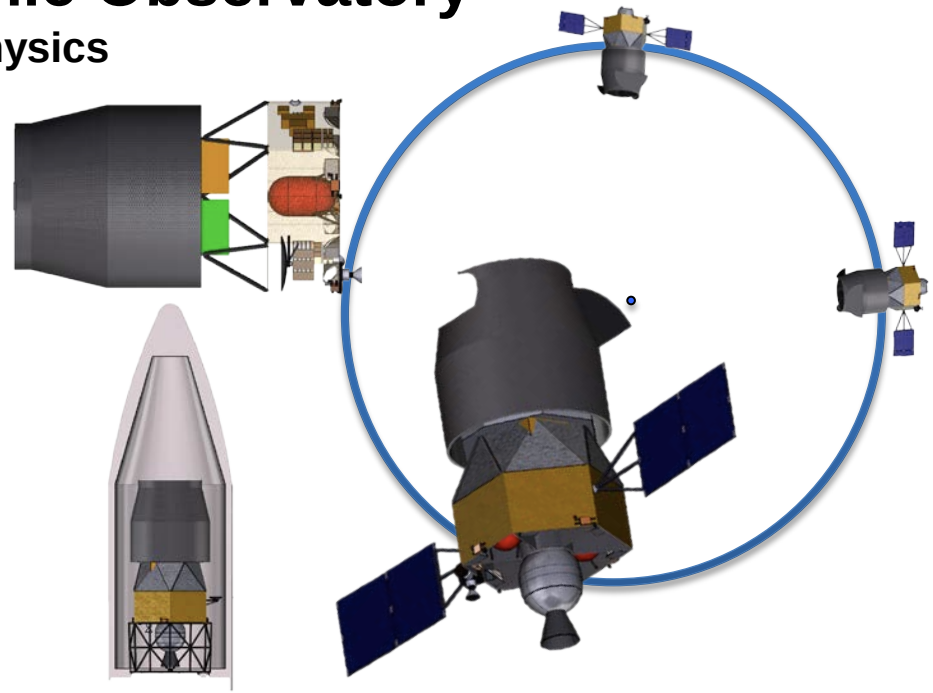
Geospace Dynamic Observatory

Heliophysics



Overview:

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Goals:

- To provide a critical link to understand the coupled Sun-Earth system
- To fill observational gaps for space weather research
- To open a window of discovery that will revolutionize our view of near-Earth space

Description:

- The Geospace Dynamics Observatory (GDO) mission observes Geospace with unprecedented resolution, scale and sensitivity.
- At 60 Re in a near-polar circular orbit (30 day period), GDO images the near-earth region with
  - three far ultraviolet, co-aligned simultaneous imagers
  - an extreme ultraviolet wide field-of-view imager of the plasmasphere
  - a spectrometer in the near to far ultraviolet range that will probe any portion of the disk and simultaneously observe the limb.
- May be combined with astrophysics mission concept
- EOM – park at Earth-Moon L2 with serviceable option to upgrade instrumentation with human or robotic capabilities

Value to NASA:

The Geospace Dynamics Observatory

- Provides revolutionary observations of Geospace required for scientific understanding the coupled Sun-Earth System – the key theme of the 2012 Solar and Space Physics Decadal Survey
- Serves the Nation by enabling predictive space weather capability for the near-earth space environment where the Nation's space assets and ground systems reside and are impacted
- Enables test-bed for human and robotic space operations at Earth-Moon L2 pointe with serviceable instrument bay

Concept Title: Geospace Dynamic Observatory (GDO)

Principle Author: James F. Spann, Manager of the NASA Marshall Space Flight Center Science Research Office. He has extensive knowledge of the NASA Heliophysics program and science having served as the 2009 Heliophysics Roadmap Center Co-Chair, Co-I for Polar Ultraviolet Imager and Participating Scientist on the IMAGE FUV instrument, the PI for several Explorer proposals, an Science Mission Directorate Discipline Scientist for 2 years for the Sun-Earth Connection Division (now the Heliophysics Division) during which he served as Program Scientists for missions in formulation, development and operation, He currently serves on the Senior Review Board (SRB) of the Heliophysics Magnetospheric Multiscale mission, and represents NASA as Co-Chair 1on the National Space Weather Program Committee for Space Weather

Mission Concept: The Geospace Dynamics Observatory mission will observe Geospace, the near-Earth space environment, with unprecedented resolution, scale and sensitivity. In a near-polar circular orbit at 60 Re with 30 day orbit period, GDO will image the earth's full disk with (1) three far ultraviolet imagers, (2) an extreme ultraviolet imager of the plasmasphere, and (3) a spectrometer in the near to far ultraviolet range that will probe any portion of the disk and simultaneously observe the limb. At the end of a 5-year prime mission, the GDO will be parked at the Earth-Moon L2 point.

Concept Category: Heliophysics

Goal of the proposed application: The goal of the Geospace Dynamic Observatory is to gain knowledge of the fundamental physical processes that determine the coupling mechanisms between the Earth's upper atmosphere, its ionosphere/mesosphere/thermosphere system, and its magnetosphere. In achieving this goal the GDO mission will provide significant input to space weather needs of the nation and humanity with long-term large-scale high-resolution images.

The GDO mission directly addresses the science that is prioritized in the 2012 NRC Decadal Survey for Heliophysics entitled "Solar and Space Physics: A Science for a Technological Society". Three of four science goals for the next decade listed in the survey are directly addressed: ***Goal 1 - Determine the origins of the Sun's activity and predict the variations in the space environment***, ***Goal 2 - Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs***, and ***Goal 4 - Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe.*** The GDO mission will not address the origins of the Sun's activity (first part of Goal 1) but will certainly provide knowledge to predict the variations in the space environment in the Geospace where the overwhelming vast majority of space weather impacts to society occur (second part of Goal 1). The GDO mission will provide new knowledge to understand the coupling in Geospace (Goal 2) and provide discoveries of fundamental processes (Goal 3) that are not possible to date using the current state of the art remote sensing and in situ observations.

Furthermore, the 2012 NRC Decadal Survey for Heliophysics identifies 4 new-start notional science missions. The GDO mission fulfills a significant portion, if not all, of two of these notional missions (Dynamical Neutral Atmosphere-Ionosphere Coupling (DYNAMIC) mission and Magnetosphere Energetics, Dynamics, and Ionospheric Coupling Investigation (MEDICI)), and the will augment and likely simplify a third notional mission called the Geospace Dynamics Constellation (GDC) mission. The notional missions DYNAMIC and MEDICI specifically reference the type of observations the GDO mission provides – UV and EUV remote sensing of Geospace. The GDC mission as described in the Decadal Survey would significantly benefit from large-scale images at very high resolution from GDO to constrain and guide analysis of the in situ observations. It is possible that the GDC mission could be simplified if the GDO mission

were to be launched.

Benefits of the Geospace Dynamics Observatory mission: The benefits of the GDO mission are many and very significant considering it long-term up-scalable mission scenario and high temporal/spatial resolution images with increased sensitivity. This mission will address high priority science Decadal Survey for Heliophysics, it will cover the science of at least two and very likely part of a third of the four notional missions recommended in the Decadal Survey, it will provide significant advancement in meeting the nation's space weather needs, and it will open a window of discovery in heliophysics never before possible because of the unprecedented capability made possible with this asset for Geospace remote sensing observations. The time and spatial resolution of the images coupled with increased sensitivity will enable observations never before made. The discoveries and advances in knowledge by confirming or redirecting theories of particle, plasma, field coupling will revise our current thinking and understanding of how the Earth interfaces with space and in impacted by solar variability.

Exceptional capabilities of this mission:

1. Unprecedented improvement in signal to noise for global-scale imaging of Earth's space environment. This will enable changes in the Earth's space environment to be resolved with orders of magnitude higher in temporal and spatial resolution compared to existing data and other approaches.
2. Unique view of the Earth. It continuously views the global-scale evolution while simultaneously capturing the changes at scales smaller than are possible with other methods. It would also have an unrivaled capability for resolving the temporal evolution, over many days, in local time or latitude.

Instrument performance comparison to previous UV Geospace imagers

Parameter	Mission Instrument					
	Viking UV	Polar UVI	Polar VIS	IMAGE WIC	IMAGE SI	**GDO**
Spatial res (km)	20x20	50x200	50x50	150x150	250x250	**1x1**
Temporal res (s)	20	36	12	120	120	**1**
Full globe	No	No	Yes	Yes	Yes	**Yes**

This combination of new capabilities is a proven path to major scientific advances. A few examples of potential advances include:

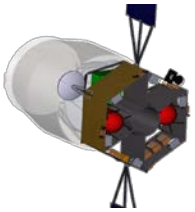
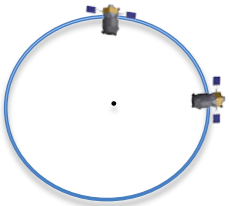
1. Unparalleled advances in the connection of the upper atmosphere to the Sun. In the aurora and lower latitudes, extending the duration of uninterrupted images would advances in understanding the transfer energy from the Sun to the upper atmosphere and in the response of the space environment.
2. Advances in the influence of waves and tides on the upper atmosphere. Increasing both the signal to noise and the duration of the observations would reveal contributions that are not identifiable using other approaches.
3. The ability to probe the mechanisms that control the evolution of planetary atmospheres. The vantage point provided by this mission allows the flux of hydrogen (which is tied to the escape of water from a planet) to be mapped globally. It also allows unique observations of changes in the atmospheric structure and their causes.

Top Level Description of Design, Operations and Results:

The GDO mission will be pointed at the Earth from over 380,000 km observing Far Ultraviolet and Extreme Ultraviolet emissions in Geospace using "solar-blind" sensors. The GDO will not image the surface or lower atmosphere of the Earth.

A preliminary study of the GDO mission concept has been performed. It employs a 3-axis stabilized spacecraft with standard propulsion and pointing systems. Pointing accuracy, knowledge, and stability of 0.1 arc-sec is easily achieved with standard technology. The desired telemetry of multiple 4kx4k sensors at 1-sec readout rate at all times will be a challenge both in terms of coverage and bandwidth. Instruments will be housed in the defined instrument deck and spacecraft systems mounted below. Tertiary telescope mirror and instrument optics will be optimized to achieve maximum field of view and simultaneous imaging. Spacecraft mission systems such as communications, telemetry, power, propulsion, thermal, structural, pointing, are proven with high technology readiness level. Operation is expected to be similar to the existing astrophysics great observatories in which observing time to address specific investigations will be competed. Additionally, a standard suite of science image products will be made available to the science community and operational and applied space weather users. The GDO prime mission life-time is 5 years with a parking orbit at end of mission at the Earth-Moon L2 location.

Results include large-scale high-resolution images in three Far Ultraviolet (FUV) wavelengths selected to maximize quantitative analysis (170 nm, 150 nm, 135 nm) and low-resolution 30.4 nm Extreme Ultraviolet (EUV) plasmasphere images at 1-second cadence.

Alternate architectures to consider during study:

1. Incorporating a serviceable instrument bay to enable upgrades and instrument modification driven by instrument performance, advancement of knowledge and technology.
2. Combination with UV wide-field astrophysics mission concepts to accommodate science requirements of two SMD divisions
3. Direct mission to Earth-Moon L2 position to focus on mid- and equatorial- latitude Geospace science in order to simplify mission concept
4. Combination with a possible Sun-viewing mission concept to create a Sun-Earth Observatory mission concept