SPECIFIC SPS CONSTRUCTION STUDIES: CONSTRUCTION TASKS-CONSTRUCTION BASE

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ABSTRACT

This paper discusses a concept for building the 5000 MW reference Solar Power Satellite in earth orbit, based on recent work performed for NASA/JSC under contract to Boeing, on the SPS System Definition Study, and on related work performed under Grumman IRAD.

INTRODUCTION

Several concepts have been recently described on how to build the Solar Power Satellite (SPS) in space. These concepts entail fabrication and assembly of the entire satellite in geostationary earth orbit (GEO), at 35800 km altitude, as well as partial construction at an intermediate low earth orbit (LEO) followed by final assembly in GEO. A concept for building the entire 5000 MW reference satellite in GEO is discussed below. Construction base operations needed to produce one SPS every six months are described and areas for near term technology development are identified.

GEO CONSTRUCTION BASE

The GEO Base concept shown in Fig. 1 was developed to build the 5000 MW reference SPS system, which uses silicon solar cells with no concentration. This 4 Bay End Builder construction base was selected for further definition in the Phase 2 study because it offered greater production capability than other concepts investigated in Phase 1. The GEO construction base is configured to avoid free flying facilities and/or assembly methods. As a result, the base has contiguous facilities for concurrent assembly and subsequent mating of the satellite energy conversion system and its power transmission antenna. The overall base is 3.44 km wide x 3.65 km long x 0.9 km deep. The base structure serves as an assembly jig which houses the required construction equipment and supports the emerging satellite during all phases of construction. The top deck of the GEO base, level J, provides facilities for cargo docking/unloading and distribution, crew quarters, command and control operations, orbit transfer vehicle (OTV) docking and servicing, and SPS maintenance support complex. Base electrical power and flight control subsystems are also provided so that all work facilities and crew support facilities can operate, as needed.

GEO CONSTRUCTION OPERATIONS

The personnel needed to activate the 4 Bay End Builder Construction Base must travel first by means of the Shuttle to LEO and finally, by means of an orbital transfer vehicle (OTV) which operates from the LEO base.

The 4 Bay End Builder Base assembles the 5 GW reference Solar Power Satellite entirely in geosynchronous orbit, as shown by the construction sequence shown in Fig. 2. The 8 bay wide satellite energy conversion system is constructed in two successive passes on one side of the base, while the microwave antenna is assembled on the other side of the base. During the first construction pass, the GEO base builds one-half of the energy conversion system, a 4 bay wide strip by 16 bays long. When this part of the satellite has been constructed, the base is indexed back along the edge of the structure to the first end frame. During the second construction pass, the remaining 4 bay wide strip is attached directly to the assembled satellite systems. Throughout the construction operation, SPS construction materials and components will be delivered by large electric orbital transfer vehicles (EOTV). These vehicles

C-5

will stationkeep at least 1 km away, while special cargo tugs transfer material pallets. GEO base crews will, of course, also be rotated as needed. At the end of the second pass, the base is then indexed sideward to mate the antenna with the center line of the energy conversion system. After final test and check out, the base separates from the satellite and is transferred to the next orbital position for SPS construction.

The reference scenario requires that one 5 GW satellite is to be constructed every six months for 30 years. In order to carry out this program, nearly 450 space workers would be needed on two daily shifts (10 hours each) to perform construction, base support, maintenance, safety and base management operations.

BASE CONSTRUCTION SYSTEM

The end builder construction system described above uses ten synchronized beam machines to automatically fabricate continuous longitudinal beams for the energy conversion system. Lateral and diagonal members of the structural assembly are fabricated with three mobile beam builder substations. The assembly sequence, as shown in Fig. 3, begins with assembly of the first end frame and its attachment to the longitudinal members. This frame is automatically indexed away as the synchronized beam builders fabricate the required length of longitudinal beam to complete the structural bay. During these operations, solar array blankets and power busses are installed in parallel. For example, Fig. 4 shows how the solar array blankets might be temporarily anchored to the base so that they can be automatically deployed during longitudinal beam building operations. The illustration also shows two cherry pickers prepared to handle and connect opposite ends of a 667.5 m solar array support beam to the SPS frame after it emerges from the 12.7 m beam builder.

NEAR TERM TECHNOLOGY EMPHASIS

Constructing the large skeletal structure of the energy conversion system (5.35 km x 10.78 km x 0.47 km), including the installation and check out of its subsystems, will not be an easy task. While plausible concepts have been derived and limited development work has been started on auto-fabrication, a great deal of additional analysis and technology development work needs to be done before we can have confidence in the practicality of this process. For example, future dynamic analysis of the satellite construction process may show that some techniques can impose stringent load conditions on the elements of the satellite, while other techniques do not. As the reference SPS concept matures, all aspects of the construction approach must be analyzed further and periodically re-examined by considering technology issues related to the satellite design, orbit construction location, base facilities, crew and operations. These efforts should also be supported by laboratory investigations of SPS construction issues related to structural fabrication and assembly, construction support and subsystems assembly methods. This effort should be focused on developing technology which can lead toward SPS beam builders, SPS beam handling, subsystem assembly, mating of large space structures and techniques for deploying/installing SPS non-structural subsystems. Subscale prototype demonstrations should be used, wherever practical.

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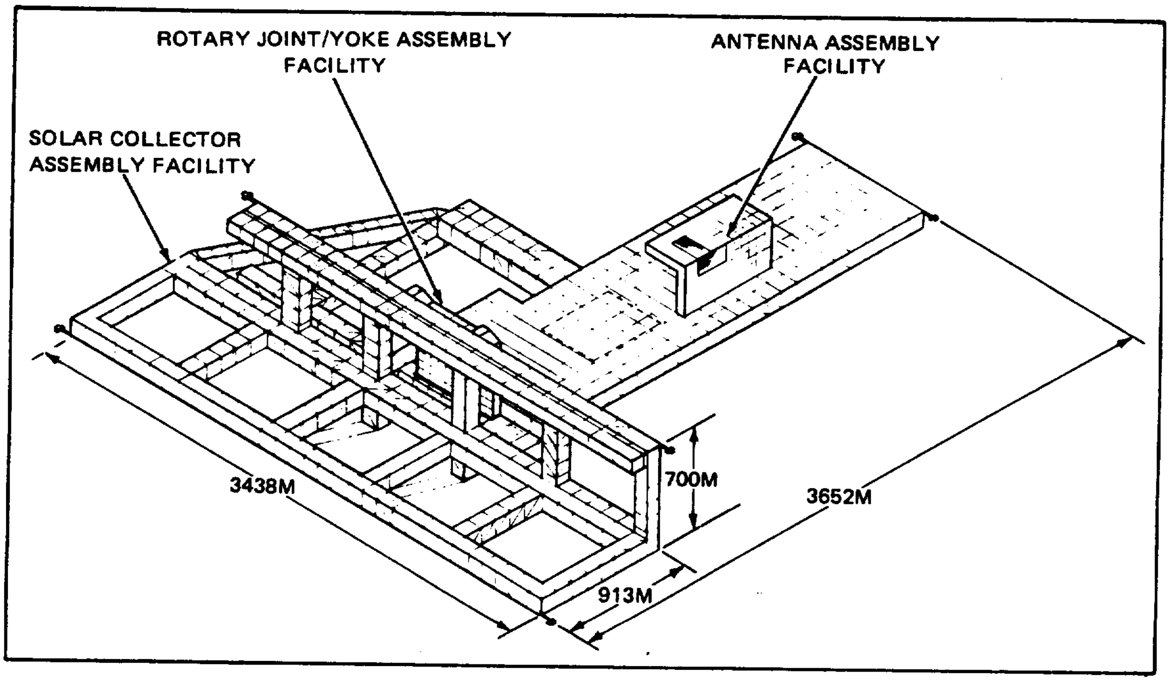

Fig. 1 4 Bay End Builder Construction Base

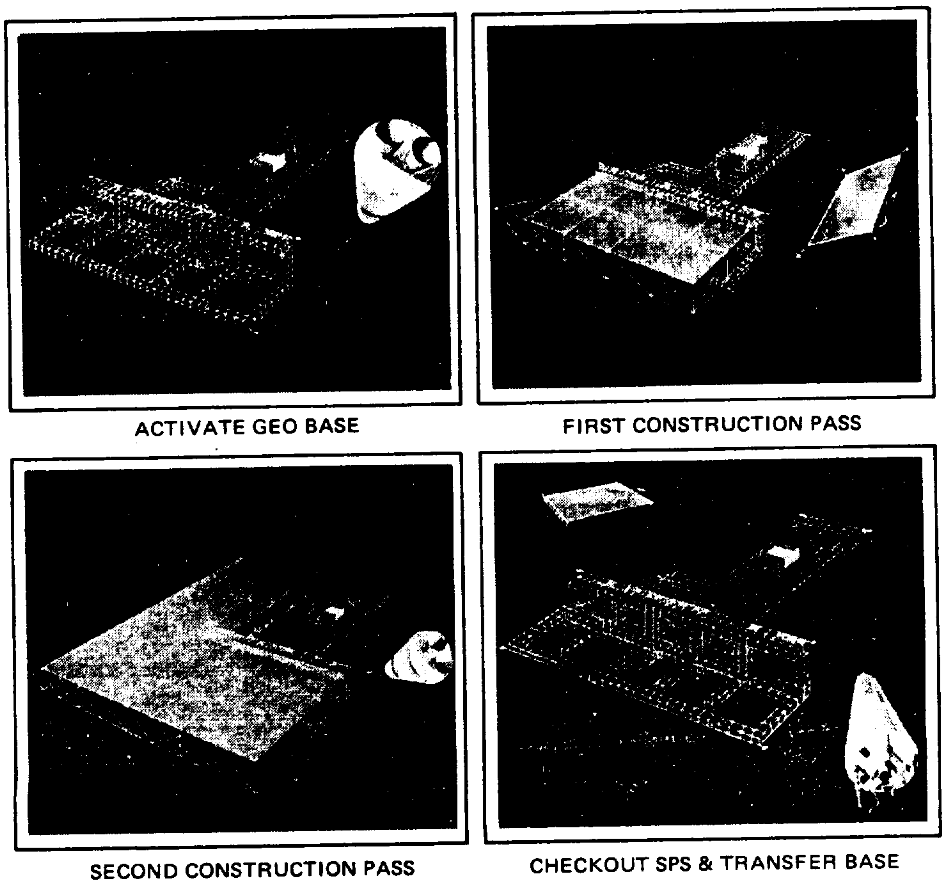

Fig. 2 SPS - 4 Bay End Builder Construction

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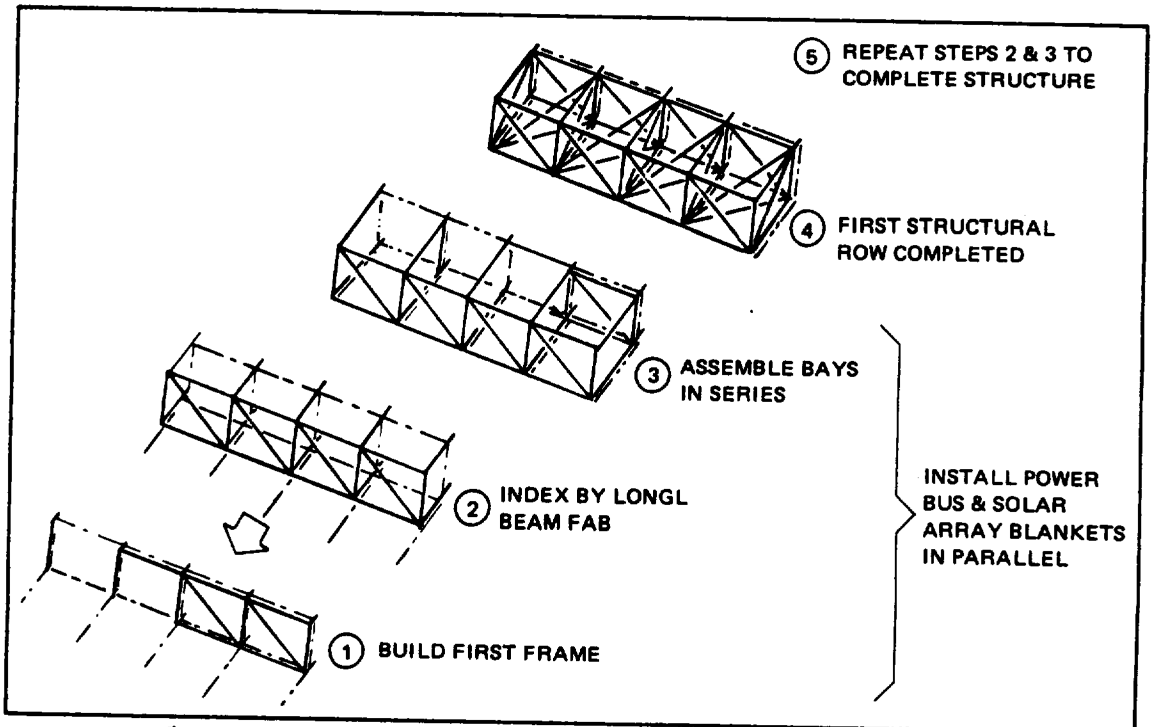

Fig. 3 End Builder Structural Assembly Sequence

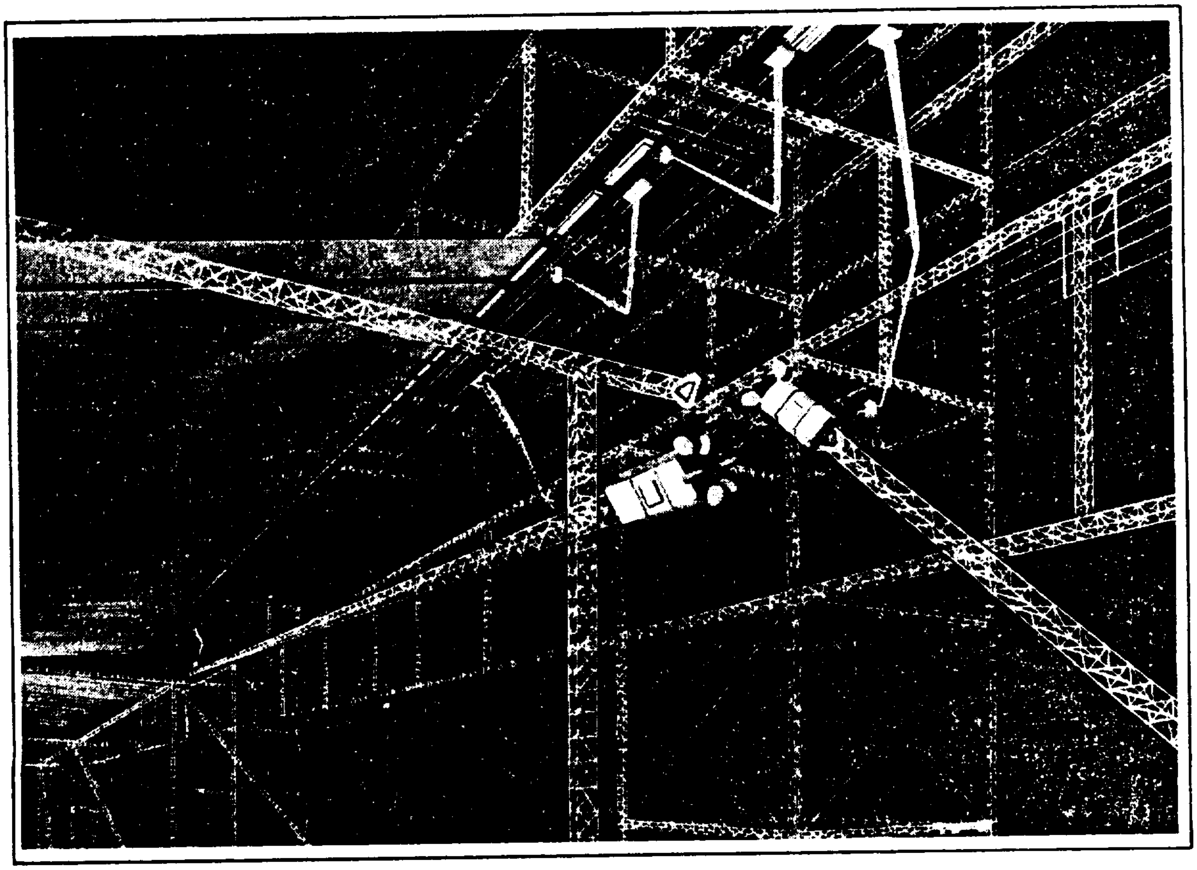

Fig. 4 SPS Assembly Operations