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Research and Development on In-Situ Measurement Sensors for Micro-Meteoroid and Small Space Debris at JAXA

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The history of Japanese R&D into in-situ sensors for micro-meteoroid and orbital debris (MMOD) measurements is neither particularly long nor short. Research into active sensors started for the meteoroid observation experiment on the HITEN (MUSES-A) satellite of ISAS/JAXA launched in 1990, which had MDC (Munich Dust Counter) on-board sensors for micro meteoroid measurement. This was a collaboration between Technische Universität München and ISAS/JAXA. The main purpose behind the start of passive sensor research was SOCCOR, a late 80's Japan-US mission that planned to capture cometary dust and return to the Earth. Although this mission was canceled, the research outcomes were employed in a JAXA micro debris sample return mission using calibrated aerogel involving the Space Shuttle and the International Space Station. There have been many other important activities apart from the above, and the knowledge generated from them has contributed to JAXA's development of a new type of active dust sensor. JAXA and its partners have been developing a simple in-situ active dust sensor of a new type to detect dust particles ranging from a hundred micrometers to several millimeters. The distribution and flux of the debris in the size range are not well understood and is difficult to measure using ground observations. However, it is important that the risk caused by such debris is assessed. In-situ measurement of debris in this size range is useful for 1) verifying meteoroid and debris environment models, 2) verifying meteoroid and debris environment evolution models, and 3) the real time detection of explosions, collisions and other unexpected orbital events. Multitudes of thin, conductive copper strips are formed at a fine pitch of 100 um on a film 12.5 um thick of nonconductive polyimide. An MMOD particle impact is detected when one or more strips are severed by being perforated by such an impact. This sensor is simple to produce and use and requires almost no calibration as it is essentially a digital system. Based on this sensor technology, the Kyushu Institute of Technology (Kyutech) has designed and developed an educational version of the sensor, which is currently on board the nano-satellite Horyu-II, which was built at Kyutech and launched on May 18, 2012 by JAXA. Although the sensor has a very small sensing area, sensor data were nonetheless successfully received. Moreover, a laboratory version of the sensor fitted on QSAT-EOS ("Tsukushi"), a small satellite, was be launched in November 2014. This version was developed and manufactured by Japan's QPS Institute to evaluate the sensor's capability regarding hypervelocity impact experiments at JAXA. JAXA's flight version, to be employed on satellites and/or the ISS, will be ready soon and a flight demonstration will be conducted on KOUNOTORI (HTV) in 2015. This paper reports on the R&D into in-situ measurement MMOD sensors at JAXA.