Status of the Dust Accumulation and Removal Technology Experiment for the Mars 2001 Surveyor Lander.

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Introduction: The Dust Accumulation and Removal Technology (DART) experiment is designed to quantify the nature of dust settling out of the Martian atmosphere. DART is part of the Mars in-situ propellant precursor (MIP) experiment which is a payload on the Mars 2001 Surveyor Lander. At the time of this writing, high fidelity development hardware has been integrated in to the MIP experiment and completed Mars environment testing.

Background:
Dust deposition could be a significant problem for photovoltaic array operation for long duration missions on the surface of Mars. Measurements made by Pathfinder showed 0.3% loss of solar array performance per day due to dust obscuration. We have designed an experiment package, "DART," which is part of the Mars ISPP Precursor (MIP) package, to fly on the Mars-2001 Surveyor Lander. This mission, to launch in April 2001, will arrive on Mars in January 2002.

The DART experiment consists of five different instruments. The first three listed below support the characterization of Mars dust. The last two instruments are experiments designed to mitigate dust build up on solar cells. All instruments are controlled by a microcontroller on a single 4”x6” electronic circuit board.

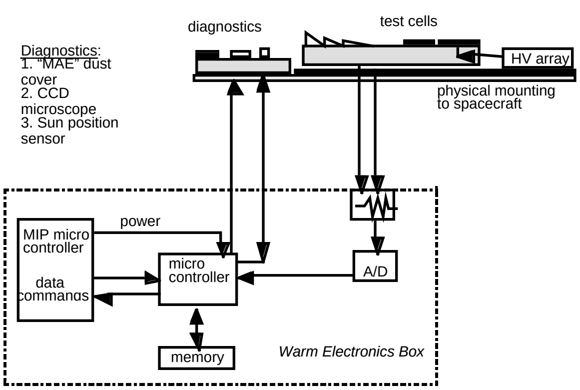

Figure 1) Block diagram of DART experiment

1) Material Adherence Experiment (MAE):
The MAE dust coverage monitor is a device to measure how much dust settling has occurred on the spacecraft. The method of measuring dust is identical to that flown on Pathfinder: dust settles on a transparent plate, and a solar cell measures the intensity of the sunlight through the settling plate. By command, the settling plate can be rotated away from the cell, and the solar cell measured again. This results in a direct measurement of the optical obscuration. By incorporating three solar cells under the settling plate, we can observe the effect of dust coverage in three spectral bands of interest.
The MAE dust coverage monitor is comprised of the following elements:
1. Transparent plate for dust settling
2. Rotary mechanism to move plate
3. 3 cells: GaInP, GaAs and a GaInP/GaAs tandem.
4. Resistors to measure photodiode current
5. Sensor element to detect position of rotation
6. Heater

2) Dust Microscope
The microscope measures the amount and properties of settled dust. It will give the rate of dust deposition, the particle size distribution, the particle opacity, and will image the shape of the larger particles. Since detailed information about dust properties is required to design dust mitigation strategies, the microscope is probably the most important instrument on DART. It is depicted in figure 2.
The microscope is comprised the following elements:
1. Settling plate. A transparent, horizontal, glass plate. Dust settling from the atmosphere will land on this plate, which will hold it at a fixed focus distance from the objective.
2. Objective lens. A lens system which magnifies the image of the front surface of the plate. We are anticipating use of a 40x objective, to resolve particles down to roughly one-micron diameter.
3. Turning prism. The turning prism bends the light path by 90 degrees to allow us to mount the microscope horizontally beneath the plate.
4. Focal plane array. The microscope focal plane uses a FUGA-15D active-pixel array.
5. Short-pass filter ("blue filter").
6. Illuminator. A light-emitting diode which illuminates the dust particles.
7. Control electronics
8. Structure. A structural frame holds the components in optical alignment and also excludes stray light.
9. Objective heater

3) Sun position sensor
The sun position sensor locates where the sun is relative to the DART experiment. We also intend to use this measurement to obtain a measure of the optical depth of the atmospheric dust (tau). The sun sensor is designed to measure sun position when the sun is within 45 degrees of zenith. A third element measures sun elevation at lower sun angles.

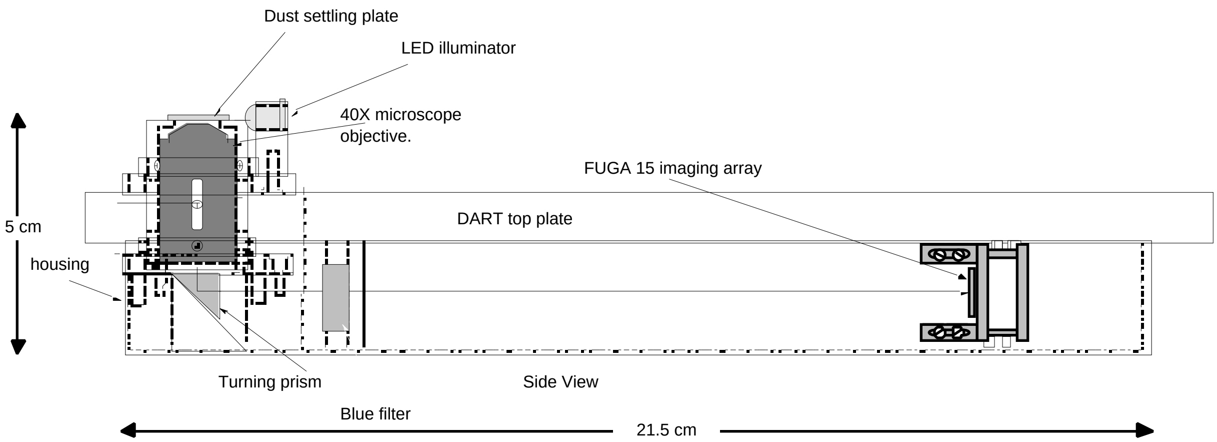

Figure 2) Schematic of DART microscope.

The sun position sensor is comprised of three each of the following elements;
1. 512 element linear photodiode array
2. Filter
3. Cylindrical lens
4.Mounting and stray-light shield

4) Tilted cells

We will test whether the dust will deposit onto tilted surfaces. Use of a tilted solar array may be the simplest solution to the dust accumulation problem. Measurements of the camera window on the Viking lander showed no dust adhering to the vertical surface. Observations of the thermal shell of the Viking landers seemed to show that dust also did not build up on the tilted surfaces. Unfortunately, this observation is anecdotal, and no quantitative measurement of accumulation could be made. Due to this observation, we have decided that a high priority is to verify the conjecture that tilted solar cells will not accumulate dust, and to get an indication of what angle is required to avoid dust coverage.

The following elements comprise the tilted cell measurement:
1. Solar cells tilted at 30°, 45°, and 60°, plus a control (horizontal) cell
1a. Solar cell tilted at 30° with low friction coating
2. Horizon mask
3. Resistors to measure current

5) Electrostatic Dust Mitigation

An electrostatic dust removal method will be tested. Electrostatic dust removal is a possible means of dust mitigation with the advantage of requiring no moving parts. Since the Martian dust is most likely charged (due to triboelectric charging and photoionization), a continuous electrostatic charge may prevent dust from settling on solar cells. A high-voltage vertical junction photovoltaic array will provide an electrostatic potential continuously to the test cell (during daylight operation). The electric field strength in the neighborhood of the cells will be approximately 100 Volts/cm. Three solar cells will be tested, one with positive potential, one with negative potential, and one solar cell to test whether a transverse electric field can sweep dust away from the cell before it accumulates. In each case, a wire at a "ground" reference is used as the second electrode.

The following elements comprise the electrostatic dust mitigation measurement:
1. Three solar cells, each fitted with a transparent, conductive, cover glass
2. Four vertical multi-junction cells wired to yield ±80V
3. Wires suspended above and to one side of the cells to establish the direction of the electric field.
4. Resistors to measure solar cell current and monitor the high voltage array

Progress to Date: The Dust Accumulation and Removal Technology (DART) experiment has completed system level tests with the MIP using high fidelity development hardware. The testing included Mars environment simulation and launch vibration. The DART team has finished its Critical Design Review and flight hardware is expected to be complete by March 2000.

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