ABSTRACT

Airborne instrumentation used during flight tests is being installed and maintained in a unique way by operational bomber testers from the Air Force’s 53d Wing. The ability of the flight test community to test on operational aircraft has always been somewhat curtailed by the need for advanced forms of instrumentation. Operational fighter flight test squadrons have aircraft assigned to them, which they modify on as needed basis, much the same as developmental testers. However, bomber operational test units must use operational aircraft to accomplish their mission as there are no bombers in the Air Force’s Air Combat Command (ACC) specifically set aside for operational tests. During test missions, these units borrow aircraft from operational bomb wings, and then return them to service with the bomb wing after testing is complete. Yet, the requirement for instrumentation on these test missions is not much different than that of developmental testers. The weapon system engineer’s typically require Mil-Std-1553, video, telemetry, and Global Positioning System (GPS) Time-Space-Position-Information airborne receiver recordings. In addition, this data must be synchronized with an IRIG-B time code source, and recorded with the same precision as the data gathered during development test and evaluation (DT&E). As a result, several techniques have been developed, and instrumentation systems designed for these operational test units to incorporate instrumentation on operational aircraft.

Several factors hamper the usual modification process in place at bases such as Edwards AFB and Eglin AFB. Primary among these is the requirement to maintain the aircraft in an operational configuration, and still meet all of the modification design safety criteria placed on the design team by the aircraft’s single manager. Secondary to the list of restrictions is modification time. Aircraft resources are stretched quite thin when one considers all of the bomb wing’s operational commitments. When they must release an aircraft for test missions, the testers must insure that schedule impacts are minimal. Therefore, these systems must install and de-install within one to two days and be completely portable. Placing holes in existing structures or adding new permanent structure is unacceptable. In addition, these aircraft must be capable of returning to combat ready status at any time.
This paper centers on the B-52 bomber, and the active aircraft temporary modifications under control of the 49th Test Squadron (49 TESTS) at Barksdale AFB in Louisiana. The B-52 presents unique design challenges all its own, in addition to the general restrictions already mentioned. This paper will present the options that the 49 TESTS has successfully used to overcome the aforementioned restrictions, and provide an appropriate level of specialized instrumentation for its data collection requirements.

**KEYWORDS**

B-52, airborne instrumentation, operational, bomber, BADAS, BAVRS, ARDS, IRIG-B, telemetry, OT&E, GPS TSPI, Mil-Std-1553, IOT&E, FOT&E

**INTRODUCTION**

The 49th Test Squadron (49 TESTS) at Barksdale AFB in Louisiana is home to several bomber operational test programs. Primary among these are the Nuclear Weapon System Evaluation Program, the bomber portion of the Air to Ground Weapon System Evaluation Program, and initial operational test of the Joint Direct Attack Munition and the Wind Corrected Munitions Dispenser. The squadron is an Air Combat Command (ACC) unit tasked to support and conduct operational testing from all three Air Force bombers. The squadron’s main focus is on the B-52 with additional testing being conducted on the B-1 and B-2. To accomplish its mission, the 49 TESTS must use operational bombers as there are no test coded bombers in ACC.

The weapon system engineers at the 49 TESTS require much of the same data collected on test coded aircraft (Mil-Std-1553, video, GPS TSPI, and telemetry). These operational aircraft must be modified to include specialized instrumentation much the same as any test coded aircraft would. However, several factors hamper the usual modification process used at the developmental test centers. Primary among these is the requirement to maintain the aircraft in an operational configuration, and still meet all of the safety of flight design criteria established by the aircraft’s single manager. Secondary to the list of restrictions is modification time. Aircraft resources are stretched quite thin when one considers all of the bomb wing’s operational commitments. When the bomb wing releases an aircraft for test missions, the testers must insure that the schedule impact is minimal. Therefore, these systems must install and de-install within one to two days and be completely portable. Placing holes in existing structures or adding new permanent structure is unacceptable. In addition, these aircraft must be capable of returning to combat ready status at any time.

The 49 TESTS instrumentation flight is responsible for both weapon telemetry payload, and aircraft instrumentation installation and checkout, while the engineering flight provides design expertise. This paper centers on the installation and operation of the 49
TESTS airborne instrumentation on the B-52 bomber. The squadron’s current modifications include Mil-Std-1553 data recording using the Bomber Airborne Data Acquisition System (BADAS) and video recording using the Bomber Airborne Video Recording System (BAVRS). The squadron will continue to expand its capabilities by introducing Global Positioning System (GPS) Time-Space-Position-Information (TSPI) and airborne telemetry recording later in 1998. All instrumentation is designed and procured by the 49 TESTS with some additional help from the 412 Test Wing at Edwards AFB.

**OPERATIONAL BOMBER TEST**

The 49 TESTS conducts operational test and evaluation of the Air Force’s bomber fleet from Barksdale AFB. These tests include Follow-On Operational Test and Evaluations (FOT&Es) of hardware/software modifications, support of Initial Operational Test and Evaluation (IOT&E) of new hardware/software, Tactics Development and Evaluation (TD&E) of the B-52, and support of Foreign Materiel Exploitation (FME) testing with the B-52. Tests are conducted both at Barksdale AFB in Louisiana and Minot AFB in North Dakota. Therefore, any system must be designed to be easily shipped between bases.

At the start of each new test program, a lead weapon system engineer is designated to determine test requirements. From these requirements, a list of required data parameters is generated. This list of parameters is handed off to the lead instrumentation engineer to determine instrumentation requirements. Thus far, the squadron’s instrumentation section has been tasked to record Mil-Std-1553, video displays, and is currently being tasked to record GPS TSPI and telemetry on the aircraft during flight.

Typically, an aircraft is borrowed from the bomb wing 72 hours prior to the mission. Within that time, the aircraft must be loaded with the test weapons, instrumented, and prepared for flight. Typical modification time is 12 hours using three people. With the addition of the GPS TSPI and telemetry recording, this time is expected to extend to 24 hours using three people.

The B-52 system program office, the B-52’s single manager, establishes safety of flight criteria for the modification process. The most restrictive of these, the crash loading criteria, requires any system to withstand a forward and upward G-loading of 16 Gs. While the B-52’s cockpit may seem full of ample space, this requirement alone eliminates most structures that could be used as tie-down points. Further, the aircraft’s readily available electrical connectors do not provide enough current to run most instrumentation systems. Lastly, crew egress is always a concern. Therefore, a concerted effort was made to reduce the amount of floor space taken up by our instrumentation systems to allow crew egress to be completed quickly in case of emergency. With these
criteria in mind, the 49 TESTS engineers began an extensive design effort to produce Mil-Std-1553 (BADAS) and video (BAVRS) recording capabilities.

BOMBER AIRBORNE DATA ACQUISITION SYSTEM

Proper evaluation of the B-52H weapon system requires the collection of all the Mil-Std-1553 avionics bus data. The avionics data is only available from avionics bus recorders temporarily installed on the aircraft. The Bomber Airborne Data Acquisition System (BADAS) using a MARS-II data recorder can reliably record all Mil-Std-1553 avionics bus data. This data contains the basic flight parameters engineers use to evaluate a weapon system such as navigation parameters. The BADAS is a palletized system designed to meet the instrumentation requirements of the B-52H test community. Additional space was left for future expansion of data collection capabilities such as telemetry recording.

The BADAS pallet is designed to be equipped with one MARS II storage module, one MARS II electronic module, one power control unit, and one time code generator. The MARS II data recorder, produced by Metrum-Datatape Inc., is capable of bulk recording all Mil-Std-1553 avionics data as well as Pulse Code Modulation (PCM) data. The MARS II electronic module is used to interface with the 1553 bus traffic originating from the Offensive Avionics System (OAS). The MARS II storage module digitally encodes the 1553 traffic and records it on a digital linear tape cartridge. Currently, the 49 TESTS uses the DATUM model 9150 time code generator to produce IRIG-B time. This time is input to all recording devices. The 49 TESTS is evaluating Datum’s GPS time code generator model 9390-3000 for future use. This time code generator will take advantage of a GPS antenna mounted in the B-52’s sextant port to provide GPS quality time code in an IRIG-B format. The new time code generator will mount in the existing bracket using a modified plate configuration.

Four different mounting brackets attach the system to the aircraft (see figure 1). These brackets interface with existing aircraft structure, thus no holes are drilled or structures created. The power control box and time code generator mount on the bunk rails. The MARS-II components mount on the floor adjacent to the bunk with attachments to the side of the bunk. This mounting scheme provides easy access for the operator and a significant margin of safety for the crew in a crash environment. BADAS installation, maintenance and operation is accomplished by 49 TESTS personnel, thus reducing the impact on aircrew and maintenance personnel. All of the controls are easily accessible to any member of the aircrew, and the main power switch is guarded to prevent inadvertent operation. Currently, operation of the system requires the operator to be in the crew bunk area. However, a new addition to the design will permit the operator to remain seated in the gunner’s seat for all operations except tape changes.
All of the units could not be placed on the bunk due to the crash loading design criteria. Installation of the floor mounts and associated equipment (MARS II storage and electronic modules) requires the panels on the front side of the bunk to be removed and the clamping mounts to be attached to the structures under the bunk. Equipment placed on the bunk (time code generator and power control) is clamped to the bunk rails.

Avionics bus connections from the MARS II electronic module are routed to the lower crew area through an existing hole in the floor on the starboard side of the aircraft, forward of the Electronic Warfare Officer's (EWO) seat. All connections to the OAS 1553 buses are made to couplers in the lower crew area. All cabling is maintained in the crew bunk area except for the bus connection cables. These cables are run across the floor of the upper deck of the B-52 under a kick plate, which attaches to existing ditching hammock mounts.

Power for the BADAS originates from the Electronic Counter Measures nose test circuit breaker located on the left load central circuit breaker panel positioned above the bunk. A 12 gauge wire is routed from the breaker through an existing hole at the bottom of the circuit breaker panel to a pilot instrumentation power switch located next to the aircraft commander, and then to the J1 connector of the power control module mounted on the bunk. The pilot instrumentation power switch provides an emergency “kill” switch for the aircraft commander, allowing isolation of the BADAS from the aircraft’s systems. The pilot instrumentation power switch is mounted to the left of the aircraft commander using existing zeus fasteners. This circuit provides 25 amps of current at 28 volts DC and 15 amps of current at 115 VAC / 400 Hz. The BADAS draws a maximum of 9 amps of DC current. Once power is applied to the power control box, this module serves as the distribution box for all instrumentation systems. The control box provides a visual indication of power application for master power and each instrumentation system. The control module also provides discrete control of the MARS II recorder and indication of some faults via the J3 and J5 connections. The MARS-II also provides an RS-232 control option. By using a laptop computer and a program provided by Metrum-Datatape, the operator can monitor the status of the MARS unit without affecting the record function. A picture of the BADAS installed on a B-52 is shown in Figure 1.
Proper evaluation of the B-52 weapon system requires the collection of several video signals, which are normally displayed to the aircrew during flight. The Airborne Video Tape Recorder (AVTR) system currently used on the B-52 (Time Compliance Technical Order 1B-52-2392) records only one of the four available video sources (Terrain Avoidance (TA), Multi-Function Display (MFD), Electro-Optical Viewing System (EVS), and AGM-142) on a half-hour ¾ inch tape. The TA video contains a display for the pilot to monitor during TA operations. The MFD video displays aircraft parameters to the navigators. The EVS video displays low light television and forward looking infrared video to the navigators. The AGM-142 video displays the real-time seeker video from the AGM-142 standoff missile. During special test flights, two or three video sources must be recorded for accurate data collection. A current T-2 aircraft modification allows the 49 TESTS to install a second AVTR and a specialized dual remote control unit to capture two video signals. This method of recording has several shortcomings, including installation time and a limited recording time per tape. The Bomber Airborne Video
Recording System (BAVRS) provides a three video signal recording capability on the B-52 using existing hardware and a specially configured triple deck recorder manufactured by TEAC America Inc.

The BAVRS is installed in the current mounting for the AVTR, next to the navigator's position. This procedure removes and replaces the AVTR with the TEAC triple deck. With the triple deck mounted in this position, the navigator is able to operate the discrete controls for the BAVRS and change tapes without unstrapping from his/her seat. The TEAC Triple Deck Recorder (TEAC part number V83AB-F973), which uses a Merlin Scan Converter internal to the unit, is a form, fit, and functional replacement of the AVTR currently used on the B-52. The Merlin scan converter allows the B-52’s 875 scan line RS-343 video format to be converted to 525 scan line RS-170 video. Once recorded on, the videotapes can be taken to any 8mm videocassette recorder and viewed. Additionally, TEAC has produced a video time insertion chip, internal to the recorder, which places an IRIG-B time stamp on the video. This option is currently being evaluated by the 49 TESTS. A new remote control unit (RCU) to control the video source input to the recorder was fabricated by the 412 TW at Edwards AFB. This unit allows the navigator to select any three video sources for recording on the triple deck. Control is provided by a TEAC remote control hand held unit (TEAC part number VS83-F) attached to the triple deck via a RS-422 interface. The power control box mentioned in the BADAS section is used to deliver power to all the units.

![Existing AVTR Mounting](image)

Figure 2
Existing AVTR Mounting
The BAVRS was designed to meet our present video recording requirements. This design was intended to provide an easily accepted mounting scheme for the BAVRS without the need for extensive construction. The mounting is rated to hold the TEAC triple deck as it is lighter than the original AVTR. The TEAC triple deck has been fit-checked in a B-52 and exactly fits in the same mounts as the AVTR. Therefore, no modification is required to the mounting scheme. The only new construction required is cabling. Alternatively, should requirements dictate, the triple deck can be mounted to the side of the bunk or to a specially designed pallet placed behind the EWO’s. Both mounts take advantage of existing hardware and are quick modifications to the plane.

The BAVRS draws a maximum of 2.5 amps of DC current from the power control box mentioned in the BADAS section. Power is then routed through a 22 gauge wire to the TEAC triple deck from the J12 connector on the power control box through the opening on the starboard side of the aircraft forward of the EWO’s seat, and into the J3 connector of the TEAC triple deck. Control of the TEAC triple deck will be accomplished using the VS83-F TEAC remote control unit. This unit, connected to J2 of the triple deck provides such controls as record, stop, and rewind for the operator. It is mounted using existing zeus fasteners either downstairs near the navigator, or upstairs at the gunner station for the flight test engineer.

The RCU is installed by removing the existing aircraft RCU, which only provides one channel of video. Video signals are routed to the RCU using existing aircraft cables. Audio signals and IRIG-B time is routed directly to the triple deck’s J-1 connector.

Figure 3
TEAC Triple deck
THE FUTURE

The 49 TESTS requirements for GPS TSPI and telemetry recording on board the B-52 have yet to be addressed with an approved aircraft T-2 modification. The fact finding process has been concluded and preliminary designs are complete. The system will leverage off existing structures and electrical connections.

The GPS TSPI requirement is to be fulfilled by the Range Application Joint Program Office’s (RAJPO) Advance Range Data System (ARDS). The full rate production plate version of this system will mount on the front of the bunk similar to the MARS-II modules in a stacking fashion. The GPS antenna used for the time code generator will be split to provide GPS signals to both the ARDS and the GPS time code generator. The ARDS datalink will be transmitted through a second antenna mounted on the underside of the aircraft in place of one of the aircraft’s electronic counter measures antennas. This routing requires a transmission line to be run through a bulkhead penetration point. This system provides differential GPS accuracies with an on-board recording and status monitoring capability. Power is provided by the power control box.

The telemetry requirement is being filled by L3Com’s CAR-810 receiver and ABS-400 Bit synchronizer. These modules will be mounted to the exterior of the power control box providing receipt of both L and S-Band telemetry in-flight. The bit synchronizer also provides a PCM decommutation function allowing the signal to be recorded on the MARS-II recorder. Power will be provided by the power control box. Separate L and S-band antennas will be used to receive the telemetry.

CONCLUSION

Airborne instrumentation used during flight tests is being installed and maintained in a unique way by operational bomber testers from the Air Force’s 53d Wing. The ability of the flight test community to test on operational aircraft has always been somewhat curtailed by the need for advanced forms of instrumentation. Operational fighter flight test squadrons have aircraft assigned to them, which they modify on an as needed basis, much the same as developmental testers. However, bomber operational test units must use operational aircraft to accomplish their mission as there are no test coded bombers in ACC. During test mission, these units borrow aircraft from operational bomb wings and return them to service with the bomb wing after testing is complete. Yet, the requirement for instrumentation on these test missions is not much different than that of developmental testers. The weapon system engineer’s typically require Mil-Std-1553, video, and telemetry, and GPS TSPI airborne receiver recording. In addition, this data must be synchronized with an IRIG-B time code source, and recorded with the same precision as the data gathered during development test and evaluation (DT&E).
To address this need, the 49 TESTS designed two modifications. The BADAS serves as the squadron’s Mil-Std-1553 data collection tool, while the BAVRS fills the squadron’s need for video data collection. Future plans call for the addition of GPS TSPI and telemetry recording. Combined, these capabilities are being used on a daily basis by the 49 TESTS to meet the challenge of operational bomber testing now and in the future.