Cargo Integration Test Equipment

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ABSTRACT
The Cargo Integration Test Equipment (CITE) is a high fidelity electrical and mechanical simulation of the orbiter cargo bay. The CITE provides the capability to test cargo-to-orbiter interface compatibility prior to installing the cargo in the orbiter cargo bay. This paper describes the technical concept and application of the CITE system. The CITE has two facilities in operation at Kennedy Space Center; one in the Operations and Checkout (O&C) building and another in the Vertical Processing Facility (VPF).

INTRODUCTION
The requirement for cargo-to-orbiter interface verification was recognized by NASA in the early 1970's as a means of protecting orbiter turnaround timelines and hence, Shuttle launch schedules. The CITE was conceived as a set of ground support equipment which would be used to verify cargo-to-orbiter interfaces and allow problem correction/retest. In early 1976, the responsibility for the CITE project was assigned to KSC. The implementation concept was approved in December 1976 with contract awards during 1977. The first CITE system, a horizontal payload test stand (see Figure 1), was activated in June, 1979 in the O&C building at KSC and subsequently used to support interface verification activities for the OSTA-1 (STS-2) and OSS-1 (STS-3) Spacelab pallets. The second CITE system, a dual cell vertical payload test stand (see Figure 2), was activated in March, 1982 and has supported interface verification activities for a Multiple Payload Assist Module (PAM-D) - satellite cargo and the Interim Upper Stage (IUS) - satellite cargo.

Figure 3 depicts the cargo operations flow at KSC. Both the O&C for horizontal payloads and the VPF for vertical payloads are an integral step in payload integration activities. Payloads/cargo's pass through the CITE system soon after arriving at KSC. Testing in CITE at this point, typically six weeks prior to launch, provides the opportunity to identify and correct cargo to orbiter interface incompatibilities without impacting Shuttle turnaround timelines. Payload testing activities culminate at the pad with test procedures that were used in CITE being used at the Pad during launch operations checkout. Hence, the CITE provides two important support functions to the STS program. First, payload checkout procedures can be performed/corrected off-line prior to time critical pad activities and second, cargo-to-orbiter interface problems can be identified prior to cargo-to-orbiter mate thereby minimizing impact to Shuttle timelines.

A supporting component of the CITE system which provides a smooth transition of operations from the CITE to the Pad is the Launch Processing System (LPS). Specially developed software and microcode when integrated with the LPS operating system and Checkout, Control and Monitor Subsystem hardware give the CITE user the capability to execute test procedures in a firing room type environment: the CITE control room (see Figure 4). The CITE control room when integrated with the horizontal or vertical test stand equipment provides a computer controlled automated simulation of the orbiter cargo bay.

ARCHITECTURE
The CITE is divided into two major areas: the test stand and control room.

The CITE test stand consists of structural/mechanical and electrical/electronic components. The structural/mechanical (S/M) provides the capability to verify the following:
- Cargo to Orbiter interface
- Payload to Orbiter envelopes
- Payload Attach fittings
- Mission Kit compatibility with the Payload and Orbiter
- Airborne support equipment with Aft Flight Deck Simulator
- Cables, fluid lines and service panel connections.

The CITE S/M system simulates the orbiter cargo bay and Aft Flight Deck in both the Horizontal Processing Facility (HPF) and VPF. Due to the closer resemblance to the orbiter cargo bay, (see Figures 1 and 5) the HPF test stand simulates the actual cargo bay to a much higher degree that the vertical test stand. Both facilities through support simulation with Aft Flight Deck (AFD) assemblies, Standard Mixed Cargo Harness (SMCH), Environmental Control System (ECS) duct system and Payload Heat Exchange Simulator.

Table 1 lists the interfaces provided for payload interface verification by the CITE S/M simulations.

The electrical/electronic provides the following capabilities:

- Verify total electrical cargo to orbiter interfaces
- Isolate electrical incompatibilities
- Monitor/patch all cargo interfaces
- Perform operational readiness (self test)
- Perform an abbreviated mission simulation
- Perform an end-to-end (e.g., NASCOM network) test.

The CITE E/E system simulates the orbiter electrical system providing power, signal monitoring and orbiter avionics interfaces. The CITE contains both flight type avionics (e.g., Multiplexer/Demultiplexer (MDM), Pulse Code Modulation Master Unit (PCMMU), Payload Data Interleaver (PDI), Payload Signal Processor (PSP), and the Payload Interrogator (PI)) as well as simulated avionics units (e.g., Master Timing Unit (MTU), and Caution and Warning Assembly (C&W)). The controlling element of the CITE E/E is the Interface Terminal Distributor (I/FTD) shown in Figure 6 which provides housing and cooling for avionics, signal conditioning and signal monitoring. Cargo to orbiter interfaces which can be verified in CITE are shown in Table 2.

The CITE control room is the controlling element of the CITE system. As shown in Figure 7, the control room interfaces with both the HPF and VPF test stands as well as the Central Data Subsystem (CDS) to provide display, monitoring, control, data conversion and data processing capability for the cargo interface verification. Control room minicomputers also communicate with the large-scale host computer in the LPS CDS for utility programs and data/program file building. The CDS also provides the capability to simulate the test stand hardware and cargo to be tested so that test procedure development can proceed without the test stand hardware and associated cargo simulation devices.

Figure 8 shows a functional block diagram of the CITE E/E Set. The elements of the CITE control room are depicted to the left of the V&DA. The CITE Master and Operations consoles contain keyboards, color displays and disk storage to provide test and monitor capabilities to the test engines. The front end processors (FEP's) provide system monitoring, preprocessing and command functions from/to the cargo. The Common Data Buffer is a high speed shared memory that permits intercommunication between the FEP's and console computers.

The record and playback assembly (RPA) is a small scale telemetry station which has the capability for recording and simultaneous playback of all CITE to cargo interface signals including FM, PCM and digital data.

A tailored version of the Launch Processing System (LPS) software is used in the CITE system and provides the capability to execute test procedures written in the Ground Operations Aerospace Language (GOAL). GOAL procedures executing in the Master and Operations consoles allow test personnel to perform payload interface verification in an automated, controlled, reproducible cost effective manner. For example, in the Horizontal stand a higher percentage of the procedures developed to checkout the OSTA-1 payload for STS-2 were used to checkout the OSS-1 pallet for STS-3.

The General Purpose Computer/CITE Augmentation System (GPC/CAS) is a simulation capability which increases the fidelity of the CITE system. The GPC/CAS contains a mixed complement of actual flight hardware (e.g., GPC, Mass Memory Unit) and simulated capabilities (e.g., command uplink) which provides the capability to verify actual payload unique flight software. The test personnel can in effect perform actual flight procedures both manual and automated in a mission simulation environment.

CONCLUSION

The CITE system described provides a basic computer controlled simulation capability which performs cargo-to-orbiter interface verification. This capability is essential to mission planning and flight schedules for the STS program at KSC. Turnaround of Space Shuttle orbiter to support current launch
schedules requires efficient problem free
cargo-to-orbiter mate in the OPF and at
the Pad. The CITE system is key to
attaining this goal and has provided
valuable information in support of early
shuttle launches.

TABLE 1
INTERFACES PROVIDED FOR PAYLOAD INTERFACE VERIFICATION BY CITE S/M SIMULATIONS

- AFT FLIGHT DECK (AFD) SIMULATOR PLATFORM
- AFD MISSION STATION SIMULATION
- AFD ON-ORBIT STATION SIMULATION
- AFD ENVIRONMENTAL CONTROL SYSTEM SIMULATION
- Xo576 BULKHEAD OR PAYLOAD INTERFACE BRACKET MOUNTING
- Xo1307 BULKHEAD OR PAYLOAD INTERFACE BRACKET MOUNTING
- STANDARD MIXED CARGO HARNESS CABLE TRAYS
- Xo645 PAYLOAD POWER PANEL MOUNTING
- Xo603 ELECTRICAL PANEL MOUNTING
- Xo1203 ELECTRICAL PANEL MOUNTING
- DATA BUS INTERFACE PANEL SUPPORTS
- REMOTE MANIPULATOR SYSTEM ELECTRICAL CONNECTOR MOUNTING
- RSP ELECTRICAL PANEL MOUNTING
- STANDARD INTERFACE PANEL BRACKETS
- HEAT EXCHANGER SIMULATOR AND PIPING
- PAYLOAD SUPPORT FITTINGS
- LONGERON AND BRIDGE RAIL SIMULATORS

TABLE 2
CARGO-TO-ORBITER INTERFACES WHICH CAN BE VERIFIED IN CITE

- KU-BAND UPLINK
- SCIENTIFIC DATA

- LAUNCH DATA BUS
- PCMMU DATA BUS
- PAYLOAD DATA BUS
- PAYLOAD INTERROGATOR
- PAYLOAD DATA INTERLEAVER
- MULTIPLEXER/DEMULTIPLEXER
- CAUTION & WARNING
- PAYLOAD SAFING
- PAYLOAD UNIQUE SIGNALS
- Xo1307/GSE SIGNALS
- TIMING SIGNALS
- AFD AC & DC POWER
- Xo1307 DC POWER
- Xo645 DC POWER
Figure 1 CITE Horizontal Test Stand
Figure 2  CITE Dual Vertical Test Stand
Figure 3  Cargo Operations Flow
Figure 4 CITE Control Room
Figure 5 Orbiter Cargo Bay
Figure 6  CITE Interface Terminal Distributor
Figure 7  CITE Control Room Interfaces
Figure 8 CITE E/E Set