National Security and Military Uses of Outer Space

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Overview

- Background (history and physics)
- Core military and national security uses of space
- Postulated future military national security uses of space
- Recent developments and trends

BACKGROUND – PHYSICS AND HISTORY

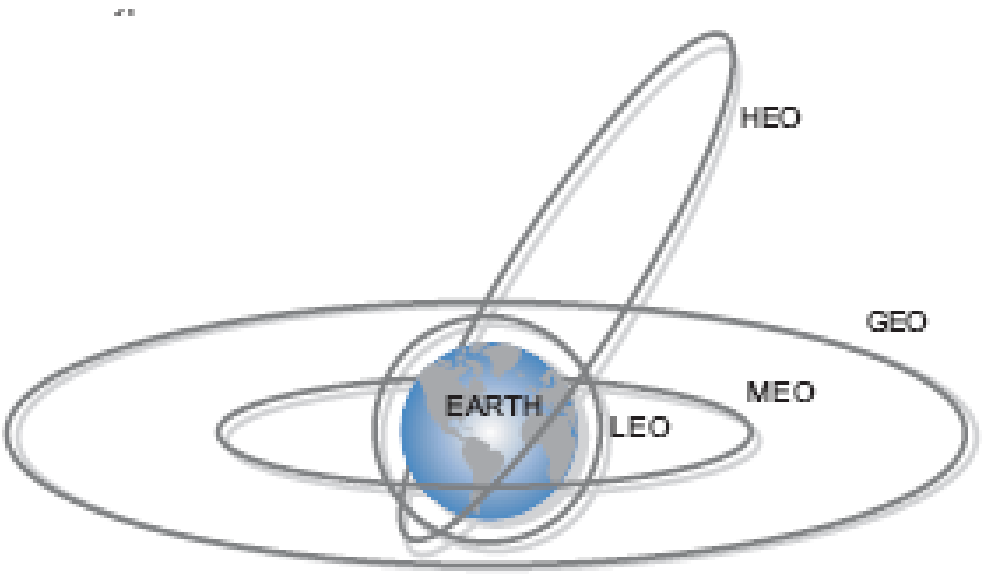
“If you don't know history, then you don't know anything. You are a leaf that doesn't know it is part of a tree. ”

— Michael Crichton

“Physics is the only profession in which prophecy is not only accurate but routine.”

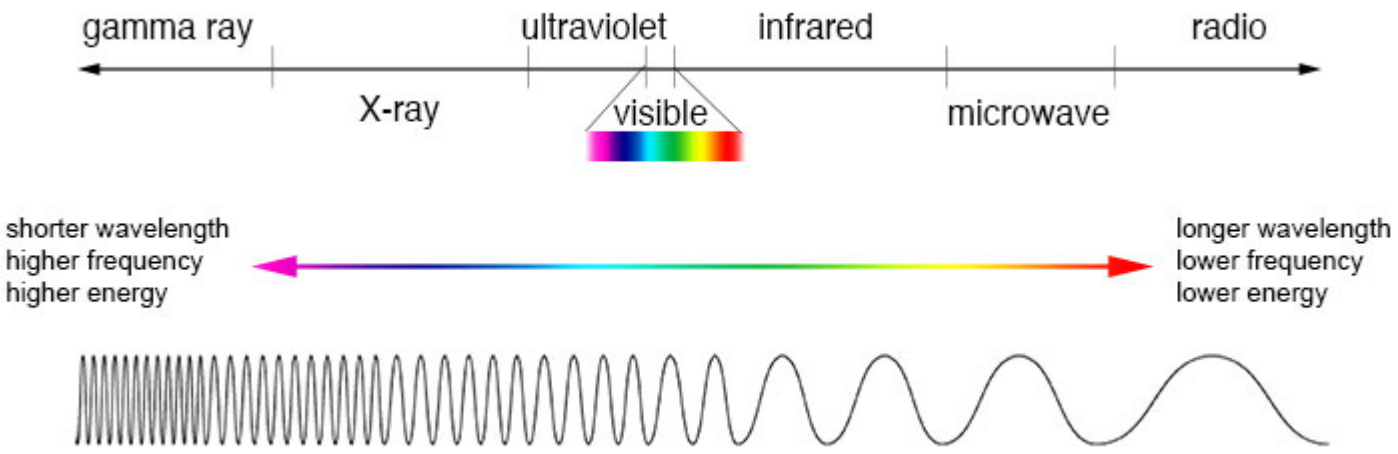
- Neil deGrasse Tyson

Basic Orbit Typologies

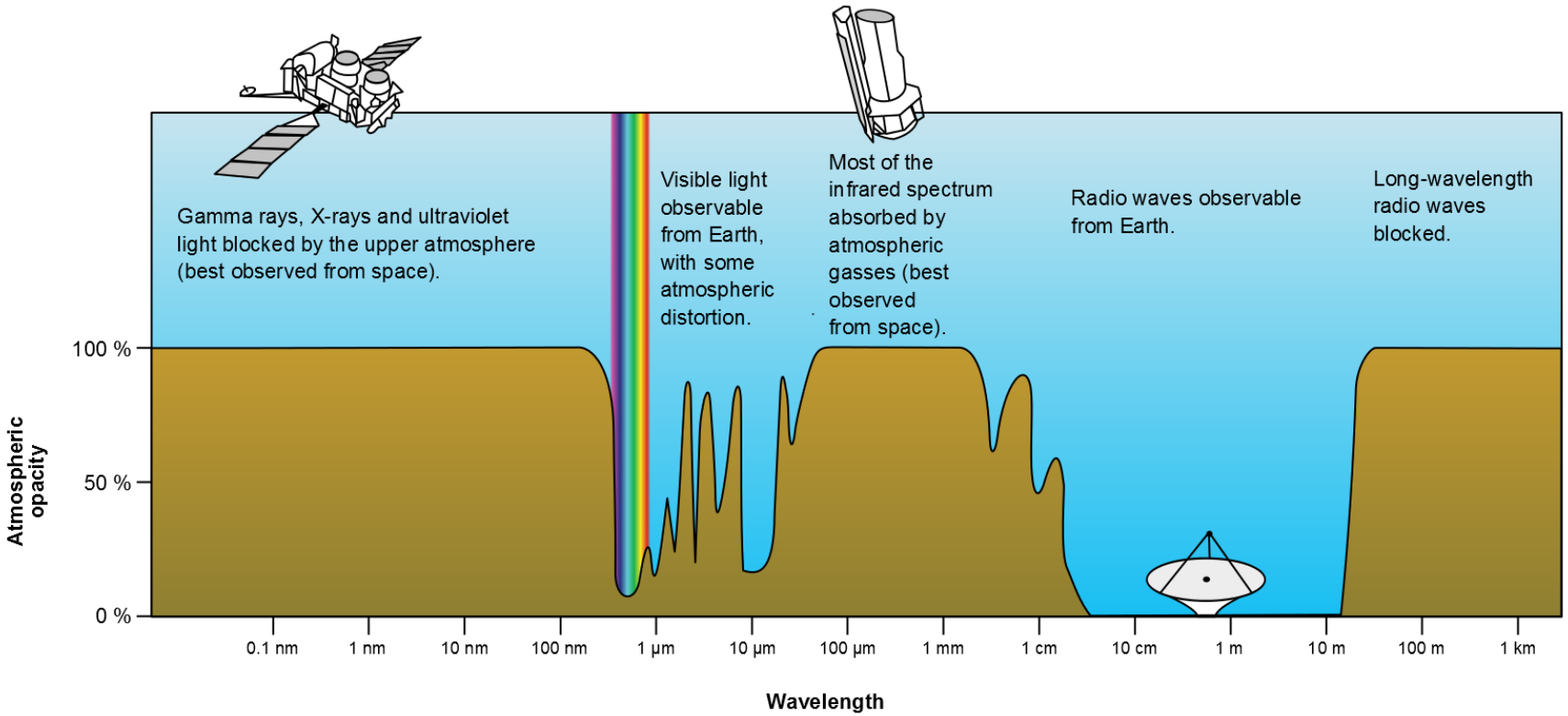


	Name	Altitude	Inclination	Shape
LEO	Low Earth Orbit	250 - 2,000 km	Varies, many 80-100°	Mostly circular
MEO	Medium Earth Orbit	10,000 - 12,000 km	Varies	Circular
HEO	Highly Elliptical Orbit	1,000 km (perigee) 40,000 km (apogee)	63°	Elliptical
GEO	Geostationary Earth Orbit	36,000 km	Typically 0°	Circular

Electromagnetic Spectrum



Effect of Earth's Atmosphere on EM Radiation



The Beginnings of the Space Age

- Most of the public perception of the Space Age is incomplete (to say the least)
  - Media and public focus on NASA and Apollo, which was the public face
  - Overall US space program was much, much bigger, and strong national security drivers

- Space originated in the Cold War struggle between capitalism and communism

- Space was an avenue for competition between the US and USSR
  - Soft Power (prestige through human spaceflight and exploration)
  - Hard Power (military capabilities)

NSC 5814 “Military Uses of Space”

a. Now Planned or in Immediate Prospect

(1) Ballistic Missiles. A family of IRBM's and ICBM's is now in the latter stages of development. Components of these missiles can be used to develop other space vehicles, for both military and scientific use.

(2) Anti-ICBM's which are now being developed.

(3) Military Reconnaissance. (see "Reconnaissance Satellites" section, paragraphs 20-23)

b. Feasible in the Near Future

(1) Satellites for Weather Observation.

(2) Military Communications Satellites.

(3) Satellites for Electronic Countermeasures (Jamming).

(4) Satellites as Aids for Navigation, tracked from the earth's surface visually or by radio.

c. Future Possibilities.

(1) Manned Maintenance and Resupply Outer Space Vehicles.

(2) Manned Defensive Outer Space Vehicles, which might capture, destroy or neutralize an enemy outer space vehicle.

(3) Bombardment Satellites (Manned or Unmanned). It is conceivable that, in the future, satellites carrying weapons ready for firing on signal might be used for attacking targets on the earth.

(4) Manned Lunar Stations, such as military communications relay sites or reconnaissance stations. Conceivably, launching of missiles to the earth from lunar sites would be possible.

“Draft Preliminary Statement of U.S. Policy on Outer Space,” U.S. National Security Council Planning Board, 20 June 1958

http://marshall.wpengine.com/wp-content/uploads/2013/09/NSC-5814-Preliminary-U.S.-Policy-on-Outer-Space-18-Aug-1958.pdf

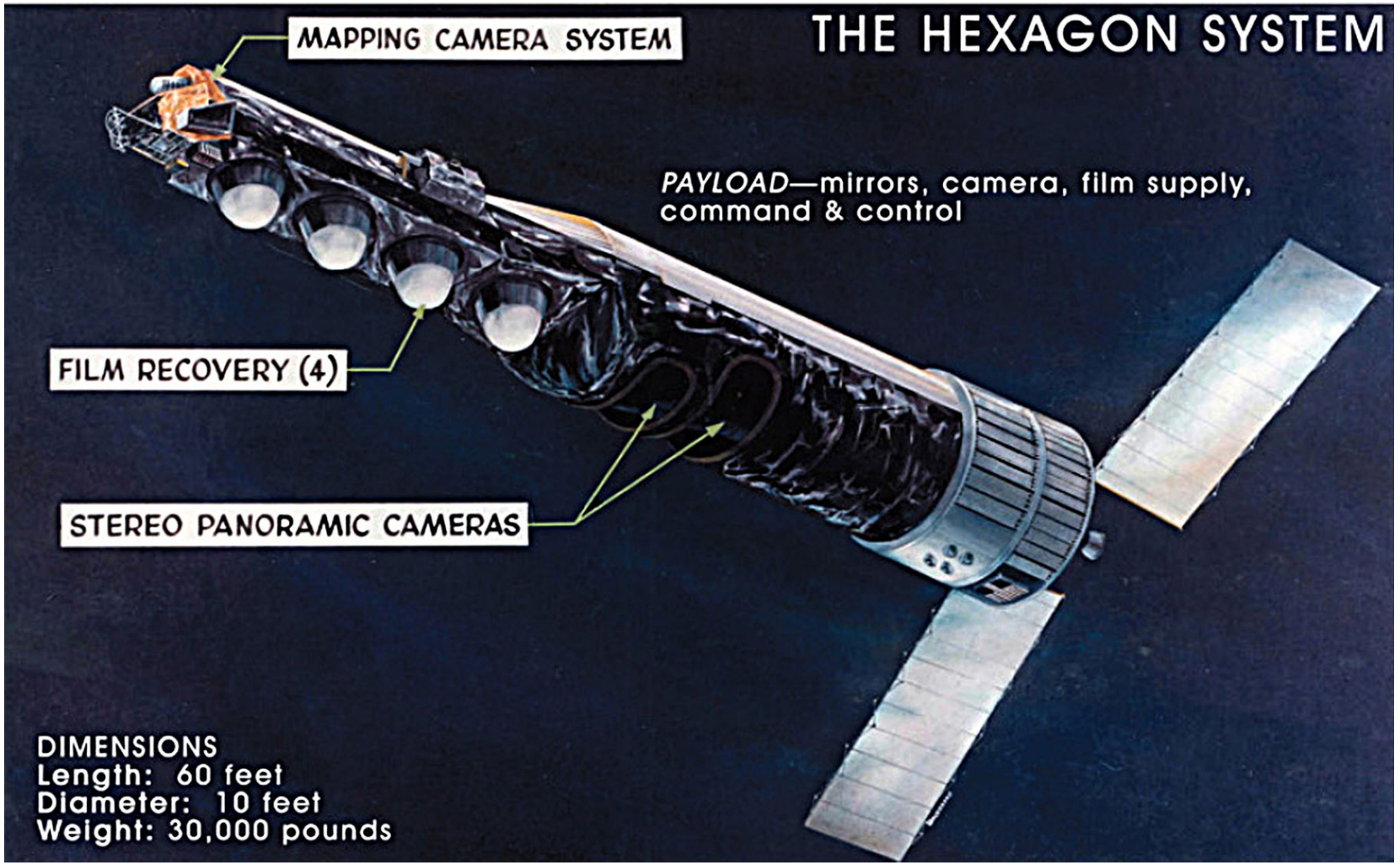
CORE MILITARY AND NATIONAL SECURITY USES OF SPACE

1. Satellite Reconnaissance

- In the 1950s, the top national security priority of the US was to collect intelligence on the Soviet military buildup
- After Gary Powers, the Eisenhower Administration turned to satellites as an alternative to airborne surveillance
  - Classified WS-117L program to develop three different types of surveillance satellites & military programs to develop rockets
  - Political promotion of the term “peaceful uses of outer space” and defining it as non-aggressive activities (as opposed to non-military)
- The US launched 130 reconnaissance satellites between 1959-1972
- Satellites were the primary means of verifying arms control treaties between the U.S. and Soviet Union

Corona imagery of China's first nuclear test

U.S. KH-9 HEXAGON “Big Bird” (1971-1994)

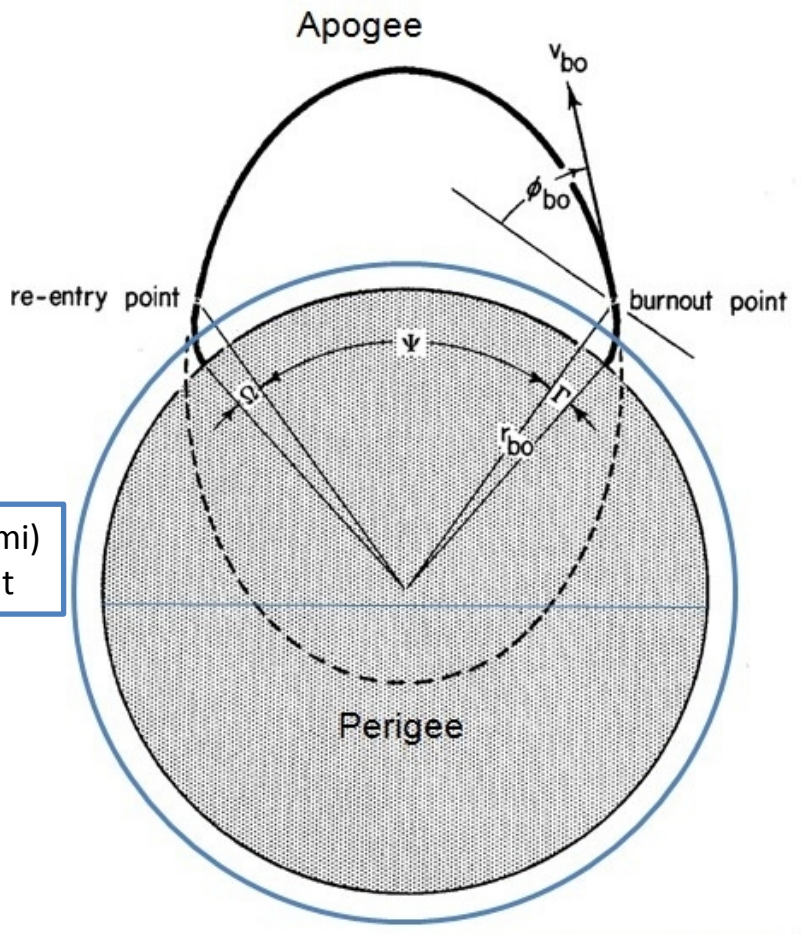


2. Launching Stuff Through/Into Space

- After World War II, the U.S. and Soviet Union "borrowed" German rocket technology
- In the early 1950s, the U.S. and Soviet Union began working on developing Intercontinental Ballistic Missiles (ICBMs)
- ICBMs and civil space launch vehicles (SLVs) are closely linked
  - Sputnik was launched on the first Soviet ICBM (R-7)
  - U.S. Army Jupiter rocket became the basis for Saturn rockets
  - Many retired ICBMs are now used as space launch vehicles

- Suborbital: object does not have enough forward speed to remain in orbit, traverses a ballistic arc & returns to the Earth
- Orbital: object has enough forward speed to remain in a specific orbit

Ballistic vs. Orbital Trajectories



600 km (450 mi) circular orbit

Maximum altitude of a ballistic missile trajectory is roughly half the horizontal distance it will travel

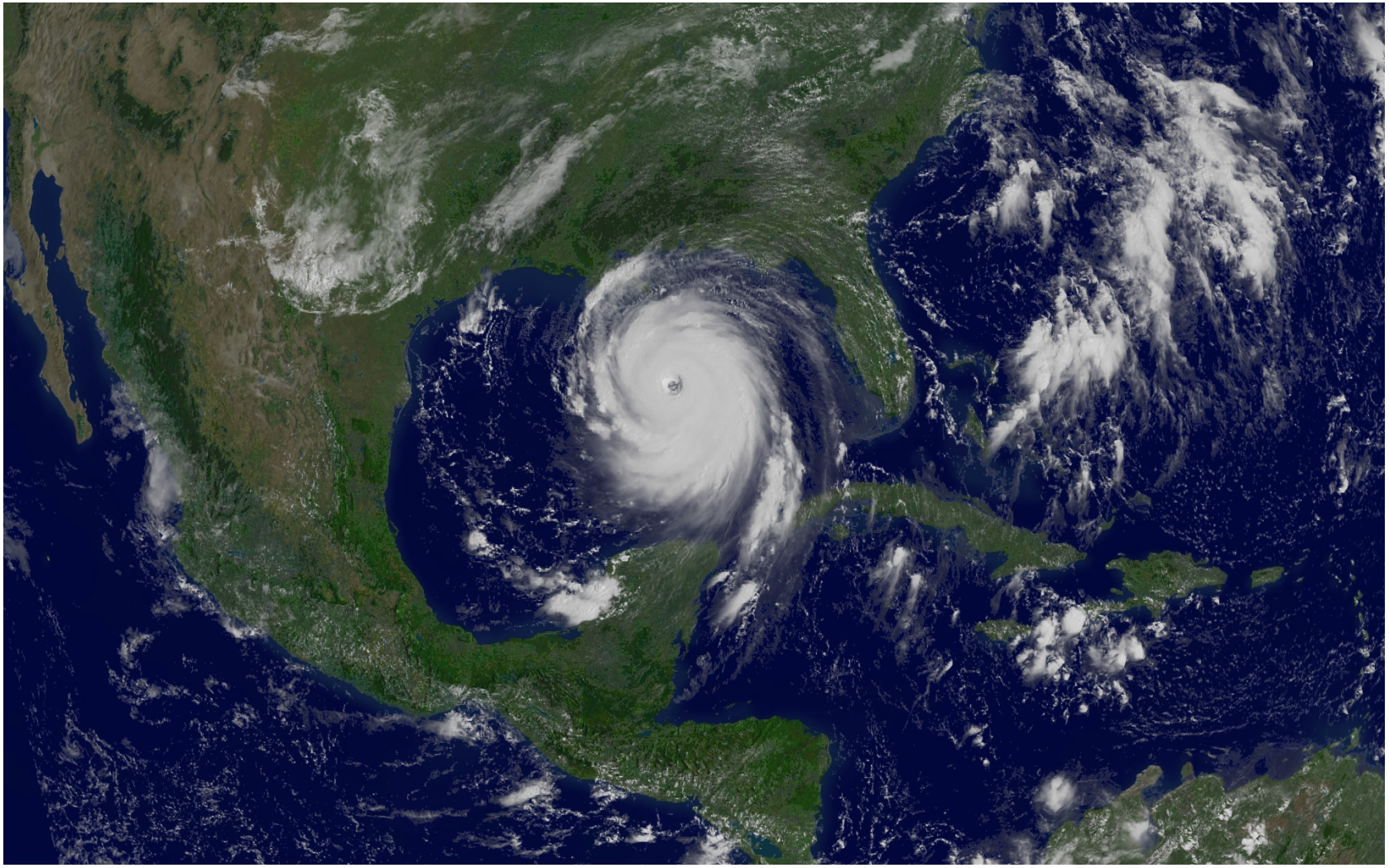
3. Meteorology (Weather)

- Military interest in weather dates back millennia
  - Throughout history, weather has always had significant impacts on warfare (rain, fog, high winds, cold temperatures)
  - Being able to predict the weather gives you a military advantage

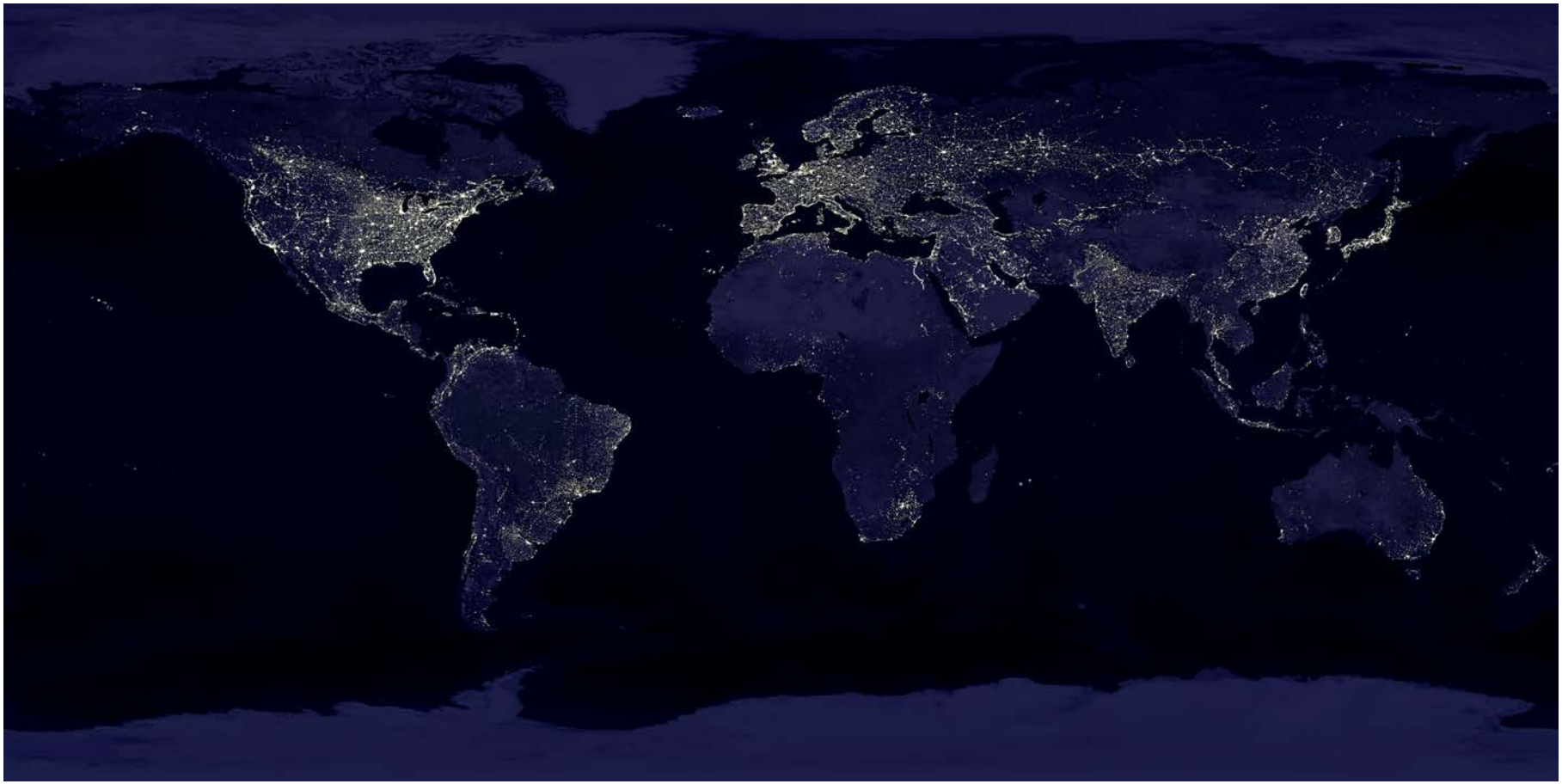
- Advent of imagery satellites that looked down from space added more impetus
  - Can't image through clouds
  - Don't want to waste film taking photos of clouds

TIROS-1 Image of the Earth (1960)

GOES-12 Image of Hurricane Sandy (2012)



“Earth Lights” Rendering From DMSP Imagery, 2013



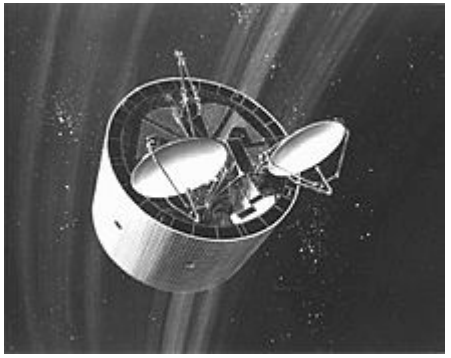
4. Communications

- Satellite communications is one of the few areas where the commercial/civil space program was first (Telstar-1, 1962)

- Strategic communications
  - Communications between the Head of State and top military commanders in the field, and delivering orders and instructions for nuclear forces
  - Encrypted, jam-resistant, survivable
  - "Hardened" to function in a nuclear environment
  - Usually done from geostationary Earth orbit (GEO)

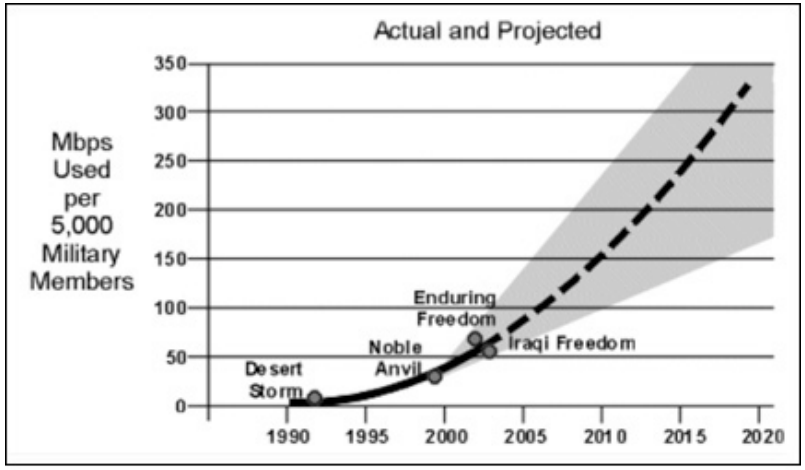
- Tactical communications
  - Communications with military units in the field
  - End user is often "mobile", sometimes needs to protect their location
  - Usually done from low Earth orbit (LEO)

Telstar-1 (1962)

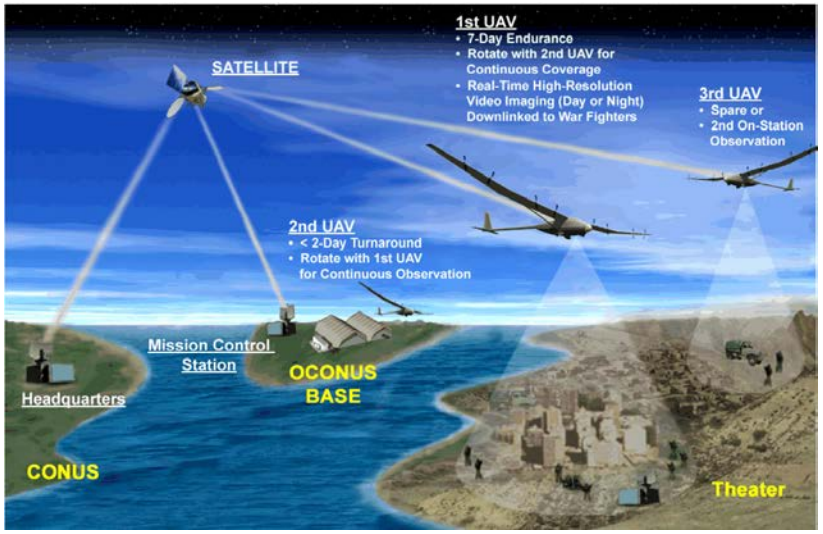


DSCS-2 (1972)

Modern Military Satellite Communications



Growth in Bandwidth Usage



UAV Operations

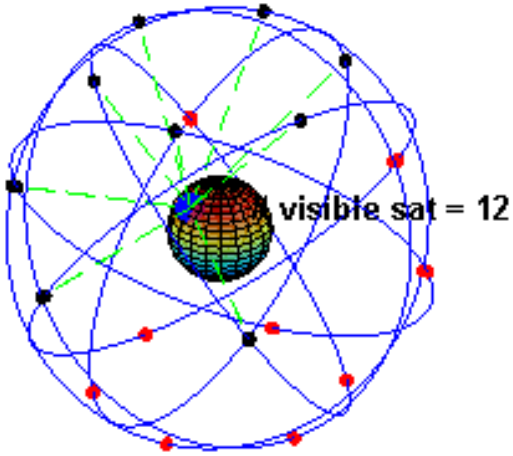
DSCS Mobile Satellite Terminal

Iridium Satellite Phone

5. Navigation

- Satellite navigation systems were developed by combining together several different technologies and/or insights
  - Doppler shift of radio transmissions from Sputnik
  - Lightweight atomic clocks

- Need at least four independent signals to solve for three unknowns (x, y, z, and time)



GPS constellation

Satellite Navigation Today

- U.S. Global Positioning System (GPS)
  - Global coverage (being upgraded with more civil signals & protection of military signals)
- Russian Global Navigation Satellite System (GLONASS)
  - Global coverage (being restored to full operational status)
- European Galileo
  - Global coverage (being built)
- Chinese BeiDou
  - BeiDou-1: regional coverage over Asia (active)
  - BeiDou-2: global coverage (being built)
- Japanese Quasi-Zenith Satellite System (QZSS)
  - Regional augmentation of GPS (being built)
- Indian Regional Navigation Satellite System (IRNSS)
  - Regional coverage (being built)

Precision-Guided Munitions

6. Missile Warning/Launch Detection

- The development of nuclear-armed ballistic missiles also prompted development of ways to increase the warning of nuclear attack

- Satellites with infra-red sensors could “see” the heat of an ICBM launch, providing up to 30 minutes of warning before warheads were picked up by radar

- Recent developments also provide tactical “theater” warning, such as of Iraqi Scud launches during the 1993 Gulf War

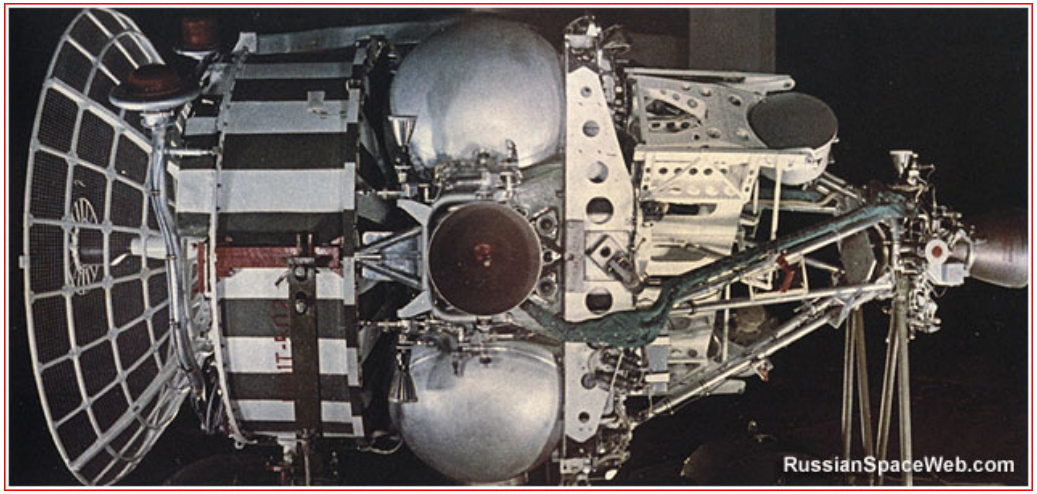
IR Warning Satellite Architecture

7. Space Control

- The increasing importance of satellites for national security & military uses invariably led to development of ways to attack (or defend) satellites

- Space Control
  - Defensive Space Control (DSC): capabilities to protect satellites against attack, or harden them against certain types of attacks
  - Offensive Space Control (OSC): capabilities to attack satellites and deny/degrade/destroy an adversary's ability to use them
  - Space Situational Awareness (SSA): knowledge about the space environment and activities in space

Many Ways to Attack Satellites



Soviet IS killer satellite (1960-1987)

U.S. Air Force F-15 launching an ASM-135 ASAT missile (1978-1988)

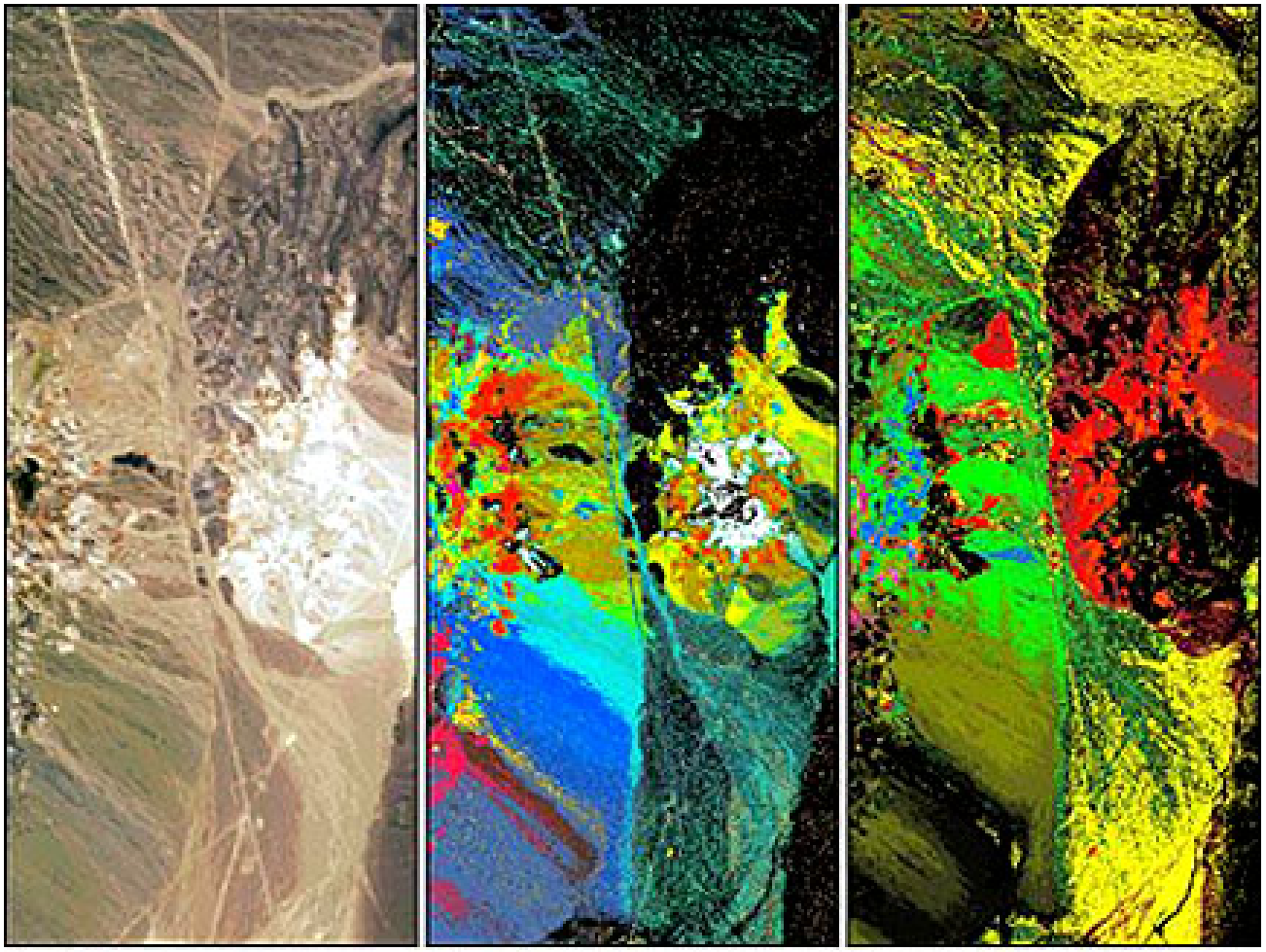
Commercially-available GPS jammer (2014)

8. Intelligence, Surveillance Reconnaissance (ISR)

- The information-collection capabilities of satellites have gone far beyond just taking “photographs”
- Satellites are now used to collect a wide range of information across the EM spectrum
  - IMINT (Imagery Intelligence)
    - Visible light, infra-red, ultraviolet, radar
  - MASINT (Measurement and Signature Intelligence)
    - Physical parameters (size, shape)
    - Particular spectral, chemical, or radio-frequency emissions
  - SIGINT (Signals Intelligence)
    - ELINT (Electronic Intelligence)
      - Radar emissions, missile telemetry
    - COMINT (Communications Intelligence)
      - Phone calls, message traffic

1-Meter Resolution Radar Image of the U.S. Capitol

Hyperspectral Image of Cuprite, Nevada



Radomes at Menwith Hill, United Kingdom

POSTULATED MILITARY USES OF SPACE

Space-Based Missile Defense

- Space-based missile defense interceptors have theoretical advantages over ground-, air-, or sea-based interceptors
  - Perform boost phase intercepts virtually anywhere in the world, at any time
- Nuclear-pumped X-ray lasers
  - Use a nuclear detonation to power an X-ray laser
- Kinetic kill satellites
  - Larger satellites releasing multiple kinetic-kill interceptors
  - 1,000 (or more) microsatellites interceptors
- Major challenges include high costs, inducing an arms race/instability, command and control, and increased congestion of LEO

Space-to-Earth Force Application

- Since the 1960s, military planners have consid
  that can be used to attack targets on Earth
  - Analogous to strategic air bombardment
- Two main technologies
  - Re-entry of hyperkinetic “rods”
  - Space-based lasers
- So far air-, sea-, and ground-based capabilities
  proven to be more effective options

Artist’s conception of “Rods from God”

Prompt Global Strike

- Goal: to be able to strike fleeting targets anywhere in the world
- Tech: ballistic missile to launch hypersonic glider with a conventional (non-nuclear) weapon on a non-ICBM trajectory

RECENT DEVELOPMENTS

Current Satellites in Orbit

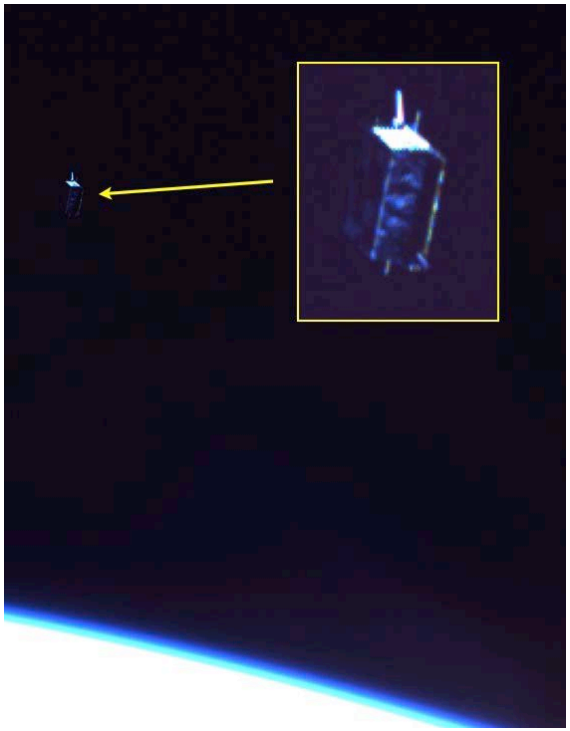
Total number of operating satellites: 1,235			
United States: 512	Russia: 135	China: 116	Other: 472
LEO: 655	MEO: 85	Elliptical: 37	GEO: 458

Total number of military satellites: 342					
Navigation	Weather	Communications	Missile Warning	Intelligence, Surveillance, & Reconnaissance	Technology Development
90	8	105	8	101	30

Source: Union of Concerned Scientists Satellite Database
(includes launches through 7/14/14)
http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/space-weapons/ucs-satellite-database.html

Rendezvous and Proximity Operations (RPO)

"getting up close and (perhaps) touching another space object"



Swedish "Mango" satellite imaged by its partner, "Tango"

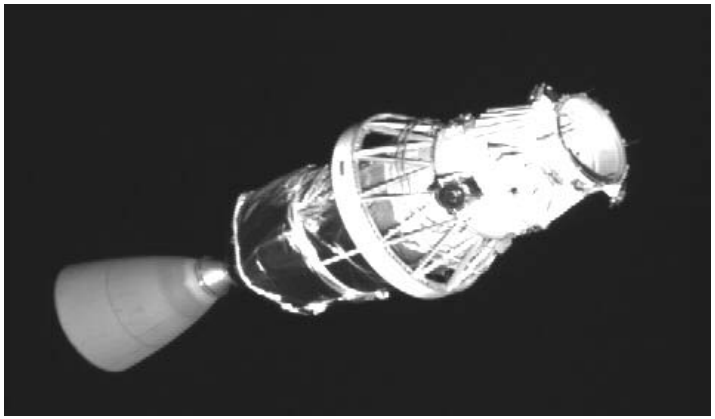
China remains silent on satellite rendezvous

BY STEPHEN CLARK
SPACEFLIGHT NOW
Posted: September 8, 2010

SHARE

The U.S. Air Force last week acknowledged tracking Chinese satellites secretly testing orbital rendezvous technologies, nearly two weeks after the spacecraft may have bumped into each other more than 350 miles above Earth.

A Department of Defense spokesperson confirmed numerous reports of two satellites deliberately flying in close formation.



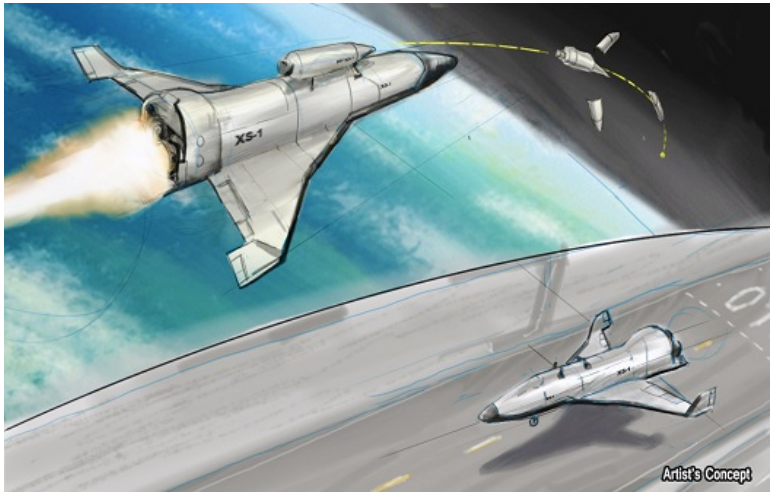
Delta II rocket imaged by American XSS-10

Operationally Responsive Space (ORS)

More rapid development & deployment of space capabilities in response to warfighter needs

Chinese Kuaizhou-1 "Swift Vessel" launch vehicle

Ball Aerospace STPSat-3



DARPA XS-1 Concept

Significant Trends

- Growing number of countries interested in developing their own national security/military uses of space
  - Increasing chances that future conflicts will have a space element
- Diffusion of “dual use” space technology from the military sector has led to many more commercial/civil applications
  - Militaries no longer have a monopoly on many of these capabilities
- Information Technology (IT) is beginning to drive innovation in space technology and capabilities, and lower barriers to entry
  - Smartphones are the new satellites

Thank You. Questions?

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