

Honeybee Robotics: An Overview of On-Orbit Servicing (OOS) Capabilities

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International Workshop on
On-Orbit Satellite Servicing

March 25, 2010

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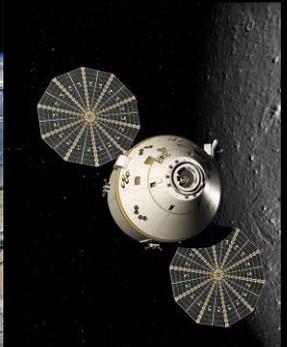
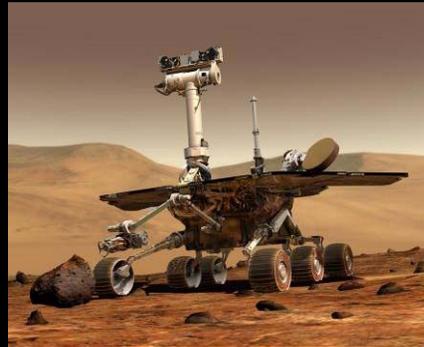
HONEYBEE ROBOTICS
Spacecraft Mechanisms Corporation



Honeybee Robotics

We are **developers** of Technology & Products for...

Advanced Robotic and Spacecraft Systems



Robotic Systems...

...Sensors & Manipulators

...End-Effectors & Tools

Spacecraft Mechanisms...

...Deployment & Positioning

...Attitude Control

...Automation Components

(motors, transmissions, slip rings, EVA/EVR compatible couplings, connectors & fasteners)

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Honeybee Robotics

- **Founded 1983 in New York City**
 - Privately-owned Small Business
 - Clean Room, Machine Shop, Test Facilities
 - Field Offices: Denver, Houston... and Pasadena planned
- **Currently 30+ Engineers, Scientists & Inventors**
 - Spanning a range of disciplines: systems, mechanical, electrical, computer science, optics, geotech./civil

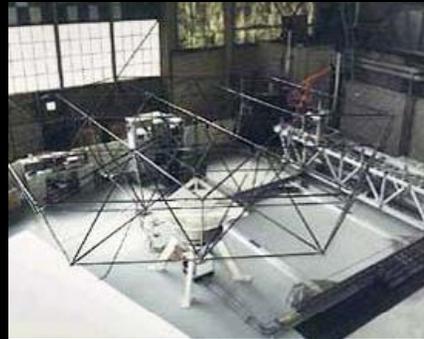
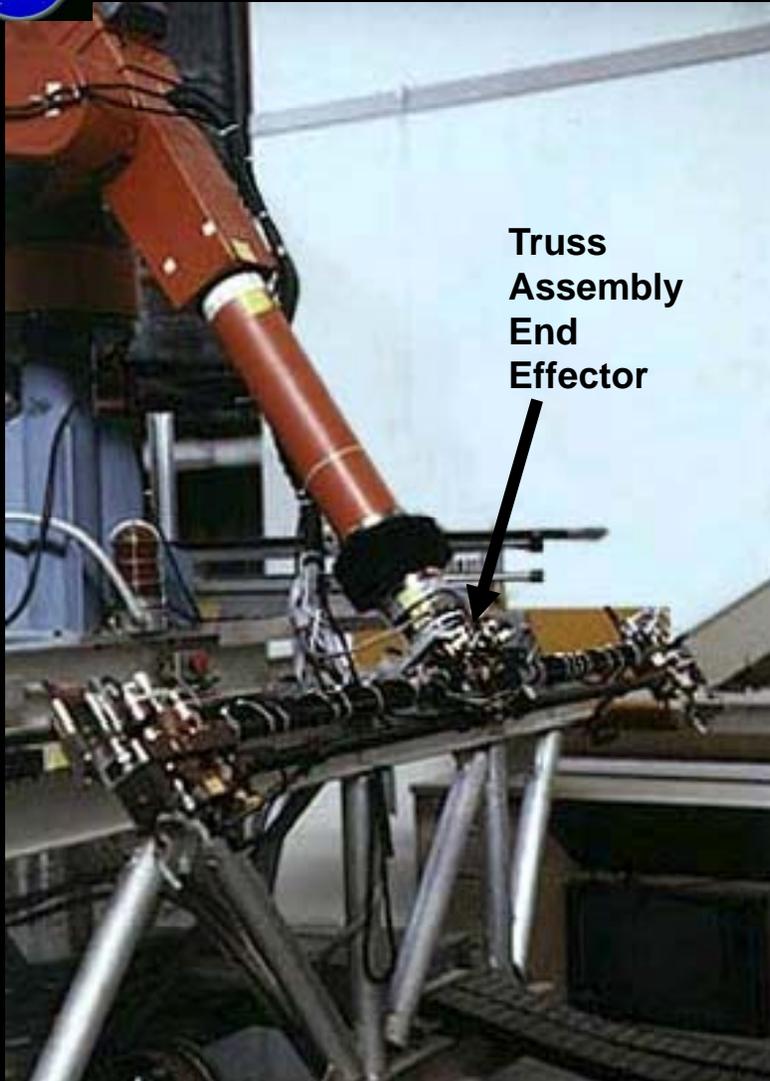




Honeybee's OOS Background

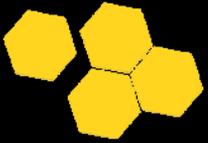


On-Orbit Robotic Assembly of Large Truss Structures



Precision, EVR/EVA-Compatible
Mechanical Joint

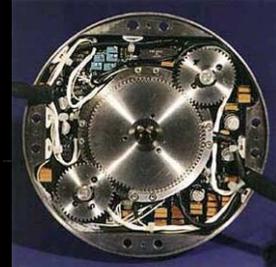
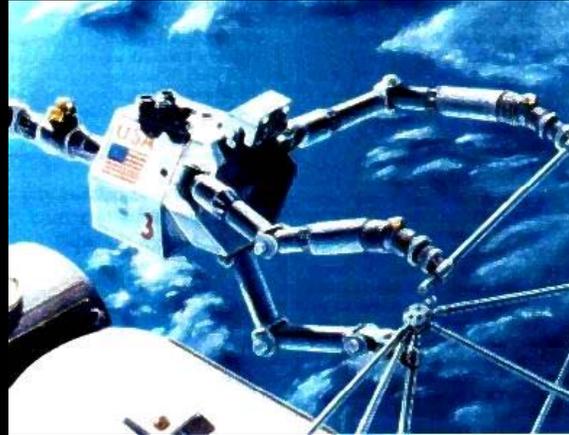




Honeybee's OOS Background



Worksite Attachment Mechanisms



End-Of-Arm Tooling

Flight Telerobotic Servicer (FTS)



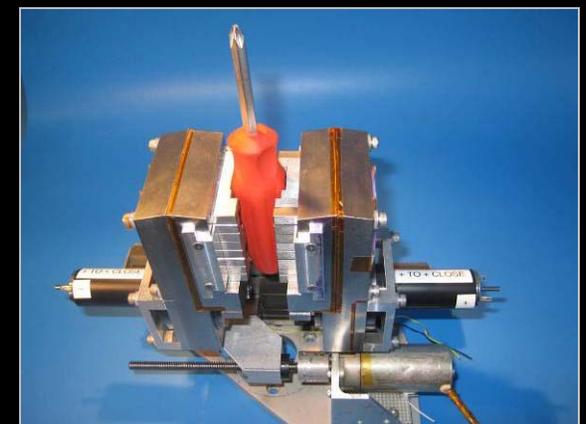
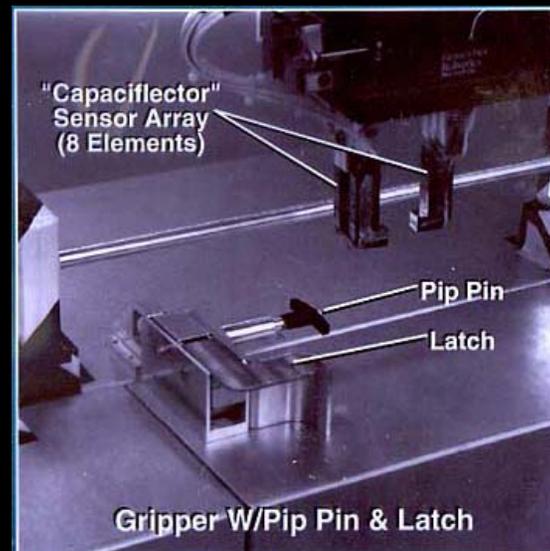
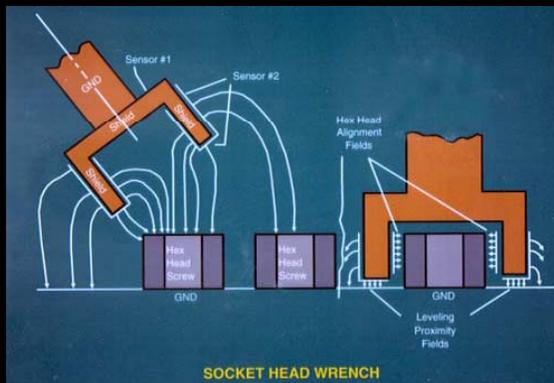


Honeybee's OOS Background



More Examples of OOS Technology Development with NASA Goddard

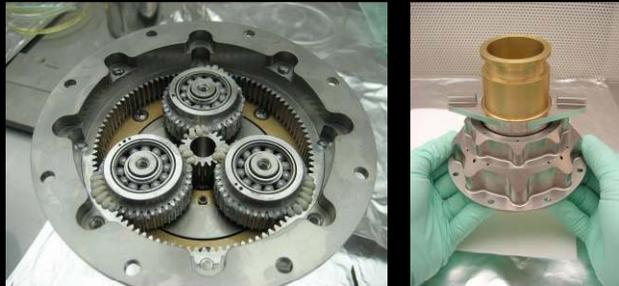
- “Capaciflector” Sensor Array
 - object recognition, avoidance
- HST Tool Box Gripper
- Conformal Gripper





Honeybee's CxP Related Technology Development

- Orion Crew Exploration Vehicle



- SADA High Precision Planetary Drive

- Surface Systems



- 3D Mini-LIDAR (vision sensor)
- Robust Connection Mechanisms (Robotic & EVA compatible)

- Other



- Robots for In-Situ Resource Utilization
- Robots for In-Situ Fab. & Repair



3D Mini-LIDAR Vision Sensor

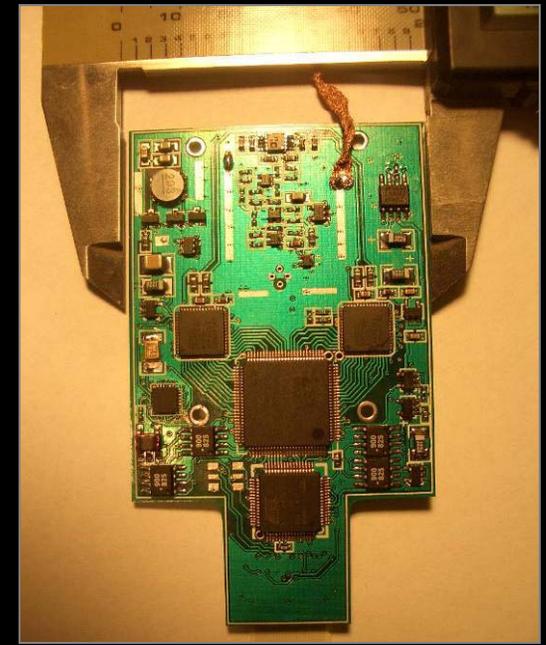
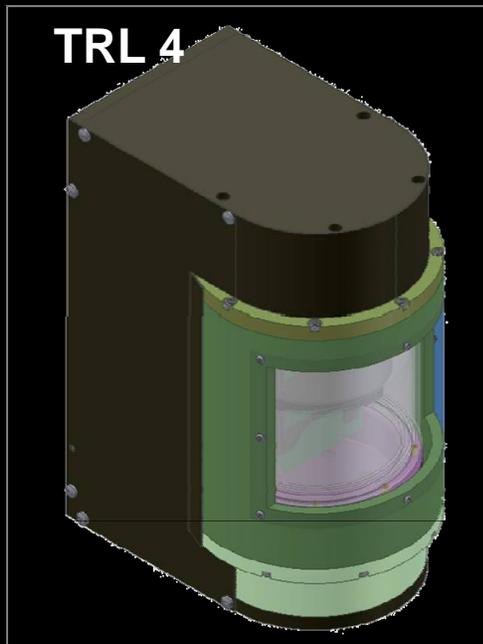
OOS *Utility*: Close Proximity Hi-Resolution, Fast 3D Mapping

- Max. Frame Rate: 25 Hz
 - FOV: 90 x 45
 - Max. Angular Resolution: 630 x 320
 - Approx. Resolution/Range*: 1 cm at 9 m
 - Volume: 76 mm x 76 mm x 127 mm
 - Power: 10-40 Watt
 - Mass: 1.2 kg CBE
- * Example optical design – may be changed to suit mission needs



ARC

Configurable frame rate, angular resolution & FOV to conserve power





Robust Connection Mechanisms

OOS Utility: Making Electromechanical & Fluid Connections



JSC
LaRC
GRC
JPL

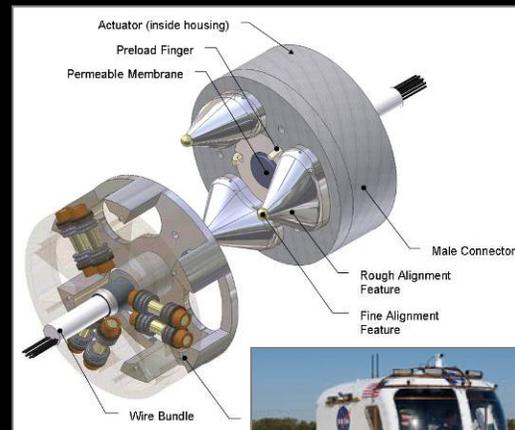
- Spacecraft berthing/docking/mooring
- Electrical and fluid power transfer
- ORU transfer
- Robotic tool quick-change

Rugged Electromechanical Connection (EVA & EVR friendly)

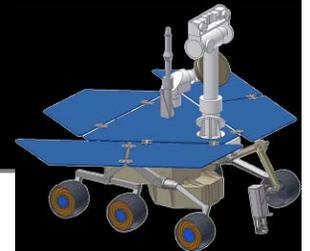
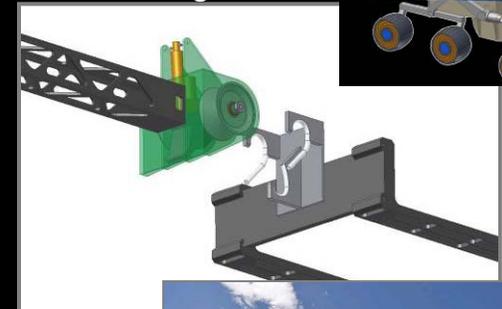


TRL 4-6

Align & Hard Dock



Tool Change





Robots for In-Situ Fabrication & Repair

OOS Utility: In-Situ Fabrication & Repair

EBF3 photos courtesy of NASA Langley Research Center



Electron Beam Free-Form Fabrication (EBF3)

Additive process → Near Net shaped parts

Cuts waste (saves mass/volume)

Intra or Extra Vehicular

Compact Robotic Positioner



Next Phase: Combine Additive & Subtractive processes

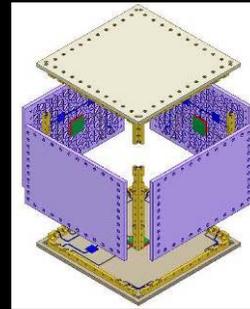


LaRC
JSC



Additional Relevant Tech Development

- Rapid Structural Assembly



Satellite Structure



Quick Fastener

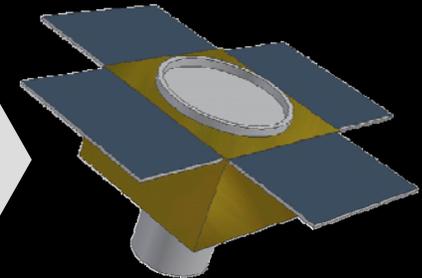
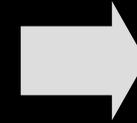


Robotic assembly

- Attitude Control & Positioning Mechanisms for Small Sats



High torque mini-CMG



10kg to 100kg satellite

- Web-Capture Spacecraft Docking System



Web Docking Prototype



- Honeybee develops Technology & Products for Advanced Robotic & Spacecraft Systems
 - Manipulation & Sensor Hardware
 - Flight Hardware
- Long history in Robotic OOS
 - Numerous NASA and industry collaborations
 - On-Orbit Assembly & Repair
 - Manipulation and fastening strategies
- Several new technologies for OOS
 - CxP → Robot Vision, Connection, ISFR
 - Other → Rapid Assembly, Small Sat Mechanisms, Docking Technology



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