OFFICE OF FORCE TRANSFORMATION

Operationally Responsive Space

TacSat-1 and a Path to Tactical Space

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LAST YEAR

STUDY CONCLUSIONS

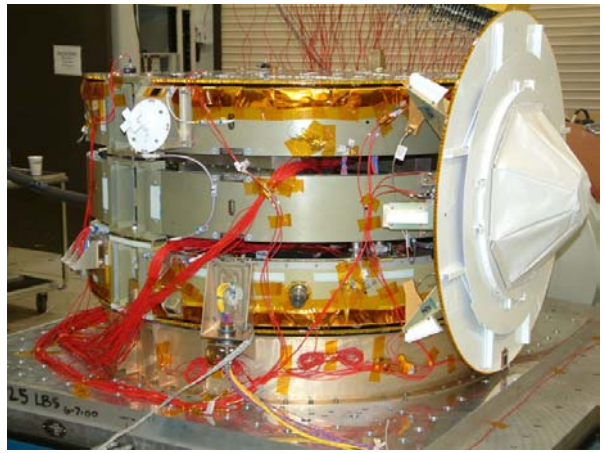
- A Tactical Micro-Satellite System, "TacSat", is a Credible Concept
  - Micro-Satellite Capabilities becoming Impressive
  - The SIPRNET is Waiting to be Exploiting
  - Promising New Launch Vehicle Developments are Underway
  - CONOPS & Coverage are Realistic for Conflict Specific Missions
- TacSats Provide a Unique Combination of Desirable Characteristics
- The Tactical Micro-Satellite Platform Provides an Efficient Mechanism to Bring New Technologies & Capabilities to the Forces
  - Consistent with Technology's Development Cycle Time
  - Increases Tiered Support and Ability to Perform Cross-Platform Mission
- The TacSat System makes Space Assets an Organic Part of the Joint Task Force

STATUS

Office of Force Transformation is Interested…Stay Tuned

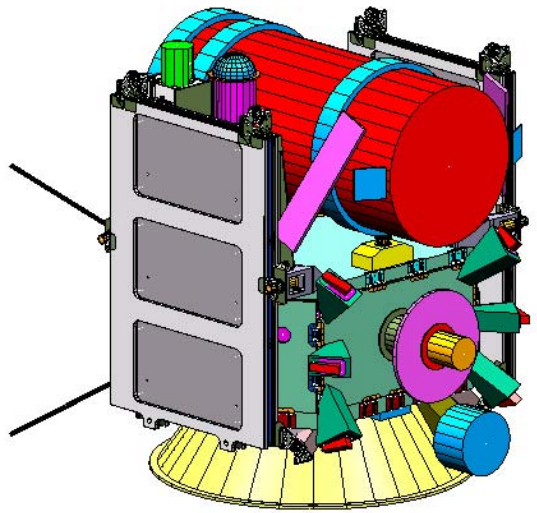
THIS YEAR

- **TacSat-1**
  - Navy Led Experiment
  - Tactical RF Payloads & UHF Link
  - Low Resolution Visible & IR Cameras
  - SIPRNET Exploitation using VMOC
  - Launch on SpaceX's Maiden Flight of Falcon
  - Spacecraft: 1 Year Start to Finish



TacSat-1 on Vibration Table

- **TacSat-2**
  - Air Force Led Experiment
  - Tactical Imaging & RF Payloads
  - Tactical CDL & UHF Links
  - Autonomous Spacecraft Operations Experiment
  - SIPRNET Exploitation using VMOC
  - Good Example of Spiral Development



TacSat-2 / Roadrunner

Picture Complements of AFRL & MSI

- **Serious, System Level, Responsive Space Planning Efforts Underway**

TacSat-1 : Components

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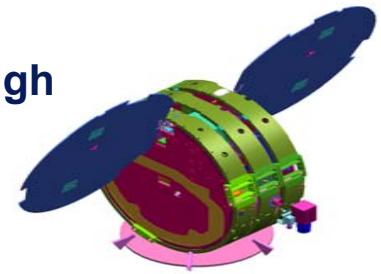
- **MicroSatellite:**
  - 110kg, 186W
  - 40in dia. x 20in high
  - 500km, 64º inc.
  - 1 year Life
- **Payloads:**
  - Cross-Platform & SEI
  - Visible (70m) & IR Cameras (850m)



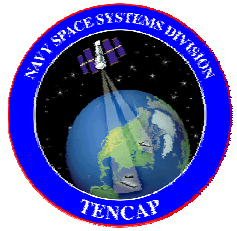
- **Launch Vehicle: Falcon**
  - New, Privately Developed
  - LOX-RP1 Rocket
  - 60klb, 70ft by 5.5ft dia.
  - ~1000 lb to 500km

- **Ground Station: BLOSSOM POINT MD**
  - Additional Coverage from AFSCN
  - Virtual Mission Operations Center (VMOC) on SIPRNET

- **Aircraft:**
  - EP-3's: 1 Fixed & 3 Mobile RORO Units
  - RJ's Expected but Number TBD

Goal: Energize the DoD and Industry in the Tactical, Responsive Space Area

DoD Partnerships



A Path to Tactical Space

Going Forward

Envisioned System Concept

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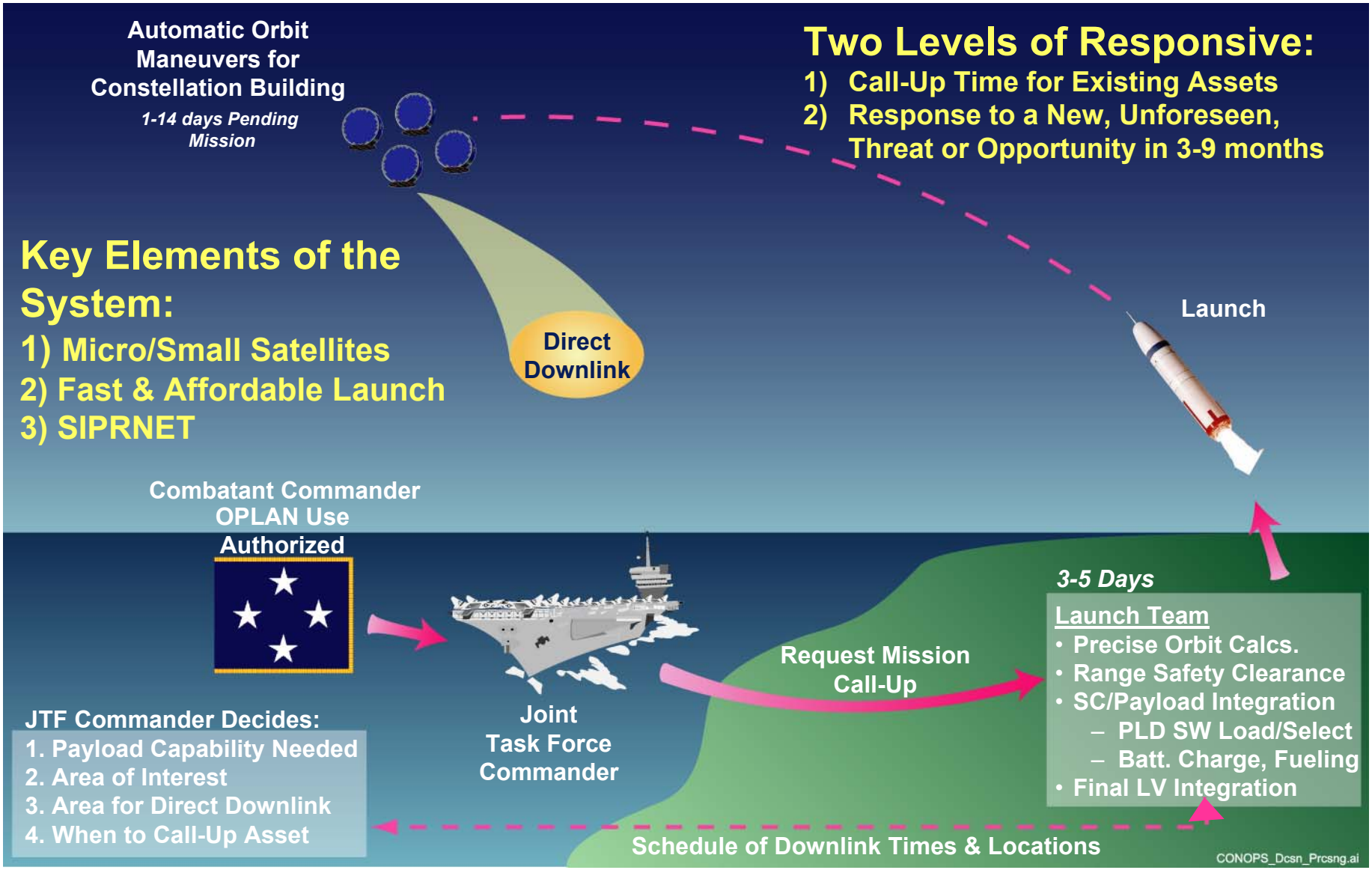

Requirements EMPHASIS is Critical

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INTERNET COMPARISON[1]

1) Internet Comms Must Continue Despite Loss of Gateways
2) Internet Must Support Multiple Types of Communications Services
3) Architecture Must Accommodate a Varity of Networks
4) Architecture Must Permit a Distributed Management of Resources
5) Architecture Must be Cost Effective
6) Must Permit Host Attachment with Low Level of Effort
7) Resources Used in Architecture Must be Accountable

[1] "Design Philosophy of the DARPA Internet Protocols", David Clark, MIT, SIGCOMM '88, Computer Communications Review Vol 18 #4, 1988

TACTICAL SPACE SYSTEM

1) Must be an Organic Part of the Joint Task Force. Implies Tactical Control and Networking.
2) Must Provide Operationally Useful Coverage
3) Must be Battlefield Class of Cost for a DEPLOYED System (# Launches + # of Spacecraft, etc)
4) Must Provide 1 Year of Operations
5) Must Minimize Time to Deploy
6) Must Maximize Payload Capability
7) Must Provide Sensing Unknown to Adversary

Emphasis of a FEW Requirements will Drive Resulting System

Parallel, Spiral Development

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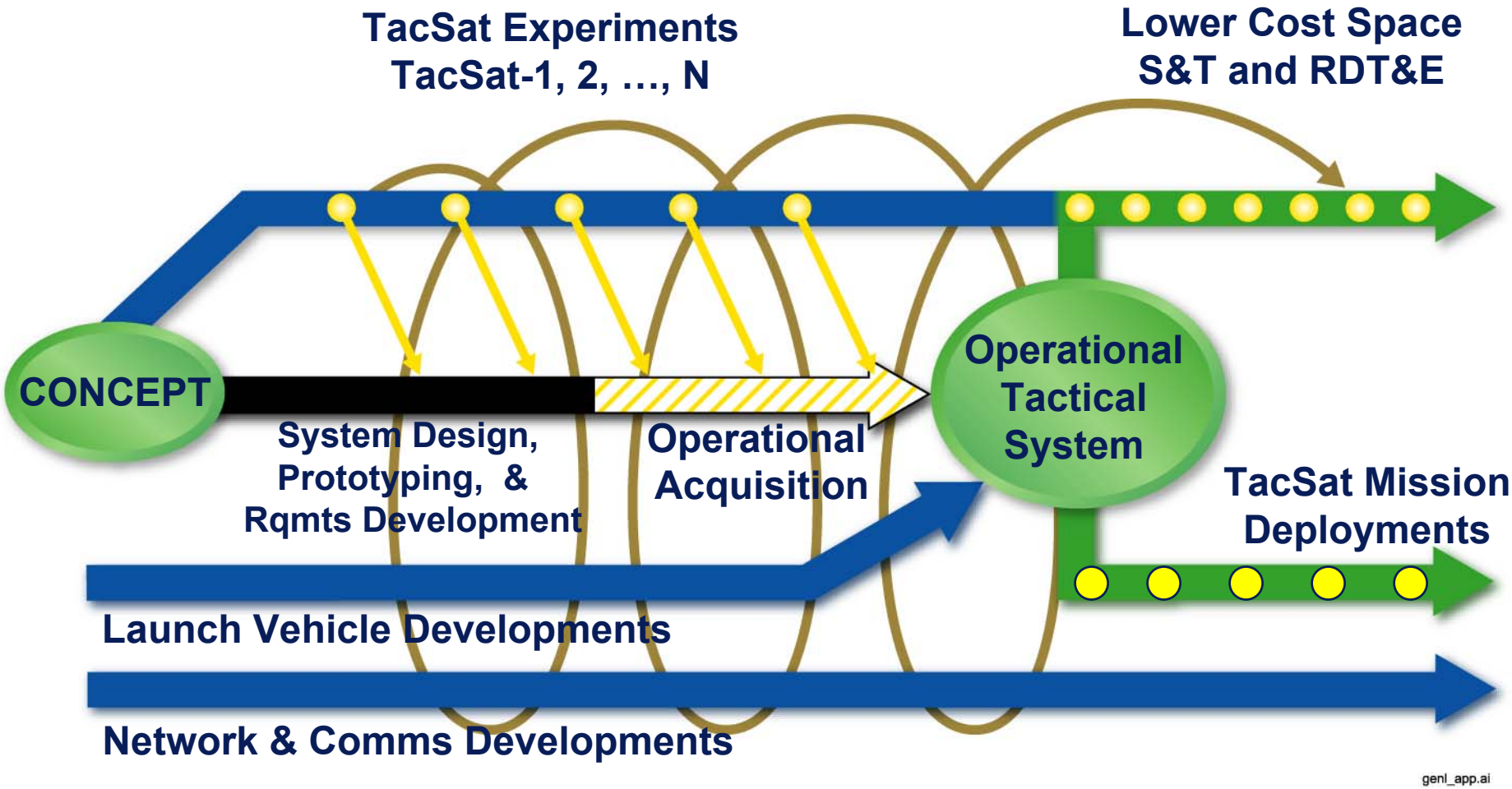
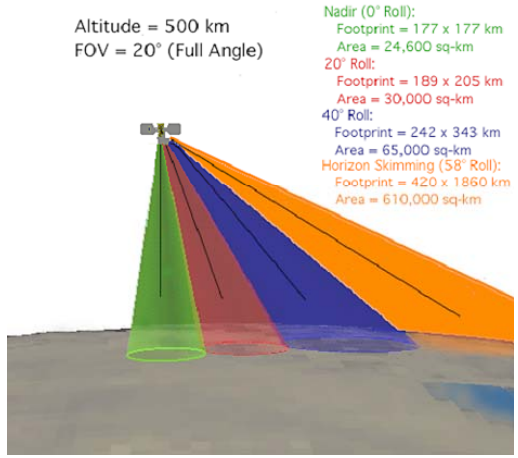
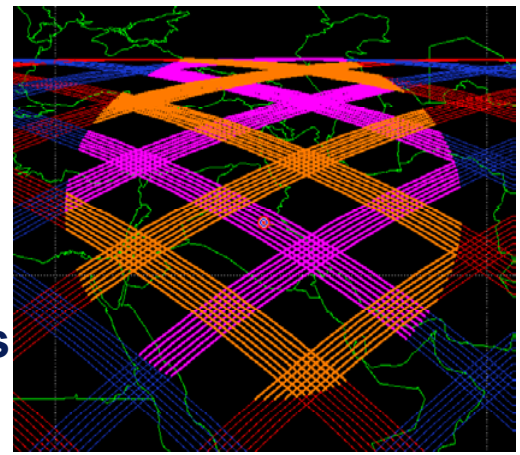


- Cooperative Buildup and Leveraging to Arrive at an Operational System
  - Parallel Efforts in Launch, Networking, TacSat Experimentation are Already Occurring

General Orbit & Coverage Considerations

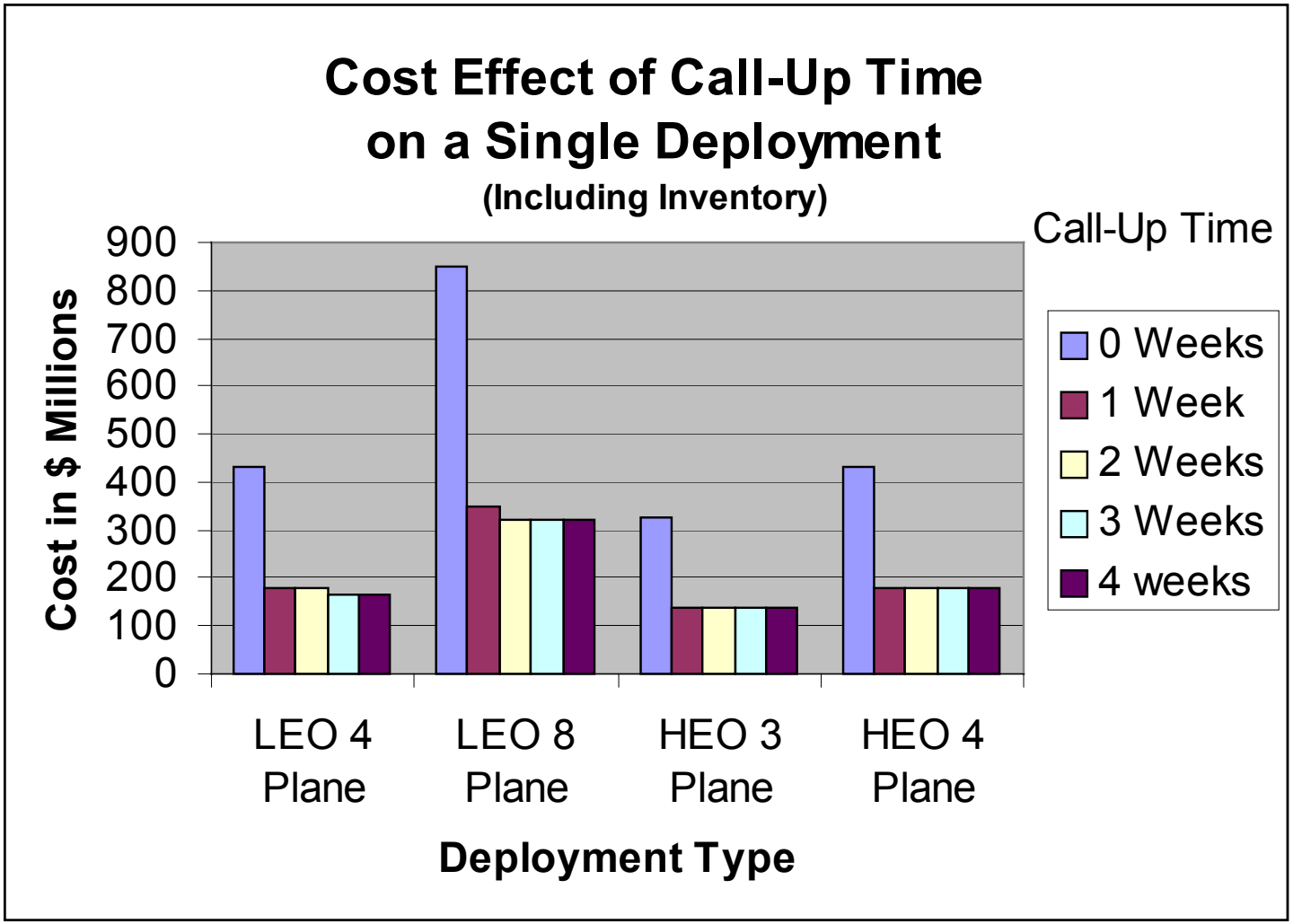
- **Coverage will Drive Operational Utility as Well As Cost**
- **Ability to Launch AFTER Knowing the Region of Interest Helps Reduce Number of Spacecraft & Launches Needed**
- **Allowing 1-2 Weeks for Orbit Maneuvering will Cut the Number of Launches Required to LEO Missions in Half**
- **Example: LEO for Mid-Latitudes (+/-78)**
  - **4 TacSats, 1 each in 0, 30, 180, 210 Plane**
  - **Ave. Revisit is 1.1 hrs**
  - **Likely Implementation…**
    - **2 Launches into Planes 180 Deg. Apart**
    - **Raise Orbit of 2 Sats (1 per Plane) by 1000km to Separate Nodes by 30 deg. (Takes ~15 days)**
- **Example: Elliptical for Long Dwells**
  - **3 Planes Separated by 120 degrees Generally Provides 24 hour Coverage, Except Near Equator**
  - **Orbit: 11,500km x 1200km at 63.4º inclination**
  - **Likely Implementation: 3 Launches, 120 deg. Apart**





Example for 1 day of Passes:
LEO 500 km & Agile 20deg FOV

Major System Cost Considerations: Call-Up Time

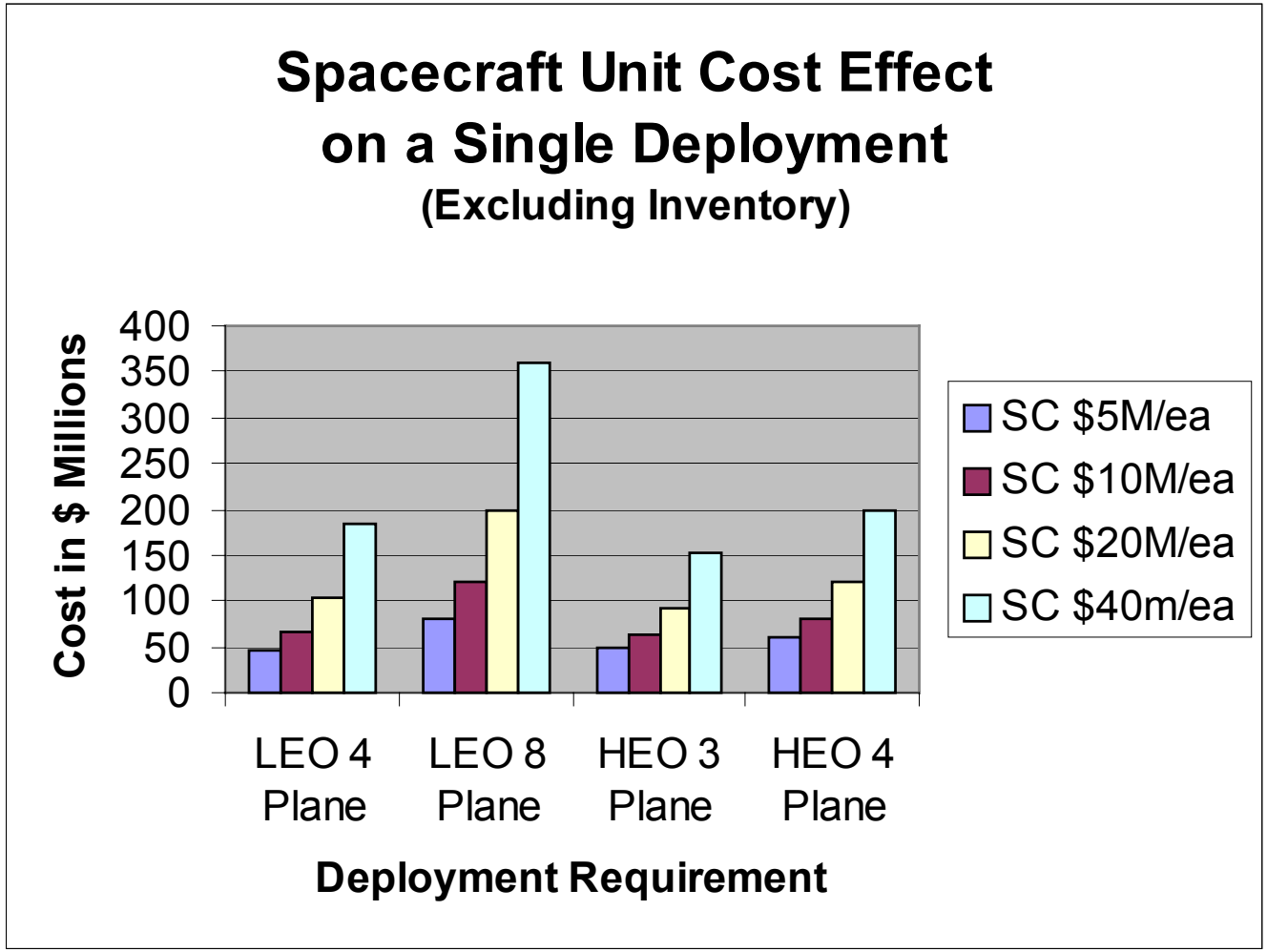


Call-Up Includes

- **Launch Processing Time**
- **Orbit Maneuvering Time**

- **Launch Processing <3-5 Days Causes Inventory Costs to Sky Rocket**
- **Call-Up Time Drives Inventory & Number of Launch Vehicles for LEO**

Major System Cost Considerations: Spacecraft Unit Cost



- Spacecraft Unit Cost is Second Biggest System Cost Driver, behind Call-Up
  - Must Carefully Trade Near Term Performance

Appropriate Missions with Today's Technology

- Select RF Missions
  - SIGNIT / ELINT
  - SEI / AIS
  - Blue Force Tracking
- Surge or Replacement Comms
  - Software Radios for Flexibility
- Near Term Imaging Missions
  - 2-3 Meter Class Visible, 5m Class HSI and IR
- Select Chemical/Bio Detection
- Data Ex-Filtration

New Capabilities & Increased Performance will Come with Technology Improvements If a Robust and Standardized Tactical Space System is in Place First

Conclusions

- TacSat-1 Experiment Provides a Tangible Implementation & 1st Step
  - Believe, and Hope, Helping to Energize the DoD and Industry in the Responsive Space Area
- Proper Prioritization of Requirements is Essential for an Operational System Development to be Successful
  - 1) Organic Part of the JTF : Tactical Control & Networking
  - 2) Operationally Useful Coverage
  - 3) Battle Asset Class of Cost for a Called-Up TacSat Mission
- System Cost Drivers Must be Carefully Traded and Matched to the Needs of the Forces
  - Call-Up Time & Performance
- Cooperative Development is Needed to Realize an Useful Tactical Space System
  - Launch, Network/Comm, Spacecraft, Ground, TacSat Experimentation

Looking Forward to Another Exciting Year!

Backup Slides

TacSat-1 Objectives

1. **Provide a Micro-Satellite Which...**
   - **Experiments With New Space Capabilities at Low Cost and**
   - **Reduces TacSat Total System Employment Risk and**
   - **Provides an Operationally Relevant Capability**
2. **Demonstrate Responsive Launch**
   - **Launch Within a Year, Start to Launch**
   - **Develop a Near Term Path for Rapidly Launching Tactical Space Capabilities**
   - **Influence Launch Vehicle Interface Design & Processes to Support Tactical Micro-Satellite Capabilities**
3. **Provide Direct Tasking Control and Data Dissemination Methods to the JTF Commander and "1st Mile" Forces**
   - **Specific Real-Time Application and**
   - **Broad SIPRNET Applications**
4. **Develop Team & Processes for Rapid Response Space Capability**

Energize the DoD and Industry in the Tactical, Responsive Space Area

TacSat-1 Approach Highlights

- Active & Efficient Sponsor Leadership & Working Relationship
  - High Involvement, Communication, and Quick Decision Making
- New, Privately Developed Launch Vehicle
- Strong Government-Industry Team Implementing the Experiment
  - Small, Technically Solid, & Mostly Co-Located Team
  - Knowledge of Critical Information and Interface Circulates Quickly
  - Allows Rapid Start-Up & Sponsor Ability to Modulate Requirements
- Using UAV Payload Hardware "As-Is" in Hermetically Sealed Enclosures
- Using Same Software for Ground Testing and Flight Operations
  - Most Reliable Approach: "Fly Like You Test, Test Like You Fly"
  - Fastest & Cheapest Approach
- Maximizing Use of Existing or Commercial Hardware
  - ORBCOMM FM29 Bus
  - Copperfield-2, SEI, UHF Radio, Rb Clock, GPS, etc.
  - In-Stock Subsystem Items (Thermal Blankets, etc.)
- Tailoring Component Testing on a Case-by-Case Basis
  - To Minimize Cost and Schedule Yet Test Primary Risks
- Mission Assurance Appropriate for Microsatellite Class Missions
- Lots of Testing

Tactical Micro-Satellites: Unique Capability Set

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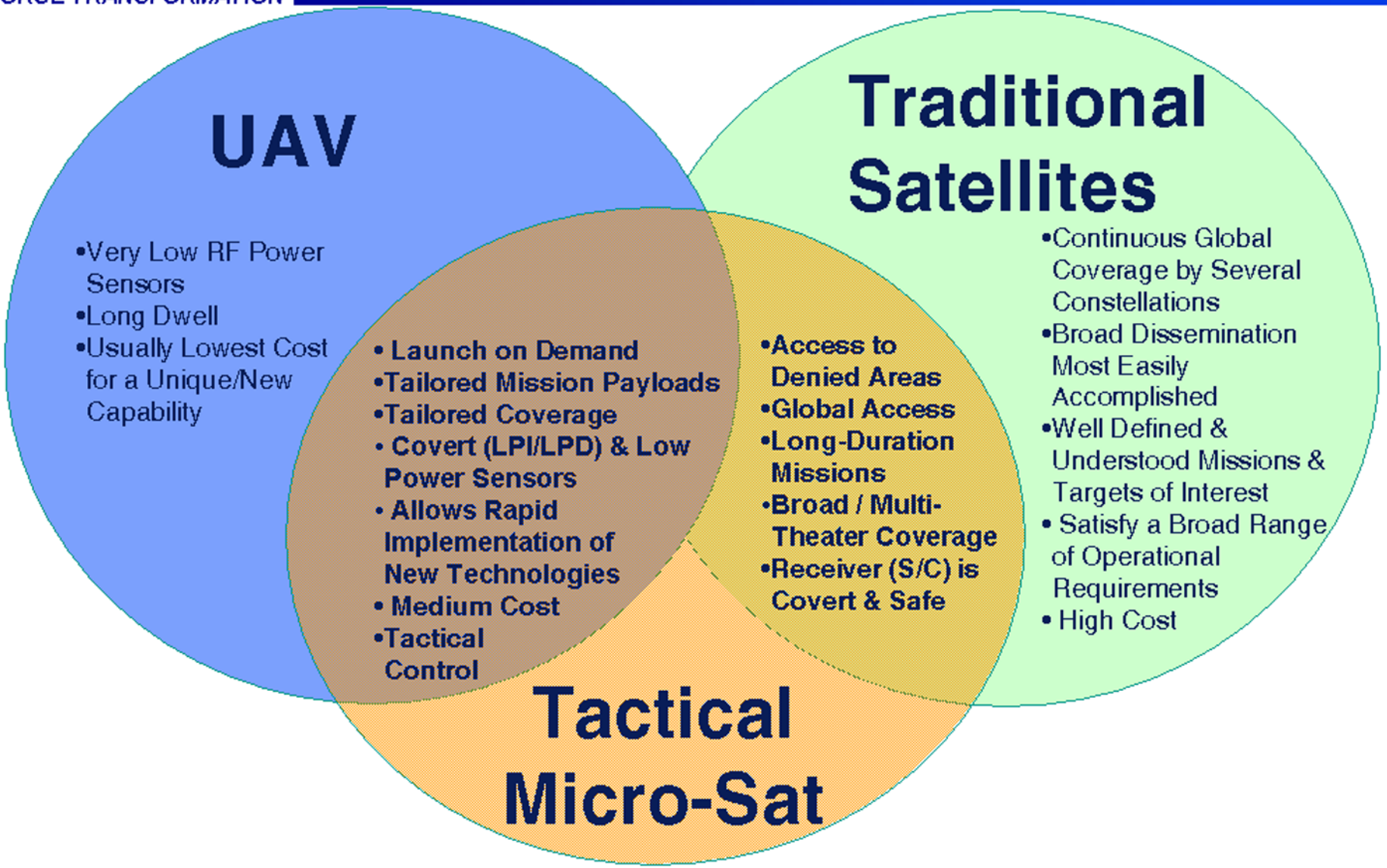

Tactical Micro-satellites offer a Unique Combination of Capabilities Creating a Valuable Niche and Allowing a Robust, Tiered Network for Tactical or Operational Tasking

NRL Transformational Space Programs

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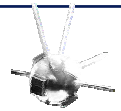
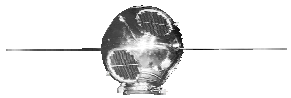
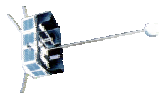
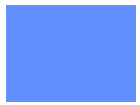
1956	Blossom Point		1st Satellite Ground Tracking Station, Mini-Track, Led to NAVSPASUR
1958	Vanguard		First Solar Power Satellite and the US's Oldest Orbiting Satellite
1960	GRAB		1st U.S. Reconnaissance Satellite
1967-1976	Timation/NTS		1st Time Navigation Satellites; Last of Series became the GPS Satellite #1
1976	Classic Wizard		Tactical Ocean Surveillance; Transitioned to an Operational System
1980 – Mid-1990	LIPS (TRAP/TRE) MATT & IDM Radios		Global Tactical Broadcast Systems -LIPS 1st Tactical Broadcast from Space -MATT & IDM Tactical Radios Transitioned to Operational Systems
1994	Clementine		"First Faster, Cheaper, Better Satellite" Rotary Club Award.
1996	Onboard Processor		Largest Supplier of Tactical Direct Downlink Reporting; Transitioned to Operational System
2003	WindSat		First Wind Speed and Direction Measurement From Space, Provides Ocean Coverage; will Transition to NPOESS