# E-Glider: A Concept for Active Electrostatic Flight for Airless Body Exploration


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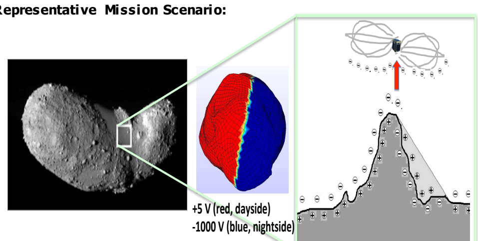
**Concept**:

- The environment near the surface of airless bodies (asteroids, comets, moons) is electrically charged due to Sun's photoelectric bombardment. Charged dust is ever present, even at high altitudes (dust fountains), following the Sun's illumination.
- We envisage the global scale exploration of airless bodies by a gliding vehicle that levitates by experiencing electrostatic lift by its interaction with the naturally charged particle environment. This Electrostatic Glider (E-Glider) concept lifts off by extending thin, charged, appendages (like some flying spiders on Earth), which are also articulated to direct the levitation force in the most convenient direction for propulsion and maneuvering. It lands, wherever it is most convenient, by retracting the appendages or by thruster/anchor.
- The E-Glider concept mimicks Nature, as it uses the electrostatic energy abundantly present in the local environment for its won locomotion.
- *The E-Glider starts the new area of electrostatic flight.*

**Representative Mission Scenario:**



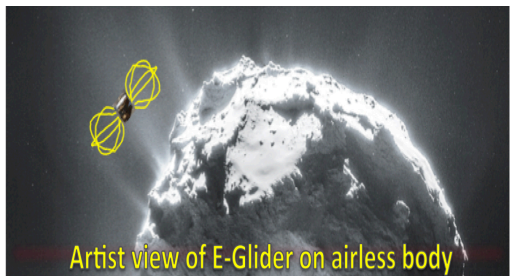

*…Imagine a small vehicle that levitates above the surface of an asteroid after ejecting strands of metallic film, forming the wings, so that it becomes "airborne", but in the electrostatic vacuum lofting around the asteroid. By articulating the wings, the electrostatic glider (E-Glider) can now hover, and maneuver around, without touching the surface. It is the first asteroid circumnavigation of an airless body by electrostatic forces, opening new avenues for low-cost, persistent, recon-naissance of airless bodies, leading to effective global scale prospecting of mineral-rich asteroids.*

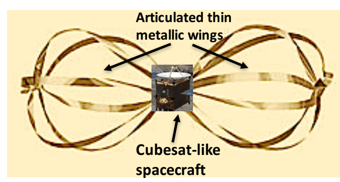
**Science Values:**

- The Planetary Science Decadal Survey calls for fine analytical chemistry (elemental, isotopic, mineralogical) of a variety of planetary bodies to address key science objectives in astrobiology, Solar System origins and dynamical evolution, and planetary processes.
- From an Exploration standpoint, paving the way for Human exploration of NEOs and Mars moons requires the retirement of strategic knowledge gaps (SKGs) such as surface electrostatic field or in-situ resources quantification.
- In-situ exploration of small bodies is not a one-type-fits-all operation or mechanism, and the E-Glider would provide the necessary robustness, scalability, and adaptivity to enable this science.

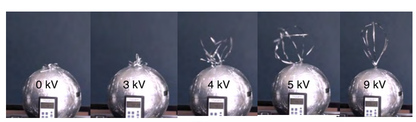
**Vision:**

- To develop an enabling capability for operation at airless bodies, a solution applicable to many types of in-situ missions, which leverages the natural environment.
- A mission based on an E-Glider would truly be a very exciting one, as it would be the first asteroid circumnavigation of an airless body by electrostatic forces, opening new avenues for low-cost, persistent, reconnaissance of airless bodies, potentially leading to effective global scale prospecting of mineral-rich asteroids.




a)

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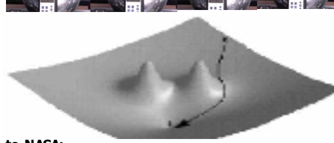


a) Test of electrostatic inflation [from Stiles&Schaub, 2010]. b) Navigating a potential field distribution from *electrostatic cartographic map.*

**Benefits to NASA:**

The E-Glider concept directly addresses the "All Access Mobility" Challenge, one of the NASA's Space Technology Grand Challenges, specifically aimed at enabling robotic operations and mobility, in the most extreme environments of our solar system.

The E-Glider will:

- open new avenues for low-cost, persistent, reconnaissance of airless bodies without interacting with the surface for locomotion, leading to effective prospecting of mineral-rich asteroids before reaching the surface to collect samples;
- provide a framework for the effective use of the coupling between the naturally existing electrostatic environment and gossamer extended surfaces as a novel mechanism for locomotion and exploration in airless bodies;
- enable new sampling techniques for in-situ spatial and temporal sensing of the environment around airless bodies, and
- lead to new concepts for robotic exploration of planets, natural satellites, and other bodies by taking advantage of existing natural plasma and charge distributions

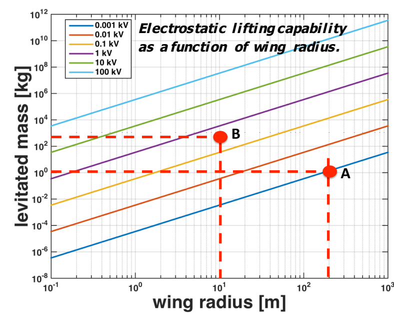
**Study objectives:**

- to show that it is actually feasible and determine the mass and optimum form factor of the E-glider;
- lay the ground for the technique of *electrostatic cartography*;
- develop the theory behind *electrostatic flight mechanics*;
- answer key questions such as: is there a sufficient electric field to use for propulsion? How to handle its uncertainty? How big is the payload that can be lifted? How large are the wings? How are the wings deployed? And
- define the elements of a small testbed for experiments to be done in Phase II.

**Study Approach:**

Analyze a mission scenario involving an electrostatic glider maneuvering above the surface of a reference asteroid, such as Itokawa:

- Study the known environmental conditions of the electrostatics of the lofting dust on the surface of airless bodies;
- Determine E-glider vehicle configurations, and specific methods for energy harvesting, mobility, communication, survivability, and instruments for in-situ sampling of dust and surface regolith; and
- Explore the possibility of generating (in Phase II) physical simulations with approximate models of the E-glider, including their energy harvesting, mobility, and comm. mechanisms.




- Electric fields of E~100-300 kV/m could take place on Itokawa, and an electric field of E=-10 V/m has been measured on the surface of the Moon under full Sun's illumination, therefore a wide range of E is to be considered.
- Assuming a gravity acceleration level of $g=10^{-5}$ m/s2, typical of asteroids such as Itokawa, and denoting by R the equivalent radius of the levitated object, the dynamical equilibrium between gravity and electrostatic forces (*E-Glider equation*) shows that the mass that can be levitated can be expressed as $m=4\pi\varepsilon_0 R^2E^2/g$, where $\varepsilon_0$ is the permittivity of vacuum.
- With 10 V, a 1 kg payload (point A, like a Cubesat, not including mass of wings) could be levitated with wings 200 m radius, while a 500 kg payload (point B, like the Rosetta spacecraft) could be levitated with wings of 10 m radius if the field was close to 1 kV.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