ADVANCED DATA ACQUISITION AND PROCESSING SYSTEMS (ADAPS) UPDATE

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ABSTRACT

The rapid technology growth in the aerospace industry continues to manifest itself in increasingly complex computer systems and weapons systems platforms. To meet the data processing challenges associated with these new weapons systems, the Air Force Flight Test Center (AFFTC) is developing the next generation of data acquisition and processing systems under the Advanced Data Acquisition and Processing Systems (ADAPS) Program. The ADAPS program has evolved into an approach that utilizes Commercial-Off-The- Shelf (COTS) components as the foundation for Air Force enhancements to meet specific customer requirements. The ADAPS program has transitioned from concept exploration to engineering and manufacturing development (EMD). This includes the completion of a detailed requirements analysis and a overall system design. This paper will discuss the current status of the ADAPS program including the requirements analysis process, details of the system design, and the result of current COTS acquisitions.

KEY WORDS

Data Processing, Commercial-Off-the-Shelf, Flight Test

INTRODUCTION

The capability being developed by ADAPS Program is critical to the successful conduct of test and evaluation at the AFFTC. The ADAPS Program was conceived to reduce development, operations, and maintenance costs, reduce data turnaround time, and improve capabilities to quickly support future programs. By eliminating vendor specific dependencies, the ADAPS Program has increased the number of options and approaches available for meeting the customer requirements. Proportional with the increased number of options and approaches is the increase in the number of COTS vendor products that can be utilized. Competition within the vendor community is

fierce, which results in the acquisition of products and solutions that represent the best value for the Government. The result is an overall reduction in the development, operations, and maintenance costs for the ADAPS Program when compared to the approach used to develop current systems. As the ADAPS Program moves towards common equipment and incrementally upgradable systems, data turnaround time is reduced. This is accomplished by archiving of test data in real-time, providing the data on-line, and by implementing uncomplicated user interfaces. Finally, by implementing a scaleable, distributed architecture using state-of-the-art COTS technologies, the ADAPS program has provided the AFFTC with improved capabilities to quickly support future programs.

BACKGROUND

The ADAPS Program is based upon a concept consisting of a design and development methodology which mandates the use of open, distributed system architectures. The ADAPS architecture consists of functional components integrated together into a system configuration. The interfaces between functional components are accomplished by implementing widely accepted Government and industry standard interfaces. Each functional component can be separately acquired and scaled to meet specific user requirements. Further system upgrades are accomplished by acquiring and/or developing only those components requiring increased capability.

The ADAPS Program is divided into three system segments, Automated Setup, Real-Time Display and Control, and Post-Test Data Analysis as represented in Figure 1. The Automated Setup Segment provides the mechanism that assures accurate information flow necessary to achieve an efficient and effective test process. This includes the tools to aid the planning, collection, and distribution of flight test information and data. The Real-Time Display and Control Segment provides enhanced real-time and post-flight processing, display, and archival of test vehicle instrumentation and avionics test data as well as Time Space Position Information (TSPI) and Global Positioning System (GPS) data. The Post Test Data Analysis Segment provides the Flight Test Engineer (FTE) with a post-test analysis system that automates the post-test data analysis process. This allows the FTE to access, select, process, analyze, and visualize, the test data using a workstation or Personal Computer (PC). The integration of these systems provides an end to end capability from acquisition of measurement data to generation of the final test report. The remainder of this paper will focus on the Real-Time Display and Control Segment of ADAPS which will be refered to as the ADAPS Real-Time/Post Flight Processing (RT/PFP) sytstem.

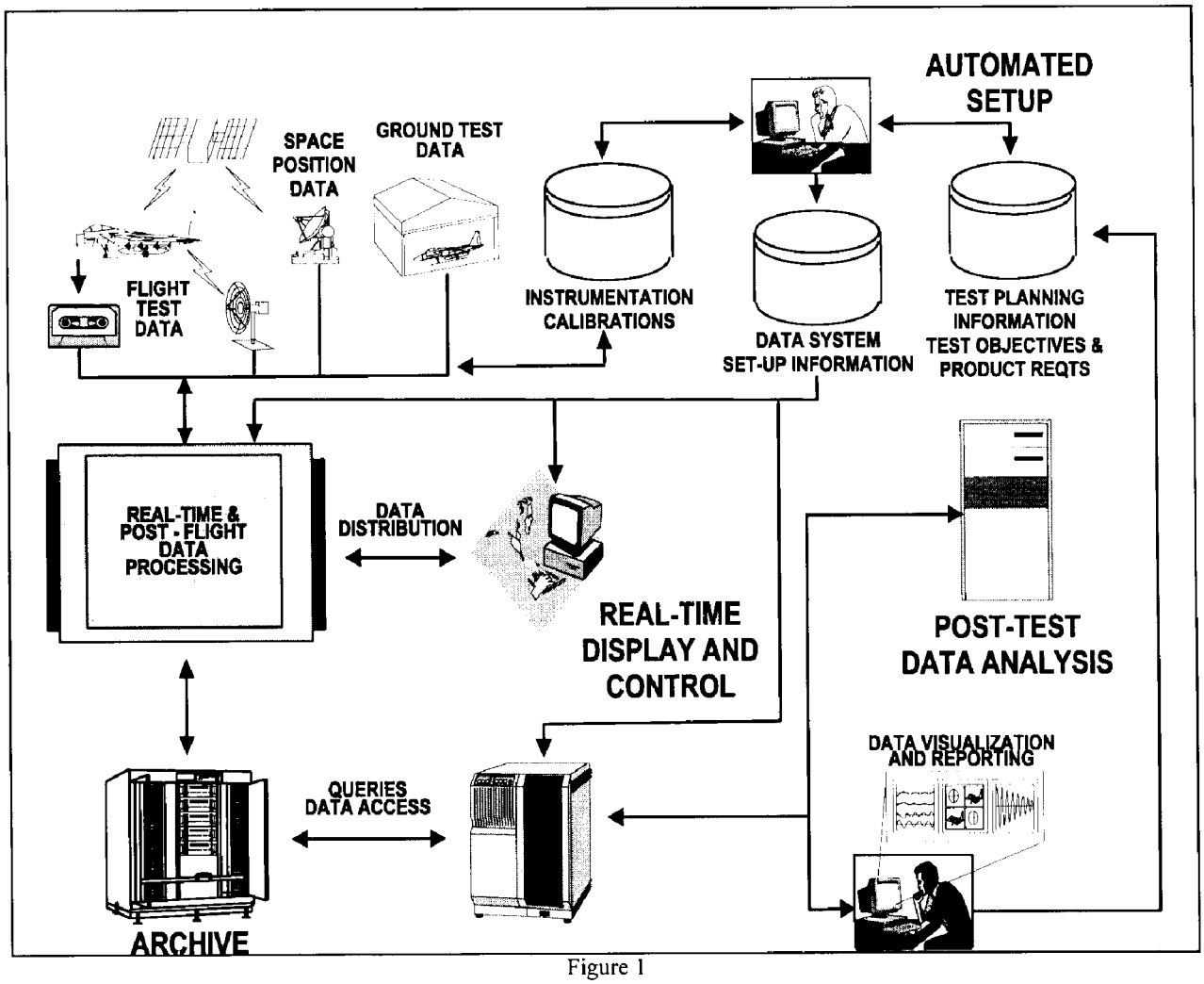

Figure 1

To implement the ADAPS RT/PFP system, an iterative, cyclical approach was used. The ADAPS RT/PFP system will be delivered in various phases beginning with conceptual prototypes and ranging all the way to final system implementation. Conceptual prototypes were used to determine the usability of COTS products, prove out concepts, and for the preparation of equipment specifications. The next step past the conceptual stage was to implement an operational prototype called the Mission Display System (MDS) in the Ridley Mission Control Center (RMCC). Further discussion on the MDS will be presented later in the paper. The next stage in the ADAPS RT/PFP phased development is the implementation of a training system. This system will be used to train operations and maintenance personnel on system functions and capabilities, and obtain user feedback early in the life cycle of the system. A series of system builds will incrementally bring new capabilities on line until all user requirements are satisfied. Using this iterative approach, the ADAPS Program will provide the platform, consisting of products that enhance the system capability, and can evolve with the user requirements. This approach will reduce overall program risk, reduce the impact of engineering changes during the

development cycle, and increase the probability that the customer will end up with a system that meets their requirements.

REQUIREMENTS ANALYSIS PROCESS

The need for the AFFTC to upgrade to an ADAPS architecture has been driven by the exponential growth of data processing requirements. Since the early 1980s, data processing and display requirements have increased due to the rapid emergence of software intensive integrated avionics systems. Figures 2 and 3 show the typical growth in processing and input measurement requirements. In the 1970s, telemetry processing requirements depicted in Figure 2, were 50,000 samples per second compared to a projected 1,100,000 samples per second in the year 2000. Figure 3 shows the input measurement requirements. By the year 2000, ADAPS will have to process a projected 32,000 measurement parameters. This phenomenal increase in the

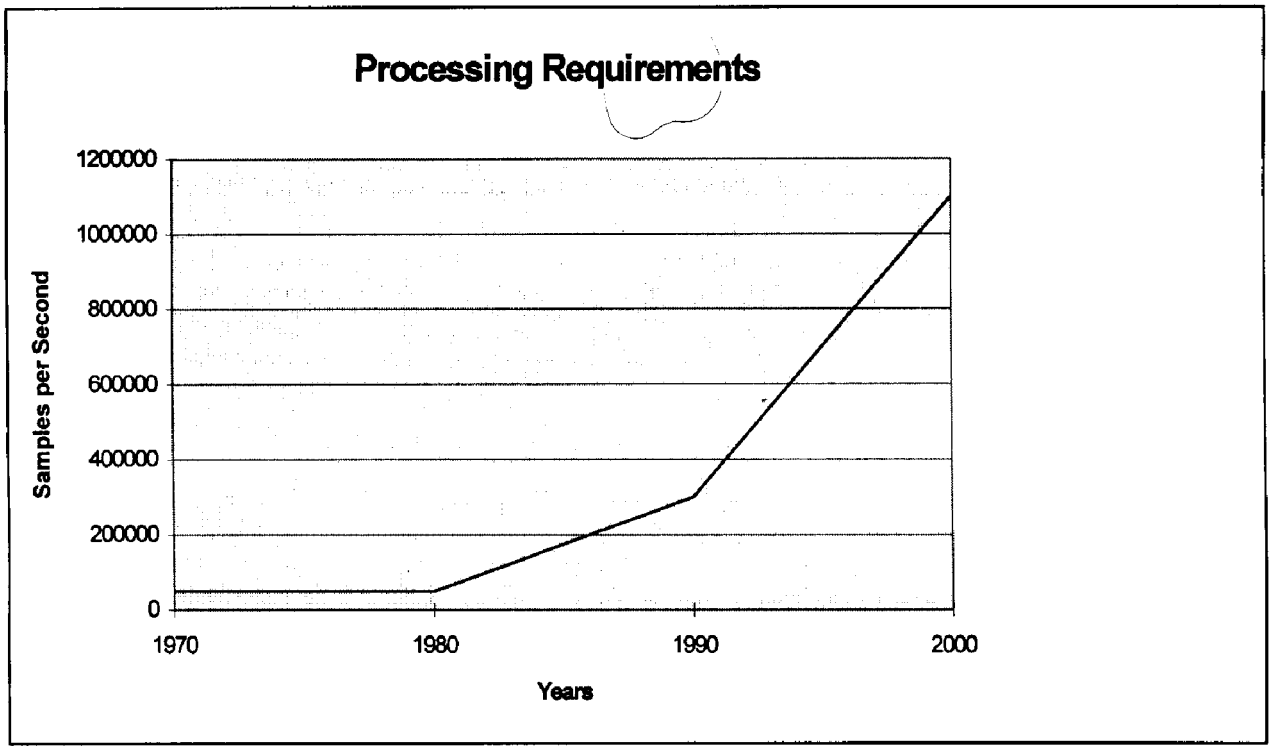

Figure 2

number of measurands requires state-of-the-art telemetry equipment to acquire and process the data, as well as new and innovative techniques to display, store and analyze the data. The telemetry and data systems that were adequate for the 1980s, are inadequate for the 1990s. In addition, these requirements will continue to grow beyond the year 2000. Therefore the ADAPS RT/PFP system must be designed and engineered with sufficient growth capacity to meet the next century's data requirements without requiring major upgrades to the system. The requirements

presented in the figures are just two of the hundreds of requirements gathered during the ADAPS requirements phase.

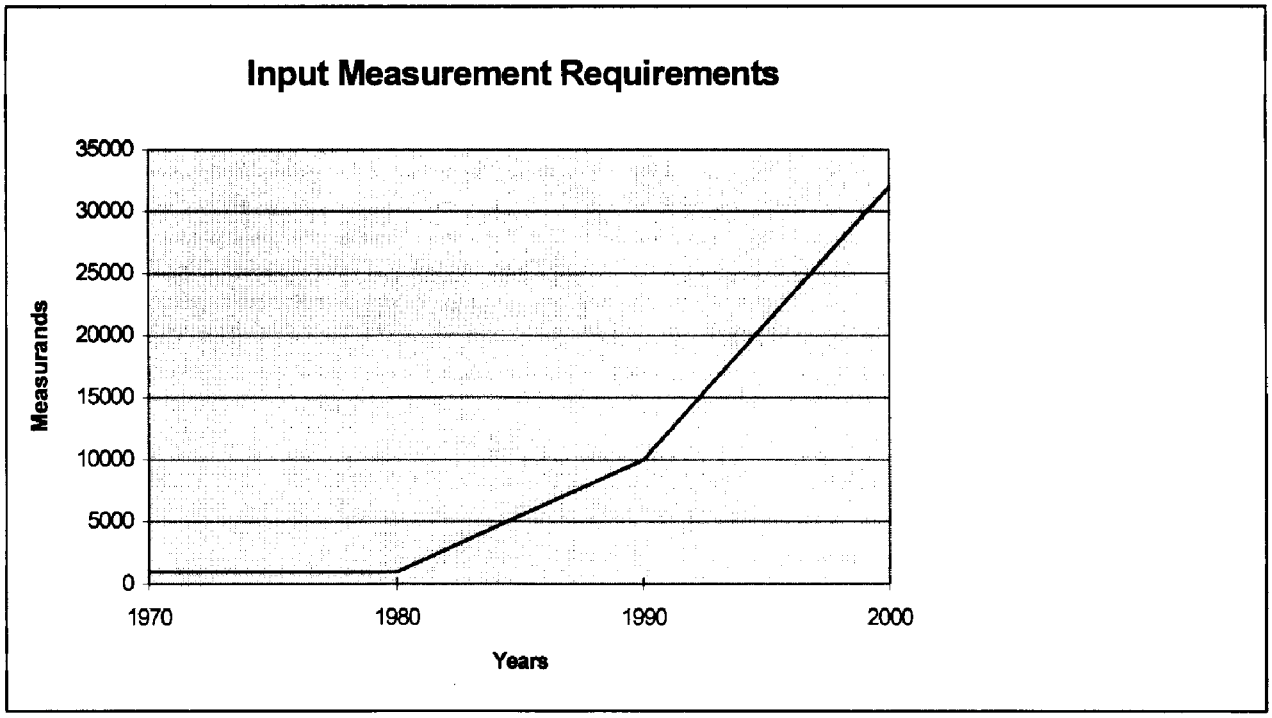

Figure 3

The requirements process was a "customer driven" process. It relied heavily on Total Quality Management (TQM) techniques. A TQM methodology called Quality Function Deployment (QFD) was used for requirements gathering and analysis. The results of the ADAPS requirements process was documented in the System Segment Specification (SSS). As with all TQM techniques, the first challenge was to identify the customer. The ADAPS Program had many different customers, each having their special needs and problems. The difficulty lay in balancing the various, and sometimes contradictory, requirements between the users. To effectively accomplish this, ADAPS used QFD as a way of structuring and balancing the system requirements.

The first step in the QFD process was to identify the key wants from the customers. To obtain the key wants, a series of multiple choice surveys were distributed to known and potential customers. In addition, information was collected from existing documents, industry surveys, and customer interviews. All of the information gathered was collected and stored in a relational database. The customers also prioritized the requirements and decided on target values for each of the requirements.

From this point on, the process became a series of iterations between all of the customers. The customer requirements were balanced off against the program cost and schedule baseline. During the whole process, no requirements were eliminated. Each input received from the customer was tracked in the database, and was traceable into the system design. By having such detailed tracking, future engineering changes may be minimized, since all known requirements will have been considered. To keep the requirements current and manage new requirements, a Configuration Control Board (CCB) has been formed. The CCB is comprised of members of the development team as well as representatives from all of the customers who provided system requirements. In the end, over 7000 requirement inputs were received from the customers. These were distilled into 900 individual system requirements documented in the SSS. Each of the 900 requirements was addressed and documented in the design phase. Also, test plans have been written to test the individual requirements after they have been implemented. During the whole ADAPS development, the customer has been a key player in every decision. ADAPS has been committed to making this system a "customer driven" development.

SYSTEM DESIGN STATUS

The ADAPS RT/PFP system development has progressed from an initial concept with representative prototype configurations through a System Design Review (SDR). The SDR was presented on 23 March 1994 and focused on the operational systems to be installed in the Ridley Mission Control Center by 30 September 1995. The SDR was the culmination of an intense effort that demonstrated that the ADAPS concept was a reality. The SDR finalized the ADAPS RT/PFP functional capabilities to be delivered, placed the system-level allocated baseline under configuration management, and obtained approval to continue with lower-level design. At this review, the ADAPS RT/PFP system design team presented a status on the system engineering management activities, reviewed the ADAPS RT/PFP mission requirements, presented the ADAPS RT/PFP system architecture, operational scenarios, and ADAPS RT/PFP system design, and discussed feasibility and risk, testing, logistics, and training. The design philosophy was:

- Maximize the use of unmodified COTS products
- Tradeoff COTS capabilities versus user requirements
- Implementation accomplished employing Government and industry standards
- Design must be modular to incorporate new vendor technology enhancements
- Design must support growth for new customer requirements

Finally, documentation presented at the SDR consisted of preliminary versions of the ADAPS RT/PFP System/Segment Design Document, External Interface Document,

and Master Test Plan. Additionally, final versions of the ADAPS RT/PFP System/Segment Specification and Configuration Management Plan were released. This set of documentation represented the design status at this point in the program.

The ADAPS RT/PFP system design meets the requirements for enhanced real-time and post-test acquisition, processing, display, and archival of test vehicle instrumentation merged with the vehicles time/space positioning information. This system as designed consists of five subsystems as shown in Figure 4 and defined as the:

- Pre-Processing Subsystem
- Data Distribution Subsystem
- Mission Support Subsystem
- Archive Translation Subsystem
- Auxiliary Processing Subsystem

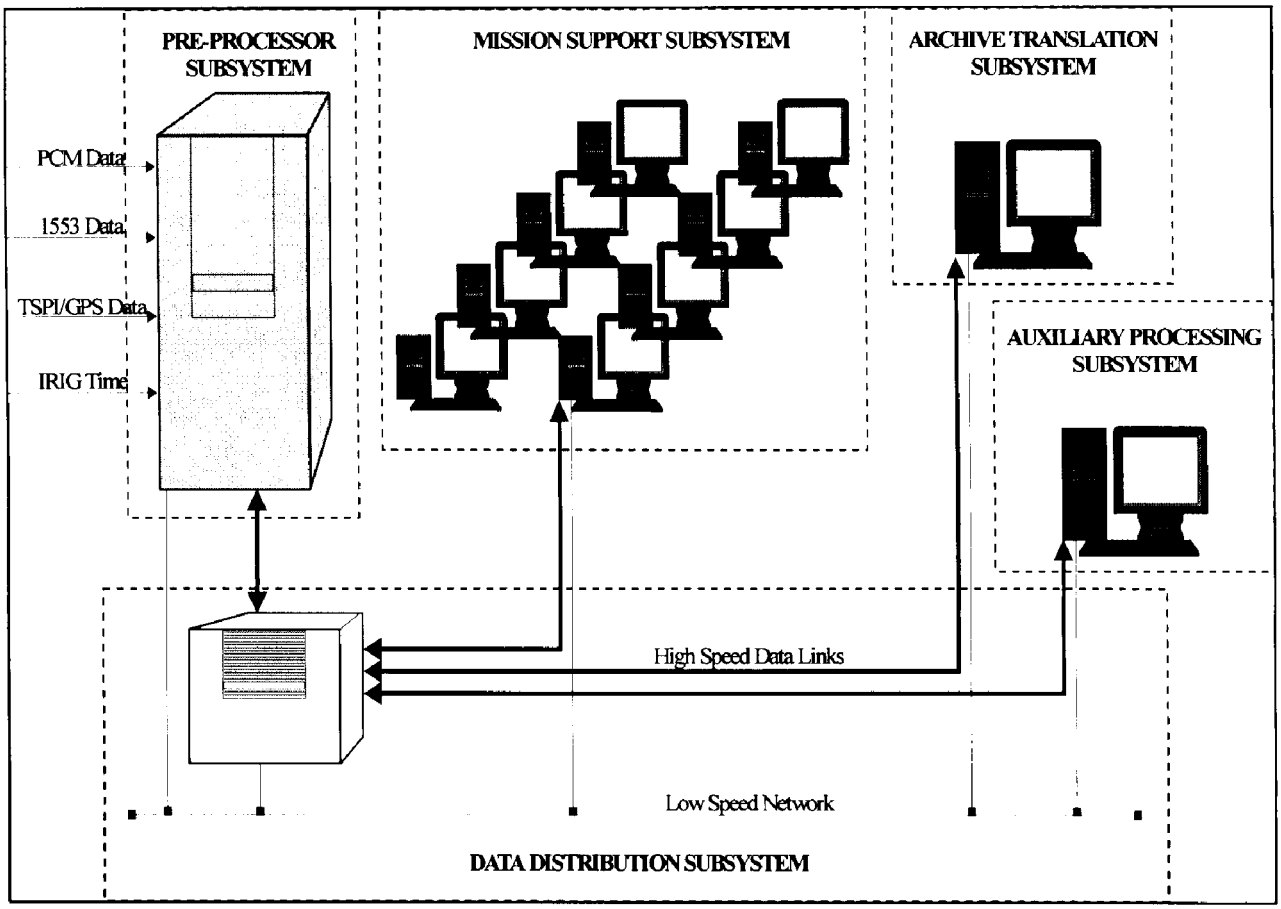

Figure 4

The Pre-Processing Subsystem performs data acquisition and merging, engineering unit conversion, derived parameter calculation, data manipulation and concatenation,

and local data recording. The Pre-Processing Subsystem incorporates an integrated setup and control capability designed to minimize the burden on the system operators and simplify system configuration changes. The Data Distribution Subsystem provides for the distribution of data and commands via low and high speed networks to and from various system processing elements. The Mission Support Subsystem makes use of engineering workstations to gather the required data transmitted to it via the high speed network and to generate the desired displays. The Archive Translation Subsystem ensures that all data acquired by the ADAPS RT/PFP system can be archived and would be available at the conclusion of the test for analysis. The Auxiliary Processing Subsystem is an integral part of the system as an additional compute resource for applications not well suited to the standard system components such as those required for support of structures and flutter testing. The ADAPS RT/PFP system provides a foundation that allows for incremental upgrade and reconfiguration as real-time and post-flight mission support requirements evolve.

As discussed earlier, incremental releases of the ADAPS RT/PFP system are planned. The first of these releases is the MDS operational prototype which is in use today. The MDS was a result of applying ADAPS concepts to an existing operational ground-based real-time telemetry system. The Integrated Flight Data Processing System (IFDAPS) had a very tightly coupled display environment. Dumb graphic terminals were driven by one host computer. The ADAPS goal was to provide a display environment that was independent of its data source, that maximized COTS components, and was inexpensive and easy to upgrade.

The solution distributed the display processing from the host computer on IFDAPS to standard VME-based graphics workstations fed by TCP/IP and shared-memory networks for control and data. This became MDS. Standards such as VME and TCP/IP allowed MDS to maximize use of COTS products by incorporating them in display generation, display modification, network communications and local storage. By the same means upgrades to these system components was easier due to less integration which saved costs.

The MDS, which resides in a Mission Control Room in the RMCC, is the "user interface" to the system. The MDS allows the look and feel of the final ADAPS RT/PFP system to be evaluated years ahead of its Initial Operational Capability (IOC). The "infancy" period of the ADAPS IOC system could now be dramatically reduced by using the customer feedback, early on, to help mold the system.

The final ADAPS RT/PFP system integrates the acquired COTS products, the Telemetry Preprocessor (TPP) and upgraded engineering workstations with the existing MDS to provide a fully functional end to end system capability. This

configuration will be complete by January 1995 and provide a platform for conducting initial system performance measurements and training operations and maintenance personnel

COMMERCIAL-OFF -THE-SHELF ACQUISITIONS

The development approach adopted by the ADAPS Program Office was to purchase as much system capability as commercially available, and to develop only those capabilities that could not be acquired. The success of this approach is directly proportional to the interaction with industry and the integrators ability to understand and predict the commercial market. This interaction is necessary for the ADAPS Program to take full advantage of COTS product developments and industry investment in new technology. The ADAPS program is attempting to drive industry through the use of strategic competitive acquisitions.

As discussed previously, the RT/PFP System architecture is divided into major functional components. Each of these components can be acquired, upgraded, and modified separately. Therefore, each functional component can be acquired from the vendor that best meets the requirements for that element of the system at the lowest cost. Two requirements contracts have been put in place as the primary vehicles for acquisition of system components. The first of these is for a TPP. The TPP contains all hardware and software to acquire and process PCM data, operate, setup and control the TPP, and prepare the data for distribution and display. The second of these contracts is for engineering workstations. This contract contains many vendor brands of equipment which allows the developers to acquire the component that best suits the requirement. With these contracts in place, the basic building blocks are available and can be easily acquired.

CONCLUSIONS

Since its inception, the ADAPS program has come a long way. Conceptual prototypes were developed to prove out the concepts and to define specifications for procurement of equipment. An operational prototype system was successfully built and transitioned into full operational use, supporting flight test customers, as the rest of the system is being constructed. A detailed requirements process was used to insure that all known and potential customer requirements were considered during the system development. This attention to detail in the beginning has made the design phase proceed smoother. Incremental builds and deliveries have been successfully used to bring on-line a continuous series of new capabilities that can be evaluated by the users.

Thus far, ADAPS has proven that COTS hardware and software can be purchased and integrated into an extensible system that will meet very demanding and stringent user requirements for relatively low cost. The key to success was an open systems design and heavy reliance on DoD and industry standard interfaces. Even though the final ADAPS configuration has not been delivered, ADAPS has proven that the concepts and technologies employed result in a system that meets the users need and provides a cost effective solution to meeting the data processing requirements for the future.