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CRITICAL TECHNOLOGY AREAS OF AN SPS DEVELOPMENT AND THE APPLICABILITY OF EUROPEAN TECHNOLOGY

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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 factors that could influence the utilisation of SPS's in W. Europe.
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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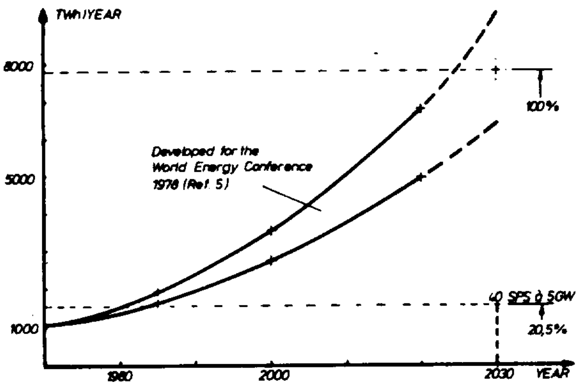

Fig. 1: Electricity Demand Model for W. Europe

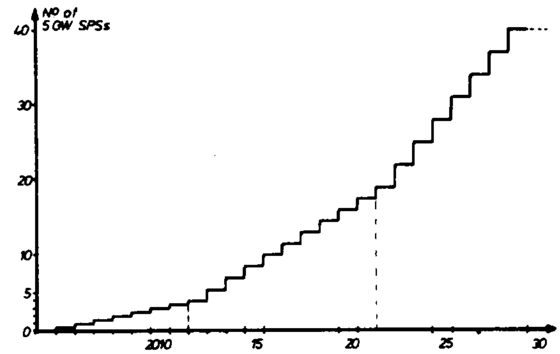

Fig. 2: Implementation Scenario for 40 European SPSs

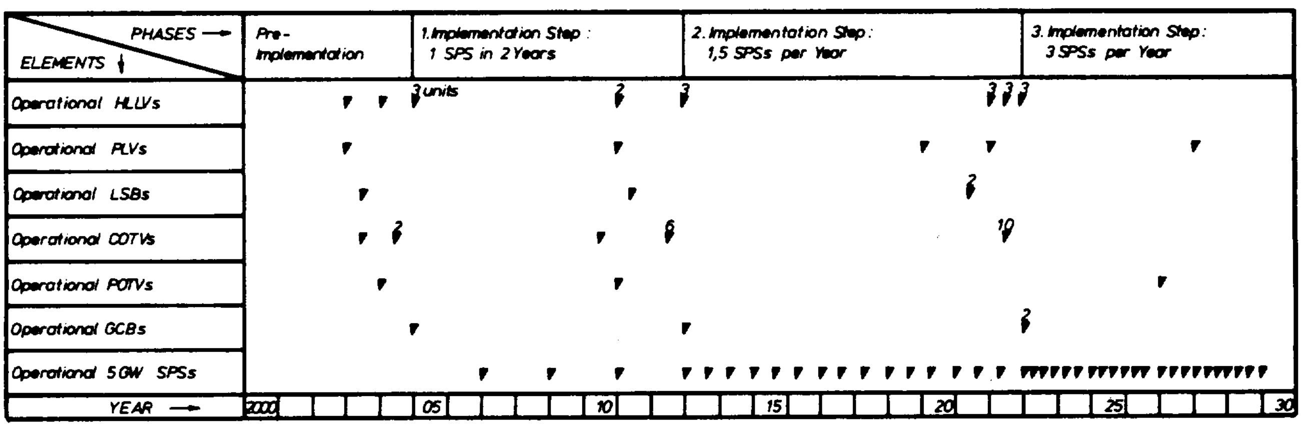

Fig. 3: Infrastructure needed for European Implementation Scenario

LAUNCH VEHICLES	ORBITAL TRANSFER VEHICLES	SPACE BASES
HLLV (150) - Heavy Lift Launch Vehicle*, IOD 1996 GLOW: 3870 t, Payload: 150 t	Exp. EPM - Electric Propuls. Module, IOD 1991 attached to GEO-Test Satellite, for orbit raising	LEO-Base-S/L deriv. Free-Flyer, IOD 1990 for constr. of GEO-Test Satellite and 2-MW-Dev. SPS, Crew 5-7
HLLV (450) - Heavy Lift Launch Vehicle*, IOD 2011 GLOW: 11020 t, Payload: 450 t * Both vehicles 2-stage winged and fully reusable; Booster: CH_4/LOX; upper stages LH_2/LOX	Small EPM - Electr. Propuls. Mod. ,IOD 1995 attached to 2-MW - Developm. SPS	Pilot LCB - Constr. Base for Pilot SPS, IOD 1997 in Low Earth Orbit (LEO) Si-opt.:Mass-500 t, Crew-30 Ga-opt.:Mass -350 t, Crew - 40
	Pilot EPM - Advanced Electr. Prop. Mod., IOD 1999 attached to Pilot Plant	
Small PLV - Personnel Launch Vehicle Opt. 1 Space Sh. derivative, 5-12 pass. Opt. 2 HERMES-Type/ARIANE, 5-12 pass. IOD 1990 (after 1999: Emergency Veh.)	COTV - Electr. Propuls. Vehicle, IOD 2001 reusable; 180 days round-trip time; Payload: 3500 - 4000 t	Final LCB - Construct. Base for COTV, IOD 2000 in LEO Si-opt.: Mass-500 t, Crew - 30, Ga-opt.: Mass-350 t, Crew - 40.
PLV (50) - Advanced Shuttle with 50-pass. module Flyback booster: CH_4/LOX; IOD 1999	Small POTV - Personnel Orbit Transfer Vehicle, reusable; LH_2/LOX, 2 stages, IOD 1992 5 - 7 pass.	LSB - Staging Base in LEO, IOD 2001 advanced LEO- Base, Mass-100 t, Crew - 10;
PLV (75) - Advanced PLV for 75-pass. module IOD 2011	POTV (80) - Large Pers. Orbit Transf. Vehicle IOD 2001, reusable, LH_2/LOX, 2 stages, 80 passengers.	GCB - Construct. Base for 5-GW-SPS Geostat. Orbit, IOD 2003 Si-Opt.: Mass- 4200 t, Crew - 240, Ga-Opt.: Mass- 3000 t, Crew - 340,
	POTV (160) - advanced version of POTV (80) for 160 passengers, IOD 2011	
IOD = Initial Operation Date		

Tab.1: Characteristics of Space Vehicles and Bases

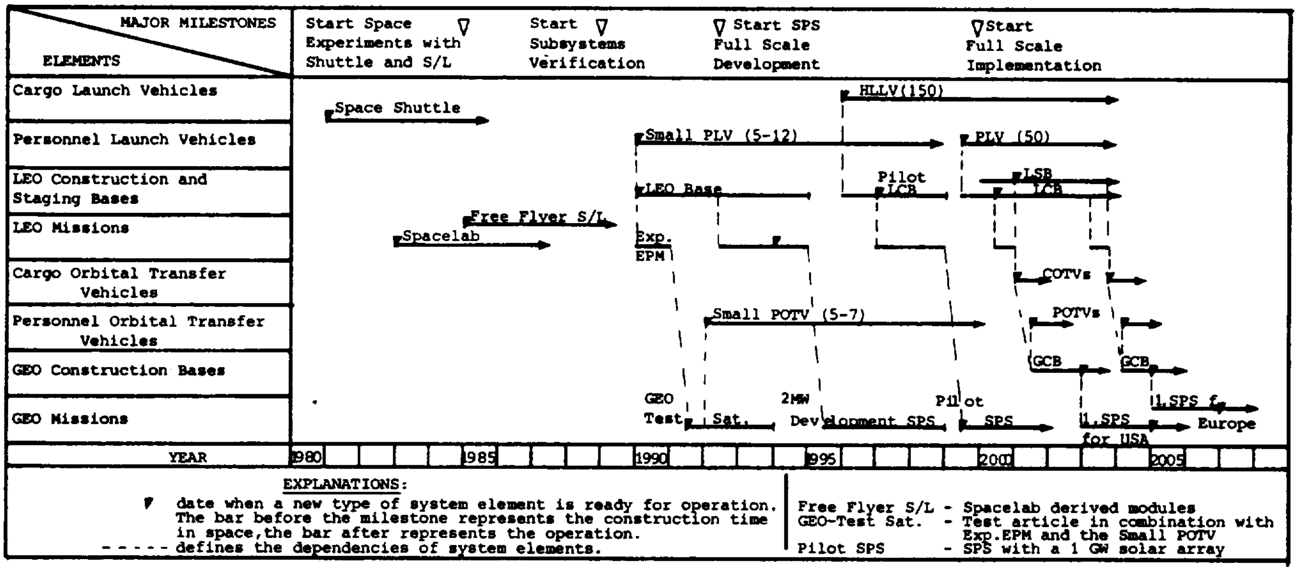

Fig. 4 : SPS Development Scenario

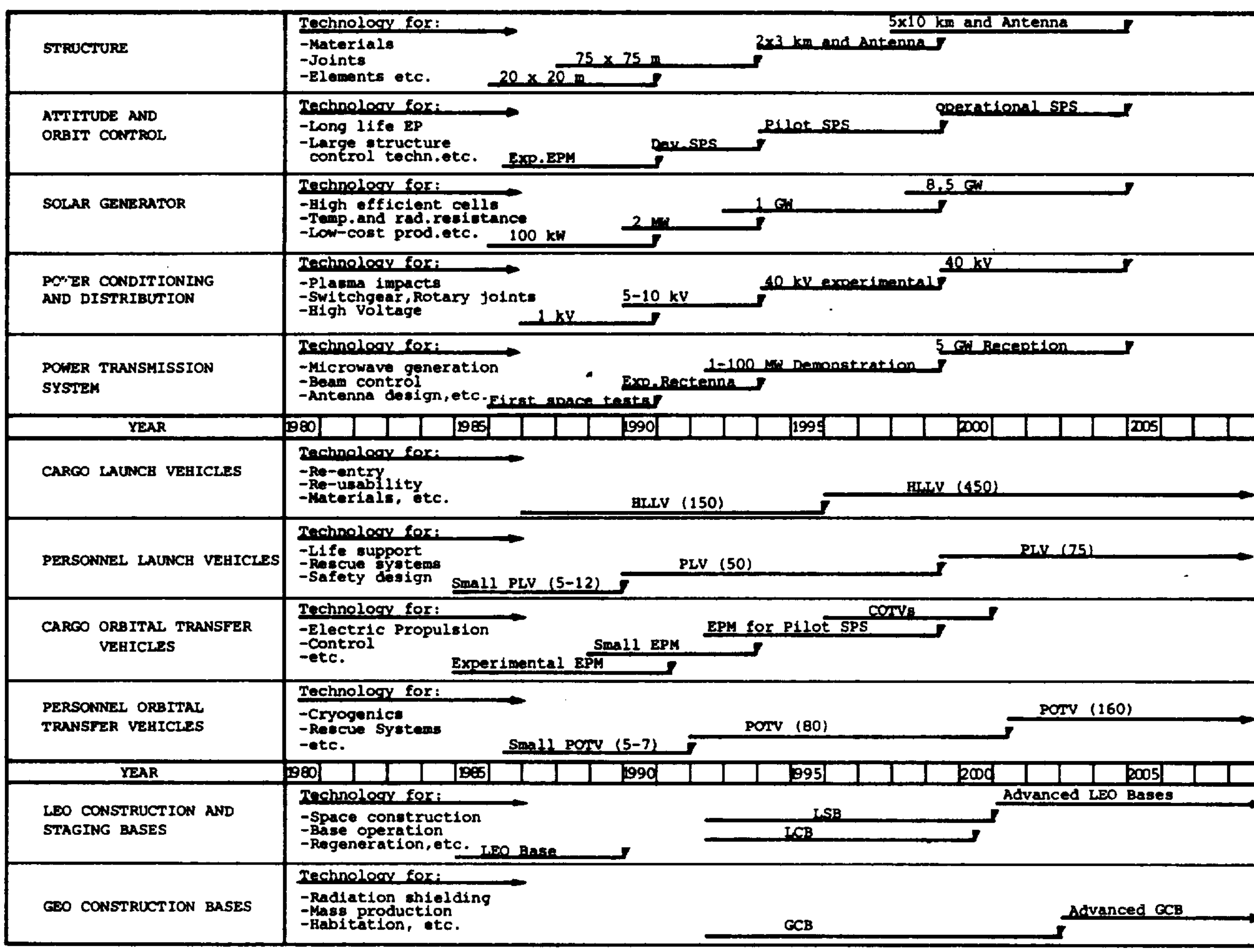

Fig.5: Subsystem Development Scenario