Progress of The Mars Array Technology Experiment (MATE) on the '01 Lander . D. A. Scheiman[1] , C. R. Baraona[2], P. Jenkins[1], D. Wilt[2], M. Krasowski[2], L. Greer[2], J. Lekki[2], and D. Spina[2], [1]Ohio Areospace Institute,22800 Cedar Point Rd., Brookpark, Ohio 44142 david.scheiman@grc.nasa.gov, [2] NASA Glenn Research Center, Cleveland, Ohio, 44135 MS 302-1

Introduction: Future missions to Mars will rely heavily on solar power from the sun, various solar cell types and structures must be evaluated to find the optimum. Sunlight on the surface of Mars is altered by airborne dust that fluctuates in density from day to day. The dust affects both the intensity and spectral content of the sunlight. The MATE flight experiment was designed for this purpose and will fly on the Mars 2001 Surveyor Lander as part of the Mars In-Situ Propellant Production Precursor (MIP) package. MATE will measure the performance of several solar cell technologies and characterize the Martian environment in terms of solar power. This will be done by measuring full IV curves on solar cells, direct and global insolation, temperature, and spectral content. The Lander is is scheduled to launch in April 2001 and arrive on Mars in January of 2002. The site location has not been identified but will be near the equator and last from 100 to 300 days. The intent of this of this paper is to describe and update the progress on MATE.

MATE has four main objectives for its mission to Mars. First is to measure the performance of solar cells daily on the surface of Mars, this will determine the day to day fluctuations in sunlight and temperature and provide a nominal power output. Second, in addition to measuring solar cell performance, it will allow for an intercomparison of different solar cell technologies. Third, It will study the long term effects of dust on the solar cells. Fourth and last, it will characterize the mars environment as viewed by the solar cell, measuring spectrum, insolation, and temperature.

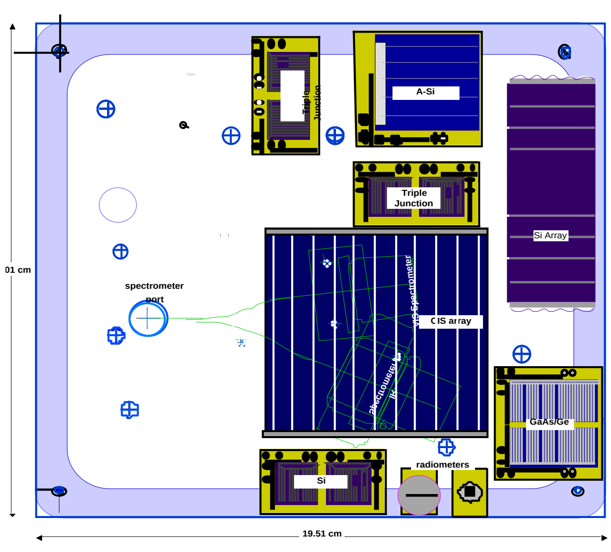

Figure 1: MATE experiment plate

Background: This flight experiment is one of five experiments that make up the MIP package. The pricipal Investigator for MIP is David Kaplan at NASA JSC. MIP is designed to demonstrate the conversion of atmosphere CO_2 into propellant, which can be used to return to earth. One of the most important resources required to produce propellant on Mars is energy. Power is required for all phases of propellant production, from the initial collection and compression of atmospheric carbon dioxide to the liquification and storage of the cryogenic propellants produced. In many propellant production systems, the power system is the single largest and most massive component. This power will be solar power.

The four other experiments on MIP are; Mars Atmosphere Acquisition and Compression (MAAC), Oxygen Generating System (OGS), Mars Thermal Environment Radiator Characterization (MTERC), and Dust Accumulation and Removal Technology (DART). The MIP experiment control and main structure is being built and operated by NASA Johnson Space Center, as is OGS. MAAC and MTERC are being built at the NASA Jet Propulsion Laboratory, and DART is being built at NASA Lewis Research Center as well. The MATE and DART experiments share a 26 cm. x 24 cm. honeycomb substrate.

Description: MATE is Mars Array Technology Experiment and its primary mission is to determine the optimum solar cell type for future missions. To do this it will measure the performance of solar cells, the solar spectrum, the solar intensity, and temperature. The flight experiment has several components, which cover a range of functions. These components are divided into several basic areas. It includes the following components:

- 10 solar cells (5 pairs)
- 2 solar cell strings
- 2 radiometers, direct and global
- 6 temperature sensors
- 1 dual spectrometer, 300 –1700 nm
- Components in warm electronics box (WEB)

Figure 1 above shows a diagram of the MATE experiment, the empty spaces are for the DART experiment and a dust cover.

The MATE experiment also includes the electronics. The schematic in figure 2 below shows the major parts of the experiment as related to the spacecraft and MIP. The experiment has a dedicated 4” x 6” circuit board in the warm electronics box. This board, when energized, is told what tests to perform, runs IV curves, senses temperature, reads insolation, scans the spectrometers, sorts the data, repeats any measurements, and then sends the data back to MIP, which it sends to the Lander. The Lander stores the data until it is ready to be transmitted. This experiment has no moving parts.

Solar Cells (10): The solar cells will be made from a variety of materials and sizes. There will be 5 pairs of different cell types. The space available, 80 mA maximum current and 6.5 V maximum voltage limit the sizes of the cells. The cell types currently selected include; high efficiency Si, Amorphous Si, two types of GaInP/GaAs/Ge triple junction space cells, and GaAs/Ge. Cells must perform well at lower temperature and lower intensity then is common to most space cells. The solar intensity on Mars is approximately one third of earth's AM0 or 45 mW/cm^2. Preliminary spectral data from Mars pathfinder and Viking have shown that the sunlight on Mars varies with dust content and tends to lose the blue part of the spectrum in the morning .

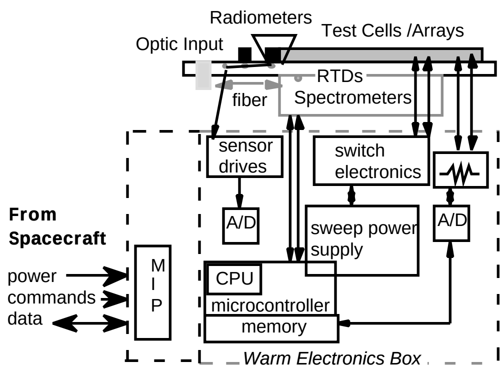

Figure 2: MATE schematic

Other factors that affect solar cell selection include weight and cost. As power requirements grow, the size of the array must also grow; weight and cost naturally become a major concern. Thin film cells offer both weight and cost savings. Studies show that large area roll out thin film arrays prove very useful for many Mars missions. Thin films include CIS and Amorphous Si, both of which are making inroads in the space community.

Solar Cell Strings (2): The strings will have the same limitations as the solar cells. These will be cells in series and therefore will not have higher currents but will have higher voltages (voltages add). Plans are to connect five cells in series for a string. One string will be high efficiency Si solar cells; the other will be a thin film CIS array. These strings are intended to test new technology as well as identify any problems with array designs.

Radiometers (2): The radiometers are thermocouple type devices that measure radiation based on thermal techniques. These are small devices that consist of multiple thermocouple junctions using thin film technology. They are very small and unlike traditional radiometers, require temperature correction. These devices generate a voltage proportional to the solar intensity. There are two radiometers, one measuring global and the other measuring direct radiation or solar insolation. The global measurement is done with a radiometer that has approximately 130• field of view. This field of view is considered adequate based on the limitations of the device and the expected amount of scattered light. A second radiometer will have a conical shell placed over it with a slit; this will measure direct radiation with the sun overhead. The direct radiometer can only be read once per day.

Temperature Sensors (6): Six temperature sensors will be scattered around the MATE experiment, two will be attached to the radiometers, two will be on the photodiode arrays of the spectrometers, and the rest will be under solar cells. The temperature sensors are platinum devices known as RTD (resistance temperature dependence). They have a well-characterized linear change in resistance with temperature (.385 %/°C). The device selected will have a 0° C resistance of 1000 Ω and be in a small ceramic case with two wires. Measurement accuracy will be 1 degree C.

Dual Spectrometer (2): The dual spectrometer consists of an input optic and two spectrometers, both having optical fiber inputs. This will span the solar spectrum from .3µm to 1.7 µm with a nominal resolution of 6-7 nm. This range was selected based on the bandwidth of solar cells and the AM0 spectrum, covering 86% of the total energy.

The input optic converts incident radiation into a diffuse light source. It consists of a tube, thin diffusing element made of Spectralon, a folding prism, and a fiber output. Light enters this diffusing element and is scattered uniformly and therefore each fiber will see the same amount of light. This diffuser extends the capability to look at the sky at any time of the day.

Status: A Development Unit (DU) was built for the MATE and DARt experiments and is currently at NASA JSC undergoing tests for the flight. The testing includes Mars simulation (temperature, pressure, and sunlight) , vibration, and EMI. This paper will include a complete description of all components on MATE, results from the DU testing, photographs, and scheduling.