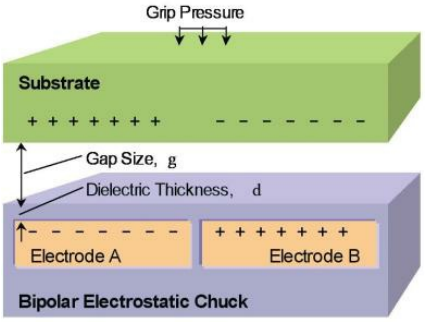
Completed Project (2013 - 2014)

Flexible Electrostatic Technology for Capture & Handling Project

Center Innovation Fund: MSFC CIF Program | Space Technology Mission Directorate (STMD)

ABSTRACT

To accomplish many of NASA's in-space transportation missions require the capture and handling of various objects in various orbits for servicing, debris disposal, and sample retrieval without the benefit of dedicated grapple fixtures and docking ports. To perform similar material handling tasks on earth, pincher grippers, suction grippers or magnetic chucks are used, but are unable to reliably grip aluminum and composite spacecraft, Insulation, radiators, or extra-terrestrial objects in the vacuum of outer space without dedicated handles. The electronic Flexible Electrostatic Technologies for space Capture & Handling (FETCH) will enable reliable and compliant gripping (soft dock) of practically any object in various orbits or surfaces without dedicated mechanical features, very low impact capture, and built-in proximity sensing without any conventional actuators. Originally developed to handle semiconductor and glass wafers during vacuum chamber processing without contamination, the normal rigid wafer handling chucks can be built from thin metal foil segments laminated in flexible insulation driven by COTS solid state high voltage power supplies. The flexible electrostatic gripper pads can adapted to various space applications with different sizes, shapes, and foil electrode layouts with even openings through the gripper pads for addition of guidance sensors or injection of permanent adhesives. With gripping forces estimated between 0.5 and 2.5 pounds per square inch or 70-300 lb./sq. ft. of surface contact, the FETCH can turn-on and turn-off rapidly and repeatedly to enable sample handling, soft docking, in-space assembly, and precision relocation for accurate anchor adhesion.



Flexible Electrostatic Technology can be Utilized for Capturing and Handling

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Management Team

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Flexible Electrostatic Technology for Capture & Handling Project

ANTICIPATED BENEFITS

To NASA unfunded & planned missions:

This new capability to sense proximity, flexibly align to, and attractively grip and capture practically any object in space without any pre-designed physical features or added sensors or actuators will enable or enhance many of MSFC's strategic emphasis areas in space transportation, and space systems such as:

1. A Flexible Electrostatic gripper can enable the capture, gripping and releasing of an extra-terrestrial sample of different minerals or a sample canister (metallic or composite) without requiring a handle or grapple fixture.(B)
2. Flexible self-aligning in-space capture/soft docking or berthing of ISS resupply vehicles, pressurized modules, or nodes for in-space assembly and shielding, radiator, and solar Array deployment for space habitats (C)
3. The flexible electrostatic gripper when combined with a simple steerable extendible boom can grip, position, and release objects of various shapes and materials with low mass and power without any prior handles or physical accommodations or surface contamination for ISS experiment experiments and in-situ repair.(F)(G)
4. The Dexterous Docking concept previously proposed to allow simple commercial resupply ships to station-keep and capture either ISS or an Exploration vehicle for supply or fluid transfer lacked a self-sensing, compliant, soft capture gripper like FETCH that could retract and attach to a CBM. (I)
5. To enable a soft capture and de-orbit of a piece of orbital debris will require self-aligning gripping and holding an object wherever possible (thermal coverings or shields of various materials, radiators, solar arrays, antenna dishes) with little or no residual power while adding either drag or active low level thrust.(K)
6. With the scalability of the FETCH technology, small satellites can be captured and handled or can incorporate FETCH gripper to dock to and handle other small vehicles and larger objects for de-orbiting or mitigating Orbital debris (L)
7. Many of previous MSFC and NASA proposals or concepts can now be realized or simplified by the development of the this initial and future FETCH grippers including commercial resupply, Exploration vehicle assembly, Satellite servicing, and orbital debris removal since a major part of these missions is to align to and capture some handle.

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DETAILED DESCRIPTION

: This proposed effort will test the proximity sensing and gripping force of the first generation FETCH gripper pads in vacuum chamber with assorted sample materials, shapes, support structures, and grip angles Additional testing will demonstrate capture/soft docking and handling of different sizes, masses, and configurations including nano-sat mock-ups on MSFC's Flat Floor. The FETCH grippers utilize phased high voltages on the gripper electrodes to induce attractive electro-static charges in the surface of the object being handled whether it is metal, composite, MLI, glass, or even rock.

1. Current docking and orbital debris capture requires pincher type grippers or probe/spears to grab protrusions or insert into cavities or penetrate objects. This requires some cooperative target design features and precision alignment to engage. . Harpoons create additional debris, explosive venting, and many other hazardous conditions. Most old satellites, derelict upper stages and asteroids don't have handles in the proper places for orbital relocation.
2. Rigid electro-static grippers have been used for years in semi-conductor manufacturing and other vacuum chamber processing with capacitive proximity sensing, very low impact capture & release, no residual contamination, and without motors.
3. A flexible electro-static or electro-adhesion gripper is all electric and can conform and capture various shapes, sizes, and materials without target preparations, generates pull-in force across the gap to grip and self-align (similar to magnetics), and releases cleanly without active motors in space.
4. Flexible electro-static Gripper pads with the correct configuration of attach points, compliance mechanisms, and electrodes can successful conform to various object shapes. Additional pad shapes, electrode patterns and openings (for sensors or permanent adhesive injection) can be designed that will sense and grip with standard programmable electro-static power supplies

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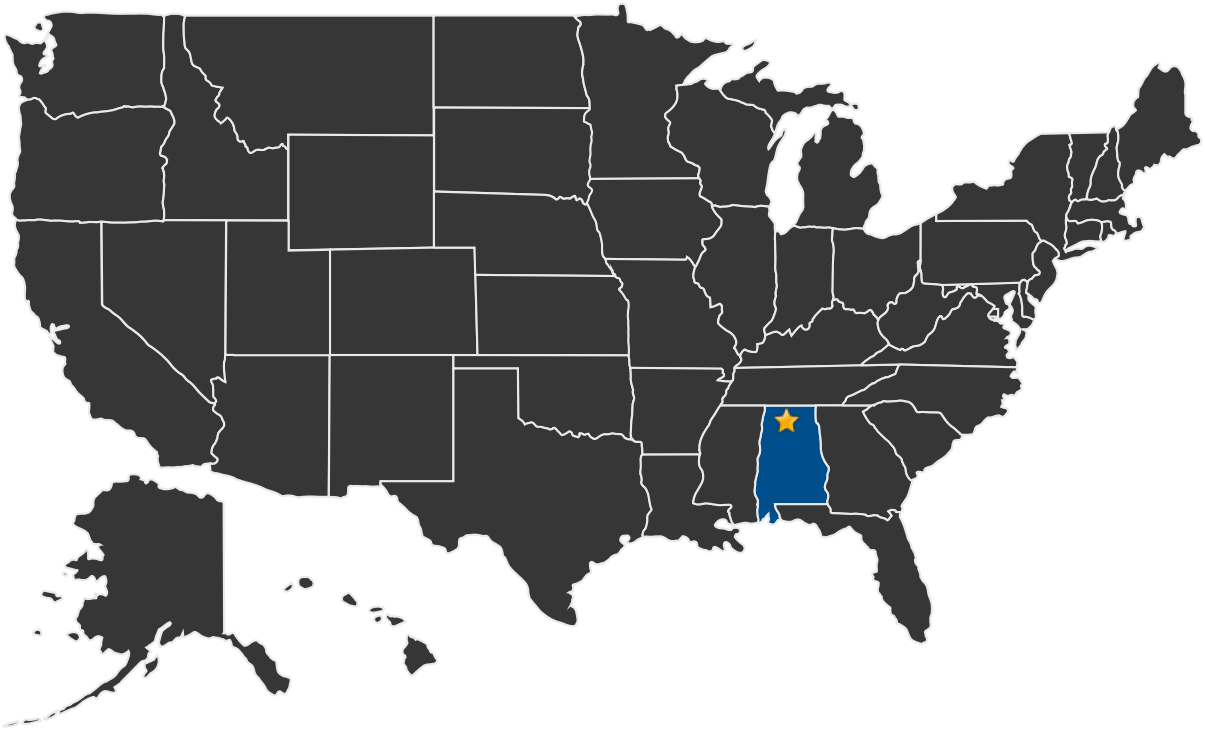
U.S. LOCATIONS WORKING ON THIS PROJECT



U.S. States With Work

Lead Center:
Marshall Space Flight Center