HORUS - HERSCHEL ORBITAL RECONNAISSANCE OF THE URANIAN SYSTEM. R. M. Smith[1] A. W. Yozwiak[1] A. P. Lederer[1] and E. P. Turtle[1] [1]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723, Rosanna.Smith@jhuapl.edu

Introduction: The planet Uranus has been of interest to scientists since its discovery by William Herschel in 1781. Since then Uranus, its satellites and rings have been the targets of Earth-based observations [*e.g.*, 1-3], especially during its equinox in 2007 [*e.g.*, 4], as well as the *Voyager 2* flyby in 1986 [*e.g.*, 5, 6]; however, numerous fundamental questions remain [7]. Designed with a NASA New Frontiers Mission in mind, the Herschel Orbital Reconnaissance of the Uranian System (HORUS) is a mission concept to travel to Uranus and four of its moons in the hopes of being able to study the system in a way that has not been previously attempted. HORUS aims to answer questions that could not be answered with a flyby mission: What characterizes the largest Uranian satellites? Why is the atmosphere of Uranus so uniquely stratified? Why is the magnetosphere oriented so far off from Uranus' center of mass and rotational-axis (Fig.1)?

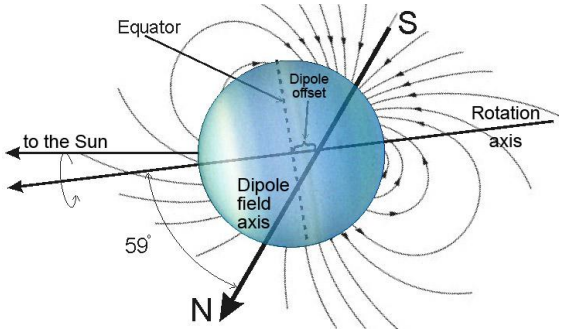

Figure 1. Uranian Magnetic Field Model [8]

Mission Description: Twenty-six interns designed and led the concept study which was developed in a setting that emphasized cooperation and compromise between science and engineering. In keeping with the Planetary Science Decadal Survey [7], the scientific objectives include maximum imaging coverage of Uranus' major satellites (Titania, Umbriel, Ariel and Miranda), particles and fields research (mapping the magnetosphere, tracking aurora, mapping the magnetic field, etc.), atmospheric science investigations (to obtain insight into Uranus' thermal structure, atmosphere dynamics and composition), and a study of the composition and dynamics of Uranus' rings. Eleven instruments were chosen for HORUS' payload including a Fluxgate Magnetometer, an Ion and Neutral Mass Spectrometer, a radio science antenna and wide and narrow angle cameras (Table 1).

Instrument	Mass (kg)	Power (Watts)
MEMORIS: Bepi Colombo	6.0	5
LORRI: New Horizons (FALCINS)	8.6	15
REX: NH Radio Science Experiment (URSA)	0.16	1.6
NH: Alice (far + extreme UV) (HAI)	4.4	4.4
RALPH: LEISA (New Horizons) (IR) (ISUS)	8.0	6
MASCS UVVS: MESSENGER (near UV) (NUVAS)	1.5	1.5
Fluxgate Magnetometer Params: Juno (FAMUS)	2.0	10
PEPSSI: NH Ion and Neutral Mass Spectrometer (NIMS)	1.5	2
Cassini CDA (cosmic dust analyzer)	17.0	12.0
EPPS EPS: MESSENGER (HADES)	0.85	-----
EPPS FIPS: MESSENGER (HADES)	2.25	2
TOTAL	35.26	------

Table 1. List of Instruments on HORUS

An intricate but practical Mission Design was created (Figs. 2, 3) and made use of a Jupiter gravity assist for the transfer trajectory to meet the constraints given (*e.g.*, a reasonable mission lifetime), and three Advanced Stirling Radioisotope Generators (ASRGs) [9,10] are used for spacecraft power (an improvement over the current state-of-the-art radioisotope thermoelectric generators, RTGs). A systems-engineering plan was undertaken that considered propulsion, guidance and control, avionics and flight software, power, radio frequency communications, radiation and environment analysis, thermal design, mechanical design and mission operations (Fig. 4).

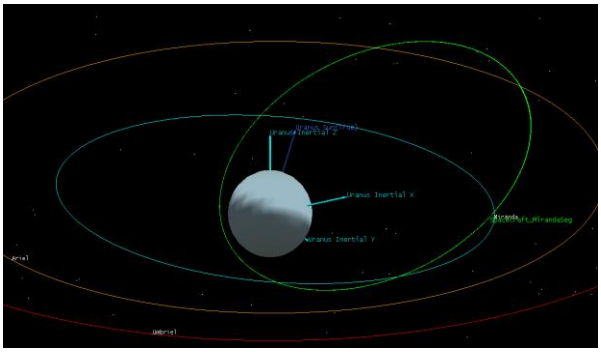

Figure 2. Moon Flyby Geometry

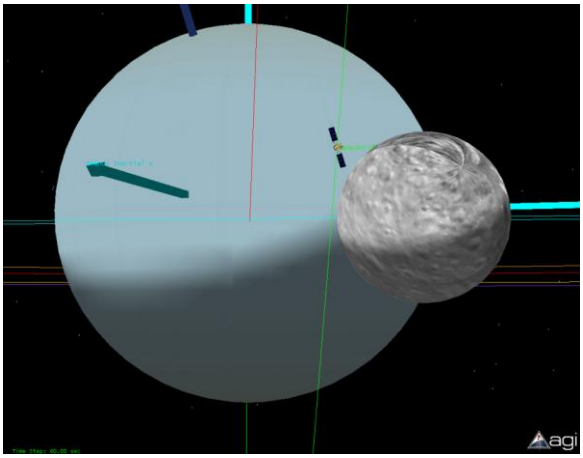

Figure 3. Miranda Flyby with Orbits and Uranus

Following the constraints given, the launch window was set for April 2021 in order to minimize launch energy and the ΔV to capture at Uranus and to make use of the most advantageous Jupiter flyby date. The mission duration to Uranus would take less than seventeen years with a minimum of a two year mission in the Uranian System.

HORUS would be the first of its kind to travel to the Uranian System with the benefits of not only fulfilling several objectives identifed by the Decadal Survey [7], but also resolving pertinent issues such as determining how physical and chemical processes dictate the main characteristics of the planets and their environments, thereby illuminating how the Sun's retinue of planets originated and evolved. The Giant Planets are the key to Solar System formation and, therefore, an orbiter mission to Uranus is essential.

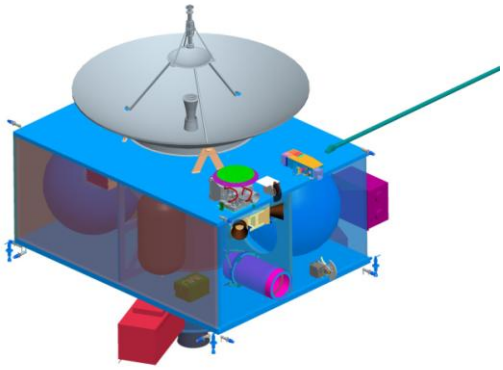

Figure 4. CAD Model of HORUS

References: [1] Hubbard W.B. *et al.* (1977) *Nature* **268**, 33-34. [2] Karkoschka E. (1997) *Icarus* **125**, 348-363. [3] Hammel H.B. (2001) *Icarus* **153**, 229-235. [4] Sromovsky L.A. *et al.* (2009) *Icarus* **203**, 265-286. [5] Stone E.C. and Miner E.D. (1986) *Science* **233**, 39-43. [6] Bergstralh J.T. *et al.* (1991) Uranus. [7] New Frontiers in the Solar System: An Integrated Exploration Strategy (2003) National Research Council. [8] "The Magnetic Poles of Uranus." *Windows to the Universe*. University Corporation for Atmospheric Research (UCAR). Web. 21 July 2009. <http://www.windows.ucar.edu>. [9] Chan, J. *et al.* (2007) *AIP Conf. Proc.* **880**, 615-623. [10] Wood, J. *et al.* (2007) *AIP Conf. Proc* **880**, 313-324.