Technology Focus: Test & Measurement

ISS Ammonia Leak Detection Through X-Ray Fluorescence

An astrophysics instrument can be used to detect and localize ISS ammonia leaks.

Goddard Space Flight Center, Greenbelt, Maryland

Ammonia leaks are a significant concern for the International Space Station (ISS). The ISS has external transport lines that direct liquid ammonia to radiator panels where the ammonia is cooled and then brought back to thermal control units. These transport lines and radiator panels are subject to stress from micrometeorites and temperature variations, and have developed small leaks. The ISS can accommodate these leaks at their present rate, but if the rate increased by a factor of ten, it could potentially deplete the ammonia supply and impact the proper functioning of the ISS thermal control system, causing a serious safety risk.

A proposed ISS astrophysics instrument, the Lobster X-Ray Monitor, can be used to detect and localize ISS ammonia leaks. Based on the optical design of the eye of its namesake crustacean, the Lobster detector gives simultaneously large field of view and good position resolution. The leak detection principle is that the nitrogen in the leaking ammonia will be ionized by X-rays from the Sun, and then emit its own characteristic X-ray signal. The Lobster instrument, nominally facing zenith for its astrophysics observations, can be periodically pointed towards the ISS radiator panels and some sections of the transport lines to detect and localize the characteristic X-rays from the ammonia leaks. Another possibility is to use the ISS robot arm to grab the Lobster instrument and scan it across the transport lines and radiator panels. In this case the leak detection can be made more sensitive by including a focused 100-microampere electron beam to stimulate X-ray emission from the leaking nitrogen. Laboratory studies have shown that either approach can be used to locate ammonia leaks at the level of 0.1 kg/day, a threshold rate of concern for the ISS.

The Lobster instrument uses two main components: (1) a microchannel plate optic (also known as a Lobster optic) that focuses the X-rays and directs them to the focal plane, and (2) a CCD (charge coupled device) focal plane detector that reads out the position and energy of the X-rays, allowing a determination of the leak location. The effective area of the detection system is ≈2 cm^2 at 1 keV.

The Lobster astrophysics instrument, designed for monitoring the sky for X-ray transients, gives high sensitivity along with large field of view (30×30°) and good spatial resolution (1 arc min). This offers a significant benefit for detecting ISS ammonia leaks, since the goal is to localize small leaks as efficiently as possible.

This work was done by Jordan Camp, Scott Barthelmy, and Gerry Skinner of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16686-1

A System for Measuring the Sway of the Vehicle Assembly Building

Tests have shown that the existing facility is safe.

John F. Kennedy Space Center, Florida

A system was developed to measure the sway of the Vehicle Assembly Building (VAB) at Kennedy Space Center. This system was installed in the VAB and gathered more than one total year of data. The building movement was correlated with measurements provided by three wind towers in order to determine the maximum deflection of the building during high-wind events.

The VAB owners were in the process of obtaining new platforms for use in assembling very tall rockets when analysis of the VAB showed that a high wind could move the building sufficiently that an upper platform might impact a rocket. The problem arises because safety requires a relatively small gap between the platform and the rocket, while a large enough gap is needed to ensure that stacking tolerances prevent contact between the rocket and the platform. This only leaves an inch or two (≈2 to 5 cm) of total clearance, so when the analysis showed that more than a couple of inches of motion could occur in a high wind, there was a potential for damaging the rocket. The KSC Applied Physics Laboratory was asked to install a system in the VAB that could measure the motion of the building in high winds to determine the actual building sway.

The motion of the VAB roof under wind load was measured optically, and under analysis, it was determined that a relatively large-aperture optical system would be required to reduce diffraction effects to less than a small fraction of an inch (≈mm) at a distance of 500 ft (≈150 m). A 10-in. (≈250 mm) telescope was placed on the floor of the building, looking at the ceiling. On the ceiling, a flat plate with three white LEDs was mounted in an "L" shape, such that the telescope was essentially looking at three stars. Software was written to track the motion of these three points using an image processing system. This provided a better than 1/10-in. (≈2.5-mm) 2D measurement faster than once a second. Data was downloaded once a month for comparison with the wind tower data.

The system was fully operational and provided enough data to show that the VAB will only move 1 in. (≈2.5 cm) at the ceiling under 70-knot winds. Adjustable platforms are not required.

This work was done by Robert Youngquist, Stanley Starr, John Lane, Stephen Simmons, and Curtis Ihlefeld of Kennedy Space Center. KSC-13773