High Speed Interplanetary Tug/Cocoon Vehicles (HITVs)

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We propose to conduct a preliminary study of a new class of space vehicles, which utilize the motional electric field in the solar wind to accelerate robotic spacecraft to velocities of a few hundred km/s. The premise behind these Tug or Cocoon type vehicles is based on a number of facts. One, is that any charged object embedded in the solar wind will be accelerated to velocities comparable to its flow speed (~400 km/s) with the magnitude of acceleration varying from tens of thousands of Gs to less than 1 G depending on its mass and total charge. Second, for typical masses of robotic spacecraft (tens of kg) the required charge on the spacecraft is very large and could disrupt its electronics circuits. However, specially designed Tug or Cocoon type vehicles could be charged to the required levels without exposing the robotic spacecraft to any charging hazards. We refer to these as High Speed Interplanetary Tug/Cocoon Vehicle (HITV). Once accelerated to the desired speeds, HITV can proceed to discharge and release the robotic spacecraft towards its destination. We envision HITV to have an expandable spheroid structure with radius of 1-10km, when fully deployed. An onboard charging mechanism controls the electric charge density on HITV and the surface material/structure can withstand large (106-109 V/m) electric fields. If used as a Tug vehicle, the robotic spacecraft is attached to HITV with a long enough tether to avoid the hazardous electromagnetic environment in the vicinity of HITV. If used as a Cocoon, the robotic spacecraft is placed within HITV where again it will be protected from large electromagnetic fields. The proposed feasibility study will address a number of outstanding issues. The highly nonlinear interaction between the solar wind and HITV will be investigated by using Particle-in-Cell (PIC) electromagnetic simulations. These simulations will allow us to better understand the nature of the resulting electromagnetic environment around HITV, and determine its acceleration under a variety of mass and charge states, as well as solar wind conditions. The onboard charging mechanism and its power requirements, as well as surface properties of HITV will also be investigated. Issues related to attitude control, reusability of HITVs and Tug vs. Cocoon designs would be addressed as well. The utilization of solar wind energy for acceleration of spacecraft to high velocities as been proposed in the past (e.g., magnetic sails, Mini-Magnetosphere Plasma Propulsion. HITV is another exciting and novel approach to the use of solar wind power to drastically reduce trip times to other bodies in the solar system. In particular, HITVs may be especially suitable for Class I and II micro spacecraft.