Future Applications of Lightweight Expandable Structures for NASA Space Science

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Dr. Gregory Davis
Chief Technologist Mechanical Systems Division
Jet Propulsion Laboratory
California Institute of Technology

50th AIAA/ASME/ASCE/AHS/ASC SDM
17th AIAA/ASME/AHS ASC
11th AIAA NDA
10th AIAA GSF
5th AIAA MDOS
Where are we now? Over 70 NASA robotic explorers, plus a number of international missions (some examples)

- **Spitzer** studying stars and galaxies in the infrared
- **GLAST** studies universe at high energies
- **ESA Venus Express** orbiting Venus
- **ESA Rosetta** to study comet in 2014
- **Hubble** studying the universe
- **Aqua** studying Earth's oceans
- **CALIPSO** studying Earth’s climate
- **Two Voyagers on an interstellar mission**
- **Aura** studying Earth’s atmosphere
- **Rovers “Spirit” and “Opportunity”** studying Mars
- **MESSENGER** encountering Mercury
- **Japanese SELENE** studying Earth’s moon
- **New Horizons** on its way to Pluto
- **Chandra** studying the x-ray universe
- **QuickSat, Jason 1 and 2, CloudSat, and GRACE** (plus ASTER, MISR, AIRS, MLS and TES instruments) monitoring Earth
NASA Science Thrusts

Science News
- Double Discovery: Super-Earth and Ocean World
- NASA Puts the Right Stuff in the Right Hands
- Celebrate Earth Day!
- Do We Need a New Theory of Gravitation?

For Researchers | For Educators | For Kids | Citizen Scientists

Earth
- Atmospheric Composition
- Weather
- Carbon Cycle & Ecosystems
- Water & Energy Cycles
- Climate Variability and Change
- Earth Surface & Interior

Heliophysics
- Sun
- Heliosphere
- Magnetospheres
- Space Environment

Planets
- Inner Solar System
- Outer Solar System
- Small Bodies of the Solar System

Astrophysics
- The Big Bang
- Dark Energy, Dark Matter
- Stars
- Galaxies
- Black Holes
- Planets Around Other Stars
Earth Science Missions
Looking back: Shuttle Radar Topography Mapper (SRTM)

SRTM, launched in 2000, is comprised of the previously flown SIR-C/X-SAR multi-frequency, multi-polarization imaging radar system including:

- A 60-meter-long, deployable mast derived from space station designs.
- Additional C-band and X-band antennas located at the end of the mast.
- Avionics for attitude and orbit determination.

Palm Springs
Now: New ways to see a changing Earth with robotic remote sensing

Atmospheric Infrared Sounder (AIRS) provides monthly global temperature maps

Jason provides global sea surface height maps every 10 days

Gravity Recovery and Climate Experiment (GRACE) provides monthly maps of Earth’s gravity

QuikSCAT provides near global (90%) ocean surface wind maps every 24 hours

Multi-angle Imaging Spectro Radiometer (MISR) provides monthly global aerosol maps

Tropospheric Emission Spectrometer (TES) provides monthly global maps of Ozone

Microwave Limb Sounder (MLS) provides daily maps of stratospheric chemistry

CloudSat provides monthly maps of cloud ice water content
Looking ahead: Earth Science missions and opportunities in 2012 and beyond

- SMAP
- DesDynI
- Jason 3
- XOVWM
- Altimeter
- Additional Decadal Survey missions and instruments
“Decadal Survey” Missions

2010–2013
- Soil Moisture Active-Passive (SMAP)
- Ice, Cloud, and Land Elevation Satellite II (ICESAT II)
- Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI)
- The Climate Absolute Radiance and Refractivity Observatory (CLARREO)
- GPS Radio Occultation (GPSRO) — NOAA

2013–2016
- Hyperspectral Infrared Imager (HyspIRI)
- Active Sensing of CO2 Emissions over Nights, Days, and Seasons (ASCENDS)
- Surface Water and Ocean Topography (SWOT)
- Geostationary Coastal and Air Pollution Events Mission (GEO-CAPE)
- Aerosol/Cloud/Ecosystems Mission (ACE)
- The Extended Ocean Vector Winds Mission (XOVWM) — NOAA

2016–2020
- Precipitation and All-Weather Temperature and Humidity (PATH)
- GRACE-II
- Snow and Cold Land Processes (SCLP)
- Global Atmospheric Composition Mission (GACM)
- Lidar Surface Topography (LIST)
- Three-Dimensional Tropospheric Winds (3D-Winds)
Looking back: Astrophysics observatories

Circa 1985

Spitzer, Hubble, Chandra, Compton

Radio, Microwave, Infrared, Visible Light, U.V., X-Rays, Gamma Rays

Temperature Scale

Chart courtesy of Mike Werner
Chief Scientist Astrophysics Directorate JPL
The Cassiopeia A supernova remnant – the debris of a dying star – hosts a range of environments requiring multi-wavelength studies. This composite image demonstrates the power of the Great Observatories.
Looking ahead: NuSTAR

Salient Features

- PI-led (PI: Fiona Harrison, Caltech) SMEX mission
- *NuSTAR* will carry the first high-energy X-ray focusing telescope using 10-m deployable boom
- *NuSTAR* partners include Caltech, JPL, GSFC, Orbital, ATK, UCB, DNSC and Columbia University
- JPL managed project
- Launch readiness date: August 15, 2011
- Science operations: 2 years
Looking ahead: James Webb Space Telescope (JWST)

Salient Features

- 2013 launch
- 5 year lifetime, 10 year goal
- 6.55 m deployable primary
  - Diffraction-limited at 2 μm
  - Wavelength range 0.6-28 μm
  - Passively cooled to < 50 K
  - Zodiacal-limited below 10 μm

- Sun-Earth L2 orbit

- 4 instruments
  - 0.6-5 μm wide field camera (NIRCam)
  - 1-5 μm multiobject spectrometer (NIRSpec)
  - 5-28 μm camera/spectrometer (MIRI)
  - 0.8-5 μm guider camera (FGS/TF)
Looking farther ahead: Astrophysics missions and opportunities in 2013 and beyond

- Terrestrial Planet Finder (TPF)
  Starshades for coronographs

- Single Aperture Large Infrared Telescope (SAFIR, 8-m class)
  Cryogenic Aperture Large Infrared Space Telescope (CALISTO)

- Advanced Technology Large Space Aperture Telescope (ATLAST, 8-, 16-m class)

- Ground-based telescopes and instruments
Concluding Remarks

There are selective opportunities for future applications of lightweight expandable structures for NASA space science. Advances in the following areas of Large Aperture Systems are enabling for both earth and astrophysical science:

**Lightweight, Precision Controlled Structures**
- deployable mounting structures
- dimensionally stable antenna supports

**Lightweight Sun and Star Shades**

**Lightweight Apertures**
- optics with mirror areal densities below those of JWST
- reflectors with large monolithic apertures
- Synthetic Aperture Radars (SAR) with integrated electronics