ODIN: A CONCEPT FOR AN ORBITAL DEBRIS IMPACT DETECTION NETWORK. J. S. O. New[1], M. C. Price[1] and M. Cole[1] Centre for Astrophysics and Planetary Sciences, School of Physical Sciences, Ingram Building, University of Kent, Canterbury, Kent CT2 7NH, United Kingdom (jn287@kent.ac.uk).

Introduction: The Orbital Debris Impact Network (ODIN) is intended to be a series of large area impact detectors for in-situ measurements of micrometeoroids and orbital debris (MMOD) in the millimeter to sub-milimeter size regime, leading to accurate MMOD environment models for different orbits.

MMOD particles in the 0.2 mm to 1 mm size regime are too small to be detected by ground based radars and optical telescopes [1] but are large enough to reduce the lifetime of autonomous missions in low Earth orbit (LEO) and jeopardise the safety of human space activities [2]. Although safety concerns are negligible for MMOD smaller than 0.2 mm in diameter, ODIN's sensors can detect objects as small as 0.05 mm for further scientific study.

The proposed design of ODIN combines unique detection technologies that maximize the information extracted from each impact. The full detector combines three 0.5 m × 0.5 m panels consisting of two 25 μm thick Kapton films with a 20 cm separation and a 7 cm thick syntactic foam backstop with a 10 cm separation (Figure 1). Multiple polyvinylidene fluoride (PVDF) acoustic impact sensors [3] are attached to the backside of both Kapton films and the front facing side of the syntactic foam to provide measurements on MMOD impact time, size, speed, direction, mass, energy and material.

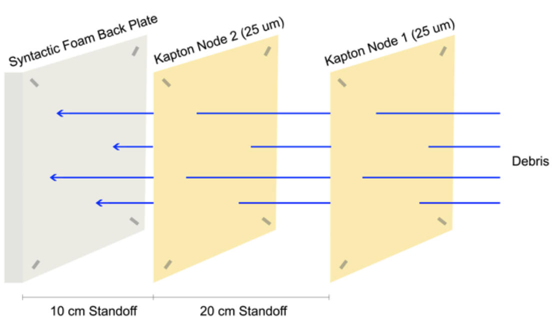

Figure 1: Schematic of ODIN set-up.

During the 47th LPSC meeting we will present details of the method used to calculate MMOD size and results from calibration experiments conducted at the University of Kent, in Canterbury, UK.

Method: Measuring the time difference between impacts on the first two Kapton films, with known spacing can be used to calculate MMOD speed. The impact location on each film can be identified by triangulating the arrival time of acoustic signals received at different PVDF sensors at known locations. Comparing the impact locations on the first two films provides a measure of the impact direction. The PVDF sensors are also used to measure impact-hole size using the peak-to-peak amplitude (p/p amp) of the acoustic signals. Investigations are underway to verify whether acoustic data from the syntactic foam backstop can be used to calculate energy and in turn, mass, momentum and possibly MMOD material.

Calibrating ODIN to calculate the size of MMOD from PVDF acoustic signals is being done experimentally using the Light Gas Gun (LGG) facility at the University of Kent [4]. We expose a prototype of ODIN (Figure 2) to spherical debris of different materials ranging from tens of micrometers to millimeters in size at speeds between 1 km s^{-1} and 7 km s^{-1}. The acoustic signals obtained by each PVDF sensor are recorded and sorted into data sets for each speed regime. The p/p amp of each signal is scaled to a set distance of 250 mm from the impact to give a unit p/p amp and plotted against hole size and debris size for each speed regime. After complete calibration, it is possible to determine the size of MMOD, at a measured speed, using the p/p amp of its acoustic signal upon impact with ODIN.

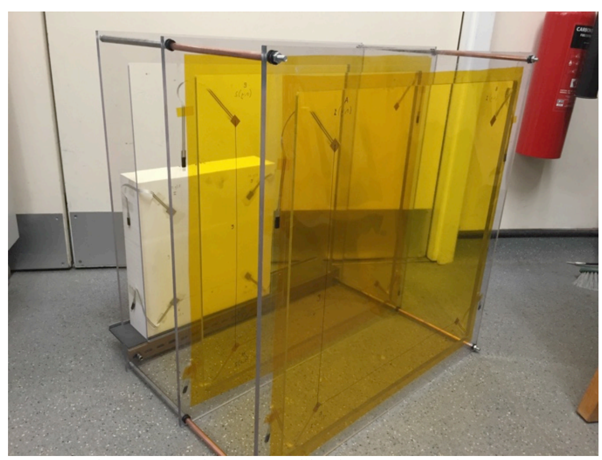

Figure 2: Photograph of the current calibration prototype of ODIN.

Results: Preliminary experiments were conducted using spherical stainless-steel projectiles at ~5 km s^{-1}. An example of the acoustic signals from a 1 mm projectile impact has been included in Figure 3 where each line corresponds to data collected from one of the four PVDF sensors on a single Kapton film.

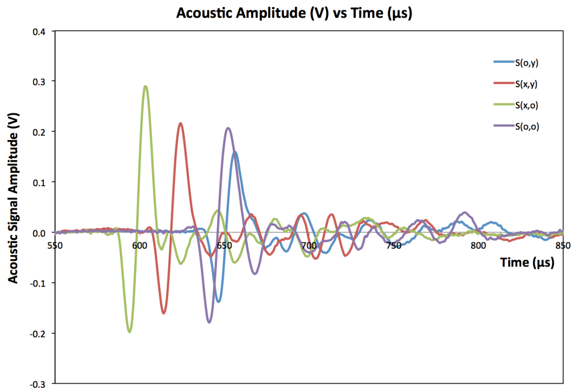

Figure 3: Plot of acoustic signal amplitude vs time. Each line corresponds to one of the PVDF sensors located at (0,y), (x,y), (x,0) and (0,0) respectively.

The p/p amp of projectiles ranging from 0.4 mm to 2 mm diameter were plotted against projectile size in Figure 4 and yielded promising results. The p/p amp for a 1 mm projectile was approximately 40 mV, when the projectile diameter was doubled, the p/p amp was ~ 80 mV (double). Furthermore, when the projectile diameter was half the size (0.5 mm), the corresponding p/p amp was ~ 20 mV.

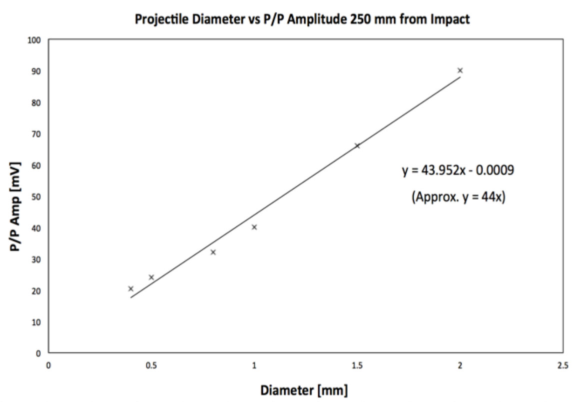

Figure 4: Plot of average unit p/p amp at 250 mm from impact vs projectile diameter.

Conclusions: The preliminary p/p amp vs projectile-size results from the first set of experimental calibration shots followed a linear trend line to a high degree where the p/p amp is approximately 44 times larger than the diameter of the corresponding projectile. However, the p/p amp was slightly larger than expected for the smaller projectiles. Previous experiments that we conducted showed that the relative hole-size to projectile-size ratio gets larger for smaller projectiles. If the p/p amp is proportional to the hole size rather than the projectile size, which is a sensible assumption, then plotting p/p amp against hole size may eliminate the inaccuracies at smaller projectile sizes. Data from the full investigation will be presented at the 47th LPSC conference 2016.

References: [1] *Handbook for Limiting Orbital Debris,* NASA Handbook 8719.14, approved July 30, 2008. [2] Christiansen E. L. et al. (2004) *Advances in Space Research 34,* 1097-1103. [3] Burchell M. J. and Standen S. and Cole M. J. and Corsaro R. D. and Giovane F. and Liou J. C. and Pisacane V. and Sadilek A. and Stansbery E. (2011) *International Journal of Impact Engineering, 36(6),* 426-433. [4] Burchell M. J. et al. (1999) *Meas. Sci. Tech., 10(1)*, 41–50.