Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Unlicensed Operation in the TV Broadcast Bands	)	ET Docket No. 04-186
	)	

COMMENTS OF ROSUM CORPORATION

Rosum Corporation ("Rosum") hereby submits comment to the above-captioned docket.

Rosum supports and applauds the Commission's initiative in seeking to promote more efficient use of wireless spectrum. At the heart of this docket is the potential to more efficiently utilize vacant UHF airwaves or "white space" in the television band for wireless communications. Potential applications for white space communications range from direct device-to-device communication to fixed wireless broadband.

White space applications can generally be divided into two categories: (1) Fixed communications between known points, and (2) Portable or Nomadic communications. In the latter scenario, the white space environment may differ from place to place, or even over time in the same location. The ability to sense and adapt to these changes automatically is advantageous from the perspective of minimizing the potential for interference with television broadcasts.

Dynamic adaptation to the white space environment implies certain functional requirements, such as the ability to sense the white space environment in real-time and the ability for the device to know its own geographic location, particularly in indoor environments where potential nomadic consumer white space communications devices such as notebook PCs would most likely be used.

There is relative consensus between various stakeholders on the feasibility of white space use for fixed wireless application. In this comment, Rosum focuses on communications between nomadic devices, and describes a method for white space receivers to determine, in real time, the white space environment and thereby permit those devices to select an available frequency that will have the minimum interference potential with television broadcasts. This method is able to detect, in real-time, television signals as low as -128 dBm, or 14 dBm below the -114 dBm threshold currently proposed by the White Space Coalition[1]. White space availability across a full sweep of 30 channels is determined in approximately 30 seconds, or roughly 1 second per channel, rather than in 4-14 minutes required in recent demonstrations[2].

About Rosum. Rosum is a privately-held company based in Mountain View, California. Rosum has developed and deployed location technology that utilizes broadcast television signals, analog and digital and from mobile TV networks, for position location and to deliver precise timing. TV signals, due to their wide bandwidth, low frequency, high power, and frequency diversity, are ideal for position location and timing in urban areas and indoors, i.e., areas where GPS signals, which are commonly used for location and timing resolution, are most challenged. In the case of

[1] See *ex parte* filing of Microsoft Corp. and Philips Electronics North America Corp., ET Docket No. 04-186, posted September 21, 2007.
[2] http://www.tvtechnology.com/pages/s.0082/t.8265.html

white space usage by nomadic consumer communications devices such as PCs, it is likely that a significant portion of white space communications would take place indoors.

In Rosum's system, TV signals are used as-is; nothing is added to TV signals, nor are they demodulated. Rosum can utilize TV signals for position and timing more than 40dB below the signal level required for viewing. This allows them to be used at ranges of 50-100 km from the transmitter, depending on power and terrain. Rosum is able to use ATSC signals as weak as -128 dBm in its system.

System architecture. To resolve position and timing, Rosum measures time-of-flight from TV transmitters to a Rosum-enabled receiver. A commercial off-the-shelf TV tuner is used. Rosum has successfully used TV RF components from a variety of commercial vendors.

At present, TV broadcasts are not synchronized to a common clock. To calculate device position, time-of-emission and time-of-reception must be precisely resolved. For this purpose, Rosum deploys GPS-referenced Regional Monitor Units (RMUs) on a per-MSA basis to provide a reference time source. 1 unit supplies city-wide coverage and 2 provide redundant coverage. RMUs monitor TV signals over a broad area in real time. The RMUs measure the timing of TV broadcasts and provide this information to a Rosum Location & Timing Server (RLTS). When calculating location, the mobile device sends its own timing measurements (ranges, or pseudoranges) to the RLTS. The RLTS corrects these measurements with the clocking information provided by the RMU, and then calculates position as shown in the diagram below:

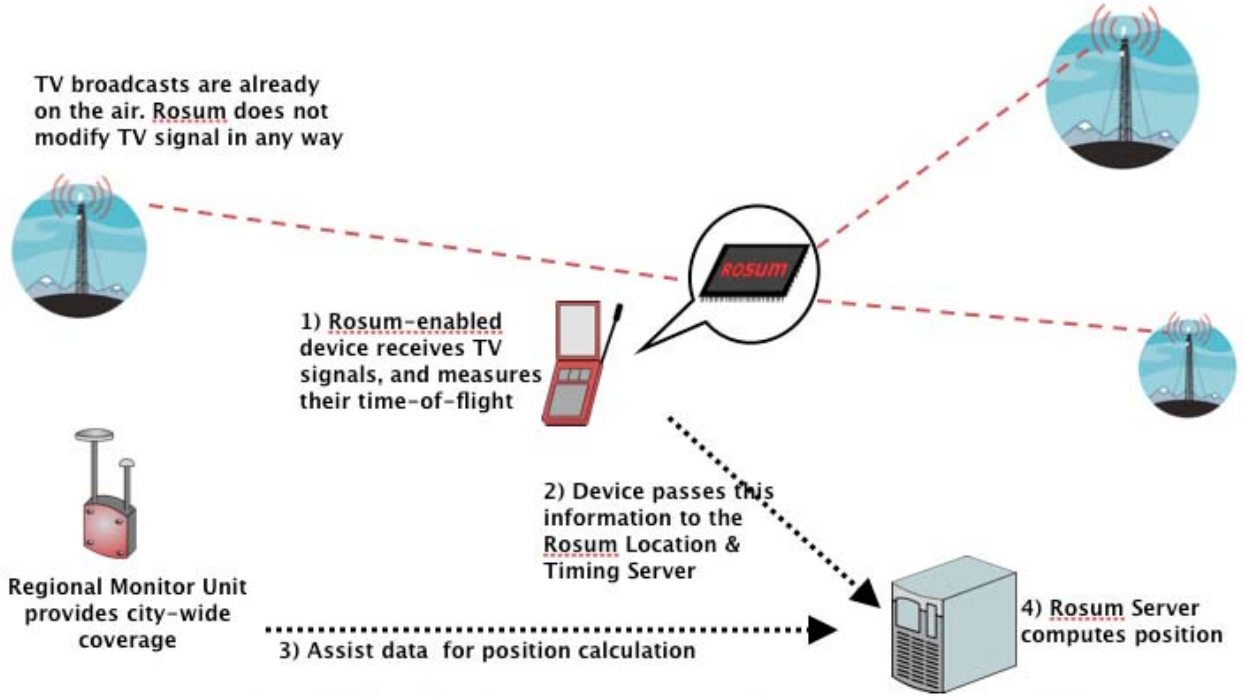

Figure 1: Rosum signal measurement and positioning architecture

Rosum reference infrastructure. Rosum deploys its RMUs on a per-MSA basis to provide real-time, broad-area awareness of the TV broadcast environment. Changes in the broadcast environment are observed and noted in real-time. For its infrastructure rollout of the Northeast Corridor from Northern Virginia to New Hampshire, an area with roughly 50M in population, Rosum deployed 18 RMUs.

A map showing coverage provided by one RMU, located in Redwood City, CA, roughly 35 km south of San Francisco, is provided below. One RMU provides coverage from lower San Francisco and Berkeley down to San Jose, or a distance of roughly 70 km. TV signals themselves can be integrated at ranges of 50-100 km.

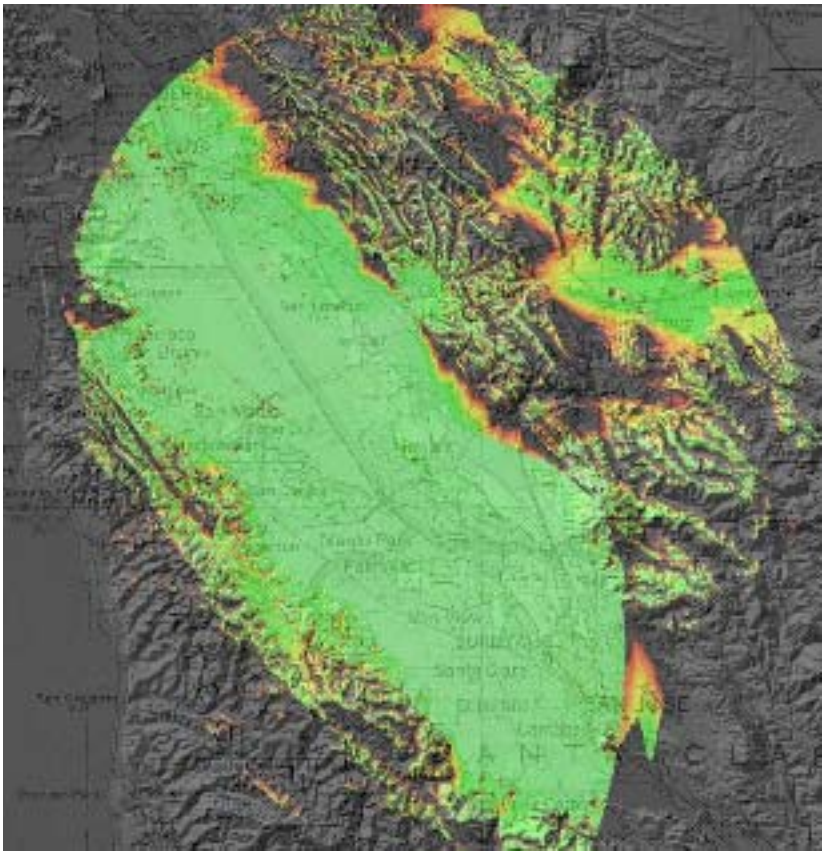

Figure 2: Coverage of 1 RMU. San Francisco Bay Area.

Deploying 3 RMUs enables “reverse triangulation” of TV transmitter location, and thus even more precise spatial awareness of the broadcast environment.

The RMU is an inexpensive CPU with a TV antenna and a GPS antenna attached, and is sited in locations with clear line-of-sight to broadcast transmitters.

Resolution of broadcast environment. Position location presumes that devices are mobile or portable and need to be found. By definition, Rosum resolves which TV channels are receivable in a given geographic area and does this in real-time without use of pre-defined channel look-up

tables. Even when in the same location, the white space environment may change over time, and Rosum dynamically adjusts to this. Examples of channels that demonstrate dynamic availability over time include low-power transmitters and college stations. Because Rosum makes aiding data on the broadcast environment available to the receiver device, Rosum can use coherent integration and is thus able to reliably detect and integrate ATSC signals down to -128 dBm as follows:

- Rosum ATSC ranging requires SNR of: 15dB
- Rosum coherent integration, enabled by aiding data, gets processing gain of: 43 dB
- Thus, Rosum can detect signals of: -28 dB
- Thermal noise floor for ATSC at 25C: -106 dBm
- Rosum theoretical detection level: -134 dBm
- RF front end noise figure: 6 dB
- Rosum practical ATSC detection level: -128 dBm

Again, signal is not demodulated, nor is anything inserted into the broadcast. Rosum is simply observing synchronization information embedded in the TV signal. As such much weaker signal can be used than is required for demodulation.

The RLTS, upon receiving a query from the Rosum-enabled devices, sends to the device a set of anticipated channels for that area. Coarse location may be discerned from real-time measurement performed on the device, or from a commercial cellular network when available, narrowing the set of available channels. In a metropolitan area, as many as 30 channels may be observable. When using TV signals for position location, typically a subset of all the available channels is used. Here we assume 15 are used. The device settles on these channels serially. Coherent integration of weak channels to discern the true line of sight signal, as required for position

location in indoor multipath-prone environments, takes roughly one second per channel. Channel integration time is thus roughly 15 seconds. Expanded to 30 channels, as per white space test procedure, channel integration time is roughly 30 seconds.

As reference to this docket, when calculating device location, Rosum's Time To First Fix (TTFF; time to calculate first location from a "cold start" with no *a priori* broadcast environment awareness) is roughly 30 seconds; iterative Time to Fix using already integrated channels is roughly five seconds. Thus, resolution of the white space environment from a cold start would never take longer than this initial 30 seconds.

Benefits of increased sensitivity. Increasing white space detection sensitivity to -128 dBm would further minimize the potential for interference with broadcast channels. Assume a broadcast channel detectable at -120 dBm. A detection method with sensitivity of -128 dBm would have a signal-to-noise ratio of +8 dB. Each dB of positive SNR ensures a "clear zone" of roughly 1 km in radius. In this example this would translate to a clear zone of radius 8 km. Broadcasters are rightfully concerned that white space communications may interfere with broadcasts and this method would greatly reduce the potential of such an occurrence.

Dynamic use of TV channels for location determination also has potential functional benefits. Geolocation enables more refined awareness of the white space environment than that provided by an area-wide look-up table. Use of TV signals for geolocation also enables devices to be located indoors where methodologies like GPS, which require line-of-sight to the sky, typically

do not work. Devices could thus be geolocated in real-time in their operational environment. N.B.: Rosum's detection method can still be applied without calculating device position.

Implications and conclusions. This submission describes a method of determining the white space environment in real-time. This method has two implications: (1) enhanced sensitivity, thereby greatly reducing the risk of interfering with adjacent weak broadcasts; and (2) increased white space determination speed, making white space resolution and usage for communications a process in keeping with user expectations created through the regular process of identifying and connecting with 802.11x networks, for example. A third implication is the ability to locate devices indoors in real-time.

The methods described here are complementary to two methods proposed for resolution of white space environment: (1) Listen-Before-Talk, and (2) Geolocation/Database, and to the Geolocation & Sensing requirements recently proposed by Motorola Inc.[3]

Use of white space in the TV broadcast band by mobile or portable devices bears immense promise as a means of improving communications, not only directly between devices but also back to the Internet. In rural areas to which tethered (cable, or DSL) broadband offerings are uneconomic and which have abundant fallow spectrum in the UHF TV band, use of white space could help drive adoption of wireless broadband, thus helping bring underserved communities online. However, this must be achieved without impeding TV broadcasts and the reliable viewing experience to which consumers are accustomed. Rosum believes that the signal

[3] See *ex parte* filing of Motorola Inc., ET Docket No. 04-186, posted October 18, 2007.

monitoring techniques described in this comment bear promise as a means of determining, in real-time, the white space environment available to nomadic devices at sensitivities far below those currently proposed.

Rosum welcomes any and all questions or comments in regards to this submission. Comments may be directed to the undersigned.

Respectively submitted,

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