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Dear Lika,

The Management Operations Working Group, at its meeting on May 10-11, 2004, received briefings on several key aspects of the Living With a Star (LWS) program and the broader Sun-Earth Connections (SEC) program. The MOWG appreciates the wide-ranging and productive discussions. However, we at times found budgetary and programmatic details lacking. Without such details, we feel we cannot fully advise the LWS program managers.

As a result of the presentations and related discussions, the MOWG arrived at several findings that we hope you will find useful in managing the program. With this letter, I would like to summarize these findings and formally transmit them to you and to the Sun-Earth Connection Advisory Subcommittee. It again proved extremely valuable to have Drs. Koskinen, Friis-Christensen, and Schwenn present as members of the MOWG and to have such a good cross-section of discipline representatives from the U.S. community.

The core basic research thrust of SEC has continued to gain momentum with growing realization that the processes that control the Earth's space environment (magnetic reconnection, particle acceleration, turbulence, shock waves) are important throughout the universe. Continued aggressive pursuit of the basic research goals of SEC is crucial both for eventual understanding of space plasma phenomena and to the effectiveness of the more applied work of the Space Weather and LWS programs.

We note that Sun-Earth Connection (SEC) research has been shown to have vast societal relevance. Solar and space physics is an engaging discipline of exploration and it contributes very substantially to numerous national goals. In particular, its research activities have provided critical information on the space environment and the disruptive, and sometimes hazardous, effects it has on human technological systems both in space and on Earth. We now have an excellent Decadal Survey (see below) that will advance our field. We have the traditional relevance of space weather and now have an even broader relevance for the Exploration Initiative. We need to execute our full program in a timely manner to support both, and in particular to support actively the Exploration Initiative. We are prepared as a community to fulfill our role in support of Exploration provided we are given the resources to do so.

The Congress and prior administrations throughout the history of the space program supported the development of major solar and space physics missions and also small

focused missions. These missions are enhanced further by the theoretical and ground-based research programs of the NSF and by space-based measurements performed by NOAA and DoD spacecraft. The relevance of space weather phenomena to technological systems is underscored by the existence of the multi-agency National Space Weather Program. A significant space-based addition to this program is being developed by NASA through its LWS mission line. The MOWG is certainly concerned about the cost growth of the SDO mission in that line, but is gratified that the overall LWS mission funding was not reduced in the recent NASA budget presentation to Congress.

In 2003, the National Research Council published the first Decadal Survey for solar and space physics entitled “The Sun to the Earth--and Beyond: A Decadal Strategy for Solar and Space Physics”. The strategy recommends a balanced research program for NASA and NSF that would also address the operational needs of NOAA and DOD. The report includes a recommended suite of programs at NASA, which were ordered by priority, presented in an appropriate sequence, and selected to fit within an expected resource profile during the next decade.

In February 2004, an SEC budget for fiscal years 2005 – 2009 was announced in response to the President’s Vision for Space Exploration. This budget represents a deficit of approximately \$200M/yr with respect to the profile that was assumed in the Decadal Survey. This budget threatens to make difficult or impossible the attainment of the research program recommended by the solar and space physics community in the Decadal Survey. The MOWG believes that high priority must be given to achieving the goals of the SSP Decadal Survey, which reflect a broad consensus of the entire SSP research community. A number of the recommended missions have critical relevance to the Vision for Space Exploration by specifying and eventually predicting the environment of interplanetary travel and planetary habitation. Other missions may be less relevant to the Exploration Initiative but, nevertheless, are crucial for the achievement of the necessary understanding of SSP phenomena.

The MOWG believes that a properly balanced program preserves the high priority established by the Decadal Survey while maintaining the frequent access to space provided quite importantly by the Explorer Program. Critical support to the Exploration Initiative is maintained by the LWS missions (SDO, Geospace Network, and Solar Sentinels). The direct connection to the Space Exploration Initiative follows from the fact that a future predictive capability for both solar activity and planetary magnetic activity will depend critically on advances in understanding of fundamental physical processes. The MOWG fully endorses the concept of establishing a ‘Level 1’ NASA requirement for an end-to-end predictive capability for solar system environmental observations and modeling that will be the explicit responsibility of LWS and SEC.

Considerable effort has been expended across the entire research community toward the analysis and prediction of space weather effects near Earth. Accurately monitoring and predicting space weather out to Mars and beyond presents a challenge that demands resources on the scale that only LWS can offer. The safety of astronauts outside the

geospace environment hinges critically upon it. By virtue of its broad scope, the LWS program is in a unique position to support the Exploration Initiative in this way.

Our principal findings are presented below. Some of our current findings are similar to, but amplify upon, the findings previously transmitted to you from our prior LWS/MOWG meetings. Our findings are intended to deal with issues that are of current high interest and thus they concentrate on present problem areas. The members on the LWS MOWG are encouraged by the manner in which the SEC Division is attempting to execute this complex, but singularly important program, and we are dedicated to helping you achieve success.

Findings:

### 1. Lower Cost Implementation Approaches

The hallmark of the LWS program is the integrated approach to investigating the connected Sun-Earth system. This means that we need concurrent end-to-end observations of the entire system. We feel particularly strongly that it is necessary to return to the original theme of LWS of having integrated/concurrent observations in order to serve our broader mandate of supporting the Exploration Initiative. This is to say, we need to find a way to move Sentinels forward, but not at the expense of geospace science and the Geospace Probes. Because of the limited resources available to implement the next elements of the LWS program we find that alternative means of implementation should be explored. We find the cost-capped PI mode to be a good example. This finding is based on the demonstrated successful track record of the SEC community using the PI-mode, cost-capped Explorer Program. Among the SEC successes are SAMPEX, ACE, FAST, IMAGE, TRACE and RHESSI. We further find that each of the forthcoming ITSP and RBSP missions is ideally suited for a PI-class mission. The AOs for these missions should reflect this possible approach and be released as soon as a viable mission is possible (without change in science scope as defined by the GMDT). The AO for the heliospheric Sentinels Mission should follow this as soon as the associated STDT report is available and is endorsed by the community (provided this can be done without significant delay to the overall LWS program).

### 2. Budgetary Restoration

The LWS MOWG understands that the LWS program cannot exist in isolation but rather needs to utilize the existing SEC missions to accomplish its goals. The currently operating missions are essential for providing the data that are needed for a healthy space weather-oriented research effort in support of LWS. Considering the comparatively low cost, these missions still provide an exceptional scientific return. The MOWG finds that if these missions are not continued, data would be lost that cannot be recovered and which may be essential, for example, to develop models that require long, uninterrupted data sets that provide the backdrop for future Exploration programs.

The MOWG is acutely aware of the substantial shortfall of funding in the presently planned FY '07 budget. Those resources for SEC are inadequate to maintain operation of its remarkable fleet of spacecraft. This fleet—were it to continue operations—could be of tremendous benefit to the LWS program until new mission elements can be prepared and launched. No process (such as the Senior Review) being contemplated by SEC or NASA is well-positioned to deal with such a fundamental budgetary shortfall. The MOWG finds that a process must be put in place to determine what level of funds are required to carry out a sensible and prudent MO&DA program in SEC. Then, NASA and SEC must seek a budgetary restoration that will allow SEC and LWS to proceed. If such a funding level is realistically established, then the 'normal' senior review can be useful and will work to lay out a future approach for SEC and LWS.

### 3. Workforce Development

With the inception of the new Exploration Vision that focuses on the human and robotic exploration of the solar system beginning with the Moon and Mars, a significant burden has been placed on the future workforce. There is an increased need for educating and training scientists and engineers. The SEC community has long held that the development of this future workforce has been most effectively achieved through a hands-on approach. The opportunity to propose and win small missions through the Office of Space Science Explorer and Suborbital Programs has been a primary avenue for this and as such has played a significant and vital role in maintaining a trained and capable workforce. We find that the upcoming LWS missions in geospace and in the heliosphere are prime opportunities for meeting this critical aspect of our field and of the Agency. Our field can contribute substantially by maintaining and ensuring engineering and hardware viability in the future. To that end, we find that every effort should be made to enable the community to participate in all aspects of the LWS missions. In particular, the PI-class missions described in Finding 1 above provide a natural opportunity for student involvement and training.

### 4. Task Force and Workshop Inputs

We find that LWS should actively promote to relevant groups within the NASA organization those areas of research that clearly support the new Exploration Vision. While SEC science provides understanding, characterization, and prediction of the Sun-Earth system, it is obviously well-poised to provide the same for the Sun-Moon and the Sun-Mars systems. As such, SEC science is very relevant to the new Exploration Vision. The LWS program addresses those aspects of this system that affect life and society. Based on current knowledge and capability, we know that the impact of the space environment on humans and technologies is very significant under many and varied conditions. Among those aspects that have direct relevance to the Exploration Vision are impact to the science (e.g., Global Circulation Models applied to Mars), human safety (e.g., predicting human exposure to SEPs on long term flights), technology (aero drag/capture, communication through terrestrial and Martian ionosphere, transition through radiation belts), and prediction of solar mass ejections. This list is by no means complete. The LWS MOWG endorses the established task force that has examined the

SEP effects on humans and finds that the other areas of application within LWS should be studied in a similar fashion. In addition we find that inclusion of independent input from such organizations as the CSSP would be highly valuable. We believe that a workshop under LWS MOWG and CSSP auspices could be very beneficial and could lead to a pivotal NRC report.

## 5. Access to Space

One of the major cost drivers for the LWS program is the rising cost of launch vehicles. This has negatively impacted the science that can be conducted within the fixed budget envelope. The MOWG finds that NASA should reopen and pursue vigorously means to reduce launch costs. Two options seem worthy of further discussion:

(a.) Opportunities may exist to fly secondary payloads on both NASA and in particular DoD missions, e.g. adapter rings that can accommodate instruments or even full payloads. Such capabilities may be particularly useful for launching payloads into Geospace orbits. However, it is important to evaluate the reality of such launch opportunities, and to do so the endorsement of and active support from the highest levels of NASA and the DoD will need to be obtained.

(b.) There are also efforts by the Air Force to create new launch vehicles that are less expensive. One that is particularly appealing is the effort to convert ICBMs into vehicles that can launch satellites. Such vehicles are quite capable, are based on existing launch technology, and are scheduled to launch Air Force payloads before needed for LWS. As with the secondary payloads, it will be important to discuss this issue at the highest levels of NASA and the DoD, so that there are no policy impediments, but rather mutual support for the use of such vehicles.

If LWS missions are to be pursued as PI-class, it will be necessary to inform the proposing PIs as to what launch vehicles are permissible. It will be advisable to offer the maximum possible flexibility, within acceptable allowance for risk, so as to minimize the cost.

## 6. Partnerships

Partnerships are defined to be agreements between NASA and other government or international agencies with the purpose of exchanging substantial goods and/or services to the benefit of all. The MOWG finds that appropriate partnerships could be crucial for achieving the LWS scientific goals. To be successful, partnerships must be made early in the program and at a high administrative level within each organization. For example, a commitment from the leaders of NASA and ESA in the near-term to work together on specific space weather research goals, such as understanding the Sun and magnetospheric/radiation belt dynamics, will facilitate discussions at the program level and allow for coordination of budgets and schedules. Similarly, a cooperative

commitment from NASA and the Air Force at the administrator and four-star general level on the necessity of developing and standardizing a secondary payload launch capability on all heavy lift launch vehicles could greatly enhance low-cost access to space for many missions that might include LWS probes.

#### 7. Missions of Opportunity

Distinct from partnerships, missions of opportunities can be arranged and executed at the principal investigator and/or NASA division level. With ever-increasing pressure on the Storm Probe budgets, the MOWG finds that missions of opportunities need to be vigorously pursued with sufficient flexibility to enable low-cost sensor suppliers and relatively rapid response.

#### 8. Support for the PICARD Mission

Verifying and understanding the long-time behavior of the solar irradiance variations is a critical goal of the LWS program. The MOWG is concerned about possible gaps in this time series from US satellites and endorses the French CNRS PICARD mission as one step toward ensuring such data continuity. The astrometric component of the PICARD mission may also provide useful constraints on the physical mechanisms of the solar cycle variability that is an important goal of the LWS research program.

#### 9. Advancing Pre-Sentinels Science with Unique Constellations of Existing Spacecraft

To help meet original expectations that programs in solar, heliospheric, magnetospheric, and ionospheric physics be simultaneous, the MOWG endorses the proposal by the LWS Heliospheric Strategy Panel to jumpstart the Sentinels science program by taking advantage of upcoming spacecraft constellations which provide unique opportunities to probe heliospheric structures. For example, in 2006-2008, the two STEREO spacecraft, Ulysses, ACE, SOHO, and Wind will all lie in a sector ideal for sampling Earth-directed CMEs. They will provide a rare combination of imaging and in situ plasma, composition, energetic particle, radio wave, and magnetic field observations to enable unprecedented analysis of CME structure and associated phenomena. It is imperative that every effort be made toward ensuring the continued operation of the spacecraft during this period. Taking advantage of existing assets will be a cost effective strategy to advance Sentinels science to be simultaneous with the ionospheric and magnetospheric missions scheduled to precede Sentinels.

We hope these findings and management thoughts are useful to you, Dr. Fisher, and the rest of the NASA staff. As always, the MOWG stands ready to help make the LWS and related programs better and healthier in any way we can.

Sincerely,

Daniel N. Baker, Chair  
LWS/MOWG