National Aeronautics and Space Administration

NASA facts

Space Technology

Game Changing Development

Human Robotic Systems: Tendon Actuated Lightweight In-Space Manipulators (TALISMAN)

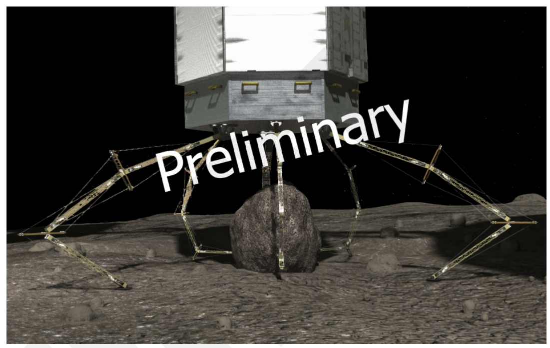
Overview

Asteroid Capture Robotics is currently focused on developing robotics solutions for capturing asteroids for infusion into the Asteroid Redirect Mission and crosscutting applications of long reach manipulators.

Background

NASA mission and exploration architecture studies show that devices for maneuvering and precisely placing payloads are critical for efficient space operations involving reusable assets or in-space assembly and construction. New missions and applications—such as asteroid retrieval and redirection, asteroid mining, satellite servicing, small payload delivery to space stations, and large space observatory assembly—can all benefit from having long-reach manipulators.

In March of 2015, NASA announced they had reached a decision on the approach for its planned Asteroid Redirect Mission (ARM). The selection was the so-called "Option B," which will send a robotic vehicle to an asteroid with the goal of removing a small boulder (<10 meters across) from its surface and returning it to an orbit about Earth's moon, where it will only



Conceptual depiction of TALISMAN used as landing legs and grapple arms for retrieval of a boulder from the surface of an asteroid.

take a few days for astronauts in a spacecraft to reach it from Earth. This problem is well suited for a long-reach manipulator; however, the state of the art in space manipulators, represented by the Space Station Remote Manipulator System (SSRMS), inherently limits its capabilities to extend reach, reduce mass, apply force, and package efficiently.

TALISMAN and SSRMS Performance Comparison

Design parameter	SSRMS	TALISMAN
Total manipulator reach	15.3 m	15.3 m
Manipulator mass	410 kg	36 kg
Packaged volume	1.74 m^3 61.4 ft^3	0.23 m^3 8 ft^3
Degrees of freedom	6 Total (2 at base, 1 at elbow, 3 at wrist)	5 total (1 base rotation, 4 hinges)

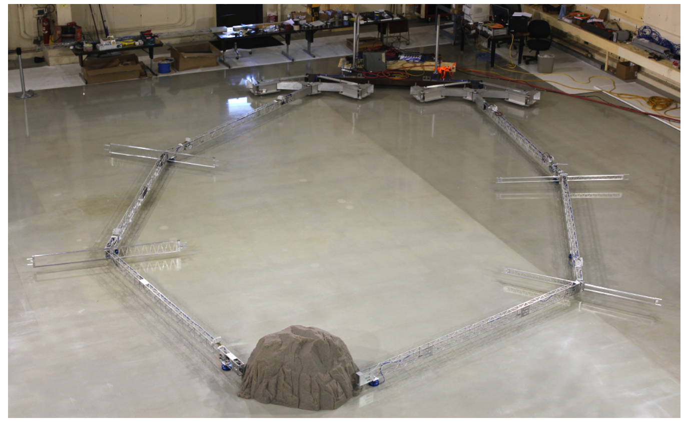
Tendon-Actuated Long-Reach Manipulator

The Human Robotic Systems (HRS) Asteroid Capture element is currently focused on developing robotic solutions for capturing asteroids, and on unfolding new and innovative robotic architectures for long-reach manipulation that incorporate a combination of lightweight truss links, a novel hinge joint, tendon-articulation and passive tension stiffening to achieve revolutionary performance.

Dubbed TALISMAN, which stands for Tendon-Actuated Lightweight In-Space MANipulator, this manipulator, when scaled to perform similar to the SSRMS, has 1/10th its mass and packages in 1/7th of its volume.

The TALISMAN architecture allows its reach to be scaled over a large range, from 10 to over 300 meters. In addition, the dexterity (number of degrees of freedom) can be easily adjusted without significantly impacting manipulator mass, because the joints are very lightweight.

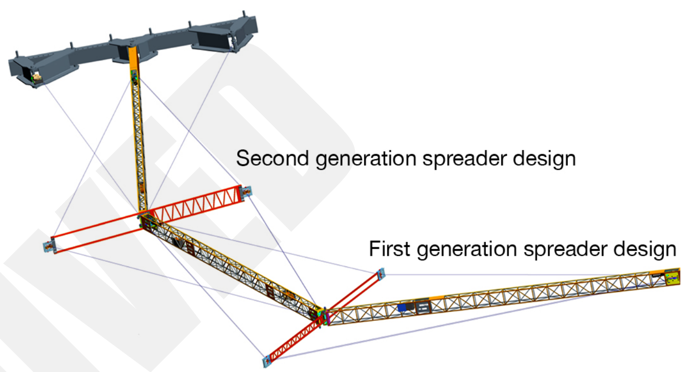
Two full-scale, 2-D TALISMAN prototypes are currently undergoing operational testing. This application is focusing on achieving high dexterity, a large reach envelope, applying and reacting to large tip forces, ability to deploy and restow multiple times, and packaging compactly for launch.



2-D TALISMAN grappling an asteroid mock-up during operational testing at NASA's Langley Research Center.

Key Features

- Uses tendon actuation, which can be semi- or fully-antagonistic, with major components being the links, spreaders, lightweight cables, motors, gearboxes.
- Increased joint stiffness due to tendon architecture.
- Lightweight joints enable the number of joints to be optimized to achieve desired packaging, efficiency, range-of-motion, dexterity, etc.
- Potential to increase manipulator stiffness using passive tension elements (very lightweight).
- Versatility; many different cable/motor/control options can be implemented.
- Modularity; links and joints are easy to scale for different applications, can combine links and joints as needed for packaging, dexterity, etc. to achieve operational needs.
- Novel hinge joint allows 360-degree rotation between adjacent links, improving dexterity and range of motion.
- Uses lightweight truss structures for links.



TALISMAN with both first- and second-generation spreaders.

Partnerships

The Human Robotic Systems project is led by NASA's Johnson Space Center, with many partnerships across the nation at other NASA centers and with numerous industry and academic partners. The Asteroid Capture Robotics task is led out of Langley Research Center.

The Game Changing Development (GCD) Program is the primary funding source for HRS. Projects under GCD investigate ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about HRS please visit
http://www.nasa.gov/directorates/spacetech/game_changing_development/human-robotic-systems.html (public)

For more information about GCD, please visit
http://gameon.nasa.gov/

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