



AEROSPACE RECOMMENDED PRACTICE

ARP5740

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Cockpit Display of Data Linked Weather Information

RATIONALE

Weather data, information, and products are widely available today to the public as well as to the aviation community. Weather information has been provided to the cockpits of General Aviation (GA) users for several years and is now being introduced into the cockpit of commercial aircraft. Guidelines for the standardization of this information are needed to ensure the appropriate display of weather information in the cockpit to adequately address issues of workload, meteorological situation awareness, training, and information management.

FOREWORD

The SAE G-10W Weather Information Systems Committee was formed in 2007 at the SAE G10 annual meeting. Various regulators as well as other standards groups including RTCA Special Committee 206, "Aeronautical Information Services Data Link," requested human factors guidance on the display of uplinked weather information on the flight deck for pre-flight planning and in flight. The G-10W Committee responded to this need and was composed of subject matter experts from a wide variety of stakeholders including original equipment manufacturers, avionics manufacturers, airlines, pilots, regulators, application providers and scientists from the human factors field.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) addresses the information content for the electronic presentation of data linked weather Meteorological (MET) information used in the cockpit. It defines guidelines for the electronic presentation of MET information (including text, graphics, textures, icons, and symbology) to the flight crew.

This ARP is applicable to certified equipment for the electronic display (whether installed or portable) of MET information in the cockpit. This ARP also provides a set of symbols that illustrate the depiction of data linked MET information on flight deck display systems such as Navigation Displays, Multi-function Displays, and Electronic Flight Bags. These recommendations complement standard symbology guidelines for airborne applications already in existence (see reference section for applicable documents).

1.1 Purpose

This ARP provides a set of user-centered design guidelines for the implementation of MET information on electronic displays. It addresses what information is useful and how it should be displayed. This document does not include all the detailed specifications required to generate a MET information display. It addresses the human factors aspects of the electronic display of MET information, but does not address the software, hardware or system integrity/availability issues associated with the certification or operational approval of an electronic display system.

The guidelines, example symbology, graphics and text identified within this document also take into consideration their integration with other non-meteorological information displayed in the cockpit. However, recommendations and guidelines for the actual integration of MET information into multi-function displays are covered in other reference material (see reference list for applicable documents).

2. REFERENCES

2.1 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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

ARP1093	Numerical, Letter, and Symbol Dimensions for Aircraft Instrument Displays
ARP1068	Flight Deck Instrumentation, Display Criteria and Associated Controls for Transport Aircraft
ARP4032	Human Engineering Considerations in the Application of Color to Electronic Aircraft Displays
ARP4033	Pilot-System Integration
ARP4102	Flight Deck Panels, Controls, and Displays
ARP4102/4	Flight Deck Alerting System (FAS)
ARP4102/7	Electronic Displays
ARP4155	Human Interface Design Methodology for Integrated Display Symbology
ARP5056	Flight Crew Interface Considerations in the Flight Deck Design Process for Part 25 Aircraft

ARP5289 Electronic Aeronautical Symbols

ARP6467 Human Factors Minimum Requirements and Recommendations for the Flight Deck Display of Data Linked Notices to Airmen (NOTAMS)

2.1.2 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA DO-267A Minimum Aviation System Performance Standards (MASPS) for Flight Information Services-Broadcast (FIS-B) Data Link

2.1.3 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

AC 00-45G Aviation Weather Services

AC 20-149A Installation Guidance for Domestic Flight Information Services - Broadcast

AC 23.1311-1C Installation of Electronic Display in Part 23 Airplanes

AC 25-11A Electronic Flight Deck Displays

AC 25.1302-1 Installed Systems and Equipment for Use by the Flightcrew

AC 25.1322-1 Flight Crew Alerting,

AC 120-76C Guidelines for the Certification, Airworthiness, and Operational Use of Electronic Flight Bags

14 CFR Part 23 Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes

14 CFR Part 27 Airworthiness Standards: Normal Category Rotorcraft

14 CFR Part 29 Airworthiness Standards: Transport Category Rotorcraft

2.1.4 Other References

Available from International Civil Aviation Organization, 999 University Street, Montreal, Quebec H3C 5H7, Canada, Tel: +1 514-954-8219, <http://www.icao.int/>

ICAO Annex 3 Meteorological Service for International Air Navigation, 2013

Available from WMO website, http://www.wmo.int/pages/index_en.html.

WMO No. 49 Technical Regulations, Basic Documents No. 2, Volume II, 2011 Edition

2.2 Definitions

Definitions used in this document shall be as noted in the Glossary of Terms found in Appendix B.

The word “shall” is used to express an essential (mandatory) requirement. Conformance requires that there be no deviation. The word “should” is used to express a recommendation. Deviation from the specified recommendation may require justification. The words “may” or “can” are used to provide alternate presentations which have been found to be acceptable.

Recommendations, guidelines and requirements are placed within the recommendations and guidelines sections.

3. GENERAL GUIDELINES

3.1 Information Guidelines

The following sections detail considerations and needs for MET information presentation to the flight crew in addition to recommendations or guidelines related to the consideration as well rationale for the recommendation or guideline.

3.1.1 Types of MET Information Available to the Flight Crew

3.1.1.1 Consideration

The flight crew needs to have access to current and forecasted MET data relevant to the intended route of flight.

3.1.1.2 Recommendation/Guideline

Data linked MET data should include the following:

- Any reports, forecasts or warnings of adverse conditions at cruising levels (Volcanic Ash, Icing, Turbulence, Tropical Cyclone, Mountain Wave, Duststorm, Sandstorm and Cumulonimbus, etc.)
- Any reports, forecasts or warnings of adverse conditions at aerodromes, including the terminal area for departure, arrival and alternate airports (Ceiling, Visibility, Wind Shear, Thunderstorms, Precipitation including liquid, freezing, and frozen, Wind Gusts, etc.)
- Synopses, Surface Analysis and Significant Weather
- Current conditions (e.g., Aviation Routine Weather Report (METAR) and Special Metrological Report (SPECI))
- Forecast conditions (e.g., area forecasts, nowcasts, and TAFs)
- Upper Winds

3.1.1.3 Rationale

The flight crew needs to have access to relevant and consistent information available to ground-based aviation MET information users (e.g., Flight Service Station (FSS), Air Traffic Control (ATC), Air Operations Center (AOC), airport operations personnel), in order to establish common situational awareness and to facilitate collaborative decision-making. The flight crew needs to have the data recommended by International Civil Aviation Organization (ICAO), as amended by the relevant civil aviation authorities for making MET decisions concerning the flight. (Reference: ICAO Annex 3, Meteorological Service for International Air Navigation, 2013)

3.1.2 Flight Crew Understanding

3.1.2.1 Consideration

The flight crew needs to have access to a legend, which describes the symbology used for MET information display. This will help the flight crew decision-making process in the presence of other MET information sources such as onboard radar, voice (radio) reports from other aircraft, and the out-the-window view.

3.1.2.2 Recommendation/Guideline

The MET information display should provide to the flight crew a legend describing the meaning of colors and symbols used to display MET data.

3.1.2.3 Rationale

The flight crew must have easy access to information that describes the meanings of colors and symbols in order to be able to interpret information correctly and easily, without an undue increase to workload. (Reference: RTCA DO-267A, Sec. 3.8)

3.1.3 Access to Validity of MET information

3.1.3.1 Consideration

The flight crew needs to have access to information concerning the validity of the MET information data presented on the cockpit MET information display. The time difference from the time the initial sourcing of the MET information to the time the MET information is displayed in the cockpit is not always apparent. Thus the issue of latency can cause misunderstanding of the real-time weather environment in which the aircraft is operating.

3.1.3.2 Recommendation/Guideline

The MET information display shall provide information indicating the valid time, indicating the latency time of observational data, or applicable time for forecast data that is currently being displayed.

3.1.3.3 Rationale

National Aeronautics and Space Administration (NASA) Aviation Weather Information (AWIN) research has demonstrated that flight crew using MET hazard graphics during rapidly changing MET conditions often take inappropriate risks because their risk assessment may be based on obsolete information. (Reference: RTCA DO-267A, Sec. 3.8)

References:

- a. Latorella, K. & Chamberlain, J. (2002). Tactical vs. Strategic Behavior: General Aviation Piloting in Convective Weather Scenarios. Proceedings of the Human Factors & Ergonomics Annual Meeting, Baltimore, MD.
- b. Novacek, Paul F., Burgess, Malcolm A., Heck, Michael, L., Stokes, Alan, F., The Effect of Ownship Information and NEXRAD Resolution on Pilot Decision Making in the use of a Cockpit Weather Information Display. NASA CR-2001-210845, December 2001.

3.1.4 Notification of Missing Information

3.1.4.1 Consideration

The flight crew needs to have notification of MET information data that is missing on the MET information display and is differentiated from MET information that is of no interest (e.g., due to no MET phenomena of that type to display or weak intensity).

3.1.4.2 Recommendation/Guideline

The cockpit MET information display shall provide information indicating MET information data that is missing, when such information is obtainable, and that MET information data is being selected for display.

3.1.4.3 Rationale

The flight crew should know what MET information data is missing in order to determine areas of uncertainty when making hazardous MET avoidance decisions. (Reference: RTCA DO-267A, Sec. 3.8)

3.1.5 Consistency between Airborne and Ground Based Information

3.1.5.1 Consideration

The flight crew needs to have access to MET information and graphics which are consistent in content with the MET information used by supporting ground facilities (i.e., controllers, dispatchers and/or flight service providers) to aid in the Collaborative Decision Making (CDM) process.

3.1.5.2 Recommendation/Guideline

Any reformatting of MET information for cockpit display or other cockpit applications should preserve, and not understate, both the geo-location and intensity of MET conditions regardless of projection, scaling, or any other types of processing. Graphic cockpit displays of MET information may not be exact replicas of that same information displayed on ground workstations due to the relatively small screen size available for cockpit displays. Even so, in order to maintain adherence to human factors principles, and to avoid the introduction of confusion and increased workload to the pilot, the content of the MET information and graphics should be consistent and standard (to the extent possible) throughout airspace operational positions.

3.1.5.3 Rationale

To support collaborative decision making, the flight crew and supporting ground facilities (i.e., controllers, dispatchers and/or flight service providers) need to be displaying (or processing) common MET information. It is highly probable that graphic cockpit displays of MET information will not be exact replicas of that same information displayed on ground workstations due to the relatively small screen size available for cockpit displays. (Reference: RTCA DO-267A, Sec. 3.8)

3.1.6 Presentation of MET Information

3.1.6.1 Consideration

In order to properly utilize the weather information being displayed, and to avoid confusion, the flight crew needs to know what MET information is contained in a specific display, such as weather observations, Aviation Routine Weather Report (METAR) reports, forecast information, or flight level wind grids.

3.1.6.2 Recommendation/Guideline

Each MET information display should clearly provide to the flight crew information concerning what type (or category) of MET information is being displayed.

3.1.6.3 Rationale

Many MET maps and charts look very similar and without a method for the flight crew to discern what is being displayed, confusion and error can be introduced into the collaborative decision making process. For example, for wind information there is a progression from an analysis map of wind observations to a forecast map of wind predictions. Except for the legend or title, the wind analysis and forecast maps look the same. (Reference: RTCA DO-267A, Sec. 3.8)

3.1.7 Indication of Active/Processing Mode

3.1.7.1 Consideration

The flight crew needs to know that the MET data link system is active and operating properly; especially for broadcast systems that are in a periodic transmit/receive mode, or when the cockpit avionics is engaged in extended processing of received MET information.

3.1.7.2 Recommendation/Guideline

The MET information display should provide an indication to the flight crew when the MET data link system is not processing information as anticipated.

3.1.7.3 Rationale

The flight crew expectation is that MET information is being received and processed for cockpit application and/or display. That expectation assumes the data link communications system and cockpit avionics are functioning properly. If there is a system failure, the flight crew can seek to obtain the MET information through other means. There should be minimum delay in flight crew knowledge that MET information is not being received and/or processed for cockpit applications and/or display. (Reference: RTCA DO-267A, Sec. 3.8)

3.2 Display Guidelines

The following sections detail considerations and needs for the display of MET information to the flight crew as well as recommendations or guidelines related to these considerations and rationale for these recommendations or guidelines.

3.2.1 Timely and Efficient Access

3.2.1.1 Consideration

The flight crew needs to have access to integrated MET information and data (e.g., Current Icing Product (CIP), National Convective Weather Forecast Product (NCWF), Automatically-Generated Turbulence Forecast (GTG)) that are used to support flight crew decisions for the intended route of flight.

3.2.1.2 Recommendation/Guideline

The MET information display should display MET information in a manner that reflects the operationally significant nature of the information, and that is not delayed or obscured by operationally less significant information.

3.2.1.3 Rationale

NASA AWIN research has demonstrated that flight crews using integrated short-term forecast MET hazard graphics (FIP & NCWF) demonstrate improved MET hazard avoidance performance over flight crews not using such graphics. In order to promote the use of such graphics, they need to be easily accessible and un-obscured by other data, so that the flight crew can take advantage of their "high-glance-value" (the ability to provide a large amount of information to the flight crew in a short dwell time) without undue increases in workload. The theoretical concept describing this rationale is found in:

References:

- a. McAdaragh, Raymon M., Toward a Concept of Operations for Aviation Weather Information Implementation in the Evolving National Airspace System. NASA TM-2002-212141, October 2002.
- b. Elgin, Peter D. & Thomas, Rickey P., An Integrated Decision-Making Model for Categorizing Weather Products and Decision Aids. NASA TM-212990, February 2004.

3.2.2 MET Depiction Relative to Ownship Location

3.2.2.1 Consideration

The flight crew needs to have information concerning his/her aircraft position, and the relative position/distance between the aircraft and areas of MET interest (i.e., that may impact the flight) on the cockpit MET information display (Workload & MET Situation Awareness).

3.2.2.2 Recommendation/Guideline

The MET information display should have the ability to display an aircraft icon indicating the aircraft's direction of travel, with range information (e.g., range rings) that is sufficient for interpreting distances for safe avoidance of MET hazard areas and/or for flight optimization. Display of aircraft position is guided by regulation.

3.2.2.3 Rationale

The preferred display method is to present estimated distance-to-be-traveled in a fixed time, given current groundspeed, since this works in tandem with distance range rings to afford the flight crew both a distance-based mental picture, and a time-based picture of where objects are in dynamic relation to the cockpit. Distance-based range rings ("J-rings") are also standard on air traffic control displays. Ownship icons with range rings have been demonstrated in flight simulation studies by NASA to be beneficial to flight crew situation awareness, while decreasing workload. They aid the flight crew in judging distances when making decisions related to hazardous MET avoidance and/or flight optimization. (Reference: Novacek, Paul F., Burgess, Malcolm A., Heck, Michael, L., Stokes, Alan, F., The Effect of Ownship Information and NEXt-Generation Weather RADar (NEXRAD) Resolution on Pilot Decision Making in the use of a Cockpit Weather Information Display. NASA CR-2001-210845, December 2001)

3.2.3 Compatibility with Other Applications

3.2.3.1 Consideration

The flight crew needs the proper display of MET information, which is to the largest extent possible, compatible with other avionics applications, so as not to cause confusion or an unacceptable level of cognitive workload.

3.2.3.2 Recommendation/Guideline

The MET information should be georeferenced such that it can be overlaid with existing geographical and geopolitical features.

3.2.3.3 Rationale

Some display formats integrate MET information with flight plan overlays to form maps. The map elements integrated in these formats need to be based on the same map projection to place the MET information overlay correctly in relation to other map elements to facilitate correlation with other cockpit display information. (Reference: RTCA DO-267A, Sec. 3.8)

3.2.3.4 Recommendation/Guideline

The MET information display should use MET plotting conventions (symbols, colors and quantitative representations) to the extent those conventions are compatible with cockpit multifunction display capabilities and the flight deck philosophy.

3.2.3.5 Rationale

The encoding and display of MET information for flight crew preflight MET briefings has a long history. Where practical symbology should be consistent between air and ground based systems. Consistency in the display will enable correct and easy interpretation of the MET information display and reduce flight crew training needs. (Reference: RTCA DO-267A, Sec. 3.8)

3.2.4 Valid Information Display

3.2.4.1 Consideration

The flight crew needs to know that only valid observations or forecast information is displayed in order to make correct decisions.

3.2.4.2 Recommendation/Guideline

The MET information display should not display MET information that has been corrupted. The MET information display should not display expired or superseded data, except in the case of providing trend information, where the status of the expired, superseded, and current information should be clearly displayed.

3.2.4.3 Rationale

The flight crew should not be misled to making an incorrect decision by the display of MET information that has expired or been superseded and that is not representative of the most current actual or forecast state of the MET conditions. (Reference: RTCA DO-267A, Sec. 3.8)

3.2.5 Display of Text MET Information

3.2.5.1 Consideration

The flight crew needs to be able to read and clearly understand MET information displayed in text format.

3.2.5.2 Recommendation/Guideline

The cockpit MET information display should break individual lines of text MET information only at spaces or other natural delimiters for coded products such as METARs and Terminal Area Forecast (TAFs).

3.2.5.3 Rationale

To prevent misinterpretation, line breaks should not occur in numerical values in coded MET information. Visibility, for example, is often stated in main and fractional portions with an intervening space. These values should remain together on the same line of the display. (Reference: RTCA DO-267A, Sec. 3.8)

3.2.5.4 Technical Note

MET information should be presented to the flight crew in a format that is appropriate to the content of the information. Some data may be better suited to graphical display, while others may be presented more appropriately by text. Because MET graphics possess the quality of "high-glance-value", they should be used rather than text whenever possible.

3.2.6 Presentation of Dynamic Information

3.2.6.1 Consideration

The flight crew needs to have the ability to easily interpret dynamic information as it pertains to MET intensity, position, and motion (direction and relative speed) in support of Collaborative Decision Making (CDM).

3.2.6.2 Recommendation/Guideline

The MET information display should display sequential MET information data, in a loop, selectable by crew, with sufficient graphical resolution (overall display size, individual weather-severity cell size, color choice), frame rate, and total number of frames, as to convey an adequate dynamic sense of position, intensity, and movement in support of decision making.

3.2.6.3 Rationale

Looping MET information relies on the sequential presentation of information to create a “movie” showing the time evolution of recent weather. This can be helpful in extrapolating trends about how complex weather patterns are likely to behave in the near future at a given location.

References:

- a. Chamberlain, Jim, Lemos, Katherine (2004). Design Considerations for Presenting Data-Linked Animated Radar Imagery on In-Flight Displays. Proceedings of the 23rd Digital Avionics Systems Conference, Indianapolis, IN.
- b. Lemos, Katherine, Chamberlain, Jim (2004). In-Flight Weather Trending Information: Optimal Looping Characteristics for Animated NEXRAD Images. DASC 04, ISBN: 0-7803-8539-X.

3.2.6.4 Technical Note

When considering the looping of graphical MET information, it should be noted that there are risks of such displays being distracting, overly demanding of cognitive resources, and of possible misinterpretation of the MET information. To be maximally effective, looping products need to follow research-based guidelines, such as those developed by NASA Langley and FAA CAMI. It should also be understood by the user that extrapolations of MET hazards can only be inferred accurately when other meteorological and terrain variables associated with the hazard are also considered. Trending of the hazard's movement is only one variable to be used in forecasting, and it should not be considered accurate in and of itself.

3.2.7 Indication of Multiple Pages of Information

3.2.7.1 Consideration

For MET information, the flight crew needs to know if more than one page is required to display the product information.

3.2.7.2 Recommendation/Guideline

When MET information presentations requires more than one page, an indication shall be displayed on each page that a next or previous page exists.

3.2.7.3 Rationale

MET products may require more than one page to display all the information, especially on smaller Multi-Function Display (MFD) systems. Flight crew may be misled into thinking that they have reviewed all the available information if there is no obvious indication that the presentation includes additional pages. (Reference: RTCA DO-267A, Sec. 3.8)

3.2.8 Display Format Consistency

3.2.8.1 Consideration

In order to reduce workload and the potential for misinterpretation for the flight crew, the MET information needs to be consistent with the flight deck design philosophy in terms of location of titles, location and visual representation of legends, element size, labeling and text styles, etc. (Reference: AC 25-11A, Chapter 5, Section 31.b.)

3.2.8.2 Recommendation/Guideline

For a specific aircraft display configuration, the format of MET information displays should be as consistent as feasible, amongst the various MET phenomena views.

3.2.8.3 Rationale

To reduce workload, potential misinterpretation, and training requirements, the MET displays should follow a consistent display format. This allows the flight crew to find and interpret the required information in an efficient and accurate manner. However when MET information is integrated into another format, such as a navigation display, consistency with the integrated format may be more important than consistency with the stand-alone MET application. (Reference: RTCA DO-267A, Sec. 3.8)

3.2.9 Means to Indicate and Access Linked Text and Graphics

3.2.9.1 Consideration

The flight crew needs to have access to related information which supports or provides additional explanatory information to the graphical display.

3.2.9.2 Recommendation/Guideline

When a MET product is comprised of both graphical and supporting or explanatory information, a means shall be provided for the flight crew to access both sets of information for concurrent display or alternate display. If there is explanatory information available with the graphic, the graphic shall indicate that such information exists.

3.2.9.3 Rationale

Some graphical MET displays are based on text products and/or require supporting information for complete understanding. To prevent any potential misinterpretation and insure full comprehension, the flight crew needs to be able to access and display the text information associated with the graphical product. Examples of this association include hyper-linking and "mouse-over pop-ups". (Reference: RTCA DO-267A, Sec. 3.8)

4. SYMBOLOGY RECOMMENDATIONS

4.1 General Display Elements

4.1.1 Color

4.1.1.1 Consideration

Color may be used, along with another visual encoding, to indicate the type of MET phenomena. Symbols should be distinguishable based on their shape alone, without relying upon secondary cues such as color and text label. Color may be used to indicate the intensity or severity of a MET phenomena.

4.1.1.2 Recommendation/Guideline

Use of color for MET information display shall be as specified by AC 20-149A Installation Guidance for Domestic Flight Information Services – Broadcast, Section 6.b, to include the following:

1. Color assignments should follow the “strategic display philosophy of increasing potential safety hazard” so that the progression from green to amber (yellow) to red corresponds to increasing degrees of threat, hazard, safety criticality, or need for flight crew awareness or response.
2. The use of red, amber (yellow), and green should be compatible, although not necessarily identical, across the various displays and indications in order to ensure they maintain their effectiveness and intended functions.
3. If used, red should be associated with conditions that represent serious near-term or serious potential threats to safety.
4. If used, amber (yellow) should be associated with conditions representing moderate near-term or moderate potential threats to safety.
5. If used, green should be associated with normal, safe operation.
6. At no time should a display simultaneously present color-coded information requiring immediate awareness and possible action in combination with like color-coded information that is advisory in nature.
7. The flight crew should be able to quickly, accurately and consistently differentiate between time-critical information and dated, non-time-critical information.
8. Colors, when used in combination, should be of sufficient contrast to allow for easy determination of the purpose of the color (AC 25-11 Chapter 5, Section 31.c.(5).(5).g).

4.1.2 Lines and Linear Patterns

4.1.2.1 Consideration

MET phenomena may be represented on the display using symbols, lines and patterns. These elements of the format may be augmented by the use of color to help inform the flight crew of the MET information being displayed.

4.1.2.2 Recommendation/Guideline

When lines and linear patterns are used, the use of labels to identify the purpose of the line or pattern should be considered. Lines are typically distinguished only by line style, color and thickness. (Reference: Yeh, Michelle and Chandra, Divya C. (2008). Survey of Symbolology for Aeronautical Charts and Electronic Displays Navigation Aides, Airports, Lines, and Linear Patterns; DOT/FAA/AR-07/66)

4.1.3 Text

4.1.3.1 Consideration

MET phenomena information can also be provided to the flight crew using text to augment the symbology and visual encodings. Text is also used, for some attributes of the MET information, as the sole source of the information (Reference: DO-267A, Section 3.8)

4.1.3.2 Recommendation/Guideline

Use of text should be consistent with other display formats, and be presented of sufficient size and contrast to be easily readable.

4.1.4 Areas

4.1.4.1 Consideration

Patterns allow a way to fill an area to distinguish the purpose of the area display. The use of a pattern should be carefully considered as the complexity of the pattern may make it difficult to differentiate one pattern from another. Patterns that require an orientation should not be used, as a heading up map orientation will cause the area orientation to change.

4.1.4.2 Recommendation/Guideline

Areas should be represented as either a bounded area or a filled area.

When a bounded area is represented with lines, the lines should have a visual effect that indicates the inside of the area.

When a filled encoding is used, the encoding should provide a contrast that is sufficient to distinguish one area from others.

A separate fill method shall be used to indicate when data for an area, or portion of an area, is missing or invalid.

The use of color to indicate an area should be consistent and used with other visual effects to distinguish between different phenomena.

4.1.5 Volume

4.1.5.1 Consideration

MET phenomena that has a vertical component may be represented graphically or using text. Patterns allow a way to represent both the horizontal and vertical dimensions of a volume.

4.1.5.2 Recommendation/Guideline

Volume may be indicated using numeric text that contains either the top or bottom altitudes of an area.

Volume may also be indicated using a varying encoding of the line bounding an area, where the encoding of the line can be discerned and indicated by a legend. Contoured lines may also be used, with either a legend or text labels to indicate the altitude for each area.

Volume may be implicitly displayed by using area layers when the data which comprises the layer is for a single altitude or altitude range (e.g., 12 000 to 15 000 feet). When the MET phenomena is so displayed, the user shall have an ability to determine, via a legend (see 4.1.8), which altitude range is being displayed.

Volume can also be represented using a profile display for weather phenomena that can be found along a defined route.

Volume may be indicated using a 3-D perspective display. When 3-D perspective displays are used, the application of the guidelines for lines, linear patterns and colors may be applied. The 3-D visual display of the MET information should be consistent with 2-D displays of the same information.

A separate method shall be used to indicate when data for a portion of a volume is missing or invalid.

4.1.6 Coverage Map

4.1.6.1 Consideration

The flight crew needs to be informed of where MET information is available and where it is not available to differentiate between missing data and no data to display.