EXECUTIVE SUMMARY

# Better Buildings, Smaller Bootprint

## Smart Building Program for the DoD

Nik Sanchez
David Mejia
Sean Reed
Rebecca Reel
Sam Tankel
Peter Rake
***Switch Automation***

Paul Richwine
***United States Army Information Systems Engineering Command***

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**ESTCP Project EW19-5329**

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Project: EW19-5329

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## ACRONYMS AND ABBREVIATIONS

AMI advanced metering infrastructure
API application programming interface
ARNG Army National Guard
ATO authority to operate

BAS building automation system
Btu British thermal unit

DoD Department of Defense

EMIS energy management information systems

IoT Internet of Things

# ACKNOWLEDGMENTS

Thanks are due to the personnel at Camp Atterbury who allowed this demonstration to take place and to all the team members at Switch Automation, past and present, who helped make this project possible through their support. Furthermore, to the Department of Defense for their commitment to exploring pathways to sustainability within the nation's largest federal agency.

# 1.0 INTRODUCTION

At the time of this project, the Department of Defense (DoD) managed an estimated 561,975 real properties spanning all 50 states, seven U.S. territories, and 42 foreign countries. DoD occupies an estimated 276,770 facilities throughout the world, valued at more than $585 billion and comprising $2.2^{+}$ billion square feet. Sixty-six percent (66%) of these are owned by DoD.[1] The scale of DoD's physical presence is reflected in its energy *bootprint*. In 2016, DoD consumed an estimated 198,031,000 MMBtus, roughly 57%, of the U.S. Federal Government's total energy budget for the same year.[2]

The utility and operational data generated by such a scale of operations is substantial. The task of effectively using this data is equally vast—made more difficult by the fact that data are generated by and stored in disparate systems of varying sophistication and detail. Implementation of a unified system to automate collection, normalization, and presentation of data, would empower DoD energy and facility managers to approach facility and installation management with efficient use of human resources and improved data informed decision-making capability.

# 2.0 OBJECTIVES

The objective of this project was to demonstrate the capacity for modern, cloud-based software to improve access to and enhance the quality of facility-related data in a cost-effective and scalable fashion, while also offering services over and above those available in standalone systems. Switch Automation worked with the Army National Guard (ARNG) and the National Guard Bureau to collect, aggregate, and normalize disparate sources of information into a single platform and offer new services, including advanced analytics and reporting, automated fault detection and diagonstics, local and remote control of building systems, and improved energy and energy demand management. This technology provides the opportunity for analysis of energy consumption and cost savings, reduced maintenance costs, and improved time efficiency of facility managers and maintenance staff. The objectives can be grouped into the following three stages of delivery:

- **Integrate and Validate Baseline Data**: The first objective was to integrate advanced metering infrastructure (AMI) and building automation system (BAS) data for 12 months to create a historical database as part of this demonstration project. Data was obtained through direct integration, but challenges with data from direct integration led to flat file (.csv) ingestion methods also being utilized. These complications are discussed further in the body of this report. This historical data used for the baseline included kilowatt-hour (energy consumption), kilowatt (KW) (energy demand), British thermal unit (Btu) consumption, as well as the typical operating posture of basic control parameters (e.g., setpoints, schedules, etc.).
- **Highlight Findings and Implement Fixes**: After baselining, the demonstration was to promote and implement advanced energy management information systems (EMIS) technology and demonstrate the capacity of advanced EMIS technology to deliver value and to set forth best practices. Further, to demonstrate targeted implementation and operationalization of EMIS technology in the traditional DoD context.

[1] https://www.acq.osd.mil/eie/Downloads/BSI/Base%20Structure%20Report%20FY15.pdf
[2] http://ctsedwweb.ee.doe.gov/Annual/Report/Report.aspx

- **Authority to Operate Acceptance**: Upon completion of the demonstration project, the objective was to provide a compelling case for adoption of this technology to the energy and facility management stakeholders. By meeting several of the key performance indicators described in Section 3 of the full report, and by obtaining a letter of attestation from participants in the demonstration, the objective is to further provide the assurances that most cybersecurity stakeholders require that this technology can complete the Risk Management Framework process and achieve Authority to Operate (ATO).

## 3.0 TECHNOLOGY DESCRIPTION

The technology required for this demonstration consisted of hardware to integrate systems "at the edge" (i.e., within the facility), software on the hardware to pre-process the data collected at the edge, and cloud services hosted off-site and applied after data was sent to the cloud.

The hardware used for this demonstration project was the Dell Edge Gateway 3003, and after July 2021 the Advantech UNO 420. This Internet of Things (IoT) device was used to host the full complement of integration drivers and data processing applications of the vendor's software stack. Software hosted on the IoT device are:

- Ubuntu Core 16 (Dell customized)
- Docker version 18.06.1-ce
- Ubuntu Core 20 (Advantech units)
- Switch Janus v1.36

Once data was integrated and sent to the cloud, it was hosted in a Microsoft Azure data center. As part of this project, a private Azure instance was established in a Federal Risk and Authorization Management Program (FedRAMP) compliant Gov. Cloud data center. This instance is available for use should this technology be adopted and ATO is achieved.

The vendor cloud software leveraged the following three distinct data ingestion methods: flat file/data mapping (.csv), appliance (edge), and Application Programming Interfaces (API). Under this demonstration project, appliance integration was leveraged for AMI, BAS, and any other available data sources at the edge. Historical utility bills were also ingested via flat file/data mapping (.csv) to backfill data which was not uploaded from the edge due to cellular connectivity issues which will be further described.

Data, once integrated to the cloud, was open to several different platform features and applications. These applications include analytics, visualizations and reporting, data tagging and trending tools, control, opportunity tracking (Events) and others briefly described in Figures ES-1 below. Further details on how these applications were applied to the project can be found in Section 2.0 of the full report.

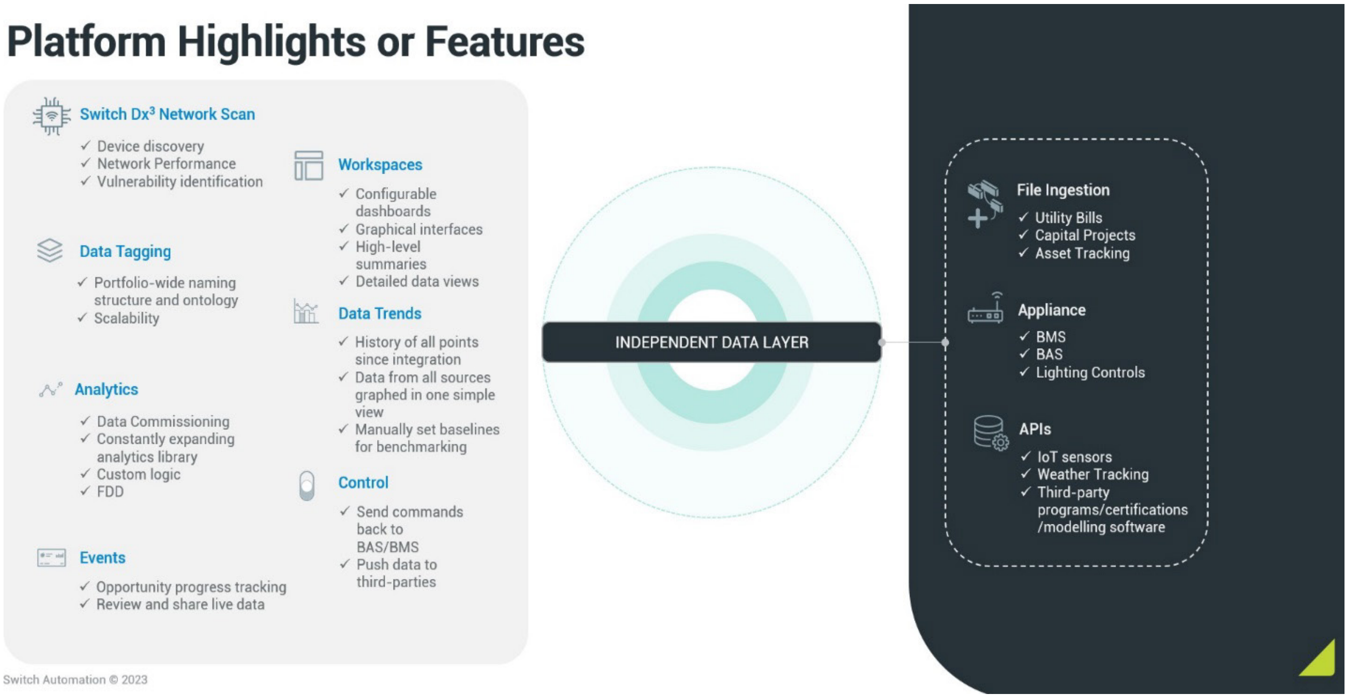


**Figure ES-1. Platform Features and Applications**

## 4.0 PERFORMANCE ASSESSMENT

Quantitative performance objectives under this demonstration project related primarily to reductions in energy consumption, maintenance costs, and equipment failure. Greater flexibility in facility operations, leveraging remote-control of facilities and a greater ability to shed and shift load had financial benefits, as well as enhanced security benefits.

Table ES-1 lists each performance objective (PO), the data required, the success criteria, and the respective results.

**Table ES-1. Performance Objectives**

| Performance Objective | Metric | Data Requirements | Success Criteria | Results |
|---|---|---|---|---|
| **Quantitative Performance Objectives** | | | | |
| PO 1 Reduced Energy Consumption | kBtu/ft$^2$ | Historical utilities/energy consumption data | Identify opportunities for ≥7% reduction in kBtus, resulting cost savings, weather and occupancy normalized | Approximate calculations show a potential of >9% kBtu reduction if all raised opportunities are implemented. Refer to Appendix B& C of the full report for further details. |
| PO 2 Reduced Power Demand | kW | Energy demand data from AMI | Identify areas for reduction in peak demand (kW) by ≥10% | Peak demand reduction is not able to be accurately compared due to issues relayed in Sections 6 and 8 of the full report. |
| PO 3 Mechanical Equipment Runtime & Operation | % hours<br><br>Events Identified | Control parameters from pilot sites<br><br>Switch Event | ≥5% identified opportunities for reduction in equipment runtime and verify desired operational schedules (presently 24/7 for some facilities) Identify events of operational improvement. | Approximately 10% of raised opportunities identified equipment or systems running excessively, for 3 of the 5 pilot sites. |
| PO 4 Improved Mechanical Equipment Maintenance Via Work Order Tracking | Count by Severity | Work order (WO) data for pilot sites | Track changes in WO criticality, response time, and maintenance visits (tracking is the first step, with the aim for reduction in quantity and severity). | Several requests for Work Order data were made by the vendor project team. This data was not provided by site team. No specific reason was cited. |
| **Qualitative Performance Objectives** | | | | |
| PO 5 Improved Analytics & Workflow | Satisfaction | User Login Tracking | Adoption of Platform features – user login once per month per site. | Site team used Opportunity tracking tool and were educated on use of dashboards, but were not active in the platform on a weekly or even monthly basis. |

## 5.0 COST ASSESSMENT

The costing framework took several factors into consideration to determine the total value invested to deliver product and service, including data connection method, API/driver development, size and complexity of site, required training, software features used, and consultative support needed. The scope and detail of each project is considered to apply a tailored "best support model" for each site.

## 6.0 IMPLEMENTATION ISSUES

This demonstration uncovered several implementation issues. Some were known prior to the demonstration, but ended up being a larger issue than expected, whilst others were uncovered through the demonstration process:

**Site Team Engagement:** The most important factor in the Switch Platform being an effective tool is active engagement and use of the tools by the site and/or facilities team(s). Unfortunately, low engagement limited demonstration effectiveness.

- **Reasons for Lack of Engagement:**
  - Project disruptions due to the COVID-19 pandemic caused several distractions with respect to priorities & availability of site teams.
  - Additionally, site team members present during project kickoff were subsequently deployed and replaced, resulting in a lack of historical knowledge of the project objectives and intent. Stakeholder (and user) buy-in was compromised as a result.
- **Challenges with Lack of Engagement:**
  - The above factors resulted in a lack of platform engagement, which led to low meeting attendance, sub-optimal opportunity resolution, and in some cases a lack of supplementary data provided to vendor.
- **Recommendations for Increased Engagement:**
  - Future uses of this technology would benefit from a "champion" who can be trained in the analytical tools made available within the platform, prioritize insights, and ensure that internal processes for opportunity resolution are followed. These individuals are then able to engage new DoD users with the technology for continuity of use, and continuity and/or expansion of program objectives and outcomes.

**Inconsistent Internet Connectivity:** The Switch Appliance pushed data to the cloud via a cellular connection. Often, this connection did not work properly, resulting in a loss of data or data that was improperly aggregated. This is <u>not</u> standard operating procedure for deployment but was necessary in this demonstration for security compliance.

- **Reasons for Internet Connectivity Issues**
  - Cellular/SIM data services were utilized as temporary measure for cyber compliance as approval for hardwired internet was not granted during the project.
- **Challenges with Internet Connectivity Issues**
  - Cellular connections regularly have issues maintaining consistent connectivity. This can be due to the location of the modem (in a concrete room or near high interference areas) or due to the location of the site (in a remote location). Cellular connections also have cost implications to the project due to cellular carrier fees and data chargers.
  - Due to poor connectivity, it was difficult to baseline utility data and maintaining a transparent view into the five pilot sites at the beginning of the project.
- **Recommendations for Improved Connectivity**
  - If SIM cards are required, it is recommended that modems with dual SIM card capabilities are utilized for increased resiliency. Dual modems were installed for this project to mitigate the above challenges faced early in the program.

- If ATO is achieved, internet connectivity issues should decrease significantly as the need for a cellular connection will no longer be present.

As noted previously, the use of cellular connections is not recommended as a primary enabler of data transport for this type of application. While valuable in select scenarios (e.g., this instance for temporary cyber compliance), cellular/SIM data services should generally be considered as a failover mechanism as appropriate.