An Overview of Program Developments for NASA's Space Environments and Effects (SEE) Program

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This paper describes many of the changes affecting NASA's Space Environments and Effects (SEE) Program since the initiation of the Vision for Space Exploration. Programmatic and procedural changes are discussed, six new technical tasks applicable to any return to the Moon or onward towards Mars are highlighted, and personnel changes and new contact information is given.

I. Introduction

NASA's Space Environments and Effects (SEE) Program was established in 1994 after the return of the Long Duration Exposure Facility (LDEF). Its purpose is to develop engineering technologies to help spacecraft mitigate the harmful effects of the space environment (natural and manmade):

- Ionizing radiation
- Contamination
- Spacecraft charging
- Meteoroid impacts
- Materials degradation
- Electromagnetic effects

Its scope is Agency-wide, meaning that although it's located at the Marshall Space Flight Center; its responsibility is to all NASA programs and missions throughout the Agency. Many of the products it develops are also of great interest to the US aerospace industry and academic institutions across the county.

The SEE Program is organized into two main sections: the Program Office, which manages and coordinates the activities of the Program and the Technical Working Groups (TWGs), which perform the technical duties of the Program. TWG membership includes personnel from the federal government, industry and academia. This broad and varied base of technical members helps SEE to maintain the US's preeminence in spaceflight activities.

The SEE Program offers a variety of engineering design products that help a designer abolish or mitigate the effects of the space environment on spacecraft. Whether at low-Earth orbit (LEO), geosynchronous orbit (GEO), planetary systems (Jovian environment) or interplanetary space (L1 Genesis mission), the SEE Program strives to provide designers with the information and engineering tools needed to achieve a successful mission. Products offered by the SEE Program include:

- Environment models
- Effects models
- Databases
- Knowledgebases

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- Design Guidelines
- Engineering Standards
- Technical Publications

Most of the products are in the Technology Readiness Level (TRL) range 4-6. However, there may be some circumstances where products are applicable above or below this range. Many different organizations have become users of SEE products, including the Department of Defense, virtually all US aerospace companies, and many different academic institutions around the country and, in some case, international organizations. All SEE Program products are export controlled and available to US citizens only. In the case of international usage, the foreign entity has established or utilized an international agreement with NASA Headquarters, allowing access to the product.

In the past, the SEE Program has utilized NASA Research Announcements (NRAs) or other appropriate NASA solicitation to competitively bid the technical work. The SEE Program would publish the requirements and accept bids from interested parties. In the fairest process possible, a technical review board, completely independent of the SEE Program, would review the proposals and an independent Selection Official would make the selections for funding. In many cases, the work was contracted to organizations outside the Agency, helping to demonstrate that SEE was interested in the best possible product for its customers.

The Agency has recently adopted a new way of doing business in response to the new Vision for Space Exploration and now requires the SEE Program to operate under new requirements. This new system will be discussed below.

II. Vision for Space Exploration

In January, 2004, President Bush established a new set of goals for NASA that included return trips to the Moon and onward to Mars. In response to this new initiative, NASA reorganized at the headquarters and field center levels and established a new Exploration Systems Directorate (Code T) that concentrates solely on achieving the initiative. The SEE Program was relocated from the old Aerospace Technology Enterprise and placed in the Human & Robotics Technology (H&RT) element within the Exploration Systems Directorate.

With change comes new ways of doing business. The SEE Program was given a funding guideline for one year (beginning in fiscal year 2005) to prepare for a new funding process beginning in fiscal year 2006. From this point on, the SEE Program is required to compete the entire program with other programs within the H&RT element. Typical multi-year budgets range in the $12-15M range but is contingent upon not only being selected for funding in the initial selection process but also passing a review gate at the end of the first year to see if the programs are meeting H&RT requirements.

Because of this new way of doing business, it unclear at this point whether the SEE Program will be issuing any new solicitations within the next several years, contingent upon being selected for funding. If selected, SEE Program dollars will be spent on H&RT needs and requirements as dictated by the goals of the Vision but how this budget is doled out is yet to be determined.

III. Technical Activities

After learning about the Agency's reorganization, SEE took the initiative to discuss with the TWGs what technologies would be most applicable to any effort to return to the Moon or move onward towards Mars. Six areas were identified for funding in fiscal year 2004:

- Apollo-era materials data mining
- Contamination of lunar dust issues
- Plasma issues
- Moon/Mars ionizing radiation issues
- Mars surface radiation issues
- Spacecraft charging in high-voltage power system

Apollo-era materials data mining: What did we learn from the Apollo lunar missions? Do we have access to this data 34 years later? NASA has a great need to compile all relevant space environment data from the Apollo era as any effort to return to the moon will require relevant materials properties data. Although the data may seem old and outdated, the Apollo program actually produced many materials that may still be useful in any new lunar

missions. However, being scattered across numerous locations and, in some cases very difficult to locate, it would be very costly and time consuming to try and retrieve this data once a design has begun. Therefore, SEE has initiated a task to produce an Agency report and database regarding Apollo-era materials information for distribution to Agency/public. Initial results show that the finished product will be much better than first envisioned.

Contamination of lunar dust issues: The issue of lunar dust contamination has already been identified by H&RT as one of the highest priority concerns. New dust mitigation technologies will have to be compared to what's been tried – and rejected – before during the Apollo program. As a subset of the Apollo-era materials data mining effort, a section specifically devoted to lunar dust mitigation issues will be included. How we avoid lunar or Mars surface contamination on a long-term or permanent basis is still unknown. Thermal control and solar arrays systems will be especially susceptible; therefore, a task to identify and evaluate existing and new technologies for contamination mitigation has been initiated.

Plasma issues: Lunar missions will require space vehicles to pass through the earth's radiation belts, outer magnetosphere and solar wind. Long duration exploration to the Moon and/or Mars requires that vehicles operate successfully in many different plasma environments. A task to produce a new charged-particle environment model that includes information on lunar and Mars environments has been initiated to provide information where none is currently available.

Moon/Mars ionizing radiation issues: New Moon and Mars missions will occur outside of the earth's protective magnetosphere. The most damaging solar particles from this perspective are protons and heavy ions, the latter being a greater concern due to the more limited availability of space data. – Therefore a task to develop a solar particle risk assessment model for protons and heavy ions has been initiated to help fill in the gaps caused by a lack of data.

Mars surface radiation issues: Transmission of radiation through the Martian atmosphere needs to be calculated to determine the radiation characteristics at the Martian surface for instrument and human protection. Recent trips to Mars by robotic spacecraft have not provided information regarding radiation levels as protective landing cocoons prohibit any atmospheric measurements during landing. In addition, variability may exist between surface radiation levels at robotic landing sites versus yet-to-be-determined human landing sites. Therefore, a task to develop a document that describes Mars' atmosphere radiation transport properties is being developed.

Spacecraft charging in high-voltage power systems: Of all the uncertainties facing new missions to the Moon or Mars, one thing is certain: power distribution systems will operate at levels that are exponentially higher than that previously used on the Apollo missions. New high-voltage power management and distribution systems for the Moon and Mars missions may lead to Paschen discharges that damage materials and spacecraft systems. Replacement and or repair could be at best difficult, at worst impossible. Power distribution systems must mitigate or prevent Paschen discharges. A task to develop Paschen Discharge Design Guidelines has been initiated to prevent this occurrence.

All six tasks were initiated in fiscal year 2004 for one-year durations. Information regarding these products, when available, will be listed on the SEE Program website at http://see.msfc.nasa.gov.

The SEE program was then directed by the Exploration System Directorate to identify and fund one year tasks in fiscal year 2005 that would support exploration to the Moon and Mars. SEE issued a solicitation and fifteen proposals were received and reviewed. Funding selections from this review are nearing completion and announcements of the selections will occur soon after the formal approval of the new program plan.

IV. Personnel Changes

In October 2004, a new Program Office staff began operating with the Exploration Systems Directorate. The new personnel and their contact information is as follows:

- Dr. Robby Newton, Manager, SEE Program (new)
  256-544-7880

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- Rick Turner, Deputy Manager, SEE Program (new)
- 256-544-5299
- rick.turner@nasa.gov

- Dr. Dale C. Ferguson, Project Manager, SEE Program (existing)
- 256-544-8316
- dale.c.ferguston@nasa.gov

- Sopo Yung, Web Services, SEE Program (existing)
- 256-544-9511
- sopo.yung@msfc.nasa.gov

V. Conclusion

NASA's Space Environments and Effects Program has already begun its efforts to support the Agency and its efforts to achieve the new goals of the Vision for Space Exploration. Efforts have already begun that address many of the most important technical issues regarding return trips to the Moon and new trips to Mars. These products will be available to NASA and the public within the next two years.