In-space Assembly of Large Telescopes for Exoplanet Direct Imaging

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Aperture size limited by launch vehicle
Future science needs will require increasingly large telescopes
In-Space Large Aperture Telescope Assembly
Evolvable Space Telescope (NGAS)

Polidan et al. 2016
In-Space Large Aperture Telescope Assembly
Using the Deep Space Gateway (cis-Lunar orbit) to assemble
In-Space Large Aperture Telescope Upgrade

Telescope returns from ESL2 for servicing at EML1

Courtesy: Future In-Space Operations (FISO) working group (2007)
In-Space Large Aperture Telescope Assembly
Free-fliers (e.g. Orion) and assembly module docked to spacecraft bus
DARPA Orbital Express (2007)

- Multiple autonomous berthing and docking maneuvers

**In-space firsts:**
- Transfer of fuel
- Transfer of a battery through the use of 3-m long robotic arm
Robotic Servicing Missions
DARPA Robotic Servicing of Geosynchronous Satellites (RSGS)
Robotic Servicing Missions
Restore-L (NASA GSFC)

- **Refueling an existing satellite (Landsat 7)**
- **Future capability demonstrations:**
  - Observatory repair
  - Instrument replacement
  - On-orbit assembly and manufacturing

NASA GSFC
Beam Assembly Teleoperator (1983)
Neutral buoyancy robot (Space Systems Laboratory)

Accumulated a large database comparing human and robot performance in space.

Demonstrated the ability of robots to assist astronauts during EVA excursions.

http://www.ssl.umd.edu/projects/rangernbv/background.html
ACCESS and EASE (1985)
Astronaut demo of large-structure piece-parts assembly

ACCESS (NASA LRC)
EASE (NASA MSFC and SSL)

https://en.wikipedia.org/wiki/EASE/ACCESS
ISS Robotic Systems
ISS Robotic Systems
Canadarm

https://www.youtube.com/watch?v=q7N4WD4pgLQ
Optical Testbed & Integration on ISS eXperiment

In-space assembly demo of a segmented space telescope (2012)

- Intended to demonstrate assembly, alignment, calibration, and operation of future space observatories
- Robotically assembled and operated
Optical Testbed & Integration on ISS eXperiment
Robotically assembled and operated

Assembled modules

Full deployment of sunshades

6 launch modules for assembly

3 Mirror Anastigmat Telescope (1.45m aperture)
Robotic Assembly of a Telescope
Modular deployable structure
In Space Telescope Assembly Robotics
Multi-limbed robot

Lee et al. 2016 (Caltech/JPL)
In Space Telescope Assembly Robotics

Multi-limbed robot

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In Space Telescope Assembly Robotics
Unobscured Ritchey-Chretien
In-Lab Telescope Truss Assembly Robotics
DARPA-funded JPL 3-m telescope assembly demo

Stowed DTMs

Use adjustable structural and power interconnects

Autonomous mobile manipulation for precision repeated robotic assembly

Assemble 3m closed kinematic truss around a central hub (spacecraft surrogate)
In-Lab Telescope Truss Assembly Robotics
DARPA-funded JPL 3 m telescope assembly demo

In-Space Telescope Assembly Robotics Risk Reduction

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Large Solution Space for In-Space Assembly

- Cis-lunar station
- Free-flying servicer
- Mobile assembly robot
- Fixed assembly robot
- Astronaut support
- Telescope spacecraft bus
- In-space manufacturing