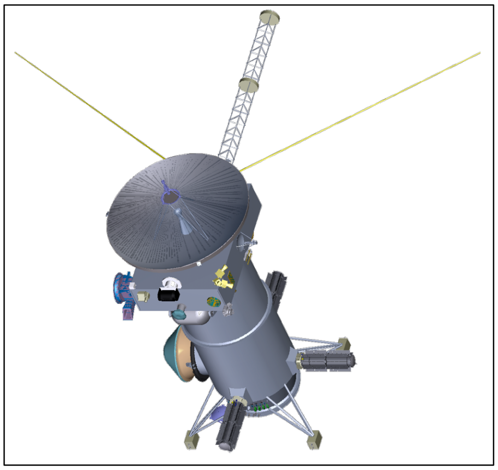
DESIGN CHALLENGES FOR THE DECADAL URANUS FLAGSHIP IN A RESOURCE-CONSTRAINED ENVIRONMENT. A.A. Simon[1], R.C. Anderson[2], M. Amato[1], P. Bedini[2]. [1]NASA Goddard Space Flight Center, Greenbelt, MD (amy.simon@nasa.gov), [2]Johns Hopkins Applied Physics Laboratory, Laurel, MD.

Introduction: *Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032* recommended a Uranus Orbiter and Probe as the top priority next Flagship mission in Planetary Science [1]. The UOP concept study was responsive to assumed likely constraints in launch date, budgetary environment, and power availability, returning broad, high priority, multi-disciplinary science while assuming no new technology development infusion [2].



The UOP Design: The Decadal UOP mission concept study assumed a launch date in 2031 with a Jupiter gravity assist to reach Uranus in 2044 (Table 1, **bold**). Probe release occurred after orbit insertion to separate critical events. The notional science payload included a Magnetometer, Narrow Angle Camera, Wide Angle Camera, Thermal IR Camera, Visible-Near IR Imaging Spectrometer, Comprehensive Fields and Particle Suite, Radio Science with USO on the Orbiter and Atmospheric Structure, Mass Spectrometer, USO, Ortho-Para Hydrogen Sensor on the probe. The notional payload was chosen for mass, power, and data volume scoping only, and was not assumed to be the final payload. The mission was powered with 3 NextGen Mod 1 radioisotope thermoelectric generator (RTG) units and propulsion was all-chemical. Communication to Earth used Ka-band transmitters and probe relay occurred through UHF antennas.

Launch Dates: While the preferred Decadal launch date in 2031 took advantage of an ideal Jupiter gravity assist, other windows were found for later dates. With no change in launch vehicle or propulsion systems, there is a cruise time penalty for windows after 2032, as they must utilize inner solar system tours to maintain sufficient deliverable mass. Given current NASA budgets, a launch date after 2032 is likely.

Table 1. Decadal study launch and cruise options

Launch Date	Path	Post-UOI Mass (kg)	TOF (yrs)
6/13/2031	**E(ΔV)EJU**	**4919.0**	**13.4**
6/15/2031	E(ΔV)EJU	4643.5	12.7
7/18/2031	EVEJU	4089.3	11.6
4/29/2032	**E(ΔV)EJU**	**5111.5**	**12.8**
5/3/2032	E(ΔV)EJU	4527.2	12.2
8/15/2032	E(ΔV)EJU	3056.3	11.8
1/8/2033	EVEEU	5933.3	15.3
5/27/2034	EVEEU	5626.4	15.2
2/28/2036	EVEEU	5240.5	15.3
1/8/2038	EVEEU	4812.3	14.2

Power vs Data Return: The Decadal assumption of three NextGen Mod 1 RTGs provided more than 490 W of power through end of mission, enabling Ka-Band communications for science data return. A notional schedule of daily 8-hr passes was sufficient to return all data with margin for additional operations. Ka-band at Uranus (19.5 kbps) is comparable to the lowest data rates returned by Cassini, which operated at 10 AU using X-band (14 to 166 kbps [2]).

Recent summaries of RPS availability [3], indicate that only a single NextGen Mod 1 unit may be available by 2030; at that reduced power level it is likely that only X-band communication would be possible, further reducing UOP data return capability by a factor of ~4.

Discussion: Exploration at 20 AU is considerably more challenging than at the gas giants, requiring a careful assessment of capabilities and science return. With Cassini and Europa Clipper as examples, planetary Flagship missions take 8 to 9 years of development before launch. Given budget and power availability realities, further study is needed on trajectory options and mission design. More work is needed to study the best trajectories and launch options, especially without a Jupiter gravity assist. Careful attention will be needed to optimize resources to maximize science return, while also constraining cost to enable other future outer planet missions. These topics will be a key focus of the upcoming Uranus Flagship Workshop in May 2024 (https://science.gsfc.nasa.gov/690/uranus-flagship)

References: [1] https://tinyurl.com/2p88fx4f,
[2]https://descanso.jpl.nasa.gov/DPSummary/Descanso3--Cassini2.pdf,
[3]https://www.lpi.usra.edu/opag/meetings/jun2022/slides/Reid.pdf