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Flight Management System (FMS)

RATIONALE

This document has been reaffirmed to comply with the SAE 5-Year Review policy.

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1. SCOPE:

This document recommends criteria and requirements for a Flight Management System (FMS) for transport aircraft.

The FMS shall provide the functions of Lateral Navigation, Vertical Navigation, and Performance Management and may include Time of Arrival Control. The FMS design shall take Human Factors considerations into account to produce a fault tolerant system.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. The latest issue of all SAE Technical Reports shall apply.

This Annex should be used in conjunction with the ARP4102 Core Document.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP4102/4	Flight Deck Alerting System (FAS)
ARP4102/6	Communication and Navigation Equipment
ARP4102/7	Electronic Displays
ARP4105	Nomenclature and Abbreviations
ARP4103	Instrument and Flight Deck Lighting

2.1.2 FAA Publications: Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

AC 90-45A	FAA Advisory Circular

2.1.3 Other Publications:

XAD/IL/0118/1-19	CAA Airworthiness Leaflet Flight Management Systems
ARINC 424	Specification Navigation Systems Data Base
ARINC 702-6	Flight Management Computer System
RTCA DO-187	MOPS for Airborne Area Navigation Systems using multi-sensor inputs
ICAO Annex 4	International Civil Aviation Organization, Annex 4 to the Convention on International Civil Aviation

2.2 Definitions:

APPROACH GATE: A point on the final approach track representing the minimum distance from the threshold at which vectored or instructed aircraft should intercept the final course. This normally will be (1) NM outside the final navaid or (5) NM from threshold, whichever is greater.

BASIC NAVIGATION: Course, Track, Path, Profile and several related terms are defined below. Recent navigation systems have tended to discard the term "Course" in favor of "Track", but still show track in angular terms. In the following definitions, great circle course and desired track angle are equivalent. Track has also been applied to the vertical plane when prefixed by "vertical" (i.e., vertical track, etc.). However, the terms "Path" and "Profile" are preferred as representing an earth referenced three-dimensional path in the sky (altitude, latitude and longitude).

BOTTOM OF DESCENT (BOD or B/D): The last waypoint in the decent flight phase. See also End of Descent (EOD).

CLEAR (CLR): A CDU term usually associated with the “Clear Key”. Pressing the Clear Key erases a previous entry in the Scratch Pad field (typically last line of the display).

CLIMB INTERCEPT POINT: The geographical position at which a designated climb altitude is attained, also referred to as "Top of Climb" point.

CONSTRAINT (CSTR): A speed or altitude or time restriction or restraint usually related to some downstream waypoint.

CONTROL DISPLAY FUNCTION (CDF): The FMS function that allow the flight crew to interact with the FMS through data entry and display of information. In current systems this function is provided by the CDU, MCDU, MCP, and various displays and status panels. In future systems the control and display function may be allocated to different hardware devices. For example a key pad and pointing device may be used for data entry and to interact with a Graphical User Interface display (GUI) on the Main Flight Displays.

CONTROL DISPLAY UNIT (CDU): In current systems this is a hardware device which allows the pilot to interface with the FMS and other systems for the purpose of displaying alpha numeric information, data entry, mode selection and alerting (See also Multifunction Control Display Unit and Control Display Function (CDF).

COST INDEX (CI): The operator's cost factors for a specific flight that takes into account variable costs, such as fuel, and time related costs, such as crew flight time pay to achieve the desired flight profile.

COURSE (CRS): The direction of horizontal travel, expressed as a clockwise angle from a reference direction (usually true or magnetic north).

2.2 (Continued):

CROSS TRACK DISTANCE/ERROR/DEVIATION (XTK/XTE): The shortest distance between the aircraft's present position and the desired track. Cross track distance is left when present position is left of the desired track and right when present position is right of the desired track.

DEFAULT: A CDF term associated with applying a pre-stored input to a data field or computation if no other value is entered by the pilot.

DELETE (DEL): A CDF term associated with deleting an item or an entire line.

DESCENT INTERCEPT POINT: The geographical position where the cruise path intersects the descent path. Also, referred to as the Top of Descent Point. Signifies the geographic position where the aircraft transitions from the Cruise Flight Phase to the Descent Flight Phase.

DESIRED TRACK: The imaginary line on the earth's surface connecting successive points over which flight is desired.

DESIRED TRACK ANGLE (DTK or DSRTK): The clockwise angle from true or magnetic north to an imaginary line or path on the earth's surface. This line describes the great circle path between two successive waypoints on the earth's surface and is also defined by the intersection of a plane that passes through two successive waypoints on the earth's surface and the center of the earth.

DISTANCE (DIST or DIS): The great circle distance between designated positions, points or waypoints.

DISTANCE TO GO (DTG): The great circle distance between the present position and the "TO" waypoint or the accumulative distance between the present position and a designated downstream waypoint or waypoints.

DRIFT ANGLE (DA): The angle between the aircraft's longitudinal axis and ground track or the angular difference between true heading and ground track angle. Drift angle is left when ground track angle is less than true heading and right when ground track angle is greater than true heading.

EARTH REFERENCE OR INERTIAL: Referenced with respect to the earth, as opposed to referenced with respect to the air mass.

ECONOMY (ECON): A FMS designation implying a favorable "economic" mode of operation. The term has been variously applied to min cost climb, cruise and descent schedules and engine climb de-rate schedules.

END OF DESCENT (EOD or E/D): The metering fix, clearance, or other scheduled end point for the main descent from enroute cruise. If a level flight deceleration segment is programmed at the end flight level, the EOD will be the downstream end of that segment. The EOD includes a geographical position, altitude and speed. It may also include a required or estimated time of arrival. See also Bottom of Descent (BOD).

2.2 (Continued):

EXECUTE (EXEC): A CDF term usually associated with safeguarding by requiring a second confirmatory action.

FLEXIBILITY (TIME): A term representing the FMS range of control over arrival time at a designated downstream waypoint or waypoints. It may be expressed as an RTA maximum and RTA minimum in respective UTC hours: minutes: seconds.

FLIGHT CONTROL PANEL (FCP): Provides control functions for the Flight Director, Auto Pilot, Auto Throttle (Flight Guidance System) and the Flight Management System. Referred to as the Mode Control Panel (MCP) on some aircraft.

FLIGHT MANAGEMENT COMPUTER (FMC): The FMC is the hardware element of the FMS that hosts the Flight Management Function.

FLIGHT MANAGEMENT FUNCTION (FMF): The FMF is a function that computes the aircraft navigation solution, predicts the performance of the aircraft along a defined lateral and vertical flight plan path and provides guidance information to the Flight Guidance system to control the aircraft to fly along that path. On many current systems the FMF is hosted in a Flight Management Computer and uses a Control Display Unit for data entry and display however the FMF does not necessarily require a dedicated computer and may be hosted on a computer that is also running other software functions and the control and display does not necessarily have to be done on a CDU.

FLIGHT MANAGEMENT SYSTEM (FMS): The FMS is the combination of hardware and software that is required to perform the Flight Management Function.

FLIGHT PATH ANGLE (FPA): The angle in the vertical plane between the horizon and the aircraft's flight path or velocity vector. The normal usage implies current angle. The velocity vector may be referenced to either the air mass or the earth in which case the FPA is either air mass or earth referenced (inertial).

FOUR DIMENTIONAL CONTROL (4D): Control of an aircraft in the dimensions of latitude, longitude, altitude and time.

FUNCTIONS: Those features which individually or collectively define the operating modes of the FMS. These functions are described in 3.2.

Global Positioning System (GPS): A space based satellite navigation system that provides accurate 3 dimensional position and time anywhere in the world.

GRAPHICAL USER INTERFACE (GUI): A methodology for control and display of information on a graphical display using a pointing device to select and act on displayed information.

2.2 (Continued):

GREAT CIRCLE COURSE (CRS): The direction of the great circle through the point of departure and the destination expressed as a clockwise angle from a reference direction (usually north) to the great circle. The angle varies from point to point along the great circle.

GROUND TRACK/ACTUAL TRACK: The imaginary line or path on the earth's surface connecting successive points over which the aircraft has flown.

GROUND TRACK ANGLE/ACTUAL TRACK ANGLE (TRK or TK): The clockwise angle from true north to an imaginary line on the earth's surface connecting successive points over which the aircraft has flown (ground track). The normal usage implies present track angle, i.e., using the most recent successive points over a relatively short period of time.

GROUND PROXIMITY WARNING SYSTEM (GPWS): A device which provides alerts based on altitude above the ground level (AGL), and may provide alerts incorporating configuration, closure rate, or other factors affecting the flight safety related to flight path and altitude AGL". See Also Terrain Awareness Warnings System (TAWS).

INS-DEPENDENT: A FMS that is dependent upon the INS for steering guidance.

LATERAL NAVIGATION (LNAV): A function which provides navigation data in the horizontal plane and provides command signals to the roll channel of the flight guidance system and pilots displays.

METERING FIX (MF): The airport arrival flow control points used by Air Traffic Control to meter spacing for landing. Usually associated with a required Flight level, Speed and ETA.

MINIMUM ENROUTE ALTITUDE (MEA): The lowest published altitude between radio fixes which assures acceptable navigational radio coverage and meets a the obstacle clearance requirements between those fixes. This minimum altitude applies to the entire width of the airway segment or route between the radio fixes.

MINIMUM SECTOR ALTITUDE (MSA): The minimum altitude that is allowed in defined sectors in the terminal area to clear obstacles.

MINIMUM VECTOR ALTITUDE (MVA): The minimum altitude that is allowed in the terminal area to clear obstacles while the aircraft is being given radar vectors by ATC.

MODE CONTROL PANEL (MCP): Provides control functions for the Flight Director, Auto Pilot, Auto Throttle, (Flight Guidance System) and the Flight Management System. Referred to as the Flight Control Panel (FCP) on some aircraft.

MULTI-FUNCTION CONTROL AND DISPLAY UNIT (MCDU): A device which allows the pilot to interface with the FMS and other systems for the purpose of displaying alpha numeric information, data entry mode selection and alerting.

2.2 (Continued):

NAVAID: A general term for ground based VHF enroute and terminal navigation aids including VOR, VOR/DME, VORTAC, DME and Low Frequency beacons. Landing systems such as ILS and MLS and space based systems such as GPS, GNSS, GLONAS. are usually not included.

NAVIGATION DATABASE (NDB): The Flight Management System (FMS) Database that contains information that will enable the aircraft to navigate along the enroute airways waypoints and airport terminal procedures that are specified in the flight plan. This database can be tailored for the geographic area and airports where the aircraft is expected to operate. The NDB is typically stored in a semi-permanent memory device so that it does not need to be reloaded each time power is applied to the FMS. This data base needs regular 28 day updates in conjunction with ICAO Annex 15 Chapter 6 Aeronautical Information Regulation and Control (AIRAC).

OPTIMUM ALTITUDE: The most economical altitude to fly based on gross weight, cost index, and trip length.

PERFORMANCE MANAGEMENT (PM): Systems which provide guidance signals to control the aircraft in climb, cruise and descent to achieve optimum or desired performance (minimum cost, minimum fuel, select IAS/Mach, maximum gradient, etc.). These guidance signals may be directed to the flight guidance system pitch channel, auto throttles and pilot displays.

PERFORMANCE FACTORS: Factors computed or applied to basic performance representing individual aircraft variance with the standard. It may be expressed as a percentage drag factor, fuel factor or be combined with specific fuel consumption (SFC). Performance factors may also represent an assigned minimum maneuver margin (buffet boundary) or minimum climb and cruise rate of climb.

PRESENT POSITION (PPOS): The latitude and longitude coordinates of the point on the earth's surface directly below the aircraft at any given instant. May also be three-dimensional, including altitude.

PROFILE PATH: An imaginary earth referenced line in space connecting successive three-dimensional points through which flight is desired and/or controlled (altitude, latitude and longitude). The flight path angle (see above) may be varying or constant, resulting in a curved or straight lateral or vertical profile.

RNAV: Navigation using an Area Navigation System or Flight Management System using one or more Navigation sensors to control the aircraft along a predefined Flight Plan Path in the Lateral and/or Vertical planes depending on the capability of the equipment that is being utilized. This term is currently used interchangeably with LNAV (Lateral Navigation) and VNAV (Vertical Navigation).

REQUIRED TIME OF ARRIVAL (RTA): A term associated with 4 dimensional aircraft control to arrive at a given waypoint at a prescribed time. Entry of an RTA implies that arrival at a geographic point in space at a given time is a higher priority that operating the aircraft to achieve optimum fixed or variable costs so the Cost Index is recomputed to achieve the Required Time of Arrival.

2.2 (Continued):

SPEED CLIMB (SPD CLB)/SPEED DESCENT (SPD DES): Vertical Modes which maintain an assigned speed (or Mach) usually with the elevator or stabilizer. The throttle/thrust setting may be fixed or variable and may be used independently. These modes may be used independently from Lateral Navigation.

TERRAIN AWARENESS WARNING SYSTEM (TAWS): A predictive device which utilizes a terrain database and aircraft altitude sensors to alert the crew of impending collision with terrain along the flight path. TAWS is a more general term for Ground Proximity Warning System (GPWS) or Enhanced Ground Proximity Warning System (EGPWS).

TIME ERROR: The difference between the current ETA and the Required Time of Arrival (RTA) at any designated downstream waypoint or waypoints.

TIME OF ARRIVAL CONTROL - SPEED MANAGEMENT: The functions which provide guidance for adjusting speed and/or flight path so as to conform with air traffic flow control arrival time requirements at a designated downstream waypoint or waypoints. The flight plan should normally include a specified altitude and an arrival speed. The command signals may be directed to the flight guidance system as well as pilot displays.

TIME TO GO (TTG): The time in min (or min:sec) to fly the great circle course from present position to the next waypoint or the cumulative time between present position and a designated downstream waypoint or waypoints.

TOP OF CLIMB (TOC): A calculated point along the Flight Plan that predicts the point where the aircraft will reach the cruise altitude and transition from the climb flight phase to the cruise flight phase.

TOP OF DESCENT (TOD or T/D): A calculated point along the Flight Plan that predicts when the aircraft should start to descend. Denotes the point where the flight phase transitions from Cruise to Descent.

TRACK ANGLE ERROR (TKE): The angle between the aircraft's ground track and the desired ground track or the angular difference between ground track angle and desired track angle. Track angle error is left when the actual track angle is less than the desired track angle and right when the actual track angle is greater than the desired track angle.

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) An aircraft system that will alert the flight crew of other aircraft in the area that may present a risk of collision.

VERTICAL BEARING (VBRG or V/B): The angle in the vertical plane between the horizon and a line from the present position in space to the next three-dimensional defined waypoint.

2.2 (Continued):

VERTICAL NAVIGATION (VNAV or VN): The function which provides guidance signals to control the aircraft during climb or descent to achieve a FPA, path or profile with the capability of crossing any downstream waypoint at a designated altitude and/or speed. These command signals may be directed to the flight guidance system pitch channel and auto throttle/thrust as well as pilot displays.

VERTICAL PATH/V PATH/PROFILE: Terms used to designate climb and descent modes which control the vertical trajectory to specific earth referenced paths or profiles which include one or more three-dimensional waypoints (latitude, longitude and altitude). Usually the path (or profile) is controlled by elevator or stabilizer and the speed by throttles or drag. Other techniques may be used. The path (or profile) may be linear or non-linear.

VERTICAL SPEED/ALTITUDE RATE: The rate of change of altitude. The term usually refers to barometric altitude rate, but may also be radar altitude rate or inertial vertical velocity.

VERTICAL TRACK DISTANCE/ERROR/DEVIATION (VDEV or VTK or VTE): The vertical distance or height between existing altitude and the programmed path or profile altitude.

WIND COMPONENT: The wind component acting along the longitudinal axis of the aircraft. A tailwind is positive.

WIND DIRECTION (WDIR or W/D): The clockwise angle from true north to the wind velocity vector.

WIND PROPAGATION: When the winds at each cruise waypoint in the flight plan have not been entered either manually by the pilot or by datalink (e.g., ACARS) forecast winds uplink the present position instantaneous wind direction and speed is typically used for the calculation of all downstream leg ETE's and ETA's. The ETE's and ETA's are continuously revised as the present position winds change.

WIND SPEED (WSPD or WS): The magnitude of the wind with respect to a point on the earth's surface.

WIND VELOCITY (W/V or WV): The direction and magnitude of the wind velocity vector.

2.3 Abbreviations:

4D	Four Dimensional (Latitude, Longitude, Altitude, Time)
ACARS	Airplane Communications Addressing and Reporting System
ADS-B	Automation Dependant Surveillance Broadcast
AIM	Airman's Information Manual
AIRAC	Aeronautical Information Regulation and Control
AMI	Airline Modifiable Information
ANP	Actual Navigation Performance
AOC	Airplane Operational Control
ATC	Air Traffic Control
ATS	Air Traffic Services
B/D	Bottom of Descent
BOD	Bottom of Descent
CAS	Calibrated Air Speed
CDF	Control Display Function
CDU	Control Display Unit
CI	Cost Index
CLR	Clear
CPDLC	Controller Pilot Data Link Communications
CRS	Course
CSTR	Constraint
DA	Drift Angle
DIS	Distance
DIST	Distance
DME	Distance Measuring Equipment
DSRTK	Desired Track
DTK	Desired Track
E/D	End of Descent
ECON	Economy
EGPWS	Enhanced Ground Proximity Warning System
EOD	End of Descent
EPR	Engine Performance Ratio
EPU	Estimated Position Uncertainty
ETA	Estimated Time of Arrival
ETE	Estimated Time Enroute
EXEC	Execute
FCP	Flight Control Panel
FMC	Flight Management Computer
FMF	Flight Management Function
FMS	Flight Management System
FPA	Flight Path Angle
GBAS	Ground Based Augmentation System
GLONAS	Global Navigation System
GLS	GPS Landing System

2.3 (Continued):

GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GRAS	Ground Based Regional Augmentation System
GUI	Graphical User Interface
HUD	Head Up Display
IAS	Indicated Air Speed
ILS	Instrument Landing System
LAAS	Local Area Augmentation System
LNAV	Lateral Navigation
LRC	Long Range Cruise
MB	Marker Beacon
MCDU	Multifunction Control Display Unit
MCP	Mode Control Panel
MEA	Minimum Enroute Altitude
MF	Metering Fix
MLS	Microwave Landing System
MSA	Minimum Sector Altitude
MVA	Minimum Vectoring Altitude
NDB	Navigation Database or Non-Directional Beacon
NM	Nautical Miles
OAT	Outside Air Temperature
PFD	Primary Flight Display
PM	Performance Management
PPOS	Present Position
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
SBAS	Space Based Augmentation System
SID	Standard Instrument Departure
SPD CLB	Speed Climb
SPD DES	Speed Descent
STAR	Standard Terminal Arrival Route
T/D	Top of Descent
TACAN	Tactical Air Navigation
TAS	True Air Speed
TAWS	Terrain Awareness Warning System
TCAS	Traffic Alert and Collision Avoidance System
TIS	Traffic Information System
TK	Track
TKE	Track Angle Error
TOC	Top of Climb
TOD	Top of Descent
TRK	Track

2.3 (Continued):

TTG	Time To Go
UTC	Universal Time Code or Coordinated Universal Time
V/B	Vertical Bearing
VBRG	Vertical Bearing
VDEV	Vertical Deviation
VHF	Very High Frequency
VN	Vertical Navigation
VNAV	Vertical Navigation
VOR	VHF Omni Range
VS	Vertical Speed
VSD	Vertical Situation Display
VTE	Vertical Track Error
VTK	Vertical Track
W/D	Wind Direction
W/S	Wind Speed
W/V	Wind Velocity
WAAS	Wide Area Augmentation System
WDIR	Wind Direction
WSPD	Wind Speed
WV	Wind Velocity
XKT	Cross Track
XTE	Cross Track Error

3. OPERATIONAL REQUIREMENTS:

3.1 FMS System Performance:

The FMS shall perform the navigation, guidance (lateral and vertical), performance management and speed-time control functions that are necessary to control and guide the aircraft along a defined flight plan in the most energy efficient and/or cost effective manner while complying with Air Traffic Management constraints.

3.1.1 FMS Responsiveness: The FMS shall provide the flight crew with the information necessary for timely decision making throughout the flight.

The FMS shall allow the crew to immediately take control of the aircraft to respond to ATC instructions. The crew can then reprogram the FMS to fly the new flight path and return control to the FMS.

Simple routing changes, (e.g., "Direct To", climbs and descents) should be able to be entered into the FMS CDF (e.g., CDU and MCP) and a flight guidance response should begin within 2 seconds.

Complex routing changes will be a function of the number of FMS CDF (e.g., CDU and MCP) entries required but once activated, the flight guidance response should begin within 5 seconds. The display presentation of related information, (i.e., ETA) should not exceed 5 seconds after entry.

3.1.2 Pilot Workload: The FMS shall not add to flight deck workload at critical phases of flight (generally departures and arrivals) compared to the workload for non-FMS equipped aircraft. Further, during any flight phase, the workload shall not be so significant as to cause crew distraction or interference with other normal duties.

3.1.3 Effect of Electrical Power Transients: Electrical transients or loss of power shall not cause the FMS to lose or change the flight plan, displays, operating modes or loaded databases.

After short duration transients operation should resume without significant pilot attention or action.

After longer duration interruptions, pilot corrective procedures shall require only correction of the time based functions such as UTC, navigation position, gross weight/fuel, etc. Appropriate warnings and procedural steps should be spelled out on the CDF or the updating and position fixing should be automated.

Erasure of the flight plan after completion of the flight should not be automatic and should require deliberate flight crew action. Clearing the flight plan should not be based on cycling power to the FMS system.

3.2 Systems That Interface With The FMS:

The FMS shall accept inputs from and provide outputs to various aircraft systems as required to perform its functions.

All inputs to the FMS should be monitored for reasonableness. Inputs that exceed tolerances should be rejected and appropriate alerting shall be provided.

3.2.1 Control Display Function: The Control Display Function (CDF) shall have the capability to control the FMS. The Control Display Function may be performed by a Control Display Unit (CDU) or another device or devices. The CDF data entry device and display shall respond to pilot inputs with a suitable feedback indicating that the inputs are being properly processed. This should occur in a timely manner that is non-distracting or disruptive to the pilot. In general, the CDF should respond within 0.5 seconds or less (complex computations shall not exceed 5 seconds) with a minimum of blinking and/or blanking and the fewest possible line changes.

3.2.1.1 Display Field Blanking: If possible, only the display field being selected or changed by the pilot should be blanked. The time for the selected/changed data field to be refreshed should be as short as possible and preferably less than 0.5 seconds.

3.2.1.2 Display and Control: The CDF shall have display, data entry and control capability. When more than one FMS is installed, the CDF shall be capable of displaying data from either system, and shall be capable of providing data and control functions to either system.

3.2.1.3 Use of Color: The use of color by the CDF is desirable. When colors are used the flight deck design philosophy should be followed to coordinate color usage.

3.2.1.4 Reasonable Manual Data Input Limits: Reasonable values ranges and limits should be established for all data entry parameters. The CDF should display a descriptive alert for any unreasonable input. The parameters listed below (not an exhaustive list) are critical to safe flight and should be carefully validated to minimize the potential for input errors:

a. Gross weight
b. Zero Fuel Weight
c. Fuel load
d. Temperature
e. Barometric pressure
f. Wind velocity
g. Cruise altitude
h. Speed
i. Flight path angle (too steep)
j. Vertical speed
k. EPR or N1
l. Altitude below obstacle clearance

3.2.1.5 Waypoint Loading: When the CDF is used to control waypoint loading into the INS or other systems, it shall load sufficient waypoints to ensure a reasonable period of uninterrupted navigation in the event of FMS failure until abnormal or backup procedures can be instituted.

3.2.1.6 Error Messages and Alerts: The CDF shall provide for the display of error messages and alerts. A message light may be provided to alert the crew that a message is waiting when it cannot be immediately displayed because another message has not been acted on or the message display area is being used for another purpose.

Messages and alerts shall be readily understood. The use of codes and non-standard abbreviations should be avoided.

Color coding may be utilized to indicate urgency or priority of the message.

3.2.1.7 CDF Failure: No failure of the CDF shall degrade the operation or function of the aircraft's basic navigation equipment.

3.2.2 Mode Panel(s): Pilot inputs to the FMS may be made through the flight guidance, mode panel(s), including direct intervention to vertical and lateral navigation and speed management modes. Information concerning selected flight modes such as Autopilot Engagement, Altitude Restrictions. Speeds, Heading Selection, Lateral and Vertical Navigation engagement shall be displayed on these panel/s using various methods including, but not limited to, data display windows, switch lighting, and switch position indication.

3.2.2.1 Readability: Panels and controls shall be clearly readable under all ambient lighting conditions (Reference ARP4102 Core and ARP4103).

3.2.3 Displays:

3.2.3.1 Electronic Navigation Display (ND) (ARP4102/7): The FMS shall assemble and process all data required to support a pictorial display of the flight plan.

3.2.3.1.1 Formats: The following formats shall be provided as a minimum: MAP, PLAN, ARC and ROSE.

MAP, PLAN and ARC formats shall present only flight plan related waypoints. The following additional selectable features are recommended:

a. Navaids
b. Waypoints
c. Airports
d. Speed, altitude, time constraints
e. Minimum Sector Altitude (MSA)
f. Minimum Enroute Altitude (MEA)
g. Restricted Areas
h. Flight Plan constraints

3.2.3.1.2 Map Range: A suitable scale factor and selection of map ranges shall be provided in even multiples, commensurate with the display size and aircraft characteristics.

3.2.3.1.3 Orientation: The Navigation Display may have the following orientations:

a. Heading-up
b. North-up
c. Track-up

The display orientation should be clearly labeled including whether it is oriented to Magnetic or True.

3.2.3.1.4 Look Ahead Display Presentation: All flight plan down stream waypoints on the selected Navigation Display scale shall be displayed. Any down stream waypoint may be selected as the center of the display.

3.2.3.1.5 Look Back Display Presentation: The capability to display a limited number of "from" waypoints on the display after waypoint passage is recommended. Flight plan waypoints removed by use of the "Direct To" function may be retained for possible re-use.

3.2.3.1.6 Flight Plan Modification: It is desirable to utilize a cursor or pointing device for interaction with the graphic display as a means of flight plan modification and/or waypoint insertion. Line texture and/or color should be used to indicate the proposed modification to the Flight Plan until the Pilot accepts the modification and it becomes the active flight plan.

3.2.3.1.7 Symbology: The following information should be displayed:

a. Track/Course: The actual track "from" and the desired track/course "to".

b. Predictive Track: Up to three 30 second segments. A predicted track display ahead of present position.

c. Altitude Intercept Arc or Symbol: Arc or symbol showing predicted distance to reach selected altitude.

d. Speed-Time Reference: Time box, speed arc (or other) symbology providing guidance for making good ETA requirements.

e. MSA/MEA/MVA

f. Path Intercept Symbol: Symbol showing predicted distance to reach calculated descent path.

g. Predicted Energy Circle

3.2.3.1.8 Display Update: Display update rates must be sufficient for smooth operational use of the functions intended. One update every 2 seconds is required for basic navigation. Requirements for predictive track or flight path displays are significantly faster (at least 16 updates per second) to ensure the display does not ratchet during turns. Data from the FMS navigation data base should be processed and formatted as required by the FMS for transmission to the Navigation Display.

3.2.3.2 Vertical Situation Display (VSD): A Vertical Situation Display should be provided in the pilot's primary field of view to enable the crew to quickly visualize the vertical path and continuously monitor deviations to it. The VSD should include the ability to select and obtain positive guidance to vertical select points. The FMS shall assemble and process all data required to support a pictorial display of the vertical flight plan.

3.2.3.3 Primary Flight Display (PFD): The PFD shall display at minimum aircraft attitude, altitude, and airspeed. Typically the FMS only provides speed and altitude targets and certain mode annunciation information to the PFD with primary flight information being provided directly from the inertial reference system and the air data computer.

3.2.3.4 Head Up Displays (HUD): The FMS shall be capable of providing data to Head Up Displays including guidance data. As with the PFD typically the FMS only provides speed and altitude targets and certain mode annunciation information to the HUD with primary flight information (i.e., Altitude, Attitude, Airspeed, Heading) being provided directly from the Inertial Reference System and the Air Data Computer.

3.2.4 Radio Navigation: The FMS shall have the locations of the ground based radio navigation aids in its Navigation Database and determine the closest stations with the best geometry to be used for navigation position determination and then be capable of automatically tuning the selected stations. The FMS shall then blend this information from these stations along with inertial navigation position into a composite FMS position taking into account the accuracy of each sensor. The FMS shall calculate the Actual Navigation Performance (ANP) also referred to as the Estimated Position Uncertainty (EPU) and compare it to the Required Navigation Performance (RNP) stored in the Navigation Database and alert the Pilot if the ANP is greater than the RNP.

When the navigation radios are placed in the manual mode, the FMC shall use the available radio data for position updating if it meets the FMS's thresholds for radio updating.

3.2.4.1 Radio Navigation Aids: The following Radio Navigation Aids shall be supported by the FMS:

a. VOR - VHF Omni Range
b. DME - Distance Measuring Equipment
c. TACAN - Tactical Air Navigation
d. MB - Marker Beacon
e. NDB - Non Directional Beacon

3.2.4.2 Radio Altimeter: The Radio Altimeter information shall be available to the FMS for vertical guidance below 2500 ft above the terrain.

3.2.4.3 Global Positioning System (GPS): The FMS shall be able to accept navigation position, altitude and time information from a GPS or Global Navigation Sensor System (GNSS) receiver and use it as a component of the FMS position navigation solution.

3.2.4.3.1 Wide Area Augmentation System (WAAS): The FMS shall be able to accept differential GPS correction information to improve position accuracy and non-precision landing guidance. WAAS is the Space Based Augmentation System (SBAS) that is planned for North America. Other Augmentation Systems are in development for other parts of the world.

3.2.4.3.2 Local Area Augmentation System (LAAS): LAAS is a Ground Based Augmentation System (GBAS) or Ground Based Regional Augmentation System (GRAS) that provides differential GPS corrections. When available the FMS shall be able to accept differentially corrected GPS information from the LAAS/GBAS/GRAS to improve GPS position accuracy beyond the accuracy available with WAAS/SBAS. The GPS Landing System (GLS) will use the LAAS/ GBAS/GRAS information to provide precision landing guidance.

3.2.5 Landing Systems: Depending on the approach selected from the FMS Navigation Database the FMS shall be able to tune the appropriate landing system.

The display presentation to the pilot, above or below vertical path and left or right of lateral path, shall be the same for all landing systems.

The paragraphs below discuss landing systems in common use today however this does not preclude the FMS from supporting other landing systems that are not in common use or that are developed in the future.

3.2.5.1 Instrument Landing System (ILS): The FMS shall be able to tune the ILS from the Navigation Database depending on the selected procedure at the destination airport (e.g., I27L) and direct the aircraft to a position to capture the glide slope and localizer at which time the guidance of the aircraft is transferred from the FMS to the ILS, flight director and autopilot.

3.2.5.2 Microwave Landing System (MLS): The FMS shall be able to tune the MLS from the Navigation Database depending on the selected procedure at the destination airport (e.g., M27L) and direct the aircraft to a position to capture the MLS approach path at which time the guidance of the aircraft is transferred from the FMS to the MLS, flight director and autopilot.

3.2.5.3 GPS Landing System (GLS): The FMS shall be able to tune the GLS from the Navigation Database depending on the selected procedure at the destination airport (e.g., G27L) and direct the aircraft to a position to capture the approach path at which time the guidance of the aircraft is transferred from the FMS to the GLS, flight director and autopilot.

3.2.6 Inertial Navigation System: The FMS shall be able to accept Inertial Navigation signals and use them in combination with navigation information from other sources for the determination of the FMS position. Inertially derived signals shall be position ground speed, vertical velocity, vertical acceleration, flight path angle and attitude.

3.2.7 Air Data System: The FMS shall be able to accept air data information. The air data input signals shall be:

- Temperature corrected barometric altitude
- Calibrated airspeed (CAS)
- True airspeed (TAS)
- Mach
- Vertical speed (VS)
- Outside air temperature (OAT)
- Angle of attack

Flight path angle and wind may also be derived from combined air data and inertial data.

3.2.8 Aircraft Systems: The FMS shall be able to accept information from the following aircraft systems and use this information to predict aircraft performance.

a. Engine Thrust / Engine Out
b. Flaps / Slats / Air Brakes status
c. Landing Gear status
d. De-Ice and Anti-Ice Systems
e. Fuel Quantity and Fuel Flow
f. APU in use

3.2.9 Data Link: The FMS shall accept inputs from and provide outputs to the current ACARS and the future CNS/ATM data link systems. This information may be used for flight planning, conflict resolution, or display purposes. FMS information such as current position and four dimensional future flight trajectory or intent should be available for transmission.

3.2.9.1 ACARS: The FMS shall be able to interface with the current Airplane Communications Addressing and Reporting System (ACARS) Airline Operational Control (AOC) and Air Traffic Services (ATS) Datalink. The FMS shall be able to accept uplinked flight plans and wind information and it shall be able to downlink prescribed information triggered by certain events in the flight.

3.2.9.2 CNS/ATM: The FMS shall support the evolving Communications Navigation and Surveillance / Air Traffic Management (CNS/ATM) environment, for example:

a. The FMS shall provide current aircraft state and intended flight path information and accept up-linked flight plan modifications in support of the future Controller Pilot Data Link Communications (CPDLC) systems.

b. The FMS shall provide accurate navigation to allow operation in reduced aircraft separation airspace with fewer ground based navigation aids.

c. The FMS shall constantly monitor the Required Navigation Performance (RNP) with the Actual Navigation Performance (ANP) or Estimated Position Uncertainty (EPU) of the system and alert the crew whenever the RNP cannot be achieved.

d. The FMS shall provide current aircraft state and intended flight path trajectory information in support of the future surveillance systems such as Automatic Dependent Surveillance Broadcast (ADS-B), Traffic Alert and Collision Avoidance System (TCAS), Enhanced Ground Proximity Warning System (EGPWS) / Terrain Awareness Warning System (TAWS).

e. The FMS shall use an accurate time standard so that maneuvers are synchronized with ATC.

3.2.10 Threat Avoidance Systems: The FMS shall accept inputs from and provide outputs to the following threat avoidance systems:

a. Weather – Onboard Weather Radar or up-linked weather information.

b. Terrain – Terrain Awareness Warning System (TAWS) or Enhanced Ground Proximity Warning System (EGPWS).

c. Windshear – Onboard windshear detection or up-linked windshear information.

d. Traffic – Traffic Alert and Collision Avoidance System (TCAS), Automatic Dependant Surveillance Broadcast (ADS-B), Traffic Information System (TIS).

This information may be used for flight planning, conflict resolution, guidance or display purposes. FMS information such as current position and future flight path trajectory should be available to onboard systems or for transmission outside the aircraft.

Measures should be taken to insure the accuracy of obstacle database inputs and proper warnings are generated if either the horizontal or vertical path conflicts with the terrain.

3.2.11 Flight Guidance: The FMS system shall provide data to autoflight systems for control of the aircraft in four dimensions (Latitude, Longitude, Altitude and Time). Typically these signals will include:

a. Pitch and Roll commands to the Autopilot

b. Thrust commands to the Autothrottle/thrust and FADEC for controlling engine thrust or display of thrust targets for manual control of thrust.

3.3 FMS Functional Requirements:

Recommendations for FMS system operation are covered in the following paragraphs.

3.3.1 Control Display Unit: The operation of the Control Display device, that provides the Control Display Function for the FMS whether it is the current Control Display Unit (CDU), the Multipurpose Control Display Unit (MCDU) or another device, shall follow a set of simple intuitive rules for data entry and display.

The use of color displays and font sizes to communicate information is recommended.

The pilot should not be required to memorize and enter codes to access functions. (Entry of codes is permissible for functions, such as maintenance functions, that are generally not intended for use by the flight crew).

3.3.1.1 Data Entry: The CDF should accept multiple formats for data entry when various formats are in common use. For example, both N040 and 040N should be acceptable for a Latitude entry. When data is not accepted a descriptive alert with the acceptable data entry format shall be provided.

3.3.1.2 Data Verification: The pilot shall be able to review all flight data on the CDF (or other suitable display) for verification both before using and during the time the data is being used by the FMS. Pilot verification of data shall not affect the navigation or performance data outputs from the system.

3.3.1.3 Data Validation: The system shall include provisions for validation of entered data where possible. For example, entry of an altitude above maximum altitude shall result in a self explanatory error message enabling correction of the entry. As a further example, entry of a distant waypoint when near the destination terminal area should present an alert message.

3.3.1.4 Inadvertent Entries: The Pilot should be required to review and accept entries that will result in flight path changes so that the probability of inadvertent entries being activated can be reduced

3.3.2 Mode Control: It shall be possible to operate the aircraft with the level of automation that the pilot desires from manual flight to Autopilot modes to full FMS controlled autoflight.

Return to full FMS controlled autoflight shall be accomplished without producing:

a. maneuvers that are uncomfortable for the passengers
b. out of limit speed conditions
c. out of limit altitudes
d. course errors
e. thrust transients
f. significant increase in crew workload.

Independent operation of lateral and vertical modes shall be selectable by the pilot and clearly annunciated when they are active.

Frequently used functions such as Heading Select, Altitude Select, etc. shall have dedicated displays and controls.

3.3.2.1 Mode Engagement: Autoflight system response to FMS inputs shall occur only with appropriate vertical, lateral or thrust modes engaged.

Engagement of new flight guidance modes shall be accomplished smoothly without abrupt or objectionable aircraft movement.

3.3.2.2 Display Philosophy: The FMS shall compute and display all appropriate commands or advisories whether the aircraft is operated in manual, semi-automatic or fully automatic flight.

3.3.3 Flight Planning: The FMS shall provide the capability to assemble a flight plan and establish fuel requirements before flight and to monitor, modify and generate alternative flight plans in flight.

The pilot shall be able to:

a. Enter the flight plan manually through the CDF
b. Select a flight plan previously stored in the Navigation Database (Company Route)
c. Enter a flight plan that has been up linked by the data link (e.g. ACARS)
d. Enter a flight plan that has been loaded from a disk.

Alternative data entry methods or devices may also be utilized.

The FMS shall be capable of formatting the flight plan information for display. This shall include the optimum or required flight plan over a specified route. The operating gross weight, current and forecast meteorological conditions, ATC restrictions and other available flight planning data shall be taken into consideration when constructing the flight plan.

3.3.3.1 Flight Plan Selection: Selection of a previously stored flight plan may be made by entering an identifier, company route number, selection of city pairs ("From"/"To") or by selection from a list of available flight plans.

3.3.3.2 Review and/or Modification: The pilot shall be able to review and modify all navigation information, in any flight plan sequence (with the exception that published terminal procedures stored in the NDB shall not be modifiable) prior to and in flight.

Modifications to an active flight plan shall not become part of the active flight plan until the pilot takes a positive action to accept the modification. Conversely the pilot shall also have the ability to cancel modifications to the flight plan before they become part of the active flight plan.

3.3.3.3 Waypoints: A means shall be provided for selection of appropriate waypoints from the Navigation Database for inclusion in the flight plan.

3.3.3.4 Duplicate Waypoint Selection: A means shall be provided to minimize duplicate waypoint selection problems. Duplicate waypoints shall be listed In a logical order (e.g., by order of distance from the aircraft) where duplicates exist.

Use of the graphic display should also be considered as a means of duplicate selection.

3.3.3.5 Manually Entered Waypoints: A means shall be provided for creation and identification of manually entered waypoints defined by:

a. Latitude and Longitude
b. Bearing and distance from a stored waypoint
c. Place, bearing, place, bearing
d. Waypoint and distance for along track waypoints.
e. This information will be maintained in a temporary area in the Navigation Database.

3.3.3.6 Inclusion of Route Segments: A means shall be provided to join routes, route segments, SIDs, STARs or Approaches, Missed Approach Procedures and Alternates into the flight plan.

3.3.3.7 Alternate Flight Plan: The pilot shall also be able to assemble and verify an alternate or diversionary flight plan without affecting the active flight plan.

3.3.4 Stored Database(s): Using data from internal database memory storage or from an external flight data storage unit, the FMS shall compute and deliver to using systems the data necessary to control the aircraft in four dimensions.

3.3.4.1 Navigation Database: The Navigation Database (NDB) shall contain the required navigation information to define flight plans in the defined operating area of the aircraft. At minimum it shall include:

a. Enroute and Terminal Waypoints and Airways
b. Enroute and Terminal Navigation Aids (VOR, DME, TACAN, NDB, ILS, MLS, GLS)
c. Departure and Arrival Procedures (SIDS, STARS, Approaches)
d. Holding Patterns
e. Airports and Runways
f. Company Routes

3.3.4.1.1 NDB Size: The size of the Navigation Database shall be sufficient to store all the navigation data required to support the operating area and route structure of the airline. A minimum of 25% spare is recommended.

3.3.4.1.2 NDB Updating: The NDB will require periodic updating to remain current with the operational environment. Typically this is done in accordance with the ICAO Annex 4 AIRAC 28 day cycle.

The pilot shall be able to verify the currency of the NDB to ensure operation with valid data.

The NDB should be capable of being updated on the aircraft. NDB update may also be provided through data link or from another valid FMS by cross load as a controlled ground maintenance function.

3.3.4.1.3 Temporary NDB: An option to provide pilot input capability of a limited number of navaids, runway thresholds and waypoints to a dedicated memory section of the database may be provided.

3.3.4.1.4 Review of Reference Data: Parameters relevant to operational needs of any stored airport, waypoint or navaids shall be capable of being called up by the pilot for review.

3.3.4.1.5 Database Integrity: The integrity of the NDB shall be preserved and will not be alterable by the pilot. The pilot may add information to the NDB as discussed in paragraph 3.3.4.1.3 above.

3.3.4.1.6 Database Validity: Before flight, an alert shall be provided to the pilot when the navigation database is invalid or expired.

3.3.4.2 Performance Database: Pertinent data for the particular installation (engine type, aircraft configuration, etc.), shall be stored in the FMS.

The FMS shall provide engine and aircraft configuration information that has an effect on aircraft performance. This information may be stored permanently in the FMS or it may be provided as a loadable Performance database (also referred to as a Model Engine database on some systems). Typically this database would contain performance information on the aircraft aerodynamic model, the engine thrust model (all engines operating and engine out), and the aircraft braking system. This information is used by the FMS to predict the aircraft performance parameters for the entered flight plan for takeoff climb, cruise, descent, and landing.

3.3.4.2.1 Performance Database Storage: Performance data should be stored in non-volatile memory separately from other databases and be suitably protected to prevent loss or changes when other databases are updated.

3.3.4.2.2 Performance Data Updates: Performance data should not require updating unless the database itself is updated or the engines are changed, however, the capability to update it shall be provided. Data stored in the database shall not be alterable by the pilot.

3.3.4.2.3 Performance Database Validity: The pilot shall be able to confirm that the engine and aircraft Performance Database is appropriate for the aircraft and engine.

3.3.4.3 Airline Modifiable Information (AMI): An Airline Modifiable Information database (also referred to as the Performance Defaults database or Loadable Defaults database on some systems) may be provided by the FMS.

This database allows the airline to define the default operating mode that matches their particular operation. This information can be usually be changed by the pilot temporally (for a given flight) to match current operating conditions. Some typical parameters that can be tailored in the AMI database are:

a. Default Climb, Cruise, Descent modes, and maximum/minimum speeds
b. Default Hold pattern time
c. Default Climb and Descent Transition Altitudes
d. Default Airport Speed and Altitude restrictions
e. Default Required Time of Arrival tolerance
f. Default Fuel Flow factor
g. Default Maneuver Margin
h. Default Cost Index
i. Default ACARS uplink and downlink messages and event triggers (This is a separate database on some systems)
j. Etc.

3.3.4.3.1 Airline Modifiable Information Storage: AMI data should be stored in non-volatile memory separately from other databases and be suitably protected to prevent loss or changes when other databases are updated.

3.3.4.3.2 Airline Modifiable Information Updates: AMI data should not require updating unless the Airline Operating Policy is updated. The capability to update AMI data from disk or through the CDF shall be provided. The airline shall have the option to allow or disallow the modification of AMI data stored in the permanent database by the flight crew. Typically, the modified settings will remain until the FMS system is restarted.

3.3.5 Data Link Interface: It is desirable for the FMS to interface with the data link (e.g., ACARS) to allow the pilot to semi-automatically insert up-linked data into the FMS and to down-link FMS data to a ground station.

The pilot shall have the capability of reviewing the data that has been up-linked from the ground station before commanding the insertion into the FMS.

It is essential for safety reasons that the FMS conduct integrity checks on the up-linked data.

Transmission of the following data are desirable:

1. Up-Link data

   a. Route Data – Flight plans, Flight path Winds, Temperatures, Active Runways, Terminal Procedures, Required Time of Arrival
   b. Performance Data – Cost Index, Cruise Altitude, Plan Fuel, Climb CAS
   c. Takeoff Data – V Speeds, Takeoff Flaps, load sheet data
   d. Descent and Landing Data – Descent Winds, Landing Runway conditions.
   e. Meteorological forecasts
   f. Requests for Down-Link information

2. Down-Link data

   a. Information Requested in UpLink message
   b. Current Aircraft State Information -. Position, Altitude, Course, Speed, Fuel, Wind, Etc.
   c. Aircraft Equipment Health – Built In Test results
   d. Aircraft Flight Plan Predictions – Predicted aircraft state information for each point in the flight plan, e.g., Estimated Time of Arrival, predicted fuel, Etc.
   e. Automatic Triggers – Automatically transmit data when an event occurs, e.g., transmit aircraft state information at Top of Descent waypoint.
   f. Manual Triggers – Transmit specified information when a prompt is selected on the CDF.

3.3.5.1 Storage of Up-Linked Waypoints: A section of volatile memory shall be provided to allow storage of temporary waypoints that have been up-linked and then referenced by flight plans that have been up-linked.

3.3.6 Performance Management: The FMS shall provide and automatically display performance data as required for the current flight phase and to complete the defined flight plan. Degraded aircraft performance modes, such as engine out, Flaps/Slats locked, unable to raise landing gear, shall be taken into account in the performance computations. In flight performance computations should consider lateral and vertical navigation inputs.

3.3.6.1 Performance Initialization: Standard recommended performance data selections should be preset to default values in accordance with airline operational requirements (see AIM paragraph 3.3.4.3). All entered data shall be modifiable so the pilot may make adjustments for current operating conditions. Typical data entry steps are outlined below.

1. General Data
    a. UTC
    b. Fuel
    c. Center of gravity
    d. Forecast winds
    e. Temperatures
    f. Cost (or flight) index
    g. Runway Slope
2. Select Climb Speed Schedule
    a. Min cost
    b. Min fuel
    c. Min trip time
    d. Max angle or gradient
    e. Max rate
    f. Select IAS and/or Mach and/or flight path angle
    g. Acceleration altitude restrictions (when required)
3. Select Climb Thrust
    a. Max climb
    b. Fixed or variable de-rate
    c. Performance based de-rate
    d. Engine Out Climb Thrust
4. Select Cruise Altitude
5. Select Cruise Schedule
    a. Min cost
    b. Min fuel (max range or Long Range Cruise (LRC))
    c. Min trip time
    d. Max endurance
    e. Select Mach or IAS
6. Select Descent Schedule
    a. Min cost
    b. Min fuel
    c. Min trip time
    d. Select Mach and/or IAS and/or flight path
    e. Angle deceleration altitude restrictions (when required)

3.3.6.2 Performance Data Modification: Aircraft permanent performance data shall not be adjustable by the pilot. The capability to change performance parameters, compute and display the effect of the change may be provided. If any flight critical parameters change the crew shall be alerted. For example, if any parameter changes that will impact V-Speeds, the V-Speeds should be blanked while they are being computed and if they change more than 2 knots the crew should be alerted. Appropriate safeguards shall be included.

3.3.6.3 Available Performance Information: Performance information to aid the crew in flight planning, normal aircraft operation, optimum flight profile control, abnormal and emergency conditions shall be available for display. These parameters may include, but are not limited to the following where 1 is recommended, 2 is desired and 3 is optional:

a.	Static and/or total air temperature:	1
b.	Takeoff computation - thrust/speeds/altitudes:	2
c.	Takeoff windshear - detection/information:	3
d.	Climb - speed/thrust (with and without ATC speed restriction):	1
e.	Cruise - optimum altitude/speed/thrust:	1
f.	Cruise climb - optimum altitude/speed/thrust:	2
g.	Step climb (up or down) - altitude/speed/thrust/time/fuel or cost comparison:	1
h.	Maximum altitude or service ceiling capability:	1
i.	Buffet boundary:	1
j.	Turbulent air penetration - speed:	3
k.	Fuel over destination, or destination and alternate:	1
l.	Range capability:	2
m.	Thrust/drift-down or climb speed/level-off altitude/step climb/cruise speed/range capability with engine(s) inoperative:	1
n.	Loss of pressurization - speed/range capability:	1
o.	Descent - speed/thrust (with and without ATC speed restriction):	1
p.	Holding - speed/thrust/endurance:	1
q.	Approach and go-around windshear - detection information:	3
r.	Landing and go-around - thrust/speeds/capability/attitudes:	1

3.3.6.4 Climb, Cruise and Descent Optimization: Climb, cruise and descent parameters may be optimized on the basis of one or more of the following criteria where 1 is recommended, 2 is desired, and 3 is optional:

a.	Minimum trip cost:	1
b.	Minimum trip fuel:	1
c.	Minimum trip time:	2
d.	Maximum rate of climb.	2
e.	Minimum rate of descent.	2
f.	Maximum angle of climb.	2
g.	Minimum angle of climb	2