ADAPS TELEMETRY PROCESSOR MID-LIFE IMPROVEMENT PROGRAM

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ABSTRACT

This paper will provide details on planned upgrades to the Advanced Data Acquisition and Processing System (ADAPS) Real-Time / Post Flight Processing (RT/PFP) telemetry processor. The ADAPS RT/PFP is used to process real-time telemetry at the Air Force Flight Test Center (AFFTC). The ADAPS telemetry processor is based on the L3 Communications O/S90 telemetry pre-processing system. New modifications to the ADAPS telemetry processor will provide increased processing capability, increased data throughput, and higher reliability.

KEYWORDS

ADAPS, Telemetry Processing, Telemetry Display, AFFTC

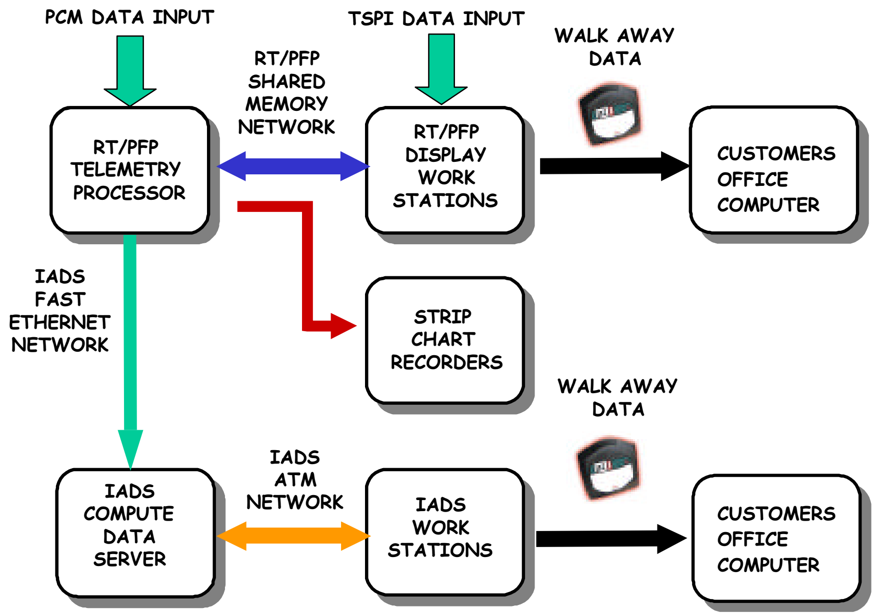
INTRODUCTION

The ADAPS program office manages the development of flight test telemetry data processing tools at the AFFTC. ADAPS functions as the real-time telemetry data processing engineering activity for three AFFTC mission control facilities. Two systems are currently used to process and display real-time telemetry at these facilities. The RT/PFP is used to perform telemetry processing and provides a SGI workstation based display capability. The Interactive Analysis and Display System (IADS) is a newer Microsoft Windows based data display and analysis tool that can be used in both the mission control room and at the customer's office for post-test analysis. The focus of this paper will be an overview of the past RT/PFP telemetry processor engineering efforts, the current telemetry processor configuration, and future planned telemetry processor configurations.

The RT/PFP launch customer was the Ridley Mission Control Center (RMCC). The first flight of the Global Hawk uninhabited air vehicle on March 29, 1996 was also the first test mission supported by RT/PFP. RT/PFP was used to provide telemetry displays for the Range Safety Officer (RSO) monitoring the Global Hawk. Since that time, the RT/PFP has been deployed to all three Range mission control facilities, two mobile control rooms, and the AFFTC modeling and simulation facility.

ADAPS REAL-TIME SYSTEM OVERVIEW

The RT/PFP has three major components, a L-3 Communications O/S90 telemetry processor, a Computer Science Corporation Universal Memory Network (UMN), and a set of SGI Indigo2 and SGI Origin 200 workstations. RT/PFP also provides engineering units (EU) data to the IADS. The IADS has three major components, a Dell compute data server, an ATM network using switches by Fore Systems, and a set of Dell workstations. Supporting the two ADAPS real-time systems is the Joint Test Data Management System (JTDMS). The JTDMS functions as the telemetry attributes management system for ADAPS.



ADAPS REAL-TIME SYSTEM HIGH LEVEL DIAGRAM

THE RT/PFP IOC1 SYSTEM

The Initial Operating Configuration 1 (IOC1) configuration was the first RT/PFP telemetry processor configuration delivered to the customer in 1995. Two EMR 8715 enclosures with an interconnect make up the IOC1 configuration. Each enclosure contains system modules including pulse code modulation (PCM) bit and frame synchronizers, floating-point processors, single-board computers, and interfaces to external processors. Data transfer between system modules occurs on two data buses. The priority command data (PCD) bus is the primary path for transferring telemetry data between system modules. The second bus is a Versa Module Eurocard (VME) bus used to distribute setup and status information. A single board computer is used to perform system control, monitoring, and diagnostic functions. Five

PCM inputs are provided in the IOC1 configuration. Each PCM input uses an internal bit synchronizer and a PCM decommutator in combination. In this configuration, a sixth decommutator is dedicated to supporting PCM asynchronous sub-frames. Time alignment with other test data sources is achieved with an external time code translator. The time code translator provides time code to a system utility module (SUM). The SUM also handles communications occurring between the VME and PCD busses. A second SUM is used to generate calibration patterns for strip-chart recorder calibration. Five Distributed Processing Unit (DPU) floating-point processors are used in the IOC1 configuration to perform EU data conversion.

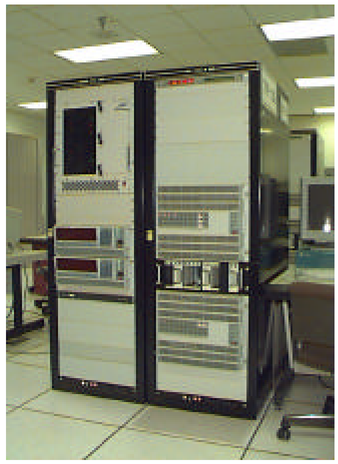
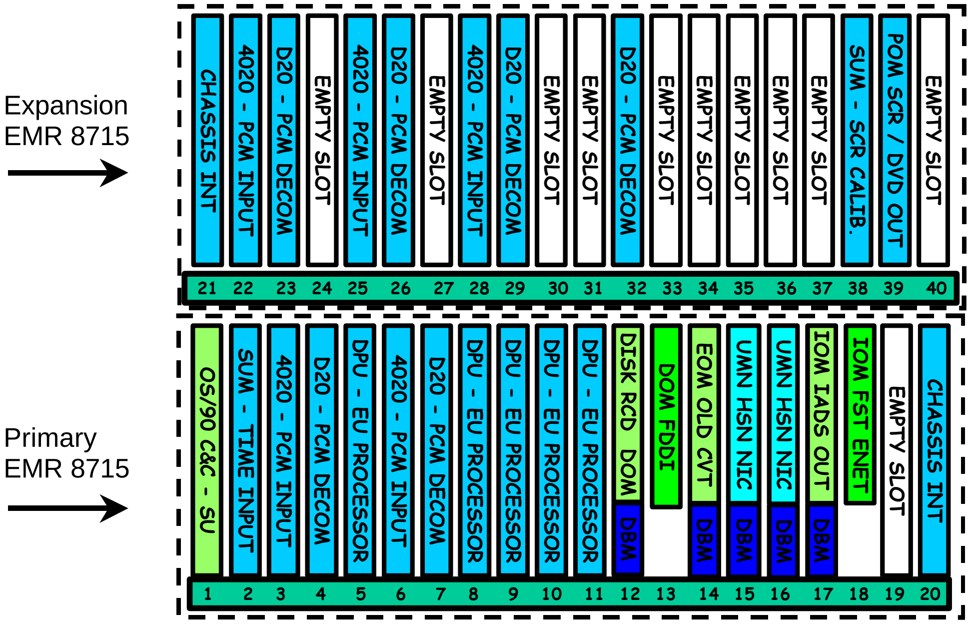


PHOTO OF ADAPS IOC 1 CONFIGURATION

The parallel output module (POM) is used to transfer data to the control room strip-chart recorders. The POM is also used to transfer data words containing pilot audio to a Continuously Variable Slope Delta-modulation (CVSD) voice decoder. Data can be recorded to hard disk on the O/S90 system using a disk output module (DOM). The IADS is sent data through the IADS output module (IOM). The IOM unit is identical to the DOM with the addition of a Fast Ethernet network interface card. Data are transferred to the UMN shared memory network by two data bridge modules (DBM), each with a UMN network interface card. An Ethernet output module (EOM) is also retained in the IOC1 configuration. The EOM is normally used to support data transfer to display workstations using an Ethernet network in the typical O/S90 implementation.

IOC1 also fielded the first enhancements made to the O/S90 software by the RT/PFP development team. These enhancements included dynamic update, new DPU algorithms, and performance tuning of existing DPU algorithms. Dynamic update allows the nearly instantaneous modification of many parameter and system attributes during a test mission. Previously these attributes could only be modified prior to the start of the test mission. New DPU algorithms were also developed that increased processing throughput, supported new features, and transferred data to the UMN network.

The IOC1 configuration of the RT/PFP telemetry processor was used to support the F-22 flight test program throughout 1997 and 1998. In the fall of 1998, F-22 aircraft #1 was modified to effectively double the amount of telemetry that would be sent to the ground. While the test aircraft was undergoing modification, the RT/PFP development team was tasked to develop an upgrade package (the IOC2 telemetry processor configuration) to support this change.



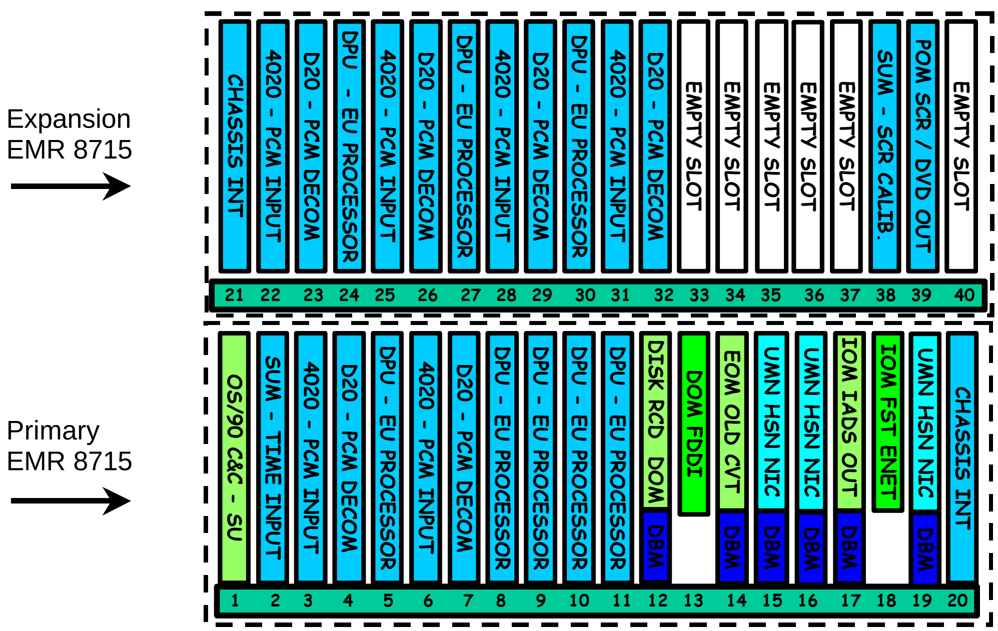
IOC1 CONFIGURATION ADAPS O/S90 COMPONENT LAYOUT

THE RT/PFP IOC2 SYSTEM

The main goal of the IOC2 effort was to keep the O/S90 system operating in the middle of its performance range rather then at the high end of its performance range while supporting the new F-22 instrumentation configuration. The first problem to be encountered was the number of PCM inputs available on the system. When the RT/PFP was in development, it was determined that the D20 decommutator used in the O/S90 was not capable of processing the entire F-22 format due to memory limitations. At that time, a workaround was implemented with the Joint Test Data Management System (JTDMS). The JTDMS is used manage telemetry attributes and is used to generate the setup files for RT/PFP. As JTDMS generated the O/S90 setup file, it divided the F-22 PCM format across three D20s. After a test run using JTDMS, it was determined that all five existing PCM inputs would be required to support the new F-22 instrumentation configuration. As a result, the capability to process a sixth PCM stream was added to the O/S90. A PCM bit synchronizer was added and used with the existing sixth PCM decommutator previously dedicated to processing PCM asynchronous sub-frames in the IOC1 configuration. In this new configuration, the sixth PCM decommutator can be software selected to function as a PCM frame synchronizer or as a PCM asynchronous sub-frame synchronizer.

EU processing throughput was increased substantially in the IOC2 configuration by upgrading the DPU to a higher clock rate version and increasing the number from 5 to 8. The existing chassis interconnect assembly (CIA) used to interconnect the primary and secondary EMR 8715 enclosures did not support the complete range of O/S90 modules including the DPU. The existing CIA was replaced with a newer CIA-II model provided by L3 Communications.

After increasing EU throughput on the O/S90, we began having problems getting this data to the RT/PFP shared memory network, the UMN. While the UMN network could support rates up to 40 MB/sec, the data bridge module (DBM) interface card used to interface the UMN network interface card to the O/S90 supported less than 4 MB/sec. An additional interface card set was added to the O/S90. With 3 interface cards, a transfer rate of nearly 12 MB/sec could be sustained, but the interfaces were operating at nearly the throughput limit. This modification did improve the situation well enough to deploy the IOC2 configuration for F-22 support, but a study was conducted to develop a long-term solution to this problem. The result of this study was to replace the existing O/S90 UMN interface with a single bus interconnect card. This new Fast Data Transfer (FDT) card would interconnect the O/S90 PCD bus with the UMN SMI-32 bus.

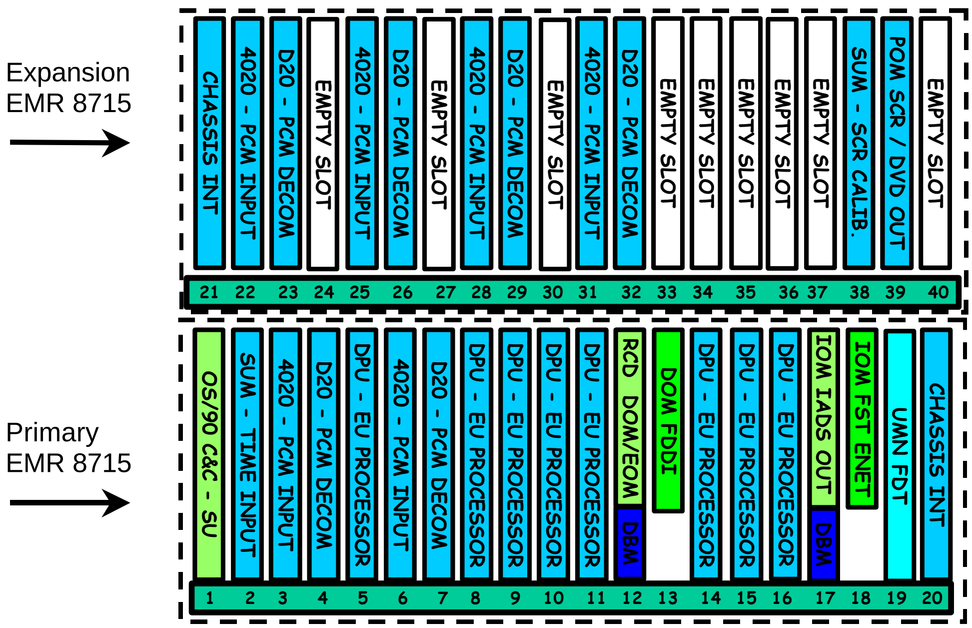


IOC2 ADAPS TELEMETRY PROCESSOR CONFIGURATION

THE RT/PFP IOC3 SYSTEM

The current IOC3 configuration of the RT/PFP telemetry processor was completed in April 2000. The FDT card development was completed in 1999. As described above, this card replaced the existing O/S90 UMN interface. The data transfer rate between the telemetry processor and the UMN increased from 12 MB/sec to 40 MB/sec. The space vacated in the primary enclosure by the UMN interface cards was filled with DPUs relocated from the expansion enclosure. The EOM single board computer was also eliminated in IOC3. This function now exists on the DOM single board computer to maintain compatibility with other O/S90 software.

Another major improvement incorporated into the IOC3 configuration was the ability for the O/S90 to perform software decommutation. This capability is used to process PCM asynchronous data merge sub-frames utilized by an air-to-ground weapon. RT/PFP has been continually improved so that it has the ability to support the telemetry from a broad selection of the air-to-air and air-to-ground ordnance used by the Air Force today. This gives the RT/PFP the ability to display telemetry from the test aircraft and all of the weapons carried onboard.

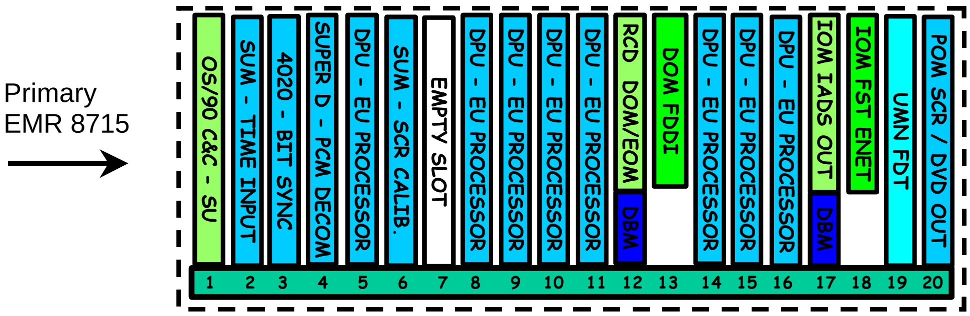


IOC3 ADAPS TELEMETRY PROCESSOR CONFIGURATION

THE RT/PFP IOC4 SYSTEM

The IOC4 configuration of the RT/PFP telemetry processor will be completed in 2001. Most of the PCM input hardware will be eliminated in this upgrade. In recent years, bit synchronizers in the O/S90 have become redundant. Bit synchronizers exist at several points between the telemetry antenna and the telemetry processor. The current 4020 bit synchronizers have been a continuing maintenance problem, as the analog section on the board requires frequent alignment. One bit synchronizer will be retained in the O/S90 as a PCM simulator.

The D20 decommutator will be replaced with a new multi-stream decommutator board. This single unit will replace the six D20s in the IOC3 configuration. After the removal of all this hardware from the O/S90, the expansion enclosure and the chassis interconnect assembly are no longer required. The chassis interconnect assembly has also been a continuing maintenance problem. When IOC4 is completed, the three low reliability O/S90 components will have been replaced (bit synchronizers, the old UMN interfaces, and the chassis interconnect). The current goal of ADAPS is to improve reliability from the O/S90 so that it does not have to be pooled with other systems in a separate data processing room at each mission control facility. A single chassis makes it easier for the customer to relocate the telemetry processor into a mission control room and decrease the labor costs associated with real-time operations.



IOC4 ADAPS TELEMETRY PROCESSOR CONFIGURATION

THE RT/PFP IOC5 SYSTEM

The IOC5 configuration of the RT/PFP telemetry processor will be completed in 2002. This upgrade will focus on support for a new data distribution network. We expect a new network interface card similar to the FDT will be required to support this new data distribution network. IOC5 could be the final upgrade to the ADAPS O/S90 systems. The IOC5 system provides the RT/PFP development team a proven stable telemetry processor to integrate with the new data distribution network. This is a lower risk method versus integrating a new data distribution network with a new telemetry processor.

POST O/S90 TELEMETRY PROCESSING SYSTEM

The telemetry processor deployed after the O/S90 will still need to process multiple streams of PCM data from existing test aircraft, air-to-air weapons, and air-to-ground weapons. A packet telemetry processing capability may also be needed in this future system. These capabilities could be coupled to smart instrumentation where the ground station “requests” the parameters needed for real-time display and analysis on the ground.

The future AFFTC telemetry processing system could start with a multi-processor single board computer with multiple 64-bit buses in a compact PCI type enclosure. This single board computer could utilize a real-time version of the Linux operating system. A compact PCI version of the IOC4 multi-stream decommutator could be used for PCM input. EU conversion could occur on the single board computer or on a separate card with multiple Digital Signal Processors. A compact PCI card version of the existing ADAPS optical data interface would link the telemetry processor to the strip-chart recorders in the control room. Compact PCI time code translators, network interface cards, and SCSI raid controllers for disk recording are all currently available.

CONCLUSION

Telemetry processing throughput at AFFTC has increased by an order of magnitude in the last 10 years and will do so again in the next 5 years. Telemetry data rates and the volume of parameters transmitted have both increased (this is good). The more data available combined with the processing power to do something with it, opens up opportunities through increased display sophistication and automated analysis to dramatically increase the effectiveness of the mission control room in flight testing. Local data recording eliminates the need to perform quick look data processing when a control room is utilized. As illustrated by this paper, telemetry processing developments like most software intensive systems are continuing efforts, evolving as the customer's requirements evolve.

REFERENCES

1. "The ADAPS Real-Time / Post Flight Processing System," presented in Proceedings of The International Telemetering Conference, Vol. XXXV, pp587, October 1999.