Passive RF Tag for Satellite Tracking:
Low-impact Solution that is Affordable for Any Satellite

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Problem to be solved — The rapid growth in microsatellite and nanosatellite launches over the past decade created a tracking and space object designation problem. Multiple space launches are placing dozens of objects into orbit, often Cubesats with identical cross-sections and ballistic coefficients, and with marginal TT&C links. Improved space situational awareness requires new technologies that can be addressed with this passive RF tag concept:

1) *closely-space object determination* to detect small and closely spaced objects in proximity to larger objects
2) *assured space object ID* to create and validate tools to ID space objects
3) *radar track association* to assign observation data to a correct object in real-time

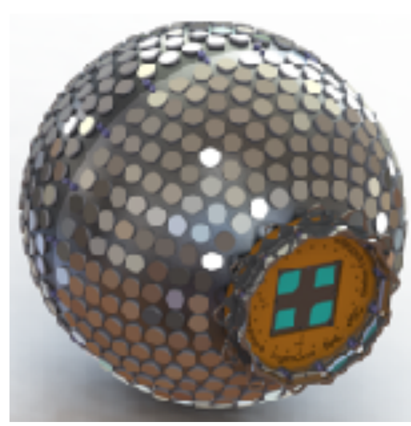
Proposed solution — We are proposing a passive RF tag that would uniquely designate each satellite in the radar tracking data, developed under DARPA SBIR Phase 1 funding (D17PC00403). The RF tag relies on energy harvesting from the Space Fence radar, avoiding dependence on satellite power. It does not require solar cells or batteries, simplifying satellite integration and launch safety approval. The RF tag itself does not transmit and thus does not create possible EMI. Instead, the RF tag modulates its antenna impedance for a peak resonance at the precise Space Fence radar frequency. The tracking radar, while illuminating the satellite, senses variable radar cross-section of the satellite (due to turning the antenna resonance on and off. This time sequence of the RCS variations provides the information signal, encoded as pseudo-random binary code, including unique satellite ID and limited state-of-the-health information. The tracking radar detects this variable satellite radar cross-section in a similar way as satellite spin or tumble rate.

Implementation status — The RF tag development prototype is shown in the figure below, left. Its development has been completed and will be delivered for an experimental launch in 2018 (attached to Starshine 4 satellite, shown below on the right). The current prototype is physically larger than the ultimate device, expected to be roughly 5 cm x 5 cm x 1 cm. The next development step (proposed as SBIR Phase 2) would focus on completing device development such that it is affordable, small, easy to integrate and could be included with any class of satellite. The passive RF tag does not require any electrical connection or interface to the satellite, except for mechanical attachment.

Utilization concept — We are proposing to offer this passive RF tag, once fully developed, as an open-source public-domain design, encouraging multiple providers and ensuring device low-cost. Several operational issues need to be addressed to fully utilize this passive RF tag: 1) software interface to decode radar pulse returns into validated binary sequences, unique for each satellite, 2) voluntary or enforced compliance to carry such passive RF tag, and 3) registry for assigning unique codes for each satellite.

Growth option — Besides further miniaturization and improved device efficiency, we are also working on navigation enhancements that would embed the relative GNSS PRN code offsets into the radar returns. This additional information would greatly improve the cross-range tracking accuracy within the tracking radar beam and minimize the number of radar tracks necessary for precision orbit ephemeris.

RF tag prototype ready for integration and flight delivery



Starshine-4 and passive RF tag prototype (within separation interface), artist concept