Boeing Test & Evaluation (BT&E)

Mobilization of Test Assets

By

Ko Ko Tha

Agenda

- Avionics System/Subsystem Testing
- Need for Test Asset Mobilization
- Test Asset Mobilization
  - Planning
  - Requirements Identification
  - Design Considerations
  - Assembly Considerations
  - System Verification
  - System Installation
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Avionics System/Subsystem Testing

- **Avionics System/Subsystem testing is traditionally being done with Lab Testing, On-Aircraft Ground Testing, and Flight Testing**
- **Lab Testing**
  - **Line Replaceable Unit (LRU) functions to design intent**
  - **LRU is safe to operate in a flight test environment but not acceptable for production installation**
- **On-Aircraft Ground Testing**
  - **Line Replaceable Unit (LRU) functions to design intent**
  - **LRU is fully qualified and can be installed in a production aircraft and delivery**
- **Flight Testing**
  - **LRU is fully qualified and can be installed in a production aircraft and delivery**

Avionics System/Subsystem Testing (Cont.)

- **Communication System/Subsystem testing**
  - —**Lab testing**
    - » **Radio RF port terminated to verify radio control interfaces**
    - » **Radio connected to the COTS radio test set**
    - » **Radios connected through attenuator for Tx and Rx**
    - » **Over-the-air live testing with antenna mounted on the roof of test facility communicating to a Second Radio**
      - - **Second Radio**
        - • **COTS Radio Communication Test Set for clear testing**
        - • **Custom Radio Test Bench for encrypted testing**
      - - **Line of Sight (LOS) between the radios are required for UHF/VHF testing**
  - —**Flight testing**
    - » **Aircraft to Ground Station**
      - - **Ground Station**
        - • **COTS Radio Communication Test Set for clear testing**
        - • **Custom Radio Test Bench for encrypted testing**
    - » **Aircraft to Aircraft**
    - » **LOS between the radios are required for UHF/VHF testing**

Avionics System/Subsystem Testing (Cont.)

- **Global Positioning Satellite (GPS) System/Subsystem testing**
  - —**Lab testing**
    - » **GPS receiver connected to GPS Simulator**
    - » **Over-the-air testing with GPS receiver in the lab and antenna mounted on the roof of test facility**
      - **GPS receiver is stationary**
  - —**Flight testing**
    - » **Flight test aircraft with GPS receiver and antenna installed**

Avionics System/Subsystem Testing (Cont.)

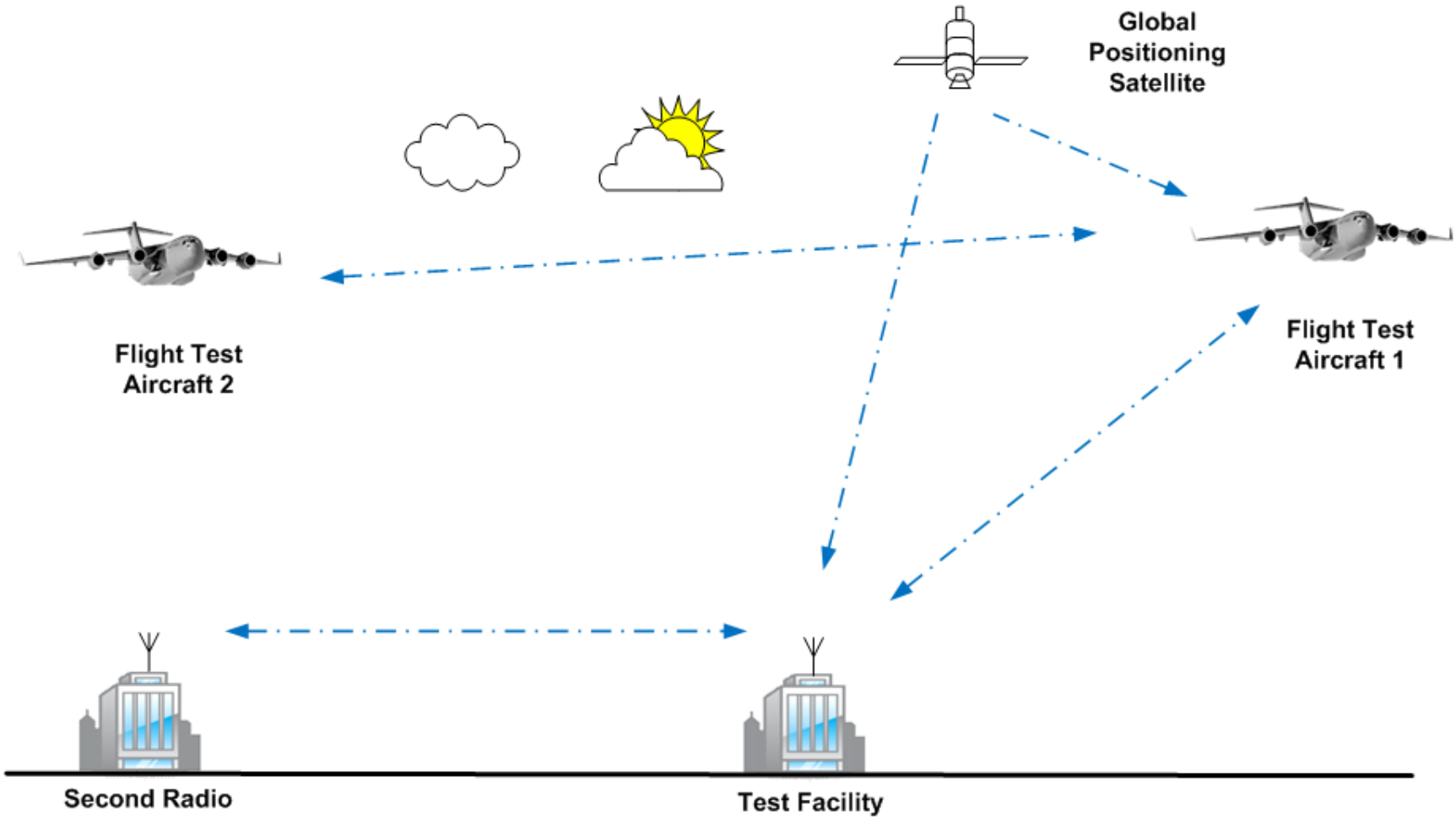

Fig. 1 : Communication and GPS System/Subsystem Over-The-Air Testing Scenarios

Need for Test Asset Mobilization

- **UHF/VHF over-the-air radio testing**
  - —**LOS is required between two radios for over-the-air testing**
    - » **Antenna mounted on the roof of test facility and Second Radio do not always have LOS**
    - » **Flight test aircraft and antenna mounted on the roof of test facility (Ground Station) do not always have LOS**
  - —**Movable Second Radio/Ground Station provides LOS**
  - —**Movable Second Radio/Ground Station is suitable for radio range testing**
- **GPS receiver testing**
  - —**GPS Receiver in the lab is stationary**
  - —**GPS Receiver is usually tested in an environment where interference and multi-path conditions are present**
  - —**Movable test bench with GPS receiver is suitable for GPS accuracy testing that requires moving test bench to different locations**

Need for Test Asset Mobilization (Cont.)

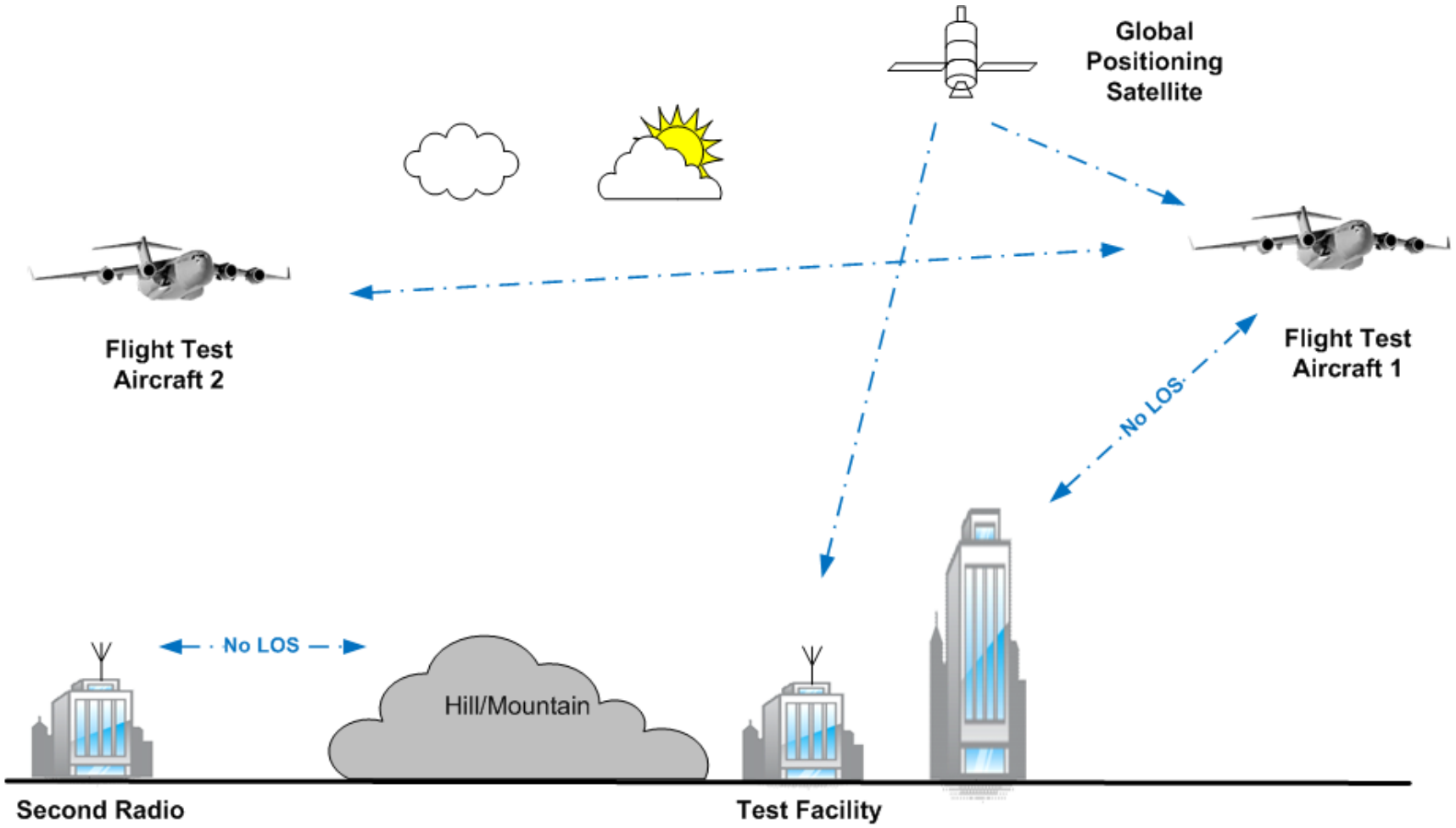

Fig. 2 : Communication System/Subsystem Testing and LOS Problem

Test Asset Mobilization

Project Planning

- **Effective planning is essential to project success**
- **Project Planning**
  - **Identify project objectives**
  - **Identify what is need to be done, when, and in what sequence**
  - **Identify required resources**
  - **Identify constraints**
  - **Identify deliverables**
- **The project plan should be verified and agreed by key stakeholders**

Requirements Identification

- Develop concept of operation
- Identify constraints
  - —Physical
  - —Electrical
  - —Enviornmental
- Define requirements
  - —Functioinal
  - —Operational
  - —Environmental
  - —Transportability
  - —Maintainability
  - —Safety

Design Considerations

- **Rack Mount Enclosure**
  - —**Size**
  - —**Ease of handle and transportation**
  - —**Ruggedness to withstand transportation**
  - —**Ventilation and cooling**
- **Rack Cooling**
  - —**Clean environment**
    - » **Perforated rack and cooling design with blowers at the bottom and exhaust fan at the top**
    - » **Space above and below the test equipment**
    - » **Air plenum and ducting if LRUs required forced air cooling**
  - —**Dusty environment**
    - » **Fully sealed rack**
    - » **Internal cooling system such as liquid cooling or rack air conditioner**

Design Considerations (Cont.)

- **Weight Distribution**
  - —**Distribute weight for lowerst center of gravity for increase stability**
  - —**Heaviest equipment such as power supplies located in the bottom**
  - —**Distribute weight evenly from left to right, front to back**
- **Power**
  - —**Aircraft LRUs require 28VDC or 115VAC 400Hz or both for their operation**
    - » **28VDC and 115VAC 400Hz power is not commonly available in the field**
    - » **28VDC and 115VAC 400Hz power supplies that can operate from 115VAC 60Hz power within the test station**
    - » **Total LRU power consumption must be determined before selecting suitable power supplies**
  - —**Circuit breakers for the LRUs and test equipment**
  - —**Emergency power off button in the front of the test station**

Design Considerations (Cont.)

- **Wiring and Interconnects**
  - —**Wiring**
    - » **Suitable wire size based on power consumption**
    - » **Twisted shielded pair wires to reduce the noise**
  - —**Grounding**
    - » **Proper grounding for safety**
    - » **Proper grounding to reduce the noise**
  - —**Connectors**
    - » **Proper connectors for the LRUs, power supplies, test equipment, and interconnects**
      - **Locking mechanism to maintain contact during movement**
      - **Different keying to ensures connectors mate to their intended mate**

Design Considerations (Cont.)

- **Maintainability**
  - —**Removal and replacement of parts in the field is often required**
  - —**Design and installation should provide best possible visual and physical access**
  - —**A high level of modularity for field maintenance**
- **Operations**
  - —**Test station needs to be operational in a short time after placement in the field**
    - » **Simple and quick interconnections and setup**
  - —**Test station layout is influenced by the way operator interfaces with the test equipment**
    - » **Average height of operator**
    - » **Position of operator**
    - » **How operator interfaces with the system**

Assembly Considerations

- **Movable test station will be transported and used in the field on an ongoing basis**
- **Assembly precautions must be taken to prevent possible damage to the equipment and wiring during movement**
  - **Equipment, panels, and trays are properly installed and right screws are used to avoid problem due to vibration during transportation**
  - **Wires and cable bundles placed in the sleeving to provide proper insulation to avoid friction**
  - **Wires and cable bundles routed properly using wire ties and strain reliefs to minimize the stress and prevent contact with rough or irregular surfaces and sharp edges to avoid damage to conductor**

System Verification

- System verification tests are performed to ensure test station meets the requirements
- Electrical testing
  - —Wiring continuity
  - —Voltage
  - —Current
- Functional testing
  - —Lab testing
    - » To ensure system meets the functional and operational requirements
  - —Field testing
    - » To ensure system meets the functional, operational, environmental, and transportability requirements

System Installation

- Selection of right transportation system
  - —House test station, test equipment, and test personnel
  - —Serve as a test facility in the field
- Space
  - —Test station
  - —Test equipment
  - —Test personnel to conduct test
- Provisions to secure test station and test equipment for transport
- Power
  - —Onboard power generator
- Heating and cooling for test personnel

Case Study

- **Project**
  - **A movable UHF/VHF ground station was needed to support Air-To-Ground testing to verify clear and encrypted voice and data communication of a new Enhanced Multiband Radio in a large military transport plane undergoing a communications systems upgrade**
  - **Develop a movable UHF/VHF ground station consisting of UHF/VHF radio, encryption unit, radio control, and user interfaces**
  - **This setup is needed for LOS communication between the flight test aircraft and the ground station required for UHF/VHF over-the-air testing**

Case Study (Cont.)

- **Project plan**
  - —**Identify project objectives**
  - —**Identify tasks and associated duration**
  - —**Identify resources**
  - —**Identify deliverables**
- **Requirements**
  - —**Concept of operation**
  - —**Identify constraints**
  - —**Define requirements**
- **Selection of transportation system**
  - —**Van with onboard power generator capable of generating 115VAC, 60Hz power**
  - —**Sufficient space for test station, test equipment, test personnel**

Case Study (Cont.)

- **Selection of Rack Mount Enclosure**
  - —**Size**
    - » **House all equipment**
    - » **Fit in the van**
  - —**Perforated rack was selected since radios and encryption unit can be operated with ambient cooling**
  - —**Communication control unit however requires forced air cooling so the mounting tray with built in fan and air plenum was designed**
  - —**Lifting eye bolts to tie down the rack to the floor of the van and forklift slots at the bottom for easy installation and removal**
- **Rack power**
  - —**Two power supplies**
    - » **One for each radio for redundancy**
  - —**Power control panel**
    - » **Circuit breakers for all equipment**
    - » **Emergency power off button**

Case Study (Cont.)

- **Weight distribution**
  - —**Power supplies and Communication Control Unit are mounted at the bottom for low center of gravity**
  - —**Panels and equipment are distributed front and back for better weight distribution**
- **Quick Setup and Maintainability**
  - —**Disconnect panels for power and signal in and out of the rack**
  - —**Hinged panels for access inside the rack**
  - —**Connectors**
    - » **Labeled for quick setup and maintenance**
    - » **Locking mechanism to maintain contact during movement**
    - » **Different keying to avoid connection mistakes**

Case Study (Cont.)

- **Rack Assembly**
  - —**Wires and cable bundles placed in the sleeving to provide proper insulation to avoid friction**
  - —**Wires and cable bundles routed properly using wire ties and strain reliefs to minimize the stress and prevent contact with rough or irregular surfaces to avoid damage to conductors**
- **Verification**
  - —**Lab testing**
    - » **Hardware level testing to verify power and wiring continuity**
    - » **Radios antenna ports connected through attenuator to verify the radio control as well as transmission and reception**
  - —**Field testing**
    - » **Install rack in the van and transport to the test site**
    - » **Over-the-air live testing between the radios located in the lab and the radios in the van**

Case Study (Cont.)

- **Project Outcome**
  - **Movable UHF/VHF ground station was deployed in the field and successfully supported the Air-To-Ground testing that verified clear and encrypted voice and data communication of new Enhanced Multiband Radio in the aircraft**

Conclusion

- **Successful mobilization of test asset**
  - —**Project planning**
    - » **Identify project objectives**
    - » **Identify what is need to be done, when, and in what sequence**
    - » **Identify required resources**
    - » **Identify constraints**
    - » **Identify deliverables**
  - —**Requirements identification**
  - —**Design and fabrication**
    - » **Movable test asset design is heavily influenced by the environment in which the test station is to be used and portability**
    - » **It is importand to identifiy the design constraints since the design constraints place an overall boundary around the system design process**
  - —**Assembly**
  - —**Verification**
  - —**Installation**