



AFRL

THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER



Responsive Space Technology

The NDIA 8th Annual Science & Engineering
Technology Conference/DoD Tech Expo

Tuesday, 17 April 2007



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Air Force Research Laboratory
Space Vehicles Directorate



- **ORS Overview**
- **ORS S&T Strategy**
- **Demonstrations through TacSats**



Congressional Direction on ORS Program Office (H.R. 5122-07)

- The SECDEF shall establish within the DOD an ORS Program Office
- Mission of the Office shall be to contribute to the development of low-cost, rapid reaction payloads, spacelift, and launch control capabilities in order to fulfill joint military operational requirements for on-demand space support or reconstitution
- Office Elements
 - S&T Division
 - Acquisition Division
 - Ops Division
 - Combatant Command Support Division
- Cost caps on ORS systems (as practicable)
 - \$20M per launch
 - \$40M per spacecraft
- 120 days for report back to Congress



Mission and Tasks

- **Mission**

- **Develop desired ORS capabilities/characteristics, advocate, plan, and conduct space ops**

- **Tasks**

- **Reconstitute lost capabilities**
- **Augment/Surge existing capabilities**
- **Fill Unanticipated Gaps in capabilities**
- **Exploit new technical/operational innovations**
- **Respond to unforeseen or episodic events**
- **Enhance survivability and deterrence**



Tiered Approach

Tier-1) On-demand with existing assets (*minutes/hours*)
Employ It

Tier-2) On-call with ready-to-field assets (*days/weeks*)
Launch It / Deploy It

Capability Already Available

Tier-3) Emergent with rapid transition from development to delivery of new or modified capabilities (*months*)

Develop It

Capability Does Not Exist

Deliver Space Effects in Response to an Urgent Need

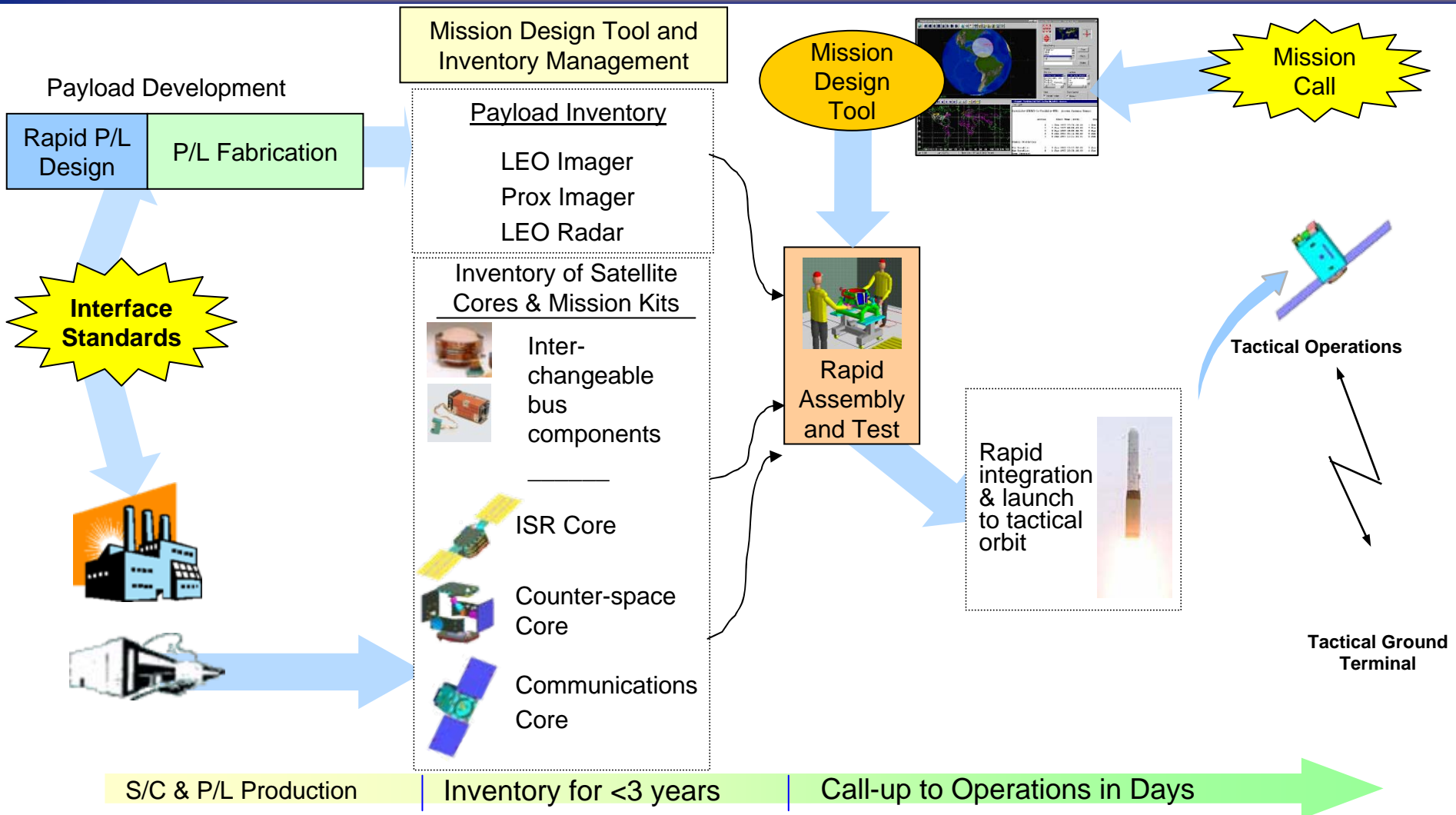


Development Strategy

1. Develop Robust S&T Portfolio
 - Address core S&T shortfalls/barriers
 - Develop a modular, plug-n-play bus to lower cost & development time
 - Adapt existing technologies (plug-n-play, aircraft sensors, COTS electronics, etc...) for small, low-cost satellites
 - Develop integrated software suite covering entire range of needs from mission planning to autonomous, on-orbit checkout and ops
2. Conduct Operational Experimentation (TacSat Experiments)
 - Testbed to validate S&T, CONOPS, and military utility
 - Warfighter CONOPS Experiments
 - Explore the military utility of small, low-cost satellites
 - Develop methods for theater tasking/data dissemination
 - Service or CoCom partner
 - Prototype of an operational system
3. Develop Innovative Acquisition Methods
 - Rapidly acquire these systems if they are useful



RSATs Responsive Space Vision



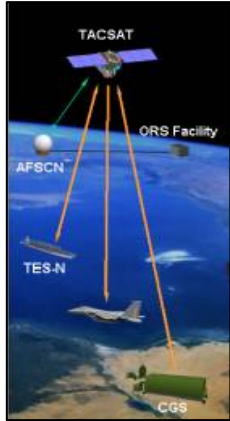
The S&T Foundation Enabling USSTRATCOM ConOps



Responsive Satellite Enabling Technology

Tactical Operations and Data Dissemination:

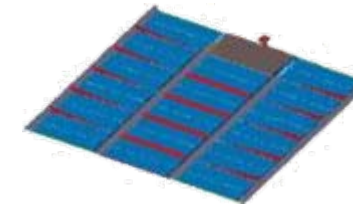
- Integrate with existing ISR C2 (e.g. Space CDL, UHF, JTRS, GBS)
- Must fit into existing warfighting architecture
- Provide decision quality data to the warfighter



- Responsive
- Affordable
- Employable
- Integrated

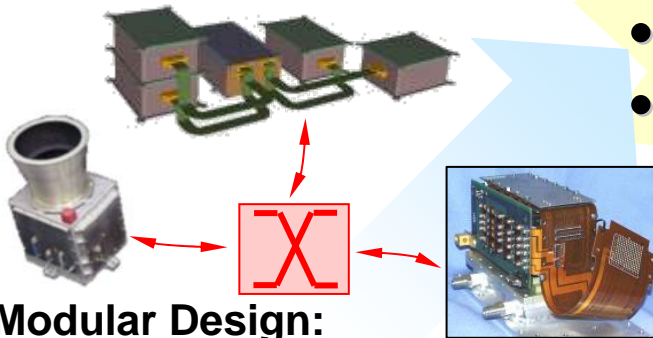
Advanced Small / Microsat Technologies:

- Lightweight, low cost apertures
- Advanced power
- Efficient propulsion
- Low cost rad-tolerant components



Modular Design:

- Plug 'n play architecture
- Standard, open architecture interfaces



Rapid Deployment & Ops:

- Mission planning tools / tailored orbits
- Fast assembly and test
- Rapid autonomous deployment and operations

Investments Being Made Across DoD S&T Enterprise

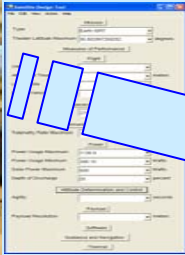


Responsive Satellite Test Bed

Where the Vision is Translated into Products



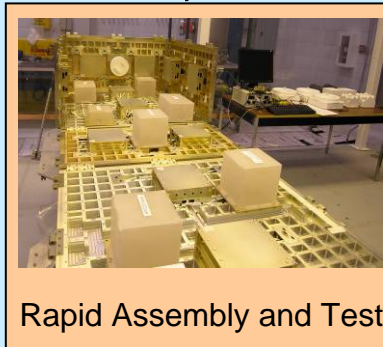
Satellite Design Toolkit



SPA-U
SPA-S
SPA-E
XTEDS –
(Electronically Readable Datasheets)

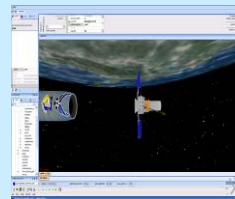


Adaptive Wiring Manifold



Rapid Assembly and Test

Satellite Data Model
S/W & Guidebook



Hardware-in-Loop Test Bed with
Full 6DOF Physics Simulation



- Star Tracker
- Structure
- C&DH
- Core Bus



ASIM
(Applique Sensor
Interface Module)



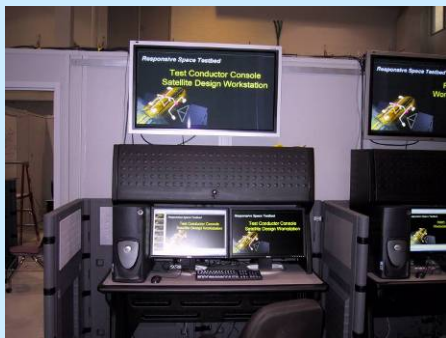
Responsive Technology Cell

2005-6 Experiments

- Push Button Tool Flow Mission Planning
- Full Plug-n-Play integration
- Elimination of written ICD's with XTEDS
- Adaptive Wiring Manifold
- Autogenerated spacecraft flight s/w
- Sub-real/real/super-real flight simulation
- 2 hour spacecraft assembly !

2006 – 2007 Objective

- Creation of first p-n-p modular bus



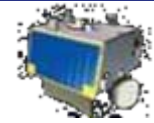
RIMS Ground Station

The Existence Proof of the Modular Plug-n-Play Satellite



Operational Experimentation

- UK TopSat
 - Conducting operational experiments with UK's low cost imaging spacecraft on orbit, delivered imagery to warfighter < 90 minutes via internet
- TacSat-1 (Lead: NRL for OSD/OFT)
 - Dual-mode target identification using Specific Emitter Intelligence (SEI)
 - Estimated launch April 07 Space-X Falcon-I
- TacSat-2 (Lead: AFRL/VS)
 - Provides enhanced SEI & Automatic Identification Systems and ~1m resolution imagery, tactical tasking & data dissemination
 - Launched 16 Dec 2006
- TacSat-3 (Lead: AFRL/VS)
 - Hyperspectral and panchromatic imagery directly to tactical user or to CONUS data center, On-board data processing
 - Estimated launch Fall 2007
- TacSat-4 (Lead: NRL)
 - “Comm on the Move”, Data Exfiltration and Blue Force tracking
 - Launch ready 2008
- TacSat-5 (Lead: TBD)
 - Initiated TacSat-5 Selection Process – 27 July 2006



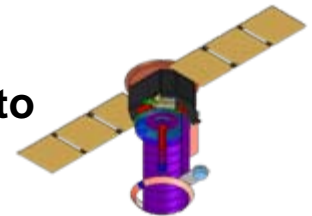
TopSat



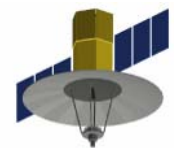
TacSat-1



TacSat-2



TacSat-3

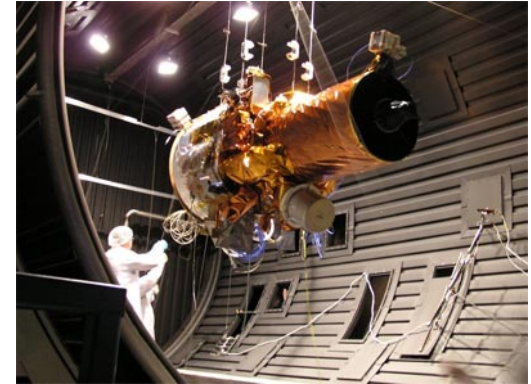


TacSat-4



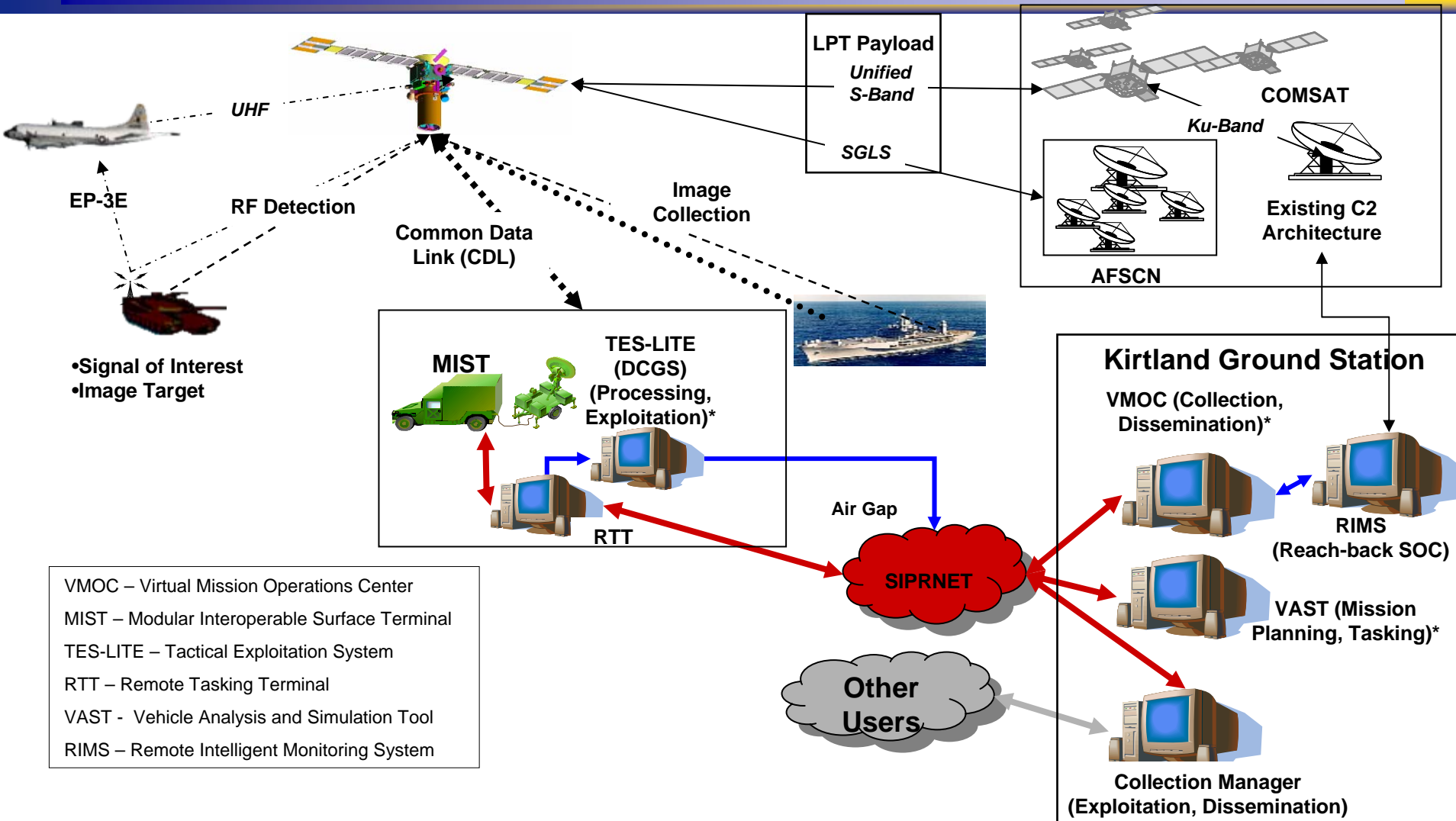
TacSat-2 Description

- **Primary Payloads:**
 - 50-cm imaging telescope (line scanner array, PAN, 3-color)
 - Specific Emitter Identification (SEI) radio and Automated Identification System (AIS) receiver
- **Spacecraft Mass: 368 kg**
- **Spacecraft Power:**
 - ~550 Watts, triple junction cells
 - 60 Watt experimental thin film PV Arrays
- **Orbit: 410 km, 40° inclination**
- **Mission Life**
 - 6 month threshold, 1 year goal
- **Mission Objectives**
 - Assess military utility of low-cost ISR satellites & ground stations
 - Evaluate concepts for simplifying and expanding warfighter access to space assets
 - Demonstrate concepts for faster acquisition, responsive launch & operations
- **MUA led by AFSPC SIDC –**
 - Exercises: Talisman Sabre, Coalition Warrior





TacSat-2 CONOPS



VMOCC – Virtual Mission Operations Center
 MIST – Modular Interoperable Surface Terminal
 TES-LITE – Tactical Exploitation System
 RTT – Remote Tasking Terminal
 VAST - Vehicle Analysis and Simulation Tool
 RIMS – Remote Intelligent Monitoring System

TacSat-2 provides theater and CONUS tasking/dissemination options



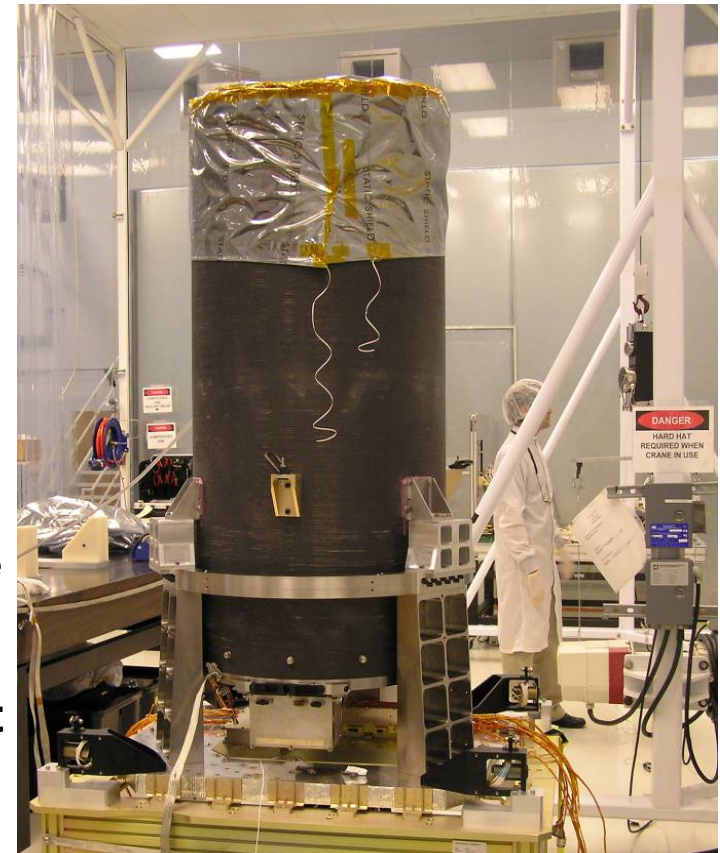
TacSat-2 Imager



- **Enhanced commercial imager, comprised of a 20-inch telescope with four-color line scanner, demonstrates low-cost space imagery**

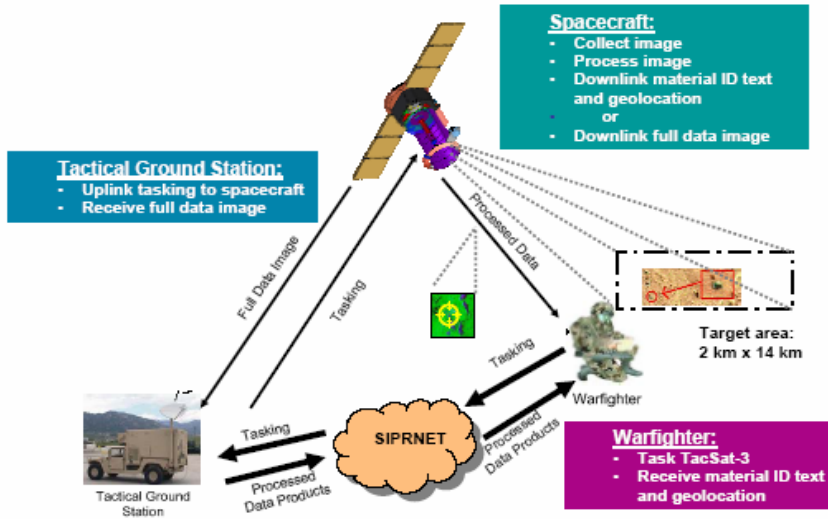
- **Capabilities**

- **5 kilometer image width with variable length**
- **Panchromatic, red, blue and green images; 3.9 – 5 kilometers image width**
- **Best expected ground sampling distance of 0.84 meters**
- **Ground processing required to construct multispectral images**



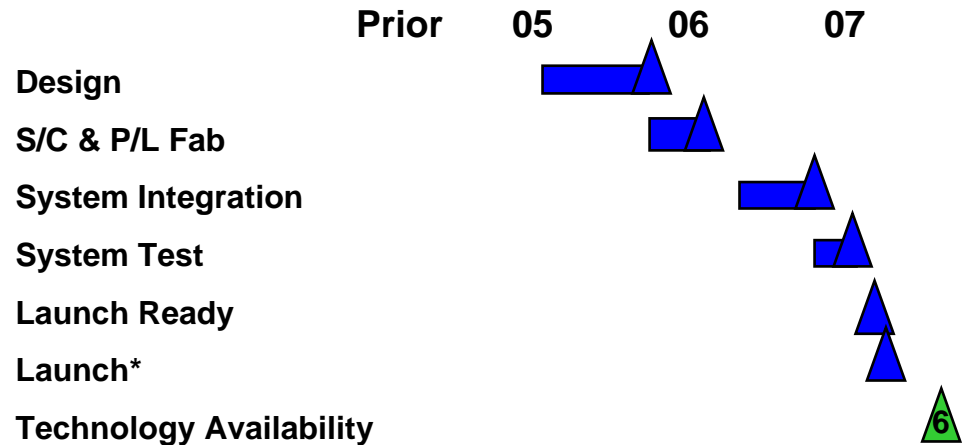


TacSat-3



Space capabilities delivered directly to the operational and tactical warfighter

Technology Investment Schedule (FY) As of 19 Oct 05



*Current Launch Date October 07

Description	Benefits to the War Fighter
Integration of technologies demonstrating new capabilities in responsiveness, mission ops, modularity of spacecraft design, low-cost payload development, & advanced modularity experiment	<ul style="list-style-type: none"> • Hyperspectral imaging products • Next generation "Plug and Play" spacecraft • Enable rapid launch within 7 days from alert status. • Responsive Theater Communications: <ul style="list-style-type: none"> -Near-real time (< 10 min) delivery of decision quality data • Low cost implementation of an objective system • Data exfiltration from unattended ocean buoys
Critical Experiment	
<ul style="list-style-type: none"> • Hyperspectral and panchromatic imager • Data exfiltration payload • Wideband and narrowband in theater comm. • Small spacecraft <400 kg • Partnerships with Army and Navy 	

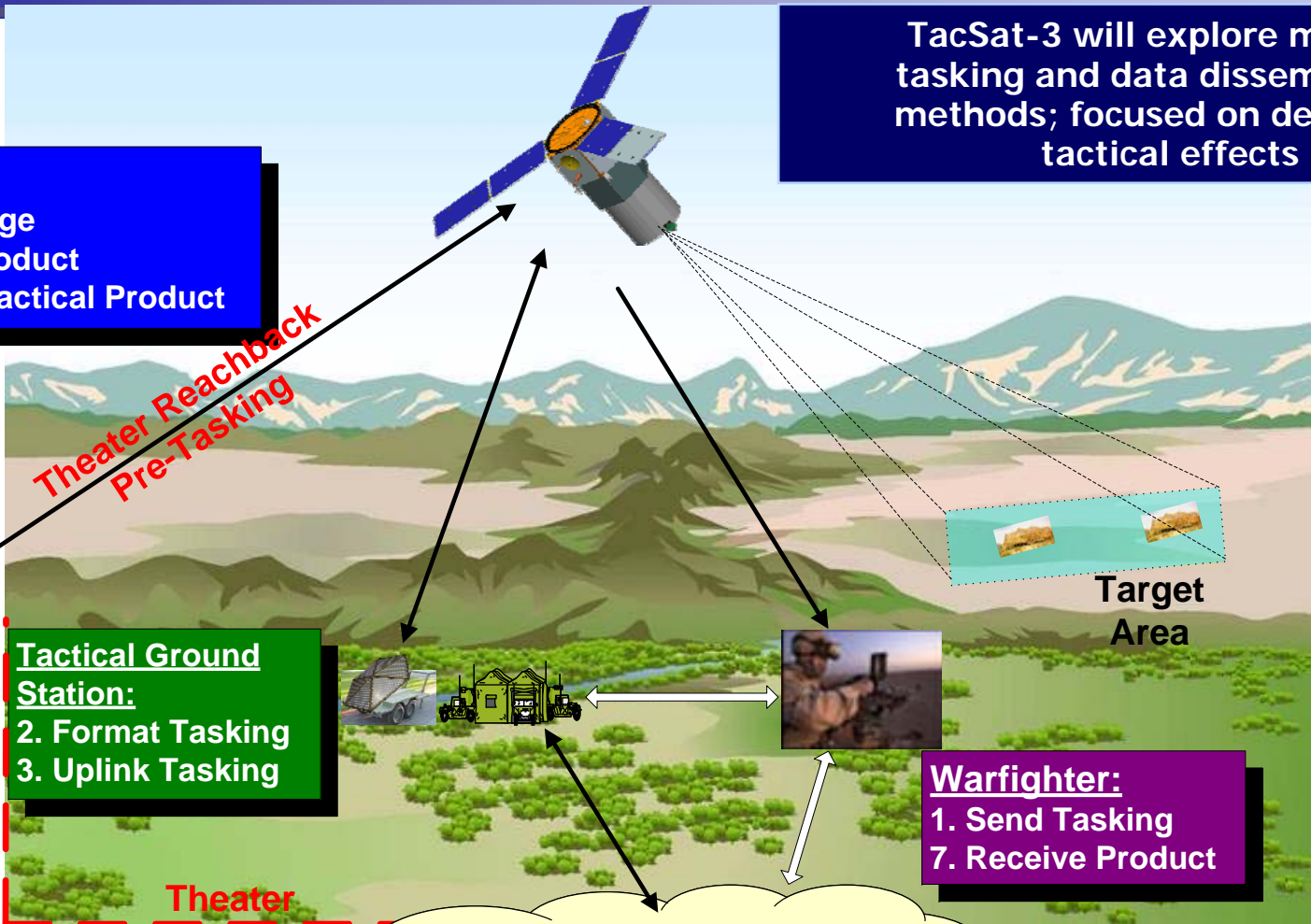


TacSat-3 CONOPS

Tactical Ops – Real Time Downlink & C2

TacSat-3 will explore multiple tasking and data dissemination methods; focused on delivering tactical effects

Spacecraft:
4. Collect Image
5. Process Product
6. Downlink Tactical Product

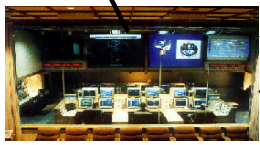
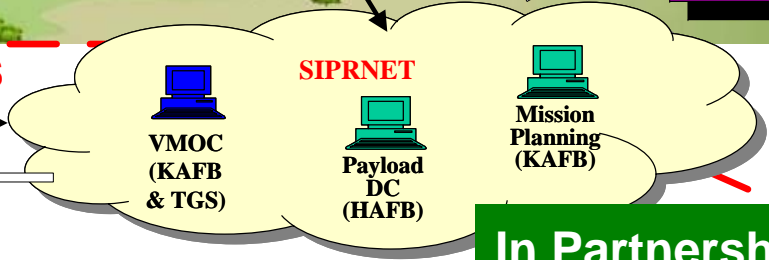


Tactical Ground Station:
2. Format Tasking
3. Uplink Tasking

Warfighter:
1. Send Tasking
7. Receive Product

Theater Reachback
Pre-Tasking

Theater
CONUS



Mission Operations Center

In Partnership with Army SMDC



*The National Defense Strategy
of
The United States of America*



March 2005

“Uncertainty is the defining characteristic of today’s strategic environment... we must posture ourselves to handle unanticipated problems – we must plan with surprise in mind”

- **Developing a radical approach to bring space capabilities to the tactical level of war**
- **Investing in the necessary S&T**
 - Modular ‘plug-n-play’ satellite bus
 - High performance tactical downlinks
 - Adaptable, agile propulsion systems
 - Lean fab, assembly, test, ops
- **Space demonstrations LEARNING BY DOING!**

Discovering and Developing New Technologies & Delivering Important New Capabilities



Backups



- **Design Goals**

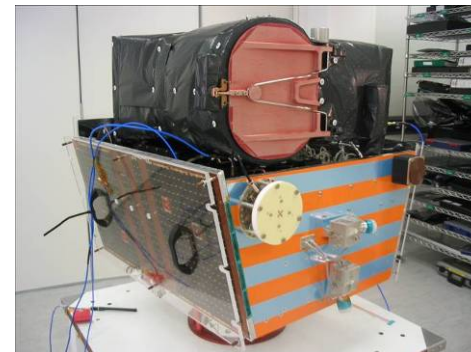
- **Cost £14M / \$23.4M DESIGN GOALS**
- **Small (~100kg/ 218 lbs mass)**
- **Ground spatial resolution (on-nadir)**
 - 2.8m (b&w)
 - 5.6m (colour)
- **Images 17km x 17km (b&w)**
 - 10km x 17km (colour)
 - Max 4 each/day
- **FoR +/-30 deg**
- **TDI x4**
- **Global revisit once every 3 days**
- **Imagery downloadable to mobile ground station**
- **Lifetime >1 year**

- **STATUS**

- **Launched 27th Oct 2005**
- **Altitude 686km SS**
- **FoV = 17km**
- **X4 TDI**
- **Ground spatial resolution (on-nadir)**
 - 2.8m (b&w)
 - 5.6m (colour)
- **S-Band and X-Band downlink to fixed UK Ground Station confirmed**
- **Successful download of imagery to RAPIDS mobile ground station demonstrated**



London, 12/2005





TacSat-1

- **Launch Ready**
 - Current launch date ~Feb 07
- **MicroSatellite:**
 - 125 kg, 186 W
 - 40 in dia. x 20 in high
 - 510 km, 64° inclination
 - 1 year life
- **Payloads:**
 - Cross-platform RF Collection and Specific Emitter Identification
 - Visible (70m) & IR (850m) Imaging
- **Ground station: Blossom Point MD**
 - With VMOC (Virtual Mission Operations Center) for SIPRNET tasking, data assess, & collaboration
 - Addition AFSCN Antenna Coverage



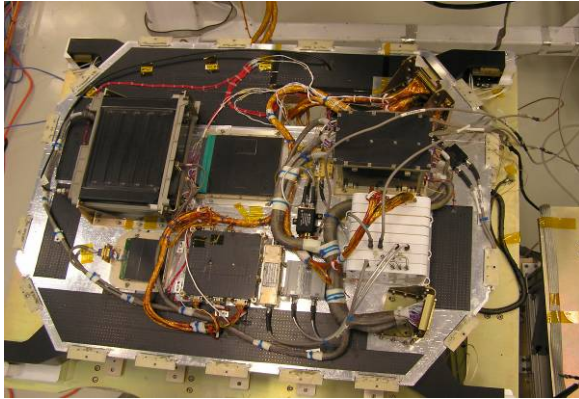
- **CONOPS Highlights:**
 - 1) Cross-Platform RF collection & geolocation using TacSat-1 and EP-3
 - 2) Specific Emitter Identification experimentation
 - 3) SIPRNET web site for payload scheduling (tasking requests), data access, and collaboration
 - Imagers installed primarily from this SIPRNET CONOP & user interface experimentation
 - Net-centric TTP's, CONOPS, and behavior analysis (e.g. self-organizing scheduling)

- **Aircraft:**
 - EP-3s: 1 fixed and 3 mobile RORO units
 - RJs expected but number TBD
 - “Arctic Lab” testing performed fall 2004





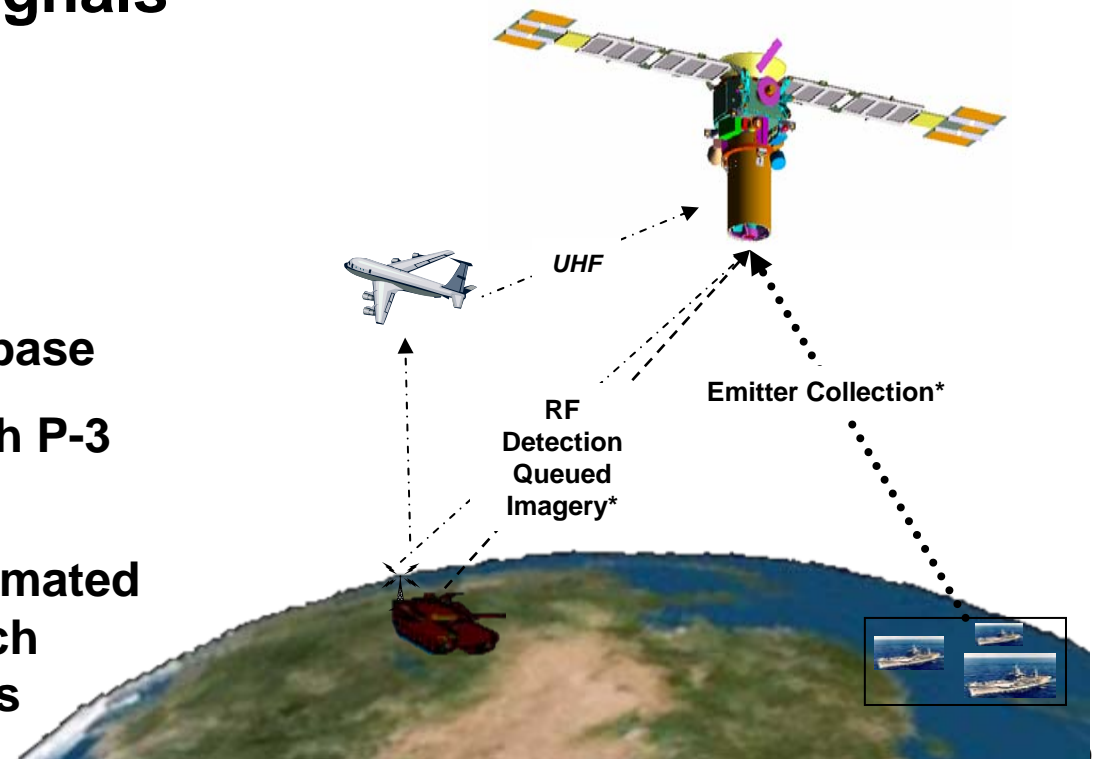
TacSat-2 TIE Payload



- **U.S. Navy's Target Indicator Experiment (TIE) consists of a wideband sensor to collect radar, radio, and handheld communication signals**

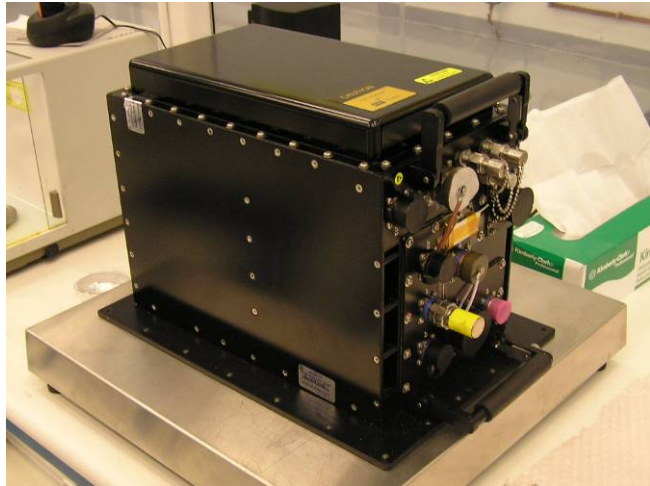
- **Capabilities**

- **Radio frequency emitter detection**
- **Signal ID by onboard database**
- **Geolocation in concert with P-3 and Rivet Joint**
- **Demonstration of the Automated Identification System, which tracks ocean-going vessels**





TacSat-2 CDL Radio



- **Common Data Link (CDL) tactical radio transmits imagery and communication data to the Modular Interoperable Surface Terminal (MIST), at the U.S. Navy's China Lake, Calif., facility.**

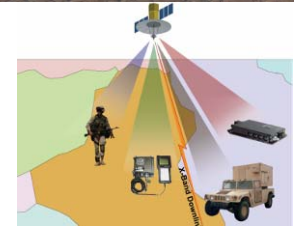
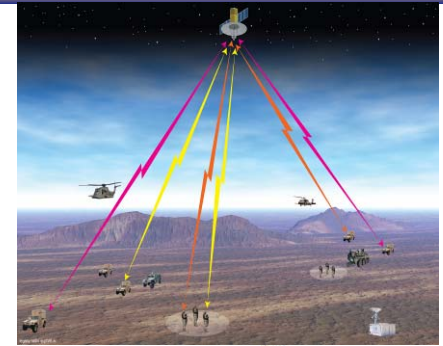
- **Capabilities**

- **Command uplink and data downlink accomplished by the apparatus**
 - ❖ **High transmission rate of 6 X 42.8 megabytes per second**
 - ❖ **Low broadcast speed of 10.8 megabytes per second**
- **MIST ground station is an operational Army system**
 - ❖ **Both uplink and downlink verified with the spacecraft**



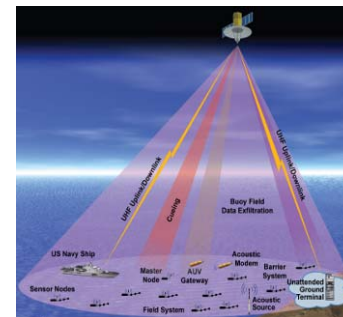
Capability Gaps/Shortfalls Satisfied

- Comms On the Move
 - A. Beyond Line of Site (BLOS) UHF Comms Legacy Radios
 - Voice: 50-100 Users; Data: 20 Users
 - B. BLOS IP Networked Comms Using Legacy UHF Radios
 - Network Users: 40-60 w/ 16 kbps Radio; 320-640 w/ 56 kbps Mode
 - Allows Configurable Comms: Point-to-Point Comm and Multi-cast
 - Supports BLOS C2PC and FBCB2 Networking
 - C. MUOS-Like Wideband Comms (256 kbps per user)
 - Wideband Allows 100's-1000 Users Per Channel
 - Early Testing and Augmentation with MUOS-Like Comms
- Blue Force Tracking (UHF BFT)
 - Collect Existing UHF BFT Devices in Underserved Areas (>10,000 Units)
 - Route Data via Existing Channels
 - Augment NTM in Underserved Areas
- Data-X
 - Data Exfiltration from Buoys & Unattended Ground Sensors
 - Collects Sensors > 1 Watt
 - Allows Direct-to-Ship Collection



Features

- One Ground Terminal Required per 4000 nm Theater
- Near Global Collection Capability
- No User Antenna Pointing Required



White-Paper Capability Gaps/ Shortfalls Satisfied			
Service \ Mission	COTM	BFSa	Data-X
Army	X		
Navy			X
Air Force			
Marines	X	X	
Strat/SOF	X	X	

Launch Ready Mid 2008