SAE INTERNATIONAL

AEROSPACE STANDARD	AS5537™	REV. A
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(R) Weather Support to Deicing Decision Making (WSDDM) Winter Weather Nowcasting System

RATIONALE

This revision has resulted in two major modifications and several minor modifications. The major modifications to this document include the removal of mention of the Vaisala AviCast system and standardization on the terminology referring to the precipitation gauges used in the WSDDM system. Vaisala has stated they will no longer be marketing, maintaining, or supporting their AviCast system and have shut down their AviCast operations.

The wording regarding the precipitation gauges has also been standardized in the document and instances of “snow gauge” and “all-weather precipitation gauge” are now simply referred to as “precipitation gauge”. Further clarification of what is meant by “precipitation gauge” has been added to section 8 and updated information regarding the specific precipitation gauges (including URLs and contact information for the associated companies) has been added. This section also now states that tipping bucket precipitation gauges should not be used with this system due to the established problems with using those gauges in winter conditions.

Other modifications to the document include grammatical improvements, new publication references, rates expressed in both mm/h and g/dm^2/h, updated figures, updated computer system requirements, and updated maintenance needs for the sensors.

TABLE OF CONTENTS

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1. SCOPE

1.1 Purpose

The purpose of this SAE Aerospace Standard is to provide guidelines for the components and configurations that define the research and commercial versions of the Weather Support to Deicing Decision Making (WSDDM) winter weather nowcasting system.

1.2 Background Information

The original motivation for the WSDDM nowcasting system (hereafter referred to simply as the WSDDM system) was to provide flight line deicing operators the most up-to-date and relevant weather information on which to base their deicing decisions. The system has also been highly useful to airport authorities for snow crew management of runway, taxiway, and road-plowing activities, as well as air carriers for ground de/anti-icing operations, departure scheduling, and regional air traffic facilities during winter weather air traffic operations.

An important key element of the WSDDM system is the use of one or more precision precipitation gauges, which provide real-time estimates of the liquid equivalent snowfall rate every minute. This measurement is essential to deicing operations due to the determination by the deicing community that the liquid equivalent snowfall rate is the key factor leading to the failure of deicing/anti-icing fluids. Currently, surface-based weather observations (Meteorological Aerodrome Reports, or METARs) do not provide liquid equivalent snowfall rates, but rather hourly snow intensity estimates based on visibility. These estimates have been shown to be misleading when wet snow, heavily rimed snow (snow that has accreted significant amounts of liquid cloud droplets), and snow containing single crystals of compact shape (nearly spherical) are occurring. Researchers have defined these hazards as high-visibility/high-snowfall rate conditions. Examination of five of the major aircraft ground deicing accidents has shown that high visibility-high snowfall rate conditions were present during most of these accidents. All of the accidents had nearly the same liquid equivalent rate of 2.5 mm/hour (25 g/dm2/h), but widely varying visibilities. The WSDDM system was designed to directly address this concern by including preciptiation gauges that measure liquid equivalent snowfall rate every minute as one of its core components.

Another important component of the WSDDM system is the two-hour nowcast of snowfall rate based on a combination of weather radar reflectivity and precipitation gauge data. These nowcasts are determined by applying a calibration factor to the reflectivity based on actual rates from the gauges and then tracking the movement of the reflectivity. Additional features of the WSDDM system includes: (1) real-time radar reflectivity from WSR-88D weather radars depicting current locations of precipitation, (2) meteorological data at the airport and two or more sites up to 80 km (~50 miles) away from the airport updated every minute and displayed in text and graphical (timeline) form, with the timeline going back a minimum of 2 hours, (3) a 2 hour nowcast of radar reflectivity based on the use of a cross correlation technique of the radar reflectivity data updated every 6 to 10 minutes (depending on the radar update frequency), and (4) a depiction of the current weather conditions from METAR hourly reports or special METAR reports (SPECIs) in text format and also depicted graphically within the WSDDM display.

This SAE Aerospace Standard recommends setting guidelines for the deployment of the Weather Support to Deicing Decision Making (WSDDM) system at site-specific airports. They are intended to provide (1) the relevant information to locate, operate, and maintain such systems and (2) hardware specifications for the equipment required to build and operate such systems.

In general, the WSDDM system is an automated system that produces real-time analyses and short-term nowcasts of winter weather conditions in the airport terminal area. The data used by the system are provided from precipitation gauges, weather radars, surface weather stations, and METAR data generated from Automated Surface Observing Systems (ASOS) and Automated Weather Observing Systems (AWOS). These data are processed by the WSDDM software to produce graphical and textual depictions of the current weather conditions. A one-hour forecast of expected precipitation rates at the airport is also produced and updated every six to ten minutes, depending on the frequency of new data received from the weather radars. The resulting analyses and forecasts are displayed via a webpage or on dedicated computer systems in a user-friendly format that is easily understood by non-meteorologists. Details regarding the graphical display and the computer algorithms used to generate the display are given in the WSDDM article in the Bulletin of the American Meteorological Society as referenced in 2.2 of this document. A PDF file of this article can be found at the following web site: http://www.ral.ucar.edu/projects/wsddm/bams.pdf.

1.3 Units

The values stated in SI units are to be regarded as the standard.

1.4 Safety

While the materials, methods, applications, and processes described or referenced in this document may involve the use of hazardous materials, this document does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and processes and to take the necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ISO 10012 Quality Assurance Requirements for Measuring Equipment

2.2 Related Publications

Weather Support to Deicing Decision Making (WSDDM): A Winter Weather Nowcasting System. R.M. Rasmussen, M. Dixon, F. Hage, J. Cole, C. Wade, J. Tuttle, S. McGettigan, T. Carty, L. Stevenson, W. Fellner, S. Knight, E. Karplus, and N. Rehak, Bulletin of the American Meteorological Society, 82, 579-595.

Common Snowfall Conditions Associated with Aircraft Takeoff Accidents, 2000: R.M. Rasmussen, J. Cole, K. R.K. Moore, and M. Kuperman, J. of Aircraft, 37, 110-116.

The Estimation of Snowfall Rate Using Visibility, 1999: R.M. Rasmussen, J. Vivekanandan, J. Cole, B. Myers, and C. Masters: J. Appl. Met.,38, 1542-1563.

The Hotplate Precipitation Gauge, 2008: R.M. Rasmussen, J. Hallett, R. Purcell, S. Landolt and J. Cole, J. Atmos. Oceanic Technol., 28, 148-164.

A New Ground Deicing Hazard Associated with Freezing Drizzle Ingestion by Jet Engines during Taxi, 2006: R.M. Rasmussen, C. Wade, R.K. Moore, A. Davis, B. Reis, T. Lisi and A. Ramsay: Journal of Aircraft, 43, 1448-1457.

How Well are we Measuring Snow: The NOAA/FAA/NCAR Winter Precipitation Test Bed, 2012: R. M. Rasmussen and Coauthors: Bulletin of the American Meteorological Society, 93, 811-829.

WMO Solid Precipitation Intercomparison Experiment (SPICE) (2012-2015): R. Nitu and Coauthors: WMO Report No. 131, 1445 pgs.

The Impacts of Automation on Present Weather–Type Observing Capabilities across the Conterminous United States, 2019: S.D. Landolt, J.S. Lave, D. Jacobson, A. Gaydos, S. DiVito, and D. Porter: J. Appl. Meteor. Climatol., 58, 2699-2715.

3. WSDDM SYSTEM DESCRIPTION

3.1 WSDDM System Types

The primary WSDDM system currently in use is shown graphically in Figure 1. The example WSDDM system shown consists of five precipitation gauges; two are installed at the airport (Denver International) and an additional three gauges located at various distances around the airport. For the primary airport site location, it is recommended the gauge be installed in a location relatively close to where the aircraft ground deicing operations occur. Data from these surface stations are typically transferred via cellular modem, ethernet connection, or radio modem. Radio modems are typically used as a backup by the WSDDM system in the event of a cellular modem failure. National Weather Service NexRAD radar data and near-vicinity METAR data are also available.

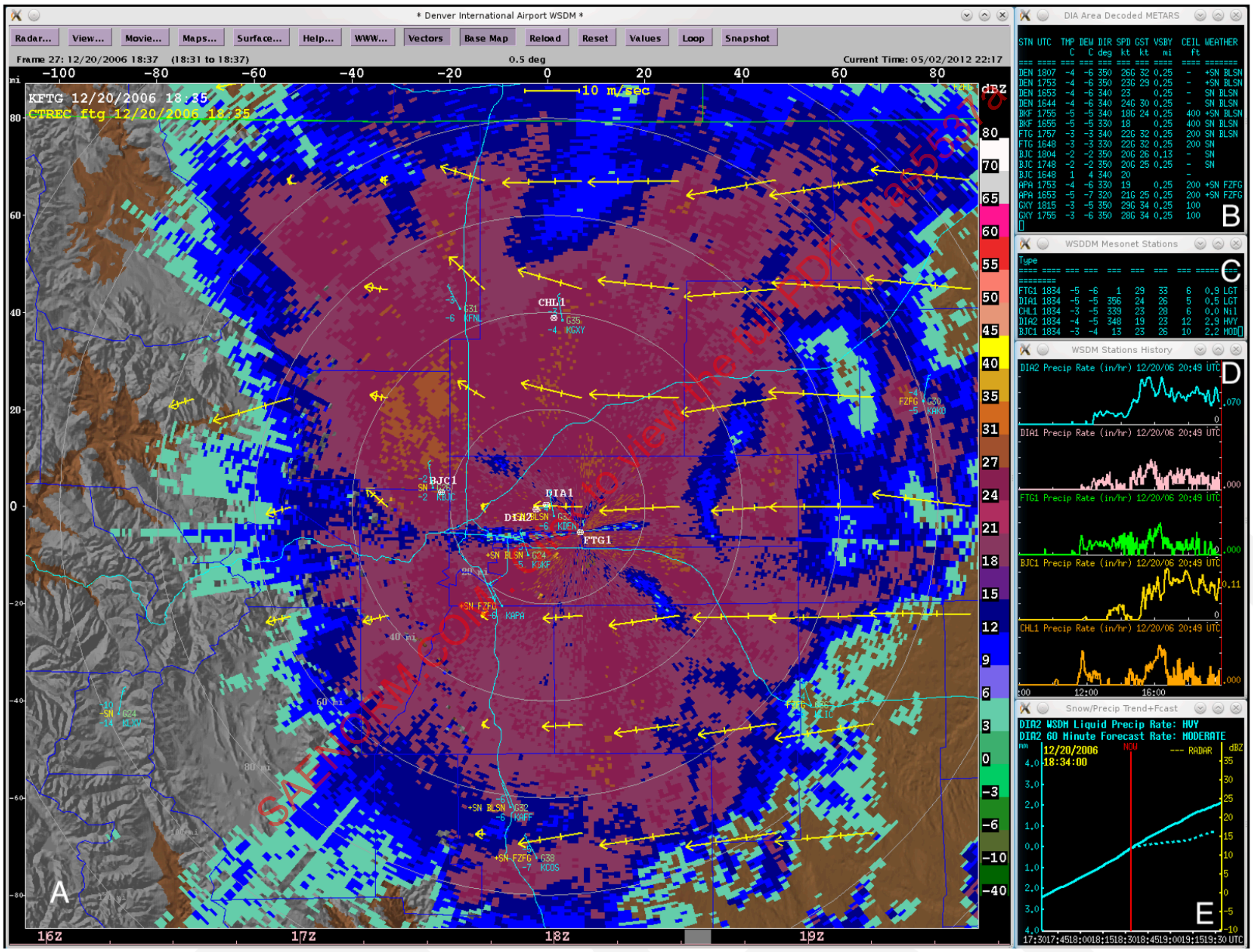

Figure 1 - WSDDM display

A - Radar imagery and feature tracking vectors showing direction and speed of reflectivities, B - recent metar observations from airport and surrounding stations, C - one minute observations from precipitation gauges at airport and surrounding sites, D - graphical display of one minute rates from WSDDM precipitation gauges, E - previous and forecast snowfall rate estimates

3.2 Precipitation Gauge Configurations for WSDDM Systems

For the primary surface WSDDM weather station located at the airport, a single precipitation gauge option is the normal configuration for a WSDDM weather station system (described above). This configuration does not provide any upstream information on approaching snowstorms. To obtain a more accurate estimate of storm motion, radar-estimated precipitation rates and forecast precipitation rates, additional surface stations upstream of the airport are recommended, specifically in the upwind direction from which an airport predominately experiences snowstorms. These additional gauges may be placed at other airports or other critical upstream locations (e.g. government owned property). These locations may be defined by the user or the WSDDM vendor (vendor should be able to supply recommendations on where and how many additional gauges to install).

If it is decided that four additional precipitation gauges are required they should ideally be located approximately 35 km (22 miles) east, west, north, and south of the airport to provide an indication of snow onset and intensity upstream of the airport (Figure 2).

If it is decided that two additional precipitation gauges are sufficient they should be located approximately 35 km (22 miles) upstream of the airport in the directions of the most frequent snowstorm tracks to provide an indication of snow onset and intensity (Figure 3).

If it is decided that one additional precipitation gauge is sufficient, then it should be located approximately 35 km (22 miles) upstream of the airport in the direction of most frequent storm track to provide an indication of snow onset and intensity (Figure 4).

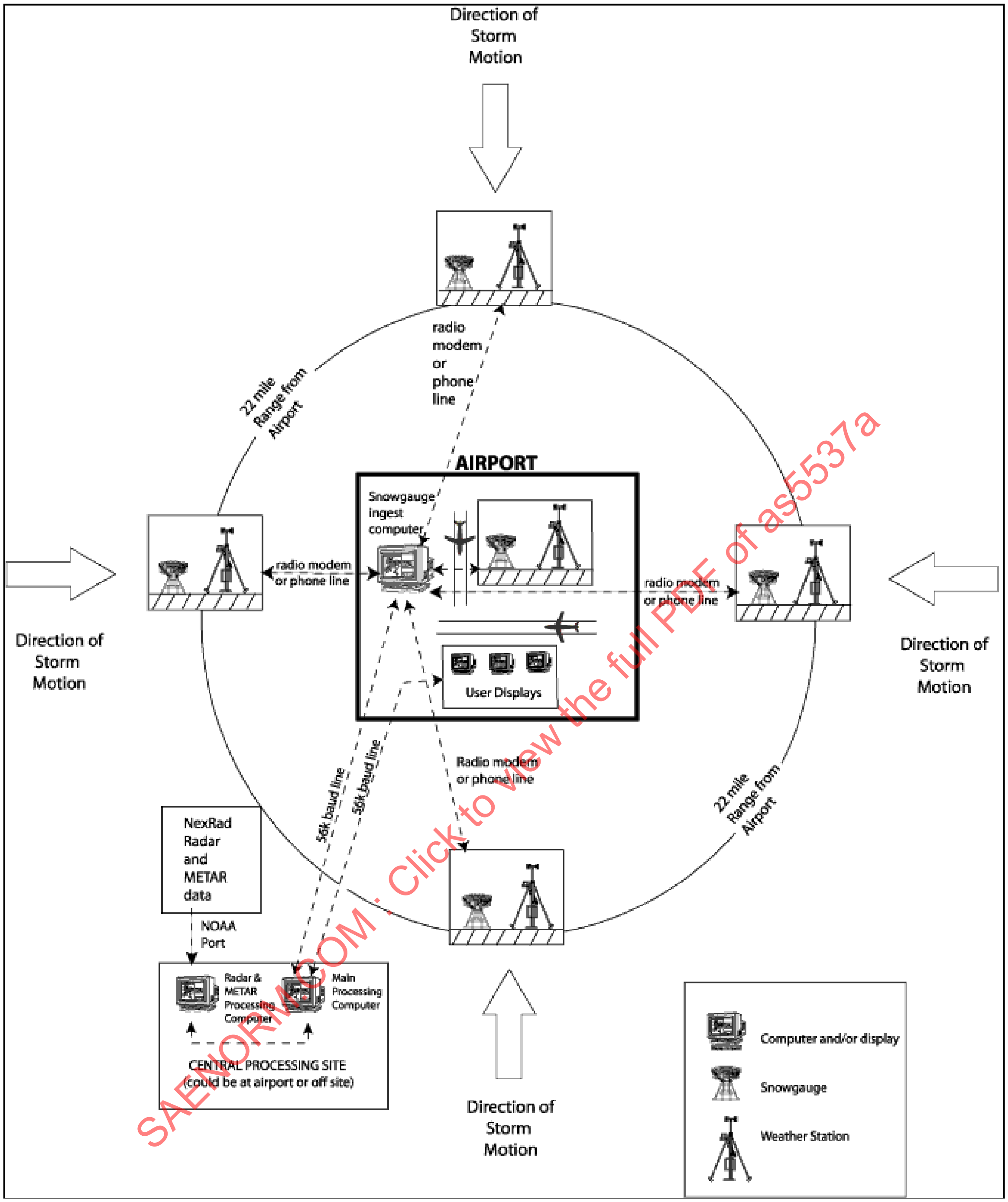

Figure 2 - Example idealized WSDDM system with four surface weather stations

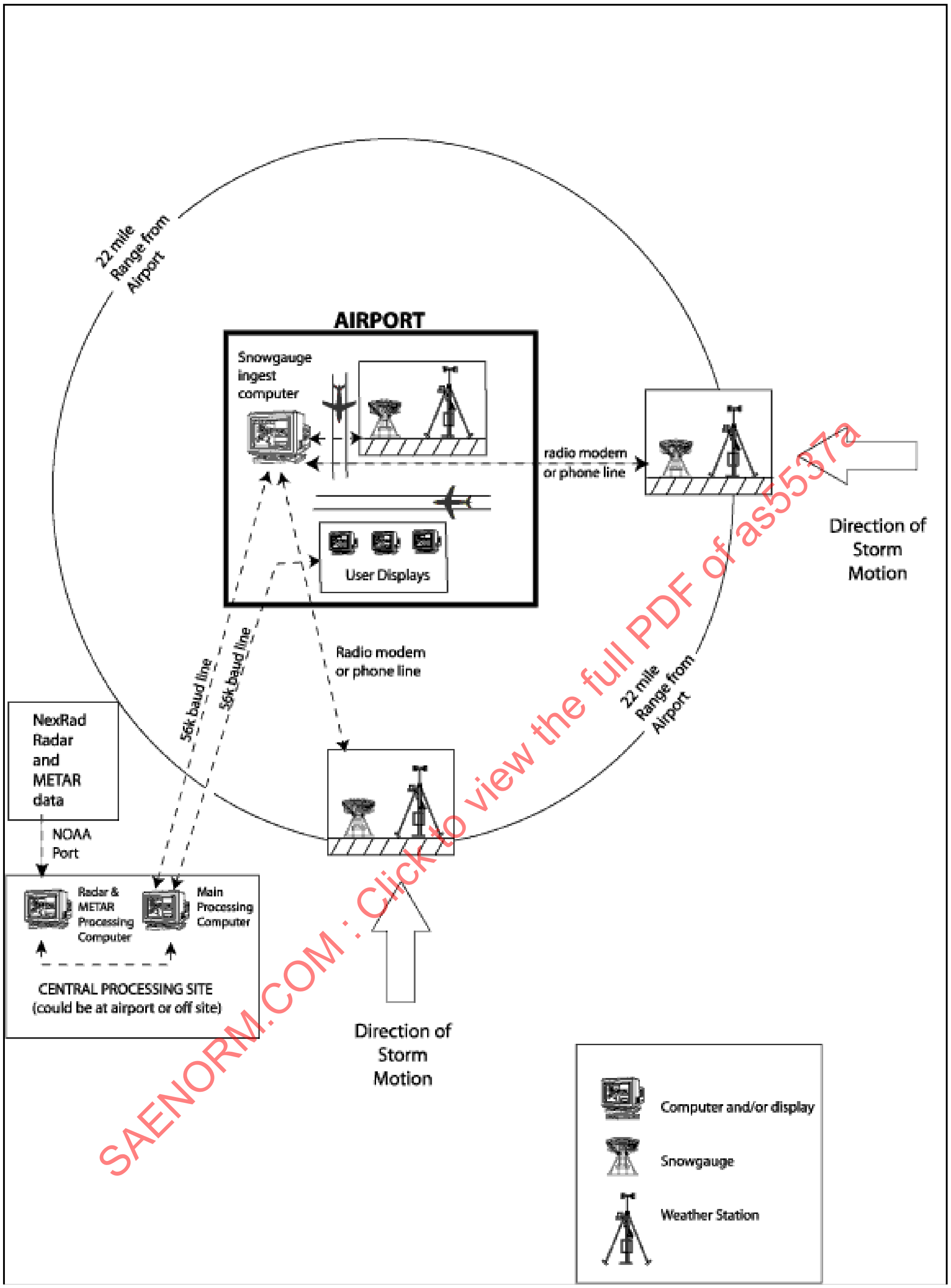

Figure 3 - Example idealized WSDDM system with two surface weather stations

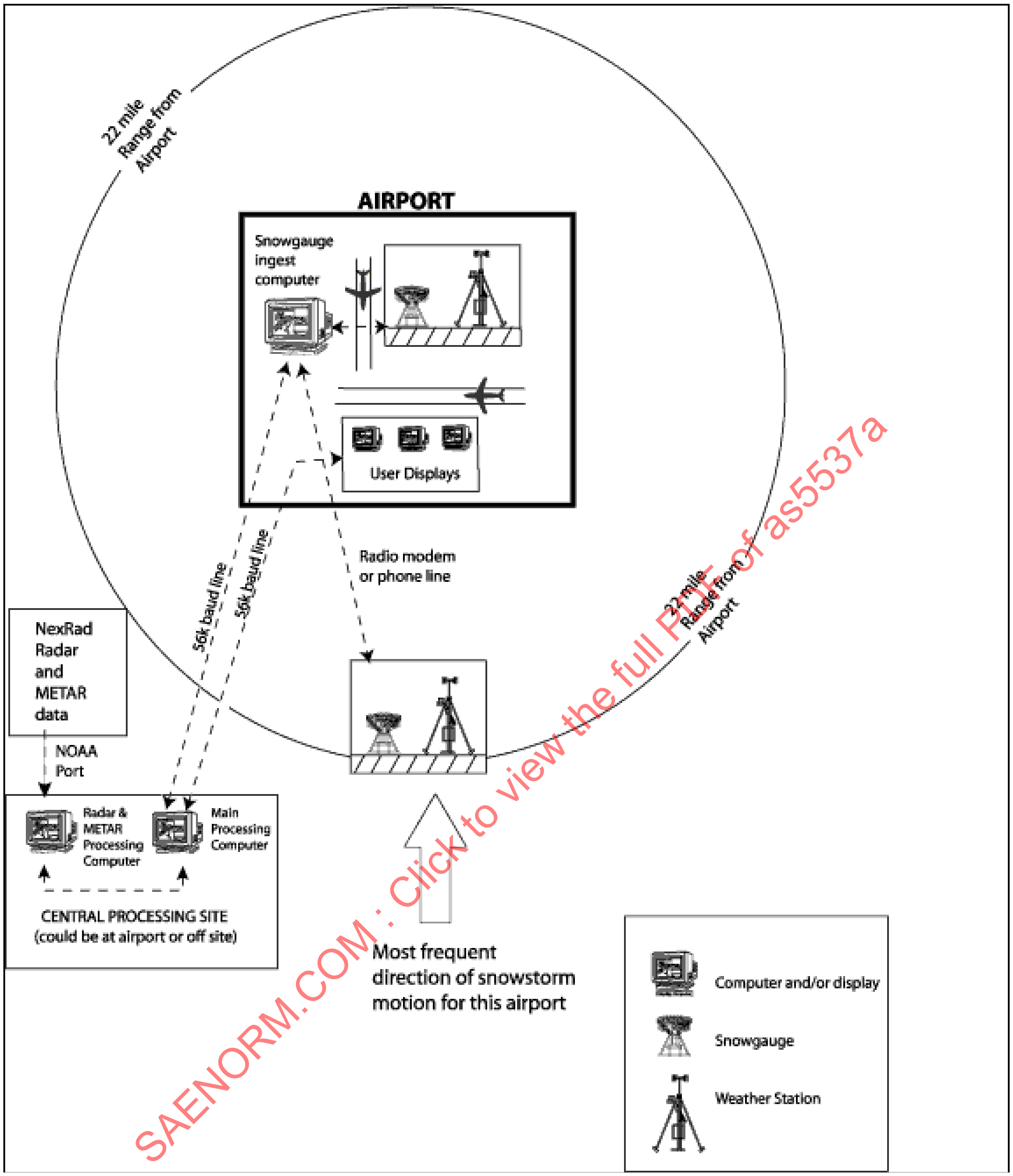

Figure 4 - Example idealized WSDDM system with one surface weather station

3.3 Key WSDDM Components

The key hardware components are as follows:

1. Precipitation gauge measuring capable of liquid equivalent rates down to 0.1 mm/h every minute. The minimum number of gauges shall be in accordance with the description in 3.2. See Section 4 for the gauge specification and Section 8 for additional siting requirements.

2. Weather sensors co-located with the precipitation gauge that measure air temperature, humidity, wind speed and direction at each of the gauge locations. See Section 5 for a detailed specification of the weather sensors and Section 8 for siting requirements.

3. Datalogger at each gauge and weather station site to ingest the data from the precipitation gauge and weather sensors, time-stamp the data, perform initial data processing and quality control, and transmit the data to a local computer. Section 6 provides a detailed specification of the datalogger.

4. Radio/cellular modems and ethernet connections at each gauge/weather sensor site to transmit the data to a central computer. See Section 7 for a detailed specification of the modems.

5. Linux-based computer to ingest data from the precipitation gauge stations, weather radar, and METAR observations. See 11.1 for a detailed specification of the computer and operating system. Software to operate the system will be provided and installed by a private vendor licensed by the University Corporation for Atmospheric Research (UCAR).

6. Option of either a dedicated WSDDM display computer at each user site or a web-based WSDDM display. See 11.2 for a description of the dedicated WSDDM display computer and operating system and 11.3 for a description of the web-based display system. The advantage of the web-based display system is lower cost and greater accessibility to the WSDDM system by a larger number of users from any location that is internet or intranet accessible. The advantages of the dedicated user display is faster access to the data, greater pan, zoom, and movie looping capability, and easier display configurability to user needs. Software to operate the display will be provided and installed by a private vendor licensed by UCAR.

4. PRECIPITATION GAUGE RECOMMENDATIONS

The WSDDM precipitation gauge shall be able to measure liquid equivalent snowfall rate every 1 minute at a rate that is verified to be ±10% of the true snowfall rate, and an accuracy down to 0.1 mm/h (1 g/dm^2/h). The true snowfall rate shall be determined using a precipitation gauge calibrated against a gauge in a Double Fence Intercomparison Reference (DFIR) or Double Fence Automated Reference (DFAR) shield. See the WSDDM and WMO SPICE publications referenced in 2.2 for further details. The currently recommended precipitation gauges are a GEONOR T-200B gauge, a Hotplate snow gauge, or an OTT Pluvio^2 gauge.

4.1 GEONOR Precipitation Gauge

The GEONOR gauge needs to be installed with a single Alter wind shield and heat tape that maintains the temperature of the orifice of the GEONOR near +2 °C when the temperature is less than +2 °C. These measures prevent the buildup of snow on the gauge orifice during wet snow conditions. See the WSDDM publication referenced in 2.2 for further details. The recommended wind shield for the GEONOR is a single Alter Shield (Figure 5). The single Alter wind shield consists of rows of vertically oriented slats. The diameter of the single Alter ring is four feet and the length of the slats is 18 inches. See the WSDDM publication referenced in 2.2 for further details. Wind-induced error corrections need to be done for the GEONOR gauge and information on this can also be found in the BAMS WSDDM article given in section 2.2. The GEONOR gauge can be purchased from: GEONOR, Inc., Tel: 570-296-4884, Fax: 570-296-4886, email: info@geonor.com.

Figure 5 - GEONOR in a single alter shield