1A.4   **MODERNIZATION OF THE AUTOMATED SURFACE OBSERVING SYSTEM (ASOS)
HARDWARE AND SOFTWARE**

Brian Macauley Hays* and Daniel Brewer
CyberData Technologies, Inc., Sterling, VA

Jennifer Dover
National Weather Service, Office of Observations, Sterling, VA

Thomas Szynborski
National Weather Service, Office of Observations, Silver Spring, MD

Michael Wolfe
Syneren Technologies Corporation, Silver Spring, MD

1.   INTRODUCTION

The Automated Surface Observing System (ASOS) program is a joint effort between the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the Department of Defense (DoD). The system serves as the primary surface weather observing network and supports both aviation and weather forecasting activities. The system is designed to report all of the basic components of a surface weather observation: Sky Condition, Visibility, Present Weather, Pressure, Temperature & Dewpoint, Wind, Precipitation Accumulation, and their associated remarks (NOAA 1998).

There are over 900 ASOS sites within the network. The ASOS sites are divided into two different class levels and multiple different service levels. The class distinctions (Class I and II) are given based upon whether additional and redundant hardware was deployed with the systems. The service level (A, B, C, D, and O) is determined by the level of augmentation provided by a weather observer and the allotted time for restoration of services after a reported failure (NOAA 1998).

The legacy system consists of four major components: the Acquisition Control Unit (ACU), the Data Collection Package (DCP), the sensor suite, and the system peripherals. The system was originally deployed throughout the early and mid-1990s.

The legacy system's operating system (OS) was Portable Software on Silicon (PSOS) and utilized a real-time clock operating on a single board computer located in a Versa Module Europa (VME) card rack to control the system (NOAA 2011 – 2016)

As with any fielded system, over time, the hardware and software are becoming obsolete and unsupportable. The NWS, FAA, and DoD have agreed that a modern hardware and software solution are required to keep the system operating well into the 21st century. The FAA is in the process of developing the next generation ASOS software to replace the legacy OS and application, while the NWS is in the process of implementing modern computing hardware for the new software to operate on.

1.1   Legacy System Overview

The current ASOS system is built around four main component groups: the ACU, DCP, the weather sensor suite, and the system peripherals. In some deployments, however, the ACU and DCP are combined into a Single Cabinet ASOS (SCA) where components from both are located in one single outdoor enclosure (NOAA 2011 – 2016).

The heart of the current ASOS system, the ACU, controls the functions of all other system components. The ACU receives and processes weather information either from sensors directly attached to it or via a radio or hardline link to one or more DCPs with attached weather sensor suites. Generally, the ACU also houses the three atmospheric pressure sensors which are vented to the outside air; in rare cases these sensors are located found in the DCP. There is only one ACU associated with any particular ASOS (NOAA 2011 – 2016).

The DCP(s) is collocated with the sensor suite and is usually located on an airfield, though there are some non-aviation sites such as Central Park in New York City. The DCP handles the polling of the sensors and then provides their data back to the ACU over the radio link. It also controls the power to each of the sensors (NOAA 2011 – 2016).

The system's peripherals are linked to the ACU via hardwire or telephone modem links. They are used to allow weather observers to interact with the system, displaying the current weather information, for maintenance technicians to work on the system, and to

Corresponding author address: Brian Macauley Hays, CyberData Technologies Inc., Sterling, VA 22314; email: Brian.hays@noaa.gov

distribute the weather information to the wider world (NOAA 2011 – 2016).

1.2 Legacy Hardware Overview

The main subcomponents of the ACU (Figure 1) are the VME card rack assembly, the modem AC power rack, the power supply assembly, the Direct Current (DC) power enclosure, the Radio Frequency (RF) and pressure mounting shelf, the I/O panel assembly, and the power distribution and control assembly (NOAA 2011 – 2016).

The DCP (Figure 2) cabinet contains a VME card rack assembly, a circuit breaker module rack, an RF modem and pressure mounting plate, four DC power supplies, a power reset assembly, a Faraday box, and a set of heaters (NOAA 2011 – 2016).

The SCA (Figure 3) contains a hybrid set of equipment from the ACU and the DCP. A typical SCA cabinet contains a VME rack setup like that found in the ACU, the modem AC power rack and telephone modems, the RF and pressure mounting shelf, a circuit breaker module rack, four DC power supplies, a power reset assembly, a Faraday box, and a set of heaters (NOAA 2011 – 2016).

1.3 Legacy Software Overview

The current ASOS software is written in the C programming language and its timing functions are operated by a real-time clock in the ACU and DCP's Central Processing Unit (CPU) boards. The architecture of the software is based around a single computer software configuration item (CSCI) that handles all of the software's functions. This CSCI is labeled as the ASOS Operational Software CSCI and is divided into five major areas: the observer interface, sensor processing, technician interface, remote DCP interface, and the communications interface (Systems Management Incorporated 1998)

The software polls and receives data from various sensors currently in the ASOS baseline as well as related data from other sources such as the Runway Visual Range (RVR) interface. Most of the sensor communication takes place in the DCP which then relays all of that information to the ACU for processing. The software automatically processes all acquired sensor data and generates various surface observation products. The system then outputs all of the data and products to the various system users (Systems Management Incorporated 1998).

The software conducts system monitoring and control processes to maintain the previously described functions. To facilitate the system monitoring functions the software conducts the following functions: system watchdog operation, acquire and store system operator and maintenance logs, maintain a data archive, conduct maintenance monitoring and remote maintenance action

support, conduct routine checks with the ASOS Operations and Monitoring Center (AOMC), and conduct overall system management (Systems Management Incorporated 1998).

2. HARDWARE MODERNIZATION

The hardware modernization will only focus on the ACU, DCP, and SCA components; the sensor suite and the system peripherals will remain unchanged, and the changes that do occur in the ACU will be made to be transparent to those devices. All of the connection points on the ACU, DCP and SCA will remain the same and will not require any cabling or other hardware changes when the new units are installed.

2.1 Acquisition Control Unit (ACU) Changes

The improvements to the ACU (Figure 4) will include the wholesale replacement of the VME card rack assembly, the upgrade of the RF modems and line drivers, the upgrade of the DC power supplies, the upgrade of the Uninterruptable Power Supply (UPS), the upgrade of the data and voice modems, and the addition of a datalogger.

The single board computer card of the VME rack will be replaced with a modern ruggedized computer, known as the embedded controller, on which the new software will run. The Serial Input/output (SIO) boards will be replaced by Ethernet capable serial servers. The Analog-to-Digital (A/D) board will be replaced by the datalogger. The audio board and CPU will be replaced in part by the audio card in the new computer and by a new audio distribution amplifier. A new Ethernet switch will link all of the Ethernet capable components inside the ACU together onto a Local Area Network (LAN).

However, some components of the ACU will carry over into the new system. The pressure sensors in the ACU will continue to be utilized as will some of the legacy modems. The modems that are kept will be those associated with the interfaces that are located on the site as upgrading them would require the replacement of the modems on the other end of the line too. The rack itself will also remain in its current location with the same legacy interface connection points. During the installation the old components will be removed and the new components will be installed into the legacy rack.

2.2 Data Collection Packages (DCP) Changes

The upgrade to the DCP (Figure 5) will replace almost every component in the box. The changes will include the removal of the VME card rack assembly, the upgrade of the RF modems and line drivers to a modern Internet Protocol (IP) based Radio Frequency (RF) modem and Dedicated Subscriber Line (DSL) line drivers, the upgrade of the circuit breaker module rack to a modern Power Distribution Unit (PDU), the

replacement of the UPS, the replacement of the DCP UPS relays and legacy heater circuity, the upgrade of the DC power supplies, and the addition of a datalogger, Unlike the ACU, the DCP will no longer contain a computer; instead all of the sensors and hardware will be polled over the LAN from the computer located in the ACU. Like the ACU, the new DCP will contain an Ethernet switch and serial servers to replace the SIO boards. The legacy heater bars, the fiber optic modems, and the Faraday box with its associated wiring will remain unchanged.

The layout of the components in the DCP will also change. A small 19 inch rack will house the serial servers, the PDU, the UPS, and the new UPS battery container. A side panel will be installed that contains all of the new DC power supplies, the datalogger, and a multiple point mounting location for either the IP based RF modem or the DSL Ethernet extender. The backplane will also be reconfigured to house the new circuit breaker racks for the AC power cabling and the mounting points for the new 19 inch rack. Prior to installation, each site will receive a new DCP cabinet to replace the legacy enclosures. This will also accomplish the goal of getting every site to have the same DCP boxes, replacing the multiple variants currently in the field.

2.3   Single Cabinet ASOS (SCA) Changes

The upgrade of the SCA will include aspects of both the ACU and DCP. The changes will include replacement of the VME rack, circuit breaker rack, the UPS, UPS relays and legacy heater circuity, the upgrade of the DC power supplies, data and voice modems, and the addition of a datalogger.

As with the ACU a computer will replace the computer board in the VME rack, serial servers will replace the SIO boards, the audio card in the computer and the new audio distribution amplifier will replace the voice and voice computer board and an Ethernet switch will tie them all together. The SCA will also follow the same upgrade as the ACU with respect to the legacy telephone modems; keeping local interfaces while upgrading external ones.

The SCA will utilize the DCP variants of the UPS and DC power supplies as these are the more ruggedized versions. The computer will also utilize a solid state hard drive as opposed to the electromechanical drives that will be installed in the ACU. The SCA will also utilize the mounting plans for the DCP to secure all of the required hardware in the cabinet. Lastly, as with the DCPs, upgraded SCAs will be shipped to replace the legacy SCA cabinets in the field.

3.   SOFTWARE MODERNIZATION

The software modernization will update the ASOS software to the C++ programming language and will completely overhaul the software's architecture. The new software would be comprised of one OS CSCI and four application CSCIs, replacing the single CSCI design of the legacy software. The name of the new software is the Weather Acquisition and Reporting Software (WARS). A graphical view of the new software is available in Figure 6.

The most dramatic change will be to the current maintenance functions; the current set of functions and screens will be revised to a more comprehensive and easy-to-navigate Graphical User Interface (GUI) format while maintaining all of the same sensor information and updating the hardware for the newly available functionality. This new interface will be known as the Maintenance Interface Device (MID). The new interface will be installed on both the ASOS itself, as well as the electronics technician's laptops and desktops as a standalone software package.

Lastly, the AOMC will have its hardware and software updated to be able to interface with the new ASOS software. The interface with the ASOS is planned to mimic the way the current system works with some improvements in efficiency of both software and hardware components.

3.1   Weather Acquisition and Reporting Software (WARS)

The Operating and Windowing System (OWS) CSCI runs the startup scripts at system boot, runs the backup scripts to backup files and clean up expired files, manages the security libraries by keeping access lists and handling encryption, initiates communications drivers, starts and runs the Open Data Distribution Service (OpenDDS), and manages the SQLite based configuration and archive databases.

The four application CSCIs are the Sensor & Interface Software (SIS), the Algorithm Software (AS), the System Control Software (SCS), and the Display Interface Software (DIS).

The SIS facilitates data acquisition from the sensor and user inputs as well as handling data output via the various interfaces such as Operator Interface Devices (OIDs), Video Display Units (VDUs), etc. The AS contains the Documented Weather Algorithms and is responsible for running all of the sensor data through these algorithms and then outputting the data to OpenDDS for distribution to the other CSCIs. The SCS is responsible for handing system configurations, controlling subsystems, implementing security functions, monitoring other system modules, periodically testing system status, all system timing functions, archiving data, and logging all system events. The DIS is responsible for correctly showing all associated graphical displays on the system. This CSCI handles both the local maintenance terminal at the ACU, the remote MID, and the new GUI based AOMC software.

As the proposed software is now broken down into multiple pieces of software a new communication method is used to facilitate messages to and from each module of software. The OpenDDS defines a typed reliable publish/subscribe service for efficiently distributing application data between participants in a distributed application. Each DDS message is initiated by a CSCI subassembly plugin (the publisher) and received by the required CSCI subassembly plugins (the subscribers).

The software will be required to maintain all of the functionality of the legacy software. Some minor changes are expected as the new hardware will not allow some functions/screens to maintain their current form but the upgrade is planned to be as transparent as possible to end users. However, some portions of the software, most notably the maintenance aspects, will be completely overhauled during this process.

3.2 Maintenance Interface Device (MID)

The MID was conceived from the need to code the new software in a timely manner as well as security concerns, both of which forced a re-examination of the current maintenance techniques. The MID will operate on both the ACU itself as well as on the technician's laptop computer. As stated previously the software will be in the form of a GUI and will have the user utilize a mouse to navigate the screens Figure 7.

The MID will feature each hardware item, sensor or interface within a box on the screen and will display their status with a color, allowing for a quick go/no go assessment of the system. Additionally, the interface colors the lines linking all of the interfaces to show communication statuses, where possible. The MID will also feature a completely overhauled system configuration setup. Instead of typing over the values on the physical or sensor configuration pages, the user now has popup text fields in which to record the data.

4. NEW FEATURES AND CAPABILITIES

4.1.1 Internal Communication Methodology

The most visible change will be the internal hardware communication format in the ACU, DCP and SCA, which will be an Ethernet-based one as opposed to the legacy serial interfaces. Each Ethernet capable device will be given a static IP address to function on the new LAN. In the ACU and SCA these devices will all be linked to the embedded controller through the Ethernet switch, while in the DCP they will be linked to the ACU via the IP based RF modems through the Ethernet switch. All of the sensors and interfaces requiring a serial interface will be connected to the serial server and assigned port numbers that the embedded controller in the ACU can poll directly as opposed to going through a computer in the DCP as the legacy system did.

4.1.2 Storage Medium

Unlike the old system which had an extremely small amount of storage space by today's standards, the new system will feature two 500 GB hard drives. These larger drives will easily be able to handle all of the data being generated by the new software. These drives will also be in a mirrored Redundant Array of Independent Disks (RAID) configuration so that both drives are simultaneously updated with all data. This allows the system to suffer a drive failure and continue to operate on the secondary drive until the primary drive can be replaced. These drives have a hot swappable feature that allows the drives to be replaced without having to power off the system, preventing unnecessary data outages.

4.1.3 Simple Network Management Protocol

The new Ethernet-based setup will allow for the institution of Simple Network Management Protocol (SNMP) on the LAN. In the legacy system, each piece of hardware had a self-test preformed once per minute to determine if it was still working correctly. With the SNMP setup, each device will send a failure message as it shuts down notifying the trap server, which will be on the embedded controller, of the problem as they occur. This protocol will allow for immediate status updates of system failures. Additionally, the system will continue to check all items status using a polling methodology on a fixed interval of no less than once per minute for a routine status update.

4.1.4 Data Storage

In addition to the larger storage space discussed above, the new software will also be storing the data in a new format. The legacy system feature data output in a text based format that mirror the screens available to the users of the system. The new system will utilize a SQLite database to house all of the data generated by the system. These SQLite database files will be archived every night and a new file will be created at midnight in order to prevent a corruption of data from destroying the entirety of the system's archive of data.

The types of data being saved by the system will also be changing. The black boxes of the legacy system's weather algorithms are no more; in their place all of the raw and intermediate values used in the calculation of the final products will be saved and archived. All of the received poll messages from the sensors will also be captured and recorded. This will allow for detailed event recreation on test systems when any failures or other problems occur. It will also allow for easier troubleshooting and examination of the system when the final weather products do not match up to expected test results. In this first iteration the expanded data will not be available to a wider audience due to the continued use of dial up modems for external communications.

Lastly, the length of time data will be kept on the system is changing. In the legacy system all of the raw sensor data was wiped from memory every 12 hours and only the processed reports and some system maintenance data was available for 30 days. In the new system all data will be saved for that same 30 day timeframe.

5. CONCLUSION

It is hoped that the ACU/DCP upgrade project will allow the ASOS to continue functioning for many more years. The new hardware should allow for fewer maintenance visits and easier troubleshooting of issues. The new software components should make the system much easier to maintain and upgrade when needed. The modular nature of the software code will be able to support additional sensors, interfaces or algorithms in a way that the legacy system never could.

Furthermore, this upgrade is not the end of the modernization but only the beginning. Many other aspects of the ASOS need to be addressed (external communications, sensor obsolescence, algorithm updates, etc.) and some are already being planned out for the coming years. However, without this essential modernization of the hardware and software, none of these other upgrades would be possible.

6. ACKNOWLEDGEMENTS

7. REFERENCES

NOAA, National Weather Service, 1998: Automated Surface Observing System (ASOS) Users Guide; U.S. Dept. of Commerce, Washington, DC, 61pp.

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NOAA, National Weather Service, 2011 - 2016: S100 ASOS Site Technical Manual Revision B; U.S. Dept. of Commerce, Washington, DC, 1423pp.
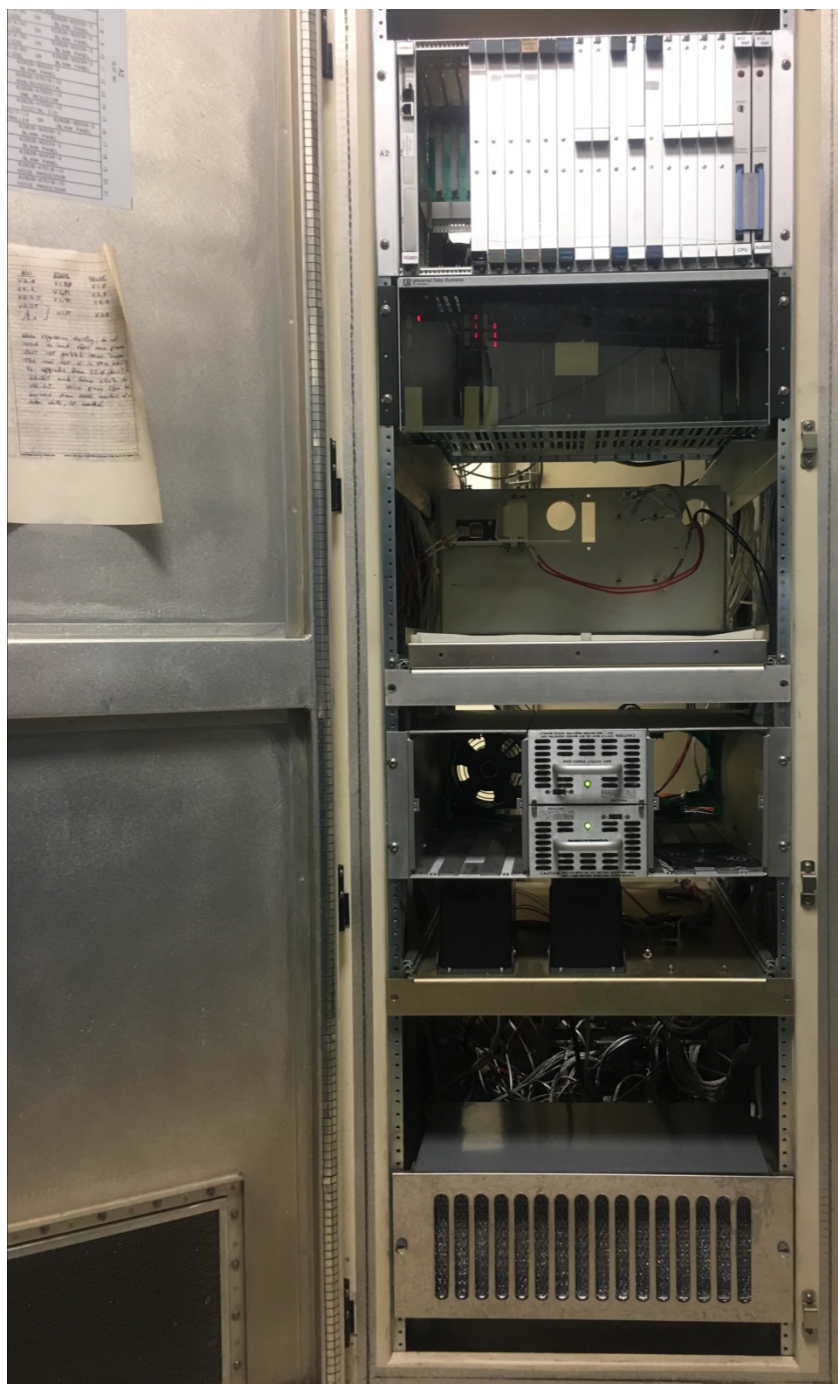
8. FIGURES

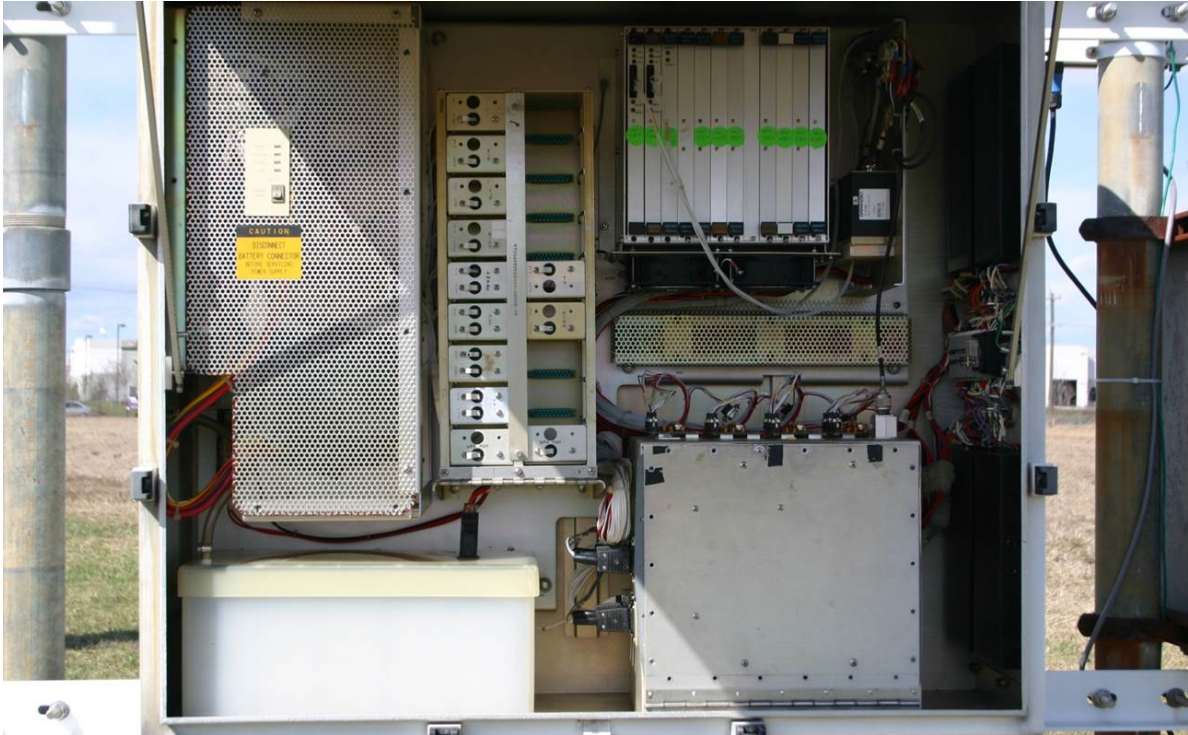Figure 1 Legacy Acquisition Control Unit (ACU) rack

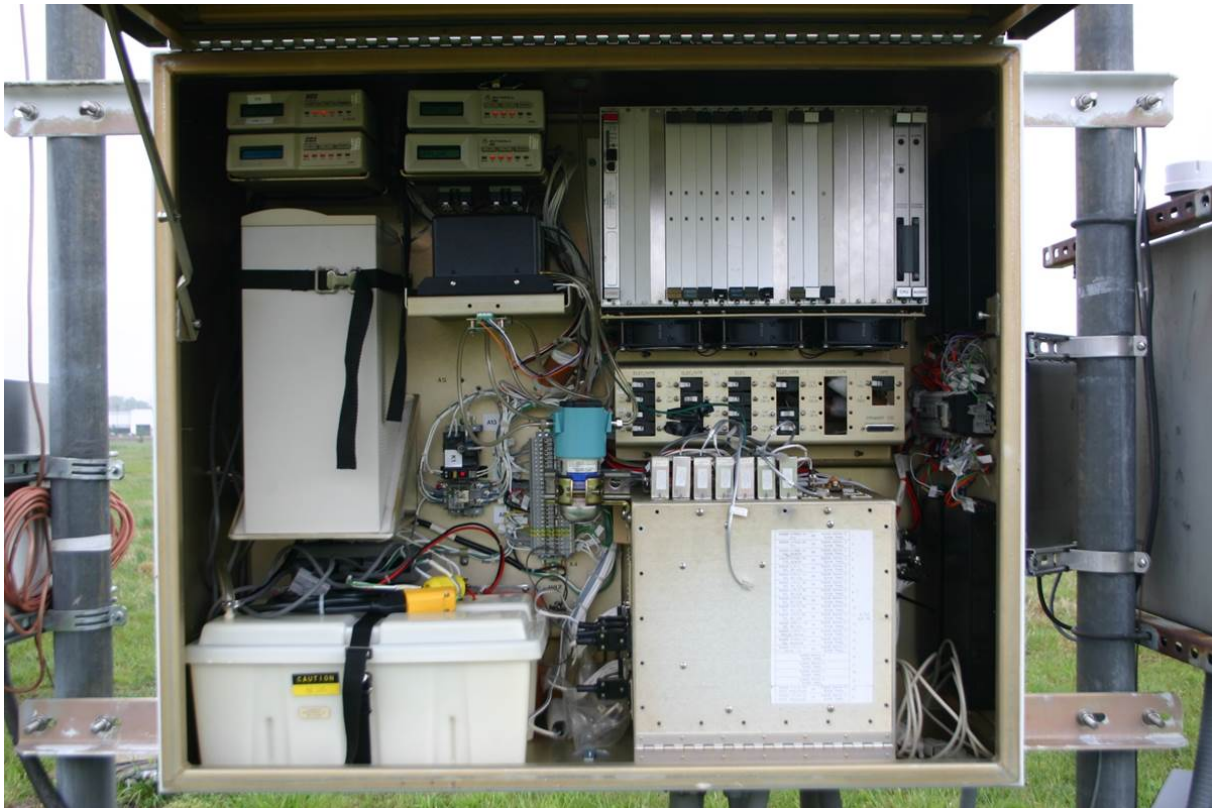Figure 2 Legacy Data Collection Package (DCP) cabinet

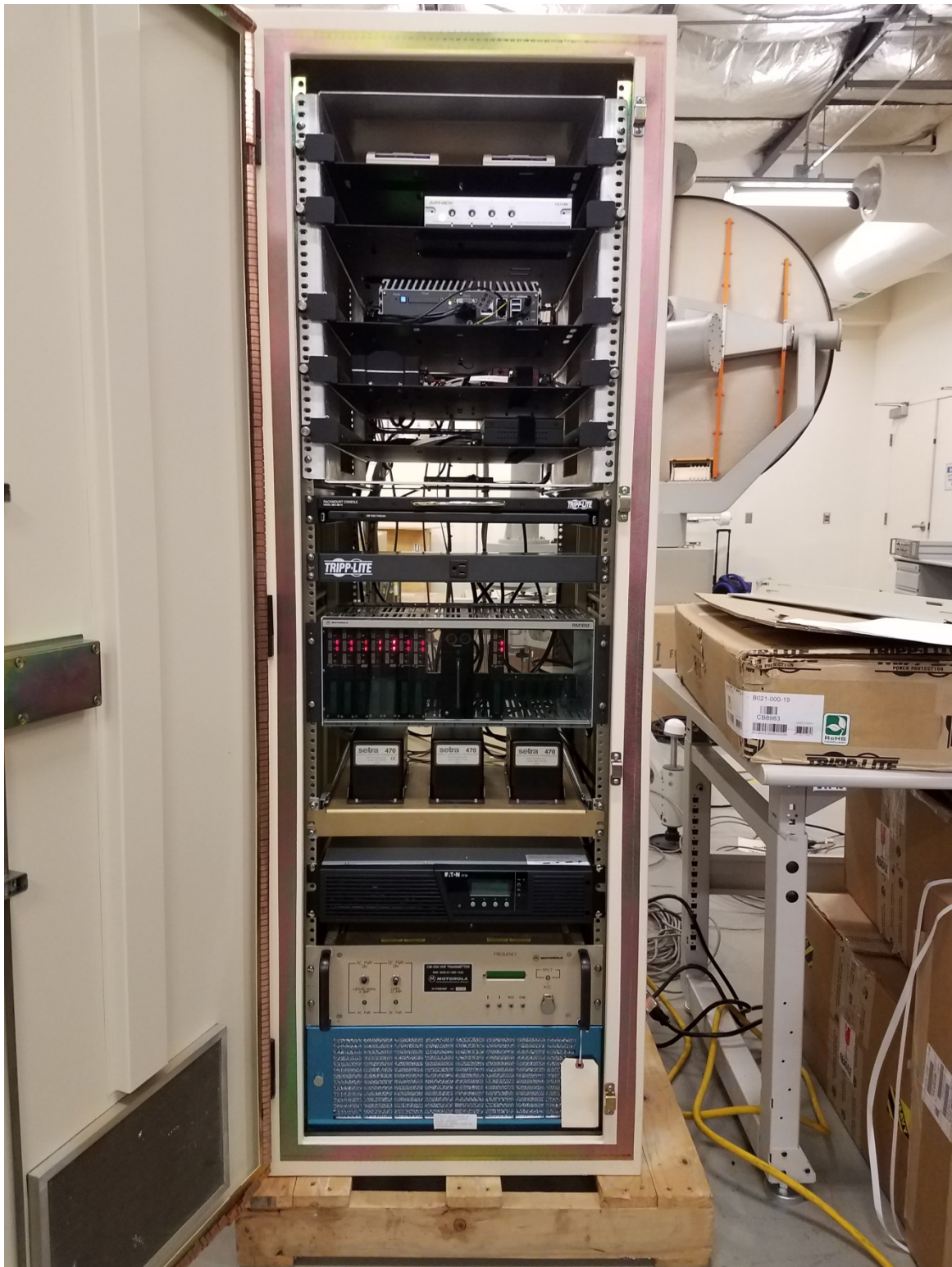Figure 3 Legacy Single Cabient ASOS (SCA) cabinet
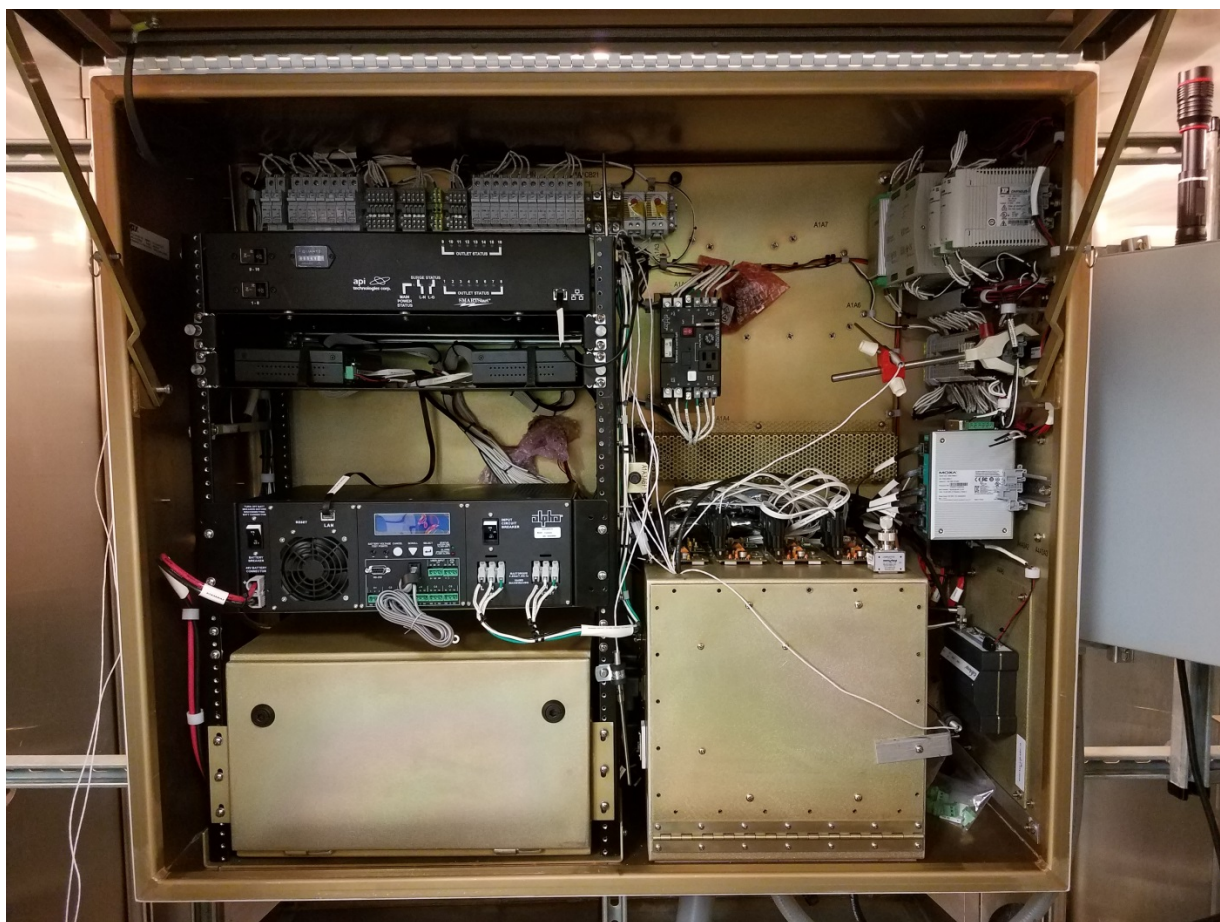
Figure 4 New ACU rack

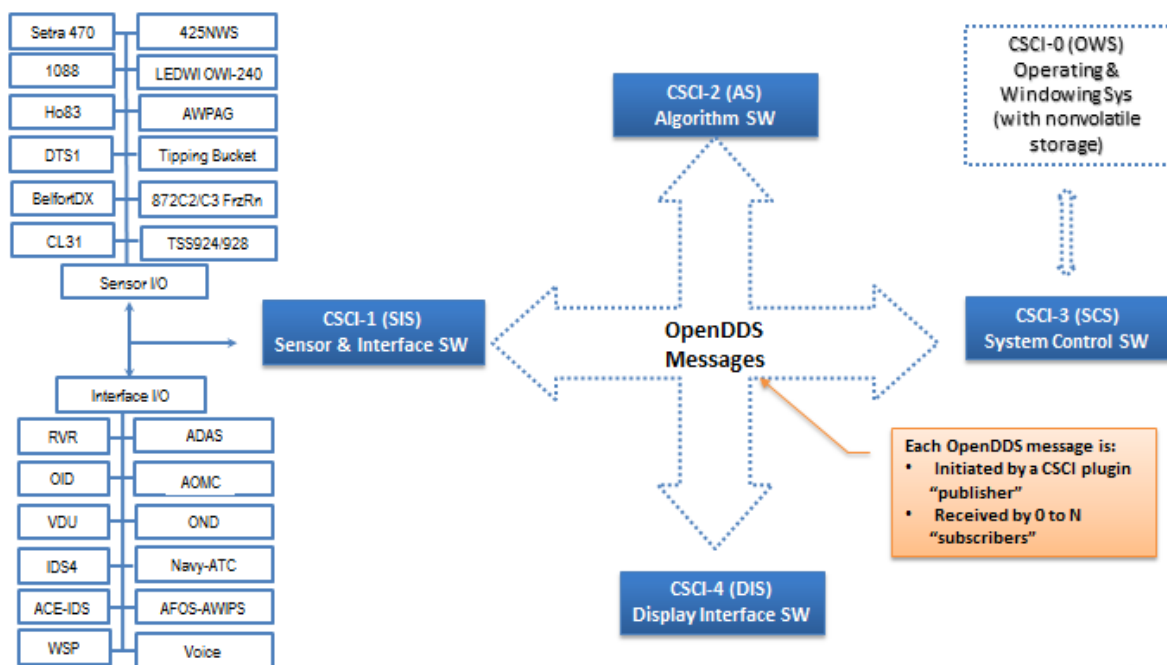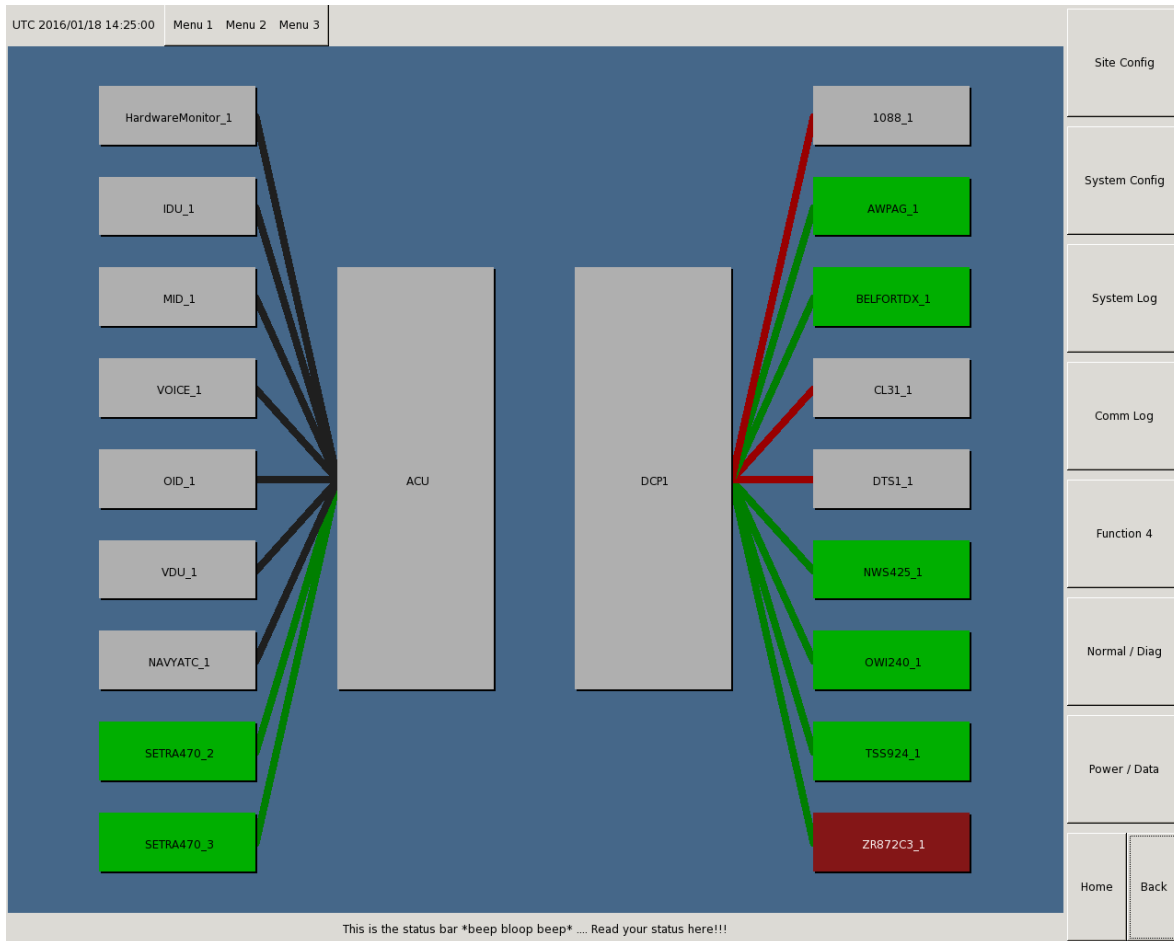Figure 5 New DCP cabinet

Figure 6 Graphical layout of WARS components

Figure 7 Maintenance Interface Device (MID) Overview Screen