CRITICAL TECHNOLOGY AREAS OF AN SPS DEVELOPMENT AND THE APPLICABILITY OF EUROPEAN TECHNOLOGY N82 22687 D. Kassing and J. Ruth Systems Engineering Department European Space Agency, ESTEC, Noordwijk, The Netherlands

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Introduction

Satellite Power System (SPS) evaluation studies conducted in Europe (Ref. 1,2) have shown that this proposed space energy system could be an additional energy source to other advanced energy systems, such as nuclear breeder and nuclear fusion reactors. The SPS could supply a significant portion of the base-load electricity required in Europe and hence could contribute to making Europe less independent on energy imports. Besides the potential benefits the studies have, however, also shown that high uncertainties exist with respect to technical feasibility, environmental acceptability, and economic practicality.

The purpose of this paper is to discuss a possible system development and implementation scenario for the hypothetical European part of a cooperative SPS effort and to characterise technology and systems requirements which could be used as an initial guideline for further evaluation studies. The technical analysis is based closely on current DOE/NASA SPS reference system (Ref. 3) and 'actors that could influence the utilisation of SPS's in W. Europe. \frown It is understood that the scenario presented by the authors is not intended either as a prediction or as a recommendation, but as a tool for further evaluations.

The Scenario

A system of forty 5 GW units could supply some 20% of W. European electricity demand in 2030 (Fig. 1). After completion of a pilot plant demonstration around 2000 which has shown that the SPS is feasible, economic and safe, a stepwise implementation phase follows with at least 2 implementation lines, one for the U.S.A. and the other for W. European SPS s (Fig. 2). Together with the 60 SPS units assumed for the U.S.A(Ref. 3), a minimum total of 100 units have to be constructed by 2030. This implementation allows a stepwise extension of the infrastructure needed for production, construction and transportation (Fig. 3).

To identify most critical technologies and systems, an SPS development plan was devised backwards from the initial operation date of the pilot plant to the present. It defines major milestones and the date when a new type of system element is required (Fig. 4). Table 1 gives assumed characteristics of appropriate space transportation vehicles and space bases. Figure 5 shows the resulting subsystem development scenarios. For the construction of the pilot plant in LEO a construction base has to be developed which would later (during system implementation) be used for the construction of the electric-propulsion COTV s.

Applicability of European Technology

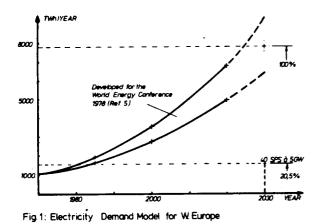
The development scenario is divided into 3 phases; each phase following up specific objectives. Since early phases should improve the fundamental understanding of the concept and assist the definition of the SPS subsystems, it is understood that hardware required for early key experiments in space could be derived in most cases from state-of-the-art technology. •

An evaluation process has therefore started at ESTEC (Ref.4) to identify those European technologies applicable to near-term studies and concept-technology verification investigations that will be needed if SPS s are to become a reality in the late 1990 s. Examples of advanced European space technologies are described including high power microwave amplifiers, antennas, advanced structures, multi-kilowatt solar arrays, attitude and orbit control systems, electric propulsion, the ARIANE launch vehicle and the near equatorial launch site in Kourou.

References

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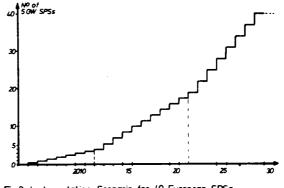


Fig.2: Implementation Scenario for 40 European SPSs

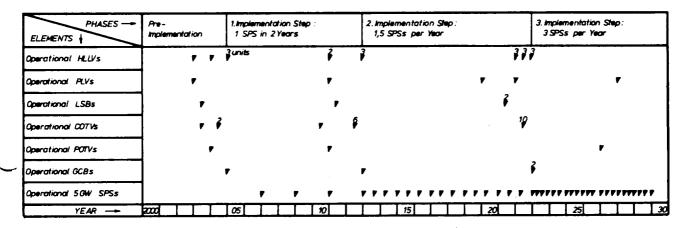


Fig.3: Infrastructure needed for European Implementation Scenario

LAUNCH VEHICLES	ORBITAL TRANSFER VEHICLES	SPACE BASES
HLLV (150) - Heavy Lift Launch Vehicle [‡] , IOD 1996 GLOW: 3870 t, Payload: 150 t	Exp. EPM - <u>Electric Propuls. Module</u> , IOD 1991 attached to GEO-Test Satellite, for orbit raising	LEO-Base- <u>5/L deriv. Free-Flyer</u> , IOD 1990 for constr.of GEO-Test Satellite and 2-MM Dev. SPS, Crew 5-7
HLLY (450) - Heavy Lift Launch Vehicle [®] , IOD 2011 GLOW: 11020 t, Payload: 450 t & Both vehicles 2-stage winged and	Small EPR - <u>Electr. Propuls. Mod.</u> , IOD 1995 attached to 2-MM - Developm. SPS	Pilot LCB - <u>Constr. Base for Pilot SPS</u> , IOD 1997 In Low Earth Drbit (LED) Signat What SCO + Conv. 20
	Pilot EPM - Advanced Electr. Prop. Mod., 10D 1999 attached to Pilot Plant	Si-opt.:Mass-500 t, Crew-30 Ga-opt.:Mass -350 t, Crew - 40
Small PLV - <u>Personnel Launch Vehicle</u> Opt. 1 Space Sh. derivative, 5-12 pass. Opt. 2 HERMES-Type/ARIANE, 5-12 pass. IOD 1990 (after 1999: Emergency Veh.)	- Electr. Propurs. Venicle, 100 2001	Final LCB - <u>Construct. Base for COTV</u> , 10D 2000 In LED Si-opt.: Mass-500 t, Crew - 30, Ga-opt.: Mass-350 t, Crew - 40,
PLV (59) - <u>Advanced Shuttle with 50-pass. module</u> Flyback booster: CH ₄ /LOX; 10D 1999	Small POTV - <u>Personnel Orbit Transfer Vehicle</u> , reusable; LH ₂ /LOX, 2 stages, 100 1992 5 - 7 pass.	LSB - <u>Staging Base in LEO</u> , IOD 2001 advanced LEO- Base, Mass-100 t, Crew - 10:
PLV (75) - Advanced PLV for 75-pass. module TOD 2011	POTV (80) - Large Pers. Orbit Transf. Vehicle TOD 2001, reusable, LH ₂ /LDX, 2 stages, 80 passengers.	
	POTV (160) - <u>advanced version of POTV (80)</u> for 160 passengers, 100 2011	Ga-Opt.: Mass- 3000 t, Crew - 340,
100 - Initial Operation Date		

Tab.1: Characteristics of Space Vehicles and Bases

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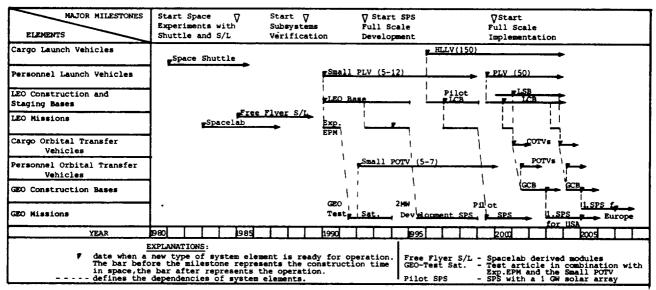


Fig.4: SPS Development Scenario

	Technology for: 5x10 km and Antenna		
STRUCTURE	-Materials 2x3 km and Antenna y		
	-Joints		
ATTITUDE AND	Technology for: Operational SPS		
ORBIT CONTROL	-Long life EP Pilot SPS		
	control techn.etc. Exp.EPM		
SOLAR GENERATOR	Technology for: 8.5 GW		
	-Bigh efficient cells		
	-Temp.and rad.resistance 2 May 7		
	-Low-cost prod.etc. 100 kW		
	Technology for: 40 kV		
PC'ER CONDITIONING	-Plasma impacts 40 kV experimental		
AND DISTRIBUTION	-Switchgear, Rotary joints 5-10 kV -High Voltage 1 kV		
	-aigh voltage <u>i kv</u>		
	Technology for: 5 GW Reception		
POWER TRANSMISSION	-Microwave generation <u>1-100 MW Demonstration</u>		
SYSTEM	-Beam contról <u>Exo.Rectenna</u>		
	-Antenna design, etc. First space tests		
YEAR	1980 1985 1990 1995 2000 2005		
	Technology for:		
CARGO LAUNCE VEHICLES	-Re-entry -Re-usability HLLV (450)		
	-Maceriais, etc. HILV (150)		
PERSONNEL LAUNCH VEHICLES	Technology for:		
	-Life support -Rescue systems PLV (50)		
	-Safety design Small PLV (5-12)		
CARGO ORBITAL TRANSFER	Technology for: -Electric Propulsion EPM for Pilot SPS		
VEHICLES	-Electric Propulsion EPM for Pilot SPS -Control Small EPN		
10010			
	-etc. Experimental EPM		
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PERSONNEL ORBITAL	Technology for:		
PERSONNEL ORBITAL TRANSFER VEHICLES	Technology for: -Cryogenics		
	Technology for: -Cryogenics POTV (160)		
TRANSFER VEHICLES	Technology for: POTV (160) -Cryogenics POTV (80) -Rescue Systems POTV (5-7)		
	Experimental Err Technology for: -Cryogenics -Rescue Systems -etc. Small POTV (5-7) 1980 1985 1990		
TRANSFER VEHICLES	Image: Institution of the second se		
TRANSFER VEHICLES	Technology for:		
TRANSFER VEHICLES YEAR LEO CONSTRUCTION AND	Experimental Err Technology for: -Cryogenics POTV (80) -Rescue Systems POTV (5-7) -etc. Small POTV (5-7) 980 1995 1980 1990 1990 1995 2000 2005 Technology for: Advanced LEO Bases -Space construction LSB		
TRANSFER VEHICLES YEAR LEO CONSTRUCTION AND	Image: Insertion Image: Imag		
TRANSFER VEHICLES YEAR LEO CONSTRUCTION AND STAGING BASES	Technology for: POTV (80) -Cryogenics POTV (160) -Rescue Systems POTV (5-7) 980 1985 1980 1990 Post 2000 Post 2005 Advanced LEO Bases -Space construction -Base operation, etc. Technology for: -Space construction -Base operation, etc. Technology for:		
TRANSFER VEHICLES YEAR LEO CONSTRUCTION AND	Image: Specific construction POTV (80) Performance POTV (160) Poto POTV (160) Poto Poto		

Fig.5: Subsystem Development Scenario