SOLAR POWER R&D FOR AIR FORCE SPACE REQUIREMENTS

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INTRODUCTION

The requirements for improved solar power system technology for DOD satellites have been stated in several studies and conference papers (ref. 1). These summarize requirements up to 100KW by the year 2000 plus need to greatly reduce the power system weight and improve lifetime. Technology is required in several areas including solar cells, array blanket technology, energy storage and power system operation, regulation and control. As the missions become more critical to Defense, we must also address military aspects such as survivability, hardening and eventually, defense.

REQUIREMENTS

The mission areas requiring power system technology advances are shown in Figure 1. The traditional roles of communication, surveillance and navigation will continue and new roles are assigned in areas of weapons. The traditional missions, however, will require more power as follows. Communications will increase in volume as the military increase reliance on satellite systems. We will also need more power to counter jamming threats and also communicate with smaller ground units. Surveillance missions power requirements increase in order to detect aircraft, ground forces and naval units in both greater detail and to handle more traffic. Early candidates for these expanded capabilities are space based radar and deep space surveillance missions using infrared detection. Some of these missions also will operate in very high radiation levels in intermediate altitude orbits and will require hardening to a variety of weapon effects such as nuclear and laser. Figure 2 shows a projection of these requirements.

TECHNOLOGY PROGRAM

The Air Force solar power system technology developments can be divided into three areas: solar cell development, hardening technology, and power system development. I will briefly discuss these three areas:

As you are all aware, we have been working on three basic solar cell thrusts, silicon, gallium arsenide and multibandgap technology. The silicon work, summarized in Figure 3, is aimed at increasing the end of life efficiency as well as reducing weight, hardening to laser weapon effects, and reducing potential costs. Main thrusts at present are the veritical junction solar cell and the development of the cold crucible CZ techniques for growing high purity starting material at reduced costs. Both the Space Division and NASA Lewis are jointly supporting this technology program. The main objectives are high efficiency, 17% BOL and maximum EOL power system, after $5x10^{16}/cm^2$ 1MEV electron equivalent dose to provide technology for the mid altitude orbit missions. The GaAs program, shown in Figure 4, which Lt Masloski will later discuss, addresses higher efficiency, demonstration of flight readiness and development of lower cost technical approaches using web technology and growth on lower cost substrates.

The multibandgap cell technology addresses demonstration of concept feasibility and is aiming for 22 to 25% efficiency with an AlGaAs/GaAs monolythic cell approach. Growth methods include both liquid phase epitaxy and chemical vapor deposition. Dr Rahilly will discuss this area in a later paper. We are also interested in the possibility of bandgap tailoring to optimize the single junction solar cell in hopes of reaching better than 20% efficiency. The area of solar power system hardening to laser radiation effects is briefly summarized in Figure 5. This area deals with two thrusts - (1) increase the temperature capability of all array components by use of welded interconnects, integral coverglass and high temperature adhesive, and (2) minimize energy absorption using reflection and filtering or avoidance. Most efforts in the past dealt with silicon cell technology but as the GaAs cell technology matures, we need to harden it also. Therefore, the advanced cell vulnerability and hardening, integral covers and high temperature contact areas address both GaAs and silicon. We are also re-evaluating concentration concepts as a means to increase system hardness. Most schemes to date involve a reduction in efficiency and increased weight to achieve hardness.

Power system technology is under development and planned by both the Air Force and NASA. To achieve the capability needed in the late 80's to 2000, the programs shown in Figure 6 are in being or planned. The early exploratory development program is basically to define the technology needed to achieve power system weight and life goals and the AD program scheduled for FY 81 is to develop the component technology needed for these advanced systems. Key developments needed are lightweight hardened blanket technology, using thin cells and substrates, high temperature technology in covers, adhesives and interconnections, etc. Much use can be made of some early NASA technology, especially the thin cell work. Newer satellites are planned over a wide spectrum of orbits including between 400NMI and 10,000NMI. These have been shown in the Lockheed programs to date to require withstanding $4.8 \times 10^{16} cm^2$/electron equivalent and maximize EOL efficiency. At these dose levels, approaches such as annealing (GaAs and Si) should be investigated. Efforts along these lines will be done as part of our basic investigations studies with such individuals as Dr. Drevinski and Henry D'Angeles of RADC and in close cooperation with the various NASA centers. Power system work in areas of regulation, control, management, energy storage and waste heat utilization and rejection are also planned for development in this program. Component technology development is planned for the next 5 years with a flight type program after that.

SUMMARY

The next two decades will see an evolution in satellite usage to support more critical military missions which will require higher end of life efficiency, lower weight and volume, autonomous operation and hardening to a variety of potential threats. We have in being, programs to provide for this improved technology. The goals of these technology programs from a system standpoint are shown in Figure 7. Many technology improvements are needed to achieve these goals and they are further complicated by hardening requirements. It is hoped that the results of the three day meeting will assist us in developing and demonstrating technology needed in the next two decades.

REFERENCES

1. E. Tom Mahefkey, Future Space Power - The DOD Perspective, CP# 809016, 15th IECEC, 18-22 August 1980.

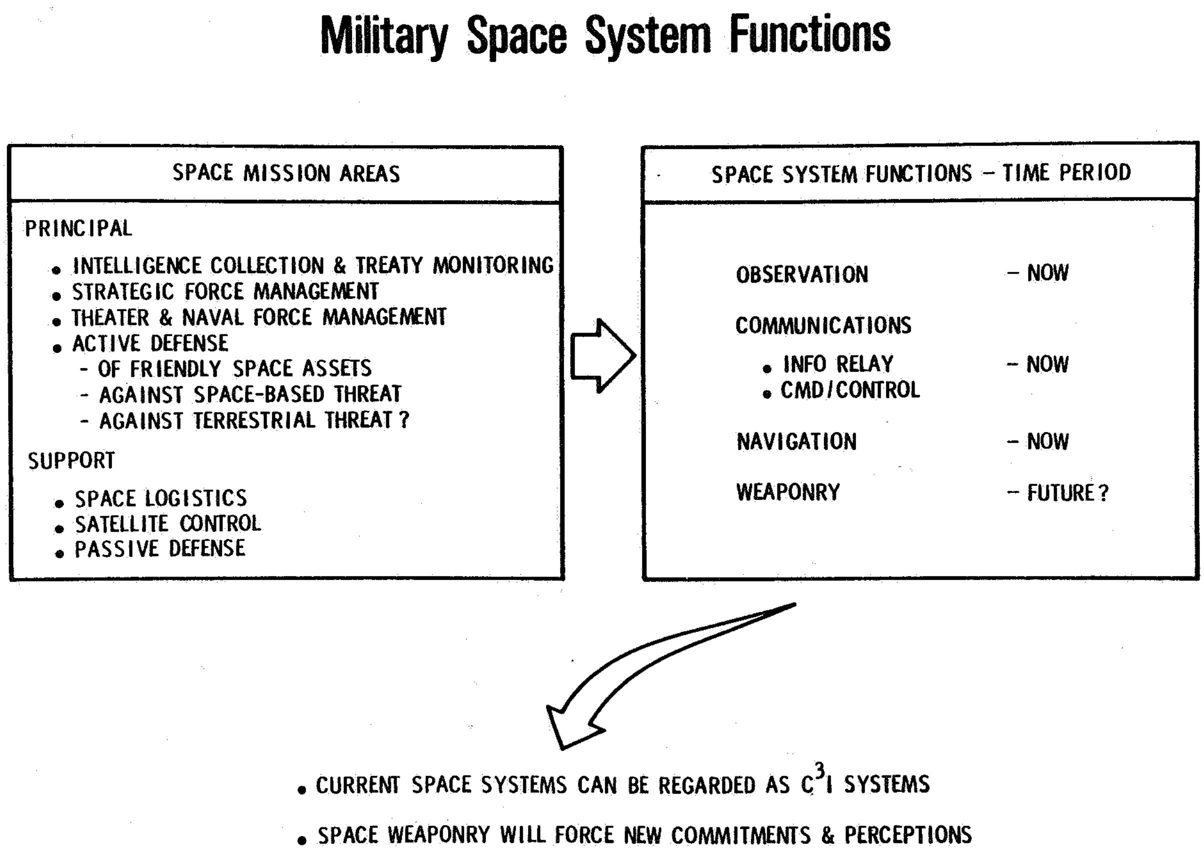

FIGURE 1

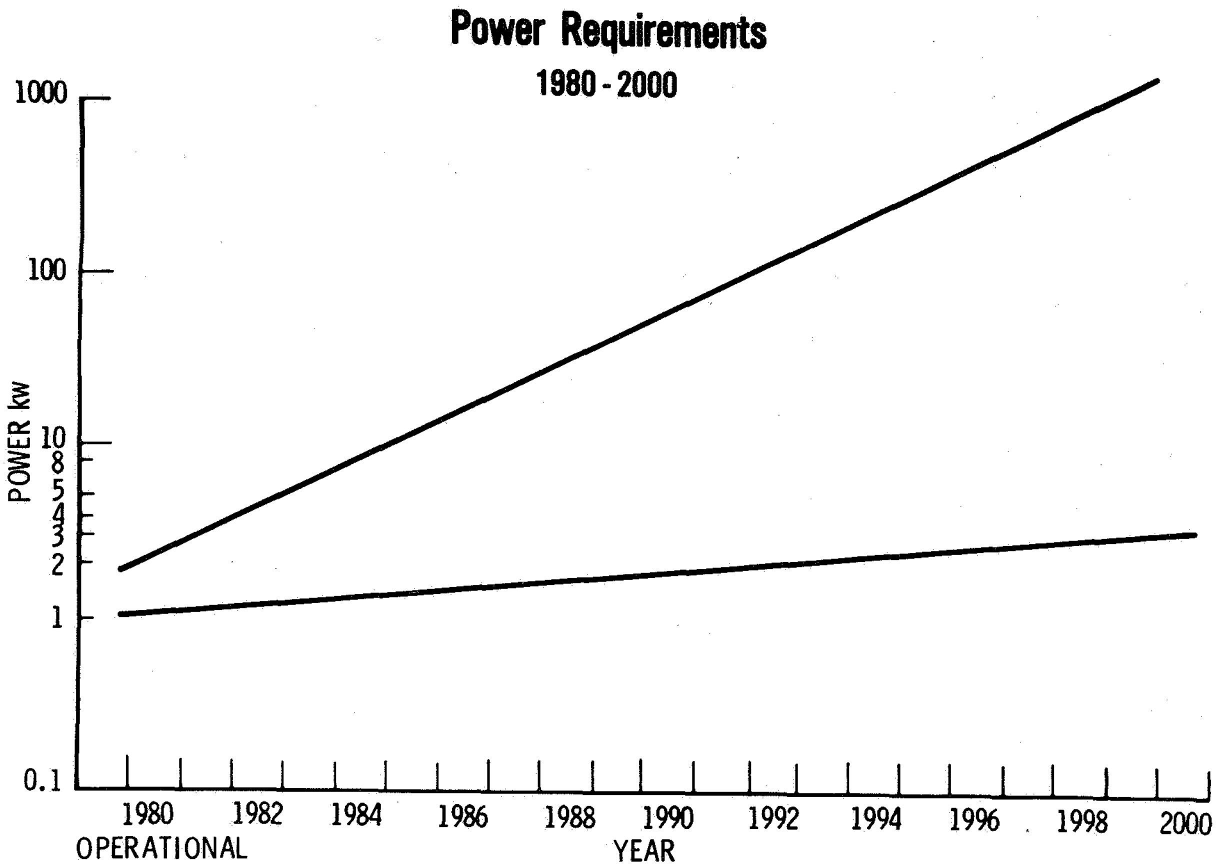

FIGURE 2

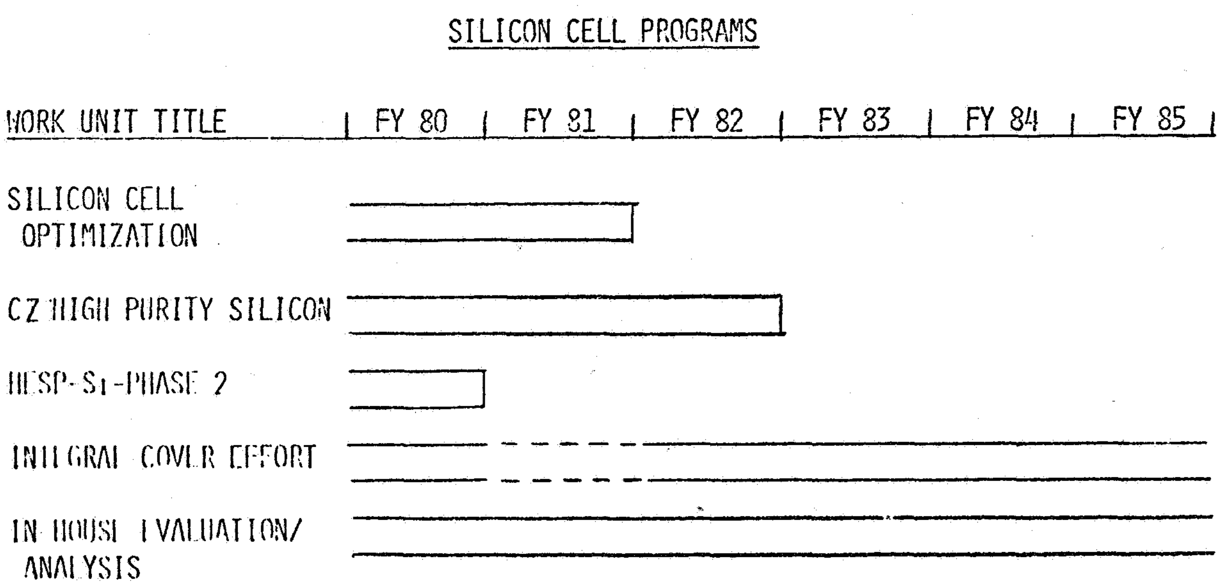

FIGURE 3

III-V PROGRAMS

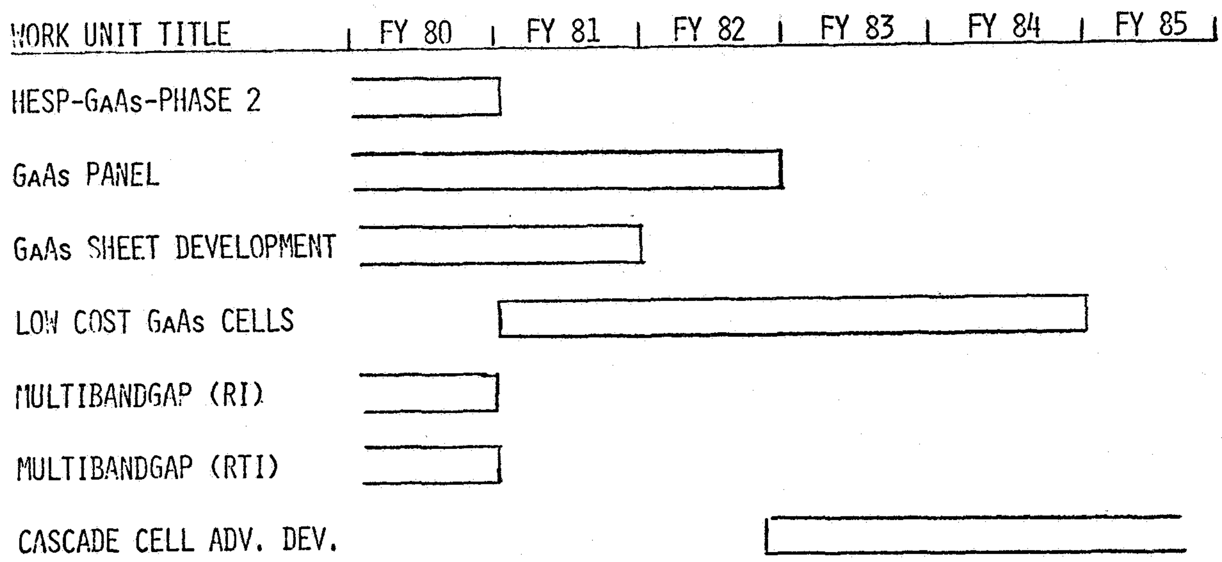

FIGURE 4

HARDENING PROGRAMS

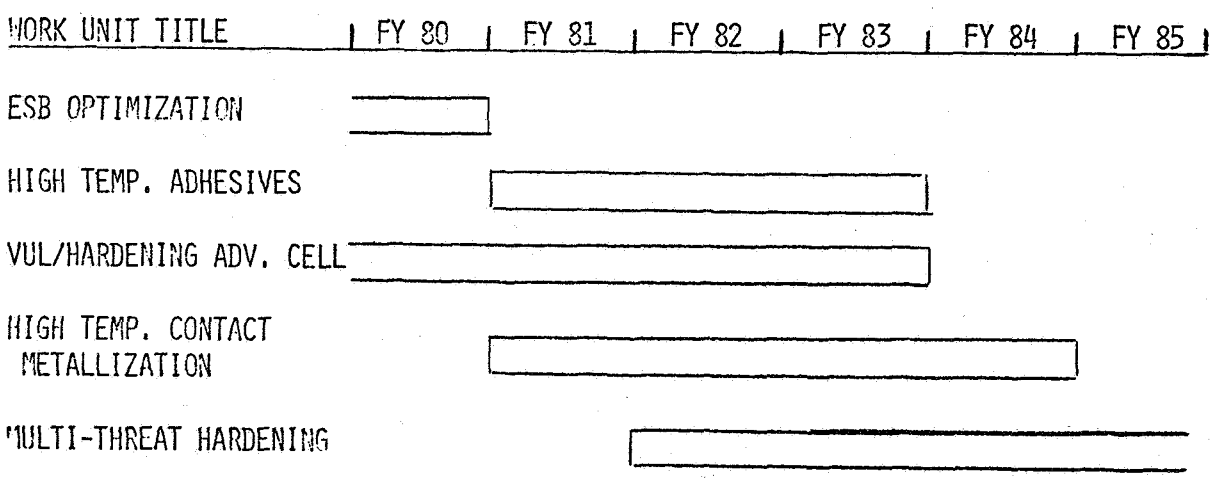

FIGURE 5

SYSTEMS PROGRAMS

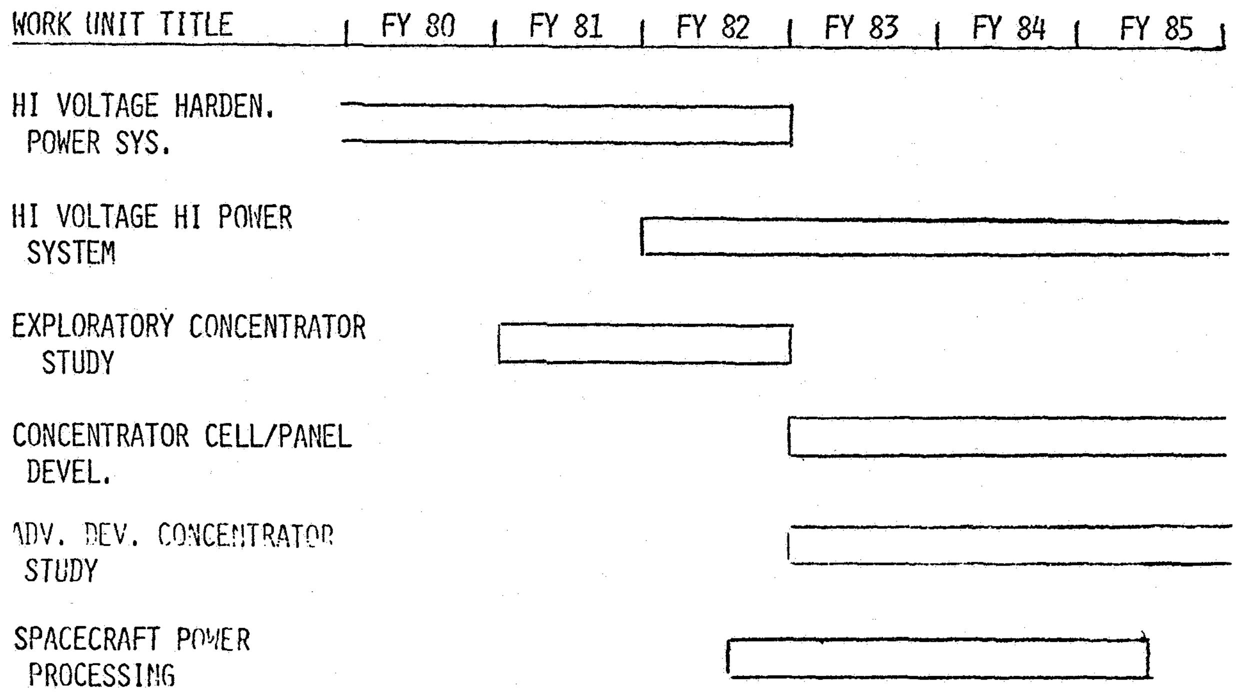

FIGURE 6

SOLAR POWER SYSTEMS

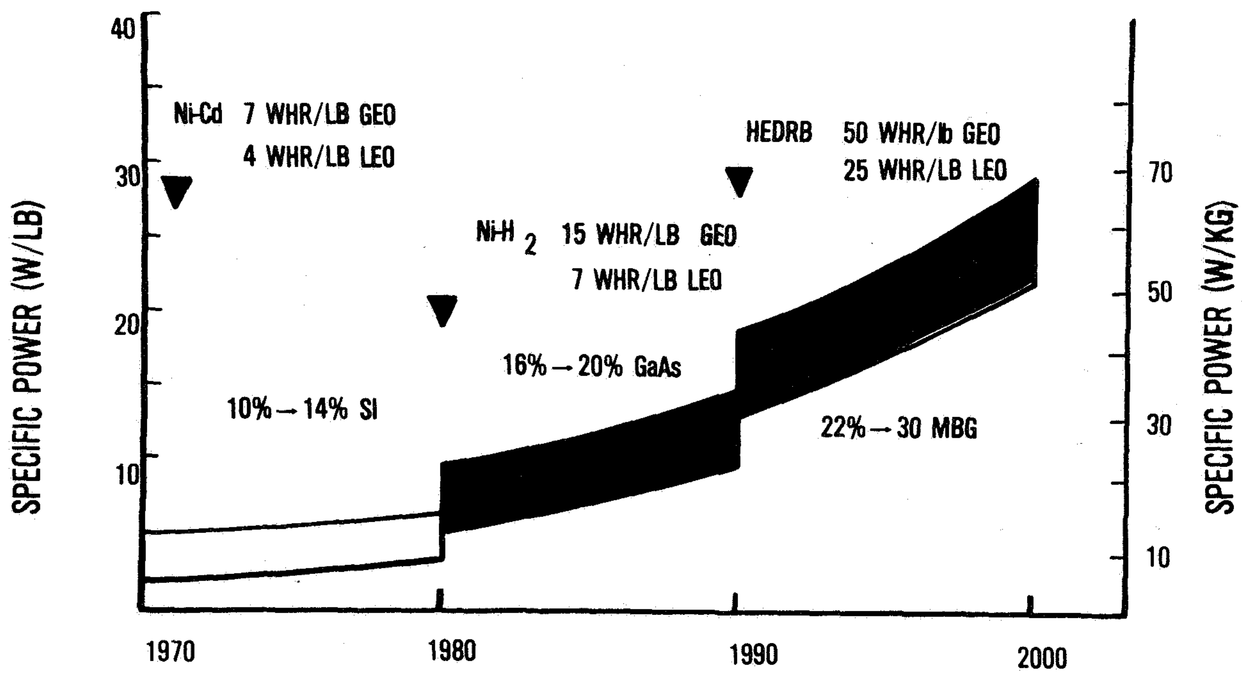

FIGURE 7