

Relative Navigation Schemes for Formation Flying of Satellites



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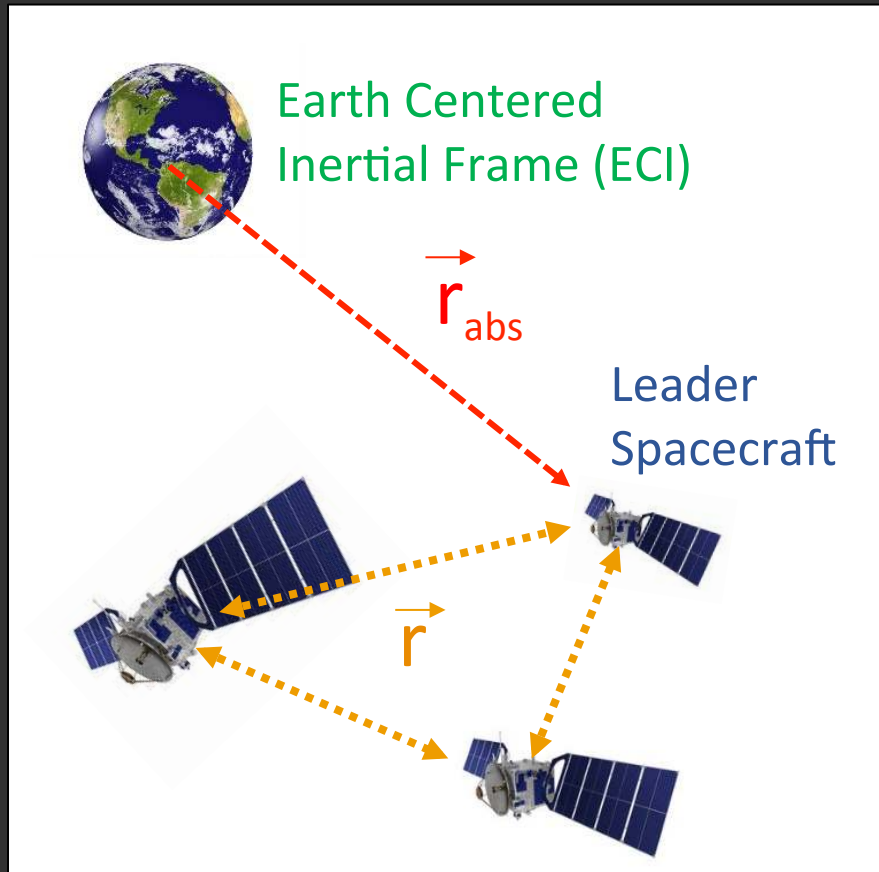
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Session VII – Big Picture

Relative Navigation Schemes for Formation Flying of Spacecraft

- Relative Navigation
- VTXO Mission
- Technologies and their suitability for deep space missions
- Summary

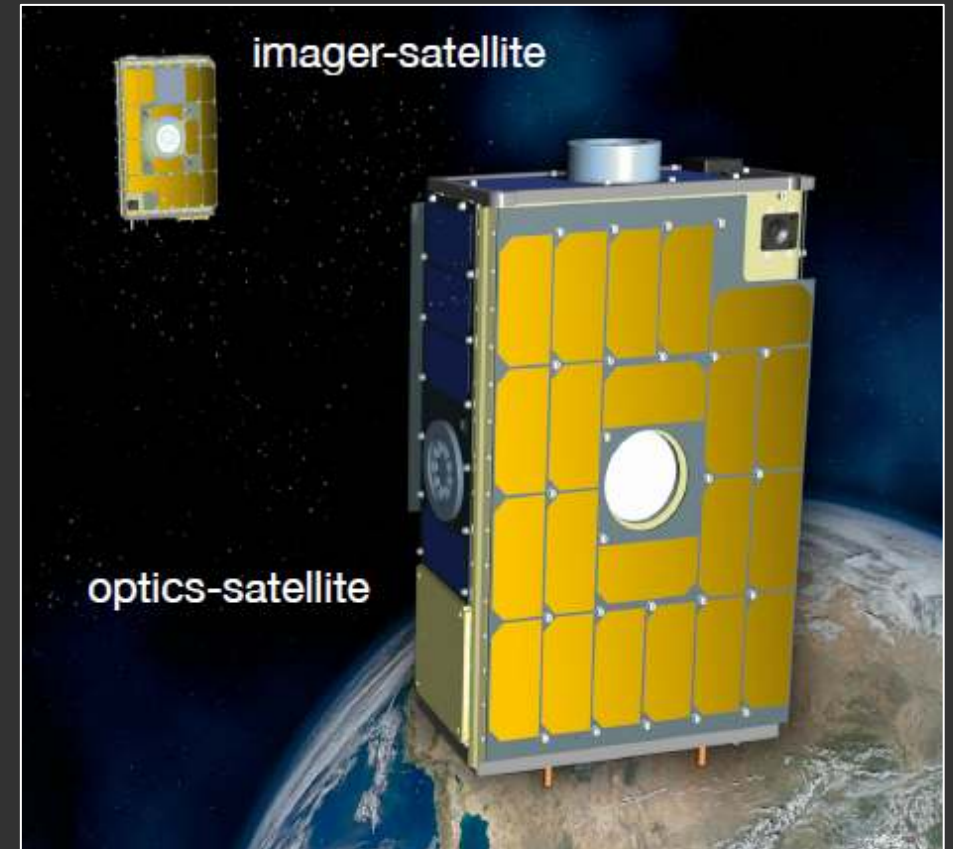


Relative Navigation



VTXO Mission

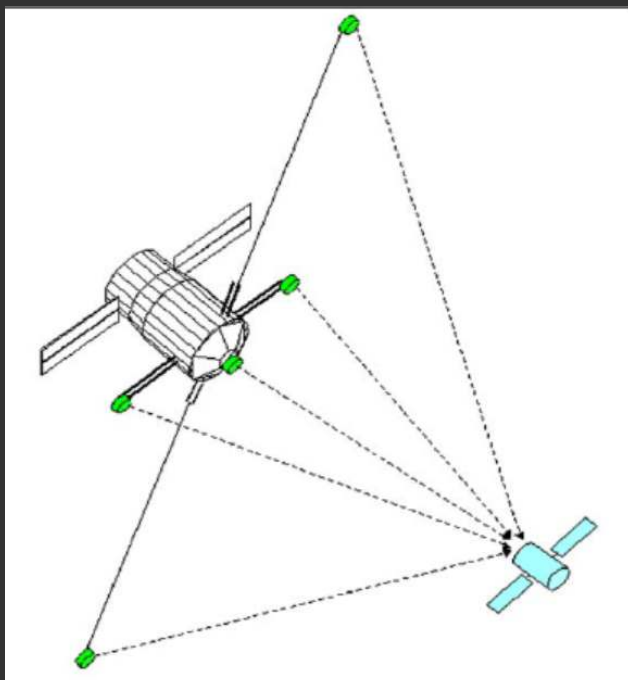
- Virtual Telescope for X-ray Observations
- X-Ray telescope
 - Sub-arcsecond to milli-arcsecond resolution
 - Focal lengths hundreds of meters
 - Imager and optics Satellites
- Investigate technologies that can be adapted to a full scale virtual telescope mission for deep space or sun-earth libration points.
- Formation flying for deep-space missions enabled by diffractive Fresnel lens



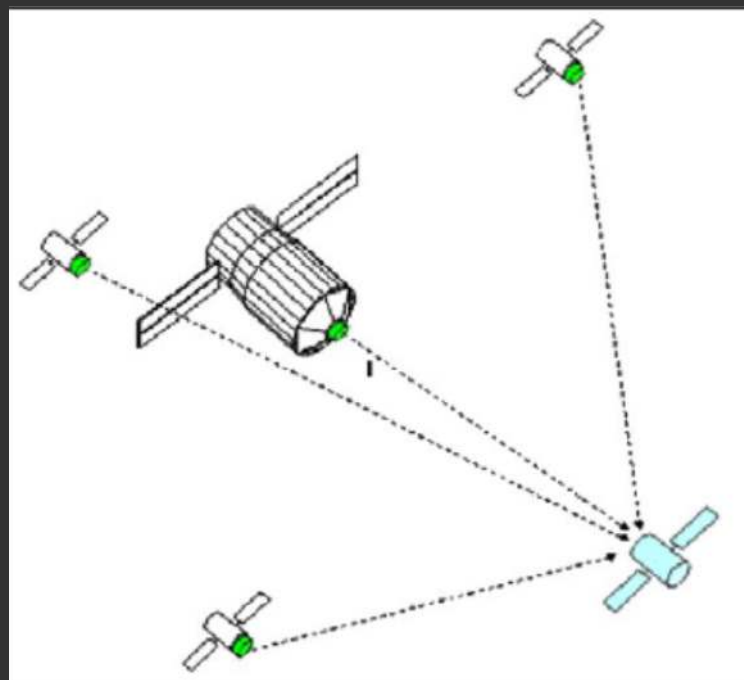
VTXO with imager and optics satellite separated by hundreds of km.

RF Communications

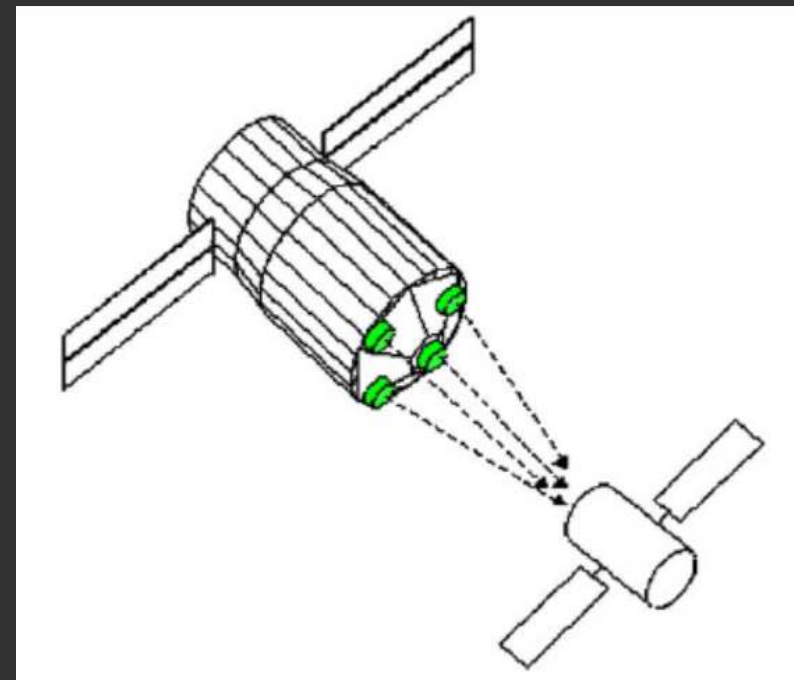
- One configuration creates a pseudo GPS Network, however instrumentation on multiple spacecraft required



Targets mounted on deployable booms



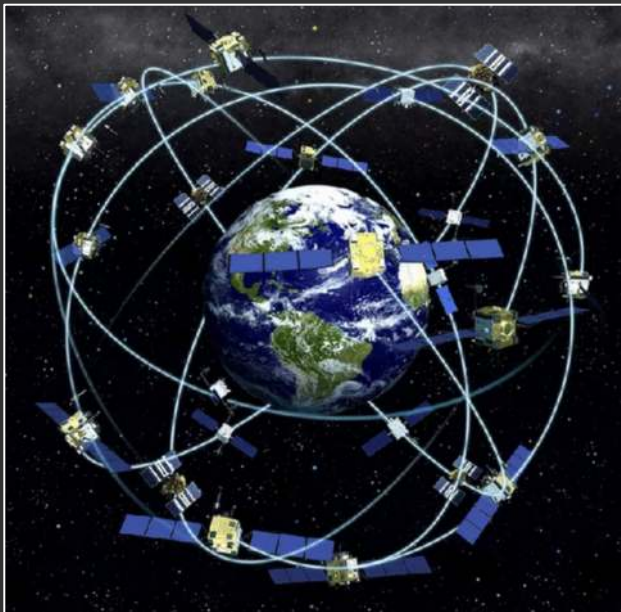
Pseudolites flying In formation



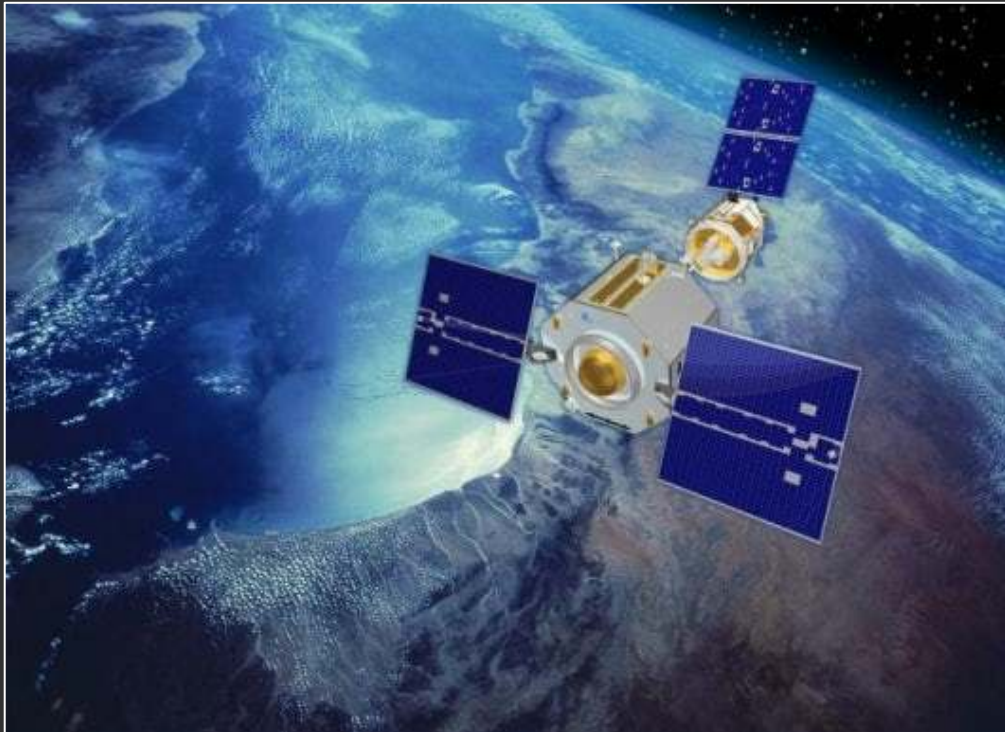
On board targets

GPS

- Earth pointing network
- Not suitable for precision formation flying in deep space



Vision Navigation & Laser Metrology



Orbital Express ASTRO and NextSat (2007)



NASA VADRE Rendezvous Experiment (2011)



Star Trackers

- Flight proven technology, Chandra X-Ray Observatory (1999), LRO (2009), SDO (2010)
- Effective for relative positioning and attitude determination
- Cannot provide absolute positioning information



Ball Aerospace High Accuracy Star Tracker

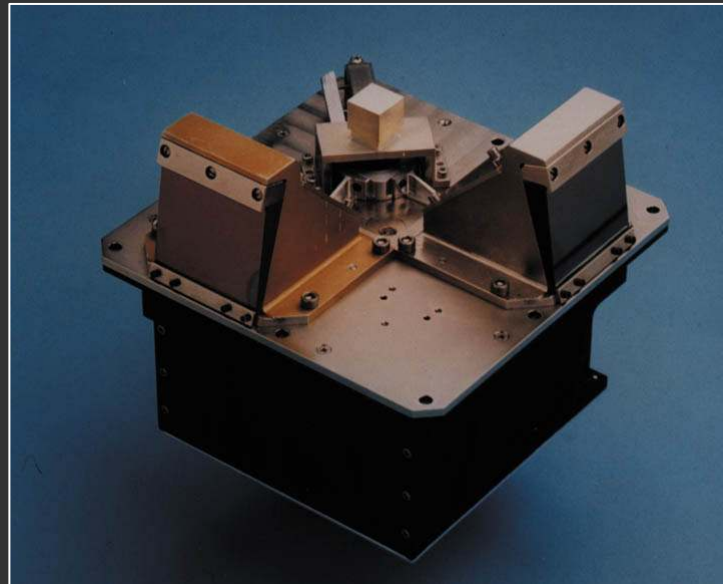


Hydra Star Tracker



Sun and Earth Sensors

- Measure direction of Sun or Earth and provide attitude information
- Limited accuracy, require secondary system for relative positioning
- Unreliable for deep space application

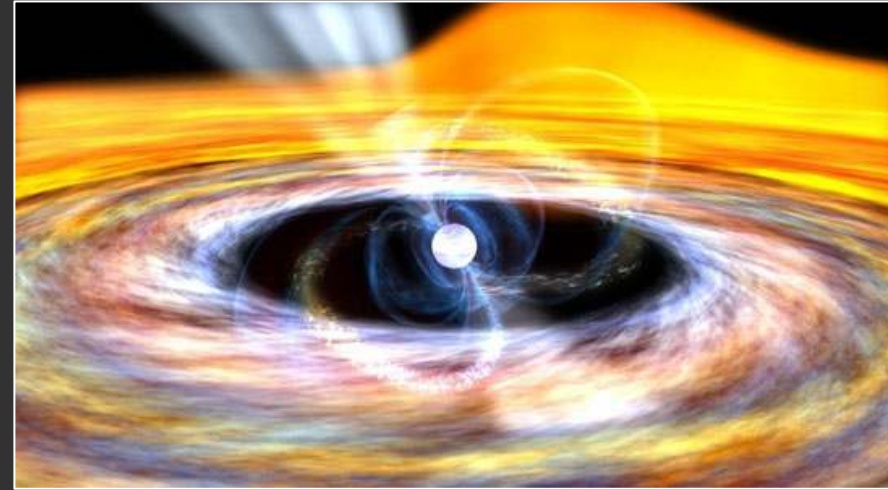
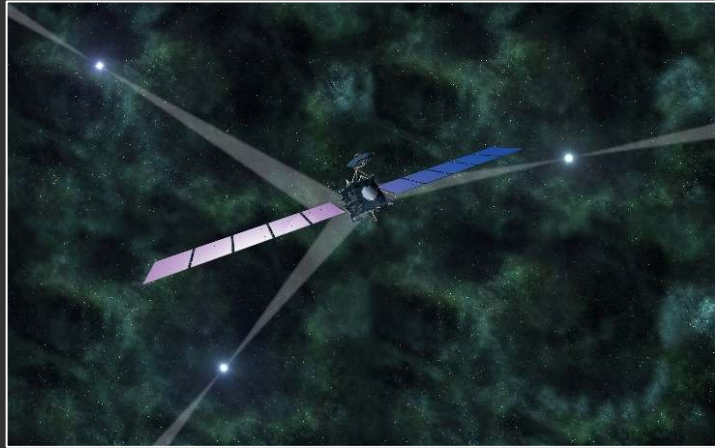


Servo Corporation of America
MiDES Earth Horizon Sensor

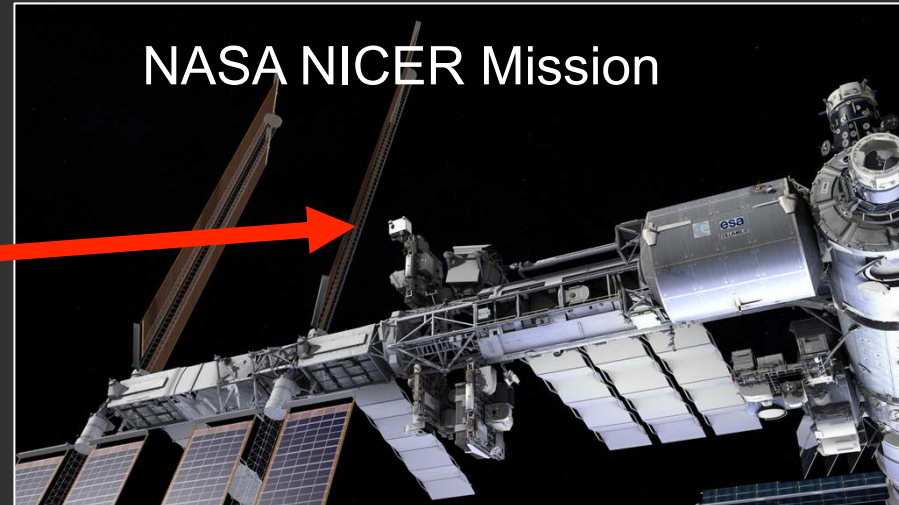


NSS Fine Sun Sensor

X-ray Pulsar Navigation



X-Ray
Millisecond
Pulsar (Artist
Representation)



NASA NICER Mission



Technical Summary

System	Standalone (rel and abs)	Absolute Range	Notable Missions
Radio Frequency	N	Any	TanDEM-X
GPS	Y	Within GNSS Network	TanDEM-X, ETS-VII, EO-1, GRACE
Vision Based Navigation & Laser Metrology	N	Any	VADRE, LISA, OE-1
Star Tracker	N	Any	CHANDRA, LRO, SDO,
X-Ray Pulsar	Y	Deep Space	NICER



Summary of VTXO Mission

- Seek to identify potential relative navigation schemes for deep space missions utilizing small satellites in place of CubeSats.
- Leverage current technologies for the VTXO 6U CubeSat Formation Flying mission
- Phased Fresnel lens with resolution significantly better angular resolution than state of the art (Chandra)
- Focal lengths on the order of 500 m. for a 3 cm. lens



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Support Slides



Notable Relative Navigation Missions

- DARWIN (2007)
- LISA (2030)
- XEUS (Under Assessment)
- SARah 2,3 (2019)
- TerraSar
- CartWheel
- GRACE
- Gemini
- Inspector
- SMART 2
- Starlight (ST-3)
- SSPS
- SPANP1 Tshinghua
- Terrestrial Planet Finder
- PRISMA
- PROBA-3
- SIMBOL-X
- DUAL
- EDSN



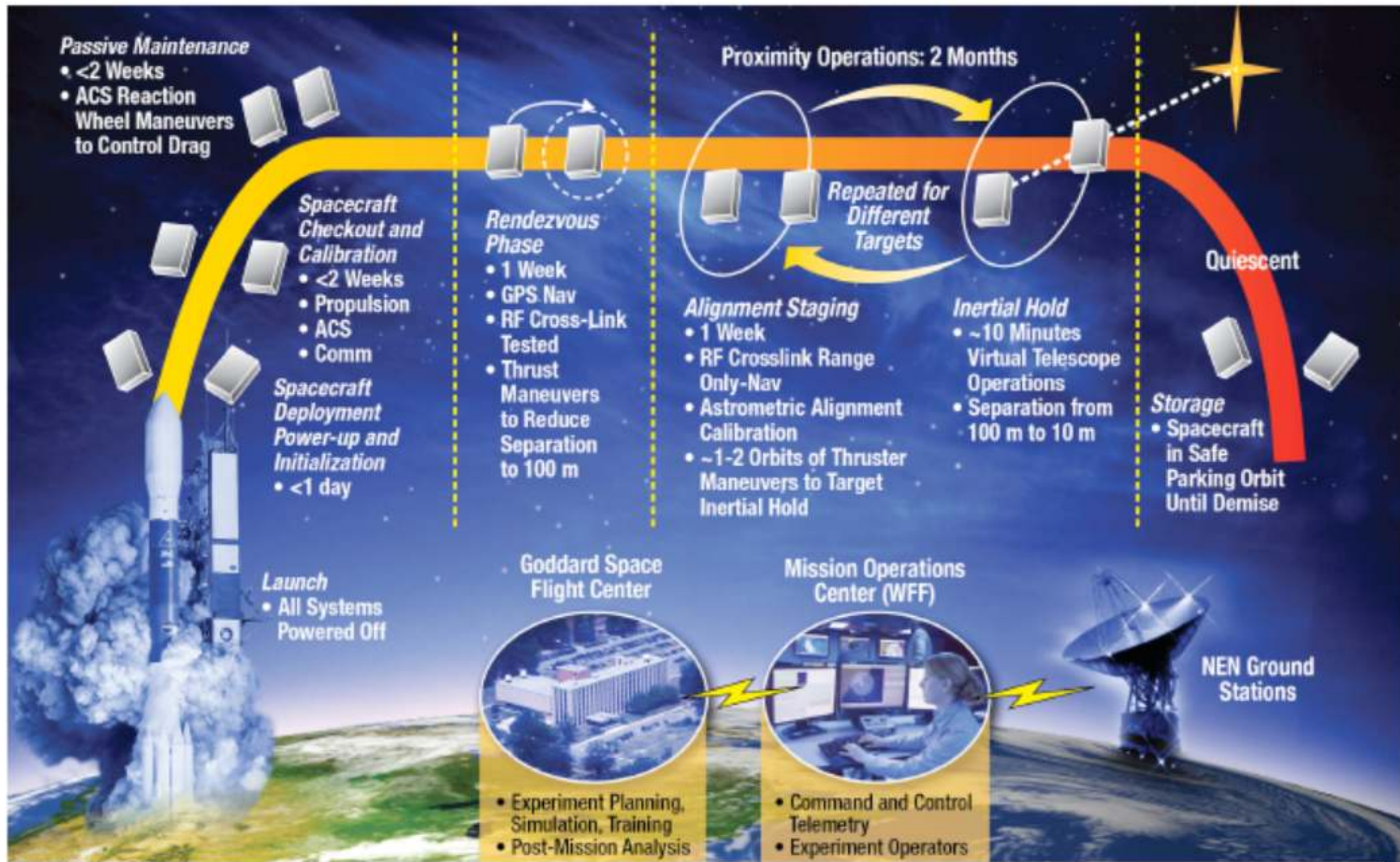


Figure 4. VTDM Concept of Operations

