UCRL- CR-107024
PREPRINT

NOV 01 1991

A GUIDE TO WRITING PROCUREMENT
SPECIFICATIONS FOR NEW AND EXISTING
CHAWS SITES

S.A. Martins
and
Cleo Fry

September 1991

Lawrence
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Manuscript date: April 1991

LAWRENCE LIVERMORE NATIONAL LABORATORY
University of California • Livermore, CA • 94550

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Foreword

Turn-key Chemical Hazard Warning Systems (CHAWS) have been designed by the Lawrence Livermore National Laboratory (LLNL) and installed at a number of U.S. Army sites. This document is intended to be used as a guide by those charged with writing procurement specification for both new and existing CHAWS sites. It discusses issues of system design and the functional requirements for both hardware and software. Suggestions are made for those interested in updating the computer platform and/or operating system used in older CHAWS designs. The topics of new-site installation and training are only briefly discussed. The reader is referred to the CHAWS User's Guides listed in the bibliography for user information.

A Guide to Writing Procurement Specifications for New and Existing CHAWS Sites

Introduction

Chemical Hazard Warning Systems (CHAWS) have been installed at a number of U.S. Army sites.* This document is intended to be used as a guide by those charged with writing procurement specifications for both new and existing CHAWS sites. It addresses some general system-design considerations as well as the theory of operation. It is recommended that the user become acquainted with CHAWS user's guides^{1,2} and with the Air-Quality user's guides³ for each installation.

The primary function of CHAWS is to provide near-real-time information about the dispersion and trajectory of hazardous airborne materials if such materials are accidentally released from areas within the CHAWS network. This is accomplished when meteorological data acquired from remote sites are automatically processed. One full-time meteorologist is required to operate the system effectively.

Secondary functions of CHAWS include the archiving of meteorological data, monitoring air quality for compliance with local standards, and the distribution of these data to authorized agencies.

Each CHAWS system has different requirements due to site geography, budget, and other local considerations. As a result, many of the specifics of the system design will vary from site to site. When hardware and software specifications are being written for an existing site, it is best to describe products that have been provided for that site. When specifications are being written for a new site, a wider range of choices is available.

The primary criteria used to select CHAWS components are that each product perform its functions satisfactorily and that it is compatible with the rest of the CHAWS system.

* The Lawrence Livermore National Laboratory (LLNL) designed and installed turn-key CHAWS at Tooele Army Depot, Edgewood Arsenal, Pine Bluff Arsenal, Lexington-Blue Grass Army Depot and Johnston Island.

General Design Considerations

Each CHAWS system is comprised of a variety of sensors, data loggers, communications equipment, computers, and software. Additional subscription services such as satellite weather maps and weather radar data, have been provided at some sites, but do not need to operate within the CHAWS data processors.

The standard CHAWS components may be organized into three functional blocks.

1. ***Remote Site Data Acquisition.*** This function is usually filled by a data logger connected to instruments such as temperature sensors, wind-speed sensors, wind-direction sensors, relative-humidity sensors, air-quality sensors and special devices such as SODARs.

In addition, some method must be provided to relay the data collected from the remote sensors to a Central Base Station. Either a radio, telephone modem, or dedicated wire set may be used. The remote site must be equipped with the same type of communication equipment as the Central Base Station.

2. ***Central Base Station*** includes one or more computers, communications equipment, and several different software subsystems.

Some of the communications equipment and software must be suitable for acquiring data from the remote data loggers. Other communications equipment and software must be suitable for sending processed data to other authorized agencies.

Hardware and software must be provided that will allow these data to be processed, displayed, and logged at the Central Base Station. Data processing includes the prediction and graphical representation of downwind hazards as a result of accidental releases from within the CHAWS network.

Moreover, because CHAWS is designed to be used in emergencies, some form of power conditioning and backup power supply must be provided for the entire system.

3. ***Distribution of Data to Other Agencies.*** This function allows data collected by the CHAWS network to be shared with other users or agencies. At the very least, all meteorological data should be shared with an Alternate Base Station, located in an area some distance from the

primary site. The alternate site should have the same capabilities as the Central Base Station. Communications between these two stations will usually be accomplished by phone modem or direct wire hook-up.

At some sites, there is a requirement for CHAWS data to be distributed to offices other than the Base Stations. In these cases, a connection to a Local Area Network (LAN), message center, or other external computational facility is required. These needs must be evaluated on a site-by-site basis. For an example of an extended distribution network, consult the manual for the Pine Bluff Arsenal Message Center.⁴

Existing CHAWS Sites

All existing CHAWS sites are based on the same general design. There are slight variations in equipment provided at each installation due to changes by the manufacturers over time and due to individual site requirements.

Remote Sensors and Data Acquisition

1. *Standard Meteorological Data Logger.* The data logger must be able to sample each sensor at 1 Hz, if required, and to perform average and standard deviation calculations on data from each channel. The HANDAR 540A Data Collection Platform (DCP) has been selected for this function at all existing CHAWS sites. The following are requirements for the data logger.

Enclosure - The data logger must be housed in a NEMA 4 weatherproof enclosure. For all existing CHAWS sites, these housings are constructed of stainless steel.

Firmware - Firmware is the data-acquisition program used by the data logger. It must be flexible enough to be used at every station of every CHAWS site. At existing CHAWS sites, HANDAR 540A DCP Revision 6.9 was selected. Later versions of this firmware may not work with the CHAWS software and earlier versions may not perform standard deviation calculations correctly.

The data loggers must be configured by the vendor or system integrator for the number and type of sensors installed at each remote site. In addition, each logger must have a unique station identification number so that it can be individually addressed by the Base Station when data are requested. The following is a list of channel configurations that may be used at one to four levels per tower.

- Wind speed averaged over 5 minutes
- Wind direction averaged over 5 minutes
- Wind direction standard deviation over 5 minutes
- Temperature averaged over 15 minutes
- Relative humidity averaged over 15 minutes
- Barometric pressure averaged over 15 minutes
- Internal battery voltage averaged over 15 minutes
- Analog inputs for air-quality averaged over 5 minutes

Memory - There must be enough memory in each data logger to store at least 6000 data points for several weeks.

Sensor Inputs - Each logger must have the potential, either present or through up-grades, to read the following sensors. The actual number and type of sensor channels required for each logger will depend on the site configuration.

- 3 wind-speed inputs
- 3 wind-direction inputs
- 5 temperature inputs
- 2 relative-humidity inputs
- 1 barometric-pressure input
- 1 battery-voltage input
- 5 0- to 5-volt analog inputs for air-quality data

Internal Power - An internal power-conditioning circuit with an internal rechargeable battery that will allow charging of the battery at a rate of 0.6 or 1.5 amps, as required, shall be provided. At existing CHAWS sites, Gel-Cell batteries have been provided. The option for direct operation of the logger from an external power supply or solar panel shall be provided.

Power Supply - An external power supply that can provide 14.2 VDC at 0.3 amps shall be provided where conditions permit. Lightning protection and power-surge protection of all equipment will be required at some sites, depending on local conditions.

Solar Panel - A solar panel that provides 0.6 or 3 amps at 16 VDC shall be supplied where other types of external power are not available.

The power output of the panel will be determined by the latitude of the site and other local conditions.

UHF Radio - A UHF radio, tuned to an approved frequency, shall be provided at all sites with approved frequencies. It will be used to transmit data from the remote logger to the Base Station in 8-bit ASCII format. It must conform to FCC regulations and to protocols used by both the data logger and the Base Station. It shall provide at least 2 watts of power when transmitting, and operate at a baud rate of 1200 or greater. It may be necessary to obtain an approved radio frequency for each CHAWS site, but a Department of Army directive issued a common frequency for all existing CHAWS sites and many planned sites.

UHF Antenna - A directional, high-gain antenna tuned to the local frequency shall be provided with each UHF Radio. Antenna-mounting hardware and coaxial cabling with appropriate connectors shall also be provided. The cable shall be long enough to reach from the antenna to the DCP and must be of proper low-loss quality.

Local Modem - Where UHF radios are not used, a telephone interface with dedicated lines shall be provided to transmit data from the remote loggers to the Central and Alternate Base Stations. It must be compatible with Base-Station communications protocols, and operate at a rate of 1200 baud or greater.

2. **Standard Meteorological Sensors.** Below is a list of the standard sensors used at existing CHAWS sites. They must be approved for prevention of significant deterioration (PSD) monitoring by the Environmental Protection Agency (EPA) and the U.S. Nuclear Regulatory Commission (NRC), and they must meet any other environmental licensing requirements. Each sensor must be provided with cables and connectors suitable for interface with the data-logging unit, above. Crossarm assemblies are required to mount the various sensors to the tower.

Wind Direction - A horizontal wind-direction vane shall be provided. The vane/potentiometer-type sensor must be rugged and meet the following specifications: a range of 0 to 360 degrees, a starting threshold of 1.72 mph, an accuracy of $\pm 5\%$, a resolution of 1° , a time constant of 0.3 sec, a distance constant of 2.4 m, and a resistance of 1000 kohms with a pot gap of 5° . It must have a maintenance interval of

2 years, and operate at between -40° and 70°C . A HANDAR Model 431A is used at existing CHAWS sites.

Wind Speed - A 3-cup anemometer shall be provided. The specification includes a range of 0 to 150 mph, a starting threshold of 1.72 mph, an accuracy of $\pm 5\%$ RMSE, a resolution of 1 knot, a distance constant of 6.1 m, and an output frequency velocity constant of 0.280 Hz/mph. Input voltage shall be in the range of 10 to 15 V, with power requirements that do not exceed 2.5 mA at 12.5 V. Output high/low pulse voltage shall be 7.0/0.65 V at 10-V input with a 10-kohm load. It must have a maintenance interval of 2 years, and operate at between -40° and 70°C . A HANDAR Model 430A is used at existing CHAWS sites.

Temperature - Thermistors shall be provided to measure air temperature and temperature gradients. They shall have a range of -50° to 60°C , with an accuracy of $\pm 0.2^{\circ}\text{C}$ between 0° and 60°C . Sensor output shall be 440 kohms to 2.8 kohms over the entire temperature range. They are to be housed in inverted, conical, naturally aspirated radiation shields. HANDAR model 432A thermistors and model 442A radiation shields are used at all existing CHAWS sites.

Relative Humidity - A humidity sensor housed in an inverted, conical, naturally aspirated radiation shield shall be provided as required. It shall have an RH range of 0 to 100% and be operable in the range of -40° to 50°C . At 20°C , and in the range of 0 to 80% RH, it must have an accuracy of $\pm 2\%$, a hysteresis of $< 2\%$, and a linearity of $\pm 1\%$. Input voltage shall be in the range of 10 to 15 V, with power requirements that do not exceed 2.5 mA at 12.5 V. Sensor output shall be 0 to 1 VDC, linear, over the entire RH range. At all existing sites, a HANDAR model 435A humidity sensor is housed in a model 442A housing along with a thermistor.

3. **Air-Quality-Monitoring System.** At sites where air quality is monitored, the following units must be installed.

Sequencer - This unit is used to sequence the automatic calibration of each of the air-quality instruments listed below by controlling the air-quality calibrator. It must be capable of doing several simultaneous zero and span calibrations on a daily basis. Two products are currently in use

at CHAWS sites. The first is the Monitor Labs Envirologger model 2000 (no longer available), and the other is Monitor Labs Envirologger II.

Calibrator - This unit provides zero and span gases to the air-quality instruments during calibration and is controlled by the sequencer, above. Zero air is produced by filtering compressed air through an activated carbon filter. Ozone is produced, when required, by an internal ozone generator. Nitrogen oxide is provided by compressed gas cylinders, and permeation tubes are used to provide SO₂ and NO₂. The calibration unit must be equipped with a signal line to the DCP that provides 0 VDC during normal operation and 5 VDC when calibrations are in progress. All calibration units supplied to existing CHAWS sites are Monitor Labs Model 8550 Dynamic Calibrator.

SO₂ Analyzer - This unit must be able to detect sulfur dioxide in the range of 0 to 10 parts per million in dry-gas using the EPA-approved UV-fluorescent method. This unit must be able to interface with the calibrator, above, and provide a 0- to 5-volt signal (corresponding to the level of SO₂ present) to the DCP. It must operate at 10 to 40°C, 0 to 95% relative humidity with a precision of $\pm 0.0005\%$, a zero drift of $\pm 0.001\%$ in 24 hours, a span drift of $\pm 0.7\%$ in 24 hours, a linearity of $\pm 1\%$, a 95%-response time of 5 minutes, and a lower detectable limit of 0.002 ppm. All SO₂ analyzers at existing CHAWS site are Monitor Labs Model 8850.

NO_x Analyzer - This unit must be able to detect oxides of nitrogen in the range of 0 to 10 parts per million in air using the EPA-approved chemiluminescent method. The unit must be able to interface with the calibrator, above, and provide a 0- to 5-volt signal (corresponding to the level of NO_x present) to the DCP. It must operate at 5 to 35°C, 0 to 95% relative humidity with a precision of $\pm 1\%$ full scale (FS), a zero drift of $\pm 0.4\%$ FS in 24 hours, a span drift of $\pm 1\%$ in 24 hours, a linearity of $\pm 1\%$, a 95%-response time of 3 minutes, and a lower detectable limit of 0.002 ppm. All NO_x analyzers at existing CHAWS site are Monitor Labs Model 8840.

O₃ Analyzer - This unit must be able to detect ozone in the range of 0 to 10 parts per million in air using the EPA-approved UV photometric method. This unit must be able to interface with the calibrator, above, and provide a 0- to 5-volt signal (corresponding to the level of O₃ present) to the DCP. It must operate at 5 to 40°C, 0 to 95% relative humidity with a precision of $\pm 0.002\%$, a zero drift of $< 0.001\%$ in 24 hours,

a span drift of <0.001% in 24 hours, a linearity of $\pm 1\%$, a 95%-response time in <20 seconds, and a lower detectable limit of 0.001 ppm. All O₃ analyzers at existing CHAWS site are Monitor Labs Model 8840.

Instrument Rack - A double rack must be provided to house all of the air-quality instruments listed above. At all existing CHAWS sites, two 19-inch racks are provided, with an overall dimension of 46-inches wide by 32-inches deep by 78.5-inches high.

Glass Manifold - A horizontal, glass, sampling manifold (heated if required) shall be mounted inside each of the air-quality-instrument shelters. These manifolds have a glass cane inlet from outside of the shelter for the air intake.

Shelters - At each site where air-quality instruments are supplied, a shelter with minimum dimensions of 8-x-10-x-8 feet must be provided. A door with minimum dimensions of 3-feet wide by 7-feet high is required. The shelter must be wired for 120-x-208-x-240 VAC, single phase, at 100 amps. An air-conditioning unit with a heating and cooling capacity of 19,000 BTU must be provided. One existing CHAWS site has been provided with a Rohn model ESB810 shelter, including a model ESHVAC-19000 air-conditioning system, and a model ESEP810 wiring package.

4. **Meteorological Towers.** A tower that is capable of supporting all of the standard meteorological sensors, antennas, and solar panels used at the site must be provided at each remote-data-logging site. The specifications for each tower will vary with each location in a CHAWS installation, depending on height and weather requirements. At one existing CHAWS sites, Rohn model 55, 60-meter towers with elevator systems have been installed. At another site, Rohn model 45GSRS 20-foot towers have been installed.

Mounting hardware that is compatible with the tower must be provided for all sensors, antennas and solar panels used at the tower.

5. **SODAR.** A SODAR unit is a monostatic doppler-sound-detection and ranging system. It must have the capability to report the height of the inversion layer up to 1000 meters above the ground, and determine wind speed, and the standard deviation of wind speed over these altitudes.

The SODAR unit must have the capacity to be polled for data at regular intervals over telephone lines, radio, or dedicated wire set by the Central Base Station. Software shall be provided for the Base Station that allows this polling to take place. SODARs are not installed at all CHAWS sites, but where they are, a Remtech model BA23A has been used.

Central and Alternate Base Stations

Two identical Base-Station systems must be provided. They must have the capability to run in parallel with one another at two different physical locations and share all meteorological and air-quality data.

1. **Base-Station Computers.** A Base-Station computer must have a multitasking and/or multiuser capacity of at least four users, a color display with a resolution of at least 640 by 400 lines, enough memory to perform all assigned functions (listed below), at least one printer port, at least one serial communications port per remote user, at least two serial communications ports for the host user, and the capacity for a computer terminal or a monitor and keyboard for each user. Each of the computer systems must be able to store at least 40 megabytes of data and must be provided with floppy disk drives.

The Base-Station Computer supplied to all existing CHAWS sites is an IBM PC/AT or true compatible computer with 1 megabyte of memory running PC or MS DOS Version 3.1 or higher. Each is provided with either a Sigma Color 400 graphics system or a VGA graphics system. Note: VGA cards may not be used where Sigma Color 400 is installed.

Data-Storage Devices must be provided for both internal and external storage of both data and software. Minimum requirements include an internal hard-disk drive with a capacity of 40 megabytes or more, and a floppy-disk drive with a capacity of 1.2 megabytes or more. When selecting floppy drives, consideration should be given to the intended use of the floppy disks and to the requirements of other machines that will be expected to read them. In general, floppy disks will be used to archive data and for the exchange of both data and software with other systems. Optional data-storage devices include streaming tape drives and mechanical/optical rewritable CD ROM drives.

The Multiuser Capability in existing CHAWS computers is supplied by the use of one Alloy PC-Slave card per remote user (installed in the host computer) and Alloy multiuser software, either ATNX or NTNX, running on the host PC/AT. Each slave card must have at least 1 megabyte of RAM. At least two of the PC-Slave cards are supplied with either a Kimtron terminal or an Alloy PCST/G terminal.

2. *Other Hardware Requirements.* The *Base Station* must have several other pieces of hardware to support its mission. These are listed below.

Printer - A printer with either a Centronics parallel or an RS-232A serial interface is required. It must have the ability to print the graphics output from the software packages listed below. It should be able to use, at the minimum, 8.5" by 11" plain paper. Consideration should be given to noise generated by the printer if it is to be located in an Operations Center.

Printers supplied to existing CHAWS sites include the IBM Proprinter, Epson FX-80, HP ThinkJet, and HP DeskJet printers.

Data Retrieval - Hardware must be supplied to retrieve data from the remote data-acquisition system described above. It must be compatible with both that system and the data-retrieval software described below. It must function at a minimum baud rate of 1200.

If a UHF radio is used, a high-gain, omni-directional antenna shall be provided with hardware to mount it outside of the building on a tower. Low-loss coaxial cable shall be installed between the antenna and the Base Station Radio.

Units supplied to existing CHAWS sites include the HANDAR model 542A Radio Base Station and the HANDAR model 547A Central Station Controller I/F card.

Communications - Communications hardware is supplied on a site-by-site basis. All hardware must have specifications commensurate with its function. The minimum requirement is for a dial-up, direct-connect modem or dedicated wire set to connect the Central Base Station with the Alternate Base Station.

Several different products have been supplied to existing CHAWS sites. These includes 1200- and 2400-baud dial-up modems, short-haul

modems for distances greater than 40 feet and direct connections where distance permits.

Back-Up Power - A back-up power system is required for all critical components of this system. For the Central Base Station, this is usually an uninterruptible power supply (UPS) that can provide enough power to keep the system running for at least twenty minutes after normal power is lost. Either independent or integrated power-surge protection is required at all sites.

For most existing CHAWS sites, a 1000 VA UPS such as the Power Systems Series 36 UPS is used at the Base Station.

3. **Software Requirements.** Various software packages, or subsystems, are required to acquire raw data, to process and log these data, and to predict down-wind hazards as the result of a toxic spill. These functional requirements are listed below.

Data Retrieval Software must have the capability to use the Data Retrieval Hardware to poll the Remote Site Data Loggers or DCPs for their data at regular intervals. It must then make these data available to the data-processing software packages listed below. At all existing CHAWS sites, an LLNL-customized version of HANDAR's BASE program, version 1.1, is used with one of the PC-Slave cards. New versions of this program will not work with Alloy PC-Slaves at existing CHAWS sites.

At sites where Remtech SODARs are installed, 1200-baud dial-up modems are installed on both the SODAR unit and on a serial port on the host PC/AT computer. SODAR Data Retrieval Software include MEX-PC.COM (with a SODAR.MEX script file) and RDSODAR.EXE. The latter program is used to place SODAR data into the daily binary files.

Down-Wind Hazard Predictions must be performed, as required, based on current data supplied by the Remote Data Loggers. At all existing CHAWS sites this function is performed by the U.S. Army's Hazard D2-PC⁵ software program running on one of the PC-Slave cards.

Data Reduction and Logging of the raw data retrieved from the Remote Data Loggers must be performed, by custom software, each time new data are received. At existing CHAWS sites, this function is performed on the host computer in the context of the batch files

GRAPHIT.BAT and LOGIT.BAT. These batch programs run a program called RDCATCH.EXE that converts the meteorological and air-quality data it finds in raw data files into a binary format and stores these data in daily files. These daily files are used to archive data and by the data-processing programs listed below.

Color Graphics Display of the predicted plume trajectories from various locations at a CHAWS site must be overlaid on a map of the CHAWS site and displayed, by custom software, on a color monitor in near-real-time. Recent meteorological data must also be plotted against time on the same screen as the trajectory map. The capability of printing the graphics that are displayed on the screen to the computer's printer must be provided. At all existing CHAWS sites, this is performed in the context of GRAPHIT.BAT by a software program called WXGRAPH.EXE. Printers supported by WXGRAPH include HP DeskJet, HP LaserJet, HP ThinkJet, Epson FX-80 and IBM Proprinter.

Data-Processing software is required to assemble weather and air-quality data for the purpose of generating five-minute averages, hourly summaries, and monthly summaries. This software must be able to exclude air-quality data taken during daily calibrations from these summaries. All data summaries must be available for view as disk files and as printed reports on paper. In all existing CHAWS installations, these functions are performed by the following software packages: WXLIST.EXE, WXSUM.EXE, AQHRS.EXE, AQTAGS.EXE, AQCAL.EXE and PE.EXE. In addition, commercially available word-processing software and spreadsheet software are desirable adjuncts to the system.

Data Quality-Control Software is required. It is used to evaluate the rate of data recovery from the remote data loggers. At all existing CHAWS installation, the custom software program RECOV.EXE has been provided to meet this requirement.

Distribution of Data to Other Agencies

The only CHAWS requirement for the distribution of data to other agencies is for the Central Base Station Computer to send a duplicate set of all raw data received from the remote data loggers to the Alternate Base Station Computer. At Johnston Island, this is accomplished by the use of a PC-Slave card and a 1200-baud dial-up

modem on each Base-Station Computer. The program WAITDATA.EXE is used to automatically send files between these two systems. The program allows other outside users with passwords to access data on either of these machines through the WAITDATA modem.

If other modes of automatic data dissemination are required, specifications for software and hardware procurement must be developed on a case by case basis.

Writing Specifications for New CHAWS Sites

Modification of the specifications of an existing CHAWS site to fit the requirements of a new CHAWS site may be the easiest way to write procurement specifications for the new one. Table 1 describes the hardware requirement for all existing CHAWS sites.

Table 1. Hardware at existing CHAWS sites.

Site code ^a	Site Type ^b	Towers, height	Levels / tower					AQ	SODAR	Hardware costs ^c
			Total	Temp.	WS	WD	RH			
TAD	1	4, 10M	2	1	1	1	0	0	0	\$377,684 ^d
	2	4, 10M	2	1	1	1	0	1		
	3	1, 30M	5	3	3	3	2	0		
EA	1	4, 30M	2	1	1	1	0	0	1	\$266,669 ^d
	3	2, 30M	5	3	3	3	1	0		
LEX	1L	1, 30M	2	1	1	1	0	0	0	\$83,540 ^d
	1P	1, 60M	2	1	1	1	0	0		
PBA	1P	2, 60M	2	1	1	1	0	0	1	\$984,000 ^e
	2P	3, 60M	2	1	1	1	0	1		
	3P	1, 60M	5	3	3	3	2	0		
	4	1, 60M	5	3	3	3	2	1		
JI	1J	2, 7M	2	1	1	1	0	1	0	\$322,000
	2J	2, 7M	2	1	1	1	1	1		

^a Site Codes are TAD - Tooele Army Depot, South, 1986; EA - Edgewood Area, Aberdeen Proving Grounds, 1987; LEX - Lexington-Blue Grass Army Depot, 1987; PBA - Pine Bluff Arsenal, 1987; and JI - Johnston Island JCAD Facility, 1990.

^b This is the tower or DCP configuration type described in the CHAWS manuals.^{1,2}

^c Costs do not include design, development, software, training, procurement, integration or installation costs. Costs are in 1987 dollars except JI where 1990 dollars are used.

^d Includes National Weather Service Subscription hardware.

^e Includes message center, weather radar service, video surveillance, lightning detector and National Weather Service Subscription hardware.

Since the Johnston Island (JI) site is the most modern, it is the best candidate for a CHAWS model. The JI site does not include SODAR. If SODAR is required at a new site, protocols and hardware specification can be extracted from the Pine Bluff CHAWS system.²

Tips on System Design for New Sites

1. *Site Configuration.* A qualified meteorologist must be consulted when developing a new CHAWS site. Factors such as topography, geography, and expected climatic conditions will be considered when determining the number and placement of towers, the type of instruments placed on each tower, and the number of levels at which each instrument type is placed. The meteorologist should also make recommendations on the need for the acquisition of SODAR units.

In general, each CHAWS site should have a minimum of four meteorological towers but no more than nine. At sites where air-quality data are required, it is recommended that four air-quality stations be installed around the periphery of the site.

The local site map must be digitized in the format used by the graphics software listed above, and installed on both Base-Station Computers. At all existing CHAWS sites, this was accomplished through the use of HITACHI.BAS at LLNL.

2. *CHAWS Site Design.* Once a qualified meteorologist has determined the type, number, and placement of instruments, a detailed list of all of these components may be made. Other personnel must then determine where the Central and Alternate Base Stations are to be installed and the extent to which CHAWS data are to be shared with other agencies. When this is finished, a survey of existing communications resources in these areas should be made. This list will include the availability of both dial-up and dedicated telephone lines, Local Area Networks, and a survey of physical access spaces that may be used to install wiring circuits.

After all of this information is compiled, it should be placed in a semi-formal document called the "CHAWS Site Plan."

3. *Systems Analysis.* Using the "CHAWS Site Plan," the Systems Analyst will determine the best way to incorporate all of the discrete functions

listed in the plan into a coherent system. This involves selecting, or designing, all hardware and software components of the system in such a way that each individual component will be integrated into the system as a whole.

A redefinition of the CHAWS computer platform and operating system may be warranted at some point, since the current design is based on 1986 technology. Please be aware that such a task will require a large investment of both time and money. Consider carefully the projected benefits of the new system versus the projected developmental costs. If this is attempted, it should be done during the systems-analysis phase.

If the multiuser capability currently used in CHAWS systems should be replaced, use of a Local Area Network (LAN) with a file server and one computer or work station per user would allow the preservation of most of the existing CHAWS software and would require the least amount of development time. This approach may result in slightly higher hardware costs when compared to retaining the PC-Slave system. Existing CHAWS networks could be expanded onto a LAN through the use of TCP/IP (transmission control protocol/internet protocol) protocols and a SLIP (serial line internet protocol) interface with one of the PC-Slave serial ports.

It is likely that the UNIX operating system will be suggested at some point for a new CHAWS system. There is no reason to doubt that such a system could be both efficient and cost effective in the long run, if many more CHAWS sites are to be developed. It would probably not be wise to make this kind of change for a single site. If the Alloy PC-Slave system is replaced by something like UNIX, every piece of software written for use on the old systems would have to be replaced or rewritten for the new operating system.

4. **System Integration.** This phase of site development overlaps Systems Analysis and System Installation. During this phase, all hardware and software components are incorporated into the system. Hardware components such as data loggers must be configured for each station, and all system and application software must be installed on their respective computers and configured for the local conditions. All communication lines between each subsystem must be installed and verified. Finally, after all components have been installed, the system must be run under

actual operating conditions to verify that the entire system functions as required.

Tips on System Installation at New Sites

1. *Management.* Because CHAWS is a network of discrete components that must function together, it is advisable to assign overall responsibility for system design, procurement, and installation to a single agency that understands the entire system. That agency should have the option of subcontracting some or all phases of the project.
2. *Training.* If the personnel hired to operate the new CHAWS site have had no experience at other CHAWS installation, it is advisable to provide formal training for them in all phases of their work. Many vendors offer training with their products at extra cost. At all CHAWS sites with air-quality stations, training has been provided by Monitor Labs. Informal training was supplied by LLNL for all other aspects of CHAWS. Because most of the rest of the system is composed of a custom configuration of products, it is advisable to have the systems analyst and systems integrator provide this training. Be sure to allow for the cost of all training when preparing requests for quotation (RFQ).

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