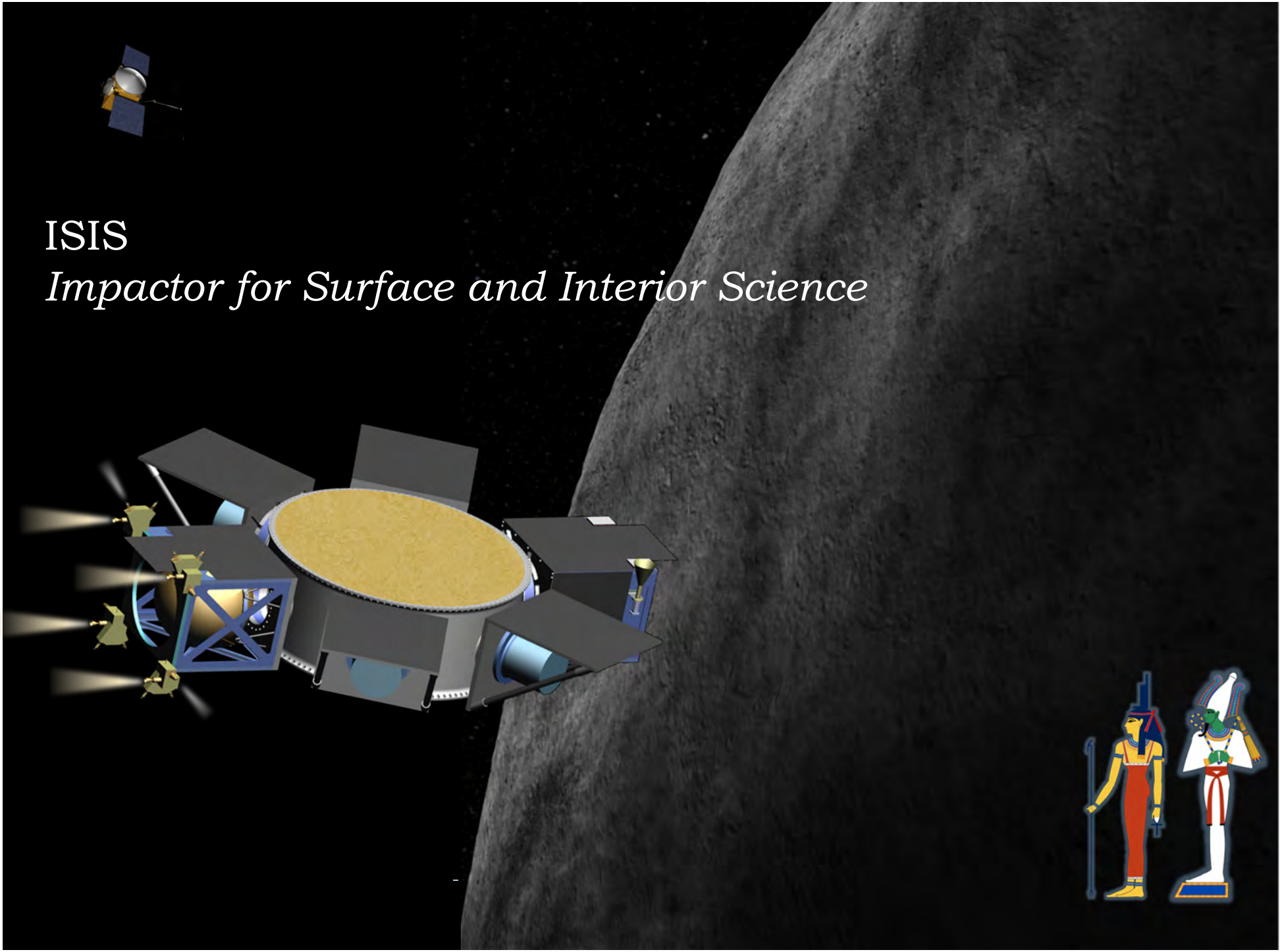

ISIS
*Impactor for Surface and Interior Science*

# ISIS Mission Concept

- Send an independent, autonomous impactor spacecraft to the target of the OSIRIS-REx mission
  - Launch as secondary payload with InSight
- ISIS arrives after OSIRIS-REx has completed its science objectives
- ISIS creates crater tens of meters in diameter and launches ejecta while the OSIRIS-REx spacecraft records the impact process from a safe vantage point
- Seismic reverberations throughout the asteroid reveal interior mechanical properties and cause global surface modifications
- After debris clears, approach asteroid for imagery of crater and spectra of pristine material exposed by impact
- Deflection experiment: Estimate of asteroid delta-V imparted by impactor obtained in ~2-3 weeks


# Cross-cutting Exploration & Science Benefits

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

- Cratering experiment – regolith properties and geophysics
- Seismic experiment – global alterations (toppled rocks, landslides) due to shock wave/reverberations, lofting of material far from impact site
- Ejecta – particulate environment, size distribution of regolith, understanding meteorite ejection from NEOs
- Characterization of any volatiles released from impact site
- Imaging of crater – formation processes, morphology and subsurface geology
- Spectroscopy of pristine material from depth provides context to OREx sample
- Measure delta-V imparted by impact – determine momentum enhancement due to ejecta


The Planetary Defense aspects of a deflection experiment will generate significant public interest.

# Potential Funding Sources

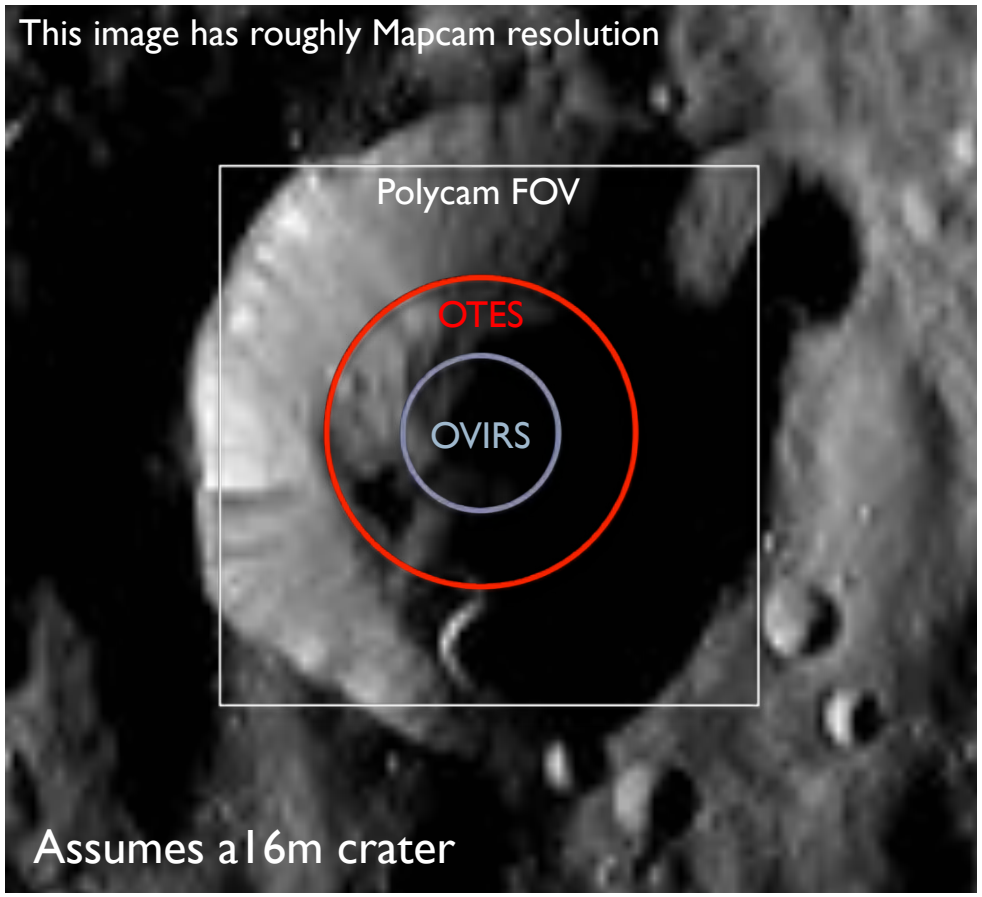
- Stakeholders in OCT, HEOMD, SMD
  - OCT – NEO Mitigation is a Space Technology Grand Challenge
    - From the OCT Grand Challenge website "A better understanding of the likelihood and consequence of these remote events are needed as are preparations for the possibility of having to divert a comet or asteroid on an impact trajectory with Earth."
  - HEOMD – Robotic precursors to human exploration
    - ISIS squarely addresses numerous "Critical" Strategic Knowledge Gaps (SKGs) for human exploration of NEAs
      - Characterize geotechnical properties, particulate environment, mechanical response, structural integrity and local stability of sub-km NEAs
  - SMD/PSD – This mission scheme is extraordinarily cost effective and aligned with Directorate objectives
    - Planetary Decadal Report, "The first and most important [criterion] was science return per dollar."

# ISIS/ORIRIS-REx Operations Concept

- Pre-impact characterization of asteroid ephemeris
- Move to safe observing location and image ejecta cone as it expands over a period of several minutes.
  - 50 km gives 0.7 m/pixel with Polycam
- Monitor ejecta as it dissipates (15-20 days)
- Perform slow flyby(s) for imaging and spectra (15-20 days)
- Enter radio science mode
  - 2-3 km terminator orbit for 15-20 days
  - Standoff at several km could be feasible but would take longer
- Total time from impact 45-60 days
  - Assume **90 days** science operations from impact to departure, including margin

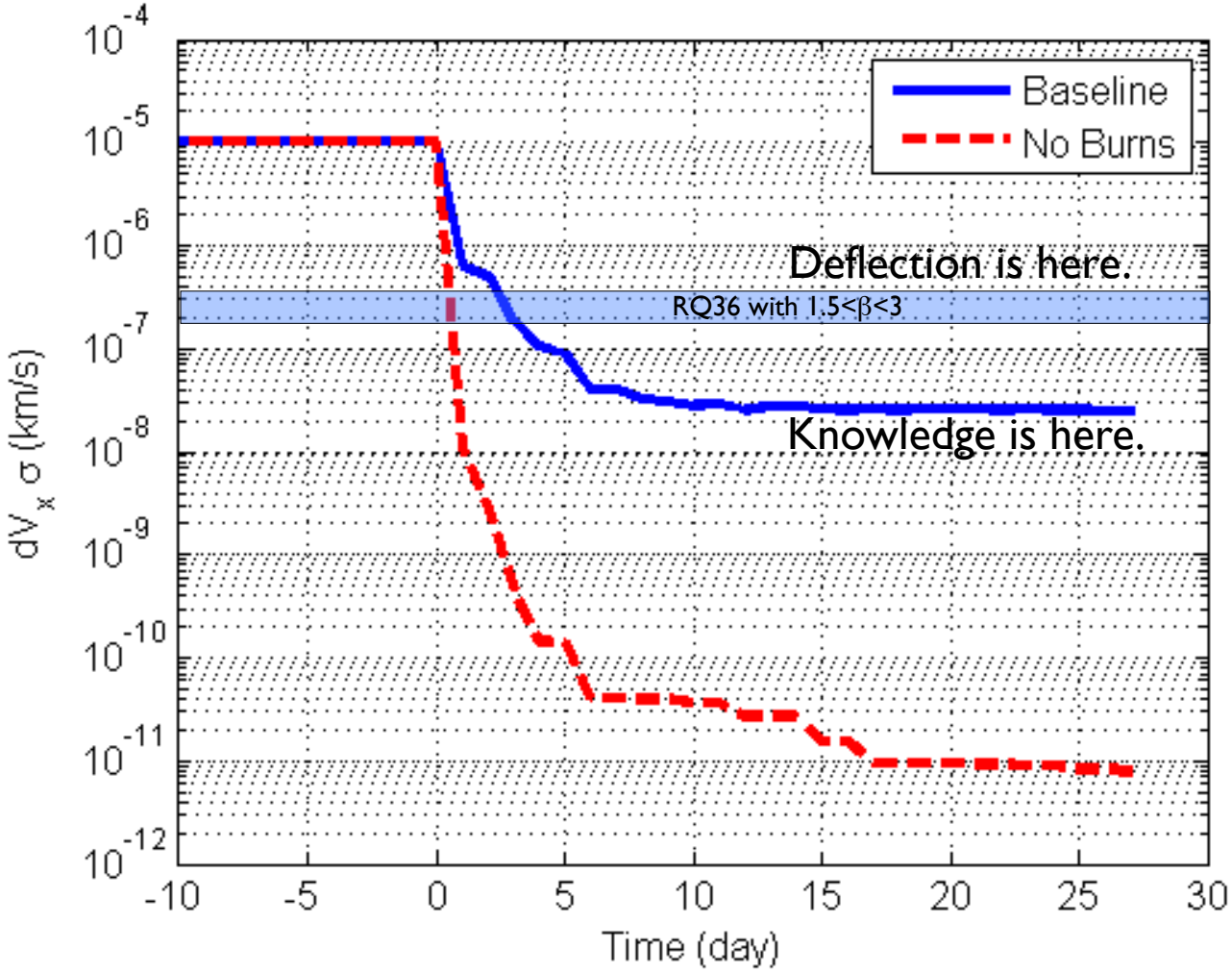
# How close to get to the crater?

- As placeholder, consider a 1.0 km altitude slow flyby
  - Polycam – 1.4 cm/pixel
  - Mapcam – 7 cm/pixel
  - OTES – 8m spot
  - OVIRS – 4m spot
- Higher altitude flybys would see graceful degradation in resolution



# Deflection Measurement

The $\Delta V$ from the impact can be measured in a few weeks with SNR ~ 10.

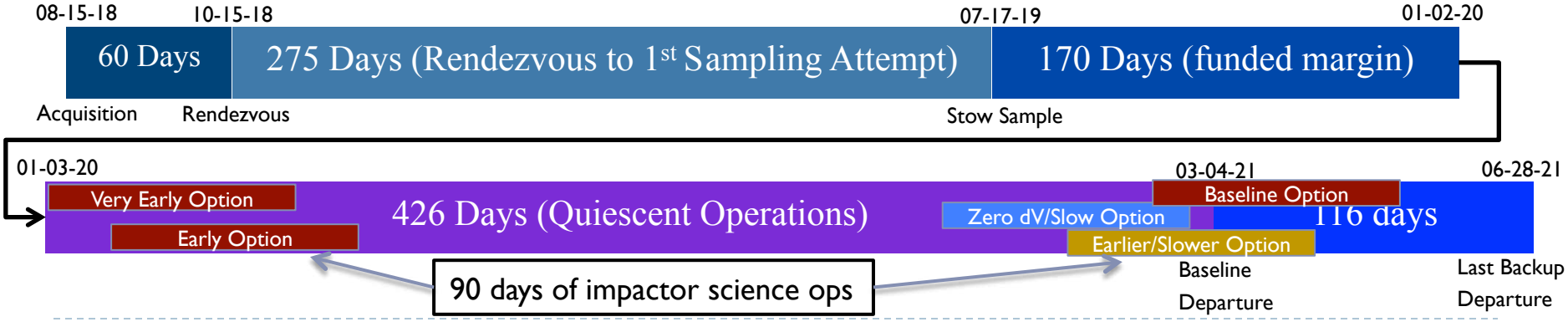


# ISIS Trajectory Options

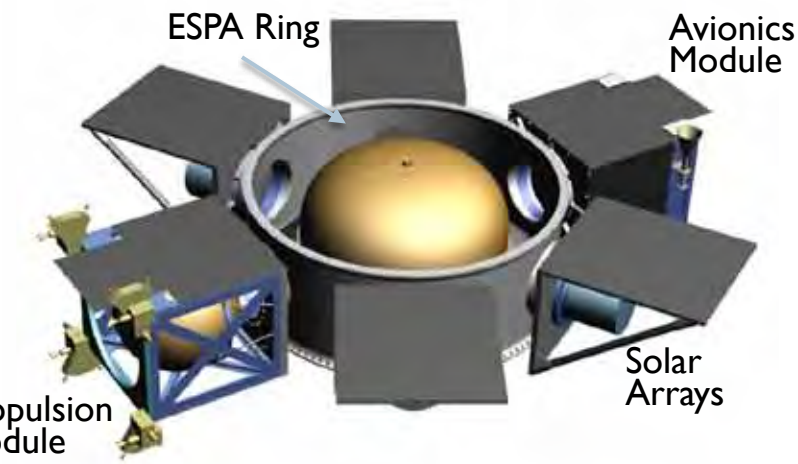
Multiple attractive options exist with InSight launch. Need to coordinate with OREx project to decide which of the following gives the best blend of science and risk mitigation.

| Arrival | Delta-V* | Schedule Margin | Impact Vel. | Remarks |
|---|---|---|---|---|
| 10-Feb-2021 | 1290 m/s | 48 days | 13.4 km/s | Baseline mission. |
| 10-Jan-2021 | 1220 m/s | 79 days | 8.0 km/s | Low impact velocity |
| 25-Nov-2020 | ~0 m/s | 125 days | 4.4 km/s | Probably too slow. Max. mass margin |
| 27-Jan-2020 | 1290 m/s | 428 days | 15.0 km/s | Potential schedule risk (Wave off) |
| 4-Jan-2020 | 430 m/s | 451 days | 14.5 km/s | Potential schedule risk (Wave off) |

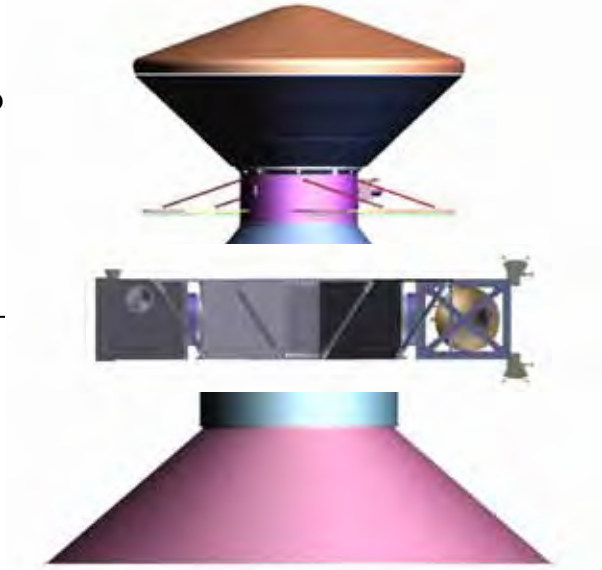
**beginning of launch period*



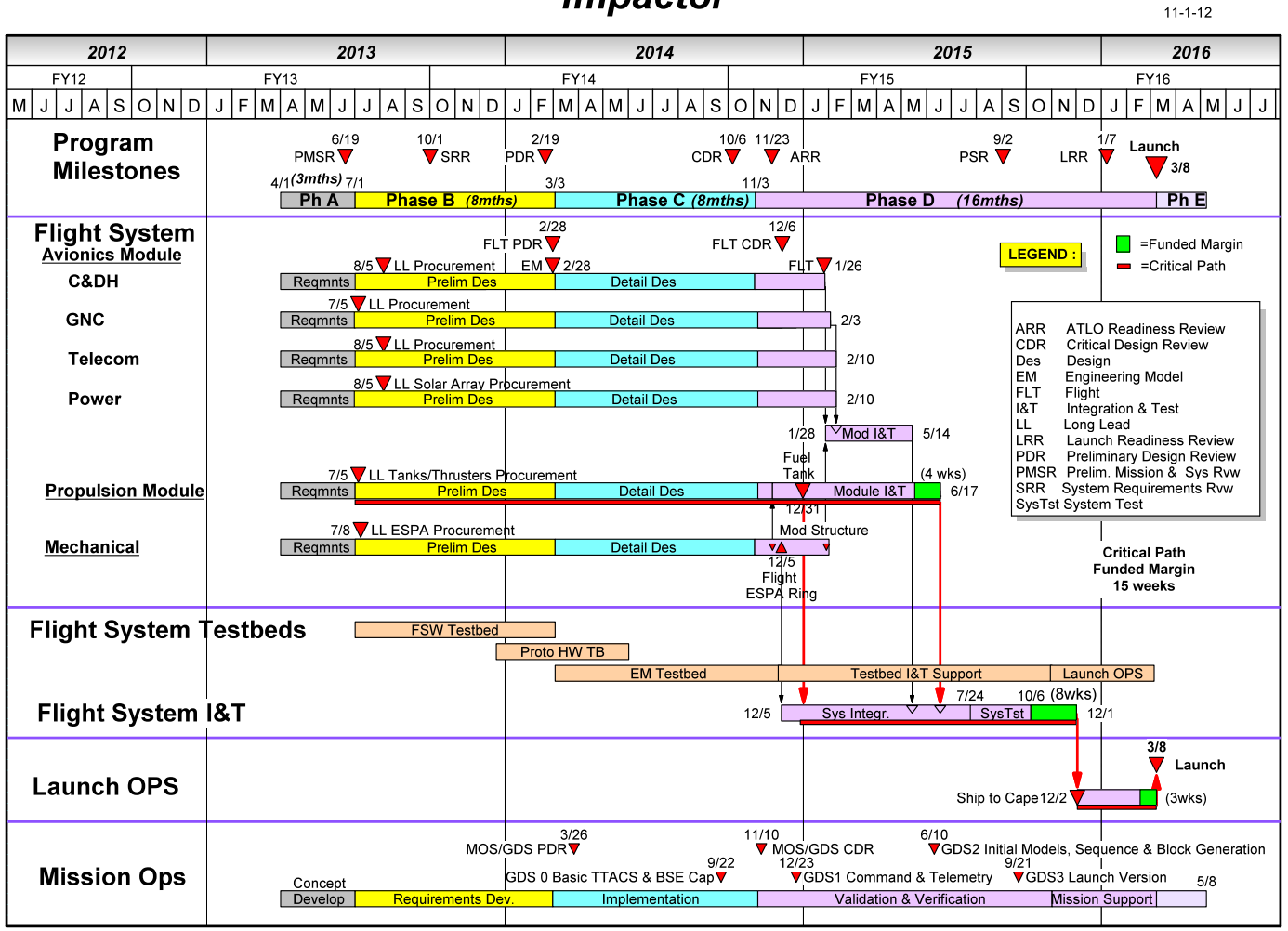
# ISIS Flight System Overview




- System designed around flight-qualified ESPA
  - Imposes no impact on host SC/LV interface
- Modular Flight System
- Spacecraft Architecture emphasizes simplicity and reliability
  - No Crosslink (to observer s/c)
  - No Pyrotechnics
  - No Deployments
  - No Mechanisms



# Development Schedule




ISIS development is achievable with 35 months Phase A-D

- Need project start date by April 2013 to meet InSight schedule
  - Later start dates increase long lead procurement schedule risks
  - Long lead items reduced through use of JPL in-house hardware and catalog parts

# Conclusions

- ISIS is a low-cost mission that addresses NASA strategic goals and provides Discovery-class science returns across a wide range of small body science disciplines.
  - The mission leverages NASA's investment in the OSIRIS-REx mission and takes full advantage of the New Frontiers-class instrumentation on the observer spacecraft.
  - Co-manifesting with InSight further improves the cost-effectiveness.
- NEAR-Shoemaker is NASA's only asteroid rendezvous mission so far. The second will be OSIRIS-REx, twenty years later.
  - The convergence of OSIRIS-REx schedule and Insight launch opportunity is an extraordinary alignment that will not be repeated again soon.
  - ISIS represents a once-in-a-generation opportunity to fly a low-cost asteroid cratering experiment.