AUTOMATION OF SURFACE OBSERVATIONS PROGRAM

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Surface weather observations are fundamental to essentially all meteorological services. Observations are necessary in order to make accurate forecasts and warnings and to support aviation operations. For example, the National Weather Service (NWS) currently issues about 500 airport terminal forecasts three times a day, and NWS meteorologists also provide real-time weather information and short-range forecasts for use in pilot briefings and to aid pilots and air traffic controllers.

A complete surface aviation observation provides precise information on weather conditions at and near the Earth's surface, and is taken and recorded at least hourly. The parameters observed typically include temperature and dew point, pressure, wind speed and direction, precipitation type and amount, visibility, and cloud cover and height.

While the NWS provides the core of the nation's weather services, other federal agencies–primarily the Federal Aviation Administration (FAA) of the Department of Transportation (DOT) and the Air Weather Service (AWS) of the Department of Defense (DOD)–routinely take surface weather observations at many locations. Together, the three agencies expend about 1,020 staff years annually on these activities at nearly 1,000 locations across the country.

At present, surface observing methods are still largely manual and labor-intensive. Approximately 1,200 NWS employees participate in taking surface observations at about 260 locations. Other routine services provided by these employees typically include issuing local weather statements, forecasts, updates, weather radio broadcasts, and pilot briefings. In addition, radar or upper-air observations are also frequently involved. Over the past decade, personnel ceiling restrictions, combined with the need to provide improved services, have severely strained staff capabilities. During periods of bad weather, the need for special observations increases dramatically, and station staff is stretched thin. Severe weather conditions such as hurricanes, tornadoes, severe thunderstorms, high winds, and winter storms do result in even greater demands placed on the limited available staff.

Through the nationwide implementation of Automated Surface Observing Systems (ASOS), this situation can be improved. In addition, advances in Doppler radar (and in information systems which integrate complex radar, satellite and surface data sets) provide the opportunity for significant service improvements. Agency modernization plans envision broad use of these technologies coupled with organizational changes and an enhancement of the workforce skill mix to use these new technologies fully. These modernizations are planned to be in place by the early 1990's. ASOS will contribute to this modernization initially through substantial reduction in the labor intensity of the observing function. This reduction in observing work load will permit significant conversion of the field work force to the professional level, and subsequently relieve the constraint of fixed staffing locations, especially at airports.

Objective and Benefits

The program objective is to effectively automate the surface weather observing function. By employing recent technology advances, the NWS will implement a system which can handle all routine observing and record-keeping chores, and which should reduce staff time now spent in taking observations by greater than two-thirds. ASOS will then enable a) redirection of staff to other services, b) flexibility in future staffing and service consolidations, and c) an upgrade in workforce professionalism.

In addition, the systems will contribute to improved aviation safety and better forecasts and warnings, and specifically will

- Operate full-time, 24 hours a day–especially important at part-time stations
- Produce better night observations–particularly in the areas of visibility and sky conditions
- Standardize observation of the visual elements (i.e., visibility and sky condition)
- Provide a continuous weather watch and rapid alert of significant weather changes
- Allow for remote maintenance monitoring
- Replace existing aging equipment

Application of ASOS

Two ASOS capability levels are planned. The first is a Basic-level System which will automatically observe the weather parameters essential for aviation operations and will operate either with or without supplemental contributions by an observer. The second is a more fully automated, Stand-alone System which will observe and report the full range of weather parameters and will operate primarily in the unattended mode.

Approximately 250 systems are planned to be in operation around the end of the decade at nearly all current NWS primary observing sites in the United States. Initially, most of these will be Basic Systems, which will be attended when the facility is open, and potentially at other times by cooperative observers. Stand-alone Systems will at first be limited to a small number of critical locations where observer attendance is impractical. Ultimately, most systems will be enhanced to a full-automation level as appropriate future key sensors become available. These systems may also be augmented to a small degree, if necessary.

When initially deployed, these systems will generate the standard hourly and special long-line transmitted weather observations, as well as provide continuous weather information direct to airport users, e.g., weather office and air traffic control tower.

At a later stage, as other modernization programs of the NWS and FAA are completed, quasi-continuous weather information from these systems will also flow directly into the NWS Warning and Forecast Offices and FAA Air Control Facilities from systems within their areas of responsibility.

Interagency Aspects

The ASOS is an NWS program. However, as the NWS, FAA and AWS (as well as other Defense components) have interdependent observing programs, the introduction of automation needs to be fully coordinated. Thus, an interagency mechanism has been established to coordinate observing policy, equipment development, and acquisition efforts among the three agencies. This mechanism, known as the Joint Automated Weather Observing Program (JAWOP), is to ensure that observations remain fully interchangeable between agencies and that, wherever appropriate, costs will be reduced by collaborative sensor developments or selected equipment procurements.

Observing Process–Manual versus Automated

Today's method of taking surface observations is still primarily manual and largely unchanged from the earliest days of aviation. Using sensors of varying sophistication, the observer personally views and records the indicated values. The observer then often calculates additional weather parameters, applies correction factors, converts data to proper units, etc. The observer then codes the observation into the proper format and manually enters it onto one or more communications systems. This sequence is repeated at least hourly at most locations, with additional "specials" taken whenever significant weather changes occur. Often, the observer must also communicate with the local control tower to ascertain tower visibility and to provide air traffic controllers with the current observation.

The Basic ASOS will relieve the observer of most of this process. The data will be automatically collected, checked, formatted, displayed and transmitted. The system will also continuously monitor weather conditions. The observer need only check for unusual and some specific conditions to determine if necessary to edit the automatically prepared observation. The Stand-alone System will usually operate completely in an unattended mode, performing the same operations as the Basic System, but incorporating additional sensors to identify and report on selected present weather elements as well. Figure 1 illustrates both the manual and automated surface weather observation.

Technology Background

Development of automated observing systems has been under way for a number of years. Research on techniques and development of automation to determine the traditionally visual elements of sky conditions, visibility, present weather, and obstructions to vision have resulted in significant improvements in automation capability. With recent advances, it is now possible to automate surface observations almost completely, providing for more standardized and objective reporting and removing most human-induced variations.

The feasibility of automation of most weather elements (excluding present weather) has been conclusively demonstrated by the Aviation Automated Weather Observing Systems (AV-AWOS) experiment conducted in 1978. This joint FAA/NWS project used a minicomputer-based system with conventional surface-type sensors, an array of ceilometers and visibility sensors, and innovative data processing techniques. This system operated side-by-side with weather observers for four months, and confirmed that the technology exists to automatically provide the minimum set of weather elements needed to satisfy aviation interests and minimal forecast requirements.

System Requirements

ASOS is to be a flexible and modular system capable of being deployed in various configurations and able to function with or without the attendance of an observer. The system is required to operate continuously with high reliability under varied and sometimes extreme weather conditions. It must be capable of providing data in multiple reporting codes and interfacing with existing and future weather sensors in differing combinations, as well as with various communications means.

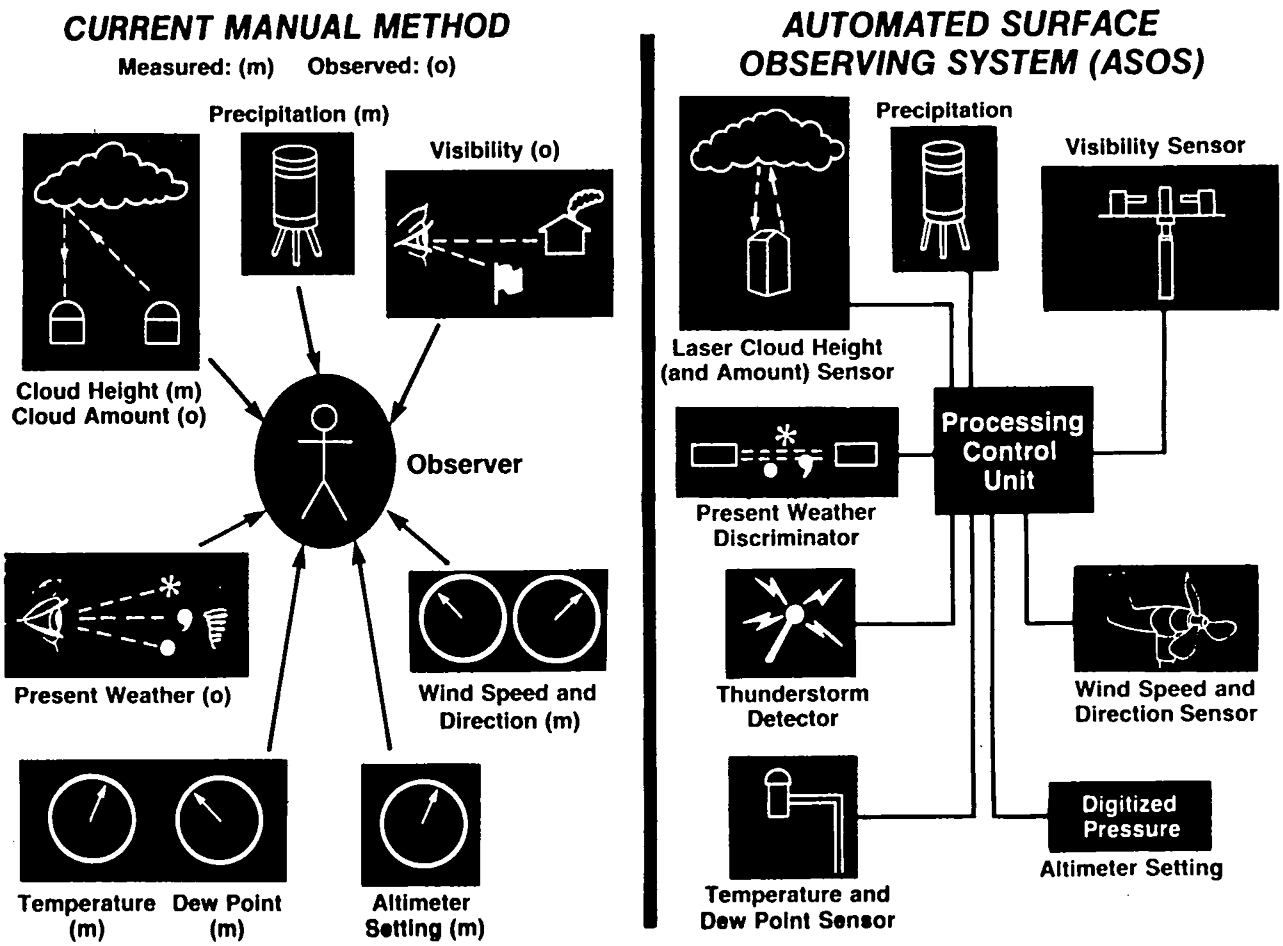

Figure 1. Surface Weather Observation.

Figure 2 illustrates the ASOS system concept, and Figure 3 illustrates a typical airport installation.

A. Automated Capability Levels

Specific configurations will vary depending upon whether the operation is unattended, attended by observers who provide a minimal level of information, or fully automated with a more extensive set of sensors for use as a Stand-alone System.

In all cases, the system will handle all the clerical tasks of local archiving, maintaining the observer's log and summaries, and formatting in various codes for distribution. The system will stay continuously on duty to detect and report significant weather changes as they occur, thus providing a continuous weather watch (which is not now possible) at NWS sites.

B. Basic System - This system will operate in two modes:

1. Unattended - This system will be configured to automatically observe the essential weather parameters needed for aviation operations and most forecast operations. Typical observed parameters will be

- Wind speed and direction, gusts, squall, wind shift, etc.
- Temperature and dew point
- Pressure characteristics
- Visibility conditions (to 8 miles)
- Limited present weather (e.g., freezing rain, precipitation occurrence, thunderstorm detection)
- Precipitation accumulation
- Sky condition (up to 10,000-12,000 feet)

The entire observation will proceed automatically, with only occasional checks by on-site personnel to verify proper operation. The observation generated by this basic, unattended system will also include selected automatically generated remarks.

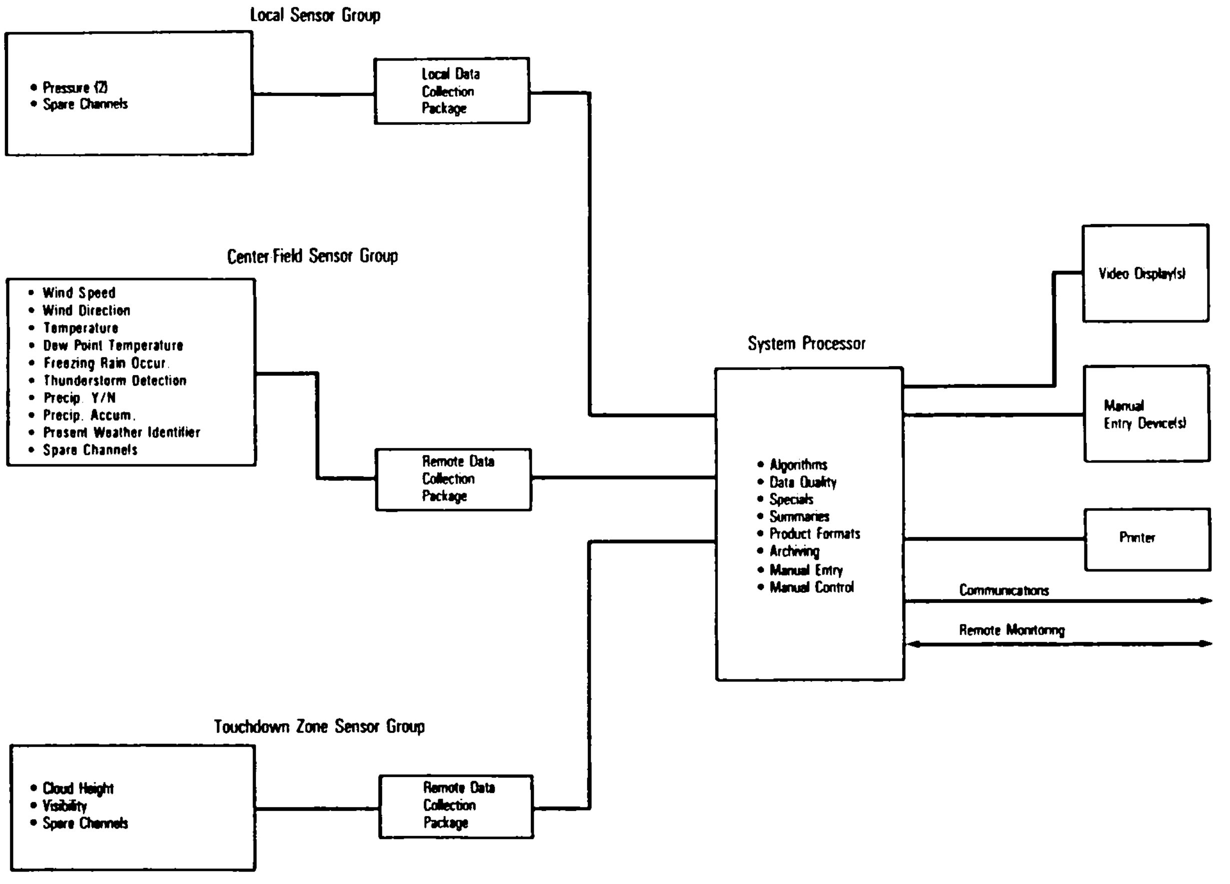

Figure 2. Typical ASOS Block Diagram.

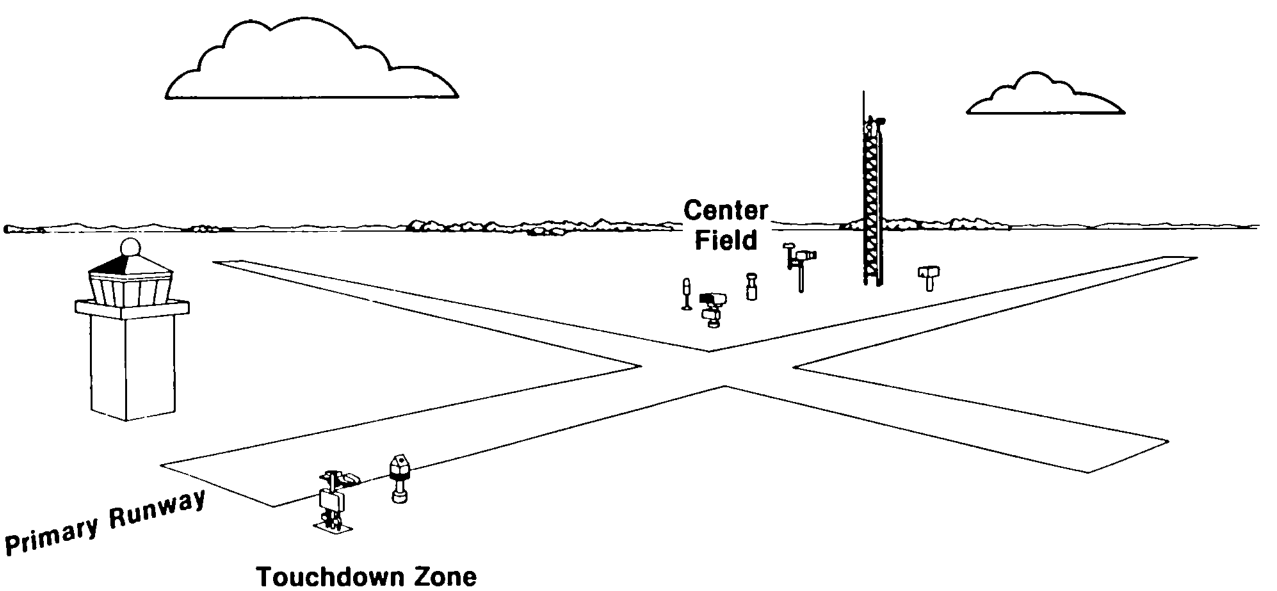

Figure 3. Typical Airport Installation

2. Attended - The attending observer will add to the observation of the basic system by providing additional selected information on present weather and adding necessary additional remarks. This input will be via manual entry keyboard, and requires little more time than that needed to maintain an awareness of on-site weather. At stations staffed part-time, the system will continue to operate after hours in the unattended mode to provide continuous 24-hour observations.

C. Stand-alone System - This system is designed to operate in an unattended mode to automatically observe and report the full range of weather parameters that can be automated. This requires additional sensor and processing capabilities beyond that of the basic system, namely:

- A present weather sensor (e.g., Laser Weather Identifier) for detection and discrimination of precipitation type and character

- Extra ceilometers and visibility sensors (at selected locations as necessary to recognize and report non-homogeneous conditions)

High system reliability and data quality assurance are essential since this stand-alone system may have neither an observer nor a local repair technician.

D. System Functions

The major functions of ASOS are grouped into four areas: 1) data collection, 2) processing, 3) product distribution, and 4) system control. These functions are described as follows:

1. Data Collection - Uses a variety of sensors to measure weather elements and provides the sensed data for processing.

2. Processing - Performs a variety of preprocessing functions including a) conversion of sensed data into specific weather parameters, b) monitoring data quality to identify erroneous, questionable, or incomplete data, c) formatting the observed parameters into standard observation products for display and communication, d) archiving of selected observations and system status information for subsequent retrieval, and e) monitoring its own performance via periodic throughput testing and diagnostic capabilities.

3. Product Distribution - Distributes or communicates data, observations, summaries, and status information to a wide variety of users. Distribution methods include local and remote displays (e.g., tower, weather office), automatic dial-out or direct connection to long-line distribution circuits, and dial-in for inquiry and remote monitoring.

4. System Control - Provides three types of control: 1) Manual Entry, which allows an observer to add data, edit, or override the automatically generated observation; 2) Inquiry Functions, which allow an operator to review previously distributed products; and 3) System Control Functions, which allow a local or remote operator to monitor or change system status, configuration, or constants, and to initiate special system functions.

Program Phases

The Automation of Surface Observations Program has been structured into four phases:

- Development
- Demonstration
- Production System Acquisition
- Operational Implementation

Figure 4 depicts the program phases and general schedule.

Development Phase

This phase, presently under way, consists of development and refinement of sensors and algorithms. Most of the sensors and algorithms necessary for operation of an attended Basic System are currently available. Some further development and algorithm refinements are ongoing to reduce cost and the remaining technical risk, as well as attain the highest possible performance level. Development of a present weather sensor for the stand-alone, unattended operation is still under way. In addition, selected currently operating but obsolete sensors are being replaced with modern sensors that will be fully compatible with future needs of automation (e.g., hygro- thermometer, ceilometer).

The objective parameters (i.e., wind speed and direction, pressure, temperature, dewpoint, rainfall, and occurrence accumulation) can be readily automated. The sensors for these are currently available, as are most of the necessary processing algorithms.

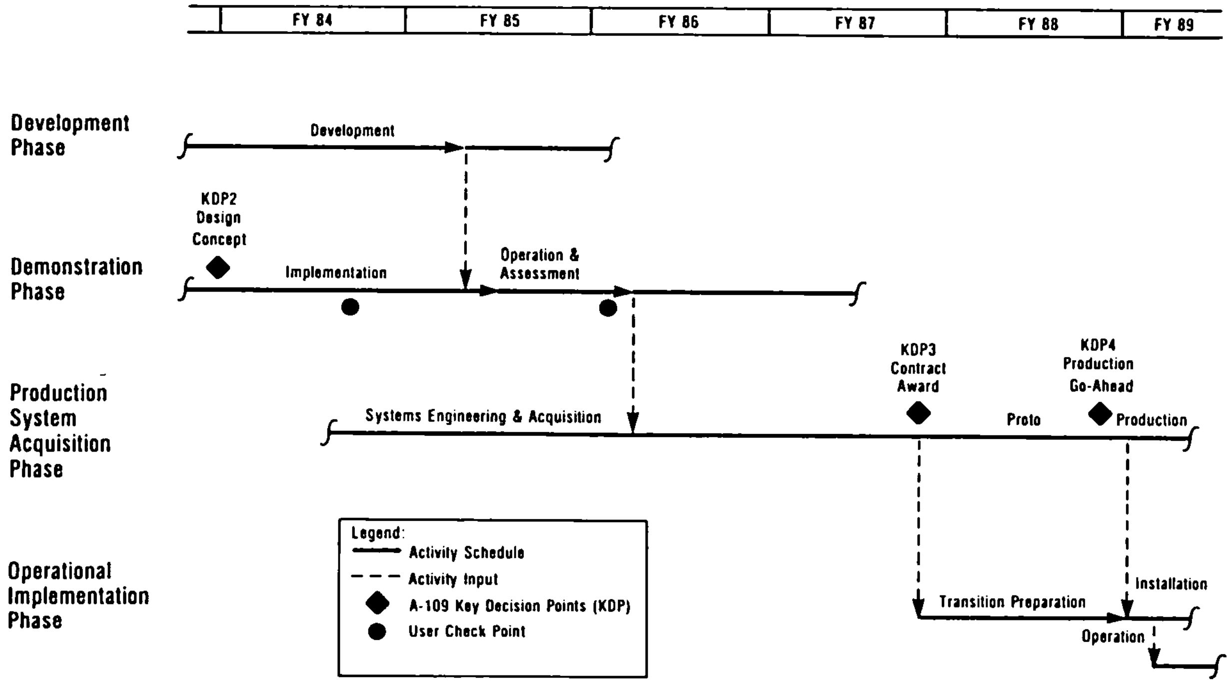

Figure 4. Program Phases and General Schedule.

Algorithms are ready for most cloud parameters (e.g., cloud height and amount, ceiling height, variable ceiling, and variable cloud amount) as well as for most visibility parameters (e.g., visibility, variable visibility, and sector visibility). However, refinements to these algorithms are necessary and will be developed in conjunction with the demonstration. Laser ceilometers are becoming commercially available and should ultimately be capable of monitoring all of the necessary cloud parameters. This sensor is especially critical to the automation program, and NWS is actively engaged in the acquisition of a next generation ceilometer which should, after development, testing, and necessary refinement, become suitable and available for automation by about 1987. Both forward-scatter and backscatter meters are proven technology for monitoring visibility and will adequately serve for the visibility measurement.

Algorithms are also available for monitoring thunderstorm occurrence and freezing precipitation. Commercially available sensors for these parameters are available; however, sensor improvements will most likely be required as field testing continues.

A. Near-term Development

Relatively low-risk, near-term development (e.g., two to four years) is needed for the sensors and algorithms that report mixed precipitation, thunderstorm location and movement, and water equivalent of snow.

The Laser Weather Identifier (LWI), which has undergone testing for several years, can detect and identify pure states of rain, snow, and hail. The LWI and its associated processing algorithms are expected to be ready for the initial ASOS procurements. An alternative approach to the LWI is also under development in order to provide additional assurance of attaining a satisfactory sensor. This is the Light Emitting Diode Weather Identifier (LEDWI). This device has less-complicated electronics, optics, and light source. This single-ended sensor is anticipated to have advantages over the LWI in terms of production cost, installation, and maintenance. Prototypes of the LEDWI are being fabricated for initial testing during the winter of 1985-1986. After this preliminary test, the decision will be made whether to further pursue the LEDWI alternative.

A lightning location sensor which will monitor thunderstorm activity should be ready soon. Deployment of ASOS with a single, on-site sensor having adequate range and heading resolution should yield an effective solution for surface observing. Alternatively, the existing and expanding networks of lightning direction-finding capability operated by other agencies (using centralized processing) may be expanded into an almost nationwide system, which has potential to provide the necessary capability in lieu of the site-specific approach. However, further research is necessary before the final decision on the approach for lightning detection will be made.

Relatively low-risk development should yield sensors and algorithms adequate for reporting precipitation occurrence and amount, and thunderstorm location. However, final refinements and development, testing, and acceptance will require a few years.

B. Longer-term Development

The need for additional development or refinement in the detection and characterization of present weather parameters is still required. Much of this work will be identified and begun within the Demonstration Phase (as part of the Climatic Test-bed Project). Specific algorithm refinements to be undertaken include capability for nonhomogeneous cloud height or cover and low-visibility conditions, as well as development of specific criteria for locations requiring multiple sensors.

C. Standards Development

Appropriate siting of sensors is essential to ensure that their measurements truly reflect the meteorological conditions. An interagency task group has been established to develop and coordinate necessary standards. This group, the Task Group on Surface Instrumentation Standards (TG/SIS), was established to develop appropriate national standards for sensor siting at airports (as well as algorithm standards and certification policy and procedures). This group will review existing guidelines and standards and reconcile individual agency criteria. The TG/SIS is under the Interdepartmental Committee for Meteorological Services and Supporting Research.

Demonstration Phase

The demonstration has two thrusts. Systems with current sensors and algorithms will function in a quasi-operational environment in the Kansas Pilot Project. Systems intended for use in algorithm and sensor testing and refinement will be deployed in the Climatic Test-bed Project. Delivery of the systems in early 1985 will be followed by operation and ongoing assessment through 1986. (A commercial system using similar sensors and many of the NWS algorithms has recently been tested and certified for official use by the municipal airport at Lynchburg, Virginia.

A. Kansas Pilot Project

The Kansas Pilot Project will provide further experience in operations and maintenance of automated systems and will be used to assess the impact on observing operations as well as to determine the most appropriate level of automation. In addition, selected forecast operations will be conducted to assess the adequacy and advantages of automated observations. The project will use a state-wide network of six observing stations exposed to a wide variety of weather (e.g., freezing rain, thunderstorms, and dense fog), as well as frequently occurring changes in the weather. All levels of system capability will be evaluated. The stations will be collocated with existing operations: 1) the Automated Meteorological Observing System (AMOS) at Elkhart; 2) the Weather Service Offices (WSOs) at Dodge City, Wichita, Concordia, and Goodland; and 3) the Weather Service Forecast Office (WSFO) at Topeka. Location of automated systems at current NWS observing sites permit comparisons of quality, timeliness, and content between the two observing methods.

Preparation for the Kansas Pilot Project is well under way, and installation is currently in progress, with operations starting by May 1985 and continuing for at least 18 months. In addition, an ASOS unit is being placed in the FAA tower at the Kansas City Municipal Airport for use by the FAA in assessing workload impact on air traffic controllers in augmenting the automatically generated observation.

B. Climatic Test-beds

The Climatic Test-bed Project will deploy automated observing systems in four other regions with distinctly different climates: 1) subarctic (Fairbanks, AK); 2) mid-latitude temperate (Dulles Airport, VA); 3) maritime (San Francisco, CA); and 4) semitropical (Daytona Beach, FL). This development project will serve to uncover weather-related factors that affect sensors and algorithms. Figure 5 illustrates these locations.

Production System Acquisition Phase

This phase covers the production system planning, engineering, procurement, and manufacturing, as well as operations and maintenance planning and provision-

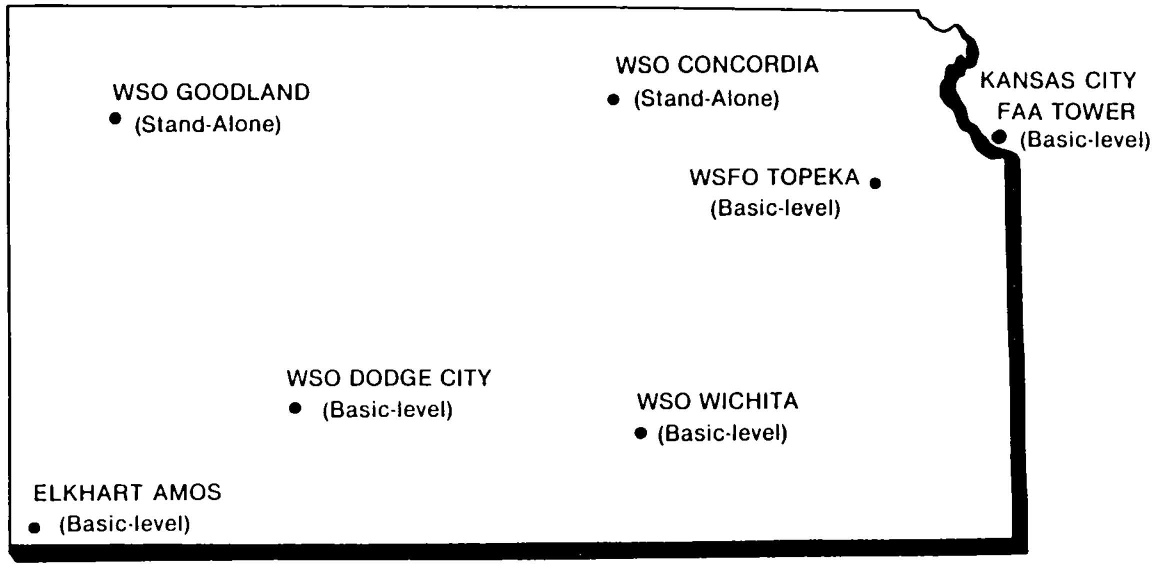

Figure 5. Kansas Pilot Project

ing. This phase will start sufficiently early to permit timely deployment of the production systems, yet allow for assimilation of development and demonstration results into the production contract effort. Final engineering will be completed for communications interface (with NWS's current automated weather information system initially; and, subsequently, to enable quasi-continuous data flow into future systems), display, archiving and system integration planning, and final system design. Rigorous testing and evaluation will be conducted throughout this phase. Support planning and provisioning will also be completed for operations and maintenance training and preparation necessary for the nationwide transition into automated observing operations. Initial efforts leading to production systems will begin with engineering planning in 1985. By late 1986, results from the demonstration effort will be integrated into the equipment and services specification, along with the results of final engineering and support planning. The production system award is planned for late FY 1987. Prototypes will be tested leading towards the final production go-ahead targeted for FY 1988.

Operational Implementation Phase

The operational implementation phase involves installation (including site survey and facilities preparation work), site and system acceptance and activation, and the transition to automated observing. The Operational Implementation Phase will start in 1988 with site preparation and operations and maintenance training. Systems will be installed and operated beginning in mid-to-late 1988, with completion of this phase planned for the early 1990's.