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Evaluating NAVFAC'S Preventive Maintenance Strategy: Cost Effectiveness and Life Cycle Impacts on Equipment Longevity

June 2025

LCDR Uziel B. Ladaw, USN

Thesis Advisors: Dr. Ryan S. Sullivan, Associate Professor
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Department of Defense Management

Naval Postgraduate School

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ABSTRACT

This thesis examines the cost-effectiveness and life cycle outcomes of the Naval Facilities Engineering Systems Command's (NAVFAC) standardized preventive maintenance (PM) plans compared to Original Equipment Manufacturer (OEM)-guided PM plans. Using a statistical analytical approach that incorporates Robert Snow Means costing, Consumer Price Index adjustments, and Uniform Classification of Construction Systems and Assemblies (UNIFORMAT) coded MAXIMO asset records, the study analyzes over $1.2 million in material and labor costs across more than 7,152 PMs, 5,725 emergency, urgent, and routine work orders (EUR WOs), and 3,659 assets from fiscal year 2020 to fiscal year 2024. Only 2.29% EUR WOs were traceable to specific assets, highlighting data limitations. HVAC systems (D30) represented 93.7% of all PMs and 63.9% of PMs with cost data. On average, NAVFAC-standard PMs cost $173.82 per task, while OEM-guided PMs were modeled at $439.01—2.5 times higher. NAVFAC PMs, though more affordable, underperformed in extending asset longevity for complex subsystems. Findings support a hybrid strategy, applying OEM frequencies to high-value or aging systems and NAVFAC standard PMs to low-risk assets. Recommendations include refining PM tracking procedures, prioritizing critical assets using asset age and design life, and piloting dynamic PM plans to improve life cycle cost control and operational readiness.

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ABOUT THE AUTHOR

LCDR Uziel Ladaw is a Civil Engineer Corps (CEC) Officer. He graduated from the United States Naval Academy with a Bachelor of Science in Mechanical Engineering and received his commission in May 2013.His first assignments included construction manager at Naval Facilities Engineering Command Washington, Public Works Department (PWD) Annapolis and Facilities Engineering Acquisition Division (FEAD), PWD Quantico. He then reported to Naval Mobile Construction Battalion (NMCB) FIVE in Port Hueneme, CA, where he conducted two deployments and held various positions, including Company Commander, Cobra Gold 2017 Detail Officer-In-Charge, and Exercise Pacific Partnership Mission Engineer. After his battalion tour, he reported to the CEC Officer School as the FEAD instructor and later transitioned into the role of Command Adjutant. He then reported to Naval Support Activity Beaufort, SC, as the Public Works Officer. After graduation in June 2025, he will report to the Pentagon as the Infrastructure Requirements Officer for the Office of the Chief of Naval Operations, Reserve. He married his wife, Elise, in October 2021, and they currently have no children. He spends most of his free time with his wife looking for the best restaurants in the area, and his hobbies include weightlifting, snowboarding, golfing, target shooting, and woodworking.

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LIST OF ACRONYMS AND ABBREVIATIONS

BOSC	base operating support contract
CBMM	condition-based maintenance management
CPI	Consumer Price Index
DoD	Department of Defense
EUR	emergency, urgent, routine
FSM	Facilities Sustainment Model
FY	fiscal year
GAO	Government Accountability Office
HVAC	heating, ventilation, and air conditioning
NAVFAC	Naval Facilities Engineering Systems Command
O&M	operations and maintenance
OEM	original equipment manufacturer
PWD	Public Works Department
OPNAV	Chief of Naval Operations
UNIFORMAT	Uniform Classification of Construction Systems and Assemblies
WNY	Washington Navy Yard
WO	work order
VAV	variable air volume

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I. INTRODUCTION

Historically, the Department of Defense (DoD) has consistently deprioritized facilities maintenance in funding and execution. As the need for new weapons systems to meet emerging threats increased, the focus on maintaining existing assets dwindled. This deferred maintenance issue has created a backlog for military installation infrastructure, resulting in compounding costs required to renovate and revitalize critical operational infrastructure and its various components. In fiscal year (FY) 2020, the DoD reported the total cost of deferred maintenance backlog at $137 billion, before the implementation of the Sustainment Management System (SMS) (Fields, 2022). To address the long-term decline of facilities, the Chief of Naval Operations (OPNAV) introduced a facilities investment strategy in 2017 that prioritized preventive maintenance (PM) to be fully funded and executed at 100%, intending to close the gap between funded and on-time PM execution across all Navy installations (Chief of Naval Operations [OPNAV], 2017). While progress was made, implementation remained slow. The Chief of Naval Facilities Engineering Systems Command (NAVFAC) enforced this requirement in an all-hands message, otherwise known as a VectorGram (VG), to NAVFAC leadership in December 2022 (Vanderlay, 2022). Since the release of VG 23–02, most Navy installations have developed installation PM plans and now operate close to, or at, 100% of planned and funded PM execution.

Although PM execution rates have improved, questions remain about the effectiveness of NAVFAC's standardized maintenance plans. NAVFAC's P-503 Planned Maintenance Manual outlines maintenance and inspection intervals for all equipment, executed by In-House Maintenance Shop workforces and Base Operating Support Contract (BOSC) contractors through either NAVFAC standard PM Job Plans or Original Equipment Manufacturer (OEM) PM guidance (Naval Facilities Engineering Systems Command [NAVFAC], 2024). NAVFAC does not mandate the use of one method over the other (NAVFAC, 2024). This flexibility has created an issue regarding which approach—standard or OEM-guided—optimally balances life cycle cost and asset longevity. Complicating this further is the significant difference in labor and material costs between OEM-guided and NAVFAC standard PM plans; OEM plans may cost two to three times more than NAVFAC standard PMs (NAVFAC, 2025). The problem is although NAVFAC may be meeting its objective of 100% annual PMs execution through its standardized maintenance plan, it may not be the most cost-effective approach for asset longevity.

This thesis addresses the following central question: Which PM approach—NAVFAC standard, OEM-guided, or a hybrid model—provides the best cost-to-longevity trade-off for dynamic assets across NAVFAC Washington's Washington Navy Yard (WNY) and Naval Support Activity (NSA) Dahlgren? The research compares the cost benefits and longevity trade-offs of each approach using dynamic equipment and components from nine designated buildings onboard the WNY and NSA Dahlgren. It draws on maintenance data containing over 28,000 observations, comprised of 7,152 PMs, 5,725 work orders (WOs) and 3,659 assets, compiled from NAVFAC Headquarters and WNY and NSA Dahlgren Public Works Department (PWD) staff from 2020–2024. Key data points include asset installation dates, maintenance history, and associated costs. The data reveals correlations between preventive and reactive maintenance, total costs, and asset longevity across various equipment types requiring recurring annual maintenance.

This analysis compares NAVFAC standard maintenance plans with OEM recommended maintenance, providing recommendations for future NAVFAC maintenance plans and requirements. Initial observations support a hybrid strategy that combines NAVFAC standard and OEM-guided PM plans, trading increased short-term costs for longer equipment lifespans. NAVFAC standard PM plans are generally more cost-effective and suitable for lower-risk equipment, while OEM-guided plans are more appropriate for high-value or complex systems. The analysis shows that a solely NAVFAC-based plan, while cost-efficient, does not consistently maximize longevity across all asset types. Conversely, a fully OEM-guided approach, though effective for longevity, is fiscally unsustainable under current constraints. Therefore, this study recommends a dynamic, asset-specific maintenance strategy that balances cost, longevity, and operational readiness. This hybrid approach–excluding utility and energy management systems–should retain NAVFAC standard PMs for lower-risk systems while targeting critical assets with OEM-guided PM plans to reduce life cycle costs, minimize reactive maintenance, and improve overall asset reliability.

II. BACKGROUND

NAVFAC is the subject matter expert (SME) regarding the U.S. Navy's (USN) facilities, and expeditionary engineering support for the U.S. Marine Corps (USMC) and USN Fleet. Every USN and USMC installation is supported by a PWD that supports current and future operations, enabling the mission to continue for all tenants onboard. The PWD mission is to implement the vision and directives of the Installation Commanding Officer in line with the objectives and larger goals of the Regional Commanding Officer. This is done through the planning, maintenance, and execution of construction onboard the installation, including all PM for installation facilities, and is completed via in-house workshop forces or BOSCs.

The size of the installation and its operational requirements dictates the size and capabilities/requirements of the in-house shops' forces and BOSCs in place to support the installation. The in-house workforce provides a wide range of support services, including, but not limited to, carpentry, masonry, low and high-voltage electrical work, plumbing, painting, and heating, ventilation, and air conditioning (HVAC) support. Third-party contractors complete requests for maintenance work that in-house forces cannot complete via a government purchase/ agreement or BOSC contractors.

A. NAVY FACILITIES MAINTENANCE MANAGEMENT CHANGES

Before 1996, PWDs, formerly Public Works Centers, relied on locally tracked maintenance logs for installation facilities (OPNAV, 1974). In 2003, NAVFAC began implementing a new maintenance software, MAXIMO. This application suite, used by multiple public and private organizations (e.g., Deloitte, KPMG, Disney, General Motors, etc.), is an enterprise asset management system used to centralize facilities maintenance (International Business Machines Corp. [IBM], n.d.-a). Developed by International Business Machines, Inc, MAXIMO is "an integrated asset life cycle management solution that streamlines the maintenance, inspection and reliability of critical equipment and infrastructure" (IBM, n.d.-b). For NAVFAC, the use of the MAXIMO application allows PWDs to plan, log, and examine installation maintenance tasks and data on a centralized system (Total Resource Management, 2015), allowing standardized management across Navy installations. However, even with the implementation of MAXIMO, PWDs handle some maintenance plans and requirements locally on a case-by-case basis, negating some of the centralized management benefits of the MAXIMO application and skewing maintenance data.

B. MAINTENANCE MANAGEMENT SYSTEMS

To create a baseline for MAXIMO maintenance plans, NAVFAC uses the Facilities Sustainment Model (FSM). The FSM is the "standardized model for forecasting facilities sustainment resource requirements" and provides a planned schedule for PMs, periodic major repairs, and emergency issues, contributing to operational readiness (Department of Defense [DoD], 2016, p. 5). By multiplying the size of the facility (i.e., square feet), the average annual unit cost for sustainment, local location adjustment factor (i.e., currency exchange rates), and inflation, the FSM provides DoD personnel with a computed annual sustainment requirement for a specific type of facility (e.g., barracks, aircraft hangar, administrative facility, etc.). However, the FSM utilizes notional models for each facility type and does not accurately reflect the actual conditions of individual facilities. This approach assumes uniform maintenance requirements of a type of facility based solely on a model and overlooks changes in specific needs. Consequently, local PWDs are tasked with estimating maintenance needs and associated costs to prolong the longevity of facilities and their assets. This is where the Condition-Based Maintenance Management (CBMM) model comes into play.

The CBMM is "a risk-based investment strategy to target limited financial resources of the most critical components of the Navy's most critical facilities" (NAVFAC, 2016, p. 2). The CBMM is a tool embedded into MAXIMO that NAVFAC uses to monitor the condition of facilities and facility components throughout their life cycles. The condition statuses are then used to plan for and influence investments in sustainment and restoration. The CBMM fills in the gaps and provides real-time field status of the conditions of the assets in the facilities. The CBMM data is then used to target and prioritize specific maintenance based on actual conditions, instead of using a fixed FSM model that may not apply or be outdated.

For example, the FSM could provide a maintenance model for a Navy barracks. However, depending on when that model was created and where (e.g., Florida vs. California), some parts of the model may not be accurate. Air conditioning/heating units for a barracks in Florida may need a larger investment in maintenance due to the extreme swings in temperature throughout the year compared to a Navy barracks in California where the climate is more consistent throughout the year. The FSM provides the baseline model for a maintenance plan while the CBMM ensures that plan is accurate for the actual facility. Using these two in conjunction allows for a PWD to properly plan and execute PM for installation facilities.

C. CURRENT CHALLENGES

While these models are highly useful in prioritizing maintenance and repairs for aging infrastructure, significant challenges remain. MAXIMO relies heavily on the user to input precise and uniform data. With multiple users at USN and USMC installations worldwide, subjectivity combined with varying differences in wording and nomenclature create issues in data traceability, impeding analysis for plans and process improvement. The FSM, focused primarily on sustainment rather than comprehensive life-cycle management, often underestimates the costs of critical repairs, leading to funding shortfalls. It also fails to consider specific degradation factors such as weather, frequency of use, and unique facility conditions, which affect individual assets. CBMM's effectiveness depends on accurate, real-time data; faulty or incomplete information compromises reports and decision-making. Without proper maintenance, facility assets face an elevated risk of premature failure, further undermining long-term operational readiness (Fields, 2022). All this variability, coupled with the diverse types and conditions of Navy facilities in differing environments, makes it difficult to standardize MAXIMO practices across all PWDs.

1. Standardized Preventive Maintenance Plans vs. Original Equipment Manufacturer–Guided Maintenance

In 2017, the OPNAV directed NAVFAC to fully fund 100% PM on USN and USMC installation. In response, NAVFAC implemented standardized PM plans to align maintenance requirements for facilities assets tracked within the MAXIMO system. These revisions provided PWDs with baseline schedules, maintenance plans, and cost estimates for application across all Navy installations (Vanderley, 2022). In FY 2023, the Navy's facilities maintenance budget was approximately $5.4 billion (Department of the Navy, 2022), and in FY2024, the requested budget increased to approximately $6.2 billion (DoD, 2023). Although Navy PWDs have adopted standardized maintenance practices, the FY2023 and FY2024 budget requests do not explicitly distinguish between NAVFAC-standardized PM plans and OEM-guided maintenance approaches.

NAVFAC-standardized PM plans are designed to establish a maintenance baseline rooted in construction and general manufacturer industry standards. However, these plans may not fully account for the specialized maintenance needs of certain facility assets. In contrast, OEM-guided maintenance plans are tailored to ensure that equipment reaches or exceeds its expected service life, although this approach can result in higher costs if the asset's planned replacement timeline does not align with its OEM-recommended maintenance schedule. Given increasing private-sector costs, standardized PM plans offer PWDs a more predictable path toward meeting readiness goals while managing available resources. However, implemented standardized plans may not fully reflect the operational environment or facility-specific conditions, which could influence asset performance and maintenance outcomes over time.

2. Operational Constraints

Manpower and funding constraints further affect PWDs' ability to fully implement maintenance plans designed to prevent premature asset failure. While standardized PM plans are executed, they may not account for variations in operational tempo, environmental factors, or unique facility demands. Some installations face challenges due to shortages in in-house maintenance personnel or limited coverage through BOSCs. BOSCs often service multiple installations across a geographic region, which may lead to resource limitations, maintenance delays, or increased costs associated with executing standard PM tasks (Cordrey, 2018).

All PWDs operate within a financially constrained annual budget. This budget covers all the requirements of a PWD, including environmental management, utilities, civilian salaries, grounds maintenance, transportation equipment, and discretionary projects. The budget may cover more depending on the size of the installation. The average PWD budget covers roughly 10% of the planned replacement value of the base, which is the cost to replace every facility and accompanying infrastructure to a like-new condition. Unfortunately, these annual budgets make it difficult, if not nearly impossible, to provide all OEM recommended maintenance, resulting in NAVFAC adopting its own standardized maintenance plans for all installation assets.

D. RESEARCH GAP AND PROBLEM STATEMENT

Considering fiscal constraints, manpower availability, and evolving operational requirements, this research examines how a combined approach—integrating NAVFAC-standardized PM plans with OEM-guided maintenance plans—may provide cost-benefits and increase asset longevity for Navy facility assets at the WNY and NSA Dahlgren. Specifically, this analysis explores whether flexibility in applying maintenance plans could allow installations to adapt to short-term operational requirements without sacrificing long-term cost efficiency or mission readiness.

A key consideration is whether reliance solely on NAVFAC standardized PM plans in shifting operational environments could accelerate asset replacement costs due to deferred or insufficient maintenance. Conversely, rigid adherence to OEM maintenance schedules without operational flexibility could divert resources from higher-priority requirements. The analysis aims to estimate the impacts of different maintenance strategies on life cycle costs and asset longevity, providing insights into the broader cost-benefit tradeoffs associated with achieving 100% PM compliance across Navy installations.

NAVFAC's development in facilities maintenance and management highlights strengths and limitations of the current PM approach. Opportunities to evaluate alternative strategies are created through resource constraints, varying operational tempos, and assumed maintenance models. The next chapter describes the sources of data, preparation methods, and analysis techniques used to assess potential benefits of combining NAVFAC-standardized and OEM-guided PM practices.

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III. DATA AND METHODOLOGY

This chapter supports the research objective of determining whether OEM aligned PM frequencies reduce life cycle maintenance costs compared to NAVFAC standard intervals. The primary research question guiding this analysis is: “Does implementing recommended OEM PM plans reduce life cycle maintenance costs and unplanned work/maintenance, otherwise known as emergency, urgent, and routine (EUR) WOs, compared to the NAVFAC standard PM plans?”

A. DATA SOURCES

Using the following datasets, a cost-benefit analysis was designed to evaluate the economic and operational trade-offs between OEM-recommended and NAVFAC-standard PM intervals. All data used were unclassified and accessed through official NAVFAC channels with appropriate permissions for academic use.

1. MAXIMO

Unclassified MAXIMO data was gathered from the NAVFAC MAXIMO database for the PWD South Potomac, Naval Support Facility Dahlgren (buildings 218, 1450, 1452, 1490, and 1610), and PWD Washington, WNY (buildings 104, 176, 200, and 201) (NAVFAC, 2025). The PWDs and respective buildings are located within Naval District Washington, specifically in Washington, D.C., and Dahlgren, Virginia. The MAXIMO data contained the asset numbers, associated building location and number, Uniform Classification of Construction Systems and Assemblies (UNIFORMAT) code, PM number, parent and child WO number, estimated and actual start and finish dates, estimated and actual labor hours, actual material and labor costs, and PM or WO description. The MAXIMO data compiled represents actual completed and logged PMs and WOs for each building by field technicians using the MAXIMO mobile application issued on government devices. This provided detailed information on each building’s PM tasks and WOs performed from FY20 to FY24. Material and labor costs were subsequently calculated and linked to specific assets.

2. Robert Snow Means

Robert Snow (RS) Means facilities’ data was collected from Gordian’s extensive online facilities maintenance and construction database. RS Means cost estimates are created by an extensive and thorough gathering of nationwide construction material, labor, equipment, industry best practices, overhead costs, and other relevant data from contractors, distribution companies, and manufacturers. This data is compiled and analyzed to produce national averages and city cost index adjustments. Variables included estimated labor hours, bare material and labor costs, in-house overhead, and total PM cost (Gordian, 2025). The dataset categorizes the estimated annual PM costs by UNIFORMAT classifications—a hierarchical system for organizing construction information based on functional building elements (Gordian, 2024), as presented in Figure 1.

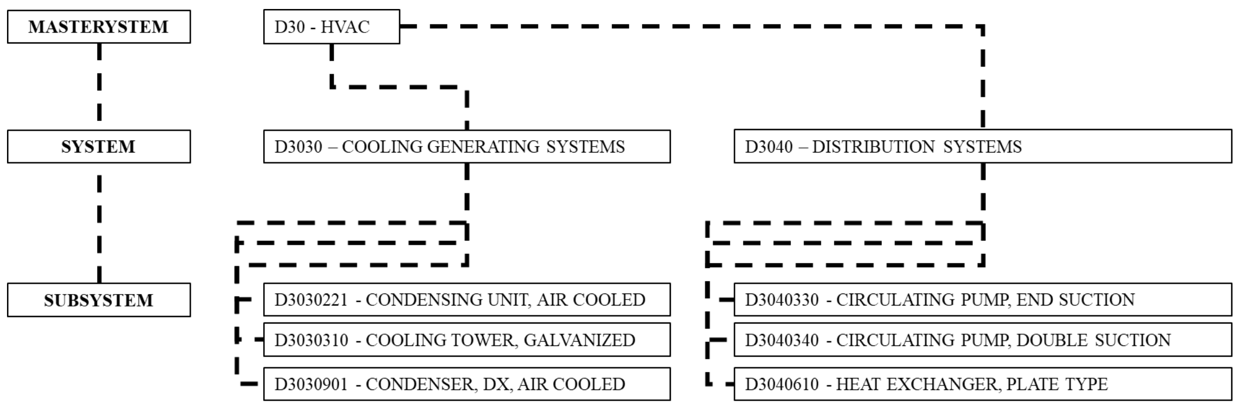


Figure 1. UNIFORMAT classification flow. Adapted from Gordian (2024).

Those categories are mastersystem, system, and subsystem classifications, with each PM line tied to an assembly code. RS Means assembly codes were mapped to MAXIMO asset data by matching the first seven characters of the UNIFORMAT subsystem codes. For example, subsystem D3040132 – VARIABLE AIR VOLUME (VAV) TERMINAL is connected to RS Means PM assembly D30451601950 – VAV BOXES, annualized. Subsystem D3040132 is connected to the D3040 – DISTRIBUTION SYSTEMS system classification and D30 – HVAC mastersystem classifications.

3. Naval Facilities Engineering Systems Command OEM Frequency Study

In 2023, NAVFAC conducted an internal study and analysis of the recommended OEM maintenance frequencies for its enterprise-wide asset database (Sharkey, 2023). It produced a consolidated dataset of assets tied to mastersystem, system, and subsystem codes and recommended maintenance intervals based on manufacturer OEM manuals. Asset maintenance frequencies fell into several categories:

- Run-to-failure [RTF] (no planned PM, only serviced via EUR)
- Five years (serviced as EUR until 5-year mark or as necessary)
- Annual (once a year)
- Semi-annual (twice a year)
- Quarterly (four times a year)
- Monthly (12 times a year)
- Weekly (52 times a year)
- Daily (365 times a year)

4. Consumer Price Index Tables

To ensure comparability with RS Means estimates, all historical MAXIMO cost data from FY20 to FY24 was adjusted using Consumer Price Index (CPI) multipliers to reflect end of FY24 dollars, as seen in Figure 2, with CPI values presented in Table 1. PMs without associated material or labor costs were excluded from specific cost-related statistical calculations but were included for frequency analysis.

$$Cost_{adjusted} = Cost_{initial} \ x \ \frac{CPI_{FY24,\ October}}{CPI_{FY_i, Month_i}}$$

Figure 2. Cost adjustment formula. Adapted from U.S. Department of Labor (2023).

Table 1. Consumer Price Index values, FY20 to FY24. Adapted from U.S. Bureau of Labor Statistics (2025).

Month	FY20	FY21	FY22	FY23	FY24
October	257.346	260.388	276.589	298.012	307.671
November	257.208	260.229	277.948	297.711	307.051
December	256.974	260.474	278.802	296.797	306.746
January	257.971	261.582	281.148	299.170	308.417
February	258.678	263.014	283.716	300.840	310.326
March	258.115	264.877	287.504	301.836	312.332
April	256.389	267.054	289.109	303.363	313.548
May	256.394	269.195	292.296	304.127	314.069
June	257.797	271.696	296.311	305.109	314.175
July	259.101	273.003	296.276	305.691	314.540
August	259.918	273.567	296.171	307.026	314.796
September	260.280	274.310	296.808	307.789	315.301

Notes: Data is from the U.S. Bureau of Labor Statistics Consumer Price Index for all urban consumers.

B. DATA COLLECTION AND CLEANING

The original MAXIMO data sample from PWD South Potomac contained duplicates due to a renovation of the local MAXIMO database. These duplicates included parent and child PM WOs, where child WOs were separated into individual task steps. To validate the integrity of the data, duplicates were deleted, leaving one child WO remaining to represent the individual PM. In contrast, MAXIMO data from the WNY contained no duplicates, verified by the PWD Washington Facilities Engineering & Acquisition Division Director and NAVFAC Headquarters Program Analyst.

MAXIMO material and labor costs reflect the value at the time each task was executed. PWD Washington's PM records contained no associated material cost entries, whereas PWD South Potomac consolidated material costs into parent annua and semi-annual PM work orders. To account for the consolidation, the material cost for each building's PMs was divided equally among the corresponding PMs within the same FY that included labor cost data. Both PWDs' EUR datasets contained material and labor cost information. However, many EUR records lacked an associated asset number or UNIFORMAT category. PWD South Potomac's EUR data exhibited missing UNIFORMAT codes across all three hierarchical levels. While PMs without labor or material cost data increased the overall number of PMs logged, only PMs with associated cost data were used in NAVFAC and OEM cost comparison calculations.

C. DATA CATEGORIES AND MAPPING

To consolidate the datasets across the two installations, official RS Means UNIFORMAT verbiage was used to correct and standardize inconsistent user-entered UNIFORMAT wording and nomenclature. Each asset was grouped according to its UNIFORMAT mastersystem, system, and subsystem codes, with PM times and costs aggregated annually by FY. After data cleaning, statistical analysis was prepared at each UNIFORMAT level for each installation separately and for the combined dataset. The following metrics were set for calculation:

- PM counts and %
- Costs for PMs per FY
- PM counts with cost data per FY
- Percentages for PMs with cost data
- Total counts, costs, and percentages for asset-related EURs and non-asset related EURs

- Ratio of asset related EURs compared to asset related PMs (counts and costs)
- Ratio of all EURs compared to all PMs (counts and costs)
- Averages, medians, minimums, maximums, and standard deviations for total PM costs across FY20 to FY24

Using NAVFAC's Facility Sustainment Equipment OEM PM Frequency Review actual NAVFAC PM execution costs and intervals were compared against estimated RS Means costs and OEM-recommended frequencies (Sharkey, 2023). This comparison enabled the calculation of:

- Over/under cost calculations (RS Means/OEM vs. NAVFAC),
- Differences in the number of PMs performed annually,
- Average asset design life,
- Average current asset age,
- Percentage differences between asset design life and current age.

D. SUMMARY OF DATA SCOPE

The complete NAVFAC MAXIMO dataset consisted of:

- 3,659 assets
- 6,902 EURs
- 7,152 PMs completed between FY20 and FY24

Of the EURs, only 70 (2.29%) were attributed to specific assets. Among all PMs, 4,570 (64.9%) included associated labor or material cost data. A total of 2,230 assets had completed PMs logged, with 1,659 assets linked to PMs with cost data. The D30 – HVAC mastersystem accounted for 93.736% of all PMs and 63.9% of those with associated cost data, highlighting the concentration of maintenance activity in this category across the nine analyzed facilities (NAVFAC 2025a).

E. DESCRIPTIVE STATISTICS

Descriptive statistics were developed to characterize the scope and structure of the collected data and provide the PM statistics for the analyzed facilities from FY20 to FY24 consolidated into UNIFORMAT category codes. Full descriptive statistic tables can be found in appendixes A and B.[1] The statistical data provided are the number of observed PMs within the

[1] Appendix A provides a statistical analysis on the individual line items of MAXIMO data. Appendix B provides a statistical analysis after the various costs are consolidated into the respective FY by asset.

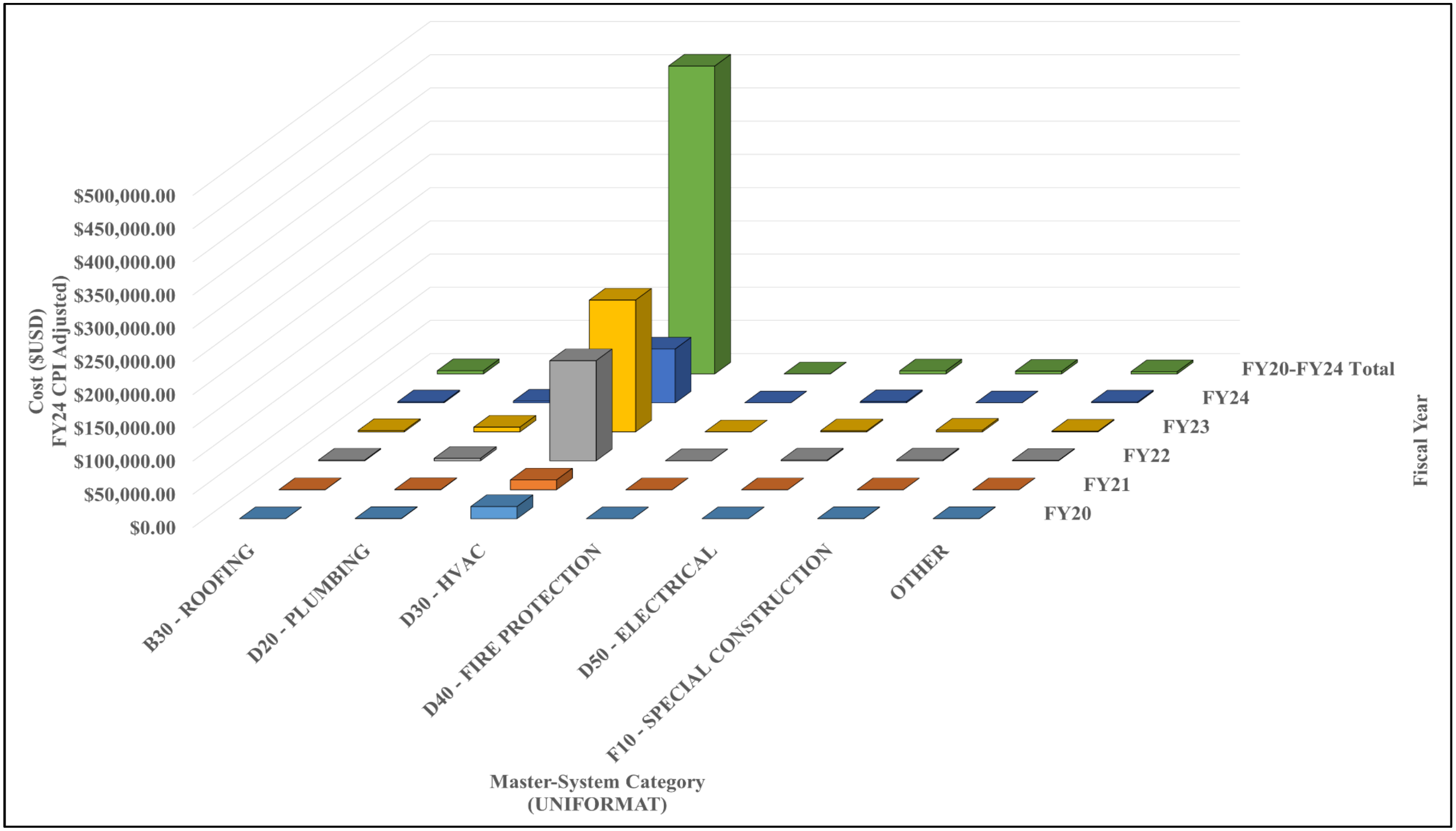
respective categories, total cost of PMs across all FYs, average (mean), median, max, and standard deviation.[2]

[2] Tables 5 and 8 correspond to buildings 104, 176, 200, and 201 on the WNY. Tables 6 and 9 correspond to buildings 218, 1450, 1452, 1490, and 1610 on NSA Dahlgren. Tables 7 and 10 correspond to the combined data of both installations

IV. ANALYSIS

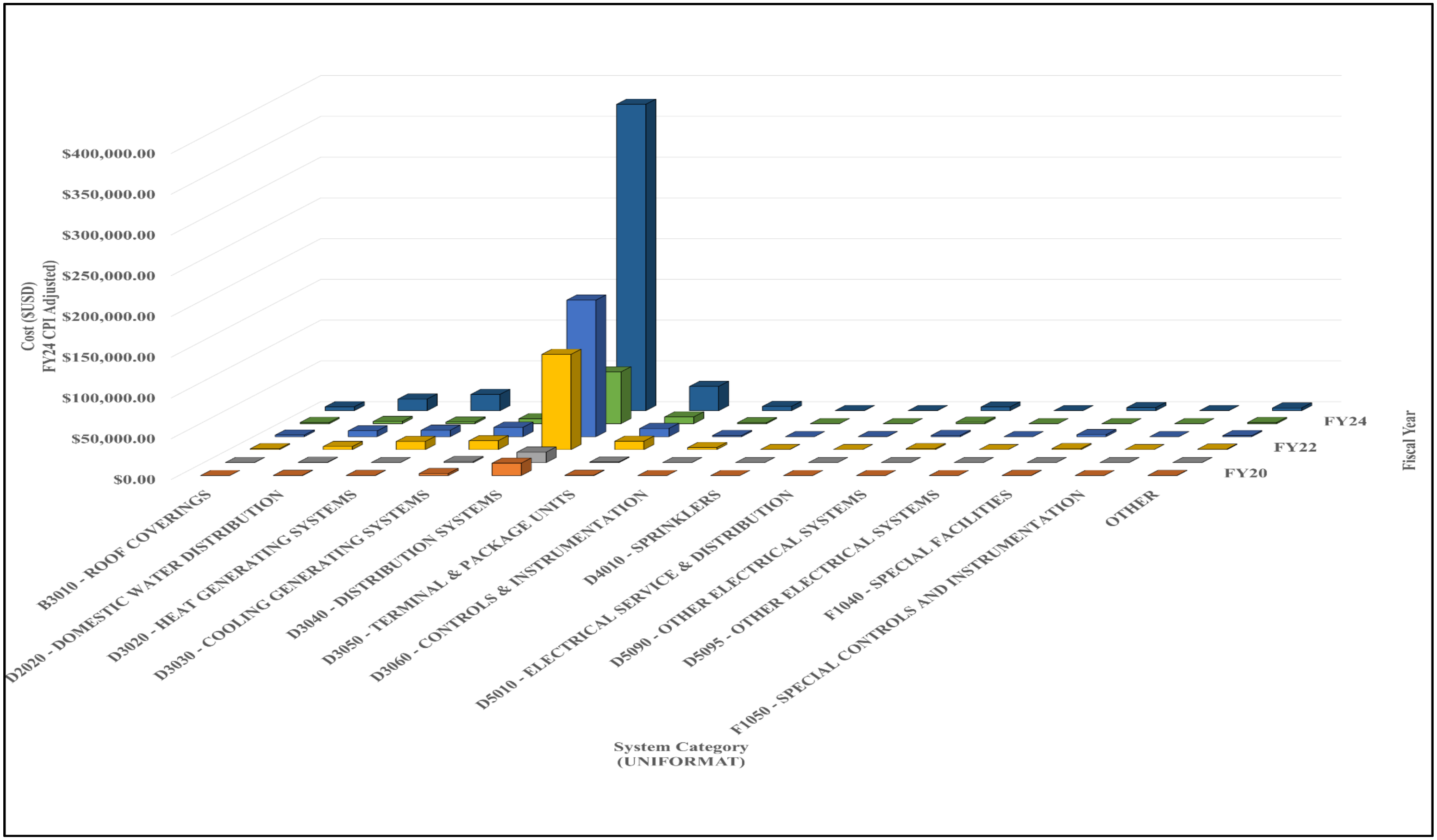
A. PM DISTRIBUTION BY UNIFORMAT CLASSIFICATION

As shown in Figure 2 through Figure 4, the assessment of preventive and unplanned maintenance performance revealed that most PMs occurred within the D30 – HVAC mastersystem ($463,544.23, 93.7%), D3040 – DISTRIBUTION SYSTEMS system ($375,966.82, 78.5%), and D3040136 – VAV TERMINAL, FAN POWERED subsystem ($137,564.95, 28.1%). Only the top fifteen subsystems with the highest PM counts are displayed in Table 3. A complete subsystem list can be found in Panel C of Appendix A.



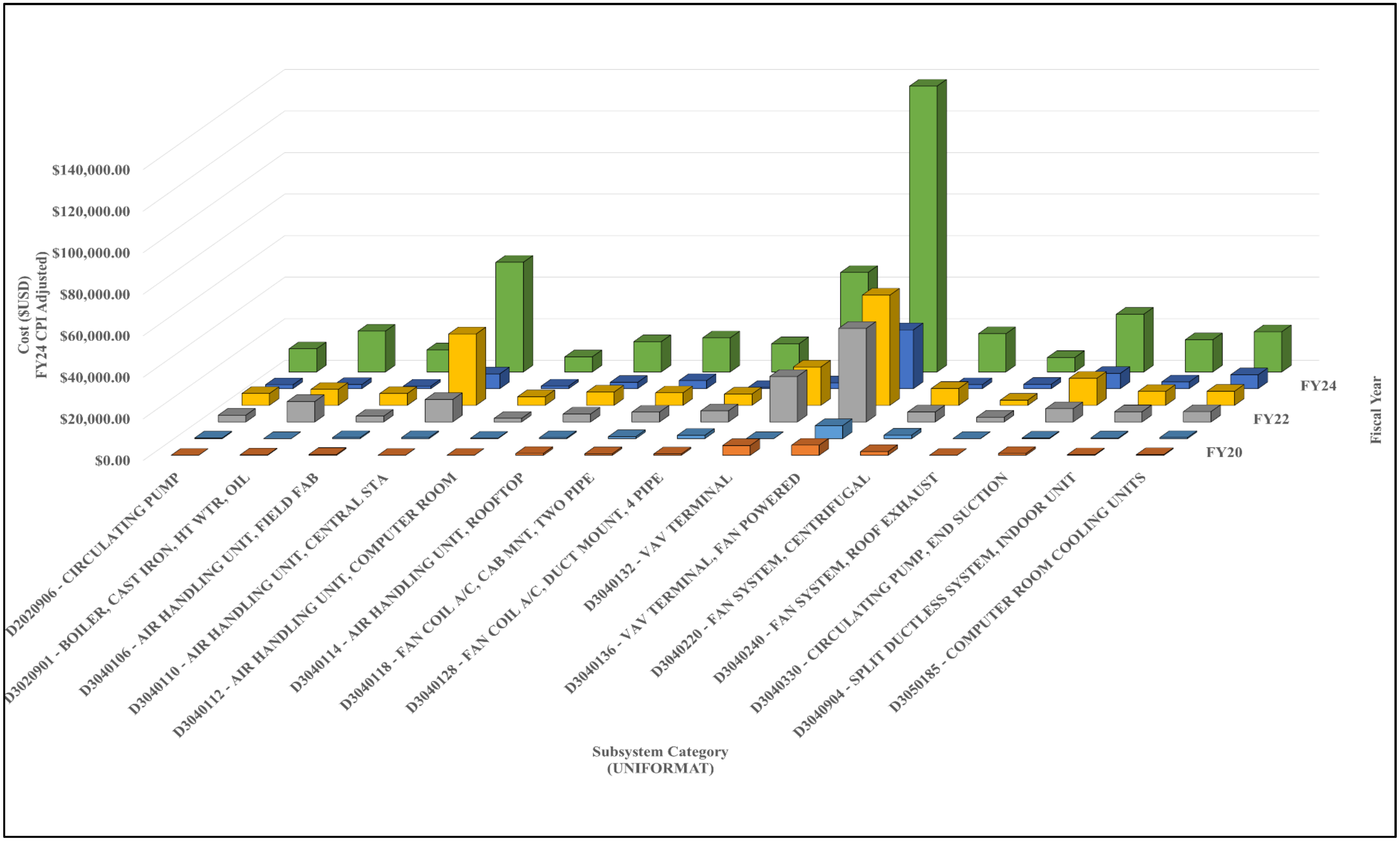
Notes: Statistics calculated from the consolidated NAVFAC MAXIMO data set, FY20-FY24

Figure 3. Individual PM data by UNIFORMAT mastersystem. Adapted from NAVFAC (2025a).



Notes: Statistics calculated from the consolidated NAVFAC MAXIMO data set, FY20-FY24

Figure 4. Individual PM data by UNIFORMAT system. Adapted from NAVFAC (2025a).



Notes: Statistics calculated from the consolidated NAVFAC MAXIMO data set, FY20-FY24

Figure 5. Individual PM data, top 15 UNIFORMAT subsystem counts. Adapted from NAVFAC (2025a).

As shown in Table 2, these categories exhibited high standard deviations—124.21 for D30, 113.99 for D3040, and 63.24 for D3040136—suggesting substantial variability and likely reflecting inconsistencies due to missing or incomplete data. Nevertheless, when examining only PMs with cost data, these categories remained the most prevalent: D30 (60.6%), D3040 (51.3%), and D3040136 (20.6%).

Table 2. Top PM count by UNIFORMAT code levels. Adapted from NAVFAC (2025a).

UNIFORMAT CODE	% of Total PMs	Total Cost FY20-FY24	Std Dev	% of PMs with Cost Data
D30 – HVAC	93.7%	$463,544.23	124.21	60.6%
D3040 – DISTRIBUTION SYSTEMS	78.5%	$375,966.82	113.99	51.3%
D3040136 – VAV TERMINAL, FAN POWERED	28.1%	$137,564.95	63.24	20.6%

Notes: Statistics calculated from the consolidated NAVFAC MAXIMO data set, FY20-FY24

B. EUR OCCURRENCE BY UNIFORMAT CATEGORY

Among EURs, most WOs fell under D20 – PLUMBING, with 3,687 occurrences (64.4%), and D2020 – DOMESTIC WATER DISTRIBUTION, with 2,651 (98.4%), consistent with operational expectations. Systems like water distribution and climate control are perpetually utilized and subject to continuous wear, necessitating regular upkeep to prevent failure. However, when filtered for asset-related EURs, the numbers drop significantly—only 35 for D20 (0.6%) and 33 for D2020 (1.2%)—suggesting a weak correlation between EURs and specific assets. The lack of identifiable assets in most EUR records is likely due to how these WOs originate. EURs are typically initiated by facility tenants or help desk operators based on observed issues, without precise knowledge of the underlying asset (NAVFAC, 2021). For instance, a tenant may report a climate issue without knowing whether the problem stems from a VAV terminal or rooftop HVAC unit. As a result, WOs are often generic and are not tagged with accurate UNIFORMAT subsystem codes.

C. CORRELATION BETWEEN PMS AND EURS

A general hypothesis in life cycle asset management is that PMs and EURs have an inverse relationship. Normally, increasing frequencies and funding investments of

PMs should lead to reductions in EUR occurrences and costs (e.g., replacing a rusted bolt or damaged component to ensure smooth operation, cleaning a filter to maintain air flow, etc.). This relationship appears valid when comparing non-asset related PM and EUR data at the D20 and D30 mastersystem categories. However, this correlation weakens when analyzing asset-related EUR and PM data.

The D20 category exhibited EUR/PM cost ratios of 0.5275 (asset related EUR costs divided by total D20 PM costs) and 55.5055 (non-asset related EUR costs divided by total D20 PM costs), in contrast to the D30 category's ratios of 0.0007 and 0.0421. With a total D20 PM value of $14,323.54 from FY20 to FY24—compared to $463,544.23 for D30—one would expect a higher asset related D20 EUR/PM cost ratio compared to the D30 category. These results suggest potential underperformance in PM effectiveness for the D20 category, or misclassification of unplanned events preventing links to specific assets. Additionally, although D30 PMs account for over 90% of the PM costs, the average age of D30 assets exceeded the average asset design life, justifying the high costs. In comparison, even though D20 PMs costs were much lower than EUR costs, most assets were within or exceeded the design life. This suggests that D20 PM and EUR costs point to reactive maintenance patterns, while D30 assets require more stringent PM management.

An increase in EURs can also be correlated to the age of the asset, which has an inverse relationship with the number of PMs. When analyzed at the subsystem level, this correlation does not hold well. The average age of assets in subsystem D3040132 – VAV TERMINAL is 23.73 years, 8.73 years over the average design life. According to the correlation of an asset's age with PMs and EURs, there should be a larger EUR/PM ratio, but the data shows the opposite with a 0.01 ratio, or 1%. In this case, the correlation of the number and cost of PMs compared to EURs is a more accurate reflection of the data.

D. EUR AND PM FREQUENCY ALIGNMENT

This concern is mitigated when considering NAVFAC and OEM maintenance frequency requirements. Within the D20 mastersystem, only seven of the 17 subsystems required annual maintenance; the remaining subsystems were designated as "run-to-failure" or lacked assigned PM frequencies. Furthermore, most D20 EURs addressed non-specific failures such as clogs or leaks—issues that were not traced to a specific subsystem (e.g., D2010110 – WATER CLOSET SYSTEMS, D2010210 – URINAL SYSTEMS). Consequently, when technicians resolve an EUR, the absence of system, subsystem, or asset data limits traceability and leads to inaccurate EUR analysis as it filters from the mastersystem to subsystem level. Without a specific asset or correct UNIFORMAT level codes, it is difficult to compile accurate statistical data for a conclusive analysis and future maintenance planning. This context explains the inflated EUR/PM ratio for D20 compared to D30 and highlights the inherent limitations in PM planning for plumbing systems not assigned routine maintenance schedules.

E. NAVFAC VS. OEM FREQUENCY COMPARISON

To evaluate the effectiveness of NAVFAC-standard versus OEM-recommended PM practices, subsystems were analyzed using variables such as average PM cost, OEM estimated annual cost, required or recommended maintenance frequency, average design life, and current average age, as noted in Table 3. The top five most frequently logged subsystems were:

- D3040136 – VAV TERMINAL, FAN POWERED (2,010 PMs),
- D3040132 – VAV TERMINAL (1,158 PMs),
- D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE (475 PMs),
- D3040330 – CIRCULATING PUMP, END SUCTION (465 PMs),
- D3050185 – COMPUTER ROOM COOLING UNITS (350 PMs).

For D3040136 and D3040132, NAVFAC and OEM frequencies aligned. Estimated OEM costs were 56% and 48% higher than the average annual PM costs, yet the current average asset age exceeded the estimated design life by 8.73 and 9.32 years. This pattern also held for D3040128, D3040330, and D3050185, where NAVFAC performed fewer PMs than OEM recommended, but the assets exceeded their design lives by 9.74, 7.93, and 2.82 years. In these cases, the NAVFAC-standard PM strategy appeared cost-effective. While the D30 mastersystem accounted for most of the PM activity, the extended asset longevity suggests these frequencies may be appropriate.

Table 3. Top 15 of subsystems with the highest PM count. Adapted from NAVFAC (2025a).

Subsystem	NAVFAC Frequency	OEM Frequency	Estimated PM Cost Savings	Design Life Difference
D3040136 – VAV TERMINAL, FAN POWERED	1	1	$39.25	9.33
D3040132 – VAV TERMINAL	1	1	$43.28	8.74
D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE	2	12	$339.63	9.74
D3040330 – CIRCULATING PUMP, END SUCTION	1	12	$62.85	7.93
D3050185 – COMPUTER ROOM COOLING UNITS	2	12	$491.35	2.83
D3040110 – AIR HANDLING UNIT, CENTRAL STA	2	4	$127.37	4.88
D3040118 – FAN COIL A/C, CAB MNT, TWO PIPE	2	12	$271.72	9.33
D3040220 – FAN SYSTEM, CENTRIFUGAL	1	2	$56.18	(5.17)
D3040904 – SPLIT DUCTLESS SYSTEM, INDOOR UNIT	1	1	$548.68	4.33
D2020906 – CIRCULATING PUMP	1	1	$334.77	N/A
D3040114 – AIR HANDLING UNIT, ROOFTOP	2	4	$193.68	9.45
D3040240 – FAN SYSTEM, ROOF EXHAUST	1	2	$84.04	4.33
D3040112 – AIR HANDLING UNIT, COMPUTER ROOM	2	12	$227.89	N/A
D3020901 – BOILER, CAST IRON, HT WTR, OIL	4	1	$125.35	(5.67)
D3040106 – AIR HANDLING UNIT, FIELD FAB	2	4	$158.81	(0.00)

Notes: Statistics calculated from the consolidated NAVFAC MAXIMO data set, FY20-FY24

F. EXCEPTIONS: WHEN NAVFAC PM MAY UNDERPERFORM

This trend was not consistent across all subsystems. For example, D3040220 – FAN SYSTEM, CENTRIFUGAL had an average annual PM cost of $103.82—$56.18 below OEM estimates. Although NAVFAC conducts only one PM annually, while OEM frequencies recommend two, the average current asset age was 5.18 years less than the subsystem's design life. Similar patterns were observed for seven other subsystems within the dataset, as seen in Table 4 below. These subsystems showed lower PM costs and frequencies but seem to underperform in expected lifespan—suggesting that under-maintenance may reduce asset longevity. However, some of the assets may still be operational and have not realized their respective design lives. Early indicators of degraded performance may have not be present in measurable EURs or failures, making it difficult to assess the full impact of reduced PM frequencies. Without consistent condition monitoring or post-maintenance inspections of these subsystems, subtle declines in efficiency or reliability may be missed, further complicating life cycle evaluations.

Table 4. Subsystems with negative age difference. Adapted from NAVFAC (2025a).

Subsystem	NAVFAC Frequency	OEM Frequency	PM Cost Savings	Design Life Exceeded?
D3050170 – SPLIT SYSTEMS AIR COOLED CONDENSE UNIT	2	12	$439.76	(7.12)
D3040340 – CIRCULATING PUMP, DOUBLE SUCTION	1	12	$146.00	(5.67)
D3020901 – BOILER, CAST IRON, HT WTR, OIL	4	1	$125.35	(5.67)
D3040620 – HEAT EXCHANGER, SHELL TUBE	1	1	$75.29	(5.50)
D5090210 – GENERATORS	4	1	$1,141.11	(5.27)
D3040220 – FAN SYSTEM, CENTRIFUGAL	1	2	$56.18	(5.17)
D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED	2	52	$3,889.00	(2.67)
D3060903 – AIR COMPRESSOR	4	365	$417.23	(1.96)

Notes: Statistics calculated from the consolidated NAVFAC MAXIMO data set, FY20-FY24

G. DATA LIMITATIONS

The following subsystems did not have a corresponding RS Means or OEM frequency within the dataset.

- D2010110 – WATER CLOSET SYSTEMS
- D2010210 – URINAL SYSTEMS
- D2010310 – LAVATORY SYSTEMS
- D2010410 – SINK
- D2010710 – SHOWER SYSTEMS
- D3020310 – GAS VENT, GALVANIZED STEEL, DOUBLE WALL
- D5010120 – OVERHEAD ELECTRIC SERVICE, 3 PHASE – 4 WIRE
- D5010902 – TRANSFORMER
- D5010906 – PANELBOARDS
- D5010908 – SERVICE DISCONNECT
- D5010909 – SAFETY SWITCH
- D5030910 – COMMUNICATION & ALARM SYSTEMS

The cause of these absences is most likely due to these components deemed RTF components with minimal risk, assets that require special maintenance outside of a routine PM schedule, or a lack of or inconsistent industry data nationwide. This data absence limits the comparison of NAVFAC PM plans and frequencies against industry standards.

V. DISCUSSION AND RECOMMENDATIONS

A. PM STRATEGY

For high-risk or aging system, NAVFAC should align maintenance plans with OEM-guided frequencies, specifically regarding D30 – HVAC assets. VAV terminals and some fan coil units that aligned between NAVFAC and OEM PM frequency showed a strong relationship between cost-effectiveness and exceeded design life. However, other subsystems like D3020901 – BOILER, CAST IRON, HT WTR, OIL and D3050130 – UNIT HEATERS, HYDRONIC could align more with OEM maintenance guidelines by reducing the number of PMs. Other subsystem maintenance plans, like D3040220 – FAN SYSTEM, CENTRIFUGAL, D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED, and D3050170 – SPLIT SYSTEMS AIR COOLED CONDENSE UNIT, could be increased to a semi-annual or quarterly maintenance schedule. Implementing a hybrid PM strategy allows PWDs to tailor PMs based on the specific asset type, frequency of use, and mission requirements while preserving costs, asset longevity, and long-term performance.

B. ACCURACY OF PM AND EUR DATA

All EUR data must be corrected to align WOs with UNIFORMAT classification, allowing for a more in-depth analysis with traceable information for future decision making. The origination of EURs from generalized tenant reports or help desk entries needs to be validated by field technicians and updated within MAXIMO. According to Naval Engineering Training and Operating Procedure and Standard (NETOPS) #41, technicians are required to assign assets or UNIFORMAT mastersystem codes before any WO is closed (NAVFAC, 2019). With only 2.29% of EURS traceable to specific assets, any further analysis of PM effectiveness is substantially weakened. Ensuring traceability of EURs allows PWDs the opportunity to connect reoccurring issues to specific assets and perform root cause analysis. This strengthens future trends recognized through predictive analysis for better investment decision making opportunities.

C. FREQUENCY REEVALUATION

Although D20 systems had the highest EUR counts (64.4%), most of them had no assigned PM frequency. NAVFAC should re-examine and reevaluate the D20 and D50 categories for frequency designations, specifically for RTF designated subsystems, and consider introducing minimum PM frequencies (e.g., semi-annual PMs for pumps and tanks). This reevaluation should identify the "low risk" assets that are disproportionately contributing to EURs. A basic PM frequency on an annual basis at minimum should reduce the number of EURs.

D. UTILIZE ASSET AGE TO INFLUENCE PM FREQUENCY

NAVFAC should incorporate design life and asset age into its PM planning process. Assets found to be older than the manufactured design life should receive a higher frequency of PMs, but some assets significantly older had PM frequencies well below the OEM recommended PM frequencies. A dynamic PM schedule that is based on the gap between age and design life and remaining service life would reduce the risk of asset failure. For example, an asset that is within three years of its design life should start to have semi-annual PMs instead of annual and begin to have quarterly PMs once it has exceeded its design life.

Additionally, NAVFAC should create an evaluation scoring system based on asset age relative to design life, PM frequency (NAVFAC vs. OEM), and historical EUR occurrence. Any assets with major age differences, ae below OEM recommended PM frequencies, and have a trend of increasing EURs should be immediately reviewed. This system could support prioritization of assets for CBMM, guide funding decisions, and focus BOSC task orders prioritization, shifting maintenance trends from reactive to predictive, ultimately reducing life cycle costs and increasing asset longevity.

VI. CONCLUSION

This thesis analyzed and assessed the cost-effectiveness of NAVFAC standard PM plans versus OEM-guided maintenance plans across nine facilities onboard the WNY and NSA Dahlgren, providing a focused evaluation within the NAVFAC Washington region. By adjusting NAVFAC PM costs to FY24 values using 2020–2024 CPI tables, and aligning RS Means-recommended costs and UNIFORMAT codes with OEM-recommended PM frequencies, a consistent cost-effectiveness comparison was conducted for various asset types. CPI adjustments and UNIFORMAT categorization enabled standardization across the dataset, assuming similar costs for comparable assets at both installations, regardless of whether PMs were executed by in-house personnel or BOSC contractors. This adjusted dataset also revealed administrative tracking deficiencies in PM documentation at both locations.

The results highlight the fundamental tension between administrative efficiency and equipment longevity. NAVFAC's standard PM plans, while offering uniformity and ease of implementation, seem to underperform in extending the lifespan of certain high-value assets when compared to OEM-guided plans. In many instances, tailoring specific assets to OEM-recommended PM frequencies would improve life cycle performance in exchange for higher short-term costs. The data driven analysis from MAXIMO, RS Means, CPI adjustments, and UNIFORMAT codes demonstrates that a hybrid approach offers the best return on investment. Targeting critical assets with OEM-guided PM plans while retaining NAVFAC standard PMs for lower-risk systems enables NAVFAC to reduce life cycle costs, minimize reactive maintenance, and improve overall asset reliability within NAVFAC Washington.

Although this study is localized to a specific region, its methodology provides a scalable framework. Further research across additional installations within NAVFAC Washington or other NAVFAC regions could strengthen and validate these findings. To support this, NAVFAC should invest in enhanced data normalization tools, expand performance tracking capabilities, and initiate pilot programs incorporating OEM-guided PM strategies, beginning with the most prevalent category of PMs, D30 HVAC systems.

By aligning future maintenance strategies with life cycle performance data, enforcing precise administrative PM data collection, and adopting dynamic PM frequencies based on asset age and design life, NAVFAC can improve infrastructure resilience, optimize readiness, control costs, and continue supporting the warfighter through effective sustainment.

APPENDIX A. SUMMARY STATS, INDIVIDUAL PM DATA

Table 5. Washington Navy Yard, B104, B176, B200, B201. Adapted from NAVFAC (2025a).

Master-System	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
D20 – PLUMBING	39	$2,876.66	$73.76	$55.80	$0.00	$274.97	69.36
D30 – HVAC	1958	$132,567.75	$67.71	$44.49	$0.00	$2,575.81	169.68
D40 – FIRE PROTECTION	2	$159.61	$79.81	$79.81	$0.00	$159.61	112.86
D50 – ELECTRICAL	94	$4,723.24	$50.25	$0.00	$0.00	$279.23	73.06
F10 – SPECIAL CONSTRUCTION	4	$102.46	$25.61	$0.00	$0.00	$102.46	51.23
System	**Observations**	**Totals**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
D2020 – DOMESTIC WATER DISTRIBUTION	40	$2,876.66	$71.92	$55.53	$0.00	$274.97	69.45
D3020 – HEAT GENERATING SYSTEMS	4	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3030 – COOLING GENERATING SYSTEMS	96	$4,981.51	$51.89	$43.73	$0.00	$189.42	50.28
D3040 – DISTRIBUTION SYSTEMS	1665	$118,298.94	$71.05	$44.49	$0.00	$2,575.81	182.66
D3050 – TERMINAL & PACKAGE UNITS	180	$8,827.02	$49.04	$44.69	$0.00	$189.93	48.59
D3060 – CONTROLS & INSTRUMENTATION	12	$460.27	$38.36	$22.49	$0.00	$110.12	41.75
D4010 – SPRINKLERS	2	$159.61	$79.81	$79.81	$0.00	$159.61	112.86
D5010 – ELECTRICAL SERVICE & DISTRIBUTION	32	$101.02	$3.16	$0.00	$0.00	$50.51	12.42
D5090 – OTHER ELECTRICAL SYSTEMS	62	$4,622.23	$74.55	$81.32	$0.00	$279.23	79.34
F1040 – SPECIAL FACILITIES	3	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
F1050 – SPECIAL CONTROLS AND INSTRUMENTATION	1	$102.46	102.45589	102.45589	102.45589	102.45589	N/A
Subsystem	**Observations**	**Sum**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
D2020901 – BOOSTER PUMP	1	$42.13	$42.13	$42.13	$42.13	$42.13	N/A
D2020902 – STORAGE TANK	26	$2,209.49	$84.98	$80.83	$0.00	$198.50	66.84

D2020903 – BACKFLOW PREVENTER	13	$625.04	$48.08	$45.04	$0.00	$274.97	72.86
D3020130 – BOILER CAST IRON HOT WATER GAS	4	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3030135 – CHILLER, RECIP, AIR COOLED	30	$1,284.23	$42.81	$0.00	$0.00	$180.23	55.65
D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED	14	$574.99	$41.07	$24.78	$0.00	$100.52	45.24
D3030221 – CONDENSING UNIT, AIR COOLED	33	$1,899.08	$57.55	$44.95	$7.15	$159.35	33.36
D3030310 – COOLING TOWER, GALVANIZED	6	$451.07	$75.18	$69.40	$0.00	$173.49	70.83
D3030901 – CONDENSER, DX, AIR COOLED	4	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3030903 – PACKAGED DX REFRIGERANT SYSTEM	9	$772.14	$85.79	$65.41	$22.08	$189.42	64.74
D3040106 – AIR HANDLING UNIT, FIELD FAB	10	$2,189.61	$218.96	$143.43	$67.53	$1,030.32	287.12
D3040110 – AIR HANDLING UNIT, CENTRAL STA	211	$45,770.09	$216.92	$148.01	$0.00	$2,575.81	337.37
D3040114 – AIR HANDLING UNIT, ROOFTOP	6	$3,432.00	$572.00	$195.97	$176.77	$1,335.12	591.15
D3040118 – FAN COIL A/C, CAB MNT, TWO PIPE	2	$99.86	$49.93	$49.93	$49.55	$50.31	0.54
D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE	86	$4,730.50	$55.01	$24.77	$0.00	$283.91	62.65
D3040132 – VAV TERMINAL	1072	$42,101.99	$39.27	$24.77	$0.00	$2,464.90	114.71
D3040136 – VAV TERMINAL, FAN POWERED	8	$1,505.09	$188.14	$68.45	$45.64	$1,042.48	345.54
D3040220 – FAN SYSTEM, CENTRIFUGAL	62	$6,959.79	$112.25	$71.04	$0.00	$1,213.67	158.04
D3040330 – CIRCULATING PUMP, END SUCTION	152	$10,911.16	$71.78	$45.64	$0.00	$2,135.96	173.98
D3040340 – CIRCULATING PUMP, DOUBLE SUCTION	35	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3040610 – HEAT EXCHANGER, PLATE TYPE	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
D3040620 – HEAT EXCHANGER, SHELL TUBE	8	$146.13	$18.27	$0.00	$0.00	$48.71	25.21
D3040902 – HUMIDIFIER	12	$452.73	$37.73	$37.73	$0.00	$75.46	39.41
D3050120 – UNIT HEATERS, GAS	3	$67.41	$22.47	$0.00	$0.00	$67.41	38.92
D3050130 – UNIT HEATERS, HYDRONIC	16	$727.22	$45.45	$48.71	$0.00	$87.74	35.89
D3050170 – SPLIT SYSTEMS AIR COOLED CONDENSE UNIT	40	$3,633.62	$90.84	$89.38	$22.81	$189.93	46.59
D3050175 – ROOFTOP A/C	2	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3050185 – COMPUTER ROOM COOLING UNITS	99	$3,178.73	$32.11	$0.00	$0.00	$134.07	41.37
D3050201 – PKG A/C, AIR COOLED, ELEC HEAT	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A

D3050901 – UNIT HEATERS, ELECTRIC	15	$1,122.62	$74.84	$52.14	$22.47	$161.86	42.45
D3050905 – HYDRONIC HEATING – FIN TUBE	4	$97.42	$24.36	$24.36	$0.00	$48.71	28.12
D3060901 – HVAC CONTROLS, ELECTRIC, DIGITAL	3	$183.14	$61.05	$50.51	$35.38	$97.25	32.25
D3060903 – AIR COMPRESSOR	7	$67.37	$9.62	$0.00	$0.00	$22.51	12.00
D3060905 – DIRECT DIGITAL CONTROL (DDC) SYSTEM	2	$209.75	$104.88	$104.88	$99.63	$110.12	7.41
D4010410 – WET PIPE SPRINKLER SYSTEMS	2	$159.61	$79.81	$79.81	$0.00	$159.61	112.86
D5010999 – OTHER	32	$101.02	$3.16	$0.00	$0.00	$50.51	12.42
D5090210 – GENERATORS	62	$4,622.23	$74.55	$81.32	$0.00	$279.23	79.34
F104002 – OTHER	3	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
F105002 – OTHER	1	$102.46	$102.46	$102.46	$102.46	$102.46	N/A

Table 6. Naval Support Activity Dahlgren, B218, B1450, B1452, B1490, B1610. Adapted from NAVFAC (2025a).

Master-System	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
B30 – ROOFING	17	$4,825.15	$283.83	$297.03	$72.91	$572.85	150.97
D20 – PLUMBING	186	$11,446.88	$61.54	$38.89	$0.00	$298.34	63.66
D30 – HVAC	4746	$330,976.48	$69.74	$56.52	$0.00	$2,122.91	99.59
D50 – ELECTRICAL	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F10 – SPECIAL CONSTRUCTION	33	$3,932.15	$119.16	$0.00	$0.00	$676.68	190.43
OTHER	72	$3,474.68	$48.26	$0.00	$0.00	$369.76	91.88

System	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
B3010 – ROOF COVERINGS	17	$4,825.15	$283.83	$297.03	$297.03	$572.85	150.97
D2020 – DOMESTIC WATER DISTRIBUTION	186	$11,446.88	$61.54	$38.89	$38.89	$298.34	63.66
D3020 – HEAT GENERATING SYSTEMS	92	$20,079.55	$218.26	$0.00	$0.00	$2,122.91	459.24
D3030 – COOLING GENERATING SYSTEMS	310	$27,392.34	$88.36	$56.33	$56.33	$1,630.00	143.25
D3040 – DISTRIBUTION SYSTEMS	3949	$257,667.88	$65.25	$56.63	$56.63	$502.42	66.34
D3050 – TERMINAL & PACKAGE UNITS	334	$21,022.93	$62.94	$56.00	$56.00	$453.30	68.19
D3060 – CONTROLS & INSTRUMENTATION	61	$4,813.78	$78.91	$87.69	$87.69	$453.30	78.34
D5095 – OTHER ELECTRICAL SYSTEMS	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F1040 – SPECIAL FACILITIES	33	$3,932.15	$119.16	$0.00	$0.00	$676.68	190.43
OTHER	72	$3,474.68	$48.26	$0.00	$0.00	$369.76	91.88

Subsystem	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
B3010610 – GUTTERS	17	$4,825.15	$283.83	$297.03	$297.03	$572.85	150.97
D2020902 – STORAGE TANK	2	$298.34	$149.17	$149.17	$149.17	$298.34	210.96
D2020906 – CIRCULATING PUMP	184	$11,148.54	$60.59	$38.89	$38.89	$243.76	61.40
D3020130 – BOILER CAST IRON HOT WATER GAS	3	$389.79	$129.93	$193.89	$193.89	$195.90	112.53
D3020136 – BOILER, CAST IRON HT WTR GAS/ OIL	7	$9.73	$1.39	$0.00	$0.00	$9.73	3.68

D3020901 – BOILER, CAST IRON, HT WTR, OIL	82	$19,680.04	$240.00	$0.00	$0.00	$2,122.91	481.45
D3030120 – CHILLER, SCROLL, AIR COOLED	27	$2,507.84	$92.88	$74.66	$74.66	$395.48	92.21
D3030130 – CHILLER, RECIP, WATER COOLED	8	$666.52	$83.31	$37.33	$37.33	$321.87	113.45
D3030135 – CHILLER, RECIP, AIR COOLED	21	$760.62	$36.22	$0.00	$0.00	$172.78	59.96
D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED	16	$1,123.26	$70.20	$28.41	$28.41	$297.85	99.55
D3030160 – CHILLER, SCREW, AIR COOLED	38	$6,071.62	$159.78	$98.44	$98.44	$666.05	183.28
D3030221 – CONDENSING UNIT, AIR COOLED	37	$4,931.54	$133.28	$62.07	$62.07	$1,630.00	277.81
D3030225 – SPLIT DUCTLESS HEAT PUMP, OUTDOOR UNIT	8	$478.11	$59.76	$79.69	$79.69	$79.69	36.89
D3030310 – COOLING TOWER, GALVANIZED	48	$4,985.00	$103.85	$4.86	$4.86	$472.38	146.04
D3030901 – CONDENSER, DX, AIR COOLED	64	$3,903.16	$60.99	$56.33	$56.33	$185.72	55.04
D3030903 – PACKAGED DX REFRIGERANT SYSTEM	20	$1,136.96	$56.85	$56.63	$56.63	$169.08	61.55
D3040106 – AIR HANDLING UNIT, FIELD FAB	71	$8,477.52	$119.40	$77.79	$77.79	$502.42	144.54
D3040110 – AIR HANDLING UNIT, CENTRAL STA	87	$7,049.30	$81.03	$69.27	$69.27	$339.98	77.33
D3040112 – AIR HANDLING UNIT, COMPUTER ROOM	88	$7,308.82	$83.05	$47.71	$47.71	$351.92	97.94
D3040114 – AIR HANDLING UNIT, ROOFTOP	109	$11,168.36	$102.46	$98.44	$98.44	$362.91	82.46
D3040118 – FAN COIL A/C, CAB MNT, TWO PIPE	239	$16,326.27	$68.31	$58.34	$58.34	$243.76	60.28
D3040122 – FAN COIL A/C, CAB MNT, FOUR PIPE	2	$72.71	$36.35	$36.35	$36.35	$72.71	51.41
D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE	389	$8,872.34	$22.81	$0.00	$0.00	$188.88	39.50
D3040132 – VAV TERMINAL	86	$5,790.84	$67.34	$71.13	$71.13	$356.71	63.87
D3040136 – VAV TERMINAL, FAN POWERED	2002	$136,059.85	$67.96	$62.15	$62.15	$362.91	59.50
D3040220 – FAN SYSTEM, CENTRIFUGAL	170	$11,461.75	$67.42	$38.89	$38.89	$351.92	75.62
D3040230 – FAN SYSTEM, AXIAL	60	$4,043.40	$67.39	$47.52	$47.52	$351.92	84.60
D3040240 – FAN SYSTEM, ROOF EXHAUST	107	$6,973.45	$65.17	$69.27	$69.27	$151.12	50.21
D3040330 – CIRCULATING PUMP, END SUCTION	313	$16,918.17	$54.05	$55.00	$55.00	$376.97	63.62
D3040610 – HEAT EXCHANGER, PLATE TYPE	16	$654.89	$40.93	$28.26	$28.26	$101.04	44.68
D3040901 – DEHUMIDIFIER	4	$317.74	$79.43	$79.15	$79.15	$103.43	19.59
D3040902 – HUMIDIFIER	20	$1,691.98	$84.60	$88.17	$88.17	$243.76	69.95

D3040904 – SPLIT DUCTLESS SYSTEM, INDOOR UNIT	222	$15,502.48	$69.83	$69.27	$69.27	$248.26	59.52
D3050120 – UNIT HEATERS, GAS	19	$1,917.94	$100.94	$121.69	$121.69	$121.69	31.37
D3050130 – UNIT HEATERS, HYDRONIC	4	$474.01	$118.50	$130.73	$130.73	$212.54	87.92
D3050175 – ROOFTOP A/C	14	$1,057.90	$75.56	$90.63	$90.63	$124.08	44.45
D3050176 – ROOFTOP AIR CONDITIONER, ELECTRIC HEAT	7	$534.40	$76.34	$80.29	$80.29	$124.55	41.21
D3050180 – ROOFTOP AIR CONDITIONER, VARIABLE AIR VOLUME	3	$131.30	$43.77	$58.59	$58.59	$72.71	38.55
D3050185 – COMPUTER ROOM COOLING UNITS	251	$16,179.24	$64.46	$55.00	$55.00	$453.30	72.42
D3050201 – PKG A/C, AIR COOLED, ELEC HEAT	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
D3050210 – PKG A/C, WATER COOLED, ELEC HEAT	10	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3050230 – HEAT PUMP, WTR SOURCE, CENT STA	7	$456.28	$65.18	$80.29	$80.29	$151.10	54.90
D3050901 – UNIT HEATERS, ELECTRIC	5	$77.58	$15.52	$0.00	$0.00	$77.58	34.69
D3060901 – HVAC CONTROLS, ELECTRIC, DIGITAL	32	$3,107.69	$97.12	$90.63	$90.63	$453.30	93.16
D3060903 – AIR COMPRESSOR	28	$1,706.09	$60.93	$62.80	$62.80	$161.23	52.09
D3060904 – AIR DRYER	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
D5095230 – UNINTERRUPTIBLE POWER SYSTEM	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F104002 – OTHER	33	$3,932.15	$119.16	$0.00	$0.00	$676.68	190.43
OTHER	72	$3,474.68	$48.26	$0.00	$0.00	$369.76	91.88

Table 7. Observed facilities, combined. Adapted from NAVFAC (2025a).

Master-System	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
B30 – ROOFING	17	$4,825.15	$283.83	$297.03	$72.91	$572.85	150.97
D20 – PLUMBING	225	$14,323.54	$63.66	$55.26	$0.00	$298.34	64.69
D30 – HVAC	6704	$463,544.23	$69.14	$49.39	$0.00	$2,575.81	124.21
D40 – FIRE PROTECTION	2	$159.61	$79.81	$79.81	$0.00	$159.61	112.86
D50 – ELECTRICAL	95	$4,723.24	$49.72	$0.00	$0.00	$279.23	72.85
F10 – SPECIAL CONSTRUCTION	37	$4,034.61	$109.04	$0.00	$0.00	$676.68	182.54
OTHER	72	$3,474.68	$48.26	$0.00	$0.00	$369.76	91.88
[redacted]							
System	**Observations**	**Totals**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
B3010 – ROOF COVERINGS	17	$4,825.15	$283.83	$297.03	$72.91	$572.85	150.97
D2020 – DOMESTIC WATER DISTRIBUTION	226	$14,323.54	$63.38	$55.26	$0.00	$298.34	64.69
D3020 – HEAT GENERATING SYSTEMS	96	$20,079.55	$209.16	$0.00	$0.00	$2,122.91	451.60
D3030 – COOLING GENERATING SYSTEMS	406	$32,373.85	$79.74	$44.95	$0.00	$1,630.00	128.42
D3040 – DISTRIBUTION SYSTEMS	5614	$375,966.82	$66.97	$49.54	$0.00	$2,575.81	113.99
D3050 – TERMINAL & PACKAGE UNITS	514	$29,849.96	$58.07	$44.81	$0.00	$453.30	62.34
D3060 – CONTROLS & INSTRUMENTATION	73	$5,274.05	$72.25	$69.27	$0.00	$453.30	74.89
D4010 – SPRINKLERS	2	$159.61	$79.81	$79.81	$0.00	$159.61	112.86
D5010 – ELECTRICAL SERVICE & DISTRIBUTION	32	$101.02	$3.16	$0.00	$0.00	$50.51	12.42
D5090 – OTHER ELECTRICAL SYSTEMS	62	$4,622.23	$74.55	$81.32	$0.00	$279.23	79.34
D5095 – OTHER ELECTRICAL SYSTEMS	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F1040 – SPECIAL FACILITIES	36	$3,932.15	$109.23	$0.00	$0.00	$676.68	185.12
F1050 – SPECIAL CONTROLS AND INSTRUMENTATION	1	$102.46	$102.46	$102.46	$102.46	$102.46	N/A
OTHER	72	$3,474.68	$48.26	$0.00	$0.00	$369.76	91.88
[redacted]							

Subsystem	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
B3010610 – GUTTERS	17	$4,825.15	$283.83	$297.03	$72.91	$572.85	150.97
D2020901 – BOOSTER PUMP	1	$42.13	$42.13	$42.13	$42.13	$42.13	N/A
D2020902 – STORAGE TANK	28	$2,507.83	$89.57	$80.83	$0.00	$298.34	77.90
D2020903 – BACKFLOW PREVENTER	13	$625.04	$48.08	$45.04	$0.00	$274.97	72.86
D2020906 – CIRCULATING PUMP	184	$11,148.54	$60.59	$38.89	$0.00	$243.76	61.40
D3020130 – BOILER CAST IRON HOT WATER GAS	7	$389.79	$55.68	$0.00	$0.00	$195.90	95.10
D3020136 – BOILER, CAST IRON HT WTR GAS/ OIL	7	$9.73	$1.39	$0.00	$0.00	$9.73	3.68
D3020901 – BOILER, CAST IRON, HT WTR, OIL	82	$19,680.04	$240.00	$0.00	$0.00	$2,122.91	481.45
D3030120 – CHILLER, SCROLL, AIR COOLED	27	$2,507.84	$92.88	$74.66	$0.00	$395.48	92.21
D3030130 – CHILLER, RECIP, WATER COOLED	8	$666.52	$83.31	$37.33	$0.00	$321.87	113.45
D3030135 – CHILLER, RECIP, AIR COOLED	51	$2,044.85	$40.10	$0.00	$0.00	$180.23	56.96
D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED	30	$1,698.25	$56.61	$28.41	$0.00	$297.85	79.13
D3030160 – CHILLER, SCREW, AIR COOLED	38	$6,071.62	$159.78	$98.44	$0.00	$666.05	183.28
D3030221 – CONDENSING UNIT, AIR COOLED	70	$6,830.62	$97.58	$44.95	$0.00	$1,630.00	205.50
D3030225 – SPLIT DUCTLESS HEAT PUMP, OUTDOOR UNIT	8	$478.11	$59.76	$79.69	$0.00	$79.69	36.89
D3030310 – COOLING TOWER, GALVANIZED	54	$5,436.08	$100.67	$9.73	$0.00	$472.38	139.54
D3030901 – CONDENSER, DX, AIR COOLED	68	$3,903.16	$57.40	$56.33	$0.00	$185.72	55.30
D3030903 – PACKAGED DX REFRIGERANT SYSTEM	29	$1,909.10	$65.83	$56.63	$0.00	$189.42	62.88
D3040106 – AIR HANDLING UNIT, FIELD FAB	81	$10,667.12	$131.69	$90.03	$0.00	$1,030.32	169.23
D3040110 – AIR HANDLING UNIT, CENTRAL STA	298	$52,819.39	$177.25	$123.08	$0.00	$2,575.81	293.32
D3040112 – AIR HANDLING UNIT, COMPUTER ROOM	88	$7,308.82	$83.05	$47.71	$0.00	$351.92	97.94
D3040114 – AIR HANDLING UNIT, ROOFTOP	115	$14,600.37	$126.96	$113.33	$0.00	$1,335.12	181.02
D3040118 – FAN COIL A/C, CAB MNT, TWO PIPE	241	$16,426.13	$68.16	$58.34	$0.00	$243.76	60.05
D3040122 – FAN COIL A/C, CAB MNT, FOUR PIPE	2	$72.71	$36.35	$36.35	$0.00	$72.71	51.41
D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE	475	$13,602.83	$28.64	$0.00	$0.00	$283.91	46.21
D3040132 – VAV TERMINAL	1158	$47,892.83	$41.36	$34.26	$0.00	$2,464.90	111.96

D3040136 – VAV TERMINAL, FAN POWERED	2010	$137,564.95	$68.44	$62.15	$0.00	$1,042.48	63.24
D3040220 – FAN SYSTEM, CENTRIFUGAL	232	$18,421.54	$79.40	$69.16	$0.00	$1,213.67	105.71
D3040230 – FAN SYSTEM, AXIAL	60	$4,043.40	$67.39	$47.52	$0.00	$351.92	84.60
D3040240 – FAN SYSTEM, ROOF EXHAUST	107	$6,973.45	$65.17	$69.27	$0.00	$151.12	50.21
D3040330 – CIRCULATING PUMP, END SUCTION	465	$27,829.33	$59.85	$48.37	$0.00	$2,135.96	112.43
D3040340 – CIRCULATING PUMP, DOUBLE SUCTION	35	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3040610 – HEAT EXCHANGER, PLATE TYPE	17	$654.89	$38.52	$0.00	$0.00	$101.04	44.39
D3040620 – HEAT EXCHANGER, SHELL TUBE	8	$146.13	$18.27	$0.00	$0.00	$48.71	25.21
D3040901 – DEHUMIDIFIER	4	$317.74	$79.43	$79.15	$56.00	$103.43	19.59
D3040902 – HUMIDIFIER	32	$2,144.72	$67.02	$75.46	$0.00	$243.76	63.88
D3040904 – SPLIT DUCTLESS SYSTEM, INDOOR UNIT	222	$15,502.48	$69.83	$69.27	$0.00	$248.26	59.52
D3050120 – UNIT HEATERS, GAS	22	$1,985.36	$90.24	$121.69	$0.00	$121.69	41.80
D3050130 – UNIT HEATERS, HYDRONIC	20	$1,201.22	$60.06	$48.71	$0.00	$212.54	56.00
D3050170 – SPLIT SYSTEMS AIR COOLED CONDENSE UNIT	40	$3,633.62	$90.84	$89.38	$22.81	$189.93	46.59
D3050175 – ROOFTOP A/C	16	$1,057.90	$66.12	$85.46	$0.00	$124.08	48.77
D3050176 – ROOFTOP AIR CONDITIONER, ELECTRIC HEAT	7	$534.40	$76.34	$80.29	$0.00	$124.55	41.21
D3050180 – ROOFTOP AIR CONDITIONER, VARIABLE AIR VOLUME	3	$131.30	$43.77	$58.59	$0.00	$72.71	38.55
D3050185 – COMPUTER ROOM COOLING UNITS	350	$19,357.98	$55.31	$38.86	$0.00	$453.30	66.71
D3050201 – PKG A/C, AIR COOLED, ELEC HEAT	2	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3050210 – PKG A/C, WATER COOLED, ELEC HEAT	10	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3050230 – HEAT PUMP, WTR SOURCE, CENT STA	7	$456.28	$65.18	$80.29	$0.00	$151.10	54.90
D3050901 – UNIT HEATERS, ELECTRIC	20	$1,200.20	$60.01	$49.54	$0.00	$161.86	47.71
D3050905 – HYDRONIC HEATING – FIN TUBE	4	$97.42	$24.36	$24.36	$0.00	$48.71	28.12
D3060901 – HVAC CONTROLS, ELECTRIC, DIGITAL	35	$3,290.83	$94.02	$90.63	$0.00	$453.30	89.88
D3060903 – AIR COMPRESSOR	35	$1,773.46	$50.67	$41.44	$0.00	$161.23	51.13
D3060904 – AIR DRYER	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A

D3060905 – DIRECT DIGITAL CONTROL (DDC) SYSTEM	2	$209.75	$104.88	$104.88	$99.63	$110.12	7.41
D4010410 – WET PIPE SPRINKLER SYSTEMS	2	$159.61	$79.81	$79.81	$0.00	$159.61	112.86
D5010999 – OTHER	32	$101.02	$3.16	$0.00	$0.00	$50.51	12.42
D5090210 – GENERATORS	62	$4,622.23	$74.55	$81.32	$0.00	$279.23	79.34
D5095230 – UNINTERRUPTIBLE POWER SYSTEM	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F104002 – OTHER	36	$3,932.15	$109.23	$0.00	$0.00	$676.68	185.12
F105002 – OTHER	1	$102.46	$102.46	$102.46	$102.46	$102.46	N/A
OTHER	72	$3,474.68	$48.26	$0.00	$0.00	$369.76	91.88

APPENDIX B. SUMMARY STATS, CONSOLIDATED PM DATA

Table 8. Washington Navy Yard, B104, B176, B200, B201. Adapted from NAVFAC (2025a).

Master-System	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
D20 – PLUMBING	10	$2,876.66	$287.67	$55.26	$0.00	$2,209.49	681.55
D30 – HVAC	904	$132,567.75	$146.65	$69.48	$0.00	$3,104.18	333.82
D40 – FIRE PROTECTION	1	$159.61	$159.61	$159.61	$159.61	$159.61	N/A
D50 – ELECTRICAL	7	$4,723.24	$674.75	$50.51	$0.00	$2,765.26	1148.41
F10 – SPECIAL CONSTRUCTION	1	$102.46	$102.46	$102.46	$102.46	$102.46	N/A
	0						
System	**Observations**	**Totals**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
D2020 – DOMESTIC WATER DISTRIBUTION	10	$2,876.66	$287.67	$55.26	$0.00	$2,209.49	681.55
D3030 – COOLING GENERATING SYSTEMS	35	$4,981.51	$142.33	$99.08	$44.95	$501.76	125.65
D3040 – DISTRIBUTION SYSTEMS	799	$118,298.94	$148.06	$67.56	$0.00	$3,104.18	351.65
D3050 – TERMINAL & PACKAGE UNITS	65	$8,827.02	$135.80	$84.38	$0.00	$594.04	144.87
D3060 – CONTROLS & INSTRUMENTATION	5	$460.27	$92.05	$67.37	$0.00	$209.75	99.63
D4010 – SPRINKLERS	1	$159.61	$159.61	$159.61	$159.61	$159.61	N/A
D5010 – ELECTRICAL SERVICE & DISTRIBUTION	5	$101.02	$20.20	$0.00	$0.00	$50.51	27.66
D5090 – OTHER ELECTRICAL SYSTEMS	2	$4,622.23	$2,311.11	$2,311.11	$1,856.97	$2,765.26	642.26
F1050 – SPECIAL CONTROLS AND INSTRUMENTATION	1	$102.46	$102.46	$102.46	$102.46	$102.46	N/A
Subsystem	**Observations**	**Sum**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
D2020901 – BOOSTER PUMP	1	$42.13	$42.13	$42.13	$42.13	$42.13	N/A
D2020902 – STORAGE TANK	1	$2,209.49	$2,209.49	$2,209.49	$2,209.49	$2,209.49	N/A
D2020903 – BACKFLOW PREVENTER	8	$625.04	$78.13	$55.26	$0.00	$330.77	103.93
D3030135 – CHILLER, RECIP, AIR COOLED	3	$1,284.23	$428.08	$398.01	$398.01	$488.21	52.07

D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED	3	$574.99	$191.66	$191.66	$91.84	$291.49	99.83
D3030221 – CONDENSING UNIT, AIR COOLED	22	$1,899.08	$86.32	$69.69	$44.95	$191.15	39.80
D3030310 – COOLING TOWER, GALVANIZED	4	$451.07	$112.77	$104.09	$69.40	$173.49	52.05
D3030903 – PACKAGED DX REFRIGERANT SYSTEM	3	$772.14	$257.38	$224.66	$45.71	$501.76	229.78
D3040106 – AIR HANDLING UNIT, FIELD FAB	2	$2,189.61	$1,094.80	$1,094.80	$679.05	$1,510.55	587.96
D3040110 – AIR HANDLING UNIT, CENTRAL STA	38	$45,770.09	$1,204.48	$1,166.09	$0.00	$3,104.18	807.50
D3040114 – AIR HANDLING UNIT, ROOFTOP	2	$3,432.00	$1,716.00	$1,716.00	$1,704.96	$1,727.05	15.62
D3040118 – FAN COIL A/C, CAB MNT, TWO PIPE	1	$99.86	$99.86	$99.86	$99.86	$99.86	N/A
D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE	38	$4,730.50	$124.49	$45.02	$0.00	$716.85	171.59
D3040132 – VAV TERMINAL	578	$42,101.99	$72.84	$49.64	$0.00	$2,506.81	152.86
D3040136 – VAV TERMINAL, FAN POWERED	8	$1,505.09	$188.14	$68.45	$45.64	$1,042.48	345.54
D3040220 – FAN SYSTEM, CENTRIFUGAL	37	$6,959.79	$188.10	$162.20	$35.79	$1,284.56	204.98
D3040330 – CIRCULATING PUMP, END SUCTION	83	$10,911.16	$131.46	$90.84	$0.00	$2,135.96	238.22
D3040620 – HEAT EXCHANGER, SHELL TUBE	6	$146.13	$24.36	$24.36	$0.00	$48.71	26.68
D3040902 – HUMIDIFIER	6	$452.73	$75.46	$75.46	$75.46	$75.46	0.00
D3050120 – UNIT HEATERS, GAS	1	$67.41	$67.41	$67.41	$67.41	$67.41	N/A
D3050130 – UNIT HEATERS, HYDRONIC	5	$682.27	$136.45	$136.45	$136.45	$136.45	0.00
D3050170 – SPLIT SYSTEMS AIR COOLED CONDENSE UNIT	8	$3,633.62	$454.20	$492.28	$264.37	$594.04	111.81
D3050185 – COMPUTER ROOM COOLING UNITS	34	$3,178.73	$93.49	$79.22	$0.00	$322.02	92.85
D3050901 – UNIT HEATERS, ELECTRIC	15	$1,167.57	$77.84	$52.14	$22.47	$161.86	45.51
D3050905 – HYDRONIC HEATING – FIN TUBE	2	$97.42	$48.71	$48.71	$48.71	$48.71	0.00
D3060901 – HVAC CONTROLS, ELECTRIC, DIGITAL	1	$183.14	$183.14	$183.14	$183.14	$183.14	N/A
D3060903 – AIR COMPRESSOR	1	$67.37	$67.37	$67.37	$67.37	$67.37	N/A
D3060905 – DIRECT DIGITAL CONTROL (DDC) SYSTEM	3	$209.75	$69.92	$0.00	$0.00	$209.75	121.10
D4010410 – WET PIPE SPRINKLER SYSTEMS	1	$159.61	$159.61	$159.61	$159.61	$159.61	N/A
D5010999 – OTHER	5	$101.02	$20.20	$0.00	$0.00	$50.51	27.66
D5090210 – GENERATORS	2	$4,622.23	$2,311.11	$2,311.11	$1,856.97	$2,765.26	642.26

Table 9. Naval Support Activity Dahlgren, B218, B1450, B1452, B1490, B1610. Adapted from NAVFAC (2025a).

Master-System	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
B30 – ROOFING	4	$4,825.15	$1,206.29	$1,470.69	$108.19	$1,775.59	752.48
D20 – PLUMBING	25	$11,446.88	$457.88	$479.91	$0.00	$628.55	121.34
D30 – HVAC	1263	$330,976.48	$262.06	$72.71	$0.00	$3,114.56	346.39
D50 – ELECTRICAL	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F10 – SPECIAL CONSTRUCTION	7	$3,932.15	$561.74	$676.68	$168.18	$768.69	244.40
OTHER	5	$3,474.68	$694.94	$211.73	$0.00	$2,325.72	956.57
System	**Observations**	**Totals**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
B3010 – ROOF COVERINGS	4	$4,825.15	$1,206.29	$1,470.69	$1,470.69	$1,775.59	752.48
D2020 – DOMESTIC WATER DISTRIBUTION	25	$11,446.88	$457.88	$479.91	$479.91	$628.55	121.34
D3020 – HEAT GENERATING SYSTEMS	13	$20,079.55	$1,544.58	$1,904.96	$1,904.96	$3,114.56	1164.50
D3030 – COOLING GENERATING SYSTEMS	72	$27,392.34	$380.45	$137.45	$137.45	$1,984.43	442.89
D3040 – DISTRIBUTION SYSTEMS	1059	$257,667.88	$243.31	$71.13	$71.13	$1,579.75	290.69
D3050 – TERMINAL & PACKAGE UNITS	103	$21,022.93	$204.11	$56.00	$56.00	$1,059.74	278.38
D3060 – CONTROLS & INSTRUMENTATION	16	$4,813.78	$300.86	$346.72	$346.72	$649.01	228.79
D5095 – OTHER ELECTRICAL SYSTEMS	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F1040 – SPECIAL FACILITIES	7	$3,932.15	$561.74	$676.68	$676.68	$768.69	244.40
OTHER	5	$3,474.68	$694.94	$211.73	$211.73	$2,325.72	956.57
Subsystem	**Observations**	**Totals**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
B3010610 – GUTTERS	4	$4,825.15	$1,206.29	$1,470.69	$108.19	$1,775.59	752.48
D2020902 – STORAGE TANK	2	$298.34	$149.17	$149.17	$0.00	$298.34	210.96
D2020906 – CIRCULATING PUMP	23	$11,148.54	$484.72	$480.51	$361.24	$628.55	68.00
D3020130 – BOILER CAST IRON HOT WATER GAS	1	$1,671.94	$1,671.94	$1,671.94	$1,671.94	$1,671.94	N/A
D3020136 – BOILER, CAST IRON HT WTR GAS/OIL	3	$0.00	$0.00	$0.00	$0.00	$0.00	0.00

D3020901 – BOILER, CAST IRON, HT WTR, OIL	9	$18,407.62	$2,045.29	$1,934.04	$0.00	$3,114.56	924.86
D3030120 – CHILLER, SCROLL, AIR COOLED	4	$2,507.84	$626.96	$581.98	$491.61	$852.26	165.15
D3030130 – CHILLER, RECIP, WATER COOLED	1	$666.52	$666.52	$666.52	$666.52	$666.52	N/A
D3030135 – CHILLER, RECIP, AIR COOLED	11	$760.62	$69.15	$38.86	$0.00	$211.63	85.85
D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED	2	$1,123.26	$561.63	$561.63	$522.83	$600.43	54.87
D3030160 – CHILLER, SCREW, AIR COOLED	5	$6,071.62	$1,214.32	$1,012.23	$811.57	$1,984.43	478.20
D3030221 – CONDENSING UNIT, AIR COOLED	15	$4,950.97	$330.06	$62.07	$0.00	$1,630.00	514.33
D3030225 – SPLIT DUCTLESS HEAT PUMP, OUTDOOR UNIT	8	$478.11	$59.76	$79.69	$0.00	$79.69	36.89
D3030310 – COOLING TOWER, GALVANIZED	6	$4,985.00	$830.83	$925.97	$0.00	$1,269.19	447.35
D3030901 – CONDENSER, DX, AIR COOLED	8	$3,883.73	$485.47	$523.33	$310.37	$548.96	85.69
D3030903 – PACKAGED DX REFRIGERANT SYSTEM	2	$1,136.96	$568.48	$568.48	$531.13	$605.83	52.83
D3040106 – AIR HANDLING UNIT, FIELD FAB	22	$10,422.56	$473.75	$51.71	$0.00	$1,579.75	570.46
D3040110 – AIR HANDLING UNIT, CENTRAL STA	17	$5,104.26	$300.25	$75.55	$0.00	$881.50	333.93
D3040112 – AIR HANDLING UNIT, COMPUTER ROOM	15	$7,308.82	$487.25	$603.20	$9.73	$855.90	295.76
D3040114 – AIR HANDLING UNIT, ROOFTOP	13	$11,168.36	$859.10	$861.17	$608.45	$1,096.72	129.05
D3040118 – FAN COIL A/C, CAB MNT, TWO PIPE	30	$16,326.27	$544.21	$519.38	$288.46	$945.72	166.73
D3040122 – FAN COIL A/C, CAB MNT, FOUR PIPE	2	$72.71	$36.35	$36.35	$0.00	$72.71	51.41
D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE	389	$8,872.34	$22.81	$0.00	$0.00	$188.88	39.50
D3040132 – VAV TERMINAL	86	$5,790.84	$67.34	$71.13	$0.00	$356.71	63.87
D3040136 – VAV TERMINAL, FAN POWERED	316	$136,059.85	$430.57	$507.92	$0.00	$1,052.75	262.92
D3040220 – FAN SYSTEM, CENTRIFUGAL	52	$11,461.75	$220.42	$69.85	$0.00	$773.67	280.98
D3040230 – FAN SYSTEM, AXIAL	12	$4,043.40	$336.95	$252.97	$0.00	$833.18	354.86
D3040240 – FAN SYSTEM, ROOF EXHAUST	14	$6,973.45	$498.10	$483.69	$290.91	$682.20	125.55
D3040330 – CIRCULATING PUMP, END SUCTION	41	$16,918.17	$412.64	$398.93	$0.00	$1,186.47	208.38
D3040610 – HEAT EXCHANGER, PLATE TYPE	3	$654.89	$218.30	$157.56	$157.56	$339.76	105.19
D3040901 – DEHUMIDIFIER	4	$317.74	$79.43	$79.15	$56.00	$103.43	19.59
D3040902 – HUMIDIFIER	8	$1,691.98	$211.50	$222.52	$81.52	$338.58	80.08
D3040904 – SPLIT DUCTLESS SYSTEM, INDOOR UNIT	50	$15,502.48	$310.05	$359.57	$0.00	$841.72	279.80

D3050120 – UNIT HEATERS, GAS	19	$1,917.94	$100.94	$121.69	$56.00	$121.69	31.37
D3050130 – UNIT HEATERS, HYDRONIC	1	$474.01	$474.01	$474.01	$474.01	$474.01	N/A
D3050175 – ROOFTOP A/C	2	$1,057.90	$528.95	$528.95	$489.25	$568.64	56.14
D3050176 – ROOFTOP AIR CONDITIONER, ELECTRIC HEAT	1	$534.40	$534.40	$534.40	$534.40	$534.40	N/A
D3050180 – ROOFTOP AIR CONDITIONER, VARIABLE AIR VOLUME	2	$131.30	$65.65	$65.65	$58.59	$72.71	9.98
D3050185 – COMPUTER ROOM COOLING UNITS	61	$16,179.24	$265.23	$0.00	$0.00	$1,059.74	326.33
D3050210 – PKG A/C, WATER COOLED, ELEC HEAT	10	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3050230 – HEAT PUMP, WTR SOURCE, CENT STA	1	$456.28	$456.28	$456.28	$456.28	$456.28	N/A
D3050901 – UNIT HEATERS, ELECTRIC	1	$77.58	$77.58	$77.58	$77.58	$77.58	N/A
D3060901 – HVAC CONTROLS, ELECTRIC, DIGITAL	8	$3,107.69	$388.46	$364.03	$283.17	$631.62	111.44
D3060903 – AIR COMPRESSOR	7	$1,706.09	$243.73	$41.38	$0.00	$649.01	295.37
D3060904 – AIR DRYER	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
D5095230 – UNINTERRUPTIBLE POWER SYSTEM	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F104002 – OTHER	7	$3,932.15	$561.74	$676.68	$168.18	$768.69	244.40
OTHER	5	$3,474.68	$694.94	$211.73	$0.00	$2,325.72	956.57

Table 10. Observed facilities, combined. Adapted from NAVFAC (2025a).

Master-System	Observations	Totals	Mean	Median	Min	Max	Standard Deviation
B30 – ROOFING	4	$4,825.15	$1,206.29	$1,470.69	$108.19	$1,775.59	752.48
D20 – PLUMBING	35	$14,323.54	$409.24	$446.86	$0.00	$2,209.49	373.41
D30 – HVAC	2167	$461,767.06	$213.91	$71.13	$0.00	$3,114.56	345.84
D40 – FIRE PROTECTION	1	$0.00	$159.61	$159.61	$159.61	$159.61	N/A
D50 – ELECTRICAL	8	$0.00	$590.41	$25.25	$0.00	$2,765.26	1089.66
F10 – SPECIAL CONSTRUCTION	8	$3,932.15	$504.33	$553.72	$102.46	$768.69	278.51
OTHER	5	$3,474.68	$694.94	$211.73	$0.00	$2,325.72	956.57
System	**Observations**	**Totals**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
B3010 – ROOF COVERINGS	4	$4,825.15	$1,206.29	$1,470.69	$108.19	$1,775.59	752.48
D2020 – DOMESTIC WATER DISTRIBUTION	35	$14,323.54	$409.24	$446.86	$0.00	$2,209.49	373.41
D3020 – HEAT GENERATING SYSTEMS	13	$20,079.55	$1,544.58	$1,904.96	$0.00	$3,114.56	1164.50
D3030 – COOLING GENERATING SYSTEMS	107	$32,373.85	$302.56	$119.67	$0.00	$1,984.43	386.07
D3040 – DISTRIBUTION SYSTEMS	1858	$374,189.65	$202.35	$69.48	$0.00	$3,104.18	321.73
D3050 – TERMINAL & PACKAGE UNITS	168	$29,849.96	$177.68	$69.71	$0.00	$1,059.74	237.67
D3060 – CONTROLS & INSTRUMENTATION	21	$5,274.05	$251.15	$283.17	$0.00	$649.01	222.59
D4010 – SPRINKLERS	1	$0.00	$159.61	$159.61	$159.61	$159.61	N/A
D5010 – ELECTRICAL SERVICE & DISTRIBUTION	5	$0.00	$20.20	$0.00	$0.00	$50.51	27.66
D5090 – OTHER ELECTRICAL SYSTEMS	2	$0.00	$2,311.11	$2,311.11	$1,856.97	$2,765.26	642.26
D5095 – OTHER ELECTRICAL SYSTEMS	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F1040 – SPECIAL FACILITIES	7	$3,932.15	$561.74	$676.68	$168.18	$768.69	244.40
F1050 – SPECIAL CONTROLS AND INSTRUMENTATION	1	$0.00	$102.46	$102.46	$102.46	$102.46	N/A
OTHER	5	$3,474.68	$694.94	$211.73	$0.00	$2,325.72	956.57
Subsystem	**Observations**	**Totals**	**Mean**	**Median**	**Min**	**Max**	**Standard Deviation**
B3010610 – GUTTERS	4	$4,825.15	$1,206.29	$1,470.69	$108.19	$1,775.59	752.48
D2020901 – BOOSTER PUMP	1	$42.13	$42.13	$42.13	$42.13	$42.13	N/A

D2020902 – STORAGE TANK	3	$2,507.83	$835.94	$298.34	$0.00	$2,209.49	1198.84
D2020903 – BACKFLOW PREVENTER	8	$625.04	$78.13	$55.26	$0.00	$330.77	103.93
D2020906 – CIRCULATING PUMP	23	$11,148.54	$484.72	$480.51	$361.24	$628.55	68.00
D3020130 – BOILER CAST IRON HOT WATER GAS	1	$1,671.94	$1,671.94	$1,671.94	$1,671.94	$1,671.94	N/A
D3020136 – BOILER, CAST IRON HT WTR GAS/OIL	3	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3020901 – BOILER, CAST IRON, HT WTR, OIL	9	$18,407.62	$2,045.29	$1,934.04	$0.00	$3,114.56	924.86
D3030120 – CHILLER, SCROLL, AIR COOLED	4	$2,507.84	$626.96	$581.98	$491.61	$852.26	165.15
D3030130 – CHILLER, RECIP, WATER COOLED	1	$666.52	$666.52	$666.52	$666.52	$666.52	N/A
D3030135 – CHILLER, RECIP, AIR COOLED	14	$2,044.85	$146.06	$84.34	$0.00	$488.21	171.60
D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED	5	$1,698.25	$339.65	$291.49	$91.84	$600.43	216.33
D3030160 – CHILLER, SCREW, AIR COOLED	5	$6,071.62	$1,214.32	$1,012.23	$811.57	$1,984.43	478.20
D3030221 – CONDENSING UNIT, AIR COOLED	37	$6,850.05	$185.14	$69.69	$0.00	$1,630.00	344.27
D3030225 – SPLIT DUCTLESS HEAT PUMP, OUTDOOR UNIT	8	$478.11	$59.76	$79.69	$0.00	$79.69	36.89
D3030310 – COOLING TOWER, GALVANIZED	10	$5,436.08	$543.61	$468.38	$0.00	$1,269.19	499.58
D3030901 – CONDENSER, DX, AIR COOLED	8	$3,883.73	$485.47	$523.33	$310.37	$548.96	85.69
D3030903 – PACKAGED DX REFRIGERANT SYSTEM	5	$1,909.10	$381.82	$501.76	$45.71	$605.83	236.92
D3040106 – AIR HANDLING UNIT, FIELD FAB	24	$12,612.16	$525.51	$356.83	$0.00	$1,579.75	585.58
D3040110 – AIR HANDLING UNIT, CENTRAL STA	55	$50,874.35	$924.99	$820.91	$0.00	$3,104.18	810.96
D3040112 – AIR HANDLING UNIT, COMPUTER ROOM	15	$7,308.82	$487.25	$603.20	$9.73	$855.90	295.76
D3040114 – AIR HANDLING UNIT, ROOFTOP	15	$14,600.37	$973.36	$862.09	$608.45	$1,727.05	324.35
D3040118 – FAN COIL A/C, CAB MNT, TWO PIPE	31	$16,426.13	$529.88	$507.75	$99.86	$945.72	182.32
D3040122 – FAN COIL A/C, CAB MNT, FOUR PIPE	2	$72.71	$36.35	$36.35	$0.00	$72.71	51.41
D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE	427	$13,602.83	$31.86	$0.00	$0.00	$716.85	69.42
D3040132 – VAV TERMINAL	664	$47,892.83	$72.13	$66.29	$0.00	$2,506.81	144.44
D3040136 – VAV TERMINAL, FAN POWERED	324	$137,564.95	$424.58	$507.43	$0.00	$1,052.75	267.25
D3040220 – FAN SYSTEM, CENTRIFUGAL	89	$18,421.54	$206.98	$140.42	$0.00	$1,284.56	251.40
D3040230 – FAN SYSTEM, AXIAL	12	$4,043.40	$336.95	$252.97	$0.00	$833.18	354.86
D3040240 – FAN SYSTEM, ROOF EXHAUST	14	$6,973.45	$498.10	$483.69	$290.91	$682.20	125.55

D3040330 – CIRCULATING PUMP, END SUCTION	124	$27,829.33	$224.43	$166.37	$0.00	$2,135.96	263.81
D3040610 – HEAT EXCHANGER, PLATE TYPE	3	$654.89	$218.30	$157.56	$157.56	$339.76	105.19
D3040620 – HEAT EXCHANGER, SHELL TUBE	6	$146.13	$24.36	$24.36	$0.00	$48.71	26.68
D3040901 – DEHUMIDIFIER	4	$317.74	$79.43	$79.15	$56.00	$103.43	19.59
D3040902 – HUMIDIFIER	14	$2,144.72	$153.19	$108.56	$75.46	$338.58	91.29
D3040904 – SPLIT DUCTLESS SYSTEM, INDOOR UNIT	50	$15,502.48	$310.05	$359.57	$0.00	$841.72	279.80
D3050120 – UNIT HEATERS, GAS	20	$1,985.36	$99.27	$121.69	$56.00	$121.69	31.44
D3050130 – UNIT HEATERS, HYDRONIC	6	$1,156.27	$192.71	$136.45	$136.45	$474.01	137.80
D3050170 – SPLIT SYSTEMS AIR COOLED CONDENSE UNIT	8	$3,633.62	$454.20	$492.28	$264.37	$594.04	111.81
D3050175 – ROOFTOP A/C	2	$1,057.90	$528.95	$528.95	$489.25	$568.64	56.14
D3050176 – ROOFTOP AIR CONDITIONER, ELECTRIC HEAT	1	$534.40	$534.40	$534.40	$534.40	$534.40	N/A
D3050180 – ROOFTOP AIR CONDITIONER, VARIABLE AIR VOLUME	2	$131.30	$65.65	$65.65	$58.59	$72.71	9.98
D3050185 – COMPUTER ROOM COOLING UNITS	95	$19,357.98	$203.77	$39.78	$0.00	$1,059.74	279.01
D3050210 – PKG A/C, WATER COOLED, ELEC HEAT	10	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
D3050230 – HEAT PUMP, WTR SOURCE, CENT STA	1	$456.28	$456.28	$456.28	$456.28	$456.28	N/A
D3050901 – UNIT HEATERS, ELECTRIC	16	$1,245.15	$77.82	$62.07	$22.47	$161.86	43.97
D3050905 – HYDRONIC HEATING – FIN TUBE	2	$97.42	$48.71	$48.71	$48.71	$48.71	0.00
D3060901 – HVAC CONTROLS, ELECTRIC, DIGITAL	9	$3,290.83	$365.65	$364.03	$183.14	$631.62	124.70
D3060903 – AIR COMPRESSOR	8	$1,773.46	$221.68	$54.37	$0.00	$649.01	280.48
D3060904 – AIR DRYER	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
D3060905 – DIRECT DIGITAL CONTROL (DDC) SYSTEM	3	$209.75	$69.92	$0.00	$0.00	$209.75	121.10
D4010410 – WET PIPE SPRINKLER SYSTEMS	1	$159.61	$159.61	$159.61	$159.61	$159.61	N/A
D5010999 – OTHER	5	$101.02	$20.20	$0.00	$0.00	$50.51	27.66
D5090210 – GENERATORS	2	$4,622.23	$2,311.11	$2,311.11	$1,856.97	$2,765.26	642.26
D5095230 – UNINTERRUPTIBLE POWER SYSTEM	1	$0.00	$0.00	$0.00	$0.00	$0.00	N/A
F104002 – OTHER	7	$3,932.15	$561.74	$676.68	$168.18	$768.69	244.40
OTHER	5	$3,474.68	$694.94	$211.73	$0.00	$2,325.72	956.57

APPENDIX C. SUBSYSTEM PM FREQUENCIES (ANNUALLY)

Table 11. Subsystem costs, overages and age differences. Adapted from NAVFAC (2025a)

Subsystem	NAVFAC PM Frequency	OEM/RS Means PM Frequency	Over/Under Cost (OEM-NAVFAC)	Design Life Difference
B3010610 – GUTTERS	1	1	(247.81)	(5.67)
D2020901 – BOOSTER PUMP	1	1	103.87	4.17
D2020902 – STORAGE TANK	1	1	(68.47)	5.33
D2020903 – BACKFLOW PREVENTER	1	1	(51.10)	4.15
D2020906 – CIRCULATING PUMP	1	1	334.77	N/A
D3020130 – BOILER CAST IRON HOT WATER GAS	4	1	1,370.42	N/A
D3020136 – BOILER, CAST IRON HT WTR GAS/OIL	4	1	2,111.08	N/A
D3020901 – BOILER, CAST IRON, HT WTR, OIL	4	1	125.35	(5.67)
D3030120 – CHILLER, SCROLL, AIR COOLED	2	12	1,381.70	4.33
D3030130 – CHILLER, RECIP, WATER COOLED	2	365	1,008.57	N/A
D3030135 – CHILLER, RECIP, AIR COOLED	2	12	1,422.32	0.33
D3030140 – CHILLER, CENTRIFUGAL, WTR COOLED	2	52	3,889.00	(2.67)
D3030160 – CHILLER, SCREW, AIR COOLED	2	52	1,145.81	4.33
D3030221 – CONDENSING UNIT, AIR COOLED	2	12	310.35	2.98
D3030225 – SPLIT DUCTLESS HEAT PUMP, OUTDOOR UNIT	1	0	545.31	9.33
D3030310 – COOLING TOWER, GALVANIZED	2	12	1,017.43	4.61
D3030901 – CONDENSER, DX, AIR COOLED	2	12	94.43	4.33
D3030903 – PACKAGED DX REFRIGERANT SYSTEM	2	12	392.70	4.93
D3040106 – AIR HANDLING UNIT, FIELD FAB	2	4	158.81	0.00
D3040110 – AIR HANDLING UNIT, CENTRAL STA	2	4	127.37	4.88
D3040112 – AIR HANDLING UNIT, COMPUTER ROOM	2	12	227.89	N/A
D3040114 – AIR HANDLING UNIT, ROOFTOP	2	4	193.68	9.45

D3040118 – FAN COIL A/C, CAB MNT, TWO PIPE	2	12	271.72	9.33
D3040122 – FAN COIL A/C, CAB MNT, FOUR PIPE	2	12	299.59	9.33
D3040128 – FAN COIL A/C, DUCT MOUNT, 4 PIPE	2	12	339.63	9.74
D3040132 – VAV TERMINAL	1	1	43.28	8.74
D3040136 – VAV TERMINAL, FAN POWERED	1	1	39.25	9.33
D3040220 – FAN SYSTEM, CENTRIFUGAL	1	2	56.18	(5.17)
D3040230 – FAN SYSTEM, AXIAL	1	4	82.57	N/A
D3040240 – FAN SYSTEM, ROOF EXHAUST	1	2	84.04	4.33
D3040330 – CIRCULATING PUMP, END SUCTION	1	12	62.85	7.93
D3040340 – CIRCULATING PUMP, DOUBLE SUCTION	1	12	146.00	(5.67)
D3040610 – HEAT EXCHANGER, PLATE TYPE	1	1	42.14	4.33
D3040620 – HEAT EXCHANGER, SHELL TUBE	1	1	75.29	(5.50)
D3040901 – DEHUMIDIFIER	1	12	520.57	N/A
D3040902 – HUMIDIFIER	1	2	218.04	13.83
D3040904 – SPLIT DUCTLESS SYSTEM, INDOOR UNIT	1	1	548.68	4.33
D3050120 – UNIT HEATERS, GAS	2	1	(70.81)	N/A
D3050130 – UNIT HEATERS, HYDRONIC	2	1	(42.81)	1.99
D3050170 – SPLIT SYSTEMS AIR COOLED CONDENSE UNIT	2	12	439.76	(7.12)
D3050175 – ROOFTOP A/C	2	4	431.63	9.33
D3050176 – ROOFTOP AIR CONDITIONER, ELECTRIC HEAT	2	4	446.87	9.33
D3050180 – ROOFTOP AIR CONDITIONER, VARIABLE AIR VOLUME	2	4	508.70	9.33
D3050185 – COMPUTER ROOM COOLING UNITS	2	12	491.35	2.83
D3050201 – PKG A/C, AIR COOLED, ELEC HEAT	2	12	590.00	9.33
D3050210 – PKG A/C, WATER COOLED, ELEC HEAT	2	12	590.00	N/A
D3050230 – HEAT PUMP, WTR SOURCE, CENT STA	4	12	233.19	9.33
D3050901 – UNIT HEATERS, ELECTRIC	4	1	7.24	9.53
D3050905 – HYDRONIC HEATING – FIN TUBE	4	1	(41.84)	9.83
D3060901 – HVAC CONTROLS, ELECTRIC, DIGITAL	4	12	(19.37)	(0.67)

D3060903 – AIR COMPRESSOR	4	365	417.23	(1.96)
D3060904 – AIR DRYER	1	52	705.00	14.33
D3060905 – DIRECT DIGITAL CONTROL (DDC) SYSTEM	1	1	350.12	5.87
D4010410 – WET PIPE SPRINKLER SYSTEMS	1	1	1,215.39	0.04
D5010999 – OTHER	1	1	24.49	(9.99)
D5090210 – GENERATORS	4	1	1,141.11	(5.27)

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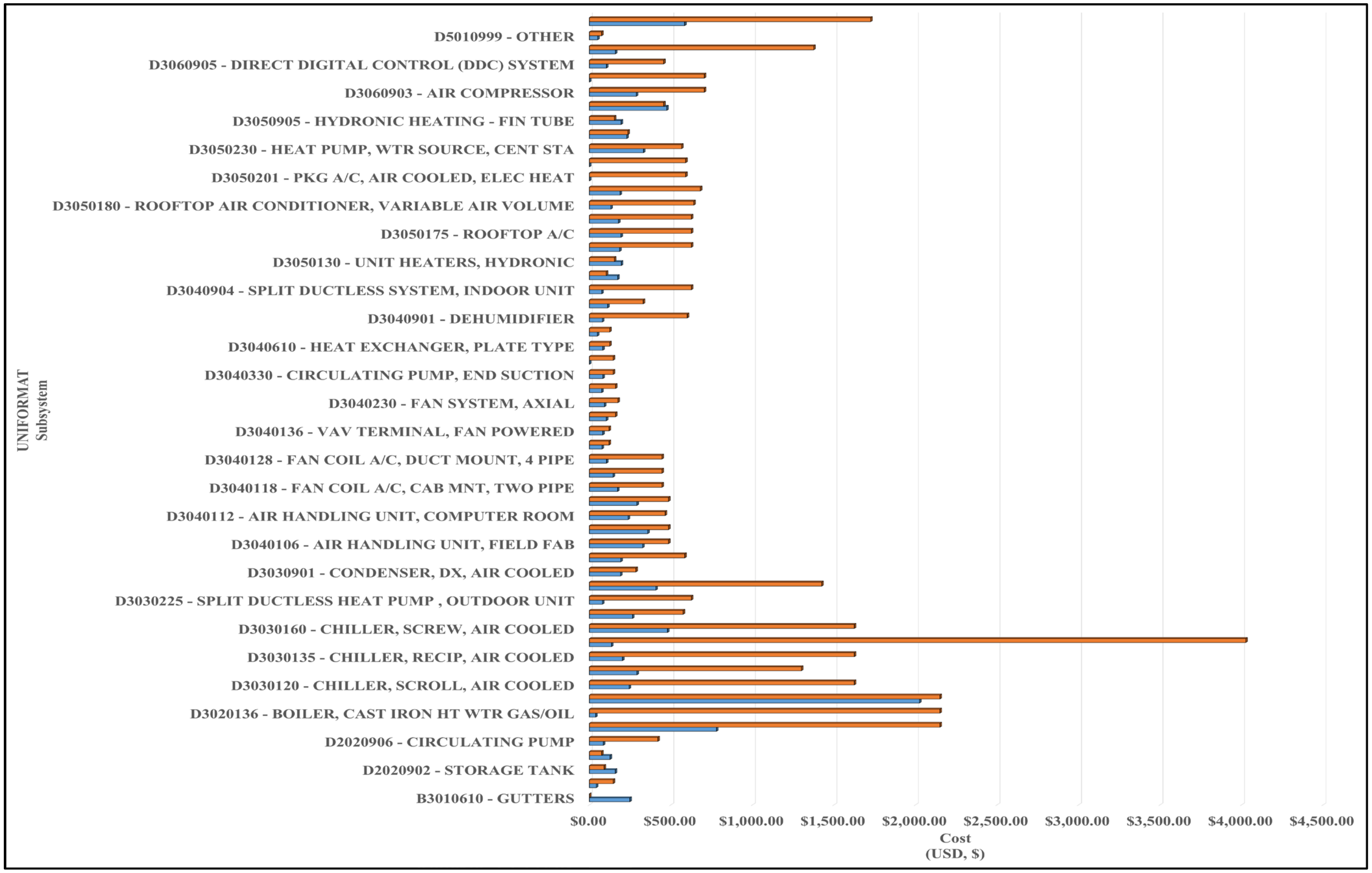
APPENDIX D. PREVENTIVE MAINTENANCE COST COMPARISON



Notes: Annual costs calculated from the consolidated NAVFAC MAXIMO data set, FY20-FY24

Figure 6. NAVFAC vs. RS Means (estimated) annual costs. Adapted from NAVFAC (2025a).

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