COMPOSITE TECHNOLOGY DEVELOPMENT, INC.

ENGINEERED MATERIAL SOLUTIONS

# *Development of a Deployable Boom for Microsatellites Using Elastic Memory Composite Material*

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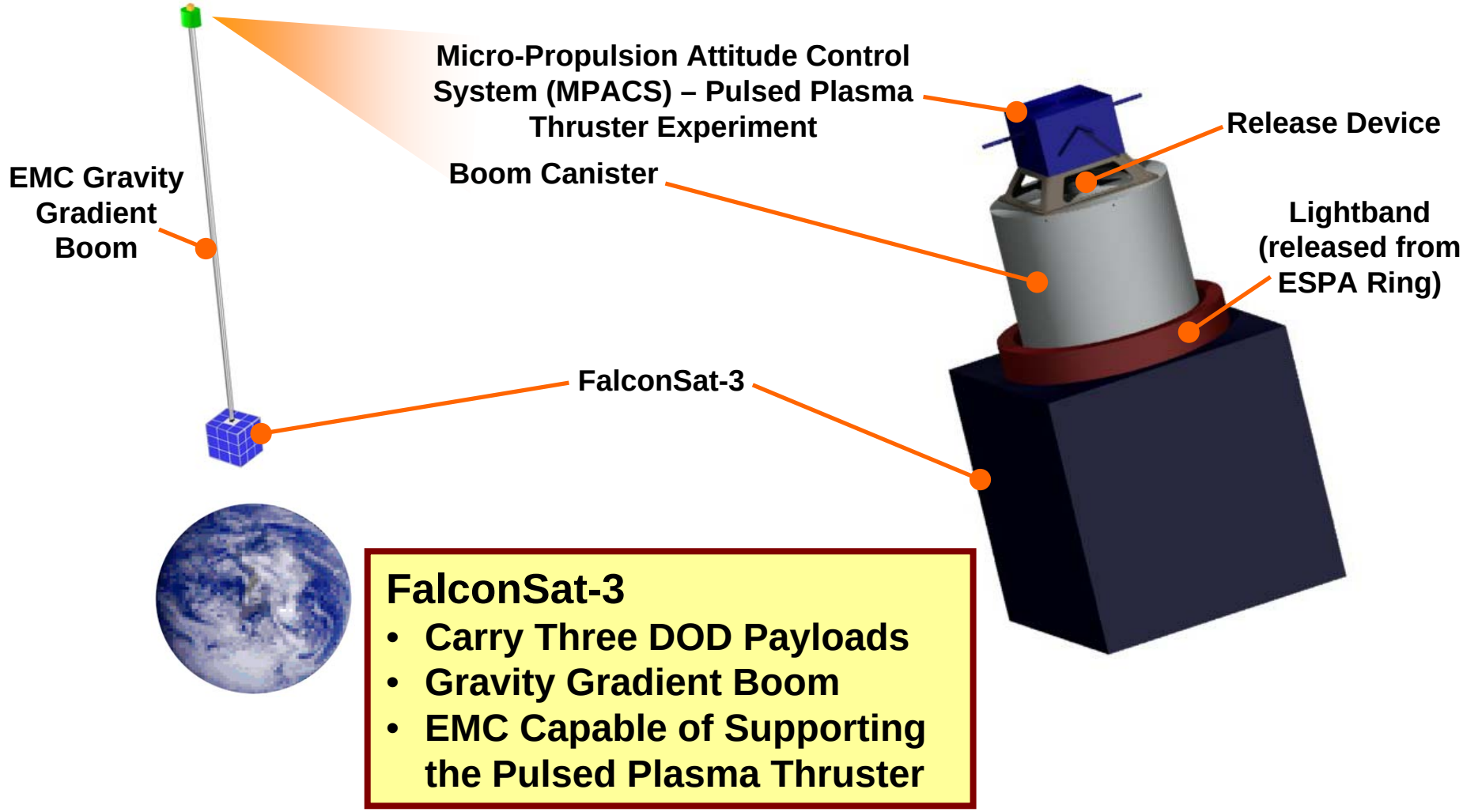
***Erik Abrahamson, Mark Lake, Will Francis, and Rory Barrett***
CTD, Lafayette, CO

***Pamala Fetchko, and Jerry J. Sellers***
USAFA, Colorado Springs, CO

***Greg Spanjers, Capt. Mark Scherbarth, and James Winter***
Air Force Research Lab, Kirtland, NM

# Elastic Memory Composite Boom System for FalconSat 3




**FalconSat-3**

- Carry Three DOD Payloads
- Gravity Gradient Boom
- EMC Capable of Supporting the Pulsed Plasma Thruster

# Program Status

- **Prototypical HW Designed, Built, and Analyzed**
  - **Deployable Boom Using Three Longeron Tapes**
  - **Alternate Approaches within context of Envelopes Investigated – Tape Configuration Trade Study**
    - **Deployment Force**
    - **Deploy Stiffness**
    - **Packaging Efficiency**
- **Converged on a Design that meets the MPACS Requirements/Interfaces/Schedule**

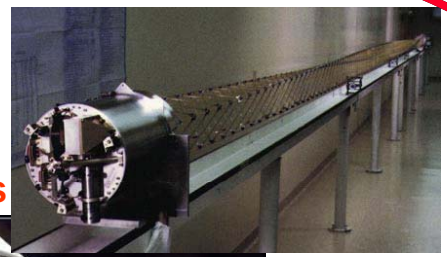
# Status of Deployable Boom Technology

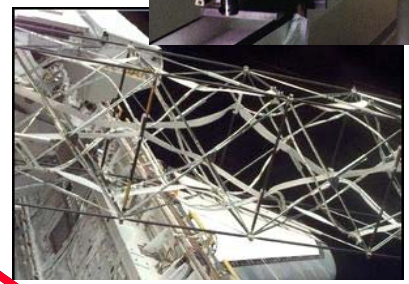
**Gravity Gradient Booms**

**Mechanically Simple**

**Structurally Inefficient**

**Deployable Truss Booms**





**Structurally Efficient**

**High Complexity**

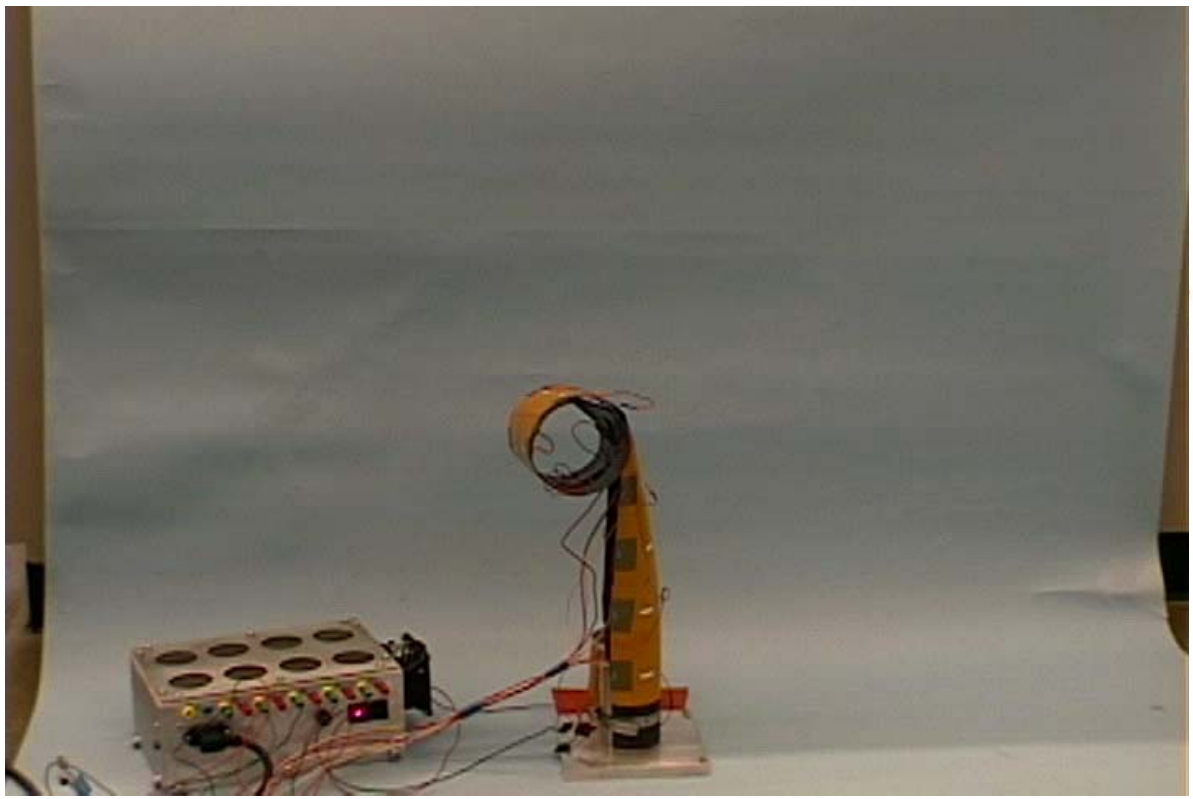
- **Reduce Mass of Restraint Mechanism**
- **Increase Specific Stiffness with Efficient Carbon/ Fiber Longerons**

**EMC**

**"Next-Generation" Boom Technology**

- **Reduce Part Count**
- **Eliminate Need for Secondary Deployment Motor**

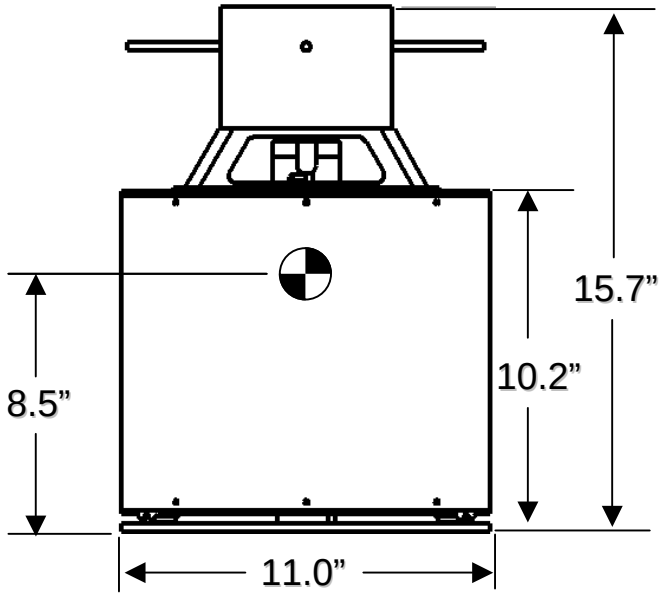
# TEMBO™ Elastic Memory Composites (EMC)

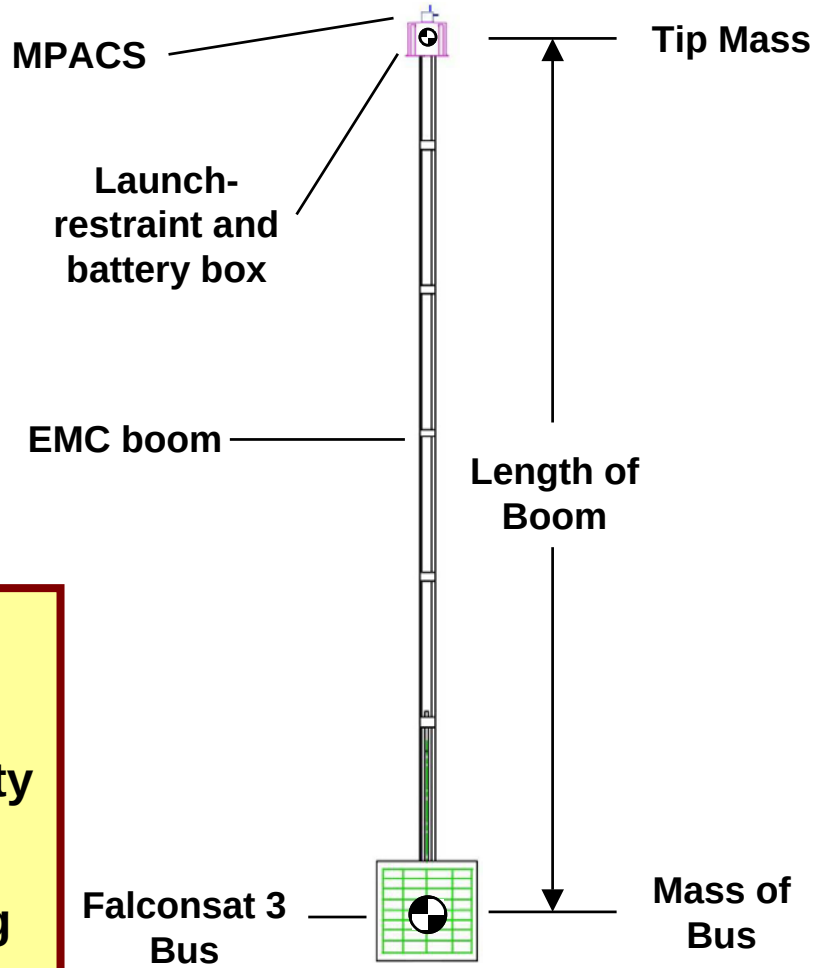


**Benefits of EMC**

- ***Higher Specific Stiffness than Metals***
- ***EMC Exhibits Highly Damped Deployment***
- ***Strain Energy is Self-Contained***
- ***Lower Part Count/ Complexity***

# United States Air Force Academy FalconSat-3 Requirements

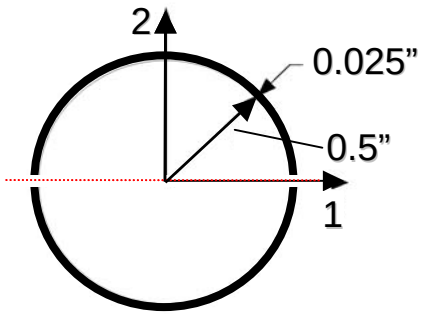


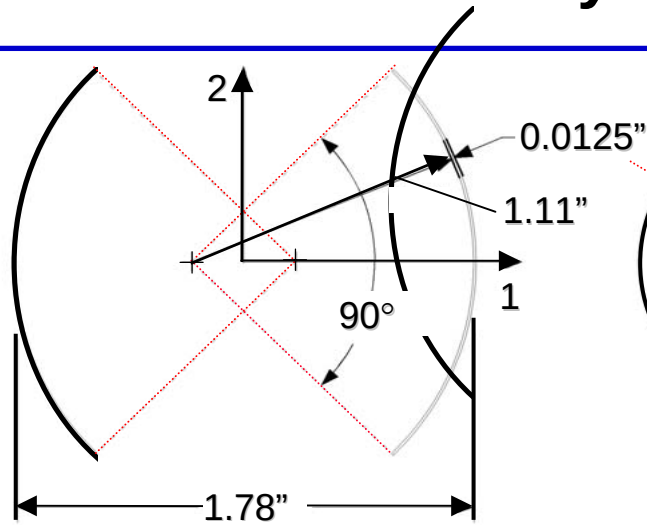

## Requirements of EMC Boom

- Comply with packaging envelope
- Provide passive gravity-gradient stability
- Deploy and maintain MPACS, allowing active pitch and roll oscillation damping to occur

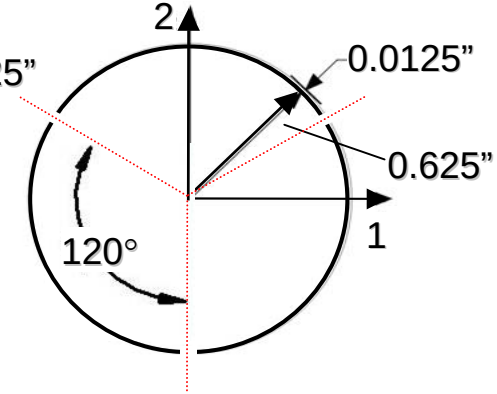
# Baseline Cylindrical Boom Trade Study




Baseline
(Two Tapes)




Alternative 1
(Two Tapes)




Alternative 2
(Three Tapes)

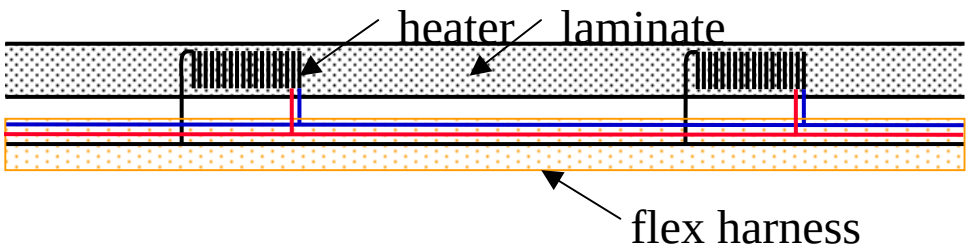
| | Baseline Configuration | Alternative 1 | Alternative 2 |
|---|---|---|---|
| **Frequency in Bending – $f_b$** | **1.0** | **1.0** | **1.0** |
| **Frequency in Torsion - $f_t$** | **1.0** | **0.37** | **0.40** |
| **Deployed Length** | **1.0** | **1.0** | **1.0** |
| **Mass of Heated TEMBO™ EMC Material** | **1.0** | **0.80** | **0.80** |
| **Laminate Strain** | **1.0** | **1.0** | **1.0** |
| **Normalized Part Count*** | **1.0** | **2.5** | **2.67** |

*Longerons, Batten Fittings and Diagonal Members

# Longeron Torque Requirement

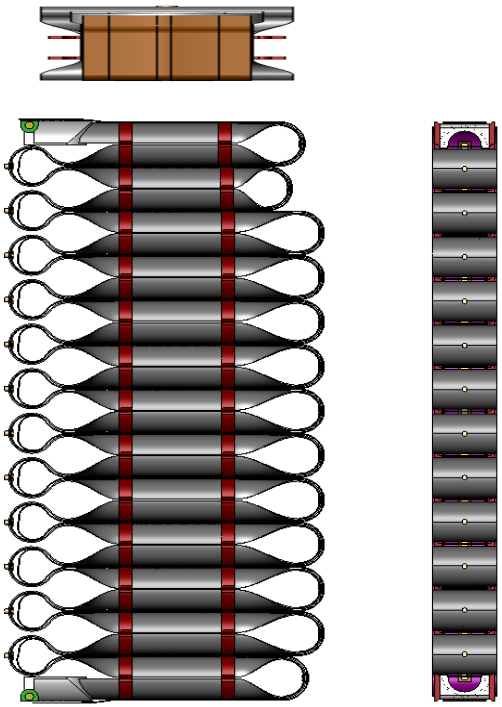
- Analysis was done on the following
  - Wire Harness Drag
  - Batten Nut to Deployable tube jamming
  - Longeron drag on canister baffles
- Wire Harness Drag drives requirement analysis
- Flex tape design
  - 3 – 24 gauge wires
  - 7 – 30 gauge wires
  - Wires run on 6 flex tapes, using 1 oz copper
- Results
  - Wire harness drag is .150 in-lbs
  - Batten drag torque is .037 in-lbs
  - Tape drag torque is .012 in-lbs
- Total drag torque in system is .20 in-lbs
- Deployment margin is 500% based on 1 in-lbs requirement

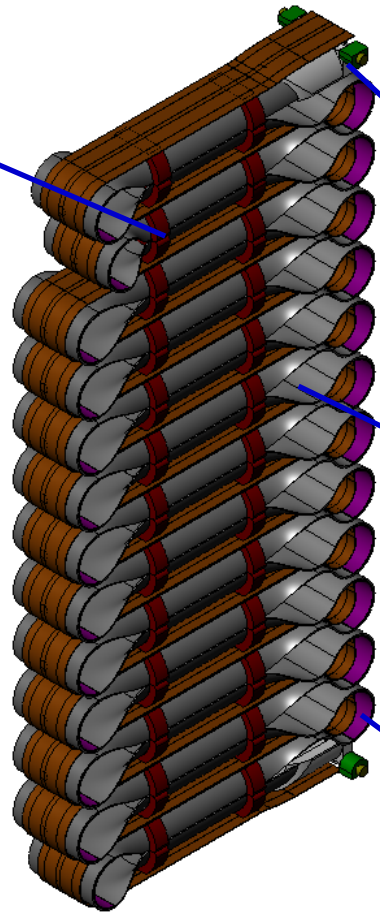
# Heater Design and Installation




**Heater Design**
- **Redundant Heating Circuits**
- **Parallel Wiring Configuration**
- **Powered Through Flex Harness**

# Longeron Packaging

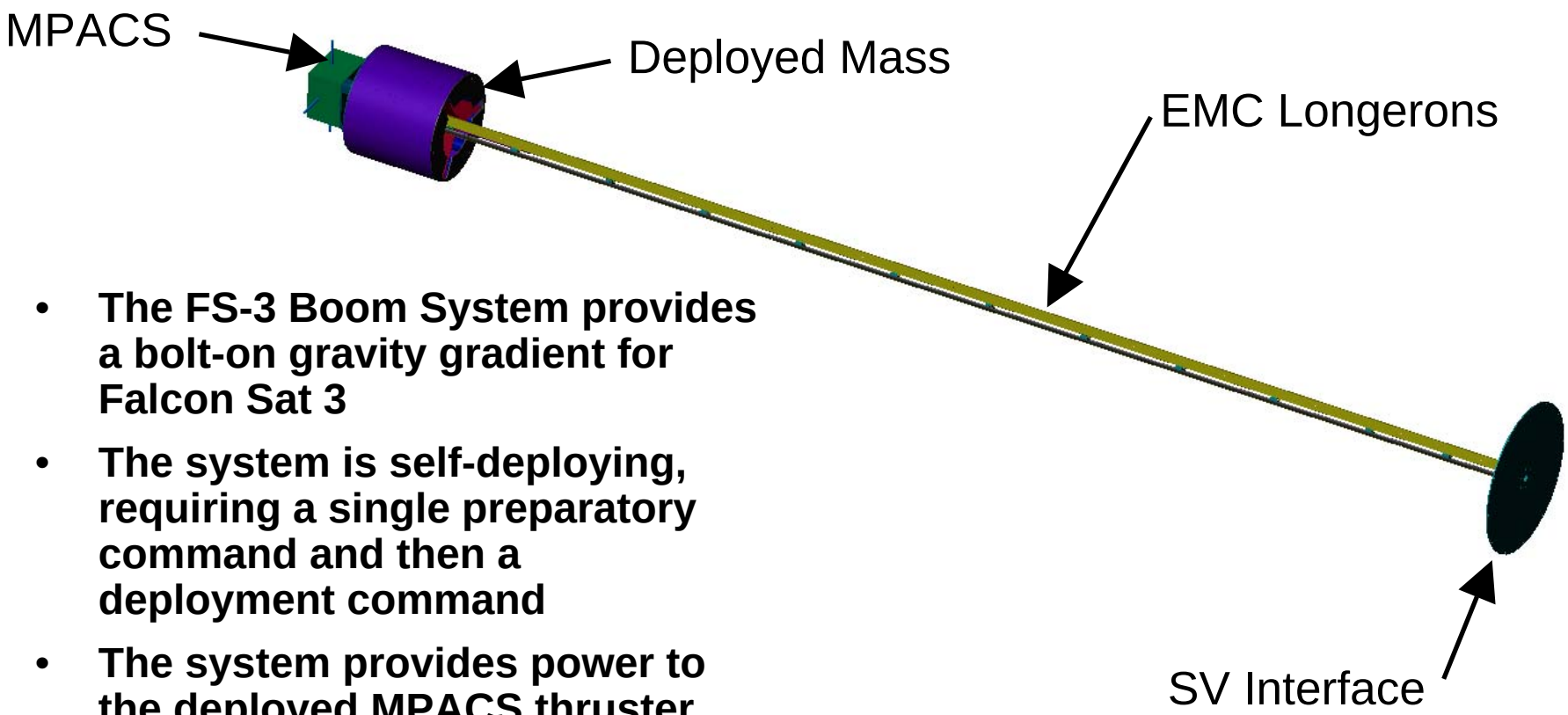





## 3D CAD Model

- Used to Negotiate ICD
- Allowed Refined Analysis of Stowed and Deployed Frequencies
- Design EMC Packaging Tool Concept

# EMC FalconSat 3
# Boom Capablities




- **The FS-3 Boom System provides a bolt-on gravity gradient for Falcon Sat 3**
- **The system is self-deploying, requiring a single preparatory command and then a deployment command**
- **The system provides power to the deployed MPACS thruster**

## Summary

- **“Next Generation” booms are attainable through the use of Elastic Memory Composites**
- **Benefits of EMC will be exploited on upcoming FalconSat-3 gravity gradient boom**
- **Development of FalconSat-3 boom has progressed on schedule**

## Future Efforts

- CTD will characterize deployment force for a variety of laminate architectures, packaging strains and longeron cross sections
- Air Force Research Laboratory has fabricated a qualification fixture to support testing of baseline boom
- Ground support equipment will be further developed to allow packaging of full scale EDU
- Flight hardware scheduled to be delivered March ‘05