Product System Domain Learning & Exchange(PLEx)

Avionics Systems

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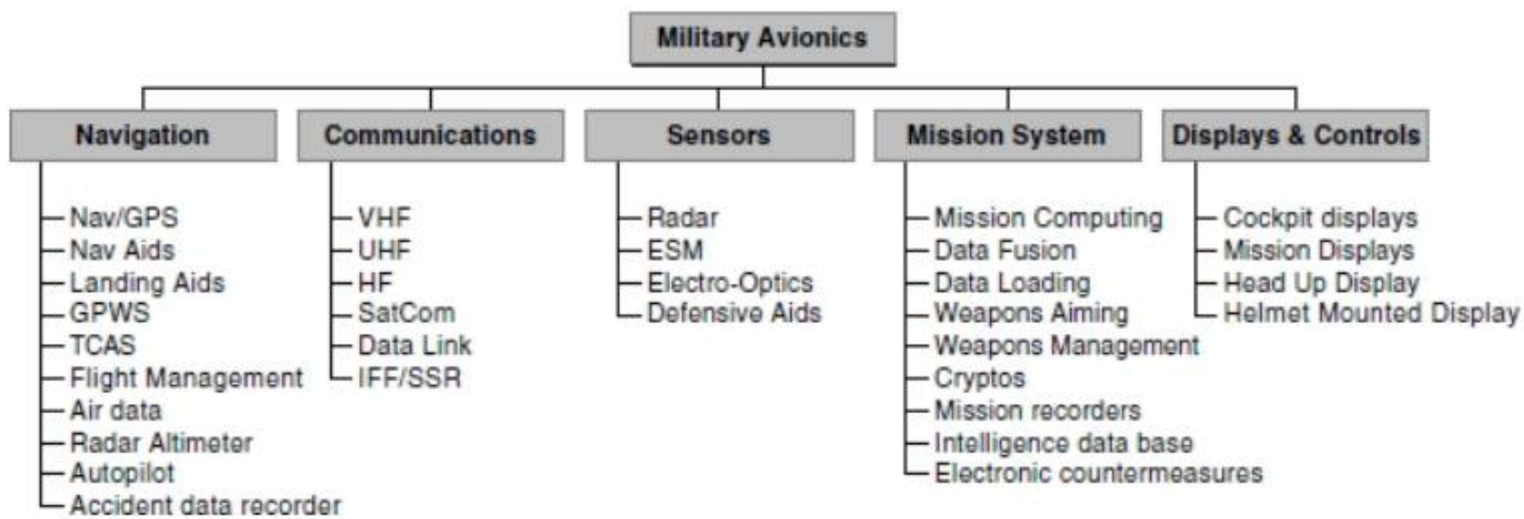
onics – Introduction (1)

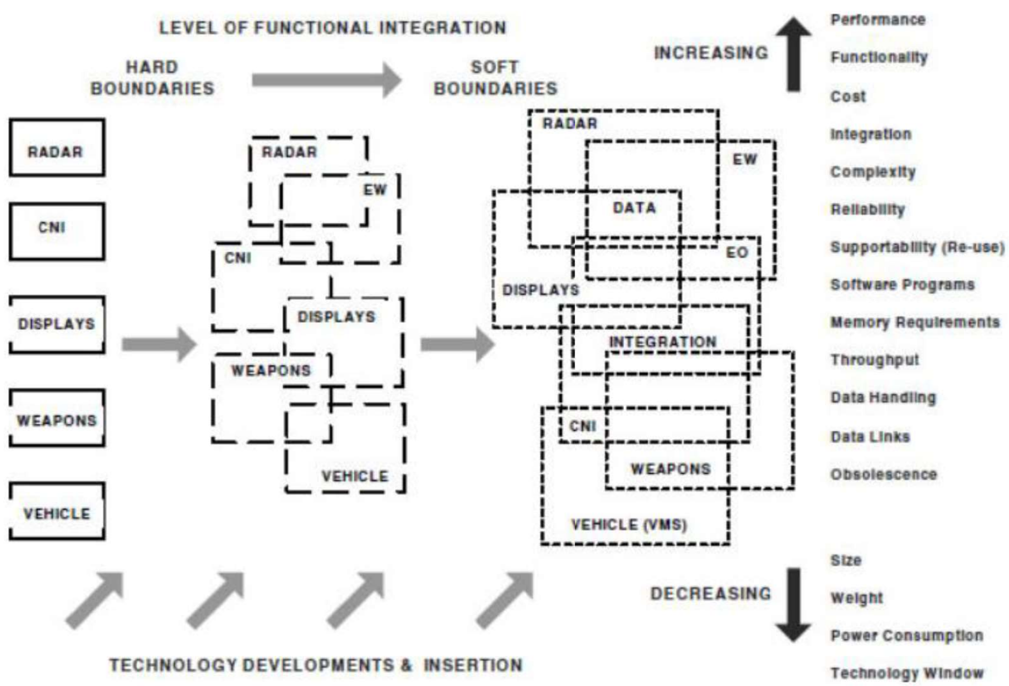
- Avionics is a word coined in 1949 by Philip J. Klass to provide a generic name for the increasingly diverse functions being provided by AVIation electrONICS.
- The birth of Avionics systems evolved from WW1 with radio communication used widely and improvised during WW2 with radar systems.
- Avionics systems include communications, navigation, sensors the display and management of multiple systems



Avionics – Introduction (2)

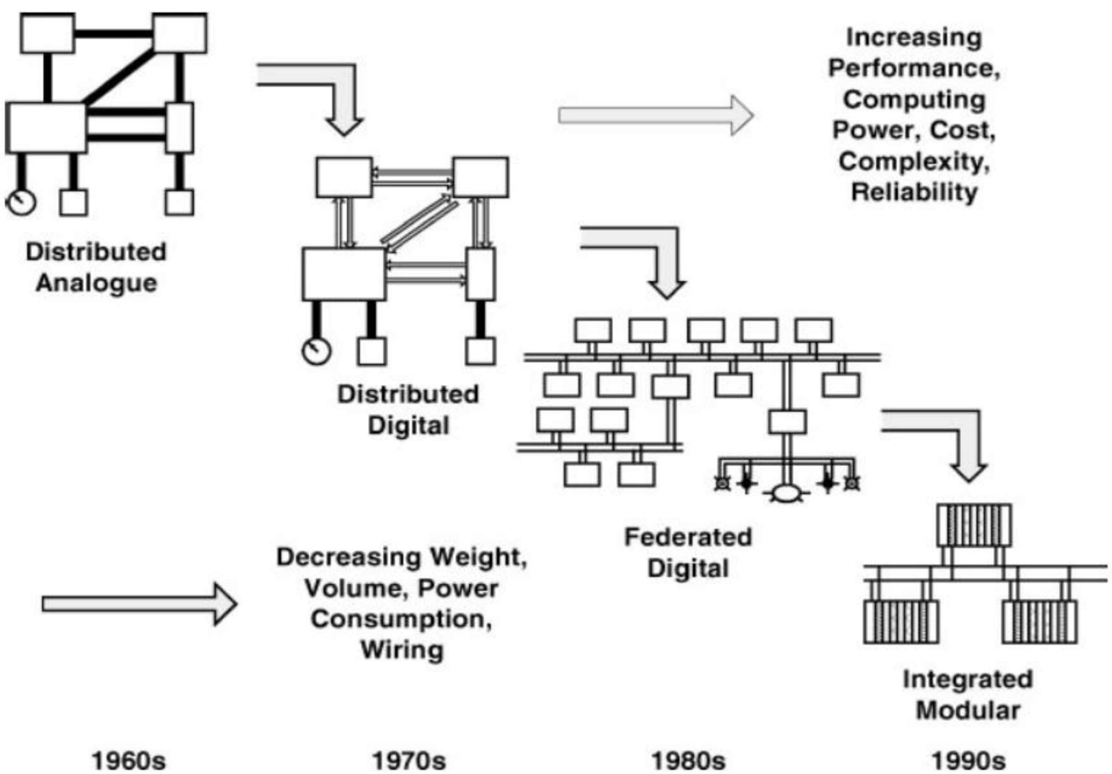
Major avionics subsystems such as radar, communications, navigation and identification (CNI) in the early stages and evolved into more complex integrated systems.

Below diagram shows the functional integration over time.



Evolution of Avionics

Evolution of avionics architectures from analogue to totally integrated digital implementation



Evolution of Avionics Architecture

- Distributed analogue (1950-60)
- Distributed digital (1960-70)
- Federated digital (1970-80)
- Integrated modular (1980-90)

istributed Analogue architecture (1950-60)

this era, the major units in systems are interconnected by hardwiring no data buses are employed.

s wiring is associated with power supplies, sensor excitation, sensor signal voltage and system
crete mode selection and status signals.

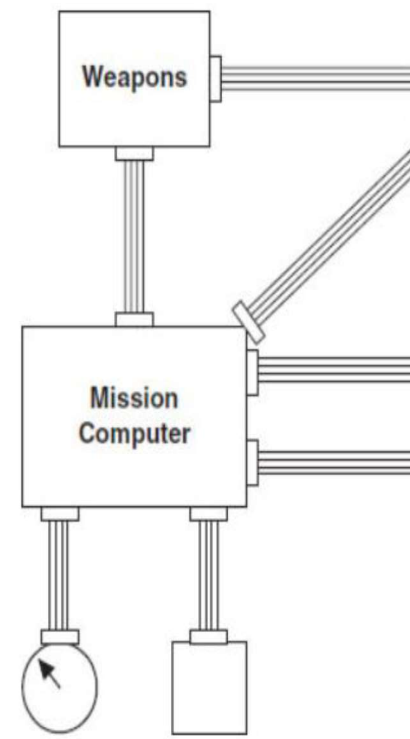
ere was huge amount of aircraft wiring and the system is extremely difficult to modify if change is
cessary.

e displays are electro-mechanical and often extremely intricate in their operation.

e systems are very bulky and heavy and tends to be unreliable as there are many moving parts.

rcrafts in that time:

- Boeing 707,
- VC10,
- BAC 1-11,
- DC-9



istributed Digital architecture (1960-70)

e maturity of digital computing devices suitable for airborne use led to the **adoption of digital computers**, wing greater speed of computation, greater accuracy and removal of bias and drift problems.

jor functional units contained their own digital computer and memory. Magnetic core was used for memory.

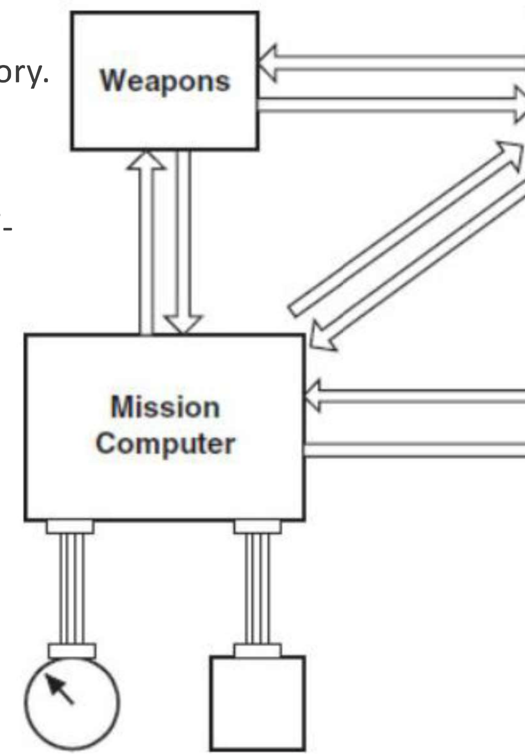
technology progressed - **electrically reprogrammable memory** used instead of magnetic memory.

ignificant development accompanying the emergence of digital processing was the adoption of serial half-lex (unidirectional) digital data buses

- ARINC 429 (civil aircraft) - 110 kbit/s
- Tornado serial (UK military) – 64 kbit/s

crafts in that time:

- **Military** – Jaguar, Nimrod MR2, Tornado and Sea Harrier
- **Civil** – Boeing 737 and 767 and Bombardier Global Express; these aircraft are relevant as many military platforms in the tanker, AWACs and intelligence gathering roles use these baseline civilian platforms.



ederated Digital architecture (1970-80)

e federated architecture –are completely digital relied principally upon the availability of extremely widely used MIL-STD-1553B data bus.

lerated architectures generally use dedicated 1553B-interfaced line replaceable units Us) and subsystems.

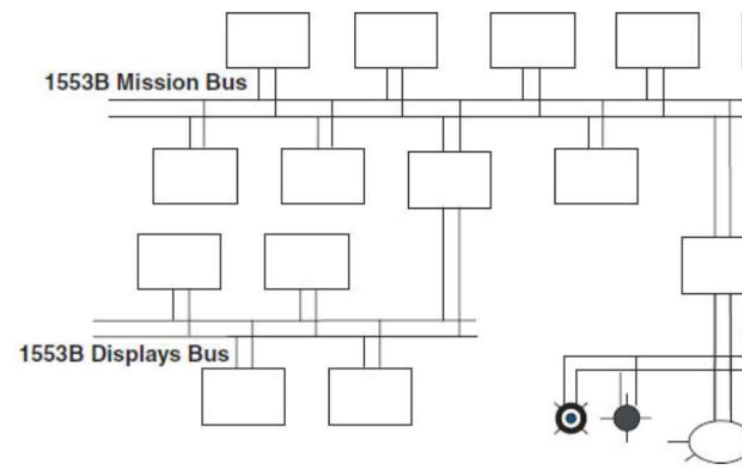
NC 629 - the civil version was introduced, distributed control approach.

veloping maturity of electronic memory ICs, in particular non-volatile memory, the erated architecture enabled software reprogramming in the various system LRUs and tems via the aircraft-level data buses.

nificant improvement in maintainability

crafts in that time:

- **Military** – SAAB Gripen and Boeing AH-64 C/D
- **Civil** – Boeing 777



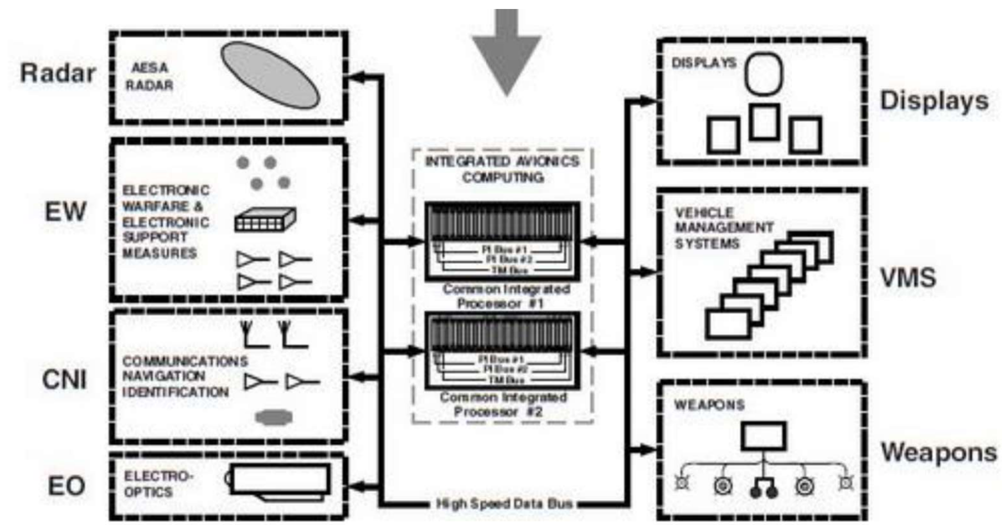
tegrated Modular architecture (1970-80)

hitectures use open standards, ruggedized commercial technology to provide the data bus interconnections between the major aircraft syst
grated computing resources.

ption of federated multibus architectures using a range of line replaceable units (LRUs), commonly known as 'b

ndardization of processors lack boxes' to the layman

ndardization of high-order language (HOL)

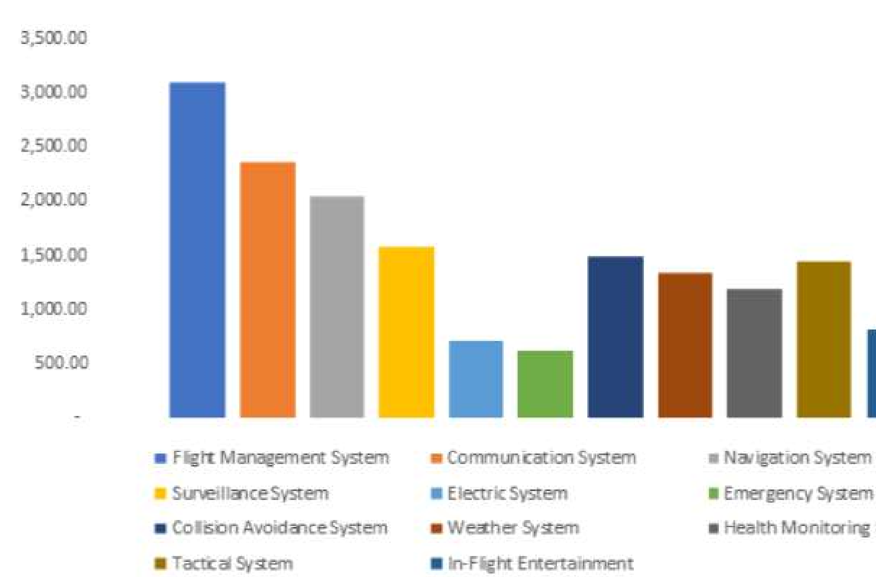


Avionics Business/Market

Aerospace Avionics Market size valued at USD 74 billion in 2018 and is anticipated to exhibit growth of around 3% from 2019 to 2025.

ase Year:	2018	Market Size in 2018:	74 Billion (USD)
istorical Data for:	2014 to 2018	Forecast Period:	2019 to 2025
eographies covered 22):	U.S., Canada, Germany, UK, France, Italy, Spain, Netherlands, Russia, China, India, Japan, Australia, South Korea, Brazil, Mexico, Chile, Colombia, Saudi Arabia, UAE, South Africa, Turkey		
egments covered:	System, Application, End Use and Region		
ompanies covered 30):	Airbus S.A.S, Aviation Industry Corporation of China Ltd. (AVIC), Astronics Corporation, Boeing, Ball Corporation, BAE Systems, Cobham plc, Curtiss Wright, Elbit System, Gramin Ltd, GE Aviation, Harris Corporation, Honeywell International Inc., Lockheed Martin Corporation, L3 Harris Corporation, Meggitt PLC, Northrop Grumman Corporation, Nucon Aerospace, Panasonic Corporation, Rolls Royce, Raytheon Company, Saab AB, Safran, Thales Group, Teledyne Technologies Inc., Transdigm Group Inc		
rowth Drivers:	•Rise in air traffic in Asia Pacific region •Developing aircraft avionics regulations in European region •Need of upgrading avionics equipment at commercial and military level •Technological advancement and implementation of latest systems •Compulsion of ACAS system •Introduction of Open Architecture		
itfalls & Challenges:	•High manufacturing cost •Threats of Cyber attacks		

Asia Pacific Aerospace Avionics Market Revenue, By System, 2018 (USD



Product System Domain Learning & Exchange(PLEx)

Domain Name : Avionics Systems

Topic name : Flight Management System

Authors
Mohana Surya (3232378)

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UCT SYSTEMS, IT & DA

Glossary
WHAT is FMS ?
Main components of FMS
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How it Works
Different Modules of FMS
Different phases of FMS involvement

What is FMS

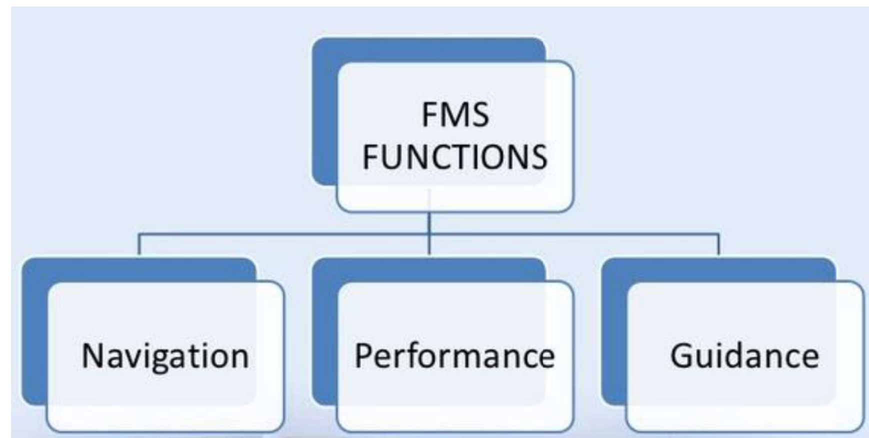
- FMS is one of the specialized component inside the flight
- It is been called as the heart of all the modern systems available inside aircraft
- An FMS is a specialized computing system that automates a wide variety of in-flight tasks, there by reduces the workload on the flight crew
- FMS mainly consists of
  - Flight Management Computer
  - Control Display Unit
  - Visual Display System

Main Components of FMS

- Flight Management Computer (FMC) generally computes by taking preliminary inputs from the CDU
- These inputs are validated with the databases that are fed into FMS.
- Once those appears to be accepted, Captain and First officer cockpit deck will be loaded and updated
- CDU – Show different waypoints through out the route corresponding alt, speed co-ordinates to be maintained
- PFD – Show the visual navigation of flight with Respect air/ground view ratio

Functions of FMS

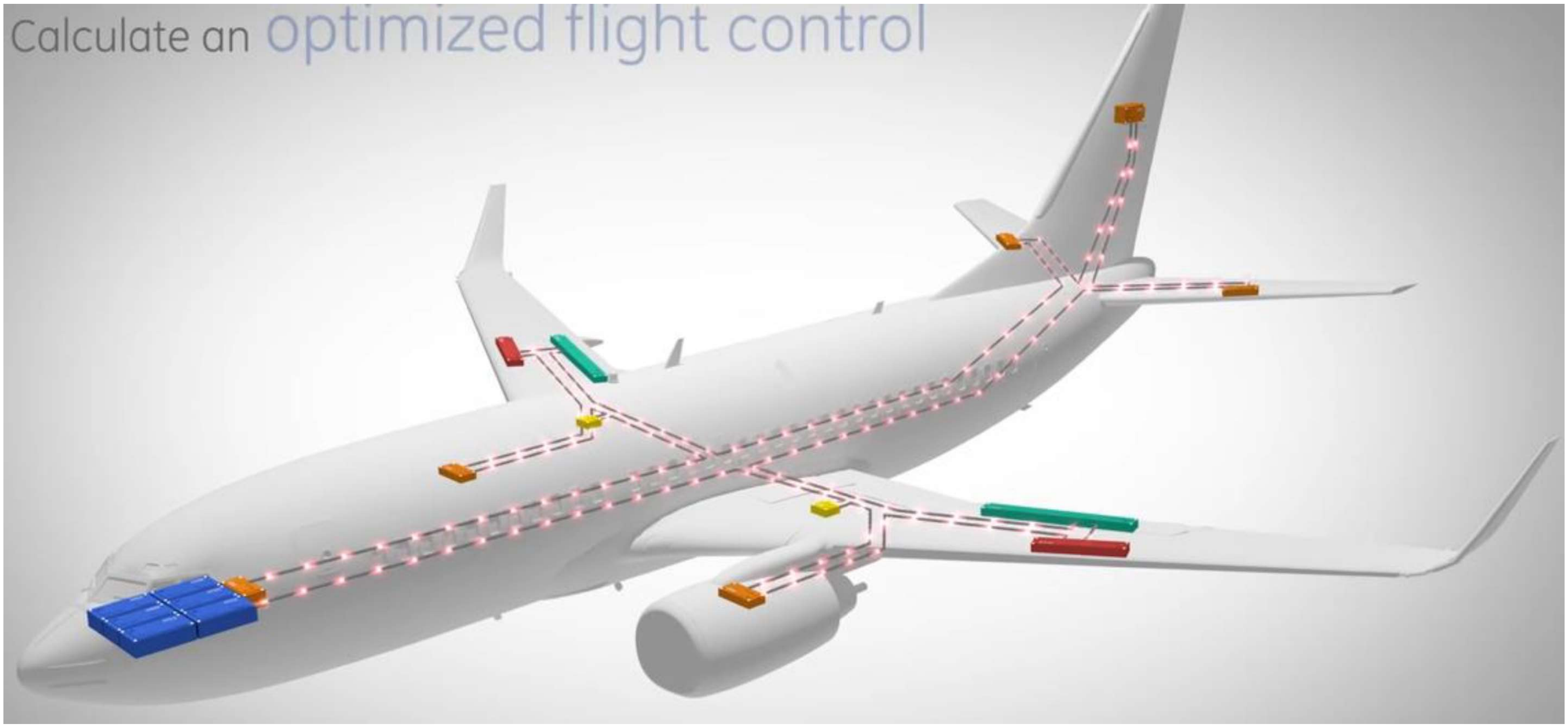
- The main applicability of FMS is broadly into 3 functional areas
- NAVIGATION :
  - Principal task of the FMS is to determine the aircraft’s position
  - For the given F-PLN & Aircrafts Position FMS calculates the course to follow
  - Autopilot can be set to follow the course
- PERFORMANCE :
  - MAX take-off weight
  - Fuel Weight
  - Center of gravity
- GUIDANCE :
  - Provides by validates the inputs from different sources of LRU
  - Continuously evaluates and provides backup checks in case of failure and Ensures the manual steps are rightly taken care



HOW IT WORKS ?

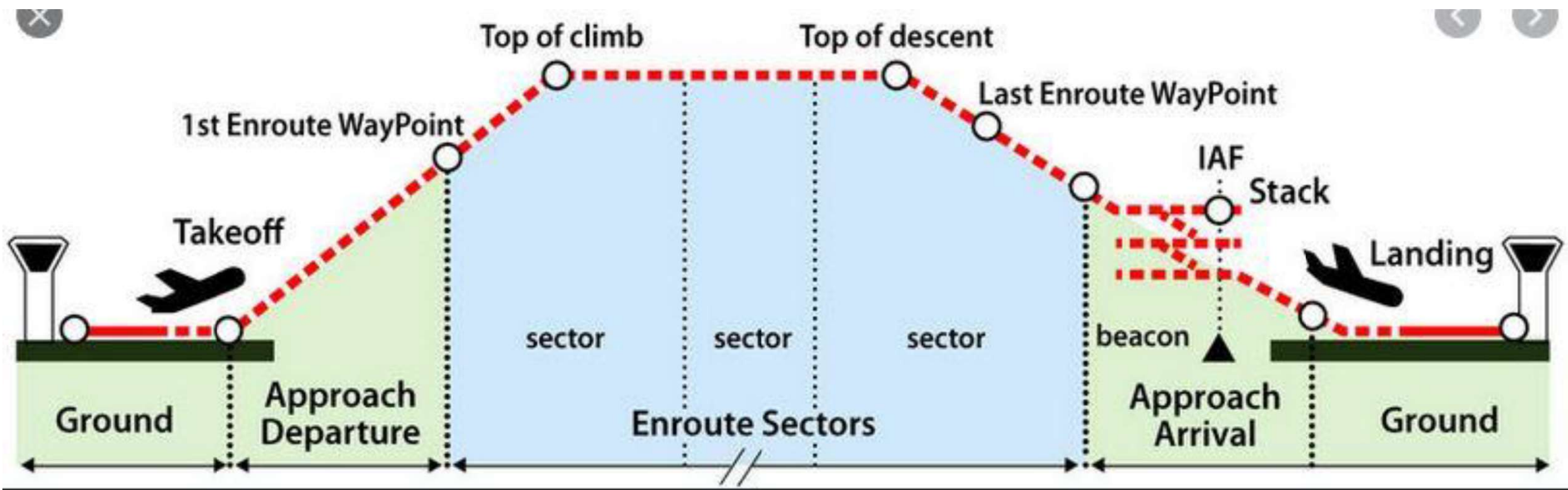
- Flight Management Compute supplied with information from
  - Navigation Systems
  - Inertial reference Systems
  - Air Data Computer
  - Engine and Systems
  - Aircraft specific performance database
  - Route , procedure and terrain database
  - EGPWS
  - TCAS
  - Data-link
  - Pilot inputs
- FMC analyze the input from each of the above source continuously re-evaluates changing parameters to provide the auto-pilot , auto-throttle

'MS modules at different parts of aircraft



Different phases of Flight

- AT the every stage of flight the FMS has it prominence
- From Takeoff to Landing FMS co-ordinates with all LRU’s helps to complete flight
- Ideal situations Takeoff and Landing are manually controlled though FMS is capable of auto Control



Links & Reference Documents

- https://www.aviationpros.com/home/article/10383545/flight-management-systems
- https://www.slideshare.net/IshwarBulbule/flight-management-system
- https://www.youtube.com/watch?v=GZsbNNiB1L4

Product System Domain Learning & Exchange(PLEx)

Domain Name : Avionics Systems

Topic name : Display Monitoring Systems

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Engine Indicating and Crew Alerting System
EICAS indicators

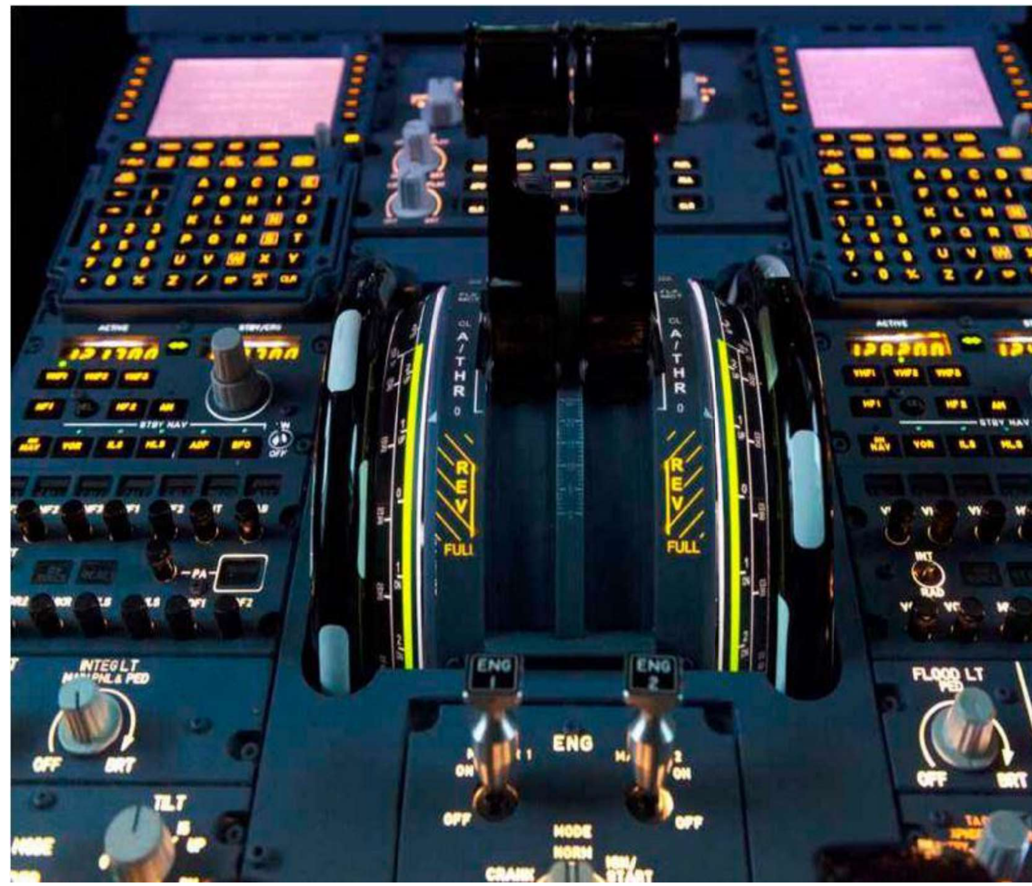
Background on Avionics Systems

- **Avionics** are the electronic systems used on aircraft, artificial satellites, and spacecraft
- Avionic systems include communications, navigation, the display and management of multiple systems, and the hundreds of systems that are fitted to aircraft to perform individual functions
- The majority of the electronic systems that are part of Avionic systems are Cockpit Display Systems , flight Controls and FMS

Cockpit Display System (CDS)

- The **Cockpit display systems** (or CDS) provides the visible (and audible) portion of the Human Machine Interface (HMI) by which aircrew manage the modern Glass cockpit and thus interface with the aircraft avionics.
- Entire Cock display System broadly classified in three categories
  - Input only devices
    - – Exclusively for visualizing the different parameters at different stages
  - Output only devices
    - – only to provide inputs to the FMS
  - Input & Output only devices
    - – Some systems which provide input (to change settings) and visualize the action performed is rightly enabled

Display Monitoring Systems



Prominence of Display Monitoring Systems

- Display systems are the vital visual indicators that monitor the various avionics, environmental, and electronic systems that keep aircraft in the air
- These displays provides GUI interfaces of flight activities during the complete flight from taxiway to landing
- Display systems mainly exchanges the Input and Output data with Flight Management System
- Each visual display system appear in two units of set inside the cockpit one for Captain and First officer
- Each unit will be driven different FMS (ideally 3 FMS will be installed in aircraft and any time 2 FMS will be in active to drive communication

Main Display Monitoring Systems

- The Major display and Monitoring systems inside the cockpit deck are
  - **PFD** – Primary Flight Display
  - **ND** – Navigation Display
  - **MCDU** – Multi Functional Control and display Unit
  - **EICAS** – Engine Indicating and Crew Alerting System
  - **MFD** – Multi functional Display

- Each display/monitoring system has its own prominence to show different parameters of flight at all phases of flight

- MFD is a hybrid display it derives the information from the different systems. Displays the pages of different systems based on the selection

Primary Flight Display - PFD

- The name of the display itself conveys this electronic unit is the most primary display among all the display units (yet other display monitoring system have high prominence)

- A **primary flight display** or **PFD** is a modern aircraft instrument dedicated to flight information

- PFD provides the pilot with data about the flight situation of that aircraft, such as altitude, airspeed, vertical speed, heading and much more other crucial information in flight

- There will be different indicators to depict stage/status/severity of different parameters

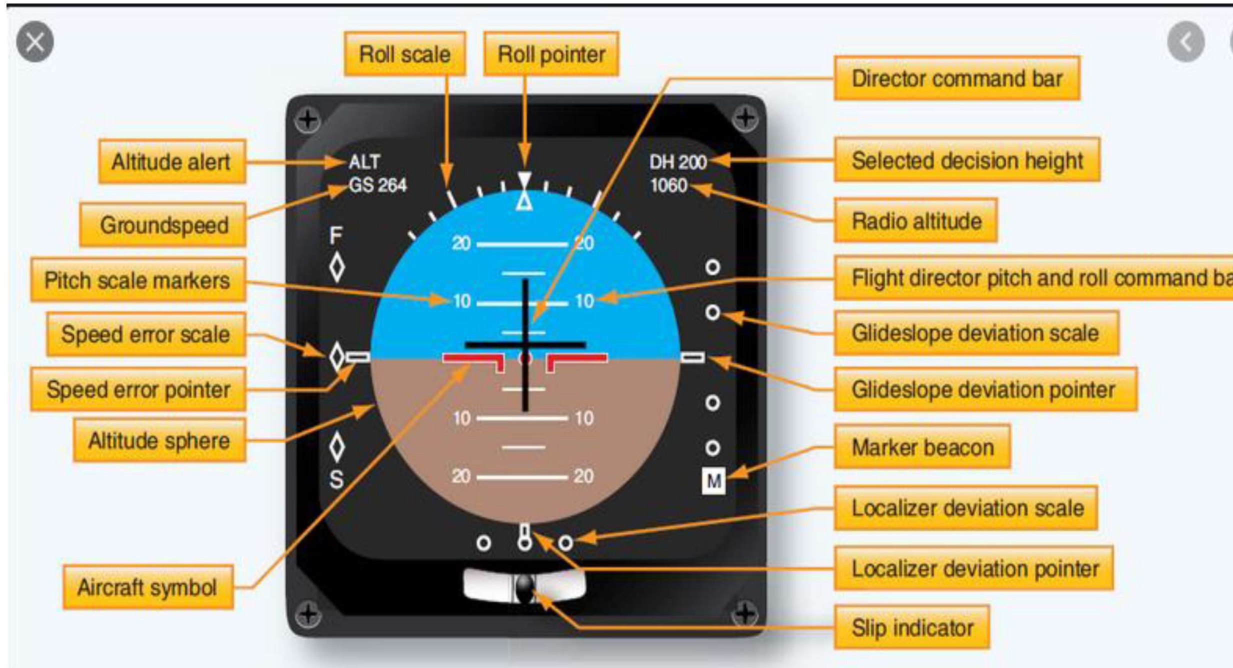
- Course of action will be taken by pilot based on the state of PFD with all indicators

- Some of the indicators are represented in the form of annunciations. There will be 2 PFD inside cockpit

Indicators on PFD

GS Ground Speed
Vref
VR
V1
Green flap speeds
Magenta selected speeds
LS / DME read / IDENT
FMA
AP on/off
Magenta selected Altitudes
Altimeter tape
VS indicator
Green mins Baro bar
Current Altimeter setting
LOC & GS scales

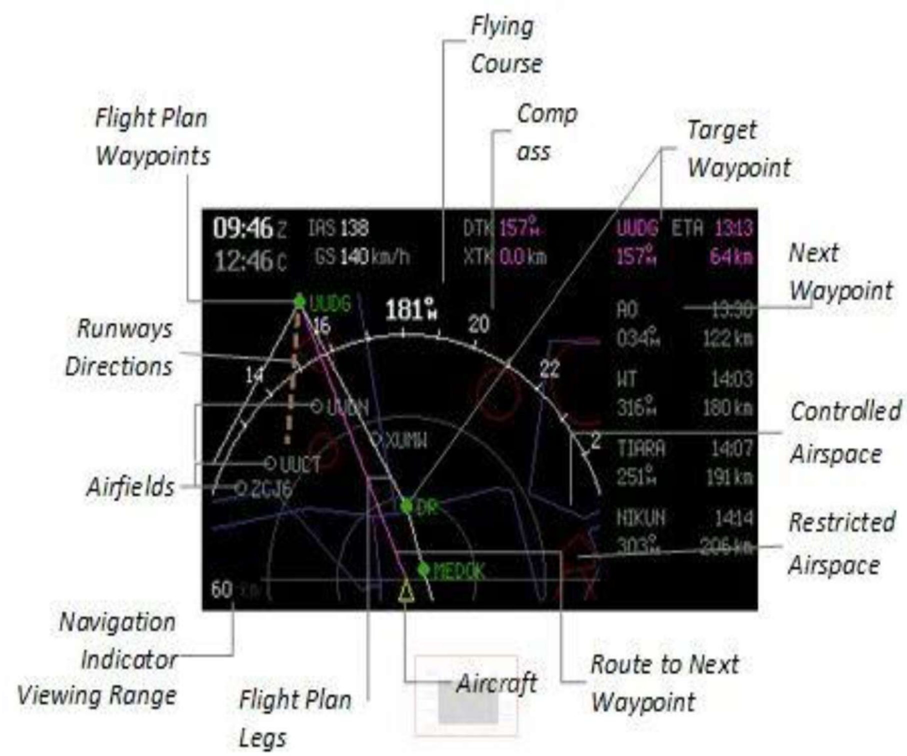
Expanded PFD



Navigational Display - ND

- ND is another kind of dynamic texture display unit.
- ND shows the information about aircraft position, its course and flight plan, air navigation objects nearby and airspace areas
- The main parameters include TCAS, Waypoints, route path, VOR and airports.
- Cockpit crew will rely on the ND to check flight direction towards the destination in many diff views
- ND shows only the vertical flight profile means aircraft movement towards the direction of destination
  But not horizontal movement (it will be shown in situational display in MFD)
- There will be two ND display unit present in the cockpit deck

Indicators and Stats on ND



Multi Functional Control & Display Unit - MCDU

- The MCDU is a combination of a keyboard and a high-performance Liquid-Crystal Display (LCD) that allows pilots to input and modify flight plans.

- It works in conjunction with the flight management system. All the inputs provided are validated in FMS

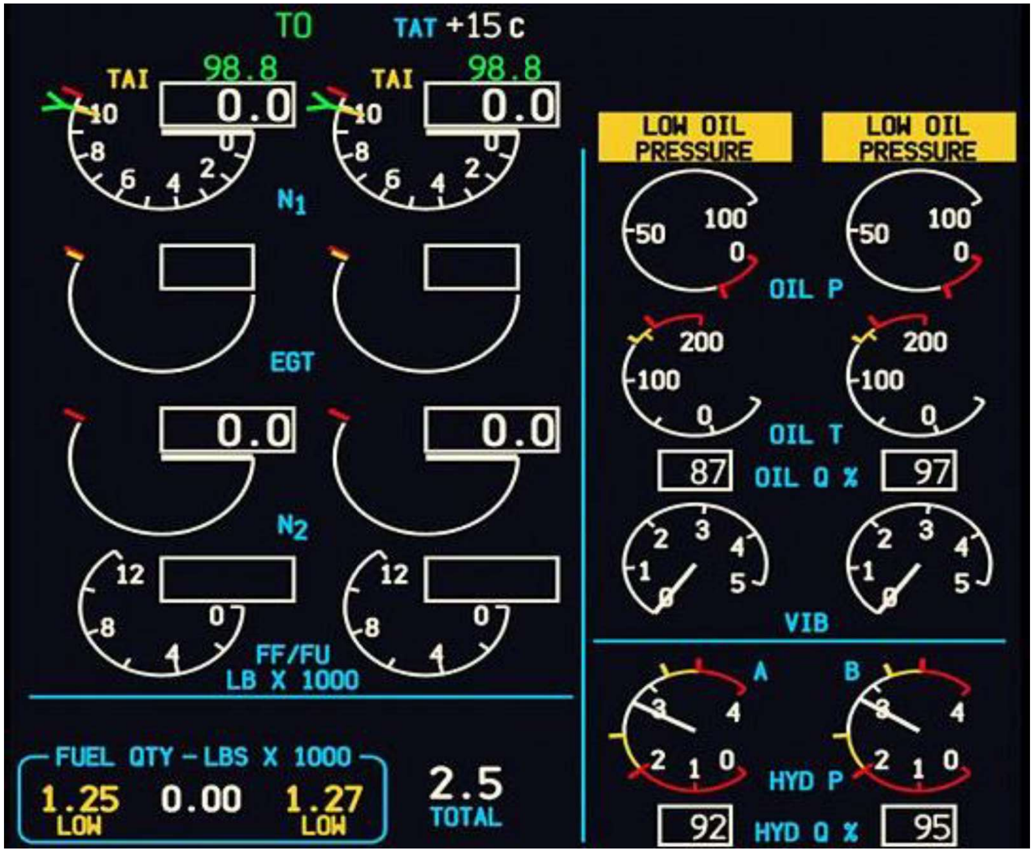
- It consists of screen and keypad to feed the input. It mainly initializes and does the following activity
  - Pre-check Flights
  - INIT A
  - FPLN
  - RADNAV
  - INIT B
  - PERF

Different pages of MCDU

Engine Indicating and Crew Alerting System-EICAS

- EICAS displays information about the aircraft's systems, including its fuel, electrical and propulsion systems
- EICAS displays are often designed to mimic traditional round gauges while also supplying digital readouts of the parameters
- It improves situational awareness by allowing the aircrew to view complex information in a graphical format and also by alerting the crew to unusual or hazardous situations
- It produces sound alert when there is fault tolerance level crossed
- Most of the indicators are with respect to engine parameters

EICAS Indicators



Engine Warning and System Displays

EWD After Start

1. IDLE INDICATION - Displays green when engines are at idle thrust. Indication flashes for 10 seconds, then becomes steady.

2. MAXIMUM EPR - Displays the EPR limit value corresponding to the full forward thrust lever position.

3. THRUST LEVER INDICATION - Displays the predicted EPR corresponding to the thrust lever position.

4. MAXIMUM PERMISSIBLE EGT - Represented by red line. If 635°C is exceeded, a red mark appears at maximum value reached. It will only disappear at the next takeoff or by maintenance action.

5. ACTUAL EPR INDICATION - Displays green.

6. ACTUAL EGT POINTER AND INDICATION When EGT exceeds 610°C, the analog needle pulses amber. When EGT exceeds 635°C, the digital display turns steady red and the analog needle pulses red.

< PREVIOUS

NEXT >

Links & Reference Documents

- https://www.aviasim.com/en/buy-a-flight-simulator
- http://www.a320dp.com/A320_DP/panels.html
- https://en.wikipedia.org/wiki/Flight_instruments

Product System Domain Learning & Exchange(PLEx)

Domain Name : Avionics Systems

Topic name : Instrument Landing System

Authors

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ILS Functioning – Marker Beacon
ILS cockpit indications
ILS Components overview
ILS system overview - Scenarios

What is Landing System

- A system that automates the Landing procedure of an aircraft (with supervision of flight crew)
- Landing system is one of the important function of FMS
- Installation of Landing system ensure the safety landing of flights
- Landing systems will be installed at Airport runways

What is ILS – Instrument Landing System

- ILS is guidance type of navigation that provides an instrument-based technique for guiding an aircraft to approach and land on a runway
- It is one of the standard precision landing aid that is used to provide accurate guidance during
- It will be mainly used in adverse weather conditions like poor visibility at runway
- It provides both vertical and horizontal Guidance to the aircraft during landing

ILS Functioning

- ILS consists of mainly 3 components
  - Localizer
  - Glide Slope
  - Markers Beacons

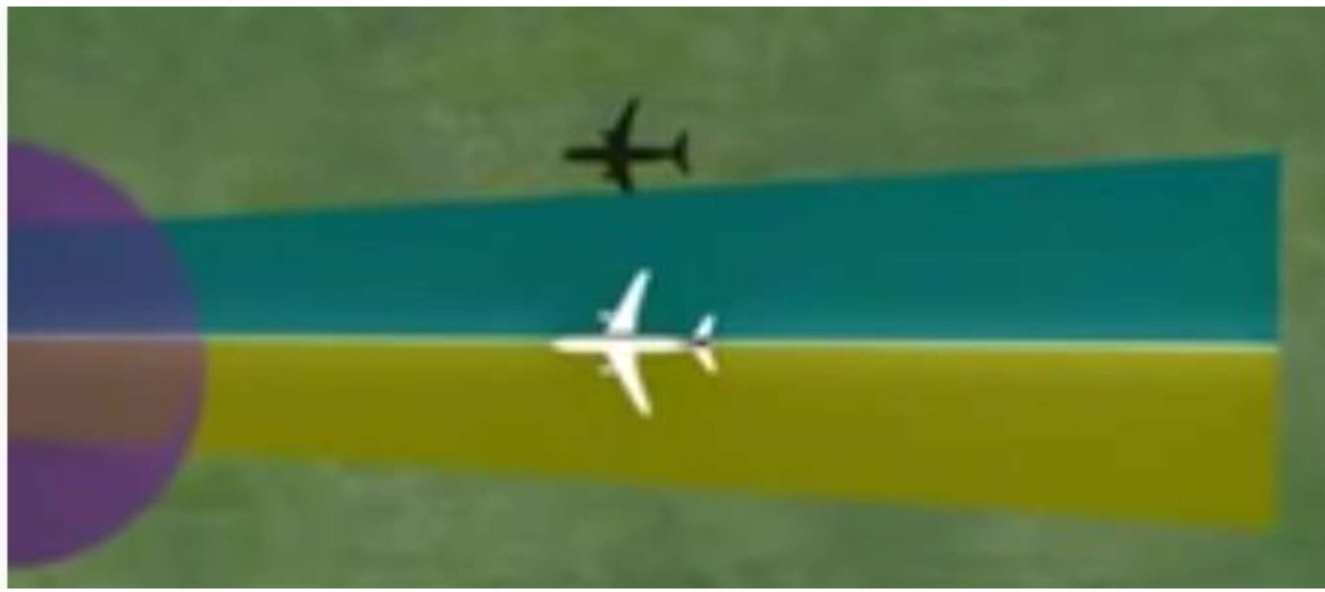
- Localizer and Glide Slope are two highly transmitting systems

- Localizer :
  - Localizer is array of antennas Installed at approx. 150 meters beyond departure end of the runway
  - Localizer is a transmitter that provides the pilot with the lateral guidance (Left – Right)
  - Each transmitter transmits a narrow beam one slightly left to the center of the runway and other slightly right to the center of the runway
  - These signals helps in indicating the aircraft is left or right to the center of the runway

ILS Functioning - Localizer

- Antennas

Horizontal Guidance



ILS Functioning – Glide Slope

- Glide Slope:
  - Glide Slope is also a array of antennas sided one side of Runway
  - It is installed approx. at 150 meters away from the runway at touchdown zone
  - It is a transmitter that provides the pilot with the Vertical guidance (Up– down)

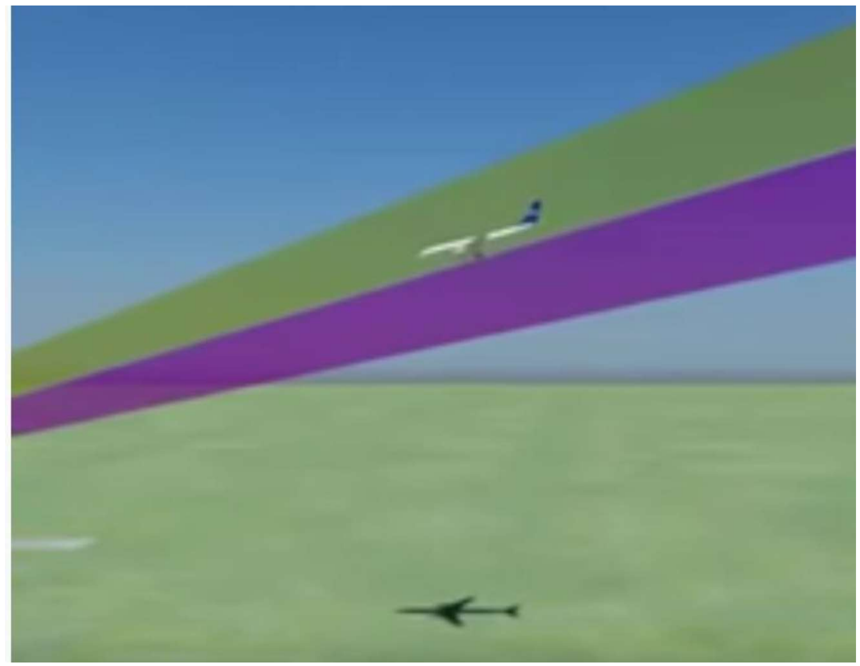
- That fact translates into ILS signal parameters that become tighter as the aircraft approaches the end of t runway, meaning the pilot must be prepared for smaller and smaller corrections to remain on course anc glideslope.

- It is the pilot's task to learn the precise speed, rate of descent and aircraft configuration needed prior to intercepting the ILS that will allow the needles to remain crossed like a huge plus sign, indicating the airc on the localizer course and on the glideslope

ILS Functioning – Glide Slope

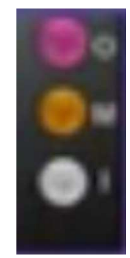
- Antennas

Vertical Guidance

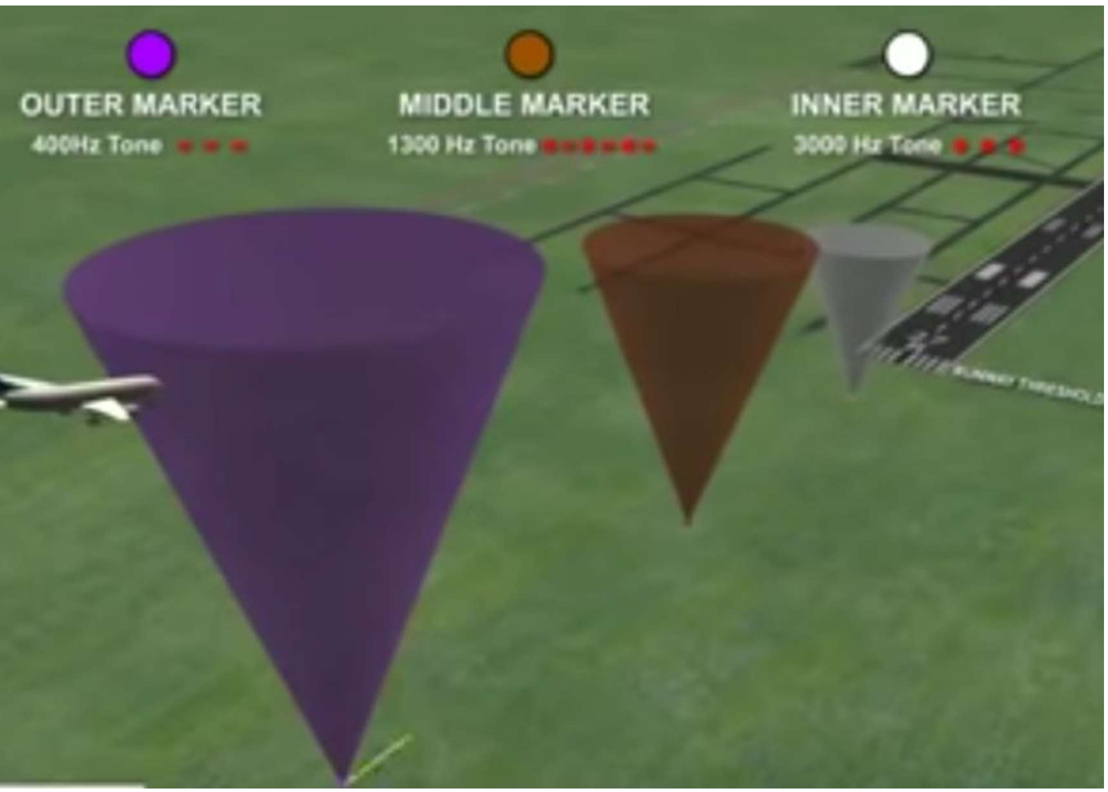


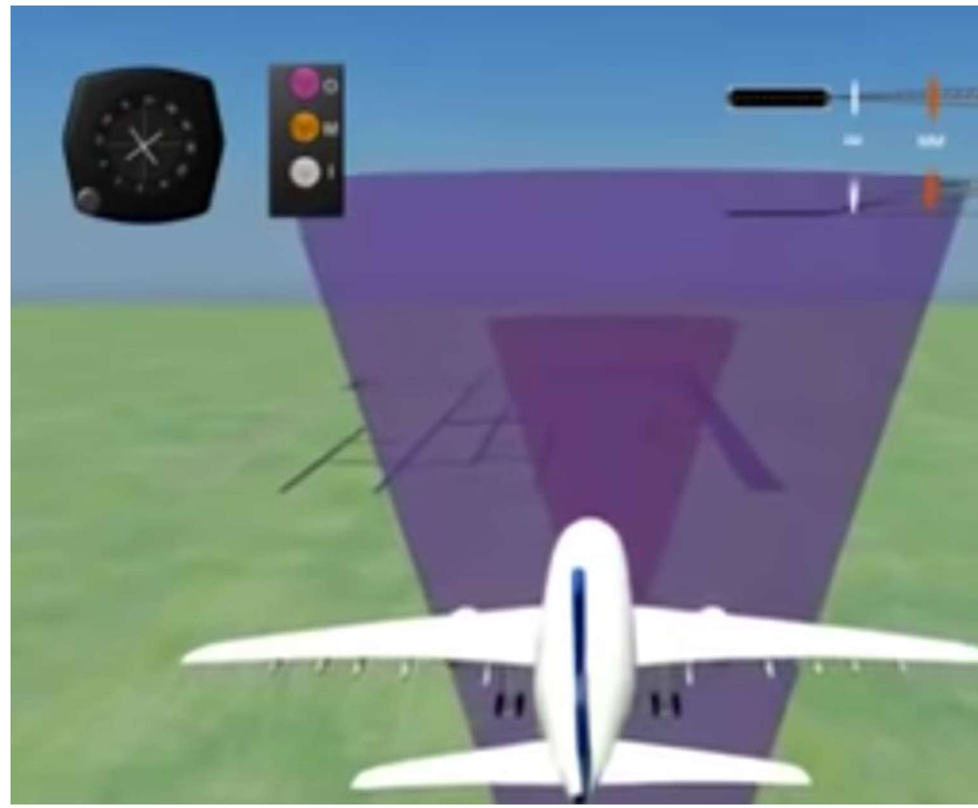
ILS Functioning – Marker Beacon

- ILS normally consists of 3 Marker Beacons (these are optional to install as part of ILS)
  - Outer Marker Beacon
  - Middle Marker Beacon
  - Inner Marker Beacon
- The outer marker is usually 5 miles from the runway
- The middle marker is about 3500 feet from the threshold
- The inner marker is normally at the runway threshold
- These beacons helps pilot to identify the location on approach
- There will be three lights to indicate aircraft is which Beacon
- when ever aircraft passes particular installed Beacons which operates at their frequencies the corresponding lights will be turned with different sound indicates



ILS Functioning – Marker

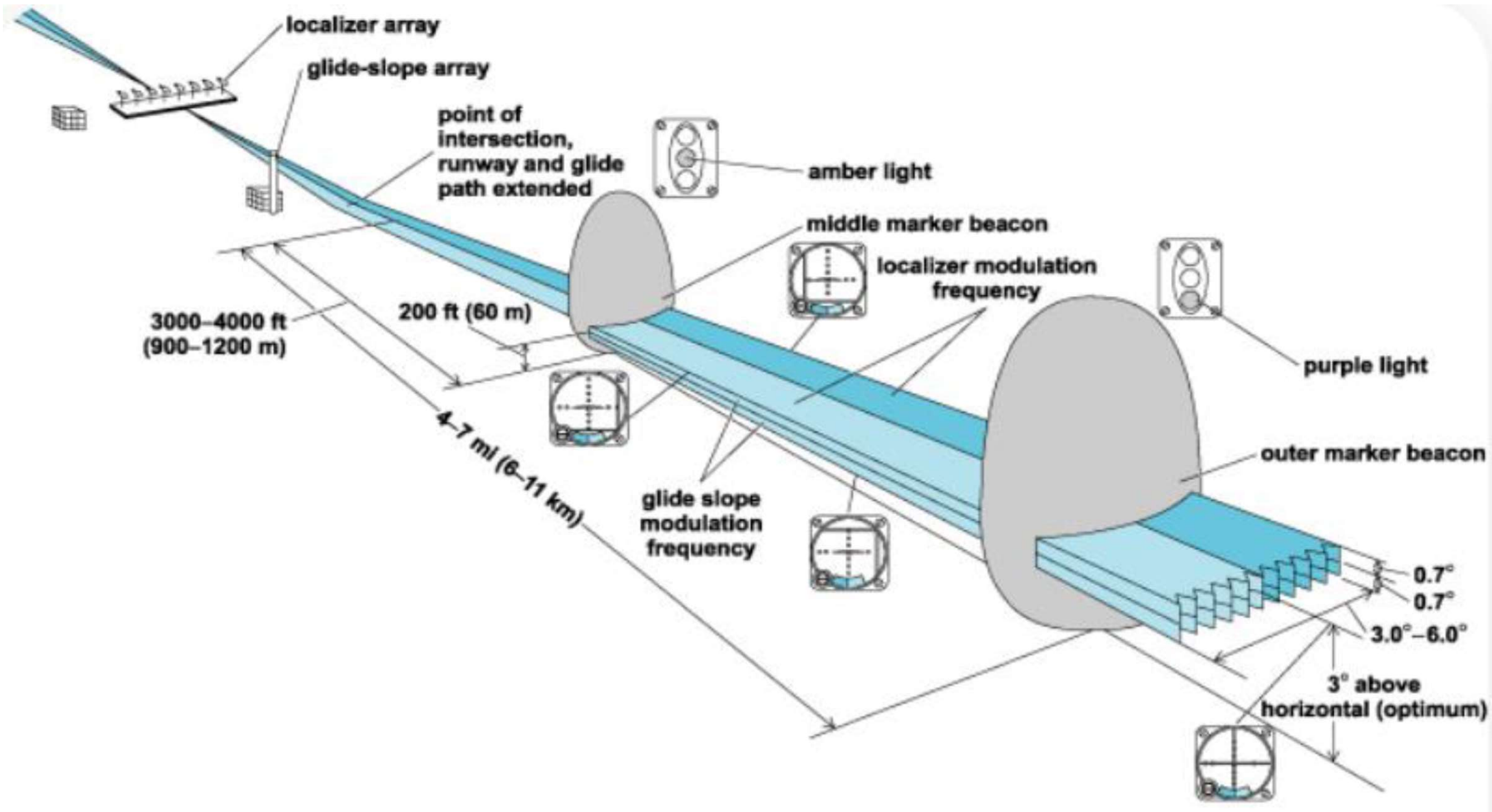




ILS cockpit indications

- On Cockpit deck there will be display called PFD – Primary Flight display
- This display will have indicators that shows the Glide slope and localizer indicators
- Localizer indicator is red vertical rectangle
- Glide Slope indicator is red horizontal rectangle
- G/S is the annunciation showing in Green indicates right vertical path
- LOC is the annunciation showing in Green indicates right horizontal path

ILS Components overview



ILS system overview - Scenarios

A) The cockpit instrument in the most basic ILS display includes one vertical needle that points to the localizer signal, while the horizontal needle represents the glideslope.

B) Some ILS systems include marker beacons at specific distances from the end of the runway that alert the pilot with white, blue or yellow lights and audible alerts in the cockpit.

C) Looking only at the ILS needles, this indication shows an aircraft flying well left of the localizer course and well above the glideslope.

Links & Reference Documents

- https://en.wikipedia.org/wiki/Autoland
- https://www.aai.aero/en/content/what-ils-and-its-different-component

Product System Domain Learning & Exchange(PLEx)

Avionics System

Collision Avoidance and Guidance System

Authors
Rajesh Subramanyam

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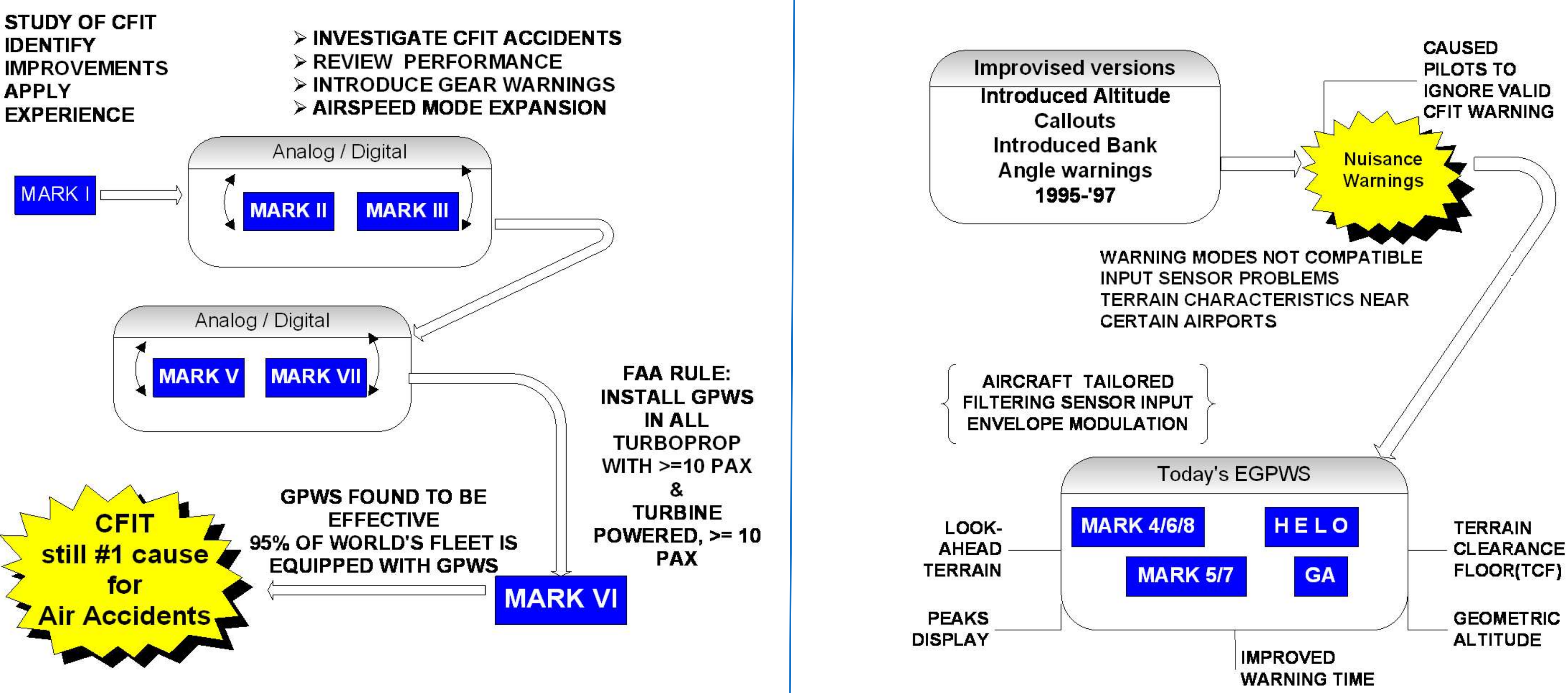
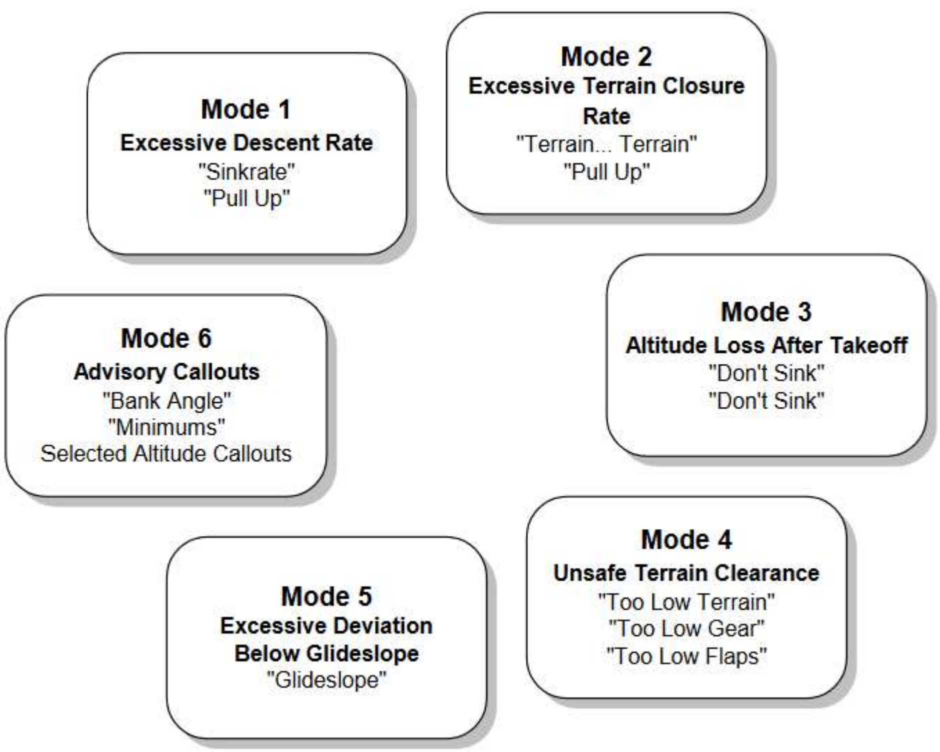
Evolution of EGPWS



What is EGPWS?

The EGPWS incorporates the functions of the basic Ground Proximity Warning System (GPWS). This includes the following alerting modes:



Additionally, Windshear alerting (Mode 7) is provided for specific aircraft types. Mode 7 provides windshear caution and/or warning alerts when an EGPWS windshear threshold is exceeded.

EGPWS Database

The EGPWS adds to these 7 basic functions the ability to compare the aircraft position to an internal database and provide additional alerting and display capabilities for enhanced situational awareness and safety (hence the term “Enhanced” GPWS).

The EGPWS internal database consists of four sub-sets:

1. A worldwide terrain database of varying degrees of resolution.

2. An obstacles database containing cataloged man-made objects 100 feet or greater in height located within North America, portions of Europe and portions of the Caribbean (expanding as data is obtained).

3. A worldwide airport database containing information on runways 3500 feet or longer in length. For a specific list of the airports included, refer to access on the Internet at website www.egpws.com

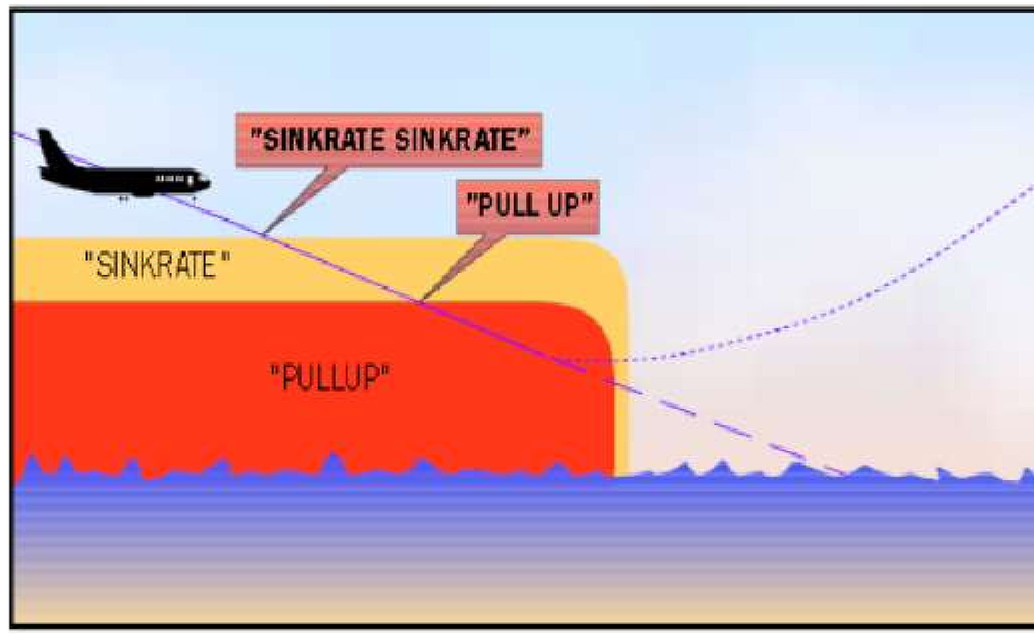
4. An Envelope Modulation database containing information on airport approach and departure profiles to support the Envelope Modulation feature.

Modes of EGPWS

Mode1 – Excessive Descent Rate

Mode 1 provides alerts for excessive descent rates with respect to altitude AGL and is active for all phases of flight. This mode has inner and outer alert boundaries as illustrated in the diagram and graph below. Penetration of the outer boundary activates the EGPWS caution lights and “SINKRATE, SINKRATE” alert annunciation. Additional “SINKRATE, SINKRATE” messages will occur for each 20% degradation in altitude.

Penetration of the inner boundary activates the EGPWS warning lights and changes the audio message to “PULL UP” which repeats continuously until the inner warning boundary is exited.

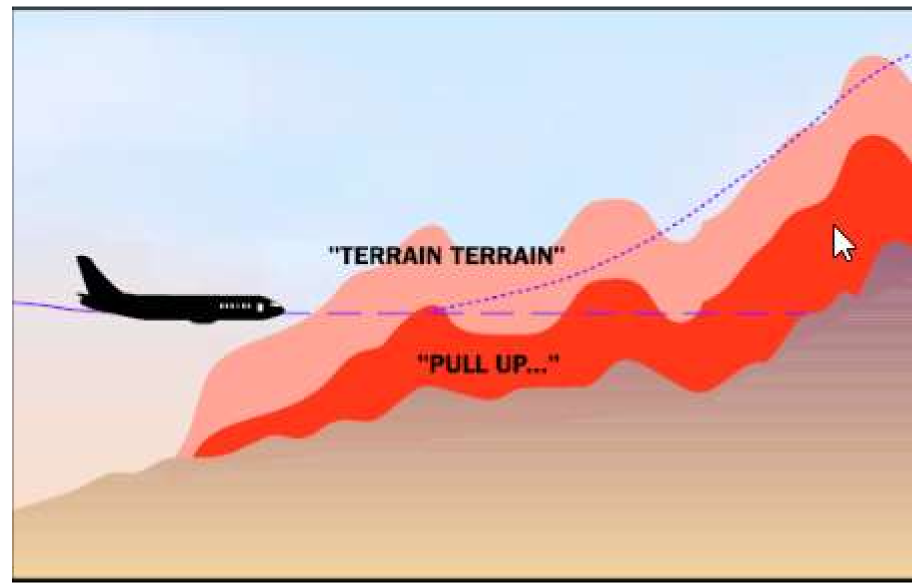


Modes of EGPWS

Mode2 – Excessive Closure to Terrain

Mode 2 provides alerts to help protect the aircraft from impacting the ground when rapidly rising terrain with respect to the aircraft is detected. Mode 2 is based on Radio Altitude and on how rapidly Radio Altitude is decreasing (closure rate).

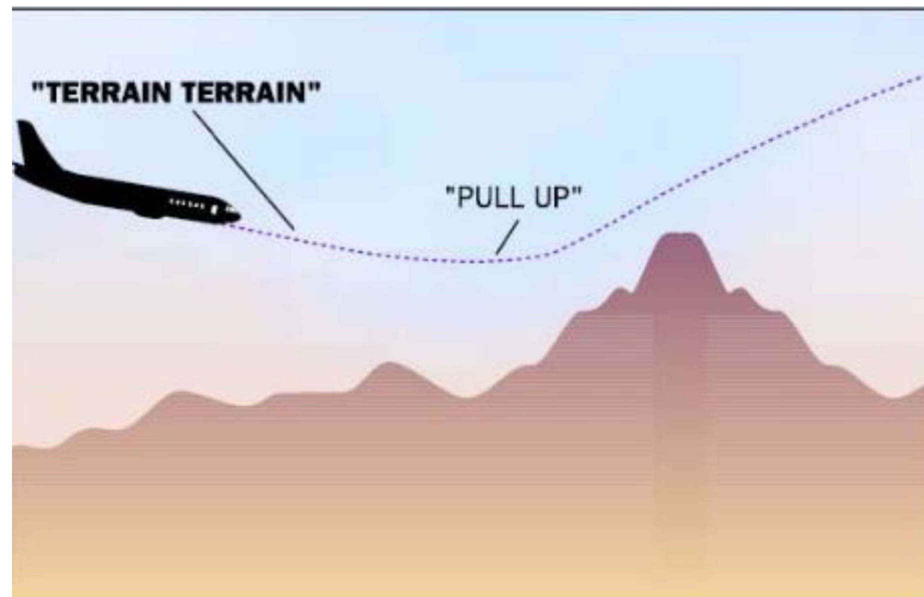
Mode 2A is active during climbout, cruise, and initial approach (flaps notin the landing configuration and the aircraft not on glideslope centerline). If the aircraft penetrates the Mode 2A caution envelope, the aural message “TERRAIN, TERRAIN” is generated and cockpit EGPWS caution lights will illuminate. If the aircraft continues to penetrate the envelope, the EGPWS warning lights will illuminate and the aural warning message “PULL UP” is repeated continuously until the warning envelope is exited



Modes of EGPWS

Mode 2B Mode 2B provides a desensitized alerting envelope to permit normal landing approach maneuvers close to terrain without unwanted alerts. Mode 2B is automatically selected with flaps in the landing configuration (landing flaps or flap over-ride selected) or when making an ILS approach with Glideslope and Localizer deviation less than 2 dots. It is also active during the first 60 seconds after takeoff.

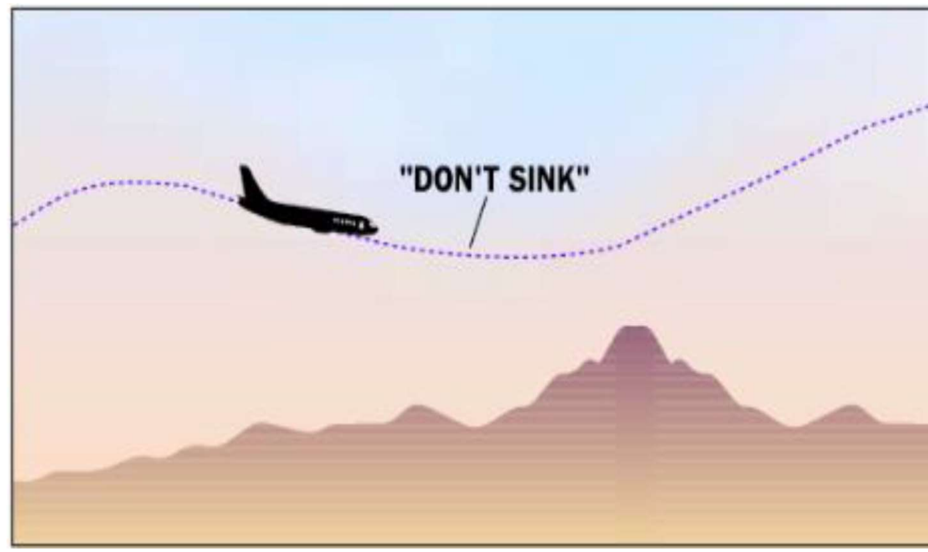
The Mode 2B envelope is selected in order to reduce the potential for nuisance alerts during an approach.



Modes of EGPWS

Mode3 – Altitude Loss After TakeOff

Mode 3 provides alerts for significant altitude loss after takeoff or low altitude go-around (less than 245 feet AGL or 150 feet, depending on aircraft type) with gear or flaps not in the landing configuration. The amount of altitude loss that is permitted before an alert is given is a function of the height of the aircraft above the terrain as shown below. This protection is available until the EGPWS determines that the aircraft has gained sufficient altitude or that it is no longer in the takeoff phase of flight. Significant altitude loss after takeoff or during a low altitude go-around activates the EGPWS caution lights and the aural message "DON'T SINK, DON'T SINK".



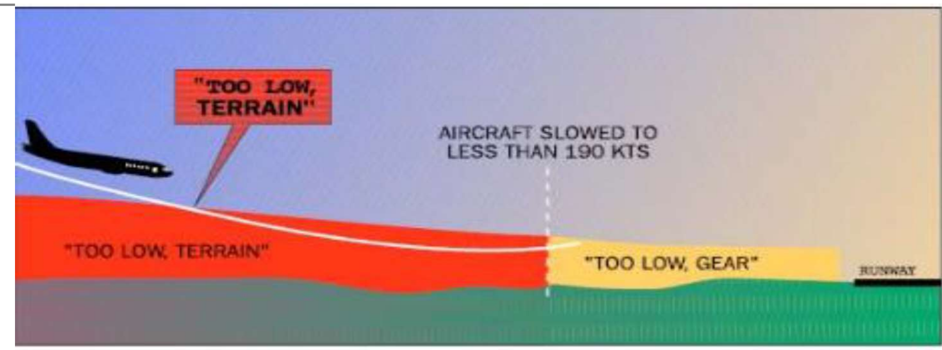
Modes of EGPWS

Mode4 – Unsafe Terrain Clearance

Mode 4 provides alerts for insufficient terrain clearance with respect to phase of flight, configuration, and speed.

Mode 4 exists in three forms, 4A, 4B, and 4C.

- Mode 4A is active during cruise and approach with the gear and flaps not in the landing configuration.
- Mode 4B is active during cruise and approach with the gear in the landing configuration and flaps not in the landing configuration.
- Mode 4C is active during the takeoff phase of flight with either the gear or flaps not in the landing configuration.



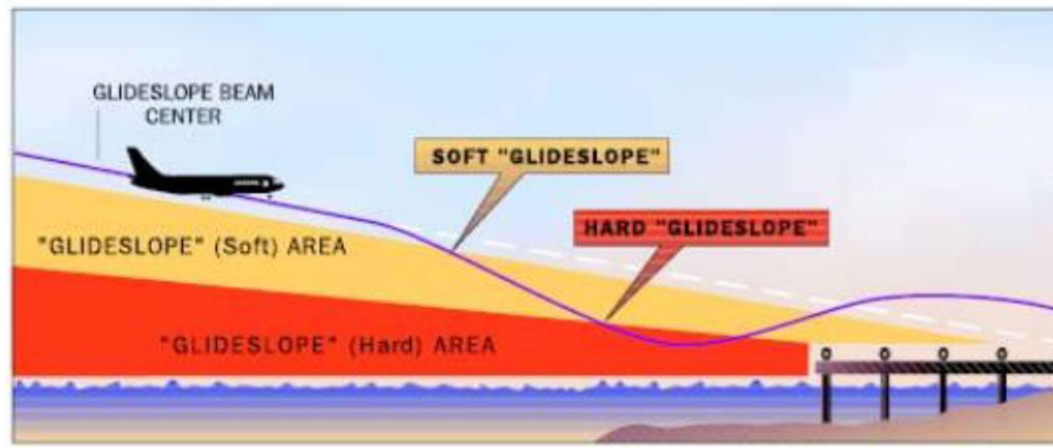
Modes of EGPWS

Mode5 – Excessive Deviation Below Glideslope

Mode 5 provides two levels of alerting for when the aircraft descends below glideslope, resulting in activation of EGPWS caution lights and aural messages.

1. The first level alert occurs when below 1000 feet Radio Altitude and the aircraft is 1.3 dots or greater below the beam. This turns on the caution lights and is called a “soft” alert because the audio message “GLIDESLOPE” is enunciated at half volume. 20% increases in the below glideslope deviation cause additional “GLIDESLOPE” messages enunciated at a progressively faster rate.

2. The second level alert occurs when below 300 feet Radio Altitude with 2 dots or greater glideslope deviation. This is called a “hard” alert because a louder “GLIDESLOPE, GLIDESLOPE” message is enunciated every 3 seconds continuing until the “hard” envelope is exited. The caution lights remain on until a glideslope deviation less than 1.3 dots is achieved.



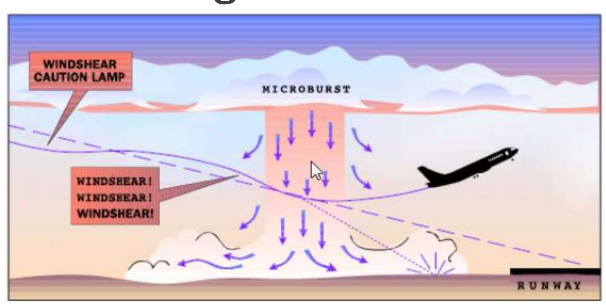
Modes of EGPWS

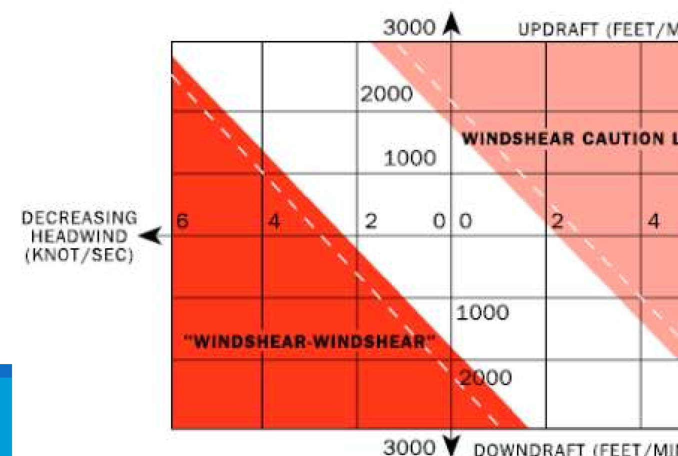
Mode6 – Advisory Call Outs

Mode 6 provides EGPWS advisory callouts based on the menu-selected option established at installation (set by program pin configuration). These callouts consist of predefined Radio Altitude based voice callouts or tones and an excessive bank angle advisory. There is no visual alerting provided with these callouts.

Mode7 – Windshear Alerting

Mode 7 is designed to provide alerts if the aircraft encounters windshear. Two alerting envelopes provide either a Windshear Caution alert or a Windshear Warning alert each with distinctive aural and visual indications to the flight crew.





Evolution of TCAS

Year 1956
- Two airliners collided over the Grand Canyon
- Airlines and the Aviation authorities initiate system development studies for an effective system

Year 1978
- A light aircraft and an airliner collide over San Diego in mid-air
- FAA initiates development of TCAS

Year 1986
- DC-9 collided with a private aircraft over Cerritos, California
- US congressional mandate requiring some categories of American and foreign aircraft to be equipped with TCAS for flight operations in U.S. airspace

Year 1995
- ICAO Annex 10 : SARPs and Guidance material for ACAS II

What is TCAS?

Traffic Alert and Collision Avoidance System - a solution to reduce the risk of midair collisions between aircraft arrived at after extensive research, analysis and flight evaluation by the FAA, the CAAs of several countries and the aviation industry.

TCAS is a family of airborne devices that function independently of the ground-based air traffic control (ATC) system and provide collision avoidance protection.

1. Detects and tracks aircraft in the vicinity of the own aircraft
2. Uses Transponder Interrogation-Replies to determine range, bearing and altitude of the intruder
3. If a potential collision hazard exists, issues visual and audio advisories to the crew for appropriate vertical avoidance maneuvers.

Types of TCAS – TCAS I

Provides Traffic Advisories (TA)

Provides proximity warning of nearby traffic to assist the pilot in the visual acquisition of the nearby aircraft

Usage in

- Turbine-powered, passenger-carrying aircraft having more than 10 and less than 31 seats in the United States
- General aviation fixed and rotary wing aircraft

Types of TCAS – TCAS II

Provides traffic advisories (TA) and resolution advisories (RA)

Recommends escape maneuvers in the vertical dimension to either increase or maintain the existing vertical separation between aircraft

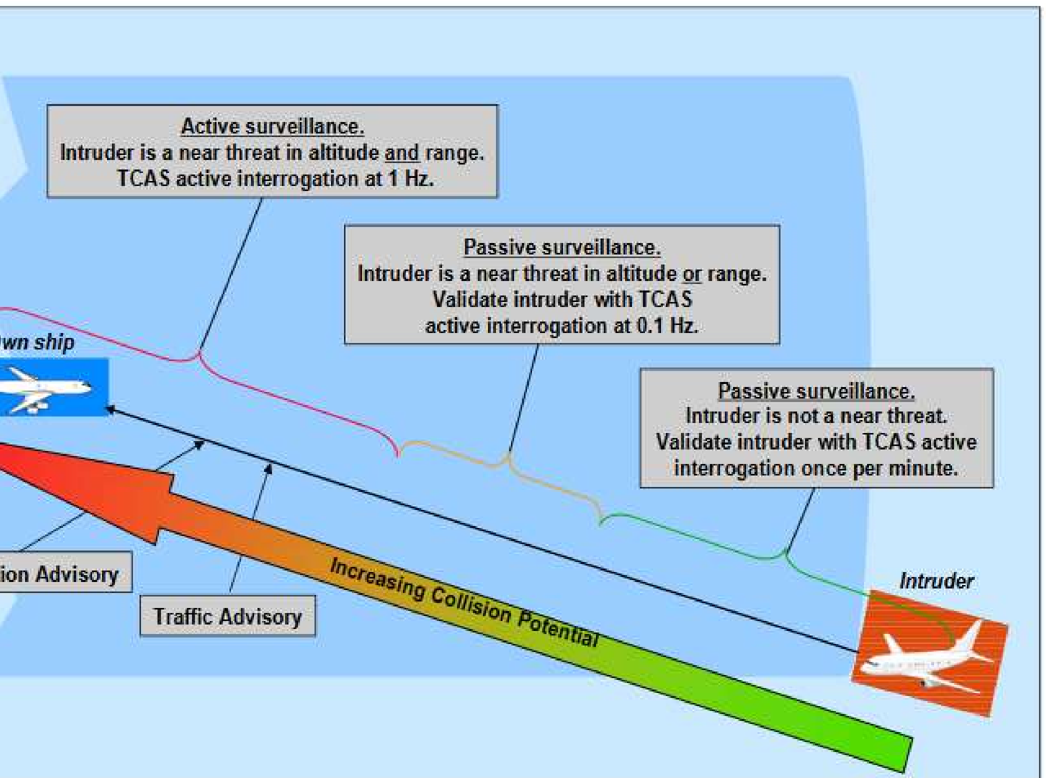
Usage in

- Aircraft carrying more than 30 passengers
- General aviation turbine-powered aircraft

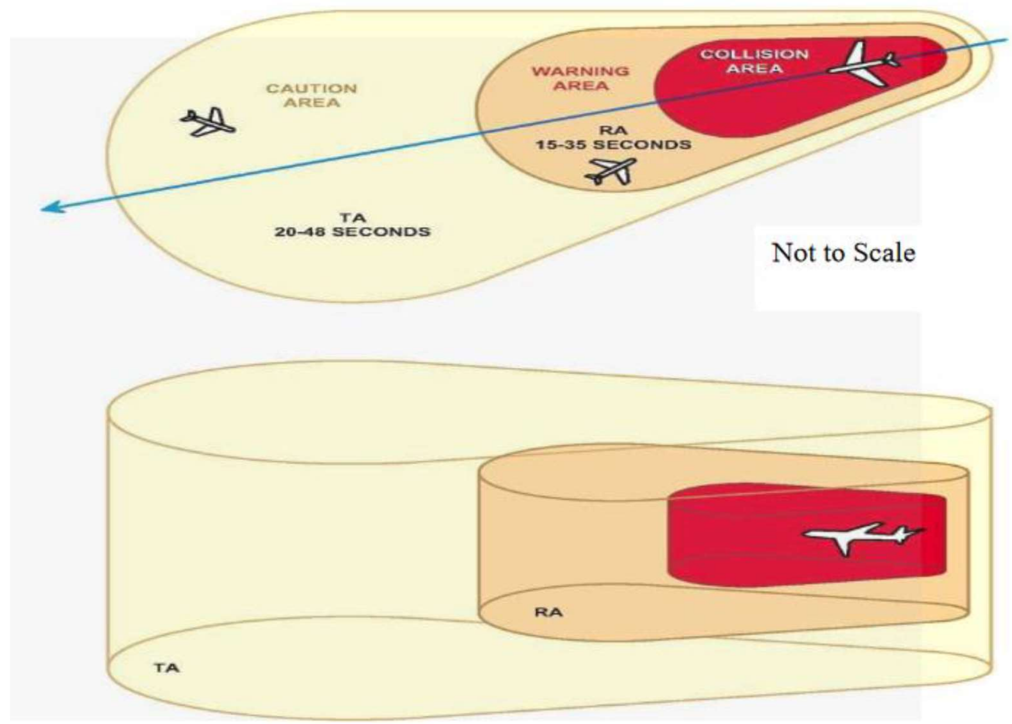
TCAS Levels of Protection

		Own Aircraft Equipment	
		TCAS I	TCAS II
Target Aircraft Equipment	TCAS I	TA	TA and Vertical RA
	TCAS II	TA	TA and Coordinated Vertical RA

TCAS Surveillance and Protection Volume



Transition from Passive to Active Surveillance



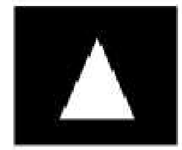
TCAS Protection Volume

Cockpit Presentation of Traffic

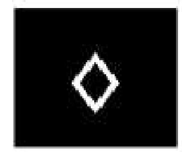
Traffic Advisory (TA) display depicts the position of nearby traffic relative to own aircraft

Assists the pilot in visual acquisition of intruder aircraft

Implemented as
- Dedicated traffic display or
- Shared weather radar display and traffic display or
- Shared Engine Indication and Crew Alerting System (EICAS) display and traffic display



Own-aircraft. Airplane-like symbol, in white or cyan.



Other Traffic, altitude unknown. Unfilled diamond in white or cyan

Proximate Traffic, 1100 feet above and descending. Filled diamond in white or cyan

Traffic Advisory (TA), 900 feet below and level. Filled yellow/amber circle.

Resolution Advisory (RA), 500 feet below and climbing. Filled red square.

Cockpit Presentation : Aural Announcements

TCAS computer generates synthetic voice advisories to supplement the displayed traffic and resolution advisories

TA aural annunciation example

- Traffic, Traffic

RA aural annunciation example

- Climb, Climb, Climb

TCAS Summary

- TCAS is a last resort tool to prevent mid-air collisions between aircraft
- Operational experience has demonstrated utility and efficiency of TCAS
- TCAS version 7 contains refinements and improvements to TCAS design and algorithms.
- TCAS II version 7 is now a world-wide mandate
- TCAS cannot preclude all collision risks.
- ATC procedures must be designed to provide flight safety without any reliance on TCAS
- Pilots and controllers should be well-versed in the operational capabilities and limitations of TCAS.

What is TAWS?

In aviation, a terrain awareness and warning system (TAWS) is generally an on-board system aimed at preventing unintentional impacts with the ground, termed "controlled flight into terrain" accidents, or CFIT.

The specific systems currently in use are the ground proximity warning system (GPWS) and the enhanced ground proximity warning system (EGPWS).

The U.S. Federal Aviation Administration (FAA) introduced the generic term TAWS to encompass all terrain-avoidance systems that meet the relevant FAA standards, which include GPWS, EGPWS and any future system that might replace them.

The TAWS improves on existing GPWS systems by providing the flight crew much earlier aural and visual warning of impending terrain, forward looking capability, and continued operation in the landing configuration. These improvements provide more time for the flight crew to make smoother and gradual corrective action

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What is AESS?

The aircraft environmental surveillance system (AESS) optimizes performance by integrating weather, traffic and terrain awareness information.

Information is exchanged between the enhanced ground proximity warning system (EGPWS), TCAS with mode S/ADS-B transponders and the RDR-4000 3-D volumetric weather radar to provide pilots with up-to-date flight safety information. Both weather and terrain information is displayed on a vertical situational display simultaneously to increase situational awareness.

Integration also increases aircraft performance while reducing weight and volume.

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Flight Data Recorders

A flight recorder is an electronic recording device placed in an aircraft for the purpose of facilitating the investigation of aviation accidents and incidents. Flight recorders are also known by the black box—they are in fact bright orange to aid in their recovery after accidents.

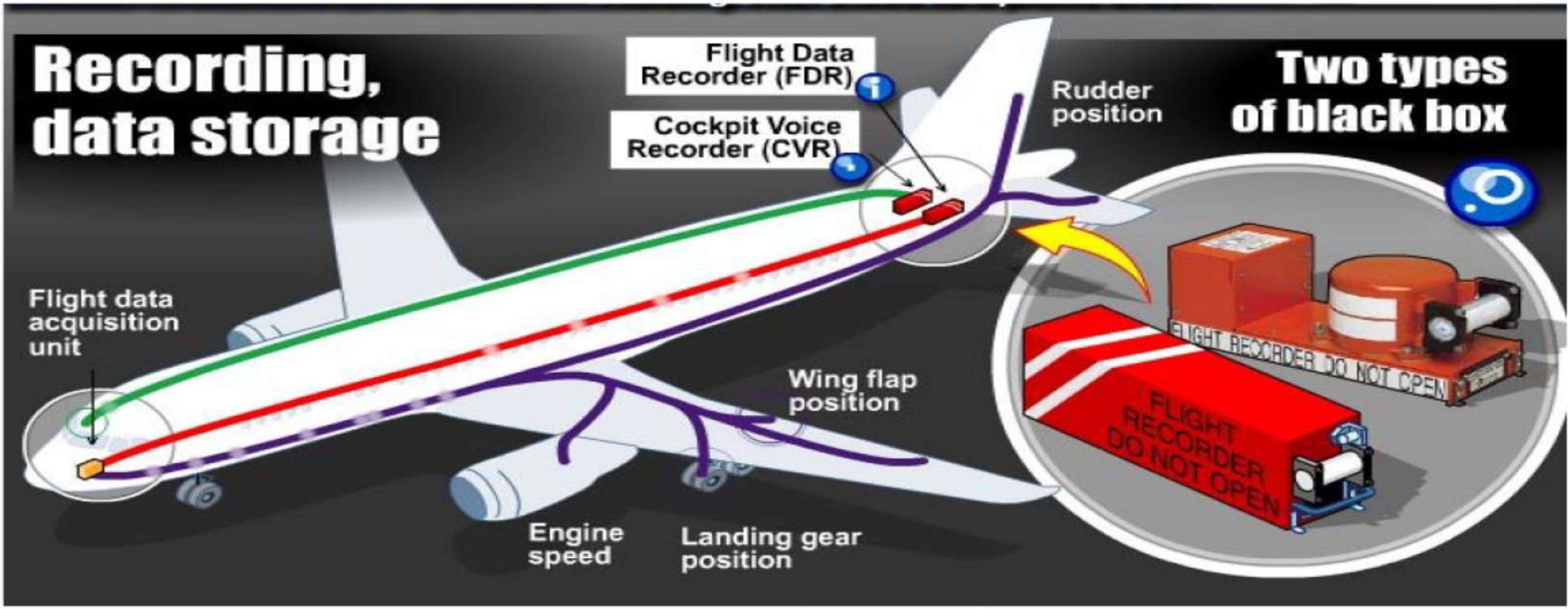
There are two different flight recorder devices:

1. Flight Data Recorder (FDR) preserves the recent history of the flight through the recording of dozens of parameters collected several times per second

2. Cockpit Voice Recorder (CVR) preserves the recent history of the sounds in the cockpit, including the conversation of the pilots.

The two devices may be combined in a single unit. Together, the FDR and CVR objectively document the aircraft's flight history, which assists in later investigation.

Flight Recorder Location



The unit is usually mounted in the aircraft's empennage (tail section)

Flight Data Recorder

Flight Data Recorder (FDR) is a device which records information about the flight of the airplane.

The data recorded on the Flight Data Recorder is used for accident investigations; the data may also be used for monitoring airplane systems.

The flight recorder system will automatically record airplane airspeed, attitude, altitude, engine performance and other data from engine start-up to engine shut-down.

Operation of the FDR must be fully automatic and not require pilot switching.

Most importantly, pilots are not able to turn the FDR off in flight or erase data after landing, to ensure data that may be relevant to an accident or incident is protected for use by accident investigation officers.

An example of a flight data recorder; the underwater locator beacon is the small cylinder on the far right.

Flight Data Recorder

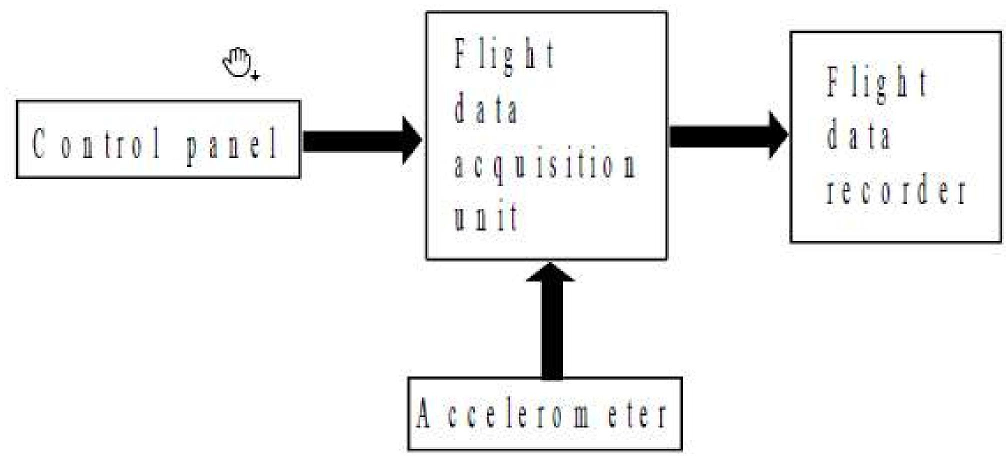
The purpose of flight data recorder is to record the data passed to it by the FDAU.

A flight data recorder will record twenty-five hours of data on a continuous tape.

To protect the tape in the event of an accident, the recorder is housed in a sealed

The FDR is normally located in a part of the airframe that is likely to suffer least in the event of an impact. Consequently, they are normally installed in the tail or roof of aircraft.

Digital Flight Data Recorders (DFDR) are fitted to many modern transport aircraft, and have the capacity to record as many as 300 parameters, including control positions and systems performance.



An under water locator beacon, which emits an ultrasonic signal when immersed in water, is attached to the front of the FDR. The beacon is turned on automatically when immersed in water, to assist in locating the recorder when under water.

Flight Data Recorder

On Model 737,757, and 767 airplanes the FDAU acquires airplane performance data for the Airplane Condition Monitoring System (ACMS). These data are for maintenance purpose.

Airline personnel retrieve the ACMS data collected by the FDAU and use it to check the operation of airplane systems and engines.

The engine data is particularly useful for identifying engine performance trends.

An accelerometer is an integral part of the flight recorder system.

Flight Data Recorder

Federal Airworthiness Regulation (FAR) 121.343 requires that 17 parameters are recorded by the FDR. The seventeen parameters currently required by the FAR are:

- Time
- Altitude
- Airspeed
- Vertical acceleration
- Heading
- Time of each radio transmission to or from ATC
- Pitch attitude
- Roll attitude
- Longitudinal acceleration
- Control column or elevator position
- Pitch trim position
- Control wheel or aileron position
- Rudder pedal or rudder position
- Thrust of each engine
- Position of each thrust reverser
- Trailing edge flap or flap handle control position
- Leading edge flap or flap handle control position

Flight Data Recorder

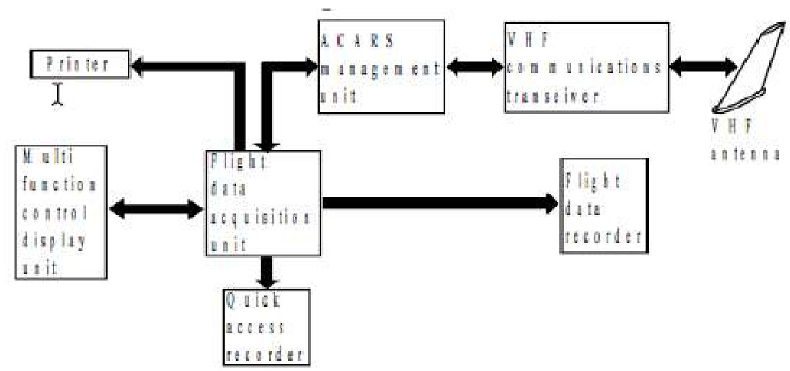
ACMS data, which contains some of the same data as sent to the flight.

The data storage device may be a disk drive installed in the FDAU itself or a Quick Access Recorder (QAR).

A QAR is a tape recorder similar to a flight recorder but without the crash protection features.

Some FDAUs can store the data in memory and then write the data to a storage device called an airborne data loader after the airplane has landed.

Airplane maintenance personnel will periodically remove the tapes from the QAR for analysis. The tape is taken from the airplane and read by the ACMS A QAR can store much more data than can a disk drive installed in the FDAU.



What is Connected Aircraft?

The Connected Aircraft is the industrial Internet of Things (IIoT) brought to aviation. Leveraging new technology and much more reliable high-speed Wi-Fi connections, the Connected Aircraft is a series of solutions designed to revolutionize modern-day flying, dramatically improving fleet management, flight safety, passenger experience, aircraft maintenance, flight operations, aircraft turnaround time and costs.

The solutions connect an airplane's components and equipment, enabling each to immediately send, receive and analyze data. This can enable more informed decision-making, operational cost reduction and an improved flying experience.

Using big data, analytics and secure communications technology, the Connected Aircraft can better anticipate issues and offer unique insights. By harnessing the power of analytics with the confidence of a secure communication link, operators can potentially avoid weather, flight disruption and additional cost, and drive faster turnaround times.

How does the Connected Aircraft help operators save money?

By providing greater visibility into operations, Connected Aircraft solutions can help reduce fuel costs and emissions. Connected Aircraft solutions help operators boost profits by streamlining and improving operations - saving operators up to $200,000 a year per aircraft.

Benefits of Connected Aircraft

The benefits of the Connected Aircraft go far beyond passengers' needs. The solution can benefit everyone who manages, works or travels by plane.

For owners and operators, the Connected Aircraft can:

1. Revolutionize flight operations—dramatically improving aircraft turnaround time.
2. Cut troubleshooting time by up to 25% via predictive maintenance.
3. Provide access to real-time information, which allows:
   - Flight and fleet operations to translate aircraft data into actionable metrics to improve efficiency and save money
   - Flight operation managers to better manage fleet trajectory and lock in schedules

Benefits of Connected Aircraft

For pilots and flight crews, the solution:

1. Provides more information about the flight environment
2. Helps all flight departments work together
3. Enables data sharing across scheduling, flight planning, tracking and post-flight groups to:
   - Improve strategic maneuvering.
   - Reduce flight times and optimizing route miles ahead of bad weather.
4. Provides pilots with access to updated and customized wind and temperature information throughout all phases of the flight
5. Delivers 3D animated views of destination airports that increase pilots' situational awareness and allow them to see and avoid bad weather and clear-air turbulence—which can lead to improved arrival times

Benefits of Connected Aircraft

It allows ground and maintenance crews to:

1. Keep operations at optimal efficiency and aircraft in optimal condition.
2. Reduce aircraft on-ground time and costs through data gateways.
3. Adjust preparations in response to weather data and see the effect of pilot decisions on arrival time.
4. Identify components that will require maintenance or replacement before the aircraft lands and ensure spare parts are available, if needed.
5. Cut troubleshooting time by up to 25% via predictive maintenance.

Benefits of Connected Aircraft

The Connected Aircraft also benefits passengers through:

1. Shorter flights
2. More punctual departures
3. Enhanced in-flight entertainment and productivity through 10X to 100X faster Wi-Fi speeds and fewer drops
4. Fewer in-flight bumps

Links & Reference Documents

EGPWS Pilot Guide - https://skybrary.aero/bookshelf/books/3364.pdf

TCAS Advisory Circular –
https://www.faa.gov/documentLibrary/media/Advisory_Circular/TCAS%20II%20V7.1%20Intro%20booklet.pdf

For more information or to add new topics,
Contact,
[Sabut, Sunil K]