49th Annual NDIA Conference
Targets, UAVs & Range Operations
Symposium & Exhibition

Boeing QF-16 Program – Ready for Test

QF-16 Full Scale Aerial Target
Boeing Global Services and Support
Maintenance, Modifications, & Upgrades
Aircraft Sustainment & Maintenance

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QF-16 Chief Architect
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Boeing Targets / Decoys / UAS

- Cost Effectively Converting Highly Reliable, NDI Air Vehicles
- Providing Foundation for New Development Programs
- Boeing’s Systems Integration Expertise and Teaming
- Application of Boeing Critical Technologies
- Synergy Among Our Targets, Unmanned Systems, and Weapons Programs
QF-16 Overview

Key Features
- Follow on for QF-4 Program: Supersonic, High-G, Heavy Payload Capability
- Satisfies Title 10 "Live Fire/Lethality"
- Provides 4th Generation Threat Representation

GRDCS/DFCS
QF-16 FSAT Roadmap
Meets All Government Milestones

Government Roadmap

- A/C Deliveries (6 F-16)
- DT/OT IOT&E Tyndall WSMR
- FRP/Deployment/Sustainment

Contractor IMS

- SRR
- CDR
- SVR1
- PRR
- SVR2
- Pre-EMD
- EMD
- LRIP
- FRP

- Support
- Flight Tests
- Ground Tests
- Build
- Develop
- Design

- Lot 1 LRIP Build 20 A/C*
- Lot 2 Build 25 A/C*
- Lot 3 Build 25 A/C*
- Lot 4 Build 25 A/C*
- Lot 5 Build 25 A/C*

* Contract BEQ


- 6 QF-16 A/C
- 6 A/C
- 18 A/C
- Lot 2
- Lot 3
- Lot 4
- Lot 5

MSA
CA
MSB
MSC
RAA
IOC

MS
A

S
P
S

APPROVED FOR PUBLIC RELEASE
QF-16 Design meets Mission Requirements

- 4th Gen Threat
- F-16 Maneuverability
- Minimized impact to RCS
- Countermeasures
- 120nm GRDCS datalink
- Weapon accuracy scoring
- Range Safety – Flt Termination
- Piloted & Unmanned
- Reliable
- Supportable – Test Equipment
- Growth – Phase II Air Superiority Target (AST)

The QF-16 is designed for Mission Success
Overview of DPE Installations

VAS – Visual Augmentation System

URAP – Universal Remote Auto Pilot

AFCC Automatic Flight Control Computer

FTS – Flight Termination System

PCS – Payload Control System

VAS – Visual Augmentation System

VSS – Vector Scoring System

Backup Altimeter

Autothrottle

CTS – Command Telemetry System

Cockpit Panels
Drone Conversions Underway at Cecil

- Cecil Field Recovery of first F-16
  - On time readiness
  - Trained and experienced support personnel

Lean cellular production supports affordable, high quality, on time performance
Exceeding Expectations

Product Improvements

- **CTS:**
  - Improved TVI clock/position
  - Improved data latency
  - Improved frequency stability
  - Antenna switch feedback
  - Surge suppression

- **Payloads:**
  - Increased payloads power
  - All 8 wing stations active
  - Pre-wired spare payload discretes
  - Modular payload design for easy programmability

- **Vector Scoring:**
  - Improved scoring coverage
  - Shock isolated TRIM units for improved scoring accuracy

- **Low profile antennas for RCS**
- **URAP available for improved navigation accuracy & GPS/TCS growth path**
- **More than double reliability**
- **Spare I/O available for growth**
- **Improved BIT and fault isolation/detection**
- **RCC-319 compliant Flight Termination System**

*The current QF-16 design improves on a successful QF-4 design*
QF-16 Peculiar Support Equipment (PSE)

- Ground Servicing Screen with B1 stand for safe cockpit exit after engine start
- PSE Communicates with QF-16 through dedicated maintenance connectors and RF
- Portable Flight Line Tester for OFP load, system initialization, and diagnostics
- Trailer-mounted Automated System Test Set for Acceptance and Pre-Mission Testing
Airborne System Architecture (Software View)

Systems With Major Airborne Software Components Highlighted in Blue

Ground Systems
- PSE
  - ASTS
  - PFLT
- GRDCS/DFCS

Airborne Systems
- DPE
  - VSS
  - AFCC
  - CTS
  - URAP
  - Radar Altimeter

Discrete connections not shown to keep diagram simple

GFE  Boeing  RF Link
All QF-16 Sim Models and Products Autocoded From Central Simulation

Configuration Managed Environment

**MATRIXx or Matlab**
- Design Tools
- Analysis Tools

**Air Vehicle Sim (AVSIM)**
- AFCC SW
  - Boeing SW
  - BAE SW
- 6DOF Sim
- Vehicle/Environment Models

**SIL**
- Vehicle Model
- AFCC

**GRDCS Simulation**

**Flight Test**

**Telemetry/Flight Data for Analysis**

**AutoCode Legend**
- QF-16 Sim
- A/V Environment
- AFCC Embedded Code
- TM Data
GRDCS Operations

GRDCS Manual Mode

- Controller inputs manual command (e.g. stick, throttle)
- Controller flies autopilot modes (e.g. altitude hold, speed hold)
- Controller initiates maneuvering

GRDCS Auto Mode

- GRDCS computes required commands (e.g. stick, throttle)
- GRDCS is controlling aircraft flight path
- Controller still initiates maneuvering (breaks Auto mode)
- Onboard software behaves the same whether in auto or manual mode

Onboard Auto Sequences

- All Attitude Recovery (AAR)
- Automatic Takeoff (ATO)
- Takeoff Abort (TOA)
- Escapes
- Autonomous (e.g. Loss of Comm)

Verifying Integration of GRDCS and DPE Software is an Important Development & Risk Reduction Activity
SIL Lab Layout Diagram – Pilot Station

- Cockpit View
- Observer View
- CsGTI PC
- COTS Stick
- COTS Throttle
- COTS Pedals
QF-16 Levels of Vehicle Control and General Control Law (CLAW) Architecture

Three Levels of Controlling the QF-16

1. **GRDCS**
   - Includes loop closures & logic for trajectory control
   - Takeoff, Landing, and Crosstrack Control

2. **Mode Logic & Sequencing**
   - Uplink

3. **Programmed Maneuvers**
   - Downlink
   - Barrel Roll
   - All Attitude Recovery
   - Loss of Comm Maneuver

4. **Basic Control Laws**
   - Stick, Pedal and Throttle Commands To F-16 Flight Control Computer
   - Pitch Rate and Attitude Hold
   - Roll Rate and Bank Angle
   - Speed Hold
   - Baro Altitude Hold
   - Radar Altitude Hold
   - Wings Level

5. **Ground Control Software**
   - On-Aircraft Control Software Inside the AFCC

6. **On-Aircraft Control Software**
   - Boeing Application Software

7. **Original Equipment**
   - Government Furnished Equipment
   - Safety Pilot (Optional)
FQT Test Definition Process

Requirements

Traceability

Test

DOORS QF-16 Software Requirements

Block Diagrams

Cmd_Mixer

Throttle

Roll/Yaw

Pitch

All Software Components

Test Matrix DB

FQT Test Definitions

Test Allocation To Test Environment

AVSIM & BAE Desktop

SIL

Flt Test

Component and System Level Tests

All Aspects Are Under Configuration Controlled

Verification Testing

Requirements Verified In:

• Verification Tests
• System Level Tests
Growth Potential

- **GPS Navigation** -
  - Accurate aircraft state estimation during all flight phases
  - Accurate heading and gyro bias estimation reduces risk
  - Mature navigator used on X-45, Phantom Eye, JDAM, SDB, others

- **Leverages Boeing’s experience and proven autonomous system software**
  - Guidance, Navigation, and Control Software
    - Autocode development process improves quality, reduces costs and schedule
  - Autonomous System Operation
    - Reduced manpower costs in support of QF-16 FSAT CONOPS
    - Improved mission assurance and first time quality
    - Improved safety, accuracy, and repeatability
    - GRDCS controlled autonomous system operation

- **QF-16 Operation at Alternate Test Ranges**
Program Summary

• The Boeing QF-16 Program leverages QF-4 supply base and maximizes the use of existing hardware and software capabilities to provide a low risk drone peculiar equipment solution.
