

SATELLITE POWER SYSTEMS (SPS) SPACE TRANSPORTATION WORKSHOP SUMMARY*

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In the course of studies of satellite power systems (SPS) over the past ten years, it has become apparent that the space transportation requirements are major elements in the technical and economic realization of the entire concept.

The space transportation requirement is usually divided into an Earth surface (ES) to low Earth orbit (LEO) part and a LEO to geostationary Earth orbit (GEO) or orbit-to-orbit portion which involves all intra-orbit operations including transfer through the van Allen Belts.

A considerable number of concepts have been studied for enhancing the capabilities of the current Shuttle Transportation System so that its role can be extended in the early SPS demonstrations and other flight operations. Beyond the growth and derivative versions of the present shuttle concept lie the possibilities for relatively low cost transportation from ES to LEO.

First steps in enhancing the shuttle will probably include the Titan based liquid Boost Module (LBM) and liquid propellant boosters (LPB) to replace the present solid rocket boosters (SRB). The next choice between new ballistic or winged boosters must still be made; as well as the choice between series (staged) and parallel operation.

Entirely new vehicles of large size will be required before the economic and environmental problems of the prototype, or even demonstration, SPS can be resolved. The need for single stage to low Earth orbit (SSTO) vehicles using either vertical or horizontal take-off and/or landing remains to be determined by future analyses or the course of events. In any event, considerable analysis, research and technology will be required before the choice can be properly made. Social impacts such as noise, and atmospheric pollution, locally and in the ionosphere, will need to be fully resolved.

The ES to LEO operational requirements and costs dominate the SPS space transportation scene. Launch vehicle technology must be driven to a rather sophisticated extent to meet the needs as currently perceived and this perception is immature at the present time. The workshop decided that, although rather advanced technology and well-developed operational management would be required to properly target the average cost of gross cargo payloads into LEO at 30 \$ (1979)/kg for the construction of the initial SPS, the further goal for repetitive construction of 30 to 60 SPS at 15 \$(1979)/kg for all operational payloads would require the use of very advanced, long-lived vehicles with a sophisticated operational organization using off-shore, equatorial launch sites, etc.

* The SPS Space Transportation Workshop with fifty-seven participants was held at the Sheraton Motor Inn, Huntsville, Alabama from 29-31 January 1980. It was managed by the Kenneth E. Johnson Environmental and Energy Center of The University of Alabama in Huntsville under contract to the National Aeronautics and Space Administration, George C. Marshall Space Flight Center. This paper was prepared for presentation at the Department of Energy/National Aeronautics and Space Administration Satellite Power System (SPS) Program Review, Nebraska Center, University of Nebraska - Lincoln, Nebraska on 23 April 1980.

The wide variety of orbit-to-orbit missions in support of the SPS demonstration, construction and operation need to be better defined before the vehicle concepts can be identified. Chemical Orbital Transfer Vehicles (OTVs) need further analysis and technology work and a reasonably early start on development to provide a capability that is needed in the present STS. Orbit-to-orbit including intra-orbit requirements of the 1980s should be coordinated with SPS requirements for chemical rocket OTVs in the 1990s and beyond. In-orbit propellant processing needs to be fully assessed.

Much work is needed on the concepting and research and technology work for electric rocket propulsion systems. Mission analyses including optimized high and low thrust acceleration trajectories are needed that serve the SPS requirements. High-power ion thrusters and magneto-plasma-dynamic (MPD) thrusters need urgent development attention to ascertain their characteristics. Much better coordination is needed between the electric rocket propulsion system technology planning and support and the overall NASA need for this kind of propulsion including the SPS.

More advanced propulsion systems such as dual-mode solid-core nuclear fission systems, gas-core nuclear rocket stages and mass-driver reaction engines (MDRE) need sustained attention. Orbit-to-orbit propulsion using high-power lasers should also be given attention.

The present ground based exploratory development (GBED) program in space transportation for SPS is entirely inadequate and such content as it has misses the target completely. Its primary aim should be to strengthen the present concepts but, at the same time and just as importantly, be careful not to close off any promising concepts or technologies. If the GBED is intended to be the next phase for SPS, it needs to be reconceived from the ground up with an order of magnitude increase in funding.

A greatly increased program of SPS space transportation analysis, research and technology is clearly needed. Efforts must be devoted to areas of systems analysis and technology readiness (including ground and space testing) that will reduce space transportation cost uncertainties in the next five to ten years.

Although the consensus of the Workshop supported the future prospects of the SPS, it was generally believed that much work is needed before space transportation choices could be made.