Automating Range Surveillance Through Radio Interferometry and Field Strength Mapping Techniques

Spaceport/Range Situational Awareness

Space vehicle launches are often delayed because of the challenge of verifying that the range is clear, and such delays are likely to become more prevalent as more and more new spaceports are built. Range surveillance is one of the primary focuses of Range Safety for launches and often drives costs and schedules. As NASA's primary launch operation center, Kennedy Space Center is very interested in new technologies that increase the responsiveness of radio frequency (RF) surveillance systems. These systems help Range Safety personnel clear the range by identifying, pinpointing, and resolving any unknown sources of RF emissions prior to each launch.

Through the Small Business Innovative Research (SBIR) program, Soneticom, Inc., was awarded two Phase I contracts and has demonstrated an RF surveillance system that dramatically increases the ability to quickly locate and identify RF emitters. The system uses a small network of nodes (Figure 1), radio interferometry (RI) algorithms, time difference of arrival (TDOA) algorithms, and field strength mapping techniques to provide the quick response.

In their first Phase I SBIR project, Soneticom showed that the RI/TDOA techniques are feasible for locating RF emitters and met three technical objectives. The first objective was to demonstrate RI algorithms that can produce an image of an area and map specific RF activity within that area. The RI algorithms consistently located RF emitters within 100 meters. The computational complexity of these RI algorithms, or more specifically, group delay interferometry algorithms, exceeds that of similar TDOA techniques by orders of magnitude. The second objective was to demonstrate RF algorithms that can identify image differences based on a set of established criteria. The third objective was to demonstrate TDOA algorithms to help capture an RF image of an area and geolocate targeted RF emitters. However, the TDOA algorithms proved to be unsuitable for the automated background subtraction techniques used to distinguish the unknown emitters.

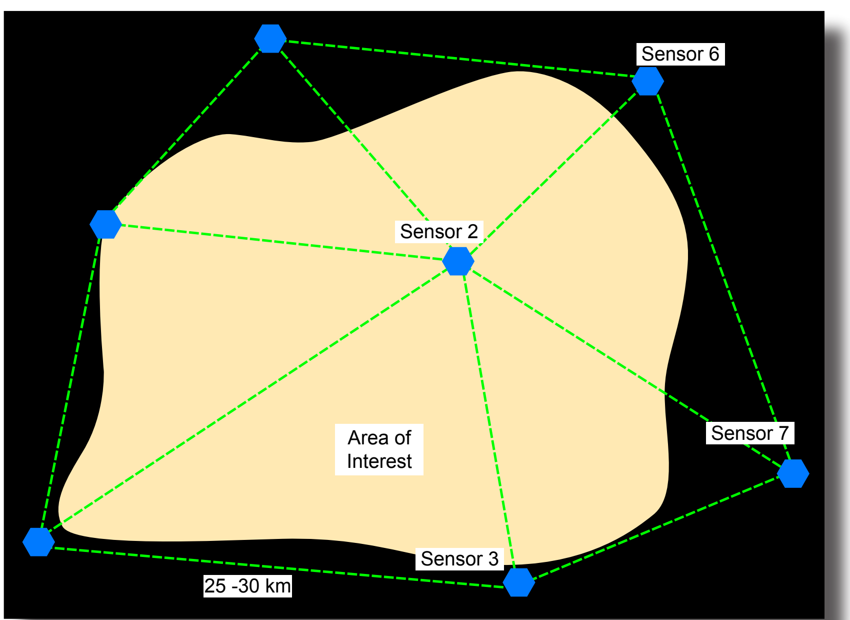

Figure 1. Example of an RF surveillance system network of nodes/sensors.

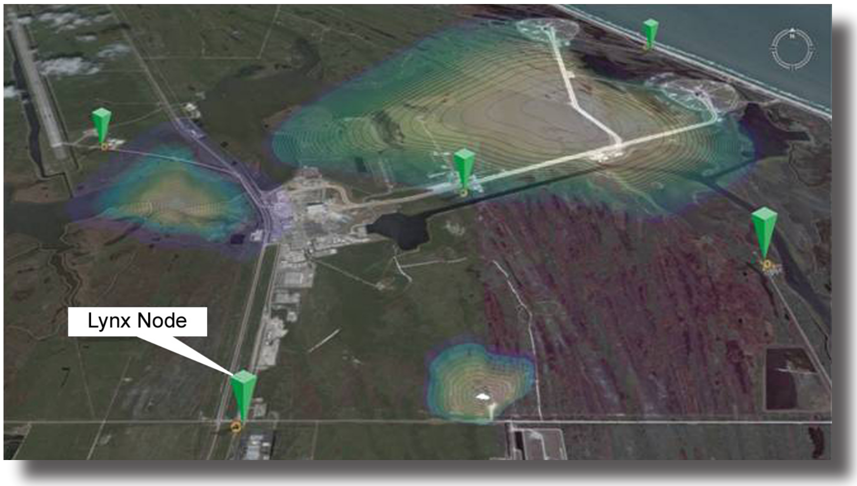

Figure 2. Conceptual EMI field strength map.

In their second Phase I SBIR project, Soneticom showed that electromagnetic-interference (EMI) field strength mapping techniques are feasible for computing signal strength contour maps of RF emitters, using radio propagation models and the company's Lynx geolocation system (Figure 2). Within the limited investigation, Soneticom's techniques reliably located the RF emitters and determined the transmitted power to within 3 dBm. Because the transmitted power is back-propagated, the accuracy of the field strength map's energy contours was largely limited to the accuracy of the topographical data provided to the propagation models. The accuracy is also affected by the assumptions made about the RF emitter's antenna patterns. This Phase I effort (1) enabled Soneticom's Lynx geolocation system to record and time-stamp the received-signal strength indication (RSSI), (2) developed and demonstrated a transmitted-power computation (TPC) algorithm for estimating the RF emitter's transmitted power, and (3) developed and demonstrated a back-propagation algorithm for estimating the RF emitter's field strength at any point in the range. The TPC algorithm computes the RF emitter's power at its location by using the RSSI and the distance to the node and by using least means squares (LMS) to fit a propagation model, such as COST231, Longley-Rice, or HATA, to the data. Reradiating or back-propagating the RF emission onto the range algorithmically through the use of the RF emitter's estimated power, computed antenna directivity, and a propagation model allowed the RF emitter's field strength to be computed at any point in the range.

Besides increasing the efficiency and effectiveness of Range Safety operations, other potential NASA applications include mitigating the effects of EMI, reducing interruptions in communication between flight and ground systems, and validating and mapping coverage areas of communication equipment. The potential non-NASA applications for the RF surveillance system include interference mitigation around commercial airports, cellular provider coverage mapping to identify poor reception areas and potential cross-cell interferences, and interference mitigation for the Federal Communications Commission (FCC) to efficiently enforce license spectrum regulations.

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