FALL AND RECOVERY OF THE MURRILI METEORITE, AND AN UPDATE ON THE DESERT FIREBALL NETWORK.

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Introduction: Beginning in 1959, a dozen projects – professional and amateur – have pursued the goal of recovering meteorites with known orbits (e.g. [1]). This combined effort yielded 10 meteorites. Although the numbers are small, even this handful generated fundamental insights: the early work provided the proof that meteorites come from the asteroid belt. But why so few? All these projects were sited in the temperate zone of the northern hemisphere: vegetated areas where recovery efficiency is marginal. Deserts are one of the few places on Earth where meteorite recovery is straightforward. This was the driver behind the Desert Fireball Network. Two meteorites were recovered during its trial phase (4 film cameras and an area of 150,000km^2). This successful proof-of-concept enabled funding for significant expansion, and upgrade to a digital, fully automated network.

Currently, the DFN has expanded to 50 high resolution fireball observatories across 2.5 million km^2 of outback Australia. The observatories are fully autonomous intelligent imaging systems, capable of operating for 12 months in a harsh environment without maintenance, and storing all imagery collected over that period, modifying observations based on cloud conditions, and automatically recognizing and reporting fireball events using neural network algorithms. Precise timing is required for orbit determination. We invented a method to embed absolute millisecond timing data into long exposures [2]. This advance enabled a cheaper system, without sacrificing sensitivity or data quality [3]. Finally, we developed a completely automated software pipeline for data reduction [4-7]. Software detects fireball trajectories in pixel coordinates, and converts them to celestial coordinates, at sub-arcminute precision, by automatically identifying surrounding stars, and using them as a referencing system. Using this pipeline, we successfully recovered a meteorite from Lake Eyre on 31st December 2015.

Fall of the Murrili meteorite: Five of our observatories imaged a 6.1 second fireball at 10:43:44.50 UTC on 27th November 2015 and immediately reported to the central server. Our data pipeline allowed us to rapidly determine a trajectory and orbit. Prior to encountering the Earth the object's orbit was defined by the following orbital elements: $a = 2.62$ AU, $e = 0.62$; $i = 3.58$ deg, $\omega = 356.3$ deg; $\Omega = 64.63$ deg, $\nu = 3.2$, $q = 0.9944$ AU, $Q = 4.3$ AU. The object encountered the Earth close to perihelion, entering our atmosphere at 13.82 km/s. We tracked it for 72 km through the atmosphere: although our observatories averaged ~100 km distant, we pinpointed its position to <20 m along most of that track. The object stopped ablating at an altitude of 18.24 km, when it was traveling at 3.83 km/s. We modelled its dark flight through the atmosphere to the ground using the WRF climate model.

Recovery of the Murrili meteorite: The meteorite fell in Kati Thanda (Lake Eyre), the land of the Arabana people. At 9,500 km^2 Lake Eyre is one of the largest salt lakes in the world. The lake rarely fills completely, but even in the dry season there is usually some water remaining in smaller sub-lakes. The surface is a thin dusting of salt on top of brine-saturated, organic-rich, thick clay mud. The site posed a challenge for recovery. The calculated fall site was 6 km from the nearest shore. Initial reconnaissance from light-aircraft identified what appeared to be an impact feature in the surface of the lake close to the predicted fall site. An expedition to recover the meteorite was assisted with members of the Arabana people, the traditional custodians of the land, who joined us as guides. Rain had obscured the original impact site, but searching on foot, with quad bikes, an aerial survey, and drone allowed recovery. The meteorite had punched a hole in the lake mud and came to rest 43cm from the surface. It was recovered on 31st December 2015, only 218m away from the predicted fall position. The meteorite is a 1.68 kg H5 chondrite (for a complete petrographic description see [8]). The name 'Murrili' was chosen by the Arabana people as significant for this region of Kati Thanda.

Summary: Murrili is the third meteorite with an orbit recovered by the DFN after camera observations pinpointed a fall position. With the recovery of our first meteorite following the digital expansion of the DFN, we have established that hardware is delivering high resolution data, with precision timing, sub-arcminute image calibration and astrometry, which allows for final trajectory, fall position and orbit data. We have tracked a number of other falls to the ground. Searches for these will commence later in 2016.

References: [1] Halliday, I. *et al.* (1996) *MAPS* 31, 185. [2] Howie, R. M. (2015) 46th Lunar Planet. Sci. Conf., 1743. [3] Howie, R. M. *et al.* (2015) LPI Contribution No. 1856, 5196. [4] Sansom, E. K. *et al.* (2015) *MAPS* 50, 1423. [5] Galloway, M. J. *et al.* (2015) LPI Contribution No. 1856, 5160. [6] Sansom, E. K. *et al.* (2014) 31st URSI General Assembly and Scientific Symposium. [7] Sansom, E. K. *et al.* (2014) 45th Lunar Planet. Sci. Conf., 1591. [8] Benedix, G. K. *et al.* (2016) *this conference*.