

NBAA Automated Flight Deck Training Guidelines



Published by the National Business Aviation Association, Inc.

Table of Contents

1. Introduction	1
1.1. Background	1
1.2. Scope	1
1.3. Prerequisite Knowledge	2
1.4. Definitions	2
1.5. Acronyms and Abbreviations	2
2. Management of Automation	4
2.1. Levels of Automation	4
2.2. Automation Management Training Objectives	4
3. Component Training Requirements	5
3.1. System Architecture	5
3.2. Electronic Display System	5
3.2.1. Display Units	
3.2.2. Display/Reversionary Controllers	
3.2.3. Engine Indicating and Crew Alerting System	
3.3. Flight Guidance System	5
3.3.1. Flight Guidance Control Panel	
3.3.2. Flight Director	
3.3.3. Autopilot	
3.3.4. Yaw Damper	
3.3.5. Pitch Trim	
3.4. Flight Management System	6
3.4.1. Control Display Unit Operation	
3.4.2. Power-up	
3.4.2.1. Tests	
3.4.2.2. Navigation Database	
3.4.2.3. Date and Time	
3.4.2.4. Software Version	
3.4.3. Initialization	
3.4.3.1. Position	
3.4.3.2. Performance	
3.4.3.3. Takeoff and Landing Data	
3.4.4. Flight Planning	
3.4.4.1. Entry and Modification	
3.4.4.2. Departure/Arrivals	
3.4.4.3. Approach	
3.4.4.3.1. Missed Approach	
3.4.4.4. Alternate Destination	
3.4.5. Holding Patterns	
3.4.6. Direct-To	
3.4.7. Position Sensors	
3.4.8. Radio Tuning	
3.4.9. Lateral Navigation	

3.4.10. Vertical Navigation	
3.4.11. Speed Commands	
3.4.12. Pilot Defined Waypoints	
3.4.13. Intercepts	
3.4.14. Performance	
3.4.15. Dual/Triple FMS Operations	
3.4.16. Flight Status Pages	
3.4.17. Lateral Offsets	
3.4.18. ARINC 424	
3.4.19. FMS Messages	
3.5. Sensors	12
3.5.1. Air Data Computer	
3.5.2. Vertical Gyro/Directional Gyro or Attitude and Heading Reference System	
3.5.3. Inertial Reference System	
3.5.4. Very High Frequency Omni Range/Distance Measuring Equipment	
3.5.5. Global Positioning System	
3.5.5.1. Receiver Autonomous Integrity Monitoring	
3.6. Weather Radar	
3.7. Ground Proximity Warning System /Terrain Awareness and Warning System	13
3.8. Radio Altimeter	13
3.9. Traffic Alert and Collision Avoidance System	14
3.10. Heads Up Display	14
3.11. Autothrottles	14
3.12. Airborne Windshear Alerting System	14
3.13. Radio/Audio Controllers	14
4. Automation Tasks by Phase of Flight	15
4.1. Ground Operations	15
4.2. Takeoff/Departure/Climb	15
4.3. Cruise	15
4.4. Descent	16
4.5. Approach/Landing	16
4.6. Missed Approach/Alternate Destination	16

Acknowledgements

The National Business Aviation Association expresses gratitude to the members of the NBAA FMS/Charting Subcommittee for the creation of these guidelines.

Cover Photo: Honeywell Primus 2000 Integrated Avionics Flight Control System for the Citation X

1. Introduction

This document provides National Business Aviation Association, Inc. (NBAA) recommended training guidelines for aircraft with automated flight decks. The document presents a training outline that represents the minimum curriculum necessary to satisfy an automated flight deck instructional program.

These training guidelines do not mandate how advanced flight deck training is to be implemented. Each training provider must determine the most effective and efficient method to meet the objectives presented in this document.

For the purposes of this document, an *automated flight deck* is defined as an integrated avionics system consisting of at least a flight management system (FMS), flight guidance control system (FGCS) and electronic display system (EDS). Training guidelines also are provided for other advanced avionics, such as autothrottle, terrain awareness and warning system (TAWS), heads up display (HUD), etc.

1.1. Background

Previous philosophies of flight training emphasized manually controlling the aircraft. This has given way to a philosophy that stresses effective use of automation to control flight path and aircraft energy. Despite this new emphasis, a 1996 report by the FAA Human Factors Team identified vulnerabilities in pilot management of automation and situation awareness. It went on to recommend that operators provide guidance on the selection and appropriate use of automation. In addition, operators were urged to examine training to ensure that pilots would begin line operations with sufficient skills for managing advanced flight decks.

On this same topic, the Australian Department of Transport and Regional Development, Bureau of Air Safety Investigation found that traditional training methods “do not adopt a holistic approach to consolidating, or developing, a pilot’s knowledge and understanding of aircraft operation.” (“Advanced Tech-

nology Aircraft Safety Survey Report,” June 1998, p.23). Nearly 60 percent of the professional pilots that were surveyed in this report stated that they would like more “hands-on” avionics and FMS training (in either a dedicated FMS trainer or fixed-base simulator). A smaller percentage suggested that a more in-depth training program on automated systems, automation philosophy and flight guidance mode characteristics would have improved their training.

Part of the challenge in developing any avionics training program is defining what should be taught and how competency should be measured. Currently there exists no consensus within the aviation community (airline, charter, business and private) on how much avionics training is enough, or for that matter, how much is too much. Therefore, a need exists to establish training guidelines for aircraft with automated flight decks.

To address this need, NBAA’s Airspace/Air Traffic Committee formed an FMS/Charting Subcommittee in 1997. Its charter focuses on issues related to FMS and automated flight decks. The FMS/Charting Subcommittee provides a forum for the exchange of information by corporate pilots, airline pilots, certification authorities, training companies and avionics manufacturers. The Subcommittee developed this document to address issues identified during their efforts to improve training and enhance safety.

1.2. Scope

This document is applicable to training programs for aircraft with integrated avionics systems standard from the aircraft manufacturer. The training objectives are designed for an initial course of instruction (i.e., original aircraft type or transition training) rather than a recurrent training program.

The avionics training devices, including simulators, are assumed to replicate the avionics in the aircraft. While this document provides training objectives for many components of an automated flight deck, it is acknowledged that not all components will be standard equipment on all aircraft.

Industry-accepted terminology, abbreviations and acronyms have been used throughout. It is recognized that an aircraft manufacturer may use different acronyms, abbreviations, or trade names to describe

certain components. It may be desirable to substitute the manufacturer's terminology in specific curricula.

As technology advances, new devices will be introduced. For example, the air data/inertial reference system (ADIRS) combines the ADC and IRS functions into a single unit. The pertinent sections of this document (ADC and IRS) remain applicable.

Procedures and equipment unique to international operations (e.g., RVSM, MNPS, etc.) are not covered in this document.

1.3. Prerequisite Knowledge

These guidelines assume prerequisite knowledge and skill in the following areas:

1. Basic IFR procedures
2. Weather radar
3. Theory and principle of crew resource management (CRM)

1.4. Definitions

The term *proficiency* in this document is defined as the ability to accurately perform the task within a reasonable amount of time. The outcome of the task is never seriously in doubt.

The term *objective* in this document is defined as specific skill or knowledge that is to be demonstrated.

The term *shall* is used to indicate a training objective that must be understood by the pilot upon completion of training. These subject areas are considered to be essential in nature and thus, must be included in the training program. Proficiency in these areas will be evaluated, either by a knowledge examination (oral and/or written) or during the course of flight training.

The term *should* is used to indicate a training objective that would supplement avionics training if discussed or taught. These subject areas are considered to be non-essential in nature and do not need to be included in the training program. Proficiency in these areas does not need to be evaluated.

The term *automation* refers to any system of automated guidance and/or control that is capable of altering (either directly or indirectly) the aircraft's flight path or energy state. It implies the allocation of

some flight function (otherwise performed by the pilot) to a machine or piece of avionics equipment. Various levels of automation are said to exist according to the extent that these systems are used in flight.

An *automated flight deck* consists of an integrated avionics system including a flight management system (FMS), a flight guidance control system (i.e., flight director and autopilot), and an electronic display system (EDS). It may also include autothrottles, terrain awareness and warning system (TAWS) and heads up display (HUD).

The term *situational awareness* is defined as the interpretation of electronic, tactile and other cues to determine current position, condition, or situation relative to the total environment.

The term *mode awareness* is situational awareness specific to automation functions. The opposite of mode awareness is often called *mode confusion*.

1.5. Acronyms and Abbreviations

Some common industry-accepted acronyms are provided below.

ACARS – ARINC Communication Addressing and Reporting System
ADC – Air Data Computer
AFIS™ – Airborne Flight Information System™
AFM – Aircraft Flight Manual
AHRS – Attitude and Heading Reference System
AP – Autopilot
ARINC – Aeronautical Radio Incorporated
ATC – Air Traffic Control
ATIS – Automatic Terminal Information Service
BITE – Built-In Test Equipment
CAS – Crew Alerting System *or* Calibrated Airspeed
CAT II – Category II
CCD – Cursor Control Device
CDI – Course Deviation Indicator
CDU – Control/Display Unit
CRM – Crew Resource Management
DA – Decision Altitude
DH – Decision Height
DME – Distance Measuring Equipment
DU – Display Unit
EADI – Electronic Attitude Director Indicator
ECL – Electronic Checklist
EDS – Electronic Display System

EFIS – Electronic Flight Instrument System
EHSI – Electronic Horizontal Situation Indicator
EICAS – Engine Indicating and Crew Alerting System
ETA – Estimated Time of Arrival
ETE – Estimated Time Enroute
FAA – Federal Aviation Administration
FAF – Final Approach Fix
FD – Flight Director
FDE – Fault Detection and Exclusion
FGCS – Flight Guidance Control System
FGS – Flight Guidance System
FL – Flight Level
FMS – Flight Management System
GA – Go-Around
GPS – Global Positioning System
GPWS – Ground Proximity Warning System
HF – High Frequency
HUD – Heads Up Display
IFR – Instrument Flight Rules
ILS – Instrument Landing System
IRS – Inertial Reference System
ISA – International Standard Atmosphere
LNAV – Lateral Navigation
MAP – Missed Approach Point
MCDU – Multifunctional Control/Display Unit
MDA – Minimum Descent Altitude
MFD – Multifunctional Display
MNPS – Minimum Navigation Performance Specification
NAV – Navigation Display
NBAA – National Business Aviation Association
NDB – Navigation Database
NOTAM – Notice to Airmen

PBD – Place/Bearing/Distance
PBPB – Place/Bearing/Place/Bearing
PCMCIA – Personal Computer Memory Card International Association
PFD – Primary Flight Display
PRM – Precision Runway Monitor
PSN – Procedure Specified Navaid
QFE – Altimeter setting referenced to airport field elevation
RA – Resolution Advisory
RAIM – Receiver Autonomous Integrity Monitoring
RVSM – Reduced Vertical Separation Minima
SOP – Standard Operating Procedure
STAR – Standard Terminal Arrival
SW – Southwest
TA – Traffic Advisory
TAA – Terminal Arrival Area
TAS – True Airspeed
TAWS – Terrain Awareness and Warning System
TCAS – Traffic Alert and Collision Avoidance System
TOC – Top Of Climb
TOD – Top Of Descent
TOLD – Takeoff and Landing Data
V1 – Takeoff Decision Speed
VDI – Vertical Deviation Indicator
VFLCH – VNAV Flight Level Change
VG/DG – Vertical Gyro/Directional Gyro
VMO/MMO – Maximum Operating Limit Speed
VNAV – Vertical Navigation
VOR – Very High Frequency Omni Range
VPATH – VNAV Vertical Path
VTA – Vertical Track Alert
WGS 84 – World Geodetic System 1984
WX – Weather

2. Management of Automation

Automated flight decks facilitate improved course guidance and aircraft performance by accomplishing many tasks previously performed manually. The traditional communication interface between pilots has been modified by adding automation.

Flightcrews operating automated flight decks must fully understand and be able to manage all levels of automation and establish standard automation configurations for various phases of flight. Improper understanding of the various levels of automation and or automation management can lead to mode confusion or loss of situational awareness.

High levels of skill in crew resource management are required to manage automated systems effectively. Therefore, training must include automation management, mode awareness procedures and the dangers of mode confusion.

2.1. Levels of Automation

For the purpose of this document, it is useful to describe aircraft operations in terms of four levels of automation.

Level 1 – raw data, no automation at all. The pilot is hand-flying the aircraft without the use of the aircraft flight guidance system. Pilots should revert to this mode of operation when unsure of the status of navigation or flight guidance system (mode confusion) or when they are rushed. This mode also is useful during terminal operations when a last minute runway change is issued and traffic awareness may be compromised if one or both pilots go “head down” to make flight guidance system changes.

Level 2 – Use of flight director and autothrottle (if installed). The pilot is hand-flying the aircraft using the flight director. Level 2 automation is typically used during takeoff and initial departure.

Level 3– Use of flight director, autopilot, autothrottles (if installed). The pilot is flying the aircraft through the flight guidance system and autopilot. This can be referred to as tactical use of automation. Situational awareness can be compromised if at least one crewmember is not tasked with the responsibility of monitoring the aircraft’s flight path.

Level 4– Use of flight director, autopilot, autothrottles (if installed), plus FMS vertical and lateral path guidance. The pilot is flying the aircraft using LNAV/VNAV. This mode can be considered as strategic use of automation. Situational awareness can be compromised if at least one crewmember is not tasked with the responsibility of monitoring the aircraft’s flight path.

2.2. Automation Management Training Objectives

The following objectives shall be understood and demonstrated:

1. Crew briefing of the automation plan for each phase of flight. The automation plan may include lateral and/or vertical mode to be used, navigation source, use of autopilot, etc.
2. Selections of appropriate levels of automation for each task (i.e., going to a higher or lower level) in order to maintain a comfortable workload distribution and situational awareness for the flightcrew.
3. FMS operation and cross check procedures. The FMS operation is accomplished accurately without requiring excessive time.
4. Flight guidance operation and cross check procedures (e.g., FD/AP, displays, autothrottles, etc.). This shall include mode awareness procedures (e.g., verbalization of flight guidance mode selections and status, annunciations, etc.).
5. Selection and configuration of aircraft displays for phase of flight.

3. Component Training Requirements

This section contains training objectives for each component of the automated flight deck. The material in this section provides a foundation for the creation of integrated system training objectives presented in Section 4 of this document.

3.1. System Architecture

Automated flight decks require the passing of digital and analog data between components. The method used to interface the components represents the system architecture.

Objectives that shall be understood:

1. The physical components that make up the automated flight deck (e.g., symbol generator, fault warning computer, etc.) and how they are interfaced via data buses.
2. Operational consequences associated with the failures of data buses and/or components that may occur inflight.

3.2. Electronic Display System

An electronic display system (EDS), with inputs from other systems, provides map, weather displays, airborne traffic and collision avoidance alerts (TCAS/GPWS), and engine and/or aircraft systems indications and or system schematics.

3.2.1. Display Units

Display units (DUs) are the visual interface between the pilots and the automated flight and navigation systems, and in some cases, aircraft systems. These displays may be known as:

- ▲ Primary Flight Display (PFD)
- ▲ Navigation Display (NAV)
- ▲ Electronic Attitude Director Indicator (EADI)
- ▲ Electronic Horizontal Situation Indicator (EHSI)

- ▲ Multifunctional Display (MFD)
- ▲ Display Unit (DU)
- ▲ Engine Indicating and Crew Alerting System (EICAS)
- ▲ Electronic Checklist (ECL).

Objectives that shall be understood:

1. Interpretation of each display (e.g., color, symbology, etc.).
2. Identification of failures modes (e.g., loss of airspeed, loss of altitude, loss of display, comparison monitors, etc.).

3.2.2. Display/Reversionary Controllers

Display controllers allow pilots to control the presentation. In the case of hardware failure (e.g., display units, symbol generators, navigation sources, etc.) the reversionary controllers allow backup display configurations and information source selections to minimize the loss of function.

Objectives that shall be understood:

1. The operation and intended function of each button, knob and annunciation.

3.2.3. Engine Indicating and Crew Alerting System

The engine indicating and crew alerting system (EICAS) is the central location for electronic presentation of engine parameters, warnings, cautions, advisories and system status messages. The display conventions and reversionary capabilities often are very different from traditional mechanical system displays.

Objectives that shall be understood:

1. The display conventions used by the EICAS (e.g., color philosophy, failure indications, etc.).
2. The operation of the CAS (e.g., inhibiting, scrolling and clearing of messages and master/warn indications, etc.).

3.3. Flight Guidance System

Flight guidance and auto-flight systems allow the crew to select guidance modes.

3.3.1. Flight Guidance Control Panel

The flight guidance control panel is the pilot's interface to the flight director and autopilot.

Objectives that shall be understood:

1. The operation and intended function of each button, knob and annunciation.

3.3.2. Flight Director

The flight director computes and displays the necessary pitch and roll commands to achieve the desired flight path.

Objectives that shall be understood:

1. Selection, deselection and confirmation of all flight director modes and submodes. This includes armed and captured annunciations displayed on the EDS associated with each flight director mode.
2. Failure modes of the flight director and operational consequences associated with each failure mode.

3.3.3. Autopilot

The autopilot interfaces to servos that move the aircraft control surfaces.

Objectives that shall be understood:

1. How to engage and disengage the AP.
2. Hazards of providing manual input with AP engaged.

3.3.4. Yaw Damper

The yaw damper trims and adjusts the yaw axis of the aircraft.

Objectives that shall be understood:

1. How to engage and disengage the yaw damper manually. If applicable, the conditions for automatic yaw damper engagement.
2. Failure modes and the operating limitations.

3.3.5. Pitch Trim

The pitch trim system is used by the crew, the autopilot and the mach trim system to maintain longitudinal control authority.

Objectives that shall be understood:

1. How to manually engage and disengage pitch trim. If applicable, the conditions for automatic pitch trim engagement.
2. Failure modes and operating limitations.
3. The operation of Mach trim (if applicable). Included shall be failure modes and operating limitations.

3.4. Flight Management System

The primary purpose of a flight management system (FMS) is to manage navigation sensors to produce a composite position. Using this position, along with flight planning capabilities, the FMS can perform navigation and guidance tasks. In addition, some FMSs provide performance predictions for the flight.

3.4.1. Control Display Unit Operation

The control display unit (CDU) is the pilot's interface to the FMS. In this document, the term CDU also applies to a system that uses a multi-functional control display unit (MCDU).

Objectives that shall be understood:

1. The operation and function of line select keys, function keys and annunciators.
2. The display conventions used by the CDU (e.g., color philosophy, inverse video, pilot required input versus optional input, etc.).

3.4.2. Power-up

3.4.2.1. Tests

Built-in test equipment (BITE) normally is incorporated into electronic equipment for self monitoring during power-up and operation.

Objectives that shall be understood:

1. How to verify that power-up tests are performed correctly by the FMS. Only the tests visible to the pilot need be understood.
2. The required action by the pilot should the power-up tests fail.

3.4.2.2. Navigation Database

The navigation database (NDB) contains nav aids, airways, departure/arrival procedures, approach procedures, airports and runways.

Objectives that shall be understood:

1. How to verify or select (if applicable) the current navigation database within the FMS.
2. Operating limitations of using an expired navigation database.
3. Navigation charts, supplemented by NOTAMs, supercede the electronic navigation database.

Objectives that should be understood:

1. How to perform a navigation database update (e.g., disks, PCMCIA card, etc).
2. The frequency of the updates (e.g., every 28 days).
3. The source of the navigation database update (e.g., FMS manufacturer, a third party, etc.).

3.4.2.3. Date and Time

Date is used to determine NDB effectivity cycle. Time is used in actual and estimated position reporting and planning.

Objectives that shall be understood:

1. How to verify or correct (if applicable) the date and time of the FMS.

Objectives that should be understood:

1. The source of the FMS date and time (e.g., directly from GPS, aircraft master clock, etc.).
2. The effects of incorrect date and time (e.g., RAIM predictions, ETE/ETA, etc.).

3.4.2.4. Software Version

The software version defines the capabilities of the FMS.

Objectives that shall be understood:

1. How to verify the software version.
2. Operating limitations associated with the installed software version.

3.4.3. Initialization

3.4.3.1. Position

The initialization of the FMS position is based upon pilot selections and entries.

Objectives that shall be understood:

1. How to initialize the FMS position (and IRS if applicable).

2. The different methods possible for initialization (e.g., named waypoint, latitude/longitude, etc.).

Objectives that should be understood:

1. The effects of initializing the FMS and IRS to an incorrect position.
2. The effects of FMS restarts on the FMS position while the aircraft is inflight.

3.4.3.2. Performance

Performance initialization is necessary for accurate performance predictions.

Objectives that shall be understood:

1. How to initialize the performance functions.
2. The required entries for the performance functions.
3. Operating limitations associated with the performance function (e.g., VNAV availability when performance is not initialized, advisory information, etc.).
4. The different performance options available (if applicable).

3.4.3.3. Takeoff and Landing Data

The takeoff and landing data (TOLD) function is the automatic computation of takeoff/landing V-speeds and performance data (if applicable).

Objectives that shall be understood:

1. How to initialize the TOLD function.
2. The required entries for the TOLD function.
3. Operating limitations (e.g., advisory information).
4. How to make adjustments to takeoff and landing data, if applicable (e.g., V1 min or max, balanced field length, etc.).

3.4.4. Flight Planning

3.4.4.1. Entry and Modification

A flight plan is a series of waypoints that define an intended route of flight. Each waypoint in the flight plan may be defined laterally and vertically. The course between two waypoints in the flight plan is called a flight plan leg.

Objectives that shall be understood:

1. How to name a flight plan.
2. Different methods of creating an active flight plan (e.g., manual entry, recall from memory, AFIS™, etc.).
3. How to store, copy and activate a flight plan.
4. How to add a waypoint to the flight plan.
5. How to delete a waypoint from the flight plan.
6. How to create pilot defined waypoints.
7. How to change the TO waypoint.
8. How to change the FROM waypoint.
9. How to change the destination.
10. How to recognize and remove discontinuities from the active flight plan.
11. How to enter an airway.
12. How to clear the active flight plan.
13. How to determine and select the correct waypoint from those that have a common identifier in the navigation database.
14. How to close the flight plan.

3.4.4.2. Departure/Arrivals

Departure/arrival procedures are contained in the navigation database. Pilots must be able to insert these procedures efficiently into active flight plans and ensure that the electronic procedures are accurate and clearly understood before commencing the procedures.

Objectives that shall be understood:

1. How to select, activate, modify and remove a departure/arrival procedure.
2. How to select a different departure/arrival once it is activated.
3. How to compare the electronic departure/arrival to the printed departure/arrival procedure (e.g., overfly waypoints, left or right turns, discontinuity, altitude constraints, speed restrictions, etc).
4. How to read ARINC 424 leg types associated with these departure/arrival procedures (e.g., waypoints that are presented on the FMS but not on the paper chart).

Objectives that should be understood:

1. Non-standard (“Special”) departure/arrival (e.g., private procedures, procedures requiring special authorization, etc).

3.4.4.3. Approach

Approach procedures are contained in the navigation database. Pilots must be able to insert these procedures efficiently into active flight plans and ensure that the electronic procedures are accurate and clearly understood before commencing the approach.

Objectives that shall be understood:

1. How to select, activate and remove an approach procedure, course reversal, and transition.
2. How to select a different approach/runway once it is activated.
3. How to review procedure turns, holding pattern course reversals, teardrop and DME arcs on the FMS and EDS. Included also is how the FMS flies these terminal procedures.
4. How to compare the electronic approach to the printed approach (e.g., overfly waypoints, left or right turns, discontinuity, altitude restrictions, vertical angles, etc).
5. How to read ARINC 424 leg types associated with approach procedures (e.g., waypoints that are presented on the FMS but not on the paper chart).
6. Background information on WGS 84 and the effects of flying approaches not charted in WGS 84.
7. Annunciation requirements for approaches (e.g., RAIM, approach, etc.).
8. AFM limitations on approaches that can be legally flown by the FMS (e.g., VOR, GPS, etc.).
9. How to use VNAV to fly approaches where the MAP is the runway threshold, past the runway threshold and prior to the runway.
10. Understand the difference between MDA and DA for VNAV approach operations.
11. How to use the altitude preselector during an approach properly.
12. How to determine the FAF and MAP for an approach on the FMS CDU and EDS.
13. Implications/risk of modifying an approach after it has been activated (e.g., deviating from the published final approach path, obstacle clearances, not entering approach mode, etc.).
14. Confirming/updating the active waypoint/leg during radar vectoring.

Objectives that should be understood:

1. Non-standard (“Special”) approaches (e.g., private procedures, procedures requiring special authorization, etc).

3.4.4.3.1. Missed Approach

A missed approach procedure is associated with every approach procedure contained in the navigation database. It is extracted from the NDB when the approach procedure is selected and activated.

Objectives that shall be understood:

1. How to append the missed approach procedure to the active flight plan during a go-around (GA).
2. How to reengage LNAV and if applicable, VNAV during the missed approach.
3. How to compare the electronic missed approach to the printed missed approach (e.g., overfly waypoints, left or right turns, altitude constraints, holding pattern, etc).
4. How to read ARINC 424 leg types associated with missed approach procedures (e.g., waypoints that are presented on the FMS but not on the paper chart).
5. How to use the altitude preselector properly during a missed approach.
6. Implications of prematurely activating the missed approach procedure on the FMS (e.g., not entering approach mode, horizontal and vertical deviation scaling, transition to the missed approach prior to completing the approach, etc.).

3.4.4.4. Alternate Destination

The alternate destination and its associated flight plan provide contingency routing in cases where it is not possible to continue to the destination.

Objectives that shall be understood:

1. How to enter, change, or remove an alternate destination for the active flight plan.
2. How to activate the flight plan to the alternate destination.

3.4.5. Holding Patterns

Holding patterns can be defined by the pilot or extracted from the navigation database with

procedures. Once activated in the flight plan, the FMS can enter, fly and exit a holding pattern.

Objectives that shall be understood:

1. How to define, modify, activate and verify a holding pattern in the active flight plan.
2. FMS defaults for holding patterns (e.g., speed, leg time/distance, etc.).
3. How to delete a holding pattern once it has been activated and placed into the active flight plan.
4. How to exit a holding pattern once it is active (e.g., automatically during course reversal, manually selected, etc).

Objectives that should be understood:

1. System limitations with regard to activating and modifying a holding pattern (e.g., too close to the waypoint, modifications to the pattern while in the hold, unable to activate a holding pattern on a waypoint while it is being laterally sequenced, etc.).

3.4.6. Direct-To

Direct-to is the ability to proceed directly to a location from the current aircraft position.

Objectives that shall be understood:

1. How to perform a lateral direct-to to waypoints in the active flight plan.
2. How to perform lateral direct-to to waypoints not in the active flight plan.
3. If applicable, how to undo a lateral direct-to (i.e., direct-to recovery).

Objectives that should be understood:

1. The relationship in sequence/timing between performing a lateral direct-to and engaging LNAV (if not already engaged) to avoid undesired S-turns.

3.4.7. Position Sensors

Position sensors provide position and velocity information required by the FMS to navigate the aircraft.

Objectives that shall be understood:

1. The types of sensors interfaced to the FMS.
2. How to access, interpret and operate the CDU pages associated with the position sensors.

3. How to remove or reselect a sensor from the navigation solution (if applicable).
4. The blending or weighting logic of sensors used to compute the FMS position.
5. Any phase of flight operating limitations for a sensor (e.g., IRS is approved for sole means oceanic operations, but not for sole means approach operations).

Objectives that should be understood:

1. The sensor priority logic (e.g., FMS 1 uses sensor 1, FMS 2 uses sensor 2, etc.)

3.4.8. Radio Tuning

Some FMSs are capable of tuning radios.

Objectives that shall be understood:

1. If applicable, tuning modes associated with a radio (e.g., auto, remote, manual, etc.).

Objectives that should be understood:

1. How to access and operate the radio tuning page of the FMS (if applicable). This includes effects on the active and preset function.
2. Familiarity with failure indications (e.g., the radio not tuning the request frequency, no valid data from the radio, etc.).

3.4.9. Lateral Navigation

Lateral navigation (LNAV) is the function in the FMS that sends commands to the flight guidance computer to steer the aircraft laterally.

Objectives that shall be understood:

1. How to arm LNAV and confirm the associated annunciations displayed on the EDS.
2. Annunciations for LNAV capture and lateral track alerts (e.g., 30 seconds prior to sequence, turn anticipation distance, etc.).
3. Operating limitations for LNAV (e.g., not approved to fly holding patterns, approaches, bank authority, etc.).
4. Conditions that result in automatic disconnects for LNAV (e.g., heading legs associated with procedures, a discontinuity, etc.). This includes annunciations displayed on the EDS and required actions by the pilot.
5. The CDI scaling for phases of flight (e.g., higher sensitivity for approach versus enroute operations, linear versus angular deviations, etc.).

Objectives that should be understood:

1. The bank authority limit for LNAV.
2. If applicable, pilot authority for controlling the amount of bank used by LNAV during course transitions.
3. How the FMS laterally sequences waypoints.

3.4.10. Vertical Navigation

Vertical navigation (VNAV) is the function in the FMS that sends commands to the flight guidance computer to steer the aircraft vertically.

Objectives that shall be understood:

1. How to engage and disengage VNAV and confirm the associated annunciations displayed on the EDS.
2. The VNAV submodes supported by the FMS (e.g., VFLCH, VPATH, etc.).
3. Operating limitations for VNAV (e.g., may not be approved for some approach type, VPATH angle limits, QFE, cold temperature, holding patterns, remote altimeter settings, etc.).
4. Annunciations associated with vertical track alerts (VTA) and when they will occur (e.g., 60 seconds prior to TOD, etc.).
5. How to enter, modify and delete waypoint altitude constraints into the active flight plan. This includes AT, AT AND ABOVE, AT AND BELOW altitude constraints.
6. How the FMS flies AT OR ABOVE and AT OR BELOW constraints (e.g., fly through windows or treat AT OR ABOVE as AT constraints).
7. How to perform an altitude crossing restriction using VNAV (e.g., "Cross 20 miles SW of Buckeye VOR at FL230").
8. How to enter, delete and modify a vertical angle in the active flight plan.
9. If applicable, any initialization requirements for VNAV (e.g., performance initialization, etc.).
10. The operational relationship of the altitude preselector and VNAV.
11. Speed protection modes provided by VNAV (e.g., VMO/MMO). This shall include how VNAV will react when airspeed limitations are encountered (e.g., pulling the aircraft off the descent path, etc.).

12. How to use VNAV to fly approaches where the MAP is the runway threshold, past the runway threshold and prior to the runway.
13. The hazards of using VNAV below the MDA or DA (e.g., while it provides guidance it does not provide obstacle protection).
14. How to perform vertical direct-tos to a waypoint and when to use the vertical direct-to.

Objectives that should be understood:

1. How the FMS vertically sequences waypoints (e.g., altitude constraints for waypoints are met when the aircraft is at the bisector of the waypoint).
2. The vertical deviation indicator (VDI) scaling for phases of flights.

3.4.11. Speed Commands

Some FMS provide the ability to define speed commands for different phases of flight (e.g., climb, cruise, descent, etc.). The speed command may be controlled either automatically or manually.

Objectives that shall be understood:

1. The different speed command modes (e.g., automatic, manual, speed intervention). This shall include how to determine the active mode and how to switch modes (if permitted).
2. How to enter, modify and delete a waypoint speed constraint.

Objectives that should be understood:

1. The criteria used by the FMS to transition between speed commands (e.g., transitioning from a climb speed command to a cruise speed command, etc.).
2. How the FMS provides speed protection (e.g., placard speeds, speed/altitude limits, etc.). This should include how the protection and annunciation provided for each VNAV mode possible.

3.4.12. Pilot Defined Waypoints

Pilot defined waypoints are waypoints that do not exist in the navigation database.

Objectives that shall be understood:

1. How to create, edit and delete the different types of pilot defined waypoints (e.g. PBD, PBBP, etc).

Objectives that should be understood:

1. If applicable, the use of EDS joystick/cursor control device (CCD) for the creation of pilot defined waypoints.

3.4.13. Intercepts

The intercept function provides the ability to intercept a desired radial or course.

Objectives that shall be understood:

1. How to fly a heading or course to intercept another course (e.g., final approach course, airway, etc.).
2. How to change the FROM waypoint to facilitate an intercept.

3.4.14. Performance

The FMS performance function is based on entries made by the pilot and input from aircraft systems. Some FMSs provide advanced aircraft performance computational capability.

Objectives that shall be understood:

1. How to access performance data from the FMS.
2. Operating limitations associated with the performance function (e.g., advisory information).

Objectives that should be understood:

1. If applicable, FMS advanced performance features.

3.4.15. Dual/Triple FMS Operations

Many aircraft are equipped with multiple FMS systems that may or may not be able to communicate with each other.

Objectives that shall be understood:

1. The different communication modes between FMSs (e.g., dual, crossfill, sync, triplex, warm spare, etc).
2. The criteria associated for the system to operate in each mode.
3. Any annunciations associated with a change in operating mode.
4. If applicable, how to switch in third FMS following failure of FMS 1 or 2.

3.4.16. Flight Status Pages

The FMS is capable of displaying a large amount of flight status information.

Objectives that shall be understood:

1. How to access flight status information (e.g., TOC and TOD, winds, etc.).

3.4.17. Lateral Offsets

A lateral offset is the ability to fly parallel to the active course line at a fixed, pilot defined offset distance.

Objectives that shall be understood:

1. How to enter, modify and delete a lateral offset.
2. Operating limitations on the use of lateral offsets (e.g., automatic canceling, not allowed for terminal procedures, etc.).

3.4.18. ARINC 424

ARINC 424 provides a standard for preparing and storing the electronic navigation database used by the FMS.

Objectives that shall be understood:

1. Familiarity with the purpose and use of ARINC 424 data by the FMS.
2. ARINC 424 naming conventions for waypoints.

3.4.19. FMS Messages

The FMS provides advisory and alerting information to the operator by means of annunciators or CDU text messages.

Objectives that shall be understood:

1. Different types of FMS messages and annunciators.
2. How to access and clear FMS messages.

3.5. Sensors

3.5.1. Air Data Computer

The air data computer (ADC) provides atmospheric data to the flightcrew and the avionics. This consists of altitudes (pressure and barometric), airspeeds (TAS, CAS, Mach), vertical speed, ISA deviation, etc.

Objectives that shall be understood:

1. ADC test (if applicable).

2. ADC instrument indications.
3. ADC failure recognition and reversionary mode selection.
4. The effects of cold weather on barometric altitude.

Objectives that should be understood:

1. How to access ADC information via the FMS (if applicable).

3.5.2. Vertical Gyro/Directional Gyro or Attitude and Heading Reference System

The vertical gyro/directional gyro (VG/DG) or attitude and heading reference system (AHRS) provide attitude and magnetic heading information to the flightcrew.

Objectives that shall be understood:

1. The operation and intended function of each button, knob and/or annunciation associated with the VG/DG or AHRS.
2. Power-up procedures (if applicable).
3. Failure recognition and reversionary mode selection.
4. Latitude operational limitations of sensor.

3.5.3. Inertial Reference System

The inertial reference system (IRS) provides attitude and heading information to the flightcrew. In addition, the IRS provides position (latitude and longitude), velocity, true and magnetic heading and accelerations.

Objectives that shall be understood:

1. The operation and intended function of each button, knob and/or annunciation associated with the IRS controller.
2. Alignment procedures and indications associated with a correct or incorrect alignment. This includes ramifications of not aligning the IRS to the aircraft present position and moving the aircraft during the alignment process. This also includes quick download align procedures.
3. Failure recognition and reversionary mode selection.
4. Power down procedures (e.g., turn off at mode controller, IRS battery discharge, etc.).

Objectives that should be understood:

1. Position and velocity drift characteristics of an IRS. Included should be the effects of excessive IRS drift on the FMS position.
2. End of flight IRS position accuracy check.
3. The effects of high latitude operations (e.g., true versus magnetic references, IRS operation, etc.).

3.5.4. Very High Frequency Omni Range/Distance Measuring Equipment

VHF omni-directional range (VOR) provides relative position to a navaid. Distance measuring equipment (DME) provides slant range distance to a navaid.

Objectives that shall be understood:

1. Tuning and identification of ground stations.
2. How to select and display VOR/DME data on the EDS.
3. Failure recognition and reversionary mode selection.

3.5.5. Global Positioning System

The global positioning system (GPS) navigation receiver derives aircraft position from a constellation of global positioning satellites. The GPS receiver continuously evaluates this information for integrity and accuracy.

Objectives that shall be understood:

1. The general operating principles.
2. The GPS NOTAM system.
3. Failure annunciations.
4. Operating limitations on the usage of GPS (e.g., failure of sensor during GPS approaches, etc.).

3.5.5.1. Receiver Autonomous Integrity Monitoring

Receiver autonomous integrity monitoring (RAIM) is an onboard means of verifying GPS integrity.

Objectives that shall be understood:

1. The concept and function of receiver autonomous integrity monitoring.
2. Current versus Predictive RAIM.
3. Fault detection and exclusion (FDE)
4. Failure annunciations associated with loss or exceedance of RAIM limits.

5. Operating limitations on the loss or exceedance of RAIM (e.g., loss of RAIM during GPS approaches, etc.).

3.6. Weather Radar

Weather radar is used to avoid hazardous weather.

Objectives that shall be understood:

1. The operation and intended function of each button, knob and/or annunciation associated with the weather radar controller.
2. How weather radar is integrated into the EDS and all display options available.
3. Limitations on the operational use of the weather radar (e.g., turn off while refueling, do not use near ground personnel, etc.).

3.7. Ground Proximity Warning System /Terrain Awareness and Warning System

Ground proximity warning system (GPWS) is a reactive system that blends radio altimeter inputs with ILS glideslope and discrete signals from gear and flap systems in order to provide warnings of impending collision with terrain. Terrain awareness and warning system (TAWS) provides the functionality of GPWS with look ahead capability by displaying terrain on the EDS.

Objectives that shall be understood:

1. Warnings and required response for safe flight (e.g., “sink rate”, “pull up”, etc.). This includes call-outs that may occur during normal operations.
2. How to perform an escape maneuver.
3. How TAWS is integrated into the EDS and options that can be controlled by the pilot.
4. Limitations on the operational use of GPWS/TAWS (e.g., WGS 84, QFE, etc.).

3.8. Radio Altimeter

The radio altimeter measures height above ground.

Objectives that shall be understood:

1. EDS symbology.
2. How to test the radio altimeter if required.

3. Operating limitations associated with the loss of the radio altimeter (e.g., unable to perform CAT II approaches, MEL, etc.).

3.9. Traffic Alert and Collision Avoidance System

The traffic alert and collision avoidance system (TCAS) provides traffic advisories (TA) and resolution advisories (RA).

Objectives that shall be understood:

1. The operation and intended function of each button, knob and/or annunciation associated with the TCAS controller.
2. Differences and significance of TCAS warnings (i.e., TA or RA).
3. How to perform a RA maneuver and ATC issues with RA maneuver.
4. Operating limitations associated with TCAS (e.g., ILS PRM, RVSM, etc.)

3.10. Heads Up Display

The heads up display (HUD) displays flight guidance information onto a combiner glass mounted in front of the pilot.

Objectives that shall be understood:

1. The operation and intended function of each button, knob and/or annunciation associated with the HUD controller.
2. Special CRM issues associated with HUD operations.
3. How to interpret what is displayed (i.e., symbology, etc.).
4. Operating limitations associated with HUD (e.g., CAT II/III, runway requirements, etc.).

3.11. Autothrottles

The autothrottle system provides speed or power control.

Objectives that shall be understood:

1. The operation and intended function of each button, knob and/or annunciation associated with the autothrottles.
2. Operating modes of the autothrottles and how the modes are annunciated on the EDS.

3. Operating limitations on the use of autothrottles (e.g., minimum engagement altitude, etc.).
4. The interaction that exists between flight director/autopilot modes and the autothrottle (e.g., for airspeed descents the autothrottle sets the throttles to flight idle, etc.).

3.12. Airborne Windshear Alerting System

A device or system which identifies the presence of windshear once the windshear is encountered. Some systems also may provide guidance information to the pilot.

Objectives that shall be understood:

1. Warnings and required response for safe flight (i.e., escape maneuver).
2. How windshear is integrated into the EDS.
3. Limitations on the operational use of windshear.

3.13. Radio/Audio Controllers

Radio/audio controllers provide for control of radio and audio.

Objectives that shall be understood:

1. The operation and intended function of each button, knob and/or annunciation associated with the radio/audio controller.

4. Automation Tasks by Phase of Flight

This section provides automation tasks required to be understood and demonstrated for each phase of flight. The training program shall provide “hands-on” practice using the avionics systems in realistic operational flight scenarios (operationally-oriented training). Various procedural tasks will be performed using the automated systems during all normal phases of flight operations (i.e., pre-flight, takeoff, climb, cruise, descent, approach and landing). All the tasks will be performed to proficiency upon completion of initial training.

The level of automation used for each phase of flight will vary depending upon SOP, aircraft equipment, environmental conditions, operation to be performed and other factors. The training program should include all these factors and allow the pilot to choose the appropriate level of automation. It also should allow pilots to perform normal and abnormal checklist procedures as they apply to avionics-related systems. It is assumed CRM is employed for all phases of flight and thus is not specified for each phase of flight.

4.1. Ground Operations

This phase includes all operations from equipment power-up and self-test through the before-takeoff checklist procedures. All initialization and configuration for the initial phases of flight are included.

Objectives that shall be understood and demonstrated:

1. Configuration of flight guidance modes and displays (e.g., selecting FD modes, navigation sources, TAWS, WX radar, TCAS, HUD, etc.).
2. Initialization of the FMS and creation of an active flight plan for the route of flight. This includes:
 - a. Use of datalink (e.g., AFIS™, ACARS, etc.) to obtain ATIS and clearance, as applicable.

- b. Selection of departure runway, departure procedure, route of flight (per clearance).
 - c. Comparison of the electronic departure to the printed departure procedure (e.g., overfly waypoints, left or right turns, discontinuity, altitude constraints, speed restrictions, etc).
 - d. Configuration and verification of takeoff data (e.g. Vspeeds, runway required, etc.).
3. Position sensor management.
 - a. Tuning of departure nav aids, if applicable.
 - b. GPS RAIM check (e.g., destination, alternate) for GPS approaches.
 - c. Quick download align procedures (if applicable).
 4. Crew briefings. This shall include automation plan for the takeoff and departure (e.g., lateral/vertical/autothrottle modes during the takeoff/departure phases, route of flight, altitude restrictions, speed limits, emergency return, etc.).
 5. Reconfiguration of the FMS for runway and departure changes.

Objectives that should be understood:

1. Non-standard (“Special”) departures (e.g., private procedures, procedures requiring special authorization, IRS quick align, etc).

4.2. Takeoff/Departure/Climb

This phase of flight is limited to changes required immediately after takeoff as the aircraft transitions from takeoff to departure and enroute navigation.

Objectives that shall be understood and demonstrated:

1. Selection of flight guidance modes and displays for takeoff and departure (e.g., selecting FD modes, navigation sources, TAWS, WX radar, TCAS, HUD, autothrottles, etc.).
2. Modification of FMS active flight plan to meet revised ATC clearances (e.g., deleting altitude/speed constraints, lateral path, etc.).

4.3. Cruise

The level cruise phase consists mainly of monitoring the flight and responding to external requirements imposed by ATC and/or weather conditions.

Objectives that shall be understood and demonstrated:

1. Selection of flight guidance modes and displays for cruise (e.g., selecting FD modes, navigation sources, TAWS, WX radar, TCAS, autothrottles, etc.).
2. Modification of FMS active flight plan to meet revised ATC clearances (e.g., direct-to, intercepts, holds, etc.).
3. Monitor performance status (e.g., fuel, obtain weather, ETA, etc.).

4.4. Descent

This phase is the transition from cruise flight to the descent. In addition, preparation for the arrival and approach phases normally is conducted during the descent. Landing conditions, procedure selection and review and approach phase briefings normally are completed during this phase of flight.

Objectives that shall be understood and demonstrated:

1. Selection of flight guidance modes and displays for descent (e.g., selecting FD modes, navigation sources, TAWS, WX radar, TCAS, autothrottles, etc.).
2. Initialization of the FMS for arrival phase. This includes:
 - a. Use of datalink (e.g., AFIS™, ACARS, etc.) to obtain ATIS, as applicable.
 - b. Selection of approach runway, approach, arrival procedure (per clearance).
 - c. Comparison of the electronic arrival/approach/missed approach procedure to the printed procedure (e.g., overfly waypoints, left or right turns, discontinuity, altitude constraints, speed restrictions, missed approach hold, etc.).
 - d. Confirmation of landing data (e.g., Vspeeds, runway required, etc.).
 - e. GPS RAIM check (e.g., destination, alternate) for GPS approaches.
3. Crew briefings. This shall include automation plan for the arrival/approach/missed approach (e.g., lateral/vertical/autothrottle modes, route of flight, altitude restrictions, speed limits, missed approach holding pattern, etc.).
4. Reconfiguration of the FMS for runway and arrival changes.

4.5. Approach/Landing

This phase of flight contains the transition to terminal and approach operations. The aircraft is configured and procedures are briefed. Flight duties are centered on ATC compliance and final approach configuration, execution and monitoring.

Objectives that shall be understood and demonstrated:

1. Selection of flight guidance modes and displays for approach/landing (e.g., selecting FD modes, navigation sources, TAWS, WX radar, TCAS, HUD, autothrottles, etc.).
2. Modification of FMS active flight plan to meet revised ATC clearances (e.g., deleting altitude/speed constraints, lateral path, updating active flight plan during radar vectors, etc.).
3. How to fly non-localizer based approaches using LNAV/VNAV (e.g., course reversals, published approach transitions, TAAs, required use of the flight director for GPS approaches, tuning of the Procedure Specified Navaid (PSN) and/or missed approach navaid, proper use of altitude preselector, approach mode annunciations, location of TOD, appropriate minimums, use of VNAV guidance below the MDA, etc.).
4. How to fly localizer based approaches (e.g., transition from FMS to localizer guidance, proper use of altitude preselector, backcourse, appropriate minimums, etc.).
5. Appropriate use of MDA or DA(H) for an approach.

4.6. Missed Approach/Alternate Destination

The missed approach phase of flight extends from the decision to execute the missed approach until the missed approach procedure is terminated. The alternate destination phase of flight starts when the decision is made to proceed to an alternate destination.

Objectives that shall be understood and demonstrated:

1. Selection of flight guidance modes and displays for missed approach (e.g., selecting FD modes, navigation sources, autothrottles, etc.).
2. Use of LNAV/VNAV to fly a missed approach (e.g., published missed approach procedure, proper use of altitude preselector, etc.).

3. Modification of FMS active flight plan to meet revised ATC clearances (e.g., deleting altitude/speed constraints, lateral path, updating active flight plan during radar vectors, holding pattern changes, etc.).
4. Initialization of the FMS for another approach. This includes:
 - a. Selection of approach runway, approach, arrival procedure (per clearance).
 - b. Comparison of the electronic arrival/approach/missed approach procedure to the printed procedure (e.g., overfly waypoints, left or right turns, discontinuity, altitude constraints, speed restrictions, missed approach hold, etc).
 - c. Confirmation of landing data (e.g. Vspeeds, runway required, etc.).
 - d. RAIM checks for GPS approaches (if applicable).
5. Modification of the FMS active flight plan to divert to alternate destination. This includes:
 - a. Use of datalink (e.g., AFIS™, ACARS, etc.) to obtain ATIS, as applicable.
 - b. Selection of approach runway, approach, arrival procedure (per clearance).
 - c. Comparison of the electronic arrival/approach/missed approach procedure to the printed procedure (e.g., overfly waypoints, left or right turns, discontinuity, altitude constraints, speed restrictions, missed approach hold, etc).
 - d. Confirmation of landing data (e.g. Vspeeds, runway required, etc.).
 - e. RAIM checks for GPS approaches (if applicable).