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THE NASA PROGRAM FOR STANDARDIZING SILICON SOLAR CELLS

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ABSTRACT

As part of an overall effort to reduce the cost of space programs NASA-Lewis has recently organized a Standardized Space Power Systems Office (SSPSO) working directly with the Low Cost Systems Office of NASA-Headquarters. One of the goals of this office is to develop low cost standard power system components such as solar cells. Estimated cost savings by using standardized solar cells in NASA missions over the next eighteen years is approximately nine million dollars. Even greater savings are expected from module and array standardization, the next phase of the planned program.

This paper will discuss the program which was initiated to formulate standard silicon solar cell and cover specifications. The program includes (1) compilation of solar cell and cover specifications, both past and present (2) elicitation of inputs from major users and suppliers and (3) establishment of tentative standardized solar cell and cover specifications. An Ad Hoc Team for Solar Cell Standards composed of experts from various NASA Centers and the DOD will review and critique the specifications developed under contract. These tentative specifications will also be reviewed and discussed at a Workshop in which all interested users and suppliers of solar cells and covers will be invited to participate. The resultant specifications will be submitted through the SSPSO to the Low Cost Systems Office for approval and implementation as standards.

INTRODUCTION

The Low Cost Systems Office, LCSO, was recently established at NASA-Headquarters to direct a program aimed at reducing the cost of space systems. In support of this program, NASA-LeRC has organized a Standardized Space Power Systems Office, SSPSO, for the purpose of developing low cost power system components. Silicon solar cells, one of the more commonly used elements of space electric power systems, are presently very expensive. One method proposed to lower their cost involves the standardization of cells, arrays and test specifications. It is estimated that standardization of the cells alone could reduce their cost by 10 to 15 percent. Such standardization, however, would have to be conducted carefully to assure results which are acceptable to most, if not all, users and suppliers. Furthermore, the standardized specifications would have to be designed to meet the requirements of a significant fraction of missions slated for the near future.

Solar cell specifications include the following:

1. Physical dimensions, materials of construction, appearance and integrity of solar cell and coverglass.

2. Electrical and performance characteristics of solar cell and optical characteristics of coverglass.

3. Sampling, inspection and electrical and environmental tests needed to demonstrate compliance with items 1 and 2 above.

The purpose of this paper is to make the solar cell community aware of the NASA plan regarding solar cell standardization so that they might be better prepared to respond at the appropriate time.

POTENTIAL COST SAVINGS

The impact of silicon solar cell standardization in terms of cost savings, while difficult to assess accurately, can be estimated on the basis of anticipated solar cell needs over the next 18 years and the estimated fraction of solar cell array costs presently attributed to the cells themselves (see Table I). According to the current NASA mission model, which includes all but DOD space programs, a total of 660 kWe of solar cell power is required over the next 18 years, or roughly 18 million 2x2 cm solar cells. Assuming a cost per cell and cover of $5.00, the total cost for the solar cells would be $90 M in terms of 1974 dollars. If the 10 to 15% savings in solar cell costs are realized as a result of cell standardization, and if it is assumed that 80 percent of the planned missions can benefit from standardization, the savings over the next 18 years (neglecting inflation) would range from 7 to $11 M. Furthermore, even greater savings are expected from module and array standardization, which would be a natural extension of the cell standardization effort.

BACKGROUND

Solar cell standardization has already been treated as part of various cost evaluation studies, (e.g., ref. 1). Of particular note was a two-day Solar Array Standardization Meeting held in San Diego, California in July of 1972. Representatives from government and industry met to explore the relationships between the benefits and the costs of standardization and to determine the long term effects standardization would have on the solar array industry in general. As a result of the meeting, it was generally concluded that the standardization of solar cells is both feasible and desirable.

For example, it was estimated that up to 90 percent of some companies solar arrays could have been built using a single solar cell design. Furthermore, one manufacturer at that meeting estimated that a 10 percent reduction in average cell cost could be achieved as a result of cell standardization. Such cost savings would be due primarily to:

1. The relaxation and/or elimination of certain specifications, such as mechanical and cosmetic requirements, and

2. The elimination of the variability in solar cell specifications. In addition, the establishment of more meaningful solar cell screening tests and the elimination of the need for developmental and qualification testing would result in further reductions in cost.

It was suggested at the Standardization Meeting that a standardized solar cell might be based solely on what's being used today; however, concern was voiced over the possibility that standardization might lead to stagnation. Furthermore, it was felt that new technology might itself lead to reductions in cost. Hence, it is essential that the standardization process provide appropriate means to incorporate advancements in solar cell technology as they become available. One observer at the Conference noted that new design features and innovations might actually be more widely accepted if incorporated within the framework of a standardization program.

STANDARDIZATION PROGRAM

Solar cell standardization efforts conducted to date have generally considered two separate time frames, before and after the advent of the Space Shuttle. In the solar array area, it is generally recognized that low level standardization (at the cell and possibly module level) should be introduced initially. Since the Shuttle promises to relax or remove certain size, shape and weight constraints, high level standardization of solar cell arrays should be possible in the future after system studies of future space requirements based on up-to-date mission models have been performed.

Accordingly, a program has been initiated by NASA to accomplish the first step in the standardization process, i.e., the formulation of standard silicon solar cell and cover specifications. Initially a group of representatives from various NASA Centers and the DOD, known as the Ad Hoc Team for Solar Cell Standards, AHTSCS, was established, see Table II. The function of the team is to participate in the selection of standardized specifications and to aid in evaluating proposals relative to any contractual effort which might be necessary as part of this program.

Table III contains the major elements of the NASA standardization program as presently envisioned. Initially, solar cell and cover specifications presently (or recently) in use will be gathered, compiled and reviewed. The specifications will then be collated to identify the similarities and differences of each. Also, during this time, requirements and preferences of users and suppliers of solar cells will be elicited. In the second step, several sets of candidate standardized specifications will be prepared based on the results of step one. These candidate specifications will cover a range of alternatives from very stringent to flexible for various classes of missions, e.g., low Earth orbit, geosynchronous, planetary probe. Only those specifications required to assure high levels of performance and reliability will be considered. Estimates of potential cost savings corresponding to each set of standardized specifications will then be made. The third step involves the convening of a Technical Workshop at LeRC consisting of all interested members of the solar cell community. The purpose of the Workshop will be to exchange final reactions, proposed revisions and recommendations. Following the Workshop, the resultant version of the specifications will be given a final review by the AHTSCS and then submitted through the SSPSO to the Low Cost Systems Office for approval and implementation as standards.

It is clear that the Technical Workshop is an important part of the standardization program. It is at this time, probably in the Spring of 1975, that appropriate parties will be given the opportunity to participate in the standardization process. It is recognized that such a Workshop will not be without certain difficulties. However, in spite of this, every effort will be made to develop statisfactory industry-wide standards. Hopefully, the Workshop will set a favorable precedent for future standardization of both modules and arrays.

SUMMARY

The overall goal of this program is to initiate the first step toward standardization of solar cell power systems through the development of standard specifications for solar cells and covers. The program will be carried out under the cognizance of a group of NASA and DOD representatives, known as the Ad Hoc Team for Solar Cell Standards. A Technical Workshop will be convened to give the entire solar cell community an opportunity to participate in the standardization process. The proposed approach attempts to achieve maximum involvement of both government and industry and as such, will provide a high probability of meeting the needs of all interested parties.

TABLE I - SOLAR ARRAY MISSION MODEL SUMMARY

1973 - 1991

	SOLAR ARRAY POWER (WATTS)		SOLAR ARRAY AREA (FT^2)	
	PRE-SHUTTLE	SHUTTLE ERA	PRE-SHUTTLE	SHUTTLE ERA
NASA:				
NON-SEP	16,000	65,000	4,000	11,000
SEP*	-	240,000	-	24,000
TOTAL	16,000	305,000	4,000	35,000
NON-NASA	69,000	270,000	11,000	40,000
TOTALS	85,000	575,000	15,000	75,000

*SOLAR ELECTRIC PROPULSION

GRAND TOTALS: SOLAR ARRAY POWER 660,000 WATTS

SOLAR ARRAY AREA 89,000 ft^2

CALCULATION OF ESTIMATED COST SAVINGS

90,000 SQ FT OF SOLAR ARRAY AREA @200 2x2CM CELLS PER FT^2
= 18,000,000 CELLS

18 MILLION CELLS @ $5.00 PER CELL AND COVER
= $90 M

FOR 80% USAGE OF STANDARD CELLS, TOTAL = $72 M

ATTENDANT SAVINGS ARE $7.2 M AND $10.8 FOR 10 AND 15% REDUCTION IN CELL COST, RESPECTIVELY, DUE TO STANDARDIZATION

TABLE II

ORGANIZATIONS REPRESENTED ON AD HOC TEAM FOR SOLAR CELL STANDARDS

AIR FORCE AERO PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
JET PROPULSION LABORATORY
JOHNSON SPACE CENTER
LEWIS RESEARCH CENTER
MARSHALL SPACE FLIGHT CENTER
SPACE AND MISSILE SYSTEMS ORGANIZATION

TABLE III

SOLAR CELL STANDARDIZATION PROGRAM

1. DATA COLLATION AND ELICITATION OF REQUIREMENTS AND PREFERENCES FROM USERS AND SUPPLIERS
2. FORMULATION OF SEVERAL CANDIDATE SETS OF STANDARDIZED SPECIFICATIONS
3. CONVENING OF TECHNICAL WORKSHOP
4. AHTSCS FINAL REVIEW OF PROPOSED STANDARD SPECIFICATIONS FROM WORKSHOP
5. SUBMITTAL OF RECOMMENDED SPECIFICATIONS FOR APPROVAL AND IMPLEMENTATION

REFERENCE

1. Evaluation of Space Station Solar Array Technology and Recommended Advanced Development Programs. LMSC-A981486, Lockheed Missiles and Space Company, December 1970.