Automatikus fedélzeti irányítórendszerek a légiközlekedésben

Légijárművek elektronikus rendszerei

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COMPUTER AND AUTOMATION RESEARCH INSTITUTE
HUNGARIAN ACADEMY OF SCIENCES

Féléves tematika

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- 1. Bevezető
- 2. UAV HIL Labor gyakorlat
- 3. Repülőgép irányítása a pilóta szemszögéből
- 4. Repülőgépek érzékelő egységei, szenzorjai
- 5. Navigáció alapjai, navigációs eszközök
- 6. Navigációs eszközök a pilóta szemszögéből
- 7. Repülőgépek aerodinamikája, repülésmechanikája
- 8. Repülőgép viselkedésének matematikai modellezése
- 9. Repülőgép automatikus stabilizálása, szabályozása
- 10. Robotpilóta rendszerek
- 11. Avionikai rendszerek mikroszámítógépes megvalósítása
- 12. Légiirányítás, légtér
- 13. Robotrepülőgép gyakorlati bemutató
- 14. Hallgatói prezentációk - Beszámoló

Avionika

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- Az **avionika** a légi járművek elektromos és elektronikus rendszereivel, berendezéseivel foglalkozó szakterület. Az *avia*tika (repülés) és elektr*onika* összevonásával létrejött szó, az angol *avionics* megfelelője.
- Magába foglalja a villamosenergia-ellátás, a világítás, a hírközlés, a navigáció eszközeit a légijármű fedélzetén, a többi légijármű-rendszer (például hajtóművek, repülésvezérlés, futómű) elektronikus és villamos összetevőit.
- Tágabb értelemben még ide sorolják a felsorolt fedélzeti eszközök ellenőrzéséhez, karbantartásához, javításához a földön szükséges műszereket, készülékeket is.
- A számítógépek széles körű elterjedésével a légi járműveken ezek szoftvere is az avionika körébe tartozik.

NASA ALTAIR Holdkomp Avionikai Rendszereinek Definíciója

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Általános Avionikai Rendszer Definiciója:

A holdkomp minden olyan integrált egysége mely a repüléssel kapcsolatos elektromos, elektronikai, vagy elektro-mechanikus funkciókat lát el, az ezekhez kapcsolódó elektromos vezetékekkel, kábelekkel együtt, valamint az ezen komponenseken futó szoftverek.

Főbb Avionikai Alrendszerek:

- Parancs- & Adatkezelő (C&DH)
- Kommunikáció & Követés (C&T)
- Elektromos ellátás
- Irányítás, Nav & Szabályozás (GN&C)
- Személyzeti interfész, kormányzás, kijelzők & audio-video
- Repülési Szoftver (FSW)

Egyéb Avionikai Alrendszerek :

- Hőmérséklet szabályozó & ellenőrző
- Mechanizmusok szabályozó & ellenőrző
- Reaction Control System Avionics
- Üzemanyag szabályozó & ellenőrző
- Tolóerő vektoráló szabályozó & ellenőrző
- Ereszkedési fő hajtómű szabályozó & ellenőrző
- Emelkedési fő hajtómű szabályozó & ellenőrző
- Élet fenntartó rendszer szabályozó & ellenőrző

Bussines Jet Fedélzeti Rendszerei (Falcon 7X)

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- Jégtelenítő (Anti Ice)
- Kiegészítő Energia Fejlesztő (APU)
- **Robotpilóta (Automatic Flight)**
- **Kommunikáció (Communications)**
- ***Elektromos (Electrical)***
- **Elektromos Kijelző (Electronic Display System)**
- Tűzvédelmi (Fire Protection)
- **Repülés Szabályozó (Flight Controls)**
- Üzemanyag (Fuel System)
- **Hidraulika (Hydraulics)**
- Levegő kezelési (Integrated Air Management System)
- Futómű és Fékek (Landing Gear & Brakes)
- Világítás (Lighting)
- **Navigáció (Navigation)**
- ***Hajtómű (Power plant)***
- Karbantartási (Maintainance)

Falcon 7X az első Fly-by-wire Bus. Jet

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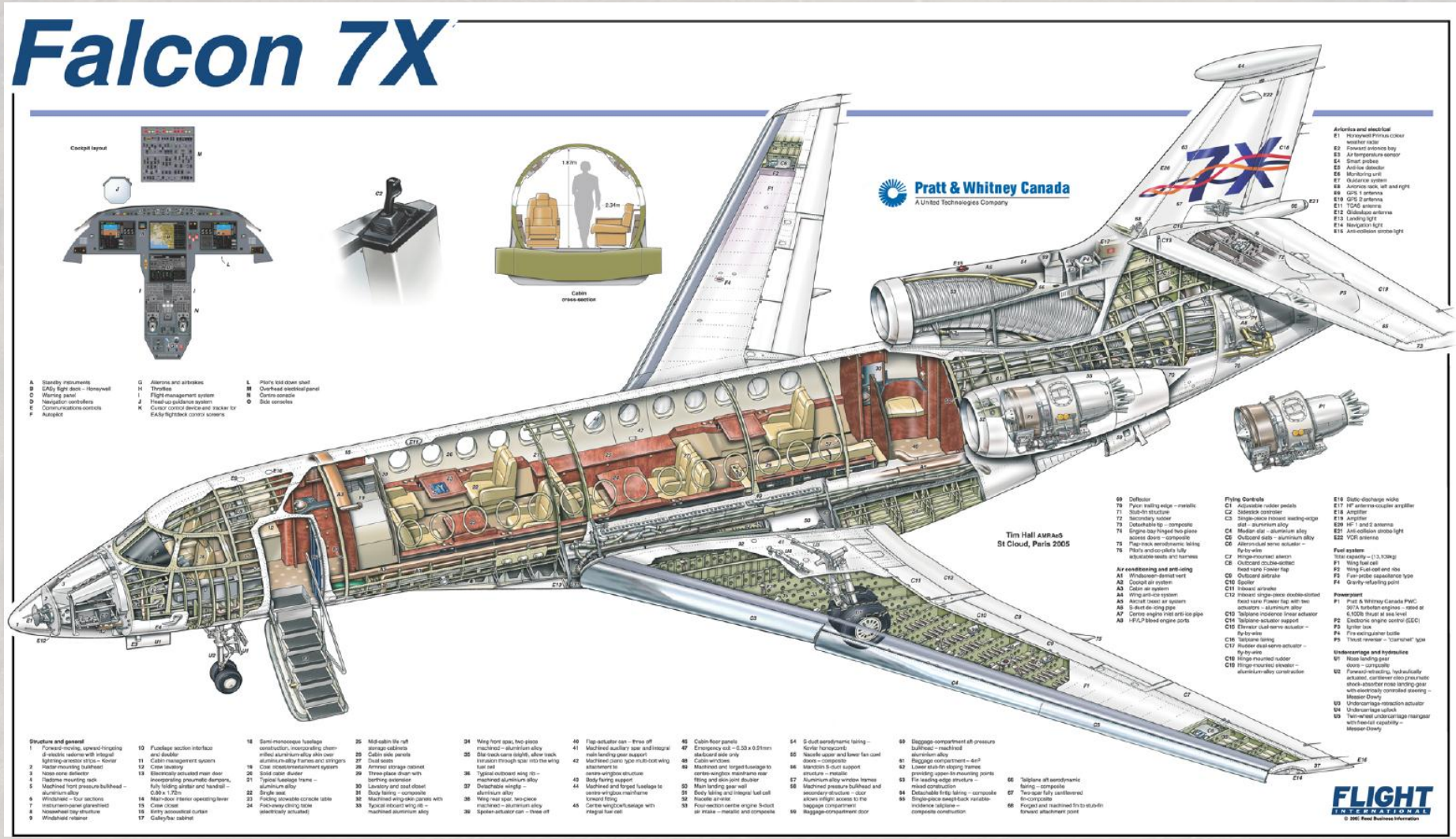


787 Integrated Systems
Component Placement Map
Auxiliary Power Unit
APS Fire Extinguisher
Cargo Bay Smoke Detectors
Primary Power Distribution Panels
Fire Extinguishers Cargo Bay/Engine
Squib Monitor Control Unit
ECS Fans
Cargo Fire Extinguisher Flow Valve
Remote Power Distribution Units
Pack Bay Overheat Detection System
Cargo Bay Fire Extinguishing Nozzle
APU Exciter Inverter
Supplemental Cooling Units
APU Starter Generators
APS Extinguishing Nozzle
APS Fire Detector
Cargo Fire Extinguishing Filter/Regulator
Cargo Bay Smoke Detectors
Remote Power Distribution Units
ECS Duct Smoke Detectors
Galley Cooling Units
Cabin Pressurization & Control System
Main Engine Start Controller
Hydraulic Pump Motor Controllers
Liquid Cooling System
Hybrid Ram Air Turbine
Electric Motor Pumps
Nitrogen Generation System
Wheel Well Fire Detection System
Cabin Air Compressors
Cabin Air Compressor Inlet Ice Protection System
Air Conditioning Packs
Cargo Bay Fire Extinguishing Nozzle
Engine Fire Detectors
Rain Removal
Primary Power Distribution Panels
Ram Air Turbine Generator Control Unit
Cargo Heating & Air Conditioning
Cabin Pressurization & Control System
Electric Motor Pump
Engine Accessory Drive
Gearbox with Oil Pump
Oil Tank (on Nacelle)
Rolls-Royce Trent 1000 Engine
Electric Starter Generators
Engine Anti Ice
Air-Thermal Management
Auxiliary Power System
Electrical System
Engine Systems
Fire Protection System
Hydraulic System
Hamilton Sundstrand
A United Technologies Company

787 Avionikai beszállítók

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Avionic Components

ECE: *Control Panels - Cockpit panel*

Korry Electronics Co: *Control Panels - Flight deck control panels, including pilots' overhead panels & switches*

Rockwell Collins Electro Mechanical Systems: *Control Panels - Pilot control systems*

Communications (Airborne)

Avionica, Inc.: *Airborne Communication Systems - satLINK Iridium communications gateway*

Avtech Corporation: *Onboard Intercom Systems - Flightdeck digital control audio system*

Cobham SATCOM: *Communication Antennas - HGA-7001 satcom antenna system*

HR Smith (Technical Developments) Ltd: *Communication Antennas - Antennas*

Rockwell Collins : *Radio Communications Equipment - Communications system including VHF-2100, SAT-2100, HFS 900D, digital flight deck audio system*

Tecom Industries, Inc.: *Communication Antennas - HGA-2100 high gain INMARSAT antenna*

Flight and Data Management

Astro-Med: *Cockpit Printers - Flight deck printers*

Astronautics Corp of America: *Onboard Computers - Dual Class 3 Electronic Flight Bags*

GE Aviation Systems: Digital *Flight Management Systems - Common Core System*

Green Hills Software Inc: *Onboard Computers - Integrity-178B operating software*

Honeywell Aerospace: *Flight Management Systems – Flight management system; flight controls*

Rockwell Collins: *Avionics Management Systems – Core network & common data network; flight deck display system & crew alert system; Integrated Surveillance System; cockpit voice & flight data recording system*

Indicators and Instruments

Goodrich Sensors & Integrated Systems: *Fuel Quantity Indicators – Fuel quantity indicating system & fuel quantity data concentrators; refuel panels*

Rockwell Collins: *LCD Displays - Flight deck display system including LCD & head-up displays*

Thales Avionics S.A.: *Electronic Flight Instrument Systems - Integrated Electronic Standby Instrument*

Navigation Aids (Airborne)

Honeywell Aerospace: *Inertial Components & Systems - Navigation package including inertial reference system, air data system , multi-mode receiver*

Warning Systems

Honeywell Aerospace Electronic Systems : *Terrain Awareness and Warning Systems - TAWS, as part of Rockwell Collins ISS*

Hamilton Sundstrand Részegységek a 787-en

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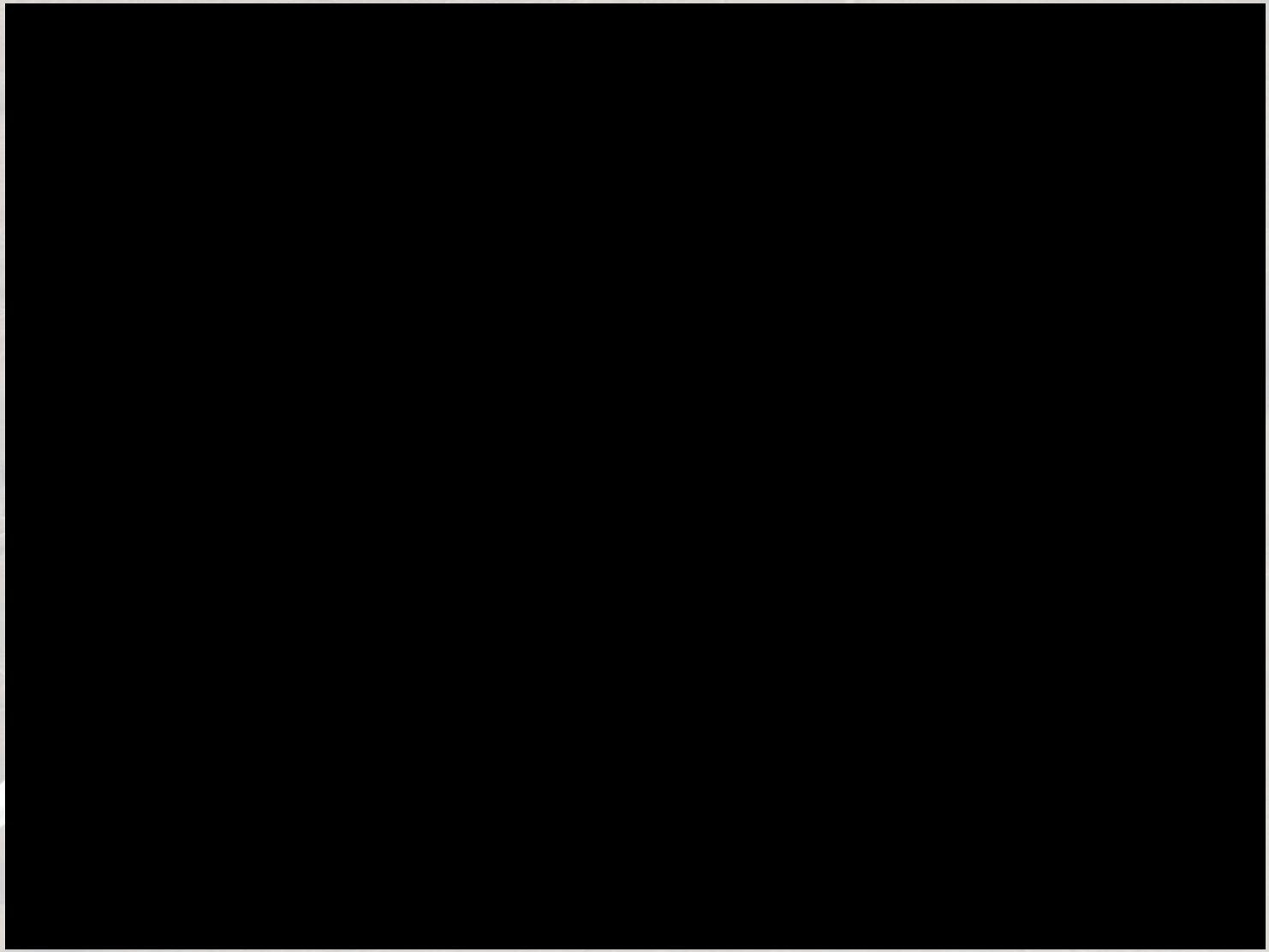

Automatikus fedélzeti irányítás fő egységei

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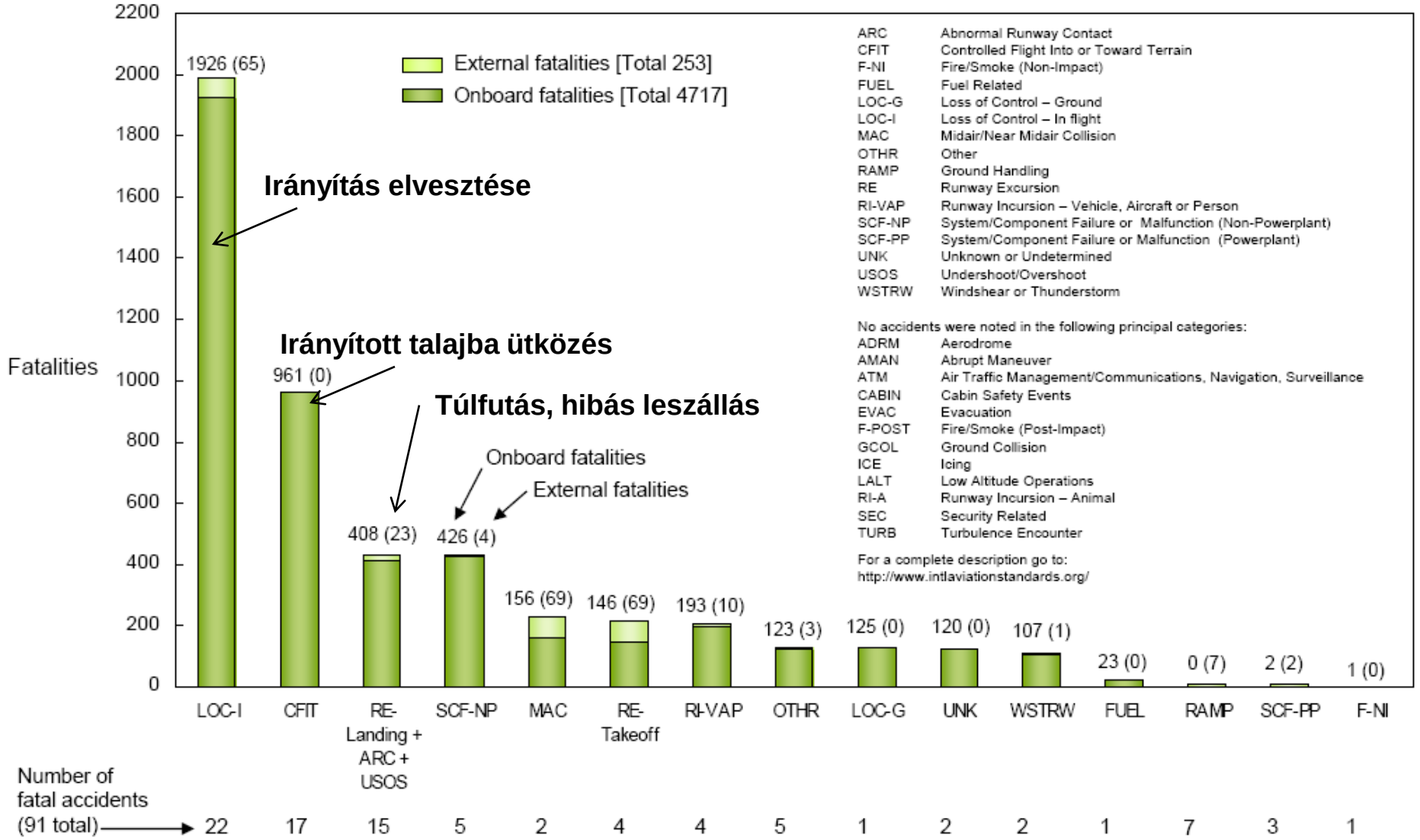
- **Kommunikáció**
- **Navigáció**
- **Pilótafülke**
- **Robotpilóta**
- **Repülésvezérlés**
- ***Arhitektúra***

Nagyfokú különbségek a megbízhatóság és technológiai fejletségtől függően:

- ***FAR 23***
  - ***Analóg műszerfal***
  - ***Digitális (Glass cockpit)***
- ***FAR 25***
  - ***Hagyományos kábeles irányítás***
  - ***Elektronikusan vezérelt (Fly-by-wire → FBW)***
- ***Pilóta nélküli Légijármű (UAV)***

Fatalities by CAST/ICAO Common Taxonomy Team (CICTT) Aviation Occurrence Categories

Fatal Accidents – Worldwide Commercial Jet Fleet – 1999 Through 2008



ARC	Abnormal Runway Contact
CFIT	Controlled Flight Into or Toward Terrain
F-NI	Fire/Smoke (Non-Impact)
FUEL	Fuel Related
LOC-G	Loss of Control – Ground
LOC-I	Loss of Control – In flight
MAC	Midair/Near Midair Collision
OTHR	Other
RAMP	Ground Handling
RE	Runway Excursion
RI-VAP	Runway Incursion – Vehicle, Aircraft or Person
SCF-NP	System/Component Failure or Malfunction (Non-Powerplant)
SCF-PP	System/Component Failure or Malfunction (Powerplant)
UNK	Unknown or Undetermined
USOS	Undershoot/Overshoot
WSTRW	Windshear or Thunderstorm

No accidents were noted in the following principal categories:

ADRM	Aerodrome
AMAN	Abrupt Maneuver
ATM	Air Traffic Management/Communications, Navigation, Surveillance
CABIN	Cabin Safety Events
EVAC	Evacuation
F-POST	Fire/Smoke (Post-Impact)
GCOL	Ground Collision
ICE	Icing
LALT	Low Altitude Operations
RI-A	Runway Incursion – Animal
SEC	Security Related
TURB	Turbulence Encounter

For a complete description go to:
http://www.intlaviationstandards.org/

Note: Principal categories as assigned by CAST.

Repülőgép (irányító) rendszereinek összefüggései

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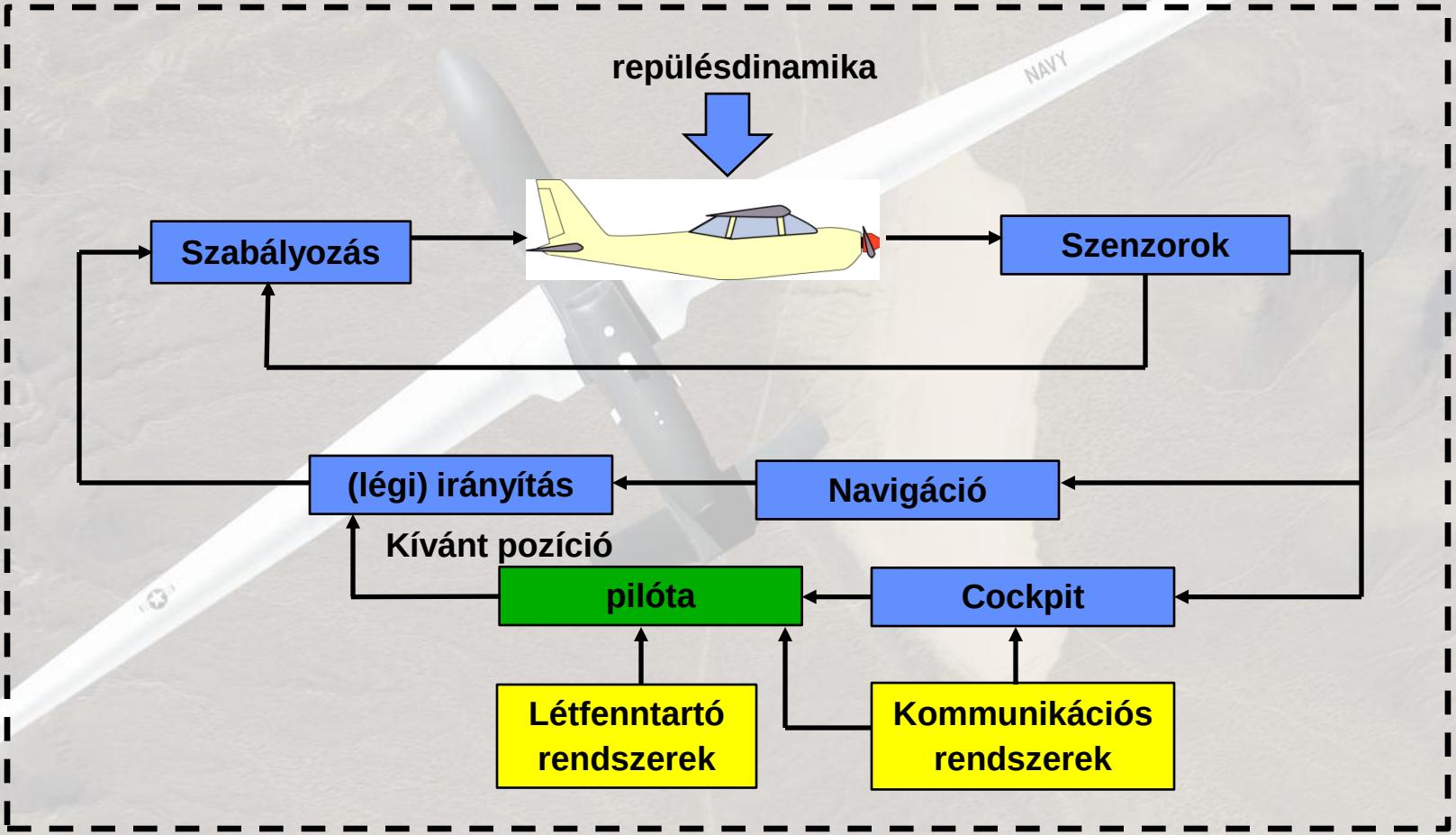

Repülés Szabályozó Rendszerek Struktúrája

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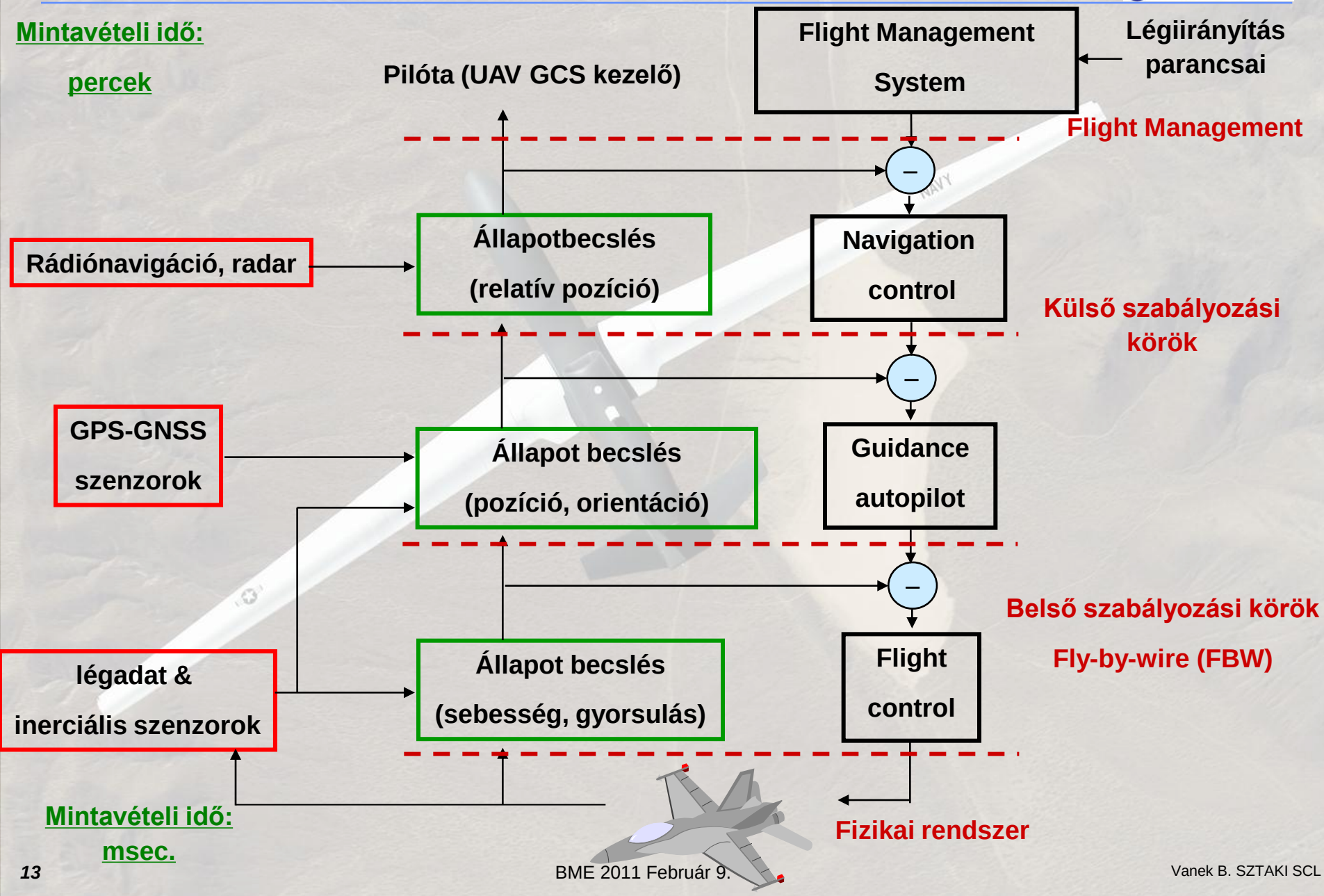

Űrsikló Redundáns Fedélzeti Irányítási Köre

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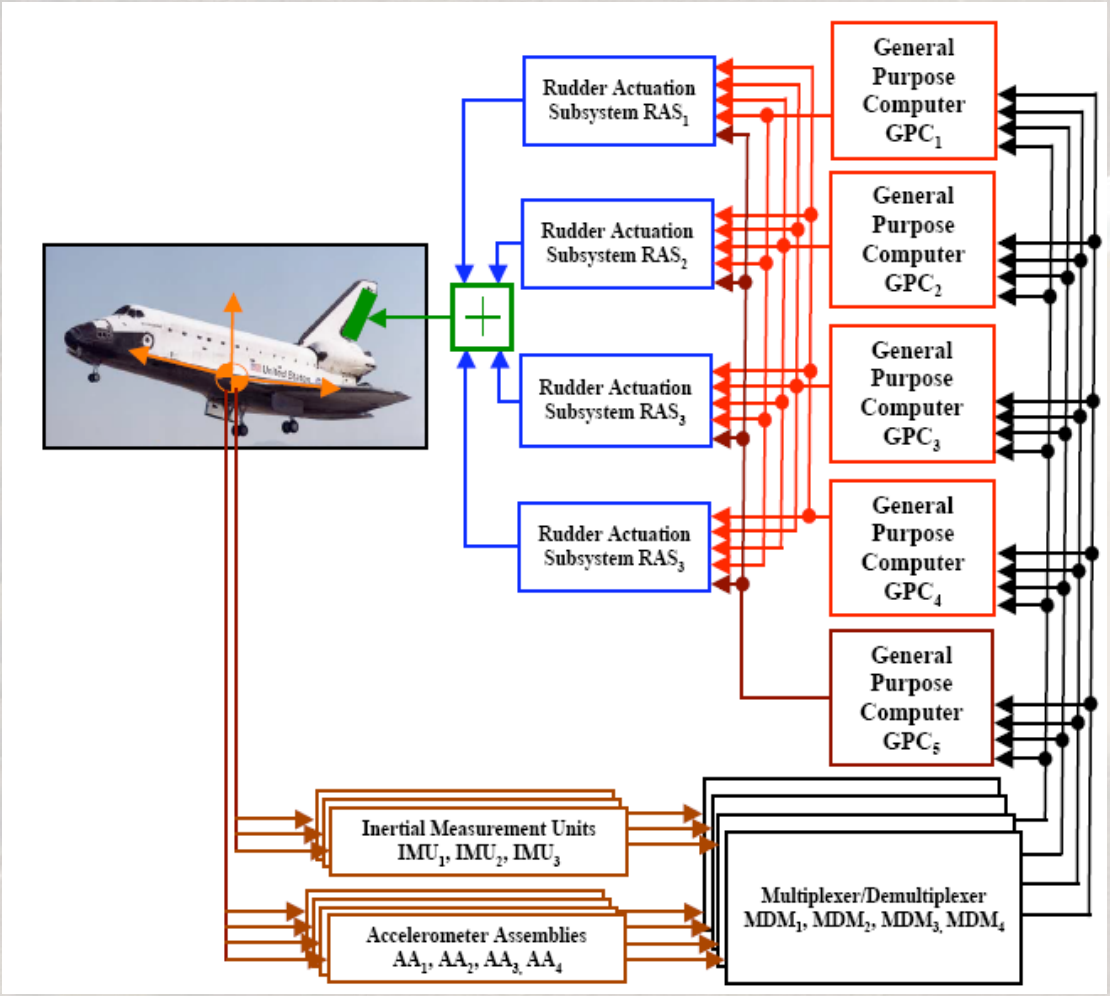

- *Kommunikáció*
- Navigáció
- Pilótafülke
- Robotpilóta
- Repülésvezérlés
- + Arhitektúra

Megbízhatóság és rendszerelmélet mindent átsző

UAV (Global Hawk) Elektronikus Rendszerei

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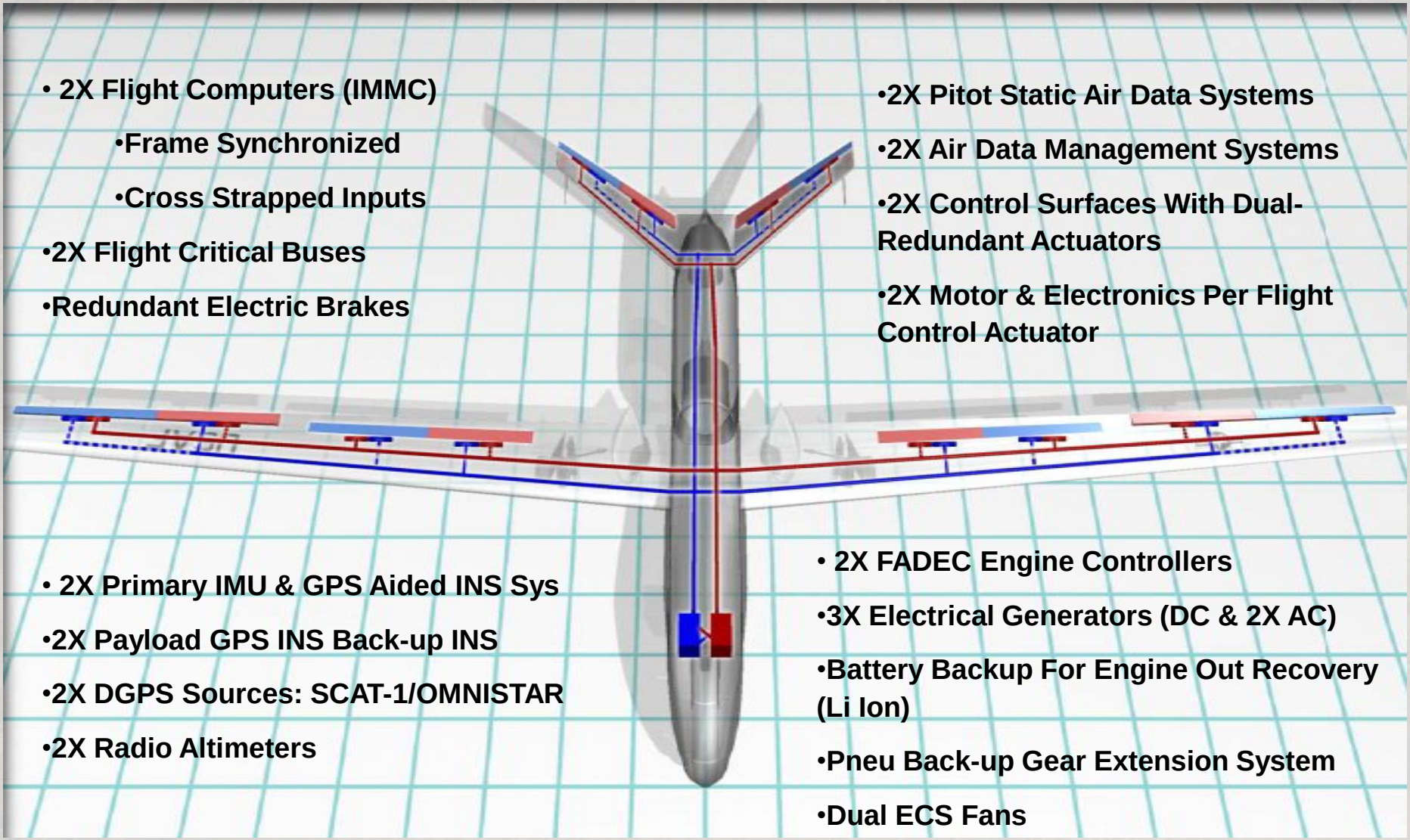

UAV Avionika

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Components	MAV	Shadow	Predator A	Predator B
Inertial Measurement Unit	BG1930	Guidestar		HG1700
Flight Management Unit	BG1930	Guidestar		
GPS	Rockwell Collins			
Power				
Air Data	static			
Actuation	Volz	DC PMBL		
Guidance, Navigation, & Control Software Algorithms	MACH, ECTOS			
Redundancy Management	n/a	n/a	n/a	
Fault Detection	n/a	n/a	n/a	
Fault Isolation	n/a	n/a	n/a	
Reconfiguration	n/a	n/a	n/a	n/a

n/a = non applicable, in that the feature is not currently included for the vehicle indicated

Garmin 1000 a Cessna C-172-en

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GPS / Com / Nav 1
Similar to Garmin 430

ADC
OAT, Pitot & Static instr.

GPS / Com / Nav 2
Similar to Garmin 430

AHRS
Attitude & Heading
Rate sensors, Slip/Skid

Optional modules
- *ADF &/or DME*
- *Stormscope*
- *Synthetic Vision*
- *Traffic Advisory S'm*

Engine / Airframe unit
Engine, Fuel sensors

Transponder
Modes A, C, S

Magnetometer

Kisrepülőgépes jövő: Építőelem elvű felépítés

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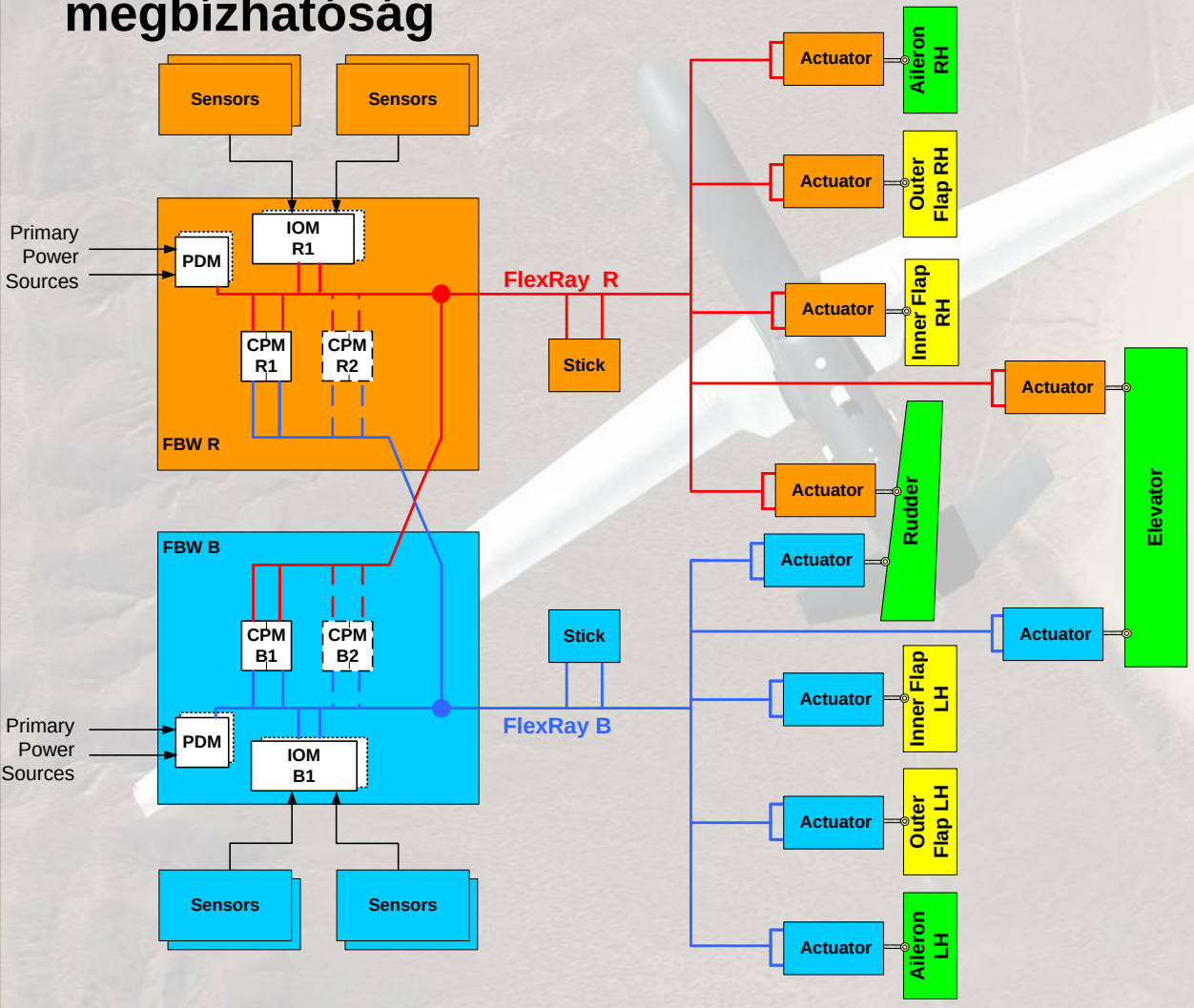
Rugalmas rendszer egyéni igényekre szabhatóan, standard modulokon alapul, boltban kapható (COTS) alkatrészek→ skálázható megbízhatóság



Katonai és kisgépes követelmény:

Katasztrofális hiba valószínűsége < 1e-07 repült óránként.

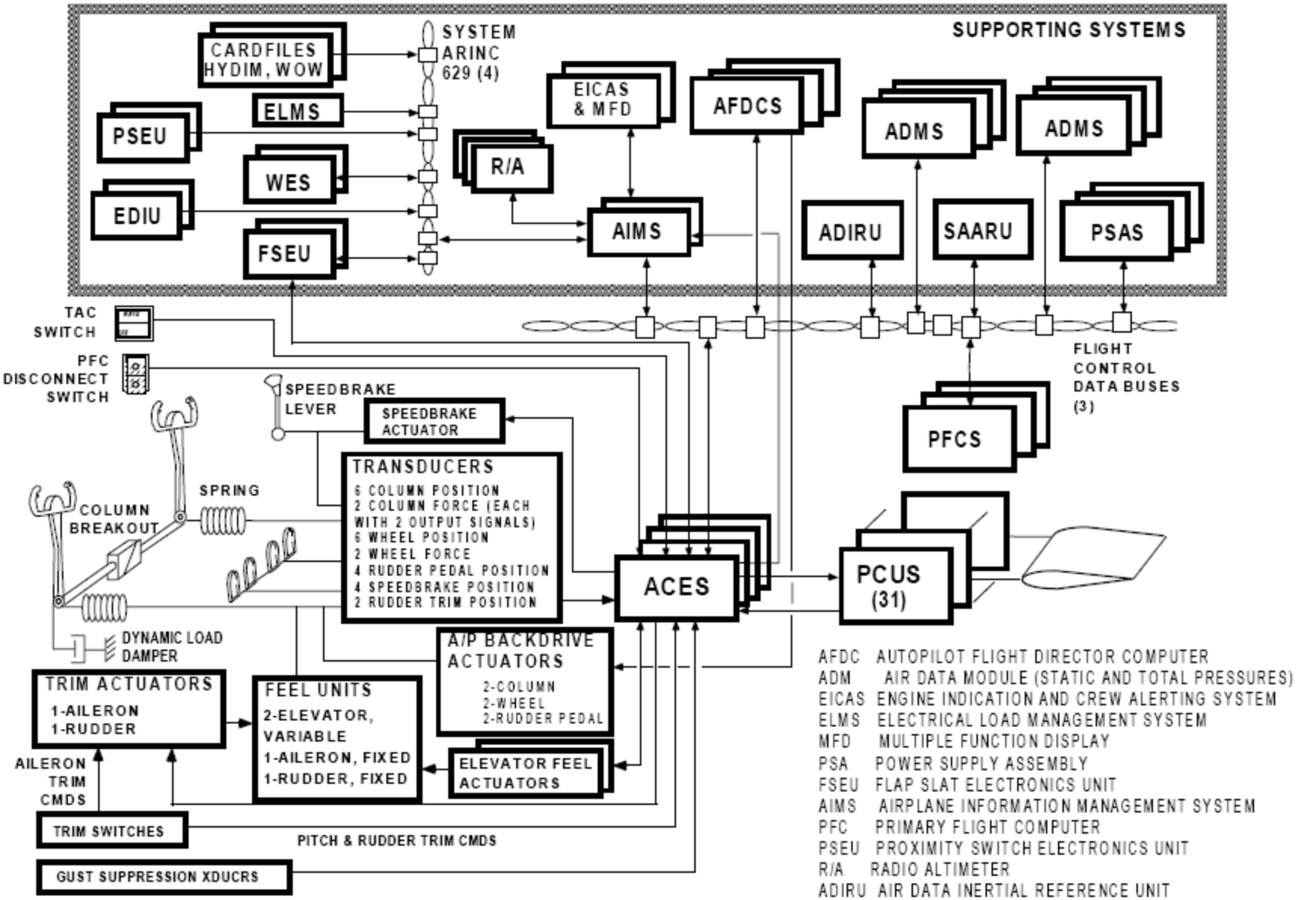
Polgári légiforgalom esetén:

Katasztrofális hiba valószínűsége < 1e-09 repült óránként.

Egy csatornás rendszer esetén MTBF = 3,000 óra

Meghibásodás valószinüsége:

0.33e-03 repült óránként



AFDC AUTOPILOT FLIGHT DIRECTOR COMPUTER
ADM AIR DATA MODULE (STATIC AND TOTAL PRESSURES)
EICAS ENGINE INDICATION AND CREW ALERTING SYSTEM
ELMS ELECTRICAL LOAD MANAGEMENT SYSTEM
MFD MULTIPLE FUNCTION DISPLAY
PSA POWER SUPPLY ASSEMBLY
FSEU FLAP SLAT ELECTRONICS UNIT
AIMS AIRPLANE INFORMATION MANAGEMENT SYSTEM
PFC PRIMARY FLIGHT COMPUTER
PSEU PROXIMITY SWITCH ELECTRONICS UNIT
R/A RADIO ALTIMETER
ADIRU AIR DATA INERTIAL REFERENCE UNIT
SAARU SECONDARY ATTITUDE AND AIR DATA REFERENCE UNIT
ACE ACTUATOR CONTROL ELECTRONICS
PCU POWER CONTROL UNITS, ACTUATORS
HYDIM HYDRAULIC INTERFACE MODULE
WOW WEIGHT ON WHEELS
WES WARNING ELECTRONICS SYSTEM

Repülésvezérlő és szabályozó rendszerek fejlődése

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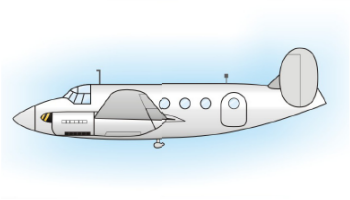
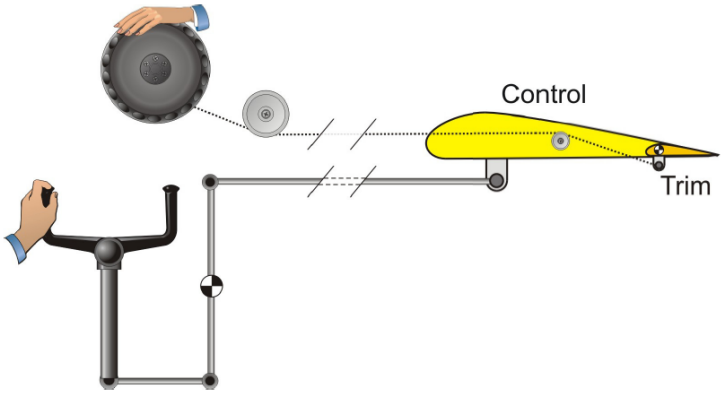
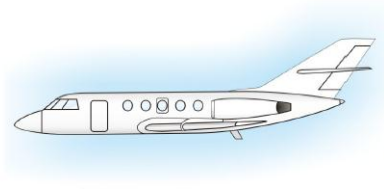
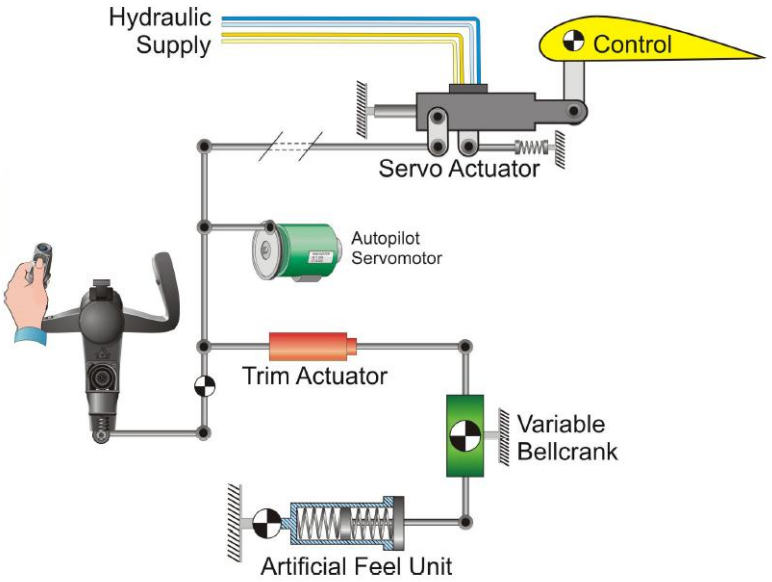


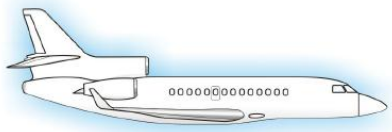
MD 315
First Flight: 1947



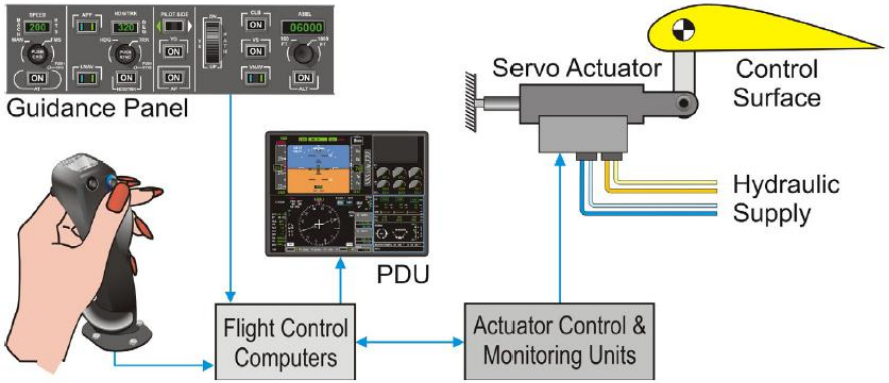


Mystère / Falcon 20
First Flight: 1963



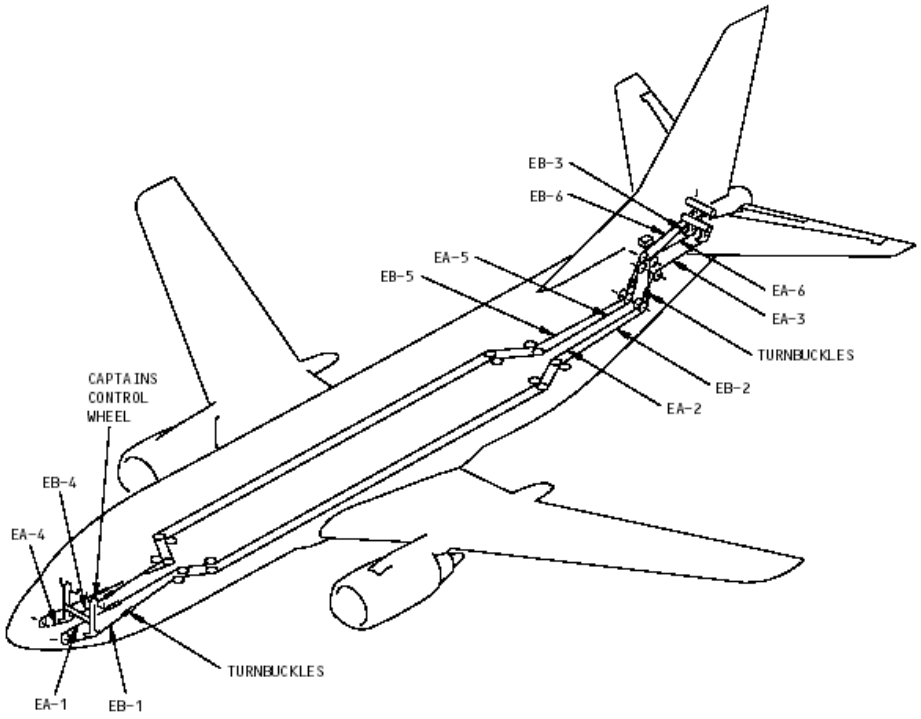


Falcon 7X
First flight: 2005

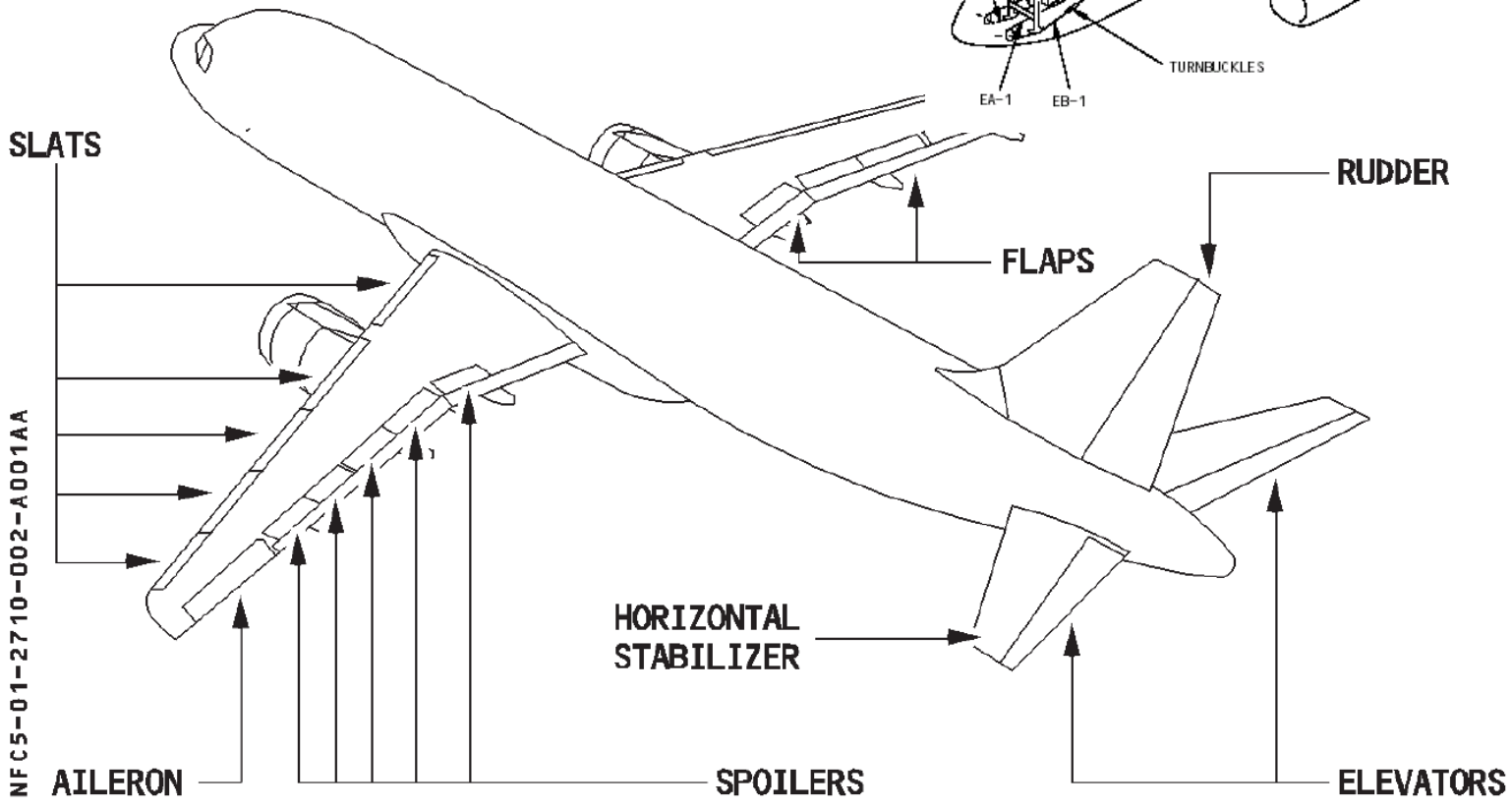


Beavatkozó felületek

Boeing 737 →

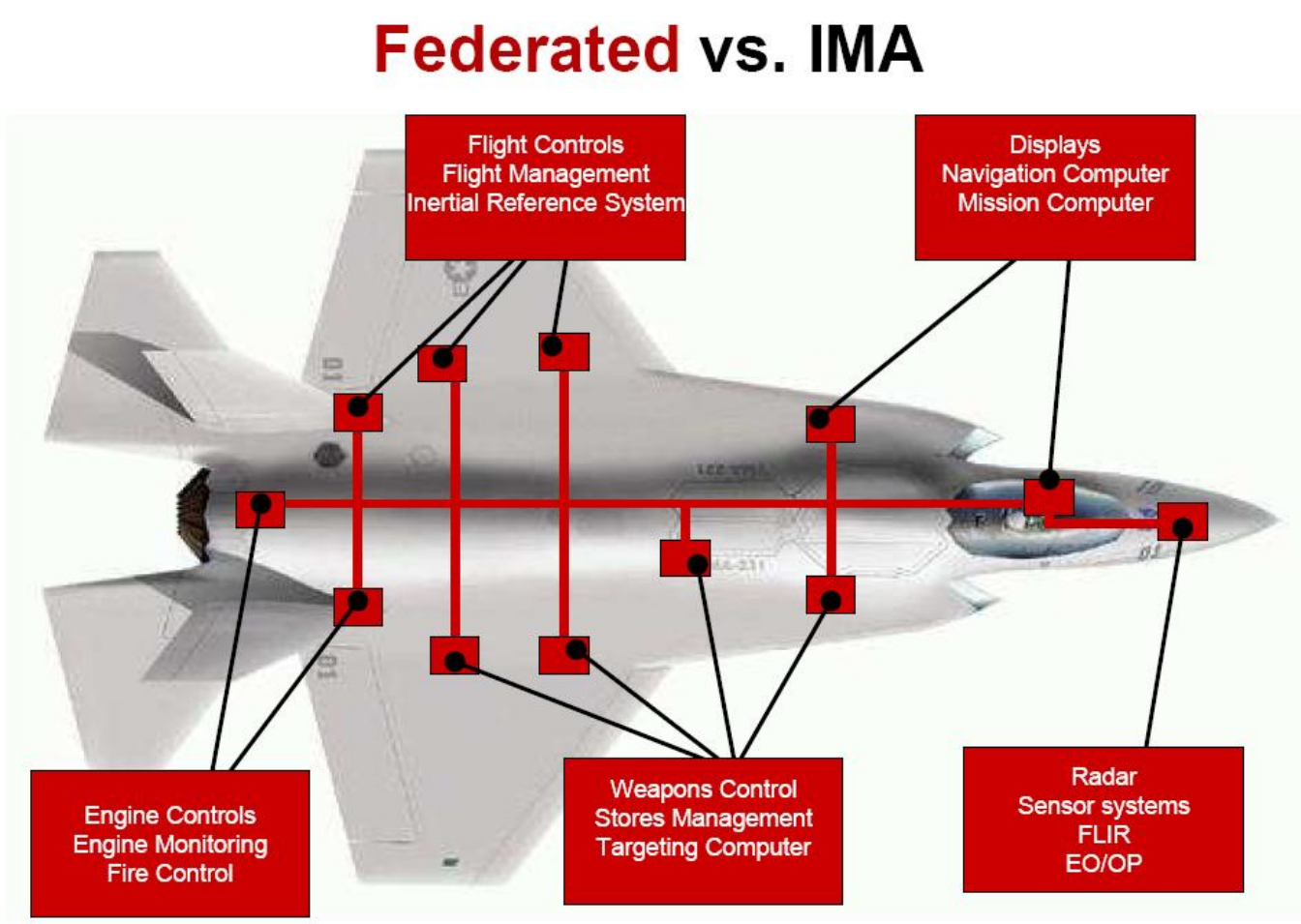


CONTROL SURFACES



← Airbus A320

Federated Avionics



PRO:

- Tradicionális jól megértett módszer
- Relatíve olcsón és könnyen tervezhető és tanúsítható
- Beszállítói rendszer erre alapul

Kontra:

- Minden funkció egy-egy külön doboz
- Gyenge SW újrahasznosítás
- Rossz felcserélhetőség
- Nem jól bővíthető
- Beszállítók kiszolgáltatottak
- Változtatások komplett újratanúsítást igényelnek

Integrated Modular Avionics

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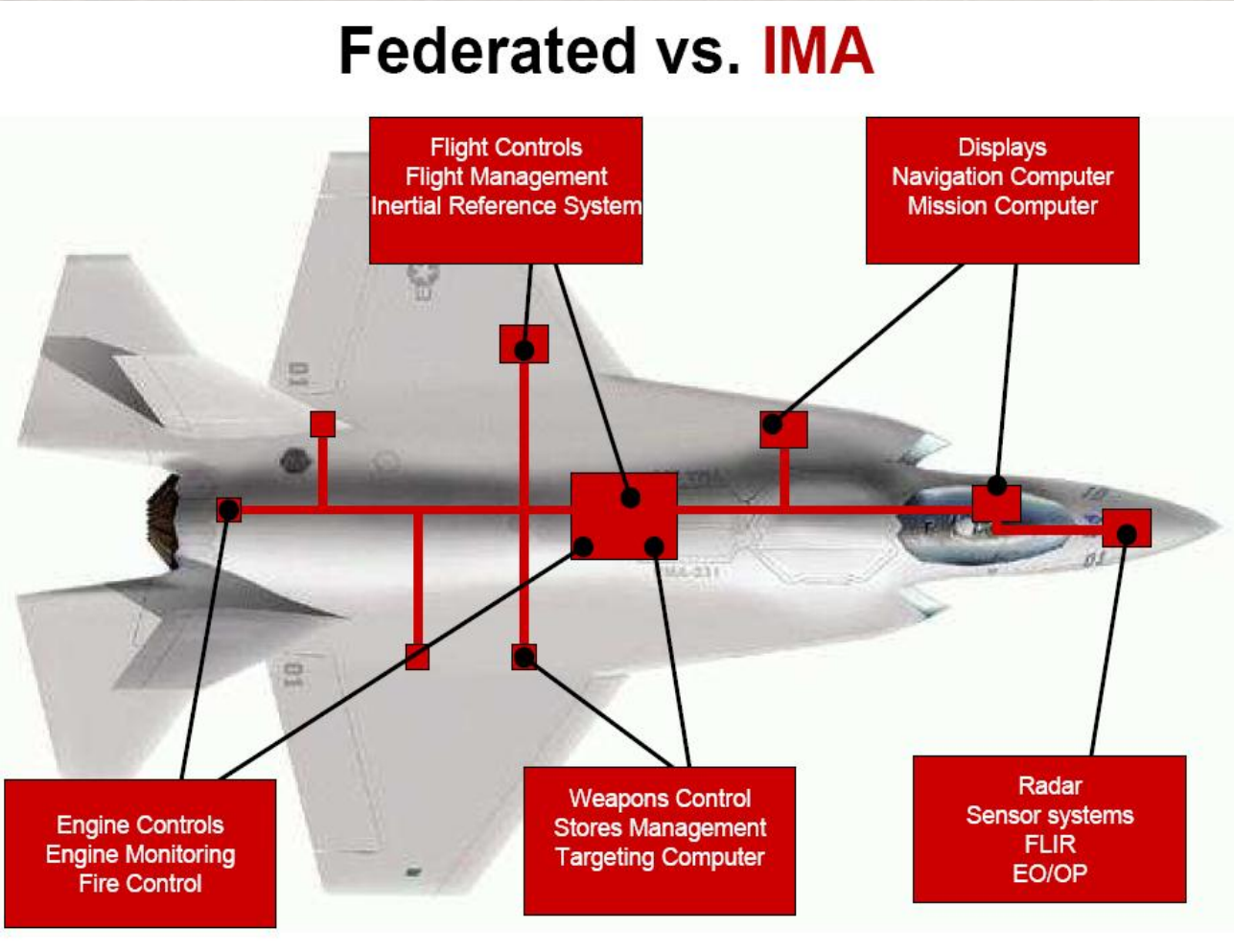

PROs

- **Több funkció egy dobozban**
- **Újrahasznosítható SW**
- **Átjárhatóság**
- **Moduláris**
- **Változtatások minimális újratanúsítást igényelnek**

Kontra:

- **“Modern” eljárás (777, A380,787…)**
- **Nem érti még mindenki**
- **Komplex tervezés és tanúsítás**
- **Beszállító halózat meg nem állt át rá**

Software partitioning defined by ARINC 653, allows different levels of criticality (DO-178B) on one core

Requires highly dependable network (TTP)

Miért is jó az IMA

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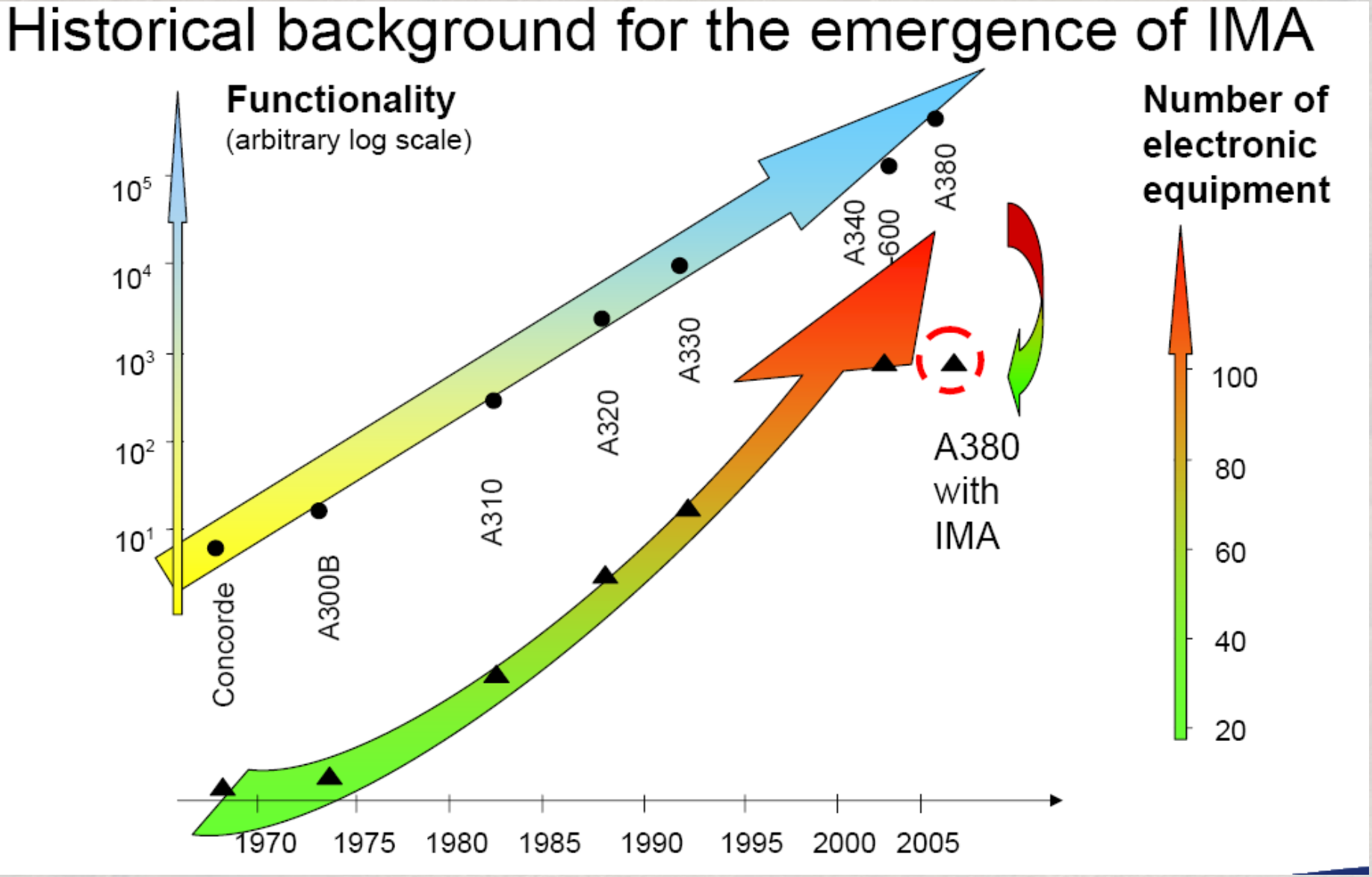

Boeing 787 IMA Architektúra (Elektromos Ber.)

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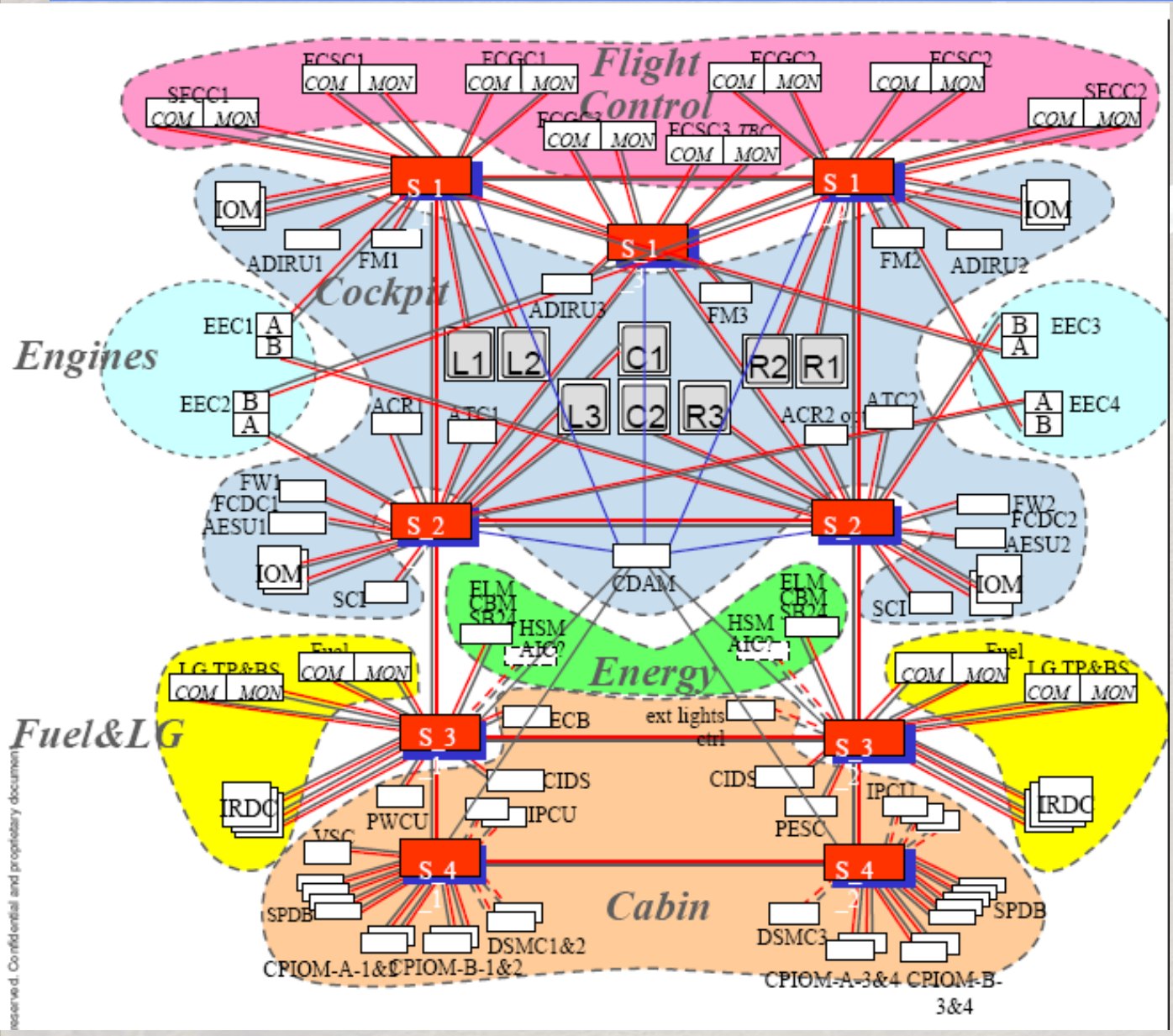
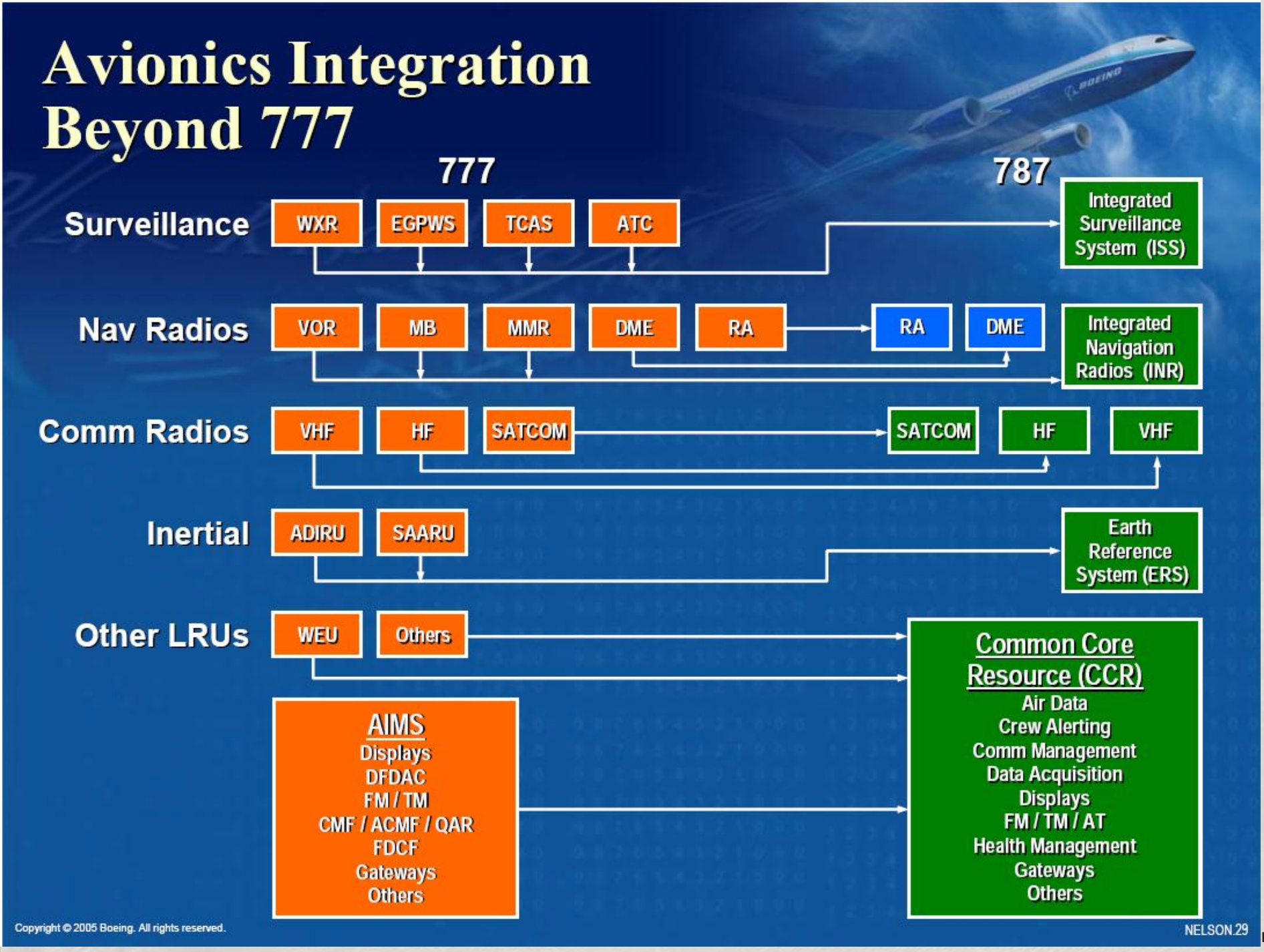


- Rendszer mérnököket igényel a megtervezése
- Beszállítók nagyobb részt vállalnak
- Univerzális kapcsolódási pontok- több beszállító azonos termékkel
- Részenként tanúsítható
- Hordozható tipusok között

Avionics Integration Beyond 777



More Electrical Aircraft (MEA) Systems

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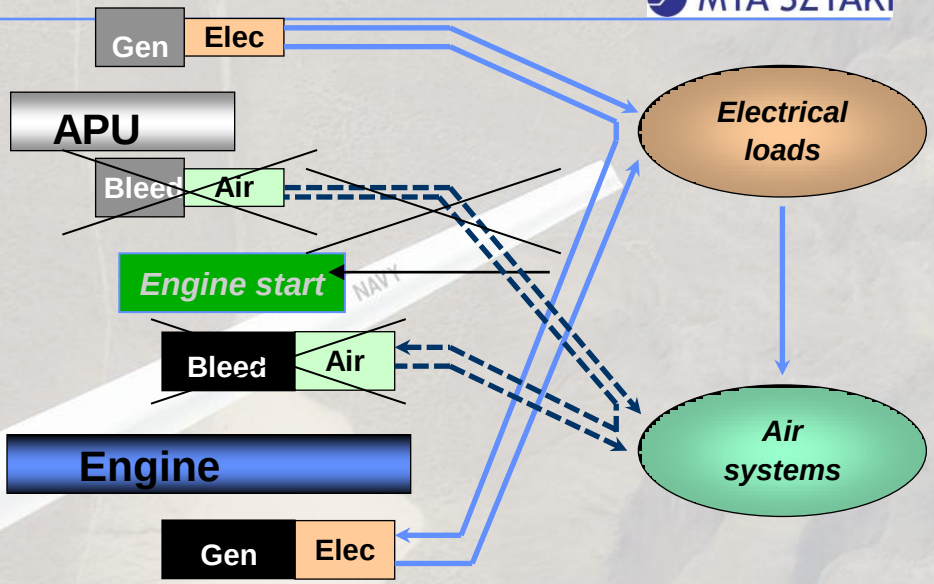
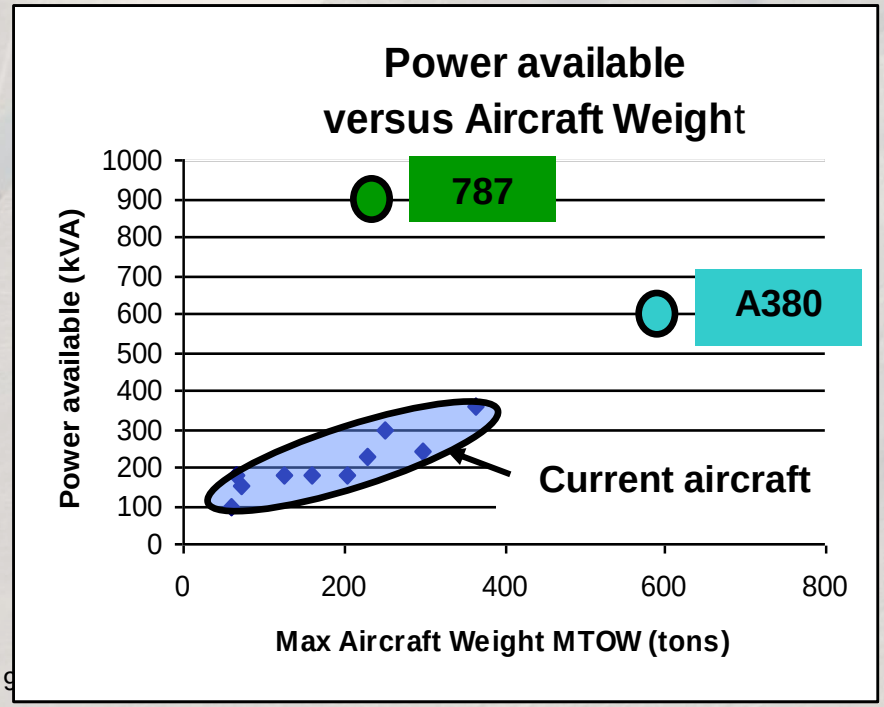
- The traditional engine, which produces thrust and pneumatic, hydraulic and electric power, is redesigned and optimized for MEA to produce thrust and electric power.
- Smaller electric engines generate the power needed for the pneumatic, hydraulic and other mechanical systems.
- For commercial aircraft new requirements are for electric engine starting, high power inverters and alternate air conditioning systems





Air Conditioning

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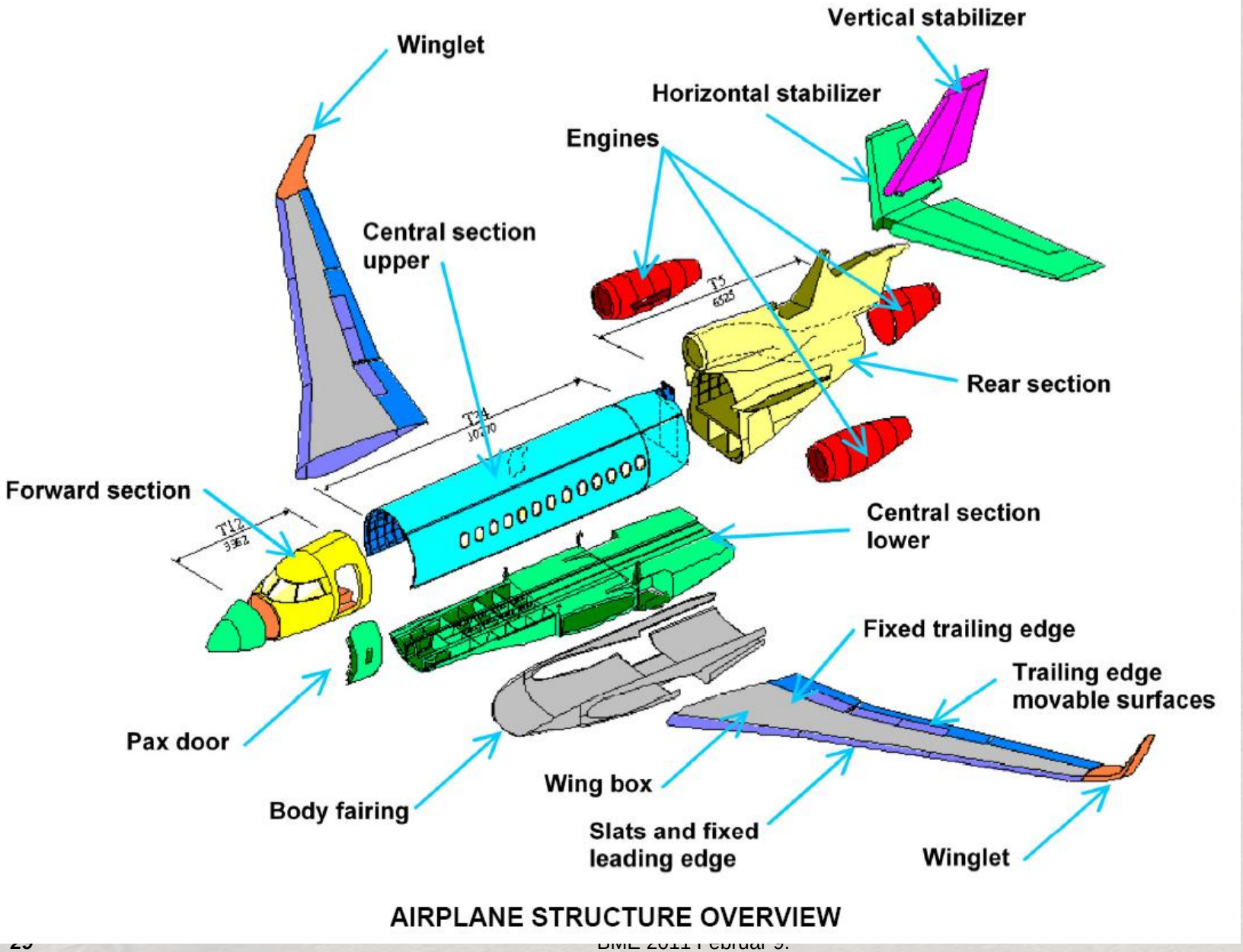
- **Airflow and Temperature Control**
- **Pressurization Control**

Hot pressurized air from the compressor sections of the engines or the auxiliary power unit is cooled through a series of processes by the Environmental Control System (ECS) Air Conditioning Packs (ACPs), remixed with some of high temperature bleed air to achieve the desired temperature, and then delivered throughout the airplane. Distribution ducts provide air to the cockpit, passenger cabin, and baggage compartment.
The higher pressure of this airflow allows regulation of the ambient pressure within the airplane to maintain an air density comfortable for breathing even though the airplane may be at the highest operating altitude limit of fifty-one thousand (51,000) feet. Air density within the airplane is controlled by regulating how much of the pressurized conditioned air remains within the aircraft. The airflow leaving the aircraft is regulated by a Thrust Recovery Outflow Valve (TROV) that opens and closes in response to automatic or manual commands to maintain the desired air density level.

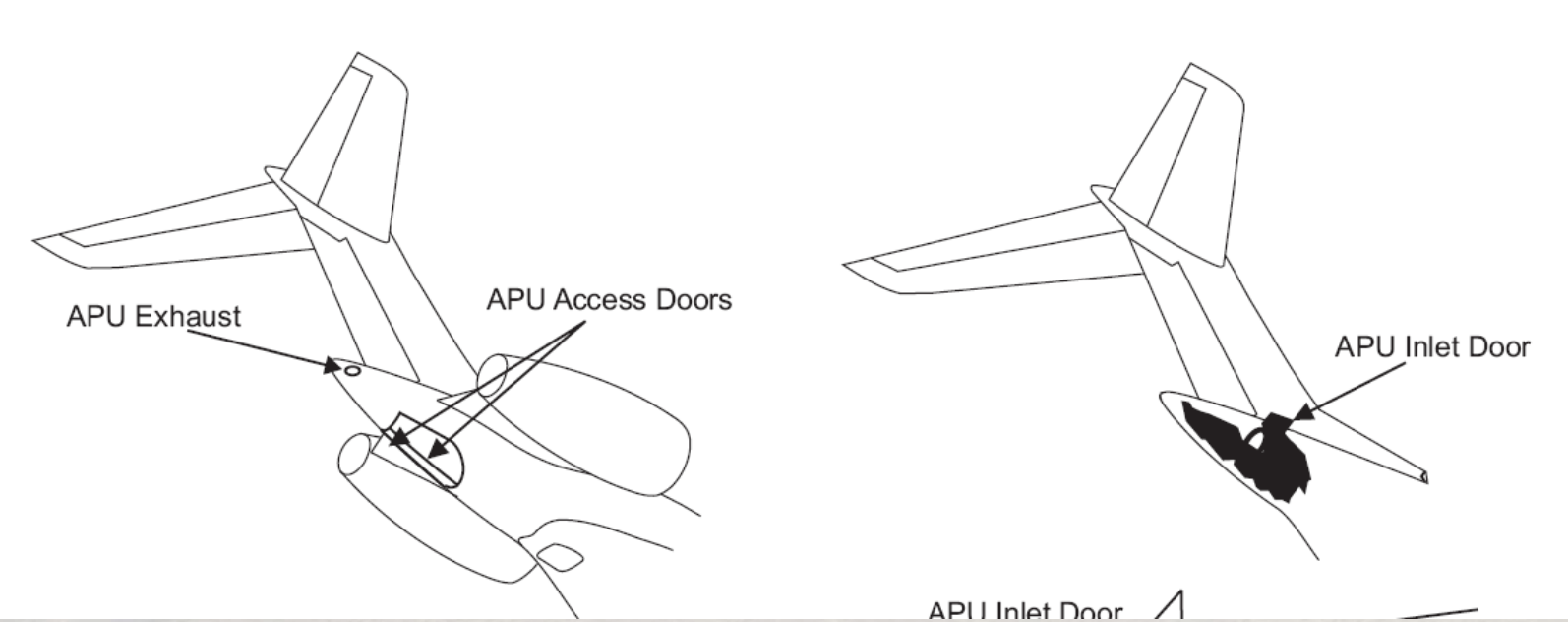
Airframe



AIRPLANE STRUCTURE OVERVIEW

APU

- **The APU provides bleed air for cabin cooling and heating through the Environmental Control System (ECS), main engine starting, and electrical power on the ground and in flight.**
- **Under high demand load conditions, the APU electrical load takes priority over pneumatic load.**



Automatic Flight Control System

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- **Flight Director – Flight envelope protection**
- **Autopilot – Coupled with FMS**
- **Thrust Director**
- **Auto-Throttle**

- **Provides functions necessary for automatic control.**
- **The system consists of:**
  - **Mode Control Panel (MCP)**
  - **THREE Autopilot Flight Director Computers (AFDCs)**
    - **Flight Director**
  - **Back drive Control Actuators (BACs) … etc.**

- **AFDS does not have direct control of Primary flight Control Surfaces.**

- **The Flow is:**

Autopilot Flight Director System

↓

Primary Flight Control Computers

↓

Actuator Control Electronics

Bleed Air

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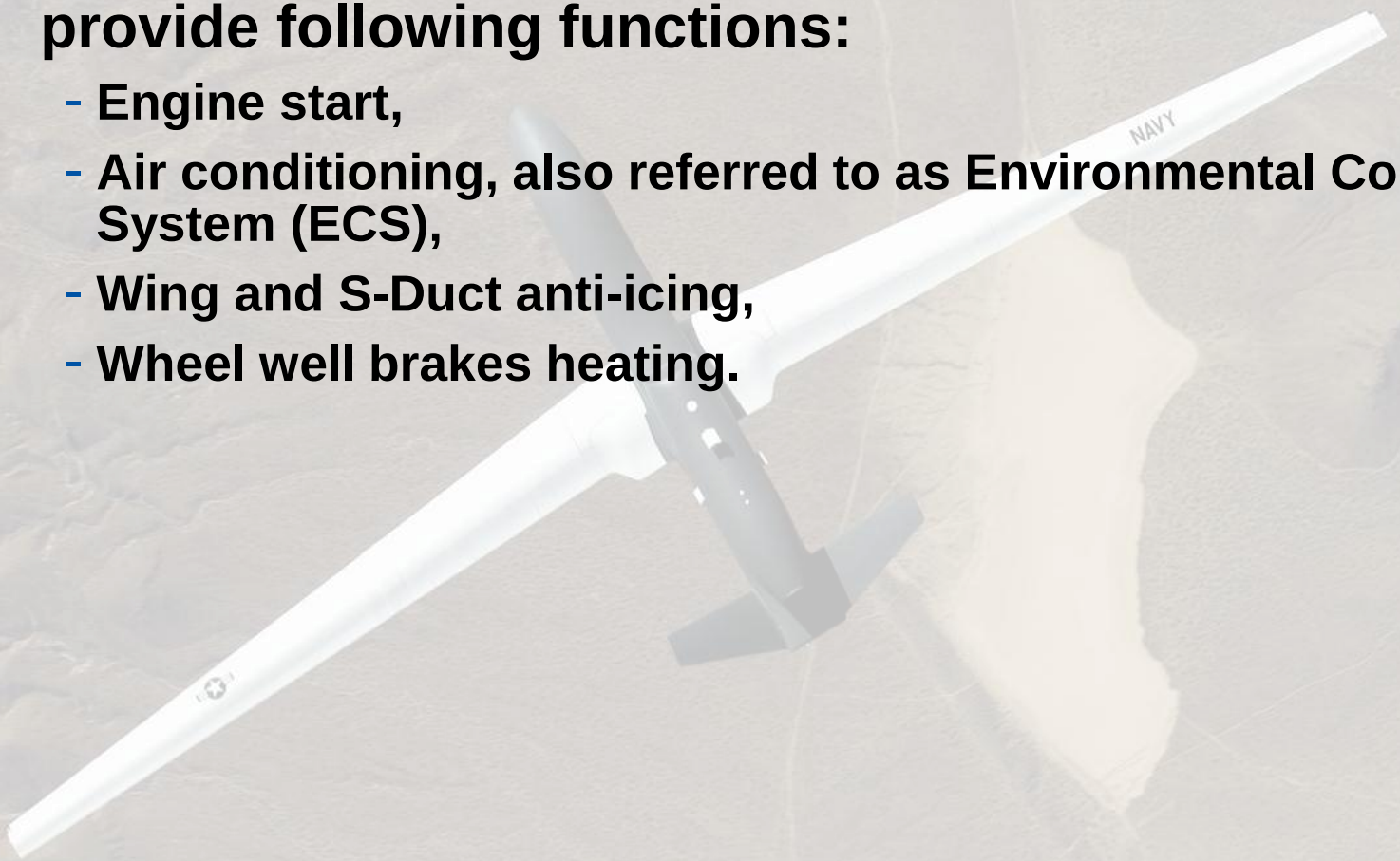
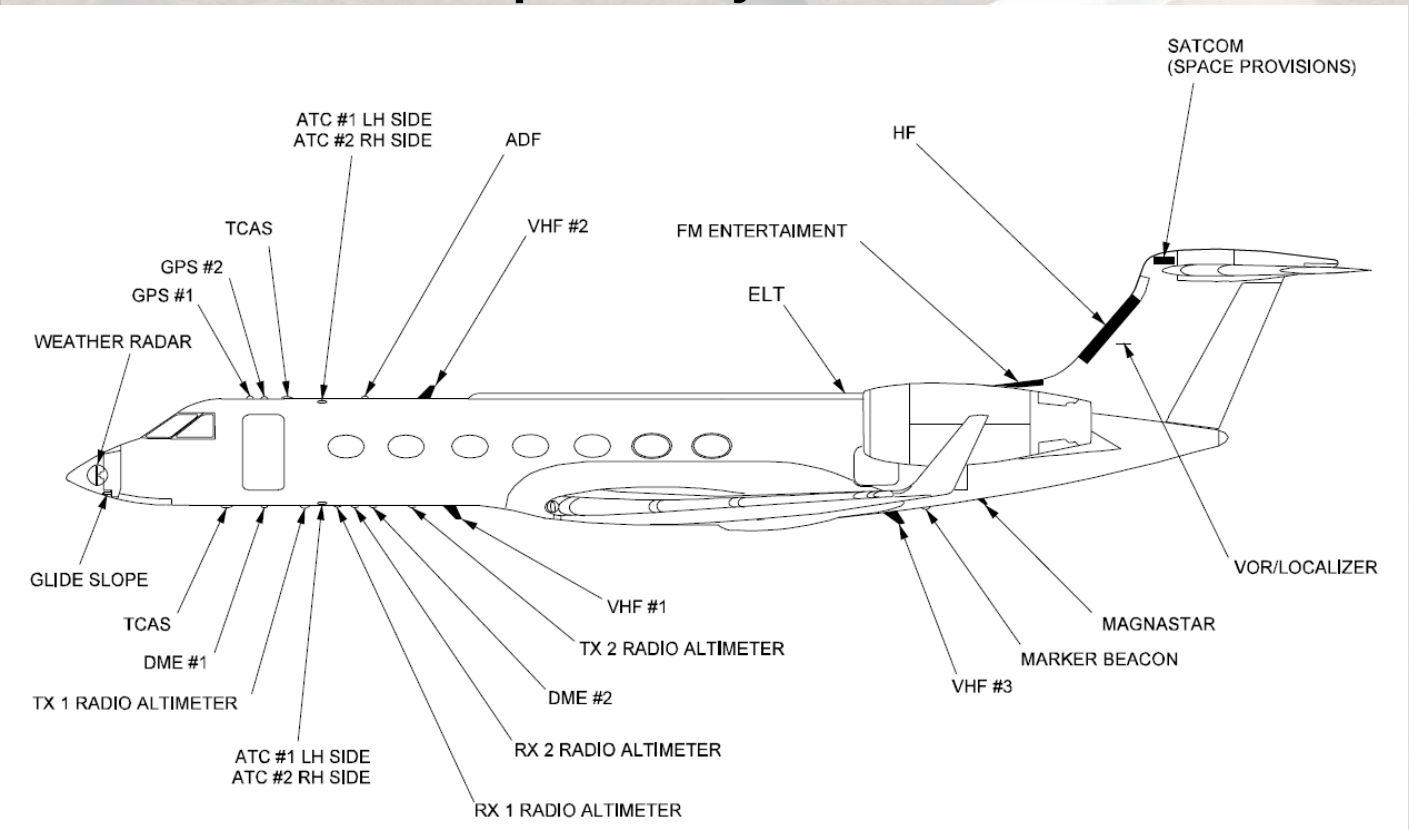
- **The Bleed Air System refers to the air distributed to provide following functions:**
  - **Engine start,**
  - **Air conditioning, also referred to as Environmental Control System (ECS),**
  - **Wing and S-Duct anti-icing,**
  - **Wheel well brakes heating.**



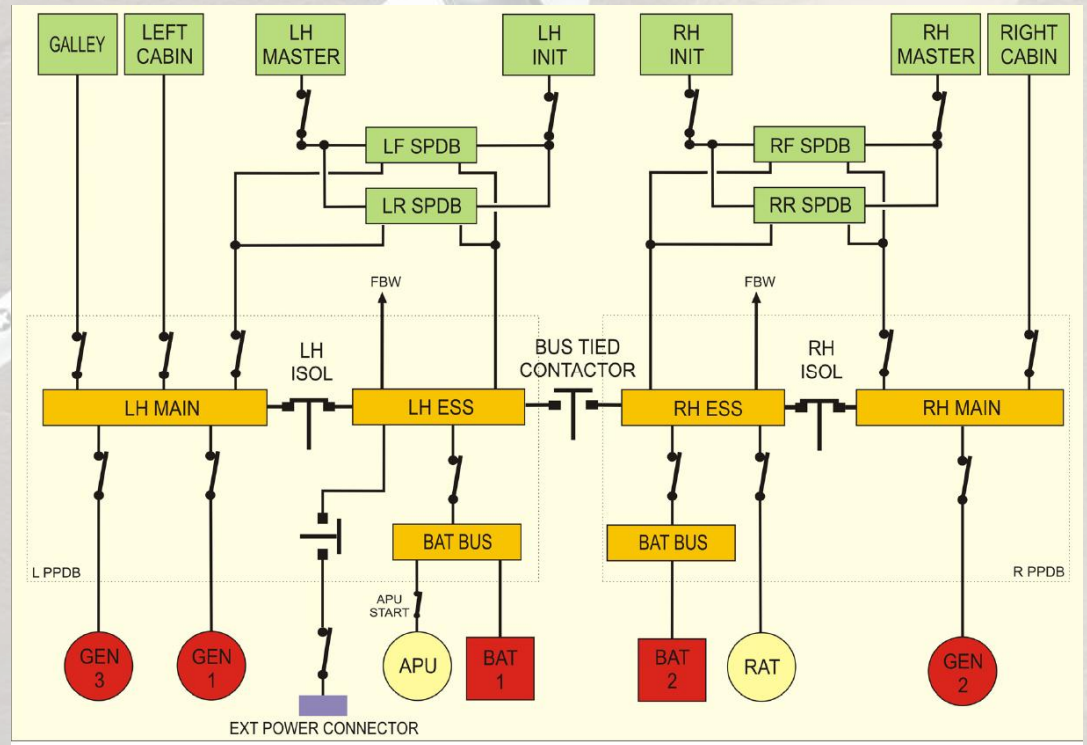
Communication System

- **The communication system includes:**
  - **VHF and HF systems, as well as the public address system and SELCAL**
  - **CMF / AFIS optional system, including weather uplink,**
  - **SATCOM optional system.**



Electrical Power

- The Falcon 7X uses 28 Volts DC power for operation of the various systems installed in the airplane.
- The electrical system is supplied by:
  - Three engine-driven generators,
  - Two Batteries,
  - A RAT in some emergency cases.
- The Primary Flight Control System and Engine Electronic Controller are also powered by dedicated Permanent Magnet Alternators.



Engines

MTA SZTAKI

- **Engine control is performed by a dual channel Full Authority Digital Engine Control (FADEC),**
- **Engines are independent of Flight Control System**
- **The Engines provide:**
  - **Thrust,**
  - **Bleed air (for ECS and Anti ice),**
  - **Mechanical energy to drive the hydraulic pumps,**
  - **Mechanical energy to drive the DC generators and PMA.**
- **Engine operation requires the following systems:**
  - **Control system,**
  - **Fuel system,**
  - **Oil system,**
  - **Ignition system,**
  - **Air-start system.**

Fire Protection

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- The fire protection system can be separated into three functions:
- - 1: Detection,
  - Engine, apu, cabin, cargo, avionics bays, wheels
- - 2: Extinction of Fire,
  - closure of the Shut Off Valves (SOV) and built-in extinguishers
- - 3. Auxiliary functions in case of engine or APU fire.
  - The corresponding Hydraulic and Fuel Shut Off Valves are closed,
  - - The corresponding generator is disconnected, (used for emergency landing procedure as, in other conditions, the engine will have been shut off first)

Flight Controls

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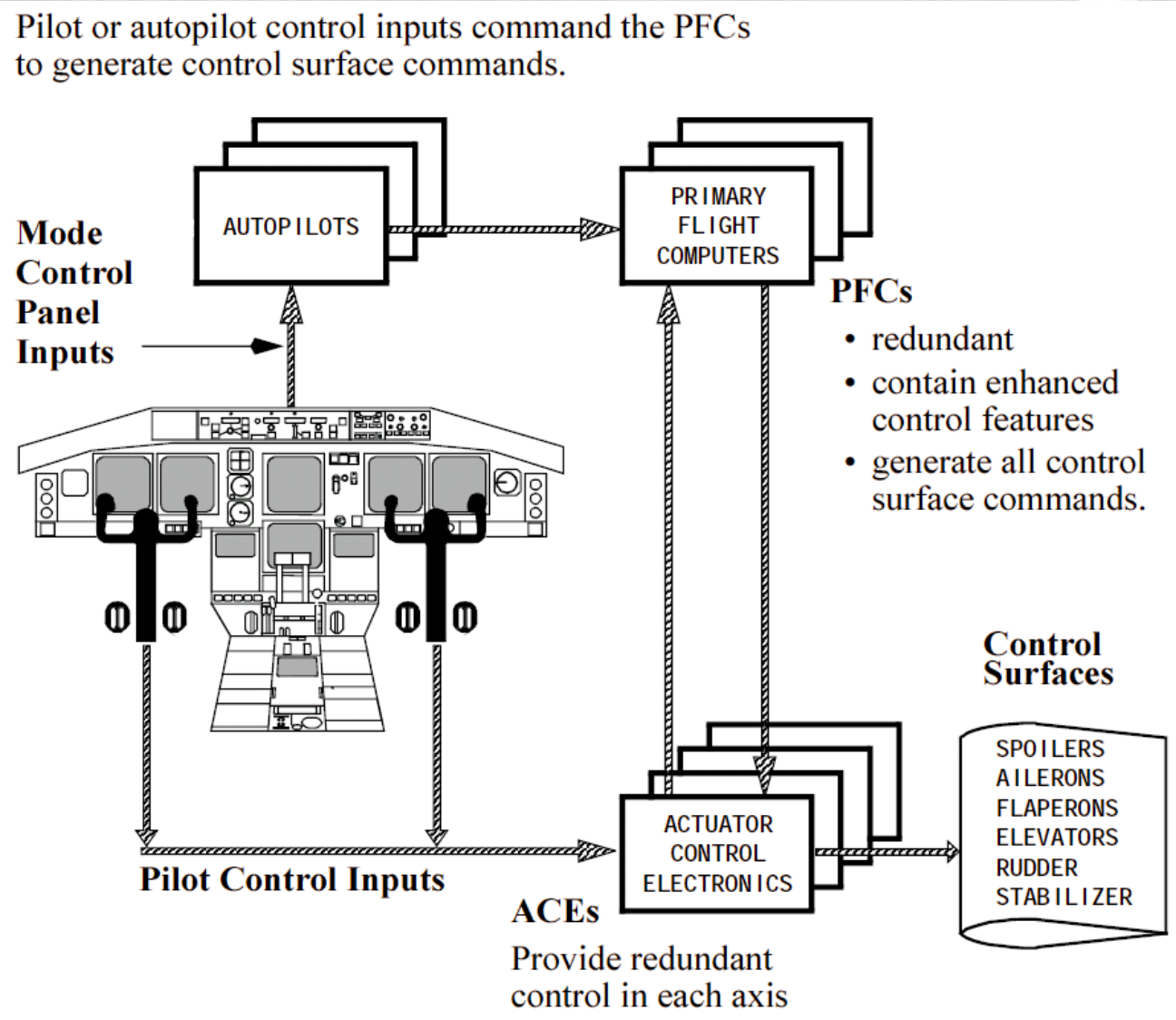
- **Electric signal command hydraulic actuation**



PFCS (Falcon 7X)

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The Primary Fight Control System (PFCS) architecture is based on six main functionalities:

- Data collection:

• From sensors (IRS, AHRS, RA, ADS,…),

• From pilots controls,

• From the Flight Director if the AutoPilot is engaged,

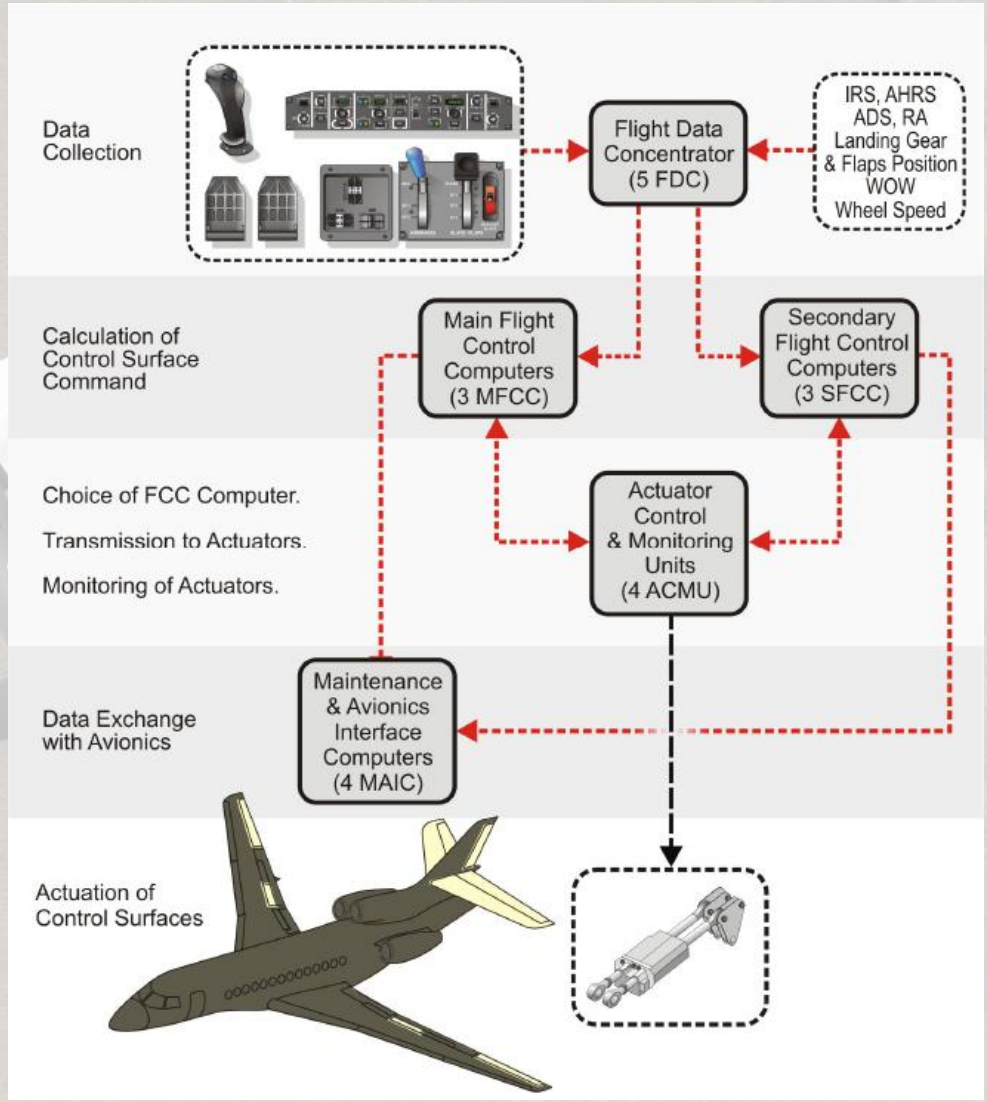
- Calculation of control surfaces commands by the main and secondary Flight Control Computers,

- Selection of Flight Control Computer for control surface commands and transmission of commands to actuators,

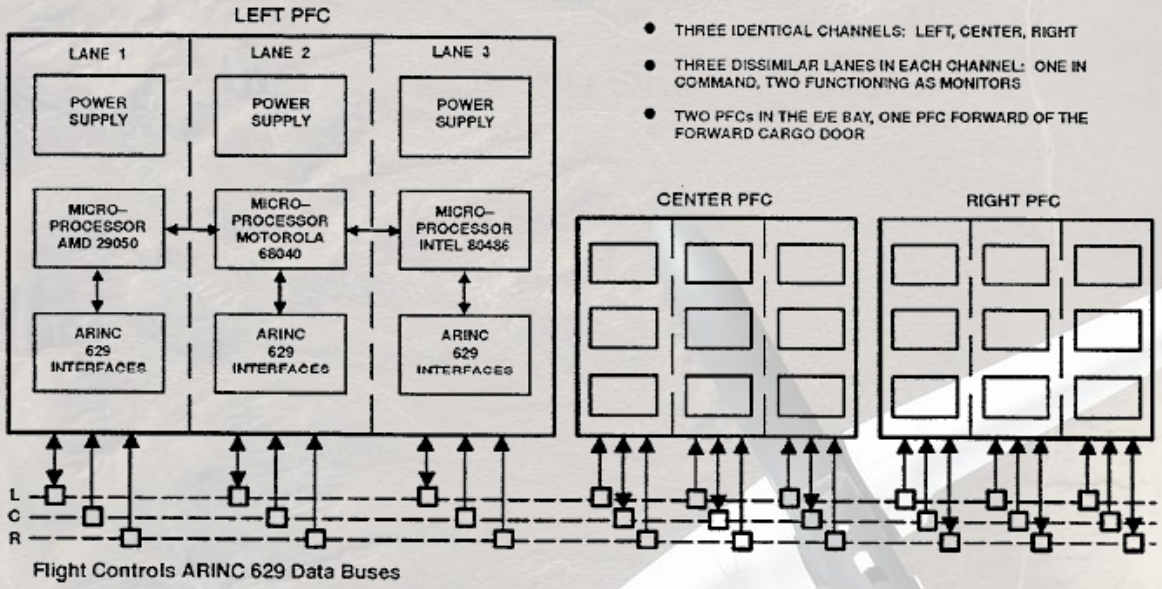
- Actuation of flight control surfaces by the actuators,

- Monitoring of actuators,

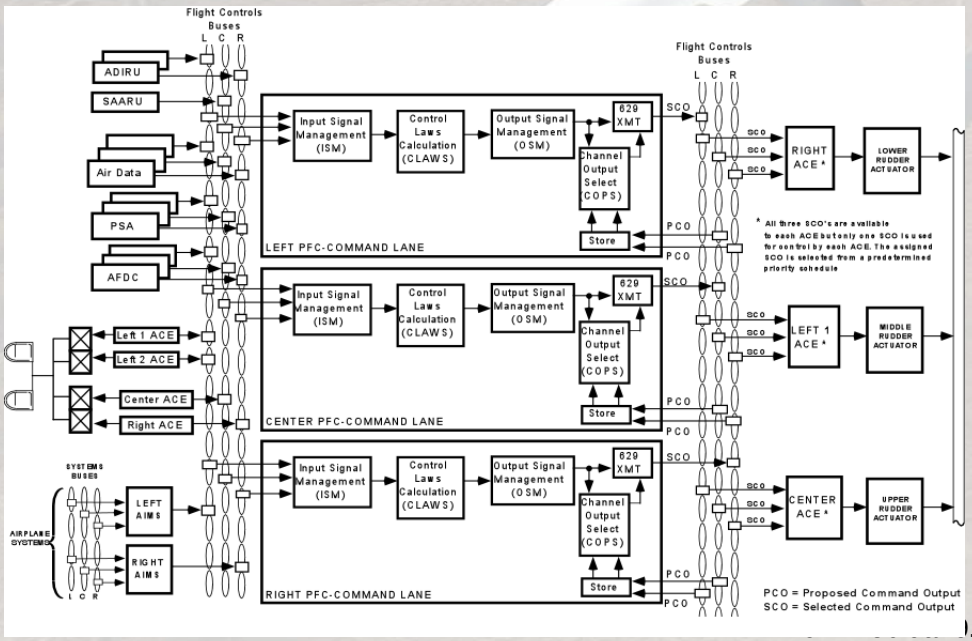
- Data exchanges with avionics.



777 FBW PFC



- THREE IDENTICAL CHANNELS: LEFT, CENTER, RIGHT
- THREE DISSIMILAR LANES IN EACH CHANNEL: ONE IN COMMAND, TWO FUNCTIONING AS MONITORS
- TWO PFCs IN THE E/E BAY, ONE PFC FORWARD OF THE FORWARD CARGO DOOR



Each PFC receives data from all 3 databuses, but transmit only on 1 databus.

This is meant to prevent a failed lane from contaminating good lane with erroneous data, or worst, prevent masquerading error.

- **Each PFC is made up 3 internal lanes**

Software “Size”

MTA SZTAKI

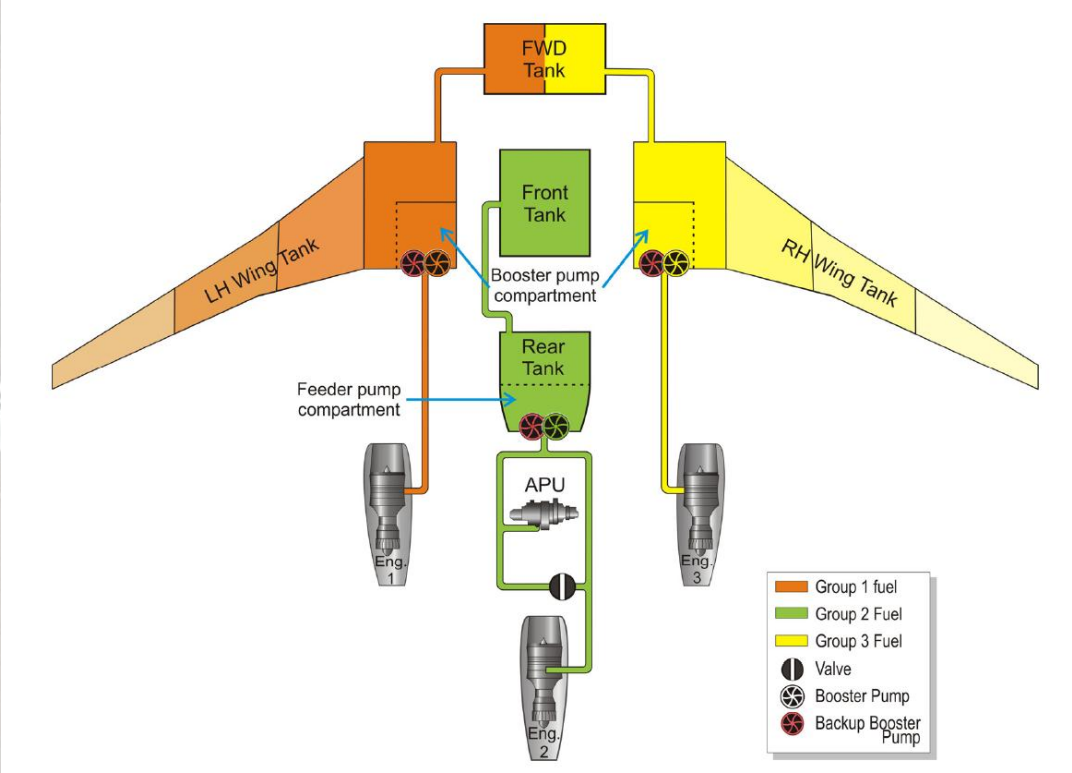
Function (or “partition”)	Commercial FBW	Military FBW
Control Laws	25 – 30%	40%
Redundancy Management	60-70%	50%
Continuous BIT (not pre-flight)	10%	10%

Redundancy Management is more complex

(and challenging to design) than the control laws !

Fuel System

- **Fuel system provides engines and APU with pressurized fuel.**
- **It is composed of three independent groups of fuel tanks that feed, in normal operation, their**
- **respective engine and the APU:**



Hydraulic System

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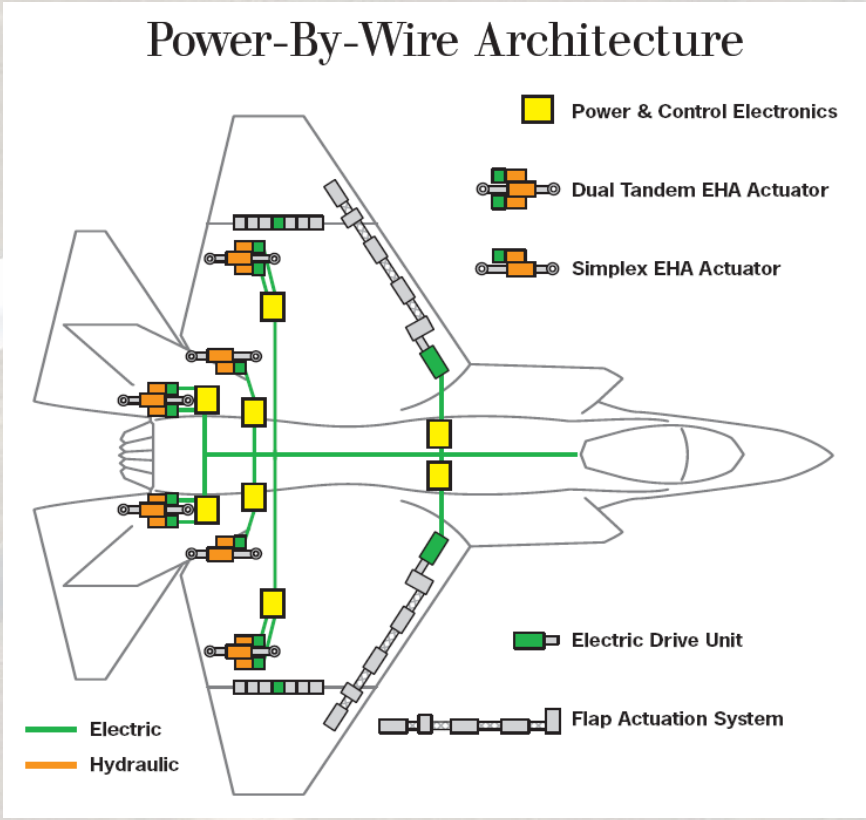
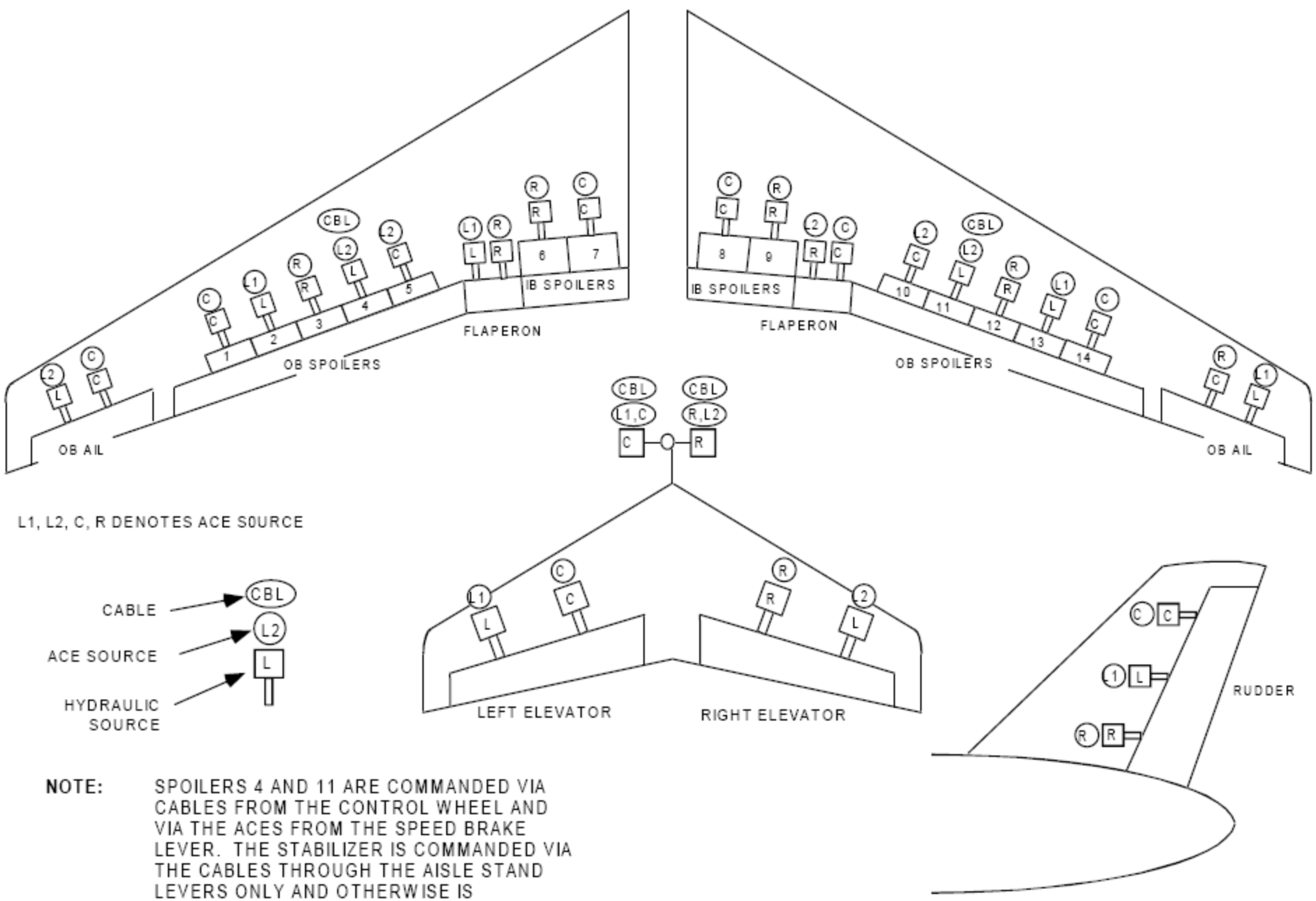
Hydraulic power system provides pressure for actuation:

- **Primary Flight Controls System (PFCS: ailerons, elevators, rudder and spoilers),**
- **Secondary Flight Controls System (SFCS: slats, flaps and airbrakes),**
- **landing gear, brakes and nose wheel steering,**
- **Thrust reverser of engines.**



In More Electric Architectures central Hydraulics is getting replaced by Electro-Hydraulic actuators

Electric signal command hydraulic actuation



NOTE: SPOILERS 4 AND 11 ARE COMMANDED VIA CABLES FROM THE CONTROL WHEEL AND VIA THE ACES FROM THE SPEED BRAKE LEVER. THE STABILIZER IS COMMANDED VIA THE CABLES THROUGH THE AISLE STAND LEVERS ONLY AND OTHERWISE IS COMMANDED THROUGH THE ACES.

Ice and Rain

MTA SZTAKI

- **The ice and rain protection system is intended to permit:**
  - **Safe flight through intermittent or continuous maximum icing conditions,**
  - **Improved visibility through windshield during taxi, take off, approach and landing in rain condition and during ground operation in dew conditions.**

The system uses three ice and rain protection sources:

- **Pneumatic source for:**
  - **Wings,**
  - **Engines air intake anti ice,**
  - **Engine 2 S-duct anti ice,**
  - **Brakes anti ice.**
- **Electrical source for:**
  - **Windshields and lateral windows,**
  - **Air data probes,**
  - **Waste water drain mast.**
- **Specific fluid for:**
  - **Windshield rain protection (rain repellent).**

Indicating and Recording

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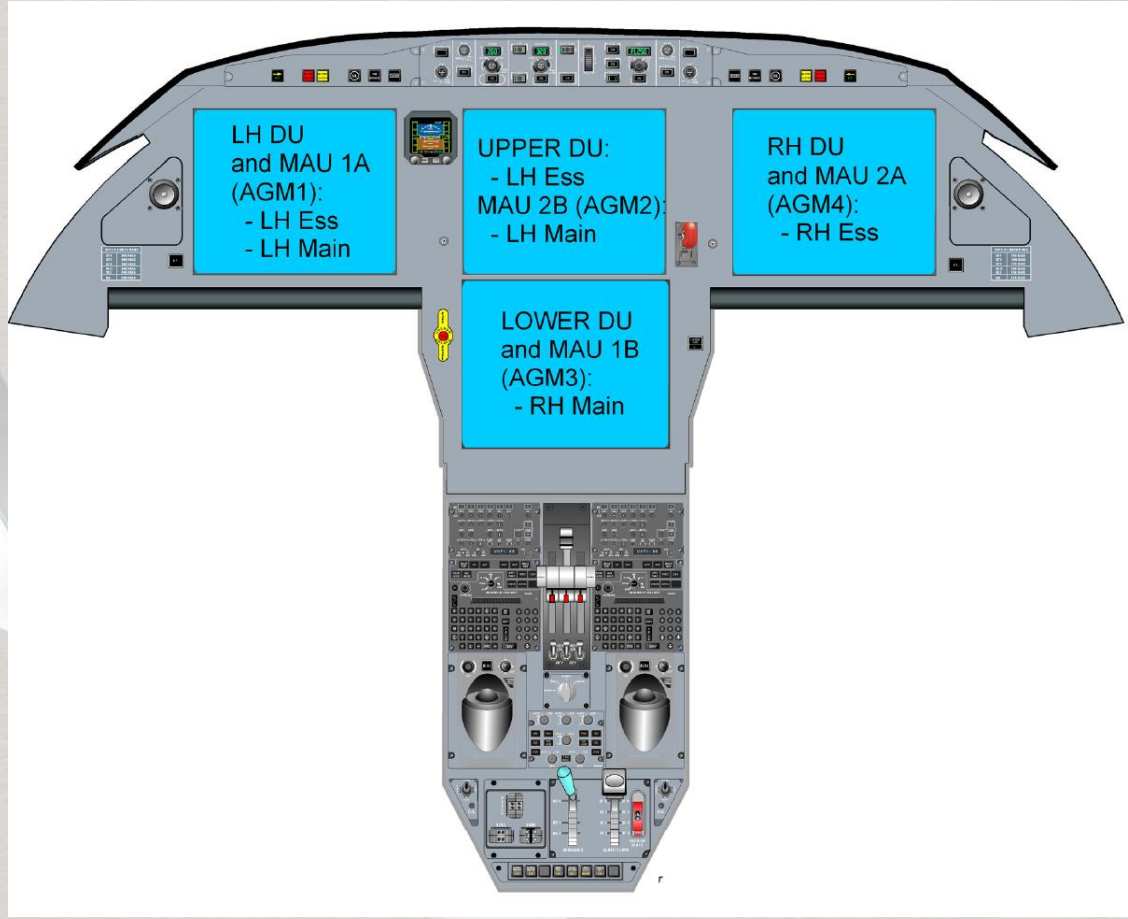
EASy Modular Avionics:

- **Displays,**
- **Crew Alerting System (CAS),**
- **Electronic CheckList (ECL),**
- **Combine recorder (Digital Flight Data Recorder and Cockpit Voice Recorder) and Emergency Locator Transmitter (ELT).**



AVIONICS FUNCTIONS

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The EASy modular avionics provides the following avionics functions:

- **Processing of display for:**
  - **Attitude information based on IRS data,**
  - **Radio Altitude information based on Radar Altimeters data,**
  - **Air Data information based on Air Data Systems data.**
- **Elaboration of data and processing of display for:**
  - **Navigation (GPS, VOR, DME, FMS, ILS…),**
  - **Flight Director / Thrust Director Guidance,**
  - **EGPWS.**
- **Transmission of FD orders to Primary Flight Control System for AutoPilot function,**
- **Elaboration of Auto-Throttle commands for Throttle Quadrant,**
- **Communication means,**
- **Transmission of TCAS guidance received from the independent TCAS.**

MULTI-SYSTEM FUNCTIONS

- **In addition to avionics functions, the EASy modular avionics provides the following functions, based on data received from airplane systems:**
  - **Display of CAS/Fault messages related to system failures,**
  - **Display of systems synoptic,**
  - **Transmission of data between systems,**
  - **Recording of maintenance data.**

Brakes/Landing gear

- Electrically controlled,
- Hydraulically actuated.
- 787 has electric brake-by-wire
- Extension retraction including panels
- Braking with ABS
- Heat and wear monitoring
- Nose wheel stearing
- Weight on wheel for FMS calculations

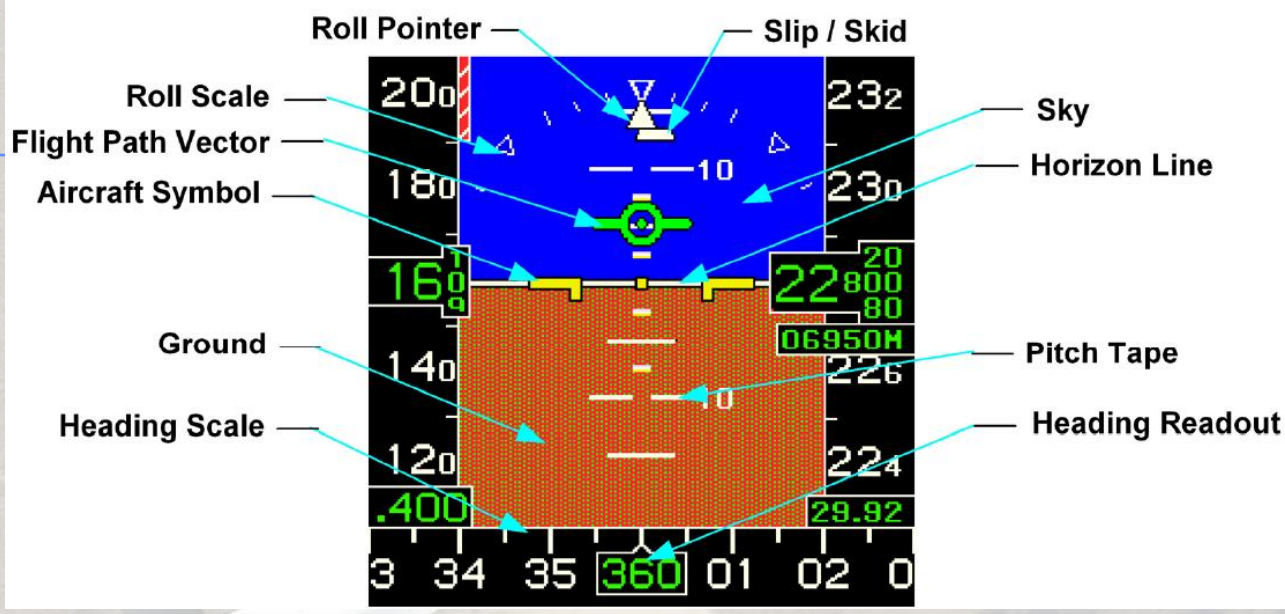
Control of the landing gear system is performed by a dua channel computer named Landing Gear and Steering Control Unit (LGSCU).

Lighting

The Airplane lighting system provides the following functions:

- **External Lighting:**
  - **Illumination of airplane environment (runway, taxiway, parking),**
  - **Illumination of airplane structure (wings, refuel area, loading area),**
  - **Signalisation of airplane visual position and track (anti collision lights, navigation lights),**
- **For Interior Lighting:**
  - **Required level of cockpit illumination according to crew comfort, environmental condition and phase of flight,**
  - **Required level of cabin illumination according to passenger comfort,**
  - **Illumination of working area for servicing, maintenance and inspection operation, (compartments, refueling panel, water filling panel),**
- **For emergency Lighting:**
  - **Signalisation of internal evacuation access and routing (interior emergency lighting),**
  - **Signalisation of External evacuation routing (exterior emergency lighting).**

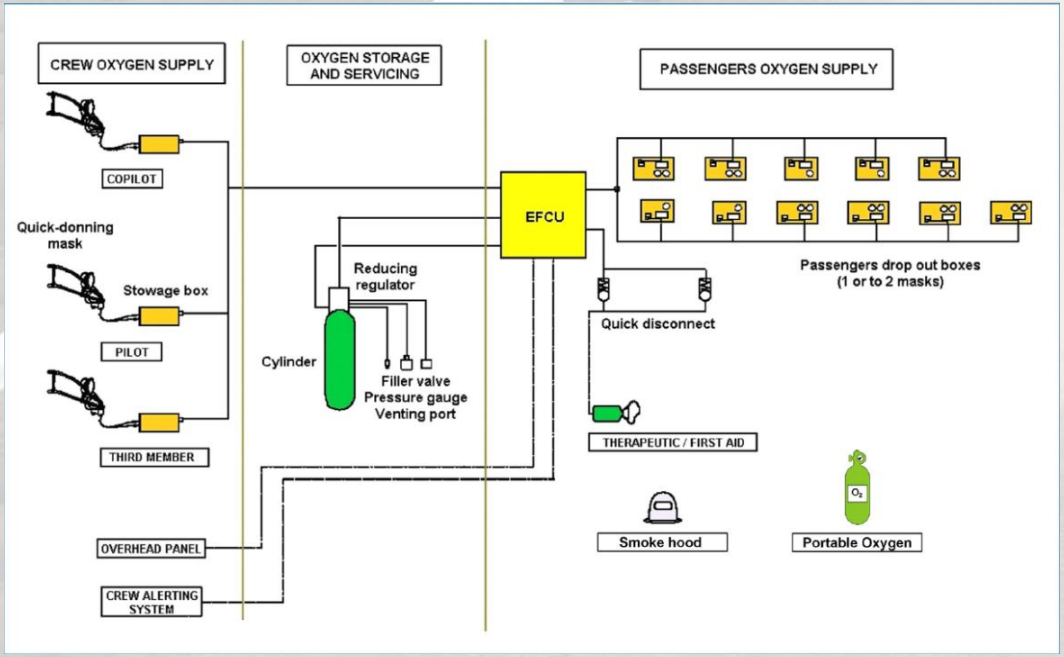
Navigációs rendszer



- **FMS: Flight Management System, (including JEPPESEN charts) – a navigáció központi számítógépe**
- **GPS: Global Positioning System – műholdas helyzet meghatározás**
- **HGS: Head up Guidance System, - pilóta látóterébe vetített kép**
- **SFD: Secondary Flight Display, - LCD kijelző repülési adatokkal**
- **WX - LSS: Weather Radar – Lightning Sensor System, - időjárási radar és villámlás érzékelő**
- **EGPWS: Enhanced Ground Proximity Warning System, - földközelség figyelmeztető**
- **ATC / TCAS: Air Traffic Control / Traffic Crew Alerting System, - légiforgalmi szituáció**
- **ADS: Air Data System, - légadat gyűjtő rendszer**
- **IRS, AHRS: Inertial Reference System and Attitude and Heading Reference System, - inerciális navigációs rendszer és repülőgép irányszög rendszer**
- **Radar Altimeter, - radaros magasságmérő**
- **NAVAIDS (VOR/DME, ADF, ILS.) – navigációs segédberendezések pld. leszálláshoz**

Oxygen system

- **The Falcon 7X is equipped with an oxygen system supplying oxygen to the passengers and the crew members in case of:**
  - **Cabin depressurization,**
  - **Smoke or noxious gas in the cabin,**
  - **Need for first aid.**
- **Controlled by the Electrical Flow Control Unit (EFCU)**



Maintainance

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- The purpose of the Centralized Fault Display System (CFDS) is to make the maintenance task easier by displaying fault messages in the cockpit and permitting the flight crew to make some specific tests.
- There are two levels of maintenance:
  - at the line stop : removal and replacement of equipment
  - at the main base : troubleshooting
- The CFDS includes :
  - the BITE (Built-In Test Equipment) for each electronic system
  - a central computer, the Centralized Fault Display Interface Unit (CFDIU)
  - two MCDUs (Multipurpose Control and Display Units), used also for FMGS (Flight Management and Guidance System), AIDS (Aircraft Integrated Data System), and ACARS (Aircraft Communication And Reporting System, if installed), which work with the CFDIU to display information or initiate tests
  - one printer.
- If a main channel of the CFDIU fails, the backup channel takes over
  - Class 1: Failures indicated to the flight crew by means of the ECAM, or other flight R deck effect. They must be repaired or entered in the MEL (Minimum Equipment List) before the aircraft can depart.
  - Class 2: Faults indicated to maintenance personnel by the CFDS, and which trigger a MAINT status entry on the maintenance part of the ECAM status page. The aircraft can operate with these faults, but they must be repaired within 10 days.
  - Class 3: Faults indicated to maintenance personnel by the CFDS, but which do not trigger a MAINT status. The operator may have these faults corrected at his convenience.

Water and waste

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- The Water system provides potable cold and hot water to:
  - The washbasin faucets in the aft lavatories,
  - The washbasin faucet and coffee maker in the galley.
- The system is controlled:
  - Automatically through the Water System Computer Unit (WSCU),
  - Manually by one of the crew members in case of WSCU failure.
- The waste water and the whole water system are drained overboard through two heated drain masts.
- The aft toilets are chemical-type with a dedicated tank and recirculating system.

Water and waste