COSPAR

Task Group on Establishing an International Geospace Systems Program (TGIGSP)

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Terms of Reference:

It is now widely recognized that Earth’s magnetosphere is a “System of Systems”, with distinct processes in the various regions, coupled within and across through a cascade of scales all coupled together. Studying this System of Systems requires not just coordinated measurements of the pieces, but constellations of in situ spacecraft to study the mesoscales tying the scales together. Such a global systems observatory network is

beyond the resources of any single space agency, and will require a coordinated effort, akin to the highly successful International Solar Terrestrial Physics Program. The small-satellite revolution and emergence of inexpensive launch vehicles has brought us to a confluence where the scientific need for coordinated multipoint measurements meets our technological implementation capability. This COSPAR Task Group will outline the scientific objectives for the System of Systems program, draft possible observation scenarios, and engage in discussions with researchers and space agency representatives about possible implementation strategies.

Background: We have made tremendous progress in understanding the near-Earth space environment, extending from ~100 km altitude out to Earth's bow shock, since the dawn of the space age some 60+ years ago. From the very beginning, exploration of Earth's magnetosphere was a worldwide effort, starting with the International Geophysical Year (IGY), which included the launch of Explorer I. The International Sun Earth Explorer Program was a joint program in the late 1970's between NASA and ESA that greatly advanced magnetotail, magnetopause and solar wind understanding. Starting in the 1980's the International Solar Terrestrial Physics Program (ISTP), a collaborative effort between NASA, ESA and ISAS, led to the coordinated missions of Geotail, Wind, Polar, SOHO, Cluster and Equator-S, and another quantum leap forward as these missions launched in the 1990s. The ISTP program revolutionized our understanding of Earth's dynamic magnetosphere and its response to solar wind driving. It is a shining example of how coordinated, worldwide efforts can be brought to bear on otherwise intractable problems.

Need: Each magnetospheric system – the magnetotail, inner magnetosphere (itself a "system of systems" with plasmasphere, ring current, and radiation belts), magnetopause, magnetosheath, and ionosphere-thermosphere-mesosphere (another system of systems) – has its own dynamics and characteristics that can be, and have been, studied separately. Similarly, we have flown missions to study processes in the electron scale (MMS), ion scale (Cluster), and magnetospheric scale (THEMIS). Yet there is a clear need to study the way the systems within the larger geospace system interact with each other – how magnetotail dynamics lead to ring current enhancements; how ionospheric outflow modifies magnetospheric response; how meso- and macro-scale reconnection and boundary waves regulates the transfer of energy into the magnetosphere. This cross-scale, system science currently relies on ad-hoc and chance alignments of uncoordinated missions, and significant progress has now stalled.

Task: There still remain major outstanding questions of how the magnetosphere responds to solar wind driving. Questions that are so fundamental to this interaction that it is surprising they are still unanswered. It is abundantly clear that the major science questions of our time are related to how mass, momentum, and energy flow from system to system. The key to this flow is through the mesoscales, the vast region between the microscales that can be studied with our fleet of in situ spacecraft, and the global, which are studied through statistical or average studies. Recent advances in numerical modeling with global kinetic simulations and high-resolution MHD simulations coupled with kinetic codes are continuously bringing new and exciting proposals on how the system works, but await observational verification. To understand this flow of mass, momentum, and energy, to fully understand this undersampled mesoscale regime, requires a reimagination of our measurement approach. To address these questions, we propose a new International Geospace Systems

Program (IGSP) COSPAR Task Group, which will refine the open scientific questions, draft possible observation scenarios, and engage in discussions with researchers and space agency representatives about possible implementation strategies. Our product will be to produce a COSPAR scientific roadmap, with publication in Advances in Space Research.

Read the COSPAR Heliophysics Guidelines here, initiated by the TGISP.