Phoenix

Mr. David Barnhart, TTO Program Manager

Briefing prepared for Phoenix Industry Day

NASA AMES

November 9, 2011

Mr. Dave Neyland
Director, TTO
Dave.Neyland@darpa.mil

Mr. Barry Ives
Deputy Director, TTO
Barry.Ives@darpa.mil

Agenda-East Coast (2 November @ Dulles Marriot)

8:00-8:30am	**Registration and Poster Set up**	
8:30-8:40am	Welcome and DARPA/TTO Introduction	Dave Neyland, DARPA/TTO/OD
8:40-8:45am	Logistics and Phoenix Personnel Introductions	David Barnhart & Jesse Margiotta, DARPA TTO
8:45-9:45am	Phoenix Vision, Goals and Objectives	David Barnhart, DARPA/TTO PM
9:45-10:30am	Phoenix Technical Elements and Interfaces, Servicer/Tender, Robotics and RPO	David Barnhart, Jesse Margiotta, Brook Sullivan; DARPA TTO
10:30-10:45am	**Break**	
10:45-11:15am	BAA Solicitation Package	Tina Stuard, DARPA/CMO
11:15-11:45am	Orbital Express Lessons Learned	Melissa Wright, DARPA SETA
11:45-1:15pm	**Lunch** (Submit morning session questions)	On site-hotel buffet $15
11:45-1:15pm	**Open Poster Session**	
1:15-1:45pm	International Space Brokers Insurance Perspective	Mike Vintner, ISB/AON
1:45-2:45pm	FREND Arm and NRL Robotic Test Facilities	Bernie Kelm and Glen Henshaw, NRL
2:45-3:15pm	Secure World Foundation: International Workshops on Servicing	Victoria Samson, Secure World Foundation
3:15-3:30pm	**Break** (submit afternoon session questions)	
3:30–4:00pm	Vdot Program Management Tool	Damian Yanez, ESI Corporation
4:00-5:00pm	Poster Sessions	
5:00-5:30pm	Question and Answer Review	

Agenda-West Coast (9 November @ NASA Ames)

8:00-8:30am	**Registration and Poster Set Up**	
8:30-8:45am	Welcome and DARPA/TTO Introduction (Live broadcast)	Dave Neyland, DARPA/TTO
8:45-9:00am	Welcome and NASA Ames Introduction	Dr. S. Pete Worden, NASA Ames
9:00-9:10am	Logistics and Phoenix Personnel Introductions	David Barnhart DARPA/TTO PM & Jesse Margiotta, DARPA SETA
9:10-10:00am	Phoenix Vision, Goals and Objectives	David Barnhart, DARPA/TTO PM
10:00-10:45am	Phoenix Technical Elements, Satlets & PODS Detailed Discussion	David Barnhart DARPA/TTO PM & Jesse Margiotta, DARPA SETA
10:45-11:00am	**Break**	
11:00-11:30am	BAA Solicitation Package (play back of Nov 2nd presentation)	Tina Stuard, DARPA/CMO
11:30-12:00pm	NASA Micro-Exploration Concept	John Hines, NASA Ames
12:00-12:30pm	NASA Power Beaming Concept	Daniel Raible, NASA GRC
12:30-2:00pm	**Catered Lunch and Poster Session** (Submit morning session questions)	
2:00-2:30pm	Vdot Program Management Tool	Damian Yanez, ESI Corporation
2:30-3:00pm	Additive Manufacturing in Space	Jason Dunn, Made in Space Corp
3:00-4:00pm	Question and Answers Review	

Who is DARPA?

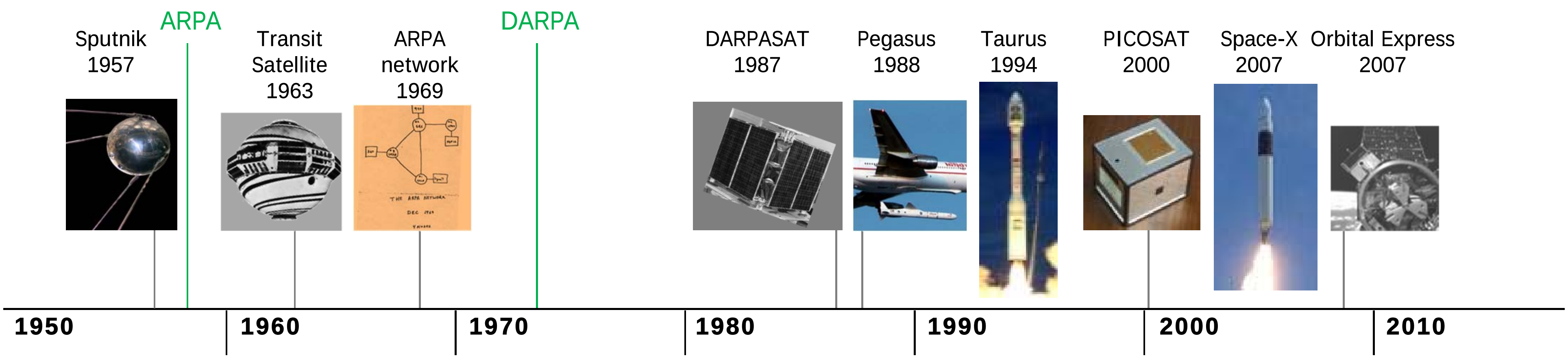
In 1958, Advanced Research Projects Agency
was created to pursue high-risk, high pay-off advanced technology.

In 1972, ARPA was renamed the
Defense Advanced Research Projects Agency.

DARPA breaks the gridlock of military competition for resources and recognition that hindered early U.S. space technology development.

DARPA's progressive, risk-tolerant leadership fostered:

- Cooperation among government agencies.
- Healthy competition in the marketplace.



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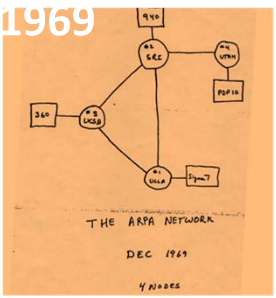
Unintended success of high pay-off investment

Original F1 engine too complicated for early launch requirements

Moon launch

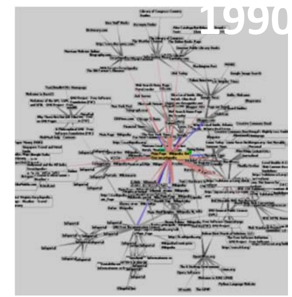
Four years later developed for heavy-lift manned missions



Original ARPAnet for sharing large volumes of lab data

The ‘internet’

Unplanned innovation turned it into the world wide web



Transit 2A satellite pioneered doppler navigation for specific military missions

GPS

Became global precision navigation technology for military and civilian use

Navstar Global Positioning System (GPS) satellite Image: USAF Research Laboratory

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Organization

AEO
Adaptive Execution Office

- Agile Programs with Frequent Development Cycles
- Conduct Systematic Rigorous
- Assessments
- Explore New Contracting Approaches
- Develop Strong Relationships

DSO
Defense Sciences Office

- Physical Sciences
- Materials
- Mathematics
- Training & Human Effectiveness
- Biological Warfare Defense
- Biology

I2O
Information Innovation Office

- Global ISR
- Cyber
- Social Networks
- Computational Social Science
- Language Transparency
- Edge Finding
- Training/ Education

MTO
Microsystems Technology Office

- Basic Science Core
- Devices
- Integration
- Power
- Architectures
- Application

STO
Strategic Technology Office

- Comms & Networks
- Global Tactical ISR
- Energy
- Hybrid Warfare
- Extreme Environments

TTO
Tactical Technology Office

- Advanced Weapon Systems
- Advanced Platforms
- Advanced Space Systems

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Tactical Technology Office

Objective

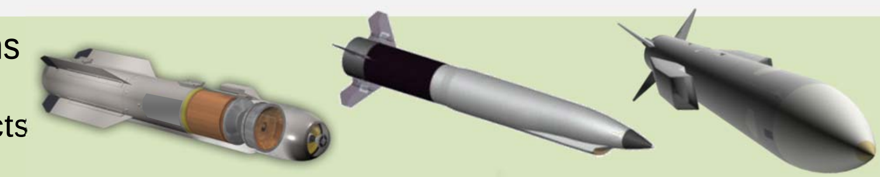
To transform the future of warfighting through high risk, high payoff development of rapid, mobile, and responsive combat performance for advanced weapons, platforms, and space systems.

Goals

- Create highly capable systems that enable "order of magnitude" improvement in military capabilities in a rapidly changing technological landscape.
- Avoid technological surprise in areas of TTO emphasis.
- Develop tactical technologies and systems that enable "game changing" tactics, techniques, and procedures that address the entire spectrum of armed conflict.

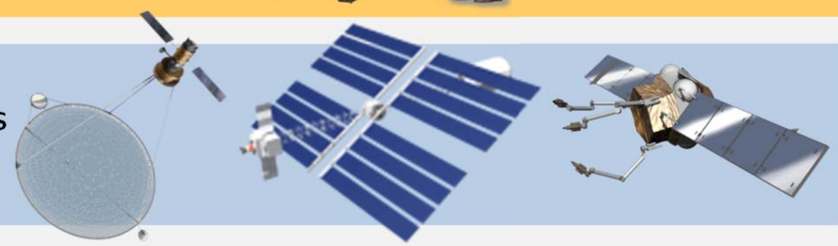
Focus areas

Advanced Weapon Systems
- Precision Strike
- Kinetic / Non-Kinetic Effects
- Responsive Engagement



Advanced Platforms
- Unmanned Systems
- X-Planes
- Manned Systems

Advanced Space Systems
- Resilience in Space Operations
- Assured Space Access
- Stability



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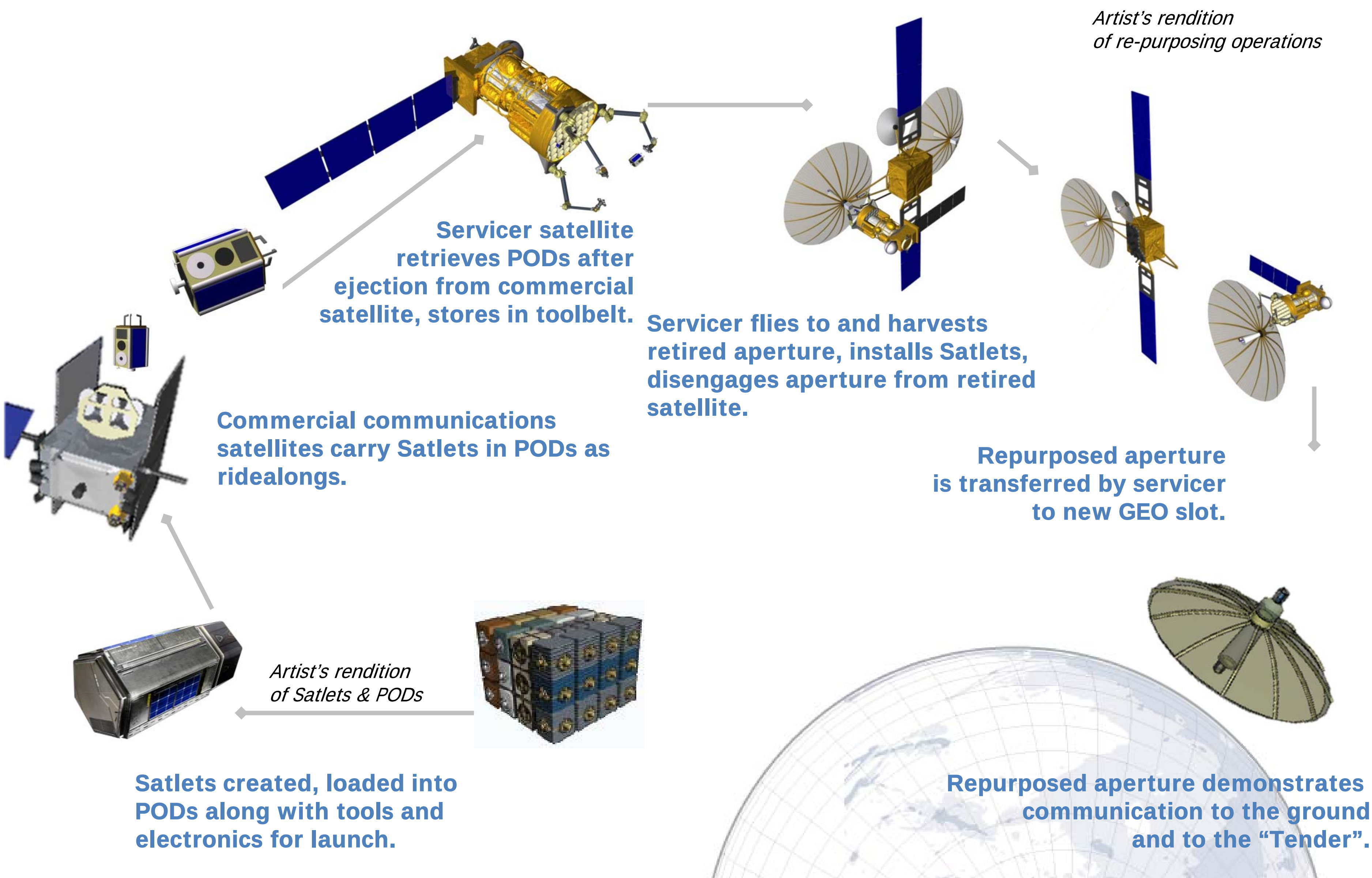
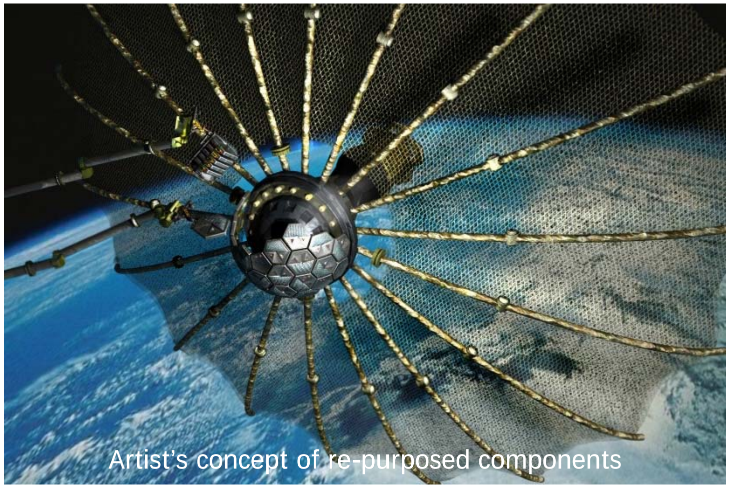
Phoenix demonstration notional concept of operations



Phoenix vision

- Change how satellites are built, shifting to on-orbit assembly.
- Ability to upgrade satellites faster to accommodate new electronics/technologies.
- Able to increase effective DoD/US Government Return on Investment by re-using highest value components on orbit.
- Allow non-traditional space suppliers and players to enter GEO using high volume low cost manufacturing through dispensed COTS hosted payload delivery.
- Enabling "assembly in space" to physically build very large apertures for both RF and optical systems.

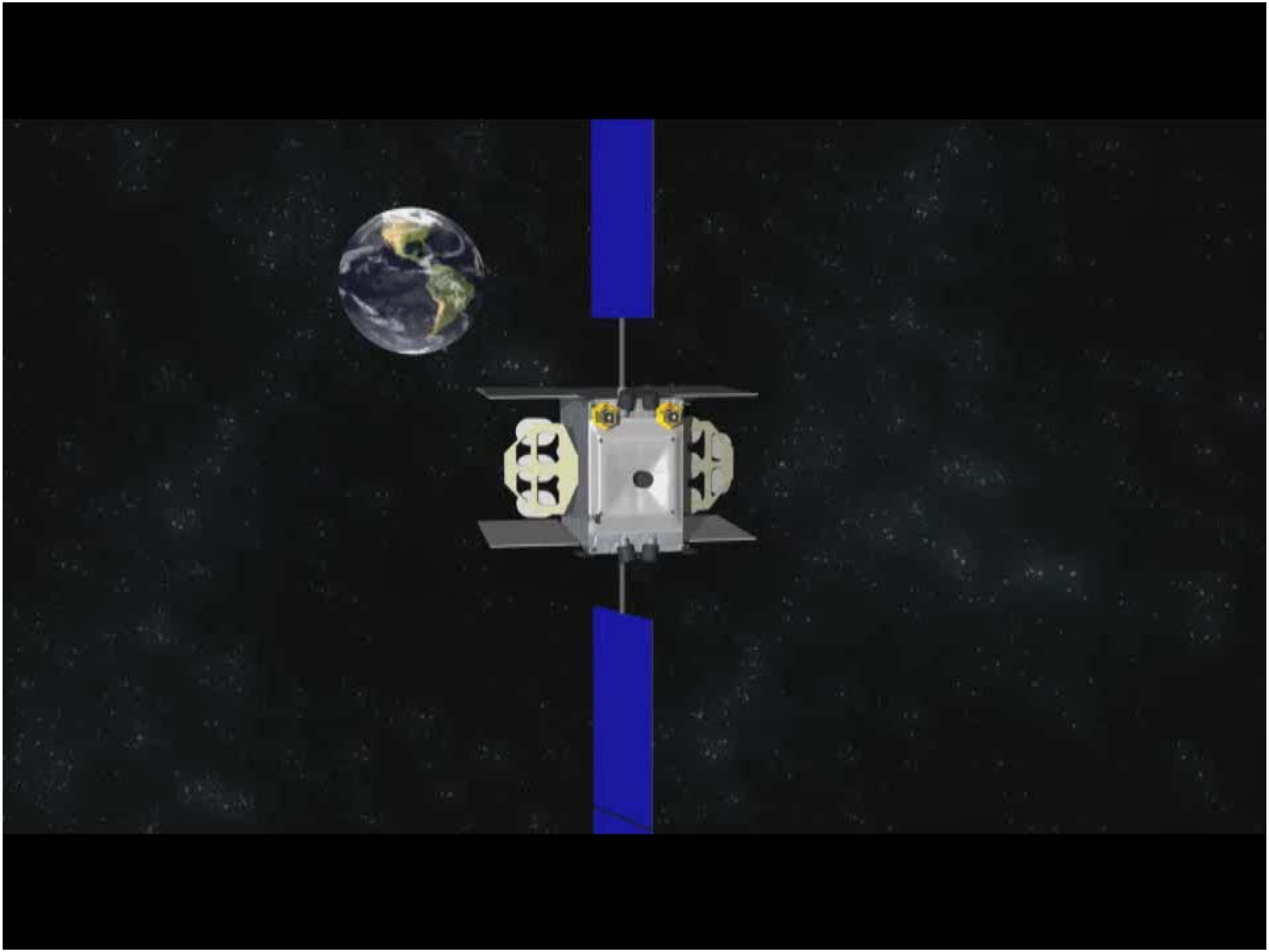

Artist's concept of re-purposed components


European SailTower SPS Concept based at GEO, courtey of ESA Artwork, L. Summerer

Doing business with DARPA...

- ☑ Become familiar with the challenges and opportunities of the program.
- ☑ Put your ideas in writing. Draft a white paper.
- ☑ Communicate with the PM; he is the key to working with DARPA.
- ☑ Look for Requests for Proposals (RFPs) and Broad Agency Announcement (BAAs) solicitations at www.darpa.mil, www.darpa.mil/sbir, or www.fedbizopps.gov.
- ☑ Think boldly. Embrace risk.

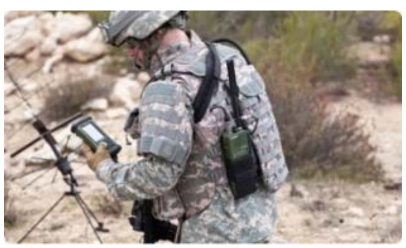
Phoenix program vision, goals and objectives



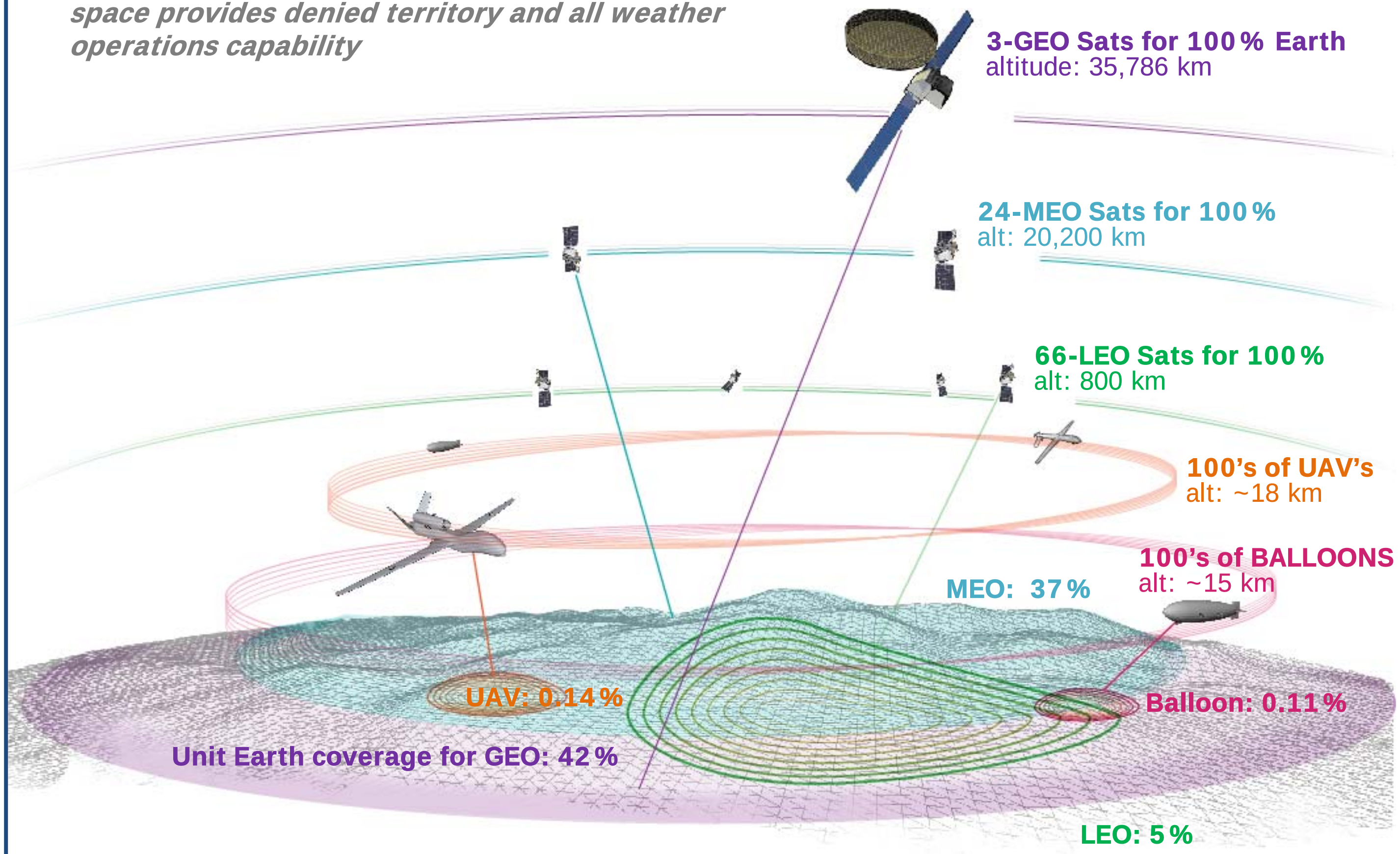
Why does it make sense to do servicing?

Example communications missions

- *Blue Force Tracking coverage with unlimited geographic expansion and contraction.*
- *Ubiquitous dedicated voice and data across ever-changing tempo of DoD users worldwide.*
- *Global support to the growing number of deployed autonomous DoD systems.*



Area coverage provides 'persistence' (0-100 %), space provides denied territory and all weather operations capability



CHALLENGE: Provide DoD with GEO-level space capability (persistence and high bandwidth) at costs comparable to today's single unit airborne systems.

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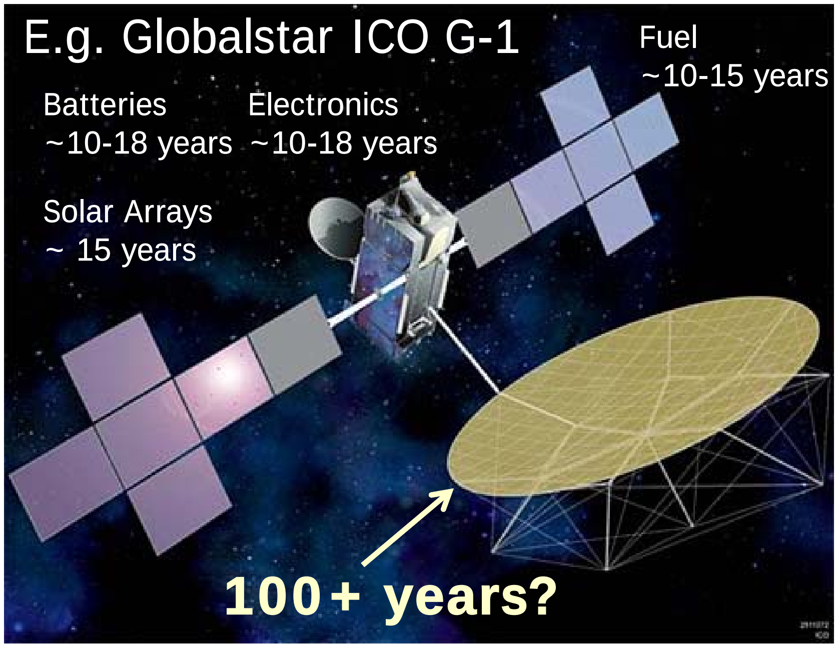
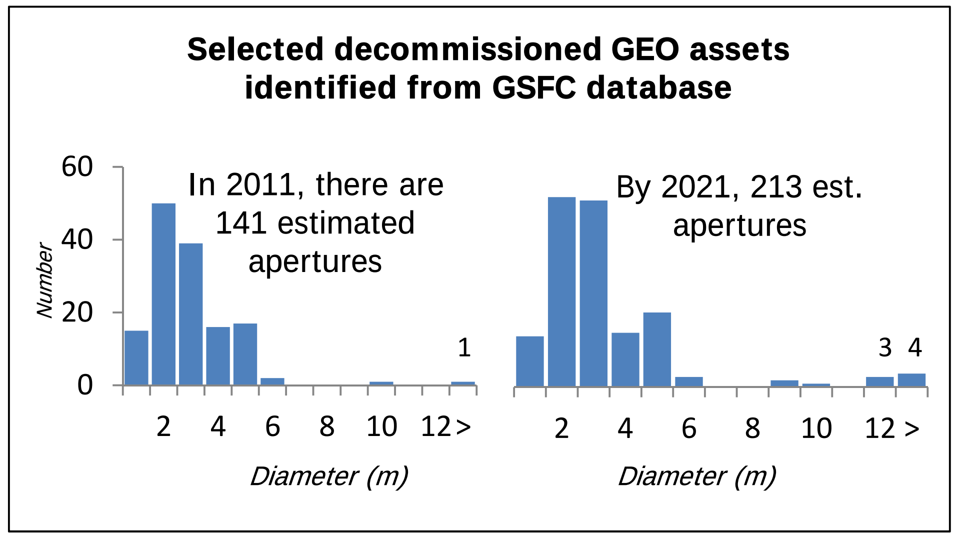
GEO-based "retired " apertures have already incurred the highest costs in a space system mission life cycle: **fabrication, launch & deployment**.



Larger apertures provide flexibility in throughput (i.e. bps), # of users, or lower power on the ground to close a given frequency.

Apertures in GEO have:

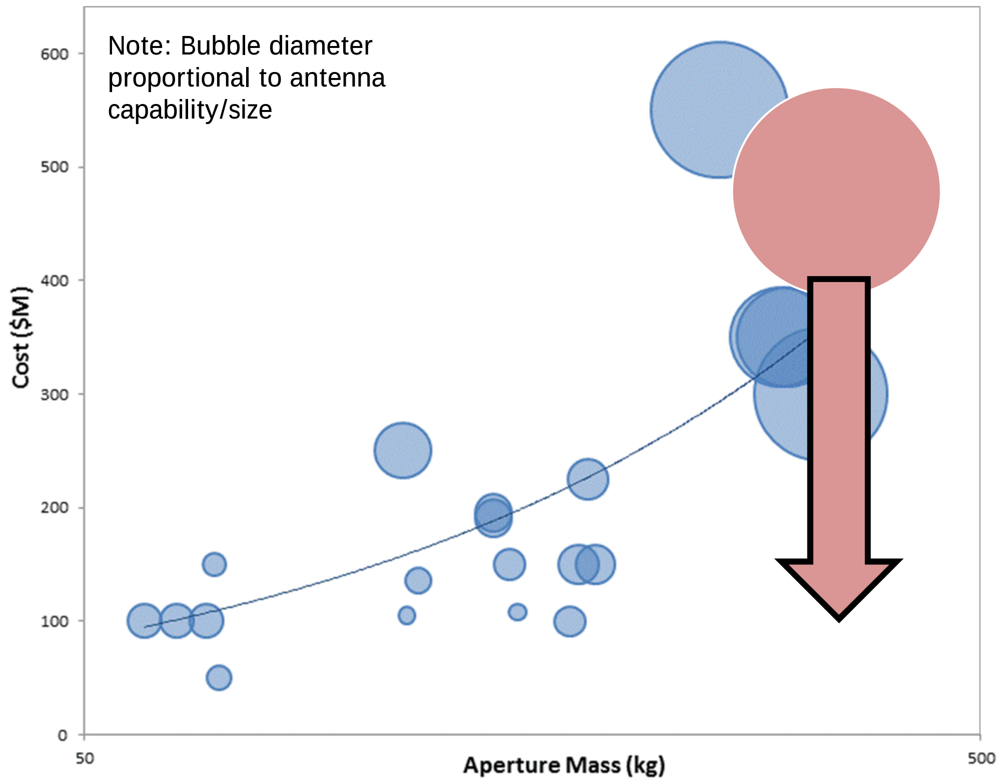
- **Stationary persistence.**
- **Large field of regard.**
- **Lifetime.**



Phoenix proposes to "re-purpose" existing apertures in GEO as a first mission demonstration of recycling on-orbit assets.

To be viable, the cost to "grab and add" supporting mass to existing apertures must be substantially below replacement costs, achieved at a much higher tempo

Traditional satellite architecture and tempo have spawned a simple cost calculus based on mass



Based on survey of commercial communications satellites cost versus 1% of Satellite Mass (to estimate aperture mass)

Yet most cost efficiency is typically through higher number of units sold/delivered per unit time…

…and an existing commercial "service" can be utilized that offers excess mass to space (i.e. GEO) on a monthly tempo

It is possible to change the cost vs mass ratio at the same performance point for space systems by combining high volume low cost manufacturing production with re-use of existing apertures…

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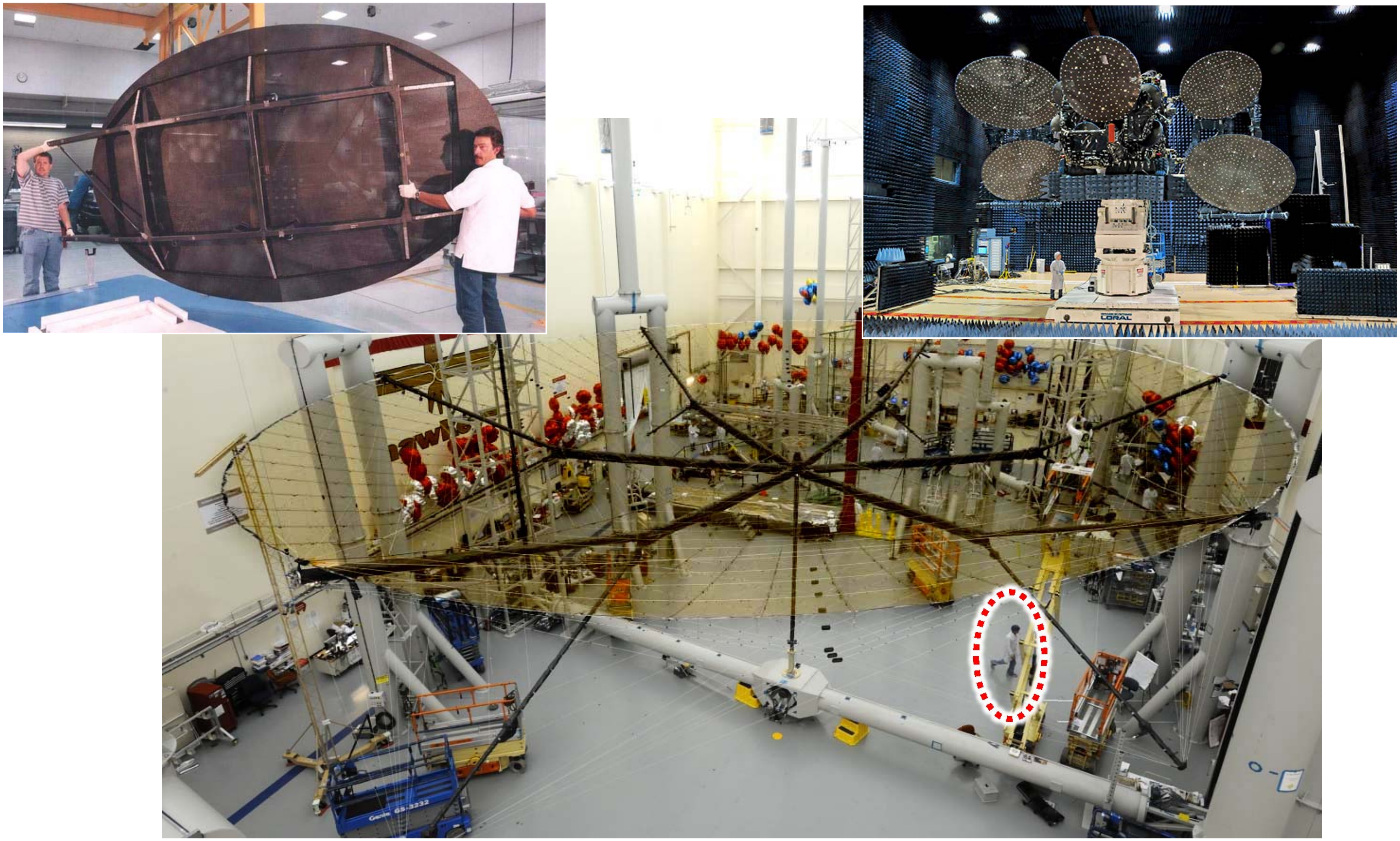
Varieties of GEO apertures



Images available on web.

Example retired GEO satellites

Phoenix demonstration to future vision

DARPA Phoenix demonstration

Retired TDDRSS

1-5 m antenna

- Small antenna enables low-cost demonstration using existing robotic arms.
- Multiple “small” antenna’s available at lowest inclination in graveyard.
- Nominal communications demonstration of uplink signal reception and downlink to existing larger aperture on ground.

Future post-DARPA vision

Largest available antenna (5m+)

Maximizes cost advantage of re-purposing over new satellite.

Link-budget advantage:

- Enables uplink from small mobile ground units.
- Enables downlink to small aperture using low-power satlet transmitter.

Wide-area coverage at VHF/UHF:

- Large antenna ground spot size is small at higher RFs.

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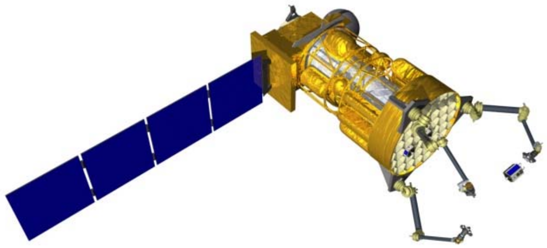
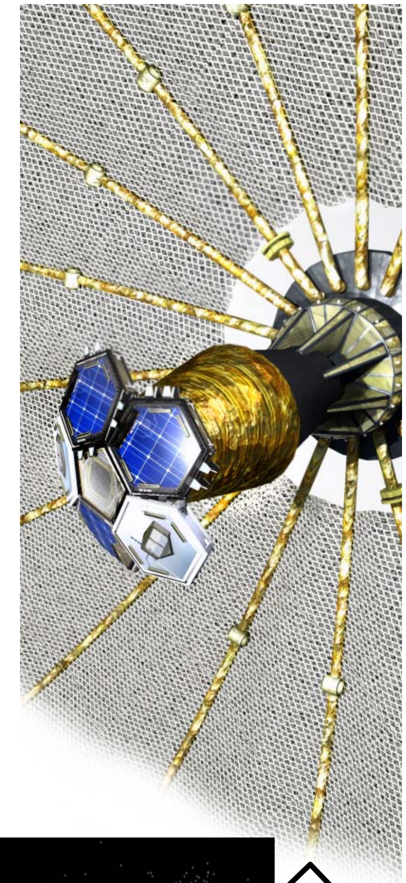
Three basic elements combine to create the Phoenix architecture

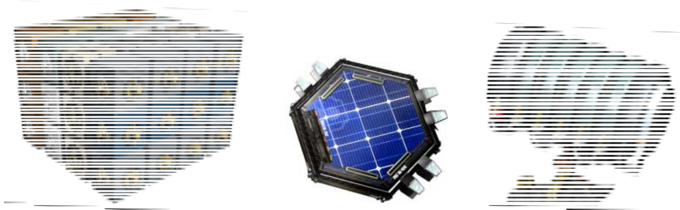
Tele-presence control of Robotic Servicer / Tender

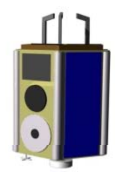


Repurposing retired components into value added systems or services



Aggregation of "Satlet's"

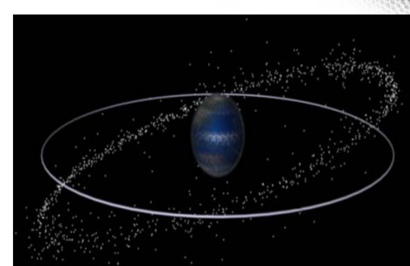




Dispensing payloads via existing Commercial Hosted Payloads service

SES-2, host to CHIRP

Intelsat 14, host to the IP Router In Space (IRIS) Joint Capability Technology Demonstration



"Graveyard" orbit

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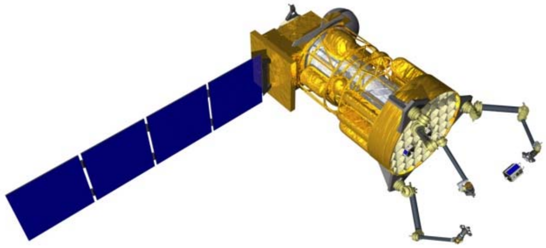
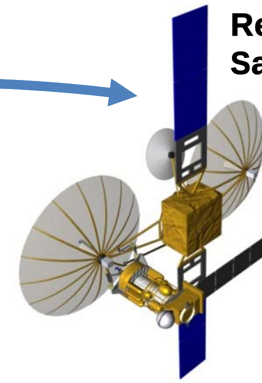
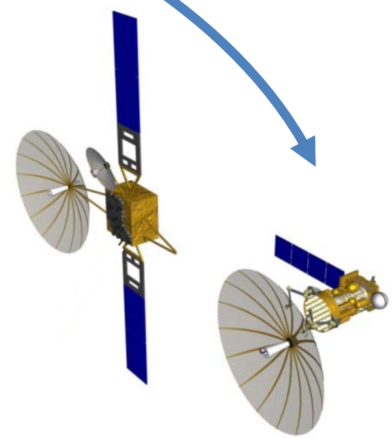
Three basic concepts are broken into individual Phoenix technical elements

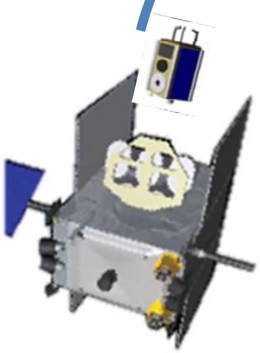




Retired Communications Satellite



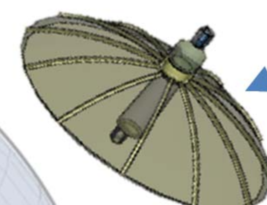
Tender / Servicer Spacecraft
- Spacecraft Bus.
- RPO Sensors.
- Primary Robotics (FREND Arms).
- Tools/end effectors and Tool Changers.
- Next generation hyper-dexterous manipulator
- Toolbelt and/or Toolcaddy.
- High performance Ground-Servicer/Tender Comms.
- Tele-presence algorithms and S/W.



Commercial Communications Satellite to host Ridealong PODs

New Technologies
- PODs (Payload Orbital Delivery system).
- Satlets (contained within PODs containers).

On Earth
- Ground Communication Facility for Service/Tender.
- Ground Operations Facility for Robotics Payload Suite.
- N-DOF Test Facility for Robotic and Ops Validation.



Notional Phoenix demonstration technical objectives

1. Build a demonstration "POD" system and load into a commercial communications satellite TBD months prior to the Servicer/Tender launch. Commercial satellite launches prior to Servicer/Tender launch.
2. Launch Servicer/Tender direct to GEO altitude and maintain attitude. Rendezvous to within TBD km of the commercial PODs carrier GEO satellite for proof of station keeping of Servicer/Tender.
3. GEO carrier communications satellite dispenses the PODs while the Servicer/Tender is on station and in view. Servicer/Tender executes a rendezvous maneuver to the ejected free-flying PODs, successfully grapples it with primary/secondary robotics arms, and stores in onboard tool belt.
4. Servicer/Tender maneuvers away from the GEO carrier satellite, executes a manuever to enter the Graveyard, and rendezvous to within TBD meters of an existing non-operational cooperating retired asset and starts proximity station keeping.

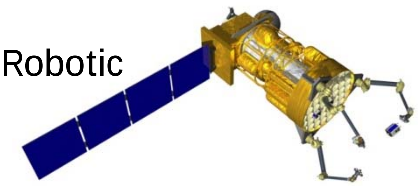
Notional Phoenix demonstration technical objectives

5. Servicer/Tender closes to zero meters, successfully merging two objects with multiple obstructions, and uses the FREND robotic arm(s) to grapple the retired satellite. Prove the ability to deploy from “toolbelt” a representative Satlet or electronics box and validate the manipulation and clasping of the Satlet to the retired satellites structure, using remote tele-presence.
6. Release and re-grasp satellite (as appropriate), using tele-presence to place “Satlets” around the station of an existing aperture on the retired satellite. Prove Satlet basic operation while attached to retired satellite. Use tele-presence to grapple the boom holding the aperture and use tools to remove the boom from the retired satellite.
7. Successfully release the retired satellite from the Servicer/Tender, while moving away with the aperture to a suitable distance. Release aperture and validate Satlet attitude stability.
8. Validate that RF communications can be restored via the repurposed aperture to a ground facility.

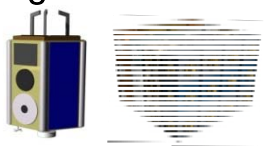
Opportunities to integrate TTO space investments into the Phoenix vision

Phoenix

Telepresence control of Robotic Servicer/Tender



Aggregation of "Satlets"



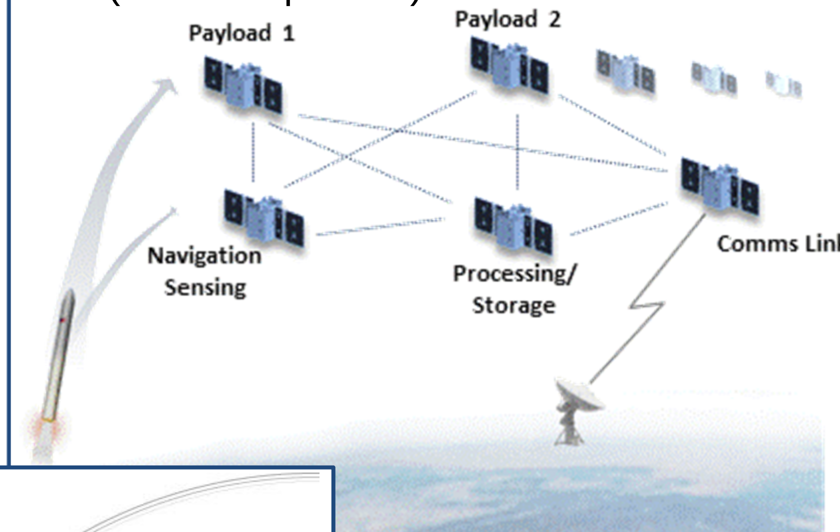
Dispensing payloads via existing Commercial Hosted Payloads service

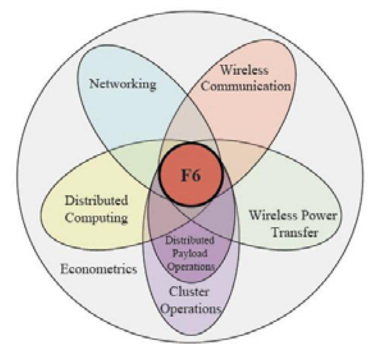
SES-2

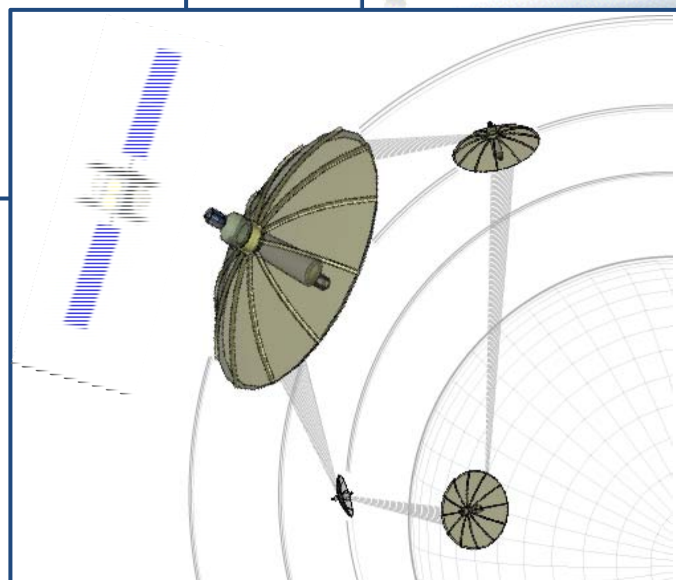
Intelsat 14

System F6

Wireless Resource Sharing and FDK (F6 Developers Kit)







F6 precepts apply to the end vision of multiple antennas flying; initial demonstration of Phoenix is not restrictive to F6 hardware instantiations.

Schedule

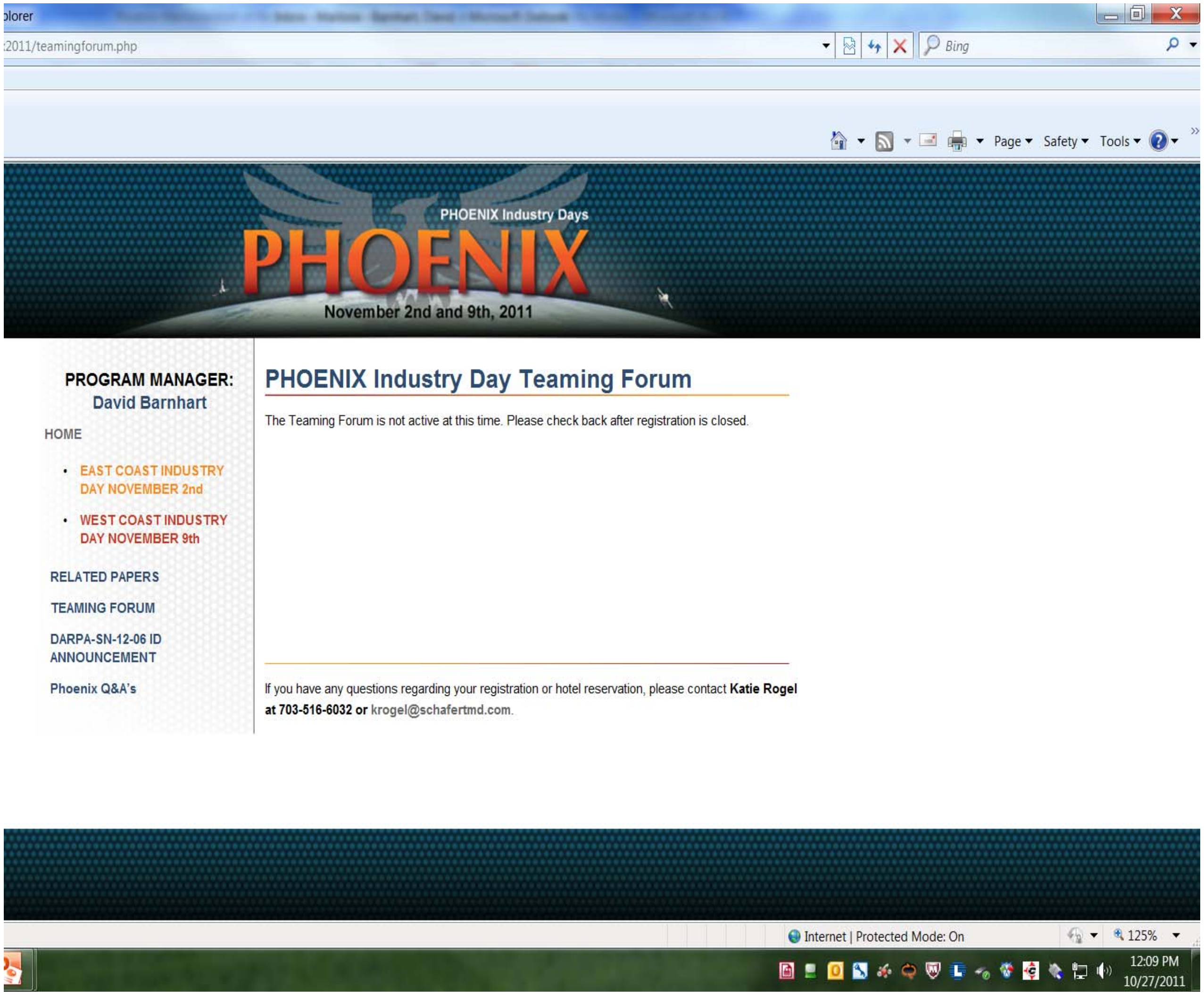
Technical Elements:	FY12	FY13	FY14	FY15	FY16
Tender / Servicer	Phase 1		Phase 2		Launch & Ops
• Spacecraft Bus modifications and completion	Govt provided				
• Rendezvous sensor suite	One or more performers				
• Robotics Payload elements					
• Primary Robotics (FREND arms)	Govt provided				
• Tools (ie end effectors, gripper, changer etc)	One or more performers				
• Toolbelt and/or Toolcaddy	One or more performers				
• High performance Ground-Servicer/Tender comms	One performer				
• Next generation hyper-dexterous manipulator	One or more performers				
• Tele-presence algorithms and S/W (Training & validation)	One or more performers				
Satlets (multiple variants)	One or more performers				
PODs	One or more performers				
Commercial bus ridealong slot (to host PODs)		One performer			
Retired Communications Satellite			Govt to agency or commercial MOA		
• Retired aperture			Govt to agency or commercial MOA		
N-DOF Test Facility for Robotic and Ops Validation	One or more performers				
Ground Communication Facility for Servicer / Tender		One or more performers			
Ground Operations facility for Robotics Payload Suite		One or more performers			

Acquisition schedule

Key Events

• 2 Nov	East Coast Industry Day, Dulles VA
• 9 Nov	West Coast Industry Day, NASA Ames, CA
~15 Dec	Phoenix BAA posted to FBO
~ 30 Jan	Proposals Due/Evaluation period
~ 13 Feb	Selection Letters drafted
~ 30 Apr	Contract awards
~ 10 May	Phoenix K/O PI meetings

Teaming Website



http://www.schafertmd.com/conference/phoenix2011/teamingforum.php

Fostering next generation engineers

- DARPA recognizes need to foster increased awareness, interest and participation by next generation engineers.
- Phoenix performers are encouraged to use traditional and non-traditional approaches to engage and utilize students in Phoenix.
- Notional examples:
    - Engineering teaching hospital creation between industrial partner and academic institute.
    - Internships for various segments of the technical project elements.
    - “Apprenticeship" programs.
    - Student participation at all levels in multi-DOF test facilities and/or operations and training.
    - Periodic special presentations to local universities or colleges as both outreach and recruitment.

From Princeton Satellite systems Website

From Cal-Poly Website

From USC Astronautics Website

Phoenix program's intention is to foster detailed team and performer integration

PI Meetings

- A high degree of interaction will be required early and often from all the various performers on Phoenix.
- Collaborative Principal Investigator meetings will be used to facilitate interactions:
  - Principal delivery mechanism of products and deliverables.
  - Formal interactions between developers of Phoenix Technical Elements to clarify physical interfaces between technologies for the system architecture.

Integrated Phoenix PI Teams Scheduling Software

- To mitigate the high degree of integration complexity possible on this space program, DARPA intends to invest in a dynamic project scheduling software product for Phoenix program performers:
  - DARPA will purchase TBD licenses.
  - Each major team/organization/performer will be given one license, 1 year free of charge:
    - All project schedules and data interface coordination will flow through this S/W product.
  - Training for the software to be produced by DARPA/ESI in 1st year up to TBD hours.
  - After 1st year, each performer is expected to utilize Vdot basic template for interaction on the Phoenix program:
    - Will be viewed as a deliverable format requirement similar to Adobe Acrobat PDF or Microsoft Word products.

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Transition opportunities

- Phoenix is seeking transition opportunities at program initiation:
  - Nature and investment in Phoenix drives early transition discussion.
- DARPA desires to transition technical system elements and experience to foster services that in turn support current/future DoD needs (system-to-service approach):
  - Phoenix plans to request concepts and ideas through the BAA toward this end.
  - Teaming, partnerships, and co-investment are encouraged.
- The BAA will encourage alternative non-traditional methods of partnership (i.e. other transaction authority (OTA) contracts and CRADA's etc.) to entertain concepts and ideas on transition opportunities:
  - Examples include but are not limited to:
    - Ground/space operations services provided by commercial operators with transition to full operations after Phoenix demonstration via service contract.
    - Hosting alternative technologies (i.e. robotic arm) to be used for Phoenix demonstration in return for S&T research and evaluation for commercial provider.

Please submit questions during the break.

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