Relative Navigation Schemes for Formation Flying of Satellites

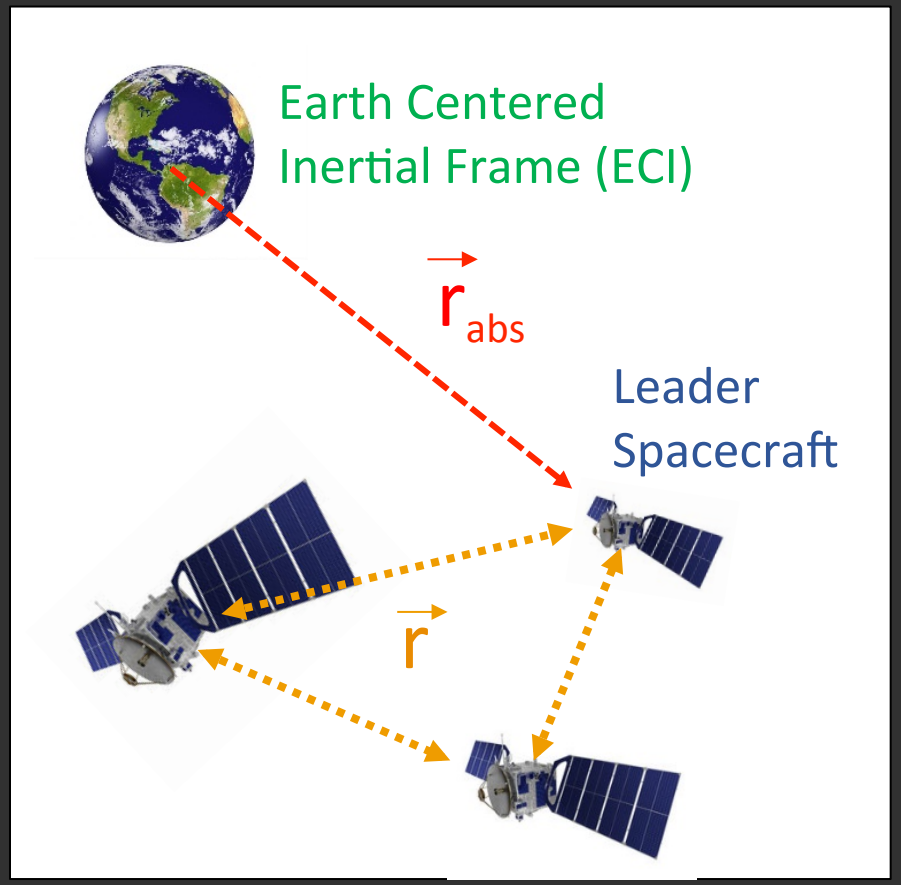
Benjamin Urioste – The University of New Mexico
Asal Naseri – The University of New Mexico
Steven Stochaj - New Mexico State University
Neerav Shah - NASA Goddard Space Flight Center
John Krizmanic - NASA Universities Space Research Association

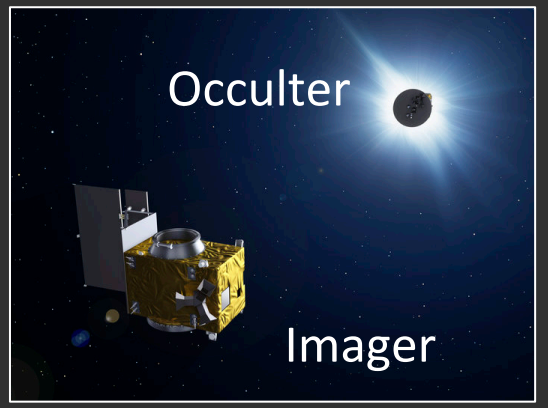
Sunday, August 6th 2017
Small Satellite Conference 2017 – Pre-Conference Workshop
Session VII – Big Picture

Relative Navigation Schemes for Formation Flying of Spacecraft

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

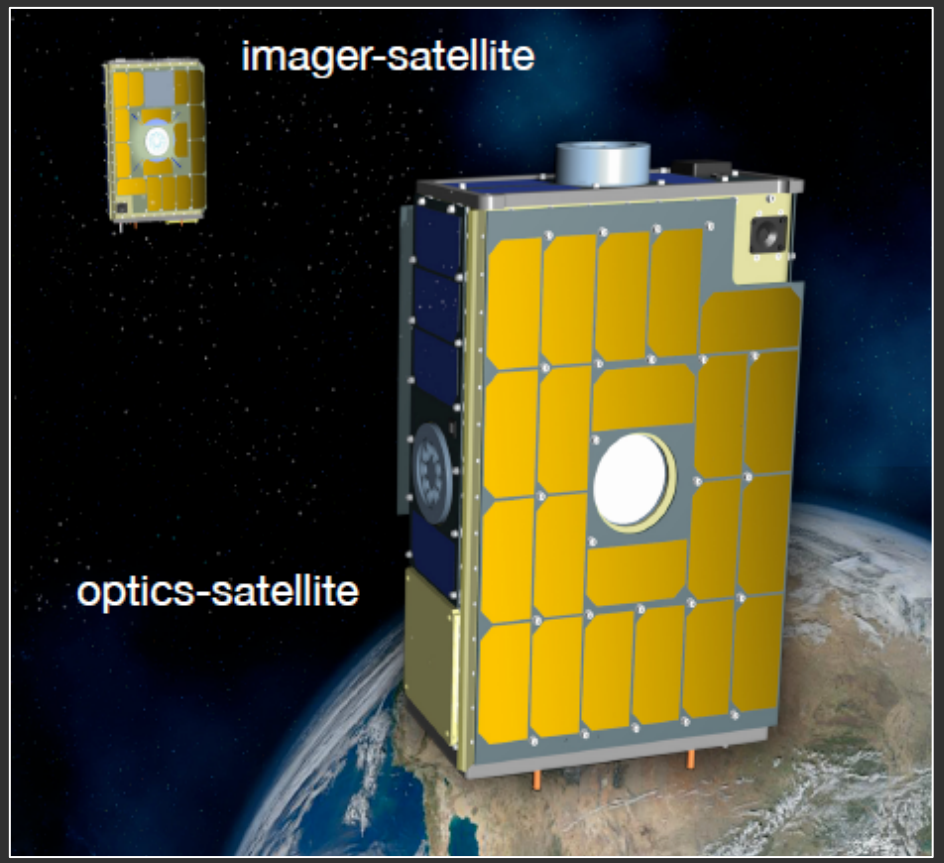
Relative Navigation





VTXO Mission

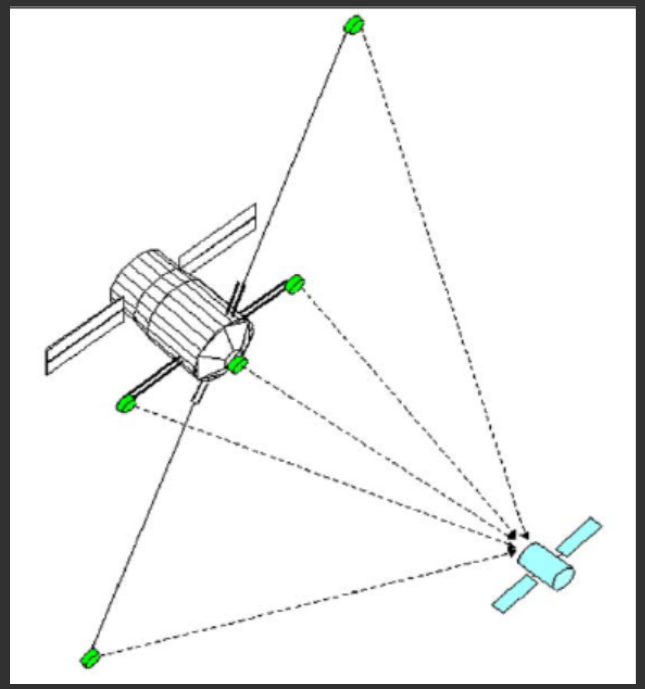
- Virtual Telescope for X-ray Observations
- X-Ray telescope
  - Sub-arcsecond to milli-arcsecond resolution
  - Focal lengths hundreds of meters
  - Imager and optics Satellites
- Investigate technologies that can be adapted to a full scale virtual telescope mission for deep space or sun-earth libration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



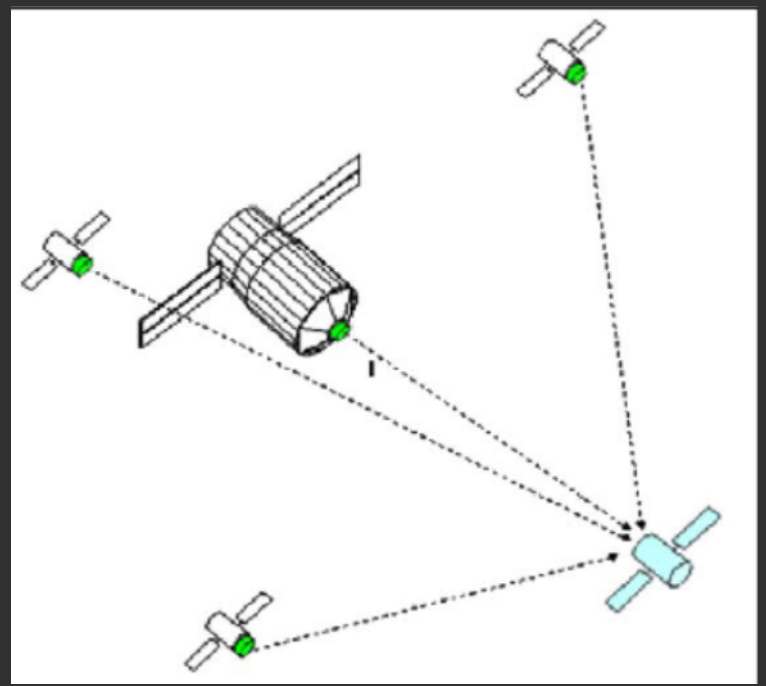
VTXO with imager and optics satellite separated by hundreds of km.

RF Communications

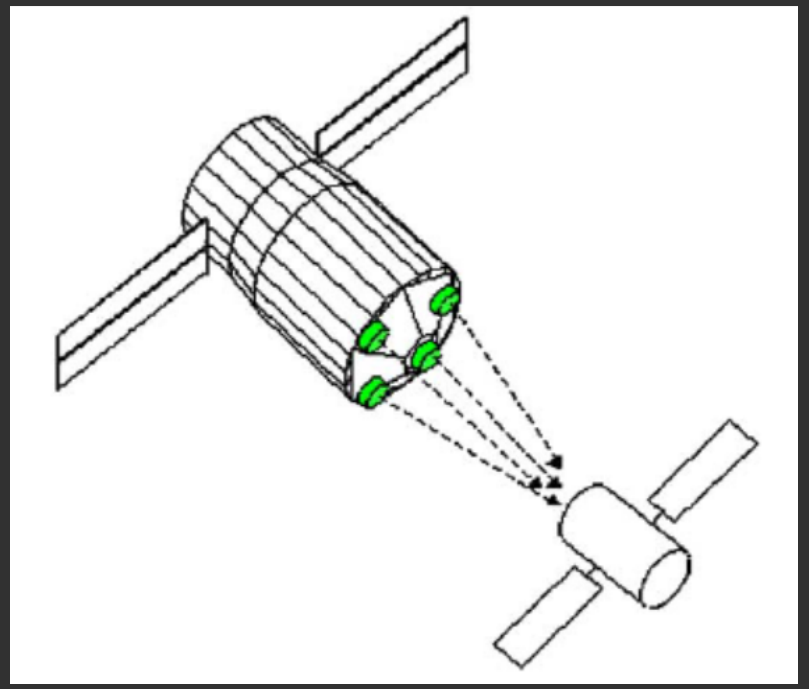
- One configuration creates a pseudo GPS Network, however instrumentation on multiple spacecraft required



Targets mounted
on deployable booms



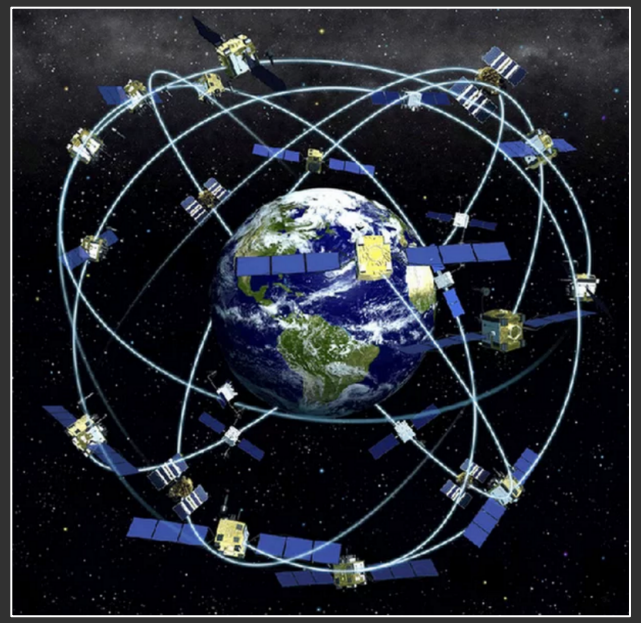
Pseudolites flying
In formation

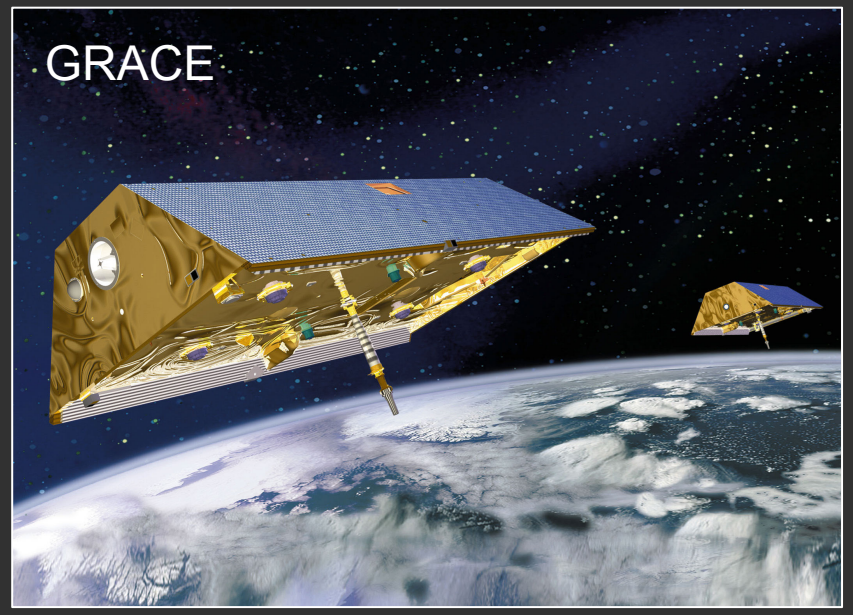


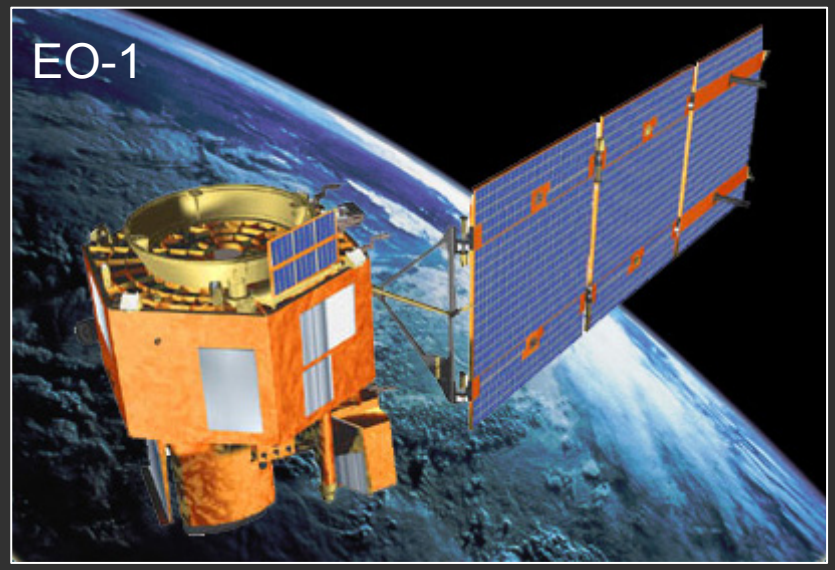
On board targets

GPS

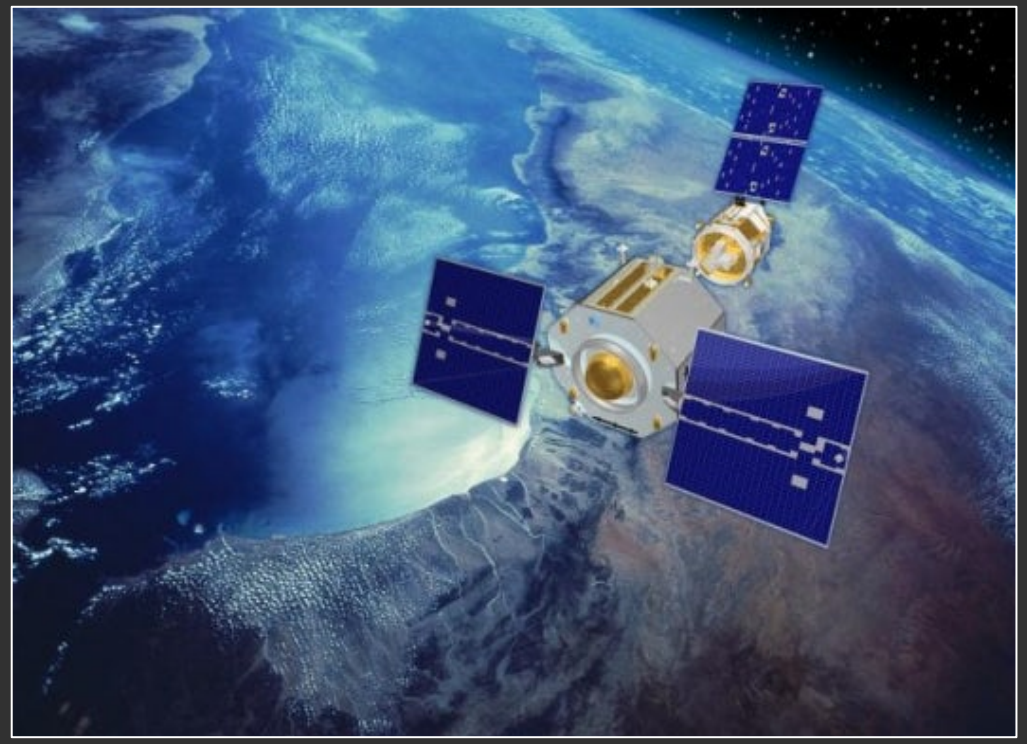
- Earth pointing network
- Not suitable for precision formation flying in deep space



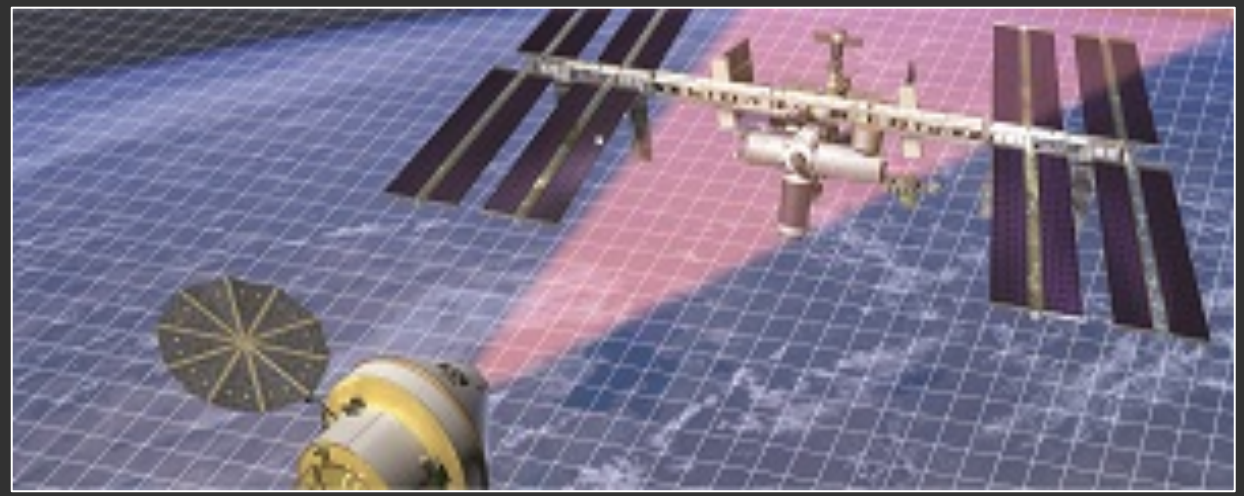




Vision Navigation & Laser Metrology



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

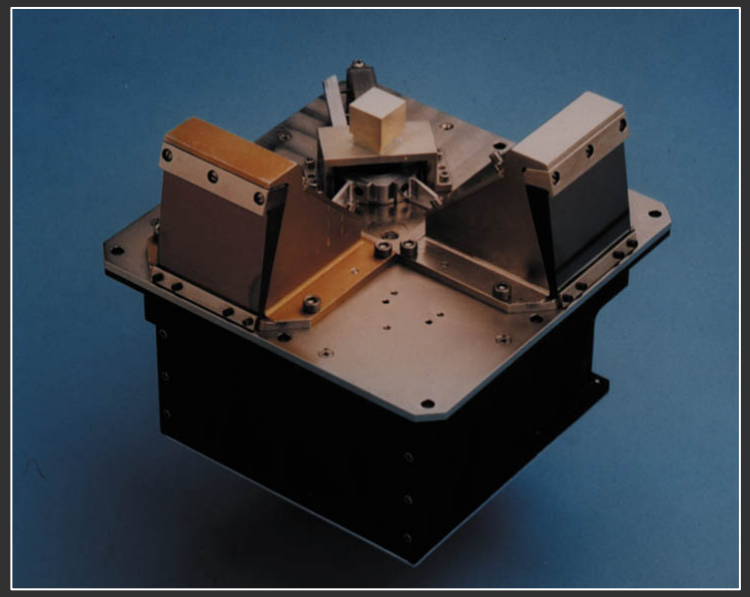
Ball Aerospace High Accuracy Star Tracker

Hydra Star Tracker

Sun and Earth Sensors

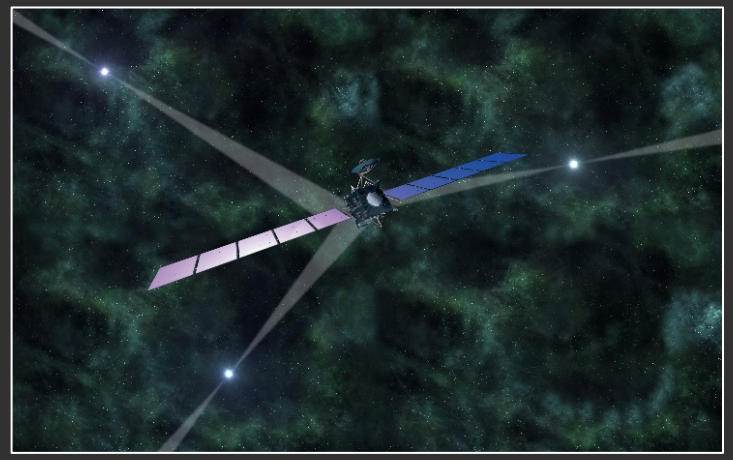
- Measure direction of Sun or Earth and provide attitude information
- Limited accuracy, require secondary system for relative positioning
- Unreliable for deep space application

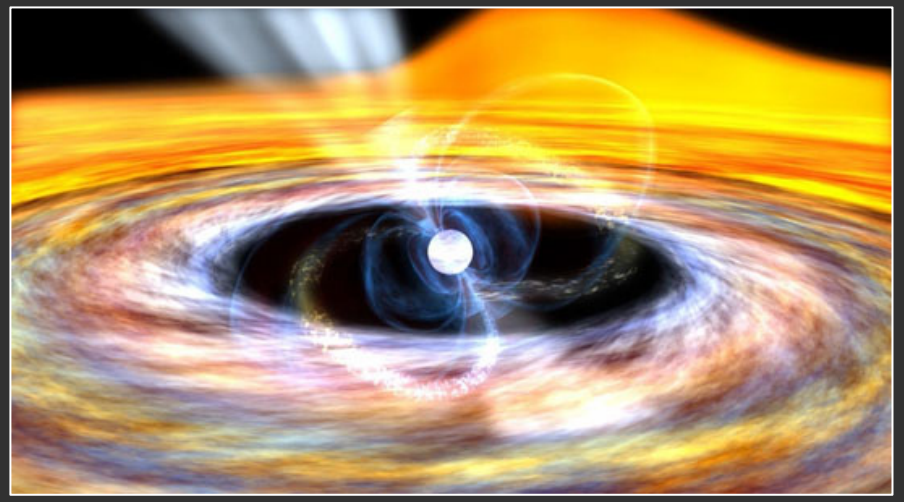
NSS Fine Sun Sensor



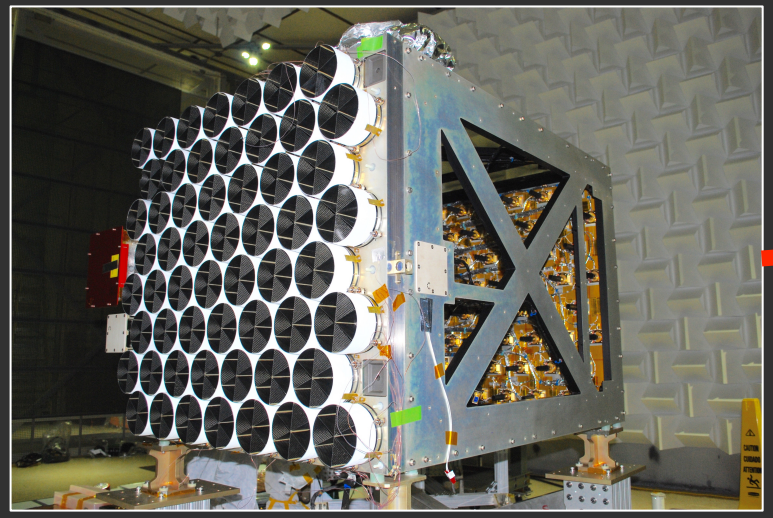
Servo Corporation of America
MiDES Earth Horizon Sensor

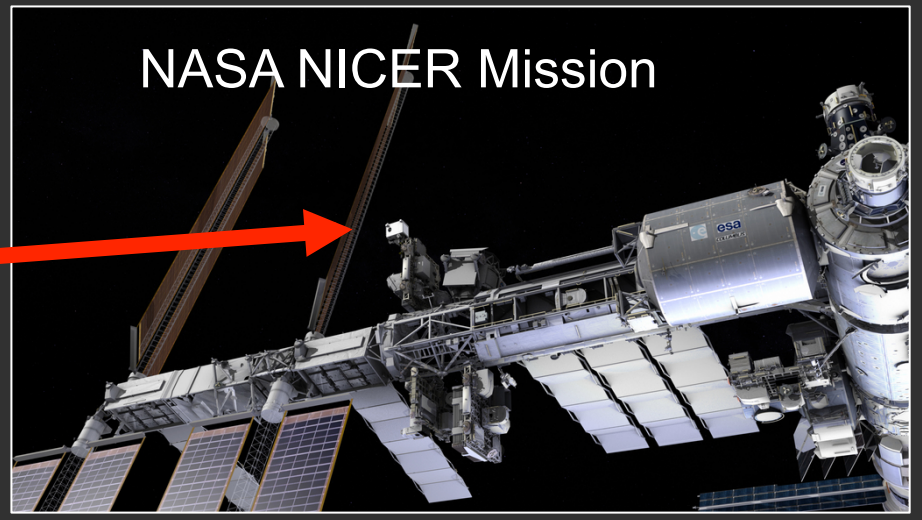
X-ray Pulsar Navigation





X-Ray Millisecond Pulsar (Artist Representation)





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

Acknowledgements

University of New Mexico

- Dr. Asal Naseri

NASA Goddard

- Dr. Neerav Shah

New Mexico State University

- Dr. Steven Stochaj

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Support Slides

Notable Relative Navigation Missions

- DARWIN (2007)
- LISA (2030)
- XEUS (Under Assesment)
- 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

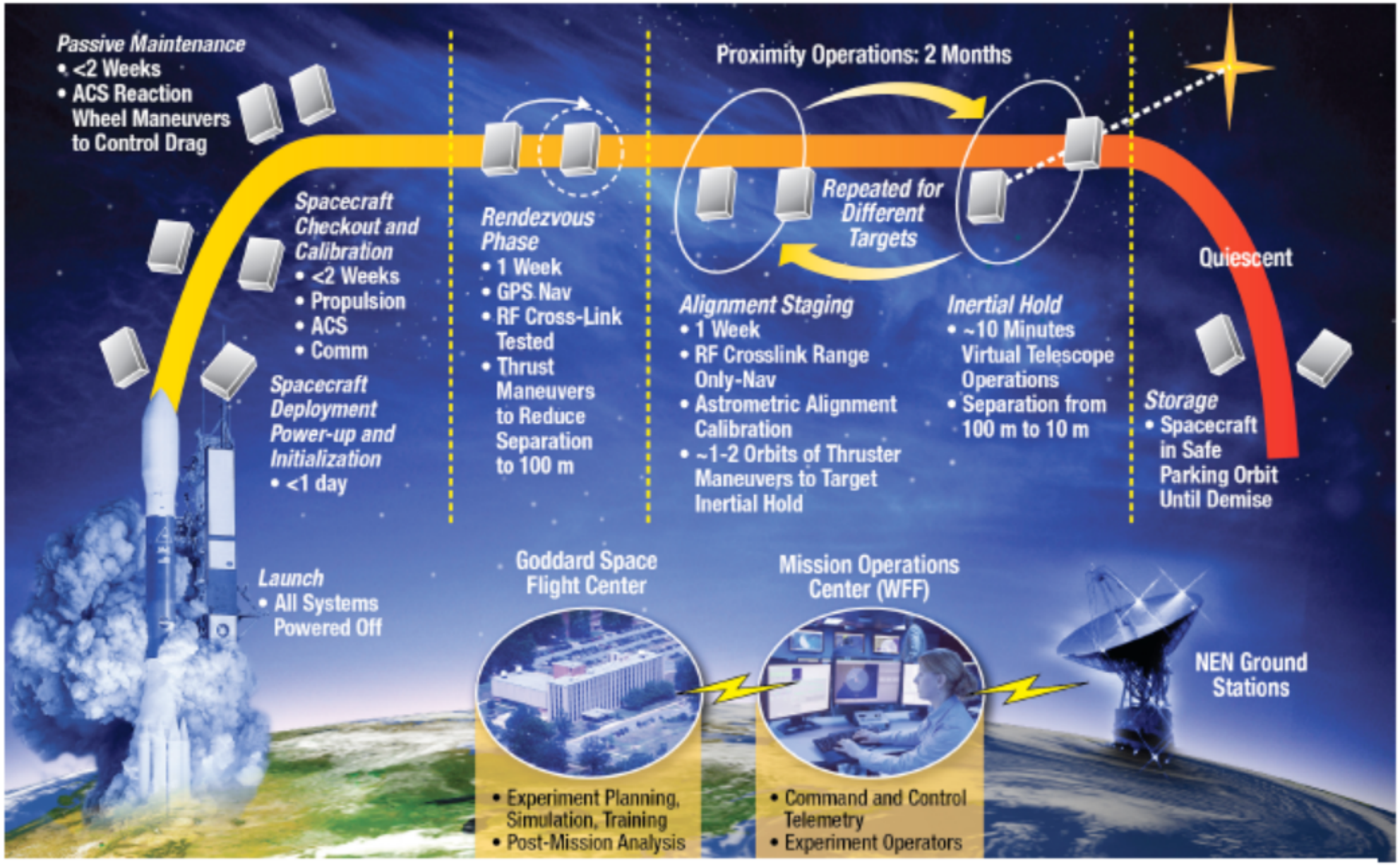
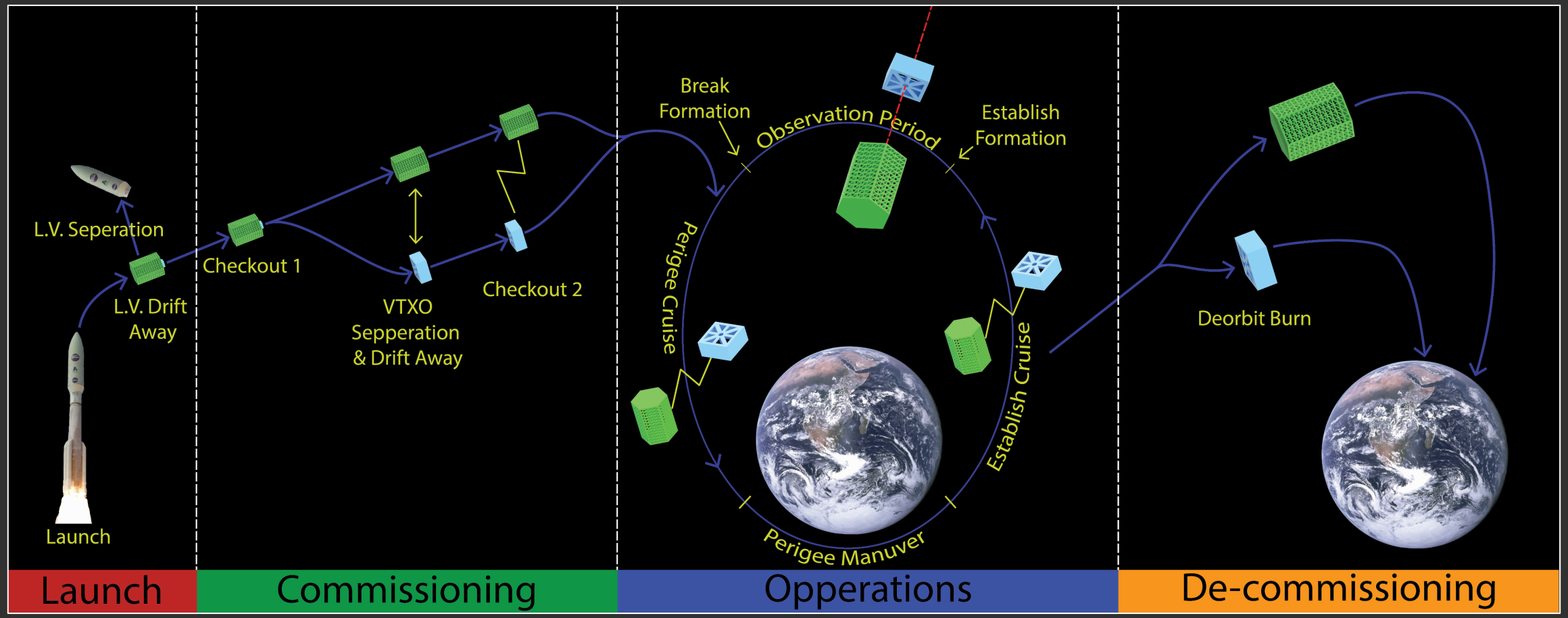


Figure 4. VTDM Concept of Operations


L.V. Seperation
L.V. Drift Away
Launch
Checkout 1
VTXO Sepperation & Drift Away
Checkout 2
Break Formation
Observation Period
Establish Formation
Perigee Cruise
Establish Cruise
Perigee Manuver
Deorbit Burn
Launch
Commissioning
Opperations
De-commissioning