Near Earth Asteroid Scout

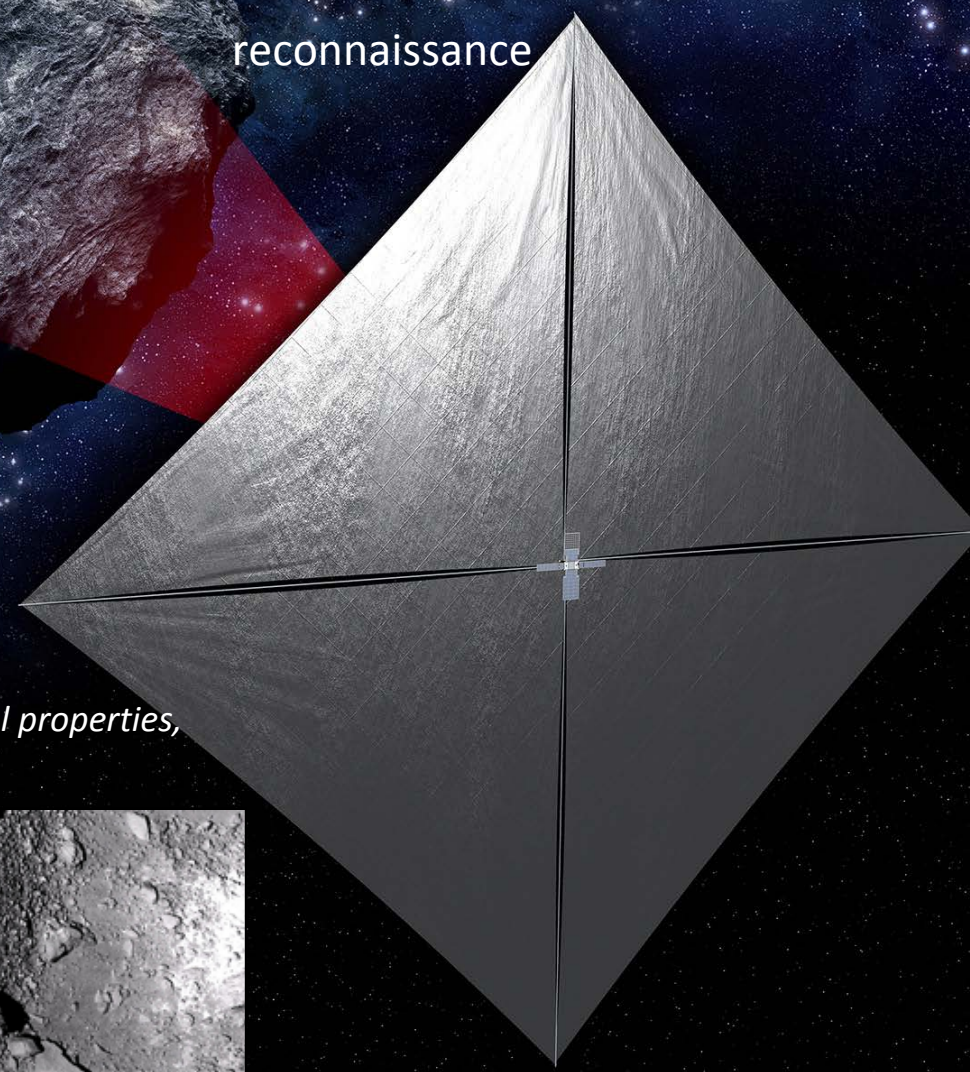
MSFC/JPL/LaRC/JSC/GSFC/NASA

GOALS

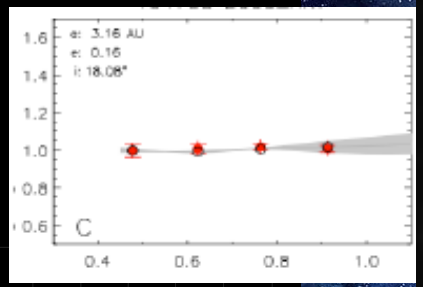
Characterize one candidate NEA with an imager to address key Strategic Knowledge Gaps (SKGs)

Demonstrates low cost capability for HEOMD for NEA detection and reconnaissance

One of three 6U Cubesats sponsored by Advanced Exploration System, Joint Robotic Program to fly on SLS EM-1

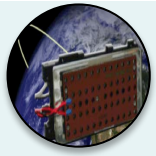
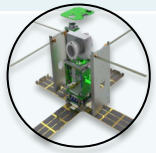


Measurements: *NEA volume, spectral type, spin and orbital properties, address key physical and regolith mechanical SKGs*



SLS EM-1 Secondary Payload Overview

- **19 NASA center-led concepts were evaluated and 3 were down-selected for further refinement toward an Mission Concept Review (MCR) planned for August 2014**
- **Primary selection criteria:**
  - Relevance to Space Exploration Strategic Knowledge Gaps (SKGs)
  - Life cycle cost
  - Synergistic use of previously demonstrated technologies
  - Optimal use of available civil servant workforce
- **Project in Development**
- **Completed a Non-Advocate Review of the Science Plan (May '14) and MCR/SRR-lite (Aug '14)**
- **Current status is technology demonstration**

Payload *NASA Centers*	**Strategic Knowledge Gaps Addressed**	**Mission Concept**
BioSentinel ***ARC****/JSC* 	**Human health/performance in high-radiation space environments** • Fundamental effects on biological systems of ionizing radiation in space environments	Study radiation-induced DNA damage of live organisms in cis-lunar space; correlate with measurements on ISS and Earth
Lunar Flashlight ***JPL****/MSFC* 	**Lunar resource potential** • Quantity and distribution of water and other volatiles in lunar cold traps	Locate ice deposits in the Moon's permanently shadowed craters
Near Earth Asteroid (NEA) Scout ***MSFC****/JPL* 	**Human NEA mission target identification** • NEA size, rotation state (rate/pole position) **How to work on and interact with NEA surface** • NEA surface mechanical properties	Flyby/rendezvous and characterize one NEA that is candidate for a human mission

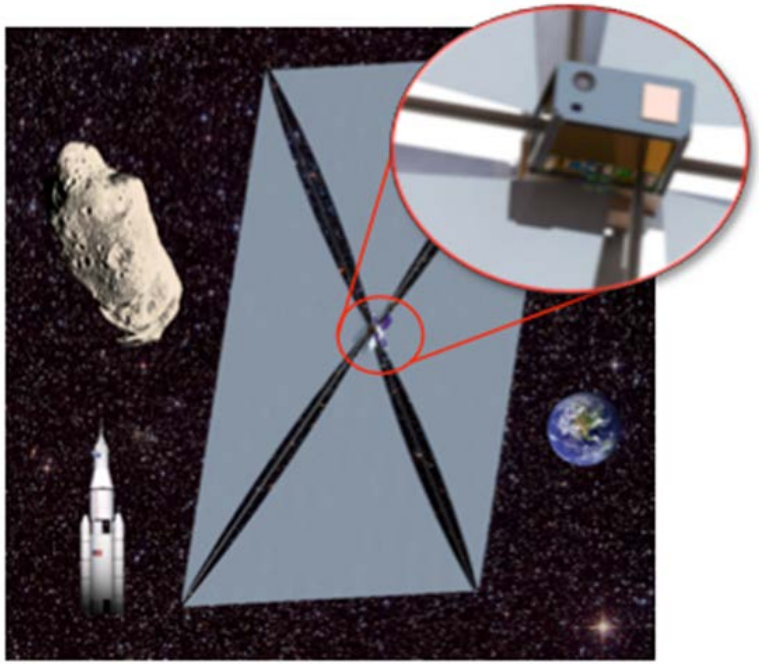
NEA Scout Overview

Why NEA Scout?:

- Characterize one candidate NEA with an imager to address key Strategic Knowledge Gaps (SKGs)
- Demonstrates low cost reconnaissance capability for HEOMD (6U CubeSat)

Leverages:

- Solar sail development expertise (NanoSail-D, Sunjammer, LightSail-1)
- CubeSat developments and standards (INSPIRE, University & Industry experience)
- Synergies with Lunar Flashlight are in review (CubeSat bus, solar sail, communication system, integration & test, operations)



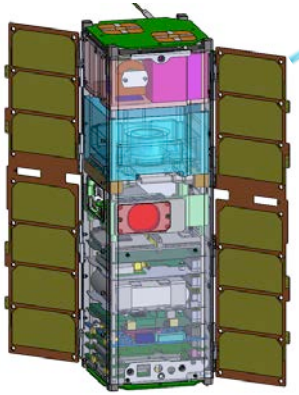
Measurements: *NEA volume, spectral type, spin mode and orbital properties, address key physical and regolith mechanical SKG*

- ≥80% surface coverage imaging at ≤50 cm/px
- Spectral range: 400-900 nm (incl. 4 color channels)
- ≥30% surface coverage imaging at ≤15 cm/px

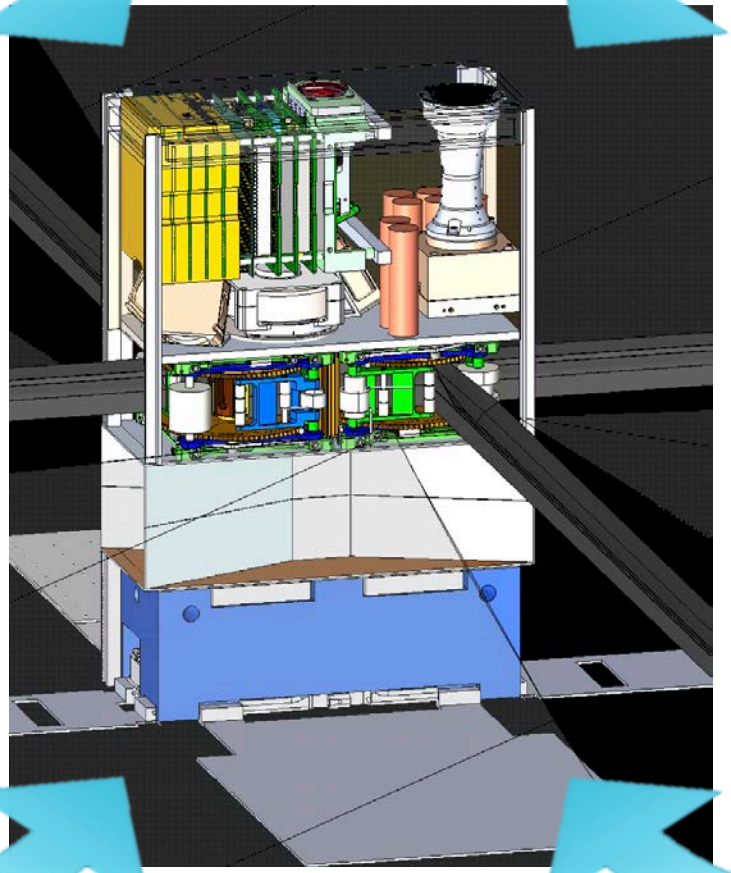
Key Technical Constraints:

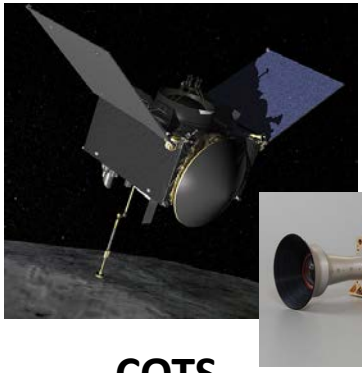
- 6U CubeSat and ~80 m^2 sail to leverage commonalities with Lunar Flashlight, expected deployer compatibility and optimize cost
- Target must be within 1 AU distance from Earth due to telecom limitations
- Slow flyby with target-relative navigation on close approach

NEA Scout Heritage & Capability Infusion



JPL INSPIRE
Spacecraft Bus





COTS
NEA Camera

JPL/CalPoly IPEX
Agile Science Algorithms

MSFC NanoSail-D
Solar Sail

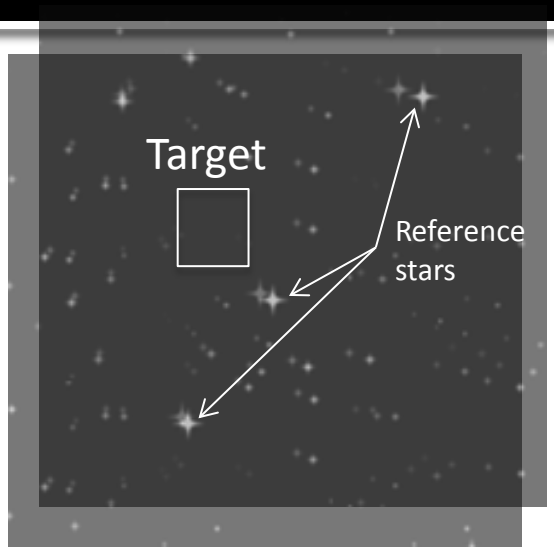
Prioritized Strategic Knowledge Gaps

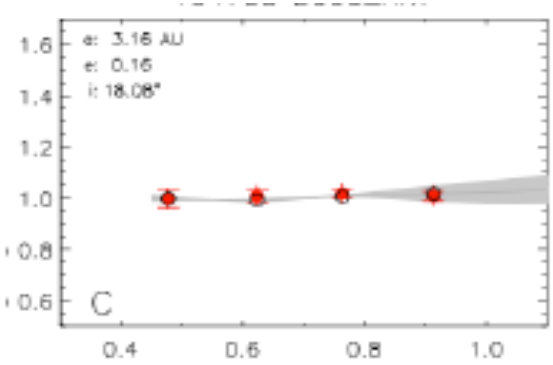
HEO-Defined Strategic Knowledge Gaps	Expected Performance	Risk Reduction or Benefit
Location (position prediction/orbit)	OCC decrease to 0	
Size (existence of binary/ternary)	High accuracy on size, detection of satellites	
Rotation rate & pole orientation	High accuracy on pole and velocity	
Particulate environment/Debris field	**Characterization of particle density in target vicinity**	
Regolith mechanical & geotechnical properties	***Indirect*** *(imagery interpretation)*	
Mass/density estimates (internal structure)	***Indirect*** *(based on taxonomic characterization)*	
Surface morphologies and properties	**Morphology at resolution of astronaut's foot**	
Mineralogical & chemical composition	***Indirect*** *from taxonomic characterization*	

Crew/Mission Operations Cost Performance Science/Engineering

Ref – Abell and Castillo, After SKG Report (Rivkin et al. 2012)

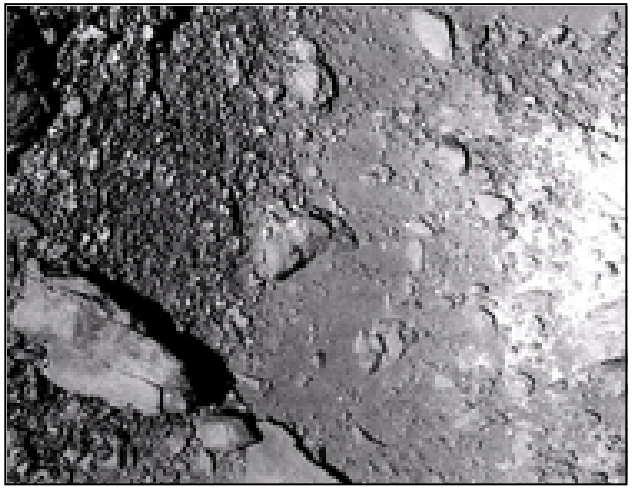
Prospective NEAScout Exploration Science Products





Target Detection and Approach
Light source observation
SKGs: Ephemeris determination and composition assessment

Target Reconnaissance
50 cm/px resolution over 80% surface
SKGs: volume, global shape, spin rate and pole position determination



Close Proximity Imaging
High-resolution imaging,
15 cm/px GSD over >30% surface
SKGs: Medium-scale morphology, regolith properties, and local environment characterization

Baseline Target: 1991 VG

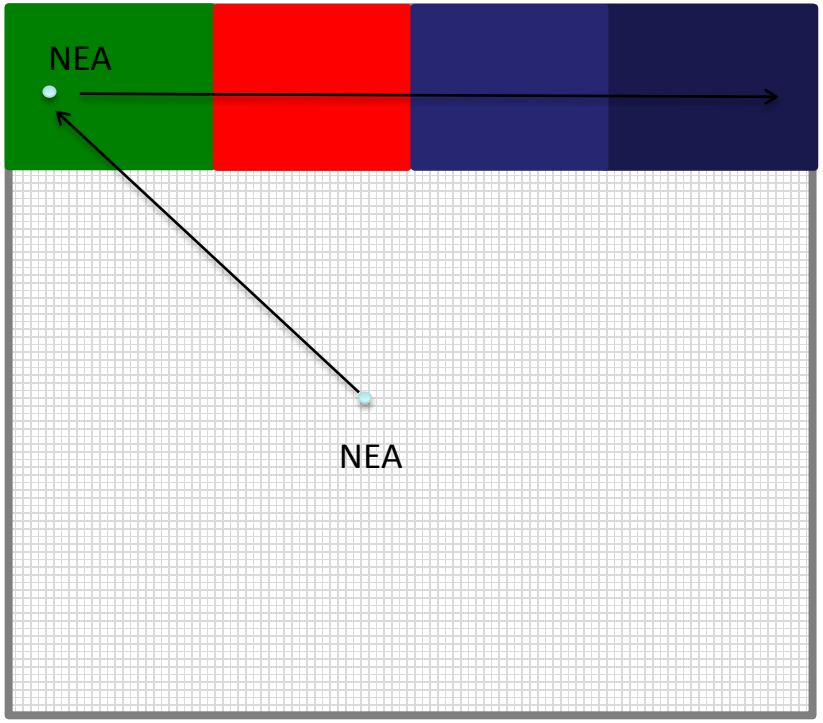
- H=28.4±0.7
- Diameter ~ 5-12 meters
- Albedo is unknown
- Position is known within 2700 km (1-σ) but optical observation opportunity in July '17 will decrease uncertainty to a few 100s km
- Rotation period between a few minutes and less than 1 hr
- Unlikely to have a companion
- Unlikely to retain an exosphere or dust cloud
  - Solar radiation pressure sweeps dust on timescales of hours or day

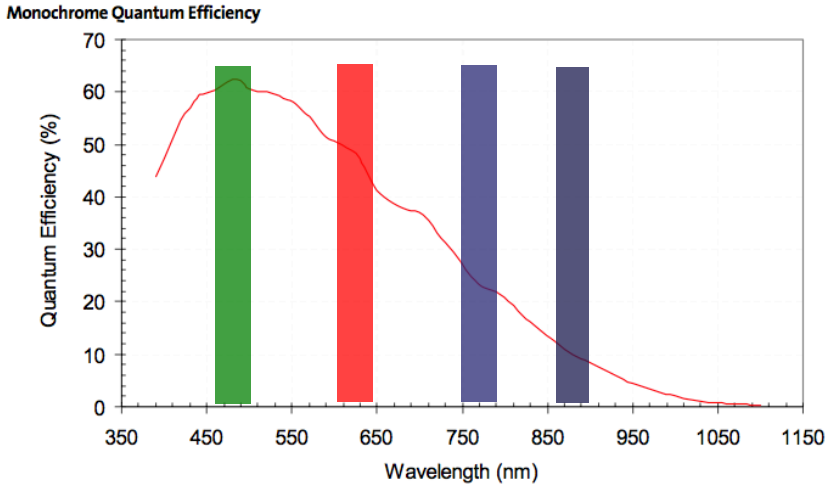
Secondary Targets	Absolute magnitude	30% albedo Diameter (m)	5% albedo Diameter (m)	Orbit Condition Code	Observation Opportunity prior to launch
2001 GP_2	26.9	10	25	6	Depends on launch date 2020-10 (Optical)
2013 BS45	25.9	11	51	0	2015-01 (Optical)
2008 EA_9	27.7	7	17	5	none
2012 UV_{136}	25.5	19	47	1	2014-08 (Optical) 2020-05 (RADAR)

Instrument Concept

Baseline

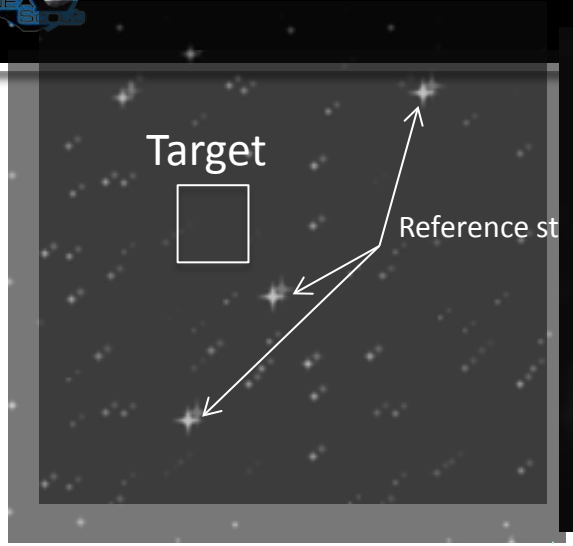
- MSSS ECAM M-50 camera with NFOV lens
- COTS, TRL 8 via OSIRIS-Rex, excellent IFOV & FOV, volume, power
- Aptina MT9P031 FPA

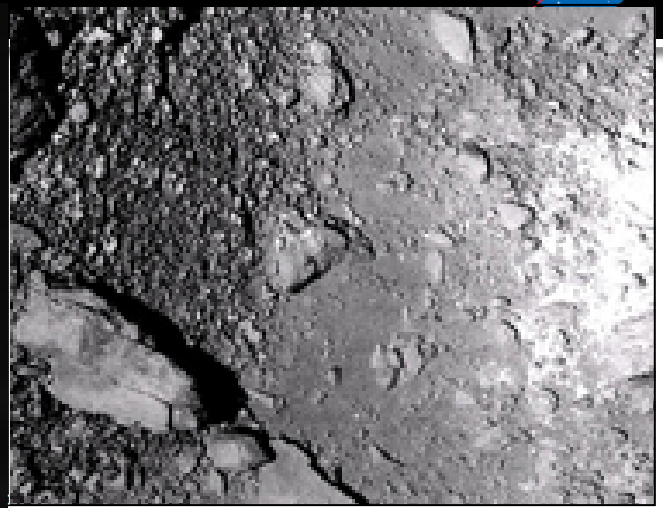




Early Testbed Setup

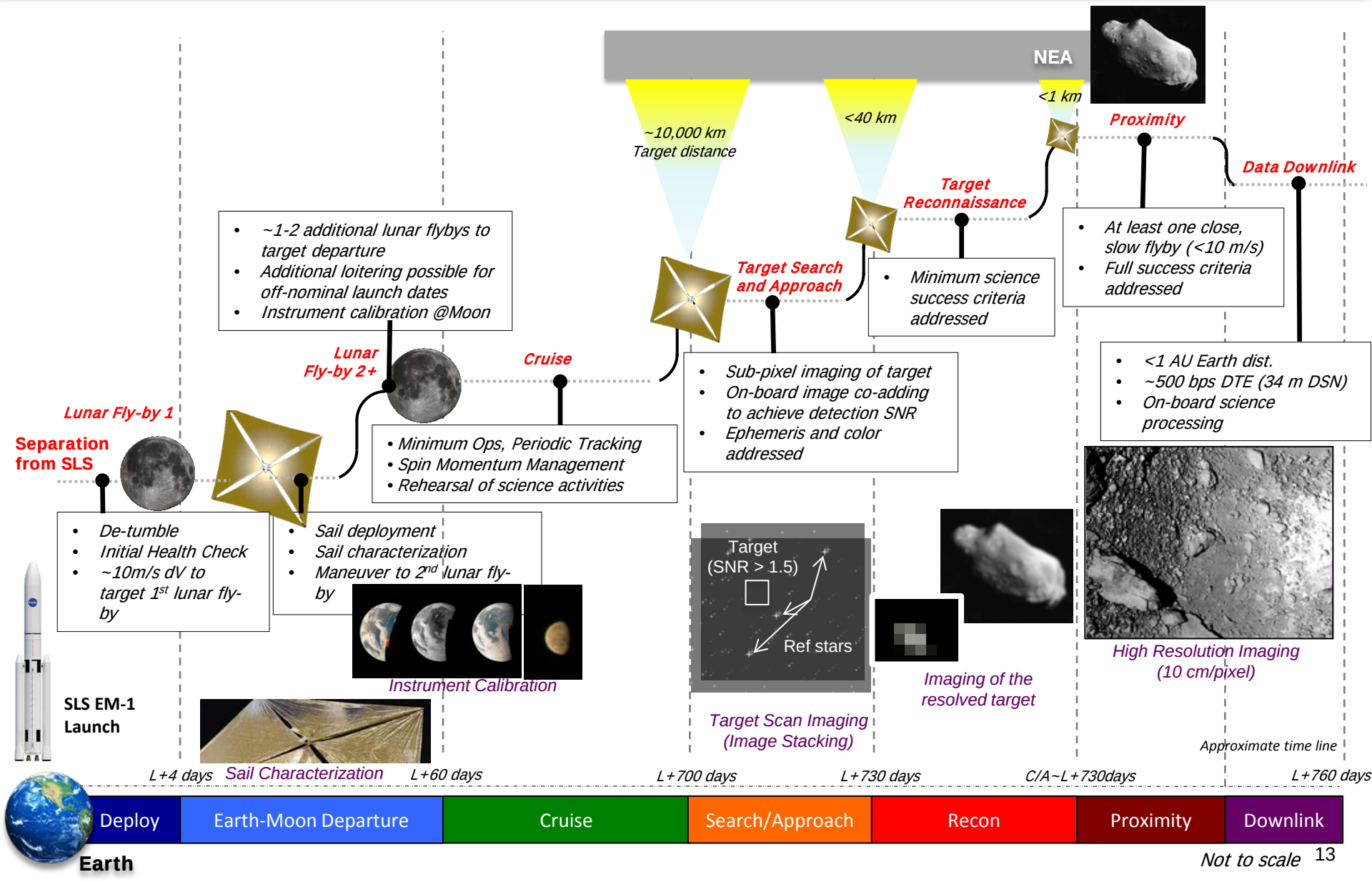
Strategies for Science Imaging with Constrained Resources





	Target Detection and approach with wide field imaging Ephemeris determination	**Target Reconnaissance with medium field imaging** Shape, spin, and local environment	**Close Proximity Imaging** Local scale morphology, terrain properties, landing site survey
CHALLENGES	Limited downlink (<500 bps) Limited camera capability Large target position uncertainty	Limited downlink (<500 bps) Short flyby time (<30 min) Uncertain environment	Limited downlink (<500 bps) Short time at closest approach (<10 min.)
APPROACH	Autonomous sky scanning sequence Image co-adding subwindowing Compression	Autonomous target pointing Thumbnails, triage, lossless compression, subwindowing	

ConOps Overview



Summary - Contribution to SKGs

- First imaging and characterization of an NEA smaller than 100 m
  - Will retire SKGs at 1991 VG (size, rotation)
  - Will also address SKGs that are relevant to all objects in that class range (e.g., surface state, local environment)
- First demonstration of a low-cost, SKG-driven mission
  - Combines asteroid detection/tracking and close proximity science capabilities
  - Paves the way for multi-spacecraft exploration of NEAs
  - Complementary to Earth-based surveys with ground truth connection to astronomical observations
- Complementary to other missions scheduled in the same timeframe (OREx, Hayabusa 2)

Status and Way Forward

- Development is going well
  - Funding pressure is pushing the team to be creative ☺
- Current ConOps for 1991 VG allows 15 m/s at closest approach
  - Current analysis for flight system slewing capability indicates that target falls off the field of view at about 0.8 km distance
  - Corresponds to ~15 cm/px resolution
  - Trades on power modes and configuration in progress to decrease velocity/increase resolution
- Development of EPO material and website under way
  - Will likely be developed under NASA's DREAM node led by NEAScout's co-I Bill Farrell
  - Possible involvement of *The Planetary Society* for activities involving the public at large, such as Asteroid Naming contest

AstroRecon 2015

Conference on Spacecraft Reconnaissance of Asteroid and Comet Interiors

January 8–10, 2015
Tempe, Arizona