National Aeronautics and Space Administration

Stilts for mobility on Ocean Worlds

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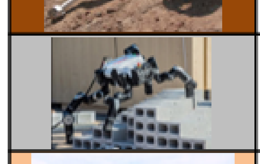
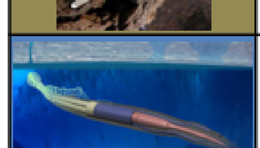
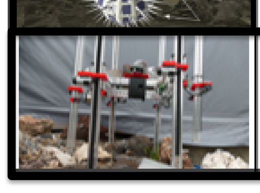
Program: Spontaneous Concepts R&TD

Project Objective:

For Ocean Worlds, is likely that orbiter and static lander missions would be followed by surface mobility, but due to rough terrain, mobility in these types of worlds remains a challenge. The surface topography data on these bodies comes from orbiters, which have limited resolution. Robot-scale surface topography and mechanical properties remain largely unknown. The "Europa Lander Study 2016 Report" places chaos features amongst the highest scientific value both for habitability and for search for life. Mobility in chaos, and other very rough terrain is therefore desirable. Previously proposed mobility concepts for ocean worlds have included deformable wheels on rocker-bogie suspensions, multi-limbed robots, and hoppers. However, wheels are not appropriate for unknown terrain; limbed approaches require complex planning with many actuators; and hoppers have limited mass budget.

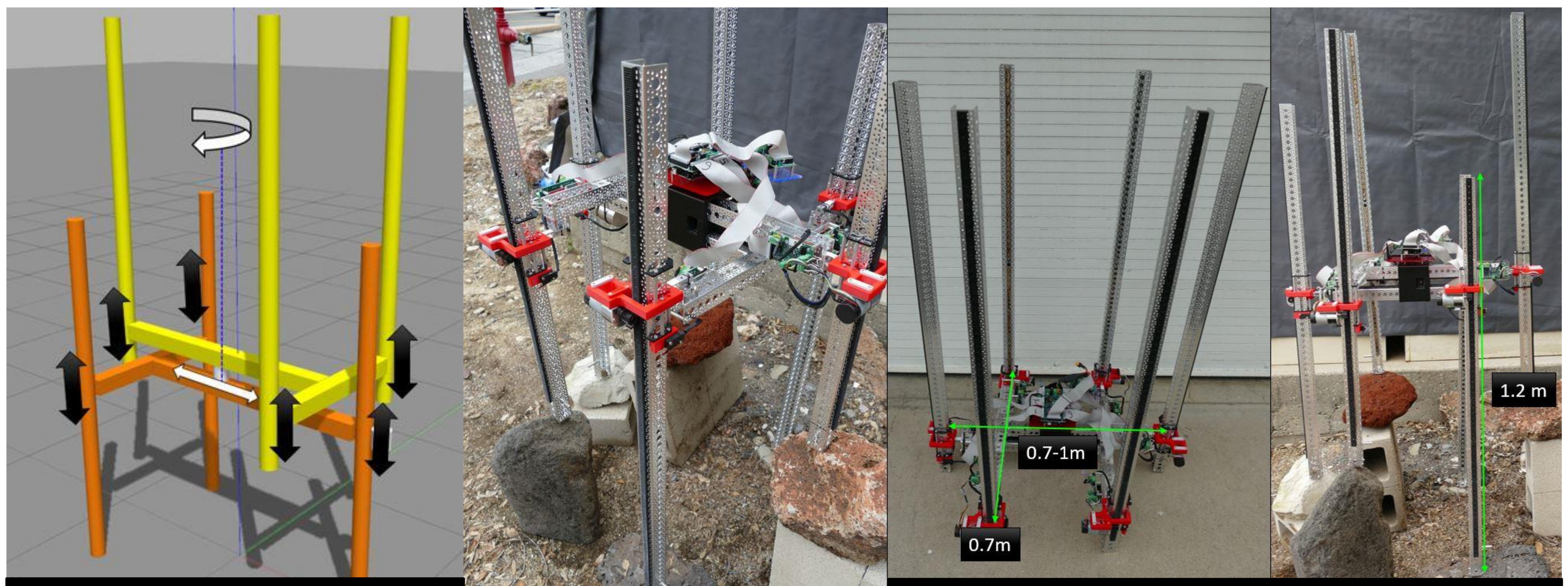
Mobility platform	Mobility DOF's	Rough terrain	Planning
 Wheeled Rover	10	N	Simple
 Rappelling (AXEL)	4	Downhill only	Complex
 Legged (Robosimian)	32	Y	Complex
 Hybrid (ATHLETE)	36	Y	Complex
 Climber	28	Y	Complex
 Snake (EELs)	36	Y	Complex
 Hopper	N/A	N	Complex
 **RoboStilt**	8	Y	Simple

Benefits to NASA and JPL:

The robotic platform developed in this task proved that rigid frame walkers built with modern mechatronics can navigate rough terrain with limited perception. A full proof of concept was developed and tested within the scope of a Spontaneous Concepts RTD, proving the simplicity of this type of mobile robots. The reduced number of degrees of freedom, compared to the roughness of the terrain that can be traversed, is a positive trait on these types of machines. Other legged mobility platforms such as quadrupeds or hexapods, have the disadvantage of requiring a large number of degrees of freedom, accurate perception, and complex controls. The peculiar mechanical architecture of rigid frame walkers reduces the requirements on perception and controls required to navigate rough terrain making these types of mobility platforms more conducive to flight. The simple robotic architecture developed in this task could be used to traverse the rough and unstructured terrain of Ocean Worlds.

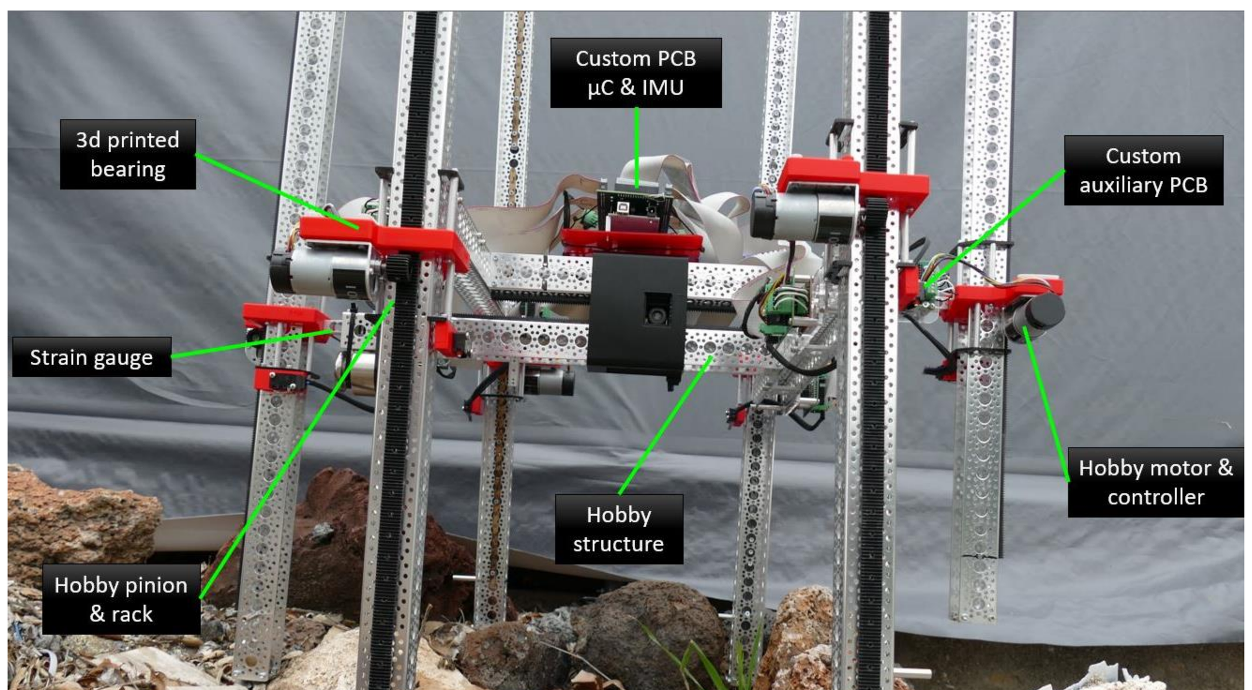
FY18/19 Results:

The robot designed and built for this task, **RoboStilt,** relies on six, long, stilt-like legs that move vertically. The stilts, grouped into two tripods, are repeatedly raised, moved horizontally, and lowered to produce a walking gait.



RoboStilt DOF's **RoboStilt general dimensions**

Low gravity worlds are amenable to the use of long stilts. With long enough stilts, the robot is able to negotiate tall obstacles or deep trenches. Full XY plane mobility and limited XYZ working volume are enabled **with only eight actuators**. The stilts do not sweep volume when walking, reducing perception and controls requirements. Stability of stilt contact points can be tested before bearing weight. With long stilts, navigation is simpler since the robot can walk over obstacles instead of navigating around them, facilitating autonomous operation. The long stilts allow the robot to ascend for awareness or hunker down for sampling. The linear motion allows precise positioning of the body on an XYZ volume, allowing multiple instruments placed on the belly to inspect the same sampling site. The system is capable of applying most of the robot's weight onto a drill placed on the belly, useful in low gravity.



RoboStilt main components

RoboStilt has a total mass of 10.5kg and a footprint of 0.7x0.7m. Max power consumption is ~16 watts. With a walking height of 0.5m, **RoboStilt's** velocity is ~13m/hr. The work on this task culminated with a successful field test inside JPL where the robot traversed over rough terrain. In this field test, RoboStilt autonomously navigated over obstacles up to 40cm in height. The robot had no perception and instead used a fixed, walking height set a priori, to clear obstacles. The mechanical rigidity of the system was such that some human support was necessary for specific poses.

RoboStilt walking over rough terrain

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