without an artificially induced notch at different rotational loading speed levels. Health monitoring verification was performed by integrating three different advanced machine-learning algorithms for anomaly detection in continuous data streams from spinning tests of a subscale turbine engine-like rotor disk up to a speed of 10,000 rpm.

This study compares an outlier detection algorithm (Orca), one-class support vector machines (OCSVM), and the Inductive Monitoring System (IMS) for anomaly detection on the data streams. These techniques were used to inspect the experimental data under the same operating conditions employed in the tests, and using the measured vibration response (blade tip clearance) as a key input to check the viability of these techniques on detecting the disk anomalies and to evaluate the performance of each methodology. The performance of the algorithm is measured with respect to the detection horizon for situations where fault information is available. Further, this work presents a select evaluation of an online health monitoring scheme of a rotating disk using a combination of high-caliber sensor technology, high-precision in-house spin test system facilities, and unprecedented data-driven fault detection methodologies.

The methodologies applied in this study can be considered as a model-based reasoning approach to engine health monitoring. Typical model-based reasoning techniques compare a system model or simulation with system sensor data to detect deviations between values predicted by the model and those produced by the actual system. In fact, a model-based reasoner uses the collected system parameter values as input to a simulation and determines if a particular set of input values is consistent with the simulation model. When the values are not consistent with the model, a "conflict" occurs, indicating that the system operation is off nominal. The results obtained showed that the detection algorithms are capable of predicting anomalies in the rotor disk with very good accuracy. Each detection scheme performed differently under the same experimental conditions, and each delivered a different level of precision in terms of detecting a fault in the rotor. Overall rating showed that both the Orca and OCVSM performed better than the IMS technique.

This work was done by Ali Abdul-Aziz, Mark R. Woike, Nikunj C. Oza, and Bryan L. Matthews of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18758-1.

⚛ Measuring Air Leaks Into the Vacuum Space of Large Liquid Hydrogen Tanks

John F. Kennedy Space Center, Florida

Large cryogenic liquid hydrogen tanks are composed of inner and outer shells. The outer shell is exposed to the ambient environment while the inner shell holds the liquid hydrogen. The region between these two shells is evacuated and typically filled with a powder-like insulation to minimize radiative coupling between the two shells. A technique was developed for detecting the presence of an air leak from the outside environment into this evacuated region.

These tanks are roughly 70 ft (≈21 m) in diameter (outer shell) and the inner shell is roughly 62 ft (≈19 m) in diameter, so the evacuated region is about 4 ft (≈1 m) wide.

A small leak's primary effect is to increase the boil-off of the tank. It was preferable to install a more accurate fill level sensor than to implement a boil-off meter. The fill level sensor would be composed of an accurate pair of pressure transducers that would essentially weigh the remaining liquid hydrogen. This upgrade, allowing boil-off data to be obtained weekly instead of over several months, is ongoing, and will then provide a relatively rapid indication of the presence of a leak.

This work was done by Robert Youngquist, Stanley Starr, and Mark Nurge of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13211

⚛ Antenna Calibration and Measurement Equipment

NASA's Jet Propulsion Laboratory, Pasadena, California

A document describes the Antenna Calibration & Measurement Equipment (ACME) system that will provide the Deep Space Network (DSN) with instrumentation enabling a trained RF engineer at each complex to perform antenna calibration measurements and to generate antenna calibration data. This data includes continuous-scan auto-bore-based data acquisition with all-sky data gathering in support of 4th order pointing model generation requirements. Other data includes antenna subreflector focus, system noise temperature and tipping curves, antenna efficiency, reports system linearity, and instrument calibration.

The ACME system design is based on the on-the-fly (OTF) mapping technique and architecture. ACME has contributed to the improved RF performance of the DSN by approximately a factor of two. It improved the pointing performances of the DSN antennas and productivity of its personnel and calibration engineers.

This work was done by David J. Rochblatt and Manuel Vazquez Cortes of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47599