Simplifying System Architecture Using Very Smart Displays

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ABSTRACT

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In the past, cockpit displays have had a limited role in that they were capable only of displaying information that was generated by other equipment in the aircraft. Examples of this can be seen when we look at system architectures consisting of separate mission computers, map generators, engine data generators, and air data computers. These individual boxes take sensor information and perform the computations, which feed the displays. With the advent of new technology offering super miniature, high-speed components, potentially all processing can now be accomplished within the displays themselves while also allowing for a wide range of interfaces. In aircraft application, this allows an architecture whereby the remote sensors feed directly into the displays, thus greatly reducing cabling requirements, reducing weight as well as reducing overall cost due to reduction of the number of boxes in the system. System reliability is also greatly improved due to redundancy of functions between multiple displays in the aircraft. This paper discusses such an application and describes a display designed for fighter aircraft applications containing multiple processing capability. New system architecture is described which takes advantage of this capability.

1. Typical Existing System Architectures

1.1. Legacy Aircraft – Analog Technology

Most legacy aircraft contain the basic architecture dictated by the nature of the analog sensors and analog flight instruments. A typical early architecture is as follows:

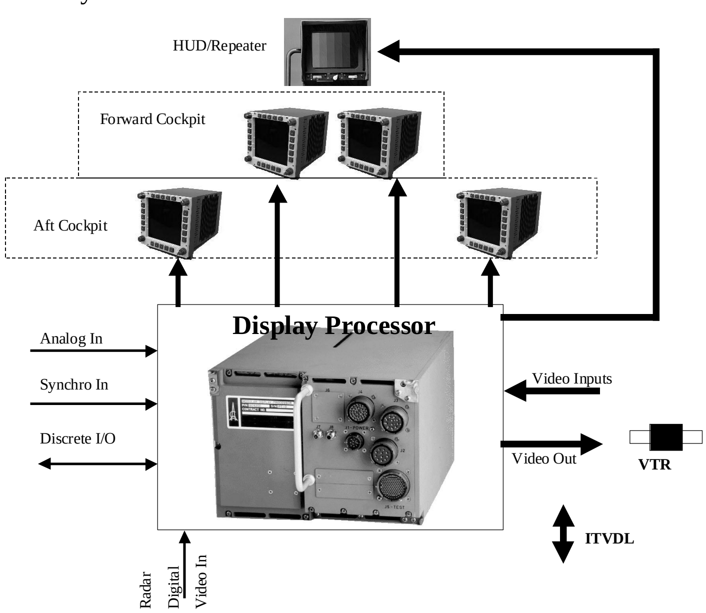
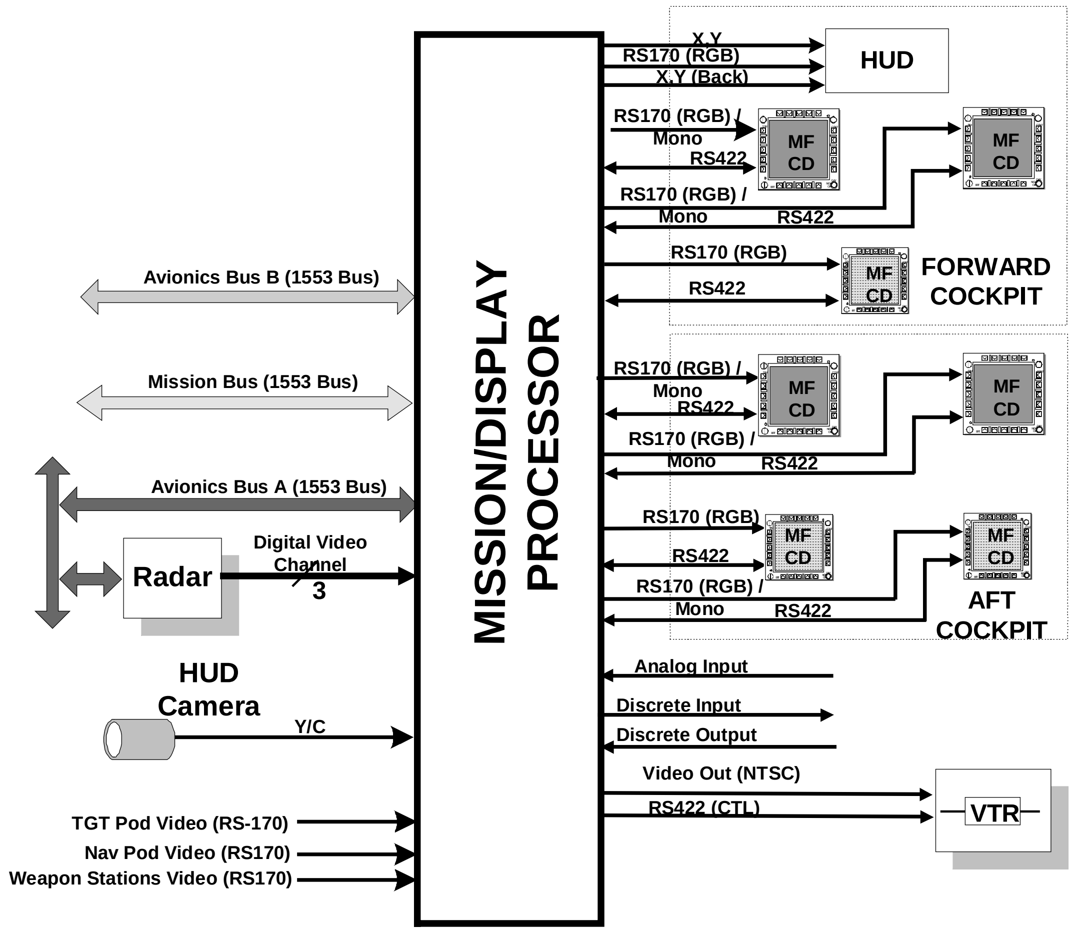


Figure 1-1 Legacy Analog System Architecture

1.2. Hybrid Digital / Analog Technology CRT/AMLCD

The above architecture was very straightforward and used the existing technology in a very efficient manner. As technology developed however, hybrid analog/digital systems began to evolve. Digital sensors with their higher accuracy became available, however, they still had to work in an analog instrument display environment. A typical architecture that resulted is as follows:



F igure 1.2-1 Hybrid System Block Diagram

While the above architecture achieved the higher accuracy brought about by the digital sensors, it did not achieve any increase in system reliability and resulted in more complexity due to the digital to analog conversions necessary to operate the analog instruments. With the introduction of CRT displays, even more complexity was added to the architecture of the system by way of the introduction of the video converter. This added complexity however, did result in achieving higher reliability of the system since information could then be switched between displays in case of any display failure. A typical system that evolved, used digital sensors and CRT or AMLCD displays. The use of the AMLCD in this configuration resulted in reduced power and weight as well as improving the reliability of the system. Either CRT or AMLCD were driven from a video source.

1.3. The All Digital Aircraft with Smart Displays

The next step in development of the system architecture resulted in the digital aircraft which connected all functional elements of the system by means of the multiplex bus. This is typical of today's aircraft which employ redundancy of displays and minimize aircraft wiring thus resulting in a much higher reliability system. In addition, the displays have been provided with a level of computing capability such that they can generate graphics within the display and need not be merely repeaters relying only on video input. Such an architecture using these "smart" displays is as follows:

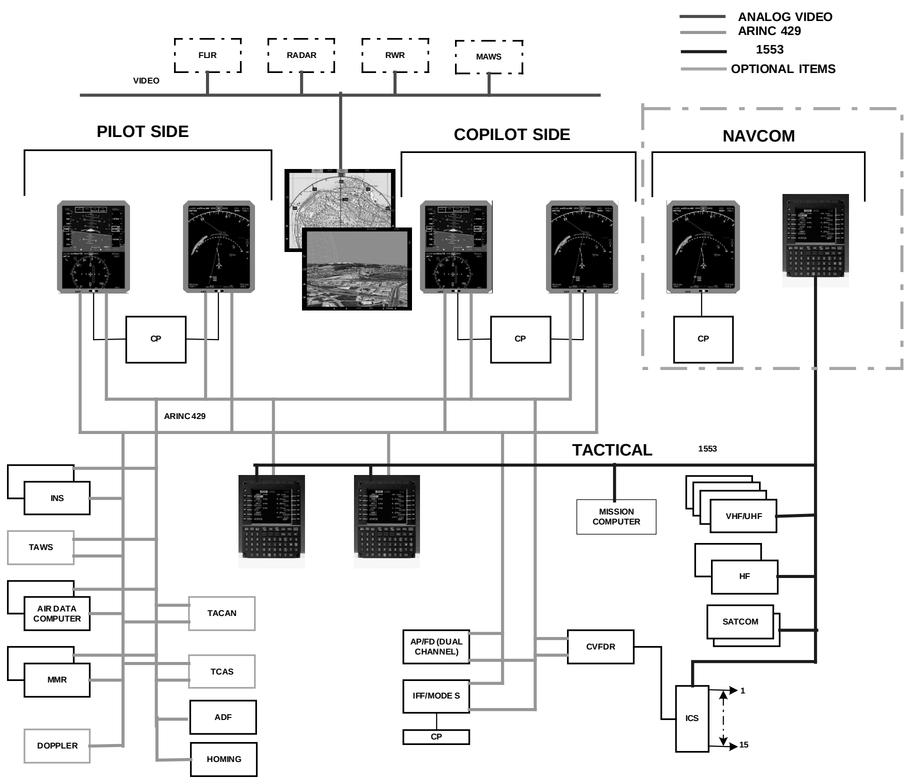


Figure 1.3-1 All Digital Architecture Function Block Diagram

2. The Multi-Processor Display, Very Smart Display

The multi-processor, very smart display is designed to meet a speecific requirement. The requirement is to provide three independent processing elements to reduce the processing requirements in existing mission processors as well as distributing the computing requirements among the the displays. The three processors preform unique functions within the display. One is the Application Processor, which provides the overall system controller function, and contains a portion of the Opertional Flight Program (OFP). In this design the OFP is limited in its capabilities, but still provides some reduction in the computational requirements of the Mission Computer. The Application Processor provides the controls for the Graphics Display Controller (Graphics Processor and Graphics Layer Assembly) using shared memory and interrupts. The Graphics Processor uses the same circuitry as the Application Processor, The Graphics Layer Assembly provides video windowing, external video capture zone, screen display positioning and scaling along with providing three layers of displayed data including symbology overlay, external video and symbology underlay.

2.1. Block Diagram

The configuration of the display is provided in the following functional block diagram.

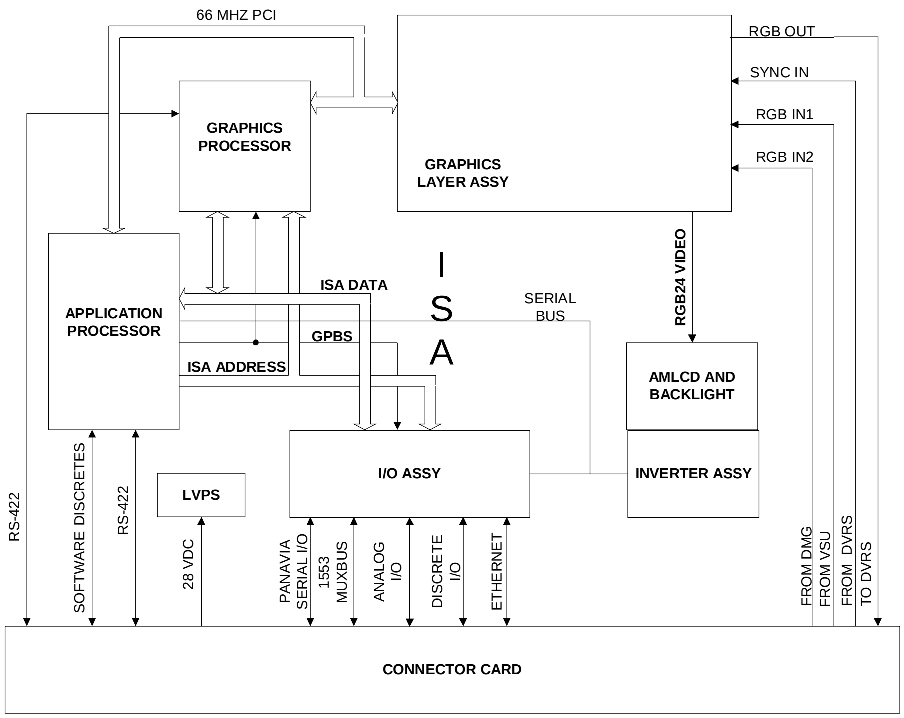


Figure 2.1-1 Multi-Processor Functional Block Diagram

2.2. Multi-processor Capability

The Astronautics Displays developed for the program have significant processing, interface, and video/graphics capabilities. The displays have dual processors for application and graphics processing respectively, and yet another advanced processor on the Graphics Layer Assembly (GLA). These multiple processors provide the capabilities that approximate a Sun Workstation. The GLA supports Dual RGB Video Inputs and a Video Recording Output. An Interface Assembly in these displays supports the MIL-STD-1553, serial and discrete interfaces.

2.3. Interfaces

This modern display provides a wide variety of inputs and outputs that would have been received by either a Mission Computer or Display/Graphics Processor. The following provides a listing of typical implementation:

Dual Video Input - RS-170 RGB (Standard) Video Input
    Digital and CCIR Available
RS-485/422 (Half Duplex, Bi-Directional)
Analog inputs
    Mux into 10-bit A/D converter
    OP Amp scaling/filtering
Discrete Inputs
Four single-wire voltage comparators

Two 2-wire receiver discretes (Differential RS-422 Type)
Reset input plus one spare
Discrete Outputs (8)
    Open collector outputs with transient protection (Go/No Go)
MIL-STD- 1553B Dual Redundant Remote Terminal
Ethernet Used for debug and integration only. Not currently functional on aircraft.
One input Transmitted true and complement form
Discrete Digital interfaces
    Interface to control panel switches
    Single wire
    Common 0V reference
    Fifteen Outputs
        6 inch display
    Fourteen Outputs
        5 inch display
    Seven inputs
28V common return (GND/OPEN)
    One output
    One input
Two special serial digital inputs
One special serial digital output

This listing of interfaces provides for the inclusion of many different sensors employing either digital or analog signal format.

2.4. Physical Description

Two displays have been designed containing the multi-processor architecture. The physical characteristics for these displays are as provided in the following table.

Table 2.4-1 Display Characteristics

Optical Characteristics	5 Inch Display	6 Inch Display
Viewable Screen Size	5.03” x 5.03”	6.25” x 6.25”
Resolution(RGB pixels)	600 x 600 119.28 Color Groups per inch (CGI)	780 x 780 124.8 CGI
Color Depth (Displayable Gray Shades)	256	256
Total Colors	16.7 Million Colors	16.7 Million Colors
Physical Characteristics		
Display Head Dimensions	7.01” x 6.69” x 1.58”	8.3” x 8.3” x 3.4
Electronics Body	6.65” x 5.55” x 7.8	6.65” x 6.14”x 6.64”
Weight (lb)	11	14
Power(watts)	140*	170*
MTBF (Hours)	4,440	4,344

*At 300 fL screen luminance/not including heaters

The unit structure consists of two sections
    Display Housing Assembly
    Rear Chassis Assembly

Both structures are fabricated from corrosion resistant aluminum alloy, 6061-T6, and chemically filmed per MIL-C-5541. The display housing is machined from solid plate, with the rear chassis is assembled from individual pieces with screws. The two sections are joined at a common bulkhead. This right-angle mechanical joint construction accomplishes EMI, sand/dust protection without use of gaskets. The cooling is by radiation, natural convection, and forced convection (with thermostatically controlled fans). Airframe-provided forced air cooling is not required. Fluid contamination is prevented by drain holes located in the display housing and Rear Chassis. Chemical-resistant conformal coat protects electronics against JP-4/-5/-8, lubricating oils and hydraulic fluids, salt spray and fungus. Figure 2.4-2 is a photograph of the displays, while figure 2.4-2 provides a view of the internal structure of these displays.

Figure 2.4-1 6" and 5" Multiprocessor Displays

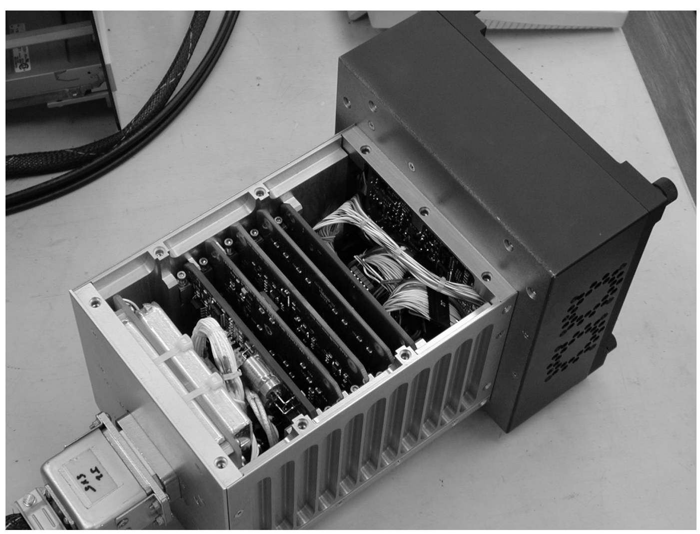


Figure 2.4-2 Internal view of Multi-Processor Display

3.The New Architecture

Using these displays as the basis for creating a new system would result in an architecture that is very simplistic. Figure 3-1 represents one hypothetical system that could be used in a new modern aircraft or as an update to an existing platform.

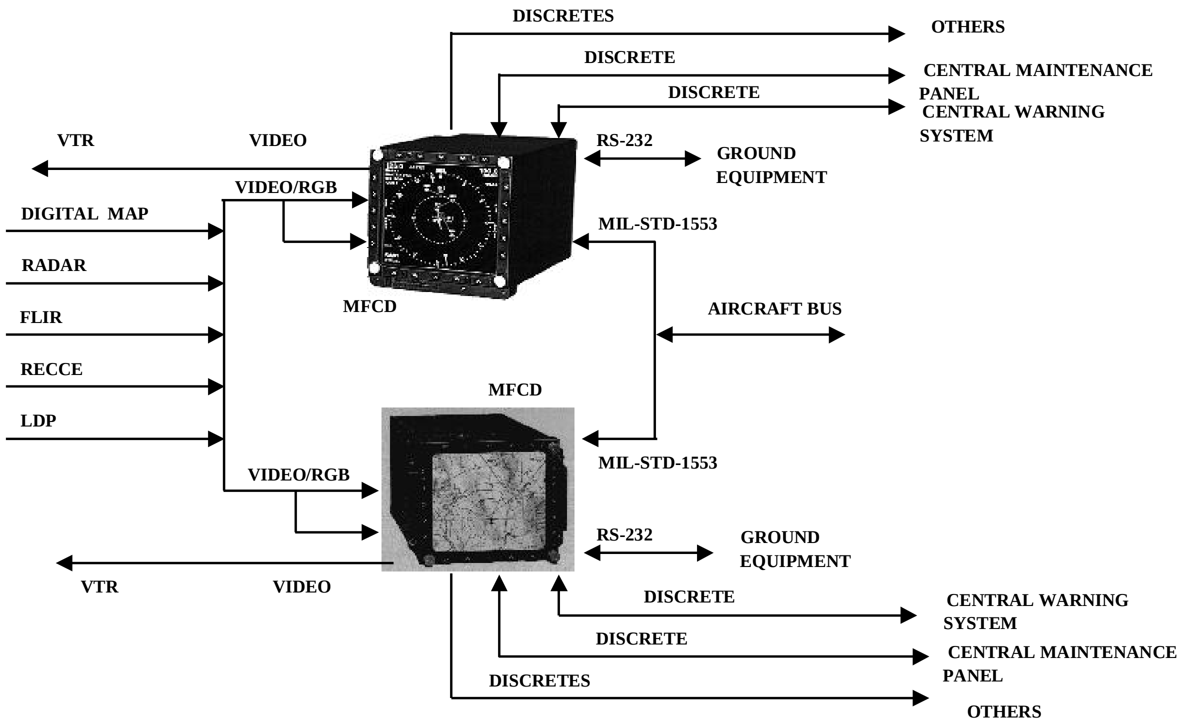


Figure 3-1Mission Capable System

This architecture is dependent on embedded OFP segments, distributed throughout the processors in the displays. Cross-communication is provided to keep each display capable of replacing a failed unit.

4. Reliability/Redundancy Issues

Current system configurations use multiple Mission Processors or Graphics generators to provide redundancy of operation. This adds weight, increases power requirements and maintenance requirements due to the additional boxes. The architecture suggested in this paper with multiple displays provides redundancy without additional boxes. Even in smaller cockpits where only two displays are used, reduncancy is still provided. Each display does provide two independent processors that can support OFP segments. The third processor in each display continues to provide video processing and graphics generation. Because all displays that are used in the architecture are connected by a communications link, data is passed to and from each to maintain operability in the event of failure.

5. Software Issues

Currently, the displays contain dedicated operational software that is not dependent on an operating system. In order to support more robust OFPs, there will be a requirement for the addition of a real time operating system.

Several of these are available on the market. However, Astronautics is currently developing a RTCA DO-178B certified operating system. As large capacity solid state memory becomes available, much larger software segments can be hosted by the multi-processor displays. It also allows functions such as an electronic map to be hosted entirely within the display.

6. Typical Savings

A preliminary analysis of the impact that these multi-processor displays will have on system parameters has been conducted based on a hypothetical architecture. This analysis provided significant reduction in several parameters. One of the most significant parameters in aircraft whether rotary or fixed wing is weight. Eliminating only 2 typical boxes with their cabling, mounting trays, etc. will amount to a reduction of at least 100 pounds.

Improvements in system reliability and reductions in maintenance actions creates a savings in spares and manpower expenditures. A very rough estimate of these improvements is about 10%. This value is very dependent on the quantity of platforms that has implemented these new multi-processor displays, therefore the provided estimate may be very conservative. The impact on cost is also estimated to be a 20% reduction in overall cockpit implementation.

7. Conclusions

The direction of future aircraft system architectures appear to follow the development, not only of new display media, but also in the development of faster and smaller components which allow the merging of previously separated functions into the display resulting in “very smart” displays. The development of smart sensors will likewise speed the simplification of system architectures. System designers must be aware of these new possibilities in using very smart displays when developing aircraft system architectures. These displays have been developed by the Astronautics Corporation of America and are being applied to high performance aircraft.