Hatfield "Pre-read" Document for Key Note

A New Vision for Interference Resolution and Enforcement

It is well understood that the U.S. is experiencing explosive growth in wireless devices and systems that must successfully operate not only in close proximity to one another in the frequency, space, and time dimensions, but also to other electrical and electronic devices that unintentionally emit (or are susceptible to) electromagnetic radiation. This increased densification of often disparate devices and systems increases the risk of disruptive and harmful interference. Moreover, the increased value of the radio spectrum resource in both commercial and non-commercial applications has put additional pressure on the Federal Communications Commission and other agencies to appropriately protect the radio spectrum resource and, in particular, to more quickly and to effectively resolve cases of interference when they do arise. The latter is especially true of services that are not only critical to the Nation's economic and social wellbeing, but to public safety, homeland security and national defense as well.

In addition, the immediate prospect of increased sharing of spectrum between and among federal government and non-federal government devices and systems has created new challenges in terms of the institutional relationships and processes that are used to detect, identify, locate, mitigate and report interference incidents. These challenges have been exacerbated by the wider availability of illegal devices capable of jamming or otherwise disrupting wireless systems that are part of the Nation's critical infrastructure. Clearly, the value of dynamically shared spectrum to commercial entities depends upon the processes and resources spectrum managers have available (a) to reduce the number of incidents of harmful and disruptive interference and (b) to resolve them quickly when they do occur. Similarly, the willingness of federal government agencies to share larger amounts of spectrum in more dynamic ways depends upon their confidence that the applicable rules, regulations and contracts/agreements regarding such sharing will be effectively enforced in a timely manner.

The changing environment for interference resolution and enforcement is illustrated by noting that, in the not too distant past, radio systems typically operated at high power, used high, fixed, outdoor antenna sites, utilized one or a relative handful of manually selected channels in bands not widely shared with other services, operated in the analog mode with a very limited number of modulation methods or waveforms, were licensed by the Commission (or authorized by NTIA in the case of government systems), and regularly transmitted unique identifying information (e.g., call letters) in the clear. Finally, end-user devices had very limited processing, storage and display capabilities and had no means of ascertaining their location.

Today, the situation is vastly different in nearly every respect. To provide the capacity necessary to communicate successfully with millions of highly mobile devices and to provide indoor coverage, systems often transmit at low power and at low elevations. They may utilize hundreds of channels assigned on a highly dynamic basis in multiple bands that may be shared with other services on an active basis. Increasingly, they operate in the digital mode using a myriad of complex waveforms that dynamically adapt to changing channel conditions. Another trend is toward communications devices (and systems) that operate on an unlicensed, lightly licensed or licensed-by-rule basis where regular over-the-air identification for interference resolution and enforcement purposes is not a requirement. Furthermore, because of the increased demand for spectrum capacity, widely deployed nomadic and mobile systems are moving higher up in the radio spectrum -- e.g., above 3 GHz. All of these developments present challenges for the traditional spectrum monitoring and direction-finding systems that are critical to being able to detect, identify, locate, mitigate and report interference incidents.

While the technological developments described immediately above present spectrum monitoring, direction-finding and other enforcement-related challenges, they also, along with other advances, hold the promise of increasing the efficiency and efficacy of interference resolution and enforcement activities. For example, modern end user devices often have increased processor power, much larger data storage capacity, more sophisticated display capabilities, connectivity to the internet and geo-location awareness. These increased capabilities are being harnessed by Spectrum Access Systems that facilitate increased dynamic spectrum sharing based upon a geo-location/database approach. These advanced SAS systems are able to determine the location and "health" of access points or end user devices. Using appropriate logic, devices that are not performing properly or are encroaching upon a protected geographic area can be identified and taken out of service remotely before they cause interference. Or, if harmful interference is detected, the system can, conceptually at least, remotely change the power of the individual access points, change the antenna radiation patterns (e.g., using beam steering), turn the access point off entirely, change channels within the band, and perform other diagnostic and interference mitigation actions.

These technological advances can also be combined with other advanced techniques to improve interference resolution and enforcement (a) by detecting and reporting on interference incidents in nearly real time, (b) by aggregating and analyzing interference data using crowd source and "big data" techniques, (c) by automatically classifying and reporting on various types of interference (e.g., interference from a defective light fixture) using processing-intensive "fingerprinting, and (d) by collecting and storing information on interference incidents to allow *ex post* forensic analysis of their root causes.

In his keynote remarks, Hatfield will draw upon these challenges and developments to present a high-level vision of the future of monitoring in supporting interference resolution and enforcement in an increasingly congested and complex radio spectrum environment. Useful background material for his remarks can be found in the following reports:

- The report for Silicon Flatirons' November 14th conference, Radio Spectrum Pollution: Facing the Challenge of a Threatened Resource, available at: http://www.silicon-flatirons.org/events.php?id=1365 .
- The report on a roundtable discussion held the same day on the topic of New times, New Methods: Upgrading Spectrum Enforcement, available at: http://www.siliconflatirons.com/events.php?id=1474.