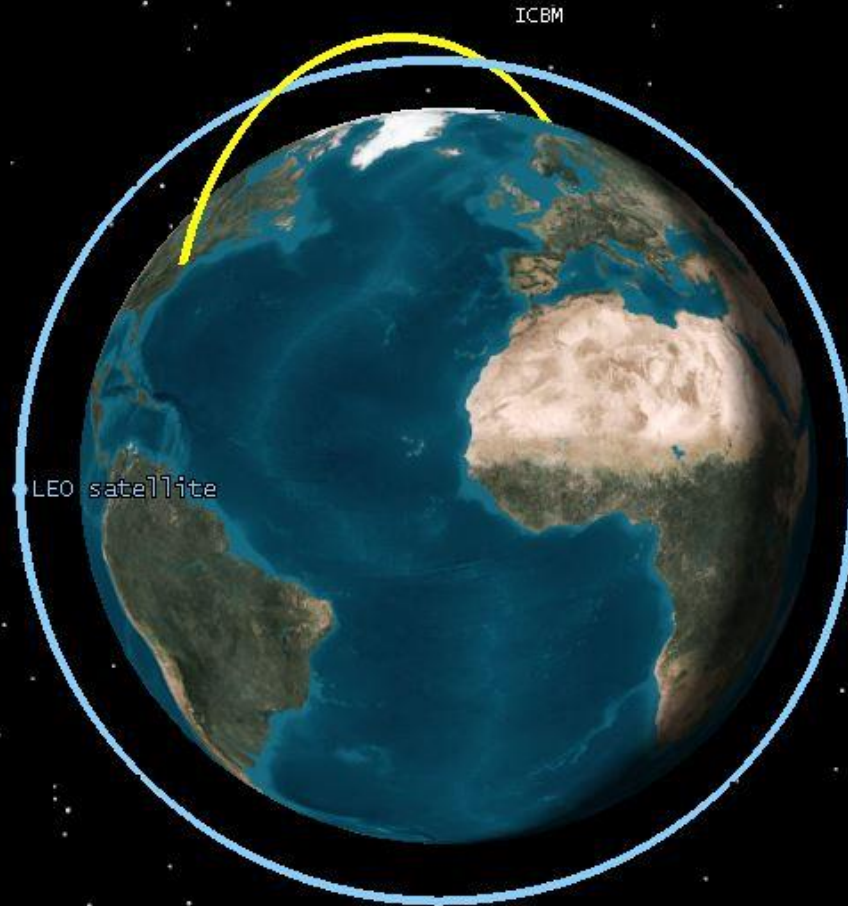




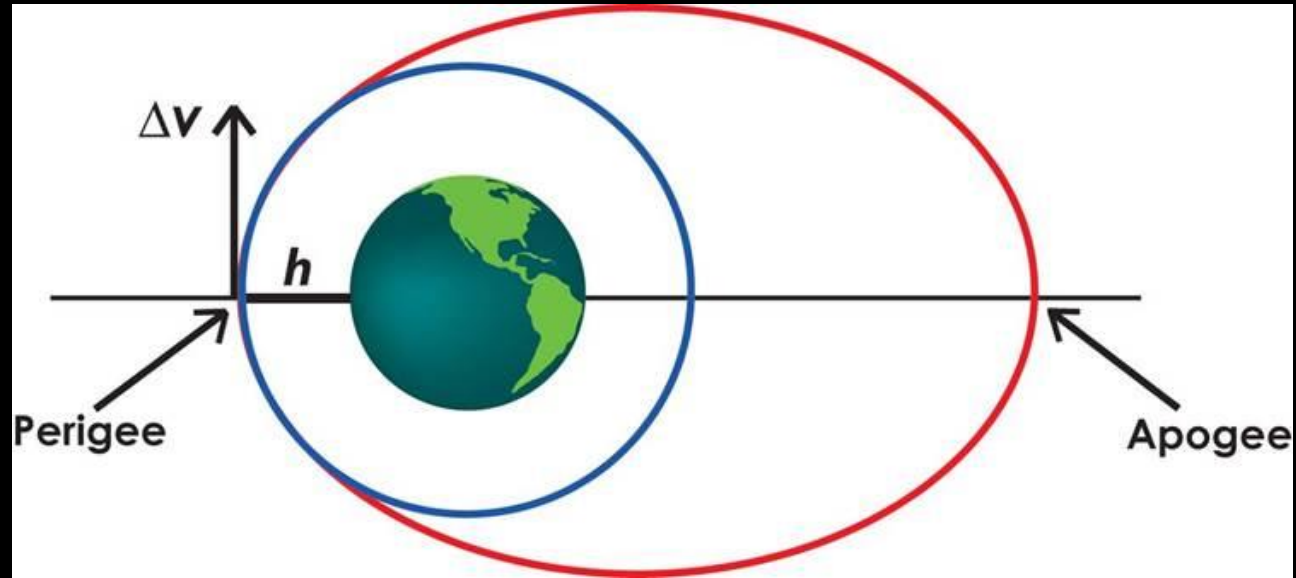
# The Physics of Space Security

Laura Grego  
[ **Union of  
Concerned Scientists** ]

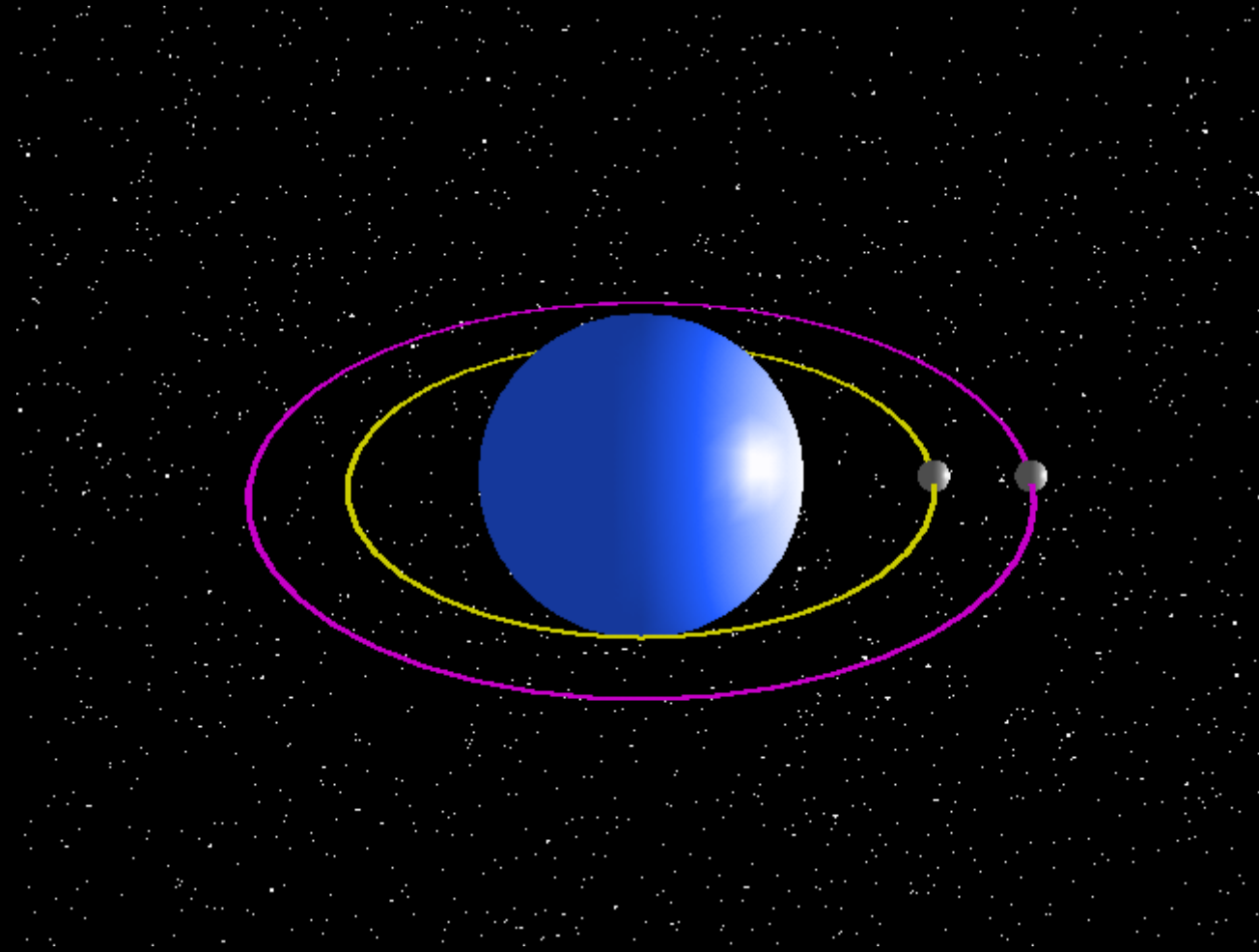
{ Space is a place, but orbit is a condition.



$$r = h + r_{earth}$$



$$V = \sqrt{\frac{G \times M_{earth}}{r}}$$



{ Satellites travel in predictable orbits.

{ Time-sensitivity & persistence require a constellation





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{ You cannot hide in space.

# Earth from Low Earth Orbit (LEO)



## Earth observations:

Passive and active sensors

Intelligence, surveillance, reconnaissance

Weather, climate & environmental science

## Short time-lag or remote communications:

Iridium, Globalstar

Proposed global internet One Web, SpaceX

# Earth from Medium Earth Orbit (MEO)



(In circular orbits)

Position, navigation & timing

GPS, GLONASS, Beidou

(In highly elliptical orbits)

Observation of northern latitudes

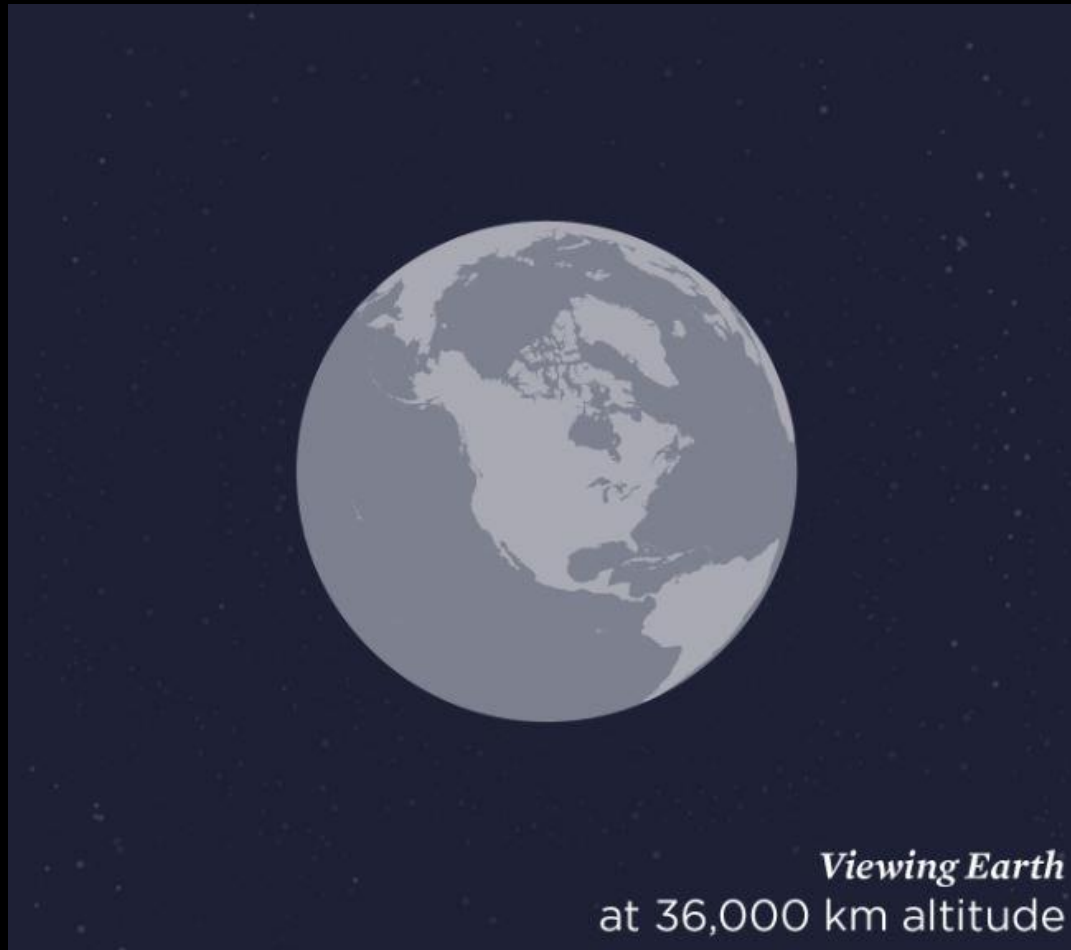
Molniya

Space science

Chandra X-Ray Observatory



# Earth from Geosynchronous Orbit (GEO)



## Communications

Broadcast, data relay

High data rate, secure, global, commercial

## Earth observation

Weather

Early warning of missile launch

Electronic intelligence

## Navigation system supplementation



{ It requires an enormous amount of energy  
(and money) to put satellites in orbit.



{ As well as to bring them down.  
You can't really "drop" bombs from space.

{ Space debris will accumulate.

• esa



1961

# Difficulties in the space environment

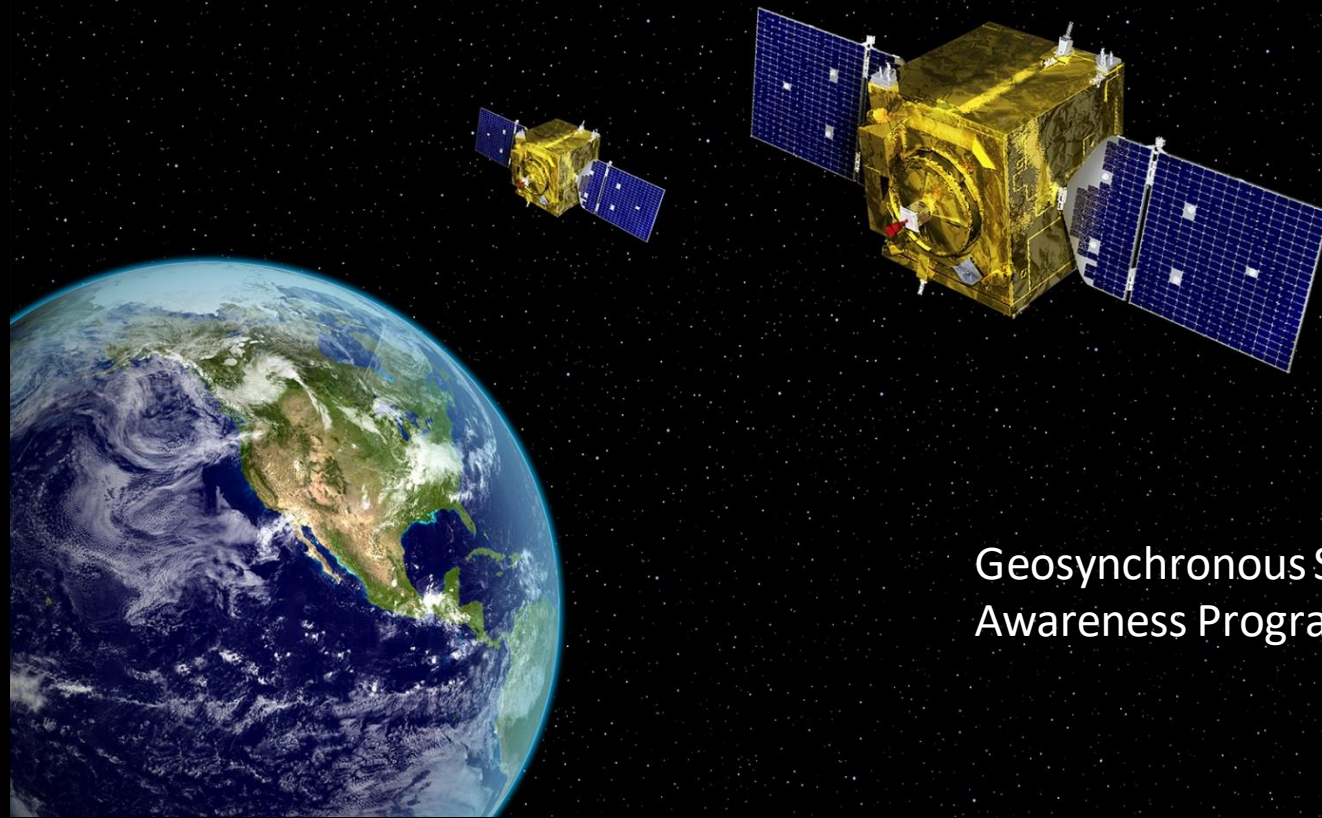
- Attributing a problem to failure or attack is difficult to do in a timely way.
- Difficulty of knowing a satellite's owner and full range of purposes.
- Short timescales for action.
- Always working in same space as multiple other states.
- Inherent dual-use nature of much of space technology. Can be offensive and defensive or neutral.

# Dual-use nature of space technology

{ Space launch vehicles and ballistic missiles



# Dual-use nature of space technology



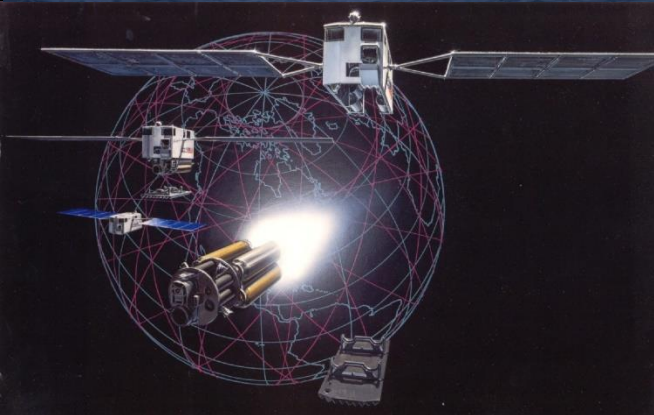
Geosynchronous Space Situational Awareness Program satellite



Proximity operations— getting up close

# Strategic missile defense systems

**Ground-, sea-, or space-based interceptors**

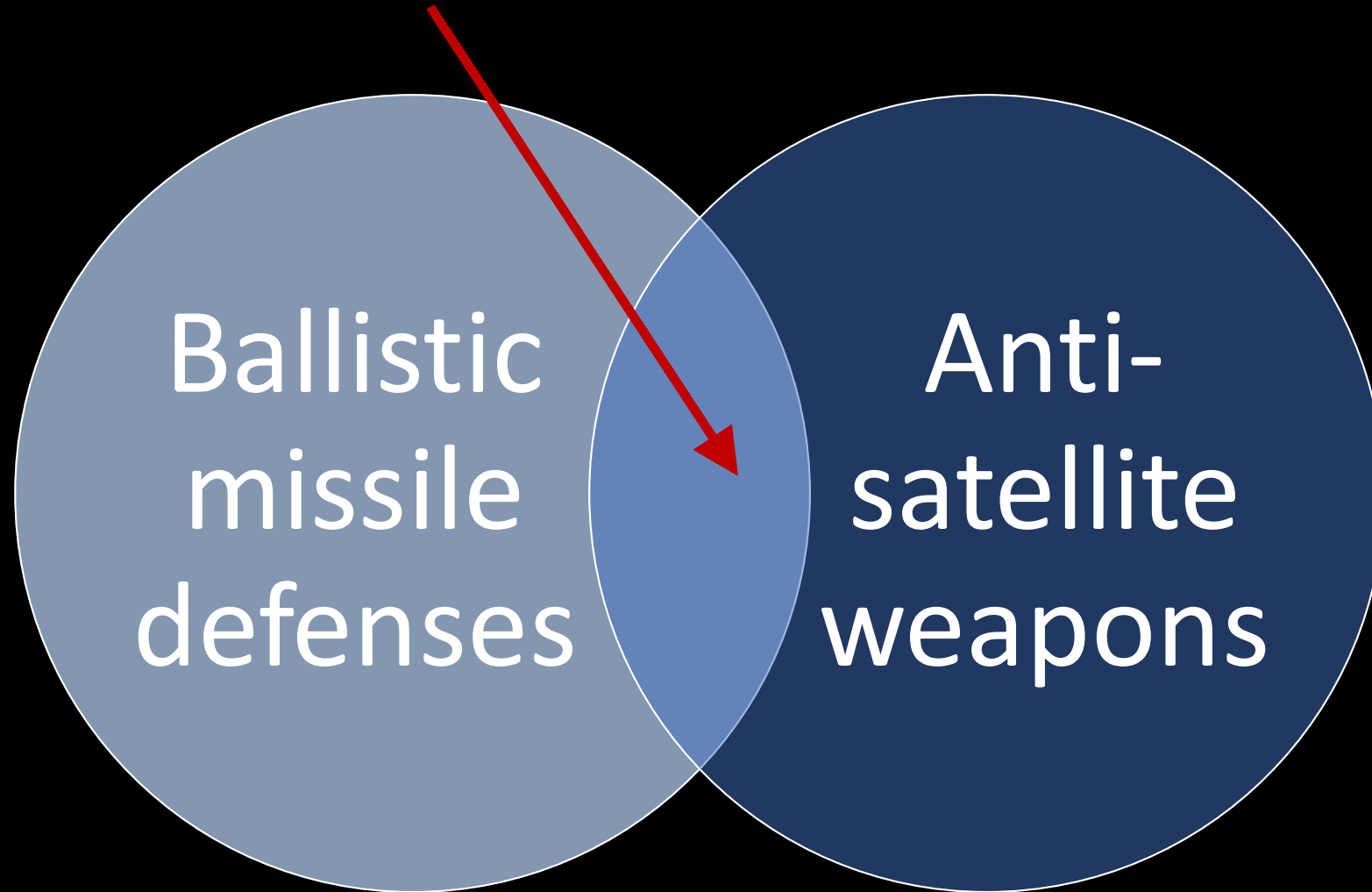


**Airplane or drone-based lasers or interceptors**





strategic missile defenses



# Difficulties & Differences

- Inherent dual-use nature of much of space technology. Can be offensive and defensive or neutral.
  - This is not an insurmountable problem.
  - And it is not true that “any” satellite can be used as a weapon.

1966



Image: Union of Concerned Scientists

# The Physics of Space Security

*A Reference Manual*

*David Wright, Laura Grego, and Lisbeth Gronlund*



AMERICAN ACADEMY  
OF ARTS & SCIENCES

RECONSIDERING THE RULES OF SPACE PROJECT