National Aeronautics and Space Administration

Geospace Dynamics Constellation
Status and Updates

EXPLORESCIENCE

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Introduction

- Recap of GDC activities
- GDC science review
  - HPD ionosphere-thermosphere strategy
  - HPD support of Artemis
  - HPD support of national interests in space weather
- GDC pre-formulation activities

Recap, GDC Activities

- GDC was recommended as the next Living With a Star (LWS) mission by the 2013 Solar and Space Physics Decadal Survey.

- HPD stood up the GDC Science and Technology Definition Team (STDT) to refine the Decadal Survey recommended science goals
  - Released an RFI for community input, responses to be conveyed to the STDT
  - STDT was convened in 2018, 17 members representing diversity of the IT community
  - STDT delivered the report to HPAC in October 2019
  - HPAC accepted the report and delivered to NASA
    - Recommendation: *Given the importance of timely implementation of GDC in the Heliophysics line of missions, HPAC recommends that an implementation team be formed by NASA expeditiously, and that any potential technology infusion/maturation related to GDC be incorporated in the upcoming FY20 call for technology development proposals.*

- HPD implemented HPAC recommendation in October 2019: GDC pre-project study stood up at GSFC (under LWS Program Office)
  - Continued pre-formulation effort based on STDT report
  - Expected completion of pre-formulation efforts in summer 2020

GDC Science

GDC Goal 1

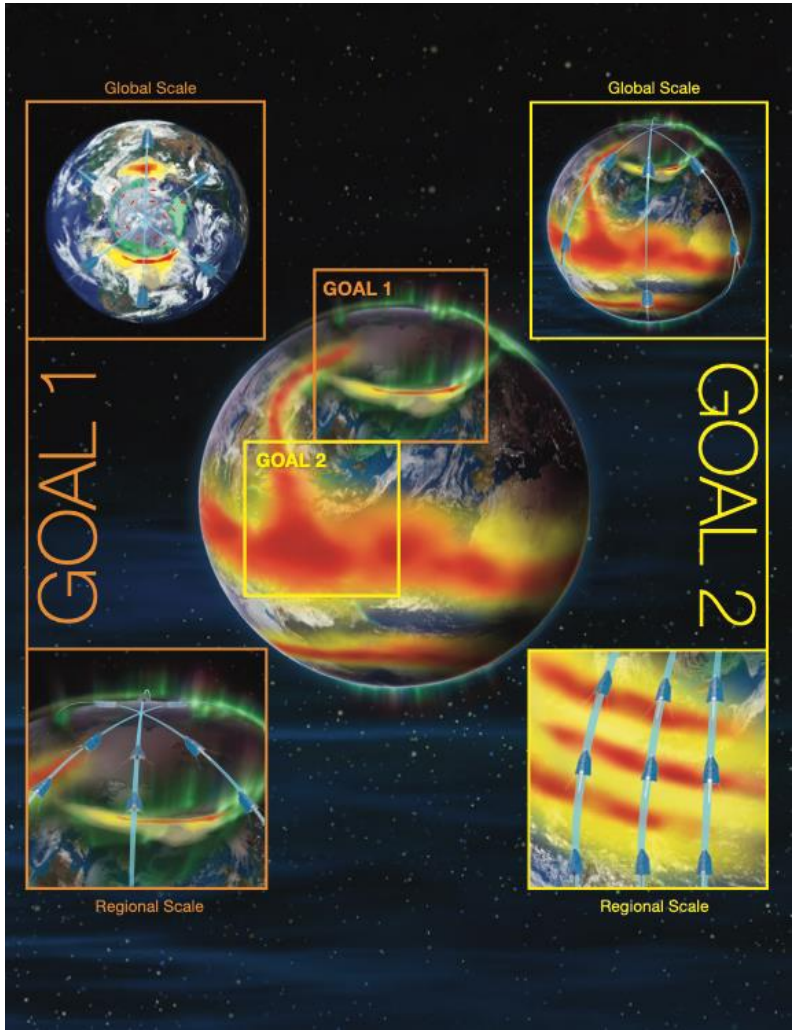
Understand how the high latitude ionosphere-thermosphere system responds to variable solar wind/magnetosphere forcing.

GDC Goal 2

Understand how internal processes in the global ionosphere-thermosphere system redistribute mass, momentum, and energy.

Baseline Mission:
Addresses both Goals, adding the low- and mid-latitude data needed to understand internal processes in Geospace (neutral atmosphere-driven effects and global redistribution of energy and momentum). **Baseline addresses Local, Regional, and Global scales, as well as cross-scale coupling.**

Threshold Mission:
Focused on Goal 1, providing critically needed information about the direct coupling between the Ionosphere / Thermosphere and the Magnetosphere, which primarily occurs at high latitudes. **Threshold focuses on "Global scale" only.**



GDC Science

- STDT refined the broad Decadal Survey recommended science questions into more-focused science objectives that the GDC mission could achieve.
- The STDT report contained 10 Science Objectives and were prioritized into three levels.
  1. Address the significant gap in understanding of the dynamic evolution of the neutral winds.
  2. Address key aspects of the coupled IT system's dynamics and evolution in response to energy inputs.
  3. Address key aspects of variability in the background IT system that affect the systems dynamics and evolution.
- For each Objective, the STDT identified the science measurements that are required and the relevant spatial-temporal scales (which flowed into constellation configuration requirements).

GDC Science, HPD IT Strategy

- HPD has recent IT missions and one more recommended in the 2013 Decadal Survey
  - ICON, GOLD, AWE PI-proposed. DYNAMIC Decadal-recommended.
- What does GDC study that other IT missions do not?
  - The high-latitude region
  - Processes on short, medium, and long timescales
  - Processes on local, regional, and global scales, including cross-scale coupling
  - The simultaneous, coupled structure and behavior of IT
- These missions each complement GDC by addressing distinct but related IT objectives.
  - ICON: Studies 1) structure and behavior of lower thermosphere on ~month timescales, and 2) medium-scale forcing from below. Low-/mid-latitude only.
  - GOLD: Studies 1) large-scale changes in thermospheric structure in response to significant geomagnetic activity, and 2) large-scale forcing from the lower atmosphere on rapid timescales. All latitudes, with focus on low and mid-latitudes.
  - AWE: Studies small-scale forcing from below on rapid timescales. Low- and mid-latitudes.
  - DYNAMIC: Studies large-scale forcing from below on relatively short timescales (hours to days).

GDC Science, Artemis

- NASA is planning a strategy for a return to the Moon as a stepping stone to a sustained human presence at Mars.

- Any preparation for a sustained human presence at Mars must factor in that planet's space environment and the IT responses.
  - Radiation environment, penetration of solar wind energetic particles
  - Space weather effects, including communications, navigation, and orbital drag.
- Mars' crustal magnetic fields means that the IT system there is more complicated than Earth's, but the fundamental physics are the same. In order to fully understand Mars' IT system, Earth's IT must be understood and leveraged as an analog.

GDC Science, Space Weather

Space Weather Mission Impacts

U.S. AIR FORCE

Solar Flares (X-Rays, EUV, Radio Bursts)

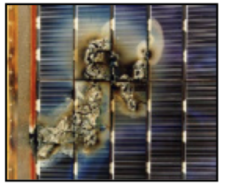
Arrival: 8 min / Duration: 1-2 hrs

- Satellite Orbit Decay
- Geolocation Errors
- RadioRadar Interference
- Frequency Interference
- High Frequency Radio Blackout
- Satellite Communication Interference

Energetic Particle Events

Arrival: 15 min to hrs / Duration: days

- High Altitude Radiation
- Spacecraft Damage
- Satellite Disorientation
- Launch Payload Failure
- False Sensor Readings
- Degraded Polar High Frequency Communication



Scintillation

Daily / Ionospheric Disturbance

- Degraded Satellite Communications
- GPS Error
  - Positioning
  - Navigation
  - Timing

Geomagnetic Storms

Arrival: 1-3 days / Duration: days

- Geolocation Errors
- Space Track Errors
- Radar Interference
- Radio Propagation Anomalies
- Spacecraft Charging & Drag
- Power Grid Failures

Space weather events create effects that impact missions across the Department of Defense

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R. Stoffler, “DoD Space Weather Operations & Mission Impacts” (SWEF, 2019)

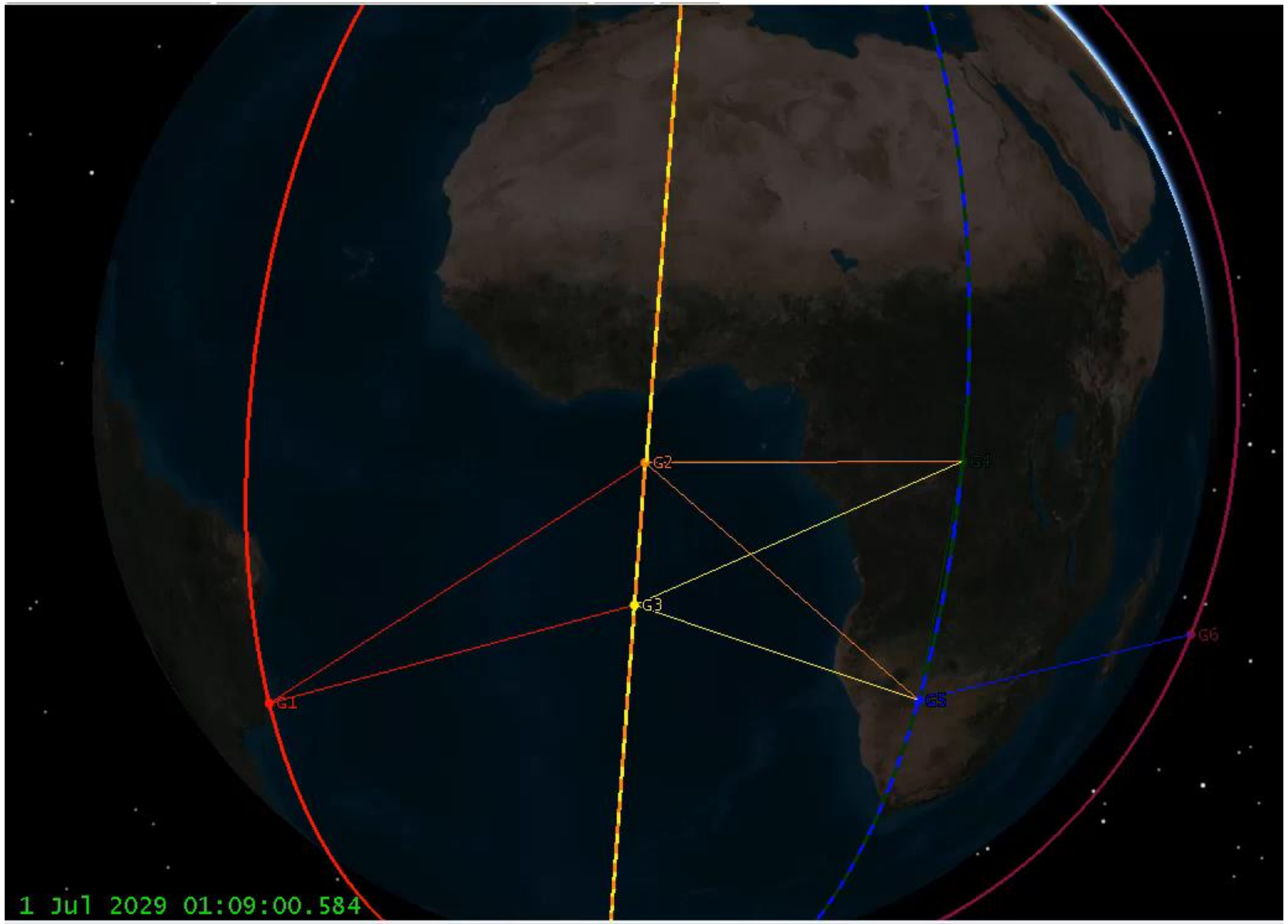
GDC Pre-Formulation

- The STDT discussions and report are the basis for the continuing pre-formulation.
  - Scientific
    - Achievable, focused science investigation
    - Science measurement requirements
    - Constellation requirements and options
    - Modeling and laboratory supporting work
    - Scientific connections to other NASA missions
  - Technical
    - Maturity of required measurement capabilities
    - Production of multiple, identical copies of each instrument
    - Instrument calibration and verification

GDC Pre-Formulation

- GSFC pre-project team has been building upon both of these aspects
  - Scientific
    - Refining science requirements
    - Analyzing constellation configurations to maximize science return
  - Technical
    - Flowing science requirements into mission requirements, analyzing technical risks
    - Two-pronged approach to mission design
      - Leaning forward, studying commercial capabilities that can be leveraged

GDC Constellation Configuration



Questions?