Implementation of Reliability, Cost, and Life Extension via Servicing Logistics

Past, Present and Future

MIT – SOLE – AIAA

SPACE EXPLORATION LOGISTICS WORKSHOP

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30 Years of Satellite Development

[Image of satellite missions and developments over different decades, from 1960 to the 1980s, highlighting various NASA satellites and their contributions to space exploration and scientific research.]
GSFC partnered with JSC in 1972 at the start of Space Shuttle development, following the Apollo era. From this partnership came a lot of good things…

- Shuttle design that assists on-orbit servicing.
  - Most effective Cargo Bay
  - Large robotic arm for capturing and repairing satellites.
- Modular spacecraft designed to be approachable, retrievable, and repairable by Shuttle astronauts.
- Generic Shuttle-based carriers to berth and service on-orbit spacecraft, not exclusive to one particular vehicle.

On-Orbit Satellite Servicing Concept, 1975
The Value of Collaboration

With serviceable spacecraft working with the Shuttle, the need arose for a grapple device—the Remote Manipulator System (RMS).

JSC and GSFC worked together, drawing in partnerships, and produced something that all programs could take advantage of. The Canadian Space Agency involved in robotics, collaborated with multiple NASA Centers to develop the Shuttle robotic arm.

From a GSFC perspective, modular spacecrafts were designed and flown on missions such as:

* Solar Max
* Landsat 4 & 5
* UARS
* Several DoD missions
* GRO
* EUVE
* TOPEX
Multi-Center Participation:

Solar Max Repair

In 1984, the first capture with the arm was during the very first on-orbit servicing mission in history—the Solar Max Repair Mission.

The value of on-orbit repair, Center partnerships, and standardized modularity suddenly became quite high.
Solar Max Repair Mission
Solar Max Repair Mission
Benefit: Avoiding Failures

- NASA rescued several commercial satellites in trouble:
  * Westar
  * Syncom IV
  * Palapa
  * Intelsat-6

- NASA also repaired Government satellites, worth millions of tax dollars.

Before deployment from Shuttle, GRO underwent planned checkout and the stuck High Gain Antenna was discovered. Emergency repair avoided a significant scientific loss.
Multi-Center Participation: What It Takes to Make It Work

• Strategic Alliances—Partners bring unique strengths to the table.

• Symbiotic Relationships—Offer experience base that no other Center has been able to achieve.

• Strategic Technologies—Develop and advance unique technologies, so that they can be offered to other Centers. (e.g., the Pistol Grip Tool) Each Center needs to communicate its strategic technologies.

• Must eliminate Center-to-Center divisiveness and needless competitions.
The Logistics Payoff

HST Monthly Calibrated Science Data Volume

Post-SM4 Data Volume

SM3B

SM2

SM1

CAL in AEG
The Logistics Payoff

Number of Refereed Papers per year based on HST, ESO/VLT, Keck and Chandra

History’s most productive telescope shows no signs of slowing down
The Logistics Payoff

Cumulative Contributions of the 10 Most Productive NASA Programs

Science News metric by G. Davidson

Year

# of Science Stories


HST
Voyager
Viking
Galileo
Apollo
STS
GRO
MGS
Chandra
Rockets/Balloons

# of Science Stories

0 10 20 30 40 50 60

HST Science Payoff
Over the Last Year
Elusive Planet Reshapes a Ring Around Neighboring Star

NASA Hubble Space Telescope's most detailed visible-light image ever taken of a narrow, dusty ring around the nearby star Fomalhaut (HD 216956), offers the strongest evidence yet that an unruly and unseen planet may be gravitationally tugging on the ring.
NASA's Hubble Reveals Possible New Moons Around Pluto

The Hubble Space Telescope has spotted two possible new moons orbiting Pluto, the ninth planet in our solar system. If confirmed, the candidate moons could provide new insight into the nature and evolution of the Pluto system.

NASA, ESA, H. Weaver (JHU/APL), A. Stern (SwRI), and the HST Pluto Companion Search Team

STScI-PRC05-19a
Hubble Finds Mysterious Disk of Blue Stars Around Black Hole

Astronomers are perplexed about how the pancake-shaped disk of stars could form so close to a giant black hole. Andromeda and its complex core can be seen in the illustration and two images. The illustration [lower, right] shows the disk of blue stars nested inside a larger ring of red stars. The Hubble photo [upper, right] reveals Andromeda’s bright core. The image at left shows the entire galaxy.
Astronomers have used the penetrating power of two of NASA's Great Observatories, the Spitzer and Hubble Space Telescopes, to identify one of the farthest and most massive galaxies that once inhabited the early universe. This galaxy appears to have grown very quickly, within the first few hundred million years after the Big Bang.
Hubble Looks for Possible Moon Resources

Preliminary assessment of these Hubble observations suggests new patterns in the abundance of titanium and iron oxides, both of which are sources of oxygen, an essential ingredient for human exploration.

These images reveal fine-scale details of the crater's interior and exterior in ultraviolet and visible wavelengths.
Hubble Finds Infant Stars in Neighboring Galaxy

Astronomers using NASA's Hubble Space Telescope have uncovered for the first time a population of embryonic stars in the Small Magellanic Cloud, a companion galaxy of our Milky Way. Hubble's exquisite sharpness plucked out an underlying population of embryonic stars embedded in the nebula NGC 346 that are still forming from gravitationally collapsing gas clouds.

They have not yet ignited their hydrogen fuel to sustain nuclear fusion. The smallest of these infant stars is only half the mass of our Sun.
Hubble View of Orion Reveals Thousands of Stars

In one of the most detailed astronomical images ever produced, NASA's Hubble Space Telescope is offering an unprecedented look at the Orion Nebula. This turbulent star-formation region is one of astronomy's most dramatic and photogenic celestial objects.
A Glimpse Into The Future
What SM4 will mean to Hubble

- Life extension to 2013 and continued **unique large-aperture access** to the essential UV-Opt-Near IR
- Continuing assault on forefront astrophysical questions
  - Some questions known today, others will emerge with time
- Exploration of Universe with HST at the apex of its scientific capability
  - *Cosmic Origins Spectrograph (COS)—New*
  - *Wide-Field Camera 3 (WFC3)—New*
  - *Space Telescope Imaging Spectrograph (STIS)—actively pursuing repair of STIS instrument*
- Advanced Camera for Surveys (ACS)—Continuing operations
- Near Infrared Camera & MultiObject Spectrometer (NICMOS)—Continuing operations
- Long-term critical synergy with other NASA space missions
- Continuing inspiration to the public and future generations of scientists and engineers
STIS Is The Most Versatile Spectrograph Ever To Fly In Space

Objectives: Demographics of Supermassive Black Holes, Active Galactic Nuclei, Interstellar Medium, Exoplanetary Atmospheres, Solar System Aurorae

- STIS brought 2D/Hi-Res/UV-Opt-Near IR spectroscopy to HST (a unique capability)
- Pioneered studies of supermassive black holes, complex dynamics of galaxy nuclei
- Produced first (only) detection of an exoplanetary atmosphere
- Was producing more papers than any other HST instrument when operations ceased
- With COS, would bring the full set of spectroscopic tools to HST

Supermassive black holes & dependencies on galaxy properties

Exoplanetary atmospheres: increasing the sample to ~ 10!

Active galactic nuclei—making full use of STIS’s unique spatial coverage to probe dynamics of complex objects
Concept for CEV support to HST Deorbit via telerobotic operation of a free-flying robot
Multi-Center Participation: Pallets

- GSFC built 17 different carriers for Shuttle in the past 20 years.

ExPRESS Pallet for Space Station
Future: Space Depot Concept

MPLM launched into 180nm orbit, with gravity gradient stable attitude

Tug orbits 20 nm below ISS, maneuvers to rendezvous with MPLM

Tug captures MPLM with Grapple Arm

Tug boosts MPLM to ISS altitude

Tug rendezvous with ISS. Proximity station keeping allows SSRMS to capture Tug/MPLM

SSRMS berths MPLM/Tug to nadir hatch on Node 2, allowing crew access to pressurized cargo and EVR/EVA access to unpressurized cargo

MPLM/Tug to nadir hatch on Node 2, allowing crew access to pressurized cargo and EVR/EVA access to unpressurized cargo
Future: Space Depot Concept

- Crew fills Tug with refuse
- SSRMS de-berths Tug, Tug maneuvers away from ISS
- Tug de-orbit burn puts Tug on de-orbit trajectory
- Tug separates prior to entry interface
- Tug boosts to raise orbit
- Tug returns to parking orbit below ISS
- Safe reentry
Increasingly large and complex optical systems to achieve priority national goals

Optical systems larger than those currently under development (aka, JWST at ~6.5 m) appear to be beyond the limit of purely autonomous deployment. In addition, the cost and lengthy development periods of these missions argue in favor of on-orbit upgrade and repair capabilities.
Is it possible to enable these critical and disparate national goals with a single facility?

A human-occupied “gateway” for sustained operations, in this case, at one of the Earth-Moon libration points.