Design, Analysis and Weight Optimization Techniques for Joint Strike Fighter Missionized Gun Pod Support Equipment

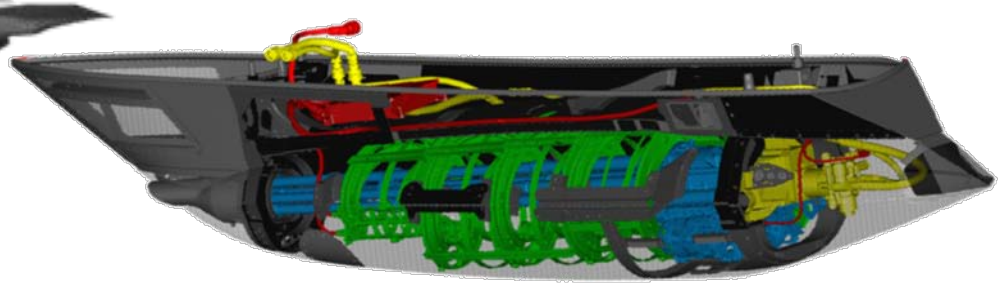
Presented by:

Gary Miller
Senior Design Engineer
General Dynamics Armament and Technical Products
Williston, Vermont USA
802-662-6030 gmiller@gdatp.com

Presentation Outline

- JSF Background
- Gun Pod Support Equipment Overview
- J75189 Ground Handling Adapter (GHA) Overview
- Design Space
- Weight and Strength Optimization
- Analysis Methodology
- Weight & Strength Optimization Summary

JSF Background



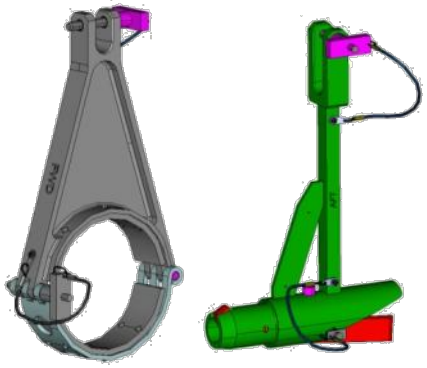
- Joint Strike Fighter
  - Three variants
    - Conventional Take Off and Landing (CTOL)
    - Short Take Off and Vertical Landing (STOVL)
    - Carrier Variant (CV)
  - The STOVL and CV variants use the Missionized Gun System (MGS). A centerline-station mounted, gun pod which houses the 25mm GAU-22 gatling gun and its ammunition handling system.

JSF Missionized Gun System (MGS) Support Equipment Overview

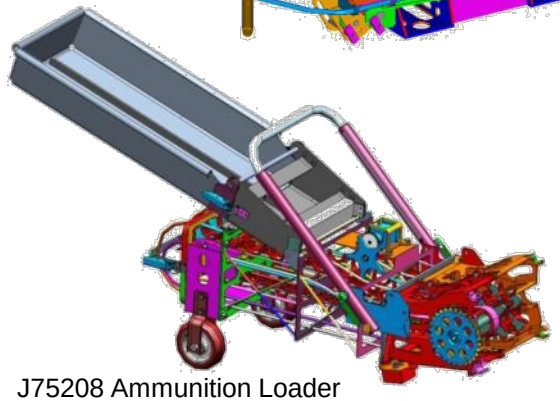
- To aid in maintenance and installation of the MGS, six pieces of support equipment were developed.

J75192 Hoisting Beam

J75189 Ground Handling Adapter

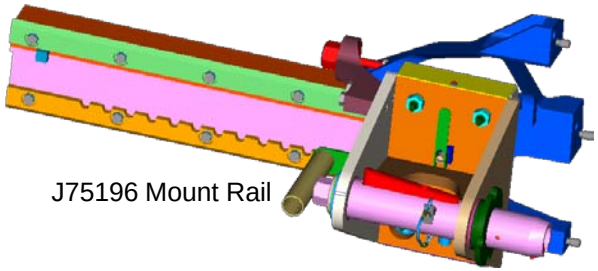


J75199 Gun Transfer Adapter



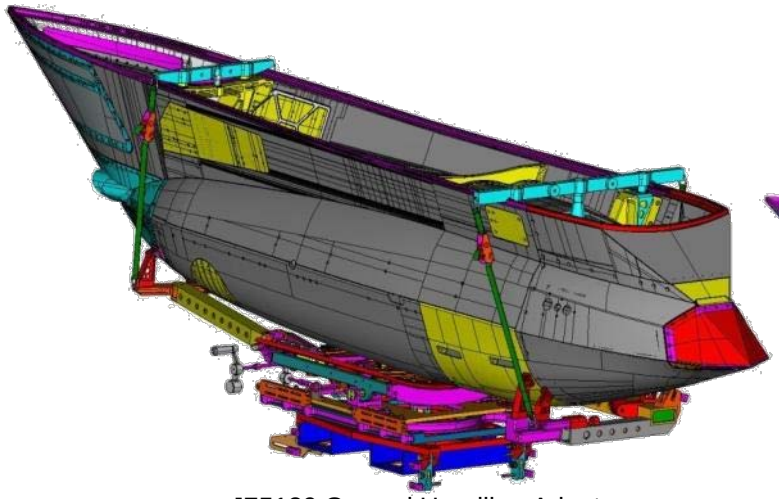
J75208 Ammunition Loader

J75197 Gun Mounting Adapter



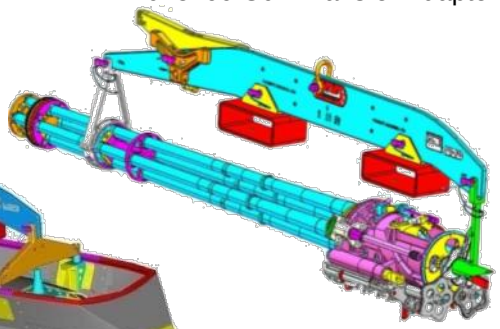
J75196 Mount Rail

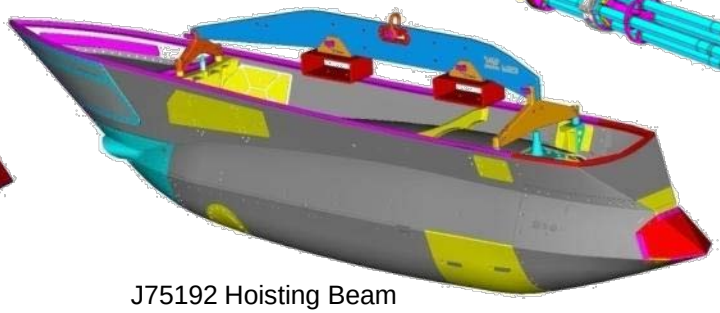
JSF Missionized Gun System (MGS) Support Equipment Overview (Cont.)



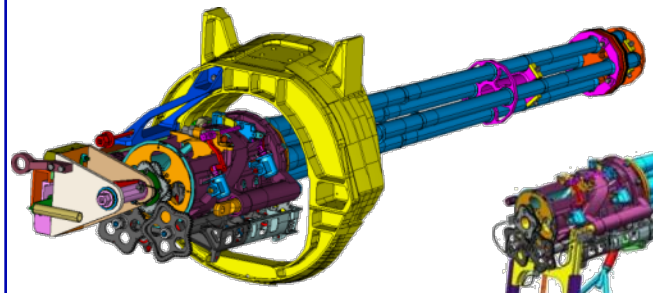
J75189 Ground Handling Adapter

J75199 Gun Transfer Adapter

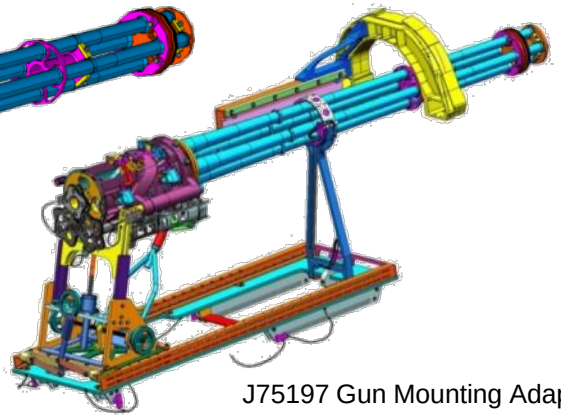




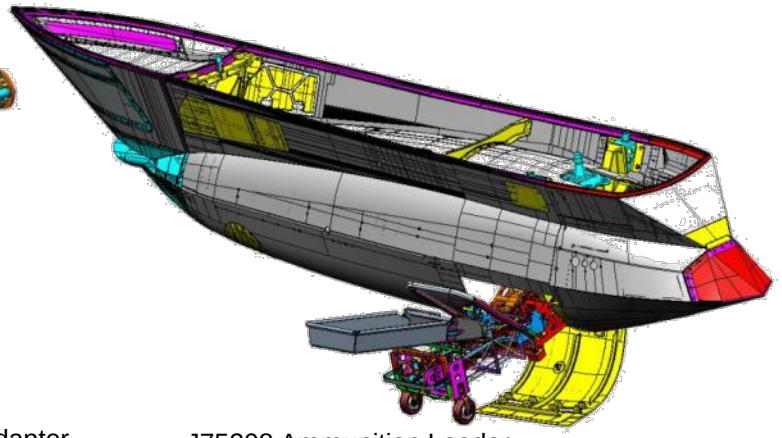
J75192 Hoisting Beam



J75196 Mount Rail



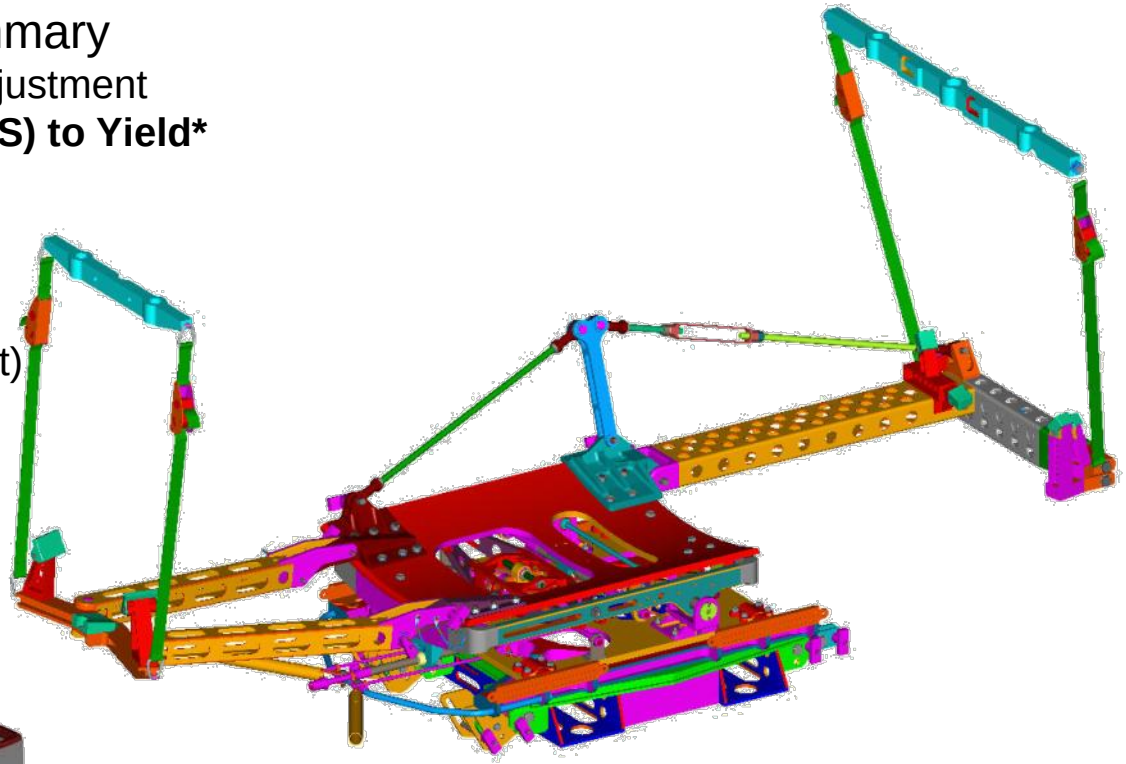
J75197 Gun Mounting Adapter

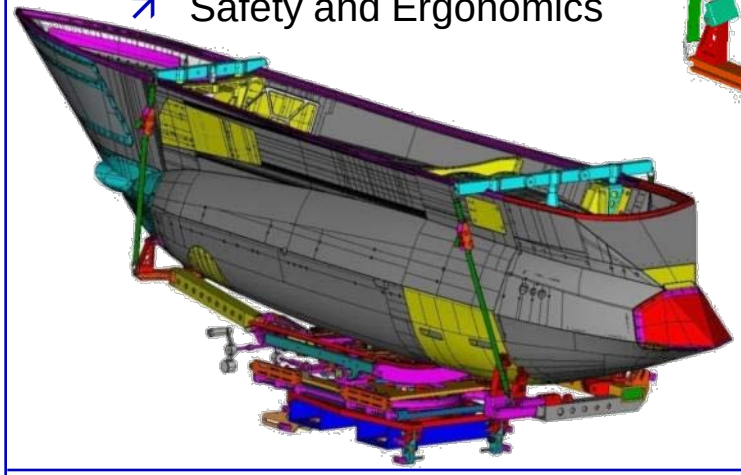


J75208 Ammunition Loader

J75189 Ground Handling Adapter (GHA) Overview

- Design Requirements Summary
  - 5 degrees of freedom of adjustment
  - **High Factor of Safety (FOS) to Yield***
  - **Sea State 6 Acceleration***
    - Wave acceleration loads
    - Deck angle
  - **Weight***
  - Wind (Sea State & Jet Blast)
  - Envelope (Operational and Logistic)
  - Environmental
  - Safety and Ergonomics

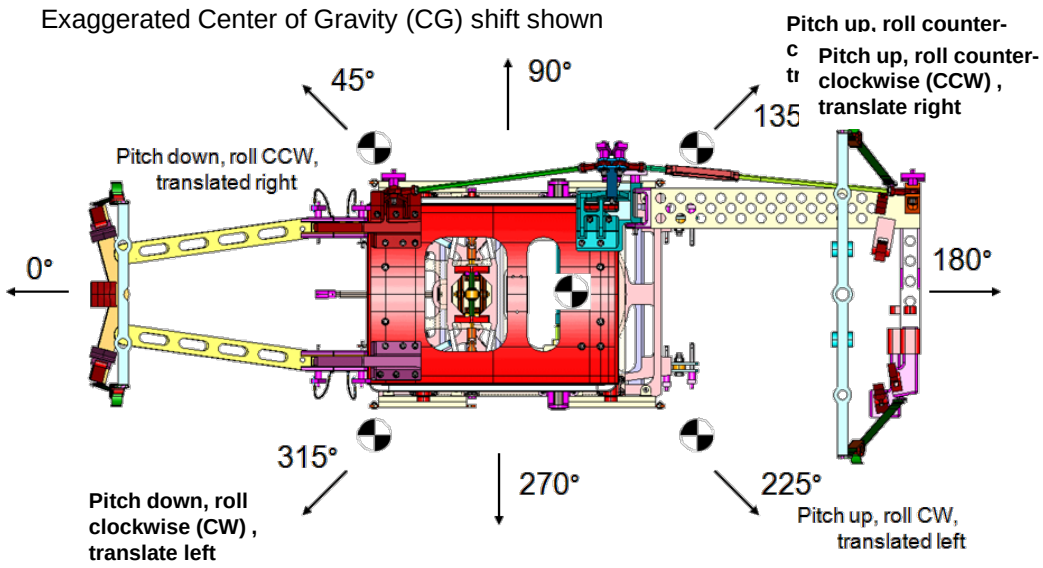


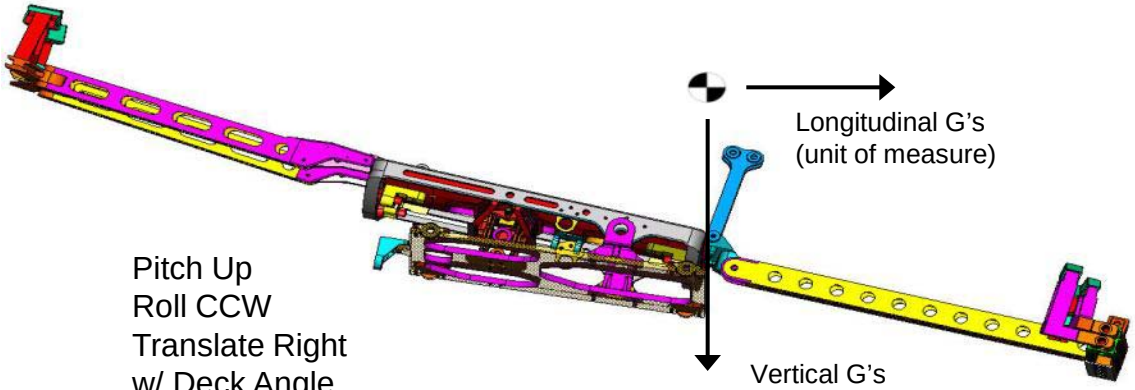


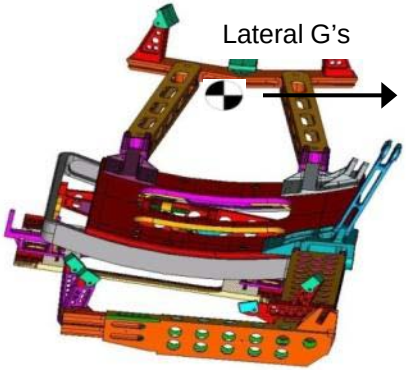
- *FOS, Load and Weight requirements result in a **>13:1** strength to weight ratio
- Longevity and human factors result in high FOS
- Broad requirements set for support equipment creates a unique design challenge

GHA Design Space
Sea State Configurations

- Total of 288 possible orientation combinations
  - GHA adjustment degrees of freedom
  - Deck Angle
  - Orientation with respect to Deck

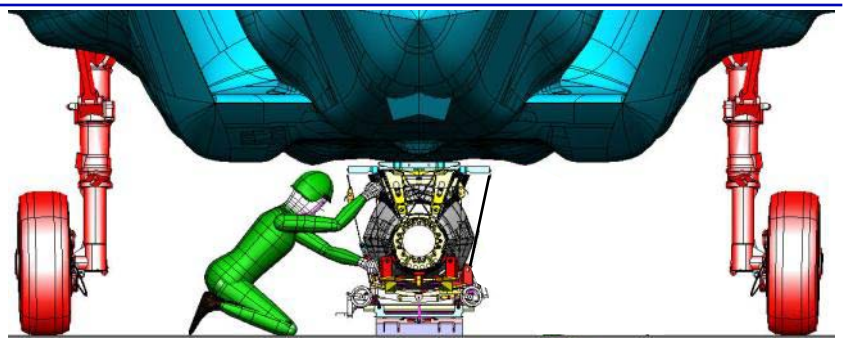


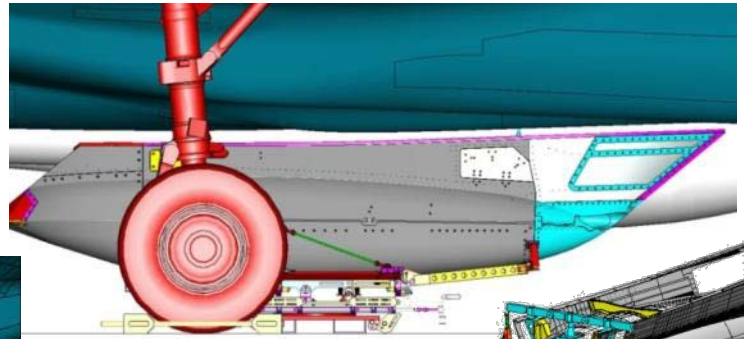


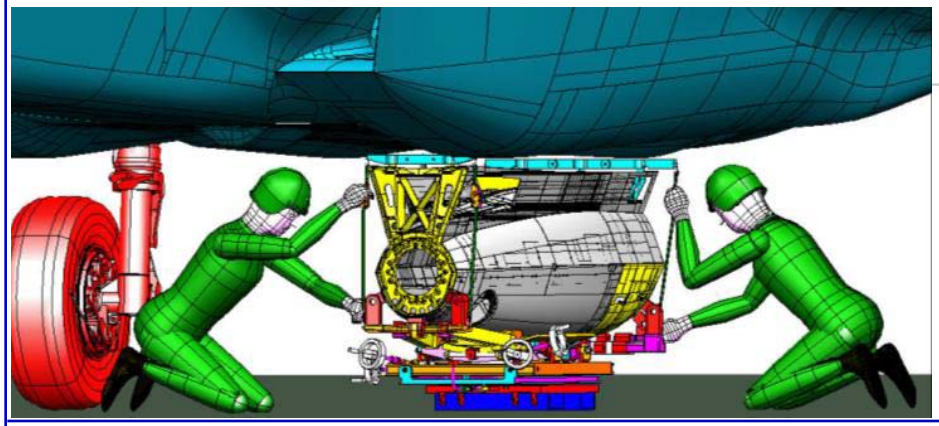


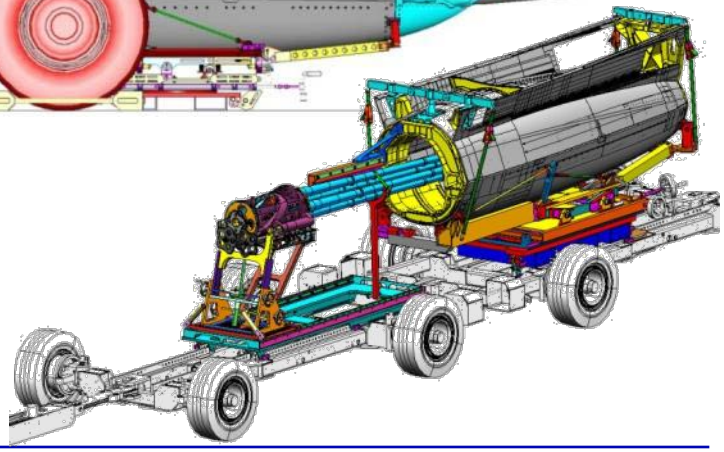
GHA Design Space Operational Envelope

- Clearance under Aircraft (A/C)
  - Worst Case A/C Configuration Shown
    - ↗ Damaged Gear
    - ↗ Max A/C weight
- Gun Extraction and Maintenance



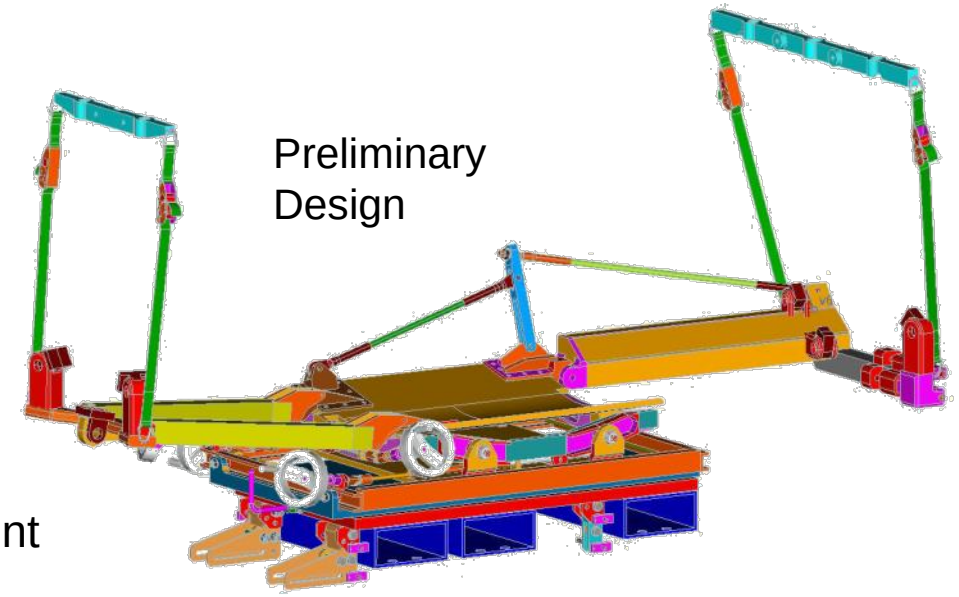




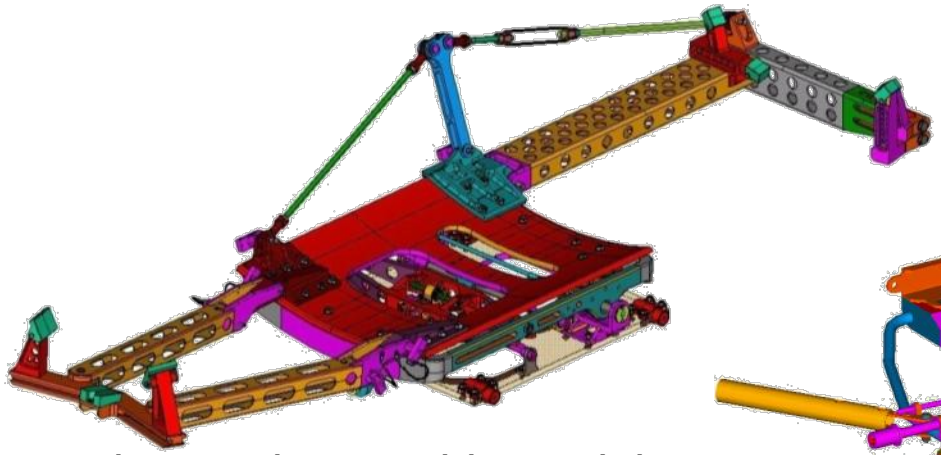


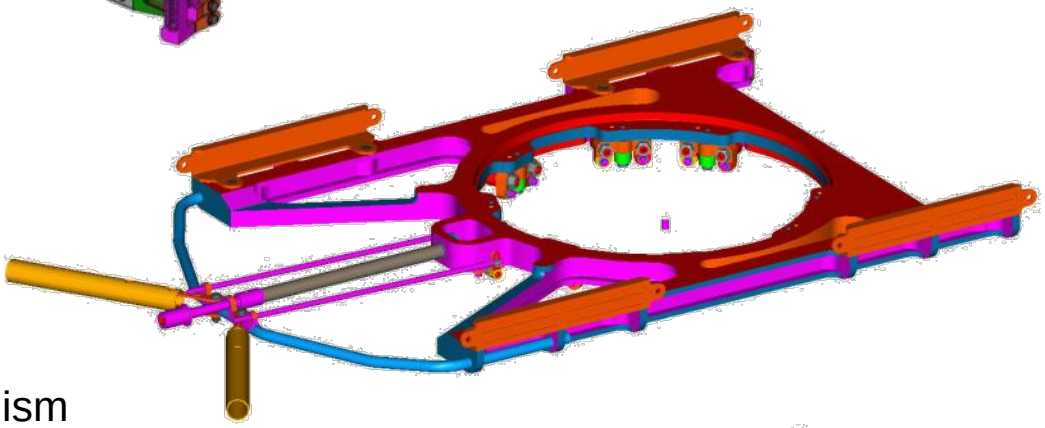
GHA Analysis
Weight & Strength Optimization

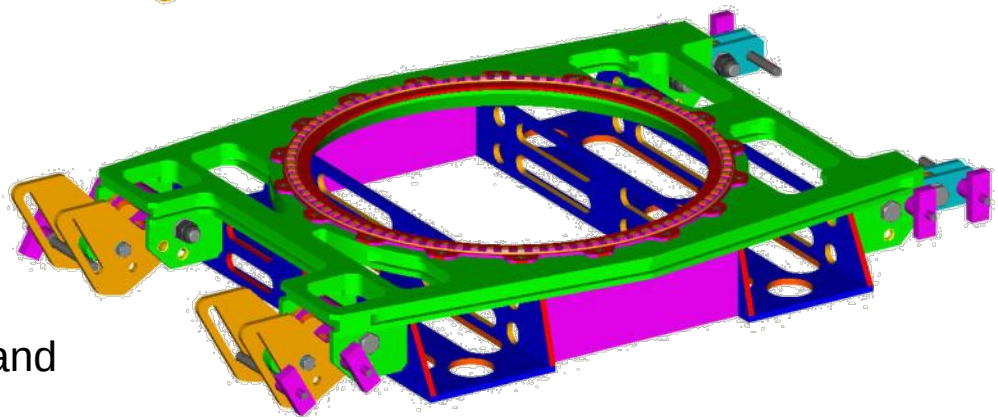
- Preliminary Design Concept Compliance Summary
  - Requirements met:
    - Functional
    - Environmental
    - Safety
    - Envelope
  - Requirements needing improvement:
    - Weight
      - Significant weight challenge to meet requirement
    - Load Capacity
      - Main structure meets requirement
      - FOS below requirement in localized areas



GHA Analysis
Assembly Analysis Methodology



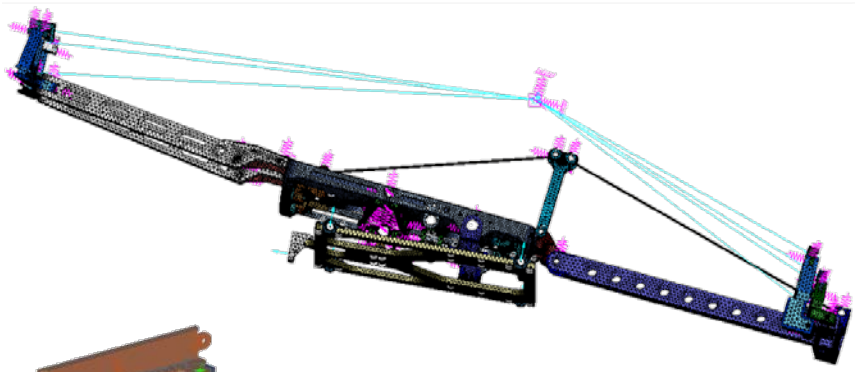


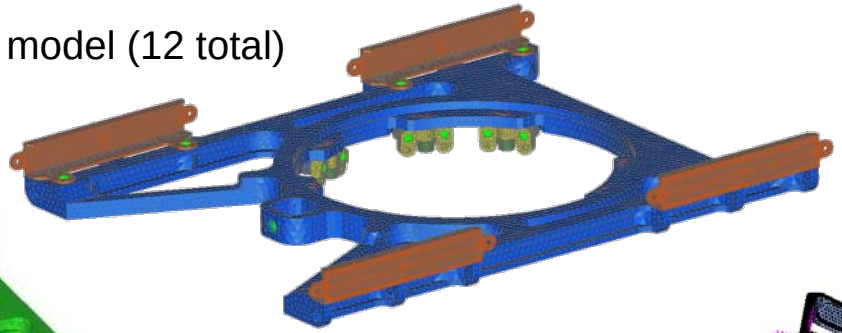


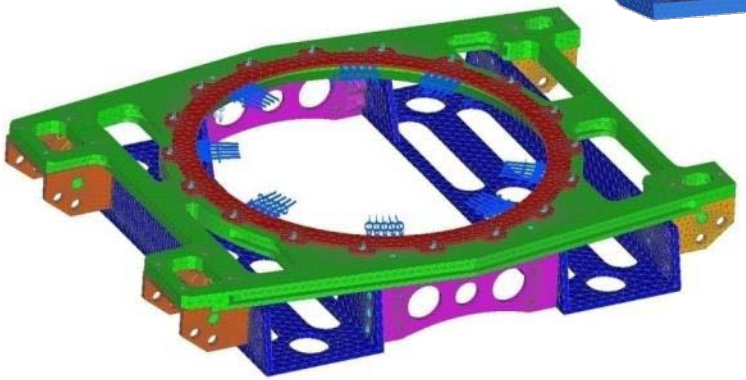
- Three subassembly models:
  - 1. Pitch/Roll/Lateral Mechanism
  - 2. Longitudinal/Yaw Mechanism
  - 3. Base Structure
  - Separate models used to reduce model sizes and complexity for iterating design
  - Interface boundary conditions selected to minimize effect of removing system level stiffness and load distribution.

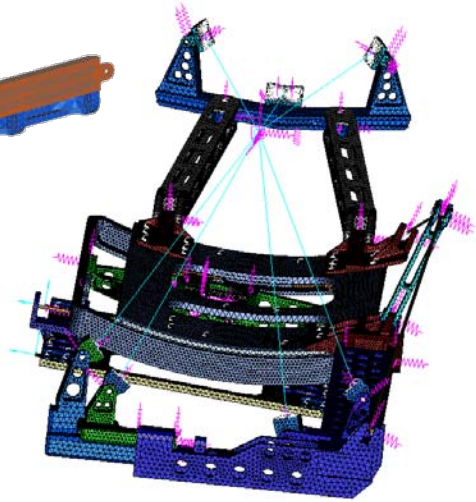
GHA Analysis
Finite Element Assembly Sub Models

- Worst case orientation used to minimize total number of load cases
- Pitch/Roll/Lateral Model (Upper)
  - 8 models covering orientation limits
  - 12 load cases (288 total)
- Longitudinal/Yaw Model (Mid)
  - 4 load cases from upper model (12 total)
- Base Model (Lower)
  - 4 load cases from mid model (12 total)

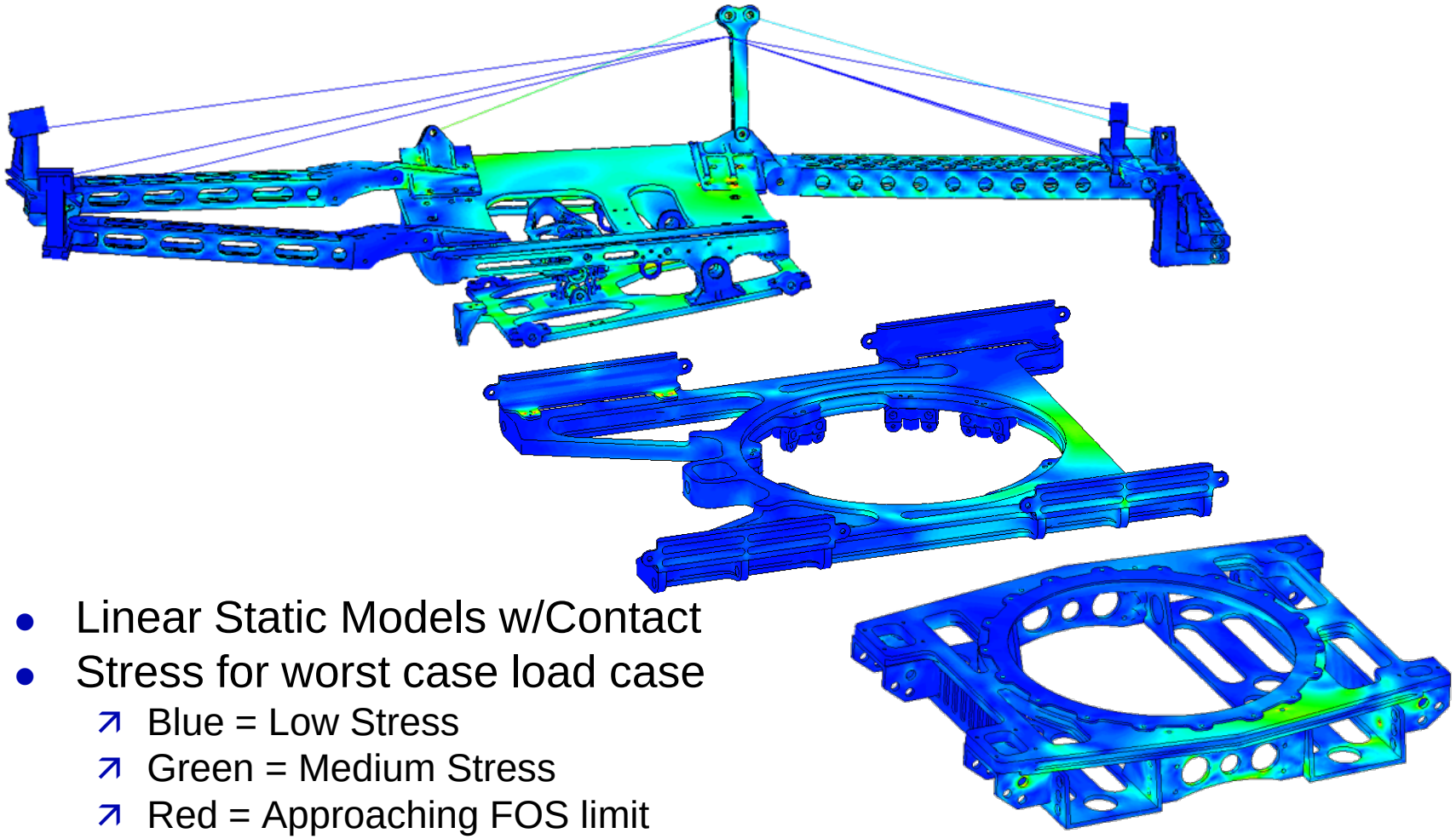








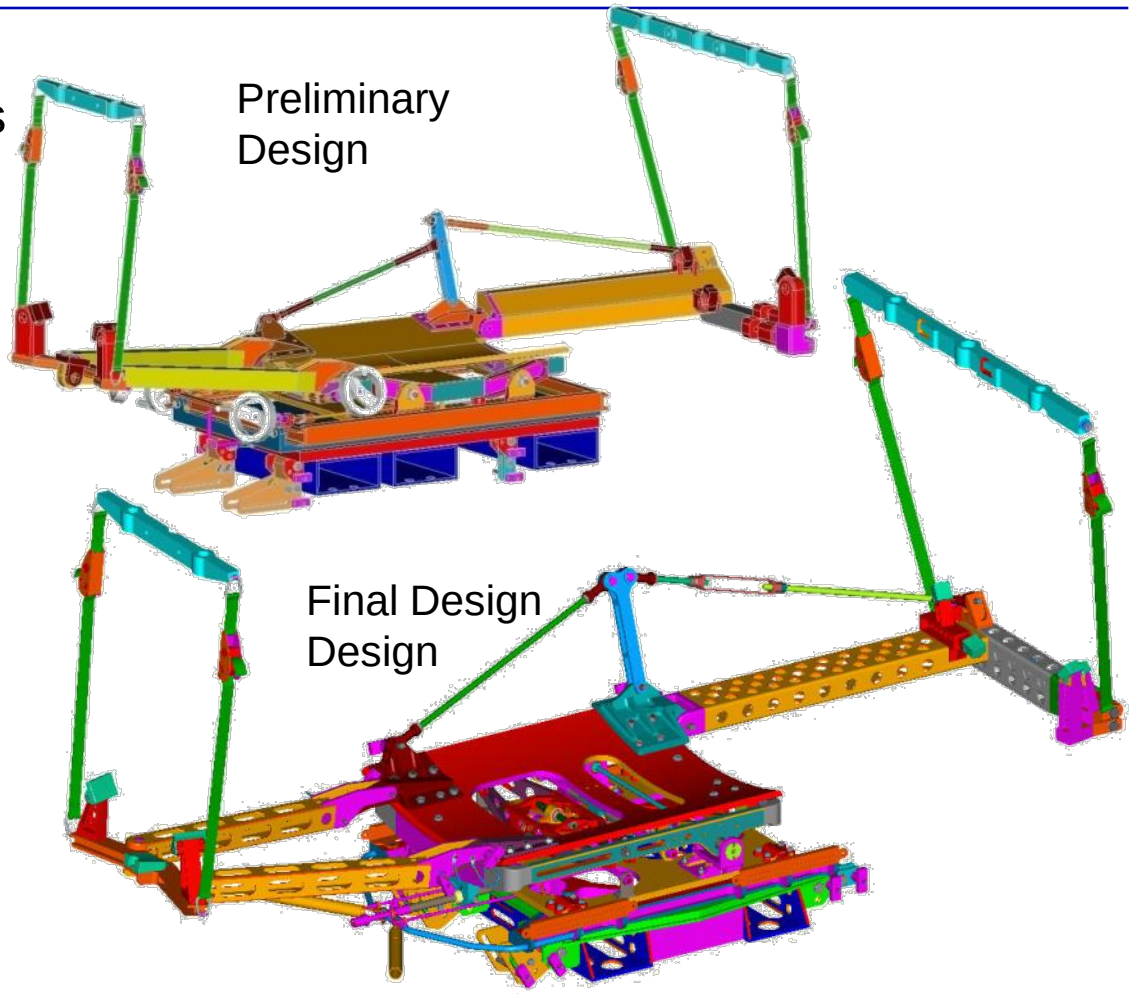
GHA Analysis
FE Assembly Sub Models (Cont.)



- Linear Static Models w/Contact
- Stress for worst case load case
  - Blue = Low Stress
  - Green = Medium Stress
  - Red = Approaching FOS limit

GHA Weight & Strength Optimization Summary

- Final Design
  - ↗ Meets requirements
  - ↗ Weight
    - 36% reduction
  - ↗ Structural Integrity
    - 3 x reduction in localized stress



Conclusion

- Preliminary design needed weight and strength improvement
- Outlined a plan for optimization
  - Material selection
  - Section optimization
  - Repackaging of mechanisms
- Final design meets requirements
- The unique combination of requirements for support equipment design resulted in a significant change in design approach and techniques compared to typical weapon design.