



AFOTEC Case Study: F-22 Air Combat Simulation (ACS) Verification and Validation (V&V)

**FAA V&V Conference
20 Oct 2011**

**Jeff Olinger
Technical Director**



Overview



- **AFOTEC Background**
- **VV&A Process**
- **ACS Description/capabilities**
- **V&V Requirements**
- **V&V Plan/execution**
- **VV&A Results**
- **Lessons Learned**

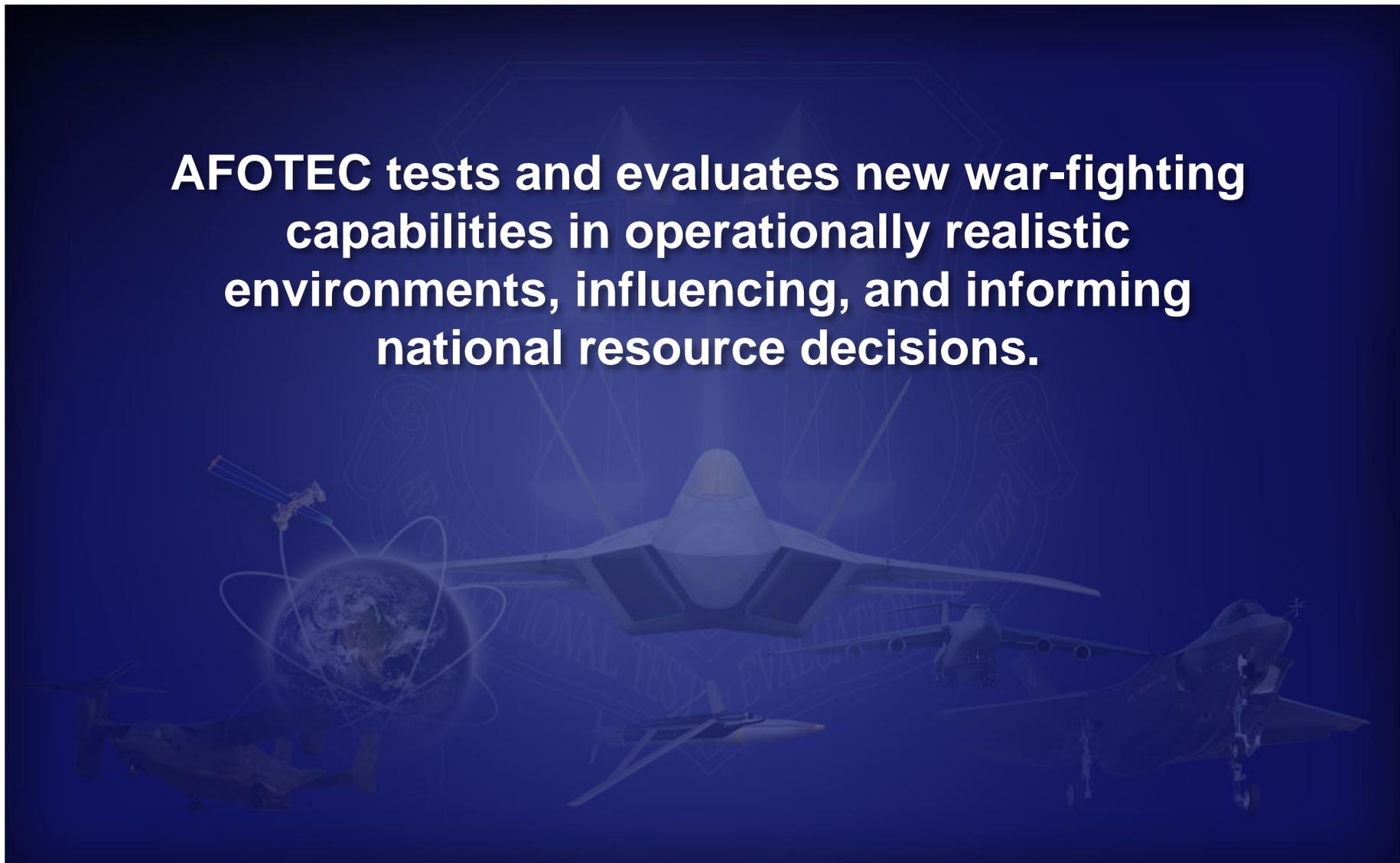




AFOTEC Mission



AFOTEC tests and evaluates new war-fighting capabilities in operationally realistic environments, influencing, and informing national resource decisions.





Scope & Responsibilities



- **Independent operational test agency for AF**
 - Reports directly to CSAF
- **Operationally tests all Acquisition Category I, II, & oversight programs**
 - Required by USC Title 10
 - Guidance & direction from DoD 5000-series
 - **ACAT I**
 - > \$365M RDT&E
 - > \$2.19B Procurement
 - **ACAT II**
 - > \$140M RDT&E
 - > \$660M Procurement





Roles & Missions



- **Operational testers test the “as is” system**
- **Developmental testers test the “to be” system**

Government Developmental Test exists to insert user inputs into the design and development cycle phase early on. Contractual agreements require trained government DT professionals as partners with industry, otherwise unconstrained cost growth and delays in fielding can occur.

Transparent Planning and Operations



Roles and Responsibilities



- **DOT&E**

- Issuing DoD OT&E policy & procedures
- Approves operational test plans for test adequacy
- Reviewing & analyzing results of OT&E for MDAPs
- Providing independent assessments to SecDef, USD(AT&L), & Congress

- **AFOTEC**

- Initial Operational Test & Evaluation, Qualification Operational Test & Evaluation, Follow-on Test & Evaluation, Operational Utility Evaluation (OUE), Operational Assessment (OA)

- **MAJCOMs**

- Force Development Evaluation, Tactics Development & Evaluation, Weapons System Evaluation Program, OUE, OA



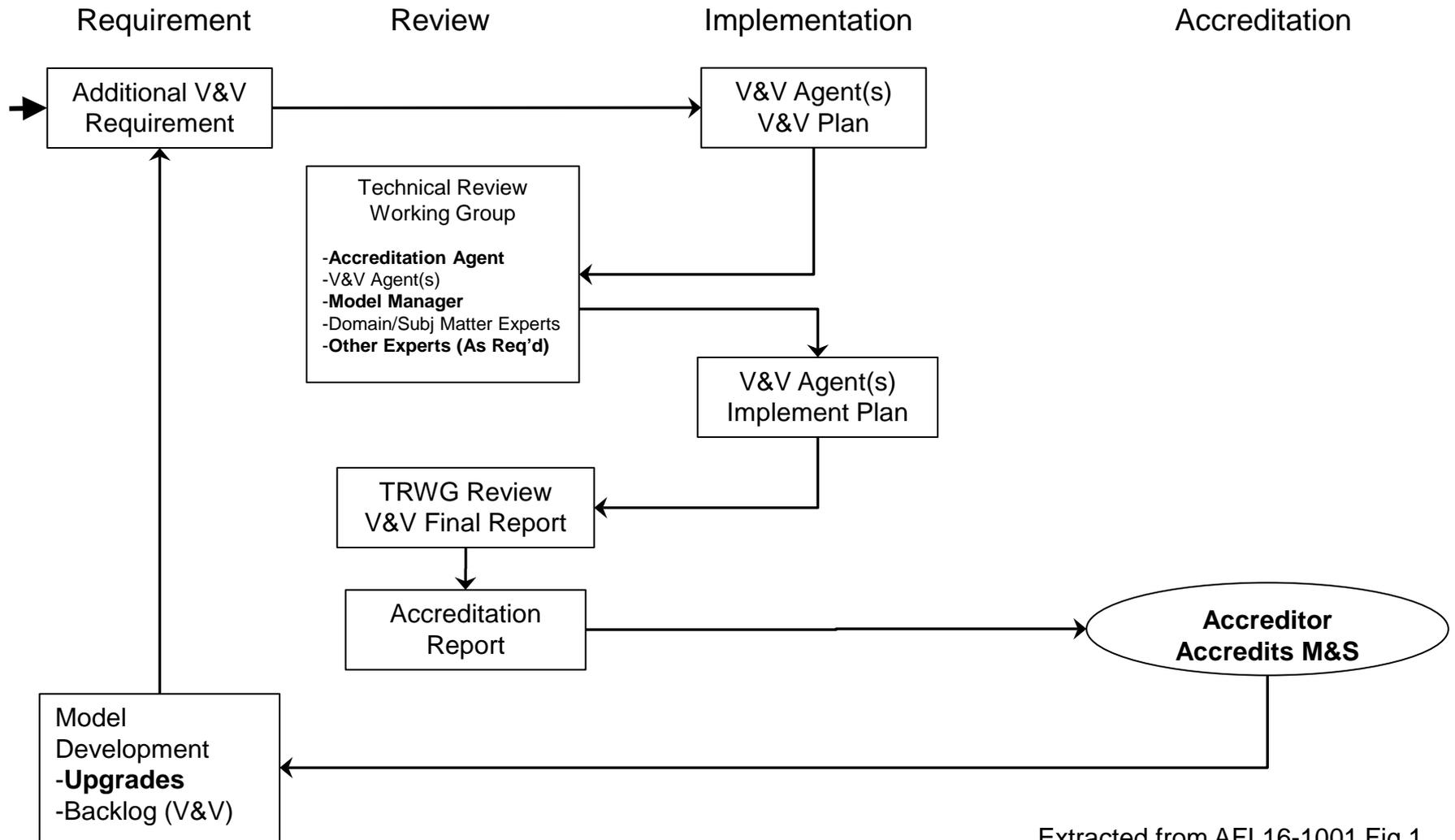
V&V Foundation



- **Different V&V requirements for different applications**
 - Technical documentation
 - Data sources
 - Software
 - Test Capabilities
- **Common elements**
 - Purpose and process description
 - Documentation standards
 - Employ agent-based activities to support accreditation
 - Criteria to assess risk of use



Air Force VV&A Process



Extracted from AFI 16-1001 Fig 1



ACS Fundamental Requirements



- **Installed system performance**
 - Production representative system
- **Software-in-the-loop**
 - Actual software complexity & limitations
 - Realistic loading on sensor allocation / timelines
- **Man-in-the-loop**
 - Man-machine interface critical to overall evaluation
 - Thinking / reactive adversary for realistic operations
- **Seamless mission flow & realistic relationship between operational tasks**



ACS Use in F-22 IOT&E



- **Specifically created to support operational effectiveness evaluation during F-22 Engineering & Manufacturing Development (EMD)**
 - Simulation requirements for IOT&E developed early in the EMD program
- **Extensive usage during IOT&E preparation & execution**
 - Pilot training
 - Test development exercises
 - Culminated in “Test-the-Test” missions
 - Formal verification & validation (V&V)
 - Accreditation by AFOTEC
 - 5 weeks / 152 trials during formal evaluation



ACS Description



F22 RAPTOR **JSF**

Primary ACS Elements

DIADS / SAMs

AWACS

Pilot Briefing Rooms
- ODS
- VBMS

4 High Fidelity F-22 Cockpits

Control Room

Viewing Room Video Wall

8 Adversary Aircraft Control Stations

Lockheed Martin Aeronautics Company



ACS Capabilities



Fly Scenarios Not Possible in Open Air Range

Reactive Countermeasures & Counter-Maneuvering

Provides Postulated Future Threats

Blue AWACS

ECM & ECCM Effects

Realistic Threat Tactics

Real Time Many v Many

Representative Threat IADS

Realistic Airspace Size versus Limited Range Airspace

Large Sample Size

Real Time Kill Removal

Repeatable Test Environment

All High Fidelity Threats (No Surrogates)

Simultaneous Air-to-Air & Surface-to-Air Battle Environment

200 Active Aircraft

Dense Battle Environment

Large Numbers of Manned Threats

Atmospheric & Terrain Effects

State of the Art Computer System

Manned Aircraft in MICS (Red & Blue)

GCI Stations

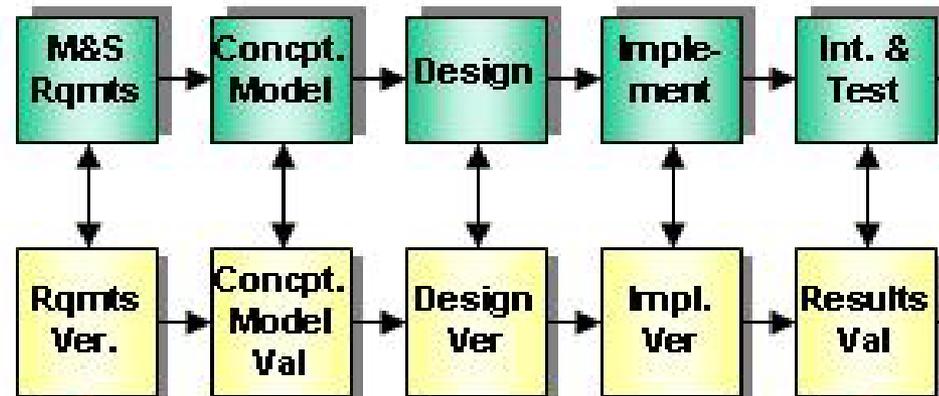
Four OFP-ITL F/A-22 Verification Cockpits in WASPs



V&V Requirements



- **Cost: Contractor proprietary**
- **Schedule: 3 years**
 - Focus on reuse, re-hosting of existing software/models
- **Performance: 10% rule**
 - Functional
 - Operating
 - Fidelity





ACS Models



- **Requirements identification key to VV&A success**
 - Includes models, modifications, and interfaces
 - Threat Model Analysis Program (TMAP)
 - Fidelity requirements focused on System Under Test (SUT) capabilities
- **Create models/modify ACS**
 - Verify stand-alone models and modifications
- **New/modified models integrated into ACS**
 - Verify integrated performance
 - As model suppliers, IPCs* must work closely with ACS
 - Support fidelity of interaction with other ACS models
 - Real-time requirements

* IPC: Intelligence Production Center (NASIC, MSIC, ONI)



V&V Plan



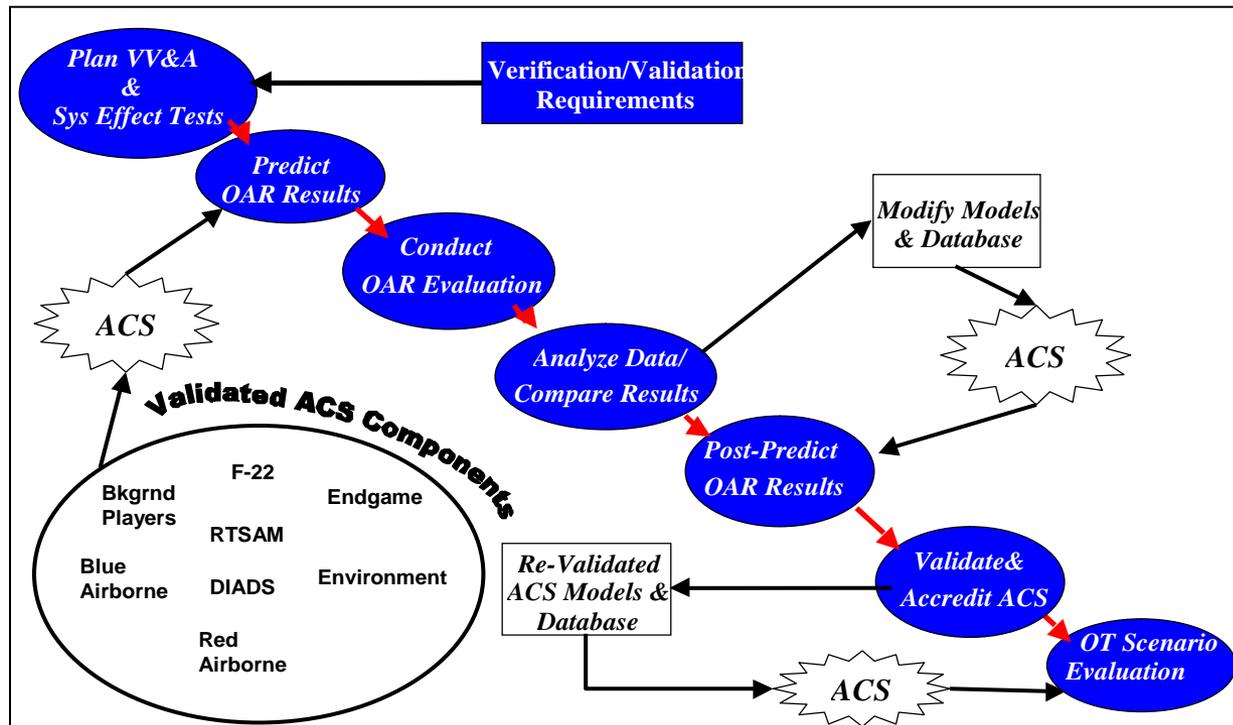
- **Accredit ACS for a specific purpose**
 - Evaluate aspects of F-22 performance not obtainable in OAR
 - ACS provides “test for score” environment
- **V&V each ACS element and ACS as a whole**
 - Aircraft (F-22)
 - Digital Integrated Air Defense System (DIADS)
 - Blue and Red airborne players/threats
 - Real time surface to air missile (RTSAM)
 - Background (player density)
 - Environment (ECM, clutter, weather)
 - Endgame
- **Separate plans...single report approved by Commander**



V&V Plan



- **Used Simulation, Test and Evaluation Process (STEP)**
 - **Goal: Give Commander sufficient information to make sound decision about using ACS for F-22 OT&E**





V&V Execution



- **Verification**
 - Prime contractor and major subcontractor efforts
 - Government Labs
 - Intelligence Centers
- **Validation**
 - Conceptual model validation
 - Results validation
 - Correlation to testing validation
 - Face validation
- **Validation Working Groups (VWGs)**



Validation & Accreditation



- **Validate performance**
 - **Validation Working Groups (VWG)**
 - Stakeholders supported by appropriate subject matter experts
 - **Correlation to Open Air Range (OAR) is capstone event**
 - Test-the-Test (TTT)
 - **Correct defects – re-verify/re-validate as required**
- **Accreditation by AFOTEC**
 - **V&V process supports accreditation with continuous documentation**



Test-the-Test (TTT) Process



- **TTT is the final step in validation**
- **OAR modeled with anticipated test conditions**
 - TMAP followed for exploited or surrogate threats in OAR
 - Executed with same procedures, safety limits, etc. as the OAR
 - Participants same as OAR – OT&E & Aggressor pilots, etc.
- **Results compared following OAR testing**
 - Quantitative metrics: mission-level and supporting MOEs
 - Face validation based on participant comments
- **Deltas are investigated and explained**
 - Differences in test conditions or procedures identified
 - Changes to models assessed & implemented as required
- **TTT re-fly**
 - Conduct if necessary
 - Correlation of virtual & OAR results must satisfy accreditation authority



V&V Results



- **Functional verification by contractor teams**
- **ACS validated by AFOTEC**
 - 98 component experiments
 - Flew 2500+ simulated sorties over 21 weeks
- **Limitations (all minor)**
 - Four for F-22 system models
 - Four for blue airborne models
 - Two Digital Integrated Air Defense Systems
 - One each red airborne model, background player, endgame, environment
- **ACS accredited for use in F-22 OT&E**



Lessons Learned



- **Attributes for VV&A success**
 - **Models created with fidelity focused towards replicating installed system performance required for mission level evaluation**
 - **Know conditions/variables that drive sensor performance**
 - **Identify data sources that support validation**
 - **DT scope & methodology are backbone to validation**
 - **Know SUT capabilities & user CONEMP**
 - **VV&A must occur at the subsystem, system, and system of systems levels**



Summary



- **Complex V&V effort**
 - Player interactions
 - Man-machine interfaces
- **Required to accomplish F-22 evaluation**
 - Represent realistic operational environment
 - Mitigate test range limitations
- **Keys to success**
 - Early influence
 - Leverage existing guidance and practices
 - Teamwork
 - Document work





Questions?