



AEROSPACE RECOMMENDED PRACTICE

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

RATIONALE

The use of portable electronic devices and graphical electronic displays on the flight deck has increased dramatically over the past several years. Additionally, the number of software programs that enable pilots and other users to receive and display Aeronautical Information such as Notices to Airmen (NOTAMs) on the flight deck has increased considerably. While many general human factors standards exist, to date, there are few standards that set minimum human factors requirements and recommendations for how NOTAMs should be displayed on the flight deck during preflight planning and in flight. It is anticipated that this document will be used by various regulators as guidance or a decision support document for certification or regulatory approval for use of the flight deck display of NOTAMs. Lastly, as NOTAM systems around the world are modernized, designers and developers of avionic systems or software programs will face challenges of a mixed-use environment where new "modernized" NOTAMs are available in different formats than non-modernized NOTAMs. This Aerospace Recommended Practice (ARP) addresses these issues and makes recommendations.

FOREWORD

The SAE G-10A Aeronautical Information System Committee was formed in January 2012 in Melbourne, Florida 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 aeronautical information on the flight deck for pre-flight planning and in flight. The G-10A 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) includes the minimum human factors requirements and recommendations for the flight deck display of data linked Aeronautical Information (AI), specifically Notices to Airmen (NOTAMs). The goal of human factors is to make it easy for users to do things right and hard to do them wrong. The guidance in this ARP supports this goal by defining minimum requirements and recommendations that focus on the text and potential graphics for NOTAMs as well as the human's interaction with these on the flight deck. In this ARP "flight deck" includes both single pilot flight decks as well as multi-pilot flight decks.

The FAA defines NOTAMs¹ as any information concerning the establishment, condition, or change in any component of, or hazard to, the National Airspace System. ICAO Annex 15 defines a NOTAM as "a notice distributed by means of telecommunication containing information concerning the establishment, condition, or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations."²

The minimum requirements and recommendations in this ARP do not replace guidelines or requirements for existing airborne applications or displays on the flight deck. It does not replace existing general human factors design standards. It also does not address every specific NOTAM category, series or type, but focuses on a subset, which includes the most safety critical NOTAMs (such as closed runways), most common NOTAMs, or ones which may affect the efficiency of the airspace such as Temporary Flight Restrictions (TFRs). This ARP also does not reference other aeronautical information such as private provider updates, such as Company NOTAMs and/or private sector charting notices or advisories such as charting errors or omissions, which might be sent to pilots via data link. Finally, this ARP does not address data integrity as the NOTAM moves from its originator to the flight deck and all the steps in between. This is addressed by the aeronautical information services data link standards developed by the RTCA Special Committee 206 while the quality of the aeronautical information is addressed by the RTCA 217 Special Committee.

There may come a time in the future when data linked NOTAMs presented in graphical format (gNOTAMs) are the primary source for NOTAMs on the flight deck. However, standardization and data quality issues must be addressed before gNOTAMs can be considered anything other than a visual supplement or an additional safety layer to text-based NOTAMs. Data quality at the origination point will be handled by quality control/quality assurance programs for each State producing NOTAMs. The aviation industry is still years away from complete standardization of all NOTAMs, but progress is being made. For example, regulators and others are working to develop geo-referenced data for airport and airspace subjects (e.g., navigation aids, obstructions, runways, taxiways, temporary flight restrictions and airspace). Similarly, regulators are creating new tools for the origination of NOTAMs that result in digital NOTAMs that are comprised of standardized elements. Such standardization allows automation (machines or software) to check accuracy, apply various sorting or filtering choices to the NOTAMs, or add other data to them such as displaying their shapes or locations over maps or other baseline data. Unfortunately, the current lack of standardization means that not every NOTAM created today is machine-readable, thus accuracy is dependent upon human analysis which is very labor intensive and costly. In the U.S. alone, approximately one (1) million NOTAMs are issued each year and the number is growing. As a result, for the foreseeable future, we remain in a mixed use environment where some NOTAMs are standardized and machine-readable but many are not. As a consequence, not every NOTAM created can be sorted, filtered, or converted to its graphical form with the accuracy that pilots and aviation regulators require.

There are advantages to having standardized gNOTAMs among every manufacturer. This increases the ability of the pilot to see, comprehend and project into the future the applicability of the NOTAM to their flight, reduces training costs, and improves pilot performance. Consistent depictions of gNOTAMs across different flight deck display manufacturers would enable pilots to move from display to display within an aircraft, and from aircraft to aircraft with more ease and would likely result in a reduction of errors. However, it is not the mandate of this Committee to stifle innovation by dictating specific symbols or graphics. Consequently, this ARP is geared toward identifying minimum human factors requirements and recommendations that will help ensure that all products meet some basic minimum standards for usability. Many choices have been left for the designer, after working with users, to determine what their highest priorities are and to find the most intuitive and efficient way to present the information.

While this ARP focuses solely on the flight deck of aircraft, the guidance may be expanded in the future to apply to displays for dispatchers, air traffic controllers, and other NOTAM users.

¹ FAA JO 7930.2 - Notices to Airmen

² ICAO Annex 15 - Aeronautical Information Services

1.1 Purpose

The purpose of this ARP is to provide specific human factors guidance regarding the display of NOTAMs on the flight deck to designers/developers and foundational information to the regulators. The minimum requirements and recommendations included in this ARP are based on input from subject matter experts and can be used to help inform other organizations that are setting standards, issuing approvals or certifications, or issuing recommendations or requirements for data link NOTAMs displayed on the flight deck. For example, it is envisioned that the requirements and recommendations contained in this ARP will be referenced by RTCA and invoked by a variety of government regulators.

This ARP is not designed to replace existing industry-accepted human factors guidance including the following:

- The FAA's Human Factors Design Standard (FAA HFDS)
- DOD Design Criteria Standard: Human Engineering (Military Standard 1472)
- ANSI/HFES standards
- All other regulatory guidance or research on human factors

Rather, this document provides specific human factors guidance that will help designers and developers tailor existing general human factors standards into specific information that will help them provide NOTAM information to the flight deck and help define appropriate user interactions with that data.

1.2 Overview

SECTION 2 - APPLICABLE DOCUMENTS AND DEFINITIONS: This section contains a list of documents that are applicable to the implementation of these requirements and recommendations. It also contains definitions of terms used within the ARP.

SECTION 3 - BACKGROUND AND ASSUMPTIONS: This section contains vital information about the current mixed-use environment concerning NOTAMs and their ability to be sorted, filtered, or graphically depicted. It also contains the assumptions made that apply to all requirements and recommendations provided in the ARP.

SECTION 4 - HUMAN FACTORS GUIDANCE FOR ALL NOTAM CATEGORIES: This section contains the human factors requirements and recommendations for all NOTAM categories.

SECTION 5 - SPECIFIC REQUIREMENTS/RECOMMENDATIONS: This section contains the specific requirements and recommendations for six different NOTAM categories selected by the Committee due to their importance to the safety, efficiency of flight and frequency of use.

SECTION 6 - LIST OF ACRONYMS: This section contains a list of acronyms used within this ARP.

APPENDIX A - LIST OF ARP REQUIREMENTS: This appendix contains the summary list of all the requirements in this ARP.

APPENDIX B - LIST OF ARP RECOMMENDATIONS: This appendix contains the summary list of all the recommendations in this ARP.

APPENDIX C - GRAPHIC NOTAM EXAMPLES: This appendix contains gNOTAM illustrations for the six NOTAM categories referenced in Chapter 5.

APPENDIX D - COLLECTION OF NOTAM CATEGORIES: This appendix includes a comprehensive, but not exhaustive list of most NOTAM categories and how they are categorized by ICAO and the FAA as well as some specific examples of text NOTAMs.

APPENDIX E - REFERENCES: This appendix contains a list of additional references that developers/designers and others might find useful as background information to this ARP.

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. Other general background references are provided in Appendix E.

NOTE: Where the documents referenced are available for free, a direct Web link is provided.

2.1 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.

ARP4032 Human Engineering Considerations in the Application of Color to Electronic Aircraft Displays

ARP4155 Human Interface Design Methodology for Integrated Display Symbology

ARP5289 Electronic Aeronautical Symbols

ARP5621 Electronic Display of Aeronautical Information (Charts)

AS8034 Minimum Performance Standard for Airborne Multipurpose Electronic Displays

2.2 Regulatory and Government Guidance Material

Title 14 Code of Federal Regulations (CFR) Parts 23, 27, and 29 and their accompanying regulations 14 CFR §25.1302 Installed Systems and Equipment for Use by the Flight Crew

14 CFR §25.1322 Warning, Caution, and Advisory Lights

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC 25-11 Electronic Flight Deck Displays

AC 120-70 Operational Authorization Process for Use of Data Link Communication System

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

Ahlstrom, V. and Longo, K. (2003). *Human Factors Design Standard* (HF-STD-001). Atlantic City International Airport, NJ: Federal Aviation Administration William J. Hughes Technical Center (hereinafter referred to as HFDS)

Available from <http://hf.tc.faa.gov/hfds/>

Federal Aviation Administration. (2013). FAA AMS Lifecycle Verification and Validation Guidelines Version 2.0.

Available from http://fast.faa.gov/VerificationValidation.cfm?CFID=55949298&CFTOKEN=63490270&p_title=AcquisitionPractices

FAA Aeronautical Information Manual (FAA AIM 2013)

Available from http://www.faa.gov/air_traffic/publications/ATPubs/AIM/aim.pdf

DOT/FAA/AM-01/17 Human Factors Design Guidelines for Multifunction Displays by Sig Mejdal, Michael E. McCauley & Dennis B. Beringer, CAMI

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, <http://quicksearch.dla.mil/>.

MIL-STD-1472 DOD Design Criteria Standard: Human Engineering

Available from <http://www.public.navy.mil/navsafecen/Documents/acquisition/MIL-STD-1472G%5B1%5D.pdf>

MIL-STD-1787 Aircraft Display Symbolology

Human Factors and Ergonomics Society. (2008). Human factors engineering of software user interfaces (ANSI/HFES Standard No. 200). Santa Monica, CA.

2.3 ICAO Publications

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

ICAO Annex 15 Aeronautical Information Services

ICAO/CAST "Phase of Flight, Definitions and Usage Notes"

2.4 RTCA Publications

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

RTCA DO-340 Concept of Use for Aeronautical Information Services and Meteorological Data Link Services

2.5 Definitions

When the following terms are used in this document, they have the following meanings:

AERONAUTICAL INFORMATION: Information such as airport or aerodrome, primary runway closures, taxiways, ramps, obstructions, communications, airspace, changes in the status of navigational aids, ILSs, radar service availability, and other information essential to planned en route, terminal, or landing operations. NOTAMs may include aeronautical information that could affect a pilot's decision to make a flight. (FAA AIM 5-1-3)

AIXM: The Aeronautical Information Exchange Model (AIXM) is designed to enable the origination, management and distribution of Aeronautical Information Services (AIS) data in digital format. AIXM version 5.1 was finalized in 2010. One main goal of AIXM is to enable the "digital NOTAM." In this concept, the traditional text string containing the NOTAM message is replaced with standardized and structured information, which is suitable for automated computer processing. AIXM was developed jointly by the U.S. Federal Aviation Administration and the European Organisation for the Safety of Air Navigation (EUROCONTROL) (see: www.aixm.aero). AIXM essentially puts each NOTAM detail such as latitude, longitude, altitude, active time, plus any other important details into their own separate "box" thus allowing each separate piece of data to be automatically sorted, filtered, prioritized or combined with other data such as a map which cannot be done via automation with the legacy free text string.

ANALOG NOTAM: A distributed NOTAM that cannot be reliably read, translated, or graphically displayed by a machine or software program.

ACCELERATE STOP DISTANCE AVAILABLE (ASDA): The runway plus stopway length declared available and suitable for the acceleration and deceleration of an airplane aborting a takeoff. (FAA AIM 2013)

BASELINE DATA: The published aeronautical information contained within navigational charts that are intended for use during flight operations. (Example: Instrument Approach Procedure chart (IAP), Airport Diagram, Enroute Charts)

CAPABILITIES: A generic term that is used to indicate any number of subjects, functions or options to help users manage the display and content of data; user selectable preferences for sorting, filtering, etc. of NOTAMs.

CONSISTENCY: Consistent means adhering to the same principles with minimal variation.

D-TAXI: A complete taxi route for an aircraft displayed on an Electronic Flight Bag (EFB), multi-function display (MFD), or primary flight display (PFD).

DATA DISPLAY: Communication of visual, audio, or other output from a computer to its users.

DATA LINK: A data communication capability comprising air/ground and ground/ground data network services, specified data linked message sets and protocols, aircraft equipment, ATS Facility equipment, and operational procedures intended to provide primary or supplemental ATS communications to the flight deck. (FAA AC 120-70B)

DESIGNER: Company, group, or individual that creates the flight deck display of text NOTAMs and gNOTAMs to users.

DEVELOPER: See designer.

DIGITAL NOTAM: A NOTAM in which the information is structured in a standardized format (such as AIXM) for electronic transmission and processing. Unlike text-string NOTAMs, digital NOTAMs can be machine read and processed and may be geo-referenced by latitude, longitude, altitude and time.

ELECTRONIC FLIGHT BAG (EFB): An electronic display system intended primarily for flight deck use that includes the hardware and software necessary to support an intended function. EFB devices can display a variety of aviation data or perform basic calculations (e.g., performance data, fuel calculations, etc.). In the past, some of these functions were traditionally accomplished using paper references or were based on data provided to the flight crew by an airline's flight dispatch function. The scope of the EFB functionality may include various other hosted databases and applications. Physical EFB displays may use various technologies, formats, and forms of communication. An EFB must be able to host Type A and/or Type B software applications. (FAA A/C 120-76B)

ELEMENTS (visual - associated with a graphical NOTAM) include icons; markings; symbols; labels; information coding such as the use of color, bold or crossed out text.

FILTER: A subject criterion that reduces the number of NOTAMs currently in view by users (e.g., users selection of VFR ONLY FILTER may remove a variety of NOTAMs from view such as IAP NOTAMs, SID NOTAMs, STAR NOTAMs, and ODP NOTAMs).

FLIGHT CREW: A single-pilot or multi-pilot flight crew.

FLIGHT DECK: The location at which the users identified in this document will operate the aircraft and use data linked NOTAMs. The flight deck includes both single- and multi-crew operations.

FLIGHT DECK DISPLAY: A screen or other display device that is intended for use during pre-flight and in-flight operations by the flight crew. The display may be installed or portable.

gNOTAM: See graphic NOTAM.

GRAPHICAL or GRAPHIC NOTAM: The pictorial representation of a text NOTAM, which may or may not include all of the text NOTAM's content (e.g., status, effective date, restrictions).

HIGHLIGHTING: Emphasizing displayed data or format subjects in some way (e.g., through the use of underlining, bolding, or inverse video).

HUMAN INTERFACE: Design provisions that enable human interactions with software and hardware systems. This may also be known as human computer interface (HCI), human machine interface (HMI), or user interface (UI).

IN-FLIGHT: All "non-preflight" or standing portions of flight as identified by ICAO and Commercial Aviation Safety Team (CAST). This includes pushback/towing, taxi, takeoff, initial climb, en route, maneuvering, approach, landing, emergency descent, uncontrolled descent, post-impact, and unknown. During these phases of flight, the flight crew "performs" by making, implementing, and evaluating tactical decisions based on a more restrictive set of data either previously data linked/obtained during preflight or obtained through primary means of data link while in-flight. [ICAO/CAST "Phase of Flight, Definitions and Usage Notes"]

INTUITIVE: A user interface that is instinctive, i.e., easy to understand as well as easy to use. One way of ensuring an intuitive interface is to perform human in the loop testing.

LABEL: Alphanumeric information that identifies or describes an object. Labels can be printed directly on or adjacent to the object, or they can be printed on a card or plate that is attached to the object or adjacent to the object.

LUMINANCE: The amount of light per unit area emitted or reflected from a surface measured in candela per square meter (cd/m^2), footlamberts (ft-L), or millilamberts (mL). $1.0 \text{ cd/m}^2 = 0.31 \text{ mL} = 0.29 \text{ ft-L}$. The luminance of a surface does not vary with the distance of the observer from the surface being viewed. Luminance is expressed in candela per meter squared or foot lamberts. (FAA HFDS)

LUMINANCE CONTRAST: The difference between the foreground (symbols, text) and the background which is often expressed as a ratio of the two.

LANDING DISTANCE AVAILABLE (LDA): The runway length declared available and suitable for landing an airplane. (FAA AIM 2013)

MAP: A representation of geographic data.

MARKING: Nonverbal information, such as colors or symbols that identifies or describes an object. Marking can appear directly on or adjacent to the object, or it can be printed on a card or plate that is attached to the object or adjacent to the object. (FAA HFDS)

MENU: A list of options from which a user makes a selection. (FAA HFDS)

MENU BAR: A narrow panel, usually along the top, side or bottom of a computer screen in menu-based computer systems that continually displays the highest-level menu options for selection by the user. The options on a menu bar are usually the names of other menus.

MENU SELECTION: A type of dialogue in which the user selects one item out of a list of displayed alternatives, whether the selection is by pointed, by entry of an association option code, or by actuation of an assigned function key.

MIXED USE ENVIRONMENT: An environment in which (1) some of the NOTAMs are machine-readable and can be displayed graphically because they contain each piece of information in a separate "box" so the NOTAM can be sorted, filtered and combined with other information for graphical depiction (2) other NOTAMs are not fully machine-readable due to lack of geo-referencing, lack of full standardization, or lack of quality, (3) different levels of data link service result in different displays of NOTAM on the flight deck, and (4) designers/developers provide only some categories of NOTAMs graphically on the flight deck.

MULTI-FUNCTION DISPLAY (MFD): The multifunction display (MFD) is a display surface that, through hardware or software controlling means, is capable of displaying information from multiple sources and, potentially, in several different reference frames. The device may be capable of either displaying different groups of data (i.e., weather, traffic, or terrain) one at a time or in a combined fashion. In some cases the data may be combined within a single common reference frame or within separate reference frames. Reference: Human Factors Design Guidelines for Multifunction Displays DOT/FAA/AM-01/17 (Oct. 2001)

NOTAM [ICAO]: A notice containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations. (FAA AIM, 2013)

NOTAM EVENT SCENARIOS: The AIXM or standardization rules that apply to each category of aeronautical information events.

NOTICE TO AIRMEN (NOTAM): Any information concerning the establishment, condition, or change in any component of, or hazard to, the National Airspace System.

NOTAM (D): An FAA NOTAM given (in addition to local dissemination) distant dissemination beyond the area of responsibility of the Flight Service Station. These NOTAMs will be stored and available until canceled (FAA AIM, 2013)

FDC NOTAM: An FAA NOTAM regulatory in nature, transmitted by the U.S. NOTAM Office and given system wide dissemination. (FAA AIM, 2013)

NOTICES TO AIRMEN PUBLICATION: A publication issued every 28 days, designed primarily for the pilot, which contains current NOTAM information considered essential to the safety of flight as well as supplemental data to other aeronautical publications. The acronym NTAP is used in NOTAM text. (FAA AIM, 2013)

NOTAM LIST: The complete list of text NOTAMs the user retrieves or is provided for the purpose of flight.

NOTAM SENTENCE: The standardization of a NOTAM imposed by AIXM which puts each piece of data into its own separate "box."

OPTION: One of the selectable items in a menu. (HFDS)

OWN-SHIP: The flight deck display of the current position of the aircraft being operated. An airplane symbol may be the primary method to represent the user's current position.

PRIMARY FLIGHT DISPLAY (PFD): A PFD presents information about primary instruments, navigation instruments, and the status of the flight in one integrated display. Some systems include power plant information and other systems information in the same display.

PREFLIGHT: The "Standing" portion of flight as identified per ICAO. This phase of flight is prior to pushback or taxi, at the gate, ramp, or in the parking area, while the aircraft is stationary. During this phase of flight, the flight crew member(s) are able to prepare for flight by considering as much information as possible, via data links, such as ACARS and ATN, to make the best go/no-go decision possible, and to check the airworthiness of the aircraft. In preflight planning, data and analysis is used to develop a strategic, "big picture" plan for flight. Also, information ascertained during the preflight phase will allow the flight crew to be better prepared once in-flight. [ICAO/CAST "Phase of Flight, Definitions and Usage Notes"]

PRIORITIZE: A user selected list that places the selected NOTAM categories or keywords ahead of other NOTAM categories or keywords provided (e.g., (1) Runway NOTAMs, (2) Taxiway NOTAMs, (3) IAP NOTAMs, etc.).

PRODUCT: Information that is produced and distributed in accordance with a published or defined format. MET examples include METARs, TAFs, and SIGMETs. AIS examples include charts and NOTAMs.

SELECTABLE: The user may choose from a list of capabilities that may be in a menu.

SHALL: The word "shall" is used to express an essential (mandatory) requirement. Conformance requires that there be no deviation, although there are generally a variety of ways to conform. A reference to the specific statute, regulation, standard, best practice, etc. normally accompanies each requirement in this document. NOTE: because this is an Aerospace Recommended Practice document and not an Aerospace Standard document, requirements do not have to be linked to regulatory requirements or statutes but may be linked to standards based upon research, best practices such as the FAA's Human Factors Design Standards, or other rationale that this Committee agreed upon.

SHOULD: The word "should" is used to express a recommendation. Note that exclusion or deviation from recommendations normally requires justification. A reference to the specific standard or guidance accompanies each recommendation in this document.

SORT: This changes the order of how NOTAMs are displayed but does not reduce the number of NOTAMs. (Example: Sort by Runway NOTAMs would change how NOTAMs are displayed from newest to oldest based upon NOTAM number - the default setting - to displaying all runway NOTAMs at the top of the list.)

STAKEHOLDERS: Any person or group that has something to gain or lose based upon the content of this ARP.

STATUS (within a NOTAM): The current availability or known state of the identified subject within a NOTAM (e.g., Out of Service, Closed, Decommissioned, Unreliable).

SUBJECT (within a NOTAM): Entity that is being identified in the NOTAM (e.g., RWY 15/33, TWY "B", Precision Approach Path Indicator, Runway Lights, High Intensity). Note that some software applications use the term "feature" for subjects.

TEXT NOTAM: A published Notice to Airmen that contains the subject, status, and any additional details communicated through the use of words, punctuation, and contractions (Example: !IAD 02/049 IAD NAV ILS RWY 1R IM DCMSN WEF 1302192007).

TAKEOFF DISTANCE AVAILABLE (TODA): The takeoff run available plus the length of any remaining runway or clearway beyond the far end of the takeoff run available. (FAA AIM 2013)

TAKEOFF RUN AVAILABLE (TORA): The runway length declared available and suitable for the ground run of an airplane taking off. (FAA AIM 2013)

UNIVERSALLY UNIQUE IDENTIFIER (UUID): A unique number or group of letters that identifies unique objects or data. KDCA is the UUID for Reagan National airport in the United States.

USERS: Any single pilot or multi-pilot flight crew who will use a flight deck display of NOTAMS.

VALIDATION: The FAA defines validation as the process that confirms that the product or work product satisfies or will satisfy the stakeholders' needs. It determines a system does everything it should and nothing it should not do. It answers the question: Was the right system built? ICAO Annex 15 defines Validation as: confirmation by examination and provision of objective evidence that the particular requirements for specific intended use are fulfilled.

VERIFICATION: The FAA defines verification as the process that confirms that the system and its elements meet the specified requirements; that the system is built as specified. It answers the question: Was the system built right? ICAO Annex 15 defines Verification as: confirmation by examination and provision of objective evidence that specified requirements have been fulfilled.

3. BACKGROUND AND ASSUMPTIONS

3.1 Introduction

This Chapter includes critical background information needed to fully understand the requirements, recommendations, and references in Chapters 4 and 5.

This Chapter is divided into two sections:

- background information about mixed use environment; and
- assumptions regarding the flight deck display of data linked NOTAMs in this ARP.

3.2 Creating gNOTAMs in a Mixed Use Data Environment

Historically, NOTAMs were strings of text that were produced and published via teletype technology and transmitted in “analog” format. These NOTAMs could not be processed reliably by a machine (e.g., data could not be sorted, filtered, or graphically displayed). The international aviation industry is currently modernizing the NOTAM system to improve the origination/collection, management, and delivery of NOTAMs. The goal is to have a system that consists of all “digital” NOTAMs. A digital NOTAM is one where the information requirements are standardized, and every piece of information contained in the NOTAM is entered into a separate data field. The resulting data file shows each piece of information in a consistent location and in its own separate “box.” Unlike text-string NOTAMs, digital NOTAMs can be machine read and thus depicted graphically because each data field has its required data in its required “box.” The modernization effort is ongoing, but for a variety of reasons not all components could be implemented simultaneously. As a result, depending on where the NOTAM was originated and by whom, a NOTAM in the current NOTAM system may be one of three types:

Digital NOTAMs with accurate geo-referenced subjects: Each piece of information in this NOTAM (e.g., the effective date) has its own separate location in the file and has its own universally unique identifier. It may be in AIXM or other format. In addition, accurate geo-referencing (i.e., geometry exists that identifies the exact location of the subject) of the NOTAM subject being described in the NOTAM is available. For example, a closed runway NOTAM may be in AIXM format and depicted graphically by using the four geo-referenced points - the four corners of the runway defined by their GPS/GNSS coordinates. When combined with other baseline information, the geographic referencing enables the drawing of points, boxes or shapes on a map and thus supports the flight deck display of the NOTAM essentially in picture form or “graphically.” These NOTAMs (gNOTAMs) can be reliably read by a machine (e.g., can be sorted, filtered based upon data in each “box”³) and because the subjects have been geo-referenced they can also be depicted reliably in graphical format by a machine.

Digital NOTAMs without accurate geo-referenced subjects: This is also a digital NOTAM with a universally unique identifier and is fully machine-readable. However, without accurate full geo-referencing of the identified NOTAM subject, it cannot be depicted graphically without human intervention. For example, a closed taxiway NOTAM may be in AIXM format and thus is machine-readable. However, because the identified taxiway is not accurately geo-referenced (i.e., geometry does not exist to identify the exact location of the subject or the taxiway is identified by the airport reference point rather than the outline of the actual taxiway), the NOTAM cannot be depicted graphically by a machine in a reliable fashion.

Other NOTAMs: All NOTAMs other than those identified above. These include: (1) legacy text string NOTAMs with little standardization describing subjects that may be geo-referenced or not, (2) other NOTAMs that may contain only partial standardization, which results in them not being fully machine-readable, and (3) NOTAMs that do not lend themselves to geo-referencing or that are perhaps better left in a standardized, text format. Although these NOTAMs come from different sources, each requires human intervention for them to be machine-readable and/or depicted graphically.

Thus, we are left with a NOTAM system that is comprised of a mixture of several NOTAM formats. This mixed use environment presents multiple challenges to the system designers and developers of NOTAMs on the flight deck.

First, it means pilots may fly to an airport where some of the NOTAMs are digital and thus can be displayed in a graphical format, while others are not.

Second, if only some NOTAMs are digital, then when sorting and filtering capabilities are applied some NOTAMs may be sorted and filtered, while others may not. If users demand that all NOTAMs or specific kinds of NOTAMs be accurately sorted and filtered then people, rather than automation will be required to perform these functions just as some dispatchers do today. Even the same category of NOTAMs such as runway NOTAMs will not always be available as machine-readable NOTAMs - since computers and their software systems sometimes fail resulting in reversion to the old “analog” system.

Third, is the varying level of data link services from air carrier to air carrier, and from the system design of each data link service, which may alter when NOTAMs are delivered to the flight deck.

Fourth, equipment designers and their customers may opt to include varying levels of avionics to support NOTAM delivery to the flight deck.

Finally, even if the data link service is available and the equipment can accommodate NOTAM delivery, system designers are unlikely to build graphical depictions of all NOTAM categories simultaneously. For example, they may opt to create graphical NOTAMs only for runway and TFR NOTAMs. In summary, these factors, when combined, result in a mixed use environment.

³ As of December, 2013 in the U.S. about 41% of all domestic and regulatory NOTAMs are created digitally at the originator with accurate geo-referenced points that can be used to create gNOTAMs including about one half (230 of 499) of all airports receiving commercial flights. Another 20% can be converted to digital due to their standardized and structured format; most of these NOTAMs are Special Activity Airspace NOTAMs.

As described above, whether NOTAMs are analog or digital matters. Only digital NOTAMs that contain all required geo-referenced point(s) can be fully sorted, filtered and graphically rendered reliably by a machine. And these different kinds of “mixed use” environments make the provision of NOTAMs to the flight deck a challenge. For example, designers must design the NOTAM display system in a way that helps prevent pilots from developing expectations and making assumptions based on the existence (or lack of) of a gNOTAM. However, even though only some of the NOTAMs can be machine read (and accurately and reliably graphically depicted), the additional safety protections afforded by using a picture rather than text encourage designers to take advantage of technology and provide the first round of gNOTAMs to the flight deck now.

This ARP provides Human Factors guidance to help system designer's deal with the mixed use environment and other unique characteristics and to provide useful information to users. Developing gNOTAMs is resource intensive; many decisions will need to be made to add gNOTAMs to the flight deck in a way that is easy for end users to fully utilize. Over time, as more and more NOTAM originators are provided with the tools to create fully standardized digital NOTAMs and with the required geo-referenced points, the number of digital NOTAMs will increase and the number of analog NOTAMs will decrease.

3.3 Assumptions

During the development of this ARP and the guidance it contains, this Committee was required to make certain assumptions regarding the systems, databases and applications involved in the relaying of NOTAM information to the flight deck. If any of the listed assumptions are violated, then the guidance provided in this ARP may not be sufficient to meet minimum human factors requirements or recommendations. Note that the actual system requirements are outside the scope of this ARP. Consequently, the only assumptions identified are those that may have a direct impact on human performance if they are not met.

The Committee assumes that:

- Designers have and will apply knowledge of existing basic human factors design principles.
- Designers will use the NOTAM specific guidance in this ARP to supplement their existing knowledge of basic human factors design principles.
- The NOTAM flight deck display will be designed to work in harmony with existing flight deck components.
- The implementation of these requirements and recommendations will support, rather than interfere with the interpretation and use of NOTAM information. That is, implementation will enhance decision making, accuracy and efficiency, and situational awareness. The tools will be easy to use and error resistant. Delivering text and/or gNOTAMs to the flight deck will not hinder timely decision-making and action, will not encourage errors, will not delay actions, will not create confusion, or otherwise interfere with flight crew tasks. The definition and operationalization of these characteristics (e.g., timely, accurate, and easy to use) will typically be based on the intended function and the overall system design, and as a result cannot be specifically defined in this ARP. For example, “timely decision-making” and “easy to use” in any given situation can only be defined by designers working directly with end users. In this case, testing will be needed to ensure that these goals have been met. See the next assumption regarding Verification and Validation.
- Verification and Validation (V&V) will be conducted by system designers to ensure that the delivery of text and gNOTAMs to the flight deck meets design specifications (verification) and supports effective and safe operations (validation). Detailed descriptions of the V&V process are available from other sources including Federal Aviation Administration (2013); Boehm (1988); Forsberg, Mooz, & Cotterman (1995); Gore (2010); Royce (1970); and Software Engineering Institute (2010).
- All users will have access to the same NOTAM source such as the U.S. NOTAM System in the U.S.
- All NOTAMs will be available from the NOTAM provider via data link. However, the frequency and timing of the updates may vary based on the services being offered by the provider, system limitations, and user preferences.
- NOTAMs will always be available on the flight deck in text format. Graphical representations are optional.

- Responsibility for data quality rests with the NOTAM's authoritative source. Any errors or omissions in the NOTAM cannot be corrected through the delivery of that NOTAM to the flight deck or the depiction of it graphically.
- The flight deck display system will accurately deliver NOTAMs to the flight deck. NOTAMs may be displayed on the flight deck on a variety of displays including Electronic Flight Bags (the FAA defines EFBs into Class 1 and 2 (portable devices such as tablet computers and Class 3 (installed devices)) as well as primary flight displays (PFDs) and multi-function displays (MFDs).
- All baseline data will be current.
- NOTAMs will be available to users for both for preflight planning and in flight operations.
- The flight deck display will include a means of indicating data link's connectivity status (i.e., connected and capable of receiving data, not connected and not capable of receiving data) to users.

NOTE: As technology becomes more sophisticated and more widely available, the line between baseline aeronautical information and temporary NOTAM data may become more blurred. That is, baseline data will no longer be assumed to be static with temporary values accompanying the baseline values, but rather all data will become temporary and thus easily and quickly changeable. The shift to machine-readable data-driven products will likely have many consequences. It may release data providers from the restrictions of the regimented update cycles (e.g., 28 days, 56 days, etc.) currently required by States. Instead, it may result in real time updates being made to an electronic system of aeronautical information. These changes may substantively change the conceptualization of what is temporary and what is baseline. Effort was made by this Committee to think ahead to the impact that these changes may have, and to develop human factors guidance that will still be useful in this new environment. However, as these changes occur, it may be necessary to edit the guidance contained in this ARP.

4. HUMAN FACTORS GUIDANCE FOR ALL NOTAM CATEGORIES⁴

4.1 Human Factors Guidance for the Flight Deck Display of NOTAMs

Chapter 4 provides general human factors requirements and recommendations that apply across all NOTAM categories, while Chapter 5 provides guidance for six specific categories of NOTAMs. The objective of providing human factors guidance is to help ensure that flight crews are provided with NOTAMs that are simple, easy to understand, and intuitive.

Chapter 4 is divided into two sections:

- human factors guidance regarding the flight deck display of NOTAMs; and
- human factors guidance regarding flight crew interaction with NOTAMs.

NOTE: In this case, the term "display of NOTAMs" refers to whatever system is used to display the NOTAM information on the flight deck. It should not be inferred that a separate system is required to display NOTAMs; the flight deck display may be integrated in many cases. "Displays" include any device or technology designed to provide information to the human sensory system. The recommendations and requirements in this ARP are about the communication and flight deck display of NOTAM information. Each entry in this section applies to visual depictions, (e.g., panel-mounted and portable visual flight deck display devices as well as head-up, wearable vision devices, and other means of communication).

Further, flight deck display is defined as what the pilot/flight crew sees; flight crew interaction with NOTAMs is defined as what the flight crew or pilot has to do in order to see or use what is displayed.

Each entry in this Chapter and the next is defined by three components: Need, Requirement or Recommendation, and Rationale. For each entry, a reference(s) is provided and may include a picture or example to supplement the reader's understanding.

⁴ NOTAM categories includes NOTAMs of all varieties, classes, keywords, etc. such as runway NOTAMs, ILS out of service NOTAMs, TFR NOTAMs or a change in frequency of a communication outlet NOTAMs. See Appendix D.

In the section labeled “Need,” the ARP explains the human factors problem or challenge that potentially exists and which the guidance is designed to prevent or mitigate.

In the section labeled “Requirement” or “Recommendation,” the ARP provides the specific human factors guidance to remedy the identified human factors problem or challenge. This section often describes what the NOTAM flight deck display shall or shall not include. Recall that the word “Shall” is associated with requirements, and the word “Should” is associated with recommendations (see 2.10 for a more complete definition of these terms). NOTE: ARP documents requirements (“shalls”) do not require a specific statute or regulation reference; only Technical Standard documents require these references.

In the section labeled “Rationale,” the ARP explains the positive result of implementing the requirement/recommendation and how the guidance mitigates the challenge and may provide specific examples to help clarify the guidance.

Appendix A provides a summary list of all the ARP’s requirements while Appendix B provides a list of all the ARP’s recommendations.

4.1.1 Create gNOTAMs Using Easy-to-Understand Elements

Need: If users are presented with graphical NOTAMs (gNOTAM) that contain visual elements (e.g., icons; markings; symbols; labels; information coding such as the use of color, bold or crossed out text) that they cannot easily understand (e.g., are too complex, too large/small, not intuitive, cannot be differentiated from each other), then users may take longer to interpret the information or they may make errors in their interpretations.

Requirement: The gNOTAM shall be comprised of elements (e.g., icons; markings; symbols; labels; information coding such as the use of color, bold or crossed out text) that allow for efficient and accurate interpretation by the flight crew. For example, icons and symbols must be large enough to be visible by the end user and shall not rely solely on color for understanding. There are a variety of ways to meet this requirement. For example, designers can use industry accepted elements if they are appropriate, meet existing human factors standards, are routinized, or do not conflict with other elements. An alternative for designers is to create new elements but they must not be easily confused with an existing element(s) and they must be appropriate in size, color, and shape given the resolution over which the gNOTAM is superimposed and the capabilities of the flight deck display. To the extent possible, the creation of a new element should be developed through collaboration with representatives from industry, government, and other international groups.

Rationale: A picture is worth a thousand words, thus the graphical depiction of text information can speed user comprehension, save “real estate” on already crowded flight deck displays, and provide flight crews with critical just-in-time information. For example, a graphical flight deck display of a TFR on a moving map compared to a long text string describing the parameters of the TFR would result in far less “heads-down” time for the user and enhance the user’s “glance factor.” A variety of marking and labels may be used for graphical depictions.

Reference: (1) ARP5289, (2) ARP4155A, (3) 14 CFR §§ 25.1302, 25.1332, (4) AC 25-11A, and (5) HFDS §§ 2.2.1 (Design for simplicity), 2.6.3 (Use familiar terms and images), 8.13.3.1 (Design of symbols), 3.1.12 (Prevent distraction from operations), and 8.3.2.1.22 (Color-coding symbols).

4.1.2 Ensure gNOTAMs are Visible, Legible, and Readable during Flight Operations

Need: If users have difficulties viewing gNOTAMs during flight operations, their ability to correctly interpret the information may result in reduced performance or increased errors during the user’s flight. For example, they may misinterpret information, miss information, or process information inefficiently.

Requirement: The flight deck display shall follow accepted human factors standards regarding visibility, legibility, readability of display subjects to ensure that gNOTAMs are readable during flight operations in all lighting conditions. Display subjects relevant to the flight operations environment may include luminance contrast, font type, font size, chromaticity differences, character spacing, word spacing, line spacing, and resolution. In addition, designers should be sensitive to the needs of users with regard to zooming in and out.

Rationale: Users shall be provided with gNOTAMs that are readable during flight operations in all lighting conditions in order to properly interpret the information. Visibility, legibility, and readability of information on the flight deck under normal operations include challenges such as: glare, brightness/night vision, noise, vibration, etc.

Reference: (1) AC 25-11A, (2) AS8034B, (3) MIL-STD-1472, (4) Broadbent, S. (2000). Font Requirements for Next Generation Air Traffic Management Systems (HRS/HSP-006-REP-01). Bretigny-sur-Orge: EUROCONTROL, (5) Xing, J. (2006). Color and Visual Factors in ATC Displays (DOT/FAA/AM-06/15). Washington, DC: Federal Aviation Administration, and (6) HFDS §§ 3.1.12 (Prevent distraction from operations), 5.1.1.1 (Make displays function under operational conditions), and 5.1.1.2 (Make displays legible under all conditions).

4.1.3 Create gNOTAMs that are Easily Distinguishable from the Baseline

Need: If users are unable to accurately differentiate between the baseline data and the change indicated by the gNOTAM then users may become confused, unable to make accurate decisions, and fail to understand how the gNOTAM affects their route of flight. For example, even if it is possible to remove the baseline frequency on an approach plate and insert the new frequency, this will make it difficult for users to recognize that the frequency has changed.

Requirement: The information conveyed in a gNOTAM about a subject shall be easily identified as being different from that subject's baseline data.

Rationale: Making it clear where there are differences between the baseline data and the new status of the subject will assist users in recognizing and processing that information.

Reference: HFDS § 3.12.11 (Highlight changed data).

4.1.4 Provide Context for the gNOTAM

Need: If users cannot place NOTAM information in the context of the existing relevant baseline information such as an airport diagram or moving map, then users may find it more difficult to understand the relationship between the NOTAM subject and other baseline information. As a result, users may find it more difficult to evaluate the impact of the NOTAM information on their flight. For example, a graphical TFR NOTAM that only shows the shape of the restricted airspace and does not show the surrounding background subjects, terrain or airspace, will not support the user in avoiding the airspace. Similarly, a TFR gNOTAM that does not accurately show the boundaries of the restricted airspace will not support the user in avoiding the airspace. Both of these situations may increase airspace incursions.

Requirement: The flight deck display of the gNOTAM shall accurately show the baseline subject identified in the NOTAM (e.g., the part of the runway actually being closed) in relation to other baseline data (e.g., other airport subjects that appear on the airport diagram). There are many ways to accomplish this including superimposing the gNOTAM over a baseline data product such as the airport diagram or moving map.

Rationale: By providing users with accurate gNOTAMs in context with other aeronautical information (e.g., moving map, instrument approach chart or airport diagram) rather than on an individual, separate plate, chart or diagram without any context will enable the users to understand the information being conveyed in context with other information and not require the users to review the new information in a new format. Providing all the new gNOTAM information in an existing, familiar format may help reduce heads down time and increase the "glance factor" required to understand the newly conveyed information in the context of other relevant baseline information.

Reference: HFDS §§ 8.1.2.1 (Context), 3.12.7 (Situation displays), and 8.3.2.1.10 (Situation displays as overlays).

4.1.5 Display NOTAMs on the Flight Deck without Obscuring Flight Relevant Information

Need: If text NOTAMs, gNOTAMs, or notifications associated with these are presented in a way that obscures information that standard or regulation dictates may not ever be obscured, or that permanently obscures other flight relevant information (e.g., baseline data), then users' understanding of that information will be compromised. For example, NOTAMs cannot obscure airspeed by regulation.

Requirement: The flight deck display shall present NOTAMs in a way that does not obscure flight relevant information that cannot per regulation be obscured and that does not permanently obscure other flight relevant information such as baseline data.

Rationale: gNOTAMs are likely to temporarily obscure flight relevant information; however, ensuring that gNOTAMs do not permanently obscure flight relevant information will enable users to remain aware of the current operational context.

Reference: (1) AC 25-11A, (2) ARP5621, and (3) HFDS §§ 8.1.1.1 (Simplicity), 8.1.1.2 (Minimal information density), 8.3.2.1.1 (Map visibility), 8.3.2.1.27 (No overlapping of symbols), 8.1.3.3 (Minimal visual competition), 8.1.3.9 (Priority of displayed information), and 8.1.3.12 (Task critical information).

4.1.6 Depict gNOTAMs Accurately

Need: If users see a gNOTAM that is not depicted accurately (e.g., not drawn to scale, shows that pavement is closed to operations when operations are still allowed), then users may be misled about the intent of the gNOTAM and may make mistakes when processing the information being presented.

Requirement: The flight deck display system shall display gNOTAMs accurately. There are many ways to ensure accuracy including ensuring that the status is depicted accurately (e.g., taxiway closure gNOTAM should be depicted beginning and ending short of the intersection with a runway or another taxiway rather than half way through the intersection with a runway or another taxiway per policy), ensuring that the context is depicted accurately (e.g., showing the edges of the TFR in their actual 3-D location on the baseline data), ensuring that the subject is depicted accurately (e.g., when superimposing a subject over baseline data, ensure that the subject is drawn to scale, and is in the proper position relative to other subjects).

Rationale: Providing users with an accurate graphical depiction will help ensure that the gNOTAM provides a usable supplement to the text NOTAM and enables the user to navigate close to the boundary without penetrating the closed portion of the gNOTAM.

Reference: (1) AC 25-11A and (2) HFDS §§ 3.4.6 (Use spatial representations where possible), 8.3.2.1.21 (Association of symbols with map features), and 8.3.1.5 (References values).

4.1.7 Indicate at a Minimum the NOTAM Subject and that its Status Has Changed

Need: If the subject (e.g., RWY 15/33) and the fact that the subject has a NOTAM associated with it (e.g., RWY is closed) are not indicated in each gNOTAM, then users may not be able to comprehend the full meaning of the NOTAM. For example, a closed runway gNOTAM must indicate which specific runway is described in the text-based NOTAM and that a NOTAM exists that provides information about the change in the status of that runway (e.g., closed).

Requirement: At a minimum, the gNOTAM shall indicate the subject cited in the associated text NOTAM and that a NOTAM exists that identifies the change in status of that subject. For example, a closed runway gNOTAM would indicate the subject runway and that a NOTAM exists changing its status.

Rationale: Providing the user with an indication of both the subject and that its status has changed enables the user to comprehend the gNOTAM even if not all parts of the NOTAM are depicted. For example, a NOTAM indicating a runway is closed must include both the subject (runway) and that there is a NOTAM that changes its status (e.g., closed).

Reference: HFDS §2.6.7 (Design to meet user requirements) and HFDS §3.12.6 (Information displays).

4.1.8 Include Additional Details in gNOTAM as Appropriate

Need: In many cases, the gNOTAM will not be able to communicate all of the details included in the text-based NOTAM. If details from the text-based NOTAM (e.g., status, operational restrictions, exceptions, time limits) are not provided as part of the gNOTAM, then users will not fully comprehend the NOTAM and its impact on their flight.

Requirement: The flight deck display system shall display additional details in the gNOTAM as appropriate.

Rationale: Providing users with a gNOTAM that includes as many of the relevant details as possible will support users' full comprehension of the current status of the NOTAMs in their route of flight and should reduce the negative impact on user workload and heads down time.

Reference: HFDS § 3.12.1 (Indicate if data are incomplete, missing, uncertain, or invalid).

4.1.9 Indicate that NOTAM Details are Missing

Need: If there are more details in the text NOTAM than are or can be provided in the gNOTAM, users may incorrectly assume that all of the details are present. The result may be a misinterpretation of the meaning and implications of the NOTAM for their route of flight.

Requirement: The NOTAM flight deck display shall include an indication (e.g., an icon, symbol) that additional details are available for the gNOTAM, but not displayed.

Rationale: Letting users know that additional NOTAM details are present but not displayed on the flight deck reduces the likelihood that they will miss important information.

Reference: HFDS § 3.12.1 (Indicate if data are incomplete, missing, uncertain, or invalid).

4.1.10 Provide a Depiction of the User's Position Relative to the NOTAM's Subject

Need: If users cannot identify their position (e.g., route-of-flight or own-ship) in relationship to the subject described in the gNOTAM, they may have difficulty determining if and when the NOTAM will affect their flight. In turn, difficulties in identifying their position in relationship to the subject may reduce user's comprehension of whether or not the NOTAM affects their route of flight.

Requirement: The flight deck display shall, if permissible by regulation and as appropriate, provide an integrated depiction that shows the user's position (e.g., route-of-flight, own-ship) relative to the gNOTAM.

Rationale: Providing the users with their position relative to the gNOTAM helps the user plan and efficiently execute their route of flight. However, there may be times when it is not appropriate such as if the user is reviewing gNOTAMs at the destination airport when the flight is just beginning.

Reference: AC 120-76B (Class III only), and HFDS §§ 3.4.6 (Use spatial representations where possible), 8.3.2.1.21 (Association of symbols with map features), and 8.3.1.5 (References values).

4.1.11 Ensure all Instances of a gNOTAM are Consistent Across Flight Deck Displays

Need: Inconsistent gNOTAM representation of the same NOTAM information - regardless of where it appears on the flight deck (e.g., portable versus installed displays) or how it is displayed (e.g., 2-dimensional, 3-dimensional) - may increase the amount of time required to interpret the gNOTAM and may result in users misinterpreting the meaning of the gNOTAM.

Recommendation: If a gNOTAM is provided on more than one display on the flight deck, the gNOTAM should be depicted consistently across those displays.

Rationale: Although deviations may be required to take into consideration the advantages and limitations of the particular flight deck display or application, users should, whenever possible, see gNOTAMs displayed consistently across all displays on the flight deck. This will help ensure that users can quickly and accurately interpret the meaning of the gNOTAM. For example, if X's are used to denote a runway closure on an airport diagram, slashes should not be used to denote that closure on that flight deck display's moving map.

Reference: AC 25-11A, and HFDS §§ 2.3.1 (Make design consistent), 8.3.1.2 (Consistency), 3.4.2 (Provide interface consistency), and 3.4.3 (Be consistent with user expectations).

4.1.12 Superimpose gNOTAMs over all Baseline Data Product(s) or Select Logically

Need: If designers opt to superimpose gNOTAMs over only a subset of the baseline data products that contain that NOTAM's subject, users may be confused and unable to make safety-critical decisions, miss important information, or develop a mistrust of the available gNOTAM. For example, if designers elect to show a closed runway only on an airport diagram and not on an instrument approach plate, there is a risk that users may land on the closed runway. This may occur because pilots may not review the airport diagram until after they have already landed.

Requirement: If a designer opts to superimpose a gNOTAM over its associated baseline subject, then the gNOTAM shall be superimposed over every display product of that baseline subject or where it could be easily viewed. For example, superimpose runway closure gNOTAMs over every baseline data product that depicts runways (e.g., moving maps, approach plates, airport diagrams). If this is not possible, superimpose the gNOTAM over a baseline data product(s) that has been shown to be logical to users (e.g., over a product that contains that subject, over a product that is likely to be viewed by users in time to be useful for their phase of flight, or in a place that users are likely to look for that information). For example, it may be less useful to show a runway closure on an airport diagram and not show it on an approach plate as pilots may look primarily at the airport diagram after they have already landed.

Rationale: Providing users with a gNOTAM over all baseline products where it appears will enable users to use the gNOTAM in each and every place where they might determine it is most useful and clear.

Reference: HFDS §§ 8.6.1.6 (Consistent coding) and 8.1.1.6 (Minimizing the User's short-term memory load).

4.1.13 Insert all gNOTAMs on the Same Selected Baseline Data Product

Need: if users are required to view multiple gNOTAMs (e.g., multiple taxiway closures, a taxiway closure and a runway closure) as individual gNOTAMs as opposed to viewing them all at the same time as a single depiction, this will increase the amount of time required to review the gNOTAMs and may decrease situational awareness.

Requirement: The flight deck display shall show all available gNOTAMs when multiple gNOTAMs exist for a given baseline data subject.

Rationale: Providing a single flight deck display that shows all available gNOTAMs will help speed processing of information and will provide a more comprehensive mental map, which may increase situational awareness.

Reference: HFDS §§ 3.12.4 (Show accurate status), 3.12.6 (Information displays), 8.6.1.6 (Consistent coding), and 8.1.1.6 (Minimizing the user's short-term memory load).

4.1.14 Insert gNOTAMs over Baseline Data in Every Place the Subject Appears

Need: If a gNOTAM is not displayed in every place on a single baseline product on which that subject exists, then users may miss or not understand pertinent information. Subsequently, users may develop inaccurate situational awareness, make erroneous decisions, or experience task inefficiencies.

Requirement: If a single baseline data product contains multiple references to a subject, the NOTAM flight deck display shall insert the gNOTAM in every place where that subject exists. For example, if a localizer frequency appears in several places on an instrument approach plate and a NOTAM is issued changing the frequency, then the gNOTAM shall appear on the plate in every place the frequency appears.

Rationale: Providing users with a gNOTAM in every place where the subject appears will always provide the users with the information anytime they need it. This is preferable to having the designers try and predict this or assuming the user will not need it at a certain time in flight.

Reference: HFDS §§ 8.6.1.6 (Consistent coding) and 8.1.1.6 (Minimizing the user's short-term memory load).

4.1.15 Differentiate between Active and Future gNOTAMs

Need: If users cannot differentiate between gNOTAMs that are currently active and those that will become active in the future, then they may develop an inaccurate understanding of how current and future NOTAMs impact their route of flight.

Requirement: The flight deck display shall differentiate between gNOTAMs that are currently active from those that will become active at some point in the future (e.g., at the time of the aircraft's scheduled arrival, within 24 hours, at some other time in the future).

Rationale: Providing information about the future status of gNOTAMs and differentiating between currently active NOTAMs and those that will become active in the future will improve strategic flight planning. For example, providing information to users in advance of a maintenance outage of an ILS will improve strategic flight planning. Note that this guidance also applies to NOTAMs that have an overall effective period, but that are only active during a subset of that effective period (e.g., 1300-1400 on Tuesdays).

Reference: (1) Title 14 CFR § 91.103 Preflight action, (2) §121.601 Aircraft dispatcher information to pilot in command: Domestic and flag operations, and (3) HFDS §§ 8.1.1.8 (Date and time information) and 8.6.1.3 (Coding data categories).

4.1.16 Provide Users with Access to Explanatory Information for gNOTAMs

Need: If users are not provided with a means of interpreting icons, symbols, colors, and other types of coding used in gNOTAMs then users may misinterpret the NOTAM information.

Requirement: The flight deck display shall provide users with explanatory information (e.g., a legend, key) that describes the meanings of icons, symbols, colors, etc. for gNOTAMs. For example, this may take the form of an on-line user guide, external electronic help file, hard copy manual, wizard, video tutorial, or other form.

Rationale: Providing users with a key or legend is critical for comprehension of icons, symbols, colors, etc. of gNOTAMs.

Reference: HFDS §§ 8.16.2.1 (Availability of on-line help), 8.3.2.1.20 (Displaying information about symbols), and 8.3.2.2.26 (Map legend).

4.2 Human Factors Guidance for Crew Interaction with NOTAMs

4.2.1 Differentiate NOTAM Information from Other Data Linked Information

Need: If users are unable to differentiate between NOTAM information and other data linked information (e.g., electronic charts) then users may fail to respond to a message that requires a response or acknowledgment.

Requirement: The flight deck display shall differentiate NOTAM information from other data linked information.

Rationale: Providing users with a way to differentiate between NOTAMs and other types of data linked information will enable the users to fully utilize all information received over data link.

Reference: (1) RTCA DO-340, and (2) HFDS §§ 8.1.4.5 (Display formats), 8.1.3.12 (Task critical information), and 8.6.1.3 (Coding data categories).

4.2.2 Display Text and gNOTAMs on the Flight Deck upon User Request

Need: If users do not have access upon request to the text NOTAMs (and the gNOTAM if available) that have been delivered to the flight deck via data link, then they may not be aware of changing conditions along their route of flight. Furthermore, they could miss or be confused by gNOTAMs, which may only exist for a subset of all NOTAMs and thus may not communicate all the relevant information required for their flight.

Requirement: When data linked NOTAMs are available on the flight deck, text and gNOTAMs shall be available for display upon user request.

Rationale: Because text and gNOTAMs are unlikely to be displayed continuously on the flight deck, it is possible that the list of NOTAMs will not be visible all the time. Providing users with access upon request to the list of available text NOTAMs and gNOTAMs increases their attention to what NOTAMs exist, how they might affect their flight and how to respond to any that impact their flight.

Reference: (1) RTCA DO-340 and (2) HFDS §§ 8.1.3.10 (User control) and 3.12.3 (Provide multiple output formats).