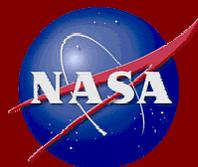

**Future Space Astronomy
and the Vision for Space Exploration:
Some Concepts to Date and Technology Priorities**

**Dr. Harley Thronson, Jr.
Director of Technology
Office of Space Science
<http://spacescience.nasa.gov>**

**Pasadena, CA
June, 2004**





A Robust Space Science Program Consistent with the “Vision”

Emphasis in four broad areas:

A new lunar robotic program and an augmented Mars robotic program to achieve science goals and support human exploration.

Robotic exploration in the outer Solar System specifically to search for life’s other potential abodes.

Seek Earth-like worlds outside the Solar System via astronomical observations.

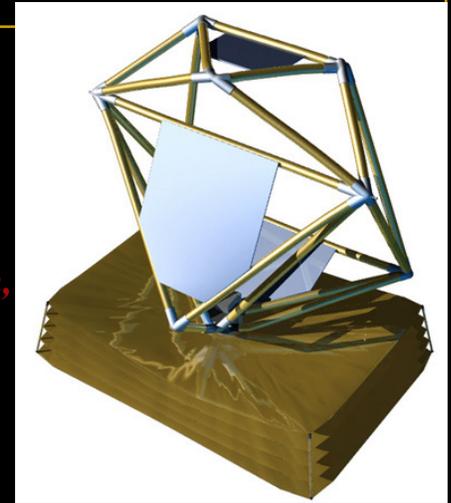
Understand and predict the effects of “Space Weather and Climate” on robotic and human systems.

. . . and the technologies to achieve this.

The NASA Exploration Team (NEXT) -- 2000 - 2002: Concepts for Future Large Optical Systems

Goal: Identify the technologies for the post-JWST optical systems that will be necessary for NASA's search for life beyond the Solar System.

*Telescope
Concept
(Dragovan,
Dooley)*



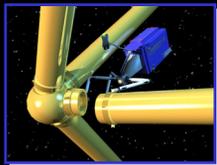
Major Architecture Elements:

- DART concept (JPL)
- Shuttle ETO transportation
- Robotic and telerobotic systems for remote operation
- Advanced EVA
- “Gateway” at Earth-Moon L1 point
- Earth-Moon transfer systems

Collaborations: Academia, JPL, GSFC, DARPA, NRO, JSC, and NASA Earth Science

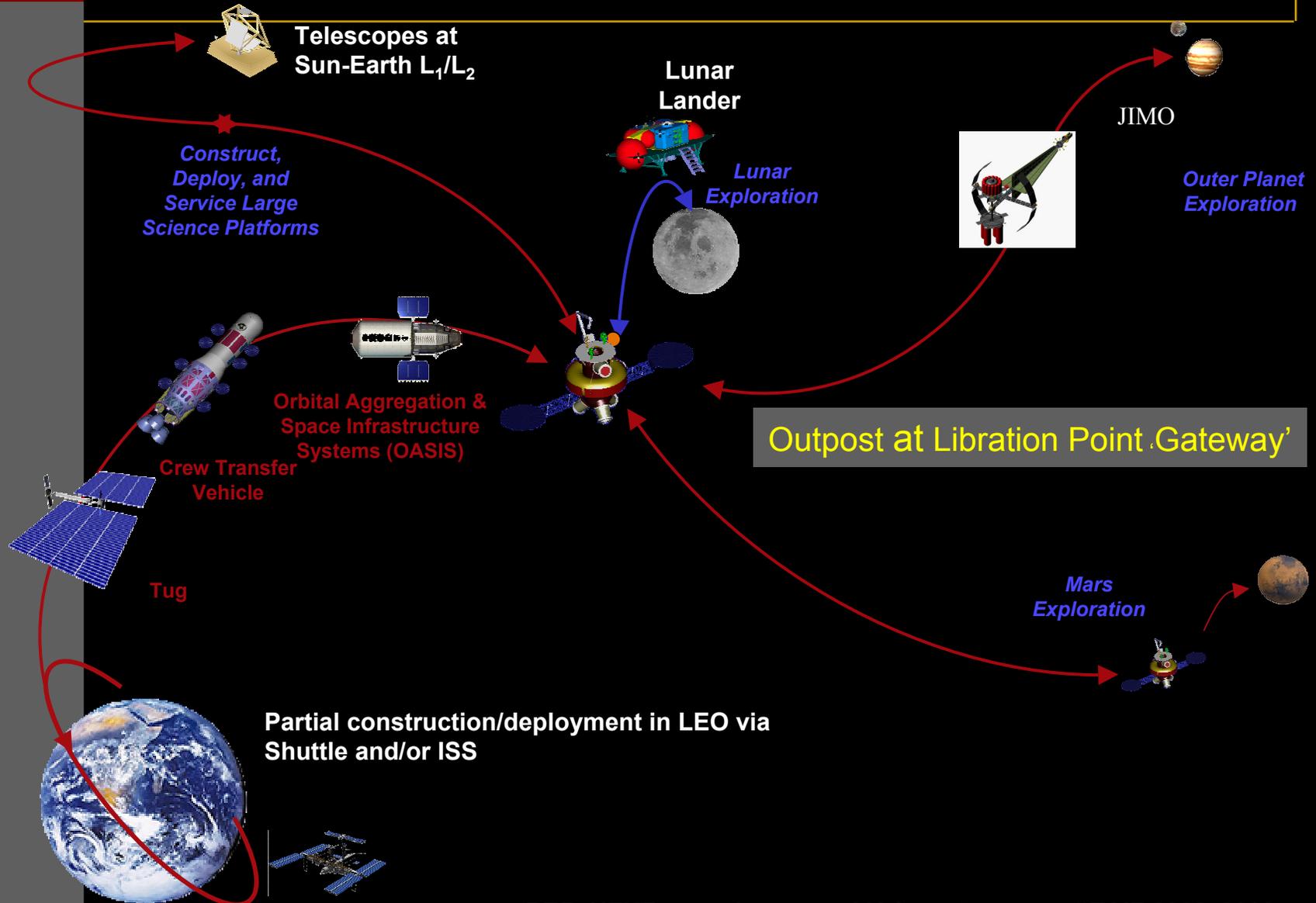


*Remote Telescope Assembly and
Deployment (Animation)*



Potential Telescope Assembly Capabilities

Basic Architecture for Stepping Outward from LEO

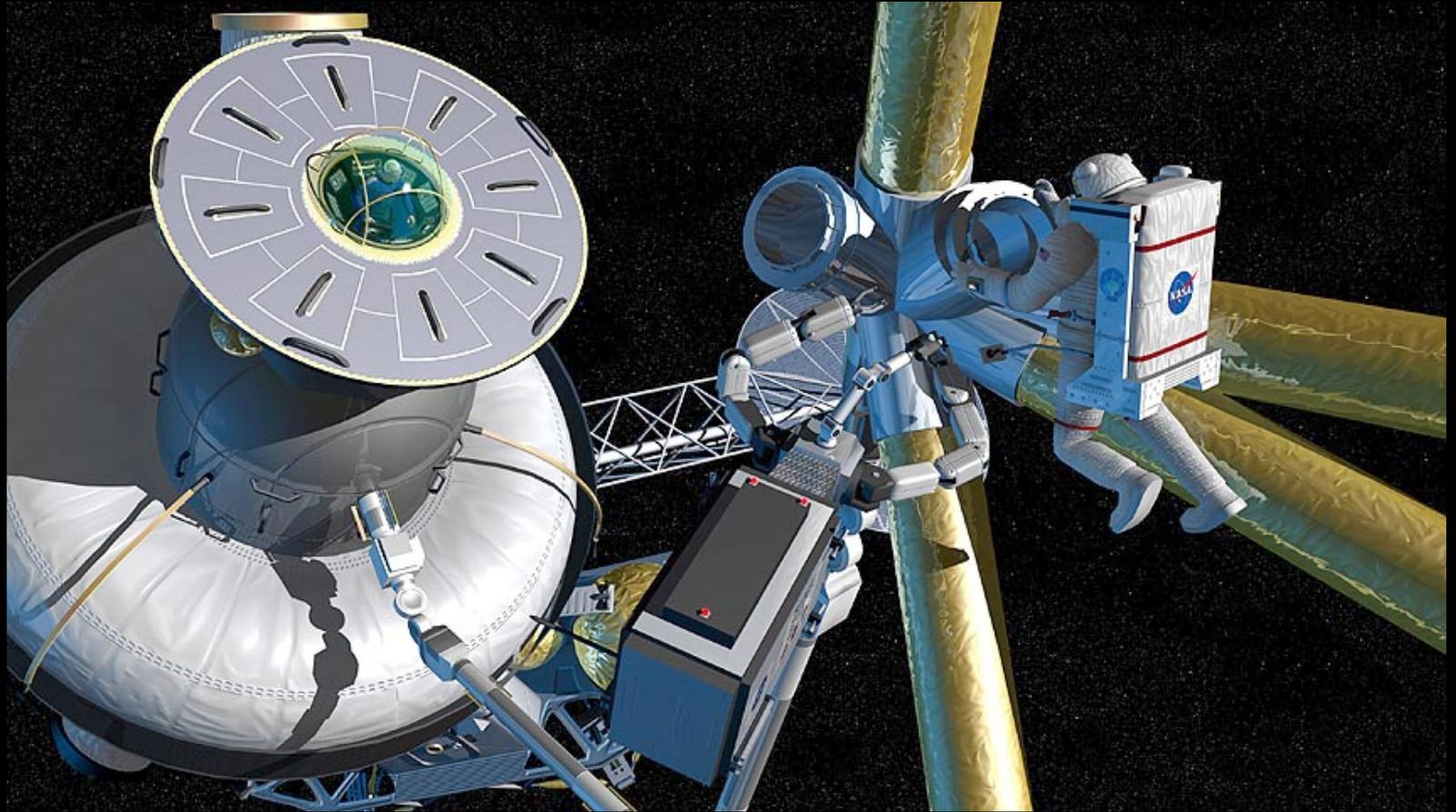


NASA Exploration Team (2002): Core Architectural Element



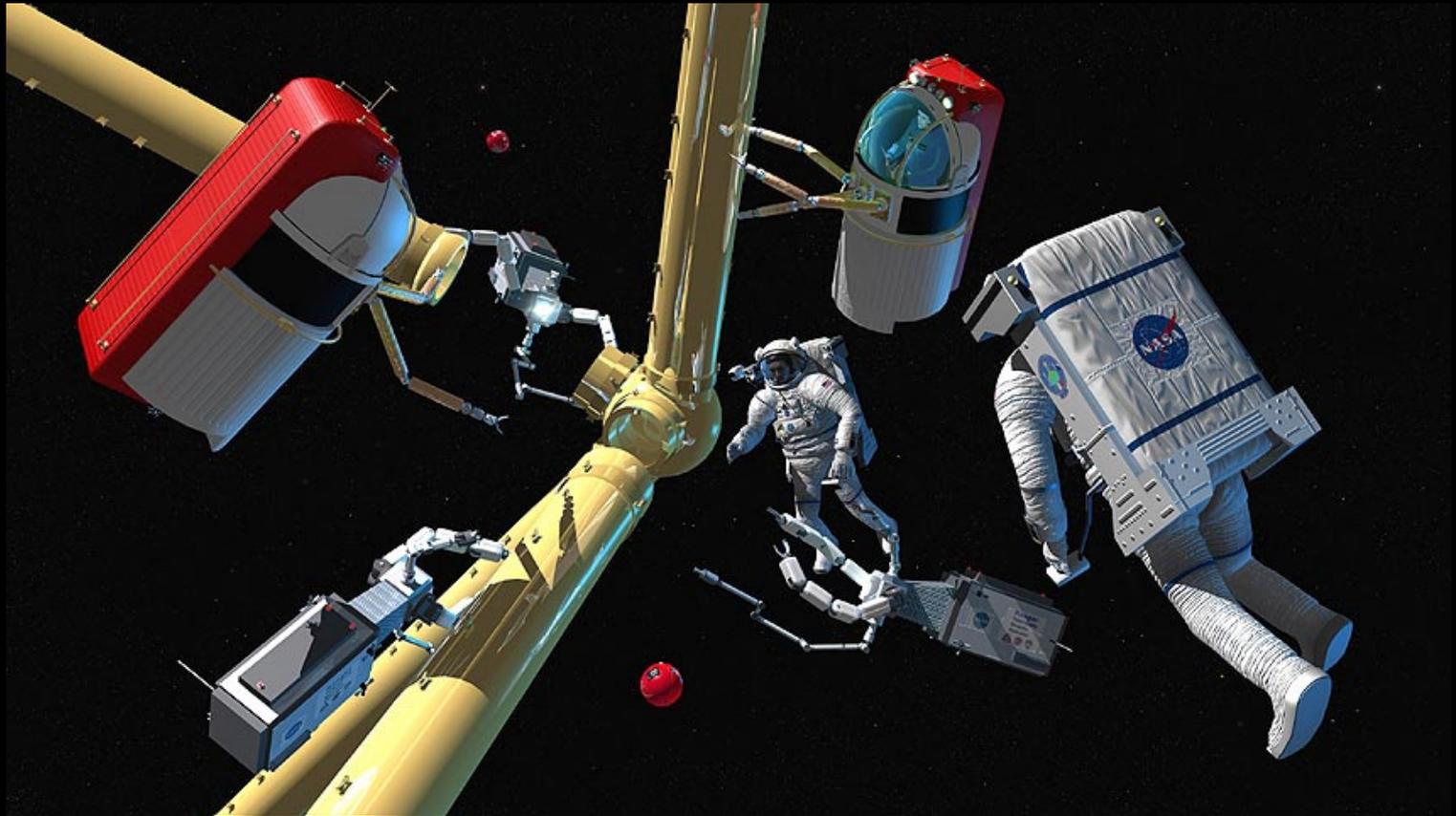
A Libration Point "gateway" facility supporting humans and robots to assemble a telescope to search for Earth-like worlds (Geffre, Ward, Thronson *et alia.*)

NASA Exploration Team (2002): Core Architectural Element



Construction techniques, options, and technologies were assessed for applicability to future large space facilities of a variety of types.

NASA Exploration Team (2002): Core Architectural Element



Analysis tools were developed and applied to optimize use of humans and robotic systems (e.g., Rodriguez, Weisbin *et alia.*)

Key Elements of Mission Architectures Studied through 2002

- Selected a large (10 m), lightweight IR/SubMM gossamer telescope, DART, as the baseline design for conducting initial set of studies. This design tests the limits of conventional deployment/assembly technologies
- Investigated three scenarios for assembly and/or deployment
 - Scenario 1. LEO assembly + E-M L1 deployment--w/astronaut assistance**
(see Filled Aperture Infrared (FAIR) Telescope Assembly 57 pg presentation from JSC, Dec 01)
 - Scenario 2. E-M L1 assembly & deployment--w/astronaut assistance**
(see Human & Robot Cooperative Teams 18 pg presentation from JPL, Jul 02)
 - Scenario 3. E-M L1 or E-S L2 fully autonomous deployment**
(see Summary Report on the NExT Telescope Team Design Workshop from JPL, Sept 02)
- For astronaut assembly concepts, Scenario 1 assumed Space Shuttle-EVA infrastructure and Scenario 2 assumed a Gateway infrastructure are operational & staffed appropriately for assembly of large structures.
- Focused on characterizing & prioritizing new technologies needed to accomplish the mission, as well as developing architectures that achieve multiple Agency goals

NExT Telescope Technology Priorities: Enabling Future Large Optical Systems

•Robotics

- Astronaut assistants (Robonauts/Remote Manipulator System/mini-AERcam)

•EVA/human infrastructure

- Contamination reduction (esp. H₂O, CO₂, O₂, N₂); from suits, airlock, Gateway
- Improvements in dexterity, accessibility, mobility, stability (incl. hand/foot locks) (see HTCI/THREADs advanced EVA/robotics roadmap)

•Instrument lightweighting and mission design philosophy

- Reduce by factors of 10! (packaging, electronics, optics)
- “Simplification is next to Godliness” to minimize risk

•Telescope structural design, materials, optical alignment

- Gossamer design (DART-like structure) vs. lightweight segmented panels (SiC . . .)
- Methods for integrating utilities into structural elements (conn., heaters, actuators)

•Thermal control of structure and reflective surfaces

- Cryocoolers for active cooling: ~ 5 - 15 K for far-IR
- V-Groove radiators for passive cooling (inflatable-rigidizable?)

•Propulsion

- Reliable contamination-free (e.g., Xe) thrusters for pointing/positioning; low-thrust orbits

•Power Generation/Storage

- Gateway robotic operations/astronaut habitat

•Comm: Large data rate from large detector arrays or science is lost

Unresolved Telescope Issues when NExT was Terminated

[Architecture Issues Discussed at AIAA, AAS, STAIF]

- Quantitative effects of contaminants on reflective surfaces need to be more thoroughly understood and documented
 - details regarding how much contamination (by constituent) can be tolerated on surfaces to be used for observations in UV, visible, NIR, FIR, etc)
- Contamination mitigation techniques need to be devised that will limit the effects of contamination to tolerable levels, for example:
 - Methods for effectively heating the structure/mirror after assembly
 - EVA suits that are much cleaner than contemporary models
 - Airlock techniques that have low contamination impact
- Structural dynamic modeling needs to be done to study
 - the impact on the structure of boost from LEO to L1 or L2 (Scenario 1)
 - the vibration stability of the autonomously deployed structures
- Effects of particle radiation from Van Allen belt on telescope instruments and electronics during boost from LEO to L1 or L2.
- What is the best mission scenario?
 - considering space junk and gravity gradient at LEO
 - considering cost of designing, deploying and staffing Gateway for L1
 - considering need to service both at initial deployment and later add-ons
- Advanced coupled thermal, mechanical, optical modeling of advanced design

Enabling the Future (1): Primer on Next Steps with NASA HQ

Recommended Next Steps for Future OSS Missions

1. Mission Science Goals Clearly Traceable to Vision/OSS Priorities
Strong recommendation by National Academy a good thing: mid-term review of 2001 Decade Review? What is your core message?
2. Follow-on Mission Concepts/Analyses that Accomplishes Four Things
 1. *Priority technology investment strategy (“Road Map”) with advocacy*
 2. *Affordable concept that achieves clear science goals*
 3. *Builds upon preceding technologies and ‘stepping stone’ for subsequent missions*
 4. *Architectural coordination with other Enterprises (OExS)/Agencies/nations?*
3. [New?] Technology Program to Deliver Essential Capabilities: low-TRL funding essentially terminated via creation of OExS
4. Advocacy Within NASA: the NASA Strategic Plan and OSS Strategy (E. Smith as PoC)
5. Repeat as Necessary

Enabling the Future (2): Developing Mission Concepts within NASA

Take Advantage of Recent/Ongoing OSS/OExS Studies

Historically, OSS has not had many formal programs to develop future mission concepts and identify the technologies to enable them.

This has changed -- somewhat -- in the past couple years via:

1. NASA Exploration Team (NExT) (extinct, with reports available)
2. OSS strategic planning process (POC: M. Allen, E. Smith)
3. OSS “Vision Missions” Results (POC: M. Allen)
4. OSS/OExS human-enabling studies (POC: H. Thronson/B. Ward/ D. Lester)

=> Identification of technology investment priorities are an essential product of these studies. Concepts and architectures, with clear advocated science goals probably next priority -- Wednesday morning at “Beyond Spitzer”?

Enabling the Future (3): Technology Prioritization within OSS

Making Technology Happen Within OSS

Historically, OSS has not had many formal programs to develop the long-range technologies necessary to enable future missions.

This has changed -- somewhat -- in the past couple years via five activities:

1. The In-Space Propulsion Program
2. The Prometheus Program (now in OExS)
3. The Advanced Communication initiative
4. Process for FY06 initiatives is about mid-way complete
5. Coordinated funding opportunities with OExS
 1. *Large space structures*
 2. *EVA, space robotics, telerobotics*
 3. *Very low-power electronics*
 4. *Others: information systems, materials, . . .*

=> Technology investment priorities are determined via technology roadmapping within OSS Divisions: Montemerlo, Breckinridge *et alia* play key roles in tech investment strategies

Draft “Next Steps”: Technology Director

Some OSS “Front Office” Options

A handful of options are underway in response to science priorities of OSS and the Vision for Space Exploration, including

- Coordinated support (with OExS) of human/robotic-enabling of future large, complex science facilities
- Identification for OExS technology funding of tech priorities useful to space astronomy although being developed for OExS
- Consideration of a new budget initiative in long-range technologies to achieve OSS responsibilities within the Vision
- Develop architecture options for OSS/OExS planning

However, over the next half year there will be Aldridge Commission report, Congressional hearings, Presidential election, HQ re-organization . . .

The Moon, Mars, and Beyond
...the search for life:
Humanity's most enduring quest

