, not just Federal laboratories. Therefore, our review analyzed BUILDER's use in contexts broader than the scope of our previous research on laboratory facilities, although we provided findings specific to laboratory facilities when pertinent.

Findings and Conclusions

BUILDER can provide standardized data and valuable insights to help Federal agencies determine priorities for, and investments in, their facilities. Despite these capabilities, BUILDER's cost modeling and scenario tools have yet to be fully explored or implemented. None of the six Federal agencies included in our interviews were sufficiently far along in their integration to use the condition prediction and other models for prioritizing repair and maintenance in their budgeting processes. Many of the Federal agencies integrating BUILDER are instead focusing on obtaining a condition index (for building a portfolio of buildings). Only a few are thinking beyond the day-to-day maintenance work plans for facility management, much less to future budget predictions for agency-wide building portfolio management. With some exceptions, there is a general lack of an articulated vision or strategic plan for how results from BUILDER will be integrated in the budgeting processes for large capital acquisition, renovations, maintenance, and repair.

In contrast, the National Nuclear Security Administration (NNSA) is actively pursuing various options to visualize and analyze BUILDER condition alongside other measures that assess risks and whether the building is meeting its intended function. This analysis provides a more complete facility investment picture for budget prioritization, and the visualization helps leadership engage in dialogue regarding facility priorities in the context of maintaining function and mission capabilities.

Several challenges need to be addressed for BUILDER results to inform budgeting decisions effectively:

- Cost books data, which are out of date, need to be updated and maintained over the long term to provide more accurate maintenance and replacement costs for building components and systems and to estimate costs of replacing systems or new construction. This is particularly relevant for specialized components and systems in RDT&E facilities. CERL researchers have acknowledged this limitation and are working to update the cost reference book.
- BUILDER's cost modeling tools and its capabilities need to be better understood by users and integrated into budgeting plans and processes. This could be facilitated by developing an easy-to-use user interface that provides reporting and data analytics, including scenario building, modeling, and tracking of investment impacts.

In addition, implementation could be facilitated by addressing challenges experienced in assessing laboratory facilities. Some interviewees emphasized the important role of critical support systems in RDT&E facilities, such as large exhaust systems that can accumulate corrosion. Systems like air-pressurized rooms require a higher level of detail than in traditional buildings. Overall, contractors found that BUILDER's catalog lacked the level of detail necessary to properly inventory and assess RDT&E buildings or did not include the right unit of measurement for their systems.

Options for Further Action

The Federal community of BUILDER users has been growing over the past decade. A formal Federal community of practice, possibly under existing interagency coordination, such as the National Science Technology Council, or other relevant working groups, could be developed with the following goals:

- Exchange lessons learned, including analysis of costs and benefits associated with implementation to inform adoption and planning.
- Identify ways to leverage resources, including understanding common needs across Federal agencies and jointly funding solutions.
- Support data analytics of condition and needs (specifically for national security laboratories facilities).

Activities under a community of practice could include:

- Identifying similar types of RDT&E facilities (e.g., biosafety level laboratories) to standardize inventories based on unique or specialized components and systems.
- Developing plans and policies to share costing data to improve accuracy of cost models for unique or specialized components and systems, such as those found in RDT&E facilities.
- Working with CERL and the DOD to identify ways to increase CERL's capacity to respond to user needs for customization (e.g., leveraging private sector services through licensing and collaborative research agreements) and sharing customized tools from early adopters.
- Exploring opportunities for improving data analytics and use of the functionality index (FI) and the mission dependency index (MDI) to better inform prioritization and budgeting. These two indices account for the asset's suitability to the building's function and criticality to the mission, respectively.

Achieving these goals and taking part in these activities could lead to improved understanding of how to implement and use BUILDER. It could also serve as a way to coordinate needs, such as for new technical features, and raise concerns to CERL researchers.

Contents

1. Introduction

The IDA Science and Technology Policy Institute (STPI) conducted an analysis of BUILDER to understand its history and adoption across the Federal Government. Developed by the Construction Engineering Research Laboratory (CERL) of the U.S. Army Corps of Engineers, Engineering Research and Development Center (ERDC), BUILDER, a web-based software application used to assess buildings, helps Federal agencies improve long-term evaluation and maintenance of their building infrastructure. In particular, it provides them with a systematic means of analyzing infrastructure data to improve risk management across building portfolios.

A 2013 STPI report had identified BUILDER as a beneficial tool for modeling long-term facility needs and justifying annual budget requests.[1] In 2012, the National Research Council released *Predicting Outcomes of Investments in Maintenance and Repair of Federal Facilities*, which recommended that Federal agencies use a knowledge-based approach for condition assessments, develop a systematic approach for performance measurement, and prioritize maintenance and repair investment based on an agency's mission and budget needs.[2] BUILDER fulfills many of the report's recommendations for Federal facility asset management. Since these two reports were published, there has been momentum to adopt BUILDER across the Federal Government.

A. Background

Concerns over the deterioration of national security laboratory facilities and infrastructure and their inability to sufficiently meet research, development, test, and evaluation (RDT&E) mission needs have been publicly discussed since at least the mid-1990s.[3] More recently, over the past decade, these issues have received increased executive branch and interagency interest. For instance, in May 2016, the National Science and Technology Council (NSTC) released "A 21st Century Science, Technology, and

[1] S. V. Howieson, V. Peña, S. S. Shipp, K. A. Koopman, J. A. Scott, and C. T. Clavin, *A Study of Facilities and Infrastructure Planning, Prioritization, and Assessment at Federal Security Laboratories* (*Revised*), IDA Paper P-4916 (Alexandria, VA: Institute for Defense Analyses, 2013), https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/ida-p-4916.ashx.

[2] National Research Council, *Predicting Outcomes of Investments in Maintenance and Repair of Federal Facilities* (Washington, DC: National Academies Press, 2012), https://www.nap.edu/catalog/13280/predicting-outcomes-of-investments-in-maintenance-and-repair-of-federal-facilities.

[3] Defense Science Board (DSB). 1994. *Interim Report of the defense Science Board Task Force on Defense Laboratory Management*. Washington, DC: DSB.

Innovation Strategy for America's National Security."[4] The 2016 strategy outlined the need to modernize the national security science and technology enterprise through proactive and collaborative investments in unique laboratory facilities to better support national security research and mission needs. These activities are aligned with the needs and priorities set out in Presidential Policy Directive 21 to improve security and resilience of critical infrastructure, including Federal laboratories.[5]

To address some of these concerns, in March 2015, the NSTC Committee on Homeland and National Security established the Subcommittee on National Security Laboratory Research Development, Test, and Evaluation Facilities and Infrastructure.[6] Members of this Subcommittee include representatives from 4 Federal agencies with national security missions—the Department of Defense (DOD), the Department of Homeland Security (DHS), the National Nuclear Security Administration (NNSA), and the Office of the Director of National Intelligence (ODNI)—and from 14 other Federal departments, agencies, and sub-agencies, including the United States Department of Agriculture (USDA), the National Institute of Standards and Technology (NIST), the Department of Health and Human Services, the National Science Foundation, and others that support the broader national security RDT&E enterprise through their scientific research missions.

Among the Subcommittee's chartered functions is developing and maintaining standards for Federal agencies to adopt metrics, processes, and tools for identifying laboratory facility and infrastructure condition, utilization, and importance of capabilities to mission. Previous government recommendations have pointed to BUILDER as a potentially useful tool to support facilities-related goals.[7] STPI produced the present report to inform the dialogue about the use of BUILDER for these purposes.

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4 NSTC, Committee on Homeland and International Security, "A 21st Century Science, Technology, and Innovation Strategy for America's National Security," May 2016, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/national_security_s_and_t_strategy.pdf.

5 Presidential Policy Directive—Critical Infrastructure Security and Resilience (PPD-21), https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil; see also NSTC, Critical Infrastructure Security and Resilience, Subcommittee, Committee on Homeland and National Security, "Implementation Roadmap for the National Critical Infrastructure Security and resilience Research and Development Plan," 2016, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/cisr_rd_implementation_roadmap_final.pdf.

6 NSTC, "Charter of the Subcommittee on National Security Laboratory Research, Development, Test and Evaluation Facilities and Infrastructure," 2015, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC//RDTE%20FI%20Subccommittee%20Charter%203-2015%20signed.pdf.

7 NSTC, Committee on Homeland and National Security, "Recommended Goals to Modernize and Revitalize Federal Security Laboratory Facilities & Infrastructure," 2014,

B. What Is BUILDER?

The DOD has an extensive portfolio of almost 300,000 buildings comprising 2.3 billion square feet in facilities alone.[8] CERL researchers developed BUILDER, as part of its Sustainment Management System (SMS),[9] and patented it in 2006. The methodology used by the SMS for a standardized facility management system includes a portfolio of modules to objectively assess capital needs using a knowledge-based approach.[10] Modules divide the SMS portfolio based on the asset type: Pavement Maintenance Management System (PAVER) released in 1977, Rail Maintenance Management System (RAILER) released in 1988, Roofing Project Management (ROOFER) released in 1989, and BUILDER released in 2000.[11] (See Appendix A for a detailed development timeline.) The focus of this report is on BUILDER's module to assess individual buildings, their systems and their components as well as portfolios of buildings.

C. Report Objectives

This report has three objectives: (1) understand to what extent BUILDER was used across the Federal Government to evaluate laboratory facility condition and repair needs; (2) assess the strategies used by agencies to adapt and adopt BUILDER, including their rationale for adoption and how it is being tailored to unique agency mission contexts; and (3) determine how BUILDER was or could be used to inform agency prioritization of laboratory facility needs and investments. Specifically, this report informs discussions about the potential need for increased interagency coordination of and targeted investments in national security laboratory facilities and infrastructure.[12] The intended audience of this report is Federal agency leadership, facility managers, and others involved in shaping national security laboratory RDT&E facility and infrastructure policies, procedures, and investment decisions.

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https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/nstc_-_federal_security_laboratory_facility_and_infrastructure_-_sept._2014.pdf.

8 J. Frisinger, "DOD Adopts Army Corps of Engineers BUILDER SMS Standard for all Facility Condition Assessment," U.S. Army Corps of Engineers, January 6, 2014, http://www.usace.army.mil/Media/News-Archive/Story-Article-View/Article/478203/dod-adopts-army-corps-of-engineers-builder-sms-standard-for-all-facility-condit/.

9 ERDC CERL, "Sustainment Management System," https://www.sms.erdc.dren.mil.

10 U.S. Patent No. 7058544 B2, "Knowledge-based condition survey inspection (KBCSI) framework and procedure," https://www.google.com/patents/US7058544.

11 Research began in 1991. Initial releases occurred in 1995; however, the first commercially available release was in 2000.

12 NSTC, "Charter of the Subcommittee on National Security Laboratory Research, Development, Test and Evaluation Facilities and Infrastructure," 2015, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC//RDTE%20FI%20Subccommittee%20Charter%203-2015%20signed.pdf.

D. Approach

STPI researchers first reviewed publicly available information on BUILDER via CERL's website.[13] To fully understand its history and its adoption across the Federal Government, we interviewed CERL officials and individuals involved in the development of BUILDER. From our initial discussions with CERL officials, we identified a comprehensive list of Federal agencies and sub-agencies that use BUILDER as a tool to assess the condition and needs of their Federal facilities. Note that BUILDER is a tool used for all types of Federal buildings, not just Federal laboratories. Therefore, our review analyzed BUILDER's use in contexts broader than the scope of the study on national security laboratory facilities, although we provide findings specific to national security laboratory facilities when pertinent.

We conducted 25 interviews with Federal agency and laboratory stakeholders, including facility managers, policymakers, and contractors that license or partner with CERL on BUILDER. (See Appendix B for details on interviews). We sought to understand the drivers for adopting BUILDER and its implementation in practice. From these interviews, we identified common challenges and strategies in adopting, adapting, and integrating BUILDER into existing agency and laboratory facility assessment processes and systems. We also used information from interviews to understand how BUILDER was being used to inform agency prioritization of facility investments, including those for laboratory facilities. Based on this information, we developed suggestions to (1) improve adoption, adaptation, and integration of BUILDER and (2) increase use of results obtained from BUILDER in management and policy decisions related to national security laboratory facility investments.

E. Structure of the Report

The remainder of the report is organized as follows: Chapter 2 describes BUILDER and provides a short history of its development; Chapter 3 outlines extent of adoption of BUILDER in the Federal Government; Chapter 4 describes the role of contactors; Chapter 5 provides an analysis of common challenges in integration; Chapter 6 describes the use of BUILDER and its results in agency prioritization of facility investments; and Chapter 7 provides considerations for improving adoption, adaptation, and integration and increasing use of BUILDER.

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[13] ERDC CERL, "BUILDER Sustainment Management System," https://www.sms.erdc.dren.mil/Products/BUILDER.

2. Evolution of BUILDER

This chapter provides a history of the development of BUILDER, a brief timeline of related Federal agency policies, and a description of BUILDER's main capabilities to measure building condition through knowledge-based inspection.

A. History

The theory and implementation of BUILDER's methodology and measures stem from the development of other modules in the SMS. In 1975, CERL began its initial research on an airfield surfaces. PAVER was developed for the U.S. Air Force to manage its inventory of runway and airfield surfaces. PAVER uses inspection data and a pavement condition index (PCI) rating from 0 (failure) to 100 (defect-free) to describe the surface condition and predict expected needs.[14] The PCI was adopted in the American Society for Testing Materials (ASTM) standards for airfield pavements in 1993 and for roads and parking lots in 1999. The other systems in SMS expand on the PCI developed in PAVER. RAILER assists facility managers in the sustainment, restoration, and modernization of military, short line, and regional track networks. The module uses a model to estimate the probability of failure and a weak link in the rail system.[15] The program combines railroad engineering technology, infrastructure management principles, and modeling into a tool to help decision-making for repairs and maintenance. In 1989, CERL released the ROOFER module, which uses a systematic approach to managing numerous roofing types, including membrane, asphalt, shingle, and metal panel.[16] Project analysis includes determining the most cost-effective repair strategies and documenting work requests and actions. ROOFER will be integrated into BUILDER for facility assessments in the near future. BUILDER is the most recent tool in the SMS portfolio. The first version of commercially available release of BUILDER was in 2000.

B. Timeline of Policy Development

In 2007, the DOD issued a policy that designated PAVER and RAILER as the data standard for condition assessments of those specific infrastructures. On September 10, 2013, Frank Kendall, the Under Secretary of Defense for Acquisition, Technology, and Logistics, issued a memorandum, "*Standardizing Facility Condition Assessments*," naming

[14] ERDC CERL, "PAVER," https://www.sms.erdc.dren.mil/Products/PAVER.

[15] ERDC CERL, "RAILER," https://www.sms.erdc.dren.mil/Products/RAILER.

[16] ERDC CERL, "ROOFER," https://www.sms.erdc.dren.mil/Products/ROOFER.

the SMS as the new standard for all asset management in the DOD.[17] Through this policy, DOD established a Configuration Support Panel (CSP) to ensure the uniform implementation of BUILDER across the DOD services and centralized modification decisions. Later, in 2013, ODNI issued a policy for agencies under its purview to adopt BUILDER SMS.[18] In addition, in 2013, NNSA established an internal initiative to adopt BUILDER that allows individual sites to work independently but under the direction of a centralized management office.[19]

C. Knowledge-Based Inspections

The SMS uses knowledge-based inspection (KBI) as an alternative to traditional deficiency or calendar-based inspection. In the traditional model, inspections are conducted on a predetermined time cycle, often annually or quarterly, to identify faulty assets and provide repair cost estimates. Due to budget constraints, facility managers may repair only the most critical assets, forgoing preventive maintenance and less critical repair work. This practice can ultimately cost organizations more than preventive maintenance because repair needs become more extensive over time and the entire asset, not just a part, may need replacement. KBI strives to optimize sustainment, repair, and restoration investments by focusing attention and resources on the most critical components at the time. Theoretically, KBI can reduce facility costs by decreasing the number of asset inspections and identifying the optimal time for maintenance and repairs.

KBI is not performed during fixed time intervals. Instead, the level of detail and frequency of KBI depend on an agency's configured life-cycle decision points for investments and the criticality of the component. KBI prioritizes resources that are most critical to an organization's mission. BUILDER established a standard set of criteria for evaluating the condition, utilization, and functionality of an infrastructure's assets. Facilities are divided into a hierarchical scale of management units with the component section as the most basic building section. Each building's component is identified, categorized, and attributed information, including the type, material, quantity, and construction.

The building condition index (BCI) is an assessment metric ranging from 0 to 100, with 100 as the ideal state, denoting a defect-free component. Component information is then recorded to form an initial baseline condition assessment to determine the optimal

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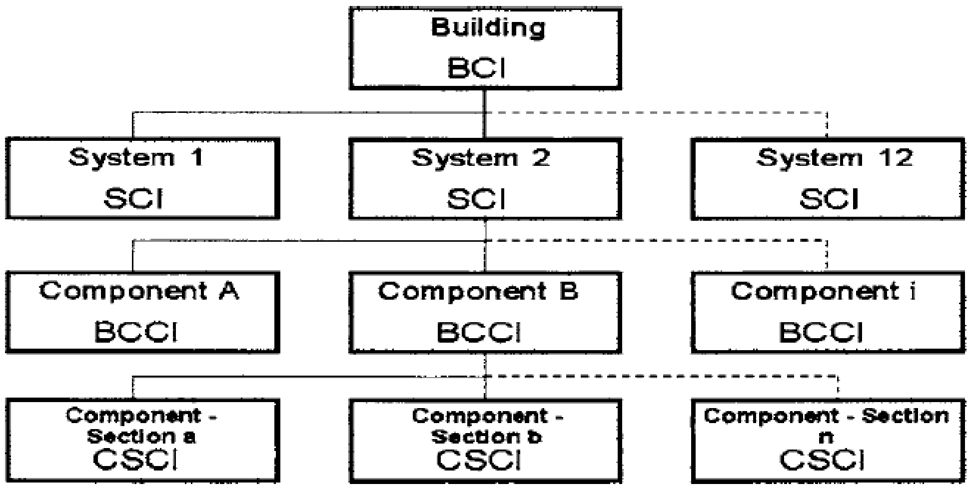
17 Frank Kendall, "Standardizing Facility Condition Assessments," Under Secretary of Defense, September 10, 2013, http://www.acq.osd.mil/eie/Downloads/FIM/DoD%20Facility%20Inspection%20Policy.pdf.

18 Personal communication with ODNI officials, August 19, 2016.

19 NNSA owns eight sites, including three national laboratories, which are run by management and operating contractors. For more details on locations, see https://nnsa.energy.gov/aboutus/ourlocations.

point to complete maintenance work and avoid more costly rehabilitation projects. The BCI is composed of several other metrics (Figure 1).



Source: Donald R. Uzarski, Michael N. Grussing, and James B. Clayton, "Knowledge-Based Condition Survey Inspection Concepts," *ASCE Journal of Infrastructure Systems* 13(2007): 72–79, Figure 1.

Figure 1. Condition Index Metrics

The component-section condition index (CSCI) reflects the presence, type, and level of distress that adversely affects the condition of a component section. BUILDER uses these variables to calculate the difference between the current age and the predicted life of a component, also known as the remaining service life. Deterioration curves predict the optimal point, or economic "sweet spot," to complete maintenance work and avoid more costly rehabilitation projects. Based on initial baseline condition assessment, condition life-cycle trends for each component are projected to model expected degradation over time. In BUILDER, users can define a minimum CSCI level to trigger preventive, repair, or replacement work based on the minimum desired condition level to support an asset's mission. For example, an organization may designate a higher CSCI standard for the roof of a hospital than for the roof of a storage warehouse. The theoretical range to complete repair work ranges from a CSCI of 70 to 80 based on the associated condition index scale. The next component-level tier is known as the building component condition index (BCCI), which is followed by the system condition index (SCI). The highest component-level tier within a building-specific system, the BCI, can be rolled into larger groups of buildings, complexes, or entire portfolios to provide measurement of condition.

In addition to the building CI measures (BCI, SCI, BCCI, and CSCI), BUILDER users can measure functionality via the functionality index (FI), which also ranges from 0 to 100, with 100 being the ideal state. The FI provides a comparison of how well a building can serve its prescribed function and meet its mission goals. Technical obsolescence or changes in codes, laws, regulations, and user requirements can interfere with a facility’s ability to support its mission requirements. Such changes may mean that a facility no longer has the proper layout, correct equipment, or accessibility compliance to meet its designated function.

A final measure supported within BUILDER, but calculated outside the tool via a separate approach is the mission dependency index (MDI). The MDI is a risk measure that indicates the importance, or criticality, of a building to an organization’s overall mission. The MDI ranges from 0 to 100 and is divided into three tiers: Mission Critical Facilities, Mission-Dependent Facilities, and Mission Independent Facilities. The failure or non-function of a Mission Critical Facility will have a significant impact on an organization. In contrast, the failure of a Mission Independent Facility can be mitigated by moving the facility’s function to another facility. Higher MDI scores indicate a critical building that needs to be maintained at the highest standard. The MDI is useful for prioritizing facility repair and maintenance work by evaluating the mission impact of interrupting a specific facility’s function. MDI can be manually inserted into BUILDER at the building level or populated in bulk from an agency’s database when linked by a unique property identifier.

3. Adoption across the Federal Government

This chapter provides a summary of the adoption, implementation, and status of BUILDER within the Federal facilities and infrastructure community. Several benefits that support the decision to transition to the new system are highlighted, and the process of integrating BUILDER is explained. A status update by Federal users is also provided in a comparative table.

A. Rationale for Adoption

The development of BUILDER aligns with a general desire among Federal facility administrators and engineers to move toward a more objective and evidence-based condition-assessment methodology. BUILDER offers that capability and does so conveniently through web-based application software that can be installed on a Federal agency's own servers, hosted by CERL, or deployed in a cloud environment.[20] The software offers several modules and tools, which provide multiple capabilities to standardize, assess, and model systems within a building or a portfolio of buildings at one or many sites. Interviewees adopted BUILDER to take advantage of at least one of these capabilities. The system can also support the functions of several types of users, from the individual facility inspectors in the field to senior decision-makers.

CERL allows users to operate the product online or on a closed network using government-owned servers. The latter supports enhanced security measures required by some Federal agencies. There is no licensing fee for Federal users because the product is completely government-owned and maintained by CERL. There are, however, *contributions* for support services that are assessed annually for each Federal organization that adopted BUILDER.[21] These services include the maintenance to support product improvements and the technical support, which is fee-for-service funding to provide specific capabilities for Federal agencies (such as helpdesk, data migration, implementation consulting, and provisional hosting). CERL provides upgrade services to all Federal users under the DOD's Configuration Support Panel (CSP). The CSP was established to oversee the implementation and modification of BUILDER across the DOD and, to an extent, for the larger Federal community. The CSP ensures that the contributions

[20] CERL typically hosts BUILDER for initial operating capability; long-term plans generally lead to Federal agencies hosting BUILDER at other locations.

[21] Contributions are essentially mandatory, as Federal users require regular updates for technical fixes and helpdesk support services via CERL.

for maintenance are standardized and uniformly proportional to the value of the building portfolio of the Federal organizations using BUILDER (starting in 2017).

Discussed below are several useful features of BUILDER both as a software tool in SMS and as a condition assessment system.

1. Impact of the Knowledge-Based Inspection

Several Federal users cited the importance of KBI methods to calculate facility condition as a significant improvement over traditional methods. Before the development of KBI, government facility managers conducted condition assessments based on a deficiency-based checklist routine. The checklist approach followed a set cycle based on a calendar year, varied in degree of inspection by user, and did not include component-level condition prediction modeling to plan for maintenance, repair, and replacement needs. This resulted in an inconsistent overview of the condition of facilities across a Federal agency. Many considered these methods weakly defensible to Congress for budgeting purposes and found there was a need to improve facility condition evaluation.[22]

In contrast, BUILDER's use of KBI allows managers to defend maintenance and repair decisions because it is able to model the life cycle and condition of a building's components and systems over time. As detailed in Chapter 2, KBI contains several inspection elements that contribute to an aggregated look at the condition of a facility. Measurable attributes of a building's systems and infrastructure are now inputs to the creation of tailored inspection plans, which can save both time and money for facility inspectors. In theory, inspectors would presumably inspect less (only when necessary depending on the criticality and condition of a component), and maintenance personnel would repair or replace components at a more economically optimal time. BUILDER generates inspection and maintenance work plans, along with several useful metrics, with ease through its application software. These outputs can aid facilities managers in prioritizing work requests within a building or across an enterprise, allowing for a more effective investment of resources.

2. Value of a Standardized but Customizable Inventory System

BUILDER follows an industry standard for building classification called ASTM UNIFORMAT II, but allows users to customize both the manner in which components and systems are sectioned within a building inventory and the *standards and policies* that are applied to each asset.[23] Standards and policies refer to the threshold triggers for investment

[22] Contributions are essentially mandatory, as Federal users require regular updates for technical fixes and helpdesk support services via CERL.

[23] U.S. Department of Commerce, "UNIFORMAT II Elemental Classification for Building Specifications, Cost Estimating, and Cost Analysis," National Institute of Standards and Technology NISTIR 6389, http://www.ct.gov/dcs/lib/dcs/uniformat_ii_report.pdf.

(e.g., when an asset falls below a specific performance requirement) and the repair or replacement rules applied to these assets by the user.[24] BUILDER's inventory customization reflects the distinctiveness of each system and section in a building, as well as each building type (e.g., barracks vs. laboratory). This customization, in turn, permits organizational-level users to set their own requirements for sustainment, restoration, and modernization across their enterprise, which may differ based on enterprise types and mission contexts (see box below provides an example).

Example of Inventory Customization:

Defense Health Agency-Specific Sectioning Requirements

The following sectioning business rules are used at the DOD Defense Health Agency (DHA):

- Physical Characteristics. Components are divided into sections when a significant variation exists in material or equipment category, age, construction history, or condition.
  - Example 1—If a wing or addition was added to an older building, the two areas of the building should be sectioned differently because the age and construction history is different.
  - Example 2—If the building roof has multiple levels of similar materials in different conditions, these levels should be sectioned differently to capture the difference in condition.
- If building wings were constructed at the same time, the construction history is not significantly different. Therefore, the wings need not be sectioned.
- Floors and Levels. Multi-story buildings shall be sectioned vertically by floor or level (in the case of a basement or mezzanine). Where they exist, interstitial spaces (typically found in more recent hospitals) shall be considered and treated as their own floors.
- Replacement Value. Due to approval limits and practical scheduling issues with such large and expensive projects, sections with a rough estimated value greater than $500,000 should be sectioned separately.
- Critical Care Spaces. In accordance with Unified Facilities Criteria (UFC) 4-510-01, for Design: Military Medical Facilities, all inventory in Operating Room Suites, Intensive Care Units, and like spaces, shall be inventoried separately from other like inventory.

Source: DHA, "DHA BUILDER™ Sustainment Management System Implementation Resource Guide (v3)," April 26, 2016.

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[24] Lance Marrano, "Sustainment Management System – BUILDER," 2014, http://mvs013-020.directrouter.com/~sameorg/images/stories/same-ifma/Marrano.pdf.

3. Potential for Long-Term Cost Savings

A potential benefit of BUILDER is a reduction over time of the overall costs to assess an agency's building portfolio. The following aspects of BUILDER can lead to direct cost savings:

- Inspectors using BUILDER can limit which building systems and components receive a detailed inspection and focus on the most critical assets first. This can include considering the condition, function, or impact on mission of an asset.
- As described in Section A.1 of this chapter, the condition assessment process allows for repair or replacement to occur at the most optimal time in the component's life cycle. This can result in increased longevity for building systems and infrastructure, which consequently reduces long-term repair and replacement costs.
- The KBI methodology, if followed, can eliminate unnecessary inspections. Many Federal users have stressed the importance of receiving more accurate facility condition data while reducing long-term maintenance costs. BUILDER can make that a possibility.

Likewise, BUILDER includes the ability to input FI and MDI to weight against condition (see Chapter 2). These two indices account for the asset's suitability to the building's function and criticality to the mission, respectively. These, together with the condition assessment, contribute to reduced spending by prioritizing repairs that are most important for the building's function or replacing infrastructure that is most important for the mission. The cost savings from contributing to the facility's budgeting and investment process is one of many benefits that can come from using BUILDER. Note, however, that long-term cost savings can be evaluated only after the product has been utilized for a sufficient period of time. Currently, no evaluations of cost savings have been conducted for any of the Federal users.

4. Aid to Budgeting and Investment

BUILDER can contribute to short- and long-term (up to 10 years) facility budgeting and investment processes in different ways. The use of BUILDER for these purposes largely depends on the functions utilized and the manner in which they are customized by Federal agencies. The impact could be long-term cost savings from better maintenance practices, prevention of costly investments that are unwarranted in a forward-looking context, support for replacement of inadequate facilities and infrastructure, or support for the consolidation or more efficient use of buildings. BUILDER can provide the quantifiable evidence that stakeholders require to inform, justify, and be held accountable for their decisions.

The following excerpt illustrates how NNSA plans to exploit BUILDER to support good decision-making:

> Through a corporate approach of using a centralized contracting vehicle, NNSA is able to manage select systems (currently roof systems and HVAC systems) across the NNSA Enterprise, therefore easing management of the systems, providing additional consistency, and improving reliability of the systems. Once system-level inventory and condition data is captured in BUILDER, it can then be analyzed to justify initiation of the next Enterprise-wide system-level management program and further provide information that can support "bulk" investment purchases in particular systems.[25]

Rather than using manual, individually created deficiencies for building portfolios, BUILDER provides Federal agencies the ability to specify acceptable condition thresholds for different sections in their inventory *by rule*, and to project when sections of a building will cross these thresholds to trigger maintenance. Thus, BUILDER provides a consistent, risk-informed, investment strategy regardless of individual assessor experiences, biases, or perspectives. BUILDER automates the assessment process and develop scenarios, allowing decision-makers to quickly determine what actions to take, which is important given short-term information needs for annual budgeting decisions.

B. Phases of Integration

The process of adopting and implementing BUILDER has four common phases of integration that all facilities and infrastructure administrators follow: adoption; planning; implementation; and data, validation, and analysis. Each is discussed in turn. The level of progression for different Federal users will vary based on several important factors including: (1) historical engagement with BUILDER and CERL, (2) the size of the organization, (3) the level of customization a user requires, (4) information assurance and security requirements, (5) coordination with existing condition assessment systems, (6) integration with an individual site's or facility's computerized maintenance management system (CMMS), and (7) policies that have been enacted to support BUILDER.

1. Phase 1: Adoption

Adoption of BUILDER involves organizational buy-in from leadership and support from the facilities and infrastructure administrators who will be tasked with planning and implementation. Several important discussions take place during this phase to provide a basis for planning, such as:

- *How will BUILDER be implemented?* Fully, partly, user customized, etc.

[25] Example provided through personal communication with NNSA, January 20, 2017.

- *What are the technical workforce needs?* Federal employees, one or several contractors, a mixed workforce, etc.
- *Who will oversee implementation at various levels?* Headquarters level, regional level, facility level, etc.
- *How are existing condition assessment systems and processes to be addressed?* Existing condition assessment support systems and formal processes can challenge the integration of BUILDER. Therefore, the decision to abandon an existing system, integrate it with BUILDER, or separately maintain the system for support that BUILDER does not provide must be made early in the adoption phase.
- *What types of supporting policies are needed?* Mandates, oversight panels, implementation guidance, etc.

Phase 1 also includes discussions about budgeting priorities and the availability of funds for technical support and assistance (e.g., from CERL or contractors that provide related services). Support costs for contractors will depend on various factors, such as types of customizations, geographic location, and number of buildings required, as well as on the extent to which the contractor will be conducting inventories and assessments. Several other elements can contribute to additional costs, and some can be unique to certain types of facilities, such as RDT&E laboratories. Chapter 4 expands more on the role of contractors and issues addressed in the adoption phase by contractors.

2. Phase 2: Planning

Strategic plans for implementation of BUILDER are developed in Phase 2 based on decisions made in the adoption phase. Planning includes developing both short- and long-term goals for workforce and training, establishing management offices, assigning responsibilities, and performing technical customizations. Concurrently as plans are developed, a pilot test is typically performed at one or more facilities in the portfolio to validate or inform specific strategies. In some circumstances, it is possible that a pilot test may prolong or postpone the adoption of BUILDER due to unexpected challenges (see the example on the next page). This could be caused by problematic organizational requirements or policies, funding limitations, or misunderstanding by facility inspectors of the context for condition assessments.

Example of Pilot Test Experience: Agricultural Research Service's BUILDER Assessments

The U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) conducted its first BUILDER pilot program in fiscal year (FY) 2013. The U.S. Army Corps of Engineers was asked to complete the initial inventory and assessment of several research facilities in Beltsville, Maryland. The first phase of the pilot program showed promise, but did not adequately capture the complexity of ARS's research laboratories.

In FY 2014, for the second phase of the pilot program, ARS engaged ALPHA Facilities Solutions to conduct assessments of two research campuses—Grand Forks, North Dakota, and Kearneysville, West Virginia. The second-phase pilots were more detailed and adequately captured the sophisticated mechanical systems and building equipment inventories. USDA ARS emphasizes that agencies with specialized research facilities should ensure that the assessment teams have adequate mechanical, electrical, and HVAC controls expertise on those teams.

As a result of the pilot program, ARS refined its process for assessments and now requires that the assessment team study the facility drawings before arriving on site. ARS also prefers to have one ARS staff member accompany the assessment team at the start of each new assessment location. In FYs 2015–16, ARS contracted ALPHA Facilities Solutions to assess 20% of its portfolio each year. ARS is pleased with the performed condition assessments and continues to refine the functionality assessments.

Source: Personal communication with USDA official, January 24, 2017.

3. Phase 3: Implementation

Implementation includes adapting BUILDER to existing environments and conducting the required initial inventories and assessments at facilities. Implementation strategies for Federal agencies are typically based on strategic plans and organizational policies, and are often prioritized by workforce and funding requirements. The implementation time for BUILDER will vary based on intended use and the types of outputs that are of value to each user. For some agencies, such as the DOD, deadlines for implementation and assessing an agency's facilities through BUILDER are preset, which affects implementation decisions and timelines.[26]

a. Implementation Strategies

The following are examples of implementation strategies employed at different Federal agencies. Advantages and disadvantages are highlighted for each example.

[26] The DOD has an internal deadline of September 10, 2018, to complete all inspections for DOD facilities and facility components using BUILDER. According to interviewees, it is widely accepted that this deadline will not be met. This is partly due to a lawsuit from a private sector interest over the DOD's implementation policy, which resulted in an implementation stay issued from April 2014 until December 2014 and prevented contracting awards to implement BUILDER.

1) Workforce

- **Contractor Workforce:** *Using only third-party contractors to conduct BUILDER inventories and assessments.* This strategy prevents overburdening of an existing facility's workforce. It may also accelerate initial assessment completion times by utilizing a trained BUILDER workforce, but could potentially incur other costs, such as travel and the need for repeat assessments due to unfamiliarity with an agency's facilities. In the long term, this strategy may build dependency on the specific contractor(s) and may or may not cost less than using trained employees.
- **In-House Federal Employee Workforce:** *Using only trained employees to conduct BUILDER inventories and assessments.* Although it may appear ideal to have a complete in-house workforce, training employees to use BUILDER is often viewed as an additional duty and could potentially overburden a facility's workforce. Depending on the missions of the Federal agency in question, it is possible to lose all or part of the facility's workforce at critical times in the assessment process. This could be the case for a military unit that would be required to deploy.

2) Inspection Types

BUILDER allows for three approaches to inspecting management units to determine condition: (1) direct rating, (2) distress survey (less detailed), and (3) distress survey with quantities (more detailed). The choice is made by the inspector. BUILDER provides a suggestion on the method to use, and a schedule is generated by BUILDER's KBI scheduling module.

- **Direct Rating:** For users seeking the least expensive and fastest approach to conducting a site survey, direct rating is the best choice. However, this method lacks accuracy because it evaluates components visually as a whole.
- **Distress Surveys:** Distress surveys are more accurate than a direct rating inspection and take more time to perform. They vary in detail based on whether or not defects are recorded (less detailed vs. more detailed). If a user has the time and resources to perform a distress survey, it could provide additional cost savings in the long term by more accurately predicting future maintenance needs. In addition, it could help engineering staff pinpoint what deficiencies are present and need to be addressed in repairs.

3) Phased Timelines for Inspections

For Federal agencies with large facility profiles, such as the DOD, it is common to prioritize the implementation of BUILDER for a subset of facilities, such as those with highest mission criticality or condition rating, when a sufficient inventory and assessment workforce is not available. BUILDER assessments are first conducted on the most important facilities identified in the portfolio. This could satisfy leadership that recognizes resources and time are limited, but wants to see progress in BUILDER implementation. One potential drawback is that some facilities in disrepair that are not traditionally viewed as mission critical could be further neglected until additional funds are made available to conduct an assessment. In the long term, such delays can ultimately cost the organization more than if the problems were recognized and addressed earlier.

4) Integration with Existing Systems

Some Federal users have integrated their existing condition-assessment system with BUILDER by matching condition ratings from their system to BUILDER's rating system. This approach can save time and money for inventory and assessment, but may affect initiation condition indices until BUILDER assessments are completed.

5) Centralization of Management

This management strategy centralizes BUILDER's use into one office or by one trained individual. Facilities (or contractors) report inventories and conditions to the central point of contact, who then interacts with BUILDER to input data and conduct analyses. This may limit user error and ensure consistency in application across facilities; however, it relies heavily on the single point of contact to understand the composition of all facilities in the user's profile.

b. Implementation Strategies at the U.S. Air Force and NNSA

The degree to which Federal users must modify or adapt their existing facility systems and workforce to support an implementation strategy will affect BUILDER integration timelines and costs. For instance, the U.S. Air Force is conducting a review of migrating its BUILDER server data from CERL to the DOD's Defense Information Systems Agency (DISA), at a cost of approximately $400,000 annually[27] in an effort to add additional layers of security and efficiency to BUILDER. Beyond the costs to host BUILDER at DISA, there will likely be technical challenges to moving the data and ensuring BUILDER operates properly on the DOD network. Addressing these technical issues could bring additional costs and affect the U.S. Air Force's integration timeline.[28] Table 1 gives specific examples of how the U.S. Air Force and NNSA have customized BUILDER and selected diverse implementation strategies.

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[27] Interview with U.S. Air Force officials, September 22, 2016.

[28] The U.S. Air Force is currently reviewing a server migration to DISA against cost alternatives, and the migration may, or may not occur.

Table 1. Examples of Federal Implementation

Category	U.S. Air Force	National Nuclear Security Administration
Type of Assessment and Workforce	Prioritized buildings that will be inspected across the entire portfolio before the DOD's deadline; used both contractors and dedicated Air Force civilian and military personnel for inventory and assessments.	Conducted condition assessments for all buildings to augment existing condition data migrating to BUILDER; used contractors and NNSA management and operating contractor personnel at sites.
Inspections and Metrics	Used direct ratings for assessing condition and requires only 7 of 13 building systems to be assessed; FI and MDI are not assessed with BUILDER.	Used direct ratings for assessing condition; has not precluded sites from conducting distress surveys; using CI, FI, and MDI to inform risk to infrastructure.
Technical Customization	Developed an internal application methodology for BUILDER for all Air Force facilities, and working with CERL to develop a Utilities module.	Customized FI at the building level to meet internal requirements, and integrated with NNSA's computerized maintenance management systems.
Workforce Responsibility	Responsible for training, data analysis, planning, and integration, but uses some contractor support for inventories and assessments.	Used some in-house expertise, but largely relies on contractors to conduct inventories and assessments across sites.
Training	Developed its own in-house training program to complement CERLs, providing both data input and analysis training to facility users; is expanding this training to include online training and training through the Air Force Institute of Technology and its technical training courses.	Used free training provided by CERL and a customized self-paced online training developed by contractors.
Use of Contractors	Relied partly on contractors in the near-term for initial inventories and assessments; however, long-term goal is to have a *fully in-house* capability.	Each NNSA site selects its own subcontractors to conduct assessments; each can choose to stay with a subcontractor at length or move to an in-house capability.

4. Phase 4: Data, Validation, and Analysis

This phase includes validating inspections and measures through quality assurance, conducting analyses at the building and portfolio levels, and utilizing built-in models to forecast priorities for repair and maintenance. Federal agencies must have fully completed all previous phases, including conducting at least one full inventory and assessment of all their buildings. Data validation is not a trivial matter, particularly given the large inventory and assessment needs for certain Federal agencies. A few Federal agencies are just now exploring ways that BUILDER results could be analyzed to inform prioritization across programs, sites, and building portfolios.

C. Status of Integration by Federal Agency

Federal agencies are currently at different phases of integrating BUILDER. Table 2 shows the status of BUILDER integration by Federal agency. Note that no users are currently in Phase 4. This is expected to change within the next 1 to 2 years as assessments across Federal agency building portfolios are completed.

Table 2. BUILDER Integration by Federal Agency

Federal Agency	Phase 1: Adoption	Phase 2: Planning	Phase 3: Implementation	Phase 4: Data, Validation, and Analysis
National Nuclear Security Administration	✔	✔	✓	
U.S. Department of Agriculture, Agricultural Research Service	✔	✔	✓	
Department of Defense, Air Force	✔	✔	✓	
Department of Defense, Navy	✔	✔	✓	
Department of Defense, Marine Corps	✔	✔	✓	
Department of Defense, Defense Health Agency	✔	✔	✓	
Department of Defense, Army	✔	✓		
Office of the Director of National Intelligence*	✔	✓		
Department of Commerce, National Institute of Standards and Technology	✓			
Department of Commerce, National Oceanic and Atmospheric Administration	✓			
Department of Veterans Affairs	✓			

✔ = fully completed; ✓ = partly completed.

* ODNI is responsible for oversight and management of the BUILDER SMS across all 16 Intelligence Community agencies.

4. Role of Contractors

The demand for BUILDER over the last decade has created a market for experts familiar with conducting BUILDER assessments. According to interviewees, the number of third-party contractors conducting BUILDER assessments and providing training to agencies is growing. The size of contractor companies ranges from small businesses, such as Clover Leaf, which works with NNSA's Sandia National Laboratories to assist in inventory data collection efforts, to international engineering firms, such as Atkins, which works with NNSA's Los Alamos National Laboratory. The role that contractors can play in BUILDER assessments depends on the organization's needs and varies among agencies.

A. Contractors by Federal Agency

When conducting BUILDER assessments, agencies use contractors to create building drawings, complete baseline inventories, reassess inventories, customize or modify BUILDER, host the BUILDER software, or perform quality control, among other purposes. Contractors are developing areas of expertise, such as meeting specific needs for health-care facilities or highly secured buildings. For example, DIGON Systems, which is known for producing customization software, works with multiple agencies to develop data visualization analytics, customize the BUILDER catalog, and integrate BUILDER with an organization's existing computerized maintenance management system (CMMS). Table 3 provides a list of contractors for select Federal agencies.

The size of an organization, its facility portfolio, and its available technical workforce play critical roles in determining the need for contractors. Organizations with large facility portfolios and a small in-house workforce have used contractors for conducting assessments to relieve the burden on their workforces. The U.S. Army has a large number of facilities that require an initial condition assessment and are working on building out an inventory according to BUILDER requirements. Currently, the U.S. Army does not have the trained workforce capacity to complete initial inventories and condition assessments before the DOD's 2018 deadline. The Army is using contractors to complete its initial inventory baseline, but is concurrently developing specialized teams from its maintenance workforce that can complete facility reassessments in the future.

Table 3. Select Federal Agencies and Contractors Working on BUILDER Integration

Organization	Type of Workforce	Contactor Name
Department of Defense, Army	Contractor: Initial In-house: Future	Varies by Army component
Department of Defense, Defense Health Agency	Contractor	Inventory and Assessment: HKS, Inc. and Calibre Systems, Inc. Joint Base San Antonio (Fort Sam Houston, Randolph, and Lackland): HDR, Inc. Pearl Harbor: AECOM Training Packets: DIGON Systems
U.S. Department of Agriculture, Agricultural Research Service	Contractor	Condition Assessment: ALPA Facility Solutions Quality Control: DIGON Systems
National Nuclear Security Administration	Varies	NNSA HQ: Calibre Systems-Functionality Module Development; DIGON Systems-Quality Control, System Integration, Online Training Kansas City National Security Campus: Burns & McDonald Lawrence Livermore National Laboratory: In-house Los Alamos National Laboratory: Atkins Nevada National Security Site: In-house Pantex Plant: In-house Sandia National Laboratories: Clover Leaf Solutions Savannah River Site: In-house Y-12 National Security Complex: Ch2M Hill
Office of the Director of National Intelligence	Contractor	LMI
Department of Commerce, National Oceanic and Atmospheric Administration	Contractor	Nelson Engineering

Source: Interviews.

Engaging an experienced BUILDER contractor is a key motivation for Federal agencies who are starting Phase 1. In an interview, a U.S. Army official said that using contractors instead of in-house workforce resulted in more consistent inventory and assessments results across their facilities. Note, however, that if the contractors are less familiar with the condition of the buildings than in-house facility managers are, they may overlook inventory items or recent repairs.

B. CERL Contractor Agreements

Federal agencies have established interagency agreements with CERL to provide for the exchange of services and funds for BUILDER support, such as any necessary agency modifications or customizations to the program. Previously, agencies paid CERL a standard fee for its services, but this process is currently under review by CERL.

CERL also partners with third-party contractors for distributing BUILDER via Cooperative Research and Development Agreements (CRADAs) and Patent License Agreements (PLAs). These vehicles are not needed for Federal use, but establishing these agreements has the benefit of expanding the pool of providers that can also help Federal agencies implement BUILDER.

1. Cooperative Research and Development Agreements

A CRADA is a formal research collaboration between a Federal laboratory (e.g., CERL) and a non-Federal partner, such as a private corporation or nonprofit institution authorized by the Technology Transfer Act of 1986.[29] CERL participates in CRADAs with private companies that wish to expand upon BUILDER research or an aspect of the BUILDER program. Contractors with a CRADA are granted a different level of access to the BUILDER program (e.g., serving as beta testers for new version releases). As a result, CRADA partners may have a deep knowledge of the BUILDER database and source code. This knowledge may be helpful in developing customized modules or integrating BUILDER with other existing systems within an organization. The first BUILDER CRADA was signed in 2000 with the University of Illinois.[30] Agreements are initially for 5 years and are eligible for renewal in 5-year increments. ERDC's Office of Technology Transfer and Outreach uses a template for CRADA contracts that details intellectual property rights, copyright disclosures, and specifies the scope of work.

2. Patent License Agreements

Contractors may also have a PLA, which allows firms to pay for the right to distribute and sell BUILDER to non-Federal users. The first BUILDER PLA was signed in 2008 with Calibre Systems, Inc. The following contractors also have PLAs for distributing BUILDER: Atkins Global, Cardno, DIGON Systems, FM Projects, North Pacific Support Services, and Tetra Tech.[31] PLAs include terms on the commercialization of BUILDER, license duration, royalties, etc. The costs associated with the patent license, including ERDC's royalty fees, are negotiated individually with each contractor. In some cases, a contractor's business model may emphasize obtaining profits through support services for BUILDER rather than selling the tool itself.

ERDC's Office of Technology Transfer and Outreach is improving the criteria used to evaluate PLA applicants to make sure companies have adequate experience and resources in their strategy to ensure successful adoption and support for their BUILDER

29 15 USC 3710.

30 Interview with ERDC official, 11/14/2016.

31 ERDC CERL, "BUILDER Sustainment Management System," https://www.sms.erdc.dren.mil/Products/BUILDER.

customers. To obtain a PLA, a contractor must submit an application to ERDC's Office of Technology Transfer and Outreach in accordance with the statute. The application requires contractors to develop a 5-year commercialization plan, including a marketing strategy, which is reviewed by an evaluation board. The criteria used by the evaluation board includes experience conducting facility inspections, status as a small business, and ability to provide specialization services, such as training or software customization. According to an interviewee in the Office of Technology Transfer and Outreach, the office is currently revising parts of its PLA application process. The new application process creates a 6-month window for accepting PLA applications, and applicants will receive a decision within 4 to 5 months of submitting their application.

Table 4. Types of CERL Agreements

	Cooperative Research and Development Agreements (CRADAs)	Patent License Agreements (PLAs)
Function	A formal research collaboration between CERL and a non-Federal partner	Grants the right to distribute and sell BUILDER to non-Federal partners
Access	CRADA partners receive broad access to BUILDER	Limited access to BUILDER
Time Period	Awarded in 5 year increments with the ability to renew	Varies according to individual contract
Highlighted Partners/Contractors	University of Illinois	Atkins Global Cardno DIGON Systems FM Projects North Pacific Support Services Tetra Tech

C. Challenges from the Contractor's Perspective

Contractors identified barriers to adopting BUILDER in the private sector. In an interview, one contractor referenced a commercial client who was interested in BUILDER but said the lack of access to BUILDER's source code would not meet the client's required security standards. Another commercial client cited the high cost of security for BUILDER and the inability to implement BUILDER while meeting the DOD's security requirements. Ultimately, both these clients did not adopt BUILDER. One contractor was also hesitant to distribute BUILDER in the commercial sector because of deficiencies in BUILDER's ability to provide accurate prices for equipment, material, installation, and labor associated with repairs, maintenance, or replacement of building systems and equipment.

Contractors encountered special issues when completing assessments in RDT&E facilities. For example, in the interviews conducted, contractors said they generally had difficulty in determining if a piece of equipment was programmatic or functional when conducting an inventory. The distinction between equipment categorization is further exaggerated due to the specialized nature of the equipment in RDT&E facilities. Programmatic items, like specialized fume hoods, may not be included in BUILDER because they are special enhancements made to buildings. However, if they are sufficiently valuable and required for proper maintenance of the building, Federal agencies may wish to include these items. Contractors also emphasized the important role of critical support systems in RDT&E facilities, such as large exhaust systems that can accumulate corrosion. Systems like air-pressurized rooms require a higher level of detail than in traditional buildings. Overall, contractors found that the BUILDER catalog lacked either the level of detail necessary to properly inventory and assess RDT&E buildings or an applicable unit of measurement for their systems.

Contractors also noted that gaining access to restricted facilities was a common challenge. One contractor said the long delays his inspectors experienced while waiting to obtain access to secured areas, in particular to research laboratories, extended the time to complete some assessments. Note that the agencies who conduct their BUILDER assessments without contractor support experience many similar challenges when inspecting RDT&E facilities.

D. Contractor Practices

Contractors have developed innovative means of addressing an agency's needs and challenges in using BUILDER. Clients have the ability to modify the cost book and service life values for a piece of equipment. One contractor is addressing the challenge of outdated cost reference books by developing a more specialized cost repair module based on RSMeans (which provides a commercially available reference for estimating building construction costs).[32] To make the BUILDER readouts and its custom reports capability more user friendly, DIGON Systems developed modules to produce more accessible customer reports for DHA. Contractors are responding to agency requests by developing modules that tailor BUILDER for agency-specific needs, such as functionality. Contractors who provide BUILDER SMS training are also developing training guides. In addition, many contractors are using proprietary software to validate the data quality of their assessments.

Integrating BUILDER with an organization's CMMS is a common challenge. CERL developed an underlying application program interface (API) to handle CMMS integration.

[32] RSMeans Data, "Building Knowledge," https://www.rsmeans.com.

CERL has developed the API to work with the U.S. Navy’s CMMS and is developing the correct integration points to work with the U.S. Air Force’s system, which is pending rollout. Contractors are working to further this API to customize CMMS integration by developing BUILDER modules that can communicate data between BUILDER and commonly used CMMS software, such as Maximo, Tririga, and Archibus. NNSA is exploring solutions for integrating BUILDER with multiple CMMSs with the help of DIGON Systems. DIGON Systems is developing a tool called SPIRE for NNSA. SPIRE will support interagency needs by facilitating system-to-system communication and data synchronization through a web interface and a server API. The API sits between a site’s CMMS and BUILDER, where it receives data posted from the CMMS, facilitates secure data communication with BUILDER, and responds by updating the CMMS records with data from BUILDER. SPIRE can synchronize facility and asset data, section data information (such as condition and age), inspection data, work items, and cost catalogs between BUILDER and the CMMS. DIGON Systems anticipates SPIRE, currently in development, to be completed in March 2018.

Contractors have created multiple solutions to improve the BUILDER assessments and facilitate easier integration with an agency’s existing facility. Note, however, that many previously mentioned modules and software are proprietary and not shared between contractors.

Practices to facilitate the relationship between contractors and agencies and increase the quality of facility assessments emerged from our interviews. Many contractors emphasized the importance of gathering information on the facility before inspectors are on site for assessments. The type of information preferred varied by contractor and facility, but overall, contractors said that receiving blueprints, floor plans, schedules, or inventory lists ahead of time assisted in the assessment process. Contractors also noted the importance of the facility managers to the assessment process. Facility managers can share valuable maintenance history, such as problematic equipment, and identify known issues that are not immediately apparent through a visual inspection, such as roof leaks. Facility managers also help distinguish programmatic and functional equipment for contractors. In high-security areas, facility managers are crucial to providing contractors with access promptly. In an interview, a contractor stated that members of his firm spend a couple of days on site to gather facility drawings and discuss security access before beginning assessments.

5. Observed Federal Agency Challenges in BUILDER Integration

Several types of integration challenges were observed across the Federal BUILDER community. Some were specific to individual agencies, but many were common challenges that any Federal user would likely face when integrating BUILDER. The most prominent examples can be categorized as follows:

- *Organizational buy-in* due to competing systems and high up-front costs;
- Technical and practical *user customization* (i.e., integrating CMMS and developing agency-specific guidance);
- *Uncertain savings* (i.e., no Federal agency has conducted a cost-benefit analysis and assessments may not be implemented according to knowledge-based methods);
- *Limited workforce* and a growing reliance on contractors, which can have future implications for assessment costs;
- User *information-assurance* requirements, which can lead to longer implementation timelines, higher costs, and limited access to BUILDER capabilities.

These five categories are further described below.

A. Organizational Buy-In

Organizational buy-in is an expected hurdle that Federal stakeholders would encounter when promoting any new product. The challenges associated with organizational buy-in are typically divided into those related to the value of the product and those related to the investment costs. Organizational buy-in goes beyond a classic cost-benefit analysis, however. It can include convincing leadership that a product provides a capability that is necessary and not currently available otherwise. At a lower level, it can include overcoming resistance to change in process and assuring the workforce that the new method will not be overtaxing. For Federal supporters of BUILDER, two common organizational buy-in challenges were observed, along with the high up-front costs.

1. Existing and Competing Systems

Existing condition-assessment systems can either be included with BUILDER in an organization's condition-assessment process or replaced completely. If implemented with another product or process, there can be both organizational and technological constraints to overcome. Leadership must ensure the two systems operate together efficiently, which usually involves longer planning, specified workforce guidance, and potentially additional costs for producing custom software. If an existing system needs to be completely replaced, both leadership and the implementation workforce must reach agreement on what capabilities of BUILDER will be employed across facilities and how the system will be included in the organization's formal condition-assessment process. Where an existing system and process has been in use for an extended period, there is often an entrenched resistance to change, especially where additional data collection and management are required.

2. High Up-Front Costs

BUILDER requires a large up-front investment for the initial inventory and assessment process, which can be amplified by the size of the building portfolio. In some cases, such as with Federal laboratories, the up-front costs for assessments may exceed that for more general types of facilities due to the complexity of the buildings. This would require the workforce, be it contracted or employed, to divert additional resources and time to properly section the facilities. Other factors that contribute to the high initial costs of BUILDER are workforce training, technological integration expenditures, and costs for server and data storage migration to support information-assurance measures. It can be difficult to convince leadership to invest in BUILDER over an alternative system if the initial costs are too high as a consequence of being funded by multiple components of the organization. Implementation costs for BUILDER may be similar to costs of assessing an agency's building portfolio, but a rigorous cost analysis has not yet been performed. The U.S. Army said it is collecting cost data for BUILDER to analyze and compare its costs with those of systems and processes previously used.[33]

B. User Customization

Although customization is considered an advantage of BUILDER, it can also be a hindrance to an organization if it delays integration time and adds cost. There are two basic forms of customization. The first is that which is *technological* in nature, such as new applications, interfaces, tools, or modifications to the BUILDER code meant to enhance the software. The second is data collection and inventory customization, which is a standard feature of BUILDER, and can be considered a *practical* tailoring of the product

[33] Interview with U.S. Army official, September 15, 2016.

for organizations. Beyond customization costs, there can be other challenges in developing both technological and practical solutions for BUILDER users.

1. Technological Solutions

The need for new analytic tools and system interfaces requires the development of additional software components. These can be highly complex to develop and difficult to integrate given the multitude of CMMSs in use across different Federal agencies. Often, Federal users must contract out the development of new software applications and interfaces and work with CERL for BUILDER software code modifications and improvements. In many cases, Federal agencies have hired specialized personnel to manage the development and implementation of complex technical solutions. In some cases, these software requests require continued coordination between the Federal agency, contractor, and CERL, necessitating multiple iterations of the software before it is completed. The development of integration systems and software applications can be costly, and there is an opportunity to coordinate the development of these systems better so that they can be jointly developed and leveraged across the Federal community of users.

2. Practical Solutions

Developing agency-wide guidance that outlines specific methods of sectioning for certain types of facilities, or setting standards and policies for individual building components, can add significant time to the integration process. This type of customization requires a deep knowledge of such facilities and involves facility experts who take part in their development. Further, practical customization goes beyond the BUILDER inventory module. It can involve mapping costing data in BUILDER to another cost reference book or developing techniques of weighting different BUILDER outputs to better inform decision-makers.

C. Uncertain Savings

One marketed benefit of BUILDER is its ability to reduce the long-term costs for condition assessment inspections, while extending the life of buildings through more efficient maintenance. As described in Chapter 2, BUILDER can optimize the time spent conducting inspections by basing future inspections on a knowledge of the building's components, rather than on a calendar-based schedule. But many Federal users are years away from reaping this benefit, because it requires both historical data from conducting assessments and available funds to perform repairs and replacements at the BUILDER-designated optimum times.[34] As a result, many Federal users express uncertainty that the savings will accrue in a reasonable time. At present, no Federal user of BUILDER has

[34] Refers to the economic "sweet spot" described in Chapter 2.

conducted a cost-benefit analysis to determine the actual costs and savings incurred through its use.

Even if high up-front costs are managed, sustained-use costs can remain equally high if contractor fees for BUILDER inspections remain constant or increase and budgeting constraints prevent the timely maintenance of building components. For those organizations that have chosen to use an internal workforce to perform BUILDER inspections, if a consistent turnover rate or personnel availability issues exist, the long-term savings can be offset by training costs. In addition, many Federal users have chosen to adhere to a calendar-based timeline for performing facility condition assessments after implementing BUILDER (e.g., every 5 years), often in an effort to align inspections with other facility management policies and requirements. This may undercut long-term savings, if management policies do not include requirements to perform component-section inspections at the BUILDER-suggested times.

D. Limited Workforce

Federal organizations that use existing facility maintenance workforces to implement BUILDER can face several challenges. If the BUILDER workforce is small relative to the size of a building portfolio, its availability may be limited by competing obligations or by the level of knowledge its members possess for different types of facilities. In addition, the existing facility's workforce may require time to get up to speed with the additional responsibilities imposed by BUILDER, particularly if its role in implementing BUILDER is not a full-time one. These constraints largely depend on the support a workforce receives from its organization. In many instances, facility managers understand the limits of their own workforce and opt to contract out BUILDER inventories and assessments. In doing so, however, these Federal users now run the risk of becoming completely reliant on a (currently) small pool of available contractors, resulting in potentially higher costs than with less contractor involvement.

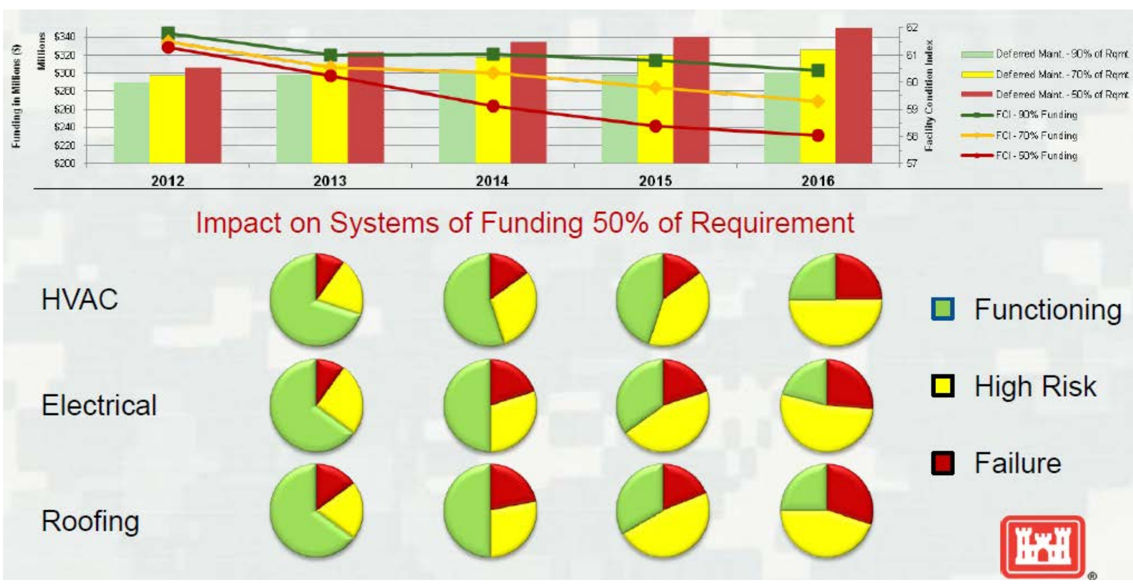
Using a complete contractor workforce could also exchange one problem for another, if the contractors are less familiar with the complexities of the laboratories. This could result in less accurate inspections due to improper inventorying or inadequate system sectioning.

E. Information Assurance

For some Federal users, information assurance requirements prevent the integration of BUILDER and its supporting applications without full server and data storage migration, additional technological modifications, or changes to existing security policies. These requirements force users to pay for the adaptations that are developed, adding to the costs and timelines for BUILDER integration. In some instances, the technological solutions are highly complex and may require multiple instantiations before a fielded version is approved. Information assurance requirements can also limit or deny the capabilities offered to users who support applications for BUILDER, as is the case with organizations that forbid remote data entry applications. CERL is completing the Risk Management Framework certification for BUILDER, which is based on NIST Guidance 800-37, *Guide for Applying the Risk Management Framework to Federal Information Systems: A Security Life Cycle Approach*. Once completed, the certification should address some information security concerns and facilitate BUILDER being implemented at Federal agencies.

6. Prioritization and Evaluating Investments

BUILDER can provide standardized data and valuable insights to help Federal agencies determine priorities for, and investments in, their facilities. CERL researchers provided an example of how BUILDER can be used to test the impact of varied funding scenarios on the condition of building portfolios and specific systems inventoried through BUILDER (Figure 2). Although funding profiles are estimated for a 5-year outlook in the example, BUILDER has the capacity to conduct analyses for up to a 10-year outlook. In addition, FI and MDI terms can be input into BUILDER, and modeling can give greater weight to mission-critical facilities that can aid in making trade-off decisions given constrained funding.



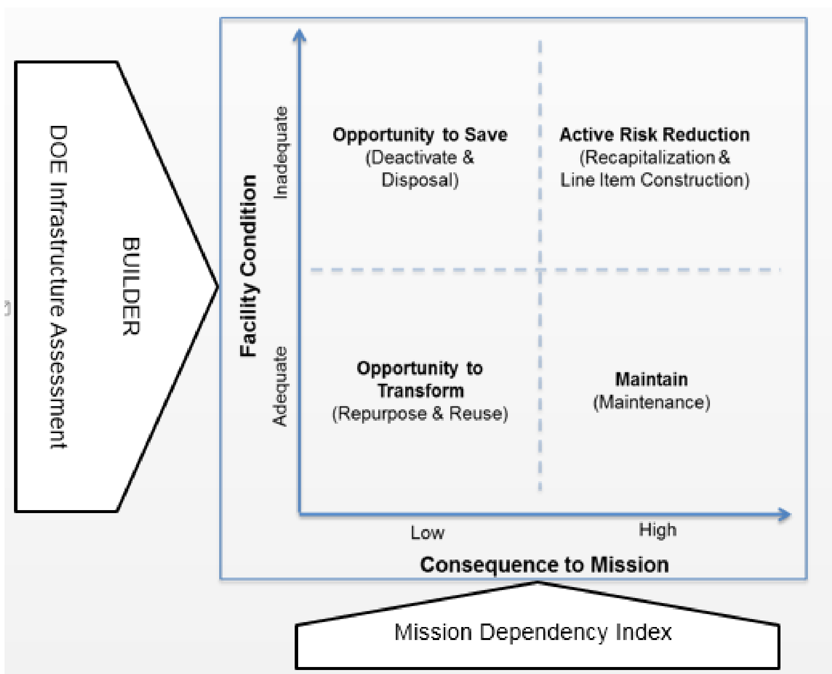
Source: Lance Marrano, "Asset Management Execution: Facility Condition Assessments through Sustainment Management Systems," Society of American Military Engineers, October 3, 2013, http://mvs013-020.directrouter.com/~sameorg/images/stories/images/SAME%20Presentation%20--%20BUILDER%20Webinar.pdf.

Figure 2. Impact Analysis on Facility Condition for Varied Funding Scenarios, at 90%, 70%, and 50% of the Requirement

Despite these capabilities, BUILDER's cost modeling and scenario tools have yet to be fully explored or implemented. The earliest adopters of BUILDER have not initiated Phase 4 to validate and analyze data. No Federal agency is sufficiently far along in its integration to use the condition prediction and other models for prioritizing repair and maintenance in its budgeting processes. Many of the Federal agencies integrating

BUILDER are instead focusing on obtaining a condition index (for building a portfolio of buildings). Only a few are thinking beyond the day-to-day maintenance work plans for facility management to future budget predictions for agency-wide building portfolio management. With some exceptions, particularly in NNSA and some parts of the DOD, Federal users lack an articulated vision or strategic plan for how results from BUILDER will be integrated in the budgeting processes for large capital acquisition, renovations, maintenance, and repair.

In contrast, NNSA is actively pursuing various options to visualize and analyze BUILDER condition alongside FI and MDI scores (Figure 3). This analysis will provide a more complete facility investment picture for budget prioritization, and the visualization will help leadership with communicating facility priorities in the context of maintaining function and mission capabilities.



Source: Jefferson Underwood, "NNSA Infrastructure Management Improvements, FIMS/Real Estate Annual Comprehensive Training," 2015, https://fimsweb.doe.gov/fimsinfo/2015_workshop.htm.

Figure 3. NNSA Use of BUILDER Facility Condition and MDI for Decision-Making

Several challenges need to be addressed for BUILDER results to effectively inform budgeting decisions:

- Cost data, which are out of date (estimates range from over the past decade) need to be updated and maintained over the long term to provide more accurate maintenance and replacement costs for building components and systems and to estimate costs of replacing systems or new construction. This is particularly relevant for specialized components and systems in RDT&E facilities. CERL researchers have acknowledged this limitation and are working to update the cost reference book.[35]

- BUILDER's cost modeling tools and its capabilities need to be better understood by users and integrated into budgeting plans and processes. This could be facilitated by developing an easy-to-use user interface that provides reporting and data analytics, including scenario building, modeling, and tracking of investment impacts.

[35] This will be accomplished through (1) consolidation of all custom inventory catalogs into one master volume (accomplished) to give agencies the ability to configure which catalog items to show/hide for their use; (2) establishment of a technical committee specifically to focus on catalog requests (accomplished), which will support more rapid catalog additions (no more than 3 months' delay); and (3) licensing of industry data. Personal communication with CERL official, January 23, 2017.

7. Considerations for the Future

Federal agencies have adopted BUILDER to obtain several benefits, including the use of a standardized, but customizable, methodology to assess their building portfolio; the potential for long-term cost savings through proper planning and prioritization; and the capacity to inform facility investment and budgeting decision. As a federally funded software tool developed by CERL, BUILDER is free to Federal agencies. Before integrating BUILDER, however, Federal agencies should consider and plan for (1) the large up-front costs that may be necessary to customize the tool to agency-specific needs, (2) the technical expertise and resources to conduct inventories and condition assessments, and (3) the additional burdens on an agency's facility management workforce. To date, there has been no analysis of costs and benefits associated with adopting BUILDER.

The Federal community of BUILDER users has been growing over the past decade. A formal Federal community of practice, possibly under existing NSTC or other relevant interagency working groups, could be developed with the following goals:

- Exchange lessons learned, including analysis of costs and benefits associated with implementation to inform adoption and planning.
- Identify ways to leverage resources, including understanding common needs (e.g., CMMS integration) across Federal agencies and jointly funding solutions.
- Support data analytics of condition and needs (specifically for national security laboratories facilities).

Activities under a community of practice could include:

- Identifying similar types of RDT&E facilities (e.g., biosafety level laboratories) to standardize inventories based on unique or specialized components and systems relevant to those facilities.
- Developing plans and policies to share costing data to improve accuracy of cost models for unique or specialized components and systems, such as those found in RDT&E facilities.
- Working with CERL and the DOD to identify ways to increase CERL's capacity to respond to user needs for customization (e.g., leveraging private sector services through licensing and collaborative research agreements) and sharing customized tools from early adopters.

- Exploring opportunities for improving data analytics and use of FI and MDI to better inform prioritization and budgeting.

Achieving these goals and taking part in these activities could lead to improved understanding of how to implement and use BUILDER. It could also serve as a way to coordinate needs, such as for new technical features, and raise concerns to CERL researchers.

Appendix A. Timeline of BUILDER Development, Pilots, and Policies: 1975 to 2015

1975: Initial research began on airfield pavement management techniques

1977: PAVER is released

1983: Initial development of ROOFER

1984: Initial development of RAILER

1988: RAILER released

1989: ROOFER released

1990: Initial development of BUILDER

1995: ROOFER version 2.1 released

1996: Tri-Service Master Plan for all Engineering Management Systems (EMS) modules (Air Force to fund PAVER enhancements, Army to fund RAILER enhancements, and Navy to fund [future] BUILDER enhancements)

2000: BUILDER 2.0 released and first version commercially available

2003: NAVY funds development of BUILDER 3.0 (web-based with single instance for entire component)

2005: Navy selects commercial tool for facility assessments in lieu of continuing with BUILDER

2006: USMC begins pilot tests of BUILDER

2007: BUILDER 3.0 released (first enterprise ready web based SMS version)

2007: Army issues AR 420-1 specifying PAVER and RAILER as the data standard for condition assessments of those specific infrastructures

2008: (November 25) OSD issues policy memo for linear segmentation of real property [Deputy Under Secretary of Defense (Installations and Environment) Memorandum: Revised Implementation Goals for Linear Segment Data Elements of the Real Property Inventory Requirements (RPIR)]

2008: USMC begins full implementation of BUILDER at all USMC installations

2009: Navy abandons commercial tool and adopts BUILDER

2010: USAF performs first pilot tests of BUILDER for STRATCOM at 11 installations

2010: DLA approves use of BUILDER for facility condition assessments

2010: NIST completed inspections in Gaithersburg, MD to calculate facility backlog and condition inspections

2011: Airforce implements BUILDER for about 60 million square feet

2011: NIST learns the BUILDER software, but doesn't continue with additional work

2012: Army conducts BUILDER pilots (Fort Hood, Fort Carson, Letterkenny Army Depot, and Sierra Army Depot)

2012: MEDCOM conducts BUILDER pilots to investigate adoption as Tri-Care Management Activity (TMA) standard

2012: NIST expands pilot site contract to Gaithersburg, MD and Boulder, CO for 4 years

2012: National Academy of Sciences (NAS) releases *Predicting Outcomes of Investments in Maintenance and Repair of Federal Facilities* recommending Federal agencies adopt the BUILDER methodology

2012: NIST rotates campuses for the next 3 years to complete outstanding work

2013: STPI study identifies BUILDER as a promising tool to evaluate facility condition for Federal laboratories[1]

2013: NNSA adopts BUILDER

2013: September 10 USD establishes SMS as the only DOD standardized facility inspection and condition assessment tool [Deputy Under Secretary of Defense (Installations and Environment) Memorandum: Standardizing Facility Condition Assessment]

2013: ODNI adopts BUILDER and formed the BUILDER Board for implementation

2013: DHA conducts two pilots (Fort Bragg and Walter Reed)

2013: USDA completes first pilot (Beltsville, MD)

2014: *VFA, Inc. v. U.S.*; private interest sued the United States as a "bid protest to challenge the decision of the Department of Defense ("DOD") to standardize its facility condition assessment needs through the Sustainment Management System ("SMS")"[2]

2014: NNSA implements BUILDER with two pilots (Lawrence Livermore National Laboratory and Pantex Plant)

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1 S. V. Howieson, V. Peña, S. S. Shipp, K. A. Koopman, J. A. Scott, and C. T. Clavin. *A Study of Facilities and Infrastructure Planning, Prioritization, and Assessment at Federal Security Laboratories* (*Revised*), IDA Paper P-4916 (Alexandria, VA: Institute for Defense Analyses, 2013), https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/ida-p-4916.ashx.

2 United States Court of Federal Claims, "VFA, Inc. v. The United States: Bid Protest; DOD's Sustainment Management System; Subject Matter Jurisdiction; Standardization Decision; Distributed Solutions; Definition of Procurement," Filed October 21, 2014, https://ecf.cofc.uscourts.gov/cgi-bin/show_public_doc?2014cv0173-62-0.

2014: USDA contracted with ALPHA Facility Solutions for two pilots (Grand Forks, ND and Kearneysville, WV)

2015: NIST wrote new contract that continues to use VFA database, refresh database every 3 years, and complete a more enhanced condition assessment in larger businesses

Projected

2017: Department of Veterans Affairs plans to fund a pilot at their Iowa City facility

2018: DOD BUILDER implementation deadline

TBA: CERL release of SMS modules for dams, fuels, and utilities

Appendix B.
Interviews

A total of 25 interviews—19 with officials across Federal agencies adopting BUILDER and 6 with contractors, including Cooperative Research and Development Agreement (CRADA) partners—were conducted over the course of 6 months. The interviews included conversations with facility managers, policymakers, laboratory stakeholders, CRADA partners and contractors who are licensees. Table B-1 lists the dates and types of interviews by Federal agency, and Table B-2 lists the same information for contractors.

Table B-1. Interviews with Federal Agencies

Federal Agency	Interview Date	Interview Type
Department of Agriculture (USDA)		
Agriculture Research Service (ARS)	9/16/2016	Phone
Department of Commerce (DOC)		
National Institute of Standards and Technology	8/10/2016	Phone
Department of Defense (DOD)		
Office of the Under Secretary of Defense for Acquisition, Technology and Logistics	8/03/2016	In-person
DOD, Defense Health Agency (DHA)		
Office of the Chief of Operations and Maintenance	8/23/2016	In-person
Walter Reed Medical Center	9/207/2016	Phone
DOD,Army		
Office of the Assistant Chief of Staff for Installation Management	9/15/2016	In-person
DOD,Army Corps of Engineers		
Engineering Research and Development Center	11/14/2016	Phone
Construction Engineering Research Laboratory	8/30/2016	Phone
DOD,Air Force		
Air Force- Air Force Civil Engineer Center	9/22/2016	Phone
Air Force Research Laboratory (AFRL) and Rome Laboratory	9/28/2016	Phone
DOD,Marine Corps		
Marine Corps Installations Command	8/31/2016	In-person
DOD,Navy		
Naval Facilities Engineering Command	8/17/2016	In-person
National Nuclear Security Administration (NNSA)		
Office of Infrastructure Planning and Analysis	8/01/2016	In-person
Lawrence Livermore National Laboratory	9/30/2016	Phone
Los Alamos National Laboratory	8/16/2016	Phone
Pantex Plant	8/16/2016	Phone
Y-12 National Security Complex	8/16/2016	Phone
Office of the Director of National Intelligence (ODNI)		
Acquisition, Technology, & Facilities	8/19/2016	In-person
Department of Veteran Affairs		
Office of Capital Asset Management	9/07/2016	In-person

Table B-2. Interviews with BUILDER Contractors

Name	Interview Date	Type of Interview
Atkins	11/10/2016	Phone
Calibre Systems	10/26/2016	Phone
Cloverleaf Solutions	11/8/2016	Phone
DIGON Systems	11/11/2016	Phone
LMI	8/19/2016	In-person
University of Illinois at Urbana-Champaign	8/01/2016	Phone

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Abbreviations

AFRL	Air Force Research Laboratory
API	application program interface
ARS	Agricultural Research Service
ASTM	American Society for Testing Materials
BCCI	building component condition index
BCI	building condition index
CERL	Construction Engineering Research Laboratory
CMMS	computerized maintenance management system
CRADA	Cooperative Research and Development Agreement
CSCI	component-section condition index
CSP	Configuration Support Panel
DHA	Defense Health Agency
DISA	Defense Information Systems Agency
DLA	Defense Logistics Agency
DOC	Department of Commerce
DOD	Department of Defense
EMS	Engineering Management Systems
ERDC	Engineering Research and Development Center
FI	functionality index
FY	fiscal year
HVAC	heating, ventilation, and air conditioning
IDA	Institute for Defense Analyses
IWG	Interagency Working Group
KBI	knowledge-based inspection
MDI	mission dependency index
NAS	National Academy of Sciences
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Administration
NSTC	National Science and Technology Council
ODNI	Office of the Director of National Intelligence
PAVER	Pavement Maintenance Management System
PCI	pavement condition index
PLA	Patent License Agreement
RAILER	Rail Maintenance Management System
RDT&E	research, development, test, and evaluation
ROOFER	Roofing Project Management
RPIR	Real Property Inventory Requirements
SCI	system condition index
SMS	Sustainment Management System
STPI	Science and Technology Policy Institute

TMA	Tri-Care Management Activity
UFC	Unified Facilities Criteria
USAF	United States Air Force
USDA	United States Department of Agriculture
USMC	United States Marine Corps