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CAR/SAM Regional Planning and Implementation Group (GREPECAS)
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Agenda Item 6: Transition from the AERMETSG Subgroup and its Task Forces to the MET Programme and its projects

RIGHTSIZING – INTRODUCTION TO THE FLEXIBLE TERMINAL SENSOR NETWORK

(Presented by United States)

SUMMARY

This paper presents the work being done in the United States (U.S.) to modernize the observing systems and networks at aerodromes to meet the demands of the U.S. National Airspace System (NAS) as well as the needs of the U.S.'s Next Generation Air Transportation System (NextGen) where the users will have greater flexibility to access weather information at any time or any place to meet their operational need.

1. Introduction

1.1 The Federal Aviation Administration (FAA) of the United States (U.S.) is developing the Flexible Terminal Sensor Network (FTSN), a cost effective next generation surface sensing capability that will, in a single system, satisfy the current and emerging surface weather sensing requirements of its National Airspace System (NAS) while also allowing users connected to the four dimensional (4D) weather cube unprecedented access to weather information collected in the terminal airspace. This work is important for future programs such as the Next Generation Air Transportation System (NextGen) in the U.S. and the Single European Sky Air Traffic Management (ATM) Research (SESAR) in Europe, where the users will have greater flexibility to access weather information at any time or any place to meet their operational need.

1.2 Over the past 30 years, the U.S. has fielded multiple surface weather sensor networks to meet the observational needs of the NAS. When first deployed, these systems replaced the human weather observations taken in and near the terminal airspace, and as weather sensing technology improved, airport terminals saw these weather systems either enhanced or joined with additional stand-alone systems that provided expanded weather sensing capabilities. Ongoing technical refreshes and Service Life Extension Programs (SLEP) can keep these legacy systems operating in a steady state capacity in the near term, but the costs to do so are increasing with no guarantee that such investments will satisfy the growing demands of the NAS and the needs of emerging decision support tools that will become more complex as NextGen is deployed. Also, from a more fundamental point of view, the emergence of multiple stove-pipe surface observation systems in the terminal airspace over time has resulted in considerable sensing overlap and

waste which must be engineered out of the NAS. Figure 1 is an example of over sensing visibility at Philadelphia (KPHL) aerodrome.



Figure 1. Close proximity of sensors at KPHL aerodrome. Red ovals are visibility sensors; blue oval is a present weather sensor. With today's technologies all can be consolidated while providing improved redundancy.

2. Discussion

FTSN High Level Design

2.1 Figure 2 shows an end-state, high level view of the FTSN and the associated flow of weather information from the individual sensors to the end user. The FTSN will encompass the functionality of several existing legacy systems, (Automated Surface Observing System (ASOS), Automated Weather Observing System (AWOS), Automated Weather Sensor System (AWSS), Low Level Windshear Alert System (LLWAS), Runway Visual Range (RVR), etc.). Details regarding FTSN components, communications, and data flow designs are presented in the following sections.

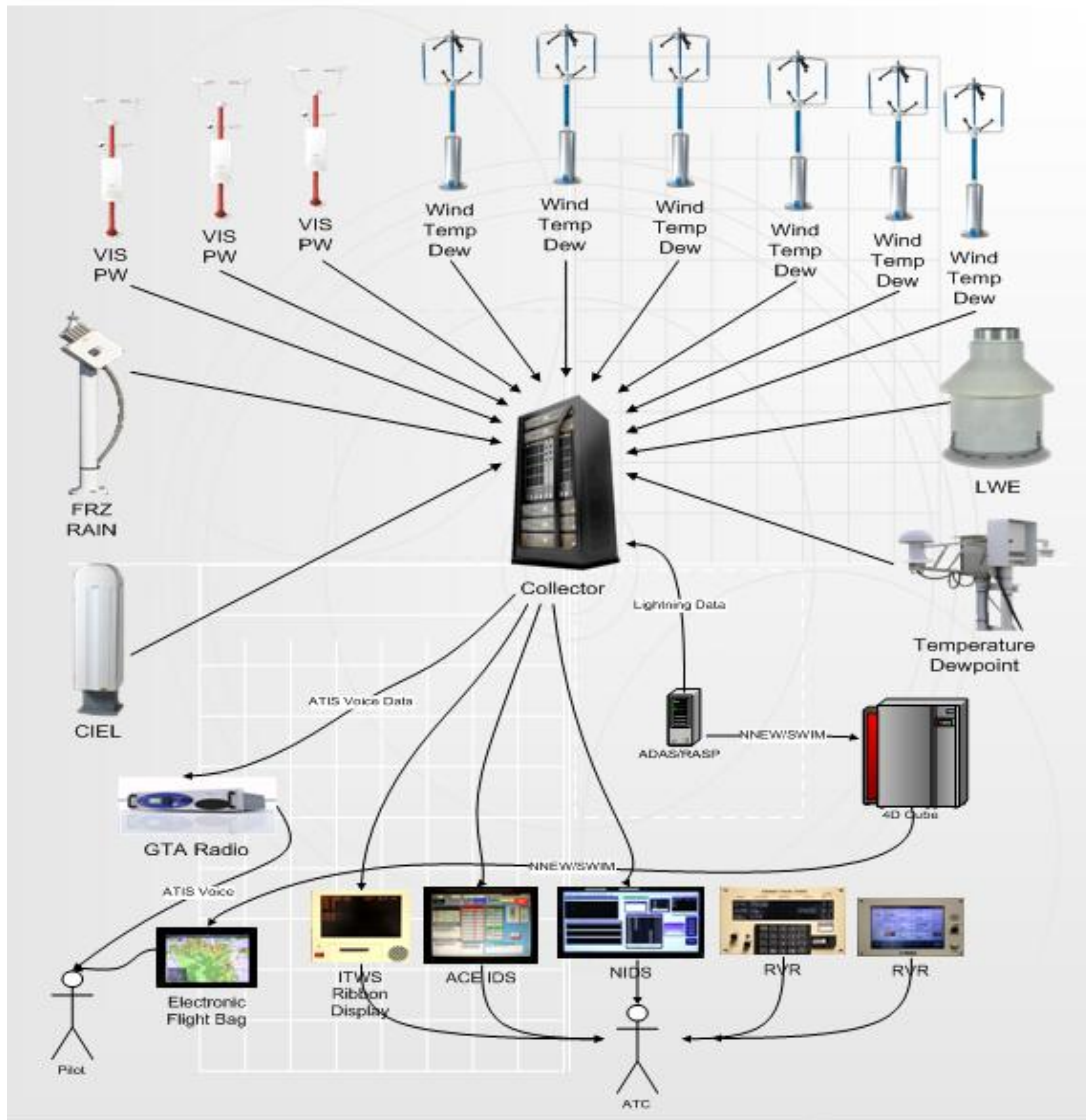


Figure 2. FTSN high-level view.

FTSN Components and Communications

2.2 The system components and physical communications links on a typical aerodrome served by the primary three legacy sensor systems, ASOS, RVR and LLWAS, is shown as Figure 3. In this example the aerodrome is also served by a stand alone weather system (SAWS) and a separate wind measuring equipment (WME) anemometer. Most of the legacy sensors included with these systems have simple analog or serial interfaces and require collocated “field” processors (FP) to collect and transmit data to the legacy “central” processors (CP). These CPs take the data from their systems’ sensors and process the information through various algorithms to produce the legacy weather products. The CPs then format the weather products into a variety of forms before the information is transmitted or displayed to users.

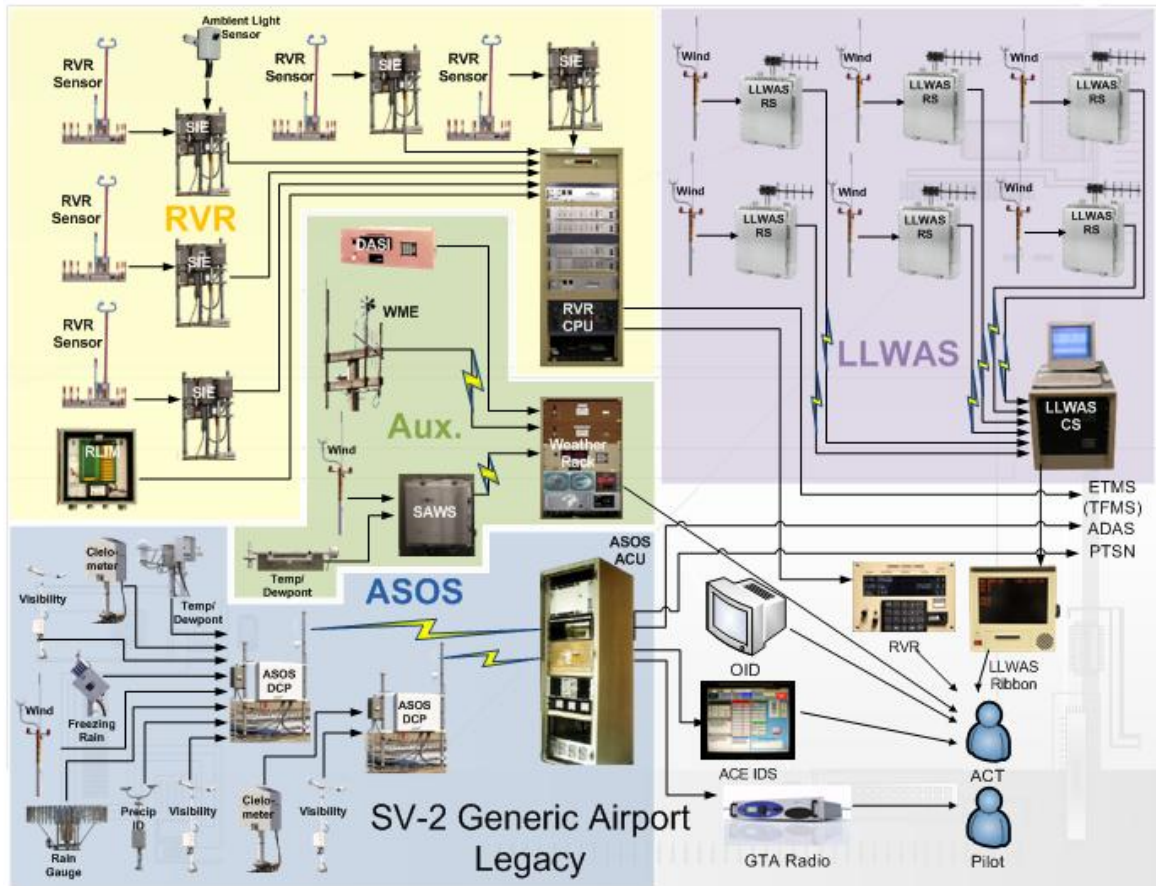


Figure 3. System View of legacy sensor systems at a generic aerodrome.

2.3 As an example, the ASOS sensors have simple RS232 based interfaces (except the Tipping Bucket Rain Gauge which has an analog interface) which have been converted to communicate via simplex fiber optic cables. The fiber optic cables connect each sensor to ASOS's FP (a.k.a. Data Collection Package or DCP). The DCP polls each sensor according to a preprogrammed schedule, collects that data and holds it awaiting a request from the ASOS CP (a.k.a. the Acquisition Control Unit or ACU). The ACU polls each of its DCPs (each ASOS can support up to three DCPs, this is design limitation) according to a preprogrammed schedule and collect all relevant sensor data via a proprietary RF radio modem link operating in the 410 MHz band. The ACU then processes the data according to its particular set of algorithms and produces a set of weather products for dissemination. In the case of the ASOS, the CP drives a number of organic display terminals (i.e. Operator Interface Device (OID) or Video Display Unit (VDU)) and communicates with a number of external systems (e.g. ADAS and ACE IDS). In addition to digital outputs, ASOS also contains a voice generator that produces a spoken version of some ASOS products and transmits that information directly to pilots via a Ground to Air (GTA) radio and to the public via telephone lines. All other legacy sensor systems operate in a similar manner, except that LLWAS and RVR generally maintain a one to one ratio between the sensors and field processors.

2.4 Figure 4 shows the streamlined FTSN design that performs all observing functions and tasks of the legacy systems with equal to or better than levels of reliability, availability and maintainability. The FTSN eliminates the need for any proprietary field processors and many sensor measurement tasks will be consolidated into hybrid multifunction sensor types. The FTSN's sensors will comply with TCP/IP network protocols and operate independently over the wireless communications

channel chosen for the FTSN. As such, all FTSN sensors will communicate directly with the FTSN’s Collector, where all of the legacy systems’ central processing computations and functions will be performed. The Collector will produce, format and transmit all required legacy weather products as well as any new weather products needed by the NAS or other external users. The Collector will be built primarily of commercial off-the-shelf (COTS) computer components and servers running a standard open source operating system, such as LINUX. Included within the Collector will be many of the functions that previously required specialized hardware in the legacy systems (e.g. The Voice Generation System in the ASOS ACU) that can now be performed on standard processors. The Collector will also incorporate a Web Feature Service (WFS) that complies with the standards developed under the SWIM and NNEW programs. The WFS will be the FTSN primary interface to the NextGen NAS and through this interface all of the FTSN’s processed and raw data will be available to authorized users and applications.

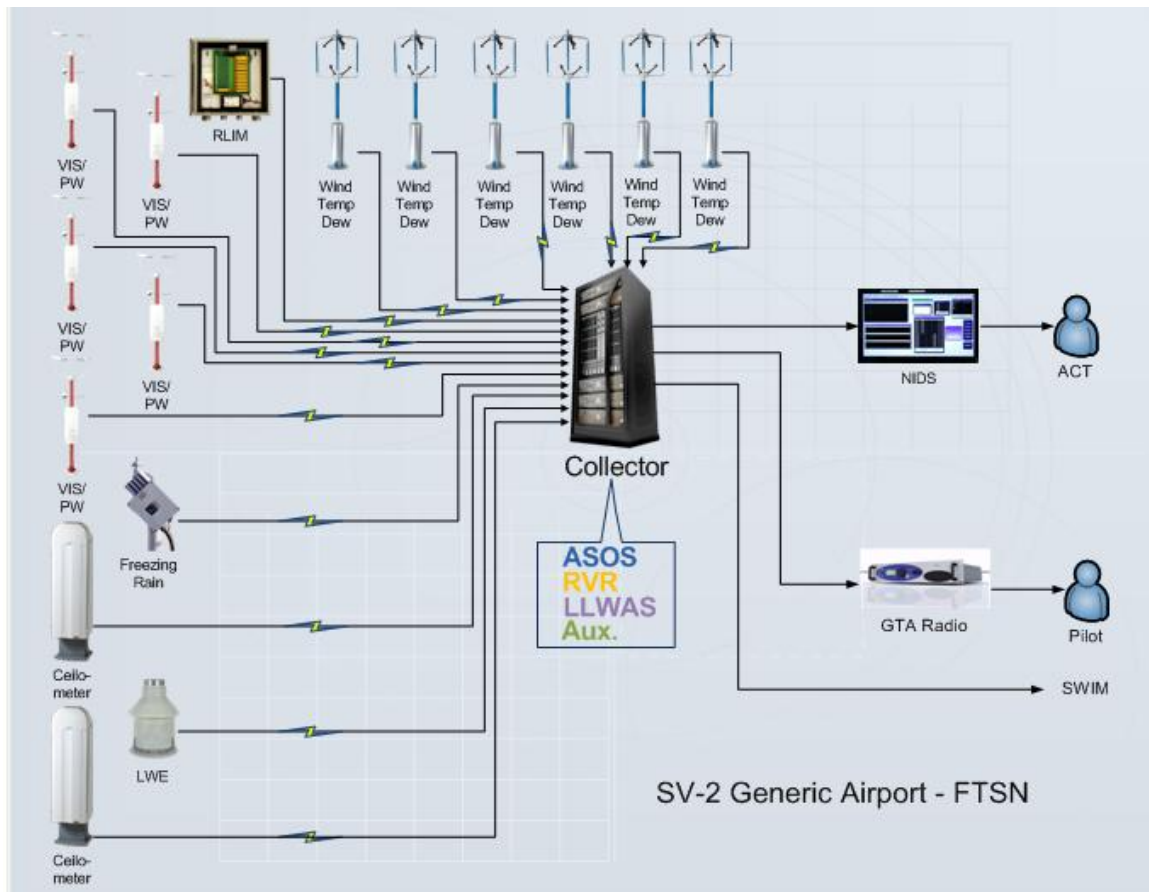


Figure 4. System View of FTSN design for generic aerodrome.

2.5 Figures 5 and 6 again illustrate the contrast between the physical components and connections of the legacy systems and those of the FTSN, except these figures document the actual configuration of a single aerodrome, in this case KPHL. Examining a single airport in detail helps points out the fact that there is no “generic” airport and that the NAS consists of over 1200 unique facilities currently equipped with one or more of the legacy weather observation systems. By looking at figures 5 and 6 it is apparent that KPHL is not currently equipped with an LLWAS, but it does have eight visibility sensors distributed around the airfield in order to provide the needed RVR coverage of its runways. It is also important to keep in mind that the legacy diagrams presented here in no way represent the full complexity of the equipment and cabling present at the actual facility. Gear and equipment like cable bundles, punch panels, demarcation cabinets, service disconnects, etc., have been omitted for the sake of

clarity, but these items are present and their configuration varies greatly from facility to facility. By looking at Figures 4 and 6 it should be clear that while the FTSN will have to adapt to many unique facilities, it is designed from the ground up as a plug-and-play system and the needed adaptability has been designed into the system.

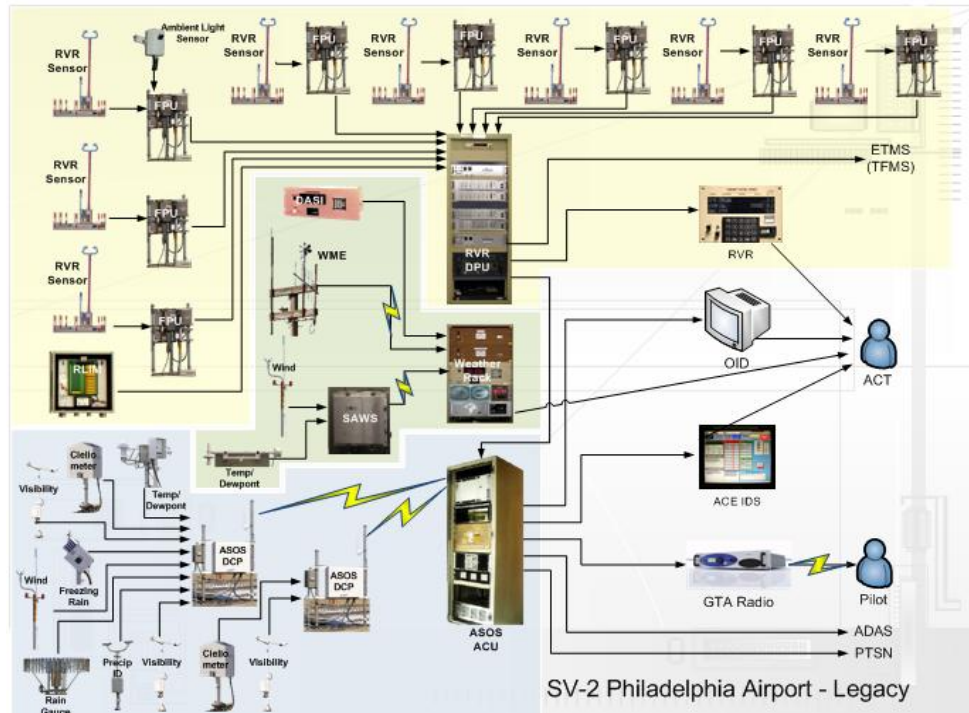


Figure 5. System view of legacy sensor systems at KPHL aerodrome.

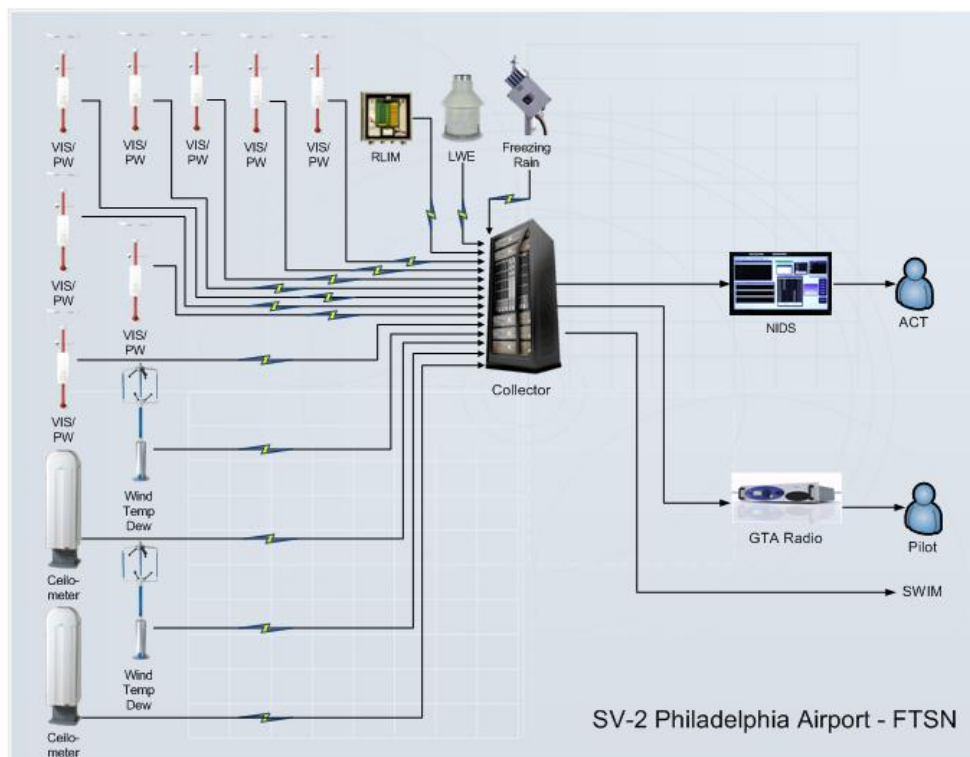


Figure 6. System view of FTSN design for KPHL aerodrome.

2.6 The data flow diagrams shown in figures 7 and 8 illustrate the basic categories of equipment that make up the legacy systems and the FTSN as well as the type and format of the data that flows between these subsystems. Legacy systems typically contain four distinct subsystem types. They are:

- Sensors – Those devices that interact with and measure the physical environment
- Field Processors – Those devices that interface with one or more sensors and in turn buffer and transfer sensor data to the Central Processors
- Central Processors – Those devices that collect and process raw sensor data and produce value added products meaningful to users
- Dissemination Devices – Display or interface devices that are either organic to or closely coupled to the legacy systems

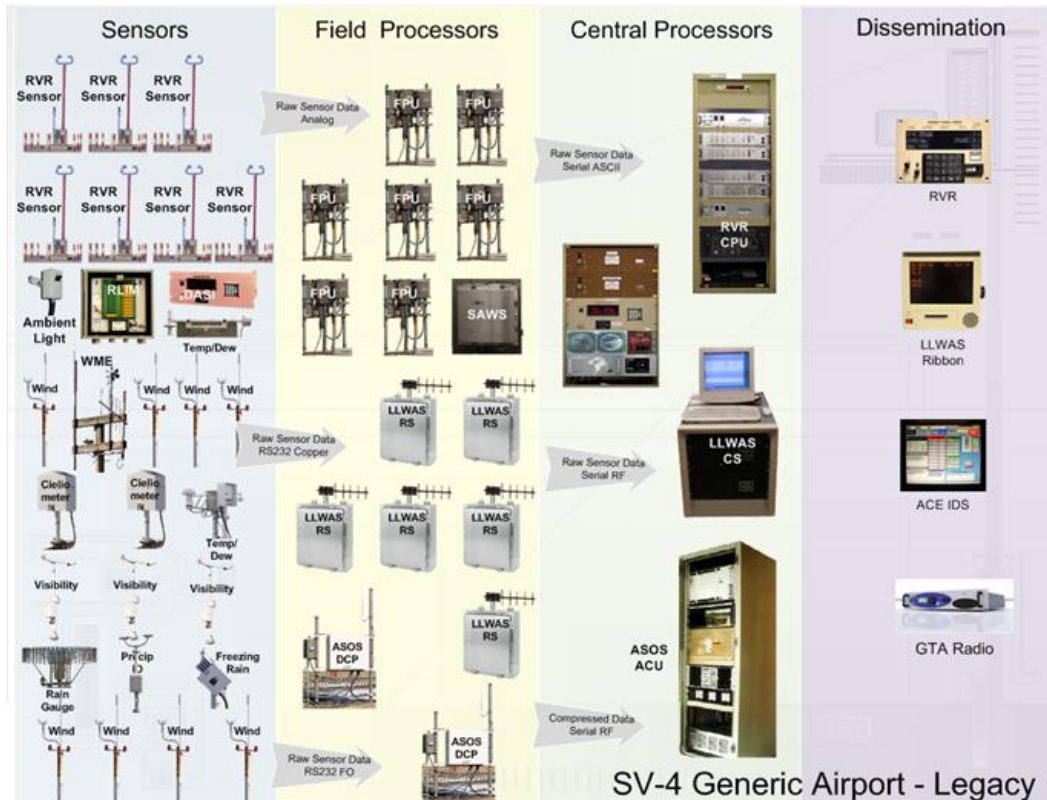


Figure 7. Data flow diagram for generic aerodrome legacy sensor systems.

The exact data types and formats are unique to the individual legacy systems and are briefly described in the following paragraphs.

2.6.1 RVR sensor heads are connected via dedicated, organic, copper cabling to the Sensor Interface Electronics (SIE) box and provide it with analog sensor information. The SIE converts the analog data into a digital form and communicates this serial data to the RVR Central Processing Unit (CPU). This serial communications was typically via a balanced line driver over twisted pair which

would pass through a number of connection points. Lately a RF radio solution has been developed out of necessity as copper cabling has failed and no new twisted pairs are available. The CPU collects data from all of the visibility, ambient light and Runway Light Intensity Monitors and processes this data into RVR readings for each visibility sensor location as well as a primary RVR reading which is communicated to the ASOS. The RVR is connected via dedicated cabling to the RVR display units. This data format is proprietary to the RVR manufacturers and serves to display the RVR data and to control some functions of the system.

2.6.2 The LLWAS sensor array consists entirely of wind speed and direction sensors. Systems utilizing original technology have electro-mechanical sensor heads providing analog signals via copper wire to the Remote Station (RS). Many LLWAS systems have been upgraded with ultra-sonic sensor heads which provide serial digital data via a copper RS232 connection to the RS. In the LLWAS architecture sensors and RSs are fielded on a one to one basis and a minimum of six sensors is required for the LLWAS algorithms to run (maximum number of sensors is thirty two). The RSs collect and buffer sensor data and transmits that data, when polled, to the LLWAS Central Station (CS). The transmission channel from the RSs to the CS is a dedicated RF link with a proprietary data format and communications protocol. It should be noted that the frequency currently utilized by LLWAS will not be available at some point in the future. The CS collects data from all of the connected sensors and monitors these measurements on a real-time basis looking for patterns in the wind flow that are indicative of hazardous weather conditions. When such conditions are detected, the CS reports to users via the LLWAS ribbon display and/or via the Integrated Terminal Weather System (ITWS), if one is present at the facility. These connections are via dedicated copper cables and utilize a proprietary data format.

2.6.3 The ASOS, AWOS and AWSS systems perform a very similar function, which is the production of automated surface observations on a regular basis and the production of special surface observations when weather conditions warrant. While the operations of the systems are similar, they do vary in some ways. ASOS is the most prevalent of these systems and the ASOS contains an array of sensor types needed to automate the surface weather observations. These sensors include: Cloud Height Indicator (Ceilometer), Visibility Sensor (with Ambient Light Sensor), Ambient and Dew Point Temperature Sensor, Pressure Sensors (two or three), Present Weather or Precipitation Identification, Rain Accumulation or Tipping Bucket Rain Gauge (some locations), Liquid Precipitation Water Equivalent (some locations), Freezing Rain Detection (some locations), Wind Speed and Direction Sensor, Lightning Detection and Range (some locations).

2.6.4 These ASOS/AWOS/AWSS sensors (with the exception of the pressure sensors) are located outside, on the airfield, and are connected to a collocated DCP via two simplex fiber optic cables. These outdoor sensors communicate via a serial communications protocol normally implemented in RS232 communications. In fact each sensor and the DCP contain a proprietary design fiber optic modem that translates a RS232 connection to fiber optic (the exception to this is the Rain Accumulation Sensor which is an analog sensor). The communications messaging is proprietary to each individual sensor vendor. Message types include measured data request/response, "canned" data request/response and diagnostic data request/response (and others depending on the individual sensor). The DCP polls each sensor and collects its data according to a preprogrammed schedule and stores the retrieved sensor data until requested from the ACU. The data is compressed and transmitted via an RF modem using a proprietary protocol. Virtually all ASOS utilize the RF link, but a few, along with some federal AWOS systems utilize twisted pair for long line communications. Once the sensor data is received by the ACU it is processed according to the relevant algorithm and the resulting data product is incorporated into the appropriate observation product, then stored or transmitted directly to users. The ACU contains a dedicated, organic voice generation system that produces a spoken word version of the surface observation data product. This product is then transmitted via a Ground to Air Radio, which may be

contained within the ACU or located elsewhere. The ACU also produces a number of real-time weather products (e.g. 5 second winds) that are presented to users via a variety of displays (e.g. Operator Interface Device or OID, Video Display Unit or VDU, etc.) The ASOS Controller Equipment Integrated Display System (ACE-IDS) is a unique example of such display systems, originally conceived as the Controller Video Display (CVD), the ACE-IDS has evolved with more advanced and flexible display capabilities and is now managed as a FAA program, separate and distinct from the NWS ASOS program. Communications between the ACU and the various display systems are via dedicated copper cables running either standard VT220 terminal messaging or proprietary messaging and protocols. In addition to its central processing function, the ACU also houses the primary pressure sensors, two for a Class II system and three for a Class I system. If the ACU is installed within a pressurized building the pressure sensors utilize a common “Gill” type vent to the outside of building.

2.7 The FTSN (shown in Figures 8) eliminates all of the field processing units used in the legacy systems and relies on modern sensor designs to communicate directly to the central processing unit (Collector) via wireless network communications protocols. The FTSN will also consolidate sensor packages where possible so that a single sensor is capable of performing more than one measurement function (e.g. wind, temperature and dew point measurements combined in a single “weather pack” sensor). This will allow the FTSN to provide all of the measurements of the combined legacy systems, many additional measurements of certain parameters, while reducing the overall number of sensors at the airport. In addition the FTSN will significantly increase the critical reliability and availability of the measurements while also increasing the serial reliability of airfield equipment by drastically reducing the amount of hardware needed to perform the observation functions.

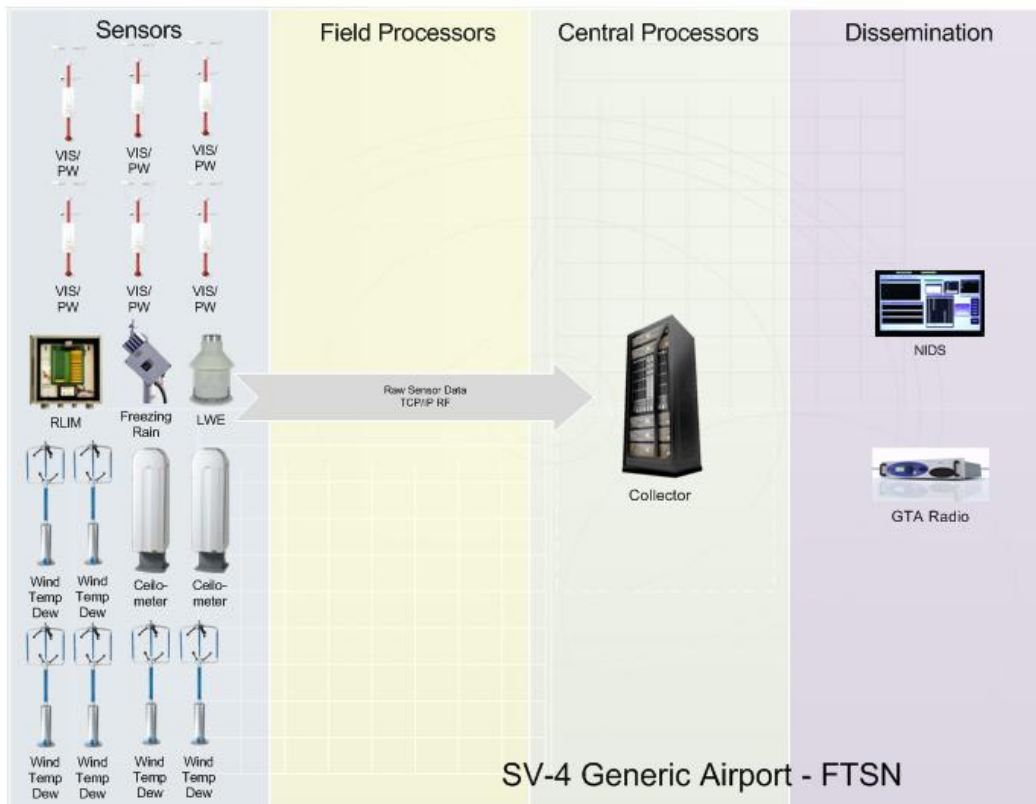


Figure 8. Data flow diagram for generic aerodrome FTSN sensor diagram.

Other Ongoing FTSN Development Activities and Timeline

2.8 Other near-term FTSN development efforts include analysis of legacy sensor systems requirements and allocation of these requirements to the FTSN subsystems. To modernize and economize communication capabilities, the FAA is studying available wireless technologies and has joined ongoing NAS wireless initiatives. To ensure the unique needs of each terminal are met, a generic terminal sensor survey process will be developed and executed resulting in detailed sensor blueprints that are coordinated with ongoing terminal maintenance and modernization activities. In the summer of 2011, the FAA conducted a market survey to determine the availability of COTS sensors that could support the FTSN (wireless capabilities, consolidated functionality) while being capable of operating in various NAS environments. Analysis of industry feedback is ongoing at the time of this paper. Legacy code and processing architectures will be modernized and consolidated with demonstrations of FTSN progress taking place over the next four years. A demonstration of the FTSN Collector capability is planned for early 2012 and will take place in the FAA's William J. Hughes Technical Center NextGen Weather Evaluation Capability (WJHTC NWECA) laboratory. A full demonstration of an FTSN prototype, including Collector and outdoor sensors placed throughout the Atlantic City (KACY) terminal is planned for 2013.

2.9 Figure 9 represents the project timeline depicting the FAA Acquisition Management System (AMS) decisions and the anticipated completion of the major work element groups to achieve the FAA's concept and requirements definition readiness (CRDR) and investment analysis readiness decision (IARD) milestones.

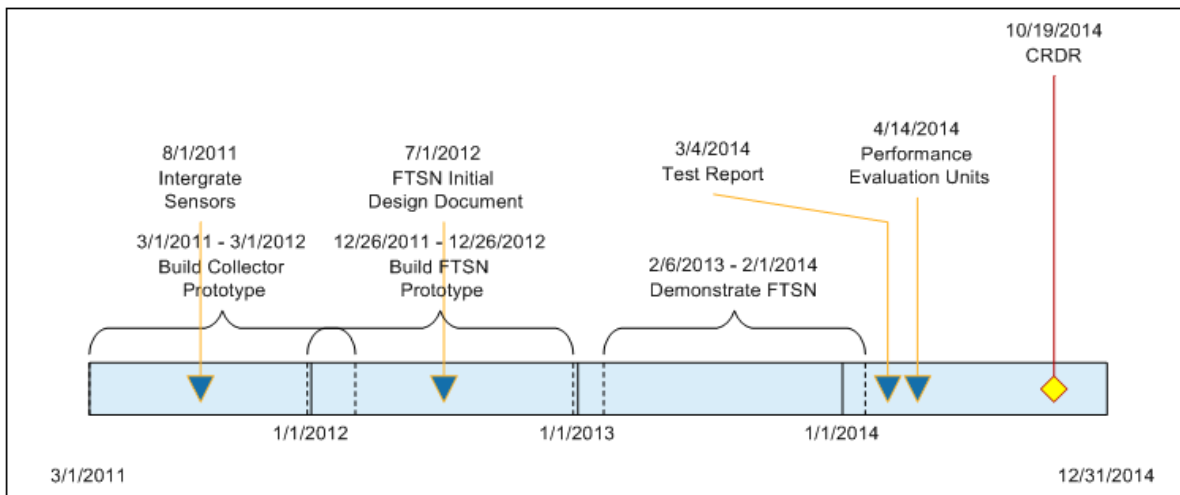


Figure 9. FTSN multi-year timeline.

2.10 Conclusion

2.10.1 When incorporated into the NAS, the FTSN will result in the elimination of close to 350 equipment cabinets and a streamlined deployment and depot of sensors and sensor spares. Initial cost estimates indicate the FTSN acquisition will save the FAA at least \$100M in equipment costs alone compared to the equipment costs required to sustain the legacy sensor systems. A detailed cost study (expected to be complete in early 2012) will document the additional substantial cost savings that will result from consolidated maintenance, training, management and other support activities. With systems engineering costs to develop the FTSN estimated to be between \$12M and \$16M, the investment in FTSN will yield substantial long term savings to the FAA.

2.10.2 The FTSN is an example of a flexible weather observation network that allows open and timely access to weather observations and their specific elements. A flexible observation program is considered an important component of future programs, such as NextGen and SESAR, in order to meet user requirements to retrieve specific weather elements at any time and at any place.

2.10.3 For additional information on this program please contact:

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