Leveraging Teamwork and Unskilled Labor in Facilities Zone Maintenance

by

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A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Approved April 2022 by the
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ARIZONA STATE UNIVERSITY

May 2022

ABSTRACT

Facilities Management is a service that should follow economic concepts of “value added” and “cost-effectiveness.” Facilities sites and campuses can be divided into geographic facilities maintenance zones to improve response time, coordination of trades, customer service, and the ownership or accountability of technicians. Facilities zone maintenance teams of multi-trade technicians can work together in a dynamic partnership to significantly reduce costs and do more with less.

Six months of field research, case studies, and crew balance analysis of primary quantitative data was used to deductively evaluate the effectiveness of the zone maintenance model. To fill gaps in skilled labor, reduce maintenance costs, and increase available skilled labor capacity the maintenance zone implemented a strategy to better utilize and schedule the labor of unskilled entry level maintenance technicians. A teamwork approach was also used to share the collective multi-trade workload and allow the zone maintenance crew to accomplish more than individual technicians could do alone.

A comprehensive literature review revealed an alarming lack of facilities management research and the vast disconnect between academic assumptions and practical real-world applications. It is evident from the case studies that more effective utilization of unskilled labor and harnessing the unique capacity of a multi-trade team are important competitive advantages of the facilities zone maintenance model. These intangible contributions and the value added to the organization can be measured and quantified through careful data collection and analysis. These studies are a reminder that significant maintenance cost savings can be achieved by eliminating labor waste and crew scheduling inefficiencies. Value can be added to the organization by reducing these and other intangible costs by focusing on continuous improvement, productivity, efficiency, and effective workflow.

DEDICATION

To my beloved grandfather Dasil George Mathews, for his financial support and encouragement that made this educational opportunity possible. Thank you for your example and legacy of faith, academic excellence, hard work, and integrity. "If I have seen further, it is by standing on the shoulders of Giants." (Newton, Isaac, "Letter from Sir Isaac Newton to Robert Hooke," Historical Society of Pennsylvania.)

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CHAPTER 1

INTRODUCTION

Background

To remain competitive and viable, companies are under constant pressure to reduce cost and improve performance (Rebernick, 2006). These corporate pressures are likewise shifted to all areas and departments of the organization including FM. Chong et al. (2018) states that “the budget allocation for maintenance is usually among the top choices to be reduced.” As a result, Facilities Managers are under constant pressure to reduce costs and do more with less.

Facilities Management (FM) is a service organization that supports the core business of an organization. A subset of this provided service is maintenance management. High performance FM programs will maximize asset life, minimize cost, and reduce the risk of failure (Chong et al., 2018). The shift from reactive to strategic types of maintenance is a more “holistic approach in facilities performance assessment” and a clear sign of FM maturity (Douglas, 2016). It is also one of the many ways that FM can add value to an organization. Especially, when the level of maintenance is strategically aligned with organizational mission and objectives (Chong et al., 2018).

The perception that Facilities Management is a merely an expense, a liability, and a “necessary evil” grow out of the inability to prove value and further lead to insufficient funding and resources to perform adequate maintenance (Chong et. al, 2018). Maintenance can be prioritized, some can even be deferred, but these are only temporary solutions to the larger problem (Chong et al., 2018). If left unchecked, the deferred maintenance backlog will increase exponentially. Eventually, it will drive up maintenance costs, increase failures, and could result in the total loss of assets.

A major objective of facilities owners is to get the “’best value’ in construction, renovation, or maintenance of facilities” (Kashiwagi et al., 2003). The value of facilities management should be proved by the lowest possible life-cycle costs and justified over the life of the facility

(Kashiwagi et al., 2003). Like the total cost of ownership perspective, but more comprehensive, the broader and more holistic focus of life cycle cost analysis includes facility condition index (FCI), preventative maintenance, repair maintenance, and capital renewal costs (Lewek, 2016).

FM is a service that should follow economic concepts of “value added” and “cost-effectiveness” (Brochner, 2017). Facilities operations and maintenance objectives, as noted by Chong et al. (2018), “are usually measured in context of time, cost, and quality.” Kaya et al. (2004) further observed, “FM struggles to demonstrate its strategic value.” Facilities management metrics, bench marking, maintenance key performance indicators, performance measures, and cost savings initiative have been utilized for decades to improve facilities services. “Despite the availability of such measures, Kaya et al., 2004 noted, it is still difficult for FM to demonstrate the 'finest' results of the added value in both financial and non-financial aspects.”

One unique challenge is that maintenance priorities are based on “conflicting management objectives,” which can create blind spots and significant vulnerabilities for FM (Hassanain, 2003). These conflicting priorities include minimizing maintenance cost, maximizing asset performance, and minimizing risk of failure (Hassanain, 2003). To reduce conflict between these objectives and mitigate risk, other approaches should be utilized such as “safety, health, or environmental concerns prioritization, expert knowledge, and age-based prioritization” to balance maintenance priorities and optimize results (Hassanain, 2003). The most critical component of any facilities operations and maintenance strategy is the alignment of maintenance priorities and resources to the overall organizational objectives and goals. This approach ensures the proper allocations of maintenance resources, reduces the risk of unnecessary expenditures, and produces a holistic view of maintenance with the highest likelihood to achieve desired outcomes.

Shortages of skilled labor, retirement of personnel, and lack of resources are cumulative challenges many FM organizations face in addition to reductions in funding (Ikediashi et al., 2014). “To solve capacity problems,” some organizations have turned to outsourcing FM services (Ikediashi et al., 2014). Other organizations rely on maintenance management and prioritization to cope with these capacity problems (Chong et al., 2018). Krueger (2017) noted that there is a “downward trend in labor force participation for most demographic groups.” He further noted that the aging population of the United States is another contributing factor (Krueger, 2017).

These factors have a cumulative effect on Facilities Managers who typically manage the largest and most valuable assets of the organization with one of the largest corresponding budgets. The FM budget is typically spread over a variety of categories such as facilities maintenance, operations, utilities, and capital renewal and improvement projects, which generates multiple targets as companies seek to trim expenditures and cut budgets. The challenge then becomes proving the value of the FM investment and the contribution the bottom line.

Context

A traditional facilities maintenance model with centralized maintenance shops of stand-alone trades and specialized craftsmen has been used at the headquarters campus of The Church of Jesus Christ of Latter-day Saints and other campuses since the 1960’s. However, many campuses have moved away from the traditional model because it does not address issues such as customer service, coordination of trades, responsiveness, accountability, and ownership (Chiarelli, 2010). To remedy these issues, an increasing number of universities and campuses in North America have adopted a zone maintenance concept, which is a hybrid of central shops and decentralized multi-trade units organized into zones.

The creation of the Headquarters Facilities Department in 2016, necessitated restructuring and significant adjustments to the organization. After years of examination and analysis, the zone maintenance model was adopted in 2020 to meet the current and future needs of the campus. A clear distinction between operational and strategic Facilities Management (FM) was also created by the department reorganization. The initial zone maintenance concept was discovered at the Association of Physical Plant Administration (APPA) 2019 Conference in Denver, Colorado and the University of Calgary was used as the basic model. The primary objectives of this significant organizational restructuring are to increase maintenance ownership, responsiveness, and customer service.

The division of operational and strategic FM naturally spurred some innovation as the organization found its footing amidst change. The implementation of a new computerized maintenance management system at the same time created additional opportunities to break long-standing traditions, improve the operations and maintenance objectives, and initiate a forward-looking asset management and cyclical capital renewal program. The minimum crew size and multi-trade created by the zone maintenance model created opportunities to do things differently by focusing on improved response, efficiency, productivity, and teamwork at the zone maintenance crew level. This intense season of adaptation and change has fostered the perfect conditions for rapid innovation and significant improvements for the department.

CHAPTER 2

THE ZONE MAINTENANCE MODEL

Zone Maintenance Organization

According to the Association of Physical Plant Administrators (APPA) Body of Knowledge (BOK), a typical zone maintenance team is composed of 6-15 multi-trade workers with a single supervisor as shown in Figure 1 (APPA, 2021). The zone model creates an operating team by partnering a Facilities Manager with a Maintenance Supervisor to lead the zone (Gasser, 2019). The zone crew size is determined by the technical complexity of building systems, size of the zone, and number of buildings.

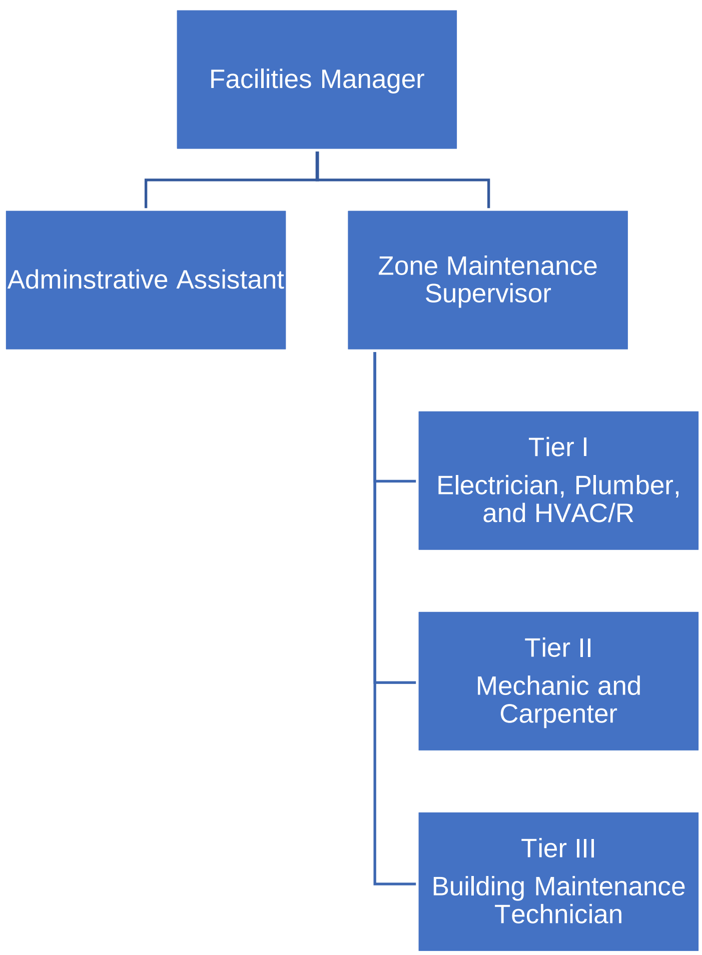

Figure 1. Typical Zone Maintenance Organization

In the zone maintenance model, individual trade shops are commonly organized into central shops to assist the zones. The individual trade shops are centrally located and organized in the traditional manner according to trade jurisdictions of the construction industry. The primary function of the central shops is to perform specialized work and to support campus operations and maintenance.

Zones and central shops should be optimally organized and appropriately sized to best accomplish the work in their areas of responsibility. Zone crews are staffed to manage the daily operations or “minimum average workload” of the zone geographic area (Efficient Plant, 1998). Conversely, central shop organizations have more skilled labor redundancy to manage larger tasks and responsibilities. The duties of central shops and zones are outlined in more detail in Table 1.

Table 1. Duties of the Central Shops and Zones

Duties of the Central Shops	Duties of the Individual Zone Shops
• Scheduled and routine work. • Large maintenance tasks and projects. • Specialized maintenance or services. • Campus network, utilities, and centralized systems.	• Immediate and urgent work. • Daily facilities operations. • Customer service • Specific area or region.

Central shops and zones should work together in accomplishing the work and allow resources to flow between the different maintenance organizations. The smaller or minimum crews of the zones may lack sufficient trade backups or have a scarcity of skilled labor in some areas (Chiarelli, 2010). Central shops and/or adjacent zones should help fill gaps in skilled labor from time to time as needed. Contract services should also be utilized to fill skilled labor gaps and perform specialized and intermittent services as needed.

Strategic Objectives of the Zone Maintenance Model

The two main types of maintenance management are centralized and decentralized. Both types of organizations have their pros and cons, and each is best suited for specific applications and certain functions (FaciliWorks, 2018). In the zone maintenance model, a hybrid maintenance organization is employed to capture the strengths of each maintenance management type while also mitigating its weaknesses.

The hybrid combination of centralized shops and decentralized zones creates a more sophisticated and interactive facilities operations and maintenance model by placing the maintenance staff closer to the buildings, customers, and equipment (Chiarelli, 2010). This increases the breadth and depth of service and creates a more holistic, strategic, and high-performance facilities management organization. The zone model also fosters multi-trade partnerships, increases accountability, and improves familiarity with facilities and assets (Cornell, 2012). Proactivity, innovation, and complex problem solving are also fostered as zone shops begin to focus on more than just the cost and quality of maintenance (Johannessen, 2015).

The smaller or minimum crews of the zones can respond more quickly to immediate and urgent work (Gasser, 2019). A multi-trade organization also allows the zones to trouble shoot problems across trades more efficiently (Gasser, 2019). This creates a specialized team that functions like a SWAT team to find and resolve the chronic, complex, and annoying maintenance problems that plague many organizations.

The hybrid organization of centralized and decentralized maintenance is best suited to respond consistently and effectively to all types of work and a variety of priorities. The intent is to create an interdependent relationship that fully leverages and utilizes the different but complementary roles and responsibilities of shops and zones. For example, decentralized zone maintenance teams are chiefly focused on immediate and urgent work, which results in a decline in productivity due to unpredictability and disruptions. Central shops, on the other hand, excel at planned and scheduled campus wide work, which maximizes their productivity and output. The result is increased operational effectiveness and improved customers service and response.

The zone model breaks down some of the barriers that exist between operations and maintenance by subtly shifting the maintenance focus to also include facilities operations and customer service (Gasser, 2019). The central shops retain their identity by trade, but the zone shops take on a new identity by the geographic area of their work, the customers they serve, and their unique strategic objectives. The zone primarily focuses on the work order cycle time to fix issues quickly and effectively as a key performance indicator (KPI). As a result, the zone goals differ from the typical maintenance KPIs which are efficiency centered and compliance driven because of the focus on rapid response work, demand maintenance, and customer service (Efficient Plant, 1998).

CHAPTER 3

LITERATURE REVIEW

Academic Research of Facilities Management

Facilities Management (FM) is a specialized, unique, and emergent multi-disciplinary profession. As a result, it is still very much in the growing and maturing stages of development in both practice and research. The International Facility Management Association (IFMA) based in the USA, originally the National Facility Management Association (NFMA), was founded in 1980 as the first association for facilities management professionals (IFMA, 2021). Over two decades later, the first academically focused FM journal in the USA, Journal of Facilities Management, was published in 2002 (Journal of FM, 2021). As a result, the field of FM is both “grossly under-researched” and is largely “unsupported by practical research” (Nutt, 1999).

Academic research and professional education are slowly emerging from the real-world practice of facilities management. An alarming lack of facilities management research and the vast disconnect between academic assumptions and practical real-world applications is especially troubling. Considerable progress has been made in forty years, but FM is still a young discipline with ample room for improvement in learning, development, and innovation. Nutt (1999) states, “FM continues to be reliant, to a large extent, on borrowed management concepts on one hand, and on the results of building performance research on the other hand.” Amaratunga et al. (2002) likewise states that, “Although FM has achieved a certain level of maturity as a discipline during the last decade, it is still in its infancy in FM process research with very little research carried out so far.”

The breadth and depth of FM responsibilities makes the diverse field particularly ripe for innovation. In their research, Amaratunga et al. (2002) borrowed the construction management concept of structured process improvement for construction environments (SPICE) and considered its application, relevance, and value to the Facilities Management organization. This only validates Nutt’s conclusion that FM is still reliant on borrowed management concepts from other industries. More importantly, it clearly illustrates that borrowing methods can also be a nearly effortless source of innovation, if they are applied, quickly improved, and adapted to FM (Roper, 2017).

The application of borrowed methods and techniques may at times prove difficult to “implement in the real world” if adjustments and adaptations from the generic research to specific or individual situations are not made (Nutt, 1999). This is due to the lack of “direct practical experience of FM” among academic researchers (Nutt, 1999). This disconnect can significantly limit the application of FM research findings and even nullify the results.

Teamwork in Facilities Management

Teamwork is increasingly common in our modern business world and is a concept that is easily adapted to FM. Teamwork is defined as “work done by several associates, with each doing a part but all subordinating personal prominence to the efficiency of the whole” (Merriam-Webster, 2020). Salas et al., 2008 defines teamwork as the “interdependent components of performance required to effectively coordinate the performance of multiple individuals. Salas et al., 2008 further states that “teams have become the strategy of choice when organizations are confronted with complex and difficult tasks.” This certainly describes the challenges all facilities management organizations face.

Workplace productivity and teamwork has been the topic of many studies and has generated a great deal of interest. The various types of teams can be divided into two main groups - intellectual work teams and physical work teams (Devine, 2002). Management or the intellectual types of teams are often the focus of many studies, but little research has been directed towards the teams at lower levels of the organization. Pitt (2008) states in an editorial that “FM is very much a people business and yet still the majority of the research papers that, we receive focus upon place and process rather than people and process.” As a result, little research has been directed towards FM, and even less has been directed towards maintenance trades and workers of the physical work teams.

A similar problem exists in the sister industry of construction. The project management teams are recognized as critical to successful project, but the teamwork that occurs at the crew level has not been properly considered. As a result, “less attention has been paid to these onsite physical construction teams” (Loganathan et al., 2020). Loganathan et al. (2020) further states:

> Despite the obvious importance of the “crew” dimension to productivity, construction management research has tended to overlook, assume, or deemphasize “teamwork” when accounting for onsite productivity. There is subsequently a need to understand the mechanisms of teamwork, where underlying the functioning of trade crews in physical onsite construction activities. (Loganathan et al., 2020)

Teamwork is especially useful in FM where resources are scarce and skilled labor is lacking. The basic premise of teamwork is that the team is greater than the sum of the parts and that through cooperation and coordination it can produce more than individual efforts alone (Mendelsohn, 1998). Workload sharing is one of the many ways teamwork increases the collective work productivity and output of maintenance teams allowing the zone maintenance crew to do more with less.

Shortages of Skilled Labor

Coping with labor and staffing shortages in Facilities Management is an emergent challenge and a growing concern. The shortage of skilled labor is also a significant concern for the construction management industry (Kim, 2020). The Association of General Contractors of America (AGC) recently reported that 80% of general contractors in the USA have reported problems hiring enough skilled craft workers to match the level of demand (AGC, 2018). These skilled labor shortages have a direct impact on the facilities maintenance organizations that draw labor from the exact same pool of skilled trades.

CHAPTER 4

METHODOLOGY

Data Collection

The objective of the research was to perform a scientific experiment of the zone maintenance model in FM using a large multi-trade organization. It explored whether facilities zone maintenance teams of multi-trade technicians have potential to reduce total costs of maintenance and increase efficiency. It also evaluated the efficiency of using specialized teams to perform complex maintenance tasks.

Participants in these studies were multi-trade technicians of various skill levels in a particular maintenance zone at a corporate headquarters within the United States. Primary quantitative research was used to measure the effectiveness of the zone maintenance model in two types of case studies. Field and case studies of the work output of individuals and overall team efficiency were analyzed to measure performance and productivity. Primary data was collected from work order reports using the maintenance management software and by on-site crew balance observations.

The case studies were conducted after a major department restructuring and strategic realignment. The organization shifted from small FM groups consisting of a Facilities Manager, Assistant Facilities Manager, and Administrative Assistant with central shop support to a zone maintenance model. The existing seven FM groups were consolidated into four geographic zones. The Assistant Facilities Manager position was discontinued and replaced by the Zone Maintenance Supervisor according to the APPA Body of Knowledge (APPA, 2021).

The zone maintenance hybrid of decentralized zone multi-trade shops and larger campus centralized shops created opportunities to change, innovate, and try new maintenance methods. The new organization placed multi-trade crews directly under a Facilities Manager and Maintenance Supervisor, which provided greater opportunities to shift resources and personnel by creating a team of diverse and varied skills. The newly created maintenance zones could more easily be organized into smaller specialized multi-trade teams to accomplish complex tasks as needed compared to the single trade shops that had existed previously. Building maintenance techs (BMT) and skilled laborers were better utilized by giving them new responsibilities and a more diverse workload to support the needs of the zone.

Case Studies

The characteristics of the electrical and heating, ventilation, and air conditioning (HVAC) including refrigeration differ somewhat because of the differences in maintenance management organizational structure. For example, some electrical work orders are assigned to the centralized electrical shop while others are designated as zone responsibilities. In contrast, the HVAC responsibilities are completely decentralized to the zone level with no central shop support.

The focus of the studies and associated data centered on direct work or wrench time using construction productivity techniques. Support or indirect work and waste were not considered in these studies. The soft skills or human and social factors of the maintenance crew such as communication, collaboration, and training were not considered. Furthermore, the assumption was also made that the in-house multi-trade maintenance crew already possessed effective team requirements such as the right “skill mix” and “complementary skills” (Fraser et al., 2013). The crew balance analysis focused solely on the output and efficiency of the team for six work cycles. Likewise, the assessment of utilizing unskilled labor to fill skilled labor gaps focused on the individual task work productivity and manhours.

Real preventive and corrective maintenance work orders were used to measure individual performance and the ability of unskilled technicians to fill gaps in skilled labor. A Computerized Maintenance Management System (CMMS) was used to track data and report findings. The zone maintenance organization implemented a strategy to use Building Maintenance Techs (BMT) to fill gaps in skilled labor by assigning less skilled electrical and HVAC tasks. The objective was not to overstep any bounds by performing the work of a licensed skilled laborer or to diminish the importance of skilled trades in facilities maintenance. Tasks were initially identified as unlicensed work and those that required the least amount of training and such as lighting PMs and HVAC filter changes. With subsequent experience and training, BMT were assigned more complex tasks and work such as cleaning ice machines and centrifugal chiller tube cleaning.

Inconsistencies such as errors and omissions in work order time entries were discovered during the research collection phase. This was due to the implementation of a new maintenance management software during the study. Additional user training and instruction was given to improve and standardize time entry to work orders. As a result, hourly gains, or skilled man-hour gains, by using unskilled labor could not be accurately measured until the midpoint of the study duration.

The teamwork portion of the case study focused on a smaller portion of the multi-trade zone shop. Field research was used to observe and measure team effectiveness during comparable cycles of complex multi-task work. The process was performing a complex series of filter changes and preventive maintenance tasks in preparation for the air balancing of a large-scale environmental controls upgrade. A specialized team comprised of an electrician, one or two HVAC technicians, and three Building Maintenance Techs (BMT) were used for crew balance analysis and team efficiency measurements.

Like construction teams, the productivity of a maintenance crew is measured differently than the output or efficiency of a team of knowledge workers. Construction productivity crew balancing techniques were borrowed to analyze repetitive short cycle work efficiency of the zone maintenance team. The labor productivity was determined by measuring and comparing the change of output per single input or work cycle.

To measure and track construction labor productivity, work is classified into three basic categories: direct work, supporting work, and waste (Dozzi & AbouRizk, 1993). Direct work is value added time or wrench time. Supporting or indirect work is required activities that are non-value added such as travel, preparatory work and instructions, material handling, tools, and equipment. It is not considered wasted time. Waste would include bathroom breaks, taking a personal call, and other functions that are both non-value added and not required.

CHAPTER 5

RESULTS

Electrical Study

Due to licensure requirements and safety considerations, the BMT were primarily assigned lighting preventive maintenance (PM) checks and relamp requests. Over a six-month period, nearly every crew member of the multi-trade zone shop was also assigned some minor electrical work orders or electrical helper responsibilities as needed. These efforts significantly reduced the workload of electricians in the central shop and zone.

As shown in Table 2, the maintenance technicians performed an average of slightly over forty-five lighting PM work orders each month for the entire zone of twenty buildings with over three million total square feet. If lights were out, the BMT would enter a corrective maintenance work order and self-perform the work by immediately relamping. If ballast problems were discovered, the BMT would enter a corrective maintenance (CM) work order for an electrician to replace the ballast and repair the light fixture.

Table 2. Monthly PM Electrical Work Orders by BMT

	May	June	July	August	Sept	October	Average
BMT 1	17	0	0	0	0	0	2.8
BMT 2	13	23	12	6	5	10	11.5
BMT 3	9	19	18	11	11	13	13.5
BMT 4	10	26	21	13	13	24	17.8
Total	49	68	51	30	29	47	45.6

Shifting the responsibility of lighting PM from electricians to BMTs resulted in an average skilled labor capacity gain of fifty-five manhours per month. Due to divisions of labor, these capacity gains were shared by the central shop and zone electricians. Using unskilled labor also reduced labor cost by over $12 an hour, which totaled approximately $660 in monthly savings.

Due to the restrictions previously mentioned, the maintenance technicians also performed a limited amount of electrical corrective maintenance (CM) work as shown in Table 3. The work performed by BMT was comprised of relamping, general electrical work, and assisting the electricians with wiring. Even with a reduced scope of work, the BMT completed approximately thirty-one hours of CM work orders each month. The work was performed at a rate of sixty-one percent of the labor cost of a skilled technician, which resulted in approximately $480 average monthly savings.

Table 3. Monthly Electrical CM Work Orders by BMT

	May	June	July	August	September	October	Average
BMT 1	4	5	0	0	1	1	1.8
BMT 2	8	15	9	8	14	20	12.3
BMT 3	4	5	5	10	5	10	6.5
BMT 4	9	3	11	21	8	14	11.0
Total	25	28	25	39	28	45	31.6

The zone HVAC tradesmen were also called to perform small electrical tasks to balance labor and resources. Though it was primarily in response to capacity issues caused by a vacated electrician position in the zone, it illustrates the subtle change in identity by trade classifications to a zone maintenance team member. The multi-trade zone has a different team dynamic and requires team members to fill in when needed and perform tasks not usually associated with their trade.

Over two weeks of skilled labor capacity was gained each month when compared to the hours of a normal work week. The monthly cumulative capacity of approximately ninety-five manhours was achieved with the combination of CM and PM electrical work, which totaled approximately five hundred and seventy-three hours in six months. The savings in operations cost by using unskilled labor to perform electrical work was approximately $1,145 monthly or $6,874 over the course of the six-month study ($13,748 annual savings). The total CM and PM work performed by BMT is shown in Table 4.

Table 4. BMT Total CM and PM Work

PM Work Orders	May	Jun	Jul	Aug	Sep	Oct	Total	Skilled Hours Saved Per Work Order	Total Skilled Hours Saved	Total Skilled Dollars Saved @$12/hour
BMT 1	17	0	0	0	0	0	17	1.21	20.57	$246.84
BMT 2	13	23	12	6	5	10	69	1.21	83.49	$1,001.88
BMT 3	9	19	18	11	11	13	81	1.21	98.01	$1,176.12
BMT 4	10	26	21	13	13	24	107	1.21	129.47	$1,553.64
PM Total	49	68	51	30	29	47		1.21	331.54	$3,978.48
CM Work Orders										
BMT 1	4	5	0	0	1	1	11	1.27	13.97	$167.64
BMT 2	8	15	9	8	14	20	74	1.27	93.98	$1,127.76
BMT 3	4	5	5	10	5	10	39	1.27	49.53	$594.36
BMT 4	9	3	11	21	8	14	66	1.27	83.82	$1,005.84
CM Total	25	28	25	39	28	45		1.27	241.3	$2,895.60
Total	74	96	76	69	57	92			572.84	$6,874.08

HVAC Study

The HVAC maintenance workload was significantly reduced by having the Building Maintenance Technicians perform filter changes, ice machine cleaning, motor lubrication, chiller checks, inspections, and other preventive maintenance (PM) tasks as shown in Figure 2. As a result, the BMT performed 30 percent of PMs in May. This percentage increased to an averaged forty percent in June, July, August, and October. In September, the BMT completed seventy-one percent of the PM work by changing filters as part of the air balancing preparations of a large-scale capital renewal project.

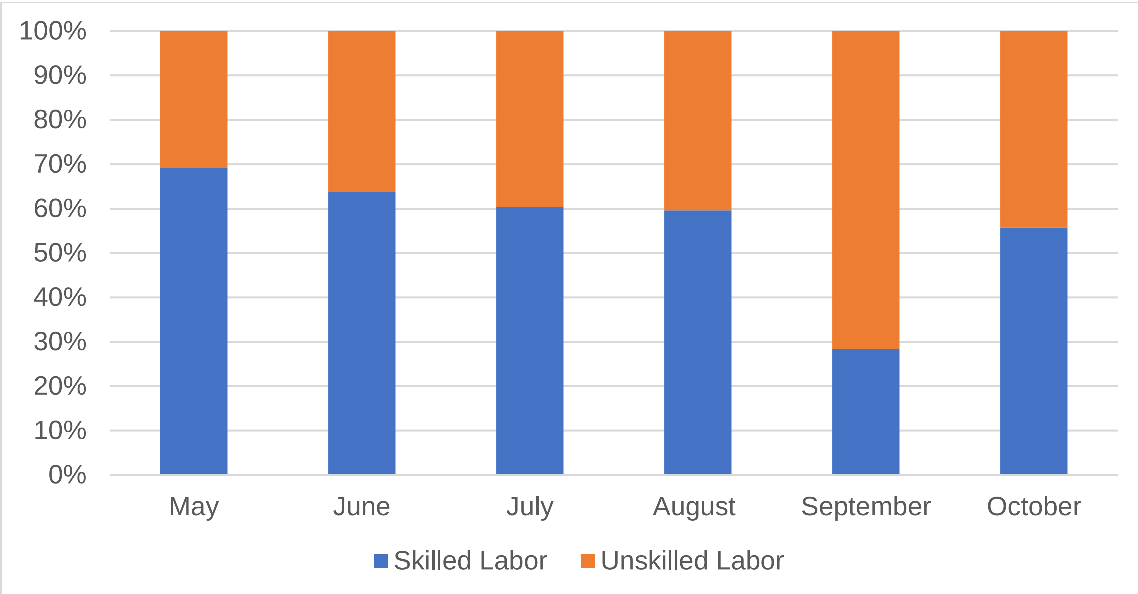

Figure 2. 100% Stacked Bar Chart of HVAC PM Work

The maintenance technicians performed an average of forty-five hours of HVAC PM work orders each month. By using the unskilled labor of BMT, forty-five manhours of HVAC capacity were gained by skilled laborers. Significant cost savings were also achieved by using less expensive labor to perform these maintenance tasks, which averaged $540 per month.

The Building Maintenance Techs even completed many HVAC corrective maintenance (CM) work orders and tasks as shown in Figure 3. They responded to quick calls and urgent work such as belt replacements, fan repairs, and ice machine alarms as well as other general HVAC work requests. As a result, the BMT performed an average of thirty-eight percent of corrective HVAC maintenance in a six-month period.

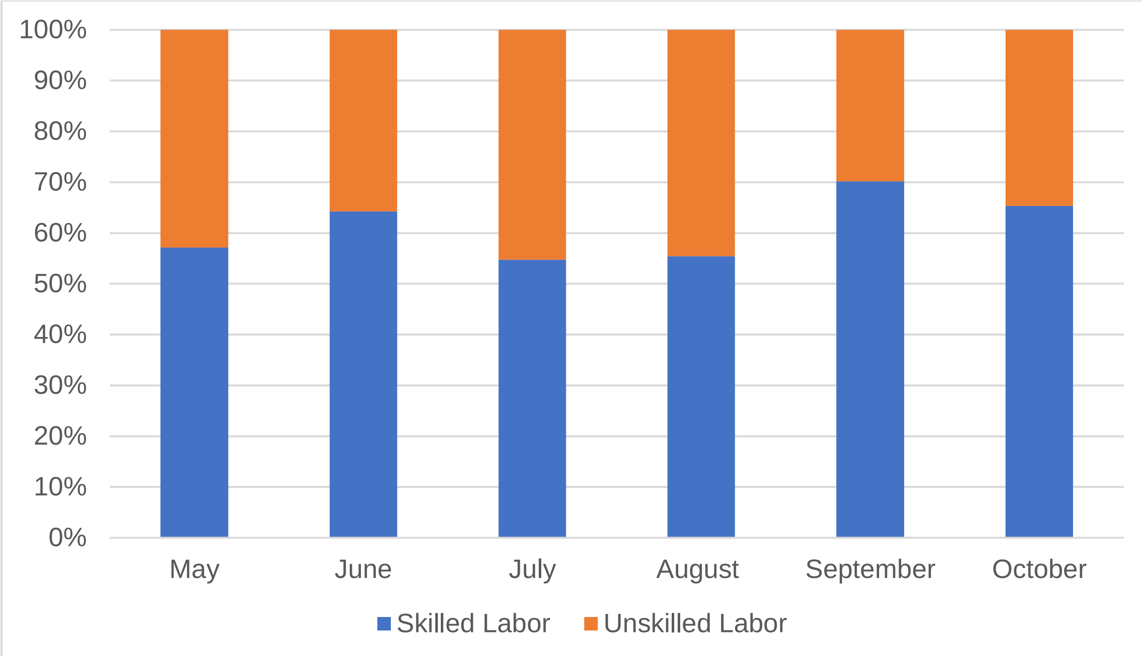

Figure 3. 100% Stacked Bar Chart of HVAC CM Work

The maintenance technicians performed an average of eighty-nine hours of HVAC CM work orders each month. Accordingly, this resulted in an average monthly gain of eighty-nine manhours by skilled HVAC laborers. The use of unskilled labor saved approximately $1,000 each month.

The skilled labor capacity equivalent to over three weeks was gained by using unskilled labor more effectively to do HVAC work. The monthly cumulative capacity of one hundred and thirty-four manhours was achieved with the combination of CM and PM HVAC work. These types of effortless changes and adjustments can produce significant monthly savings in operations and maintenance costs. The collective cost savings of using unskilled labor to perform HVAC work was $1,540 monthly, which would yield a potential annual savings of $18,480.

Zone Teamwork and Crew Balance Analysis

The efficiency and potential of the multi-trade zone shop was evaluated using crew balance analysis during a series of complex filter changes and preventive maintenance tasks. The data collection and analysis were performed for six repetitive work cycles of a series of preventive maintenance (PM) filter and equipment check work orders. The crew size ranged from five to six laborers throughout the day. The first set of three cycles was observed before lunch using a crew of five laborers. The next set of three cycles was observed after lunch using a crew of six to perform identical work.

During the first set of three cycles, laborer one commenced each cycle by performing a lockout/tagout of the air handler unit as shown in Table 5. Then, laborers two, three, and four started removing the old filters with laborer four also checking belts in the process. During this time, laborer five was carefully keeping records of filter sizes and date changed information. Laborer one began to perform belt and equipment checks while also applying grease. Laborers two and three were busy cleaning and vacuuming the air handler filter areas. During this time, laborer four was unpackaging the new filters and laborer five was removing the old filters from the cramped work area. Halfway through the cycle, laborer one shifted to preparing for the next unit and delivering filter boxes. Laborers two, three, and four worked together to install the new filters. Laborer five continued to remove the new filter boxes and packaging waste. The cycle ended with laborer one carefully removing the lockout/tagout and restarting each unit.

Table 5. Crew Balance for Crew of Five

Start	Laborer 1	Laborer 2	Laborer 3	Laborer 4	Laborer 5
9:00 AM	Lock Out Tag Out	X	X	X	X
9:02 AM	X	Remove Filters	Remove Filters	Remove Filters/check belts	Record Keeping
9:04 AM	Grease, belt and equipment check	Remove Filters	Remove Filters	Remove Filters/check belts	Record Keeping
9:06 AM	Grease, belt and equipment check	Remove Filters	Remove Filters	Remove Filters/check belts	Haul old filter trash
9:08 AM	Grease, belt and equipment check	Vacuum air handler	Vacuum air handler	Unpackage new filters	Haul old filter trash
9:10 AM	Grease, belt and equipment check	Vacuum air handler	Vacuum air handler	Unpackage new filters	Haul old filter trash
9:12 AM	X	Vacuum air handler	Vacuum air handler	Unpackage new filters	Haul old filter trash
9:14 AM	Prepare next unit and deliver filter boxes	Install new filters	Install new filters	Install new filters	X
9:16 AM	Prepare next unit and deliver filter boxes	Install new filters	Install new filters	Install new filters	Haul new filter trash
9:18 AM	Prepare next unit and deliver filter boxes	Install new filters	Install new filters	Install new filters	Haul new filter trash
9:20 AM	Prepare next unit and deliver filter boxes	Install new filters	Install new filters	Install new filters	Haul new filter trash
9:22 AM	Restart the air handler unit	X	X	X	Haul new filter trash
22 Minutes	**10**	**10**	**10**	**10**	**10**
Total Units	**60**				
Effective Units	**50**				
Effectiveness	**83%**				

The average cycle duration was only twenty-two minutes and each cycle appeared to be nearly identical. Each of the five laborers was active for twenty of the twenty-two minutes or effective units. The overall effectiveness for the first set of three cycles was eighty-three percent.

The next set of three cycles began like the first as laborer one commenced each cycle by performing a lockout/tagout of the air handler unit as shown in Table 6. Then, laborers two, three, and four started removing the old filters with laborer four also checking belts in the process. During this time, laborer five was carefully keeping records of filter sizes and date changed information with laborer six being idle. Laborer one began to perform belt and equipment checks while also applying grease. Laborers two and three were busy cleaning and vacuuming the air handler filter areas. At the same time, laborer four was idle and laborer six was unpackaging the new filters. Laborer five was also removing the old filters from the cramped work area. Halfway through the cycle, laborer one shifted to preparing for the next unit and delivering filter boxes much like the earlier set of cycles. In like manner, laborers two, three, and four worked together to install the new filters. Laborer five was idle as laborer six removed the new filter boxes and packaging waste. The cycle ended with laborer one carefully removing the lockout/tagout and restarting each unit.

Table 6. Crew Balance for Crew of 6

Start	Laborer 1	Laborer 2	Laborer 3	Laborer 4	Laborer 5	Laborer 6
12:30 PM	Lock Out Tag Out	X	X	X	X	X
12:32 PM	X	Remove Filters	Remove Filters	Remove Filters/check belts	Record Keeping	X
12:34 PM	Grease, belt and equipment check	Remove Filters	Remove Filters	Remove Filters/check belts	Record Keeping	X
12:36 PM	Grease, belt and equipment check	Vacuum air handler	Vacuum air handler	Remove Filters/check belts	Haul old filter trash	X
12:38 PM	Grease, belt and equipment check	Vacuum air handler	Vacuum air handler	X	Haul old filter trash	Unpackage new filters
12:40 PM	Grease, belt and equipment check	Vacuum air handler	Vacuum air handler	X	Haul old filter trash	Unpackage new filters
12:42 PM	X	Vacuum air handler	Vacuum air handler	X	Haul old filter trash	Unpackage new filters
12:44 PM	Prepare next unit and deliver filter boxes	Install new filters	Install new filters	Install new filters	X	X
12:46 PM	Prepare next unit and deliver filter boxes	Install new filters	Install new filters	Install new filters	X	Haul new filter trash
12:48 PM	Prepare next unit and deliver filter boxes	Install new filters	Install new filters	Install new filters	X	Haul new filter trash
12:50 PM	Prepare next unit and deliver filter boxes	Install new filters	Install new filters	Install new filters	X	Haul new filter trash
12:52 PM	Restart the air handler unit	X	X	X	X	Haul new filter trash
22 Minutes	**10**	**10**	**10**	**7**	**6**	**7**
Total units	**72**					
Effective Units	**43**					
Effectiveness	**60%**					

The average cycle duration remained unchanged at twenty-two minutes for each cycle. The active or effective units for laborers one, two, and three stayed the same, but laborers four, five, and six were only active for twelve or fourteen of the twenty-two minute cycle. The overall effectiveness for this set of three cycles dropped to sixty percent.

The first set required little communication and appeared to be spontaneous and synergistic. The second set, on the other hand, appeared awkward and required more verbal communication between technicians for pacing and to sequence tasks. The addition of a single laborer in the second set did not add value or reduce the cycle duration. On the contrary, it reduced team efficiency by over twenty percent and demonstrated the fallacy of trying to resolve maintenance issues by simply throwing more bodies at the problem. For the maintenance crew, it taught some very practical lessons of the importance of pausing and evaluating situations. The entire crew intuitively recognized the inefficiency, but collectively tried to push through it instead of making crew balancing adjustments.

This study proved that crew balance analysis can be an effective spot check to evaluate team configuration and output for short circular types of teamwork. It also served as a reminder that stacking trades is a vital and important scheduling technique and that increasing the number of laborers does not always translate to being able to quickly accomplish more work. In this case study, the output duration was the same with less workers and the result was a more effective use of labor. This proved that a minimum crew approach can produce a real world 'less is more' scenario and has the potential to significantly increase the capacity of skilled labor.

Improvements and adjustments have since been made to the team composition and efficiency of the specialized crew. The introduction of a Milwaukee M18 cordless grease gun has reduced the optimal crew size to four while maintaining similar efficiency rating and cycle durations. Lean principles are an effective way to identify waste, reduce costs, and make continuous improvements in FM.

CHAPTER 6

DISCUSSION

To overcome the skilled labor shortage, facilities maintenance organizations should implement strategic plans to consistently build capability and develop in-house talent from within the organization. When organizations create opportunities for unskilled labor to advance and enter the skilled labor workforce, which requires apprenticeships, vocational education, and licensure, they can cultivate and grow their own labor pools. From an organizational perspective, it is critical for maintenance organizations to grow talent from within to maintain appropriate staffing levels and to fill future needs in skilled labor.

One unique strength of the zone maintenance model, according to the APPA Body of Knowledge (BOK), is that it “provides a career ladder from entry-level maintenance worker to highly skilled multidisciplinary technician without requiring formal supervisory responsibilities” (APPA, 2021). Implementing this component of the zone model has the potential to dramatically improve morale, career satisfaction, motivation, productivity, and the responsiveness of maintenance employees. Career paths and ladders improve employee skills and capacity while also adding significant value to the organization and considerable cost savings are achieved.

The training and development program of the four BMTs consisted of on-the-job training by skilled laborers to increase their capacity. It was strategically organized from simplest types of work to more difficult and complex job functions in planned rotation schedules. It was easily implemented with little supervisory oversight and has already resulted in the upward career mobility of a BMT who was recently promoted to be an electrical apprentice.

Another distinct advantage of the zone maintenance model is being able to spontaneously organize into multi-shop teams when needed. This unique versatility allows the zones to rapidly tackle deferred maintenance backlogs, mitigate workload, and do more with less. The major conceptual change from traditional centralized maintenance organizations creates the unique ability to troubleshoot and solve complex problems across trades with less effort and without the need to coordinate between the shops (APPA, 2010).

There is another far more important phenomenon that occurs as technicians of different trades and proficiency levels interact with other members of the zone maintenance team. As individuals and as a team, they begin to think differently and develop a more holistically view of maintenance from a variety of different trade perspectives and viewpoints. “Through interactions,” as Cooke (2015) observed, “team members coordinate cognitively with each other, integrating ideas and creating new knowledge.” This innovative multi-trade team cognition is precisely what spurs and “encourages development of a better trained, more versatile workforce that takes ownership of their buildings” (APPA, 2010). The result is a proactive multi-trade crew united in a dynamic partnership that performs holistic facilities maintenance by using “interactive team cognition” and strategy (Cooke, 2015).

Lessons Learned

Resistance to change can hinder the zone maintenance model implementation process and severely limit its success across organizations. The transferability of these results can be nullified by managers, supervisors, and workers unwilling to adjust to organizational changes. It requires having the right people in the right places within the organization.

Replicating the results of these studies requires a high level of acceptance to change, innovative thinking, and a desire to try new techniques. It also requires some individual adaptation because each zone is unique with very different challenges. Managers and supervisors play a critical role in proactively managing change during the zone implementation process.

Clearly communicating the strategic purpose and objectives of the zone model is crucial in the initial stages of implementation. Communication transparency is particularly important when expanding the role of unskilled labor to reduce push back, hesitation, and resistance from skilled laborers. Skilled laborers need to fully understand that the objective is not to reduce the workforce but to increase their capacity to perform higher level work functions within their trade.

CHAPTER 7

CONCLUSION

The dynamic multi-trade teams of the facilities maintenance zones create two distinct advantages for responding to the enormous demands to reduce costs and the constant pressure to do more with less. Zone maintenance teams of multi-trade workers can create a significant competitive advantage by troubleshooting across trades and working together to solve complex multifaceted problems. A zone comprised of multi-trade workers at various proficiency levels can also more effectively utilize the unskilled entry-level maintenance workers to fill gaps in skilled labor of the different trades. Though not considered as part of this study, it noteworthy to mention that along with direct work capacity gains of skilled labor there was also a corresponding reduction in support work by using unskilled labor to perform certain tasks. By removing organizational silos and barriers created by divisions of labor between trades, the zone maintenance model creates a more synergistic team that can significantly add value to the organization by using resources effectively and balancing manpower more efficiently.

The zone-based strategy of using unskilled labor to fill skilled labor gaps proved to be extremely effective response to the pressure to do more with less. The plan was surprisingly quick and easy to implement with the incremental training and instruction of maintenance technicians. This not only provided a significant opportunity to build the capacity and skills of the BMT staff, but it also created a more diverse set of assigned tasks and increased work variety in meaningful ways. Assigning electrical and HVAC corrective and preventive maintenance tasks to unskilled labor technicians reduced the workload of skilled technicians in the zone and central shop, which significantly increased available skilled labor capacity and reduced overall maintenance costs.

The reduction in support work functions performed by skilled labor such as travel, material handling, and preparatory work was another favorable outcome of using unskilled labor. This also illustrates an intangible ripple effect that occurs with these types of productivity gains and cost savings. These simple improvements and adjustments seem to grow and multiply across organizations spurring new ideas and greater innovation.

Team workload sharing and harnessing the multi-trade capacity of the zone increased the collective work productivity and overall maintenance output. The small multi-trade team competed filter changes in a single day which would have taken the HVAC technicians days or even weeks to accomplish with juggling the demands of other work. Planning and crew balancing is another way the zone maintenance crew can do more with less by effectively reducing skilled labor workload and increasing their available capacity. As a result, teamwork has proven to be another appropriate response to the pressure to reduce facilities costs and enabled the zone maintenance team to do more with less.

These studies are a reminder that significant maintenance cost savings can be achieved by eliminating labor waste and crew scheduling inefficiencies. Value can be added to the organization by reducing these and other intangible costs by focusing on continuous improvement, productivity, efficiency, and effective workflow. The workforce utilization and teamwork of zone maintenance crews can boost performance, increase collective output, and maximize skilled labor availability. Facilities contributions can be measured, data can be collected, and the evolving trends and patterns can be properly analyzed. The emerging insights can be applied to quantify the facilities management impact to the bottom line and drive strategic decision making.

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