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APPENDICES 2-9: Campus Summaries and Detailed Equipment Evaluation and Survey Photos

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LIST OF ACRONYMS AND ABBREVIATIONS

Schools and Universities

ASU	Appalachian State University
ECU	East Carolina University
ECSU	Elizabeth City State University
FSU	Fayetteville State University
NCA&T	North Carolina Agricultural and Technical State University
NCSA	North Carolina School of the Arts
NCCU	North Carolina Central University
NCSU	North Carolina State University
UNCA	University of North Carolina at Asheville
UNCC	University of North Carolina at Charlotte
UNC-CH	University of North Carolina at Chapel Hill
UNCG	University of North Carolina at Greensboro
UNCP	University of North Carolina at Pembroke
UNCW	University of North Carolina at Wilmington
WCU	Western Carolina University
WSSU	Winston-Salem State University

Technical Acronyms and Abbreviations

AC	Air Conditioning
ACT	A proprietary CMMS software system
ADA	Americans with Disabilities Act
AHU	Air Handling Unit
APPA	Association of Higher Education Facility Officers
ASAP	As Soon As Possible
ASME	American Society of Mechanical Engineers
ATS	Automatic Transfer Switch
BAS	Building Automation System
BTU	British Thermal Unit
BUR	Built-up Roof
CARS	Campus Alarm Reporting System
CM	Corrective Maintenance
CMMS	Computerized Maintenance Management System
CMU	Concrete Masonry Unit
CW	Chilled Water
DC	Direct Current
DDC	Direct Digital Control
DHW	Domestic Hot Water
EFIS	Exterior Finish and Insulation System
EMCS	Energy Management and Control System
EPDM	Elastomeric Polyurethane Membrane
FACILITY FOCUS	A proprietary CMMS software system
FACP	Fire Alarm Control Panel
FAS	Fire Alarm Systems
FCU	Fan Coil Unit
FMO	Facilities Management Office
FOD	Facilities Operations Department
FPE	Fire Protection Equipment

FPLS	Fire Protection Life Safety
FRP	Fiber-reinforced Plastic
FSO	Facilities Services Office
FTE	Full time equivalent
GSA	General Services Administration
GSF	Gross Square Foot
GWB	Gypsum Wallboard
HP	Horsepower
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
HW	Hot Water
ID	Identification
Kv	Kilovolt
KVA	Kilovolt Ampere
KW	Kilowatt
LBS	Pounds
MAINSAVER	A proprietary CMMS software system
MAXIMO	A proprietary CMMS software system
MBTUH	Mega-BTU's per hour
MCC	Motor Control Center
MDP	Main Distribution Panel
MER	Mechanical Equipment Room
METASYS	A proprietary EMCS product
MP2	A proprietary CMMS software system
MSF	Million Square Feet
NA	Not Applicable
NFPA	National Fire Protection Association
O&M	Operations and Maintenance
OFM	Office of Facilities Management
OPP	Office of Physical Plant
PCBs	Poly Chlorinated Biphenyls
PIV	Post Indicator Valve
PM	Preventive Maintenance
PMO	Preventive Maintenance Order
PPM	Parts Per Million
PPO	Physical Plant Office
RF	Radio Frequency
RS MEANS	RS Means Facilities Maintenance Cost Data
SC	Service Call
SO	Service Order
SOP	Standard Operating Procedure
UNC	The University of North Carolina
UPS	Uninterruptible Power Supply
VAT	Vinyl Asbestos Tile
VAV	Variable Air Volume
VCT	Vinyl Composition Tile
VET	Veterinary
VT	Vinyl Tile
WO	Work Order
WOS	Work Order System
WWT	Waste Water Treatment
WY	Work Year

1.0 EXECUTIVE SUMMARY

The University of North Carolina, Office of the President, requested a review and report on the maintenance programs and conditions at the 16 campuses across The University of North Carolina system.

From October through December 2003, Jacobs Chanen performed on-site reviews of the 16 campuses that comprise the University system. The objective at each site was to determine if a formal maintenance program is in place, if the program is adequate, if there are sufficient human resources in place to execute the program, and if actual conditions indicate that the required maintenance is being performed.

The maintenance program at each campus was assigned a rating of Excellent, Good, Marginal or Failing.

The following campuses were rated "Excellent":

- East Carolina University (ECU)
- University of North Carolina-Charlotte (UNCC)
- University of North Carolina-Wilmington (UNCW)

The following campuses were rated "Failing":

- Elizabeth City State University (ECSU)
- North Carolina Central University (NCCU)
- North Carolina School of the Arts (NCSA)

The 10 remaining campuses were rated as "Good."

Staffing and a formal maintenance program were found to have a major impact on overall program success. Those campuses in the failing category were understaffed and/or did not have a formal maintenance program. Conversely, other campuses in the good or excellent category were also understaffed, but achieved greater success through a formal maintenance program.

Across all 16 campuses, the maintenance effort is understaffed by approximately 140 work years. With the limited resources available, we recommend more emphasis be placed on Preventive Maintenance (PM). Greater PM effort will reduce Corrective Maintenance (CM) requirements and improve equipment reliability and service life.

There appears to be little maintenance management standardization among the 16 campuses. We feel a certain level of maintenance management standardization and the implementation of a "best practices" program system-wide would facilitate communication and sharing of ideas and have a positive impact on the University maintenance management program.

Overall improvement of program management combined with complete equipment inventories and work order tracking systems could bring all campus systems into the good or excellent categories. Focusing on routine and preventive maintenance can improve equipment condition for Fire Protection and Life Safety Systems, HVAC, and High Voltage Electrical Systems.

The following report provides a system-wide summary and 16 detailed individual reports addressing the results of each campus survey.

2.0 OVERVIEW

2.1 Background

The University of North Carolina, Office of the President, requested a review and report on the maintenance programs and conditions at the 16 campuses within the University system. The purpose of the review was to determine to what extent the campuses are fulfilling their operational responsibilities to perform orderly, efficient maintenance operations and that maintenance programs are in place to preserve facility assets.

2.2 Survey and Methodology

Jacobs Chanen, a joint venture between Jacobs Facilities, Inc. and Chanen Construction Company, Inc., was tasked to perform an operational review including site survey, maintenance program analysis, and general condition assessment for each of the 16 campuses, and to report the findings and participate in briefings of the results.

Jacobs Chanen conducted reviews of the maintenance management programs at each of the University's 16 campuses. As part of this effort, interviews were conducted with Associate Vice Chancellors and Directors of Physical Plants where possible. The Jacobs Chanen team was augmented with UNC personnel to assist in surveying efforts and report on the programs. The objectives were to:

- Determine if a maintenance program is in place
- Determine the adequacy of the maintenance program
- Determine if adequate staffing is in place to perform the maintenance
- Determine if maintenance is being performed
- Determine the condition of equipment and building systems
- Identify best practices to be shared with other campuses

The survey was confined to "building maintenance" capability, even though most Facility Operations Offices are staffed to perform housekeeping, motor vehicle maintenance, grounds keeping, minor construction and alterations, pest control, refuse removal and planning and design.

The condition of facility equipment was assessed using a sampling plan for specific buildings and for equipment within those buildings. The sampling plan took into consideration campus size, building functions, building sizes and building ages. For smaller campuses (up to 3 million square feet), 20 % of the campus square footage was sampled. For medium and larger campuses, 10% of the campus square footage was surveyed. Digital photographs were taken of

typical conditions at each campus and used to illustrate the conditions that were observed.

Maintenance program reviews were performed by reviewing documentation and procedures, analyzing workload statistics, and by calculating maintenance workload from existing equipment inventories and staffing information from each campus. Initially, staffing requirements were to be calculated from a formula that examined workload from Preventive Maintenance, Corrective Maintenance and standing job orders. This formula was replaced by a ratio of staff workers to total square footage, since several campuses were unable to provide all the data necessary to use the original formula.

This narrative report provides a summary of findings, issues and recommendations resulting from the operational review. Specific details of each campus survey are provided in the individual campus reports in Appendices 2-17.

2.3 Overall Condition Rating

The overall condition rating for each of the campuses is a compilation of findings for equipment assessment and overall program management. The ratings were developed by Jacobs Chanen in an attempt to distinguish campus findings. Specific findings for each campus are listed in the individual campus reports in Appendices 2-17. Four condition ratings were assigned as follows:

- Excellent –All equipment inspected is well maintained and operating efficiently. Occasional minor deficiencies found are of no operating significance, critical or of a safety nature.

- Good – A majority of the equipment surveyed is well maintained and in good operating condition. There are no serious deficiencies.

- Marginal – Equipment surveyed is operating but shows neglect. Equipment is not being regularly maintained.

- Failing – Equipment surveyed is in poor condition or is not operational. Critical or major equipment is maintained on a breakdown basis. Failing sites have significant problems related to three or more of the following:

    a. Fire Protection and Life Safety Systems
    b. High-Voltage Electrical System
    c. Heating, Ventilating, Air Conditioning (HVAC) System
    d. Lack of a preventive maintenance program
    e. Lack of a work order system
    f. Severe staffing shortfalls

Based on the above classifications, *Table 1. Overall Condition Rating* displays the condition ratings for all 16 campuses:

Table 1. Overall Condition Rating

Condition Rating	Campus
Excellent	EAST CAROLINA UNIVERSITY (ECU)
	UNC CHARLOTTE (UNCC)
	UNC WILMINGTON (UNCW)
Good	APPALACHIAN STATE UNIVERSITY (ASU)
	FAYETTEVILLE STATE UNIVERSITY (FSU)
	NORTH CAROLINA STATE UNIVERSITY (NCSU)
	NORTH CAROLINA AGRICULTURE & TECHNICAL STATE UNIVERSITY (NC A&T)
	UNC ASHEVILLE (UNCA)
	UNC CHAPEL HILL (UNC-CH)
	UNC GREENSBORO (UNCG)
	UNC PEMBROKE (UNCP)
	WESTERN CAROLINA UNIVERSITY (WCU)
	WINSTON-SALEM STATE UNIVERSITY (WSSU)
Failing	ELIZABETH CITY STATE UNIVERSITY (ECSU)
	NORTH CAROLINA CENTRAL UNIVERSITY (NCCU)
	NORTH CAROLINA SCHOOL OF THE ARTS (NCSA)

2.4 General Findings

Overall findings reveal that several recurring themes are common in maintenance programs across the University system.

- Many campuses have a large amount of plant equipment that has already exceeded its original design service life. HVAC and other mechanical equipment account for most of this equipment and tend to have the greatest mission impact in the event of sub-optimal operation or failure. Preventive maintenance and self-inspection are generally under-resourced and often sacrificed to fund more urgent requirements.
- Staffing shortages exist at most of the campuses. There is a direct correlation between campuses with the lowest condition ratings and the most severe staffing shortages.
- The Computerized Maintenance Management System (CMMS) is not standardized across the 16 campuses and limits the overall ability of University officials to optimize the management of maintenance scheduling, asset inventory and tracking, labor and performance, materials purchasing and control, and work order completion.
- Maintenance programs that take into account and provide adequate oversight of all components of all building systems are not in place at all 16 campuses.

- National standards for Fire Protection and Life Safety Systems are not completely followed by fifteen campuses and five campuses have one or more fire protection or life safety systems that are in alarm mode or non-operational.
- None of the campuses have a complete and accurate inventory of plant equipment.

2.5 General Recommendations

Recommendations in this report have been made to accommodate those campuses with the greatest need first. Since many effective practices are already in place at various campuses that could be developed and incorporated into maintenance programs system-wide, a Best Practices Section 5.4 has been developed for sharing of ideas. Where applicable, these best practice ideas have been incorporated into the recommendations for the purpose of minimizing financial impact to the University system budget. Detailed recommendations by category can be found in Section 6, Recommendations.

3.0 FACILITY MANAGEMENT AND OPERATIONS

3.1 Maintenance Program

Major components of a controlled maintenance program include Asset Management, Preventive Maintenance, Work Order Management System, and Staffing. This Section documents standard practices, specific issues that were identified during the surveys, and a summary of the campuses that should take corrective action.

3.1.1 Asset Management

As part of the overall maintenance program, asset management requires a complete and accurate inventory of facilities and equipment components associated with those facilities. Maintenance systems and work schedules can then be developed from these detailed inventories. A good equipment identification system is essential to track maintenance work on specific equipment and determine the root cause of problems that occur. The operational review indicates:

- None of the campuses have a complete and accurate inventory of plant equipment.
- Master inventories for HVAC and other mechanical equipment components are mostly complete, but major components of electrical systems, fire protection systems, and building automation systems and controls are typically missing.
- Several smaller campuses do not maintain master inventories, but rely on local trade shops to maintain the inventories.
- Identification systems vary from campus to campus. The best system observed, NCSU, had a specific procedure for continuous equipment updates by setting periodic reviews of new construction projects to add new equipment to the inventory and formal reviews of demolition contracts for removal of eliminated equipment items from the inventory. (See Section 5.4 Best Practices)

HVAC systems consume a majority of maintenance resources. Maintenance programs must include all equipment in the inventory including electrical systems, fire protection and life safety systems, and building automation systems and controls.

- Only six campuses, ECU, UNCA, UNC-CH, UNCC, WCU and NCSU, have developed schedules and maintenance procedures for major items of electrical systems, life safety systems, interior finishes, and exteriors as part of the scheduled maintenance program.

3.1.2 Preventive Maintenance

Scheduled, planned or Preventive Maintenance (PM) is the most cost effective use of maintenance resources over the long term. By contrast, sporadic, unplanned or Corrective Maintenance (CM) is the least cost effective way to maintain facilities. A high percentage of time for PM versus CM or standing job orders indicates efficient use of resources. The ideal target for PM is between 30-40% of the shop capability.

- Most campuses have a high workload distribution of CM work (90%) in proportion to PM work according to work order logs, indicating less priority being assigned to PM tasks. UNCC has the best percentage, logging about 30% of its hours against PM tasks.
- The other 15 campuses logged an average of 5-10% of their productive hours against PM.
- NCSU structured their PM frequencies based on the capability of an undersized workforce. While this method improves PM statistics, the overall effect of this strategy is less preventive maintenance of equipment and failure to address the true PM services workload.
- All campuses had established PM programs based on detailed equipment inventories, except NCSA, WSSU and NCCU. These campuses relied on periodic tours or tradesperson expertise to determine the level of maintenance to be performed.

PM programs should define the What, When, Where, and How for maintaining each equipment class and include a work order with sufficient instructions and descriptions of the work to be done. These details are necessary to permit workers to accomplish the task with the same standard of performance for each item of equipment.

Currently, the manner in which work is performed varies greatly among the campuses, along with the form and function of the PM work orders. Survey findings indicate:

- Most PM work orders have been shortened to simple checklists for ease of recording work performed or malfunctions.
- At least three standards are in use for determining work frequencies and schedules, including Facilities Maintenance Cost Data (RS Means), Association of Higher Education Facility Officers (APPA), or locally developed standards by supervisory personnel.
- Approximately half of the campuses use a zone system to assign staff to specific buildings or areas for maintenance. Condition of equipment tended to vary from zone to zone. Consistency of performance could be improved by utilizing standard detailed work orders across the campuses.

- Three campuses, NC A&T, NCCU, and NCSA, perform daily operational checks, which create the potential for over-maintenance. Of these, NCCU and NCSA, were rated as failing overall and maintenance is inconsistent.
- ASU uses annual servicing schedules of specific equipment. WSSU uses seasonal servicing associated with start-ups or shut downs of central plants. Both of these practices create a potential for under maintenance.

3.1.3 Facility Self-Inspection

An effective maintenance program provides for regular building inspections by the facility maintenance staff "experts" on a routine basis. Reliance on work generation solely from a customer complaint perspective is usually insufficient to detect technical problems in a timely manner.

- ECU, UNCA, UNC-CH, UNCC, WCU, and NCSU have established at least annual inspections of campus buildings as part of their scheduled maintenance program. This technique can also be used to effectively generate workload for shops during off-season and provide for a more comprehensive maintenance approach.
- Compared to those campuses that use a self-inspection procedure, campuses that do not have greater incidences of building system deficiencies (e.g., architectural finishes, roofs, and exterior envelope).

3.2 Work Order Management System

Work orders are typically tracked and managed via a Computerized Maintenance Management System (CMMS). The CMMS is not standardized across the 16 campuses. Multiple types and versions of maintenance systems are in use, with varying degrees of system implementation and different levels of expertise at each of the campuses. The CMMS is usually modularized to perform any or all of the following functions:

- Asset Management
- Preventive Maintenance Scheduling
- Work Order Management
- Material Purchasing and Control
- Labor Tracking and Management
- Financial and Fiscal Management

The predominant Work Order Management System in use by the smaller campuses is the MAINSAVER system, while the Facility Focus system is

preferred at the larger campuses. *Table 2. CMMS Summary* displays the various systems in use at each campus.

Table 2. CMMS Summary

Campus	CMMS System
ECU	MAINSAVER
ECSU	MAINSAVER
UNCP	**MP2**
UNCW	Facility Focus
FSU	ACT
UNC Chapel Hill	Facility Focus
UNC-CH – Cogeneration Plant	MAXIMO
NCSU	
• Faculty Operations Department (FOD)	Facility Focus
• Student Services	Manual Tracking
• Residence	MAINSAVER
• Athletics	Manual Tracking
NCCU	**MAINSAVER**
NC A&T	MAINSAVER
UNCG	MAINSAVER
NCSA	**MAINSAVER**
WSSU	MAINSAVER
ASU	**Locally developed system**
UNCA	**ACT**
WCU	**ACT**
UNCC	Facility Focus

The survey indicates:

- Highlighted campuses need assistance to upgrade or replace the current CMMS. These upgrades or replacements are necessary for several reasons: the current system is unable to provide necessary data or reports, loss of trained staff, inability to obtain vendor support, or in the case of ASU, the system will not be operable on the reconfigured campus network.
- ECU has the highest level of expertise with the MAINSAVER product.
- Several campuses have dedicated personnel to operate and maintain the CMMS for the facility department.
- NCSU has two systems in use.

3.3 Staffing

As staffing and success of programs across the University system were reviewed, a required staffing effort based on GSF was developed. The ratio of one trades staff member per 50,000 GSF of space is considered by the industry a reasonable rule of thumb. *Table 3. Staffing Comparisons* shows the current ratio is one staff member per 57,870 GSF, resulting in a deficit of required employees at most campuses. The "Present GSF/Worker" and "Deficit" numbers in the table are shown in bold for campuses with the greatest need for additional staffing.

Table 3. Staffing Comparisons

UNC School	Campus GSF	Present Trades Staff	Present GSF/Worker	Req'd Staff/ 50KSF	Deficit Staff	Deficit %
Excellent Campuses						
ECU	3,700,000	69	53,623	74	-5	-7%
ECU-HA*	950,000	18	52,778	19	-1	-5%
UNCC	4,030,000	63	**63,968**	80	**-17**	**-21%**
UNCW	1,960,000	33	59,394	39	-6	-15%
Good Campuses						
ASU	3,540,000	66	53,636	70	-4	-6%
FSU	1,100,000	21	52,381	22	-1	-5%
NCSU	10,800,000	175**	**61,714**	216	**-41**	**-19%**
NC A&T***	2,370,000	27	87,778	47	-20	-43%
UNCA	961,000	20	48,050	19	1	-5%
UNC-CH	13,000,000	254	51,181	260	-6	-2%
UNCG***	3,888,000	77	50,494	77	0	0%
UNCP	975,000	18	54,167	19	-1	-5%
WCU	2,360,000	36	**65,556**	47	**-11**	**-23%**
WSSU***	1,080,000	15	72,000	20	-5	-25%
Failing Campuses						
ECSU	950,000	15	**63,333**	19	**-4**	**-21%**
NCCU	2,000,000	23	**86,957**	40	**-17**	**-43%**
NCSA	850,000	12	**70,833**	17	**-5**	**-29%**
Totals	**54,514,000**	**942**	**57,870 (avg)**	**1,085**	**-143**	**-13%**

*NOTES: *ECU-HA refers to the Health Affairs department at ECU, which has facilities staff located in a separate building.*
***Present building trades staff figure of 175 persons includes 40 vacancies.*
****Campuses with HVAC or other shop trades contracts in effect or pending.*

Survey results indicate:

- Campuses with the lowest overall condition ratings also are among the campuses with the most severe staffing shortages.
- As a percent of required staff based on the 1 staff per 50,000 GSF of space, NC A&T, NCCU and NCSA have the greatest deficits. Neither NCCU or NCSA have HVAC, electrical or building envelope trades contracts to supplement the staff.
- With a deficit of 41 maintenance personnel, NCSU shows the highest deficit of all campuses. The deficit number does not show another 40 vacant positions, which have been included in the 175 present trades staff figure.
- Unlike other campuses, maintenance services at NCSU are performed by four distinct staffs: Central Facilities Operations, Student Services, Residence Life, and Athletics. The 175 present trades staff figure includes all of these groups.

Information collected during the survey process indicates local labor markets affect staffing deficits. The local markets affect staff retention in various ways:

- ECSU and WCU are affected by the lack of any significant industrial base in the geographical area and have been unable to recruit sufficiently skilled trades.
- NCSU competes with the labor market in the Raleigh area and consistently has about 40 vacancies.
- NCSA, WCU and WSSU do not offer competitive salaries in their geographical areas and therefore cannot retain sufficient staff.
- WCU considers itself the regional “training ground” for staff, who leave for more competitive salaries once sufficient knowledge and experience are gained at the campus.

4.0 FACILITY EQUIPMENT AND BUILDING SYSTEMS

The Facility Equipment and Building Systems Section examines existing conditions related to the technical maintenance of the major equipment systems. Please see Appendices 2-17, Detailed Campus Reports, for detailed listings of equipment assessed by campus.

4.1 Fire Protection and Life Safety Systems

Fire Protection and Life Safety Systems require maintenance and testing at prescribed intervals, and retention of documentation for inspection by regulatory entities. The National Fire Protection Association (NFPA) provides specific intervals for maintenance testing of components of Fire Protection and Life Safety systems. Survey results indicate:

- Five campuses, UNCA, WSSU, ECSU, UNCG, and NCCU have one or more systems that were in alarm mode or non-operational.
- Campuses are not performing testing of fire alarm systems in accordance with NFPA guidelines, with the exception of UNC-CH.
- Typically, only annual inspection and testing are performed and most campuses have minor documentation deficiencies.

4.2 High Voltage Electrical Systems

The campuses are served by a variety of utility companies and in some cases the campus is the local utility. Reliable electrical service at each campus mandates an effective maintenance program be in place for electrical distribution systems. Maintenance approaches to high voltage electrical systems vary across the campuses and include fully staffed shops, assignment as part time duties, contracted services, and support from local utilities.

Survey results indicate:

- In general, high voltage electrical systems did not receive as high a level of maintenance as mechanical systems.
- High voltage electrical systems at UNCG, UNCW and WCU are in need of repair or upgrade and/or increased maintenance effort.
- ECU and NCCU have completed surveys of their systems but have not yet implemented a full maintenance program or been able to obtain the necessary resources to do so.

4.3 Heating, Ventilating, Air Conditioning (HVAC) Systems

HVAC systems represent about 80% of the plant equipment inventory. At several campuses, major components of the HVAC system were beyond their design service life. However, in each case these components appeared to be in good operating condition. Obsolete and aging mechanical equipment generally requires additional attention and maintenance. Overage equipment may present a future challenge for maintenance departments to keep the equipment operating and should be programmed for replacement.

Survey results indicate:

- HVAC equipment is generally in good condition except at ECSU and NCSA where equipment is in fair condition. At ECSU and NCSA some units were not running, some filters were missing, valve leaks were detected, and some systems made noticeable noise, indicating the equipment was not operating properly.
- There were numerous instances where minor details of maintenance could be improved. This includes inadequate filter changes, improper tensioning of belts and alignment of pulleys, clogged or dirty fan coil units, improper lubrication, missing insulation and corrosion.
- Housekeeping in equipment rooms should be improved. There were many instances of equipment rooms being dirty, cluttered and used for general storage.
- Excellent maintenance was accompanied by a sense of pride and ownership by the maintenance staff. ECU, UNCC, and UNCW have performed excellent maintenance on their HVAC systems. Common characteristics include:
    a. Equipment was in exceptional operating condition.
    b. Attention to the details of lubrication, adjustments and cleaning was evident.
    c. Return of equipment to original condition after repairs was standard, including replacement of insulation.
    d. Mechanical spaces being kept clean and free of materials and debris.

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5.0 CONCLUSIONS

5.1 General Program Management

While there is commonality in the overall mission and types of facilities and equipment across the University system, maintenance programs and equipment condition vary dramatically from campus to campus. Standard University policies, guidance and procedures did not appear to be in place.

Maintenance programs system-wide can be improved by establishing comprehensive standard procedures. Standard procedures should increase efficiencies in managing assets and inventories of equipment. Focus should be placed on:

- Developing accurate master equipment inventory lists
- Developing maintenance schedules for all building systems equipment
- Standardizing electronic systems
- Emphasizing PM versus CM

Standard maintenance tasks to be utilized by all maintenance technicians in performing preventive maintenance can help insure equipment receives the proper level of care. Supervising this effort must be a priority of all levels of management to ensure the success of the program.

5.2 Resources for Preventive and Corrective Maintenance

Preventive maintenance is under resourced at most campuses. The first step in correcting this situation is to determine the annual PM and CM backlog. PM/CM backlog is the annual requirement to perform scheduled maintenance on the plant equipment inventory plus repairs that are expected to occur during the year plus repairs that have been deferred from previous years. PM and CM workload backlog should be the central focus in allocating maintenance budgets to campuses.

PM backlog should also be documented so staffing requirements can be determined. The PM backlog must be based on the level of effort required to perform necessary maintenance. Emphasis can then be placed on augmenting staffs with the greatest shortages.

Since budgets are unlikely to allow for replacement of all aging and obsolete equipment on the CM backlog in the short term, a system of priorities should be established that targets components most in need of replacement. A scoring system should be established to evaluate and prioritize these requirements against those factors held as most important to the University to gain a better understanding of the state of maintenance and repair at each campus. Overage

equipment that cannot be funded for replacement should be treated with improved PM, with emphasis on key mechanical equipment.

Resource allocation is always a challenge when budgets are limited. While this assessment did not survey the University's budget process, many of our findings, conclusions and recommendations are dependent on additional budget. In programming for or distributing funds, the complexity of facilities should be taken into consideration. For instance, spaces such as laboratories typically require more sophisticated equipment and more maintenance. In order to simplify the budget process, some large plant holders establish a unit maintenance and repair cost, usually per square foot for various building types such as dormitories, laboratories, libraries, classrooms and gymnasiums. Quantities of each facility type are then multiplied by the respective unit cost and aggregated into a maintenance requirement that can be used for budgeting and allocating funds.

5.3 Outsourcing

Across the University system, comparatively few services are now being obtained through contracts. Contracted services are almost universally limited to complex building systems such as elevator maintenance, HVAC controls, special chiller maintenance or fire protection system maintenance and inspection. Rather large in-house staffs are maintained to perform housekeeping and grounds keeping functions at all campuses. These services may be available by contract at lower cost than through in-house performance. Outsourcing can also be used, particularly at smaller campuses, to supplement the workforce to free highly skilled in-house workers from less demanding tasks.

For existing and additional service contracts, contract management and quality assurance are essential to making sure service contracts are not abused. Among the campuses that were using service contracts, only NCSU and UNC-CH indicated that they had designated an individual to perform service contractor liaison and surveillance, albeit in most cases a part-time or collateral job.

The University should consider instituting a formal service contracts standard operating procedure, with training and certification as necessary to ensure contractor work is properly performed. The program should include reports provided by the contractor, inspection of work performed, and notations on contractor invoices in order to provide an audit trail for the services.

5.4 Best Practices

An economical and effective way to implement efficient practices is for maintenance managers and technicians to exchange technical information and day-to-day issues with each other across the University system.

The University's approach to this operational assessment provided an example of this type of interaction and sharing of experience. Across the entire University system we found smart, dedicated people with good ideas. The synergy from further interaction could have tremendous benefit to the University and should be encouraged and formalized among the campuses at the Physical Plant Managers/Facility Directors level and separately at the shops level.

Some Directors of Physical Plant/Associate Vice Chancellor's indicated that costs to make improvements to their facilities management programs and to increase productivity exceed current budget capability or present staff expertise. These challenges appear to be daunting when considered collectively. However, several desired programs such as a strong Computerized Maintenance Management System (CMMS), Equipment Inventory Management Systems, or centralized Energy Management and Control Systems (EMCS) are already in place at one or another of the 16 campuses.

The task is to bring the best practices at each campus to the attention of the other campuses and make available the knowledge of how to develop these practices system-wide. Campuses could be set up as Centers of Expertise in their subject areas for the purposes of assisting other campuses to achieve the same level of expertise in the future.

We believe the following list of the best practices encountered during the survey process only scratches the surface of the University's knowledge base.

5.4.1 Inventory Management at NCSU

The NCSU asset inventory system closely tracks and manages equipment with a four section numbering system that identifies a piece of equipment and its location by maintenance zone, building and room. The identification numbers are affixed to the equipment with a gummed label and are read through a bar-coding system. The system is augmented by a regular review of new construction project documents to identify potential new additions, or to note items being demolished so that assets can be removed from the system.

5.4.2 Web-based Service Desk & Documentation Programs

ECU has developed a web-based service order system that links directly to the maintenance shops to expedite the execution of work minimizes the need for human intervention in the work order decision process and saves an active work order custodian from having to decide what work to approve. All department standing procedures and instructions have been made web-accessible on the campus website. The time from work request to closeout was the shortest observed of all campuses. Physical Plant

customers interviewed were extremely satisfied with the overall timeliness of the work request system.

About half of the campuses post Standard Operating Procedures (SOPs) on a website and this practice should be implemented at the remaining campuses that have a campus website.

5.4.3 UNCA EMCS

UNCA integrates all mechanical system controls under a single Environmental Management and Control System (EMCS), which continually monitors alarms, equipment operating instructions, and energy consumption from a central location. Mechanics are dispatched directly when alarms or malfunctions are received, thereby responding to problems before they can escalate to major customer complaints or outages. In addition, the system is being used to save energy by enabling timely shut down of non-essential equipment during periods of high-energy use.

5.4.4 UNCW Mold Prevention/Abatement Program

UNCW's unique coastal location places it in a continual high humidity environment that fosters mold growth. The campus has implemented an aggressive surveillance program as part of their Preventative Maintenance (PM) and a Corrective Maintenance (CM) program to find and counter the growth of mold throughout the campus. This program has resulted in changes to design specifications for banning specific materials that harbor mold. Mold, when discovered, is immediately isolated and designated for removal, cleaning or restoration.

5.4.5 ECU, UNC-CH, NCSU, UNCC Work Management Systems

These larger campuses have progressed beyond basic task ordering and day-to-day work force management to root cause analysis of problems and dynamic solutions to problems. Work performance is monitored shop by shop for efficiency and adjustments are made to work order planning and scheduling to account for variances in resources and capabilities. Data is maintained within the work order system and can be easily retrieved and sorted as necessary to provide management with useful reports to track and trend performance. This is the ideal model that each campus should be striving to achieve.

5.4.6 Vice-Chancellor Involvement

At several campuses, the responsible Vice-Chancellor is personally involved in the programs of the Physical Plant Office. Their strong leadership and influence are reflected in the positive attitude and high levels of motivation among the employees. We noted a linkage that when

this type of influence was encountered, there was a good to excellent program at that campus. As in most organizational hierarchies, when top management becomes personally involved in the success of the program, the organization usually responds. The results are a continuous improvement in the conduct of business and success at that location.

5.4.7 Students as Part-Time Labor

Several campuses with technical programs employed students as part-time labor to supplement administrative and managerial functions as well as the trades efforts. This is an economical solution that provides students with an opportunity to obtain valuable on-the-job experience in a facility-related field.

6.0 RECOMMENDATIONS

In addition to implementing the best practices found at various campuses, this Section lists specific recommendations that directly correspond to findings listed earlier in this report. *Table 4. Condition Assessment - Facility Equipment and Building Systems* lists recommendations to amend existing conditions of equipment and building systems:

Table 4. Condition Assessment - Facility Equipment and Building Systems

Equipment	*Campus Responsible*	*Recommendations*
1 **Fire Protection & Life Safety**	All campuses, except UNC-CH*	▶Adopt NFPA inspection and testing standards for fire/life safety systems at all campuses including quarterly inspection of fire alarm control panels and batteries.
	All campuses, except UNC-CH and ECU*	▶ Incorporate NFPA guidelines into campus's respective maintenance procedures.
	UNCA, WSSU, ECSU and NCCU	▶Immediately bring all inoperative systems back to a fully functioning mode.
2 **High Voltage Electrical System**	ECU and NCCU	▶Provide a High Voltage electrical maintenance capability at each campus through in-house staff or contract support.
	UNCG, UNCW and WCU	▶Provide maintenance or upgrades as necessary for high voltage systems.
3 **HVAC**	All campuses, except ECU, UNCC & UNCW	▶Adopt HVAC maintenance program practices of full stewardship to correspond to current practices at ECU, UNCC and UNCW.

**Note: UNC-CH and ECU already follow NFPA guidelines and standards.*

The overall program assessment reviewed five key components of the facility management and business operations. *Table 5. Program Review - Facility Management and Operations* lists specific recommendations that directly correspond to findings listed earlier in this report:

Table 5. Program Review - Facility Management and Operations

Component	*Campus Responsible*	*Recommendations*
1 **Asset Management**	All campuses	▶Master equipment inventories should be developed and kept up to date for all campuses. All major items that are to be maintained, including High Voltage electrical distribution items, emergency generators, fire protection, alarms and suppression systems, HVAC systems, building automation and control systems, elevators, and central utility production equipment should be included.
	UNCW, ASU, FSU, NC A&T, UNCG, UNCP, WSSU, ECSU, NCCU, and NCSA	▶The maintenance program must include ALL equipment in the inventory, not just HVAC. Develop schedules and procedures for regular maintenance.
2 **Preventive Maintenance**	NCSA, WSSU, and NCCU	▶ Develop a formal PM program at the three campuses that are lacking one. Include in the program PM procedures, task frequencies and schedules, and workload estimates to permit efficient use of resources.
	All campuses, except UNCC*	▶Raise the priority for the PM efforts. Set a goal to log at least 20% of productive time on PMs. Techniques might include using dedicated contracts or in-house teams for selective PM efforts, decreasing emphasis on discretionary or project work from the in-house workforce, or instituting consistent local PM performance standards.
	All campuses	▶Except where local conditions prescribe a more rigorous approach, standardize the PM programs to those prescribed by manufacturer's recommendations or industrial standards for each equipment class to eliminate over or under maintenance.
	All campuses	▶Incorporate task descriptions into campus PM work orders to standardize work performance on equipment that is essentially the same at all campuses. The U.S. General Services Administration (GSA) has developed very good task descriptions for typical building equipment.

Table 5. Program Review - Facility Management and Operations

Component	*Campus Responsible*	*Recommendations*
3 **Facility Self-Inspection**	UNCW, ASU, FSU, NC A&T, UNCG, UNCP, WSSU, ECSU, NCCU, and NCSA	▶Each campus should initiate self-inspection programs for each of their buildings on at least an annual basis.
4 **Work Order Management System**	All campuses	▶In the long term, the University should select and transition to a common CMMS system for the medium and small campuses as a minimum. For those locations that were classified as either inadequate or marginal, except ECSU, we recommend the system be implemented immediately. Those campuses should be given assistance and guidance either from other campuses with highly successful programs or through contracted services. Other campuses classified as satisfactory should transition to a common CMMS over a 4 to 6 year period much the way ECU has developed their program.
	All campuses	▶ECU should be used as a resource for campuses that have MAINSAVER implementation problems.
	UNCP, NCCU, NCSA, ASU, UNCA, and WCU	▶In the short term, upgrade or replace the current CMMS at campuses where the system is unable to meet program requirements.
	NCSU	▶Combine any multiple Computerized Maintenance Management Systems into one.
5 **Staffing**	ECSU, NCSA, and NCCU	▶Recommend priority be placed on filling staffing deficits at campuses with the lowest condition ratings: ECSU 4 Positions NCSA 5 Positions NCCU 17 Positions
	All campuses**	▶Consideration should be given to using maintenance service contracts as an alternative to filling in-house staffing deficits.
	All campuses	▶The University should review the salary scale and make appropriate adjustments to provide the proper environment to retain dedicated and skilled staff.

**UNCC logs approximately 30 percent of their hours as PM tasks.*

***NC A&T, UNCG, and WSSU are already utilizing some service contracts.*

7.0 ACKNOWLEDGEMENTS

The Jacobs Chanen team was assisted throughout this survey by members of the University. The individuals listed in Table 6 performed the technical assessment of each of their counter-part campuses throughout the survey. We wish to acknowledge their contribution to this survey, as without their services these proceedings would not have been able to be successfully completed.

Table 6. Acknowledgements

Name	University	Subject Area
Chris Aaroe	UNCG	Building Envelope
Steve Siler	UNCG	HVAC Systems
Mark Vesely	UNCP	High Voltage Electrical
Ray Winstead	NCSU	High Voltage Electrical
Carl Wilkerson	UNCW	Building Envelope
Pete Altman	UNCC	HVAC Systems
Mark Bristol	UNC-CH	Fire Protection Systems
Joe Grimsley	ECU	HVAC Systems
Carroll Ensley	WCU	High Voltage Electrical
Johnny Cline	NCSU	Building Envelope
Mike McKinnon	FSU	HVAC Systems
Mike Miskow	UNC-CH	Fire Protection Systems

APPENDIX 1: SUGGESTIONS FOR PROCESS IMPROVEMENT

The following suggestions are provided for consideration in helping improve efficiency and provide cost effective business operations solutions.

Tracking and Measuring PM

Our experience is that facility management organizations that track and measure performance make strides in improving effectiveness and productivity. One method is utilizing a bar coding system to track performance and parts consumption of Preventive Maintenance Orders (PMO). Bar coding adds the benefit of being able to keep an up to date equipment inventory, which is the basis of an effective maintenance program.

In conjunction with a scheduled maintenance program, maintenance mechanics can be issued a daily volume of PMO's along with a relatively inexpensive bar code reader. By reading barcodes placed on the equipment being maintained, the completed PMO confirms that the mechanic went to the proper site because the tag on the piece of equipment was "swiped" when work started and again when the job was completed.

This method is effective because it tracks both labor and equipment. Data gathered can include actual time worked, travel time to the next site, equipment description and serial number, where the equipment is, what parts were used and in what quantities. This information can be downloaded at the end of the day and the supply system can be programmed to automatically notify vendors when bin level minimums are reached, and shelves would be replenished "just-in-time" to support daily operations. The vendor would carry the cost of maintaining inventory and need for storage space is minimized.

Effective Management of Service Orders to Free Resources for Preventive Maintenance

Service Orders (SO), or short duration corrective tasks, are unplanned tasks that take no more than one day to complete and are usually called in by customers one request at a time.

A large percentage of incoming work falls into the SO category and usually requires a maintenance mechanic to investigate the reported condition prior to completing any work. This means each SO typically requires multiple visits to obtain the proper tools and repair parts. The average time per call using this method is approximately 1.5 to 2 hours per task and mechanics can accomplish no more than four to six of these jobs per day.

With fixed budgets or manpower, the only way to free resources to perform preventive maintenance is to do this work more efficiently.

Efficient SO operations are best performed with the "one-man, one-truck, one-radio" (1-1-1) concept. At those campuses that screen for SOs, this process begins with a technically oriented service order receptionist who can review all received service orders daily, determine most of the materials required for each task, and plan and schedule each mechanic's efforts by bundling the service orders in an assigned work area. The bundled SOs are then passed to supply where each mechanic's list of service orders is filled and staged on the truck that evening. The goal is that the mechanic's truck is ordinarily equipped to carry about 60% of the materials/parts to be used over the course of a days work. Materials that are not normally found on the truck will be staged the evening prior to the task performance, using the material list provided by the service order receptionist. Once the materials are staged each SO is reprinted listing each element of materials loaded on the truck along with its applicable barcode.

The following day the mechanic swipes each SO's barcode throughout the day with a handheld barcode reader. The barcode swipes track the facility number, start time, materials as they are used, and completion time. The bar coder is downloaded at the end of the day so that the Inventory Control System can automatically reorder parts. The mechanic is equipped with a radio permitting response to emergency type SOs.

For maximum efficiency, either overload the task orders or add Preventive Maintenance Orders (PMO) to the mechanics daily load. PMO's can be bar coded exactly like SOs to account for worker's time and materials used. This process often leads to competition between mechanics and usually yields completion of 10-14 SOs per day versus 4-6 per day. Ideally, the system will yield one person accomplishing the work that two and one half persons formerly did.