DARPA Perspective on Space

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Breakthrough Technologies for National Security

Diminishing returns for monolithic systems

Rethink complex military systems

Electromagnetic spectrum dominance
Position, navigation, & timing beyond GPS
Air superiority in contested environments
Maritime system of systems
Robust space
Overmatch on the ground
Defense against mass terrorism

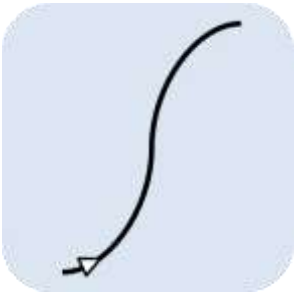
Information is exploding

Harness information

Scalable cyber capabilities
Electronics with built-in trust
Big data tools
Next-generation artificial intelligence

First-mover advantage

Create technological surprise



Outpacing infectious disease
Neurotechnologies
Synthetic biology
Chemistry, physics, math, materials
Understanding complexity
Human-machine symbiosis

TTO Space Focus

Space R&D is fundamentally different; demonstrations occur in the operational domain, resulting in more oversight and policy complexity

History

DARPA History

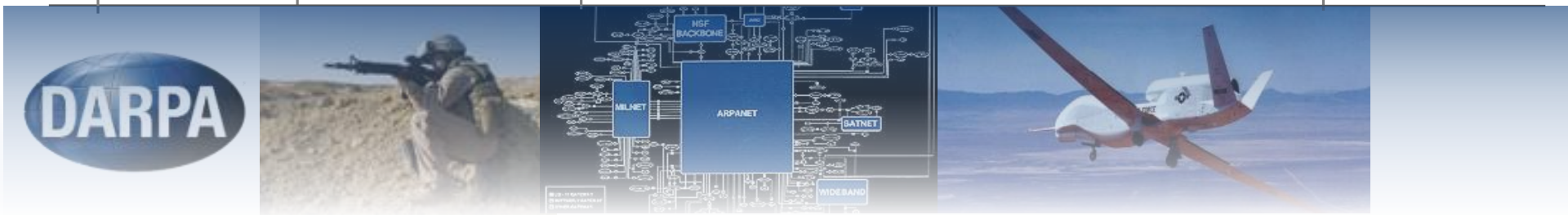
SATURN F1
Rocket Engine
1960

Speech Recognition
1971

Stealth Fighter
1983

Microelectromechanical Systems
(MEMS)
1991

1960 1970 1980 1990 2000



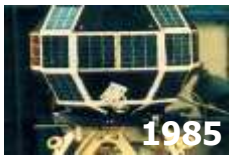
ARPA Established
1958

M16 Assault Rifle
1965

ARPANET
1969

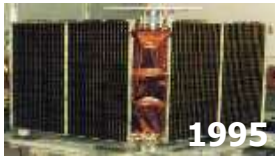
Global Hawk
1998

TTO Space Systems



Global Low Orbiting Message Relay (GLOMR)

Pegasus



DARPASAT

Taurus

Falcon Small Launch Vehicle

Artist's concept

MiTEX

Orbital Express (OE)

Space Surveillance Telescope (SST)

DARPA Technical Offices

BTO — BIOLOGICAL TECHNOLOGIES OFFICE

- Biological Complexity at Scale
- Neurotechnologies
- Engineering Biology
- Restore, Maintain and Improve Warfighter Abilities

DSO — DEFENSE SCIENCES OFFICE

- Math, Modeling & Design
- Physical Systems
- Human-Machine Systems
- Social Systems

I2O — INFORMATION INNOVATION OFFICE

- Empower the Human within the Information Ecosystem
- Guarantee Trustworthy Computing and Information

MTO — MICROSYSTEMS TECHNOLOGY OFFICE

- Electromagnetic Spectrum
- Tactical Information Extraction
- Globalization

STO — STRATEGIC TECHNOLOGY OFFICE

- System of Systems (SoS)
- Battle Management/ Command and Control (BMC2)
- Communications and Networks (C&N)
- Electronic Warfare (EW)
- Intelligence Surveillance, and Reconnaissance (ISR)
- Positioning, Navigation, and Timing (PNT)

TTO — TACTICAL TECHNOLOGY OFFICE

System Focus Areas:

- **Ground**
- **Maritime**
- **Air**
- **Space**

Crosscutting Themes:

- **Agile Development**
- **Cooperative Autonomy**
- **Unmanned Systems**
- **Power and Propulsion**

Platform and System Focus Areas

Ground Systems

Deployable, mobile capable forces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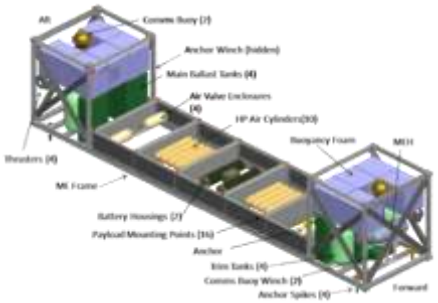
Maritime Systems

Control the sea, influence events on land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Air Systems

Extend range and minimize time


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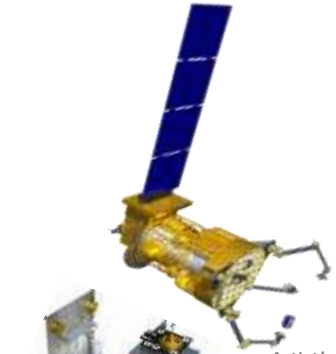
Space Systems

Resilient and flexible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Cross-Cutting Themes

Agile development approach, cooperative autonomy, unmanned systems, power and propulsion

Challenges in Space

Launch Flexibility

- Current launch has no surge capability and long call-up times
  - 2+ years to get "into the queue"
  - Custom-built production line of a few (Maserati model) vs. assembly line of thousands (Ford model)
- Fixed launch sites are vulnerable

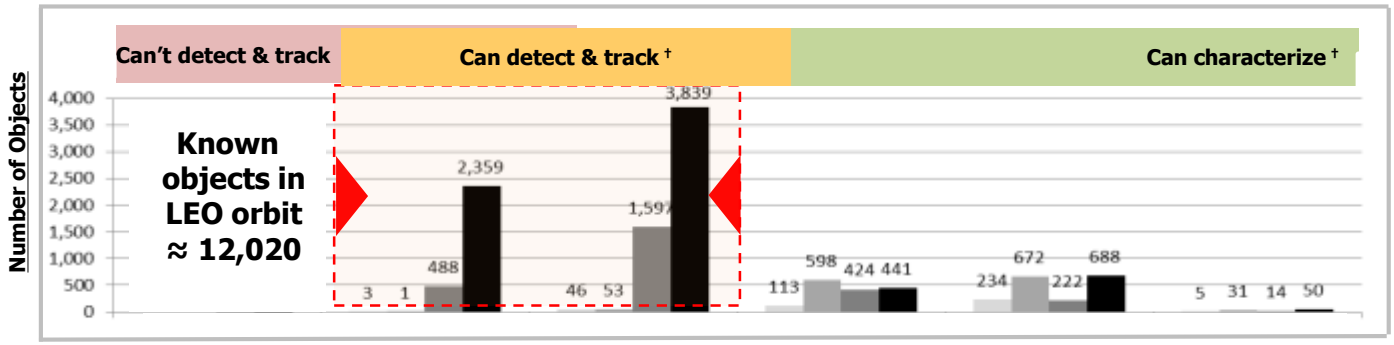
Architectures

- DoD payloads launched on Evolved ELV at >$3B/year & growing
- Small payloads launched at $50M+ on few remaining Minotaurs
- Today's high value spacecraft are fragile: uninspected, unprepared, and rapidly become obsolete

Space Domain Awareness

- There are approximately 16,000+ objects in 10^{14} km^3 (240,000 oceans)
  - Approximately 12,020 in low Earth orbit (LEO), 1,890 in medium Earth orbit (MEO), and 1,890 in geosynchronous Earth orbit (GEO)

LEO



What's Changing and What's Happening

- Commercial
  - Easier access to space
  - Growing, lucrative satellite communications (SATCOM)
  - Expanding micro/smallsat capabilities
- Wealthy visionaries
  - Space tourism
  - Space transportation
- Emerging technology
  - Satellite servicing
  - Additive manufacturing
  - Position, navigation, and timing (PNT) options
- NASA investments (orbital and suborbital)
  - New entrants

DARPA Vision for Robust Space

- Flexible, affordable capabilities
  - Resilience for a congested, contested environment
  - Affordable, routine, and reliable access to space
  - Aircraft-like space access reduces "time to space"
  - Rapid small satellite constellation insertion/restoration
  - Space robotics
    - Repair vital space assets
    - Assemble unlaunchable, very large satellites

- Real-time space domain awareness
  - Real-time detection, tracking, and attribution
    - Currently catalog maintenance and days to weeks of forensics
  - Real-time indication and warning, command and control
    - With displays and decision tools

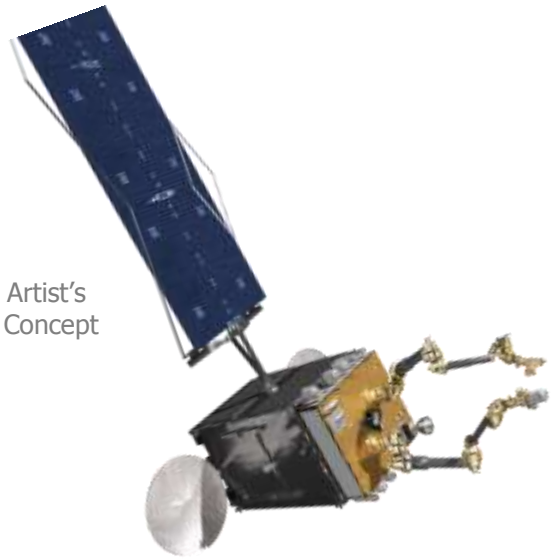
Experimental Space Plane

Goals:

- Fly 10X in 10 days, no upper stage/payload
- Design the objective system for >3,000-lb payload at <$5M/flight
- Fly demo system one time with orbital payload >900 lbs

Demo aircraft-like space access, reduced time to space & lower launch cost

Robotic Servicing of Geosynchronous Satellites (RSGS)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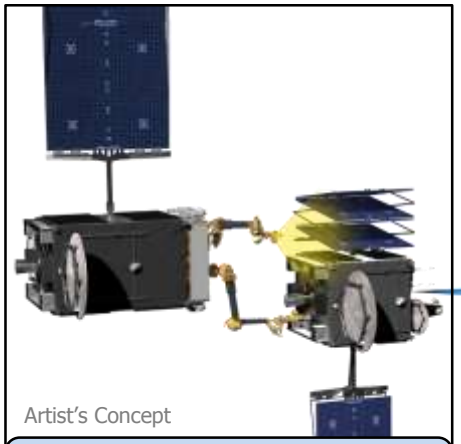
Goal:

To create a dexterous robotic capability in GEO, that provides increased resilience for the U.S. space infrastructure, and the first step toward a transformed space architecture with revolutionary capabilities

Envisioned Mission Ensemble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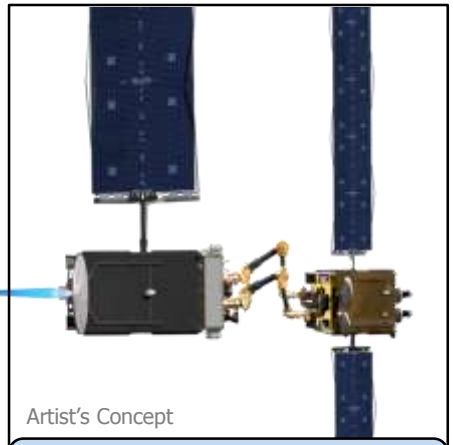
Cooperatively **inspect** spacecraft experiencing anomalies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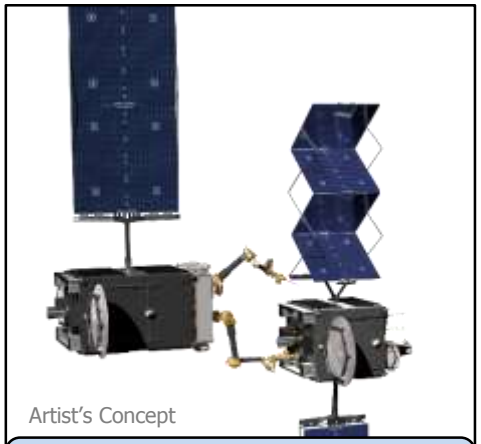
Cooperatively **assist** with orbit adjustments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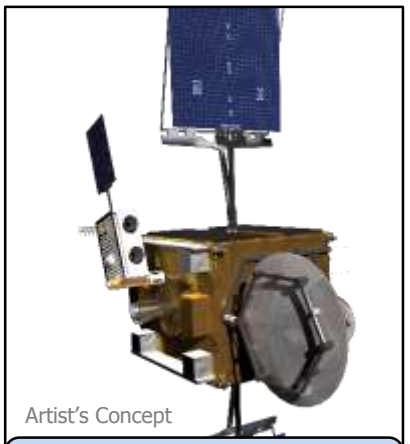
Cooperatively **correct** mechanical problems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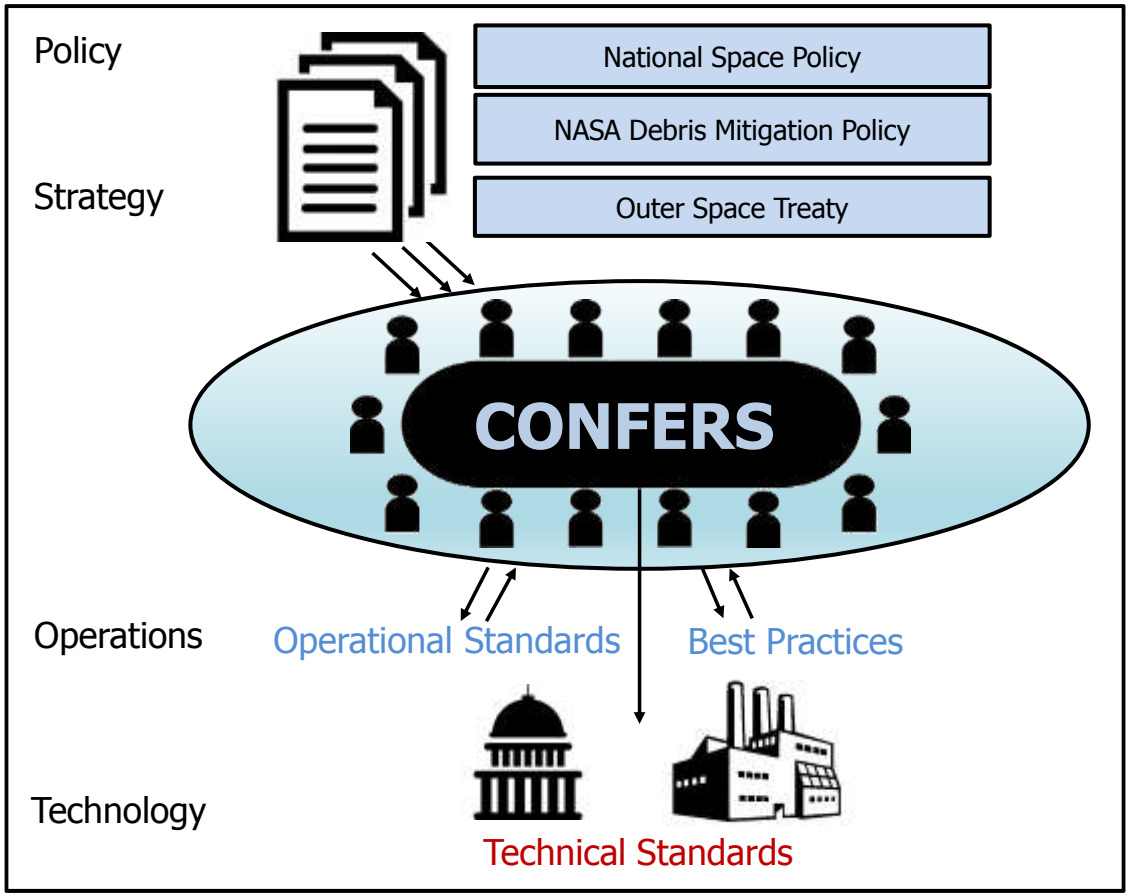
Cooperatively **install** self contained payloads on-orbit

Consortium **F**or **E**xecution of **R**endezvous and **S**ervicing (CONFERS)

Create an industry/government consortium to develop technical standards for safe on-orbit rendezvous and servicing operations



CONFERS Enables:

- Enhanced on-orbit safety through establishment of "rules of the road"
- Increased commerce resulting from clear definitions for safe commercial operations
- Creation of behavioral norms that allow for transparent international engagement
- Streamlining of future USG mission authorization with a technical foundation

Hallmark: Enabling Space Enterprise Command & Control

Goals:

- Create a flexible testbed
  - Integrate and test software tools
  - Enhanced decision-making using cognitive science advances
- Perform real-time information fusion
  - Multiple sources
  - Integrated data
  - Share common operating picture
- Develop new tools
  - Flexible course of action generation and evaluation
  - Incorporate modeling and simulation
- Technology spin-off to joint space operations centers


Artist's Concept

Hallmark will provide architecture and tools to enhance current and future space enterprise command and control decision making

www.darpa.mil

Mission

The Defense Advanced Research Projects Agency (DARPA) was established in 1958 to **prevent strategic surprise** from negatively affecting U.S. national security and **create strategic surprise** for U.S. adversaries by maintaining the technological superiority of the U.S. military.

To fulfill its mission, the Agency relies on **diverse performers** to apply multi-disciplinary approaches to both advance knowledge through basic research and **create innovative technologies** that address current practical problems through applied research.

As the DoD's **primary innovation engine**, DARPA undertakes projects that are finite in duration but that create **lasting revolutionary change**.