Abeona: Design of a Nuclear-Electric Vehicle for Transport to Neptune and Triton. G.A. Landis,[1] S.R. Oleson[2], E. Turnbull[2], D. Smith[2], S. McCarty[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], and T. Packard[3]. [1]NASA Glenn Research Center, Cleveland OH, 44135 geoffrey.landis@nasa.gov, [2]NASA Glenn Research Center, Cleveland OH. [3]HX5 LLC, Cleveland, OH. [4]Power Computing Solutions, Avon Lake, OH

Introduction: In support of a NIAC project designing a "hopper" mission to Neptune's moon Triton [1,2], we have done a design study of a Nuclear Electric Propulsion (NEP) transport vehicle for transportation from Earth orbit to Neptune and Triton. We have named this vehicle "Abeona," after the Roman protective goddess of travelers.

Power and Propulsion: NASA has recently been developing the "Kilopower" nuclear reactor as a power source for future exploration missions [3], and a 1-kW prototype reactor was tested under the Kilowatt Reactor Using Stirling TechnologY (KRUSTY) program [4]. The initial Kilopower concept was designed for electrical power of 1-10 kW, but analysis of lunar applications shows that a next-generation reactor with increased performance is feasible with only incremental changes in the design. This study assumed a 17.5 kW next-generation Kilopower-derived reactor, of which 14.1 kW is used for the electric propulsion system, and 3.4 kW includes other spacecraft systems and power growth allowance.

Figure 1 shows the vehicle. An extensible truss distances the reactor from the spacecraft, to position the main body of the spacecraft behind a shield to minimize neutron flux. Figure 2 shows the vehicle 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 [5] running Xenon propellant. In addition to the two active thrusters, three additional thrusters are required to achieve the required lifetime, and the design incorporates a sixth as spare in case of engine failure. 5189 kg of propellant are expended in the mission.

The baseline trajectory assumed a 2037 launch on a SLS Block-I vehicle or a Falcon Heavy into an initial trajectory for a 1.75-year Venus/Venus/Earth (VVE) flyby sequence. The VVE sequence gives a 15-year interplanetary time of flight to the Neptune system. A Jupiter flyby would have decreased the required ΔV, but was not available in the time frame desired. At arrival, the vehicle delivers the atmospheric probe, does a chemical capture into Neptune orbit, then makes a low-thrust spiral down into low Triton Orbit to support the lander/hopper operations. Following landed operations, it raises itself out of Triton orbit to do investigations of other moons and of Neptune itself.

Table 1 shows the mass breakdown. This 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 lander/hopper and a Neptune atmospheric probe. Total mass includes a mass growth allowance (MGA) according to AIAA standards [6], 23% of the system mass.

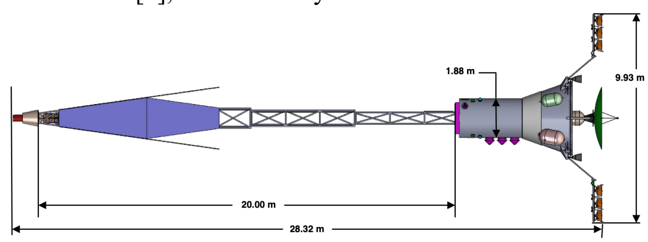
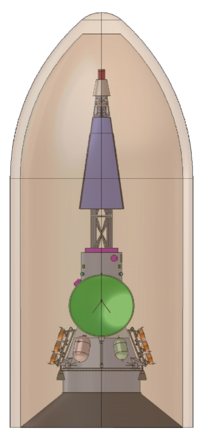


Figure 1: Abeona vehicle in flight configuration



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

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