The New Work of Building Operations in the Digital Age:

The Impact of IoT on Facility Management and Operational Practices

Report 1 of 2: Organizational Shifts to Practice

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Table of Contents

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Report 1 of 2 - Organizational Shifts in Practice with IoT

Introduction

Technological transition in order to achieve sustainable and operational improvements is difficult in any organization as it takes time to learn and adapt to new systems and overcome growing pains in the process.

However, as UW Operations seeks to leverage technology to improve the sustainability of campus buildings and infrastructure, staff must find ways to adapt to new systems and learn how to best re-organize, restructure, and optimize the use of new building technologies for both organizational and sustainable growth. Within the last decade, University of Washington (UW) Facilities has been in the midst of a technological transition as the University has adopted Internet of Things (IoT) technologies and other Direct Digital Controls (DDC) to aid in the management of their campus facilities. This has involved replacing many of the existing building control systems, many of which included pneumatic systems, with interconnected digital alternatives in the form of sensors and other IoT devices. This research was done in collaboration with University of Washington Facilities and investigated how the organization and the practices of their operators, engineers, managers, and technicians have and continue to shift to accommodate the use of such data driven technologies.

As stated above, such an organization-wide technological transition is difficult and it takes time to explore new practices and negotiate changes to existing routines and structures. There is an abundance of research available that articulates how IoT systems can be integrated into building systems, however little research has focused on the organizational impact of the integration and use of such technologies. This research aimed to aid in filling this gap in knowledge by using qualitative research methods to understand how organizational practices are changing with the integration of digital building control systems. In this research, we spoke directly to a diverse range of members of the UW Facilities team in order to get a realistic and practical perspective on how their work is changing and what requirements are emerging to best leverage the use of IoT devices and systems. The findings of this study highlight the need for FM organizations to adapt to evolving technologies, highlighting areas of change including data centralization, interdisciplinary collaboration, advanced skill set requirements, leadership strategies, and the redefinition of traditional practices and standards.

With this report, we hope to reflect the themes shared with us by the diverse range of facilities personnel we interviewed and provide a summary of the findings in relation to both our study, and the research literature on this topic. Our goal is to highlight the key challenges and shifts in practice identified, offering insights that can help inform future practices.

Document Structure

In Table 1 below, the findings of this research study are listed. Following this table, each one of these findings will be discussed individually. Within each individual finding, a quote collected from our interviews with UW Facilities personnel that encapsulates the main topic of each finding will be shared. Following this, a brief description of the finding based on a robust literature review around this topic as well as the fieldwork we conducted on site with UW Facilities will be provided. The full analysis is published in Daniel Dimitrov's Ph.D. Dissertation.

Table 1: *UW FM Study - Organizational Shifts in Practice*

Category:	**Findings:**
1. Breakdown of Disciplinary Silos - Centralization and Democratization of Data	1.1: Centralized Inventory Management
	1.2: Centralized Communication and Data Distribution
	1.3: Increased Need for Interdisciplinary Collaboration
	1.4: New Communication Necessities – Breaking Down Disciplinary Communication Barriers
	1.5 Vendor Management, Relationship Building, and Collaboration
2. Bridging the Gap - Institutional Knowledge and "New" Knowledge	2.1 Balancing “New” Knowledge with Institutional Knowledge
	2.2: New Technical Skill Set Requirements - Learning/Understanding Device Coding and Programming
	2.3: New Technical Skill Set Requirements - Learning/Understanding Network Connectivity, Data Flow, and IoT System Architecture
	2.4: Introduction of Data Analytics
	2.5: Advanced Device Troubleshooting
3. Leadership Requirements	3.1: Managing Personnel Resistance to Change
	3.2: Establishing Management Consistency
	3.3: Enhanced Training and Education Requirements
	3.4: Creation of New Roles - Operational Technology Manager
	3.5: Creation of New Roles - Building Handover Director
4. Challenging Entrenched Organizational Practices, Standards and Norms	4.1: Restructuring the Traditional Construction Decision-Making Hierarchy
	4.2: Re-structuring Traditional Building Maintenance Handover Documentation
	4.3: Creating New Maintenance Cycles to Accommodate IoT
	4.4: Increasing the Frequency of Updating Standard and Shared Documentation

Findings

<u>Category 1: Breakdown of Disciplinary Silos - Centralization and Democratization of Data</u>

The findings suggest that an integrated and centralized approach to the management and maintenance of IoT systems is required to leverage their capabilities. This calls for centralizing and democratizing data from all disciplinary groups and an initiative to develop organization-wide processes and procedures around data standardization in type and form, distribution, and storage. This additionally calls for increased efforts around interorganizational communication and collaboration. The findings of this study show that the following shifts in organizational operations are required for IoT system management within the larger thematic topic of disciplinary silos:

1.1. Centralized inventory management
1.2. Centralized communication and data distribution
1.3. Increased need for interdisciplinary collaboration
1.4. New communication necessities: Breaking down disciplinary communication barriers
1.5. Vendor management, relationship building, and collaboration

1.1. Centralized Inventory Management

"Instead of everybody having their own spreadsheet, which is what is going on right now– we need a master database. Once that master database becomes synced and complete, then we can slowly start peeling off everybody's Excels"

Prior research studies show that disciplinary silos are likely to exist in the AEC and FM industry alike that inhibit centralized data distribution, storage, and interorganizational communication, calling for a breakdown of these silos for optimal performance. Traditional FM organizations often exhibit a fragmentation of disciplinary groups (Atkins, 2014), each operating independently in their approach to management. This siloed structure often results in inefficiencies and decentralized data management among various departments and specialties. When each disciplinary entity manages their data independently, it can cause confusion and create a non-holistic strategy towards the management of a technology that spans across disciplinary boundaries. When IoT technologies require a diverse group of professionals for management, troubleshooting, and problem resolution, a centralized information system that everyone can access can help increase transparency, understanding, organization, and a unified and informed approach to addressing IoT management requirements.

"if we have a million points, but the data isn't well organized or named anything sensical, then it can be difficult for anyone to make use of it."

Data becomes valuable for procedural enhancements when it is comprehensible to FM users, thereby encouraging its ongoing utilization. Ensuring data usefulness requires a collective organizational effort to synchronize data tracking and standardize its format across the organization. This highlights the growing importance of standardized inventory management, and particularly the centralized management and tracking of devices, their specifications, locations, and other critical lifecycle management information.

1.2. Centralized Communication and Data Distribution

"the project folks, they just deliver all the stuff [building and device information] to records…but does anybody convey that down to the shop folks? It could be all in the right places where you need to get to it, but this side of the group doesn't know where it is"

Centralized data management and inventorying is only useful if there is an organization-wide awareness of where building information exists and how it is to be accessed. The holistic approach towards data management and storage additionally calls for centralized communication and information distribution outside of individual disciplinary silos. When data cannot be easily located and used by FM personnel it can discourage the use of centralized data sharing and communication pathways and further diminish trust in centralized technologies and procedures for FM personnel. This can push employees to rely on tacit knowledge networks for information retrieval and further diminish data centralization efforts.

1.3. Increased Need for Interdisciplinary Collaboration

"we're trying to establish, re-establish, build relationships between different groups that wouldn't normally be working very closely together. And that could be anything from a subcontractor on a project to a trade. Somebody in the trades to the IT Department to the Construction PMs and CMs, and everybody in between"

"you're adding more people involved to troubleshoot issues. 10 years ago, it was just one service technician that would go out to the field to fix that irrigation system. Now, you're having to deal with three or four people to fix it"

IoT systems are complex and their configuration, management, and troubleshooting require diverse skills and well composed groups. This means that to most optimally manage IoT systems, management groups must integrate a diverse range of interdisciplinary professionals for device configuration, troubleshooting, and life-cycle management. Currently, interviewees express that the management of IoT devices and systems is usually defaulted to the facilities control shop, or the UW Operational Control Engineering Group. However, the optimal management of such systems requires the teamwork of a wider group of disciplinary professionals who can bring their unique skills to the table in solving problems around these complex technologies, including IT, Operational Technologies, and Facilities personnel.

1.4. New Communication Necessities – Breaking Down Disciplinary Communication Barriers

"being able to communicate with different levels of the organization. So, being able to communicate with blue-collar workers, white-collar workers, and everything in between… being able to communicate with people in IT. All those groups have different generalized ways of communicating… and that's a skill"

With the use of IoT systems comes the necessity for facility personnel to be able to communicate with a more diverse range of disciplinary professionals than in current practice. As managing IoT technologies requires a more holistic organizational approach, so too does communication need to span across disciplines which traditionally do not work closely together on a regular basis. For example, new work appears for facility managers, operators, engineers and technicians alike in being able to communicate with IT personnel which therefore calls for an understanding of technical terminologies and an ability to communicate efficiently with technical jargon. It will take an enhanced effort for teams to break down their communication barriers and begin to meet and communicate regularly around the commissioning, maintenance, and repair of such IoT technologies. This will come with enhanced efforts in learning discipline specific terminologies such as "IT language" and finding ways to communicate effectively during this transition.

1.5. Vendor Management, Relationship Building, and Collaboration

"sometimes it gets difficult because they don't understand us, we don't understand them, and we're trying to solve the problem together"

As the diversity of both type and application of IoT systems continues to rise in the management of integrated facilities so too does the need for growing communication and collaboration between facility groups and device vendors/manufacturers. Facility personnel rely on vendors to provide the foundational information required for device management and to be available to resolve vendor specific issues throughout the IoT lifecycle, particularly in the more turbulent initial deployment periods. Thus, the establishment of strong vendor relationships and the careful selection of vendors during decision-making periods is becoming increasingly crucial for later operational success with the use of vendor provided technological systems. In addition, holding vendors accountable for the feasibility of their systems and providing adequate support leads to the necessity for higher levels of collaboration, relationship building, and evidence based decision-making when selecting vendors. For example, when discussing the IoT integrated "smart" greenhouse in the Life Sciences Facilities, interviewees shared the struggles they experienced in managing the new systems and getting adequate support from the small European vendor that was brought on board for this project. Eventually, this vendor went out of business and the Facilities group was unable to adequately manage the new greenhouse, eventually resorting to more traditional management practices due to the lack of support they were receiving.

Category 2: Bridging the Gap - Institutional Knowledge and "New" Knowledge

Bridging the gap between institutional knowledge and "new" knowledge entails developing a balance between the essential skills required for IoT management and development, such as device coding, programming, and network communications expertise, and the indispensable institutional knowledge gained from hands-on experience and time. This institutional knowledge refers to things such as an understanding of existing mechanical systems within buildings and how they operate, as well as an intimate familiarity with the unique attributes of buildings on campus. Achieving this balance is crucial for effectively operating IoT technologies while leveraging the invaluable insights derived from years of practical experience in FM. In this section, the work of bridging the gap between these different skill sets will be discussed in detail, including the following topics:

2.1. Balancing "new" knowledge with institutional knowledge
2.2. New technical skill set requirements- Learning/understanding device coding and programming
2.3. New technical skill set requirements- Learning/understanding network connectivity, data flow, and IoT system architecture
2.4. Introduction of data analytics
2.5. Advanced troubleshooting

2.1. Balancing "New" Knowledge with Institutional Knowledge

*"individuals now have to have an IT background of some sort to at least understand the basics of network communication. Something that staff never needed…it's **someone who can understand both worlds**, the trade side and the IT side, and be that kind of glue that holds things together"*

"I think it's both knowing the digital technology and how the IT infrastructure works but also simultaneously knowing how the mechanical systems operate, knowing how electrical systems operate, knowing how plumbing systems operate"

Although the transition to the use of IoT systems calls for an increased and rather critical understanding of technical details in the form of topics such as device programming and configuration, network connectivity, and system architecture, gathered interview data exposes that an understanding of existing mechanical systems and traditional building components is still critical to managing IoT integrated facilities, especially within buildings that have been retrofitted with IoT upgrades. Thus, it becomes important for FM teams to seamlessly bridge the gap between the mechanical and technical realms, ensuring the optimal operation of buildings situated at the intersection of these expertise. With the integration of IoT systems, there's a growing demand for professionals who can work within both worlds, including personnel adept in the nuances of trade-specific knowledge that also possess a deep understanding of IT technicalities and infrastructure. Creating a team which can understand "both worlds" is a tall task that will require increased efforts from FM organizations to leverage the unique skills of individuals and find ways to train their teams to have both mechanical and technical system knowledge. Alternatively, teams must find ways to integrate professionals with critical knowledge in either domain together to optimize the management of IoT systems within existing and unique buildings.

2.2. New Technical Skill Set Requirements - Learning/Understanding Device Coding and Programming

"it can be harder to tell how a digital controller is necessarily configured just by looking at it. In the past maybe with pneumatic, you could at least trace the wires around and see this component. I know what that component is. So, even if I don't have the diagram, I can at least see what it is. If I spend some time, I can figure it out, but with digital controllers you can't really know how a computer is programmed just by staring at the hardware device"

At the UW, similar to other state-funded organizations, IoT devices are acquired from a list of approved manufacturers and installers. Each device acquired from these manufacturers is uniquely configured for its purpose and its programming requirements are unique to both the individual device and its manufacturer/vendor. This necessitates that facility personnel overseeing device configurations and maintenance familiarize themselves with a range of programming requirements essential for configuring devices. They must also acquire the skills needed to adapt to evolving programming requirements and emerging technologies as they become integrated into current systems. New work forms for FM personnel in learning the coding/programming requirements of IoT systems, and more importantly understanding them well enough to be able to translate these skills into programming requirements for other IoT devices as they are deployed and connected to existing systems.

2.3. New Technical Skill Set Requirements - Learning/Understanding Network Connectivity, Data Flow, and IoT System Architecture

"A lot of people don't understand the technology. It's difficult for us to find qualified people that can come in and work on these systems without needing a lot of training. Years of training"

"A basis of networking communication for one. Understanding how data flows through a network. I would put that at the top. The ability to do basic troubleshooting of an IT device"

Skill set shifts for FM personnel in the effort to raise the organizational awareness of advanced technology's data flow, network connectivity, and system architecture in relation to inter-connected IoT devices/systems. Based on the collected data, connectivity and communication errors are some of the most common issues that FM personnel face around device troubleshooting. This makes an understanding of these details critical to FM employees. As the skills required to maintain the devices for building controls shift, the knowledge of personnel maintaining these systems must also shift.

2.4. Introduction of Data Analytics

"There's a big push on campus right now for analytics, so that we can determine what kind of adjustments we need to make to conserve energy"

"We get a lot of data from chillers, VFDs, lighting, control systems, and even metering that now comes in. We now have the ability to trend all that data. You can really look deeply into how the building's operating"

IoT system utilization opens the door to new work in the arena of making the unprecedented influx of data meaningful to the organization through the introduction of data analytics, meaning that the organization must hire personnel adept at these skills or train their current workforce in data analytics principles. This push towards data analytics creates new work for facility employees in multiple facets. Firstly, it creates new requirements around organizing the new abundance of data in a meaningful way so that it can be used for analytical purposes. Once the data is properly organized and separated from the larger data pool, new work forms in filtering the vast amounts of data to extract the meaningful information related to device performance or system health. Once the data is organized and filtered, it now becomes possible to begin trending data in order to transition from a reactive maintenance system, such as what was present with the use of pneumatic control systems, to a more predictive maintenance system drawing from data trends, historical/archival data, and probable scenarios.

2.5. Advanced Device Troubleshooting

"Things we can analyze are: Are things operating according to schedule, or is the equipment turning off or modulating as we expect it to? And we come up with corrective actions"

The abundance of new data also opens doors in advanced device/system troubleshooting for maintenance and more accurate problem prescription and corrective action. With the ability to pinpoint issues before they escalate and the ability to have a more data informed approach to system troubleshooting, facility teams can proactively schedule maintenance tasks, optimize energy usage, and preemptively address potential disruptions if they are adequately knowledgeable and trained in performing these tasks. However, advanced troubleshooting abilities means more work develops for FM personnel in ensuring individual devices and whole systems are operating according to desired parameters, which can get increasingly more precise and time consuming. This often leads to new practices in regularly checking control dashboards and applications, increasingly responding to alerts that did not exist with older control systems, and an overall more intensive troubleshooting approach to devices and monitoring their productivity.

Category 3: Leadership Requirements

The findings of this study show that enhanced leadership and management are needed to implement and utilize IoT systems on an organization-wide level. Strong and effective leadership is essential to implementing new technologies into existing organizations and adequately navigating the organizational transition around their use. In this section, the leadership requirements around implementing and utilizing IoT systems within the FM organization at the UW includes the following topics:

3.1. Managing personnel resistance to change
3.2. Establishing management consistency
3.3. Enhanced training and education requirements
3.4. Creation of new roles - Operational Technology Manager
3.5 Creation of new roles - Building Handover Director (T2O)

3.1. Managing Personnel Resistance to Change

"there's a point where you can win them over by making it their idea…Because a lot of the reluctance is because they're embarrassed… Once they get ownership, boom, they turn to a whole new person"

"if you're dictating down, 'You will do this.' That's never really going to be successful in any meaningful way. So, working with people in the shop to say, 'here's this new thing. Yeah, there's extra complexity, but here are these tools that might make your job easier'"

New practices become evident for leadership in the form of responding to and managing personnel resistance to change. Leaders are challenged to find the best ways to integrate and change daily routines within teams composed of both tech-savvy professionals and personnel with high levels of mechanical knowledge but limited computer skills. Conversations with multiple higher-level managers led to the emergence of two major strategies that helped ease the tension of transition during turbulent times, guiding managers' approach to work during the technological transition. The first of these strategies involved gradually introducing IoT technologies to increase employee buy-in. By implementing these technologies iteratively, employees could organically recognize the benefits they offer within their existing work processes. In addition, focusing on the immediate benefit of the technology on the daily operations of individual employees also emerged as a dominant strategy for leadership in best managing employee resistance to change.

3.2. Establishing Management Consistency

"I think that consistency of who's working on the system is important. Like I said, being familiar with it [the device/system] is half the battle"

"The University said, 'Yeah, we'll do this thing'. But they never said who is gonna be responsible for managing this system once it's installed…They're [the client] the ones that were requesting this, but they didn't want the management of it once it was in place"

With the abundance of new opportunities for IoT integration, especially in a setting such as a university where customizable spaces are critical for creating precise research environments, the distribution of management responsibilities and creation of system specific champions becomes increasingly important. With this, the new work of establishing **management consistency** over the lifecycle of IoT devices and systems is rising in importance and becoming a critical element to the success of systems when things such as unexpected breakdowns occur, or device troubleshooting is necessary. When specific IoT systems are implemented to solve unique problems but are not allocated to a specific system management group, it causes confusion, pullback, and disarray within FM groups. Management consistency and the allocation of responsibility over the lifecycle of devices is necessary to address problems when they arise in the field so that they can be solved by professionals with system familiarity and an understanding of their unique configuration and requirements. Establishing system champions and management consistency can also ease confusion around IoT device integration and increase personnel's sense of ownership over systems.

3.3. Enhanced Training and Education Requirements

"My personal belief is that education and outreach continue to be a kind of top priority, especially education"

"There are big retraining gaps in raising staff skill sets and modifying what their role is from being hands-on mechanics of mechanical devices to mechanics of digital devices. It is a very different skill set"

To bring personnel up to speed on the technical knowledge necessary to manage systems and work with a diversity of disciplines on IoT related problems, enhanced training and education opportunities must be provided by management. This could encompass internal training sessions covering aspects like IoT integration, network connectivity, and specific programming prerequisites. Alternatively, it could involve more extensive and detailed training sessions, possibly extending over longer periods, conducted in collaboration with IoT device vendors or manufacturers during building handover phases. The prolonged learning curve of adapting to IoT system integration and utilization must be addressed by FM leadership with longer and more intensive training periods and procedures, while continuing to provide expert support during initial adoption and transition periods. This can help combat resistance to change, increase personnel comfort with new systems, increase buy-in, and increase productivity as personnel feel equipped to solve problems when they arise and have the knowledge to properly address issues.

3.4. Creation of New Roles - Operational Technology Manager

"We don't need IT support. We need OT support, operational technology support. It's the world of physical to IT – when they meet."

"their role now is to take all these technologies as they're coming and figure out a way to have a communication channel to the folks that are gonna get the item …I use the word 'liaison' – can liaison between these different folks"

Interview data sheds light on the opportunity to develop a new facility role centered around the commissioning, operation, management, and maintenance of operational technologies such as IoT systems. Facilities is actively implementing this new role and have named it "Operational Technology Manager", or OT manager, who's responsibilities revolve around the management of IoT systems and serve to fill the gap between FM and IT necessities in the management of these technologies. This OT manager role can fill multiple needed responsibilities such as championing incoming IoT systems, connecting and assigning the proper teams for device integration and issue resolution, assigning management roles for incoming devices, and managing the centralized data storage and distribution of IoT system data. Most importantly, as expressed in the collected interview quotations above, the OT manager can liaison between IT and FM as well as all other required parties for IoT management.

3.5. Creation of New Roles - Building Handover Director

"having somebody whose job is really that transition to occupancy– doing the finishing stages of construction and return of the building to UW I think would be very beneficial"

"they diluted that [T2O] by giving everybody who's in the project delivery groups the transition to occupancy responsibilities. So, this project manager's understanding is different from that one which is different from the third which is different from the fourth guy"

Another potential opportunity for the creation of a new organizational position lies in the development of a "Building Handover Director", or a "Transition to Occupancy Manager". The main goal of this position would be to help facilitate the handover of important building information from project delivery groups to the FM team. In addition to this, the introduction of this position could give the FM division representation throughout the project's design and construction phases to help ensure compatible systems are being integrated into the existing IoT environment. Currently, the handover of building documents and information is the responsibility of the project delivery team which often struggles to juggle their construction responsibilities and simultaneously fulfill their handover obligations. The interview data clearly indicates that numerous issues in IoT system configuration and maintenance arise due to the absence of comprehensive handover documentation and a general lack of familiarity with specific systems and devices when they are introduced to FM teams tasked with their integration and management. Creating a role to help facilitate the accurate and holistic handover of building information as well as serve as FM representation in decision-making around choosing IoT systems during design phases would help alleviate some of these tensions which operators are experiencing down the line.

Category 4: Challenging Entrenched Organizational Practices, Standards and Norms

This study shows that in many instances, the existing organization practices, structures, and norms are not adequate in fulfilling the requirements of implementing and managing IoT systems effectively. Entrenched norms and practices must be challenged in order for an organization to use IoT systems and innovate beyond the use of existing technologies that are familiar and comfortable. To address this challenge, organizations must be willing to challenge and adapt entrenched practices, standards, and norms. In this section, the following topics within this category will be addressed:

4.1. Restructuring the traditional construction decision-making hierarchy
4.2. Restructuring traditional building maintenance handover documentation
4.3. Creating new maintenance cycles to accommodate IoT technologies
4.4. Increasing the frequency of updating standard and shared documentation

4.1. Restructuring the Traditional Construction Decision-Making Hierarchy

"A lot of times the standards of quality really aren't up to speed. Then there's the learning curve of how it was programmed, where they installed the field devices, because we don't know where they are at. We have to rely on the contractor to show us"

"The project never thought to ask those that were gonna be actually doing it, because of this communication trail. Why would these folks [decision-makers] be talking to our shop folks? They're talking to our PDG folks. Our PDG folks should be talking to our engineers. Our engineers should be talking to folks down here"

The use of IoT technologies calls for a restructuring of the traditional construction decision-making hierarchy through the integration and early involvement of FM representatives within design meetings in the planning/construction phases of the building life-cycle. This becomes necessary in order to leverage invaluable FM knowledge around topics such as IoT device network connectivity, device compatibility, unique building intricacies, vendor specific knowledge, and other building information which can only be acquired through the experience that FM personnel have in daily building management and interaction. The integration of FM personnel into decision-making procedures can only serve to decrease tension and confusion post building handover, decrease design errors, increase device/system compatibility with existing systems, and decrease the need for costly rework or repair later down the line.

4.2. Re-structuring Traditional Building Maintenance Handover Documentation

"These devices need a very different sort of submittal and as-built and owner's manual, with all sorts of very dynamic and specific information, like what version of the software actually got commissioned onto the devices. Like something that no one would ever really think about"

"You need to rethink the way that you write a specification for these kinds of [IoT] devices, and a new way of asking for the submittal for that kind of device, and a new way of requiring testing, commissioning, and documentation of that device"

Traditional design documentation and building handover documents (Ex. O&M Manuals, as-built documentation, specifications, design guides) need to change in form to accommodate IoT devices/systems rather than the static building components which they traditionally represent. The traditional format of these documents does not fully fulfill their intended purpose when managing IoT devices and systems, as they necessitate a different set of information to be included in critical handover documentation. With the use of IoT devices, data handover documents are no longer solely supporting static building elements, but more dynamic technological systems. In adjusting the form or type of data handover documentation around newly implemented IoT devices, our interview data shows that such documents must now consider information on things such as the interoperability of devices and the intricacies of network connection, device communication, configuration, compatibility, software update cycles, and software and hardware maintenance requirements to ensure that IoT systems are not "treated as if they're a static component of the building, just like everything in construction used to be".

4.3. Creating New Maintenance Cycles to Accommodate IoT

"Older systems that are less IT-heavy, you can honestly let them run for 20 to 30 years with minimal input and time. But IT systems don't last as long"

New practices around developing and maintaining IoT device maintenance and replacement cycles, as opposed to traditional static building component maintenance cycles, is becoming important with the continuously growing use of IoT devices/systems. The maintenance, updating, repair, and decommissioning cycles of IoT technologies are not on the same timescale as static building components, requiring new work in restructuring the operational procedures and frequency of maintenance and decommissioning related work activities. Due to the connectivity and communication requirements of IoT systems, the frequency at which maintenance activities such as software updates need to occur rises compared to less IT dependent building technologies which require less frequent attention. Due to this, new work forms for building operators in ensuring that IoT systems are up-to-date while keeping in mind their reduced lifespan.

4.4. Increasing the Frequency of Updating Standard and Shared Documentation

"I think once a year, twice a year maybe, they update the design guide. And right now, governance over the design guide is sort of, I don't want to say it's ad hoc, but as operators, we feel that it's a bit ad hoc"

In relation to the necessity to restructure IoT device/system maintenance cycles, new work appears for FM personnel in the necessity to update shared organization-wide documentation on a more regular basis than was necessary prior to the integration of IoT systems. In order to encourage personnel to maintain a device inventory and utilize shared documents such as the facility design guides, O&M manuals, and as-builts, these documents must stay updated, relevant, and critical to the work being performed on a daily basis by building operators. This means that increased efforts must be put into updating such documentation to encourage its continued use so that it does not become obsolete. Similarly to above, the current update cycles for such organization-wide documentation are no longer compatible with the use of technologies like IoT systems which require a more integrated and frequent document updating approach.

Conclusion/Study Overview:

This report has highlighted the University of Washington's experience in IoT and digital integration for building operations, demonstrating how practices shift organizationally with this digital transformation. Overall, the findings of this study fall into four major categories as seen in Table 1, including the following:

1. Breakdown of Disciplinary Silos - Centralization and Democratization of Data
2. Bridging the Gap - Institutional Knowledge and "New" Knowledge
3. Leadership Requirements
4. Challenging Entrenched Organizational Practices, Standards and Norms

Within Category 1, shifts in organizational practices around the centralization of data, centralized communication and data distribution, the increased need for interdisciplinary collaboration, and requirements around relationship building with IoT vendors were discussed. Within Category 2, requirements around bridging the gap between institutional knowledge and "new" knowledge, new technical skill set requirements, the introduction of data analytics, and advanced device troubleshooting were discussed in detail. In Category 3, leadership requirements around managing personnel resistance to change, establishing management consistency, enhanced training requirements, and the creation of new roles and responsibilities were established. Lastly, within Category 4, requirements around restructuring entrenched decision-making hierarchies, restructuring traditional documentation structures and forms, and creating new maintenance cycles to accommodate IoT technologies were discussed in detail.

In conclusion, the integration of IoT technologies in facilities management requires a holistic approach that combines technological innovation in the form of IoT with organizational restructuring, enhanced communication, and continuous education. With such shifts to organizational practices, FM organizations can realize the full potential of IoT devices and systems and therefore increase efficiency, reduce operational costs, and improve facility performance.