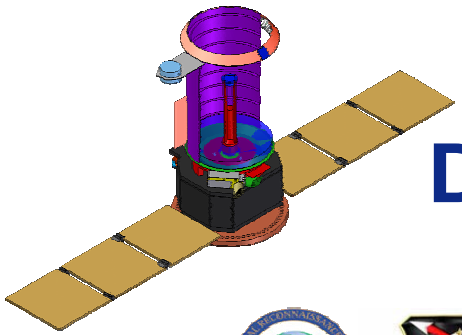
Air Force Research Laboratory|AFRL

Science and Technology for Tomorrow's Air and Space Force



Tactical Satellite 3: Requirements Development for Responsive Space Missions

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TacSat-3 Chief Engineer

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TacSat-3 Program Manager

Office of Force Transformation
Department of Defense

U.S. AIR FORCE

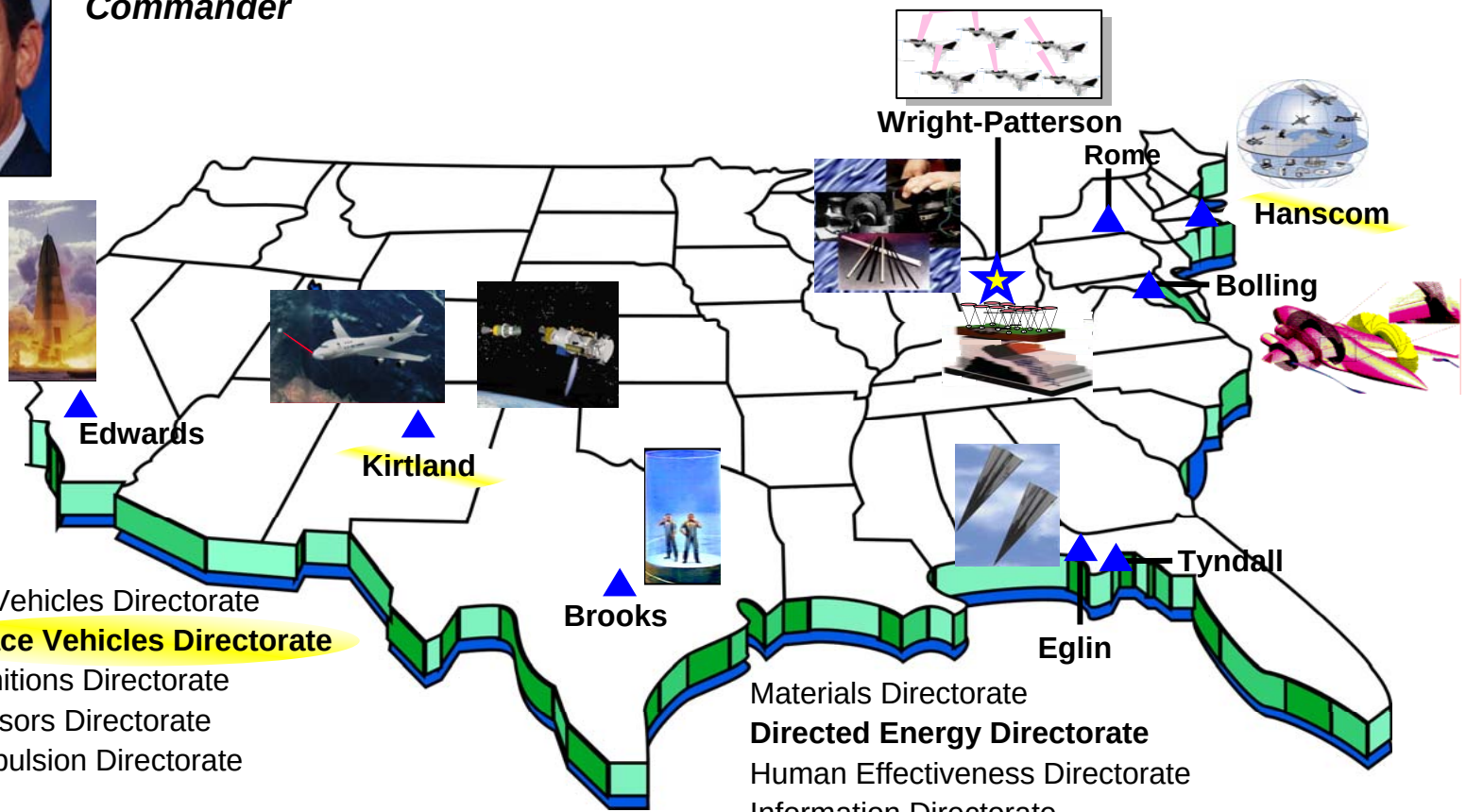
Overview

- Responsive Space
- TacSat-3 Mission Overview
  - Mission Objectives Development
- TacSat-3 Mission Success Criteria
- Design Example

Introduction to Responsive Space

Air Force Research Laboratory

Major General Perry Lamy
Commander



Air Vehicles Directorate
Space Vehicles Directorate
Munitions Directorate
Sensors Directorate
Propulsion Directorate

Materials Directorate
Directed Energy Directorate
Human Effectiveness Directorate
Information Directorate
Air Force Office of Scientific Research

"anticipate, find, fix, track, target, engage, assess - anyone, anytime, anywhere"

Responsive Space Directed By Senior Leadership


White House photo by Eric Draper

President's National Security Presidential Directive/NSPD-40, 6 Jan 2005

"Demonstrate an initial capability for operationally responsive access to and use of space —providing capacity to respond to unexpected loss or degradation of selected capabilities, and/or to provide timely availability of tailored or new capabilities—to support national security requirements;…"

Former CSAF

"JWS takes next step in transforming capabilities by operationalizing space directly to the benefit of the warfighter with an agile, responsive, commander-oriented, combat space vision focused primarily at the tactical and operational levels of war, but able to integrate with the National Security Space architecture."

Former USECAF TEETS:

- **From notification of desire to launch to actual launch "measured in hours and days, not weeks and months"**
- **"…augment the combatant commander's knowledge of the battlefield"**
- **"…tailor the small satellite's orbit to maximize coverage of the theater"**
- **"…build a stockpile of small satellites and booster rockets [to be] dispatched very quickly to respond to the combatant commander's needs"**

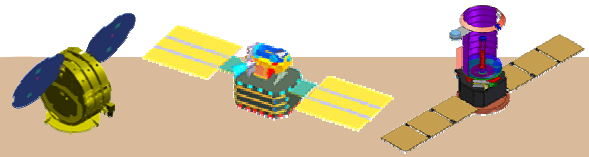
Joint Warfighting Space Operational Concept

Responsive Space Inventory – rapid reaction capability, “Dell computer-like”

Responsive Payloads

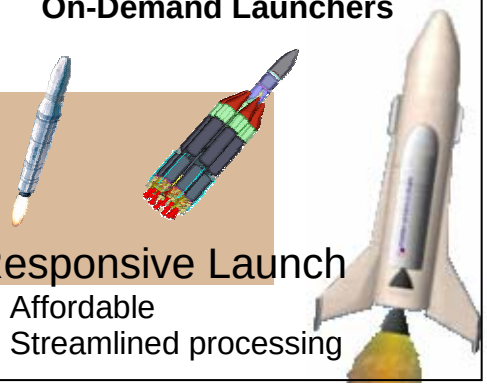
Payload Flexibility
- Mix-and-Match Sensors
- Tailorable Comm capability

Responsive Buses

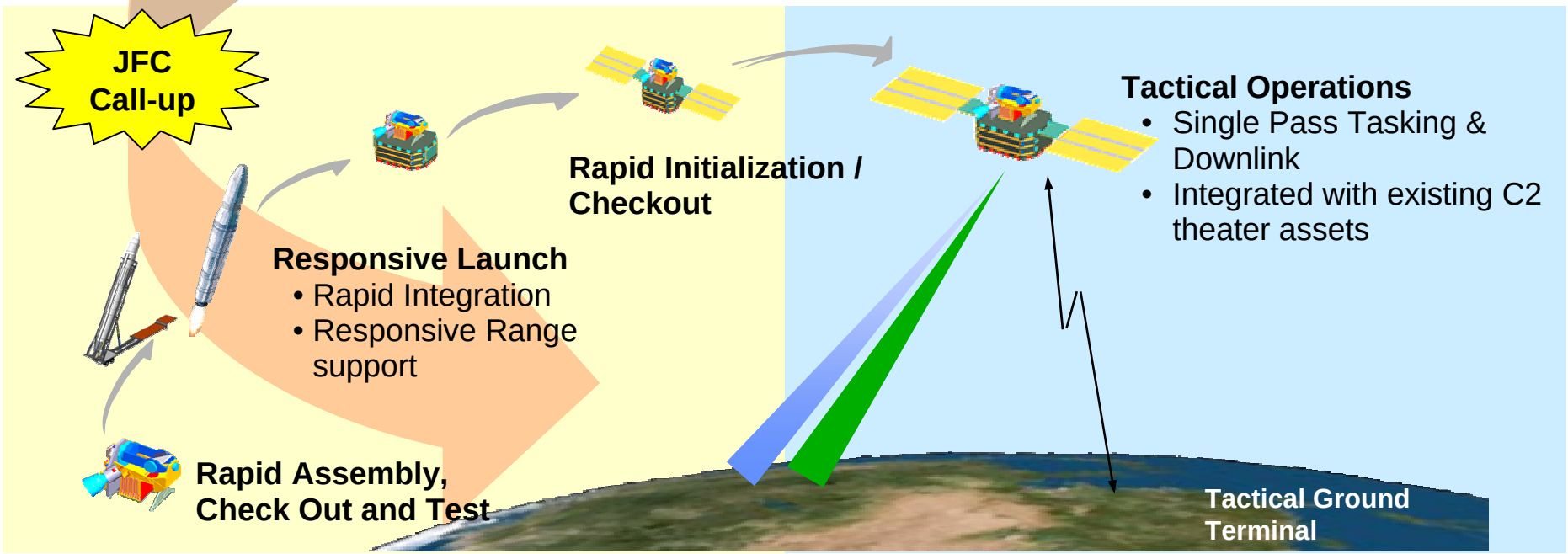


Bus Standardization
- Plug n Play Modularity
- Standard interfaces

On-Demand Launchers

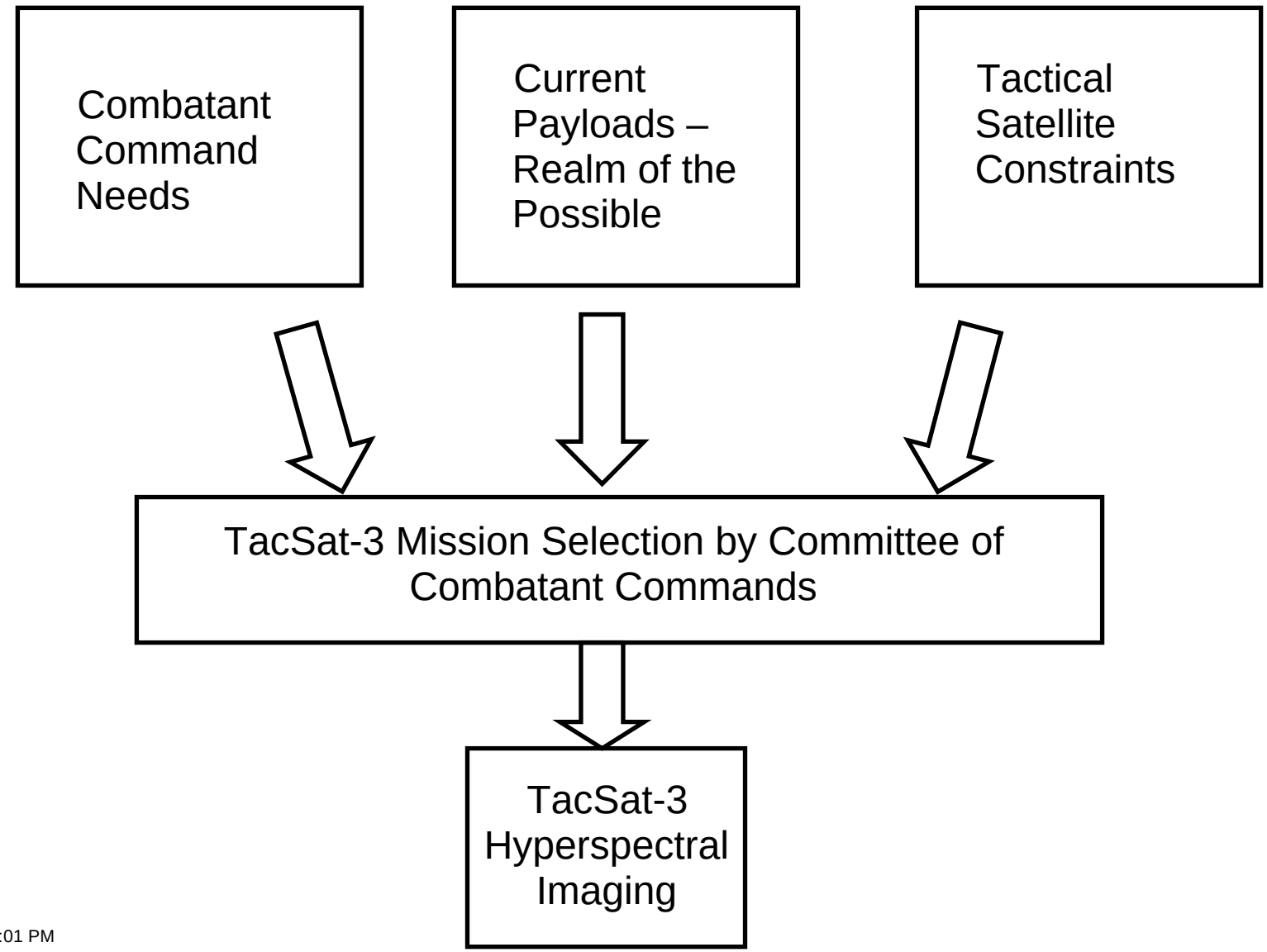


Responsive Launch
- Affordable
- Streamlined processing



TacSat-3 Mission Objective Development

TacSat-3 Mission Selection



Key Points to Success

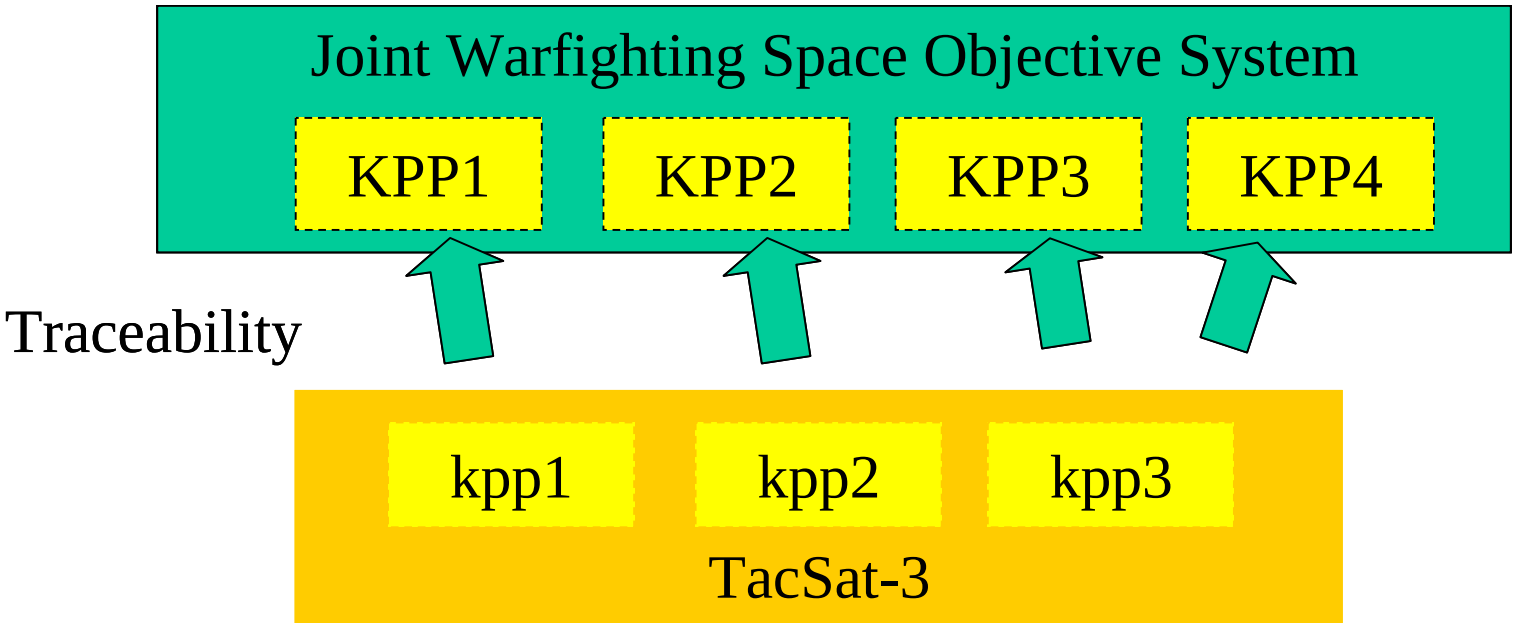
- All Major Stakeholders Involved
  - Combatant Commands Represent Primary Customer: Warfighter
  - Each Service Had a Vote
- Ultimately Melded Requirements and Capabilities
  - Traditional Requirements Based Approach
  - Non-traditional Capabilities Bounded
- Responsive Space Paradigm Essential
  - Programmatic Constraints of Cost and Schedule Immediately Considered
  - Responsive Delivery to Tactical Warfighter Prime Objective
  - Clear and Unambiguous Direction and Leadership

TacSat-3 Mission Objectives

- **TacSat-3 will *demonstrate traceability for*:**
  - **Hyperspectral Imaging Products:**
    - Rapid response to a user defined need for target detection and identification
  - **Next Generation Plug & Play Capability:**
    - Rapid development of the space vehicle – integrated payload and spacecraft bus – by using components and processes developed by the Operationally Responsive Space Modular Bus Program
  - **Enable Rapid Launch within 7 days from Alert Status:**
    - Rapid deployment from alert status for launch to theater control within 7 days
  - **Responsive Theater Communications:**
    - Responsive delivery of decision-quality information to operational and tactical commanders by enabling tactical tasking and data delivery
  - **Low Cost Implementation Of An Objective System**

- **Secondary Objective: Demonstrate Science and Technology payloads on a space available basis within cost and schedule constraints**

Defining Traceability



- **A Demonstration Mission Traceable to an Objective System**
- **Final Operational System Always a Part of Design Philosophy**
- **Objective System Still Based on Small Spacecraft Paradigm**

TacSat-3 Mission Success Criteria

Mission Success Criteria Principles

- Need to Correlate Key Elements of Objectives to Design Requirements
- Essentially Level 0 Requirements for the TacSat-3 System
- Key Elements of a Mission Success Criteria
  - Directly Map to Mission Objective
  - Relate Requirement to Whole System, Specific If Necessary
  - Must Have Realistic Metrics
  - Must Define a Threshold and Goal
    - Threshold Defines Success or Failure for Mission
    - Thresholds Hold Minimum Realistic & Acceptable Performance Level
    - Goal Gives Measure of Desired Level – Important for Traceability
  - Must Include Programmatic Constraints: Cost and Schedule
    - Executing Program within Cost and Schedule Just as Important as Technical Performance

Low-Cost Militarily Significant Product
Hyperspectral Imaging Products Direct to Warfighter

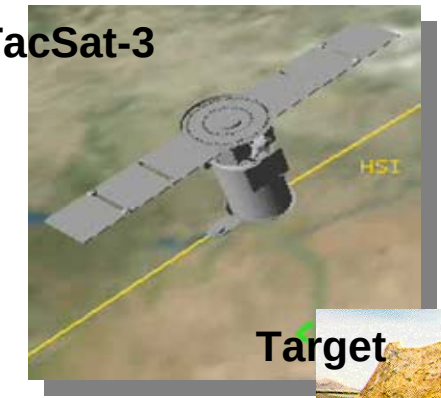
U.S. AIR FORCE

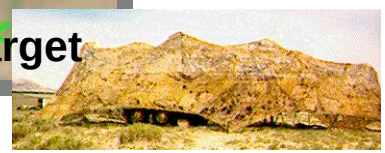
Hyperspectral Imaging

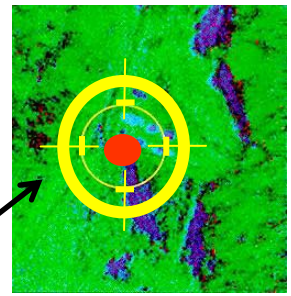
- Demonstrate tactically significant Hyperspectral Imagery collection and processing sufficient to meet militarily relevant detection thresholds

Tactical Data Delivery

- For a single-pass opportunity, the time period from a specified target collect to delivery of a processed product to the warfighter level must occur within 10 min (Threshold: 30 min)



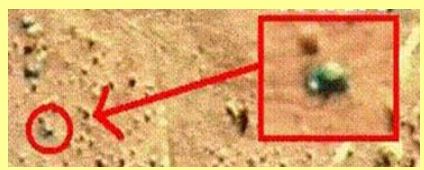




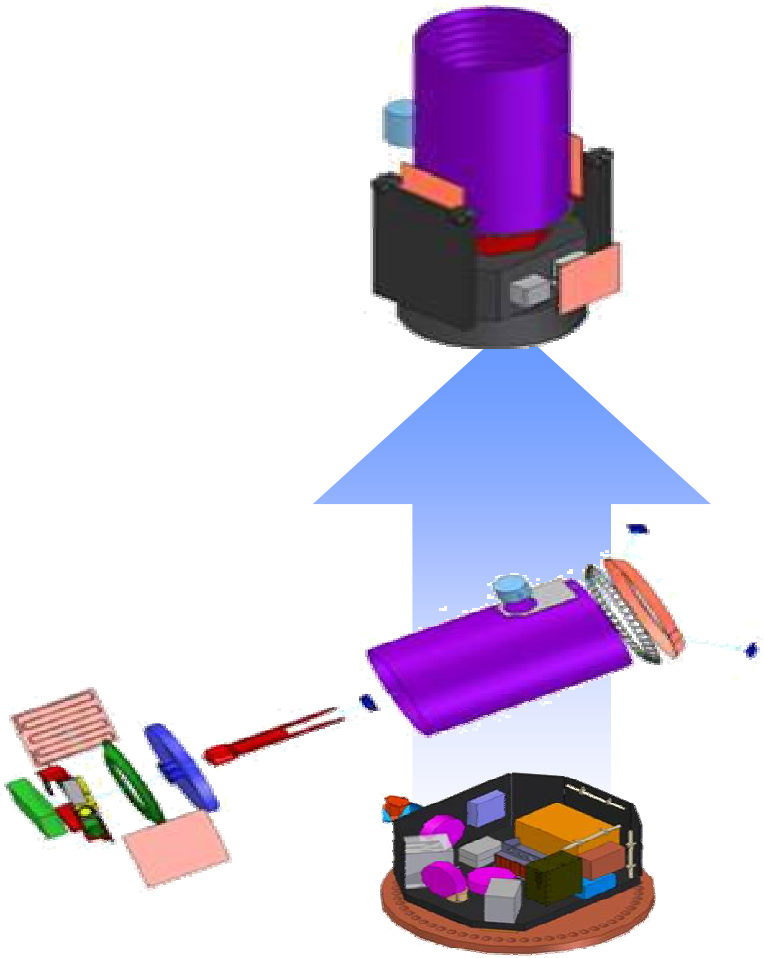
Tactical delivery of HSI products direct to Warfighter

Ground Segment
- Warfighter
- Tactical Ground Station
- Net-based Ground Communications

In-theater downlink
- Latency No Greater than 10 min

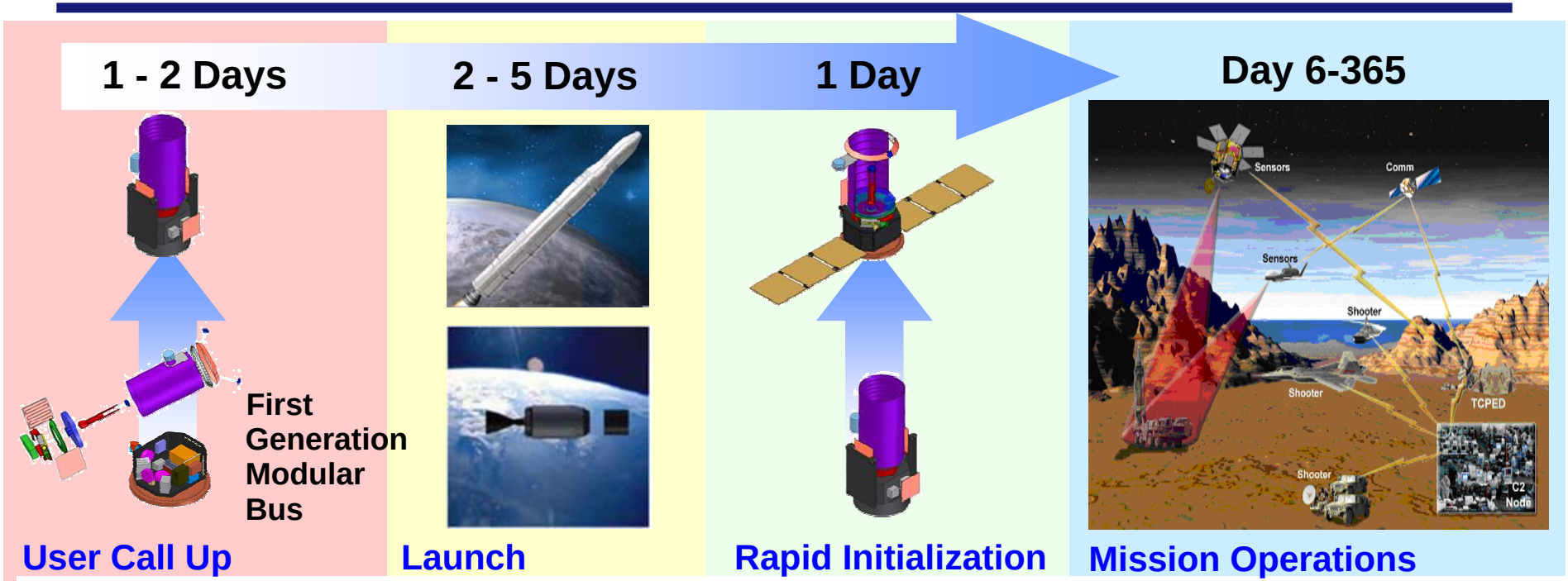


Modular Bus



- Demonstrate common Plug & Play electrical and software interfaces between bus components and between the bus and payload

Responsive Launch



- Demonstrate traceability to support deploying the spacecraft from an alert status to integration with launch vehicle within 2 days (Threshold: 2 days)
- Demonstrate traceability to support performing launch vehicles processes from spacecraft/launch vehicle integration to spacecraft separation on-orbit within 4 days (Threshold: 6 days)
- The launch vehicle must deliver spacecraft to an orbit altitude providing at least 12 months of orbital lifetime (Threshold: 6 months)
- Perform spacecraft checkout and payload functional checkout with overlap to complete initial checkout and attain readiness for theater tasking in 1 day (Threshold: 2 days)

Responsive Development

- Cost
  - Zero cost growth from the baseline cost presented by TacSat-3 Program Management
- Schedule
  - Meet the following development thresholds :
    - ARTEMIS sensor development – 15 months
    - Modular bus development – 10 months
    - Integration and testing – 3 months
- Future Cost
  - Demonstrate traceability to a total cost per launched spacecraft for an objective system of $20 Million or less.
- Reliability
  - Provide operational lifetime of 12 months (goal); 6 months (threshold) with 80% mission capability effectiveness. This effectiveness level is measured against the Success Criteria thresholds.

Design Example: To Cover or Not to Cover?

- Telescope Not Baselined with Cover
- No Cover Generates Risks
  - Contamination During Launch
  - Optics Degradation During Launch and During Mission Ops
  - Ensure Solar Exclusion From Optics
  - Dark Current Calibration of Sensor Performed Against Black Sky (Deep Space)
- Deployable Cover
  - Eliminates Risks Associated with No Cover
  - Adds Failure Mode (Cover Stuck Closed)
  - Adds Cost to Mission
  - Grows Mass and Complexity on Space Vehicle
  - Grows Schedule Beyond Success Criteria Threshold
  - Better Dark Current Calibration

Decision: No Cover

- Why No Cover?
  - Risks Mitigated or Accepted
    - Contamination Shown Not to Significantly Decrease Optics Performance (Lower Risk Accepted)
    - Optical Degradation Mitigated by CONOPS – Minimize Space Vehicle Pointing in Ram Direction – Also Shown Minimal Degradation in a Year (Lower Risk Accepted)
    - Solar Exclusion Risk – Probability of Sun in Optical Axis over 1 Year Mission Minimal (Lower Risk Accepted)
  - Prime Reason: Increase to Cost, Schedule and Complexity
- Risk Mitigation Cannot Increase Cost or Schedule to Program
  - Why Fail Two Missions For Possible Solution?
  - Must Manage Risk Smartly

Summary

- Mission Objectives On Firm Foundation
- Programmatic Constraints Part of Mission Objectives
- Key to Mission Success Criteria
  - Manageable
  - Measurable
- Design Options Which Fail the Cost and Schedule Mission Are Not Options

"The TacSat effort to develop smaller, less expensive satellites that launch on short notice is the best thing we have going for us in space right now", ***Rep. Terry Everett (R-Ala.) Chairman, House Armed Services Strategic Forces Subcommittee***