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Conceptional Designs For a Mars Tumbleweed

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A novel method for collecting in-situ data on Mars is to use a "tumbleweed" with instruments, which can be blown by the winds on Mars. Unlike Mars' rovers, airplanes and airships, it requires no propulsion system and can collect data at multiple locations and travel large distances. In order to travel by blowing wind over it, the design of a tumbleweed should have high drag, low mass, and low rolling resistance. Due to the low atmospheric density on Mars, the Reynolds number of the blown atmosphere is very low, which has a significant effect on the shape of the tumbleweed and its drag coefficient. Initial estimates of the size of a Mars tumbleweed were made by the Spacecraft and Sensors Branch at NASA Langley Research Center and found to have a diameter of about six meters. Consideration was given to the atmospheric density and winds measured by Viking I and II and the Mars Pathfinder, and also the height of the atmospheric boundary layer on Mars. The proposed instrumentation package is to have, as a minimum, sensors for pressure and temperature, a video camera, and three-axis accelerometers. The data is to be transmitted to a Mars Orbiter, which would relay it back to earth. If a GPS were in place on Mars in advance of the deployment of the tumbleweed, then it could be used to locate the position of the tumbleweed on Mars. The Mars Tumbleweed design project was a collaboration between the NASA Langley Research Center's Spacecraft and Sensors Branch, the NC State University senior spacecraft design class, and the sixth grade class of Fred J. Carnage Middle School. The goals were to study concept designs for Mars, down-select to one design, and construct and test an earth demonstrator.

Tumbleweed Concept Designs: Four concepts were proposed initially and they are known as Dandelion, Box-Kite, Tumblecup, and Wedges. Subsonic wind tunnel tests were made on all four designs to determine their drag coefficients. In order to achieve low Reynolds numbers, (50,000 to 100,000) the wind tunnel speed had to be so low (4 to 8m/s) that existing wind tunnel balances were not accurate and a new balance had to be designed for these experiments. In addition to the drag coefficient other parameters used to determine a figure of merit were the mass and number of parts for manufacturing. The students in the sixth grade class at Fred J. Carnage Middle School constructed their own wind tunnel by aligning two columns of tables, turned on end to form a channel down the classroom, and using a fan at one end propelled the tumbleweeds constructed by the students down the tunnel. The distance they traveled from the fan was used in determining their efficiency. Also, for the deployment of the tumbleweed from a spacecraft, the sixth grade students made parachutes and dropped them with their tumbleweed attached from a third story window at the school. The time of flight from the drop to hitting the ground was measured and used in judging the efficiency of the different designs. After comparing the figures of merit for the four concepts, the concept called Box-Kite was determined to be the best one for further analysis; therefore construction and testing of an earth demonstrator began. The Box-Kite consists of a center sphere with instrumentation surrounded by circular tubes with flexible sails running from the center sphere to the outer circular tubes. Due to the differences in the atmosphere and gravity between Mars and Earth, it was determined that the diameter of the tumbleweed should be reduced from six meters on Mars to two meters for the earth demonstrator.

Tumbleweed Earth Demonstrator: The diameter of the outer circular tubes is two meters and they were fabricated from lightweight fiber/Kevlar� composite material. The instrumentation package, housed in the spherical core, consists of a GPS receiver, three accelerometers, pressure transducers, temperature sensors, a video camera, and a transmitter to send data to a remote ground station. Rolling tests were performed to determine the rolling resistance. Simulated wind tests were also performed indoors using a wind tunnel to simulate the wind, but with the tumbleweed rolling on the floor. Outdoor tests are in progress and should be completed by August 15, 2003. The results will be included with the poster.