Infrastructure for a Permanent LUVOIR Observatory in Space

FOUNDATION FOR CONTINUING ASTRONOMY IN SPACE

NASA MIRROR TECHNOLOGY DAYS
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REVIRESCO LLC
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  - Ronald S. Polidan
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- Images by NASA
  - Unless Specifically Noted Otherwise

A COMPLETE OBSERVATORY……

ON THE MOUNTAINTOP

REQUIRES………

A COMPLETE INFRASTRUCTURE……

ON THE MOUNTAIN

LARGE……

W. M. Keck Observatory

SMALL……

In-Space Astrophysics

Requires an Evolving Science Fleet

- Determine What Ground Observations Do Not Do Well (Or At All)
- New Flagship Class Capabilities Every Decade or So
  - Vital for critical high resolution observations
  - And for general astronomy / astrophysics observations
- Supplement With Smaller Systems: Probes and Explorers
  - More rapid programmatic response to newly identified questions
  - And less expensive
  - May want to service, replenish, and switch instruments on all space platforms
- Indicates need for an In-space Astrophysics Infrastructure
  - To support all sizes of Space Telescopes and Instruments
  - And science spacecraft designed and built for upgrades, major and minor

Embryonic Space Observatory

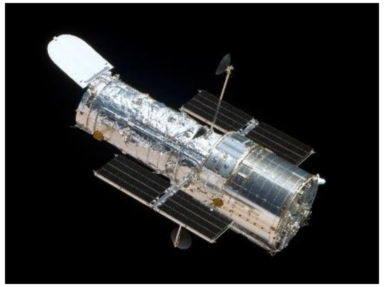
- Starts small but with a full scale Observatory in the future
  - Lifetime approaching a century
    - Constant growth, modification, and upgrading
    - And removal of obsolescent elements
    - Provide the same science as a sequence of Flagships
  - Support smaller auxiliary telescopes in a complete infrastructure framework
    - Added wavelength coverage (complete spectrum)
    - Perhaps in same SEL2 Halo Orbit, but separated
  - Similar to Mt. Wilson – 100” telescope opened in 1917
    - Approximately same aperture as Hubble
- The Evolvable Space Telescope (EST) Provides an Initial Concept
  - Perhaps the Embryonic Observatory itself
  - And a core capability for long-term growth

Evolution

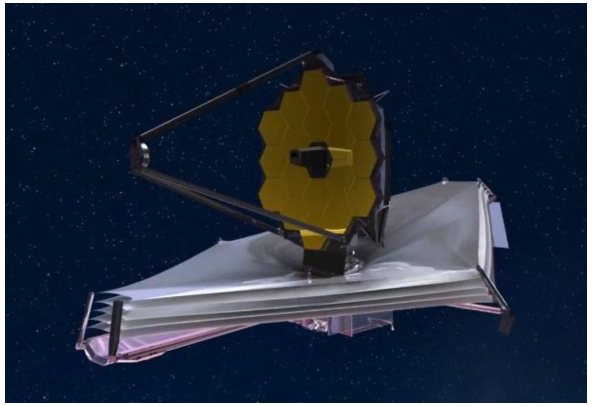
- The Beginnings:
  - The Evolvable Space Telescope (EST)
  - In-Space Assembly and Servicing Infrastructure
    - Large scale to small scale to touchup
    - Significant dependence upon developments outside SMD
- Conduct Upgrades and Servicing Missions
  - Expedite Selected Upgrades, Repair Malfunctions
  - Possibly Enable Earlier Launches with “Incomplete” Technology/Subsystems
  - And Provide Operational Demonstrations of Servicing as Confidence Builders
- The Goal: a semi-permanent LUVOIR Observatory at SEL2

Two Telescopes – An Observation

- Hubble Space Telescope (HST) began life with an in-space support infrastructure
  - The Space Shuttle
  - Lifetime has reached 25 years
  - And continues……….

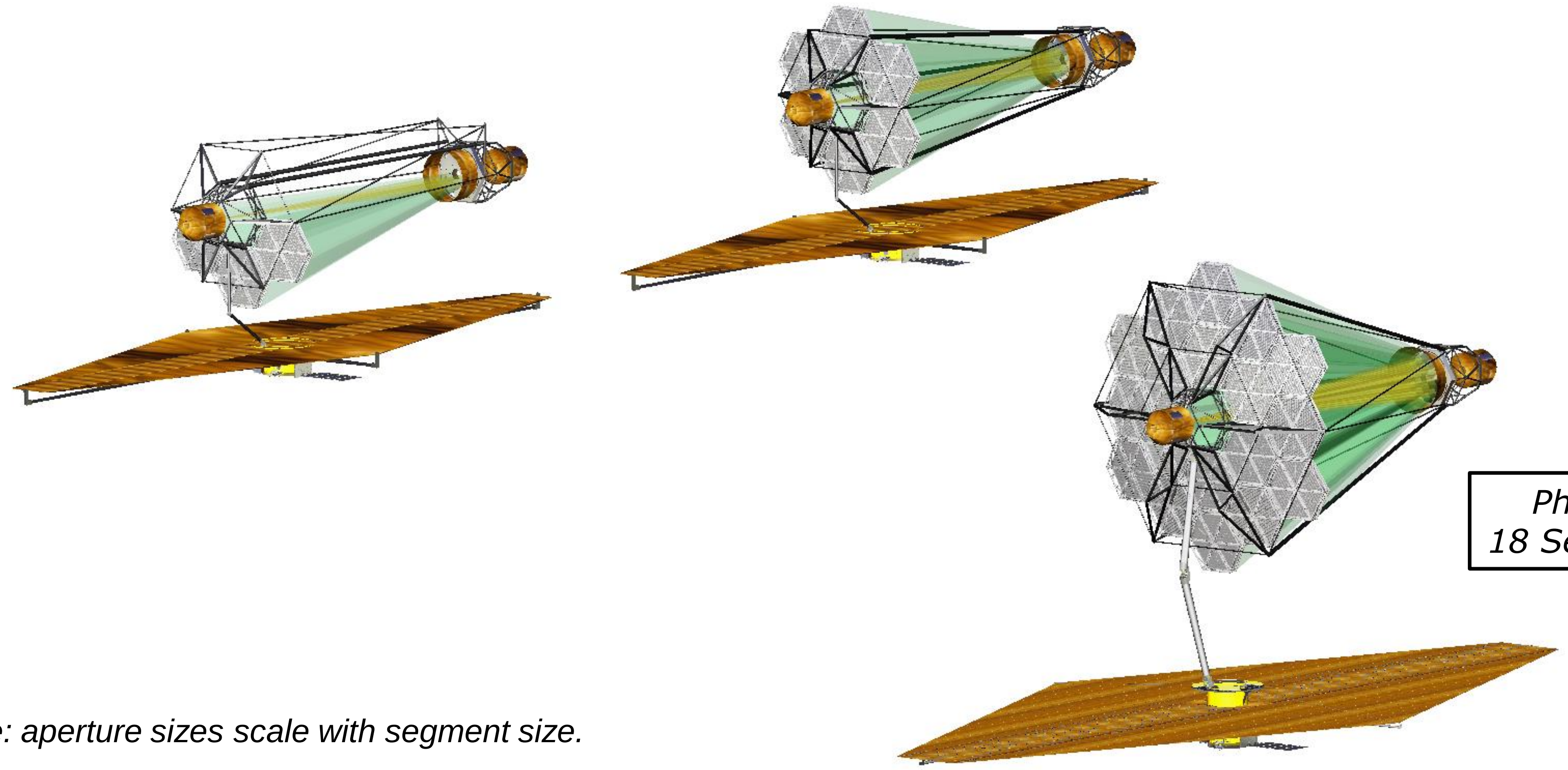


- James Webb Space Telescope (JWST) will begin life with no in-space support infrastructure
  - Expected lifetime of 10 years
  - And………….



Evolvable Space Telescope

Three Phases



Note: aperture sizes scale with segment size.

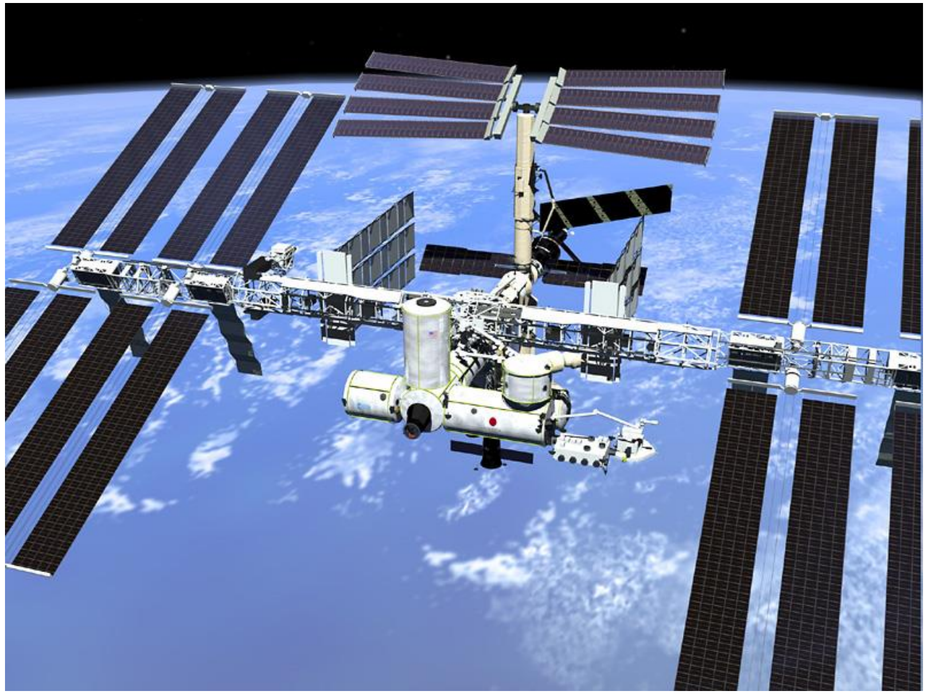
Assembly and Service Infrastructure

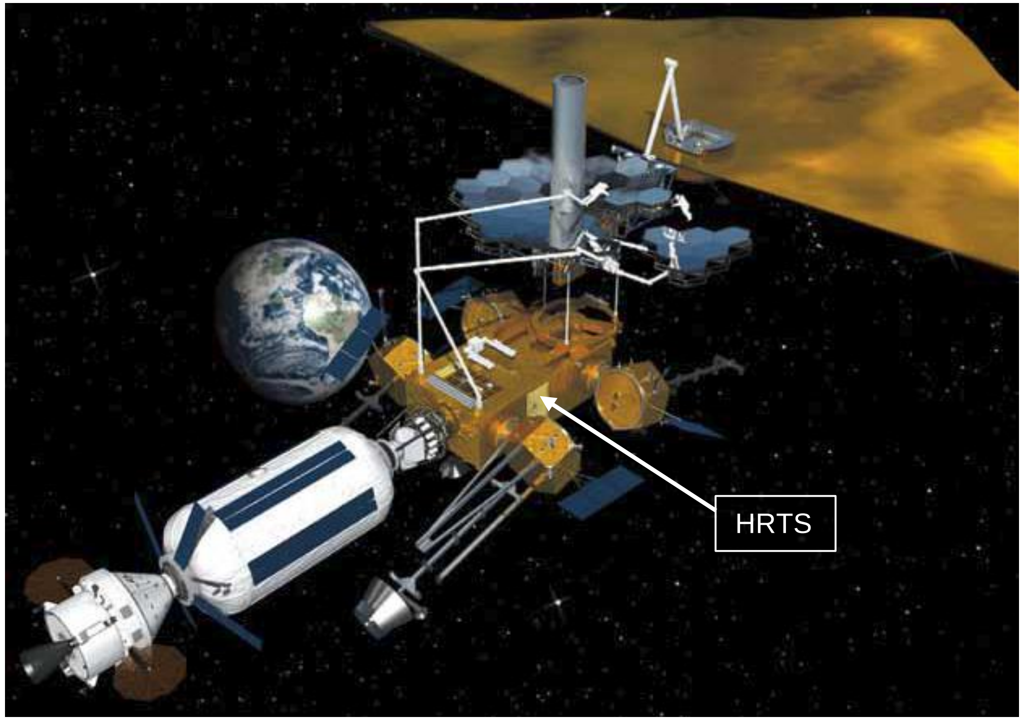
- MacroPlatforms: Crewable; e.g., ISS, Deep Space Habitat (DSH)
  - Capable of complete servicing missions, manned or unmanned
- MiniPlatforms: Generally not equipped for crew
  - Too small or inappropriate for life support (mission length, etc.)
  - But can carry out "significant" servicing (to be defined)
- MicroPlatforms: e.g., SPHEREs
  - Limited roles, but potentially important, such as:
    - Evaluating servicing in volumes too small or hazardous for other systems
    - Inserting small components into such areas
    - Rehearsing orbit maneuver

An Effective Long Term Infrastructure Must Include A Mix of All Three
But Attention Has Focused on Macro and Micro – With Little Exception
Hence, A Need to Consider Mini

MacroPlatforms

International Space Station (ISS)



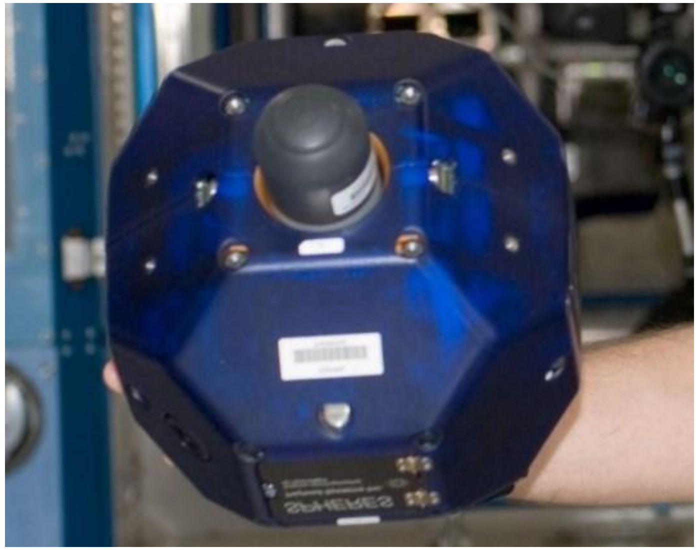


Deep Space Habitat (DSH) and Human/Robotic Telescope Servicer (HRTS)* Assembling a Large Space Telescope

*Appendix F: Notional Mission 5, "On-Orbit Satellite Servicing Study: Project Report", Goddard SFC, Oct 2010

MicroPlatforms

SPHERES



Demonstrate Telerobotic/Autonomous Guidance, Navigation, Rendezvous, and Docking Under Microgravity Conditions

CUBESATS

NASA CubeSat

MiniPlatforms

Principal Area of Interest

- Systems have been studied, but not built and deployed
  - Functions performed by subsystems on the parent mission spacecraft
  - Robot arms on the Space Shuttle, ISS
  - And EVA by Astronauts
- Representative studies
  - Goddard GEO Servicer*
  - Single Person Spacecraft (SPS)
- Following discussion - MiniServ

*Appendix F: Notional Mission 1, "On-Orbit Satellite Servicing Study: Project Report", Goddard SFC, Oct 2010

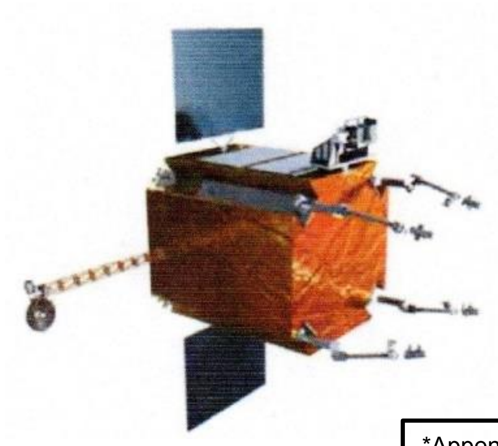
Representative Studies

Single Person Spacecraft (SPS)

- By Definition, A Manned Vehicle
  - Provides Scale for MiniPlatforms
  - Specific Functions, Notably to Replace Space Suits
- Limited by Crew Needs to Neighborhood of Large Manned Systems:
  - International Space Station
  - Deep Space Habitat (DSH)/Transport (DST)

Goddard GEO Servicer*

- Chemically Propelled System
  - ~3700 kg Wet Mass
  - Vicinity of Geostationary Orbit
- Mission To Move About 10 Non-functioning Satellites from GEO to Disposal Orbit (300 km Above)
  - Does Not Service, Replenish, or Upgrade



*Appendix F: Notional Mission 1, "On-Orbit Satellite Servicing Study: Project Report", Goddard SFC, Oct 2010

MiniServ

Unmanned, Long Endurance, Long Range Service Vehicle

- Limited to Deep Space
- Capitalize Upon Libration Point Dynamics
- Perform Limited Servicing Functions

CHARACTERISTICS

- Modularity/Flying Framework
- Libration Points Exploitation
- Small Size
- Expendability
- Reusability
- Flexibility – Short and Long Term

VALUE AND UTILITY

- Unplanned Service
- Assembly and Servicing Assistance
- Escort Duty for MacroPlatforms
- Enable Missions Prior To Large Scale Infrastructure
- Side Excursions in Deep Space

Application Examples (1)

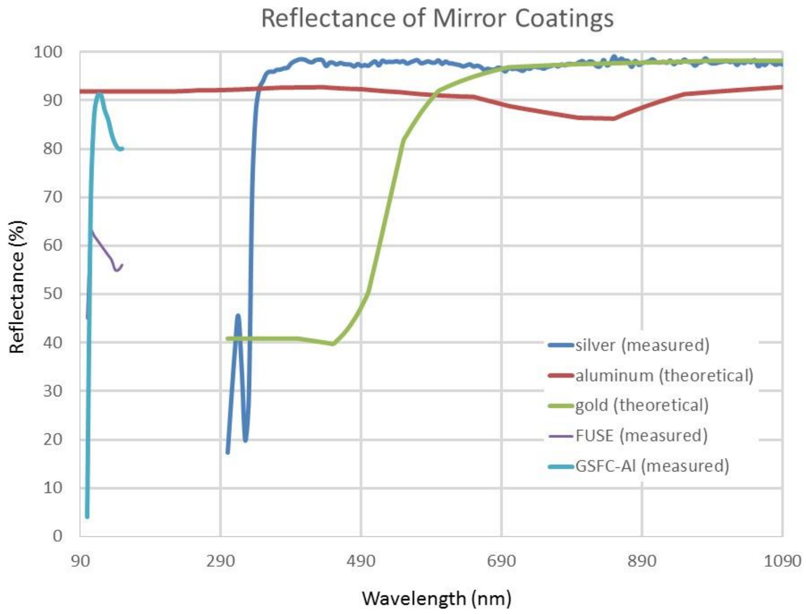
Unplanned Telescope Service

- Base at DSH in Earth – Moon Libration Orbit for Minimal ΔV to SEL2
- Include Small Inventory of Repair Parts at Base
  - Consumables as Well
- Develop a Small Additive Manufacturing Capability for the Base
  - Requires Technology for All Materials Needed on Telescope

Application Examples (2)

Mirror Coating in Deep Space (SEL2)

- Bare Aluminum for UV (eliminate need for protective coating)
- Re-coating (gold, silver,…) for extended system duration – visible, IR
- Repair reflective solar/thermal shades
  - May affect trade between parasol and barrel
- Requires technology development for optical coating in deep space
  - Uniform coating in microgravity
  - Deposition controlled to mirror surfaces only
  - Investigation of Al reflectivity degradation in SEL2 orbits



ZeCoat Corp, D. Sheikh

Application Examples (3)

Reprovisioning Consumables for Deep Space Systems

- Reduce need for transits of large systems (Telescope, HRTS)
  - Minimize mission loads on DSHs required for human exploration missions
  - Enable more responsive telescope operations
  - Replenish additional spacecraft in same SEL2 Halo Orbit without incurring expense of HRTS operation
- Expand design space for cryogenic missions
  - May not need high capacity active cooling
  - With attendant weight/vibration
- Enable Addition of External Occulter Late in Program Life Cycle
  - See next chart for specific possibility

WFIRST/AFTA Starshade

- WFIRST/AFTA currently planned as next major space astrophysics initiative
  - Could serve as the collector for an external occulter system with relatively minor modifications (To Be Defined) AND IF deployed in SEL2
    - But currently planned for geostationary or Earth drift-away
  - No Starshade planned for deployment, primarily due to long repositioning times required and correspondingly low yield
  - Results enhanced with better propulsion on Starshade
    - And could be used late in WFIRST/AFTA mission to characterize identified exoplanets
- Greater propellant load could be provided by refueling with an early MiniServ
  - Eliminate need to rotate Starshade through propellant depot (or launch anew)
  - Conceivably one of two that could rotate between refueling site and depot
  - Telescope and Starshade would operate in same SEL2 halo orbit
- Concept details need to be fleshed out
  - Changes to WFIRST/AFTA required to enable concept
  - Potential exoplanet yield/characterization enhancement enabled

WFIRST/AFTA Starshade

Reviresco LLC

"A probe class starshade mission can rendezvous with and effectively leverage WFIRST-AFTA to capture early spectra from Earth-like exoplanets and critically inform the design of future exoplanet flagship missions.

Continuing dark energy observations in parallel with starshade observations minimizes the impact to primary mission objectives.

WFIRST-AFTA can be made starshade ready with minor modifications to the baseline coronagraph instrument and by adding a radio system for starshade communications and range measurement."

Para 5.1, "Starshade for WFIRST-AFTA", Exoplanet Exploration Program Analysis Group (ExoPAG) Report to Paul Hertz Regarding Large Mission Concepts to Study for the 2020 Decadal Survey, Hq NASA, 1 Oct 2015

OBSERVATIONS

- The Next Steps in Large Space Telescopes Will Depend Critically Upon:
  - The In-Space Infrastructure Available to the Program Office
  - Or – That Can Be Made Available at the Right Time
- Little to No Infrastructure Limits Development to A Single, Expensive Flagship
  - Essentially A Single Telescope with a Limited Lifetime (5 – 10 – 15 Years)
  - Which Could be Reused with a Very Expensive Service/Rebuild Program
  - Or To Smaller, Special Purpose Telescopes (Probes and Explorers)
- A Developing/Extensive Infrastructure Enables a True Observatory
  - Start Against the Current Most Pressing Science Issues Using Current Technology
  - Build Upon Current Capabilities and Systems
  - Maintain Vibrant Technology Programs for Both Science Missions and Infrastructure
  - And Evolve the Observatory as Technology Develops and Science Issues Deepen
- The Infrastructure Must be a Shared Enterprise
  - All Space-Oriented NASA Directorates
  - Other National/International Space Agencies and Organizations

Plan Space Telescope Technology and Concepts to Capitalize on Servicing

ONE MORE TIME

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