Wideband Radar

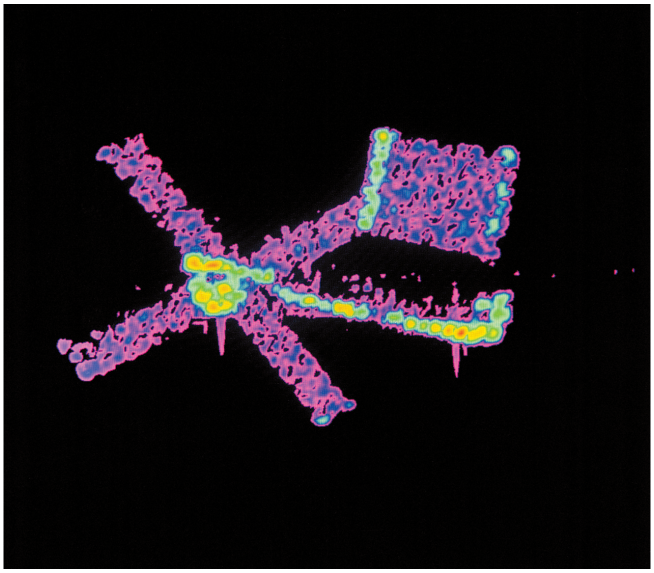
Lincoln Laboratory researchers built the world's first long-range wideband radar and launched a new era in defense radar and satellite imaging capability.

Military radars "hunger" for resolution in angle, range, and velocity. High resolution helps mitigate clutter and jamming, improves the accuracy of tracking, and, most importantly, enhances the identification of enemy targets. This target identification is critically important to ballistic missile defense (BMD) radars since a missile attack can contain many objects, most of which are incidental missile junk or nonlethal decoys. The defense radar has only a handful of seconds to decide what is lethal and what is non-lethal. The radar needs all the help it can get in this sorting or discrimination process.

In the mid 1960s, the Laboratory's missile defense analysts in the Radar Measurements Division had concluded that a BMD radar should operate at a high microwave frequency of 5 to 6 GHz for a wide range of reasons (mitigation of nuclear blackout and jamming, to name a few). Such a radar would need an extra margin of discrimination capability if an enemy were to flood the defense with numerous small objects that were not creditable warheads but that could tie up the radar's resources in deciding what was what. A method to quickly "discriminate" these objects was needed and the analysts hit upon the idea of a very wideband signal with the concurrent exceedingly fine range resolution that could dismiss these physically "short objects" with a single radar pulse. Range resolution of about one foot was needed in this "wideband" pulse and that was at least a factor of 10 to 100 better resolution than that of conventional BMD radars of that era.

The prospect of such a radar was viewed by some as a very high-risk venture. They argued that one would have difficulty generating and amplifying this wideband pulse with its 500 MHz of instantaneous bandwidth. Some thought the atmosphere might disperse the signal, and all argued that tracking with such resolution and processing the returns would be a daunting task.

The sixty-eight-foot-diameter ALCOR radome, shown on the left, houses the forty-eight-foot-diameter antenna and its pedestal. ALCOR, which became operational at Kwajalein Atoll in 1970, was the first high-power, long-range, wideband field radar.



Simulated wideband radar image (actual radar images of satellites remain classified) of the NASA *Skylab* orbiting laboratory, with a damaged solar panel on one side and a partially deployed solar panel on the other.

Lincoln Laboratory convinced the Advanced Research Projects Agency (ARPA) to take on these challenges with the argument that high range resolution was invaluable to BMD radars (and most other radars—military or civilian). In 1966, the ALCOR (ARPA-Lincoln C-band Observables Radar) project was launched with a plan to deploy a wideband radar at the Kwajalein Test Site, where the Laboratory already operated the lower-frequency TRADEX radar and where the lower-frequency ALTAIR radar was under construction.

The ALCOR design was a C-band (5.6 GHz) radar with a 40 ft dish in a 68 ft radome. A 4-megawatt peak power transmitter and low-noise parametric amplifiers gave it a substantial long-range capability. It radiated a wideband signal with 500 MHz of instantaneous bandwidth and a narrow band signal of 6 MHz for acquisition and routine tracking.

The Lincoln project was led by Larry Lynn, who had done a tour at Kwajalein and had a background in advanced radars. The Laboratory designed and built the wideband signal generating and processing hardware. Subcontractors were selected for the antenna, transmitter, low-noise amplifiers, computers, and the building. The radar began to come together at Kwajalein in early 1968, and the plan was to achieve an operational capability in two years. In late 1968, Lynn was promoted to site manager and was replaced as ALCOR leader by Bill Delaney, who maintained that Lynn went out just in time, as ALCOR faced many daunting problems with its hardware systems. All the wideband signal gear worked like a charm; it was the more mundane hardware that caused problems.

A most able and dedicated site team slowly solved the problems with strong back-home support from the Laboratory. While the radar was in a somewhat shaky initial state, it was operated on live missile firings into the Kwajalein range, and these first glimpses of one-foot resolution data on incoming missile bodies and their hypersonic wakes caused a stir in the BMD community. Demands for more of this data poured forth.

Another community of scientists was intensely interested in ALCOR wideband data—the satellite-identification community. This community was experimenting with range-Doppler imaging of satellites with narrowband radars, but a fine-resolution signal would make a great difference in the definition of their images. ALCOR would often track satellites as the system was exercised and members of this community "hung out" at ALCOR to get their hands on wideband data. The first images were also startling in detail and ALCOR picked up another national mission in radar satellite imagery.

ALCOR blazed a substantial trail and all missile defense engagement radars and all missile defense–related instrumentation radars that followed ALCOR have wideband capability. Satellite identification radars have also followed suit, led by the Laboratory's most impressive Haystack radar with wideband signals soon to increase to 8 GHz in bandwidth, providing range resolution approaching one inch!

—BILL DELANEY

Delaney is a veteran of 53 years of association with the Laboratory. He is currently the Director's Office Fellow and is a former Assistant Director. He has been involved with the Laboratory's space program since its inception.