CORNELL

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December 31, 2003

Dear Dr. Giles,

Please find below the LWS Geospace Mission Definition Team response to the 12 December, 2003 update on Geospace investigations. The GMDT thanks you for the presentations on plans for the Geospace missions, core investigations, and potential teaming with partners. We appreciate the opportunity to review progress made since the GMDT report was submitted on August 29, 2002 and we further appreciate being asked to comment on the scientific consequences of various options. We trust that you will find this response helpful and that the response can be used to initiate further progress in LWS-Geospace.

First the GMDT notes that presentations prepared by Dr. Fisher, yourself, Dr. Guhathakurta, Dr. Friis-Christensen and Dr. Haagmans were made to the Team. The GMDT further notes that they were asked to consider the following points.

1. Assess the adequacy of the current Core mission launch dates, particularly with respect to solar drivers.
2. Identify and evaluate the benefits of an "original payload" SWARM trade-off with the GEOSPACE missions to LWS/Geospace science.
3. Identify measurements which require mission simultaneity, considering all available assets, rather than LWS in isolation.
4. Evaluate the impact on Geospace science if unforeseen circumstances eliminate availability of SWARM data.

The launch dates presented to the GMDT for consideration were:

1. Geospace Core mission without SWARM
    a. ITSP spacecraft 3/2010-9/2010
    b. FUV imager 10/2010-4/2011
    c. RBSP spacecraft 3/2012-9/2012
2. Modified Geospace mission with SWARM wherein the RBSP spacecraft and FUV imager are unchanged, only one ITSP spacecraft is

launched, and the SWARM spacecraft includes the addition of one EFI instrument on each of the four SWARM spacecraft

a. ITSP spacecraft 1/2010-7/2010
b. FUV imager 10/2010-4/2011
c. RBSP spacecraft 1/2012-6/2012
d. SWARM EFI 1/2009-6/2009

The GMDT further acknowledges that the SWARM project would be willing to consider the addition of a neutral wind/density instrument in place of (or in addition to) an accelerometer. The SWARM project additionally expressed an interest in launching SWARM as soon as possible, perhaps as early as 2007 or 2008 in order to maintain continuity of measurements with the CHAMP project.

The GMDT first considered the proposed launch schedule of the Core mission without SWARM and reached two conclusions

1. If the ITSP spacecraft and FUV imager are not launched before the next solar maximum, they will not be able to make measurements when the EUV flux from the sun is a maximum and when the ionosphere reaches maximum density. Because the most significant societal impact of the ionosphere occurs at maximum density, the GMDT concluded that the dates noted above are perilously close to solar maximum and every effort should be made to assure that there is no further delay. This point is essential for all of the goals of section 2.3 of the GMDT report (Ionospheric-Thermospheric Variability) and absolutely critical for goal 2.3.5 (What are the Space-Weather Effects of Ionospheric Variability at Mid-Latitudes?).
2. Among the priority radiation belt science goals defined by the GMDT are the investigating the creation and energization of outer zone electrons by high-speed solar streams, during magnetic storms, and changes in the radiation belts produced by shocks propagating in the solar wind (for example see section 2.2.1 of the GMDT report, Which Physical Processes Produce Radiation Belt Enhancement Events?). These phenomena reach a maximum in intensity and rate a few years after solar maximum. Hence the 2012 launch dates for the RBSP spacecraft are also perilously close to the period of optimum science and every effort should be made to assure that there is no further delay.

The GMDT also considered the advantages of teaming with the SWARM mission and found the following advantages.

1. SWARM may be launched earlier (2007-2009) and is likely to be active near solar maximum.

2. SWARM is likely to have an operational period overlapping the SDO mission and would benefit from data acquired by the EUV instrument.
3. The high inclination orbit of SWARM with the magnetometer and EFI instruments will yield energy input into the auroral regions.
4. The four spacecraft in multiple orbits will, by themselves, yield better local time coverage and will also yield gradients in the meridional direction.

The GMDT concluded that items 1, 2, and 3 were significant although the auroral regions are not a priority goal of the Geospace missions. Item 4 was thought to be less significant because the DMSP/NPOESS missions will yield similar orbital coverage as SWARM.

The GMDT also considered the disadvantages of teaming with the SWARM mission and found the following disadvantages.

1. The SWARM orbit is not optimal for mid-latitude investigations. No zonal gradients will be measured and certainly no zonal gradient at two latitudes will be measured.
2. If SWARM is too early, it will not overlap the remaining ITSP spacecraft and FUV imager. At least two years of overlap are required for a sensible data set.
3. The Geospace program would lose coordinated spacing between simultaneous spacecraft and the ability to investigate spatially confined and time varying I-T features.
4. Vector neutral winds will not be measured on two spacecraft although this could possibly be corrected by inclusion of a neutral wind instrument on the lower two SWARM spacecraft (450 km).
5. Investigation of ionospheric irregularities and scintillations are not included in the SWARM system design. This could possibly be corrected with faster data links and increased data volumes.
6. SWARM does not have neutral mass composition measurements implying loss of ability to calculate local recombination rates. This omission takes on added importance if there is no overlap with the FUV imager.

In noting these disadvantages the GMDT concluded that items 1-5 were critical to the success of the Geospace science goals. Item 6 is significant to the success of the Geospace science goals and becomes critical if there is no overlap with the FUV imager.

In summary the disadvantages of teaming with the SWARM mission outweigh the advantages. The cost savings of teaming with the SWARM mission were consistent with this conclusion. The cost studies presented to the GMDT indicated that the savings created by including an EFI instrument on the SWARM spacecraft and deleting one ITSP-LEO spacecraft were much

less than the estimated overrun of the allotted budget by the Ionospheric-Thermospheric investigations. The small budget relief does not compensate for the loss of several core measurements targeted at mid-latitudes.

As requested the GMDT also considered the consequences of teaming with the SWARM mission and then unforeseen circumstances eliminating the availability of SWARM data. In this case only one ITSP spacecraft would be launched. If this should occur, the GMDT felt that the ionosphere-thermosphere science goals should be redefined to reflect the new realities.

The Team thanks the SWARM project for considering the possibility of including Geospace science goals in preparing their mission concept and for their presentations to the GMDT. The Team further feels that the SWARM mission with an EFI instrument can make significant contributions to some Geospace science goals if NASA supports an EFI instrument without Geospace mission funds.

Sincerely,

Professor Paul M. Kintner, Jr. for the members of the GMDT