



# ***F-35 Corrosion Program***

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# Fleets F-35 will Replace

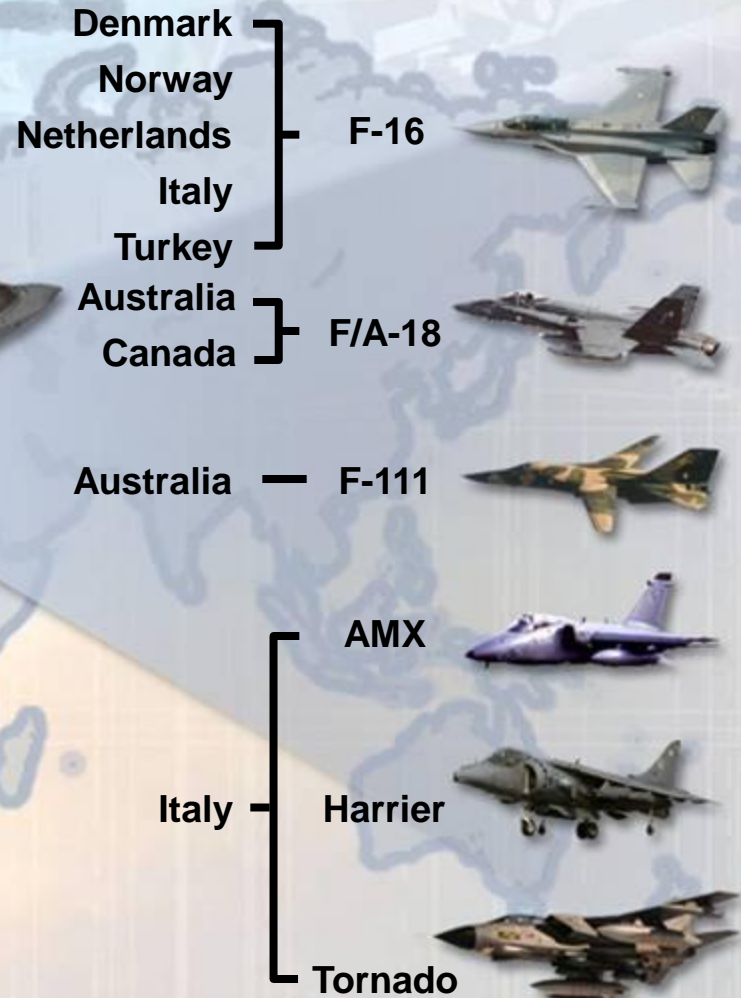


## Domestic and UK



**F-35  
Joint  
Strike  
Fighter**

## International





# JSF Family Of Aircraft

One Program -- Three Variants  
Meeting Service and International Needs



## Conventional Take-Off and Landing (CTOL)

## Carrier Variant (CV)

Larger Wing and Horizontal Tail Area

In-Flight Refueling Door (Boom)

Probe and Drogue Refueling (Basket)

Internal 25mm 4-Barrel Gattling Gun

Strengthened Landing Gear and Tailhook

Wingfold and Ailerons Added

Centerline Gun Pod with 25mm Gun

## Short Take-Off and Vertical Landing (STOVL)

Probe and Drogue Refueling (Basket)

3-Bearing Swivel Nozzle

Lift Fan

Roll Posts

### All variants

- 450-600 nm Range
- 1.6 Max Mach (Limit)
- Stealthy
- Same Weapons
- Similar Avionics
- Similar Flight Envelope
- Same Basic Engines



# F-35 Characteristics



- **Key Attributes:**
  - **Stealth**
  - **Integrated Avionics**
  - **A/G Munitions**
  - **Intraflight DL**
  - **Adv A/C Survivability**
- **General Features**
  - **Single seat**
  - **Speed: 750 kts or 1.6M**
  - **Ceiling: 50,000 ft+**
  - **Engine: PW F135; FET F136**
- **Sensors**
  - **Fully integrated open architecture system**
  - **A/G – A/A radar/SAR**
  - **Electro Optical A/G Targeting system**
  - **A/A IRST**
  - **Electronic Support Measures (ESM)**
  - **Short range EO spherical coverage**



**CTOL**  
Length: 51.4 ft  
Wing Area: 460 ft<sup>2</sup>  
Weight (Empty): 29,036 lbs  
Internal Fuel: 18,840 lbs  
Range: 600 + nm

**STOVL**  
Length: 51.1 ft  
Wing Area: 460 ft<sup>2</sup>  
Weight (Empty): 32,161 lbs  
Internal Fuel: 14,003 lbs  
Range: 500 + nm

**CV**  
Length: 51.4 ft  
Wing Area: 668 ft<sup>2</sup>  
Weight (Empty): 32,072 lbs  
Internal Fuel: 20,085 lbs  
Range: 600 + nm

**LETHAL SURVIVABLE SUPPORTABLE INTEROPERABLE**



# JSF Team Prime and Major Sub-Contractors



**NORTHROP GRUMMAN**

- Center Fuselage
- Weapons Bay Door Drives
- Arresting Gear
- Carrier Version (CV) Control and Test
- Radar
- Software
- Low Observable Support System
- Training Courseware and Management Systems

**BAE SYSTEMS**

- Aft Fuselage
- CV Wing Fold
- Fuel System
- Crew Escape
- Life Support
- EW System
- U.K. Support Center
- Throttle/Side Stick
- Horizontal/Vertical Tails
- Flight Control Computer
- STOVL Control and Test
- U.K. Rqts/Stores/SW



**LOCKHEED MARTIN**

Prime Contractor

- Air System Verification
- System Integration
- Mate Through Delivery
- Edges & Control Systems
- Autonomic Logistics
- Mission Systems
- Vehicle Systems
- Training System
- Forward Fuselage
- Wing



# The Pipeline



- Approximately 100 Aircraft in Flow (LRIP 1 – LRIP 5)
- Will Have Fielded ~ 50 Aircraft by The End of CY12
  - *Will need pilots and maintainers trained through the ITC to support Fleet expansion*



**Academic Training Center**



**JSF Squad Ops/AMU Hangars**



# Corrosion Program



# Background

- **HASC directed OSD Office of Corrosion Policy and Oversight to conduct an evaluation of the F-35**
  - *Corrosion Evaluation Team (CET) assembled*
  - *Conducted site reviews at JPO and 5 contractor facilities*
  - *Similar reviews were also conducted at F-22 sites*
- **CET findings reported back to the HASC**
  - *Drawn extensively from F-22 lessons learned*
  - *F-35 JPO response provided as an attachment to the report*



# CET Finding Change Management

- **CET Concern:** Risk that equipment tested to lower corrosion requirements based on location will not be re-qualified to standard corrosion requirements if location or orientation is changed.
- **JPO Response:**
  - *CM Plan requires JPO concurrence of Major B changes*
  - *JPO participates in LM Change Request (CR) technical reviews*
  - *All changes affecting materials must be evaluated by M&P IPT*
  - *Changes potentially affecting corrosion are reviewed at F-35 Corrosion Prevention Advisory Boards (CPAB)*
    - Includes equipment location changes
  - *Many opportunities to identify risk resulting from change*

**Program has Insight into Changes Affecting Corrosion -  
Has Taken Recent Action to Participate in Early CR Reviews**



# CET Finding Use of Magnesium

- **CET Concern:** Aircraft magnesium components are interfaced with aluminum engine anodized gearbox which is not primed/top-coated.
- **JPO Response:**
  - *Magnesium components are coated with best practice coatings*
  - *Additional surface barrier requirements being pursued for gearbox*
  
  - *There are very few Mg components on the aircraft*

**Program Acknowledges CET Finding –  
Is Pursuing Additional Surface Barrier Protection on the Gearbox**



# CET Finding Use of Magnesium

- **CET Concern:** Components qualified by similarity rather than test.
- **JPO Response:**
  - ***Most challenging component was tested by full-scale testing***
    - Chosen based on geometry, environment, location
  - ***Design incorporated best performing coating based on test results***
    - Other components were qualified by similarity using updated coatings
    - No additional testing is currently planned
  - ***JPO and LM continually evaluates new coatings/technologies for future improvements***

**Program Qualification Testing Approach Effective -  
Thorough Assessment of Most Challenging Component**



# CET Finding

## Use of Non-Chromated Paint

- **CET Concern:** Use of water-borne non-chromated primer, especially in non-inspectible areas.
- **JPO Response:**
  - *Primer selected in 2004 tested to military coating spec requirements*
    - Best non-chromated primer (with low VOCs) available at time
  - *Initiated independent testing of baseline primer to failure to compare to legacy chromate failure modes (2010)*
    - May increase required inspections if baseline primer with topcoat is not as effective as 1-2 coats of chromate primer used on legacy
  - *White topcoat is used in all fuselage bays—further reducing risk*
  - *Use of chromated primer in non-inspectible areas still under review*
  - *Assessing DoD/industry R&D efforts of other non-chromated primers*
    - Pursue improvement if/when technology readiness warrants



# CET Finding Flexure Testing

- **CET Concern:** Corrosion Testing does not include fully representative operational situations (flexing of joint under loading conditions).
- **JPO Response:**
  - ***Conductive gap filler qualification testing included severe spectrum fatigue testing as part of environmental testing***
    - Most susceptible coating component to cracking on legacy platforms
  - ***Representative coatings/gap filler on CG-1 full-scale drop test***
    - Inspections of critical joints have shown no significant damage to coatings during severe aircraft carrier landing conditions
  - ***Representative coatings/gap filler installed on F-16 flight test bed***
    - Inspections have not shown joint issues
  - ***F-18 carrier-based flight testing of LO topcoat in-work***
  - ***There is no current test standard to perform this test***

**Program Acknowledges Legacy Program Challenges –  
Has Taken Steps to Minimize Risk via Surrogate Platforms**



# CET Finding

## Full Scale Climatic Testing

- **CET Concern:** The climatic test may be cut/reduced in scope and may not fully test drainage and corrosion performance.
- **JPO Response:**
  - *The program **will not** reduce climatic test duration / scope*
    - Validated during Summer 2010 Tech Baseline Review
    - Decision made after completion of CET site reviews
  - *Will incorporate legacy program lessons learned*
    - Specific interest in assessing internal drain paths

**Program Actions Have Mitigated CET Concern –  
Robust Climatic Test Planned Incorporating Lessons Learned**



# CET Finding Life Cycle Cost Methodologies

- **CET Concern:** Life cycle cost assessment methodology used for trade studies does not specifically account for corrosion impacts.
- **JPO Response:**
  - *Program method is a parametric based on multiple legacy programs which does not specifically break out corrosion*
    - Similar to methods used for other legacy programs
  - *Will continue to pursue improved modeling*
    - Surveyed Office of Corrosion Policy and Oversight website
    - Working with the CET did not realize better LCC models
    - Will assess whether current legacy program realities can influence current parametric based models

**Program Acknowledges CET Concern –  
Will Continue to Work with OSD to Improve Techniques**



# Lessons Learned from F-22

- **Design**
  - **Reduced use of conductive gap fillers**
    - Fewer than 25% of permanent gaps use conductive gap filler
  - **OML coatings/materials use that are not galvanically dissimilar**
    - System requirements retain risk—not as dissimilar as F-22 baseline
  - **Ensure sufficient internal drainage system**
  - **Specific use of design best-practices to minimize corrosion:**
    - Elimination of aluminum honeycomb
    - Fiberglass barrier ply at composite/aluminum interfaces
- **Process**
  - **Greater participation in industry change management process**
  - **Integration of “standard” and signature M&P communities**
  - **Active management and use of CPAB expertise**
    - Active participation in F-22 CPAB exchanges



# Lessons Learned from F-22



- **Test**

- *Inclusion of sulfuric salt spray and increased neutral salt spray for materials and systems qualifications*
- *Early corrosion testing of conductive gap filler in a representative operational environment.*
- *Extensive testing of full stack-up panel seams with simulated damage exposed to accelerated and outdoor (beach) exposures*
- *Maintaining a robust full scale climatic test*

**F-22 Lessons Learned Have Been Realized –  
Many Industry/Government SMEs Have Transitioned to F-35**



# Summary



- The F-35 has a comprehensive corrosion prevention program
  - *Leveraged legacy aircraft **design lessons learned***
  - ***Integrated the best processes from Navy and Air Force standards***
  - *Focused on early assessment of materials in an operational environment*
  - ***Maintains active engagement in technology development communities***
- The Summer 2010 Technical Baseline Review validated approach
  - ***No significant gaps in design or testing were identified***
- Corrosion is always a systems engineering trade
  - *Suggests a “corrosion-proof” aircraft is unlikely*
  - ***Resulting “corrosion-resistant” design improved over legacy LO aircraft***
- The CET required the JPO to broadly review/defend prior decisions
  - ***Technical consensus of findings did not occur in all cases***



# *Questions?*