Department of Transportation
Federal Aviation Administration

Specification
FAA-E-2935

STAND ALONE WEATHER SENSORS (SAWS) SYSTEM

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1.0 STAND ALONE WEATHER SENSORS (SAWS)

1.1 SCOPE OF SPECIFICATION

This functional specification provides a description of the Stand Alone Weather Sensors (SAWS) system and stipulates the general and functional requirements applicable to the system and its components. Section 2.0 lists the Federal Aviation Administration (FAA), Department of Defense (DoD), and industry documents that are applicable to this procurement. Section 3.0 provides a description of the functional specification requirements for the SAWS system. Section 4.0 describes the workmanship requirements for the SAWS hardware.

1.2 APPLICATION

The SAWS system is intended to operate and display continuously a select set of weather parameters. The required parameters include wind (speed, direction, and gusts), ambient temperature, dew point temperature, and altimeter setting. The system will operate as a stand-alone system independent of any other system, except power. Communication from the sensor site to the display will be via UHF radio data link or hardwire transmission. The SAWS system will be permanently installed with power from an FAA provided power source. Multiple displays shall be provided in the tower along with provisions for additional displays, if required.

2.0 APPLICABLE DOCUMENTS

The following Government documents on the release date of this specification are applicable to the extent specified herein.

AC 50/5345-43	Specification for Obstructions Lighting Equipment
AC 70/7406-1H	Specification for Obstruction, Marking & Lighting
AC 150/5220-16B	Automated Weather Observing System (AWOS) for Non-Federal Applications
AC 150/5370-2C	Operational Safety on Airports During Construction
ANSI.HFS-100	Human Factors Engineering of Visual Display Terminal Workstations (1988)
ANSI/J-STD-001B	Requirements for Soldered Electrical and Electronics Assemblies (1997)
CFR 47	Part 300, Section 5, Manual of Regulations and Procedures for Federal Radio Frequency Management
DOT/FAA/CT-96/1	Human Factors Design Guide for Acquisition of Commercial-off-the-Shelf Subsystems, Non-Developmental Items, and Developmental Systems
FAA Standards 019B	Lightning Protection, Grounding, Bonding & Shielding Requirements for Facilities (10/90)
FAA Standards 020B	Transient Protection, Grounding, Bonding & Shielding Requirements for Equipment (1992)
FAA-C-1217F	Electrical Work, Interior
FAA-E-2911	National Airspace System (NAS) System Level Specification – National Airspace System (NAS) Infrastructure Management System (NIMS) Managed Subsystem
FAA-G-2100F	Electronic Equipment, General Requirements (11/93)
FAA Order 6560.13	Maintenance of Aviation Meteorological Systems and Miscellaneous Aids

FAA Order 6560.20B	Siting Criteria for Automated Weather Observing System (AWOS)
FAA Order 6950.19A	Practices and procedures for Lightning Protection, Grounding, Bonding and Shielding Implementation
FCC	Rules and Regulations, Volume II
FCM-S5-1988	Federal Standard Algorithms for Automated Weather Observing Systems used for Aviation Purposes
MIL-STD-461C	Measurement of Electromagnetic Interference Characteristics
NEC	National Electric Code, 1999
OFCM FCM-H1-1995	Federal Meteorological Handbook No. 1, Surface Weather Observations and Reports, Washington, D.C., Dec. 1995

3.0 SYSTEM REQUIREMENTS

3.1 SECTION OVERVIEW

This section presents the SAWS' functional requirements. Section 3.2 lists the system characteristics: these include a description of sensors and the requirements for operating environment, reliability, and maintainability. Section 3.3 presents the detailed functional requirements for each of the sensors. SAWS software requirements are described in Section 3.4. The contractor shall provide the SAWS system, including sensors and peripherals to meet the requirements of Section 3.

3.2 SYSTEM CHARACTERISTICS

3.2.1 System Description

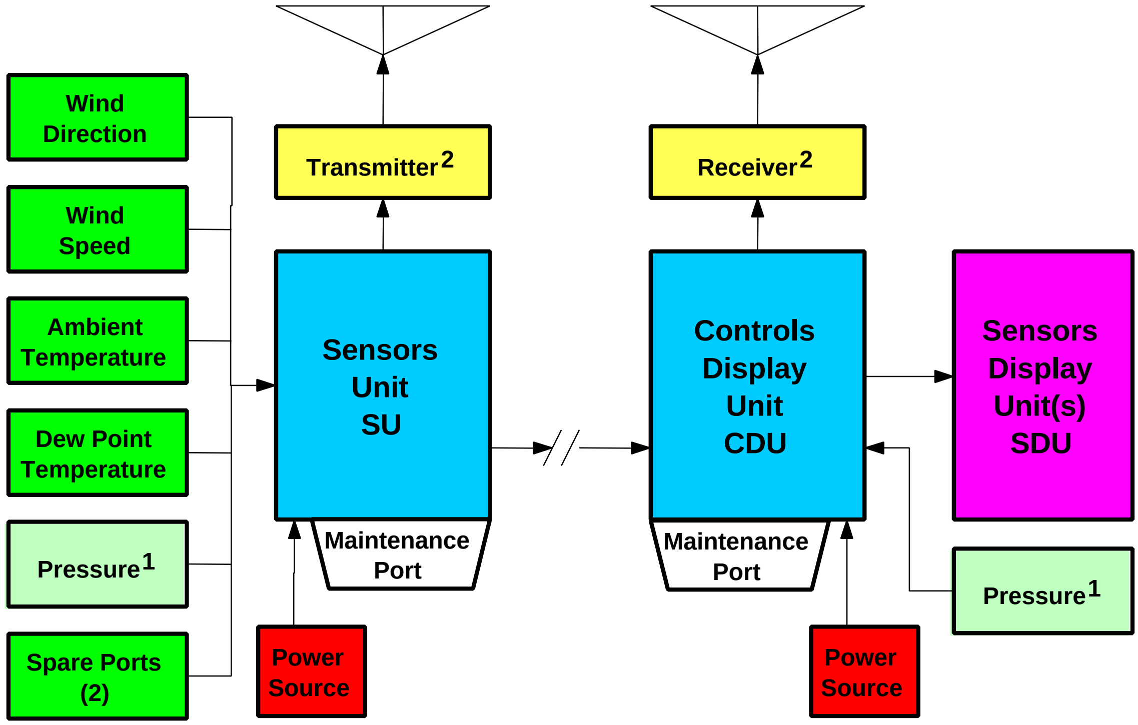
The SAWS system is characterized by:

- having highly reliable components;
- making maximum use of commercial off-the-shelf (COTS) parts;
- displaying the required weather sensor data to the operators;
- being easily maintained;
- being functional within the airport environment; and,
- presenting an acceptable display in both bright and dark tower environments.

A dependency or interface with other systems is not permitted. This system shall have Year 2000 Compliance. FAA Century Date Change requirements can be obtained from the Office of Information Technology Internet Web Page, http://www.faa.gov/ait.

Figure 3.1, SAWS system block diagram, depicts the required configuration. As defined in the block diagram, the SAWS configuration consists of:

- wind speed sensor
- wind direction sensor
- ambient temperature sensor
- dew point temperature sensor
- 2 barometric sensors
- 2 power supply units (PSU)
- sensor unit (SU) with maintenance port
- control and display unit (CDU) with maintenance port
- transmitter/receiver radio frequency (RF) link equipment or,
- hardwire connectivity ports (RF link equipment not required if hardwire available and in adequate condition)
- sensors display units (SDU) (up to 7 per system)
- 2 spare RS-485 serial ports, or equivalent



1. May be located at either the SU or CDU.
2. Radio or long-line communications link.

Figure 3.1 SAWS System Configuration

The sensors (except possibly for pressure), SU, and transmitter equipment shall be located on the current F-420 wind tower. The contractor shall provide all hardware required to attach the sensors and components to the F-420 towers at heights that conform to FAA Order 6560.20B. An option for a stand-alone tower shall be provided where the F-420 does not exist or its installation or condition is unacceptable for SAWS placement. The CDU shall be located in an indoor environment. The required sensor parameters shall be transmitted to the CDU via hardwire or free space utilizing contractor supplied radio link equipment.

All field sensors and associated sensor processing shall be at the SU. All field sensor testing shall be capable of being accomplished at the SU with a confirming overall system check accomplished by comparison between the expected and actual displayed information on the SDU.

3.2.2 Sensors

The SAWS system shall be comprised of, in part, environmental sensors capable of measuring the required meteorological variables. These sensors shall provide signal output representing the sensed weather element data to the SU.

Section 3.3 contains the detailed performance requirements for the sensors. The following are general requirements that apply to all sensors:

- Sensors shall be interchangeable (i.e., each sensor type shall be able to operate at all sites).
- System inputs/calibrations shall include but not be limited to the following:
  - Pressure sensor elevation
  - Pressure sensor calibration (not to exceed 0.05 in Hg)
- Sensors shall operate within the operational environment described in Section 3.2.3.

3.2.3 Operational Environment

The SAWS system shall be designed and fabricated to operate within the minimal range of the environmental conditions listed in Table 3.1. These include the full range of indoor and outdoor environments likely to be encountered. Operating as a stand-alone system, the SAWS system shall be designed to operate in those environments. Because of the requirements to use interchangeable system components, the most severe operating environmental parameter shall prevail in determining all equipment specifications.

In addition, the SAWS system shall survive shipment over long distances via air and surface transport. Thus, the SAWS system shall be able to withstand shock and vibration encountered during handling and shipment.

Table 3.1, Parts 1 and 2, list the minimal range of required outdoor and indoor limits that the system shall be able to operate within.

Table 3.1 OUTDOORS MINIMAL ENVIRONMENTAL LIMITS (Part 1 of 2)

ENVIRONMENTAL CONDITION	OPERATIONAL LIMIT
High temperature	+55°C
Low temperature	-70°C
Relative humidity	5 % to 100 % RH
Wind	Up to 85 knots
Rain	Up to 3 in/hr. with 40 knots wind
Freezing Rain	Ice accretion to 0.5 in/hr.
Hail	Up to 0.5 in diameter
Electromagnetic interference	Exposure to airport environment (Par. 3.2.4.4)
Pressure	16.9 in Hg to 31.65 in Hg

Table 3.1 INDOOR MINIMAL ENVIRONMENTAL LIMITS (Part 2 of 2)	
ENVIRONMENTAL CONDITION	OPERATIONAL LIMIT
High temperature	+30°C
Low temperature	+10°C
Relative humidity	5 % to 90 % RH
Electromagnetic interference	Exposure to airport environment (par. 3.2.4.4)

3.2.4 General Performance Requirements

The following sections address requirements that are applicable to the SAWS system as a whole.

3.2.4.1 Input Power

The SAWS system shall operate from a 120 volts (± 10 percent), 60 Hz AC (± 5 Hz), single-phase power source in accordance with the power factor, harmonic distortion, and inrush current specifications in FAA-G-2100F.

3.2.4.2 Loss of Power

The SAWS system shall return to normal operation without human intervention after a power surge or outage at either the SU or CDU. When power is restored, the system shall not display erroneous data. All weather parameters shall achieve normal indications within 3 minutes.

3.2.4.3 SAWS Sensors Tower

The SAWS sensor suite and SU shall be mounted on the existing F-420 center field wind tower. If there is no existing F-420 wind sensor tower or if the existing tower is unacceptable, a similar suitable tower shall be provided and located in accordance with the siting provisions of FAA Order 6560.20B.

When a tower is used for the SAWS sensors it shall be equipped with daytime marking and nighttime lighting in accordance with the guidelines set forth in AC 70/7460-1H, Specification for Obstruction Marking and Lighting.

1) It shall be lighted with a dual L-810 fixture placed within 5 feet of the top of the tower. The two lamps on the L-810 shall be wired in parallel, and conduit shall be utilized. The standards for the L-810 fixtures may be found in AC 50/5345-43, Specification for Obstruction Lighting Equipment, which may be ordered from the Department of Transportation, Utilization and Storage, M-443.2 Washington, D.C. 20590.

2) Since the nominal height for this tower is 30 to 33 feet and since most towers are manufactured in 10 foot sections, a waiver to AC 70/7460-1H has been granted to permit a six-band marking, with the bands alternating between aviation orange (the top band) and aviation white. The tower height shall not exceed 33 feet unless obstruction or vegetation in the area makes it necessary.

3.2.4.4 Electromagnetic Interference

The SAWS design shall minimize susceptibility to Electromagnetic Interference (EMI) and operate without any electrical interference in the complex electromagnetic environment of an airport. Equipment radiated and conducted emissions requirements shall be in accordance with MIL-STD-461C. Emissions and susceptibility to electromagnetic interference shall be controlled such that the equipment complies with the requirements of MIL-STD-461C for the test methods listed below:

a) CE01 conducted emissions, power and interconnecting leads, low frequency (up to 15KHz).
b) CE03 conducted emissions, power and interconnecting leads, low frequency (0.015 to 50 MHz).
c) CS01 conducted susceptibility, power leads, 30 Hz to 50 KHz.
d) CS02 conducted susceptibility, power and interconnecting control leads, 0.05 to 400 MHz.
e) CS06 conductive susceptibility, spikes, power leads.
f) RE01 radiated emissions, magnetic field, 0.03 to 50 kHz.
g) RS01 radiated susceptibility, magnetic field 0.03 to 50 KHz.
h) RS03 radiated susceptibility, electric field, 14 kHz to 3 GHz only and at 10 volts/meter.

3.2.4.5 Transient and Lightning Protection

The SAWS system shall be protected against damage or operational interruptions due to electrical power disruptions and lightning-induced surges on all sensor input lines, sensor supply lines, and incoming power and communications lines. Equipment and personnel shall be protected from lightning currents and voltages, from power line transients and surges, and from other electromagnetic fields and charges. The lightning protection as a minimum shall be designed in accordance with the FAA Standards 019 (Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities) and 020 (Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment) for all equipment and structures.

3.2.5 Reliability and Maintainability Requirements

3.2.5.1 Reliability

Within the environmental limits in Table 3.1, a SAWS system failure shall be defined as the inability to display altimeter setting, wind speed, wind direction, wind gust, ambient temperature, and dew point temperature in accordance with the accuracy and performance requirements of the specification. The meantime between failure (MTBF) shall not be less than 8,760 hours for the entire system.

3.2.5.2 Maintainability

The Meantime to repair (MTTR) for a SAWS system failure shall not exceed 1 hour. MTTR shall include failure diagnosis time and actual repair time (once the parts, tools, and manuals are available). Repairs shall be accomplishable by a single person. A technician shall be capable of displaying the sensor values of interest for maintenance and/or periodic verification via an external connection. Technicians shall not have to perform preventative maintenance more than once annually. Members of the FAA evaluation team will address ease of performing maintenance in the field (Human Factors (HF)). The system will comply with DOT/FAA/CT-96/1. Some examples:

- Hinged doors with non-removable fasteners are preferred over removable panels held in place by screws.
- LRUs that can be exchanged by using canon plugs are superior to those where wires have to be connected and disconnected to circuit blocks.
- An LRU which “slides” into place is preferable to one that has to be held while screws or bolts are put in place with the free hand.
- An LRU should not be exceedingly large or heavy.
- Weatherproofing of outdoor enclosures shall not require caulking.

3.3 MAJOR COMPONENTS

The following sections identify the parameter functional requirements. Testing to verify that sensors meet functional requirements will be conducted during Factory Acceptance Inspection (FAI). A test plan shall be required of the selected vendor and submitted to the FAA for approval in accordance with the Statement of Work.

3.3.1 Weather Sensor Parameters

At a minimum, all weather parameters shall be displayed numerically and readily identified and discriminated from each other.

3.3.1.1 Wind Display

PURPOSE To display each second, the running 15-second, 30-second, 1-minute, or 2-minute average wind speed (U) in knots (kts) and wind direction (A) in azimuthal degrees (°) relative to magnetic north. Gusts (G) will also be displayed when criteria are met. A selector switch allowing for selection of a 15-second, 30-second, 1-minute, or 2-minute average winds shall be incorporated at either the SU or CDU.

The numerical wind data shall be displayed in the following special format:

dddss(s)Ggg(g)

where

ddd = wind direction (degrees)
ss(s) = wind speed (knots)
G = gust indicator
gg(g) = gust speed (knots)

d, **s**, or **g** shall be a digit from 0 to 9, while **G** shall always be the letter G.
There shall be no spaces between entries.

The following quantities are defined for reference in later sections which provide additional clarification on wind reporting.

u = one second sampled wind speed
U = average wind speed
a = one second sampled wind direction
A = average wind direction
G = wind gust

Wind Speed:

- If the running 15-second, 30-second, 1-minute, or 2-minute average wind speed (U) in knots (kts) utilizes a minimum of 12, 23, 45, or 90 valid samples (u), respectively, of the previous samples, show U to the nearest knot as **ss** in the display. First **s** is 0 if U is less than 10 knots. Third **s** is reserved for U exceeding 100 knots; otherwise, it is not used.
- If U is valid and less than 2.5 kts, display wind as "**CALM**". There shall be no display of wind direction or gusts with "**CALM**".

Wind Direction:

- If the running 15 second, 30-second, 1-minute, or 2-minute average wind direction (A), in azimuthal degrees (^{o}) relative to magnetic north, utilizes a minimum of 12, 23, 45, or 90 valid samples (a), respectively, of the previous samples, show A to the nearest 10 degrees as **ddd** in the display. First **d** is 0 for winds from 10 to 90 degrees, inclusive. Last **d** is always 0. North wind is 360.
- The average value of A must account for the stepped transition between 1^o and 360^o i.e., average of 330º and 10º is 350º, not 170º.

Wind Gusts:

U is an average of all one-second winds (u); SAWS shall be designed so that averaging period of U is 15-seconds, 30-seconds, 1-minute, or 2-minutes.

- In addition to buffer for computation of U, maintain a buffer to hold all u for 1 minute and a gust buffer (G) to hold all g for 10 minutes.
- Run tests below for each retrieval of a valid u:
  - Test 1: If U is equal to or greater than 9 kts and if the maximum u (u_{max}) in the 1 minute buffer exceeds U by 5 kts or more, set g to u_{max} in G.
  - Test 2: If the difference between the maximum 10-minute value (g_{max}) in G and the current value of U (g_{max} -U) is equal to or greater than 3 kts, Display g_{max} as **gg** to follow **G** as the gust velocity on the display.
- Omit **Ggg(g)** from display if criteria of Test 2 is not met. The third **g** is reserved for winds exceeding 100 knots.

Invalid wind data shall be treated as follows:

- Record as '**M**' for Missing, if U is outside prescribed operating capabilities of instrument/system.
- Record as '**M**' for Missing, if u or a has remained the same for a prolonged period of time (> 10 minutes).

- Display as "**M**" for Missing, if less than 12, 23, 45, or 90 of the samples are not valid or available for computing the next 15-second, 30-second, 1-minute, or 2-minute averages, respectively.

3.3.1.1.1 Wind Speed

SPECIFICATIONS

▪ Minimum Range:	2 kts $\leq$ U $\leq$ 85 kts
▪ Minimum Accuracy:	greater of ±2 kts or ±5% of U
▪ Minimum Starting Threshold:	2 kts
▪ Maximum Distance Constant:	10 meters
▪ Minimum Icing Conditions:	0.25 inches radial thickness of clear ice with U > 10 kts
▪ Display Resolution:	1 kt

3.3.1.1.2 Wind Direction

SPECIFICATIONS

▪ Range	1^o-360^o
▪ Minimum Operating Wind Speed Range:	2 kts $\leq$ U $\leq$ 85 kts
▪ Minimum Accuracy:	$\pm 5^o$
▪ Alignment:	Magnetic North
▪ Starting Threshold:	2 kts
▪ Maximum Time Constant:	2-seconds (to within 5^o of A)
▪ Minimum Icing Conditions:	0.25 inches radial thickness of clear ice with U > 10 kts
▪ Display Resolution:	1^o
▪ Allowable "Dead Band"	5°

3.3.1.1.3 Wind Gust

All G data are from algorithms, using values of u; see paragraph 3.3.1.1.

3.3.1.2 Ambient Temperature

PURPOSE To display each second, the running 1-minute average (T_{amb}) of the sampled ambient temperature (t_{amb}) in degrees Celsius (^oC), utilizing a minimum of 45 valid samples out of the previous 60 one-second samples.

SPECIFICATIONS

▪ Minimum Range:	-55^o C $\leq T_{amb} \leq +55^o$ C
▪ Minimum Accuracy:	$\pm 1^o$ C over the entire range of the sensors
▪ Display Resolution:	1^o C

- Maximum Time Constant: 2-min per any 5°C change

INVALID DATA

- Display 'M' for Missing, if this value requires forced airflow and there is an airflow failure.
- Display as "M" for Missing, if less than 45 valid samples are available for computing the next 1-minute average.
- Display "M" for Missing, if t_{amb} has remained the same for a prolonged period of time (≥ 30 minutes).
- To a reasonable extent, provide for automatic detection of any temperature sensing, processing or display problem, its location (at the SU, CDU or SDU) and its nature.

OTHER

- To determine the display value, round the 1-minute average value of T_{amb} to the nearest degree, using 0.499^o as the threshold.

3.3.1.3 Dew Point Temperature

PURPOSE To display each second, the running 1-minute average (T_{dp}) of the sampled dew point temperature (t_{dp}) in degrees Celsius (^{o}C), utilizing a minimum of 45 valid samples out of the previous 60 one-second samples.

SPECIFICATIONS

- Minimum Range: $-35^o\ C \le T_{dp} \le +35^o\ C$
- Minimum Accuracy:

Relative Humidity	Ambient Temp. T_{amb}	
25-95%	$-29^o\ C \le T_{amb} < 0^o\ C$	1^o C RMSE; 3^o C MAX
15-75%	$0^o\ C < T_{amb} \le 55^o\ C$	1.5^o C RMSE; 2^o C MAX
75-100%	$0^o\ C \le T_{amb} \le 35^o\ C$	1^o C RMSE; 1.5^o C MAX

- Display Resolution: 1^o C
- Maximum Time Constant: 2-min per any 5°C change

INVALID DATA

- Record as 'M' for Missing, if sampled t_{dp} requires forced airflow and there is an airflow failure.
- Display as "M" for Missing, if 1-minute average value of T_{dp} exceeds the corresponding 1-minute average of T_{amb} by more than 2^o C.
- Display "M" for Missing, if T_{dp} has remained the same for a prolonged period of time (≥ 30 minutes).
- Display as "M" for Missing, if less than 45 valid samples are available for computing the next 1-minute average.

OTHER

- Display T_{dp} as equal to T_{amb}, if 1-minute averages of T_{amb} and T_{dp} fall within the range $0^o\ C < T_{dp} - T_{amb} < 2^o\ C$.

3.3.1.4 Pressure – Altimeter Setting

PURPOSE To display each second, the altimeter setting (AS) for the elevation of the airport in inches of mercury (in Hg) computed from the lowest 1-minute average pressure of a redundant pair or set of atmospheric pressure sensors that utilizes at least 45 valid samples out of their respective 60 1-second samples and that agree to within ±0.02 in Hg of each other.

SPECIFICATIONS

- Pressure (P) Range 17.58 in Hg ≤ P ≤ 31.65 in Hg
  (and +1.5 to –3.0 in Hg from the standard atmospheric pressure at that location)
- Minimum Pressure Accuracy ±0.01 in Hg over Pressure Range
- Minimum Differential Pressure Accuracy 0.01 in Hg

  (over 3 hours with T_{amb} constant to within ±3° C and with P constant to within ±0.1 in Hg)

- Maximum Drift ±0.01 in Hg over 6-months
- Display Resolution: 0.01 in Hg
- Pressure Sensors shall have a provision for setting the sensor to the station elevation to the nearest 1-foot over the range of –100 feet to +10,000 feet.

INVALID DATA

- For each pressure sensor, record the sampled P as 'M' for Missing and Display the 1-minute average AS as 'M' for Missing, if venting is required and the venting system fails.
- For each pressure sensor, record the sampled P as 'M' for Missing and Display the 1-minute average AS as 'M' for Missing, if either pressure value is outside prescribed operating range.
- Display AS as "M" for Missing, if less than 45 valid samples are available for computing the next 1-minute average from either pressure sensor.
- If computed absolute value of the 1-minute average pressure difference between the two sensors exceeds 0.002 in Hg, display AS as ‘M’ for Missing.
- If the P sensor resides more than 90 ft above the field and there are no valid 1-minute average values of the ambient temperature (T_{amb}) during the previous 5-minutes, Display AS as 'M' for Missing.

OTHER

- Utilize the lowest 1-minute average pressure value P to compute AS according to the following formulae.

  If the elevation of the pressure sensor is within 90 ft of the field elevation, set the field pressure P_f to the lowest valid sensor pressure P_s and the field elevation H_f equal to the sensor elevation $H_{s:}$

$$P_f = P_s \quad \text{and} \quad H_f = H_s \, .$$

If the pressure sensors are located more than 90 feet above field elevation, set field elevation equal to the actual field elevation and obtain field elevation pressure P_f from the lowest valid sensor pressure P_s, using:

$$P_f = P_s \cdot e^{0.0104 \frac{H_a}{T_K}} \quad \text{with}$$

$$H_a = H_s - H_f$$

$$T_K = T_{amb} + 273.16 \, .$$

H_a is the elevation of the sensor H_s relative to that of the field H_f, T_{amb} is the last valid 1-minute average ambient temperature displayed during the previous 5-minute period in degrees Celsius, and T_K is the last 1-minute average ambient temperature in degrees Kelvin.

To obtain Altimeter Setting AS, use

$$AS = \left[P_f^{0.1903} + \left(1.313 \cdot 10^{-5} \right) \cdot H_f \right]^{5.255} \, .$$

- To determine the AS Indicator Display value, round the 1-minute average value of AS down to the nearest 0.005 in Hg. Use this value to derive the Display, rounded to the nearest 0.01 in Hg.

3.3.2 Data Collection and Processing

3.3.2.1 Sensors Unit (SU)

In the operational mode, the SU shall accept field sensor data and process these data before RF or hardwire link transmission to the CDU. Data collection, calculation, and data processing functions shall reside in the SU.

The SU shall have the capability to acquire data from the sensors at the SU. It shall contain the system hardware and firmware to perform the following: system timing and control, signal conditioning, data acquisition, data processing, data formatting, and data quality checks. The SU shall be modular in design and configured for specific arrangements of sensor inputs and communication. The SU housing shall be NEMA4 metal type enclosure, EMI proof and shall be made of corrosion resistant materials. The SU shall possess expansion capability for at least two future interfaces (RS-485 serial port or equivalent). Besides an output from the SU to the transmitter, the SU shall provide a means of testing in either analog or digital format the real-time outputs of the wind speed, wind direction, ambient temperature, dew point temperature and, if colocated with the other sensors, each barometer output and the computed altimeter setting. The outputs shall be after the input interface, signal processing, and computational circuitry, but prior to any system averaging or delay of greater than 1 minute. The contractor shall provide any specialized test equipment necessary to make these readings; or, a usable data output (such as an ASCII format RS-232 serial output) via an SU output port that would enable a FAA provided laptop computer to display these readings. There will also be access via a 25-pin serial interface (or equivalent) port to allow for connection of a laptop for maintenance troubleshooting and corrective action purposes. Port access to the SU shall be capable without opening the complete enclosure. A typical configuration for the SU would be as presented in Figure 3.2.

3.3.2.2 Timing and Control

The SU timing and control (T&C) functions shall include sequencing and control of data acquisition, signal conditioning, scaling and conversion, data formatting, processing, commands, and data transfer. A watchdog timer shall be used to produce a system reset/reboot in the event of hardware malfunction or unrecoverable data acquisition error.

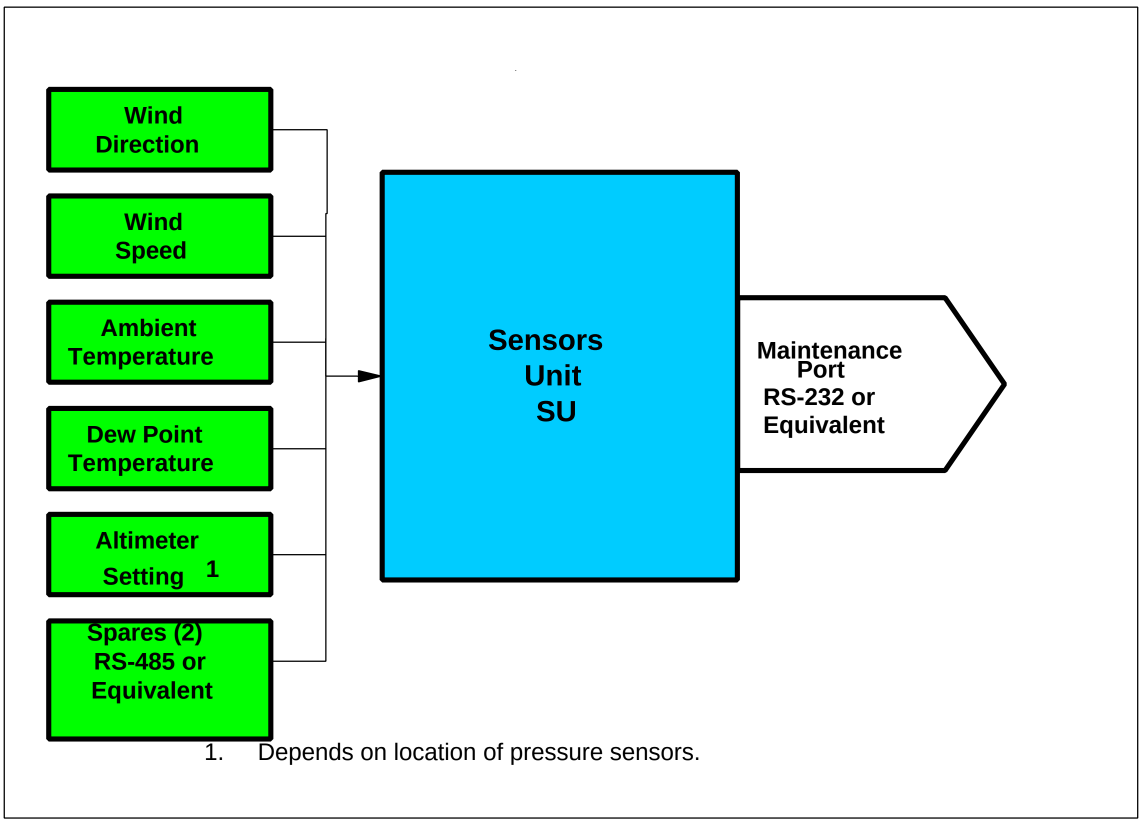


Figure 3.2 Sensor Unit Configuration

3.3.2.3 Data Acquisition and Signal Conditions

The preconditioned signals (analog, digital, or other) shall be converted to digital words for transmission to the CDU. Analog signal conditioning circuits, when needed, shall be converted utilizing analog to digital techniques. Signals that are preconditioned in the sensor (either analog or digital) shall be buffered in the SU prior to transmission to the CDU.

3.3.2.4 Data Processor

The following SU data processing capabilities shall be provided:

- Convert data received from the sensors into engineering units.
- Process the sensor data using the algorithms provided in Section 3.3 for display.
- Perform quality check on the parameters. When errors are detected, the system shall discontinue reporting of affected parameters, and display an "M" to the SDU. The system shall restart parameter reporting upon restoration of the system's operability.

3.3.2.5 Data Reduction

The SAWS data reduction software shall include quality control checks to ensure that the data received is accurate and complete. If data from any sensor is erroneous or missing (e.g., the sensor loses power, etc.), that parameter shall be reported as M for "missing" and displayed to the operator. The processor shall continue to sample these data, and if the error condition is corrected, the sensor parameter shall be reinserted and displayed to the operator.

The processor shall set upper and lower limits on the sensor outputs that correspond to the normal operating limits of the sensor in order to prevent the reporting of possibly false values such as negative wind speed.

The processor shall recognize continued static data output that usually indicates a malfunction. If the sensor output is static for a sustained period of time, the parameter shall be reported as M for "missing."

3.3.2.6 Data Formatting

As a minimum requirement, the SU shall collect and transmit the following sensor data to the CDU for display:

- Current 1-second update observations
- Current sensor data - input signals for algorithms in Section 3.3, i.e., temperature for one-second, etc.

3.3.2.7 Data Quality

Sensor quality checks defined in Section 3.3 and the contractor's addenda to the algorithms shall be processed by the SU to assure that reliability and maintainability requirements described in paragraph 3.2.5 are fully met. Whenever this processing indicates that a parameter should be missing, the system shall replace the appropriate parameter with "M" as defined in Section 3.3.

3.3.2.8 Power Control and Distribution

The SU shall provide power to all associated sensors and peripherals (i.e., radio link). Upon restoration of normal power after a shutdown, the system shall automatically restart all functions.

3.3.3 Sensor Data Transmission Requirements

Sensor data transmitted from the SU to the CDU shall be possible via hardwire connection or a contractor supplied FM, or PM UHF radio link (pre-assigned frequencies and bandwidth will be provided by the FAA) using a data format that includes an effective error control method such as a Cyclic Redundancy Check (CRC) or Longitudinal Redundancy Check (LRC). The transmitter shall have FCC type-acceptance and radiate at a power to be variable from 0.1 to 1.0 watts at the transmitter. The transmitter power is to be adjustable over this range. The transmitter tolerance shall be as per FCC Rules and Regulations, Vol. II and FAA Order 6560.13 paragraph 155. The system shall use directional antennas. The minimum receiver sensitivity shall be -98 dbm. The transmitter/receiver (Tx/Rx) installation shall be capable of accurate transmission/reception of data signals experiencing a 20 dB (power) signal fade over a distance between the transmitter and receiver of up to 3 miles. When employing a radio link, the transmitter shall be collocated with the SAWS's housing structure and the antenna may be mounted on the wind tower. The system shall comply with all applicable standards contained in CFR47 (Telecommunications), Part 300, Section 5, Manual of Regulations and Procedures for Federal Radio Frequency Management.

3.3.4 Controls and Display Unit (CDU)

The CDU shall acquire signals from the SU via RF transmission link, ensure the received signal is correct by using a compatible error control method as used with the SU, format, and prepare the acquired sensor parameters for display use. The CDU shall be able to accept up to two displays with no keyboard interaction between the CDU and the display units. It shall also have an output port, such as an ASCII format RS-232 serial output port, needed to allow a FAA supplied computer to display the information received from the SU for test or additional display purposes. A typical CDU configuration would be as presented in Figure 3.3.

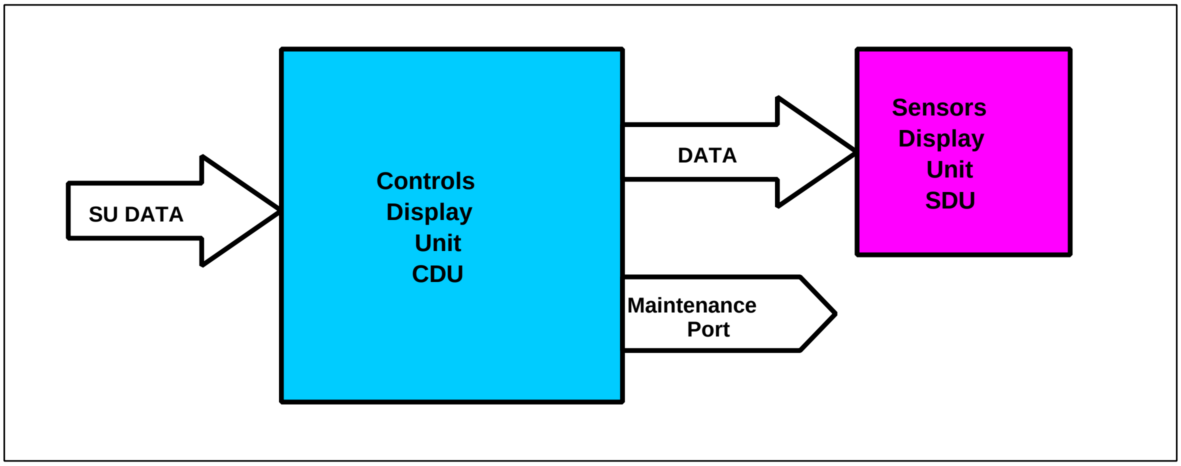


Figure 3.3 Controls and Display Unit Configuration

3.3.5 Display Requirements

The SAWS sensors display unit (SDU) final display and format will be approved by the FAA at the Final System Review (FSR). The system shall consist of up to seven displays per site. The SDU shall be readable by a person with normal vision (corrected to 20/20) in light levels varying from total darkness to 10,000 foot candelas at a distance of eight (8) to ten (10) feet and an angle of not less than 50 degrees in all directions. The screen shall be non-glare. The display dimensions shall be approximately 5” x 8”. Additional requirements for the display are as follows:

- Controls shall consist of:
  1) On/Off switch
  2) Brightness control

The display shall accept serial data from the CDU and display the required parameters to the operators. Display units shall be in compliance with DOT/FAA/CT96-I and ANSI/HFS-100.

3.3.6 Remote Maintenance Monitoring

The SDU shall display, in small, non-obtrusive type, status of the SAWS sensors.

The SAWS shall have local operator interface device (OID) and dial-out modem capability for local or remote maintenance monitoring. The system shall generate maintenance and system data that can be viewed and acted upon with a local OID and remotely by a conventional alphanumeric ANSI terminal, not limited to any one manufacturer, or a personal computer with the proper communications software.

The system shall incorporate an expansion capability to allow interface and communications with the proposed FAA remote maintenance monitoring system as specified in the FAA NAS Infrastructure Management System (NIMS) Managed Subsystem ICD, Appendix 10.

3.3.7 SDU System Expandability

The SAWS design shall demonstrate how more than seven displays could be accommodated.

3.4 SOFTWARE REQUIREMENTS

3.4.1 Operational Software

The contractor shall be responsible for the SAWS sensors data processing (in accordance with Section 3.3). The system shall be able to accept inputs for sensor elevation and calibration.

4.0 WORKMANSHIP

4.1 HARDWARE DESIGN AND CONSTRUCTION

4.1.1 Special Packaging and Housing Considerations

The following applies to all outdoor enclosures of electronic equipment and sensors:

- Shall be made of material that is lightweight, resistant to corrosion, and contain fasteners and hardware that do not corrode and are compatible with the base material of the enclosure. The access door, fasteners, and hardware shall provide a simple but effective means of holding the door open to allow for hands-free access to the contents of the enclosure. The fasteners or hardware shall not be removed to allow access.

- Shall be sealed and protected from intrusion, damage, or functional degradation from water, moisture, animals, birds, and insects.

- Interiors shall be shielded from EMI as necessary as per paragraph 3.2.4.4.

The following are requirements for cables and connectors:

- Cables shall be adequately shielded to prevent conducted or radiated interference.
- Provisions shall be provided for grounding the shields on either end of the cables. The shield ground method shall provide for connections to the power line grounding conductor.
- Power and signal returns shall be configured to permit single-point grounding at each SU site.
- Connectors shall be environmentally protected for units that are exposed to the outside environment, shall include a strain relief, and shall be compatible with the base metal of the enclosures. All spare connectors shall have moisture proof dust covers.

4.1.2 Safety Design Criteria

4.1.2.1 Personnel Hazards

Toxic products and formulations shall not be used for the manufacture of the SAWS system. No Class I, ozone depleting substance (ODS), shall be used in manufacturing or cleaning of components, parts, or end items for the SAWS system. Class I ODS, agents are defined as chlorofluorocarbon, halon, carbon tetrachloride, and methyl chloroform. Contractor shall exercise ODS requirements in accordance with 10 CFR 20 Regulations.

4.1.2.2 Grounding

The design and construction of the SAWS shall ensure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals are at ground potential at all times during normal operation. Any external or interconnecting cable, where a ground is part of the circuit, shall carry a ground wire in the cable in the same manner as the other conductors. In no case, except with coaxial cables, shall the shields be depended upon for a current-carrying ground connection. Antenna and transmission line terminals shall be at ground potential.

Ground connections to shields, hinges, and other mechanical parts shall not be used to complete electrical circuits. A point on the electrically conductive chassis or equipment frame shall serve as the common tie point for static and safety grounding.

All grounding conductors shall be routed as directly as possible without loops, excess length, or sharp bends. An equipment-grounding conductor provided and installed in accordance with the FAA's Standard 020 shall ground all equipment enclosures and housing.

4.1.2.3 Bonding

High quality bonding shall be designed and incorporated into the SAWS and its installations in accordance with the FAA's Standard 020. The system shall comply with all applicable NEC standards as well as applicable FAA-G 2100F, FAA Standards 019B, Order 6950.19A, and FAA-C-1217F .

4.1.2.4 Shielding

Shielding shall be provided to protect equipment and interface lines (all signal data, control, power lines, and cables) from lightning currents and discharges. Shielding shall also be provided for the containment of interference and signals produced by equipment and to protect susceptible equipment from related environmental signals and interference in accordance with the FAA's Standard 020.

4.1.2.5 Flammable Materials

Unless otherwise specified herein materials that are not self-extinguishing, capable of supporting combustion, or that are capable of causing an explosion shall not be used.

4.1.2.6 Transient and Surge Suppression

All transients and surge arrestors, suppressors, circuits, suppressors required at service entrances to existing building and shelters, and components required for the system and equipment shall be furnished and installed by the SAWS prime contractor as per paragraph 3.2.4.5.

4.1.3 Moisture and Fungus

Materials resistant to moisture and fungus shall be used whenever possible. If fungus nutrient materials are used, such use shall require prior approval of the procuring activity. Screws, bolts, slit-fits, screw threaded inserts, and press fits shall be assembled using a suitable preservative to prevent corrosion and shall comply with the FAA-G-2100F.

4.1.4 Soldering

Assembly and soldering on the SAWS system shall be in accordance with company workmanship standards. These standards shall be patterned after ANSI/J-STD-001B Class 3 or equivalent.

4.1.5 Electrical Overload Protection

Overload protection shall be provided for the SAWS system. Devices such as fuses, circuit breakers, time delays, cutouts, or solid-state current interruption devices shall be used to open a circuit whenever a circuit shorts. No overcurrent protective device shall be connected in series with any conductor which is grounded at the power source unless the device simultaneously opens all load conductors in the circuit and no pole operates independently, or as otherwise allowed by the FAA's Standard 020. All contractor-designed equipment shall use circuit breakers that are readily accessible to the operator.

4.1.6 Electrical Connectors

Selection and use of electrical connectors shall be in accordance with the FAA-G-2100F. Contact crimp, installing, and removal tools shall be in accordance with the FAA-G-2100F or as specified in the individual connector specifications. However, the variety of tools required within a system shall be kept to a minimum.

4.1.7 Occupational Safety and Health Administration (OSHA)

The contractor shall observe all OSHA and other pertinent safety regulations governing the installation and/or removal of the SAWS systems being delivered or removed. All SAWS components shall comply with OSHA regulations and FAA standards and practices for equipment in ATCTs and terminal radar approach control facilities. The contractor shall also comply with the provisions of AC 150/5370-2C, Operational Safety on Airports During Construction.

Appendix A

Acronyms

A

AS	Altimeter Setting
ASOS	Automated Surface Observing System
ATCT	Air Traffic Control Tower

C

°C	degree Celsius
CDU	Controls and Display Unit
CE	Conducted Emissions
COTS	Commercial Off-The-Shelf
CRC	Cyclic Redundancy Check
CS	Conducted Susceptibility
CWO	Contract Weather Observer

D

dB	Decibel
DOD	Department of Defense

E

EMI	Electromagnetic Interference

F

°F	degree Fahrenheit
FAA	Federal Aviation Administration
FAI	Factory Acceptance Inspection
FCC	Federal Communication Commission
FSR	Final System Review
FM	Frequency Modulation

H

H_a	Field Elevation
hz	Hertz

I

inHg	Inches of Mercury

L

LRC	Longitudinal Redundancy Check

M	
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
N	
NDI	Non-developmental item
O	
ODS	Ozone Depleting Substance
P	
P_a	Field Pressure
PM	Phase Modulation
PSU	Power Supply Unit
R	
RE	Radiated Emissions
RF	Radio Frequency
RH	Relative Humidity
RMM	Remote Maintenance Monitoring
RMSE	Root Mean Square Error
RS	Radiated Susceptibility
Rx	Receiver
S	
SAWS	Stand Alone Weather Sensors
SDU	SAWS Display Unit
SU	Sensor Unit
T	
Td	Dewpoint temperature
Tx	Transmitter
U	
UHF	Ultra High Frequency