ADVANCED INSTRUMENTATION CONTROL SYSTEMS FOR F/A-18E/F

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ABSTRACT

The purpose of this paper is to present the use of production aircraft equipment and wiring for control of the onboard instrumentation system. The major advantages and challenges associated with the use of existing production equipment versus dedicated instrumentation wiring and hardware will be explored. Many of the issues raised, including non-interference with existing avionics, are complex. It is the hope of the author that this paper will generate awareness and discussion on these issues.

BACKGROUND

Test and Evaluation of military airborne vehicles requires increasingly complex data acquisition systems. Historically, instrumentation systems have used unique Cockpit Control Panels (CCP) and discrete wiring to control the instrumentation equipment onboard the aircraft. This required routing numerous wires, usually using spare pins in production connectors, from the cockpit to instrumentation system. Newer systems minimized wiring count by transitioning from discrete wiring to dedicated serial communication buses (i.e., RS-232 and RS-485). Recent designs have transitioned to using the production aircraft Digital Display Indicator (DDI) to provide the instrumentation control functionality, and to use the existing aircraft MIL-STD-1553 bus to provide the communication path to the instrumentation equipment.

The requirement for new instrumentation system control originates from the following:
1) As cockpit space becomes more constrained, there is a need to eliminate the unique instrumentation Cockpit Control Panels.
2) As spare pins giving access to the cockpit become less available, wire routing needs to be reduced.
3) Lowering the cost of flight testing by reducing the time for the installation and removal of wiring required for the data acquisition system.
4) Providing additional control and status information available to the pilot.

All of these needs suggest making the instrumentation system an integral part of the avionics suite of the aircraft. Pilot control and system status could be provided by a DDI INSTRUMETATION page and system communication via the production MIL-STD-1553 bus, thus eliminating the unique instrumentation cockpit control hardware and wiring.

CURRENT IMPLEMENTATION OF DDI-CONTROLED INSTUMENTATION ON AESA AIRCRAFT

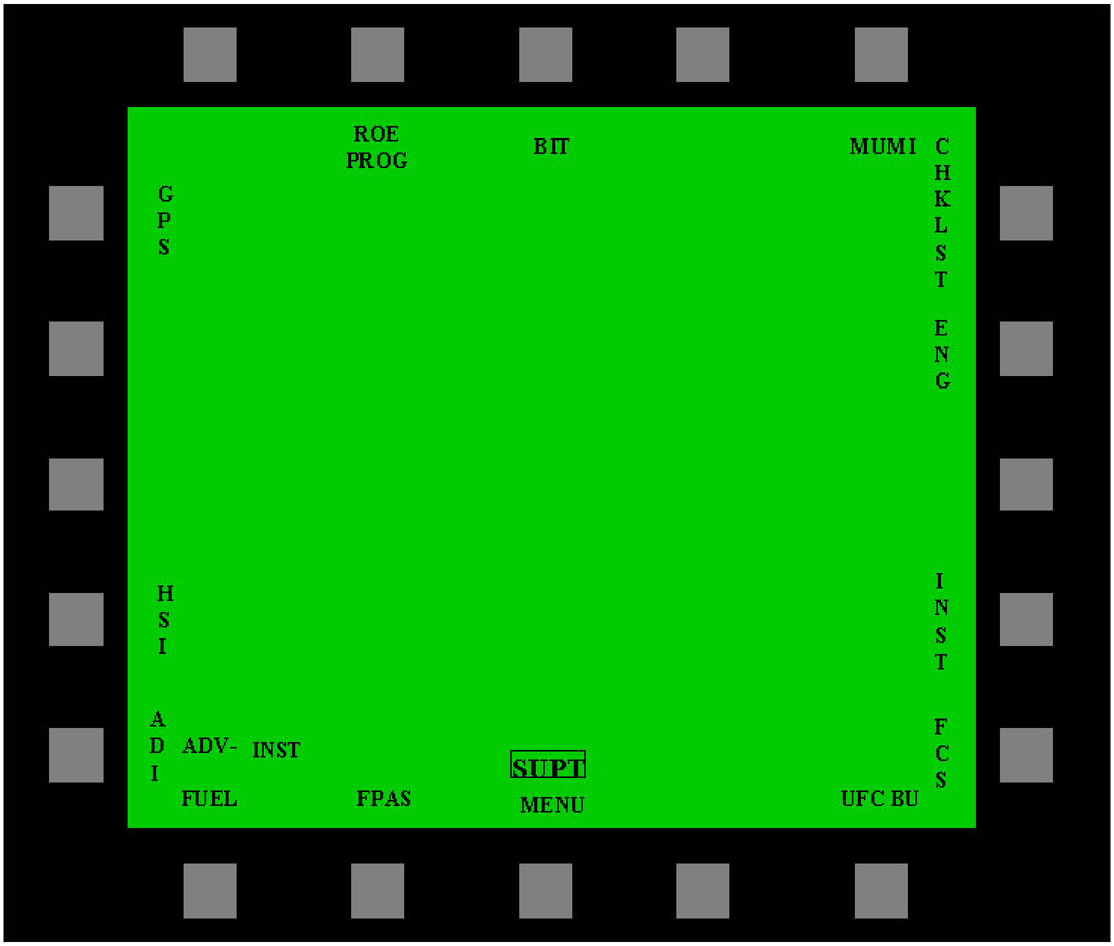
Flight test of the Active Electronically Scanned Array (AESA) radar at The Naval Air Warfare Center Weapons Division, China Lake demonstrated the feasibility of embedding all of the instrumentation functionality in the aircraft tactical Operational Flight Program (OFP). The implementation of this system relied heavily on the efforts of previous programs such as the RECCE team at China Lake working with the Boeing, the airframe manufacturer. The REECE team needed a new approach to controlling some specific instrumentation being used to collect synthetic aperture radar images. This command and control infrastructure became a the building block for later work with the Advanced Targeting Forward looking infrared (ATFLIR) program at China Lake, CA.

In the AESA program, instrumentation control of bus monitoring, video source selection, recorder on/off and status, data and video telemetry control, and IRIG time synchronization all are pilot selectable using the aircraft DDI key buttons. The instrumentation system is assigned a unique MIL-STD-1553 bus remote terminal address. The aircraft OFP has a dedicated "Instrumentation" page with a buttons to control the various functions.

The pilot selects the "INST" button from the display and is taken to the first level or "page" for instrumentation and can make selections based on what is identified in the mission cards. These settings are saved upon system power-down as the default for the next mission. During aircraft pre-flight these can also be set to take workload away from the pilot.

Another advantage of this scheme is that all the message traffic related to the control bus is stored in the system memory to be reviewed for post-flight data analysis and to correlate to possible problems or events. This type of data process review has not been possible up until this system design. These messages are down linked real-time to the range or mission control center to be used by the flight test engineers or system experts on site. This is a valuable tool in troubleshooting problems as the flight is still on going.

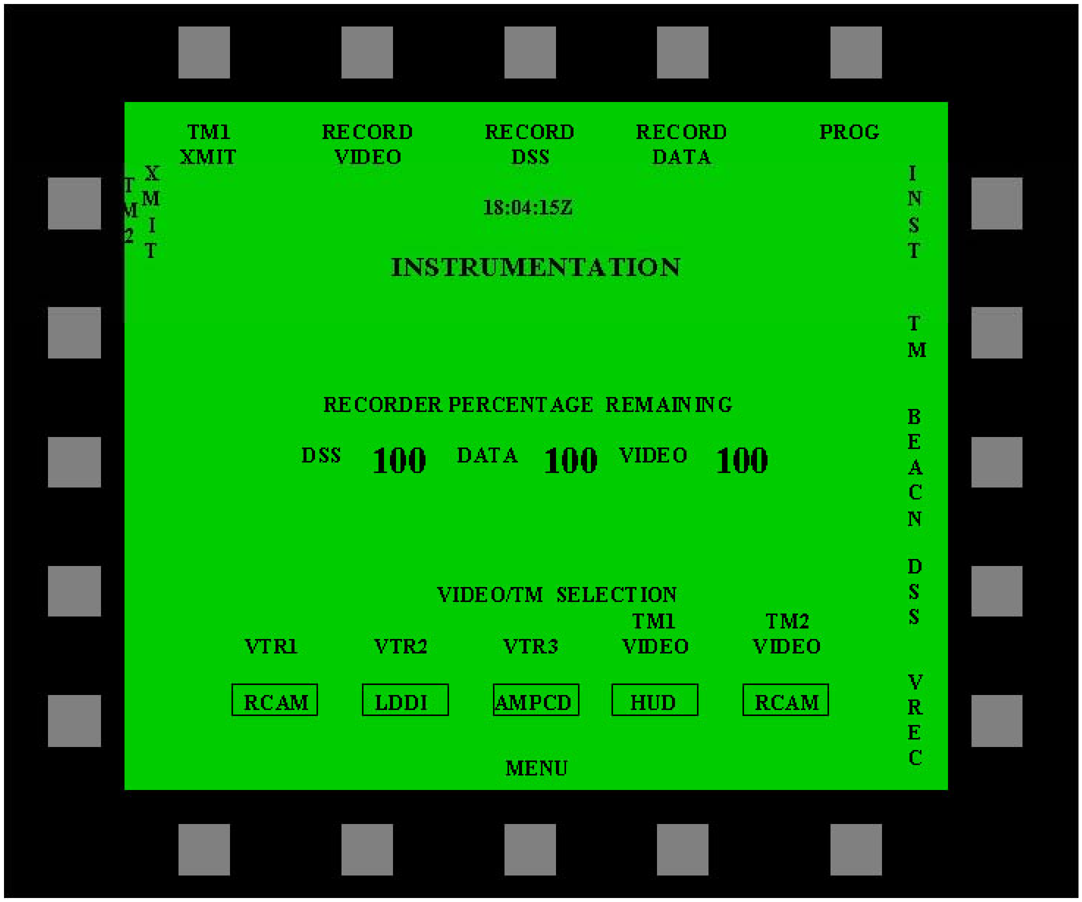
The figures shown on the following pages are the actual DDI pages with a brief description of the use of each of the buttons:



Top Level Control Page

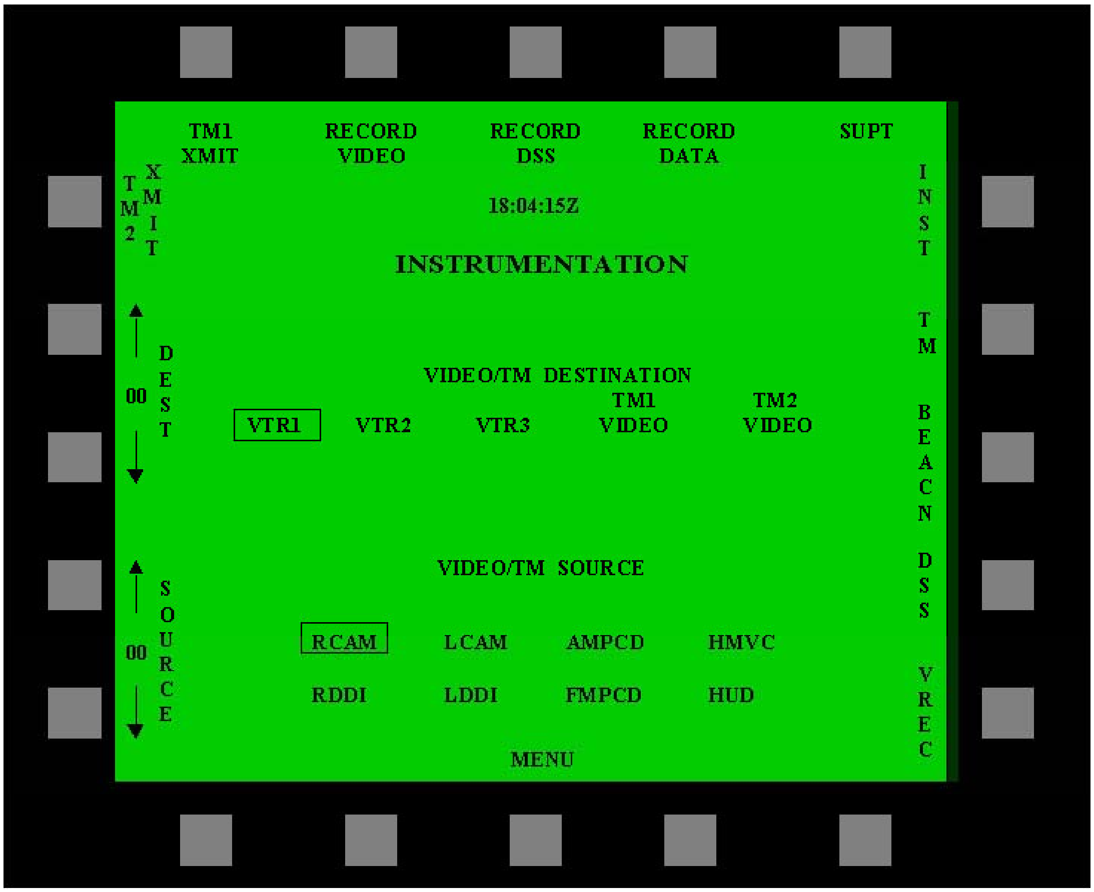
**The Instrumentation Page is identified in the lower right hand corner
This is the entry button for all Instrumentation Command and Control**

INST (PB 14) – Becomes available after Instrumentation system power on (INSTRU PWR ON). Entry point for DDI instrumentation control pages .**ADVISORY INST** – Displayed by either an instrumentation AV MUX 2 fail or a failure on an instrumentation subsystem. NOTE: INST advisory is cleared after AV MUX 2 communication is stored or by entering the DDI instrumentation control pages for an instrumentation subsystem failure.



DDI Instrumentation Control Pages

TM2 XMIT – Turns on video transmitter when selected.
TM1 XMIT – Turns on data transmitter when selected.
RECORD VIDEO – Puts video recorder into record mode.
RECORD DSS – Puts high bandwidth data recorder into record.
RECORD DATA – Puts data recorder into record.
PROG – Changes DDI instrumentation control pages from PROG page to SUPT page and from SUPT page to PROG page.
INST – Puts VIDEO, DSS, and DATA recorders into record. (RECORD ALL)
TM – Turns on video transmitter and data transmitter. (XMIT ALL)
BEACN – Turns on beacon transponder when selected.
DSS – Turns on power to high bandwidth recorder.
VREC – Not Used.
HR/MIN/SEC Z – Displays IRIG time



TM2 XMIT – Turns on video transmitter when selected.
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TM – Turns on video transmitter and data transmitter. (XMIT ALL)
BEACN – Turns on beacon transponder when selected.
DSS – Turns on power to high bandwidth recorder.
VREC – Not Used.
HR/MIN/SEC Z – Displays IRIG time.
DEST UP AND DOWN ARROWS – Selects VIDEO/TM destination. (e.g.. VTR1 destination is selected, VTR1 source can be changed.**SOURCE UP AND DOWN ARROWS** – Selects VIDEO/TM source. (e.g.. VTR1 destination is selected, VTR1 source can be changed.

THE FUTURE

The aircraft tactical OFP and the instrumentation system currently have a unique interface. If any new functionality is to be made to the system, a corresponding change to the OFP would be needed. This suggests advancing future designs to make a more generic interface between the DDI and the instrumentation system. To allow increasing the instrumentation functionality without requiring the updating of the OFP, a generic interface between the two systems which would support future control functions could be provided. The DDI button legends could be made generic with the DDI center display controlled directly by the instrumentation transmit messages via the 1553 bus. This scheme is being considered for the new EA-18G aircraft scheduled to begin flight-testing summer of 2006. The EA-18 has some new requirements that will be addressed in this command and control effort. One such requirement is based on needing to route several data inputs to either the telemetry path or the on-board recording path on a mission-by-mission basis. With the new design philosophy this would be accomplished by changing the instrumentation software while leaving the OFP intact further reducing the cost and scope of this plan.

Another aspect of this plan that also addresses a reoccurring problem is that common command and control schemes have been missing from the east and west coast Naval development communities. With this new design aircraft instrumentation on either east coast or west coast could take advantage of these improvements because the hooks in the software release would be active in all future F-18 lots. Flexibility and capabilities will certainly bring more and more advances in supporting the flight-test communities objectives.

CONSIDERATIONS

The implementation of controlling the instrumentation system using production hardware must always be weighed against non-interference of the performance of the existing avionics. With the flight-testing done so far with the AESA aircraft, no interferences have been identified and the aircrew are satisfied with the ergonomic aspect of these controls. This was another consideration upon the decision of designing the layout and focus of the system. The test pilots are used to controlling a large percentage of their aircraft operations such as stores management, weapons and higher-level functions from these displays already.

With the earlier design instrumentation systems the control panels were usually located in the right hand console of the F/A-18 and were difficult to operate in high lighting conditions or heavy pilot workload situations. There was also an issue with how much feedback could be displayed from the small panels such as recorder status, time remaining or BIT (Built-in Test). With the new DDI controls, pilots are able to make real-time inquiries on many aspects of the instrumentation system and report this finding down to the engineers at the mission, or range control centers. This new feature allows for more accurate information about the aircraft instrumentation and critical systems.

CONCLUSIONS

The benefits of a DDI-controlled instrumentation system are real and significant. There is a reduction in required hardware and wiring in the cockpit. Significantly more information will be able to be passed between the pilot and the data acquisition system, allowing for more real-time control of the instrumentation system. Increasingly complex instrumentation hardware will be more easily controlled using a MIL-STD-1553 bus rather than discrete signals or previously used serial buses. An example of this accommodation is currently being tested on the AESA fleet here in China Lake. The Smith's Industries "AVSR (Airborne Video Solid-state Recorder) is being commanded and controlled via a 1553 message architecture and is functioning well. A BIT (built-in Test) function via the 1553 is in development for this year.

The Navy and Boeing are currently in design sessions to identify more ways that these command and control infrastructures can help the aircraft test community with the upcoming EA-18G program. These capabilities are only limited by the creativity of the engineers within this type of flexible architecture.

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ACKNOWLEDGEMENTS

The forward thrusts for this advanced instrumentation control and design are the results of the individual and group efforts of Jeff Hutmacher, Bruce Thompson and Michael Harker of the Advanced Weapons Laboratory, China Lake, CA. These individuals have provided design, fabrication and engineering support to make the current programs possible. We are also working with them to bring about the next generation of controls to reality with the EA-18G program currently in development.