BLANKET TECHNOLOGY

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The workshop participants felt that the questions presented for their consideration were too amorphous, with respect to definition of terms, to address quantitatively. There was general agreement that the subject of "welding" or "joining" was a significant issue. It was concluded that systems requirements would force a reassessment of the conventional approach to interconnecting cells into blanket or array modules. Defense applications (hardening) were identified as the key requirement that would force a movement away from the standard method (solder) of forming array circuits. The panel also agreed that requirements associated with the impending NASA Space Station and in-bound missions would lead to alternative interconnecting approaches. It was concluded that the diverse requirements of future space missions (high temperature and extended thermal cycling) might not be met by one approach, such as parallel-gap resistance welding. The panel suggested that other options such as high temperature solders and brazing be considered for the various mission requirements that were anticipated.

The panel agreed that blanket technology was potentially suitable for in-orbit annealing to temperatures of 200°C provided that conventional soldered connecting techniques were replaced by "welding". Some concern was expressed about the ability of adhesives to retain their optical properties after this type of thermal excursion. The members stated that annealing would require new types of qualification testing since most thermal cycling failures occurred at elevated temperatures.

Approaches to providing 200°C in-orbit do exist. However, the panel strongly recommended that trade-offs must be performed between the added weight, cost and risk associated with blanket annealing and the end-of-life (EOL) advantages gained. The consensus was that the method of providing the required temperature must be simple (low risk) or annealing will not be considered by mission planners. The panel stated that the annealing conditions (continuous versus periodic) must be more adequately defined before a complete answer to the subject of annealing could be provided.

The issue of GaAs blanket technology was addressed by the panel. It was agreed that the results of the WPAFB sponsored GaAs Solar Cell Manufacturing Technology (MANTECH) program, aimed at demonstrating production capability, would be the determining factor in deciding whether to pursue GaAs blanket development. The need for reliable, pertinent information on the behavior of GaAs solar cells under simulated space operating conditions was deemed critical in order to provide planners with sufficient data to determine the merits of employing GaAs blankets and arrays for future missions. Until significant quantities of well characterized GaAs solar cells are available, no serious attempt to initiate development of GaAs blanket technology will likely occur.

The question of future progress in the development of high performance blankets and arrays prompted a lively discussion focused on what properties constitute "high performance" and what was the present status of blanket and array performance with respect to specific power (W/kg). This discussion led to the conclusion that mission system's level requirements usually forced the utilization of technically "compromised" or "detuned" blankets and arrays, with less than optimum specific power, for mission applications.

The panel suggested that the Space Telescope array which is 20 W/kg beginning-of-life (BOL) is most representative of current state-of-the-art array technology. It should be noted that the Space Telescope blanket specific power is approximately half of what is forecasted for the "SEP" blanket (~55 vs 105 W/kg). It was concluded that blanket components, and their associated mass contributions, can vary dramatically depending on the design approach provided to satisfy system requirements.

To further illustrate this conclusion, it was observed that many future mission requirements, especially those involving defense and manned applications, will demand that arrays and blankets be designed for "toughness" and survivability, conditions which will lead to a reduction in specific power. It was suggested that the technologists need to consider such "realistic" mission requirements in their approaches to achieving "high performance" blankets and arrays.

Having established the fact that beginning and end-of-life specific power were not easy subjects to define, the members addressed the question of future advancements in this area, providing both assessments and goals. It was the general opinion that further progress would be evolutionary (conservative) in order to satisfy mission reliability concerns. Thus it was anticipated that the next step in blanket progress would incorporate 100 μm silicon solar cells and covers to replace the current assemblies (200 μm cells, 150 μm covers). It was also agreed that flexible substrates could probably be reduced to ~ 75 μm thickness.

The group anticipated that by 1990, blankets with a specific power of approximately 100 W/kg would be used for space missions, and during the 1990s this figure would probably increase to 150 W/kg, depending on mission requirements. It was pointed out that the shortfall in Shuttle launch capability could very likely demand blankets with even higher BOL specific power. It was therefore suggested that blanket goals expressed in terms of kg/m^2 and W/kg be established. These goals (see Table 1) are much higher than what the group projected for space flight use. This was done because of the realization that system's requirements inevitably lead to a reduction in specific power. There was consensus that no realistic forecast of array specific power, either BOL or EOL, could be made without information on the spacecraft and its associated mission requirements.

A special joint session was held with the Silicon Research and Technology workshop group. This meeting was extremely productive since it exposed the researchers to the complex decision making process that must be performed by the blanket technologists, and made the technologists aware of the frustrations associated with developing advancements that do not gain acceptance for flight use. A discussion followed on the subject of what factors determine mission acceptance of new technology. It should be mentioned at this point that the blanket workshop members feel strongly that this type of interaction between researchers and technologists is extremely beneficial and recommended that this type of combined workshop become a feature of any subsequent SPRAT Conference, since this is the only meeting where the entire spectrum of photovoltaic technology is represented.

Suggestions were made on how to increase the chances that research innovations will find acceptance for space flight use. It was agreed that a key interface between the two disciplines was the device manufacturers who must demonstrate that research derived advancements can meet the requirements of a given subsystem mission requirement. Researchers must be aware that the information needed to determine flight acceptance covers a wide area that goes beyond the more obvious figures of merit such as efficiency and resistance to the space radiation environment.

A schematic illustrating the relationship between mission requirements, technology selection and the ongoing effort in developing advanced photovoltaic technology is presented in Figure 1. The mission generates a series of performance requirements based on the expected environment and an estimate of technology readiness. As these requirements filter down to the array subsystem, the element of risk becomes a dominant factor and the constraints placed on the array increase due to the requirements of each major system for subsystem support. This results in technology compromises.

Assessment of risk is largely determined by the existing data base that is available for any blanket or array component being considered for use. This approach often precludes "better" components from being implemented, since the tradeoff between risk and a less than optimum subsystem usually results in the selection of an engineering compromise that accomodates the component which has the larger supporting base of statistically significant performance data. Therefore every effort must be made to assure that advanced technology is tested thoroughly and transferred to the device manufacturers in a timely fashion.

It should be pointed out that although NASA and DOD provide most of the support for space photovoltaic research, not enough attention is devoted to assuring that a proper transfer of this technology is made to the manufacturers. This topic might make a very interesting subject for future SPRAT Conference workshops to address.

Workshop Participants

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Table 1

Goals for Blanket Technology

Year	Mass Per Unit Area	Specific Power (BOL)*
1982	1.05 kg/m^2	105 W/kg
1985	0.65 kg/m^2	170 W/kg
1995	0.50 kg/m^2	280 W/kg

* EOL cannot be stated without knowledge of specific mission environment

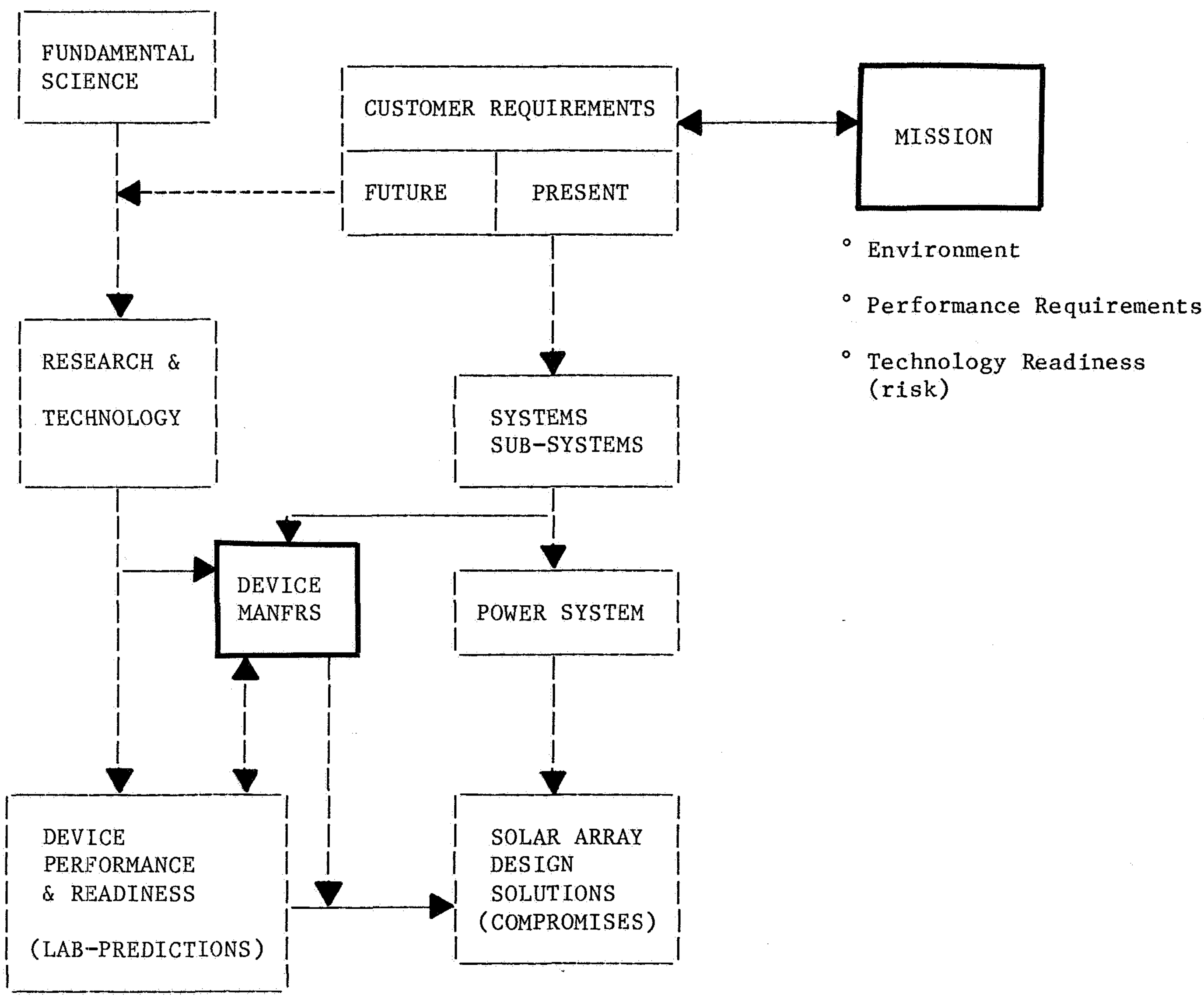

Figure 1. Technology Relationships for Mission Applications