SNS COLLEGE OF TECHNOLOGY

COIMBATORE-35

DEPARTMENT OF MECHATRONICS ENGINEERING

19MCT402-APPLIED MECHATRONICS ENGG.

Unit – 3 AVIONICS

AVIONICS ARCHITECTURE

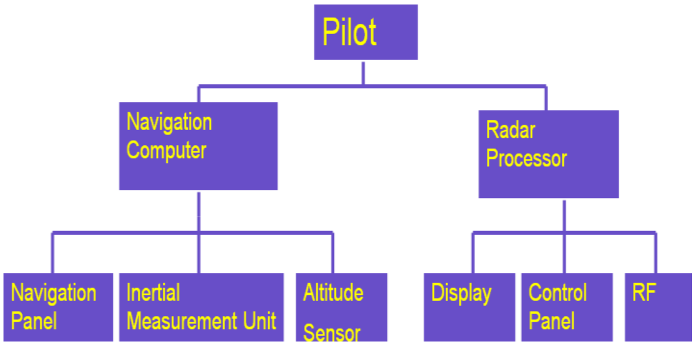
First Generation - DISJOINT ARCHITECTURE

The early avionics systems were stand alone black boxes where each functional area had separate, dedicated sensors, processors and displays and the interconnect media is point to point wiring.

The system was integrated by the air-crew who had to look at various dials and displays connected to disjoint sensors correlate the data provided by them, apply error corrections, arrange the functions of the sensors and perform mode and failure management in addition to flying the aircraft

This was feasible due to the simple nature of tasks to beperformed and due to the availability of time.

FGA - DISJOINT ARCHITECTURE



First Generation - CENTRALIZED ARCHITECTURE

As the digital technology evolved, a central computer was added to integrate the information from the sensors and subsystems. The central computing complex is connected to other subsystems and sensors through analog, digital and other interfaces.

When interfacing with computer a variety of different transmission methods are required and some of which needs signal conversion (A/D).

Signal conditioning and computation take place in one or more computers in a LRU located in an avionics bay, with signals transmitted over one way data bus.

Data are transmitted from the systems to the central computer and the data conversion takes place at the central computer

Advantages

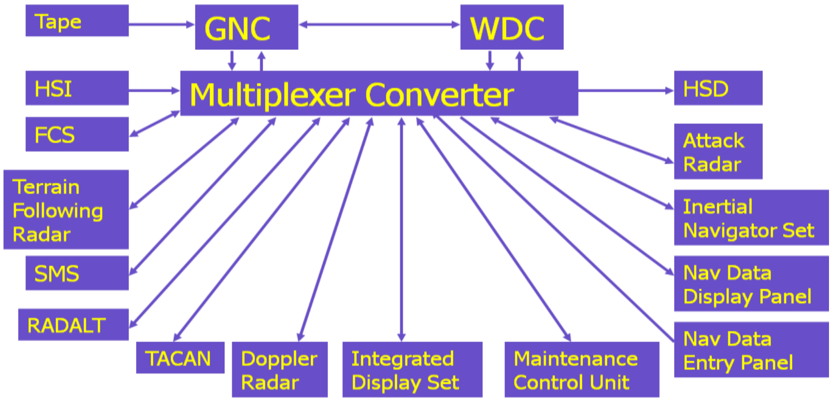
Simple Design
Software can be written easily
Computers are located in readily accessible bay.

Disadvantages

Requirement of long data buses Low flexibility in software Increased
vulnerability to change

Different conversion techniques needed at CentralComputer.

FGA - CENTRALIZED ARCHITECTURE



Centralized Architecture

Second Generation – FEDERATED ARCHITECTUREFederated: (Join together, Become partners)

In this SG-Federated Architecture, each system acts independently but united (Loosely Coupled).

Data conversion occurs at the system level and the datas are send as digital form – called Digital Avionics Information Systems (DAIS)

Several standard data processors are often used to perform a variety of Low – Bandwidth functions such as navigation, weapon delivery, stores management and flight control Systems are connected in a Time – Shared Multiplex Highway.

Resource sharing occurs at the last link in the information chain – via controls and displays. Programmability and versatility of the data processors.

Advantages

It provides precise solutions over long range of flight,weapon and sensor conditions

Sharing of Resources

- Use of TDMA saves hundreds of pounds of wiring
- Standardization of protocol makes theinterchangeability of equipments easier
- Allows Independent system design and optimization ofmajor systems
- Changes in system software and hardware are easy tomake
- Fault containment – Failure is not propagated

Disadvantages

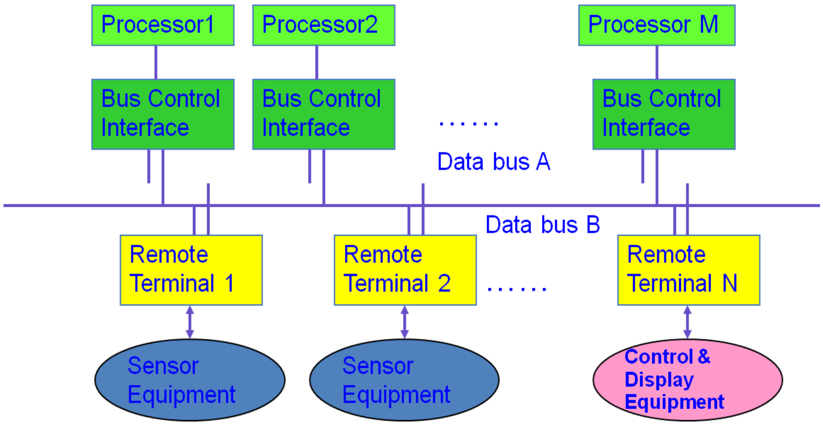
Profligate of resources

Second Generation – DISTRIBUTED ARCHITECTURE

It has multiple processors throughout the aircraft that are designed for computing tasks on a real-time basis as afunction of mission phase and/or system status. This Architecture is used in modern avionics system. Processing is performed in accordance with the sensors and actuators.

Advantages

Fewer, Shorter buses Faster program executionIntrinsic Partitioning



Distributed ArchitectureDisadvantages

Potentially greater diversity in processor types which aggravates software generation and validation.

Second Generation -HIERARCHICALARCHITECTURE

This architecture is derived from the federated architecture. It is based on the TREE Topology

Advantages

- ❖ Critical functions are placed in a separate bus and Non-Critical functions are placed in another bus.
- ❖ Failure in non – critical parts of networks does notgenerate hazards to the critical parts of network.
- ❖ The communications between the subsystems of aparticular group are confined to their particular group.
- ❖ The overload of data in the main bus is reduced.
- ❖ Most of the military avionics flying today based onhierarchical architecture.

SGA - HIERARCHICAL SYSTEM

- This architecture derived from the federatedarchitecture.
- It is based on the TREE Topology.

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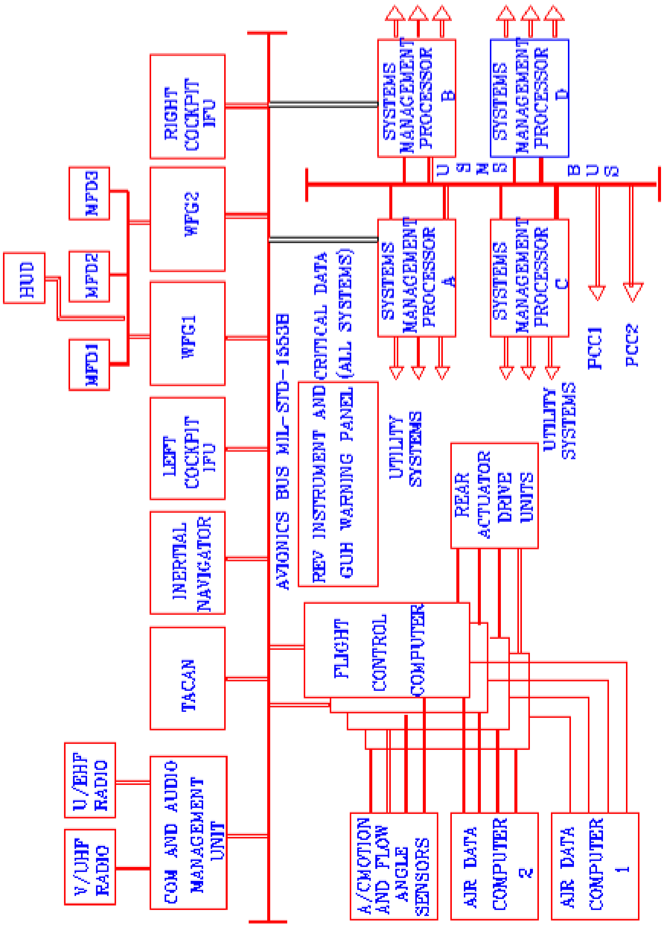


Hierarchical System Architecture

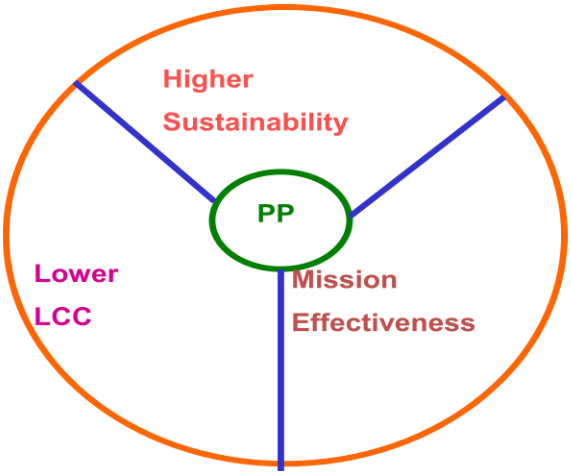
Third Generation Architecture - PAVE PILLAR

Pave Pillar is a US Air Force program to define the requirements and avionics architecture for fighter aircraft of the 1990s.

The Program Emphasizes,

- Increased Information Fusion

- Higher levels and complexity of software
- Standardization for maintenance simplification
- Lower costs
- Backward and growth capability while making use of emerging technology – Voice Recognition /synthesisand Artificial Intelligence.
- Provides capability for rapid flow of data from the system as well as between and within the system
- Higher levels of avionics integration and resource sharing of sensor and computational capabilities
- Pilot plays the role of a weapon system manager.
- Able to sustain operations with minimal support, fly successful mission day and night in any type of weather
- Face a numerically and technologically advanced enemy aircraft and defensive systems.



Pave Pillar CapabilityAdvantages

- Component reliability gains

- ❖ Use of redundancy and resource sharing
- ❖ Application of fault tolerance
- ❖ Reduction of maintenance test and repair time
- ❖ Increasing crew station automation
- ❖ Enhancing stealth operation
- ❖ Wide use of common modules
- ❖ Ability to perform in-aircraft test and maintenance ofavionics
- ❖ Use of VHSIC technology and
- ❖ Capability to operate over extended periods of time at severe, deployed locations and be maintainable withoutthe Avionics Intermediate Shop.

Fourth Generation Architecture - PAVE PACE

US Air Force initiated a study project to cut down the cost of sensors used in the fighter aircraft. In 1990, Wright Laboratory – McDonnell Aircraft, Boeing Aircraft Companyand Lockheed launched the Pave Pace Program and Come withthe Concept of Integrated Sensor System (IS^2). Pave Pace takesPave Pillar as a base line standard. The integration concept extends to the skin of the aircraft – Integration of the sensors and this architecture was originally designed for Joint Strike Fighter (JSF) which is shown in figure 4.7.

FTGA – PAVE PACE

- Modularity concepts cuts down the cost of the avionicsrelated to VMS, Mission Processing, PVI and SMS
- The sensor costs accounts for 70% of the avionics cost.
- Pave Pace takes Pave Pillar as a base line standard.
- The integration concept extends to the skin of theaircraft integration of the RF & EO sensors.
- Originally designed for Joint Strike Fighter (JSF)

Data Bus

It provides a medium for the exchange of data andinformation between various Avionics subsystems. It provides the Integration of Avionics subsystems inmilitary or civil aircraft and spacecraft.

Types

Command/Response :Centralized Control Method Token Passing : Decentralized Control MethodCSMA/CA : Random Access Method

MIL STD 1553B:

The MIL STD 1553B is a US military standard which defines TDM multiple source-multiple sink data bus system. It is widely used in military aircraft in many countries. It is also used in naval surface ships, submarines and battle tanks. The system is a half duplex system.

- The system was initially developed at Wright PattersonAir Force base in 1970s.
- Published First Version 1553A in 1975
- Introduced in service on F-15 Programme.
- Published Second version 1553B in 1978.

Elements of MIL-STD-1553B

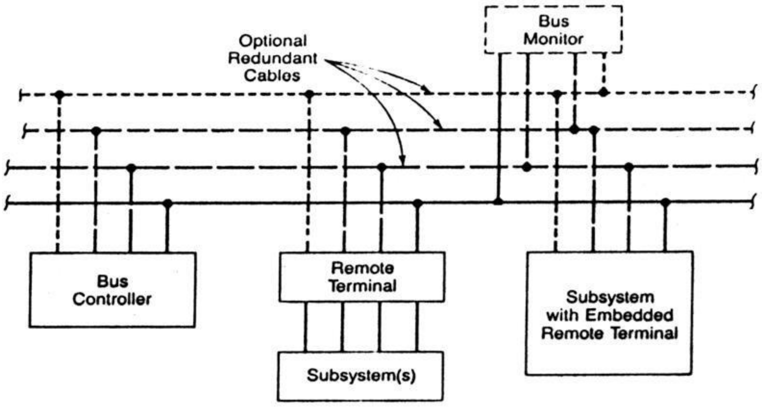
- ❖ Bus Controller (BC)
- ❖ Remote Terminal (RT)
- ❖ Monitoring Terminal (MT)
- ❖ Transmission Media

The basic bus configuration is shown. The system is a command response system with all data transmission being carried out under the control of the bus controller. Each sub-system is connected to the bus through a unit called a remote terminal (RT). Data can only be transmitted from one RT and received by another

RT followinga command from the bus controller to each RT.

Broadcast Mode:

The operation of the data bus system such thatinformation transmitted by the bus controller or a remote terminal is addressed to more than one of the terminals connected to the data bus is known as the broadcast mode.



Data Bus system Architecture

In this bus system three types of words are transferred. Theword format is provided in figure 4.9

- Command words,
- Status words,
- Data words.

A command word comprises six separate fields, they are; SYNC, Terminal address, T/R, Subaddress / Mode, Data word Count/Mode Code and Parity bit.

A status word is the first word of a response by an RTto a BC command. It provides the summary of the status/health of the RT and also the word count of the data words to be transmitted in response to a command.

A status word comprises four fields, they are; SYNC, Terminal Address, Status field and Parity bit.

The data words contain the actual data transmitted between stations. The data field is 16 bits. The SYNC signal is the inverse of the command and status word SYNCs. The most significant bit of the data is transmitted after the SYNC bits.

There are ten possible transfer formats, but the three most commonly used formats are,

- BC to RT
- RT to BC
- RT to RT

Specifications of MIL-STD 1553B

Data Rate	1 Mbps
Word Length	20 Bits
Maximum data transmission rate	50,000 words/s
Maximum terminals connection to the bus	31
Message Length	32 word strings
Data Bits per Word	16 bits
Transmission Technique	Half Duplex
Encoding	Manchester II Bi-Phase
Protocol	Command Response
Transmission Mode	Voltage Mode.

ARINC

ARINC (Aeronautical Radio Incorporated) is a nonprofit organization in the USA which is run by the civil airliners with industry and establishment representation, which defines systems and equipment specifications in termsof functional requirements, performance and accuracy, input and output interfaces, environmental requirements, physical dimensions and electrical interfaces.

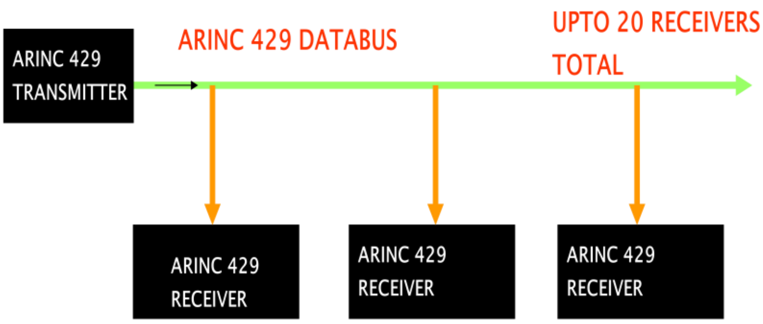
ARINC 429

- Single point failure in 1553B leads to Certificability problem in civil aircraft. Addition of remote terminal requires changes in bus controller software which

  requires frequent certification. So ARINC 429 Standardwas adopted in the year 1977 and made its appearance in the C-17 transport aircraft. The ARINC 429 architecture is shown in figure 4.11.
- It is a Point to Point Protocol System.
- It is a specification that defines a local area network for transfer of digital data between avionics system elements in civil aircraft.
- It is simplex data bus using one transmitter but no more than twenty receivers for each bus

implementation. There is no physical addressing. But the datas are sent with proper identifier or label.

- ARINC 429 is viewed as a permanent as a broadcast or multicast operation
- In this system two alternative data rates of 100kbps and 12-14 Kbps are possible.
- There is no bus control in the data buses as found in MIL-STD 1553B. It has direct coupling of transmitter and receiving terminals.



ARINC 429 ARCHITECTURE

ARINC 629 ARCHITECTURE

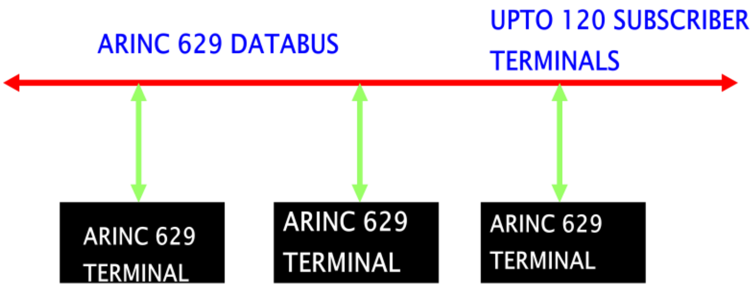
History:

1977 - Boeing began to work on "DATAC" project
1977 - 85 - DATAC Emerged as ARINC 629
1989 - ARINC 629 was adopted by AEEC
1990 - ARINC 629 was first implemented in BOEING-777

ARINC 629 Specifications

Data Rate	2 Mbps
Word Length	20 Bits
Maximum terminals connection to the bus	31
Message Length	31 word strings
Data Bits per Word	16 bits
Transmission Technique	Half Duplex
Encoding	Manchester II Bi-Phase
Protocol	Carrier Sense Multiple Access Collision avoidance
Transmission Mode	Voltage Mode, Current Mode, Fiber Optic Mode

ARINC 629 Architecture



ARINC 629 ARCHITECTURE

cockpit display system

The cockpit display system provides a visual presentation of the information and data from the aircraft sensors and systems to the pilot. This helps the pilot to fly the aircraft safely.

Civil cockpit display systems provides,

- Primary Flight Information
- Navigation Information
- Engine Data
- Airframe Data
- Warning Information

Apart from this data the military cockpit display system provides,

- Infrared Imaging Sensors
- Radar
- Tactical Mission data

- Weapon Aiming
- Threat Warnings

The HUD has enabled a major improvement in man machine interaction and it helps the pilot to view and assimilate the essential flight data generated by the sensors and systems in the aircraft.

HUD basically projects a collimated display in the pilot‟s head up forward line of sight, so he can view both the display information and the outside world at the same time. The pilot can able to observe both distant outside world objects and display data at the same time without changing the direction of gaze or re-focus the eyes. During the landing phase the pilot can view the essential flight data such as artificial horizon, pitch angle, bank angle, flight path vector, height, airspeed and heading with the help of HUD.

HUD uses high brightness display and it projects some of the information normally on the primary flight displays and selected systems or weapons data into the Line of Sight of the pilot without substantially dimming or obscuring the outer view. HUD allows the pilot to simultaneously see critical aircraft information while viewing the outside scene. Every HUD contains a Display generator and Combiner. The combiner combines the collimated display symbology with the outside world scene. The display symbology is generated from the aircraft sensors and systems.

The relay lens magnifies the display and corrects for some of the optical errors. The relayed display images are reflected by the fold mirror to the collimating lens

In the current HUD, Display Generator – CRT with P43 (Green) phosphor Combiner – mirror with several unusual properties:

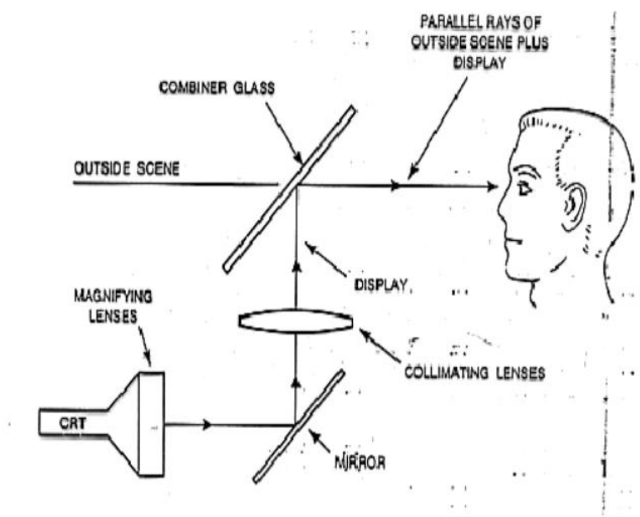
• Reflective coating – Highly wavelength selective in angle of incidence so that only that light which impinging within a very narrow range of angles will be reflected.

• Combiner is sometimes incorrectly referred to as Hologram, but it contains no image information as found in true hologram

High performance aircraft HUD‟s use one of two basic designs for the combiner

- Single element combiner HUD
- Three element combiner HUD

Single element combiner HUD



Merits

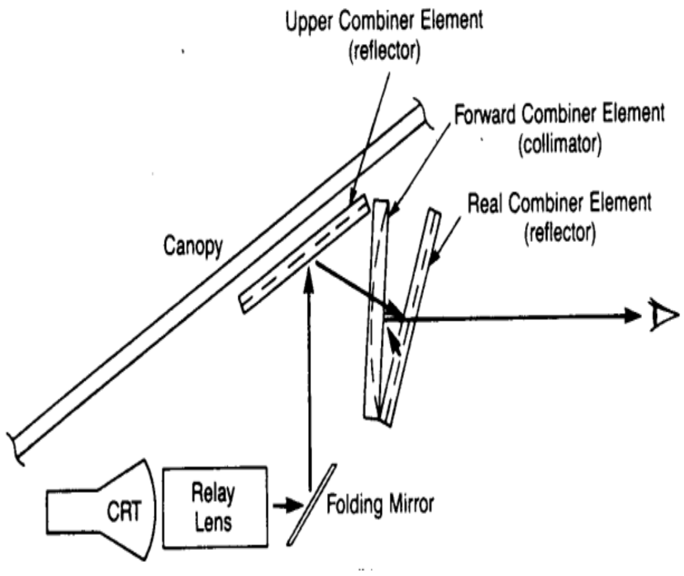
- Simplest design of the two methods

- Transmission of outside scene is higher
- Transport aircraft uses this method

Demerits

- Less advantageous than three-element combiner HUD.

Three element combiner HUD



Merits

- Used on high-performance aircraft to achieve better producibility
- This design has achieved 30o horizontal and 20o vertical field of view
- All three elements contains gelatinous combiners as the middle layer, but only the forward element is curved to collimate the image from the CRT.

Colour HUD"s are controversial for two reasons:

- There may be some loss of brightness, although brightness is becoming less of an issue as color CRTS improve
- Colours may be confused with or lost in the natural exterior scene

Practical problem

HUD occupies large volume and the necessity to be mounted in the cockpit with the combiner in LOS to the pilot On high performance aircraft, HUD is mounted at the top of and behind the instrument panel. So that the combiner is between the top of the panel and the canopy in the pilot"s LOS when looking straight ahead. For civil transport, HUD is mounted above the seat of each cockpit crew member, and the combiner is hinged to swing down into the LOS when HUD is in use, generally only during approach and landing. Single element combiner can be used as an alternative for civil transport.

In military Aircrafts

The pilot freely concentrates on the outside world during maneuvers. In combat situations the pilot can scan for possible threats from any direction. The military Aircrafts HUD is shown in figure 3.20. The combined FLIR with HUD enables the pilot to fly at low level by night in fair weather. This provides a realistic night attack capability.

In Civil Aircrafts

The HUD provides situational awareness and increased safety in circumstances such as wind shear or terrain/ traffic avoidance maneuvers. If the flight path vector is below the horizon the aircraft is descending. Flight path vector provides a two dimensional display of drift angle and flight path angle. It helps the pilot to land the aircraft safely in conditions of very low visibility due to fog.