The BCT-302 1553 Test Bus Card

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ABSTRACT

The desire to control an LRU and/or MIL-STD 1760 store via an independent 1553 stream on current weapon platforms created the need for the development of the BCT-302 1553 Test Bus Card. This solution solves the issues of integration without the need to perform an aircraft OFP change. The BCT-302 is a customized MIL-STD-1553 card for use in Teletronics Technology Corporation, (TTC), Airborne Instrumentation Multiplexer (AIM) and High-Speed Avionics Data Acquisition Unit (HSAVDAU) products.
The BCT-302 card consists of two redundant MIL-STD-1553 ports. Each port is independently configurable by the AIM/HSAVDAU host processor to function as a Bus Controller (BC), Remote Terminal (RT) or Bus Monitor (BM).
The system is capable of cherry picking parameters from any 1553 bus and retransmitting assembled messages to a weapon and/or an LRU in a 1553 format.
This paper describes the design requirements of the BCT card and how those requirements were met during an AIM-9X launch on an F-22.

KEYWORDS

LRU, Instrumentation, 1553, Test Bus

INTRODUCTION

The desire to control an LRU and/or MIL-STD 1760 store via an independent MIL-STD-1553 stream on current weapon platforms created the need for development of the BCT-302 1553 Test Bus Card. The design goal was a proof-of-concept demonstration to launch a new weapon using the aircraft instrumentation system as the MIL-STD-1553 interface and without requiring an aircraft OFP change.

The system solution was required to utilize the existing F-22 ARIP instrumentation system which is based upon Teletronics Technology Corporation's (TTC) AIM/HSAVDAU product family. An alternate system solution utilizing the QRP (Quick Response Package), also AIM/HSAVDAU based, was additionally required. This necessitated the development of a card (BCT-302) to reside in an AIM/HSAVDAU chassis that provided the capability of two-way MIL-STD-1553 communication with any LRU or weapon. The initial weapon supported was an AIM-9X.

The AIM/HSAVDAU system is capable of cherry picking parameters from any aircraft MIL-STD-1553 bus. This capability was required in system solution to obtain time and inertial data from the aircraft and reformat/assemble the data in the 1553 format required by the weapon. The system used an existing BIM-553F card to monitor the 1553 bus. Future capability could include PI-bus, or PCM inputs.

The AIM/HSAVDAU system also supports the capability to record and telemeter data for mission safety. The record format is IRIG Chapter 10.

The basic BCT-302 card requirements included:

- Operation in an AIM/HSAVDAU chassis.
- Provide two (2) MIL-STD-1553 compliant bus connections (ports)
- Dual redundant bus
- Each port independently configurable to operate as:
  - Bus Controller
  - Remote Terminal
  - Bus Monitor
- Support input/output discretes required by AIM-9X and aircraft side interface
- Support minimum set of discretes required by missile for launch
- Support minimum set of messages required by missile for launch
- Aircraft drives valid RT address to missile via address interface
- Aircraft drives valid RT address to BCT-302
- System solution will support a single missile per card
- System is configurable via TTCWare configuration software

BCT-302 Hardware Design

The initial goal for the BCT-302 hardware design was to support an AIM-9X missile and future weapons that are MIL-STD-1760 compliant.

The BCT-302 card was designed to operate within an AIM/HSAVDAU chassis occupying a single I/O slot. Multiple BCT-302 cards can function within a single AIM/HSAVDAU chassis. The BCT-302 card is comprised of two independent dual-redundant MIL-STD-1553 ports. Each 1553 port is software configurable to be Bus Controller (BC), Remote Terminal (RT), or Bus Monitor (BM). The 1553 interfaces and their associated RT addresses and parity are accessible via two DB-25 connectors. In addition six discrete outputs, implemented using solid-state relays, and four 28VDC/open discrete inputs are provided on the connectors. The card provides an onboard temperature sensor to monitor the thermal condition of the BCT-302. The card provides non-volatile EEPROM for storing board-related manufacturing information (model, serial number, etc.).

As a bus controller, the BCT-302 supports periodic and a-periodic messages within major and minor frames. This is the primary mode of operation for control of a weapon. As a remote terminal, the BCT-302 provides multi-protocol supports, including MIL-STD-1553A, MIL-STD-1553 Notice 2, STANAG-3838, General Dynamics 16PP303, and McAir A3818, A5232, and A5690. As a bus monitor, the BCT-302 selects and captures 1553 messages based on RT addresses, transmit/receive messages and sub-addresses. The Remote Terminal and Bus Monitor modes of the BCT-302 card were intended for future applications.

The discrete inputs and outputs support external control functions for the initial weapon application and future applications.

Figure 1 depicts the BCT-302 card and Figure 2 illustrates the BCT-302 connector layout.

Figure 1 BCT-302 Card

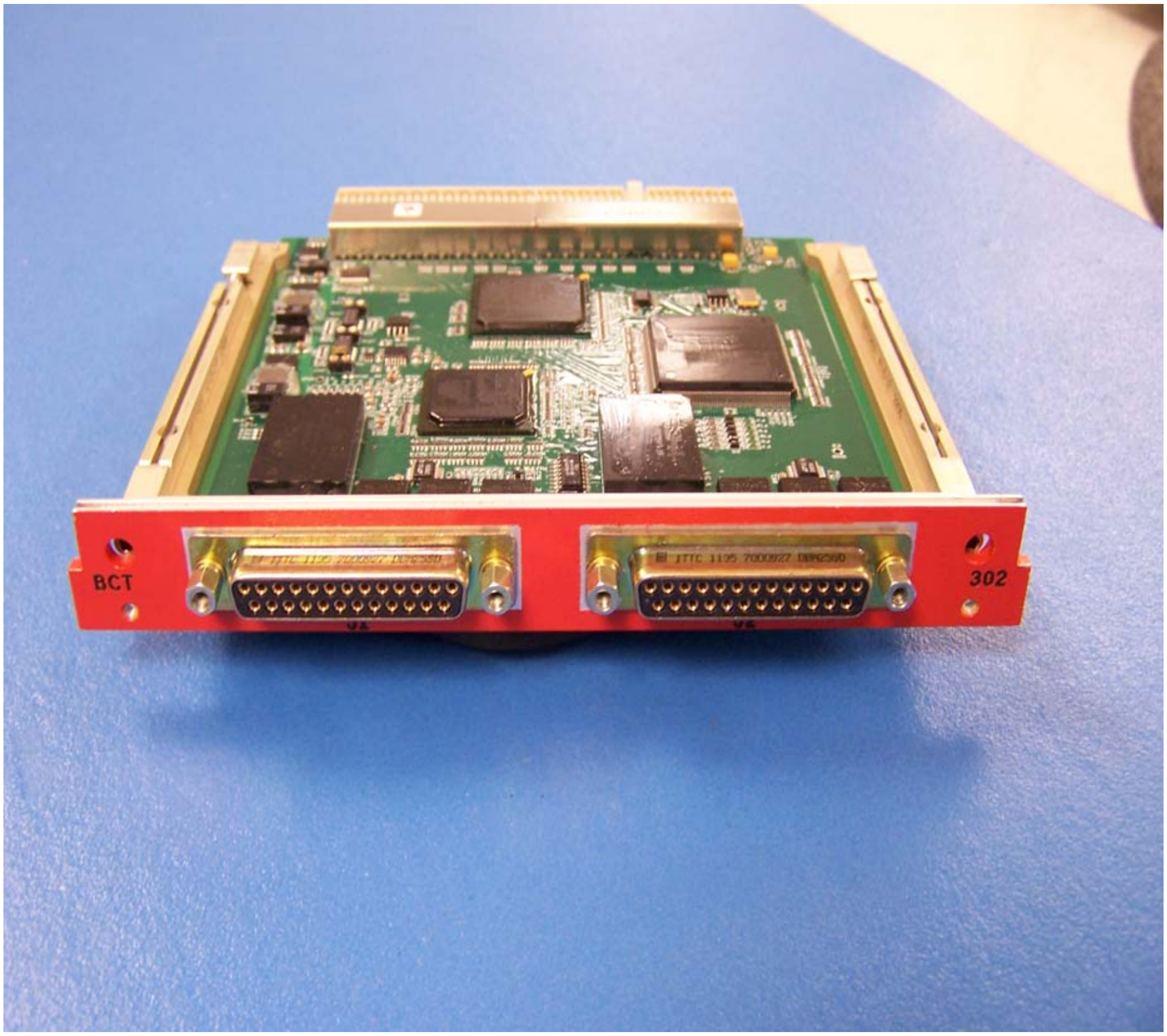
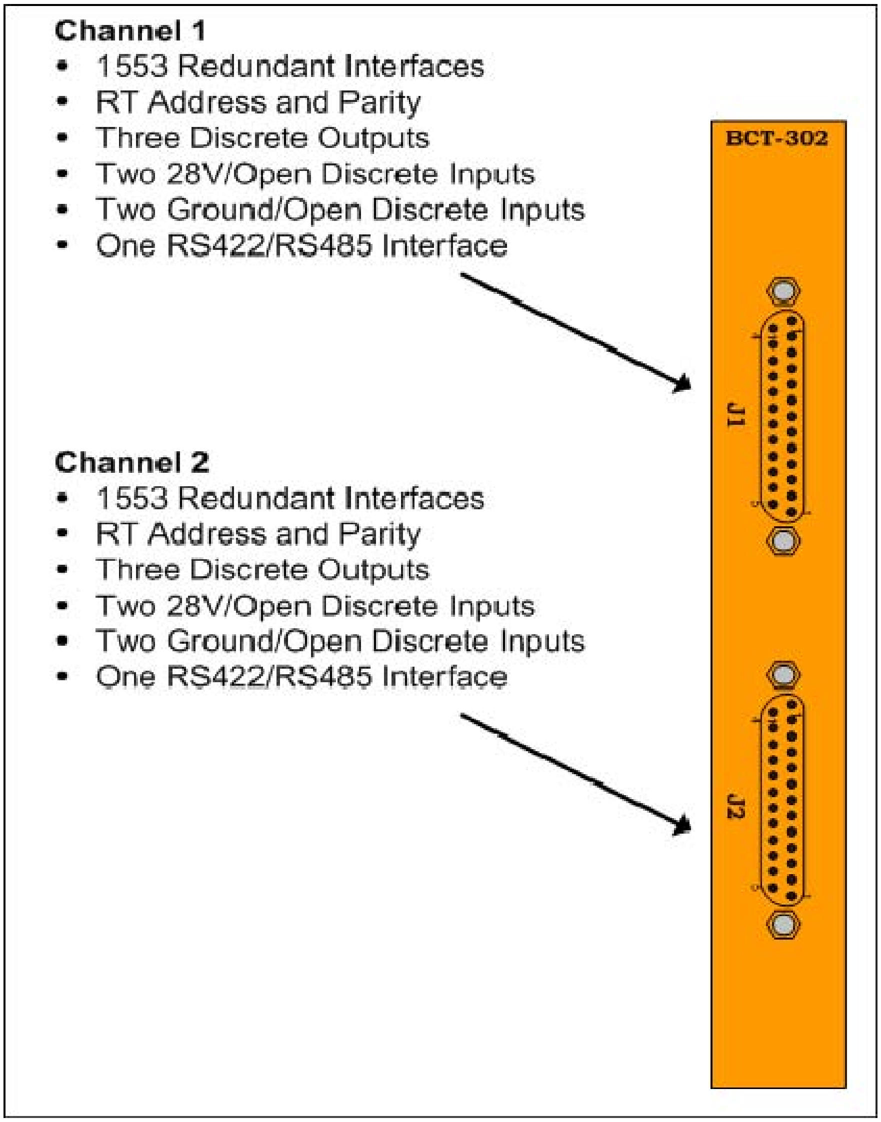


Figure 2 BCT-302 Connector Layout



SYSTEM DESCRIPTION

The BCT-302 acts as a MIL-STD-1553 bus controller to the missile and supports several discrete I/O interfaces to a control panel, launcher, and missile. Two other AIM/HSAVDAU cards are utilized in this application. A BIM-553F MIL-STD-1553 data acquisition card is used to passively monitor (or snoop) a single aircraft MIL-STD-1553 bus for specific messages containing time and inertial information. The BIM-553F card is part of the aircraft standard instrumentation configuration. The OVH-300, a CPU card, is present in each AIM/HSAVDAU chassis and executes the instrumentation system software. The instrumentation system software was updated to support the BCT-302 card and missile launch application.

The supported missile is MIL-STD-1760 compliant. Several BCT-302 discrete signals are assigned to support the MIL-STD-1760 signal set. Other discrete I/O, beyond MIL-STD-1760, were required and assigned to the BCT-302-1 to support the missile launch and for safety of flight considerations. All BCT-302 discrete I/O are under software control and monitoring. Discrete inputs to the BCT-302 support Weapon Present, Power Available, Doors Open, Launcher Extended, Safe-to-Launch, and Weapon Release. Discrete outputs from the BCT-302 support 115VAC/28VDC Power Control, Launch Enable, Release Consent, and Umbilical Retract. A small panel box was constructed for the pilot interface to the BCT-302. The panel box includes switches for controlling the Power Available, Safe-to-Release, and Weapon Release discrete inputs to the BCT-302. The balance of discrete I/O signals exist between the BCT-302 and launcher/missile: Weapon Present, Release Consent, Launch Enable, and Umbilical Retract. Figure 3 illustrates the configuration.

The system software controlling the BCT-302 implements a strict state machine to control and launch the missile. The initial state of the system is the missile in a powered-down state, the launcher is retracted, and weapons bay doors are closed. All discrete inputs and outputs are off with the exception of Weapon Present. Refer to Figure 4 through Figure 6 for the launch sequence. The pilot begins the launch sequence by opening the weapons bay doors and extending the launcher. Software detects this condition via the Doors Open and Launcher Extended discrete inputs and will permit power up of the missile. When the pilot turns on the power switch on the panel box, software detects this change via the Power Available discrete input and asserts the Power Control discrete output, thereby powering up the missile. Software starts a MIL-STD-1553 message exchange between the BCT-302 and missile to begin initializing the missile. Snooped time and inertial data message from the BIM-553F card are transformed and continuously passed to the missile to provide it with time synchronization and inertial data. Software continuously monitors the missile state via MIL-STD-1553 message exchange. This includes the MIL-STD-1760 Store Monitor message and other missile-specific messages.

Once the missile reaches a ready state, software will permit launch of the missile. The pilot turns on the Safe-to-Launch switch on the panel box. Software detects this condition via the Safe-to-Launch discrete input and then asserts the Launch Enable discrete output. Next the pilot depresses the Weapons Release switch on the panel box. Software detects this condition via the Weapon Release discrete input and begins a timed discrete/message sequence to the missile. Software asserts the Release Consent discrete output followed by a MIL-STD-1760 Store Control message with Commit to Separate Store set (the launch message). The missile begins its launch sequence and responds with

Committed to Separate Store in the MIL-STD-1760 Store Monitor message. Software detects the Committed to Separate Store response and asserts the Umbilical Retract discrete. Once the missile fires and leaves the launcher rail, software detects it's away via de-assertion of the Weapon Present discrete input. The pilot concludes the launch sequence by turning off Safe-to-Launch and Power on the panel box and then retracts the launcher and closes the weapons bay doors.

The system software controlling the BCT-302 was designed to ensure safe conditions at all times. Additionally, the BCT-302 FPGA implements a heartbeat/watchdog mechanism to ensure an alive-and-well exchange between software and hardware. Any detected fatal software or hardware fault would immediately terminate power to the missile and de-assert all other discrete outputs to preclude a launch.

Figure 3 BCT-302 System Configuration

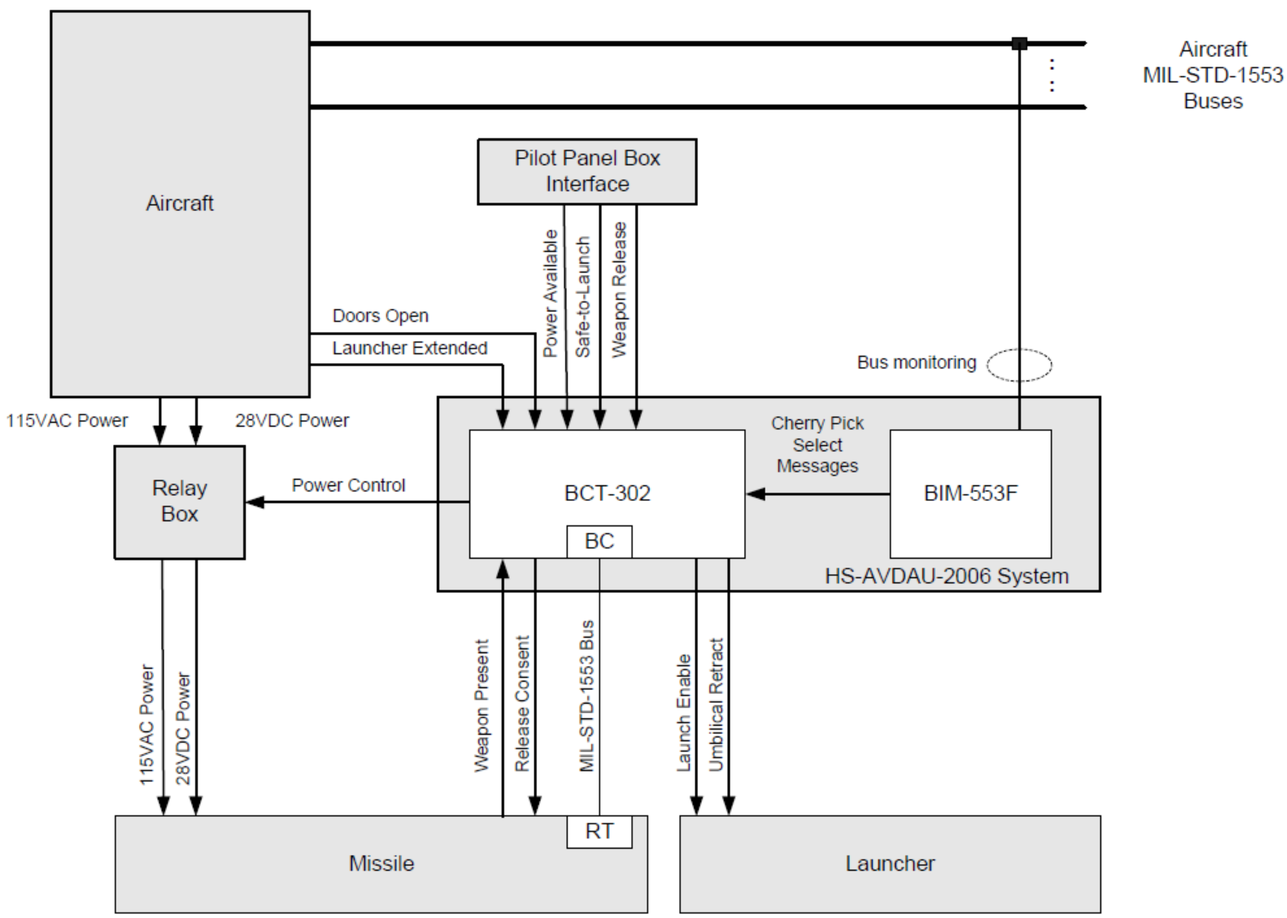


Figure 4 BCT-302 Launch Sequence

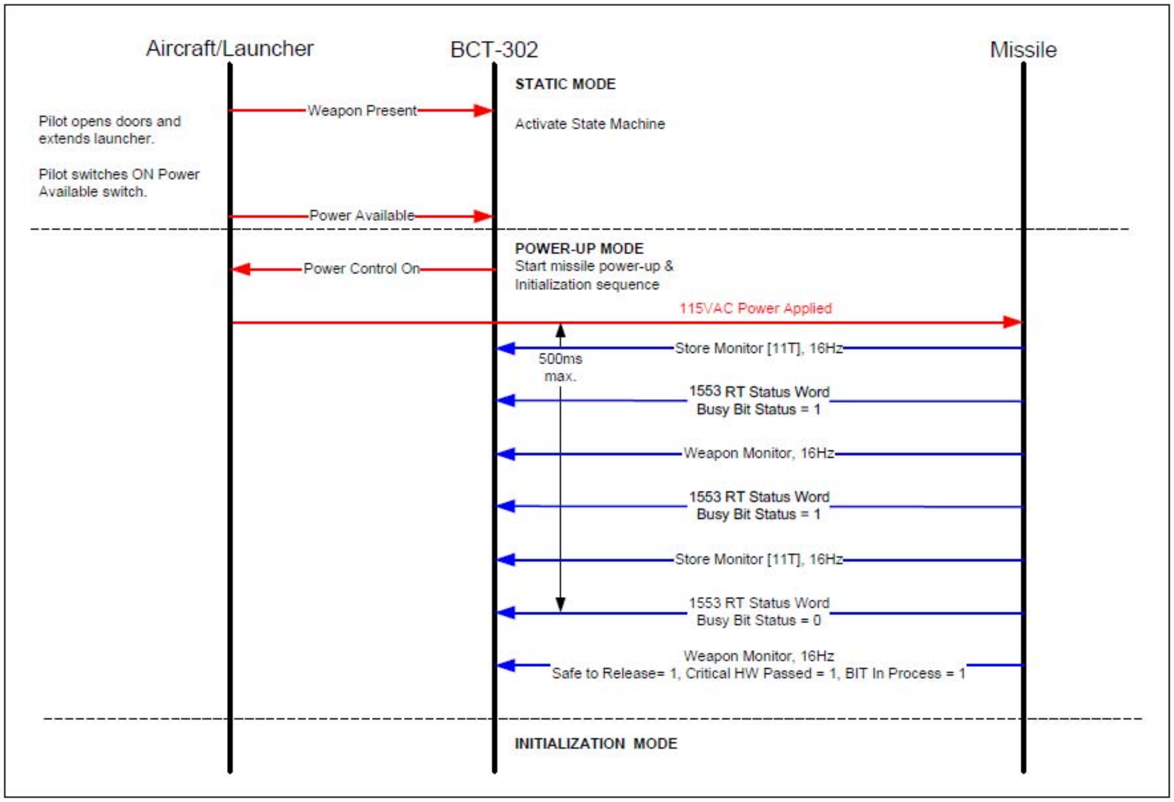


Figure 5 BCT-302 Launch Sequence (continued)

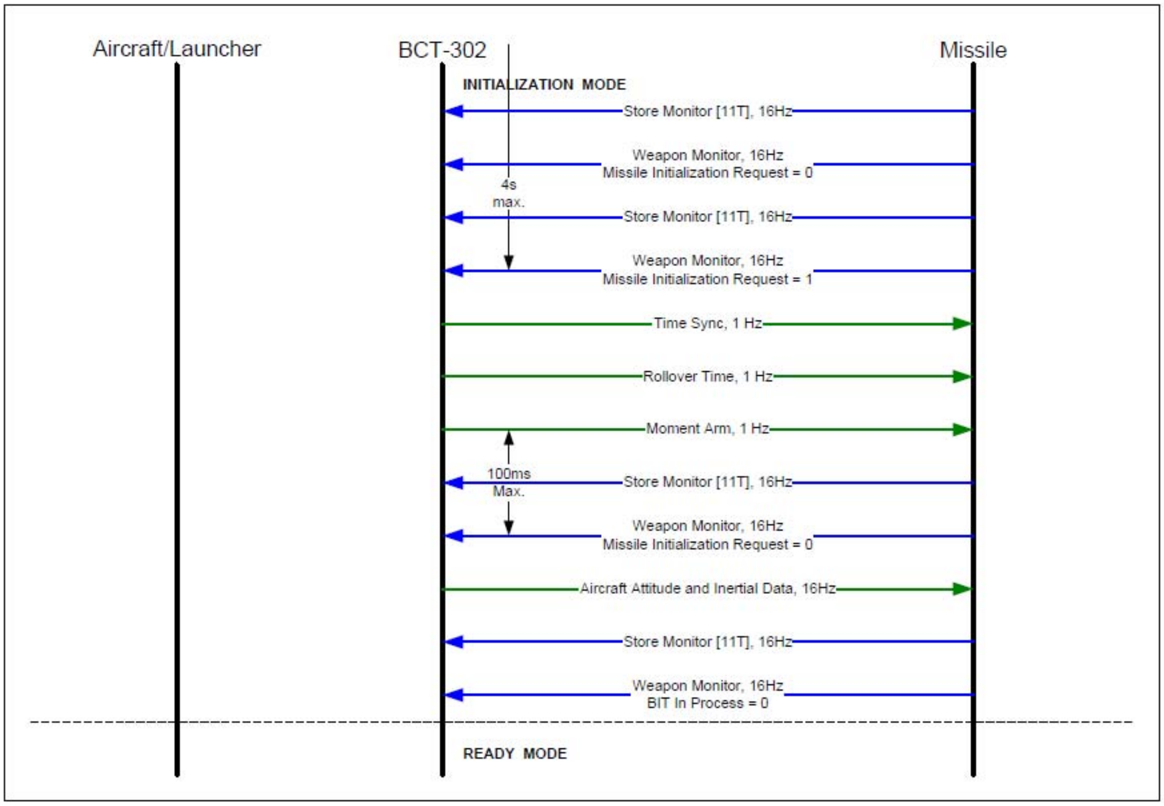
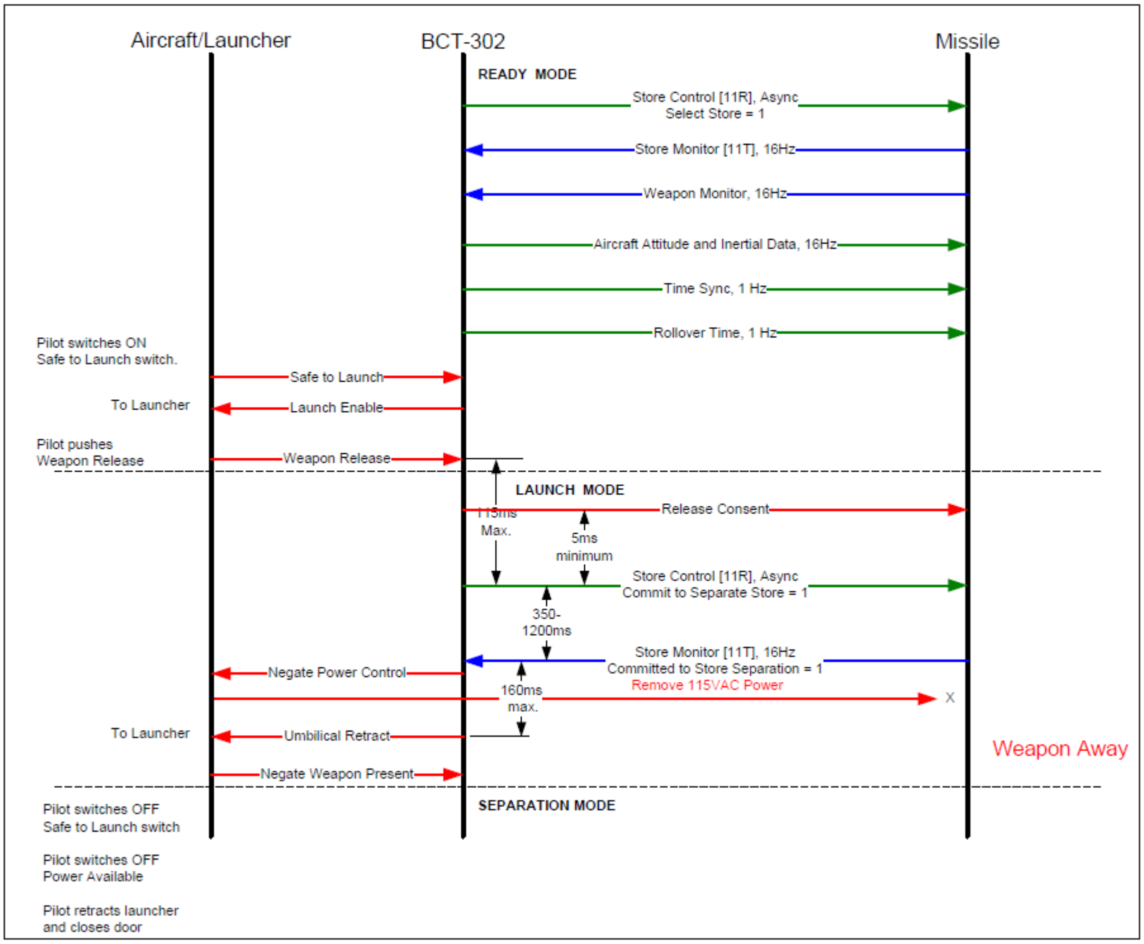


Figure 6 BCT-302 Launch Sequence (continued)



Test Strategy

The test strategy to validate the functions of the BCT-302 consisted of the following phases:

- Design Verification Test (DVT)
- Integration test in the aircraft vehicle system lab
- Aircraft ground test with missile simulator and/or test missile
- Aircraft captive carry flight with test missile
- Live missile launch from aircraft

The major validation goals common to each phase were the following:

- Verify monitoring of aircraft 1553 messages, data transformation, and remapping to missile 1553 messages
- Verify bus controller to RT transactions
- Verify discrete input/output operation
- Verify time synchronization between aircraft, BCT-302, and missile
- Verify all missile phases of operation from power-up to launch
- Verify status information

The test strategy was designed to progressively validate the system solution starting in a lab environment with aircraft and missile simulations, evolving to an aircraft and test missile environment, and ultimately concluding with a live launch from an aircraft.

Figure 7 depicts the design verification test configuration. The configuration supports verification of the major validation goals. An AIM-2004 chassis hosted the BCT-302 card under test, a BIM-553F bus monitor card, and other resources to record data and export status information over a CAIS bus. A personal computer (PC) hosted aircraft and missile simulation applications that utilized an installed Ballard MIL-STD-1553 card to act as an aircraft bus controller and missile remote terminal on separate 1553 channels. The simulated aircraft message channel connected to a BIM-553F bus monitor card. The missile channel connected to a BCT-302 1553 port operating in bus controller mode. The aircraft simulation transmitted inertial and time 1553 messages. The missile simulation responded to bus commands from the BCT-302. A stub connection was placed on the bus between the BCT-302 and Ballard card missile channel to permit a separate BIM-553F port to record the 1553 message exchange between the BCT-302 and missile for analysis. A discrete test box connected to the BCT-302 supported exercising discrete I/O required for the application. A CAIS test box was used to observe status information exported via the CAIS from the AIM system.

Figure 8 depicts the instrumentation system on the aircraft. This configuration was used in all post DVT testing in the vehicle systems lab and on the aircraft.

Figure 7 BCT-302 DVT Configuration

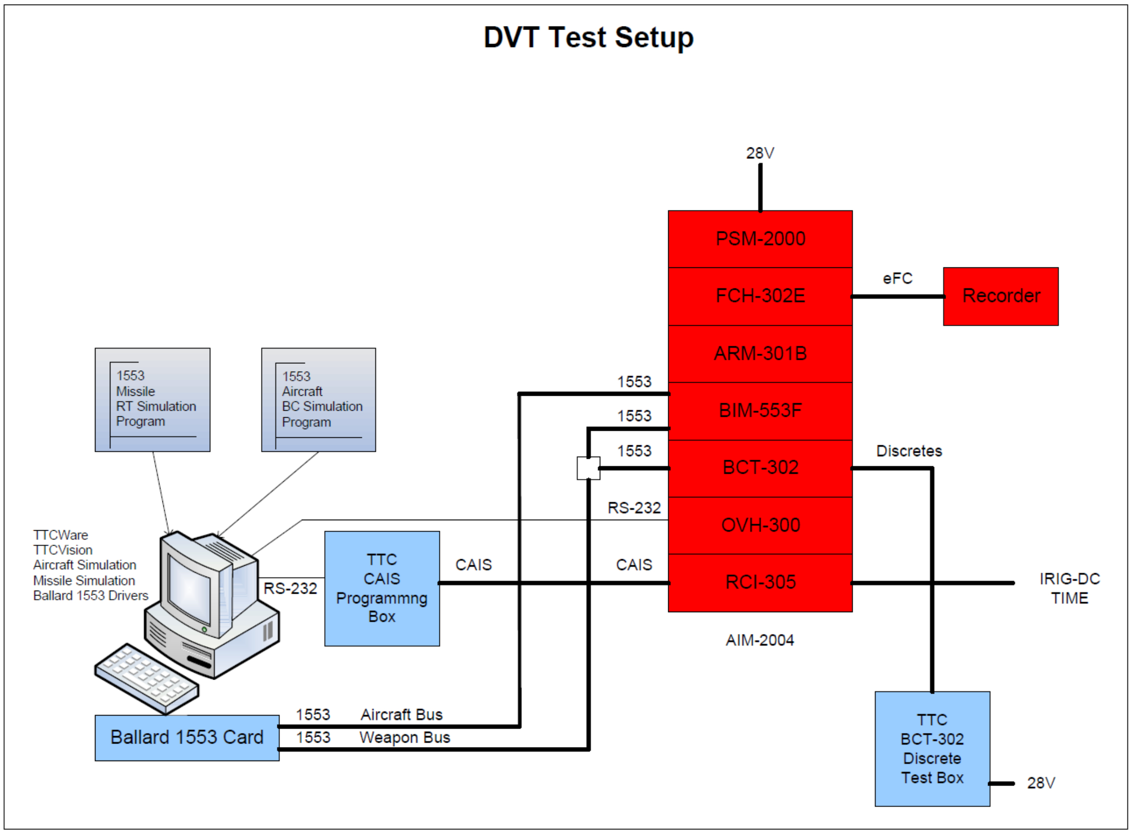
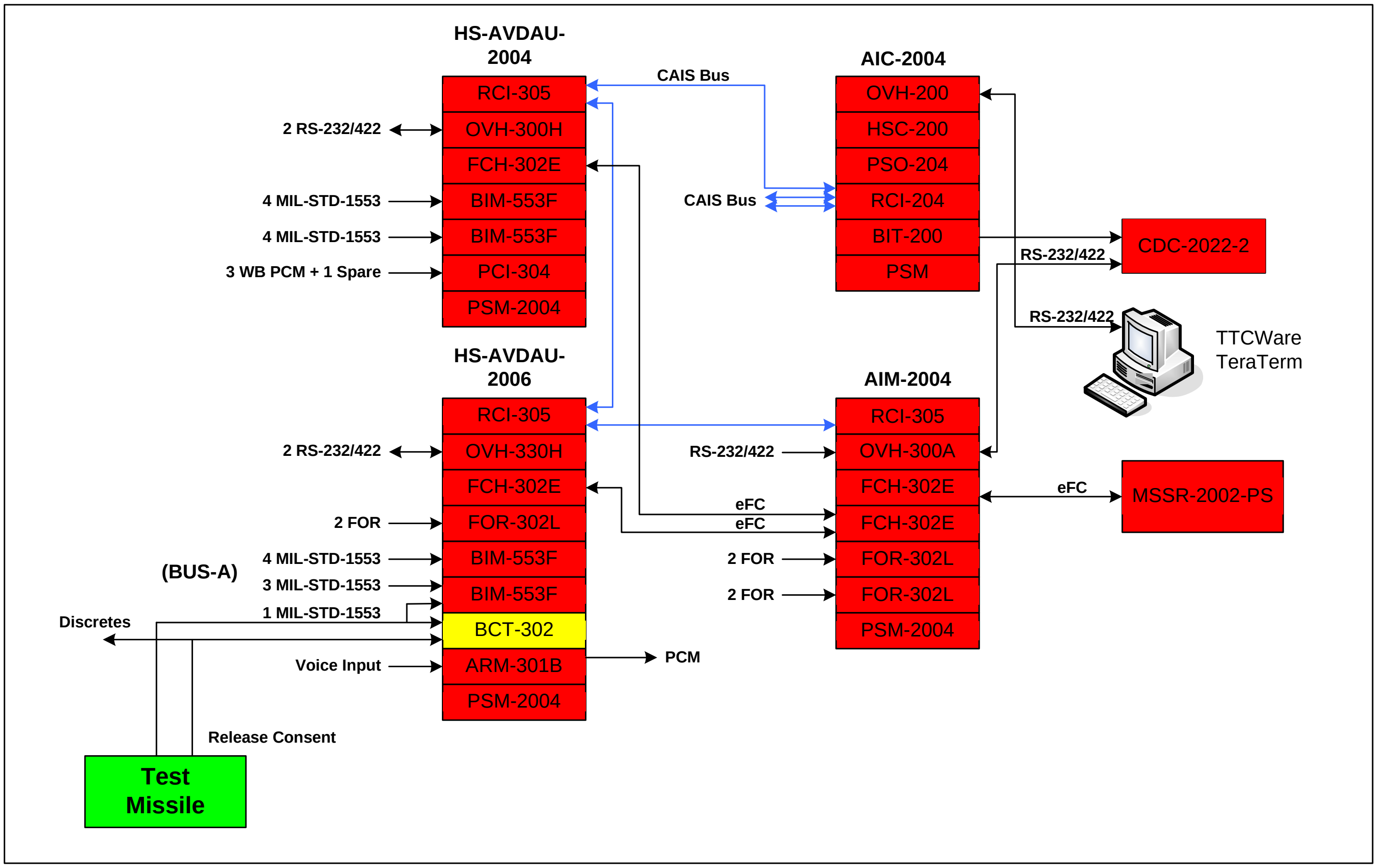


Figure 8 Aircraft Instrumentation System with BCT-302 Card



CONCLUSION

The BCT-302 system development has been a success. Without the need for an OFP change to develop a weapon for the warfighter, the possibilities are endless. The test program has been completed and the BCT-302 is being utilized for weapons development on the F-22. There are currently several other development programs for which the BCT-302 is being considered.