DESIGN STUDY OF NUCLEAR-ELECTRIC TRANSPORT VEHICLE FOR ICE GIANT MISSIONS. S. McCarty[1], S.R. Oleson[2], G.A. Landis[2], E. Turnbull[2], D. Smith[2], B. Faller[2], J. Fittje[2], J. Gyekenyesi[3], A. Colozza[3], P. Schmitz[4], B. Klefman[2], C. Heldman[2], B. Dosa[2], T. Packard[3] and N. Izenberg[4] [1]NASA Glenn Research Center, Cleveland OH, 44135 steven.mccarty@nasa.gov, [2]NASA Glenn, Cleveland OH. [3]HX5 LLC, Cleveland, OH. [4]Power Computing Solutions, Avon Lake, OH, [5]Johns Hopkins Applied Physics Laboratory, Laurel MD.

Introduction: "Abeona" (named after the Roman protective goddess of travelers) is a design study of a Nuclear Electric Propulsion vehicle for delivery of a science mission to the ice giant planets and their moons. We have analyzed missions to both the Uranus system (travel time 10 years), or the Neptune system (15 years).

Power and Propulsion: NASA has recently been developing the "Kilopower" nuclear reactor for future exploration missions [1], and a 1-kW prototype reactor was tested under the Kilowatt Reactor Using Stirling TechnologY (KRUSTY) program [2]. This study assumed a 17.5 kW next-generation Kilopower-derived reactor [3], of which 14.1 kW is used for the electric propulsion (EP) system, and 3.4 kW for other spacecraft systems and power growth allowance.

Figure 1 shows the vehicle. An 8-meter extensible truss distances the reactor from the spacecraft, to position the main body of the spacecraft behind a shield to minimize neutron flux from the reactor. Figure 2 shows the vehicle with the truss in stowed position for launch inside an 8.4-m fairing for a SLS launch.

Propulsion. Primary propulsion for the mission consists of two NEXT-C ion thrusters [4] running Xenon propellant at a specific impulse of 4107 s. Three additional thrusters plus a spare are incorporated to achieve the required lifetime and redundancy. A bipropellant engine is used for orbital insertion at Uranus (or Neptune)

Missions: *Uranus/Titania Mission.* A trajectory to Uranus was analyzed including a tour of the moons. For the example case, we looked at a tour focusing on Titania, the largest of the Uranus moon; but all the moons could be visited. The baseline assumed a 2034 launch on a SLS Block-IB vehicle or a Falcon Heavy. The trajectory uses a Jupiter flyby, with 7.63 km/s of EP ΔV, for a 10-year flight time to Uranus. After dropping an atmospheric probe into Uranus, the vehicle captures into a 120-day orbit using 0.5 km/s of chemical ΔV, and then uses EP to raise its periapsis to Titania's orbital distance. The vehicle has a 2.6 km/s of EP ΔV dedicated for the moon tours, culminating in a low orbit of Titania for close-up exploration of an outer planet moon.

Neptune/Triton Mission. A Neptune/Triton mission was analyzed for a 2037 launch. Since a Jupiter flyby was not available in the launch timeframe desired, the trajectory used a Venus/Venus/Earth (VVE) flyby sequence for gravity assist, yielding a 15-year time of flight to the Neptune system. At arrival, the vehicle delivers the atmospheric probe, does a chemical capture into Neptune orbit, then makes a low-thrust spiral down into a low Triton orbit to support lander/hopper operations, and finally boosts out of Triton orbit again to investigate other moons and Neptune itself.

Vehicle: Table 1 shows the mass breakdown of the vehicle for the Neptune/Triton mission. The vehicle mass here includes 188 kg of science instrumentation on the vehicle itself; but not the 1,164 kg payload transported to the Neptune system, comprising the Triton and Neptune probes. Total mass includes a mass growth allowance [5] of 23% of the system mass. About five tons of propellant are expended in the mission.

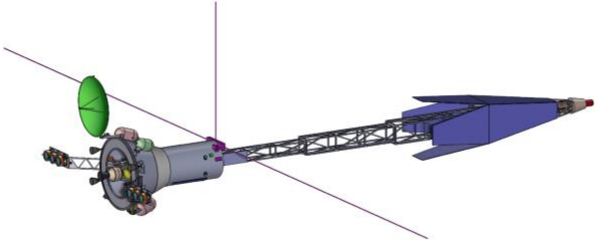
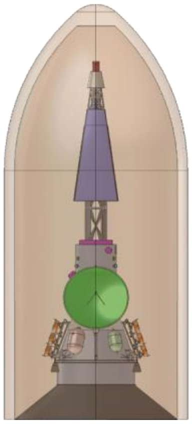
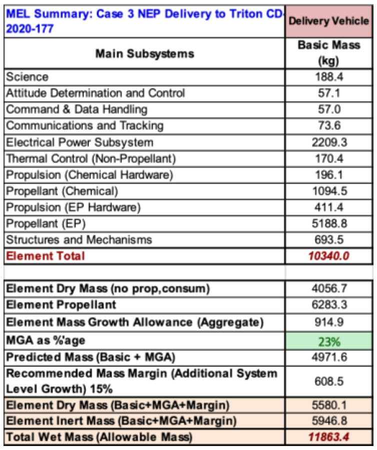


Figure 1: Abeona vehicle in flight configuration





MEL Summary: Case 3 NEP Delivery to Triton CD-2020-177	Delivery Vehicle
Main Subsystems	**Basic Mass (kg)**
Science	188.4
Attitude Determination and Control	57.1
Command & Data Handling	57.0
Communications and Tracking	73.6
Electrical Power Subsystem	2209.3
Thermal Control (Non-Propellant)	170.4
Propulsion (Chemical Hardware)	196.1
Propellant (Chemical)	1094.5
Propulsion (EP Hardware)	411.4
Propellant (EP)	5188.8
Structures and Mechanisms	693.5
Element Total	***10340.0***
Element Dry Mass (no prop,consum)	4056.7
Element Propellant	6283.3
Element Mass Growth Allowance (Aggregate)	914.9
MGA as %'age	23%
Predicted Mass (Basic + MGA)	4971.6
Recommended Mass Margin (Additional System Level Growth) 15%	608.5
Element Dry Mass (Basic+MGA+Margin)	5580.1
Element Inert Mass (Basic+MGA+Margin)	5946.8
Total Wet Mass (Allowable Mass)	***11863.4***

Fig. 2 (left): Abeona vehicle in launch configuration. Table 1 (right): Abeona mass by subsystem

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