AVIATION—AUTOMATIC WEATHER OBSERVING SYSTEM (AV-AWOS) PRELIMINARY SYSTEM DESCRIPTION

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Final Report

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18 p. (RD-75-5)
(MTR-6831)
Contract No. FA69NS-162

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16. Abstract

The Aviation Automatic Weather Observation System (AV-AWOS) Preliminary System Description is a summarization of the descriptive material contained in the FAA Engineering Requirement, FAA-ER-450-015 and the NWS AV-AWOS Development Plan supplemented by information from NWS with respect to their on-going development work. At this point in the development cycle, there are a number of areas that require further definition for guidance to the development activities. These areas are identified by a list of questions in Appendix A. The description can be updated as these questions are answered and as development progresses until it ultimately describes the operational AV-AWOS to be deployed in the field.

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PREFACE

Under the terms of Interagency Agreement DOT-FA73WAI-394, The National Weather Service (NWS) is in the process of developing the Aviation Automatic Weather Observation System (AV-AWOS) for the Federal Aviation Administration (FAA). The end product of this development program will be a set of performance - type procurement specifications with which FAA will procure a yet to be determined number of AV-AWOS. Development guidance to the NWS is contained in FAA Engineering Requirement, FAA-ER-450-015, December 20, 1972; however, the interagency agreement has provisions for adding requirements by amendments thereto. Experience has shown that requirements tend to change as additional information becomes known and as the design of interfacing systems become more firmly established. To assure that the procurement specifications, when delivered, do accurately define a system that will satisfy FAA's requirements it will be necessary for FAA to identify desired changes and make them known to NWS early enough in the development cycle to permit them to be consolidated in the prototype specifications. A purpose of this document is to facilitate the early identification of features and details of the AV-AWOS, as it is currently being developed, that do not meet FAA requirements. Appendix A contains an initial list of questions which require intra-agency coordination to provide further guidance to the AV-AWOS development effort.

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1. INTRODUCTION

As early as 1959, the concept of relieving FAA personnel from the additional burden of weather observing duties was a subject of discussion between the Federal Aviation Agency and the Department of Commerce. In that year, FAA's annual statement of aviation weather requirements, written in accordance with Section 310 of the Federal Aviation Act of 1958, introduced the subject as: "a complete remote reading observing system is necessary to preclude FAA personnel from leaving their important operating positions in order to take observations". Subsequent annual statements amplified this general requirement and changed the emphasis from "remote reading system" to the present concept to "automatic meteorological observation station".

As recently as 1971, the Department of Commerce reported that the system could not be realized because reasonable cost equipment to measure two parameters of major interest to aviation, ceiling and prevailing visibility, was still unavailable. Subsequently, the Flight Service Station Automation Program, with the proposed closing of numerous manual Flight Service Stations has intensified the requirement for automatic weather observing; and the availability of new sensors for ceiling and visibility has made the attainment of an automatic weather observing capability promising. Planning activities as summarized in Section 1.1, below, have brought into being the program to develop the Aviation Automatic Weather Observing System (AV-AWOS).

1.1 Background

Several planning and study activities have been influential in furthering the concept of automatic weather observing for FAA facilities. Documents produced by these activities, summarized below, give a comprehensive look at the steps leading to the development of the AV-AWOS.

1.1.1 Engineering and Development Program Plan - Weather, FAA-ED-15-1

The FAA Engineering and Development Program Plan - Weather covers: progress; accomplishments; current objective; prospects for products; and funding for the subprograms under the Weather Data Acquisition and Weather Data Processing program elements.

1.1.2 A Proposal for the Future of Flight Service Stations (FSS), U.S. Department of Transportation

A proposal for the future of FSS's, December, 1972, contains the results of a DOT directed study made by the Joint OST/FAA FSS

Evaluation Team. The team proposed an automated FSS system concept which included recommendations to replace manned FSS's with unmanned self service terminals and to develop the AV-AWOS. The AV-AWOS will be required to replace manual surface weather observation stations that will be eliminated by the closing of manned FSS's.

1.1.3 FAA Engineering Requirement, Automated Aviation Weather Observing System, FAA-ER-450-015

This Engineering Requirement formally expresses FAA's requirement for a four phase AV-AWOS development effort to be conducted by an external agency. The stated overall objective is to test and evaluate an automated aviation weather observing and display system. Guidance is given as to what is to be accomplished in each phase; however, a considerable amount of latitude is left with the developing agency for the selection of sensors and for detailed system design.

1.1.4 Acquisition Paper - Acquisition for Automated Aviation Weather Observing System

Two subprograms covered in the Engineering and Development Program Plan - Weather: Visibility and Ceiling (151-462) and Automated Aviation Weather Observing System (151-465) were combined in this acquisition paper and approved by the Transportation Systems Acquisition Review Board for four phases of development, culminating with specifications for an automated aviation weather observation system having the capability to sense, process, transmit and display weather data.

1.1.5 Interagency Agreement DOT-FA73WAI-394 Between Federal Aviation Administration and National Weather Service

This is an agreement that the NWS shall furnish or cause to be furnished all necessary qualified, professional, technical and administrative personnel, and facilities and equipment, including the necessary instrumentation and test equipment, to accomplish the work defined in FAA Engineering Requirement, Automated Aviation Weather Observing and Display System, FAA-ER-450-015. Engineering requirements may be added by amendment to this agreement.

1.1.6 The Development Plan for the Aviation Automated Weather Observation System, National Weather Service

Pursuant to the Engineering Requirement FAA-ER-450-015 and the Interagency Agreement DOT-FA73WAI-394, the NWS Development

1. Runway visibility (RVV)*
2. Runway visual range (RVR)*
3. Other than RVV and RVR, automatic remarks will be limited to those dealing with variability in time of a parameter as measured by a point source sensor (e.g., variable cloud height or variable prevailing visibility).

2.1.2 Manual Inputs

Provision will be made for manual input of remarks to supplement the automatic remarks.

2.1.3 Frequency of Updating Weather

In addition to updating observations for routine hourly teletypewriter weather sequences, AV-AWOS will have the ability to update all weather parameters on a near real time basis. This will give the system the capability of providing data for all currently required national and local reports.

2.2 Weather Dissemination

In the context of this description, weather dissemination refers to the distributing of automatically observed and processed weather information to users or to interfaces with systems that make the information available to users.

2.2.1 Service A Teletypewriter Circuit

Hourly and special surface reports will be automatically prepared and input to the Service A Teletypewriter Circuit.

2.2.2 Output for Independent Information System

Provision will be made for interface with an output to an Independent Information System in American Standard Code for Information Interchange (ASCII).

2.2.3 Display Readouts

Display readouts will provide an effective method of disseminating observed and processed weather information to local and area

*AV-AWOS will be capable of processing data from RVV and RVR sensors where they are colocated; however these sensors are not provided as elements of AV-AWOS.

users. Each AV-AWOS will have the capability of presenting: wind speed, wind direction, peak wind, temperature, dew point, altimeter setting, sky condition, cloud height, prevailing visibility, runway visual range (see Section 3.1.4) and time on up to ten locals displays and up to ten additional remote displays over regular telephone lines. The local displays will service local towers and Flight Service Stations and be made available to airlines and independent operators at their expense. The remote displays will service remote Flight Service Stations and Air Route Traffic Control Centers.

2.3 Recording

Reported data, including dates and times of reports, will be recorded and stored for FAA operational and legal purposes and for NWS archival purposes.

3. FUNCTIONAL DESCRIPTION

Grossly oversimplified, the functions of the AV-AWOS will be the inputting, processing and outputting of weather data. Figure 3-1 depicts schematically the relationship of the inputs, processor, and outputs whose functions are described in this section.

3.1 Inputs

With the exception of a manual input device, all inputs to the system will be automated weather sensors and indicators needed for the processing of weather data. It should be noted, however, that not all sensors described below will be incorporated in all systems. The input configuration of each system will be determined by the observation requirements of the location at which it is to be deployed.

3.1.1 Remote Automatic Meteorological Observing System (RAMOS) Sensors

A basic group of weather sensors that have been used in NWS's RAMOS program will initially be used for AV-AWOS. Subsequently these may be replaced by sensors of equal or improved performance:

a. Temperature sensor
b. Dew point sensor
c. Wind direction sensor
d. Wind velocity sensor
e. Pressure sensor
f. Cumulative precipitation sensor
g. Yes/No precipitation sensor

3.1.2 Sensors in Development, Test and Evaluation

Though much work has been done with respect to automating the observation of sky condition/cloud height, visibility and present weather, no sensors have been specified for these critical parameters of aviation weather. In fact, the viability of the AV-AWOS depends on the development, test, evaluation and selection of appropriate sensors for these areas. In the absence of specific sensors, this section discusses various candidates and work yet to be done with sensor selection.

FIGURE 3-1
SCHEMATAGRAM OF AV-AWOS

3.1.2.1 Sky Condition/Cloud Height

The NWS is conducting an intensive study of the problem of automating sky condition/cloud height observation at its Sterling Research and Development Center (SRDC). For the developmental model the primary candidate sensor for sky condition/cloud height is the Sperry Galium-arsenide Lindar Ceilometer (GALC). Data is being gathered from four types of ceilometers with the goal of arriving at a cost effective solution. Two standard Rotating Beam Ceilometers (RBC), three GALC's, an Impulsphysics Ceilograph II (IMPC) and an American Optical Erbium Ceilometer (AEC) are being studied to determine whether a single sensor time averaged or multiple sensors over an area time averaged will be needed to report representative cloud information automatically. Algorithms for processing data from the different sensor configurations will be developed. The results of this study in the form of cost-effective alternatives will be presented to FAA for a decision.

3.1.2.2 Visibility

Concurrent with the ceilometer study at SRDC, a similar study is being conducted to determine a cost-effective solution to the automation of prevailing visibility observations. For the developmental model the primary sensor for prevailing visibility is the Videograph, a backscatter measurement device. Data is being gathered from a network of three Videographs; two Transmissometers; and hourly surface weather reports from nearby Dulles International Airport. The data will be studied with a goal of developing a solution or alternative solutions for FAA decision.

3.1.2.3 Present Weather

The only present weather parameter for which aircraft operations are restricted by Federal Aviation Regulations is freezing precipitation. To sense this condition, an aircraft ice accretion detector will be incorporated in the initial AV-AWOS. The reporting of hail, thunderstorms, fog, and snow is also being investigated.

3.1.3 Manual Input

A manual input will provide a capability to manually supplement the remarks section of hourly and special observation reports.

3.1.4 Transmissometer

The AV-AWOS will have the capability of accepting the inputs from Transmissometers and related sensors (day/night and runway light setting sensors), though these sensors are not considered to be elements of the AV-AWOS. Where they exist or are to be installed as the result of separate programs, Transmissometers and related sensors will be interfaced with the AV-AWOS. From these inputs Runway Visual Range will be calculated and reported.

3.2 Data Processing Functions

The AV-AWOS will utilize a minicomputer to perform three major functions: data multiplexing, data processing, and data storage. These functions will be controlled by system software concerned with the overall system operation including all input-output operations and various housekeeping functions. As a data multiplexer, the processor will control and coordinate all of the system's input-output channels to direct when a data word is to be transmitted or received. As a data processor, it will solve complex mathematical algorithms for output; and it will manipulate the processed data into pre-determined formats. Algorithms for the processing of the RAMOS sensor inputs are available, however the algorithms for sky condition/cloud height and prevailing visibility are being developed. In addition, it will sense the occurrence of "significant" changes in weather conditions and initiate appropriate reports required by the changes. As a data storage device, it will store processed data as well as the operational program.

3.3 Outputs

3.3.1 Service A Teletypewriter Circuit

Each AV-AWOS will interface with a Service A Teletypewriter circuit for the transmission of hourly and special observations. These output messages may differ slightly in format from those on manually prepared tapes; however, they will be compatible with the teletypewriter circuits and their contents will be readily understood by aviation weather users.

3.3.2 Independent Information System

Interface circuitry will permit the output of weather data over telephone lines in ASCII format to an independent data storage and processing facility.

3.3.3 Displays

Each AV-AWOS will have the capability of driving 10 local displays over two-wire cables and 10 remote displays over long distance telephone lines. The viewing angle of displays will be 45° either side of center, horizontally and vertically; and the readability will extend to a distance of 12 feet without "wash-out" under normal ambient illumination conditions. Displayed data will be presented in English language, with standard contractions, rather than in meteorological symbology.

3.3.4 Recording Equipment

Recording equipment interfacing with the system processor will make recordings of data that is output by the system in the form of weather reports. The equipment will have the capacity to accumulate in storage 90 days of reports for research investigation. Operational requirement for 15 days of reports will be contained within the 90 days of stored data.

3.4 System Features

As a system, the AV-AWOS will have several features that will contribute to its usefulness in the FAA inventory.

3.4.1 System Reliability/Availability

Redundancy of major system components may be used in meeting the Meantime Between Failure design goal of 10,000 hours. A monitoring function will detect equipment failures or degradation of output occurancies and provide appropriate alarms for the initiation of corrective maintenance. Following power failures, the system will automatically resume normal operations and the Mean Down Time, following system failures, will not exceed 30 minutes.

3.4.2 System Update Time

Initially, weather parameters will be updated each minute. A fast update rate coupled with the systems versitile dissemination capability will make near real-time weather information available to local and area users who previously had to rely on hourly reports. Experience may show that the design update rate, once per minute, is not an optimum compromise between system processing load and data accuracy on one hand and the need for fresh information on the other. Appropriate analyses may indicate a more nearly optimum update rate.

APPENDIX A

AV-AWOS DEVELOPMENT GUIDANCE

A review of Engineering Requirement, FAA-ER-450-015, and the NWS Development Plan has identified areas of these two documents that need amplification in order to provide more specific guidance for the development of AV-AWOS. This need for amplification is expressed in the list of questions contained in this appendix.

1. Who will be authorized to get AV-AWOS displays?

   The broad guidance contained in FAA-ER-450-015 for 10 local and 10 remote displays needs further definition. Overall system design, as well as, display characteristics will be influenced by the numbers and locations of displays.

2. What will be the content, format, and update rate of displayed information?

   System complexity can be minimized if identical content and format are displayed on all displays. Is there a valid requirement for variations or for a request and response capability?

   What will be the size and type of display devices and where will they be located?

   If display devices are to be located in existing consoles, their size and configuration will be constrained by available space. Different locations may require different sizes and types of display devices.

4. Which of the items currently being reported such as: remarks, present weather, obstructions to visibility, etc., will be required to be reported automatically in order to satisfy users of aviation weather?

   As the current manual system evolved, users of aviation weather have became accustomed to getting many items of reported weather phenomena that have been simple to report by human observers. To automatically report these same phenomena may be expensive, impractical, or impossible. There is a need to review what is being reported with a purpose of determining: what is absolutely necessary; what should be reported more accurately or more frequently; what would be "nice to have", if affordable; and what is not really required for aviation safety?.

5. What will be the requirement for the reporting of special observations automatically?

Plan describes the orderly actions that will be taken by NWS and selected contractor(s) to develop an AV-AWOS of proven design with performance specifications ready for FAA procurement. Four phases are described with the Development Plan, itself, being Phase I. The remaining phases are summarized below.

Phase II, Design and Operation of the Development Model will include the fundamental design effort. NWS, with contractor support will perform background studies and investigations to develop the configuration for the developmental model. The model will be tested and evaluated to permit design modification before final design of the prototype model. Estimated completion of Phase II is March 1976.

Phase III, Design and Construction of the Prototype Model will be done by contract to NWS. At this level of design, compatibility of the observing procedures will have been assured and will be incorporated into performance specifications to which the AV-AWOS prototype must adhere. Estimated completion of Phase III is June 1976.

Phase IV, Installation, Evaluation, and Production Specifications. During this phase, the prototype system will be installed at an operational location and subjected to a complete test and evaluation. The emphasis will be on maintainability and reliability of the automated system to assure its capability for uninterrupted operation. Also included in this phase will be the documentation of the design, preparation of the procurement specifications, and a full report on the entire development activity. This will be a contractor activity supervised by NWS and is estimated to be completed by January 1977.

Throughout all phases of the development program, interagency coordination will be stressed. In addition to periodic progress reports, FAA approval will be requested for all major system decisions. Moreover, to assure that all interagency impacts are evaluated and decisions reached, two formal interagency coordinating activities will be pursued. One will be involved in obtaining agreement on new automated coding procedures. The other will assure that each agency is aware of AV-AWOS automation techniques being selected, and will assure that the AV-AWOS system can take advantage of any development effort of any other agency that is appropriate.

1.2 System Development Objective

The system development objective is to develop an automated weather observation system to replace manual observations at locations where Flight Service Stations will be closed as part of the Flight Service Station Automation Program.

1.3 Scope

This description of AV-AWOS is limited to a summarization of the descriptive material taken from the Engineering Requirement FAA-ER-450-015 and the NWS Development Plan for AV-AWOS, supplemented by information from the NWS with respect to their on-going development work. At this point in the development cycle, there are a number of areas that require further definition for guidance to developmental activities and to provide amplification to this description. These areas are identified in the form of questions listed in Appendix A.

1.4 Purpose

This document has a three-fold purpose.

1.4.1

To provide, initially, a concise, non-technical description of the AV-AWOS for general information purposes. This description can be updated as development progresses until it ultimately describes the operational system to be deployed in the field.

1.4.2

To provide a baseline document for use by the FAA Headquarters staff in the internal coordination of positions in response to the contractor's [NWS] specific proposals and periodic progress reports.

1.4.3

To provide a baseline description of the system that is being developed in accordance with FAA-ER-450-015 and the AV-AWOS Development Plan for the purpose of making coordinated determinations as to the adequacy of this system in meeting FAA's automatic aviation weather observation requirements.

2. OPERATIONAL DESCRIPTION

The AV-AWOS is being developed to replace manual observing, dissemination and recording of weather parameters. This section discusses the operational features the system will have as the result of existing guidance and initial development intentions. These features will be altered if evaluation during the development process indicates that the system will be unacceptable for integration into the National Aviation System.

2.1 Weather Observing

In addition to the reduction of manpower requirements, a goal of AV-AWOS is to provide more representative observations for aviation users. Computer processing of sensor data provides for more objective measurements and more repeatable observations for given conditions than is possible by human observers. The observing definitions and procedures described in Federal Meteorological Handbook No. 1 may require modification in order to accommodate automation techniques and procedures.

2.1.1 Weather Parameters

Weather sensor data will be processed to provide the following aviation weather, which, with the possible exceptions noted above, will be in accordance with the Federal Meteorological Handbook No. 1:

a. Cloud height
b. Sky cover
c. Prevailing visibility
d. Present weather (data amplifying Group II of the hourly weather report):

    1. Precipitation (Yes/No)
    2. Freezing precipitation

e. Pressure
f. Temperature
g. Dew point
h. Wind direction
i. Wind velocity and gusts
j. Altimeter setting
k. Remarks:

Some of the conditions which currently require the taking, recording and reporting of special observations are related to the weather phenomena addressed in question number 4, above. Therefore, there is also a need to review the requirement for special observations in light of the results of the above study.

6. How will "ACFT MISHAP" observations and reports be handled?

7. How, by whom, and under what conditions will manual inputs be made?

   The requirement for a manual input capability should be reviewed. Should an effective automatic system have a requirement for the inclusion of a manual input device which will unquestionably add to the cost and complexity of the AV-AWOS.

8. Will non-aviation parameters be automatically provided to the NWS?

   By mutual agreement FAA is currently providing to the NWS: sea level pressure, pressure change, precipitation amount, and temperature extremes. The NWS is investigating ways of getting these data automatically. Exempting AV-AWOS from providing these data as discrete outputs will reduce the processing load.

9. What will be the updating frequency for the observations?

10. What will be the interface with FSS/ Interim? Final?

11. What will be the interface with Service A?

12. What is the requirement for FAA data storage and how will the data be stored?