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Standard Specification for Performance for Weather Information Reports, Data Interfaces, and Weather Information Providers (WIPs)[1]

This standard is issued under the fixed designation F3673; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 In this specification, the standard of performance for weather information reports, analyses, and services performed by a weather information provider (WIP) in support of extensible traffic management (xTM) systems, unmanned aircraft systems (UAS) and vertical takeoff and landing (VTOL) systems operating from the surface to 5000 ft (1524 m) above ground level (AGL) are addressed.

1.2 This specification does not define how to report a meteorological aerodrome report (METAR). This specification supports evolving international and the sovereign civil aviation authority (CAA) and air navigation service provider (ANSP) regulations.

1.3 *Relationship to International WIP Standards*—One objective of this specification is to harmonize the standard across CAAs internationally to enable subject matter compatibility across standards developed by other standards development organizations (SDOs). The existence of multiple standards for the same subject matter can occur when a region's regulator requires that a necessary standard be developed by a particular SDO. In these cases, ASTM International may seek to establish a cooperative arrangement with the applicable SDO to ensure consistency between the related standards.

1.4 This specification provides an initial version to provide guidance to commercial aviation operations including, but not limited to, UAS and VTOL users, for weather measurements and analyses. Research and development activities will continue to inform and lead to modifications to this specification.

1.5 This specification will not cover the standard of performance for weather forecasts.

1.6 *Units*—The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3341/F3341M Terminology for Unmanned Aircraft Systems

2.2 *IETF Standard:*[3]

IETF RFC 5905 Network Time Protocol Version 4: Protocol and Algorithms Specification

2.3 *ISO/IEC Standard:*[4]

ISO/IEC 27001 Information Security Management Systems

3. Terminology

3.1 *Definitions*—Terminology used in multiple standards is defined in Terminologies F3341/F3341M and F3060.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *application programming interface, API, n*—inputs and outputs for operations intended for use by two or more software modules.

3.2.2 *derived weather data, n*—data from non-weather measurement systems translated into a weather data element, for example, generating wind reports derived from flight control systems and telemetry.

[1] This specification is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.02 on Flight Operations.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from the Internet Engineering Task Force (IETF), 1000 N West Street, Suite 1200, Wilmington, DE 19801, https://www.ietf.org/.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3.2.3 *K-index, n*—K-index and, by extension, the planetary K-index are used to characterize the magnitude of geomagnetic storms.

3.2.3.1 *Discussion*—*K*P is an indicator of disturbances in the Earth's magnetic field rated 0 to 9. Geomagnetic storms can affect communications and global positioning system (GPS) accuracy with a K-index greater than 3 indicating potential impacts are possible.

3.2.4 *OpenAPI, n*—open-source format and initiative for designing and creating machine-readable interface files that are used in producing, describing, consuming, and visualizing RESTful APIs and web services.

3.2.5 *present weather, n*—any weather or obstructions (obscurations) to vision occurring at an observation location and includes precipitation, obscurations, well-developed dust/sand whirls, squalls, tornadic activity, sandstorms, and dust storms occurring at the time the present weather was observed and time stamped.

3.2.5.1 *Discussion*—Present weather may be evaluated instrumentally, manually, or through a combination of instrumental, camera optical, and manual methods.

3.2.6 *qualified weather information provider, WIP, n*—WIP that satisfies the civil aviation authority (CAA) requirements to provide weather information.

3.2.6.1 *Discussion*—This standard is foreseen to be one possible means of compliance to support WIP qualification.

3.2.7 *shall, should, may, and will, v*—shall indicates a mandatory requirement, should indicates a recommended requirement, may indicates an optional requirement, and will indicates futurity and it is not a requirement.

3.2.8 *space weather, n*—phenomena that lie wholly or in part outside the Earth's atmosphere.

3.2.8.1 *Discussion*—Space weather can disrupt GPS guidance, RF signal, compass, and the ability to communicate with an unmanned aircraft system (UAS). The potential impact of space weather will be provided by the K-index.

3.2.9 *weather, n*—state of the atmosphere at a given time and place.[5]

3.2.9.1 *Discussion*—This will refer to weather as the following phenomena: visibility, clouds, cloud height, winds, temperature, dew point, pressure altitude, precipitation, thunderstorms, turbulence, icing, and present weather. It encompasses phenomena produced from non-atmospheric sources that cause impacts to aviation (for example, smoke or pollution impacts on visibility and so forth).

3.2.10 *weather alert, n*—proactive notification disseminated by a WIP for specific airworthiness or operationally impactful weather provided for specific thresholds requested by the user for weather that is occurring or may occur.

3.2.11 *weather analysis, n*—enhanced depiction or interpretation of observed weather data, or both, conducted objectively by machine analysis and subjectively by humans.

3.2.12 *weather analysis data, n*—weather data elements, such as precipitation, wind, temperature, and so forth, that meet the applicable performance tiers in this specification.

3.2.12.1 *Discussion*—Analyses of weather phenomena are an enhanced depiction or interpretation, or both, of observed weather data, generally combining a set of observations, weather model analysis, remotely sensed data, or data derived from non-weather sensor sources.

3.2.13 *weather area data, n*—weather data on a horizontal or vertical plane in a specified space and time with three or more points connected to depict a weather data element area; examples include cloud ceiling height, two-dimensional (2-D) depictions of weather radar reflectivity, and 2-D weather analysis of a weather element.

3.2.14 *weather data sets, n*—collection of data that may be obtained from in situ sensors, remote sensors, or be derived from other data sources.

3.2.15 *weather data tier, n*—category of weather information reports and analyses based on the performance of the sensor and the quality of the data produced by the sensor and modeled after instrument landing system (ILS) categories with Weather Data Tier 3 being the most precise followed by Weather Data Tier 2 and then Weather Data Tier 1.

3.2.16 *weather information provider, WIP, n*—provider of one or more essential or enhanced weather-related services.

3.2.17 *weather line data, n*—weather data on a horizontal or vertical line connected by two or more measurements of a weather data element during a specified time; examples include a line of thunderstorms, thunderstorm gust front, and atmospheric profile measurement.

3.2.18 *weather point data, n*—weather data element at a specific point and time; examples include temperature, dewpoint, wind speed and direction, and so forth.

3.2.18.1 *Discussion*—Generally, the data become increasingly unrepresentative further from the point of measurement.

3.2.19 *weather volume analysis, n*—weather data element represented by horizontal, vertical, and perpendicular planes (x, y, z) with eight or more points to depict a volumetric weather region at a specific time.

3.2.19.1 *Discussion*—Analyses of weather phenomena are an enhanced depiction or interpretation, or both, of observed weather data generally combining a set of observations, weather model analysis, remotely sensed data, or data derived from non-weather sensor sources.

3.3 *Acronyms:*

3.3.1 *AGL*—above ground level

3.3.2 *ANSP*—air navigation service provider

3.3.3 *API*—application programming interface

3.3.4 *ASOS*—automated surface observing system

3.3.5 *AWOS*—automated weather observing system

3.3.6 *CAA*—civil aviation authority

[5] Glossary of Meteorology, https://glossary.ametsoc.org, and *Pilot's Handbook of Aeronautical Knowledge*, FAA-H 8083 25B, Chapter 12, Weather Theory, https://www.faa.gov/aviation/phak/pilots-handbook-aeronautical-knowledge-faa-h-8083-25b, (blend of definition from two sources).

3.3.7 *GeoJSON*—geographic JSON[6]

3.3.8 *GPS*—global positioning system

3.3.9 *ICAO*—International Civil Aviation Organization

3.3.10 *ILS*—instrument landing system

3.3.11 *IWXXM*—ICAO meteorological information exchange model

3.3.12 *JSON*—JavaScript object notation[7]

3.3.13 *METAR*—meteorological aerodrome report

3.3.14 *NAS*—National Airspace System

3.3.15 *PIREP*—pilot report

3.3.16 *QNH*—atmospheric pressure (Q) at nautical height (aviation radiotelephony code)

3.3.17 *SDO*—standards development organization

3.3.18 *TAF*—terminal area forecast

3.3.19 *UAS*—unmanned aircraft system

3.3.20 *UTC*—universal time coordinated

3.3.21 *VTOL*—vertical takeoff and landing

3.3.22 *WIP*—weather information provider

3.3.23 *xTM*—extensible traffic management

4. Significance and Use

4.1 The purpose of this specification is to define performance requirements for qualified WIPs that provide services to users. In this specification, the transition to a weather data performance standard is introduced. With this specification, support of users is supplied by offering a tier-based weather data quantification framework to support user risk-based decisions. This specification serves to provide information that enables users to most effectively apply WIP services.

4.2 This specification applies to all phases of flight to enable risk-based operational decision-making.

4.3 Providers publishing weather data or services for sale or for use by users shall be qualified.

4.4 This specification is designed to support evolving international and the sovereign CAA and air navigation service providers regulations. Specifically, this specification is designed to address:

4.4.1 Commercial aviation operations;

4.4.2 Determination of meteorological conditions using capabilities enabled by a more diverse set of sensors with sensor performance information;

4.4.3 Operations up to a few hours in length;

4.4.4 Vehicles that may be sensitive to minute changes in conditions;

4.4.5 Multiple classes of WIP services to support:

4.4.5.1 Measurement and weather analysis of attributes such as, but not limited to, winds (for example, surface and aloft; three-dimensional (3-D) wind), visibility, ceiling/cloud height, temperature, dewpoint, barometric pressure, precipitation, icing, and turbulence; and

4.4.5.2 Alerting of weather conditions that may adversely impact UAS operations;

4.4.6 Aircraft flight control and telemetry data may be used to derive encountered winds aloft;

4.4.7 JSON/GeoJSON data formats and standard compliance; and

4.4.8 Support for automated aircraft reporting of in-flight weather measurements.

4.5 A single WIP is not required to provide all weather information identified in this specification. For example, a WIP might wish to provide only wind data sets. WIPs may also provide additional, value-added capabilities and still be compliant with this specification if the value-added capabilities do not conflict with the services defined in this specification and the implementation of services defined in this specification conform to the applicable requirements. In this specification, aspects common to all roles and services, such as data performance standard, reliability of service, security, auditing, and handling are addressed.

4.6 WIPs may provide various services or sets of information to support operations using data that meet quality standards generated from sensors that meet data performance standards. Services are groupings of one or more WIP services that a user may select to conduct planning and execution of flights.

4.7 *Operational Considerations in Using This Specification:*

4.7.1 This specification is focused on weather conditions impacting flight operations that operate from the surface to and including 5000 ft (1524 m) AGL. Future revisions may expand above 5000 ft (1524 m) AGL.

4.7.2 Weather sensors are subject to a wide range of meteorological conditions (wind, rain, snow, extreme temperatures, and so forth).

4.7.3 This specification covers measurement of attributes such as: winds (surface and aloft; 3-D winds), visibility, ceilings, temperature, dewpoint, barometric pressure, precipitation, present weather, precipitation type, thunderstorms, icing, and turbulence.

4.7.4 This specification supports weather data mapping and imagery services for users to visualize data sets.

4.7.5 This specification supports continuous WIP automated or human-enhanced weather-monitoring services.

4.7.6 This specification supports weather alert notification services to report when there is an area where weather potentially exceeds specific thresholds.

4.7.7 *Space Weather*—Autonomous vehicles are dependent on GPS and wireless communication services. Space weather can significantly impact these capabilities. Service providers may provide space weather information on potential impacts to GPS and communications.

[6] For more information, see IETF 7946, available from the Internet Engineering Task Force (IETF), 1000 N West Street, Suite 1200, Wilmington, DE 19801, https://www.ietf.org/.

[7] For more information, see IETF 8259, available from the Internet Engineering Task Force (IETF), 1000 N West Street, Suite 1200, Wilmington, DE 19801, https://www.ietf.org/, or ISO/IEC 21778:2017, available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

4.7.8 UAS that operate over large bodies of water may be impacted by additional environmental factors such as sea states and salt spray. These conditions are not addressed in this specification.

4.7.9 WIP data may be sent to any user.

5. Weather Data Performance Requirements

5.1 Key weather measurement information covered in this specification includes the following in 5.1.1 – 5.1.16. This list is not inclusive—some parameters may require future revision of this specification to the extent regulation fails to adequately cover existing weather information reports.

5.1.1 Wind direction will be expressed in clockwise degrees from true north and wind direction AGL reported with elevation AGL.

5.1.2 Wind speed, including magnitude of any gusts, with wind speed for weather information reports AGL reported with elevation AGL.

5.1.3 Height of the lowest broken or overcast layer and location of clouds.

5.1.4 Visibility, both prevailing and slant range.

5.1.5 Temperature and dew point for surface and AGL weather information reports provided with elevation AGL.

5.1.6 Measurement or determination of convective activity (for example, thunderstorms), which may include a proximity for reference.

5.1.7 Measurement or determination of precipitation type.

5.1.8 Location and time of the observation.

5.1.9 Appropriate QNH with geographical location of its applicability.

5.1.10 Measurement or determination of precipitation intensity.

5.1.11 Measurement or determination of present icing.

5.1.12 Measurement or determination of wind shear with a reference AGL.

5.1.13 Measurement or determination of present turbulence with a reference AGL.

5.1.14 *K-Index*—The planetary K-index is an official observation for space weather and WIPs will use an approved source of K-index for dissemination and use by users.

5.1.15 Measurement or detection of lightning present.

5.1.16 Vertical wind that measures updraft and downdraft strength may be addressed in future revisions of this specification.

5.2 *Weather Data Formats and Interfaces:*

5.2.1 *Interface Requirements*—Data exchange formats shall be JSON/GeoJSON compliant. WIPs may exchange data using IWXXM format.

5.2.2 WIPs shall meet cyber-security requirements in accordance with ISO/IEC 27001.

5.2.3 WIPs shall use OpenAPI to define data exchange requirements.

5.3 *Standard of Performance for Weather Data Tiering*—Weather data come from a variety of sources. They can be measured directly, derived via algorithms from non-weather sensors, or be inferred from remote sensors over a wide area. The purpose of weather data tiering is to maximize the available data for operations while recognizing that all data may not be of the same quality, nor will all operations require the same fidelity of data. The tiering was developed with Weather Data Tier 1 being the least accurate data tier and Weather Data Tier 3 being the most. Additional tiers can be stood-up in the future if a higher level of data quality and accuracy is required, such as flight within urban environments and higher risk flight areas.

5.3.1 *Tier 3:*

5.3.1.1 *Tier 3 Weather Data*—These are data that are obtained from in situ sensors, remote sensors, or derived from other data sources. This tier requires the highest data performance rates. All Tier 3 data shall have metadata with quantification of accuracy tier for use in risk management.

5.3.1.2 *Reporting*—Weather information reports with available observed elements will occur every 2 min for in situ measurements and every 15 min for remotely sensed or derived elements.

5.3.1.3 *Present Weather*—The data that denote precipitation type should provide an indication of the type of precipitation occurring. When more than one type of precipitation is occurring, report the dominant type, which will be the type that is occurring most frequently over the previous 10 min. If the dominant type cannot be determined, use the hierarchal scheme of reporting (frozen, freezing, liquid). When present weather is indicated, but the type is unable to be determined, it will be reported as "unknown precipitation."

NOTE 1—The requirements for drizzle and ice pellets reporting are not currently met by ASOS and AWOS automated systems.

(1) Range:

(a) Identify the type of precipitation correctly when the liquid equivalent precipitation rate equals or exceeds 0.002 in./hour (0.05 mm/hour).

(2) Accuracy:

(a) In a temperature range of -2 °C - +3 °C:

In 90 % of cases, identify rain correctly;

In 90 % of cases, identify drizzle correctly (for sensors that can report drizzle);

In 90 % of cases, identify snow correctly; and

In 90% of cases, identify ice pellets/freezing rain/freezing drizzle correctly.

(b) When the temperature is <-2 °C:

In 90 % of the cases, identify snow correctly.

(c) When the temperature is >+3 °C:

In 90 % of the cases, identify rain correctly; and

In 90 % of the cases, identify drizzle correctly (for sensors that can report drizzle).

(3) Rain or Ice Pellet Intensity Criteria:[8]

(a) Light—Up to 0.10 in./hour (2.5 mm/hour); maximum 0.01 in. (0.25 mm) in 6 min: 90 % of the cases.

(b) Moderate—From 0.11 in./hour to 0.30 in./hour (2.8 mm/hour to 7.6 mm/hour); more than 0.01 in. to 0.03 in. (0.25 mm to 0.76 mm) in 6 min: 90 % of the cases.

(c) Heavy—More than 0.30 in./hour (2.8 mm/hour); more than 0.03 in. (0.76 mm) in 6 min: 90 % of the cases.

[8] https://www.icams-portal.gov/resources/ofcm/fmh/FMH1/fmh1_2019.pdf.