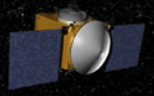
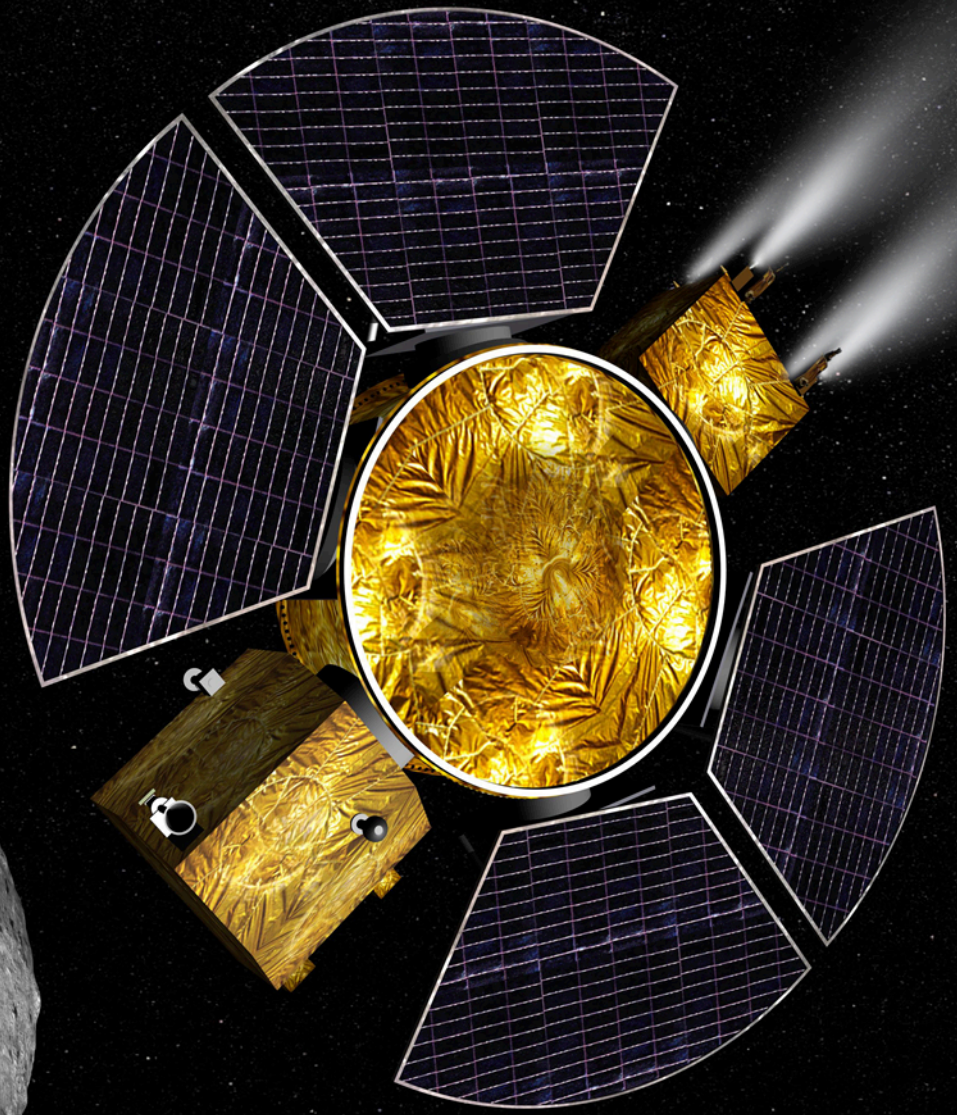


# ISIS

## Impactor for Surface and Interior Science




Steve Chesley

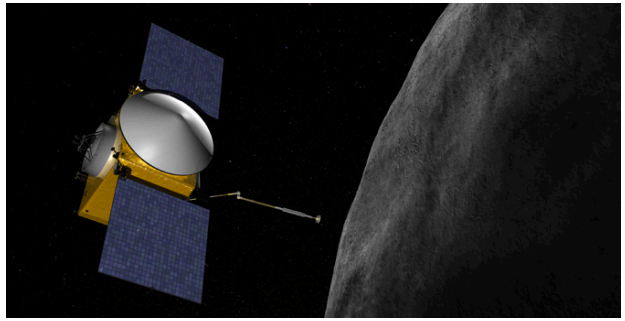
*Jet Propulsion Laboratory, California Institute of Technology*

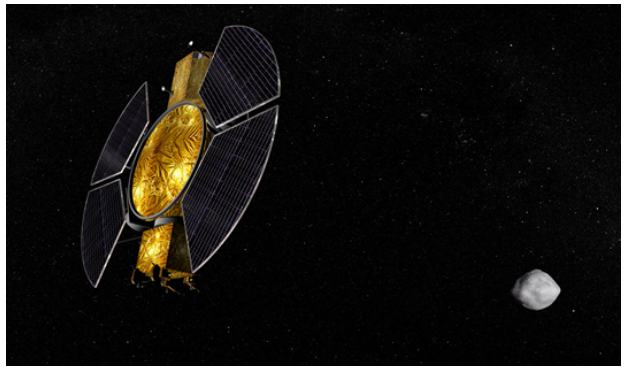
Small Bodies Assessment Group

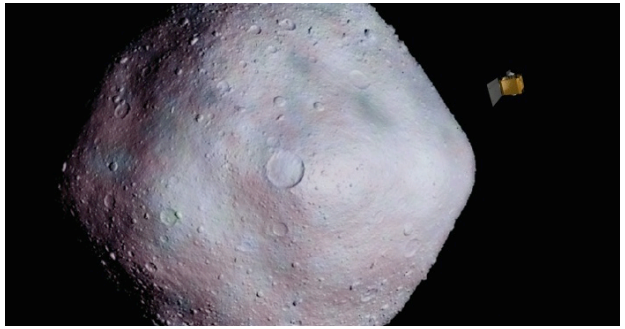

January 8, 2014

# ISIS Mission Concept

- ISIS launches as a secondary payload
  - Multiple host launch options available
  - Flight system based on ESPA minimizes impact on primary payload
- After 2-4 year cruise, ISIS impacts the asteroid Bennu while OSIRIS-REx is in a position to observe
  - Arrival is timed after OSIRIS REx has collected its sample, during period of "quiescent" operations
- ISIS creates crater tens of meters in diameter
  - OSIRIS-REx images the impact from a safe vantage point
- After debris clears, image crater and collect spectra of pristine material exposed by impact
- Measure asteroid delta-V due to impactor

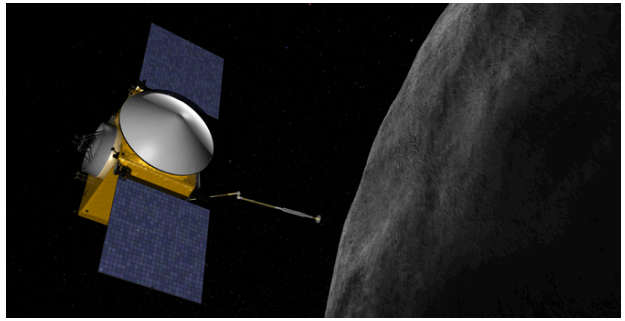


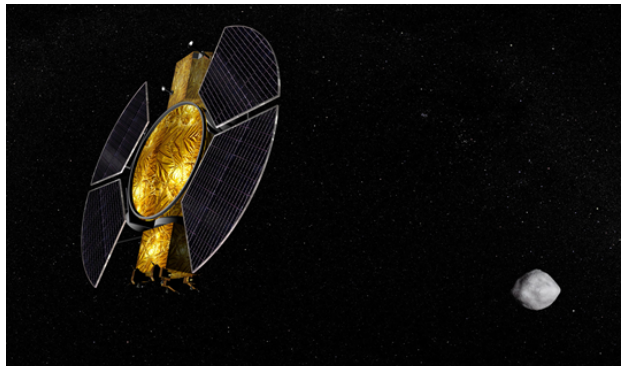


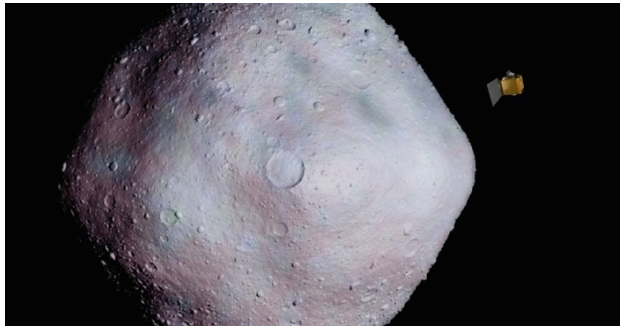


# ISIS Mission Concept

***ISIS** would leverage significant NASA investments to deliver potential Discovery-level science while providing a first-time demonstration of asteroid deflection at a fraction of the cost of a stand-alone mission.*







# ISIS Addresses The NEO Grand Challenge

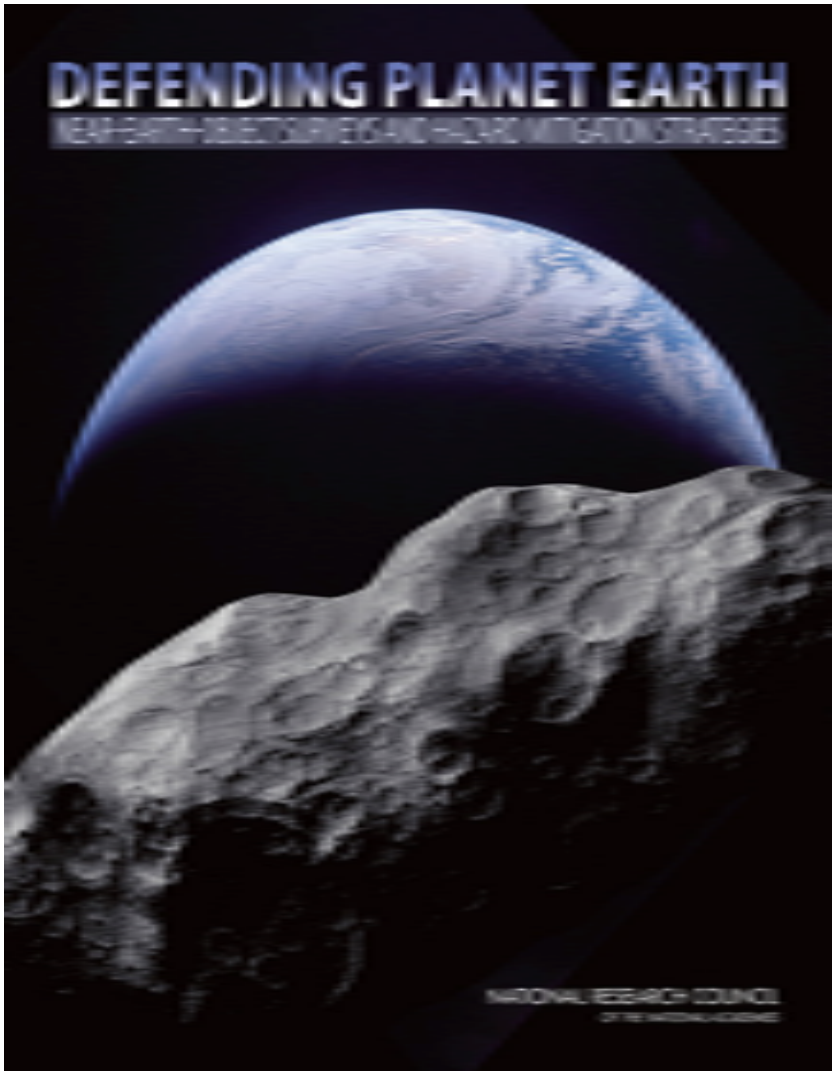
- June 18 NASA Asteroid Initiative included the Grand Challenge to "find all asteroid threats to human populations and *know what to do about them*."
  - An intersection of Technology, Exploration and Science goals
- Specific program goals include: "Accelerating efforts to improve detection, characterization, and *mitigation of potentially hazardous asteroids* to help plan for the defense of our planet against the threat of catastrophic collisions"


Meteor Crater


Chelyabinsk

# ISIS Addresses Planetary Defense Objectives

***Recommendation***: "If Congress chooses to fund mitigation research at an appropriately high level, **the first priority for a space mission in the mitigation area is an experimental test of a kinetic impactor along with a characterization, monitoring, and verification system**… This mission would produce **the most significant advances in understanding**… in a realistic mitigation scenario."



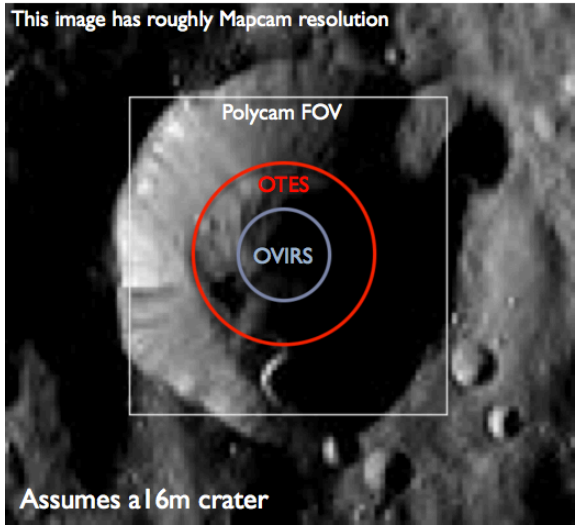
# ISIS Addresses Small Body Exploration SKGs

**2012 SBAG reports details Strategic Knowledge Gaps for Human Exploration goals.**

| SKG Theme | SKG Category | SKG Example |
|---|---|---|
| II. Understand how to work on or interact with the SB surface | II-C. SB surface mechanical properties | II-C-1. Macro-porosity of SB interior |
| | | II-C-2. (Critical) Geotechnical properties of SB surface materials |
| | II-D. Mobility around and interaction with surface in microgravity conditions | II-D-1. (Critical) Anchoring for tethered activities |
| III. Understand the SB environment and its potential risk/ benefit to crew, systems, and operational assets | III-A. The particulate environment in the proximity of Small Bodies | III-A-1. (Critical) Expected particulate environment due to impact ejecta |
| | | III-A-2. Possible dust/gas emission via sublimation from volatile-rich objects |
| | | III-A-4: (Critical) Possible particulate environment in the asteroid exosphere due to charged particle levitation following surface disturbances |
| | III-D. Local and global stability of small bodies | III-D-1: (Critical) Local structural stability based on remote |
| | | III-D-2: (Critical) Global structural stability based on remote measurements |
| IV. Understand the SB resource potential. | IV-A. NEO Resources | IV-A-2. Knowledge of how to excavate/collect NEO material to be processed |
| | | IV-A-3. Knowledge of extracting and collecting resources in micro-g. |

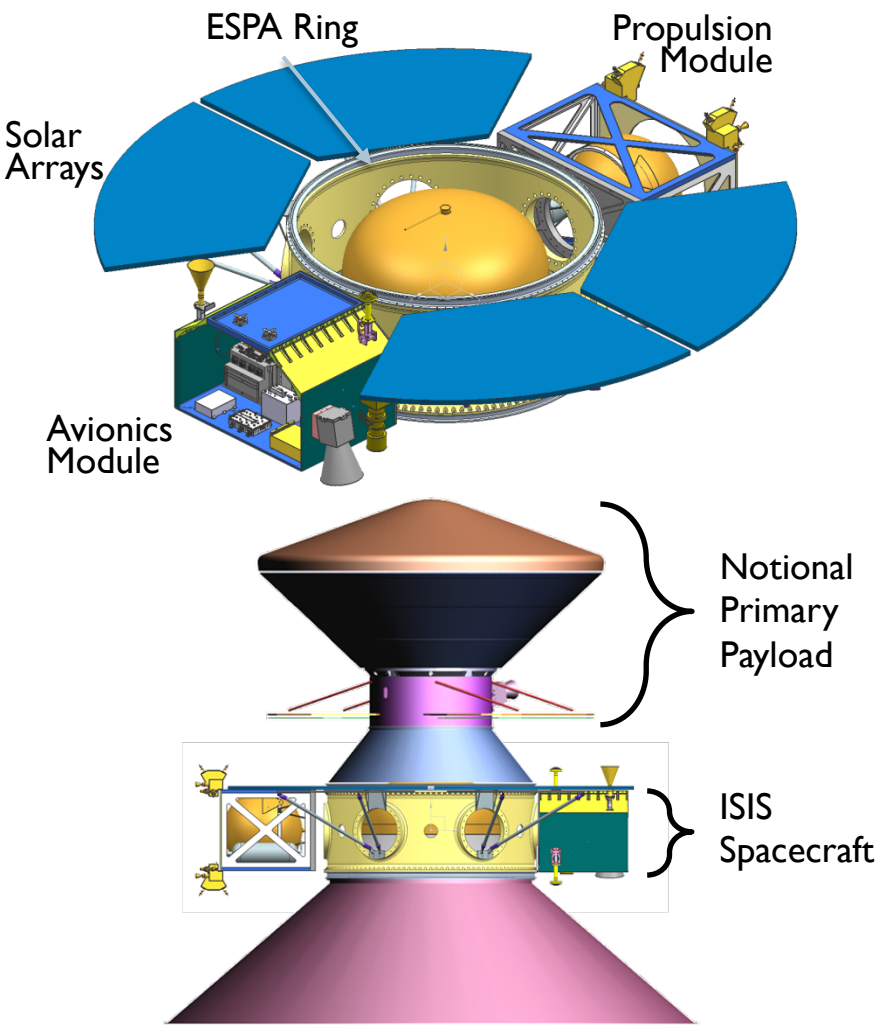
# ISIS Addresses Major Science Questions

- What is the local response?
  - Ejecta field properties
    - Creation of meteorite precursors
    - Ejecta blanket
    - Re-impacts
  - Crater morphology
  - Possible volatile release
- What is the global response?
  - Trajectory change ($\Delta V$, $\beta$)
  - Rotation change ($\Delta\omega$, $I_{zz}$)
  - Change in shape
  - Seismic activity
    - Internal structure
    - Material mobility
    - Particulate environment
  - Debris Environment
- What are the geotechnical properties of the near-surface material?
  - Strength
  - Cohesion
  - Porosity
  - Particle size distribution
- What is the geology of the sub-surface?
  - Stratigraphy
  - Structure
  - Composition
  - Mineralogy
  - Weathering




**ISIS delivers potential Discovery-level Science, closes Exploration SKGs and demonstrates NEO Deflection Technology, all for a fraction of the cost of a Discovery mission.**

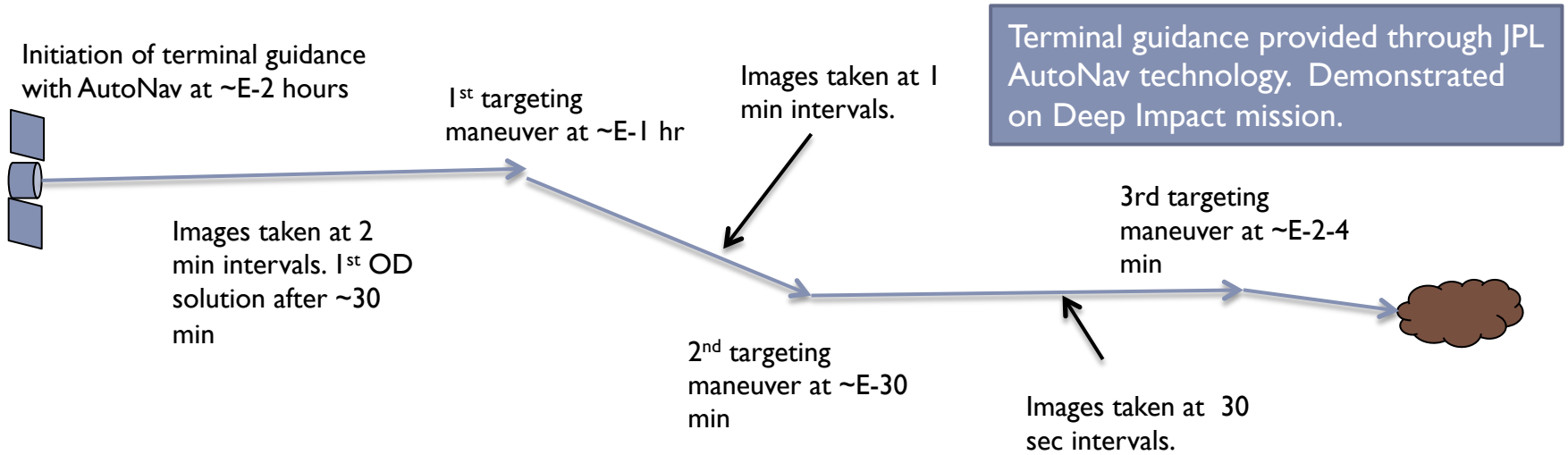
# ISIS Flight System Overview




- System designed around flight-qualified ESPA

  - Imposes <u>no impact</u> on host SC/LV interface
- Modular Flight System
- Spacecraft Architecture emphasizes simplicity and reliability
  - No Crosslink
  - No Pyrotechnics
  - No Deployments
  - No Mechanisms
  - No Science Instruments

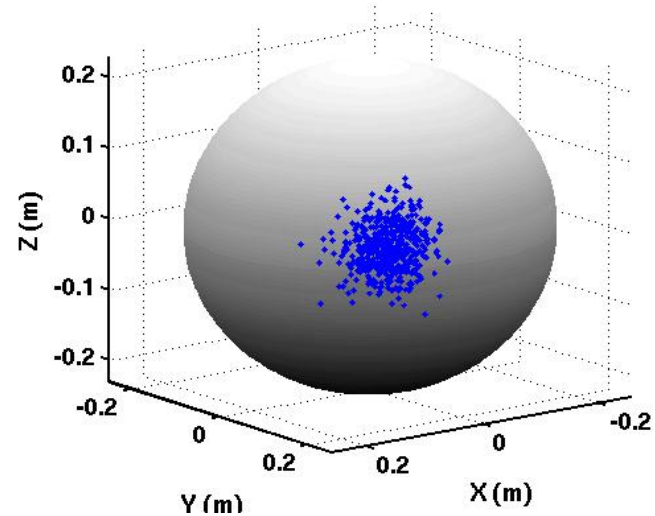
# ISIS Targeting Scenario



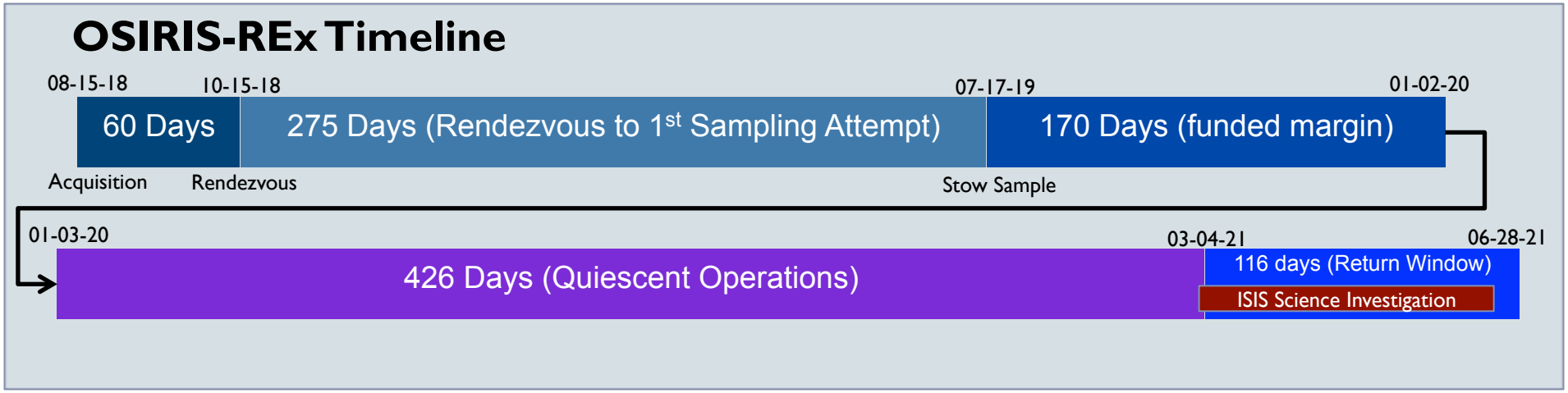

Terminal guidance provided through JPL AutoNav technology. Demonstrated on Deep Impact mission.

**Abort Scenario**

Spacecraft would be on a miss trajectory until first terminal maneuver at 60 min before impact. Targeting would not occur unless pre-defined, NASA-approved criteria are met. Abort commands could be issued as late as 30 minutes before impact.



# ISIS/OSIRIS-REx Operations Concept




| Notional ISIS Baseline Mission | |
|---|---|
| Launch | Late 2017 |
| Arrival & Impact | March 2021 |
| Impact Velocity | 14 km/s |
| Impact Mass | 600 kg |
| Impact Energy | 78 GJ (~19t TNT) |

## OSIRIS-REx Activities

1. Pre-impact characterization of asteroid ephemeris
2. Image impact from a safe location
3. Monitor ejecta as it dissipates
4. Crater reconnaissance
5. Radio science and global remapping

# ISIS Potential Launch Opportunities

| Launch Opportunity | Launch Date | Maneuver ΔV (m/s) | Impact Velocity (km/s) | Status |
|---|---|---|---|---|
| InSight Primary | Mar-2016 | 1220 | 14.9 | Originally the primary option. No longer available due to schedule and fiscal issues. |
| OSIRIS-REx | Sep-2016 | 360 | 11.0 | Ideal launch opportunity, but not an option due to schedule and fiscal issues. |
| InSight Backup | Nov-2017 | 600 | 13.8 | Good option, but unlikely to materialize |
| b612 Sentinel | Aug-2017 | 1200 | 8.0 | Privately funded NEO survey mission is awaiting donor commitments to move into Phase A. 2018 and later launches not suitable. |
| Generic Mars 2018 | May-2018 | 600 | 13.8 | Good, but no obvious EELV launches on schedule |
| GTO – Target Bennu | Mid-2017 to late 2018 | 700 – 1100 | 10 – 15 | Assumes extra help from LV in some cases. Feasible, but many options to be considered. Need to know specifics of candidate GTO launch. |
| GTO – Target 1999 JU3 (Hayabusa 2) | Early 2017 to mid-2018 | 900-1100 | 8.0 – 9.5 | |
| SLS Test Launch | 2017-18 | Similar to or better than GTO. But not ESPA compatible | | |
| Dedicated launch | 2018-19 | 0 – 500 | 10 – 15 | Any of the GTO escape cases can be used. Many of the solutions are ballistic. |

# Current ISIS Planning Activities

- Direct engagement with OSIRIS-REx project
  - Objectives include development of
    1. Science Management plan
    2. Operational implementation plan
    3. ISIS-related requirements
    4. ROM cost to OSIRIS-REx project for ISIS investigation
  - Face-to-face OREx/ISIS meeting planned for late January to conclude interaction
- Working to develop new baseline mission plan
  - Consulting with satellite and launch providers to identify suitable GTO launch in late 2017 or early 2018
  - Phase A start early to mid-FY15
- Continuing with higher fidelity debris clearing simulations
- Objective is to be ready for a quick start in the event that budget situation improves
  - Working toward HQ report ~Feb. 2014