Spectrum Efficiency Research

Outputs

- Development of signal capacity model.
- Signal capacity results for Washington, DC area.

NTIA is the Executive Branch agency responsible for spectrum management of Federal users. As demand for spectrum has increased, NTIA and the Federal Communications Commission (FCC) have continued to examine ways to improve the efficient use of the spectrum. For example, in June 2003, President Bush released a new initiative that directs the development of a radio spectrum policy for the 21st century to better manage the Nation's airwaves, enhance homeland security and economic security, increase benefits to consumers, and ensure U.S. leadership in high-tech innovations.

A major use of Federal spectrum is to support communications with agents from many different agencies. Typically, each separate Federal agency builds a mobile radio system, which it uses to talk with its own agents. Because there are so many of these independent radio systems, NTIA has worked hard to make these systems work more efficiently, studying and promoting isolated individual technical efficiency factors,[1] with arguably only moderate success. ITS and NTIA's Office of Spectrum Management (OSM) determined that greater improvements in Federal spectrum efficiency might be obtained by studying broader aspects of how agencies provide services to their mobile users. Specifically, we decided to compare the relative effectiveness of the many single-agency mobile radio systems now used to a possible future radio system shared between multiple agencies.

Since the 162-174 MHz band near Washington, DC is the most intensely used Federal mobile radio band, we decided to study it first. The first phase of the study (described in these pages) analyzes current Federal use of the radio spectrum by developing a quantitative model of the "signal capacity" (SC) of agency use. The second phase — planned for completion next year — will use these quantitative results to develop modern alternatives to the current individual agency systems. Depending on the apparent overall benefits predicted, one or more concepts could be selected for further development.

[1]R.J. Matheson, "A survey of relative spectrum efficiency of mobile voice communications systems," NTIA Report 94-311, Jul. 1994.

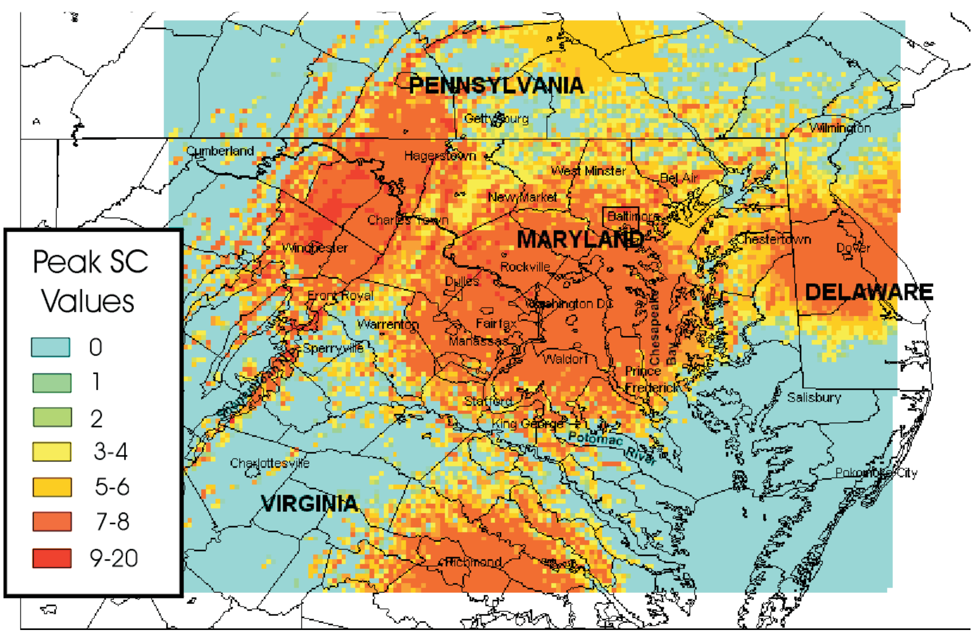

Figure 1. Example of peak signal capacity map for a few selected Federal agencies.

The signal capacity model counts the number of independent radio channels that can be received by a mobile user at every location near Washington, D.C. Maps of signal capacity values for all Federal agencies were assembled, and examples are shown in Figures 1 and 2. Although the signal capacity data could have been derived in several ways (e.g., RSMS channel occupancy measurements at multiple sites), we decided to use the Government Master File (GMF) of all federal radio licenses with propagation coverage prediction programs to obtain the needed data. The GMF contains reasonably complete data on all Federal transmitters, and a terrain-based Longley-Rice model was used to calculate signals from each transmitter at 1-mile increments over an area 200 miles on a side.

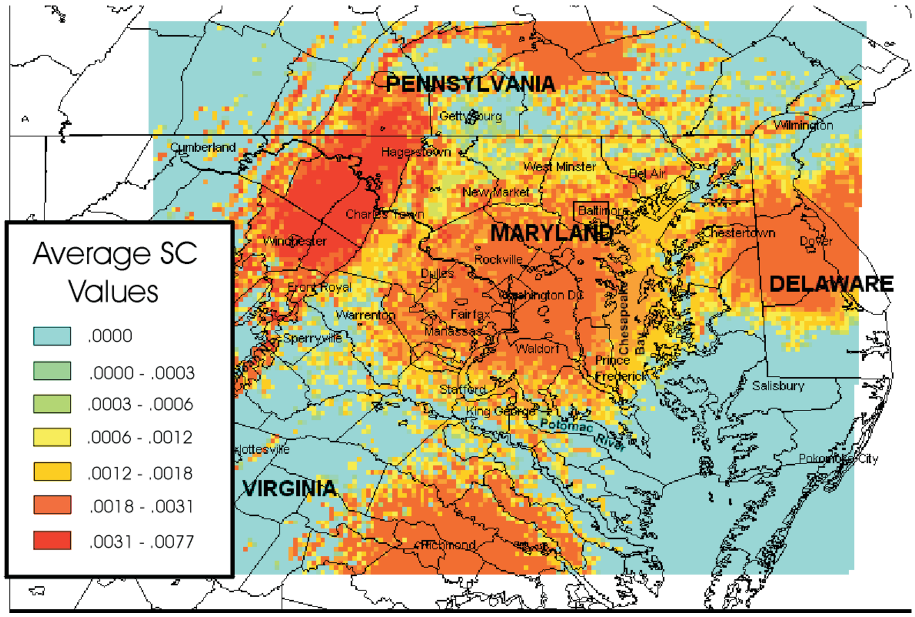

Figure 2. Example of average signal capacity map for a few selected Federal agencies.

Different signal capacity algorithms were developed for various mobile radio architectures, dependent on how the SC values added if adjacent sites in a network both provided coverage to a single location. In simulcast systems and some repeater systems, the coverage from adjacent sites provides the same signal content, so coverage from adjacent sites does not increase SC values. However, other architectures (e.g., trunked radio systems) provide independent signals from adjacent sites, so SC values increase according to coverage from multiple sites. Following much coordination with agency representatives, NTIA personnel assigned specific "function codes" to each GMF entry, which told the SC computer program how data from each assignment was to be analyzed. Once the SC values are calculated for a network of assignments, maps from individual networks can be added together on a point-by-point basis to get SC maps for much large collections of users.

Figure 1 (on the previous page) shows an example of a Peak SC map for a few selected Federal agencies in the Washington area. Note that a Federal user in downtown Washington or at outlying Federal installations could receive as many as 20 independent signals. Many rural areas have much smaller SC values; in fact, there are many areas that could not receive any signals at all from the selected group of agencies.

Figure 2 (above) shows a similar map of Average SC values, produced from Average SC network maps of the same selected agencies. Average SC maps contain values showing the average number of independent users per square mile that could be supported by the analyzed radio networks. The average SC maps will allow site capacity to be scaled according to the coverage area of that site in follow-on system design work based on these maps. The ratio of peak SC to average SC values gives an approximate measure of the coverage area of typical sites. In this case, for example, the maximum graphed values are peak = 20, average = .0077. The ratio between these values shows a typical site coverage area of 2900 square miles, corresponding to a circle with a radius of 29 miles.

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