

Launch Pad 39 Hail Monitor Array System



Localized-Weather
Forecasting and
Measurement

Weather conditions at Kennedy Space Center are extremely dynamic, and they greatly affect the safety of the Space Shuttles sitting on the launch pads. For example, on May 13, 1999, the foam on the External Tank (ET) of STS-96 was significantly damaged by hail at the launch pad, requiring rollback to the Vehicle Assembly Building.

The loss of ET foam on STS-114 in 2005 intensified interest in monitoring and measuring damage to ET foam, especially from hail. But hail can be difficult to detect and monitor because it is often localized and obscured by heavy rain. Furthermore, the hot Florida climate usually melts the hail even before the rainfall subsides.

In response, the hail monitor array (HMA) system, a joint effort of the Applied Physics Laboratory operated by NASA and ASRC Aerospace at KSC, was deployed for operational testing in the fall of 2006. Volunteers from the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network, in conjunction with Colorado State University, continue to test duplicate hail monitor systems deployed in the high plains of Colorado.



Shuttle Launch Pads 39A and 39B.



Location of hail monitor stations, HM-1, HM-2, and HM-3, at Launch Pad 39A.

The HMA system consists of three stations approximately 500 ft from the launch pad. The hail monitor sensor is basically a metal plate in the shape of a shallow pyramid. It deflects hail from the sensor surface after one hit, thus preventing multiple bounces from the same hail stone. A microphone pickup is mounted beneath the center of the metal plate. The output of this microphone is connected to an electronic circuit that digitizes and processes the microphone signal and then transmits a trigger pulse to one of six output channels. Each output channel represents a signal that is twice as large as the previous channel, thereby categorizing the hail stone into one of six sizes, from diameters of about 10 to 20 mm, in 2-mm steps. The six output channels are connected to six liquid-crystal diode (LCD) counters, which create a permanent record of all hail hitting the sensor. The counters are manually reset after a hail storm.

The HMA system was first deployed to Launch Pad 39B for support of STS-115 in September 2006 and then to Pad 39A for support of STS-116 in December 2006. The system's deployment in support of STS-117 collected and analyzed data of foam damage from a freak hail storm on February 26, 2007, that delayed the launch of Atlantis for nearly two months (also see "Hail Size Distribution Mapping," page 52).

Support of STS-118 showed another important use of the hail monitor system. On July 13, 2007, hail was observed on the ground at the Vehicle Assembly Building, but no hail was recorded at the pad occupied by Endeavour. United Space Alliance Ground Operations personnel check the hail monitors every morning when a vehicle is on the pad and after any storm suspected of containing hail. If no hail is recorded by the hail monitors, the vehicle and pad inspection team has no need to conduct a thorough

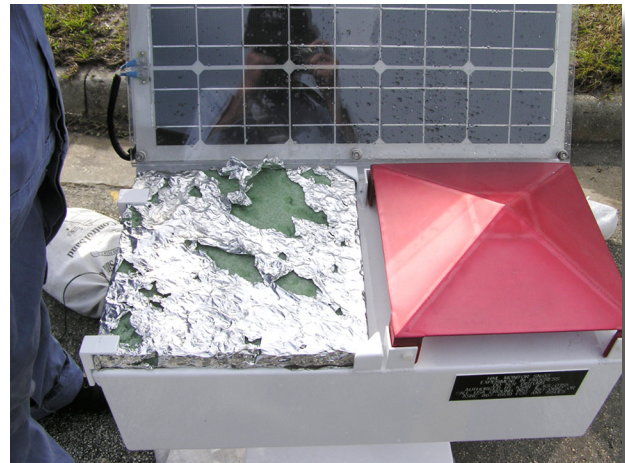


Hail monitor station 3 (HM-3) at Launch Pad 39A.

inspection of the vehicle immediately following a storm. During one week while Endeavour was on the pad, numerous hail storms occurred all around KSC. The HMA showed no detections, indicating that the Shuttle had not been damaged by hail at any time during those frequent local hail storms.

Contact: Dr. John E. Lane <John.E.Lane@nasa.gov>, ASRC Aerospace, (321) 867-6939

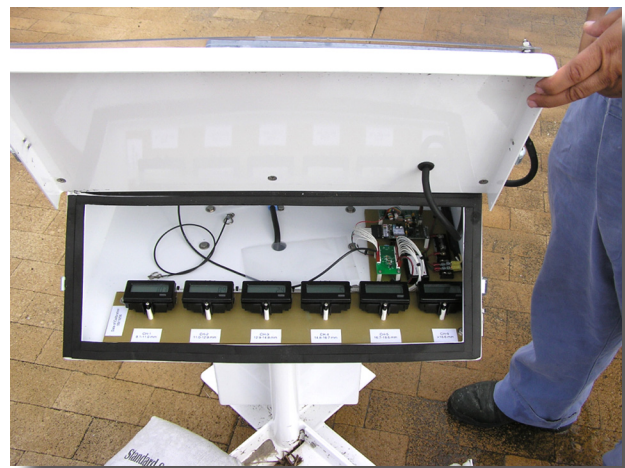
Participating Organizations: NASA-KSC (Dr. Robert C. Youngquist), ASRC Aerospace (William D. Haskell, Mark C. Minich, Joseph N. Dean, and Michael W. Csonka), CoCoRaHS, and Colorado State University



Close-up of HM-2 after February 26, 2007, hail event, showing ripping of the passive hail pad surface from 60-knot horizontal winds.



HM-2 after the February 26, 2007, severe hail event at Launch Pad 39A.



Under-the-hood view of HM-2, showing LCD counters and digital-signal-processing electronics.