



F-35 Joint Strike Fighter Structural Component Optimization

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JSF Is a Multi-Service, Global Program



F-35A

F-35B

F-35C



CTOL
(USAF)

STOVL
(USMC, USAF and UK)

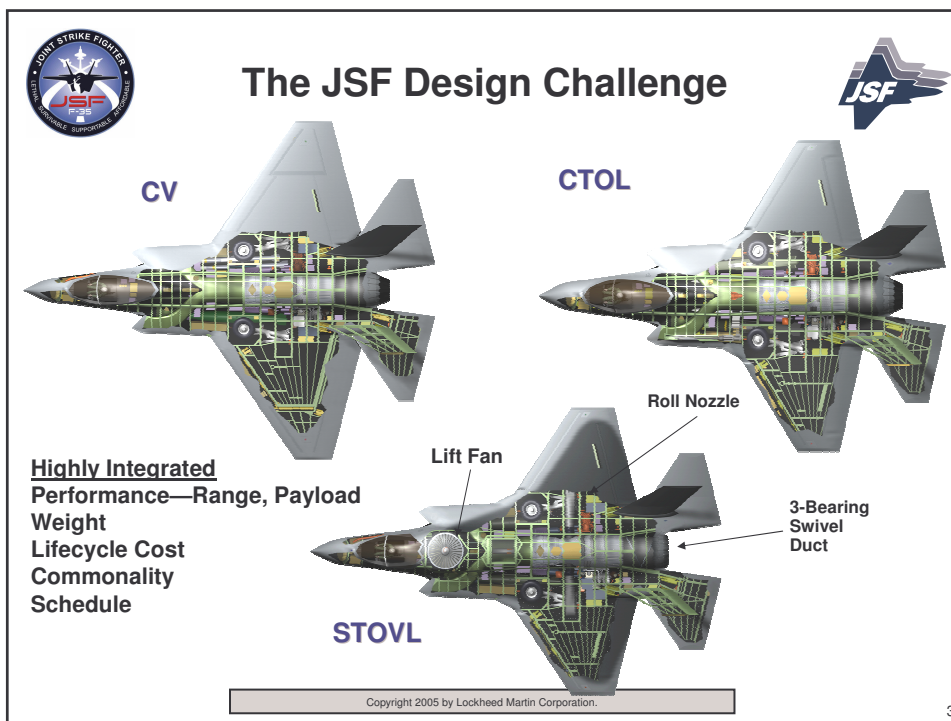
CV
(USN)



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F-35 Weight Challenge

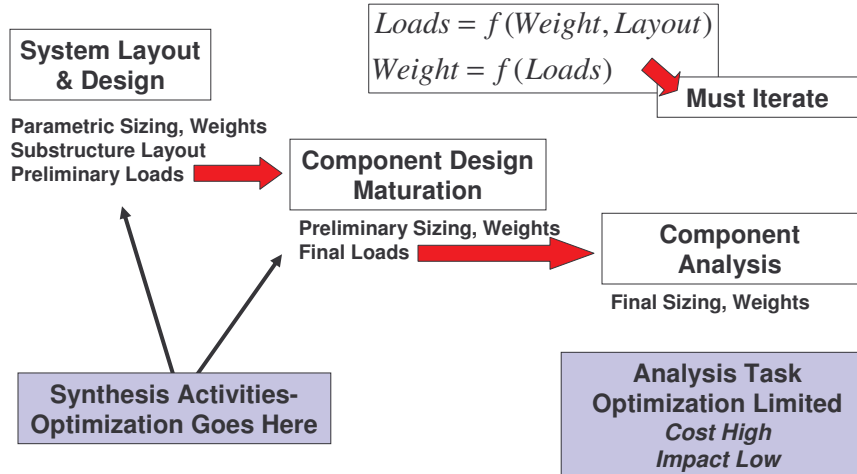
- **Spring 2004 STOVL Variant Design Weight Challenged Ability to Meet Key Performance Parameters**
- **STOVL Weight Attack Team (SWAT) formed in 2004**
 - Chartered to derive innovative concepts and methods for eliminating weight from the JSF Variants
 - Studied all facets of performance improvement
 - Removed significant weight from Air System
- **Aggressive Weight Minimization Focus Continues Through Detail Part Design**
 - Weight must not creep back in
 - Weight control organization
 - Individual part weight reviews
- **Structural Optimization Toolset Filling Important Role**
 - Realizing weight savings

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Aircraft Structural Design Process



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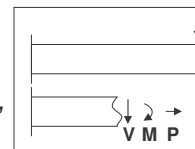
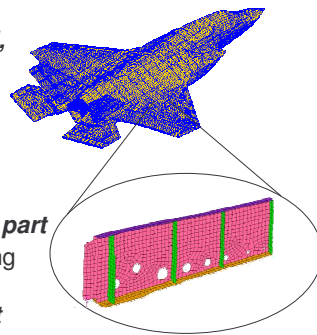
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Detail Part Structural Analysis on JSF



- **Air Vehicle Analysis**
 - Performance, stability, aerodynamics, control, flutter, dynamics, other specialties
 - Air Vehicle loads FEM
 - Global deformation
 - Internal loads
- **Airframe Structural Analysis**
 - Extract internal loads applicable to individual part
 - Each part is heavily influenced by surrounding part stiffnesses
 - Analyze all critical failure modes for each part
 - Static
 - Stability
 - Durability and damage tolerance (DaDT, i.e. crack initiation and growth)
 - Margin written against resolved section stresses, not FEM stresses



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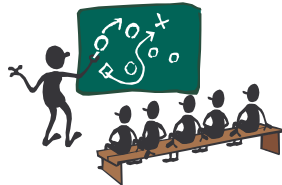
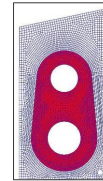


Optimization on F-35



PARTS—Focus on Identified High Potential Classes

Compact fittings—topology, shape, gauge
Planar webs with cutouts—gauge

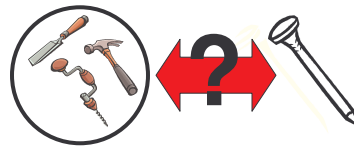


PEOPLE—Optimization Tiger Team

Increase learning curve
Share lessons learned

TOOLS—HyperWorks, NASTRAN

Efficient interface
Process integration



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Ideal Optimization Process



Topology

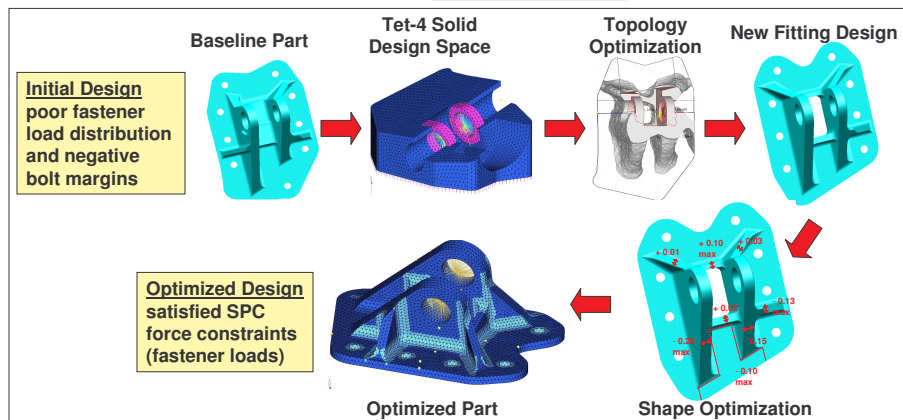
–Load Paths
–Material Distribution



Shape, Gauge

–Strength
–Stability
–Sizing

Works Well for
Compact
Fittings



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Broader Optimization Process



Optimization Model Formulation is Critical

- Constraints
- Geometry
- Loads
- Boundary Conditions
- Global stiffness, deformation

Results Dismissed
If Inadequately
Addressed

Requires
Greater Effort
for Integrated
Structure

Topology
-Stiffness

Gauge

- Strength
- stability

Topology
-Stiffness

Gauge

- Strength

Analysis Check
-Stability

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The Value of Optimization



- Does optimization save weight or time?
 - *The parts must get to minimum weight*
 - *Can they get there within the allocated schedule?*
- New Knowledge and Skills Required
 - *Tool AND process training is necessary for effective optimization*
- Greatest Leverage When Used Up Front
 - *Reduce risk of downstream rework*
 - *Insight into load paths*
 - *Include constraints earlier*
 - *Leverage experience*
 - *Make informed decisions*
 - *Ascend part learning curve faster*



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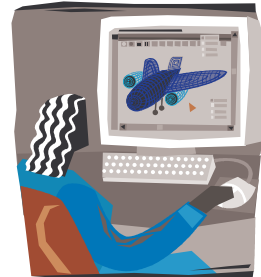
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The Role of Optimization in Aerospace Structural Design



- **Objective: Good Preliminary Design, Starting Point for Analysis**
 - **Part configuration—stiffeners, cutouts**
 - Low probability of downstream change
 - **Sizing—gauge thicknesses**
 - May need to be adjusted slightly
 - **Minimum simplifying assumptions**
 - Realization factors—acceptance, value
 - **Not substitute for detailed analysis**
- **What is Needed**
 - **Optimization with balanced loads**
 - **Section stresses**
 - **Seamless translation to/from NASTRAN**



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