TBAD Overview

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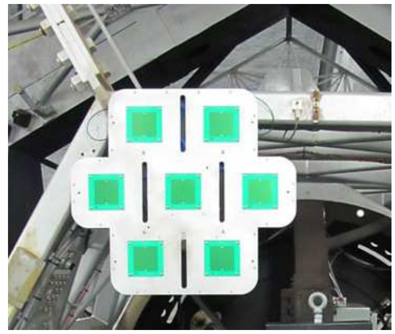

Figure 1: TBAD antenna on Keck II telescope

Figure 2: Discriminator (top) and Decoder boxes

The Transponder-Based Aircraft Detector (TBAD) is a device developed by astronomers at UCSD to protect aircraft from accidental illumination by lasers propagated through the atmosphere. TBAD works by passive detection of omni-directional transponder signals at 1090 MHz from aircraft either sponteously or in response to external interrogations. These strong signals are decoded (altitude, identity, coordinates, velocity, etc.) and their detected levels used to judge whether an airplane is at risk of illumination. By using the ratio of the signal from a phased array antenna to that of a single antenna element, TBAD can ascertain whether an airplane is within approximately 15° of the boresight direction—independent of transmitted power, distance, polarization, etc. Unlike optical or infrared solutions, TBAD is unfazed by clouds, meteors, satellites, birds, moths, bats, or lightning. False alarm rates are exceptionally low. The only obvious failure mode is a non-transmitting aircraft. In the U.S., the Federal Aviation Administration (FAA) requires that all aircraft above 10,000 ft (referenced to mean sea level) have a functioning transponder unless flying within 2,000 ft of the surface. In practice, the vast majority of airplanes—even general aviation aircraft flying under visual flight rules (VFR) carry operating transponders.

A first-generation TBAD unit began operation at the Apache Point Observatory (APO) in December 2008. A third-generation unit was installed on the W. M. Keck Observatory's Keck II telescope in April 2012. Fourth-generation units (minor upgrades) are now installed on Keck I, Gemini-N, Gemini-S, Subaru, and both Large Binocular telescopes. Four telescopes have received FAA approval to operate TBAD without spotters, and others are working on verification.

Numerous sky tests, variously involving normal air traffic, NASA-led volcano-mapping grid-pattern overflights, and chartered overflights have all proven that TBAD successfully issues a close-laser-shutter command well before any airplane reaches the telescope boresight.

For observatory integration, a roughly 0.6 m square antenna is mounted facing the sky and co-boresighted with the telescope, free of obstructions within 20°. A nearby electronics box ("discriminator"), dissipating about 4–5 W of power, connects to the antenna via short RF cables and to a 1-U rack-mount microcontroller box ("decoder") via a 12-conductor cable up to 60 m in length. The decoder unit is the origin of the shutter control (TTL) signal, and can be connected to a computer or terminal server for data logging (not essential to protection function). Logged information includes Mode-A and Mode-C data, as well as Mode-S and ADS-B messages (containing coordinates, velocity, heading, etc.) for aircraft so-equipped.

A complete system, including antenna, discriminator, decoder, interconnect cabling, a test transmitter (called TSIM) for calibration/verification, and template data-logging software can be delivered for approximately $30k. Observatory staff will spend a few weeks of engineering time to carry out installation and software integration.

Contact Tom Murphy (`tom@aircraft-avoid.com`) or visit `aircraft-avoid.com` for more information. Phone: 858.232.2668. A paper describing the concept appears on the astrophysics preprint server: arXiv:0910.5685.