



F-35

Corrosion Prevention and Control Programs

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***F-35 Materials and Processes
Collocate from the Air Force
Research Laboratory***

25 March 2009





Overview



- **The F-35 Program – where are we now?**
- **F-35 and Corrosion**
 - *Prevention and Control Methodologies*
 - *Accomplishments*
 - *Thoughts on Maintenance*
 - *Ongoing Areas of Research*



VISION

DELIVER AND SUSTAIN
THE MOST ADVANCED, **AFFORDABLE** STRIKE FIGHTER AIRCRAFT TO
PROTECT FUTURE GENERATIONS WORLDWIDE.

MISSION STATEMENT

BE THE MODEL ACQUISITION PROGRAM FOR JOINT SERVICE AND
INTERNATIONAL COOPERATION.
DELIVER TO OUR WAR FIGHTERS AN **AFFORDABLE** AND EFFECTIVE
NEXT GENERATION STRIKE FIGHTER WEAPON SYSTEM AND SUSTAIN
IT WORLDWIDE.



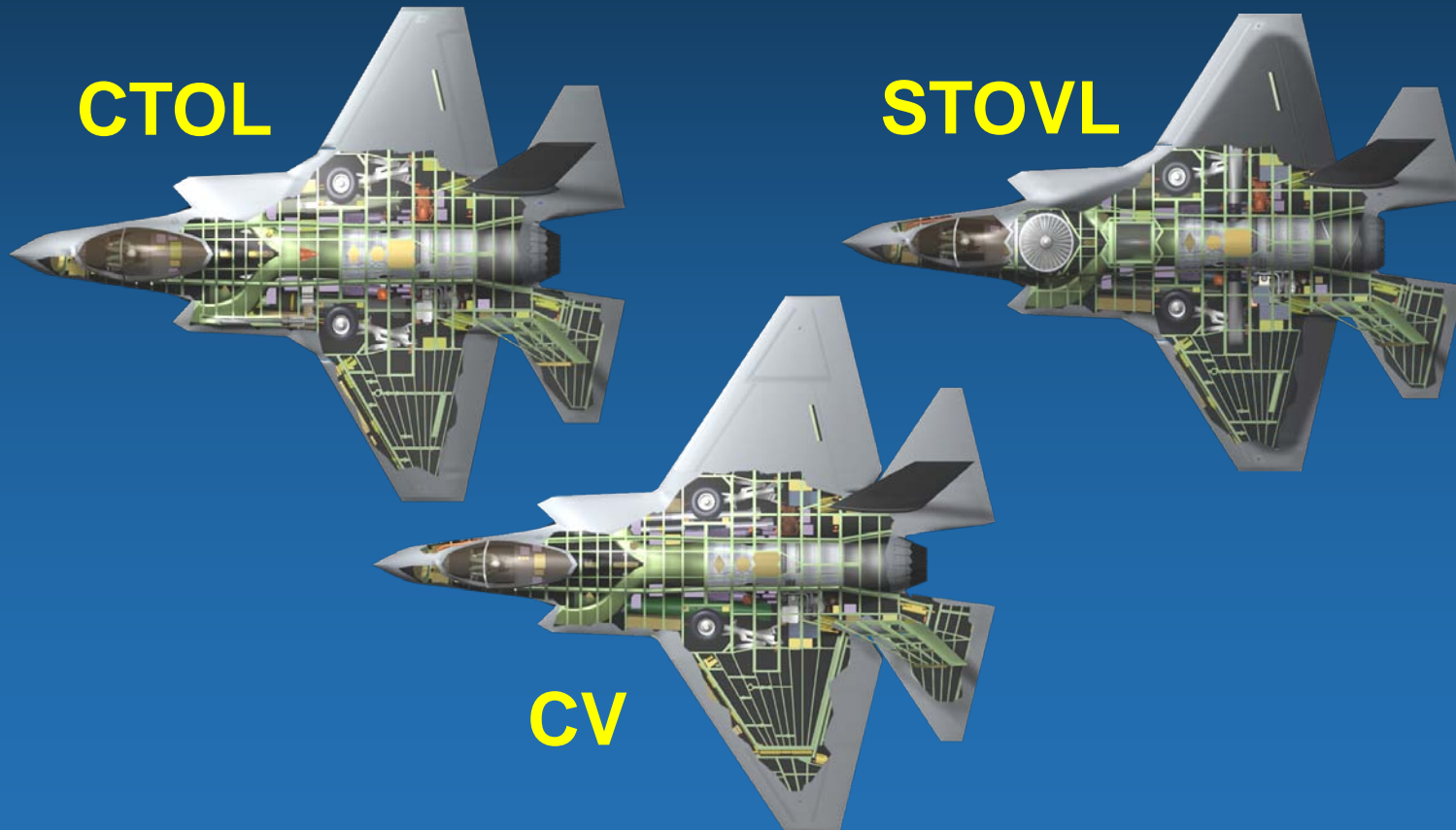


F-35 Family of Aircraft



A family of **affordable**, multi-mission, strike fighter aircraft utilizing matured/demonstrated 21st century technologies

Over 3000 planes to be built!





F-35 Overview



- **Joint Program**

- **U.S. Air Force, Navy, & Marine Corps**
- **International Partners**
 - United Kingdom, Italy, The Netherlands, Turkey, Canada, Australia, Denmark, Norway
- **Security Cooperative Participants**
 - Israel, Singapore
- **Joint Program Office**

- **3 Variants**

- **High Level of Concurrency**
 - **Design, Build, & Test all occurring simultaneously**

- **Primarily constructed from Aluminum, Titanium, and Composites**

Conventional Take-Off and Landing (CTOL) F-35A



Carrier Variant (CV) F-35C

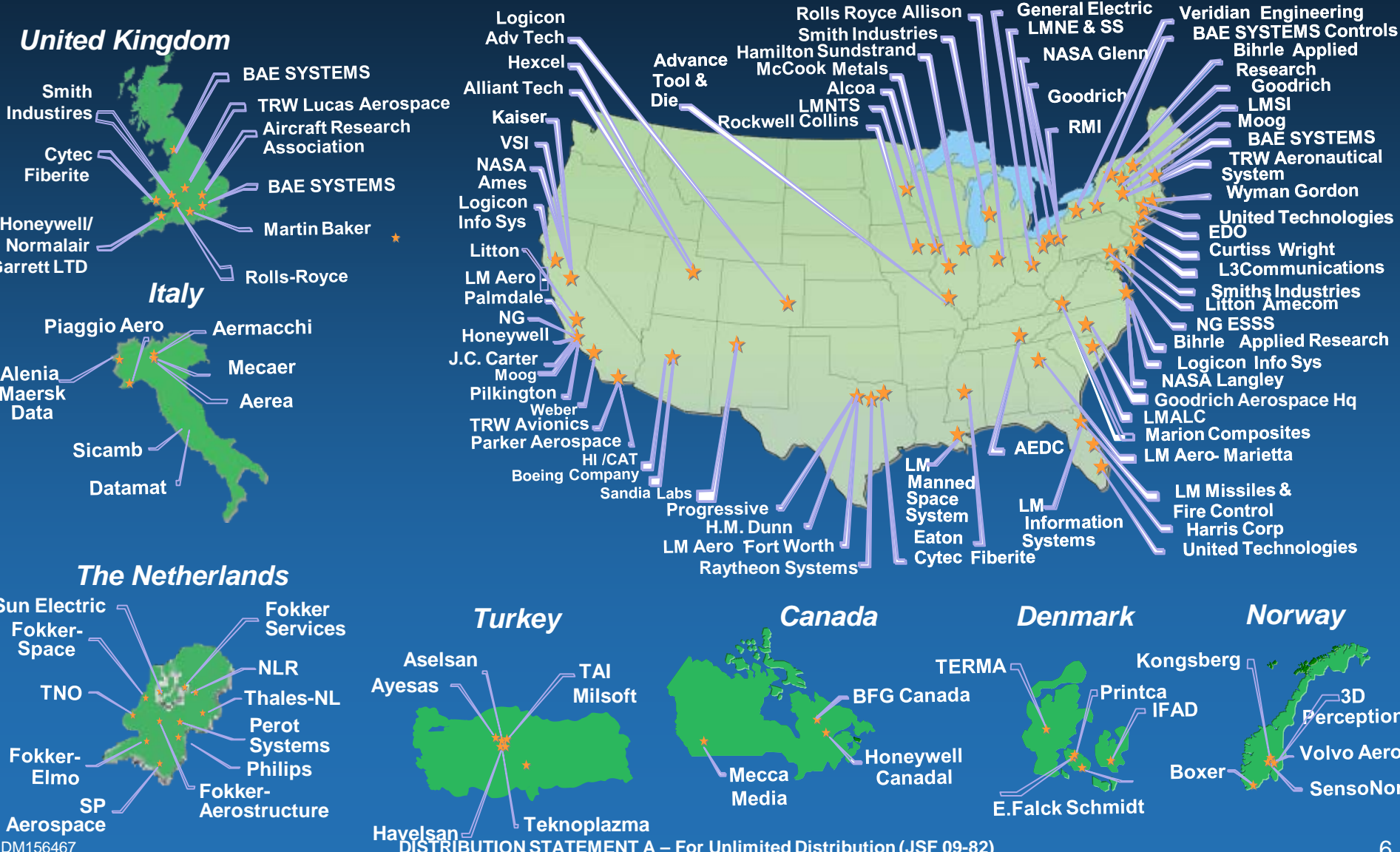


Short Take-Off and Vertical Land (STOVL) F-35B



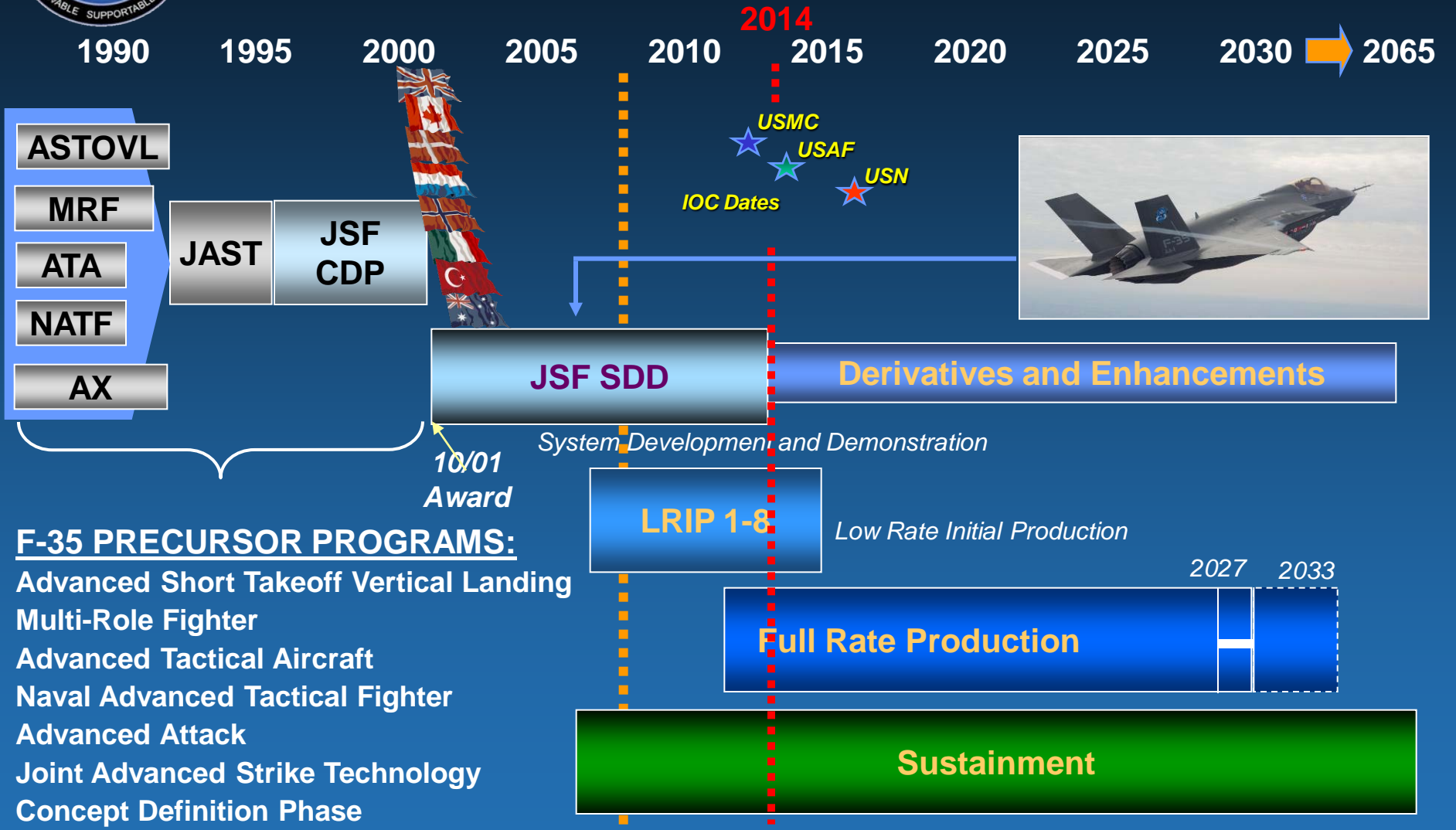


International Supply Base





F-35 Acquisition Timeline



- F-35 PRECURSOR PROGRAMS:**
- Advanced Short Takeoff Vertical Landing
 - Multi-Role Fighter
 - Advanced Tactical Aircraft
 - Naval Advanced Tactical Fighter
 - Advanced Attack
 - Joint Advanced Strike Technology
 - Concept Definition Phase

F-35 Passing Through The Eye Of The Needle



Current Milestones

(as of 13 March 09)



- **AA-1 has over 100 flight test hours**
- **First F-35A to make First Flight in June 2009**
- **First F-35B STOVL mode operations (Hover Pit) around March 2009**
- **First F-35C to roll off assembly line around May 2009**
- **19 aircraft currently in assembly or flight/ground test, including all of LRIP 1 aircraft and beginnings of LRIP2**
- **By the end of 2009, all SDD aircraft are scheduled to be completed**



What will the F-35 Program look like in 5 Years (2014)?



Producing 130 AC/Yr



Supporting 210 Field Aircraft



20 AC in Operational Test



180 Students/Yr Thru ITC



5 USMC Squadrons in place

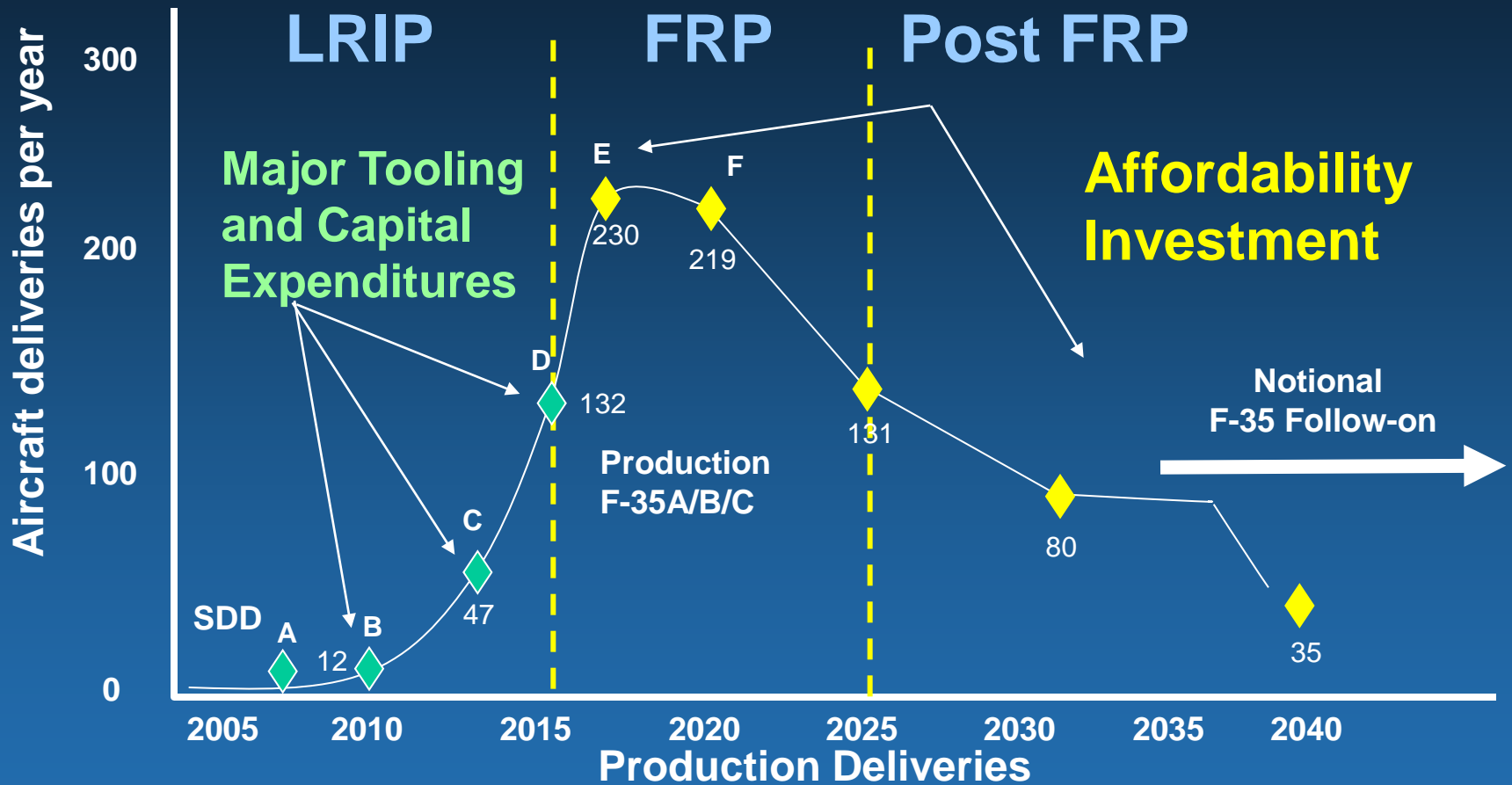


Block 4.0 in Development

Producing, Testing, Training, Deploying, Improving



Affordable Manufacturing Potential Production Insertion Points



Affordable Generation Of 1 Aircraft Per Day Through

- Reduce span time, touch labor, and improve process flow
- Reduce aircraft unit recurring flyaway (URF) and capital costs
- Supplier base development and supply chain stability



F-35 and Corrosion



- **Corrosion Prevention & Control Requirement**
 - The JSF Air System shall be *durable, damage tolerant, fault tolerant, fatigue resistant, and **corrosion resistant*** and be capable of being maintained and operated to meet the intended mission usage
- **Requirement to use environmentally friendly materials and processes wherever possible, to include use of non-chromated primers**
- **Taken a cradle to grave approach:**
 - *Design Considerations*
 - *Methods for inspecting and restoring corrosion preventative features*
 - *Maintenance and Repair methods when corrosion is discovered*



Corrosion Prevention/Control Philosophy



- Defined as the rigorous application of engineering design and analysis, quality assurance (QA), nondestructive inspection (NDI), manufacturing, operations and support technologies to prevent the initiation of corrosion, avoid functional impairment due to corrosion, and define processes for the tracking and repair of corrosion problems
- CPAB typically meets 1-2x per year to discuss progress
- Control plans are considered evolutionary and updated once per year with updated test results and allows for implementation of new technologies and procedures



SDD Corrosion Prevention/Control Accomplishments



- **Active minimization and mitigation of galvanic couples, especially aluminum, titanium, and composite matchups**
- **NDI Techniques/Procedures**
- **Extensive testing and qualification of nonchrome coatings**
- **Materials and systems on aircraft must pass a minimum of the ASTM G85 SO₂/Salt Fog test (336 hours), even for CTOL!**
- **Actively incorporating lessons learned from legacy programs**
 - *Cross attendance at CPAB's, corrosion surveys*
 - *AFRL/RX Collocated Engineers*
 - *Informal discussions*



Thoughts on Maintenance



- **Documentation and procedures in progress – plans to incorporate maintainer perspective through workshops, schoolhouses**
 - *Maintainers invited on regular basis to discuss with F35 staff and inspect planes*
- **Planes expected to follow service standard wash requirements**
- **Visual (mirrors/flashlights) and NDI/NDE used for inspections**
 - *Standard NDI technologies supplemented by emerging tools for use on coatings and other features*



JSF Autonomic Logistics System

Highly Supportable Aircraft

- Smart / Reliable Design
- Prognostics and Health Management
- Remove and Replace (R/R) Maintenance
- On Condition Maintenance
- Reduced Maintenance Skill Groups
 - AFSC, MOS, etc.

Training System

- Integrated Training
- Embedded Pilot Training
- On Demand Maintenance Training
- Air Vehicle Software Reuse



Support System

- Sustaining Engineering
 - 24/7 Help Desk
- Electronic Joint-Service Tech Data
- Intelligent Maintenance Management
- Global Supply Chain Insight
- Support Equipment Management

Autonomic Logistics Information System

- Distributed Information System
- Enterprise Resource Solution
- Secure
- Scalable
- Deployable

Autonomic Logistics Provides Order Of Magnitude O&S Savings



Current Research Areas and Future Work



- **NDI Technologies**
- **Chromium and Cadmium replacement technologies – to have equivalent/better properties than current systems**
- **Corrosion Sensor Validation**
- **Corrosion testing of 100% production representative features including joints, structure, and OML stack-up**
 - *Design approach validation*
 - *Real world and laboratory exposures*
 - *Evaluating pristine and damaged panels*



Summary



- **F-35 is a program off the drawing board - Low Rate Production
Lots already in assembly**
- **International Supply Chains and Joint Requirements add unique requirements to the program**
- **Corrosion prevention/control mindset was built into program from the beginning, and plans reviewed/updated regularly**
- **Evolutionary testing of improved materials and processes is ongoing and will continue well into the future**



Questions?