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Application Of A Large Computerized Ground System To Shuttle Payload Software Intergration

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ABSTRACT

A concept for the integration of Shuttle experiment/payload software is proposed. A key element in this software integration process is the Launch Processing System (LPS), being developed by NASA/KSC. The concept uses the Sortie Lab as a representative experiment carrier. This concept permits the installation and checkout of experiment software prior to hardware installation onto experiment carriers. In addition it assures software compatibility, prior to payload installation, between the various elements, i.e., experiments, carriers, orbiter, and ground support system software.

INTRODUCTION

The coming of the Space Shuttle as an operational launch vehicle will require that new concepts be developed for the integration of future payloads. We will no longer have the luxury of a launch vehicle dedicated to a payload, and all that this implies. With a very limited number of launch vehicles (orbiters) a slip in the schedule of an orbiter may impact a number of succeeding payloads. Therefore, to obtain maximum utilization of the orbiter, the probability of orbiter schedule impact risk must be minimized.

The new integration concepts will have to be developed in the areas of hardware, software, and mission integration. In this paper we address the software integration problem and propose a payload software integration concept. The Sortie Lab is used as a representative experiment carrier for the purpose of illustrating the concept.

SHUTTLE ERA PAYLOADS

There are five broad categories of Shuttle era payloads.[1] Their principal characteristics are:

- Automated Satellites - Shuttle Delivery
  - Unmanned
  - Orbital requirements within the performance capabilities of Shuttle
  - Examples: Earth Resources Satellites, Orbiting Solar Observatories
- Automated Satellites - Propulsion Stage
  - Unmanned
  - Orbital requirements are such that a third stage or tug is needed
  - Typically synchronous earth orbit, planetary flybys and probes
- Man-tended Orbital Observatories
  - Unmanned during operation
  - Manned maintenance
  - Example: Large Space Telescope
- Space Station (Manned Facilities)
  - Manned
  - Long term operation
- Sortie Laboratories
  - Manned
  - Short term operation (7 days)
  - Remains attached to orbiter

SORTIE LABORATORY[2,3]

We have chosen to use the Sortie Lab as an example of an experiment carrier, with which to describe our software integration concept. This particular carrier is a general purpose laboratory designed to support a wide variety of experiments in space. Sortie Lab missions are normally performed over a seven day period in low earth orbit (100 to 235 nautical miles). It remains attached to the orbiter throughout the mission. A nominal crew of two to four flight experiment operators are used to operate the experiment hardware.

Physically the Sortie Lab is conceived as a reusable pressurized cylinder with an attached pallet which fits within the orbiter payload bay. Laboratory accommodations include: standard equipment racks; storage; work benches; a crew station console for monitoring subsystems and experiment operation; standardized connectors for power, data, vacuum, and lighting; airlocks; viewports.

In addition, the Lab has self-contained subsystems to support the crew and experiments. These include: environmental control and life support; electrical power system for experiment and subsystem support; a data management system; and associated control and display consoles.

SOFTWARE REQUIREMENTS

The specific requirements for Sortie Lab experiments depends on the particular mission and experiment complement. In general, however, certain experimenter needs must be provided for, such as:

- Command and control, especially for pallet mounted hardware.
- On board data processing
- Data formatting and recording
- Caution and Warning
- Downlink control
- Providing orbiter dynamics and orbital data to experiments

From the overall systems viewpoint, we must assure software interface compatibility between the various elements:

- The individual experiments and the Sortie Lab data management systems
- The integrated Sortie Lab and the orbiter data management system elements
- The integrated Sortie Lab and the ground system software.

A software incompatibility, discovered late in the processing flow, could very well delay the launch and seriously impact succeeding orbiter scheduled payloads.

PAYLOAD INTEGRATION FLOW

To put the software integration into context an overall hardware integration flow is shown in Figure 1. The basis for this flow is the sequential checkout of the hardware in a building block manner. The Sortie Lab racks and experiment support and interfacing hardware comes together with the experiment hardware at an experiment integration site. The individual experiments are checked and then built up into an integrated experiment assembly. Standard ground checkout equipment is used which simulates the Sortie Lab functional interfaces. The integrated assembly is shipped to the launch site for installation into the Sortie Lab set up on the maintenance and test stand. Final integrated system tests are performed using simulated orbiter interfaces, where required. Prior to orbiter installation, a demonstration of the compatibility of the payload orbiter interfaces is performed in a Shuttle Integration Device.

LAUNCH PROCESSING SYSTEM

Before we describe how software integration fits into the integration flow described above we describe one of the key elements in this software integration concept. This element is the Launch Processing System (LPS), currently being defined by KSC.

The LPS can be defined as a unified, automated ground processing institutional system which will provide for the rapid and efficient checkout, launch and maintenance of the Space Shuttle, payloads, and other future space vehicles. The system will also provide for the operation and control of the utilities, logistics, and other ancillary functions attendant to the primary vehicle launch processing function.

The range and scope of this system is shown in Figure 2. It is composed of the following subsystems:

(1) A large data system comprised of two (or more) large scale computers, associated mass storage, and communications interfaces.

(2) Field systems which provide support for:

   (a) real time activities such as launch countdown.

   (b) On-line support type functions for such things as maintenance, payload checkout, subsystems testing, etc.

LPS consoles are an integral part of the total system. These consist of a keyboard, cathode ray display tube and mini-computer. They are located throughout the launch site and provide the communications link between the various functional areas and the central data system.

SOFTWARE INTEGRATION FLOW

Figure 3 depicts the software integration flow of our proposed software integration concept. In the lower left is an LPS cluster comprised of the central data system and associated ground station. Contained in the data system are computer simulations of both the Sortie Lab and Shuttle Orbiter Data Management Systems (DMS).

The sequential buildup, verification and integration of the experiment software is shown across the top of the Figure. Beginning at the upper left we show the experiments and an LPS console at the experiment integration site. Via telephone lines the Sortie Lab data management system simulation is read into the LPS console minicomputer. The software interface between each individual experiment and the Sortie Lab DMS is then checked out and verified.

Upon arrival at the launch site and prior to installation into the Sortie Lab, the integrated experiment assembly software is again verified using an identical LPS console tied directly into the LPS cluster.

The integrated experiment assembly is then installed in the Sortie Lab on the maintenance and test stand. Here we have the entire flight payload, the experiments, the Sortie Lab, and its subsystems (data management system, recorders, control and display, etc.). This is then tied into a simulation of the orbiter DMS in the LPS cluster. The performance of the experiments, Sortie Lab, and its subsystems are monitored in the ground station. The next level of software interface verification has been completed i.e. carrier to orbiter.

Using simulated or prototype orbiter subsystems, a final compatibility demonstration is performed using a Shuttle Integration Device or the equivalent. All monitoring can again be done through the LPS ground station.

Similarly, after orbiter installation, the experiments and other systems are monitored during the Avionics Operational Tests (AOT) in the Maintenance and Checkout Facility (MCF) and on the Pad. During flight the capability will exist for data monitoring in the LPS ground station via links to the MCC and telemetry ground stations.

SUMMARY

We believe that this concept has many attractive features which recommend it for consideration as a technique to be implemented in the Shuttle era. The principal features are:

- It permits early initiation of experiment software development and verification.
- It permits the user to have a common software interface at the experiment integration site and and the launch site.
- It provides the user access to the large LPS data base and its computational capability.
- It allows concurrent development and integration of software and hardware.
- It will encourage experimenters to use common GSE instead of special purpose payload GSE and hence result in lower cost payload operations.
- It assures compatibility of experiment flight software and launch processing ground software prior to delivery to the launch site.
- It assures compatibility of experiment, Sortie Lab, and orbiter flight software prior to payload installation.

ACKNOWLEDGEMENT

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(3) Sortie Lab System Utilization Characteristics, Marshall Space Flight Center, 27 June 1972.

ILLUSTRATIONS

PAYLOAD INTEGRATION CONCEPT

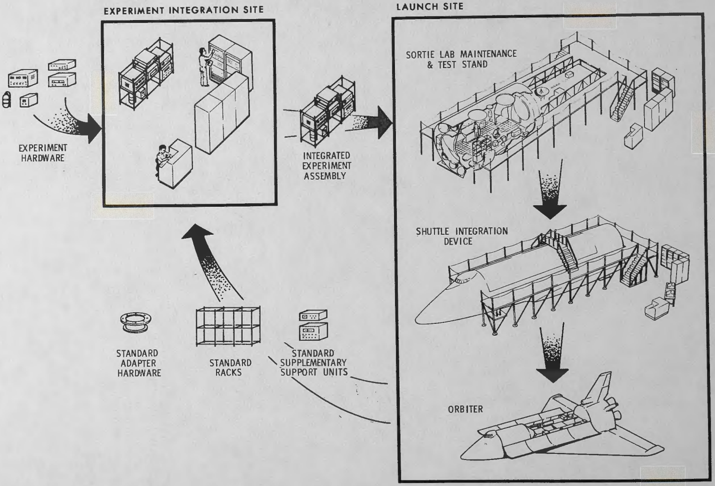

FIGURE 1

KSC LAUNCH PROCESSING SYSTEM

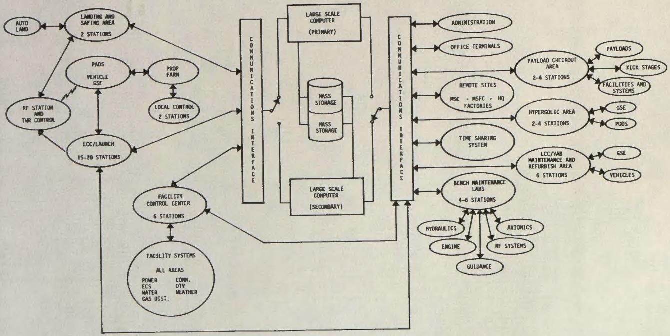

FIGURE 2

SOFTWARE INTEGRATION FLOW

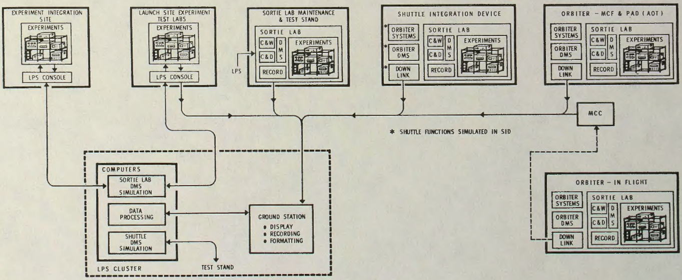

FIGURE 3