

Defense Facility Management:

How Cybersecurity is Enabling Smart Facility Technologies

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1. Executive Summary

KBR has significant experience with facility management (FM) smart technologies (ST) through its various Department of Defense (DoD) projects. ST for FM has matured significantly over the last decade with numerous vendor offerings appearing on the market. The value proposition centers on tapping the immense data resource within Operational Technologies (OT). This resource resides in the almost unlimited number of microprocessor-based machinery controls that produce Near Real Time (NRT) measurement of the facility operational state. ST mines state values from OT systems and creates data-driven intelligence to bring facility awareness to a new level by providing extensive information on performance degradation and identifying NRT actions that can lead to greater efficiencies, cost reduction and improved reliability. The combination of OT data and ST intelligence opens up a whole new frontier of FM process improvement possibilities and holds great potential to disrupt and re-shape existing paradigms for sustaining and modernizing DoD installations.

The KBR experience highlights two key barriers to ST adoption: cybersecurity (CS) and connectivity. It cannot be ignored that ST market offerings cannot be utilized in the DoD environment if not secured and authorized according to DoD CS policies and procedures. The same CS issues apply to the OT systems themselves, which DoD is heavily engaged in given the threat to facilities. And for ST to mine data from OT systems, network connectivity must be present, both to OT systems and the DoD business application environment. The realization of the importance of CS to ST success is the subject of this paper, and how DoD CS efforts are also providing the necessary connectivity. Indeed, DoD CS efforts are creating a natural fit for exploiting ST capabilities and improving economies, just at a time where CS costs are skyrocketing for the same systems ST can improve.

Based on our project experience, key CS design elements are presented including a CS approach to enabling ST by providing a secure virtual environment and connectivity to OT systems and the business environment. This approach is significant because ST becomes programmed into the enterprise deployment of CS technologies allowing for a ST enterprise deployment in tandem. ST design elements are presented for an integrated CS/ST framework showing how one enables the other. To showcase the value of such an approach, select examples of ST capabilities are presented that demonstrate how ST is improving FM intelligence in the areas of energy and utilities. To further the understanding of the ST value proposition, potential applications extending deep into the full FM functional community are posited for future consideration. And given the similarities between facilities and sea-going vessels at

the machinery utilization level, potential sea-based applications are presented as well to fully develop the picture of the DoD ST frontier.

2. Introduction

The Department of Defense (DoD) installations are highly self-reliant and include a wide range of facilities including buildings, utilities, industrial plants, etc. Each of these facilities use a range of internal mechanical and electrical systems to support their operation. And these systems employ Facility-Related Control Systems (FRCS)¹ which are digital-based and subject to cyberattacks. FRCS defenses provide a wide range of security controls against both internal and external threats. These defenses are typically managed by a security stack of hardware and software providing access control, intrusion detection, anti-virus applications, etc. for multiple facilities and FRCS via existing installation communication networks – essentially a FRCS CS infrastructure.

Coincidentally, this is the same infrastructure needed for facility management ST that are near real time (NRT) and operate on FRCS data. If exploited for ST, CS investments become quite valuable in their ST return potential, primarily in lower energy and capital maintenance costs through improved system performance. This paper examines a realistic CS programmatic approach allowing exploitation of the ST opportunity. The approach described herein provides for design and deployment of a regionalized FRCS CS solution accompanied by a follow-on ST enterprise deployment. Design concepts for both the CS and ST solutions will be explored along with resultant ST capabilities. Further, since ST focuses on mechanical and electrical systems, parallels will be drawn to DoD weapons platforms (e.g. sea-going vessels) that employ these same systems, demonstrating that where secure data infrastructure exists for hard asset control systems, ST capabilities for advanced performance management is enabled.

3. FRCS Description and DoD CS Approach

UFC 4-010-06¹ provides a detailed description of FRCS components with Figure 1 providing a graphical description of the different component levels. The UFC distinguishes the components within the 5-Level Architecture as “Standard IT” and “Non-Standard IT” with the distinguishing feature being primarily the ability to address the components using Internet Protocol (IP). Components that are IP addressable (i.e. have IP addresses) are typically Standard IT. Components that do not have IP addresses, such as sensors and actuators, are Non-Standard IT. From a CS design perspective, IP addressable components (Standard IT) are the most vulnerable to attack and the focus of security controls. These components are typically at the higher levels of the architecture with prime examples being computer applications with IT operating systems such as Microsoft Windows or Linux.

FRCS CS design separates the Standard IT and Non-Standard IT into two separate boundaries with each having their own CS strategies and authorizations. Since the Standard IT components utilize similar security controls, these controls can be provided by a CS enclave which can serve multiple control systems. Non-Standard IT components require tailored controls for each control system and generally are peculiar to the control system vendor product. To fully secure a control system, security controls for

¹ See DoD's Unified Facility Criteria (UFC) 4-010-06, “CS of Facility-Related Control Systems”, Section 1.1 for an FRCS description. https://www.acq.osd.mil/eie/Downloads/IE/UFC_4_010_06.pdf

the Non-Standard IT components must be configured and authorized then connected to the Platform Enclave to complete the FRCS CS solution.

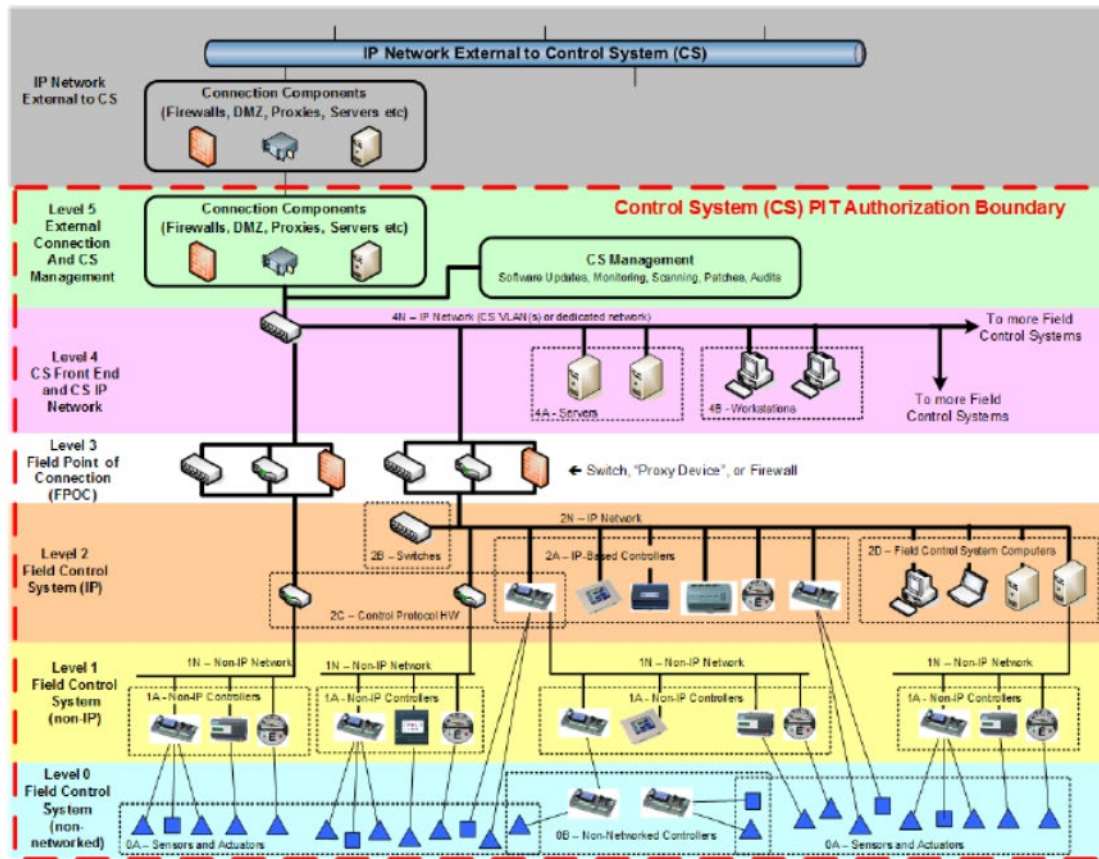


Figure 1: 5-Level Control System Architecture of UFC 4-010-06

4. Regional FRCS CS Enclave and FRCS/ST Hosting Environment

For Standard IT components, a regional FRCS CS enclave addresses FRCS Standard IT components while also providing secure connection to the FM business environment². The enclave brings all regional FRCS under a single security umbrella via an extensive communication network between multiple installations. Figure 2 provides a notional structure for this enclave which is based on the UFC 5-Level Architecture model.

As shown, the enclave provides for a Regional Core Stack that is located at the regional headquarters installation. Via DoD inter-base networks, the regional core stack can communicate with remote installations. Each remote installation is designed with a local security stack as part of the enclave to

² DoD FM business environments typically include enterprise applications for real property management, meter data warehousing, workload management, and Geographical Information Systems (GIS).

provide security services in case of communication outages with the regional stack. Each installation within the enclave has a dedicated and isolated FRCS network connecting local FRCS to the appropriate

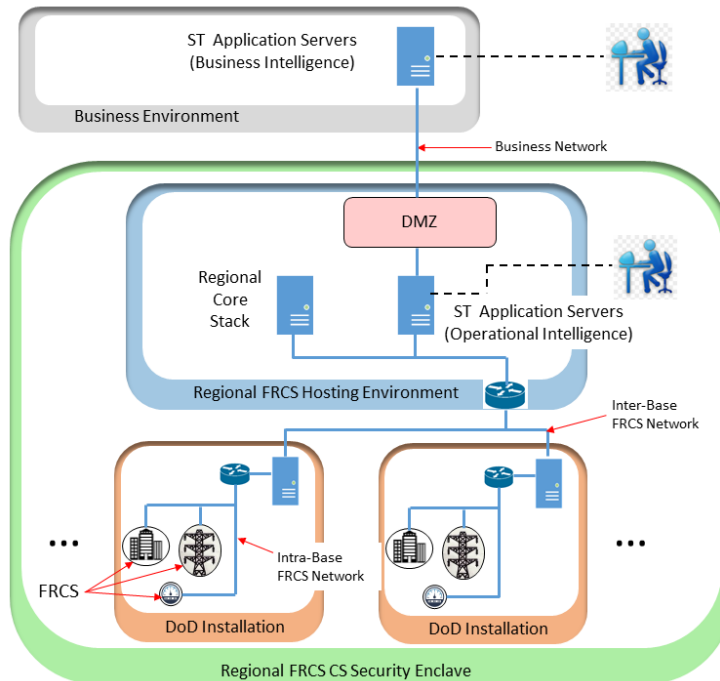


Figure 2: Regional FRCS CS Enclave Notional Diagram

security stack. Within the security stack, a variety of services are provided including hosting of “front end” FRCS applications that support multiple facilities. Communicating through the stack router, the enclave provides coverage for dispersed FRCS via the installation’s FRCS network. In Figure 2, different FRCS are shown and include Utility Control Systems (UCS), Building Control Systems (BCS), and Advanced Metering Infrastructure (AMI) meters.

Outside the enclave environment, Figure 2 shows the FM business systems. A key design element of the structure is the separation of FRCS from the business systems using a demilitarized zone. The demilitarized zone is provided in anticipation of data sharing between FRCS and the business environment while maintaining a closed FRCS enclave, i.e. no internet FRCS connections. Data exchange between the regional enclaves and the business environment is across existing enterprise business networks.

The enclave design structure lends itself to enabling the ST application by providing four key elements:

1. Connectivity to FRCS
2. Virtual hosting environment
3. Hosting environment security controls
4. Connectivity to the business environment

And being a regional platform, it becomes a very fertile environment for an ST application where aggregation of large amounts of facility data across numerous systems is enabled.

5. ST Application Design

Following DoD standard system engineering process, ST begins with defining system objectives and high-level capability expectations in a written Capabilities Development Document (CDD). Figures 3 and 4 provide notional diagrams of ST design concepts typically provided in a CDD³. Figure 3 provides a ST vision diagram depicting the ST Control Station connecting and interacting with various building, utility, and metering across multiple installations for cost savings and improved reliability; and improved business intelligence by exporting data to the FM business environment. Figure 4 provides a notional ST architecture showing the interrelationships between FRCS, the enclave, and the business environment applications. ST Operations Centers are shown using a COP, or Common Operating Picture, and operational analyses using FRCS data provided by dedicated interfaces.

For purposes here, an Initial Operating Capability (IOC) is defined as the initial goals of a ST programmatic implementation that focuses on high return areas of energy and utilities where most commercial ST applications are targeted. The most readily apparent goals for DoD FM would be:

- Reduce Cost
- Reduce Energy Consumption
- Support Mission Assurance

The CDD also identifies Key System Parameters (KPPs) and Key System Attributes (KSAs) which frame high level system capability requirements. In general, expected CDD salient features would be:

- Integration of all FRCS within a region
- Collection and utilization of operational data for facility management
- Transfer of operational data to external business applications
- Operator displays allowing for effective action-based decisions
- Demand response command and control
- A common data language
- COP⁴ for operators and users
- Business dashboards that allow for effective business-based decisions
- An Open System Architecture (OSA)

To support system design and deployment CDD capability statements would be decomposed into a detailed acquisition Performance Work Statement (PWS) for IOC capabilities.

³ See "Navy and Marine Corps Smart Grid Capability Development Document."

<https://www.navfac.navy.mil/content/dam/navfac/Public%20Works/PDFs/UES/Navy%20and%20Marine%20Corps%20Smart%20Grid%20CDD%20Industry%20Version%202014.pdf>

⁴ COP is defined as a "single identical display of relevant [operational] information shared by more than one command. A COP facilitates collaborative planning and assists all echelons to achieve situational awareness."

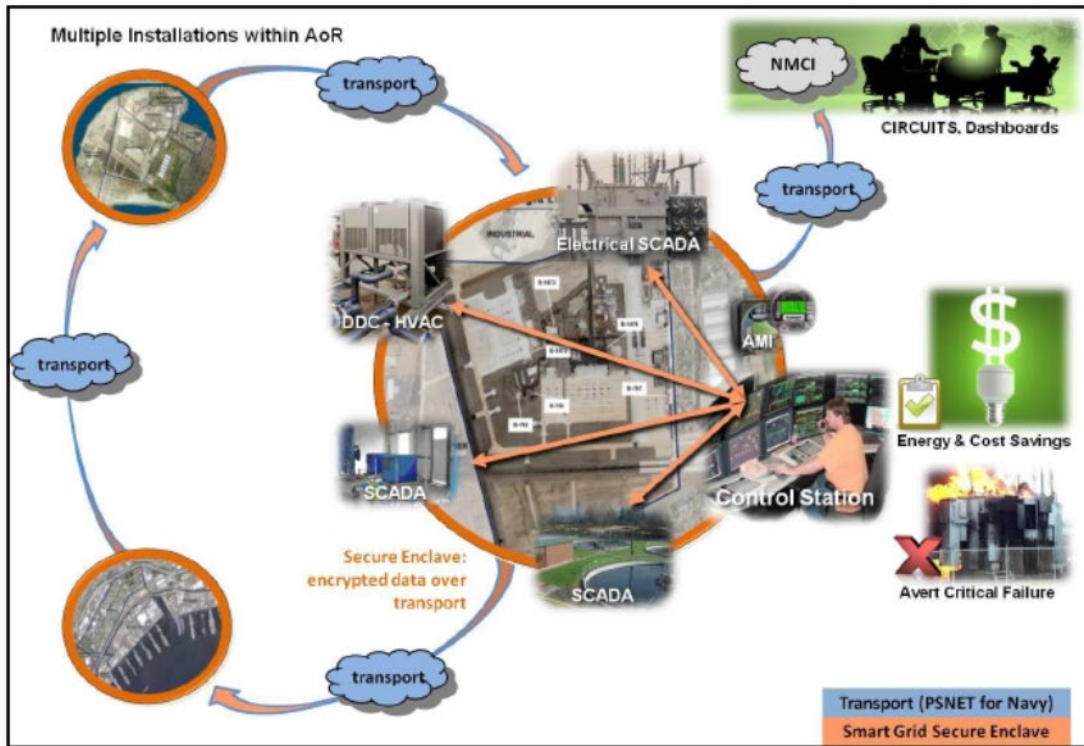


Figure 3: Navy and Marine Corps Smart Grid CDD Vision Diagram

PWS detailed requirements for ST would be quite extensive but four principal functional areas are relevant to all ST use cases including IOC and extended capabilities beyond IOC:

1. COP
2. Advanced Analytics
3. Supervisory Control
4. Reporting

The CDD and PWS combine to provide a comprehensive basis of design for the ST application that once deployed and integrated with regional FRCS provide extensive FM intelligence, diagnostics, and control capabilities.

6. ST capabilities and the DoD environment

Facility management in the DoD reflects the complexity of the defense mission. Facility management centers on sustaining and modernizing DoD's 513 installations and 562,000 facilities⁵. DoD facility planning criteria provides for 9 categories of facilities:

⁵ See "Department of Defense Base Structure Report FY 2015 Baseline."
<https://www.acq.osd.mil/eie/downloads/bsi/base%20structure%20report%20fy15.pdf>

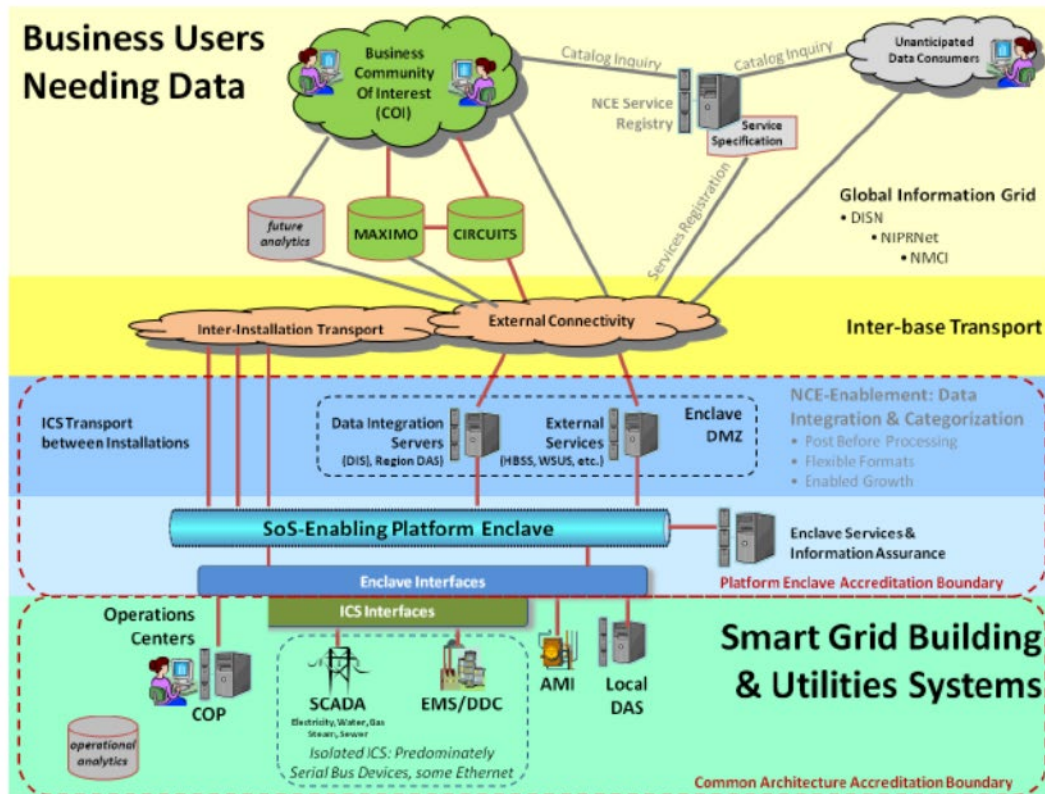


Figure 4: Navy and Marine Corps CDD Operating Environment

1. Operational and Training
2. Maintenance and Production
3. Research, Development, Test and Evaluation
4. Supply
5. Medical
6. Administrative
7. Housing and Community
8. Utilities and Ground Improvements
9. Real Estate

Facility management functions include:

- Installation Planning
- Design and Construction
- Property maintenance and repair
- Transportation
- Real Estate management
- Environmental compliance
- Acquisition
- Information technology

When assessing ST capabilities against the challenge of the DoD mission, extraordinary possibilities reveal themselves for process improvement and paradigm change with major cost reduction and improved system performance potential given DoD's size and diverse facility portfolio. Following are examples, briefly described, of expected ST IOC capabilities. IOC capabilities are narrowly focused in comparison to the universe of possible ST applications. Like any new technology application, ST will follow a maturity cycle so in addition to the following IOC examples, insights into extended ST applications will be explored as well.

IOC Capabilities - COP:

ST software allows for the creation of a "digital twin" of the mechanical and electrical facility systems and their machines that has a consistent look and feel and a single data model. This digital twin is created for multiple building and utility systems within a DoD installation by interfacing with their FRCS and extracting the control system databases. Combining FRCS data on controlled equipment with other DoD asset data stores such as as-built drawings, real property inventory databases, and work management systems, system designers can ascertain a specific design configuration for a facility system. An accurate site assessment is critical to developing an accurate design and ultimately, a digital twin.

When digital twins are created for multiple facilities and multiple systems and integrated into the ST application, and populated with NRT sensor and analytical data, a virtual environment is created that allows the user to navigate amongst the installation's real operating environment with ease including the ability to drill down into different levels of system views e.g. facility view, system view, equipment view, etc. The ST user experience is also guided by the ST actionable intelligence that brings operational issues to the surface via Key Performance Indicators (KPIs), fault notifications and alarms. Following this heads-up information, the user can utilize the ST diagnostic tools to discover root causes and take corrective action either through issuing work orders or using ST controls and settings to correct directly via ST operator action.

When digital twins include geospatial views showing multiple facilities on an interactive installation map, ST capabilities are extended. An example is associating conditionally formatted meters and electrical distribution lines to highlight the extent of a power outage in NRT for improved outage response.

IOC Capabilities - Advanced Analytics - Automated Fault Detection and Diagnostics (AFDD):

AFDD is one of the more powerful ST technologies, especially in the case of HVAC systems. Figure 5 below presents the user display of a specific fault example⁶. The fault rule is designed to detect when mechanical cooling is occurring when the system is in economizer mode. Economizer mode uses outside air under the right conditions to provide cooling without the need for mechanical cooling i.e. "free cooling". As shown the chilled water valve signal is about 60% during the economizer signal time period when it should be zero. Mixed air and return temperatures are identical indicating no outside air

⁶ See "Real World Examples of Analytics in Action" for more AFFD examples demonstrated by Skyfoundry's SkySpark application, a leading AFDD product for HVAC. <https://skyfoundry.com/file/408/A-Collection-of-Case-Study-Examples-Show-the-Benefits-of-Analytics.pdf>

beneficial impact and a possible issue with economizer damper operation, i.e. damper won't open to allow outside air introduction and free cooling.

These examples show where ST capabilities can identify performance degradation that would otherwise go undetected. The loss of economizer functionality does not impact the performance of the HVAC system in managing occupant comfort so without occupant complaints the issue would only be uncovered by direct maintenance inspection. AFDD identifies the issue when it first occurs so action can be taken early to correct and restore system efficiency. The act of correcting this economizer fault is also an example of the condition-based maintenance concept and of building HVAC re-commissioning. Building re-commissioning is typically performed in 5-year cycles on a wholesale system basis. In this case, by correcting AFDD faults as they occur re-commissioning now becomes continuous commissioning where HVAC performance tuning is maintained on a continuing basis. The economic potential of continuous commissioning through condition-based maintenance capabilities is considered to be one of most attractive cost reduction opportunities for HVAC systems.

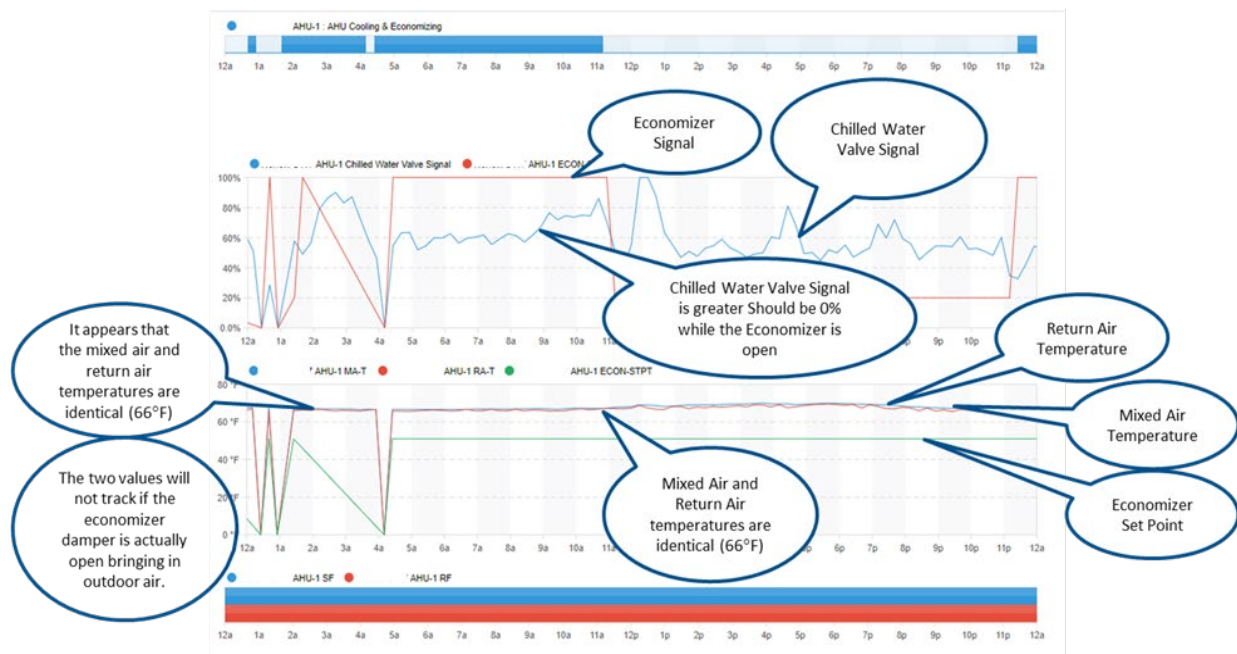


Figure 5: Example AFD Economizer Fault

IOC Capabilities - Advanced Analytics – KPIs:

An example of actionable KPIs is the development of HVAC zone metrics. The following three zone metrics are fundamental to monitoring HVAC performance at the building, installation, and regional levels:

1. Zone Comfort Index i.e. performance to zone space temperature set point
2. Space temperature setpoint policy compliance

3. Zone occupancy metric

The Comfort Index evaluates the individual zones in a building to determine if the system is meeting space temperature setpoint setting, or “holding temperature” for the zone. These determinations are rolled up into a building zone comfort metric that measures the percentage of building zones that are holding temperature. The metric is again rolled up to the installation and regional levels to measure the percentage of building zones that are holding temperature at the installation and region levels.

The value of this KPI is seen at a number of different levels. For the operator, who has a regional view, the KPI supports an examination of overall HVAC maintenance organization performance. The KPI allows the operator to dissect performance at the regional, installation, and building levels. The KPI also allows the determination of zones that are not holding temperature and the need for maintenance action prior to occupancy complaints. This is another example of ST capabilities where NRT actionable intelligence on zone performance allows the maintenance organization to detect a zone issue before occupant complaints are received.

Space temperature setpoint policy compliance metric, or “Compliance Metric”, is useful for ensuring policies on space temperature setpoint settings (e.g. 76°F in the cooling season) are carried out. Such policies are common in DoD energy programs but difficult to implement because of a lack of transparency on actual setpoint settings. With ST, zone space temperature setpoint settings are accessed from the building’s HVAC control system. For each building, ST displays present to the user a listing of zones and their status (compliant or non-compliant). The Compliance Metric is calculated for each building as a percentage of zones with compliant settings. The Compliance Metric is also rolled up to the installation and regional levels as a percentage of compliant zones for each level. With this ST capability an operator can assess compliance performance and drill down to zones where settings need to be adjusted. ST control capability enables the operator to adjust space temperature setpoint settings. While likely unpopular with occupants ST does provide the capability to easily enforce energy program policy with direct and immediate energy consumption and cost reduction.

The zone occupancy metric, or Occupancy Index, measures the percentage of time that zones’ space temperature setpoint settings are scheduled as an occupied state, in turn an indication of the amount of time the zone is scheduled as unoccupied. During scheduled times for unoccupied states, control systems relax space temperature setpoint settings to conserve energy. Knowing the specifics of zone setpoint scheduling is useful in evaluating how well unoccupied periods are being used to conserve energy. The Occupancy Metric provides the capability for the operator to evaluate how well occupancy schedules are taking advantage of unoccupied states to lower energy consumption and costs. The Occupancy Metric determines the percentage of time that a zone is scheduled as occupied. For a building, the metric is the average percentage of time that all zones are scheduled as occupied. For an installation, the metric is the average of the metric for buildings, and for the region it is the average for installations. With ST providing this KPI, the operator can assess opportunities to improve setpoint scheduling and take action using ST control capabilities to make the necessary adjustments.

IOC Capabilities - Advanced Analytics – Energy Analysis

The ST application provides for automated generation of well-known energy analytic products that support energy analysis and conservation measures such as building load profiles, load duration curves, energy use intensity, and water use intensity. These analyses are used to optimize facility operation and

identify energy investment opportunities. These analytical products are generated from connected meters that measure energy and water consumption. In addition to automatically generated energy analytics, the ST application takes advantage of common tools such as MS Excel by providing the user with capability to export historical data for custom engineering analysis and evaluation. This is useful for more in-depth analyses such as a peak shaving analysis for determining the optimum installation electrical purchase peak from the local utility provider.

IOC – Capabilities – Advanced Analytics – In Port Ship Energy Consumption Profiles

For large sea-going vessel applications, ST creates the unique capability to develop consumption profiles when an individual ship visits port. For example, when in port, ships are connected to external utilities so that internal power and steam production can be shut down (“cold iron”) for maintenance and crews can be rested. Connection points to these external utilities are in many cases metered, especially in the case of electricity. Like facilities, ships have an energy conservation program objective and having energy information while in port is useful to support those objectives during these port visits. The challenge is that an individual ship has a number of connection points and to obtain an energy profile for the entire ship, the meters for connection points have to be associated with the ship during its visit. ST provides an application that tracks pier meters to identify when they register consumption, and indication that a ship has been connected. The ST application provides a feature to the operator that allows registering meters to a specific ship in the inventory. Once the visit has expired (assigned meters register zero consumption) the ST application generates an energy load profile for the port visit. This energy profile can be used by ship operators to assess energy conservation measures while in port.

IOC – Capabilities - Advanced Analytics – Advanced Pattern Recognition (APR):

APR is a predictive analytical tool for identifying machinery degradation much earlier than other methods and shift maintenance management from reactive to proactive⁷. Early detection of failing machinery components provides the opportunity to take corrective action during planned maintenance cycles and avoid unexpected breakdown. APR uses historical OT data to model system operation over its varied operational states and detect anomalies between actual and expected performance. These anomalies are used to guide maintenance experts in diagnosing emerging failure modes. Typical APR applications target large, expensive, and complicated equipment (e.g. gas turbines, boilers, chillers, etc.). See “Extended Capabilities – APR for Building Energy Monitoring” for adapting the technology to energy program objectives.

IOC – Capabilities – Supervisory Controls – HVAC:

ST interfaces with OT-based FRCS provide limited two-way communication where FRCS HVAC controllers can accept inputs that adjust control logic setpoints such as desired space temperature. Using this capability, ST operators can evaluate property space temperature settings and make adjustments to improve energy conservation efficiency or enforce space comfort conditions policies. Operating at the regional level, this “Active Facility Management”, or AFM capability far exceeds the efficiency of managing such objectives through individual FRCS systems. Supported by digital twin graphics and

⁷ See “Real-Time Digital Condition Monitoring for Power Plant Optimization” for information on an example APR commercial application: Predict-IT by Engineering Consultants Group. <https://ecg-inc.com/products/predictit#video>

customizable reports and control features, the operator can efficiently navigate and manage numerous buildings across multiple installations from a single workstation.

IOC – Capabilities – Supervisory Controls - Electrical Distribution Switching:

As with HVAC FRCS, ST can also interface with DoD Installation electrical distribution systems at the substation and switching station level. When coordinated with the command's safety oriented and highly controlled switching order process, ST can provide the capability to remotely switch circuit breakers in support of maintenance actions or outage response when a standard Supervisory Control and Data Acquisition (SCADA) solution is unavailable. The value is seen in improving safety of operations by eliminating the need for maintenance crews to enter utility spaces during switching operations and observe from a distance outside arc flash hazard zones. The ST switching capability is provided as part of an overall electrical distribution application complete with digital twin and analytics.

IOC – Capabilities – Supervisory Controls – HVAC Demand Response:

ST control capability includes the ability to change, within a building, zone space temperature set points to follow a pre-designed demand response strategy to employ load reduction for electrical peak shaving purposes during peak events. ST controls provide for different levels of demand response load reduction available to the operator and are executed by changing the amount of setpoint relaxation. At the IOC level, this capability is demonstrated for individual buildings and can manually be coordinated when peak events are signaled by the installation's energy and utility managers. IOC demand response capability also serves to provide the building blocks for further demand response automation and capabilities (Extended Capabilities – Supervisory Controls – Installation Automated Demand Response).

IOC Capabilities – Reporting:

The ST user experience goes beyond a navigation platform to investigate multiple assets and system types across multiple installations. To provide coverage of the numerous performance issues occurring in such a large population of facilities, the ST application acts as heads up display that brings issues to the operator for further diagnosis using sophisticated tools and extensive data. Taken as a whole, geospatial and digital twin representations, AFDD, APR, KPIs, and alarms all coordinate to monitor an extensive set of equipment and systems and report to the operator the location and nature of performance issues needing attention. Metaphorically, ST enables facilities to "talk" to its caretakers on their care and feeding needs - the essence of FM ST.

Extended Capabilities - Building HVAC Re-commissioning

The HVAC re-commissioning starts with the developing of a scope of work for re-commissioning that identifies components that need replacement or repair. This is normally done by an engineering inspection and evaluation. However, the ability to assess the current state of HVAC systems is limited by the lack of system design information, historical data and ability to observe and analyze system operation. ST digital twin and analytical outputs greater expand engineering inspection and evaluation capabilities. For example, ST provide ready access to listings of failed and stale sensors. These listings can be directly inserted into re-commissioning scopes of work for project execution. Fault and alarm histories can be used to identify component repair and replacement needs. Digital twin graphics can be used to evaluate system components. For example, HVAC duct work and zone terminal units can be evaluated for integrity and proper balancing using ST information.

Extended Capabilities - Building HVAC Energy Audits

The same ST capabilities for HVAC re-commissioning can be employed to conduct energy audits with greater accuracy and efficiency. Historically energy audits are challenged by the lack of data on system performance. An example is chiller replacements where a modern chiller with potential lower Kw/ton performance can be used to replace older, less efficient chillers. To justify this capital expense, historical performance data is needed to accurately support an economic analysis. With ST data, historical recordings provide profiles of chiller loads and energy consumption that can be used to accurately predict future energy consumption with a more modern chiller. This demonstrates the value of having such extensive data available from a ST application that is readily assessable to end users.

Extended Capabilities – Supervisory Control - Installation Automated Demand Response:

The goal of electrical demand response at the installation level is to limit peak demand on the serving utility to reduce utility costs. Peak demand occurrence is limited to those few periods in time where installation loads are greatest e.g. hot and cold weather and/or high operational tempo. Demand reduction during these periods is served by both generation and load reduction. Generation is usually provided by fuel consuming equipment (e.g. diesel generators) and comes at an operational cost. Load reduction occurs when loads are intentionally reduced e.g. building demand reduction by relaxing comfort conditions. The cost with load reduction is personnel comfort which can reduce productivity. ST allows for optimization of these variables across the installation and programming of demand response for multiple assets towards the common goal. The ST application provides the detailed load data for engineering and economic analysis of the optimum purchase peak and then monitors fence line consumption to determine in NRT when demand response should initiate and calculate required demand reduction. Demand assets would be grouped into a portfolio of demand response assets with each evaluated and programmed into a response scheme. Response schemes can exploit load reduction opportunities while also limiting negative personnel comfort impacts by rolling comfort set points. This illustrates the synergistic benefits of ST where extensive deployment across the installation is achieved.

Extended Capabilities - Building Envelope Assessment

Using the extensive meter data available, ST analysts have an efficient platform for correlating building energy load to outside air temperature readings across the four seasons using linear regression. The slope of these best fit curves (load versus temperature) is a relative measure of envelope insulating performance. The higher the slope the less efficient. A comparative analysis across the thousands of metered buildings will quickly reveal energy investment opportunities for window replacement, window film retro fits, crack sealing, insulation improvements, etc.

Extended Capabilities – Electrical Distribution SCADA:

For DoD, ST holds potential for direct replacement of existing installation SCADA systems. Typical COTS SCADA products are designed for large, extensive utility providers and have powerful capabilities for managing complex distribution systems over large geographical areas. DoD installations are quite small and simple systems in comparison and not all installations are SCADA outfitted. Further, where ST integrates buildings, utilities and meters on a GIS platform, ST SCADA capabilities can extend beyond current SCADA applications that typically terminate at the substation/switching station level. Potential ST SCADA capabilities under this scenario for electrical distribution include:

- Using building and meter readings to geographically display extent of outages to aid in response
- Creating a digital twin of electrical distribution one-line diagrams for greater operational awareness and utility planning analysis using NRT and historical readings from all available instrumentation

- Creating voltage heat maps using building and other load meters. Voltage heat maps are useful in optimizing circuit line ups and connected solar photovoltaic production.

Extended Capabilities - ST-Ready Facility Design Criteria:

Implementation of ST is expected to reveal a number of insights into control system instrumentation that has a significant impact on ST capabilities. AFDD fault rules are more capable where robust instrumentation exists. Facility HVAC design criteria prescribes a minimum set of instrumentation points that are needed for proper HVAC functioning. Revising design criteria to include additional instrumentation to support expanded ST capabilities where economically justified is an engineering means of advancing smart facility technologies and providing future facilities that are “ST-ready”.

Extended Capabilities - Military Construction (MILCON) HVAC Commissioning and Acceptance:

New construction of ST-ready facilities allows for them to come online connected to the ST application where performance of the new HVAC system can be readily evaluated for compliance with construction plans and specifications. This is particularly true for Testing, Adjusting, and Balancing (TAB⁸) where construction contractors commission and test the new system. ST can provide detailed data and information on TAB performance as well as documentation of overall system performance to improve DoD’s contract enforcement capabilities.

Extended Capabilities – Environmental Compliance and Climate Change:

Most environmental measures are data-driven as is ST. ST capabilities to support environmental compliance are only limited to available instrumentation. For example, steam boiler monitoring of emission controls is typically performed by Continuous Emission Monitoring (CEM) systems. If ST is applied to the boiler plant then CEM data can be imported into the ST application for creation of improved intelligence on boiler emission history and status. Wide dissemination of CEM data and related intelligence is enabled including environment oversight organizations and the command office. In the case of climate change and the pursuit of installation net zero objectives, ST meter data on fence line utility consumption (electricity and gas), and manual data on batch energy deliveries (e.g. fuel oil and propane) enables ready calculation and monitoring of the installation’s carbon footprint. ST detailed historical data on carbon footprint performance can also be used to accurately assess potential of footprint reduction proposals (e.g. solar panels, wind turbines, etc.) to aid in climate change investment analysis.

Extended Capabilities – Building Infectious Disease (ID) Threat Reduction

ST applications can provide varying levels of building ID Threat Reduction which advance with added instrumentation. By integrating certain building systems (e.g HVAC, security access control, occupancy sensors) ST can provide comprehensive access, occupancy, and environment control to reduce the ID threat to personnel⁹. ID threat reduction capabilities include automated measurement of occupant core

⁸ See Uniform Facility Guide Specification UFGS 23 05 93, “Testing, Adjusting, and Balancing for HVAC.”

<https://www.wbdg.org/FFC/DOD/UFGS/UFGS%2023%2005%2093.pdf>

⁹ See “Reducing Infectious Disease Risks with Smart Building Technologies and Management Systems”, 2021, Schneider Electric, Christopher Roberts and Patrick Donovan.

http://community.ifma.org/knowledge_library/m/free_fm_content/1058340?CategoryID=0&Education=0&Type=8&GalleryPostSort=PostDate&SortOrder=Descending&baseID=0&PageIndex=1&GalleryViewType=Horizontal&GalleryID=0

temperatures to detect fevers, controlling space conditions to elevate space temperature and humidity, elevating outside air ventilation, and monitoring occupancy via people flow counters, area counters, and occupancy sensors.

Extended Capabilities - HVAC Base Operating Services (BOS) Contracting:

In cases where DoD requires contract support services for HVAC systems, performance work statements can be made more relevant by specifying that a certain level of Comfort Index be maintained. With HVAC systems the primary objective is to hold temperature and the Comfort Index is a NRT measurement of how well this objective is met. Adoption of the Comfort Index in a ST supported environment allows for NRT measurement of contract performance compliance. This extends ST capabilities to improved Base Operating Services (BOS) acquisition functions by making performance work statements more defined and enforceable.

Extended Capabilities - Transportation:

When the ST includes a geospatial component, transportation vehicles with Global Positioning System devices can track vehicle movements in NRT and record these movements. This enables two important capabilities. First is the optimization of work routes for maintenance crews. Second is the analytical capability related to inventory management. DoD transportation programs regularly assess vehicle inventory requirements to support vehicle acquisition, maintenance, and retirements. This is normally performed with onsite assessments. With ST data on vehicle utilization these assessments can be performed remotely and more accurately.

Extended Capabilities - Elevation of ST Information to the Business Environment:

Exporting OT/ST data from the closed CS enclave to the DoD business environment via an enterprise ST application exposes the immense OT/ST data resource to the entire FM community. This new and extensive data resource promises to transform FM strategic planning and operations management as the organization exploits a much more robust data-driven environment to perform at new levels of efficiency and effectiveness. Executive management is now empowered with more accurate and timely accountability (e.g. ST KPIs) for performance monitoring and improved management controls. Program analysts become less reliant on field data calls and access the data directly from the machines, aiding in planning analysis and evaluating process improvement initiatives. Operations dashboards are more timely and informative with NRT and actionable intelligence.

Extended Capabilities - ST Applications for Naval Vessels:

Many of the same mechanical and electric machinery used in facilities also are utilized onboard naval vessels (gas turbines, boilers, chillers, air handlers, etc.) and are managed by Naval Sea Systems Command (NAVSEA) Hull, Mechanical, and Electrical (HME) programs. The ST concepts of a digital twin COP, advanced analytics, and reporting (perhaps less so for Supervisory Control) apply to the shipboard environment where many of the ST use cases are directly applicable. However, new shipboard ST capabilities are likely needed to take advantage of ST potential. One use case would be transmission of shipboard NRT ST data to a duplicate ST application shoreside where remote engineering support can monitor and analyze ship HME operations to better plan scheduled shipyard maintenance and support HME crews while on station.

...and the list goes on.

7. Conclusion

Within the DoD, the interdependencies between CS and ST are both necessary and mutually supportive. While CS provides the security environment and connectivity that ST requires, ST leverages the CS technology and infrastructure to create an economic and operational benefit against the large expense of securing facilities against the increasing cyber threat. Building off of these capabilities, military services can extend this powerful technology deep into the enterprise FM community to exploit the immense OT data resource that exists within FM facility systems and machinery. Investigations into FM process improvement opportunities are expected to reveal many new potential ST applications leading to a much higher level of data-driven intelligence, diagnostics, and decision support.