folded beams allow a much smaller footprint to achieve the same flexibility as the conventional configuration.

The breadboard sensor was tested in a water tank testbed. The testbed includes a "false bottom" plate and a running conveyor belt. The false bottom plate simulates the riverbed, and provides an opening for attaching the sensor mounting plate and an air pocket for separating the encoder from the water. The running belt is placed parallel to the direction of measurement, and is placed on a structure different than the false bottom for vibration isolation. The belt was running at controlled speed of up to 2 m/s in both forward and opposite directions, about 38 mm above the false bottom plate where the sensor was mounted. An average position change is about 620 nm, corresponding to a change in direction of the boundary shear stress. The fluctuation is believed to be caused by the turbulence of the flow.

Another flexure with a 3D configuration was proposed as well. The 3D version was designed to allow for a plate to rotate about an axis defined by three sets of flexures. The plate is mounted on a beam that passes through this axis and extends on the other side of the axis where it has a free end. An optical or capacitive sensor would read the displacement of the free end of the beam, which would be used with the flexure's stiffness to calculate the shear force on the sensor plate. This configuration could use the horizontal blade to separate the test media, such as water, from the optical or capacitive sensor, but would present more manufacturing and packaging challenges.

Model-Based Method for Sensor Validation

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Fault detection, diagnosis, and prognosis are essential tasks in the operation of autonomous spacecraft, instruments, and *in situ* platforms. One of NASA's key mission requirements is robust state estimation. Sensing, using a wide range of sensors and sensor fusion approaches, plays a central role in robust state estimation, and there is a need to diagnose sensor failure as well as component failure. Sensor validation can be considered to be part of the larger effort of improving reliability and safety.

The standard methods for solving the sensor validation problem are based on probabilistic analysis of the system, from which the method based on Bayesian networks is most popular. Therefore, these methods can only predict the most probable faulty sensors, which are subject to the initial probabilities defined for the failures.

The method developed in this work is based on a model-based approach and provides the faulty sensors (if any), which can be logically inferred from the model of the system and the sensor readings (observations). The method is also more suitable for the systems when it is hard, or even impossible, to find the probability functions of the system. The method starts by a new mathematical description of the problem and develops a very efficient and systematic algorithm for its solution. The method builds on the concepts of analytical redundant relations (ARRs).