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AVIONICS PAYLOAD SUPPORT ARCHITECTURE

SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM
PAYLOAD ACCOMMODATIONS
AVIONICS PAYLOAD SUPPORT ARCHITECTURE

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OVERVIEW

This paper addresses concepts for vehicle and payload avionics architectures for future NASA programs, including the Assured Shuttle Access program, Space Station Freedom (SSF), Shuttle-C, Advanced Manned Launch System (AMLS), and the Lunar/Mars programs. Emphasis is on the potential available to increase payload services which will be required in the future, while decreasing the operational cost/complexity by utilizing state of the art advanced avionics systems and a distributed processing architecture. Also addressed are the trade studies required to determine the optimal degree of vehicle (NASA) to payload (customer) separation and the ramifications of these decisions.

MAJOR OBJECTIVES

The avionics payload support architecture for future NASA space programs is designed to meet several major objectives. The typical customer vehicle avionics requirements include reliable provision for command, telemetry, video services, onboard data storage capability, and the capability to access vehicle data (e.g., attitude, state vehicle, timing, etc.) through some sort of "gateway". The extent and requirement for these services depends upon the type of payload (deployable, attached, scientific experiment, etc.) and the type of mission (e.g., short versus long duration). A deployable payload which only resides in the NSTS orbiter for a few hours on-orbit typically requires different services than will attached SSF scientific experiments.

From the NASA budgetary perspective, it is important to utilize an avionics payload support architecture which reduces the labor intensive integration, flight to flight reconfiguration process, mission operations support and crew/controller training.

In order to accomplish this, it is desirable to reduce the interdependence of the vehicle and payload where practical. By selectively designing the payload architecture to include a separate distributed payload data management system, including separate data storage as well as processing equipment, the payload capabilities are not limited by competition with the vehicle's requirements and the payload schedule is not tied to a mature vehicle's reconfiguration schedule. (See figure 1.) It would also be desirable to have a separate uplink and downlink capability for the same reasons as outlined above. This capability may be more of a cost impact and must be weighed as such.

An additional consideration in the design of the avionics payload support architecture is the utilization of government or industry standards such as the 80386 processor, the 1750A processor, the 1553 data bus, etc. This will enhance the budgetary aspect of the program by allowing the use of commercial off-the-shelf (COTS) hardware and software, as well as providing the customer with standards for their design and software development that match those available on the open market. Additionally, a customer could then transition easily from host program to host program (e.g., Shuttle to Space Station Freedom) without major electronic redesign. Other benefits to this approach would be derived if the system was designed to allow provision for program interchangeability of components and the capability to easily upgrade the system as new capabilities are developed.

MAJOR MILESTONES

The concept of the use of a distributed avionics support architecture for payload applications is not a new one. It was proposed in the 1970's during the design phase for the NSTS orbiter. It was not implemented due to philosophical and budgetary considerations. As a result, the STS currently assumes an increased cost for payload reconfiguration flight to flight, does not provide sophistication in payload software control, provides minimal payload data storage capability, provides only minimal vehicle data to major payloads, and provides no vehicle avionics services to the scientific experiments flown in the middeck. In order to alleviate some of these concerns, and with the advent of the microcomputer technology, the STS is now providing customers with the option of using the STS payload and general support computer (PGSC), which is a modified GRID 1530. The STS-provided PGSC is flight qualified. Its utilization is under configuration control by the STS relative to the user interface. This insures standardization in order to reduce crew/ground training and simplify procedure development. The Interface Control Document (ICD) and user guidelines for the PGSC were published in 1989 and the system flew on STS-30 and STS-34 for the Fluids Experiment Apparatus (FEA) and Polymer Morphology (PM) payloads, respectively. Numerous other payloads have requested its use. Most notable is the Tethered Satellite System (TSS).

The PGSC does not directly have a link to the orbiter communication system which limits ground control of experiments. This, in turn, potentially limits scientific return from payloads and also places a greater burden on the flightcrew (training and timeline impact). In some applications, such as TSS, this is overcome by use of the STS smart flexible multiplexer/demultiplexer (SFMDM) which is connected to both the orbiter communications system, as well the PGSC.

Another major milestone toward the recommended payload support architecture was the original SSF payload support architecture definition. It included a distributed processing architecture, standardized testing, checkout, and training, and, in general,a decoupling of vehicle and payload services. Unfortunately, the 1989 budgetary scrub exercise resulted in the potential deletion of many of the distributed payload avionics capabilities at the Permanent Manned Configuration (PMC) such as a separate payload local area network (LAN), separate payload data storage capability, and separate payload command uplink capability. It was proposed that this configuration would be eventually upgraded with the later full-up configuration. Of concern is that the full-up configuration is not funded and will itself probably be confronted with a stringent budget. In addition, the cost and labor required to upgrade the system by the astronauts will be time consuming and complex.

The Shuttle-C payload services definition served as another milestone. Although the proposed payload services provided by the Shuttle-C are somewhat minimal, it did propose placing the majority of the payload services responsibility on the payload customer and thus simplifying the payload integration and operations costs.

TECHNOLOGY ISSUES

Some technology issues exist for the above mentioned programs. For the STS orbiter, the issues and work that are ahead as part of the Assured Shuttle Access program include replacing certain components such as the pulse code modulator master unit (PCMMU)/payload data interleaver (PDI) due to parts obsolescence. This opens the opportunity to enhance the downlink data capability as well as provides redundancy in the payload PDI link. Cost, schedule impacts to vehicles in the flow, and compatibility with the orbiter communications system are issues being worked in this area. Another item under investigation is the replacement of the orbiter payload recorder with one more suitable to the typical payload's bit rates and data recording requirements. Another technology issue relates to the need for further advances in connector and cabling design in order to reduce both volume and weight. This is, of course, a concern with all of the programs. Another area that needs further work is to develop a capability, via modem or a separate SFMDM type "black box", to provided communication services to orbiter payloads, such as middeck scientific experiments.

The major technology issues for the SSF program, relative to avionics payload support architecture, are in the integration of existing avionics technologies to control multiple real-time systems and limited vehicle resources, such as power, communication, assets, etc.

The Lunar/Mars programs require more sophisticated avionics capabilities in order to meet the expected needs of these payloads over extended periods of time and with a greater communication lag between the ground operation team (including scientists) and the vehicle. This will lead to an increased requirement for automation and expert systems capability. In addition, it is estimated that the data storage capability required for some payloads which are proposed for the Mars mission would be on the order of 1X10E12 bytes, which is two orders of magnitude greater than what is currently available. In addition to this need for increased onboard data storage, it is anticipated that there will be a requirement for some level of pretransmission data compression for the Mars mission which has historically been a concern to the vehicle and scientific communities.

Another area which warrants further exploration for each of the NASA programs is advancement in technology to increase the operational efficiency of the above programs in areas such as automation, robotics, expert systems, voice recognition, speaker independent systems,enhanced video display capability, etc.

TRADE STUDIES

Perhaps more important than the technology issues mentioned above are the trade studies that are required to determine the NASA position relative to the payload community. The overall concern is the appropriate degree of NASA/user separation. This lies at the heart of many policy decisions relative to the handling of payloads. The question concerns the balance of common services provided by the vehicle (NASA responsibility) versus those provided by the customer (user responsibility). For example, if the Agency were to provide an industry standard architecture (ISA) processor with display capability, an I/O consisting of MIL-STD-1553B data busses, storage medium, and access to vehicle system data via a gateway, should the Agency provide the real-time ADA operating system with the application software being the responsibility of the user? If so, what is the interface criteria between the operating system and the application programs? Where does the responsibility lie between NASA and the customer? Would NASA supply the background display structure and the customer provide the dynamic fill to reduce and minimize crew training, whether ground or flight? Is there some interface line that can be drawn between host vehicle and user responsibilities that is beneficial to both in cost and integration schedule flexibility? If this type of standardization is used (in the example), the customer can utilize relatively inexpensive ground versions of the flight hardware for software development, validation, and payload checkout. When drawing this "line", developing a policy, or developing a criteria, serious deliberation and consideration should be given to safety (i.e., when can closed loop control not be implemented by the customer), mission success, reliability and/or redundancy, minimizing crew training, integration of the cargo complement (i.e., multiple payloads), and data processing security (i.e., protection of customer proprietary information).

SUMMARY/RECOMMENDATIONS

In summary, it is important to keep in mind that the major goal of the operational NASA missions is related to payload/experiment activity, be it deployment of a satellite or a long-range scientific experiment. It is important to insure that the NASA programs provide services to make those programs, whether it is Shuttle-II, SSF, or some advanced upper stage, accessible to users. In addition, it is important for NASA to make responsible decisions in the design of its programs to insure that they have not cut costs for DDT&E, which will result in increased costs in the out-years that significantly exceed what would have been the initial DDT&E cost investment. It is time for the Agency to address commonality between programs to reduce DDT&E cost and "redesign the wheel" tendencies. It is equally important that these designs provide the user a low cost means to utilize the host vehicle capabilities without complex, time consuming integration processes, which is a major complaint of shuttle users. Program commonality and simplified integration processes with respect to payload accommodations provides the same cost and labor benefits to the customer that could be realized by NASA. Commonality provides options to the user for access to space. In simple terms, more programs and more experiments could be started, developed, and flown for the same budget, if cross program avionics commonality is imposed in the out years. However, DDT&E monies must be expended now to realize such a benefit.

In order to further pursue these areas, several things must be accomplished. Development of a payload/host vehicle policy is required to distribute responsibility, when practical and cost effective, to the user. It may be necessary to rearrange these responsibilities based on the type of host vehicle (i.e., Shuttle-II versus Shuttle-C). Whatever the result, this policy should provide a framework for avionics hardware and software commonality between all host vehicle programs and should delineate the separation of responsibilities between host vehicle and user.

An avionics payload support architecture must then be developed to support the resultant policies. Paramount to this design is addressing standardization-use of those industry or government standards that impose program cross utilization, a means of technology evolution to resolve parts obsolescence concerns. The final system should also include functions that minimize the out years operating base, such as built in test and checkout.

It is in NASA's best interest to develop such a payload support architecture for use across programs to use new avionics technology to increase operations efficiency and thus reduce recurring operations costs.

KEY CONTACTS

Other sources of information on these areas are as follows:
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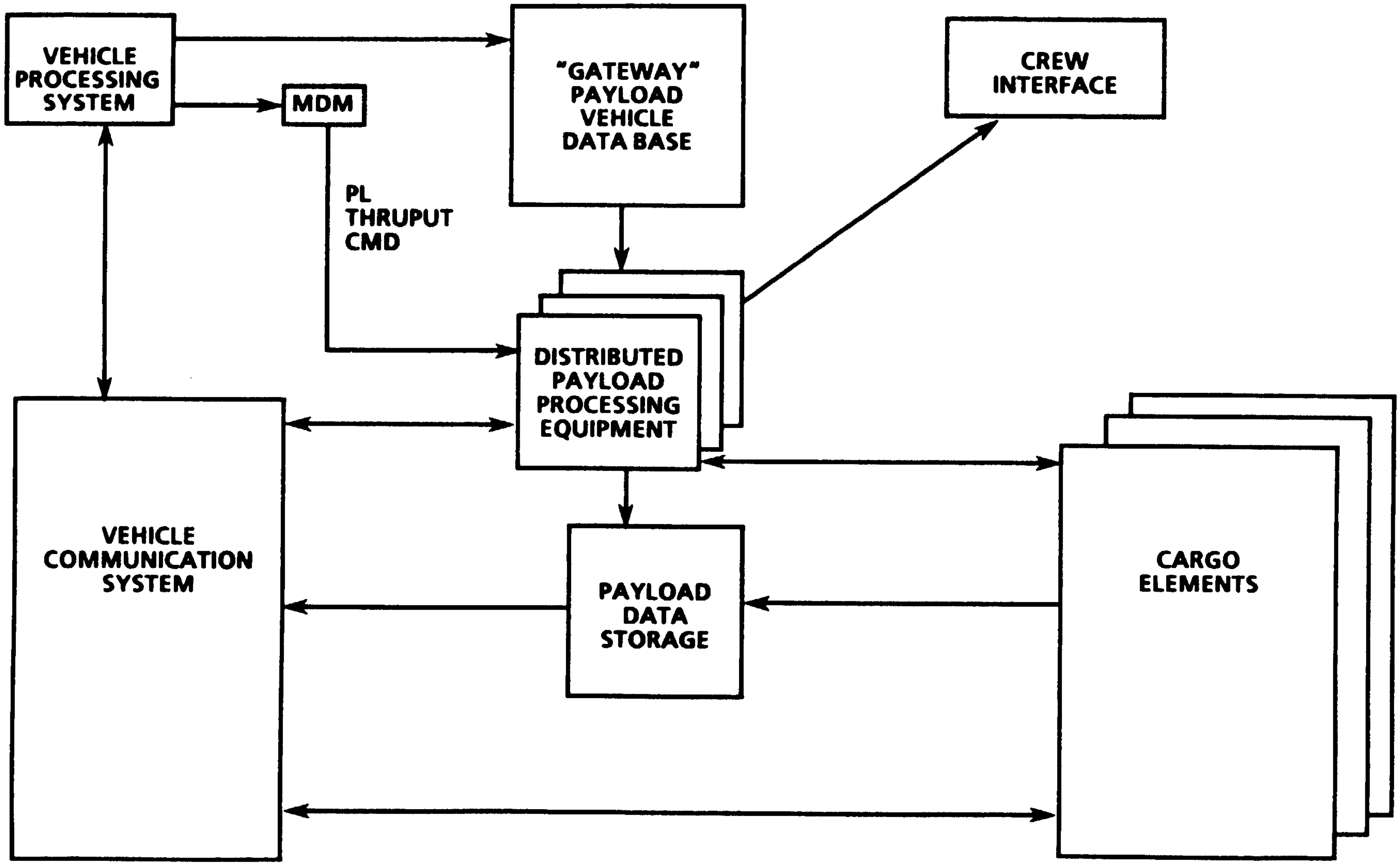

Figure. Example of a Proposed Advanced Avionics Payload Support Architecture

SATELLITE SERVICING SUPPORT