MISSION CONCEPTS TO 4015 WILSON-HARRINGTON. L. S. Sollitt[1], K. Kroening[1], R. Malmstrom[1], T. Segura[1], and C. Spittler[1], [1]Northrop Grumman Space Technology, One Space Park, Redondo Beach, CA 90278.

Introduction: 4015 Wilson-Harrington is a transitional small body, exhibiting characteristics common to both asteroids and comets [1,2]. It is an Earth-crossing object, with a perihelion of 0.993 AU and an aphelion of 4.285 AU. A thorough study of this object could reveal a great deal about the relationship between asteroids and comets, and shed light on theories on the formation of the Solar System. As such, it represents a high-value target for a future in-situ mission to characterize its composition and structure, or return a sample.

We have examined two different potential mission concepts: an orbiter/lander, and a sample return. Potential mission architectures include primary payload concepts and secondary payload concepts based on the LCROSS mission. For all of the following missions, chemical thrusters were assumed, with an I_{sp} of 315 sec. One reason for this assumption was to allow for an ASRG power system, which would not be sufficient to run electric thrusters.

Orbiter/Lander: In this mission concept, a spacecraft would rendezvous with 4015 Wilson-Harrington, orbit it, and eventually land. Multiple landings are contemplated, effectively turning the spacecraft itself into a rover, able to visit multiple sites. The spacecraft would remain landed on the body for disposal. This mission concept would be suitable for a Discovery-class mission.

Sample Return: As implied by the name of this concept, this mission would return samples from 4015 Wilson-Harrington. Apart from the return of a sample, which could be either warm or cryogenic (depending on the class of mission), it would be very similar to the orbiter/lander mission, and would similarly visit several sites on the object. A warm sample mission might be suitable for a New Frontiers-class mission; a cryogenic sample return might be a flagship-class mission.

Secondary Payload Architecture: We looked at two potential secondary payload architectures, based on the NASA LCROSS mission. LCROSS is a spacecraft based on an EELV Secondary Payload Adapter (ESPA) ring, and is launching in April 2009 as a secondary payload to NASA's LRO mission. For this architecture, we examined two different classes of primary payloads: geostationary transfer orbits (the mission would be a secondary payload for a commercial or military GEO mission) and a trans-lunar injection (the mission would be secondary to an unmanned lunar mission. Orbiter/lander missions are possible, with cruise times of 6.6 years for a GTO launch and 6.4 years for a trans-lunar launch. The GTO secondary payload architecture would require a total delta-V of 4.0 km/sec to land on Wilson-Harrington; for a 778 kg dry mass spacecraft, the total wet mass would be 3365 kg. The numbers are slightly more favorable for a trans-lunar launch: 3.6 km/sec delta-V, and a wet mass of 2788 kg. However, these masses are large enough that they already strain the limits of the secondary payload architecture. A sample return mission is not practical with this architecture. A mission profile for a secondary payload is shown in Fig. 1.

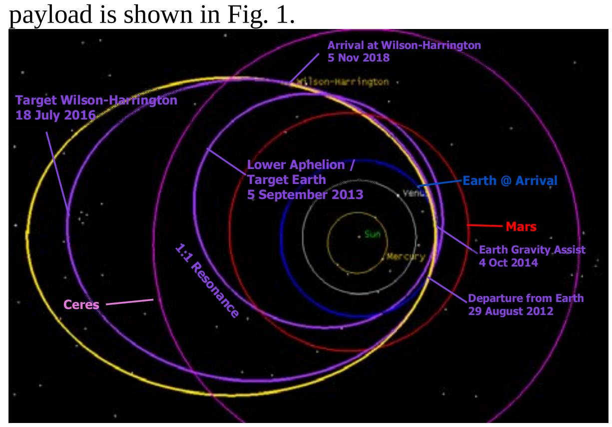

Figure 1. *Trajectory for an orbiter/lander mission, secondary payload architecture.*

Primary Payload Architectures: For primary payload missions, we examined two different launch scenarios: a high energy launch (C3 of 69 km^2/sec^2), and a lower-energy launch (C3 of 28 km^2/sec^2). For these two different launch scenarios, we evaluated the capacity of two limiting-case launch vehicles: an Atlas V 401 and an Atlas V 551. Orbiter/lander and sample return concepts were examined for each of the launch scenarios and vehicles. The trajectories of the orbiter/lander missions are identical to the sample return missions up to the Earth return. The results of the calculations are shown in Table 1.

Mission Type	Launch C3 (km2/s2)	Atlas V	Duration (year)	ΔV (m/s)	Wet Mass (kg)	Dry Mass (kg)
Orbiter/Lander	69.1	401	4.09	1714	545	297
Orbiter/Lander	69.1	551	4.09	1714	1630	889
Sample Return	69.1	551	8.06	2356	1630	707
Orbiter/Lander	28.0	401	6.19	1772	1940	1039
Orbiter/Lander	28.0	551	6.19	1772	3820	2045
Sample Return	28.0	401	10.16	2414	1940	825
Sample Return	28.0	551	10.16	2414	3820	1625

Table 1. *Results for various primary payload concepts.*

The high energy trajectories result in dry masses that seem fairly small. For instance, an orbiter/lander on an Atlas V 551 has a dry mass of 889 kg. For comparison, the dry mass of the DAWN spacecraft is 740 kg. However, launch would be on a larger Atlas, which might push the mission out of the Discovery class. The high-energy Atlas V 401 launch results in a dry mass of 297 kg, which is already reasonably small. These missions have a duration of 4.09 years to rendezvous, which would be suitable for a Discovery-class mission. The results for a high energy sample return with an Atlas V 401 are not included, as the dry mass was so low as to render the mission impractical.

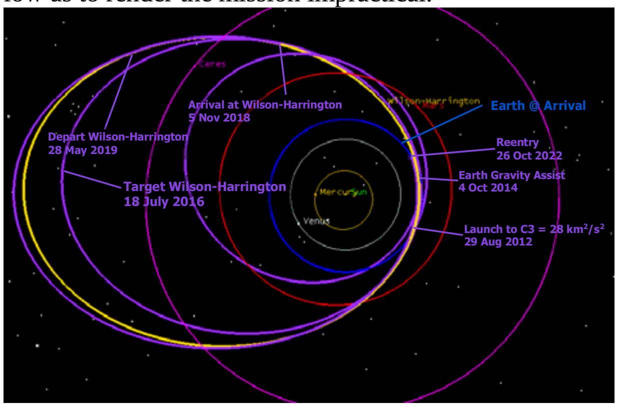

Figure 2. *Trajectory for a 10.2 year sample return mission (low-energy launch).*

A lower-energy launch (C3 of 28) adds some years to the mission (6.19 years to rendezvous for the orbiter/lander vs. 4.09), but the resulting delivered dry mass is much higher. For instance, an Atlas V 401 delivers 1039 kg of dry mass to Wilson-Harrington at a C3 of 28, vs. 297 kg at a C3 of 69. This is for an added 2.1 years of mission time. One intriguiging possibility is the sample return mission on an Atlas V 401 with the low-energy launch. At a mission duration of a little over ten years, the delivered dry mass to Wilson-Harrington is 825 kg. This might be high enough to allow for a practical mission, but with a lower-cost launch vehicle. The trajectory for this mission is shown in Figure 2.

Conclusions: A viable mission to 4015 Wilson-Harrington is possible with a number of different primary payload architectures. This could be done either with a Discovery-class orbiter/lander mission, or with a New Frontiers-class sample return. One intriguing possibility is using a lower-cost launch vehicle (Atlas V 401) to potentially enable a sub-New Frontiers-class sample return architecture. A secondary payload architecture might also enable a lower-cost orbiter/lander mission, but strains the boundaries of what is considered a secondary payload to do so.

References:

[1] Marsden, B.G. (1992) *IAU Circular No. 5585*
[2] Yeomans, D. (2000) *Nature, 404, 829-832.*

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