Raytheon ... in conjunction with ... SCOPE Senior Consulting Program for Engineering

Integrated Defense Systems

TEAM 14

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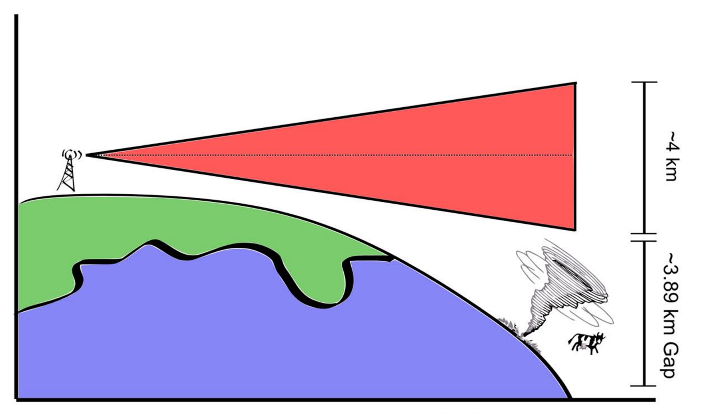
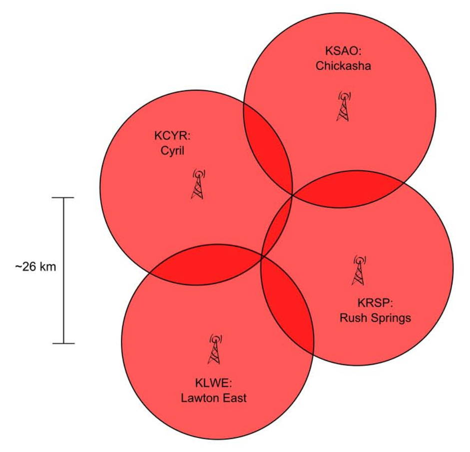
Area of Opportunity





Beamwidth and Gap @ 240 km

(Leftmost) Figure depicting the problem with conventional radar systems. The spaces between radar towers causes gaps to form beneath the beam where low-forming weather events can form.

(Rightmost) Layout of the CASA IP1 test site. The towers are approximately 30 kilometers away from their nearest neighbors. This configuration was used while calculating terrain attenuation to relate the model to a real world example

The current U.S. weather radar system, NEXRAD, has been extremely useful to meteorologists and scientists in capturing wind speed and rainfall measurements for accurate storm diagnoses. However, this long-range radar system is poor at detecting atmospheric conditions, such as tornadoes and flash floods, at or near ground level due to the curvature of the Earth. One in five tornadoes in the United States are undetected by NEXRAD, and approximately 80 percent of all tornado warnings turn out to be false alarms.

In response to this issue, a consortium of partners from industry, academia, and the government, including Raytheon IDS, have formed a National Science Foundation Engineering Research Center called CASA. CASA proposes a solution of deploying a dense network of low-cost and low-power radars to monitor imminent weather. With the dense network, weather events which would have gone ignored by NEXRAD are observed and reported.

Project Proposal

In the CASA specification, all of the information collected by dense network needs to be transmitted to a Master Command and Control (MCC) Center for processing and interpretation. In order to maintain installation location flexibility, and to reduce the cost of purchasing, mounting, and maintaining additional hardware, an alternative wireless communication system has been proposed. As each tower already has a high-power, highly directional antenna, a study is proposed to determine the practicality of using pre-existing radar hardware to establish communication links between towers while not actively scanning for weather.

The SCOPE team's task is to investigate the feasibility and possible throughput of such a system, and then make recommendations to Raytheon IDS and CASA about a proposed physical layer architecture (PLA).

The project's ultimate goal is to provide Raytheon with a judgement about the feasibility of using existing hardware to implement wireless, X-band communication links. To this end, the SCOPE team identified sources of attenuation, created a simulation and analyzed the data obtained from the simulation when it was applied to IP1.

Simulation and Modeling

Attenuation Due to Rain

The attenuation of wireless signals through rain is known to be a function of the rate of rainfall. Rain attenuation in the model uses the 1986 CCIR model, and has the following relation that defines the attenuation factor (dB/km):

Therefore, at X-band frequencies, it is reasonable to expect anywhere between 1 to 5 dB of attenuation over a distance of 30 km, from medium (5 mm/h) to heavy rainfall (20 mm/h).

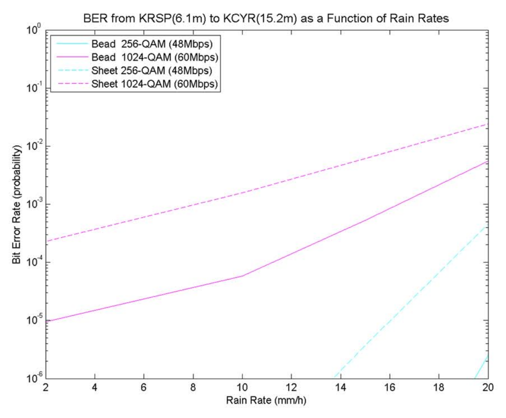


Figure represents the modeled relationship between rain rate and probability of a bit error while transmiting using both 256-QAM and 1024-QAM while rain is either sheeting or beading on the surface of the radome. The specifications of IS1's KRSP and KCYR towers were used to calculate these probabilities.

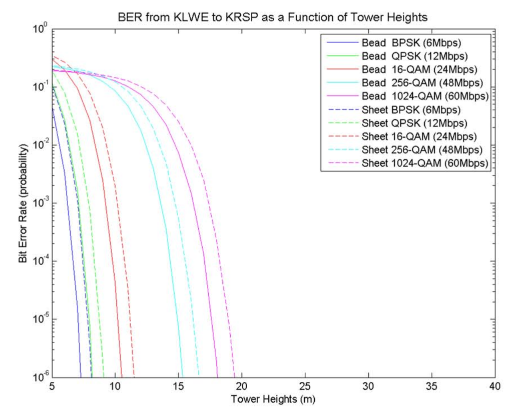


Figure denotes the relationship between height of the tower and probability of a bit error while transmitting 256-QAM and 1024-QAM with either rain sheeting or beading on the surface of the radome.

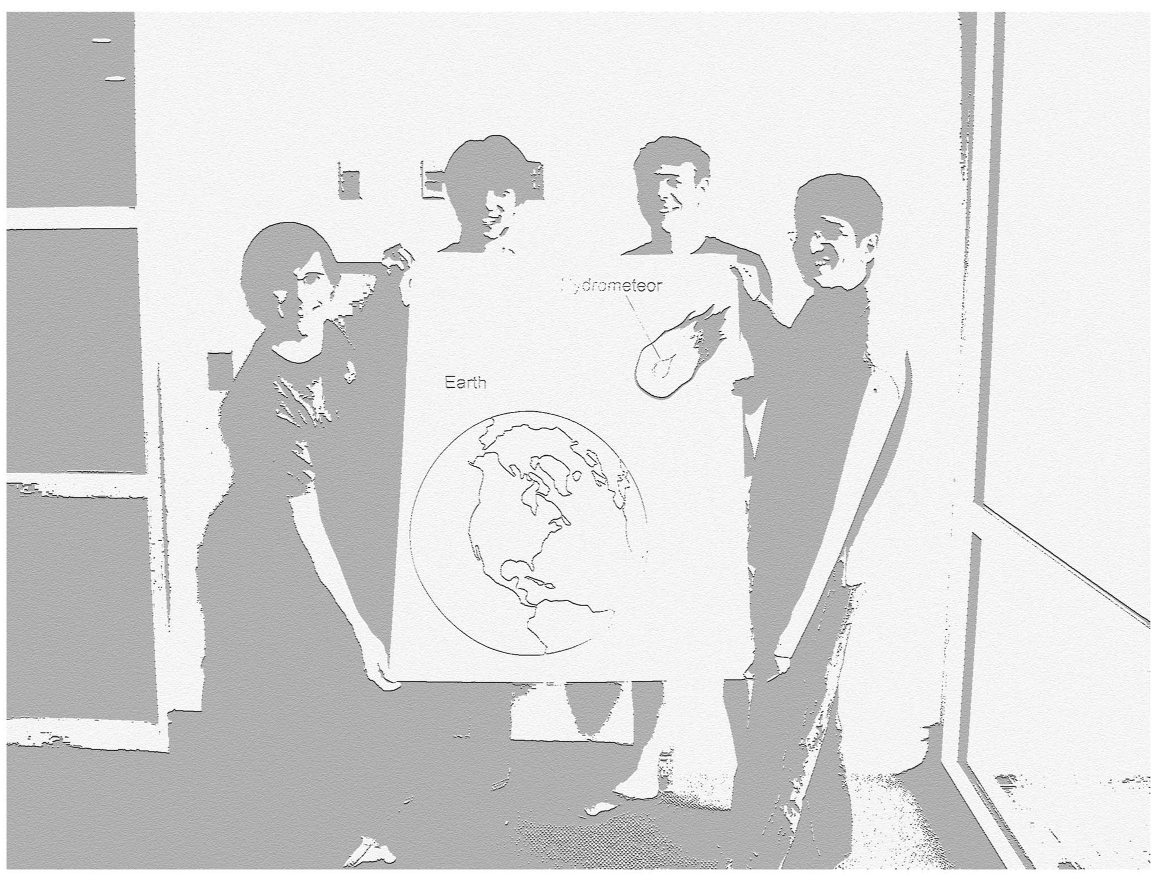
An almost direct and linear correlation between tower height and probability of error is observed when the model is applied to IS1's KLWE and KRSP stations.

Attenuation Due to Terrain

The simplest way to determine attenuations due to terrain is to use actual terrain data, as terrain affects signals in many different ways. To this end, we used NASA elevation data, and the Longley-Rice terrain model, implemented in the open-source program SPLAT. The Longley-Rice terrain model uses this terrain data along with a user-input antenna pattern, and terrain parameters including Earth's dialectric constant, Earth's conductivity, the amount of atmosphereic bending, and frequency in MHz to perform line-of-sight, free space path loss, knife edge and multipath based attenuation calculations. However, because these attenuation calculations are based on actual terrain data, we are required to specify a location for all of our tests.

Other Sources of Attenuation Researched

Trees, Wet Radome Losses, Fog, Clouds, and Dust, Atmospheric Gas Resonance



The Olin SCOPE Team:
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Not Pictured: Siddhartan Govindasamy (Advisor), Mark Somerville (Angel Advisor)
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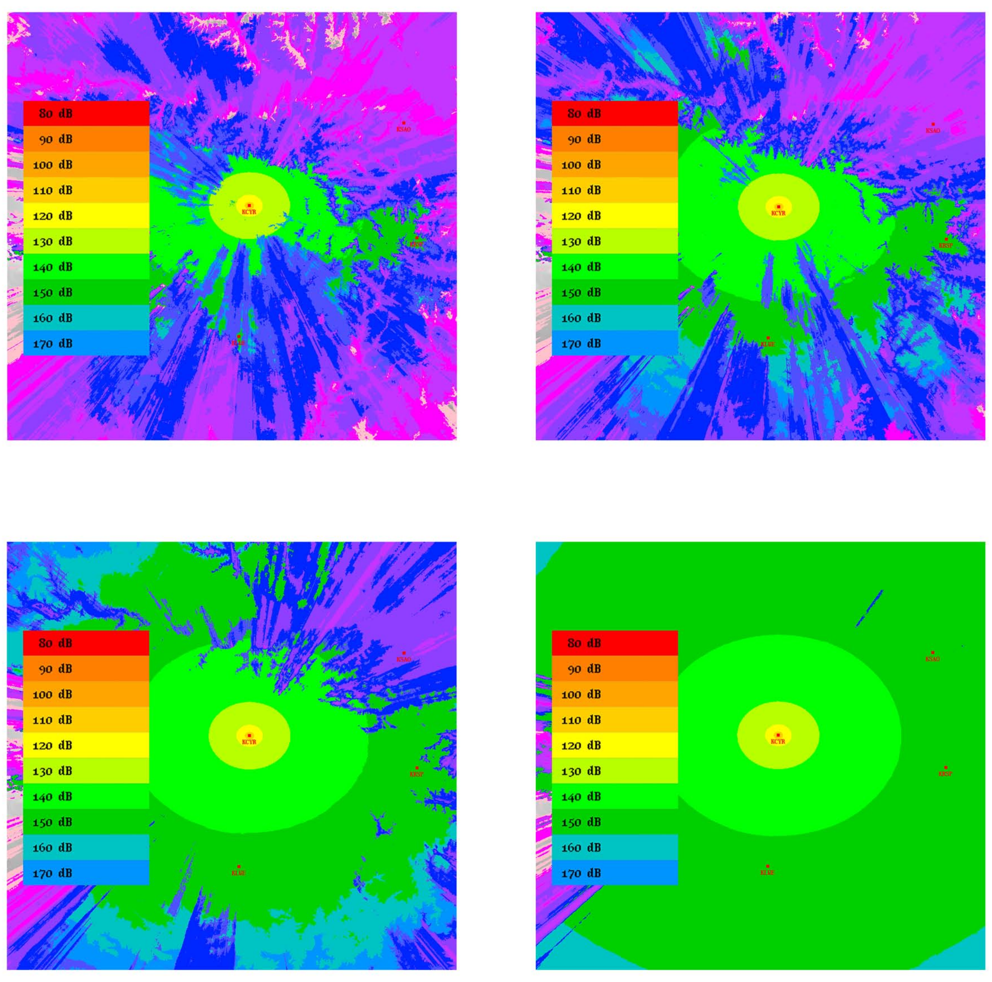
Longley-Rice Visualization



Four topographies taken from IP1's KCYR tower location clockwise from top-left the tower height is set at 20m, 30m, 50m, and 100m. As the height of the tower is increased, the area within which the tower can transmit while accruing less attenuation due to terrain increases.