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EX PARTE OR LATE FILED

January 31, 2000

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

VIA HAND DELIVERY

Magalie Roman Salas, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Re: *Ex Parte* Presentation in WT Docket No. 99-168.

Dear Ms. Salas:

On behalf of Motorola, Inc., and in accordance with Section 1.1206 of the Commission's rules, enclosed are an original and one copy of an *ex parte* presentation submitted in the above-referenced proceeding. The documents reflect the substance of oral *ex parte* presentations made today to Commissioners Susan Ness and Gloria Tristani and members of their staffs as well as Thomas Sugrue and members of his staff. Notifications of those oral *ex parte* presentations will be filed separately.

The submission consists of five documents: (1) a fact sheet regarding the introduction of cellular architectures into the Public Safety guard bands; (2) a chart demonstrating the universal opposition of Public Safety agencies and equipment manufacturers to cellular architectures in the guard bands; (3) a further technical analysis of the interference impact of cellular operations in the guard bands; (4) an article from *Mobile Radio Technology* entitled "A Conflict of Public Interest" regarding interference to Public Safety licensees at 800 MHz, where cellular-like systems are deployed immediately adjacent to Public Safety operations without the use of guard bands; and (5) proposed rules which provide for the exclusion of cellular architectures from the Public Safety guard bands.

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If you have any questions or need any additional information, please let me know.

Respectfully submitted,

Robert L. Pettit
Counsel for Motorola, Inc.

Enclosure

cc: The Honorable William E. Kennard
The Honorable Susan Ness
The Honorable Harold Furchtgott-Roth
The Honorable Michael Powell
The Honorable Gloria Tristani
Ari Fitzgerald, Esquire
Mark Schneider, Esquire
Bryan Tramont, Esquire
Peter Tenhula, Esquire
Adam Krinsky, Esquire
Tom Sugrue, Esquire
Dr. Dale Hatfield
Christopher Wright, Esquire
James Schlicting, Esquire
Kathleen O'Brien Ham, Esquire
Mr. Julius Knapp
Stan Wiggins, Esquire

Guard Band Fact Sheet

Argument: The FCC is not under any obligation to take special care to protect the 700 MHz Public Safety allocation.

Fact: The Congressional language contained in the Balanced Budget Act of 1997 requires the FCC to"ensure that public safety licensees continue to operate free of interference from any new commercial licensees". *Conference Report 105-217* at 580 (emphasis added).

Argument: Public Safety agencies welcome the introduction of cellular architectures into the Public Safety guard bands.

Fact: Universally and unequivocally, the Public Safety entities that have filed in the proceeding oppose the introduction of cellular architectures into the Public Safety guard bands. IACP, APCO, Major Cities Police Chiefs, ASHTO, Fire Chiefs, State Foresters, among others – all opposed. Not one entity has filed in support of cellular architectures. As APCO stated, "There is simply too much risk of interference [from cellular architectures] to critical services that protect the safety of life and property. . . . When potential interference to public safety communications is at issue, the Commission must have certainty, not broad proposals for untested technology." (The Public Safety community's opposition – and that of Public Safety equipment manufacturers – is summarized in the attached chart.)

Argument: In theory, there's no reason why cellular architectures can't be made to work in the Public Safety guard bands.

Fact: Even in theory, the introduction of cellular structures in the Public Safety guard bands will cause unacceptable interference. Using numbers previously supplied by FreeSpace Communications, Motorola's conservative analysis (already filed in this proceeding) demonstrated that a typical cellular overlay on a typical Public Safety service radius would create 64 interference "holes". In the aggregate these holes would create objectionable interference within 9.5 square miles of the of the Public Safety system's service area and would create complete outages in an area totaling 4.6 square miles. That's not even counting subscriber transmitting devices (either fixed or mobile), and it also assumes that the cellular-like deployment would use zero-gain antennas.

Using the latest theoretical iteration of FreeSpace's ever-changing proposals still shows that 64 interference "holes" with a radius of up to 100 meters would be created. Even under this best-case scenario, that's the equivalent of removing at least 64 city blocks from a typical Public Safety service area. (Motorola's analysis of FreeSpace's latest numbers is attached.) Again, that's not even taking into account subscriber transmitting devices (fixed or mobile), and it assumes the use of zero-gain antennas.

Argument: There's no evidence that cellular systems fail to work well with Public Safety operations.

Fact: There's a growing body of evidence that cellular architectures simply aren't compatible to Public Safety operations – where they operate without guard bands immediately adjacent to Public Safety systems. In fact, that's the major reason underlying the creation of guard bands in the first place.

As Public Safety agencies have alluded, there are a growing number of instances – in Arizona, Anne Arundel County, Maryland, and elsewhere – of interference from cellular systems to Public Safety operations at 800 MHz, where cellular systems operate without guard bands immediately adjacent to Public Safety systems. A good example of this problem is described in the attached article from *Mobile Radio Technology* describing Public Safety's experience in Washington County, Oregon. The fact that there are confirmed instances of cellular interference at 800 MHz demonstrates that the FCC should not compound the problem by allowing spectrally closer, cellular-like operations at 700 MHz.

Argument: All the Commission has to do to meet its obligation under the Balanced Budget Act to "ensure" protection to Public Safety is to adopt a rule prohibiting interference and let the commercial auction winners and Public Safety licensees work it out later. After all, this is just a dispute among commercial enterprises who ought to be allowed to sort things out in the marketplace.

Fact: Deferring the problem until after the auction of the guard band spectrum will not "ensure" protection to Public Safety operators. Far from it. Fundamentally, this "solution" represents an invitation to further Commission proceedings to define, arbitrate, and adjudicate individual questions of interference; protracted negotiations over literally dozens of base stations and customer sites; and almost inevitable lawsuits. That's undoubtedly one of the reasons that Public Safety agencies universally

oppose introduction of cellular architectures into the guard bands. They need the certainty that the Balanced Budget Act requires – not an invitation to a lawsuit or further Commission process.

The Commission has evidence now that the introduction of cellular architectures in the guard bands will cause interference to Public Safety operations. It's not a question of one business interest against another business interest. It's simply an issue of physics. Just as the Commission may predict that broadcast operations in the guard bands would cause objectionable interference to Public Safety licensees, the FCC may also reliably predict from the available evidence that cellular operations in the guard bands will also cause interference. To meet its statutory obligation, the Commission should act now to obviate that interference.

Cellular architectures have not been demonstrated to work in bands adjacent to Public Safety spectrum. As far as the record in this proceeding demonstrates, the proposals of cellular architecture proponents exist solely on paper. No equipment. No tests. Not even an experimental license to conduct tests. Apparently, proponents of cellular architectures in the guard bands intend to "prove" their equipment only after they're given access to the guard bands, not before. Yet, surely the Congressional language contained in the Balanced Budget Act of 1997 directing the FCC to "ensure" protection of Public Safety communications requires something more than paper promises.

As the Commission has learned through experience, prudent technical rules can spell the difference between useable spectrum and un-useable spectrum. The FCC has wisely forestalled such a result in other spectrum bands – the GWCS band at 4 GHz, for example, where the Commission has delayed any spectrum auction until technical and interference problems are resolved. Given Congress' directive, the Public Safety guard bands deserve no less consideration.

Argument: In theory, the interference that would be caused by cellular architectures is no different from that which would be caused by traditional two-way business operations.

Fact: As Motorola has previously (and extensively) explained in this proceeding, traditional two-way architectures are fundamentally different from cellular architectures. For example, two-way business operations are frequently co-located with Public Safety licensees so that any resulting interference can be easily predicted and corrected for, and two-way business operations are often geographically limited within a Public Safety service area. By contrast, cellular stations and subscriber sites are necessarily dispersed over a wide area. In addition, narrow band two-way operations facilitate the ability to frequency coordinate; if one particular frequency doesn't work, there is a high likelihood that another frequency can be found that will work. By contrast, the use of wide-band channels will greatly increase the difficulty of finding another useable frequency.

But the real proof here lies in decades of operational compatibility. As the Commission is aware, two-way business operators have a strong record of operating in channels adjacent to Public Safety.

In short, the Commission should ensure that Public Safety operations are protected from interference by prohibiting cellular architectures from the guard bands. To do otherwise would be to:

- ignore the problems created by predictable interference holes created by cellular operations;
- ignore the unanimous recommendation of Public Safety agencies;
- ignore the unanimous recommendation of Public Safety equipment manufacturers;
- ignore the record of interference to Public Safety communications at 800 MHz; and
- accept the theories and paper promises of proponents who did not participate in the comment rounds of this proceeding and who have never manufactured and proved any equipment – much less Public Safety-compatible equipment.

The Views Of Public Safety Agencies And Public Safety Equipment Manufacturers On Cellularized Technology In The Public Safety Guard

SUPPORT	OPPOSE
None	**International Association of Chiefs of Police: (representing more than 16,000 police executives)** • IACP "strongly oppose[s] the use of cellular and cellular-type architecture in the guard bands." (IACP Jan. 18, 2000 Comments at 1) • This is based in part on "[r]ecent complaints by IACP members relative to interference caused from cellular type systems to their police radio systems in the 800 MHz bands...." (IACP Jan. 18, 2000 Comments at 1) • "We again urge the Commission to only permit compatible land mobile systems in the guard bands". (IACP Jan. 18, 2000 Comments at 2)
	Association of Public-Safety Communications Officials-International, Inc.: • APCO "generally opposes the use of cellular or cellular-type architectures in the guard bands. There is simply too much risk of interference to critical services that protect the safety of life and property." (APCO Jan. 18, 2000 Comments at 4-5) • While APCO has indicated that "as a theoretical matter, . . . [certain steps] could substantially reduce the potential for interference" from cellular architectures like FreeSpace's, "APCO has serious doubts as to whether the proposed interference protection can be achieved as a practical matter, and whether rules of general applicability implementing such protections could be developed and enforced." (APCO Jan. 18, 2000 Comments at 5 (emphasis in original))

SUPPORT	OPPOSE
None	• "[W]e have grave concerns as to whether [the cellular architecture proposed by FreeSpace] would work in reality." (APCO Jan. 18, 2000 Comments at 6) • "When potential interference to public safety communications is at issue, the Commission must have certainty, not broad proposals for untested technology." (APCO Jan. 18, 2000 Comments at 6-7)
	Major Cities Police Chiefs Association: "[O]ur members' experience at 800 MHz in Phoenix, Arizona, and the TWA 800 tragedy, to [c]ite only two, has demonstrated that public safety and high density, commercial use systems such as ESMRs and cellular systems, are not good spectrum neighbors with public safety." (Letter from Jerry Keller, Sheriff, Acting Chairman, Major Cities Chiefs, Jan. 14, 2000 at 2)
	International Association of Fire Chiefs (represented by Land Mobile Communications Council): • "To avoid harmful interference to public safety users in the 746-806 MHz band, the LMCC strongly urges the Commission not to allow any commercial providers using cellular-like system architecture to operate in the 6 MHz designated as the guard band." (LMCC Jan. 18, 2000 Comments at 3) • The Commission should "*carefully* craft technical rules in the guard bands that will provide for the maximum protection for public safety users in the adjacent bands and which are premised on ***proven*** interference-avoidance techniques." (LMCC Jan. 18, 2000 Comments at 4 (emphasis in original))

SUPPORT	OPPOSE
	Central Station Alarm Association (represented by Land Mobile Communications Council): • "To avoid harmful interference to public safety users in the 746-806 MHz band, the LMCC strongly urges the Commission not to allow any commercial providers using cellular-like system architecture to operate in the 6 MHz designated as the guard band." (LMCC Jan. 18, 2000 Comments at 3) • The Commission should "*carefully* craft technical rules in the guard bands that will provide for the maximum protection for public safety users in the adjacent bands and which are premised on ***proven*** interference-avoidance techniques." (LMCC Jan. 18, 2000 Comments at 4 (emphasis in original))

SUPPORT	OPPOSE
	International Municipal Signal Association (represented by Land Mobile Communications Council): • "To avoid harmful interference to public safety users in the 746-806 MHz band, the LMCC strongly urges the Commission not to allow any commercial providers using cellular-like system architecture to operate in the 6 MHz designated as the guard band." (LMCC Jan. 18, 2000 Comments at 3) • The Commission should "*carefully* craft technical rules in the guard bands that will provide for the maximum protection for public safety users in the adjacent bands and which are premised on ***proven*** interference-avoidance techniques." (LMCC Jan. 18, 2000 Comments at 3 (emphasis in original))

SUPPORT	OPPOSE
None	**National Association of State Foresters (represented by Land Mobile Communications Council):** • "To avoid harmful interference to public safety users in the 746-806 MHz band, the LMCC strongly urges the Commission not to allow any commercial providers using cellular-like system architecture to operate in the 6 MHz designated as the guard band." (LMCC Jan. 18, 2000 Comments at 3) • The Commission should "*carefully* craft technical rules in the guard bands that will provide for the maximum protection for public safety users in the adjacent bands and which are premised on ***proven*** interference-avoidance techniques." (LMCC Jan. 18, 2000 Comments at 3 (emphasis in original))
	The American Association of State Highway and Transportation Officials: • "We are concerned that the operation of systems employing cellular-like frequency re-use pattern could result in greater interference and RF "noise floor" considerations which would not occur if the usage is limited to traditional wireless telecommunications usage." (AASHTO Jan. 18, 2000 Comments at 5) • "Licensees operating in the guard bands immediately adjacent to the Public Safety frequency bands should be technically equivalent to Public Safety systems infrastructures which are best exemplified in Land Mobile Radio systems operations." (AASHTO Jan. 18, 2000 Comments at 5)
	Major County Sheriffs' Association: • "[O]ur members' experience with the 800 MHz in . . . Arizona, and the TWA 800 tragedy has demonstrated that public safety and high density, commercial use systems such as ESMRs and cellular systems are not good spectrum neighbors with public safety."

SUPPORT	OPPOSE
	Motorola: • "There should be no mistake about this point: If the FCC allows subscriber-based cellular architectures access to the public safety guard bands, there will be unacceptable interference on a significant scale to adjacent public safety systems." (Motorola Jan. 18, 2000 Comments at 2)
None	**EF Johnson:** • "There are significant cases of destructive interference occurring today in the 800 MHz band from systems which use cellular type architectures in full compliance with the FCC's technical rules, only a few MHz apart from the affected public safety system. EF Johnson believes that this should not be repeated in the 700 MHz band." (EF Johnson Jan. 18, 2000 Comments at 2)
	Com-Net Ericsson Critical Radio Systems: • "We are concerned that . . . [cellular] architectures may increase the risk of interference to the adjacent public safety spectrum. Unfortunately, we are unaware of any changes in OOBE and/or rational frequency coordination procedures that could be employed to uniformly control and hopefully eliminate any additional interference presented by cellular-like frequency re-use schemes." (Com-Net Ericsson Jan. 18, 2000 Comments at 5)

SUPPORT	OPPOSE
	Dataradio Corporation: • "Based on its extensive real-world experience in manufacturing wireless radio products for use in other bands, Dataradio strongly recommends that operation in the Guard Bands be restricted to architectures and technologies similar to those used in the neighboring 700 MHz public safety bands." (Dataradio Jan. 18, 2000 Comments at 1)

Cellular Architectures Won't Work in the Guard Bands

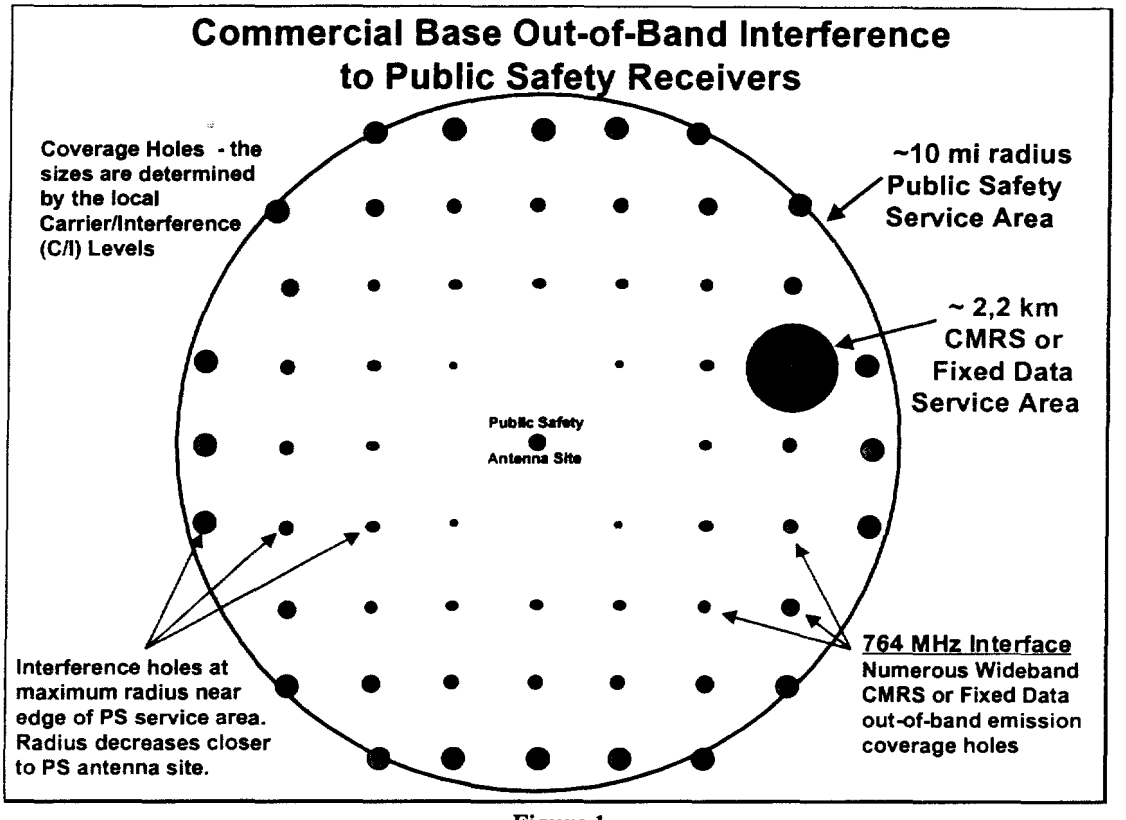

Figure 1

Cellular Architectures Create Interference Holes Around Transmitters
• One PS site covers a wide area • To cover the same area with a cellular deployment you need many sites • PS base is talking to PS mobiles • Nearby in spectrum (at 764 MHz) the cellular base is talking to cellular subscribers • As PS mobile approaches the cellular base site, he cannot hear his own signal because of interference from the cellular base site. • The magnitude of this effect is largest at the fringe, shown by the increasing sizes of circles approaching the edge. In the physical world these large effects are not only felt at large distances from the Public Safety base site. They are felt wherever the Public Safety signal strength is weak, which occurs in areas shadowed by terrain, inside buildings, etc. • Motorola used a 76+10logP OOBE specification and estimated a 350 meter maximum hole size with a 243 meter average. • Changing this analysis to use a 87 + 10logP OOBE specification changes these results to a <u>100 meter maximum hole size with a 69 meter average</u>.

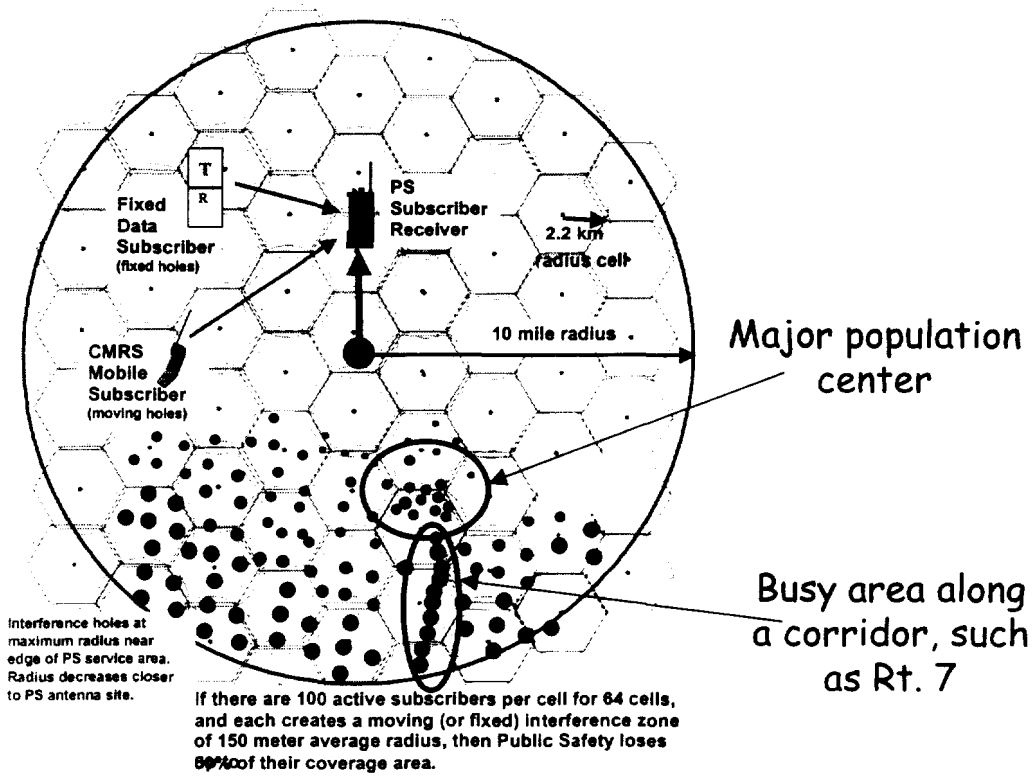

Figure 2

Base-to-Mobile and Subscriber-to-Mobile Interference is Also Created

Base-to-Mobile and Subscriber-to-Mobile Interference is Also Created

Base-to-mobile – (Relevant for the FreeSpace proposal and all other cellular system proposals)

- The base-to-mobile interference is described in Figure 1
- In a successful cellular system deployment, cells will be "split" in order to add capacity, and, therefore, more base stations will deployed in areas of high user densities (roads, major buildings, population centers, etc.)
- This dense scattering of interference holes can also be used to describe this situation in which many base stations are added in order to cover high usage areas.

Subscriber-to-mobile – (Relevant only for all non-FreeSpace cellular system proposals)

- PS base is talking to PS mobiles
- Nearby in spectrum (at 776 MHz) the cellular subscribers are talking to the cellular base.
- As PS mobile approaches the cellular subscriber, he cannot hear his own signal because of interference from the cellular subscriber.
- The magnitude of this effect is largest at the fringe, shown by the increasing sizes of circles approaching the edge.
- Motorola used a 65+10logP OOBE specification and included 10 dB margin for the effects of power control. This gave an estimated 218 meter maximum hole size with a 150 meter average.
- This is an extremely serious case because of the large potential number of cellular subscriber units, and their position is not known.

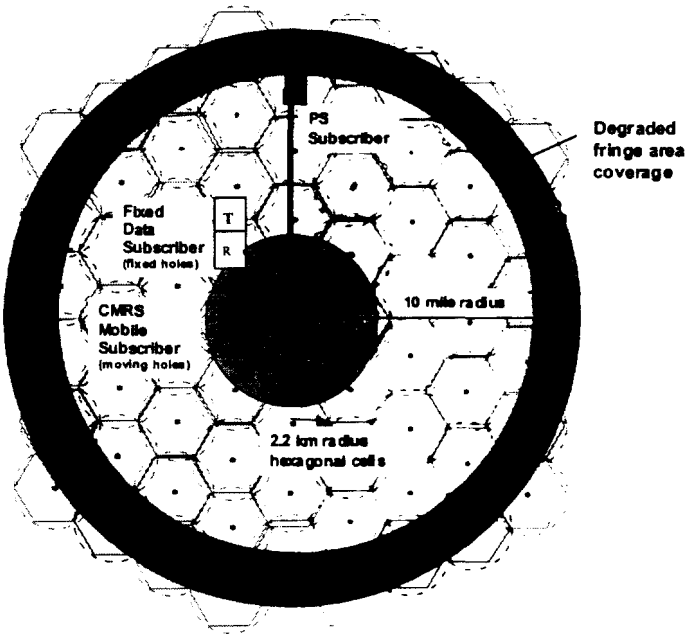

Figure 3

Subscriber Units Will Interfere with Public Safety Base Stations
• PS mobiles are talking to PS base station • Nearby in spectrum (at 794 MHz) the cellular subscribers are talking to the cellular base stations. • Emissions from the commercial subscribers will cause interference to the PS base station. • The magnitude of this effect is largest for the subscribers close to the PS base station, shown by the dark circle at the center. • Motorola used a 65+10logP OOBE specification and found that all subscribers within 1.2 km would cause excessive interference. • An analysis including reasonable antenna gains shows that all units within 3.4 km would cause excessive interference • This is an extremely serious case because of the large potential number of cellular subscriber units, and the effect from these subscriber units is additive.

IM/EMI ISSUES

A CONFLICT OF PUBLIC INTEREST

Conflicts between 800MHz commercial mobile radio service and public safety communications have cropped up across the country. When does nuisance interference become harmful--life threatening--interference, and how can it be identified and solved?

By Joe Kuran

Police, fire and emergency medical services agencies depend on radio communications to protect people and property. Any type of interference to the operation of dedicated public safety frequencies diminishes an agency's ability to provide service, and it endangers the public. A situation we encountered in Northwest Oregon in 1998 demonstrated that commercial mobile radio services (CMRS), particularly enhanced specialized mobile radio (EMSR), through frequency use, site placement and output power, can seriously interfere with nearby public service communications.

Operational overview

Washington County includes the Tualatin River Valley and mountainous terrain on the western outskirts of the Portland metropolitan area in Northwest Oregon. The Washington County Consolidated Communications Agency (WCCCA) provides emergency dispatch radio communications for 21 public safety agencies in Washington County, as shown in Figure 1, below right. Washington County covers 84[illegible] square miles, with a population of 350,000. In 1991, voters approved a levy to construct a new [illegible] system that included a Motorola Smartnet trunking system.

Because of limited resources and limited available frequencies, a [illegible] channel trunked simulcast system was chosen. This system would give WCCCA maximum area coverage with a minimum number of frequencies. WCCCA constructed [illegible] simulcast sites with 10 frequencies each. Given the large area that had to be covered, four sites were strategically chosen and, as with traditional radio systems, the repeater sites were [illegible] mountaintops for maximum coverage. See Figure 2 on page 18. With this design, WCCCA can provide radio service for more than 2,000 users, covering about [illegible] of Washington County. This system gives WCCCA good mobile coverage and fair portable coverage on the valley floor, which contains the bulk of the population.

The one big limitation of WCCCA's system is good portable radio coverage inside certain buildings. To overcome this building penetration problem, WCCCA has installed bi-directional amplifiers in many buildings, such as the county [illegible]. Some high-traffic buildings, such as the Washington Square shopping mall, had to be excluded from in-building coverage. Due to the extreme expense and difficulty in establishing who would be the responsible party, no bi-directional amplifiers were ever installed, so presently there is marginal public safety coverage in this commercial area.

Defining interference

There are several types of radio interference. *Co-channel interference* occurs between similar frequency channels used in the same geographic area. *Adjacent channel interference* can be caused by a transmitter operating on a channel bordering either side of the channel in question. The transmitter sidebands mix with the carrier being received on the desired channel, creating noise or "splatter." Interference can also be caused by electromagnetic interruptions. *Harmful*

Kuran is technical systems manager for the Washington County Consolidated Communications Agency, Beaverton, OR. He is the frequency coordinator for the state of Oregon for the Association of Public-Safety Communications Officials—International.

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interference has a specific connotation. As defined by the *Communications Standard Dictionary*, it is

> "any *emission, radiation* or *induction* that endangers the functioning or seriously degrades obstructs, or repeatedly interrupts a *communication service*, such as a *radio navigation service*, a *search and rescue communications*, or a *weather service*. It is assumed that these services are operating in accordance with approved standards, regulations and procedures. Harmful interference causes *circuit outages* and *message losses*, as opposed to interference that is merely a nuisance or annoyance that can be overcome by appropriate measures. In order to be harmful interference, it must seriously degrade the performance of the *communications*, *radar*, or other *electrical* or *electronic system*."

Interference with public safety communications from properly operated commercial radio services has traditionally not been a problem in our operating area. As with our own system, land mobile repeater sites were located on mountaintops and end users were on the valley floor. When the 800MHz (824MHz–849MHz and 869MHz–894MHz bands) cellular service was introduced, with cell sites located on the valley floor, there were still few problems. Public safety 800MHz bands (806MHz–821MHz and 851MHz–866MHz) enjoyed adequate separation from cellular.

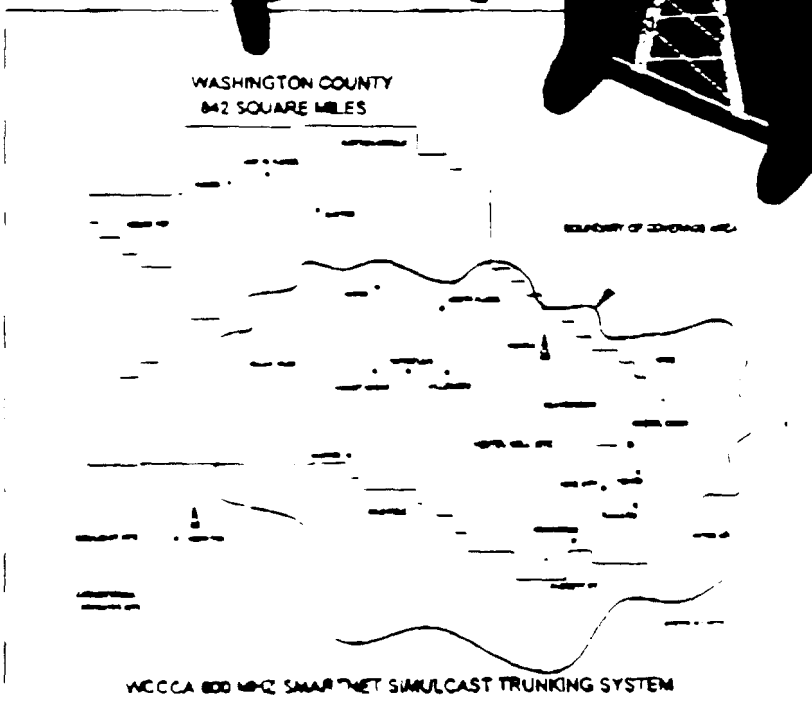


Figure 1. This map of Washington County, OR, shows the general area of WCCCA's 800MHz service area. Using simulcast trunking, WCCCA covers a large area, using only 10 frequencies, and supports more than 2,000 users. All simulcast sites are on mountaintops for maximum coverage. A Nextel site (center) is on the valley floor.

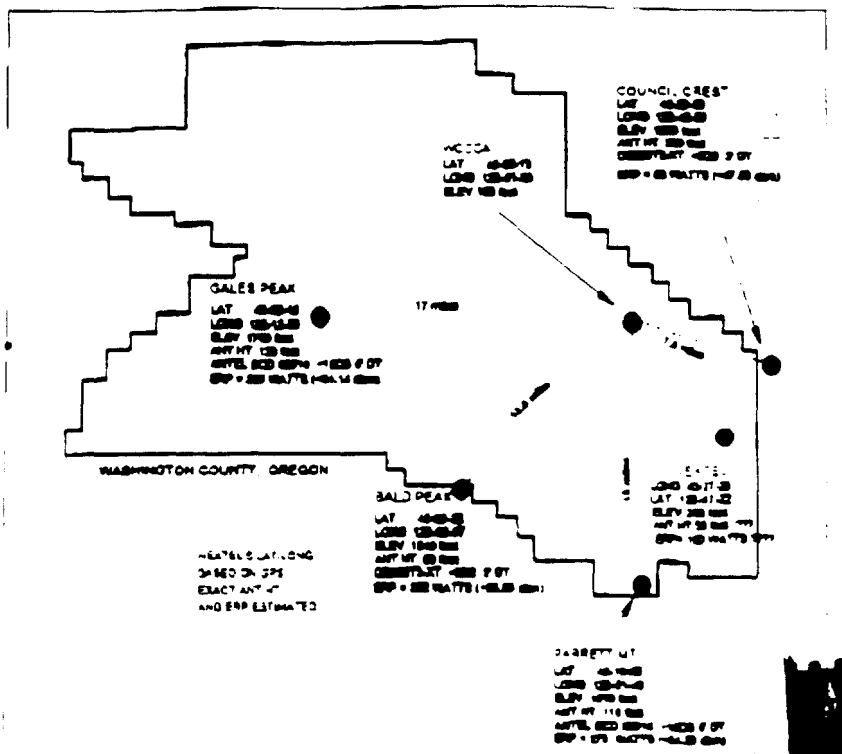
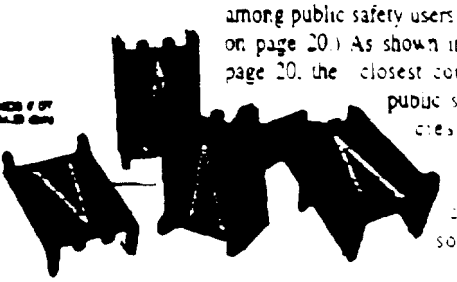


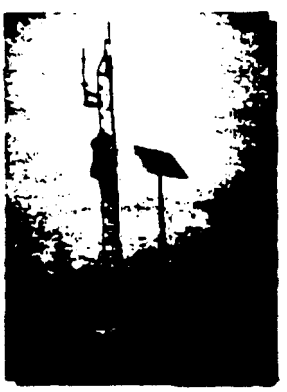
Figure 2. Technical details of WCCCA's 800MHz repeater sites. Elevation comparisons are made between the WCCCA sites and the Nextel site under study.

which was also grouped in one bandpass, while public safety was grouped in another. This situation changed with the introduction of 800MHz ESMR into the valley.

Enter ESMR

The FCC band plan for the 1998 800MHz SMR auctions divided the band into three pools: a public safety, industrial/land transportation and business pool, a general category pool, and an SMR category pool. The pools are interspersed from 810.25MHz to 816MHz and from 855.25MHz to 861MHz. In the FCC's 800MHz auction that closed in December 1997, McLean, VA-based Nextel Communications was the high bidder for the Portland-Salem, OR, economic area, which at that time encompassed an estimated 2,310,000 pops. The operator began service in 1998, placing 800MHz (806MHz–821MHz and 851MHz–866MHz bands) cell sites on the valley floor, among public safety users. See Figure 3 on page 20.) As shown in Figure 4 on page 20, the closest commercial and public safety frequencies come to each other's four 25kHz channels away, so there is no





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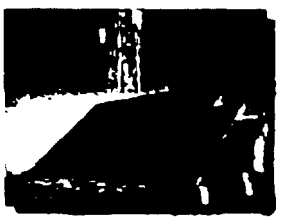

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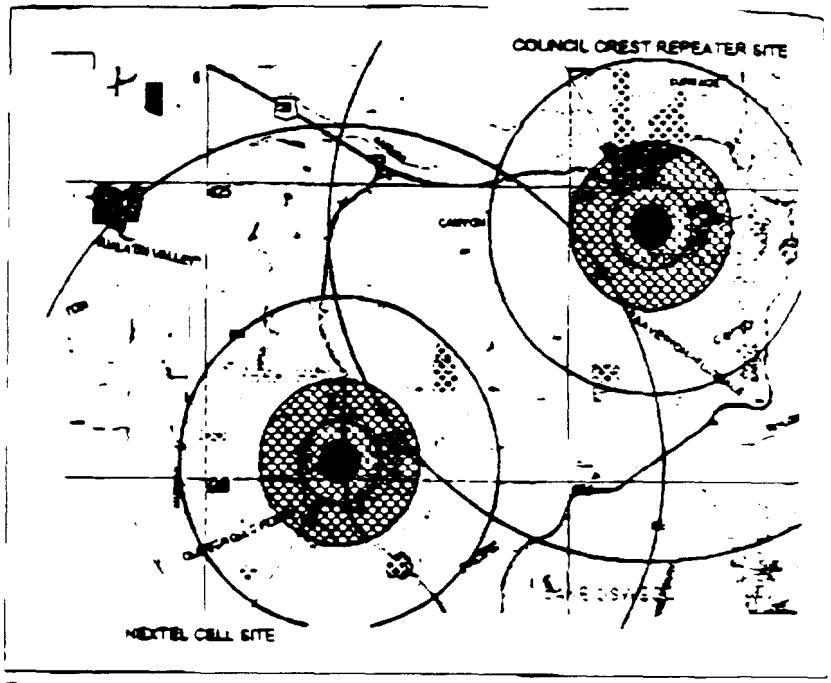
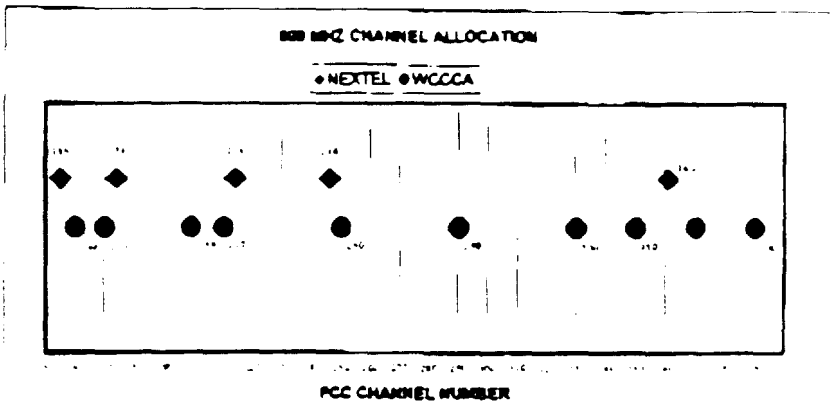


Figure 3. The relationship between Nextel and WCCCA's closest 800MHz trunking site. The color bands show the relative field strength from the two sites. WCCCA's Council Crest site is located on a mountaintop to provide wide-area coverage. Nextel's site is on the valley floor, in the heart of WCCCA's core radio service coverage area.



FCC CHANNEL NUMBER	FREQUENCY (MHz)	CHANNEL USER	SPACING TO CLOSEST FREQUENCY (kHz)
255	854.8625	NEXTEL CH 309	
260	[illegible]	WCCCA CH 10	[illegible]
[illegible]	[illegible]	WCCCA CH 9	[illegible]
274	[illegible]	NEXTEL CH 347	
299	[illegible]	WCCCA CH 8	[illegible]
[illegible]	[illegible]	WCCCA CH 7	[illegible]
214	[illegible]	NEXTEL CH 427	
246	[illegible]	NEXTEL CH 491	
[illegible]	[illegible]	WCCCA CH 6	[illegible]
[illegible]	[illegible]	WCCCA CH 5	[illegible]
[illegible]	[illegible]	WCCCA CH 4	[illegible]
[illegible]	[illegible]	WCCCA CH 3	[illegible]
361	[illegible]	NEXTEL CH. 721	
[illegible]	[illegible]	WCCCA CH 2	[illegible]
[illegible]	[illegible]	WCCCA CH 1	[illegible]

Figure 4. The relationship between the commercial frequencies and Washington County's 800MHz frequencies. The closest commercial frequency is at least four 25kHz channels away. Therefore, the interference is not adjacent-channel interference.

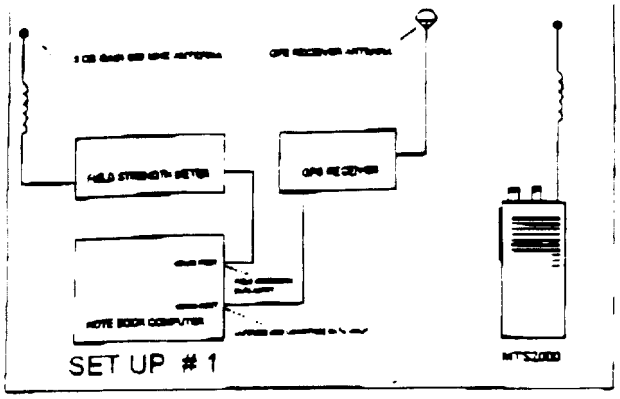


Figure 5. Field strength meter test measurement setup. A Z-Technology model R-505 meter was used. The GPS receiver provides location information to the notebook computer, an NEC Versa 5080X, running STI-9400 Mobile Signal Analysis System software from Survey Technologies.

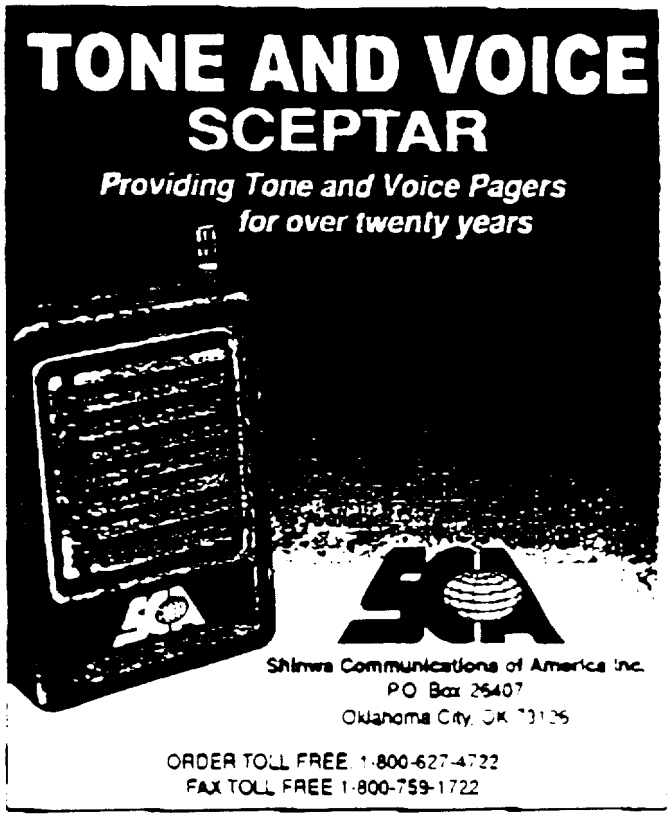
possibility of adjacent-channel interference. However, because the band plan for 800MHz intermixes commercial frequencies with public safety frequencies, there is no chance of any group bandpass filters, as in the case of cellular. A problem was brewing, as we soon found out.

When we get behind closed doors—only

The first incident to bring an interference issue to the attention of WCCCA was a radio service complaint from one of the fire departments. This fire station, one of 33 in the county, is designated Fire Station 253. It serves one of the busiest areas of the county because it is next to a major freeway and next to the Washington Square

Figure 6. This signal strength contour map depicts the 800MHz coverage of WCCCA's system. The red area indicates what the agency first thought was a 'hole' in its radio system. Later, the area was found to match closely to the signal contour from the commercial site. The red area shows where the portable radios stopped receiving.

Circle (21) on Fast Fact Card



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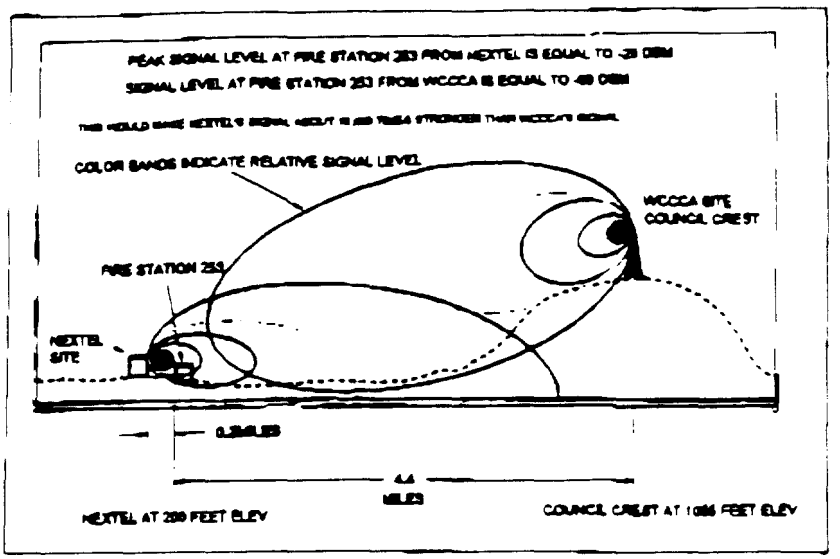


Figure 7. The geographic relationship between the Nextel site and the Washington County 800MHz repeater site. Usually, 800MHz trunked simulcast systems are located in high places (mountaintops) for maximum radio coverage. The commercial site's situation on the valley floor greatly increases the chances for creating interference.

shopping mall, where, as mentioned before, we have no in-building coverage.

The engine company is equipped with an 800MHz Motorola Spectra radio, an 800MHz Motorola VRM 600/DATA 911 mobile data terminal (MDT) and several 800MHz Motorola MTS2000 portable radios. The station is also equipped with an 800MHz base radio used for "tapping out" the station. "Tapping out" a carry-over term from the old days of alerting stations by Morse telegraph is the emergency alerting system that rings the station bells and turns on the lights.

The engine company first complained to WCCCA Technical Services about poor radio communications. Its main complaint was that it was difficult to hear what fire dispatch was saying. This created a life-threatening situation because Station 253 was not always getting tapped out. The base radio was not always responding to the alerting signal.

WCCCA's technical staff began troubleshooting the problem. The usual procedures, such as checking antenna and receiver performance, revealed no evidence of a problem. Attention was then directed to the trunking system itself. At first, the WCCCA technicians thought there might be a simulcast phasing error. This, too, proved to be a dead end. The next area of investigation was determining the signal strength at, and around, Station 253.

The expected signal strength level should be about −65dBm at Station 253. This is based on calculations for ideal conditions (our closest trunking site is only 4.4 miles away), with an average of 55W ERP and with 9dB antenna gain and 3° antenna downtilt. As shown in Figure 5 on page 22, a Z-Technology R-505 field strength meter (range, 0dBuV to +110dBuV, accuracy ±2dB), a GPS receiver and a notebook computer were mounted in a jeep to log field strength readings of WCCCA's control channel #1 (860.7375MHz). (See Figure 6 on page 22.) Computer analysis and mapping of signals

Circle (24) on Free Info Card

Figure 8. A signal-strength contour of the Nextel site. The blue and magenta plots show where Nextel's signal level is −38dBm or greater. Our tests demonstrated that in an area of greater than −38dBm, our portable radios stopped receiving any signals.

was performed with the STI-9000 Mobile Signal Analysis System from Survey Technologies. At first, the field strength reading around the station did not make a lot of sense. Some areas had the expected field strength level, and then there were areas where the signal dropped off to nothing. At first, WCCCA thought there was a signal hole in the simulcast system coverage. Because Station 253 has a relatively low elevation, WCCCA came to believe that this might be normal. However, because this involved public safety communications, WCCCA felt that it needed a more definitive explanation.

Two key issues led WCCCA to start suspecting an "outside" interference problem. First, it was discovered that the portable radios worked better inside the engine bay with the bay door closed. Second, the base radio got a more intelligible signal from fire dispatch using an inside antenna than when it was connected to the main outside antenna.

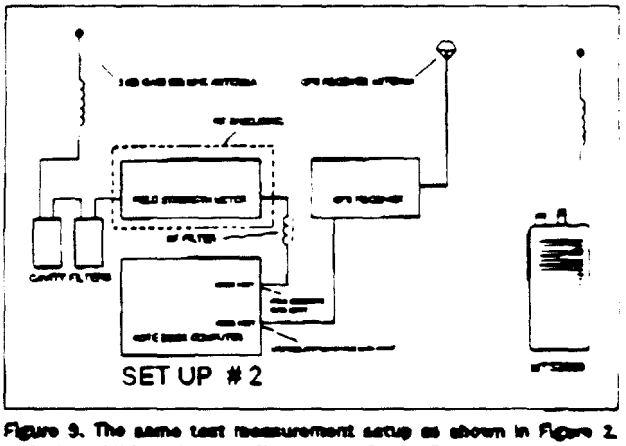


Figure 9. The same test measurement setup as shown in Figure 2, with the addition of cavity filters and RF shielding to overcome the massive commercial RF signal.

Figure 10. This contour map was generated to verify that WCCCA's 800MHz system actually had some radio coverage in this area. (Refer to the second test setup shown in Figure 3 on page 20.) By using extensive RF shielding and filtering, WCCCA was able to acquire enough readings in this area to demonstrate there was not a "hole" in the coverage.

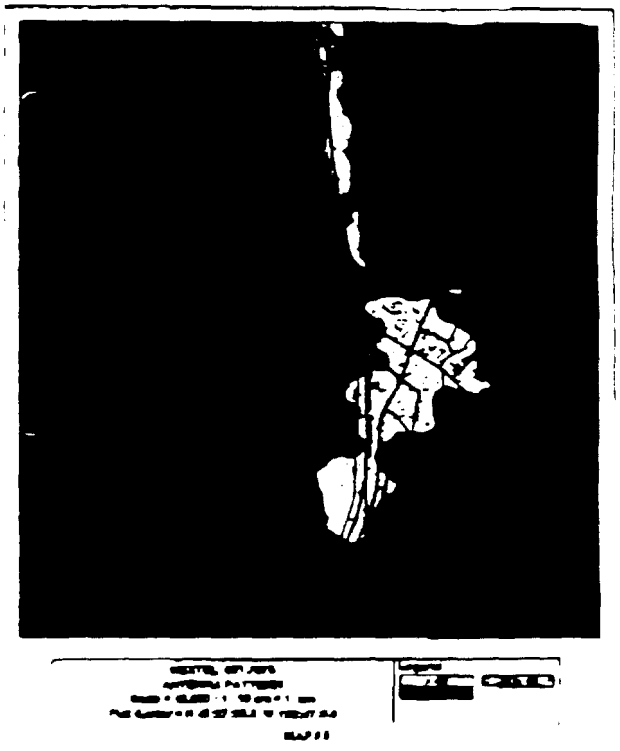
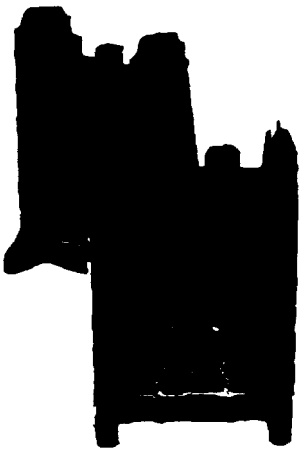
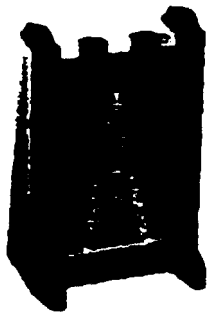


Figure 11. This contour map is a composite of those shown in Figures 9 and 10. The yellow area indicates where the WCCCA's radios stopped receiving. This area is where Nextel's signal strength is greater than -38dBm—roughly the same area where the radios encountered problems. ("Greater than -38dBm" can be much greater; readings as high as -25dBm were sampled in this area, then averaged with the others.)





Noisy neighbors

WCCCA's investigation of other radio systems in the area discovered that a Nextel Communications site was located about ¼ mile to the west of Station 253, as shown in Figure 7 on page 24. The site uses Motorola integrated digital enhanced network (IDEN) technology and 12 repeaters that constantly transmit data. The measured field strength at Station 253 from the Nextel site peaked out at about −25dBm. The signal level from WCCCA's simulcast system averages about −69dBm at Station 253. During the signal strength tests as shown in Figure 6, the meter would not function properly in close proximity to the constantly keyed commercial repeaters.

During the testing, a Motorola MTS2000 portable radio was also tuned to monitor WCCCA's control channel. When the field strength meter would cease to function, the portable radio would also cease to function. (The red area in Figure 6 indicates those areas.) That is why the portable radios worked better in the engine bay with the bay door closed. The metal bay door actually provided enough RF shielding to let the radio barely receive Fire Dispatch. With the bay door open, the radios lost all reception. When Engine 253 had to respond to an accident, the call was sent to the MDT, but as soon as the bay door was opened, mobile data experienced a high error rate, and the message was scrambled.

Also, because of the RF overload from the commercial repeater signal, the mobile radio on Engine 253 was unable to receive a clear signal from Fire Dispatch.

To verify the condition, Nextel agreed to a WCCCA request to shut down its site for a brief period. A portable radio was immediately able to receive Fire Dispatch loud and clear in the open air in front of the station. A receiver desense test conducted at the station indicated that the Spectra receiver was being desensed 20dB or more by the commercial site transmitters. We now faced a situation of harmful interference from a commercial source operating within FCC guidelines.

Mapping the effect

To map out the exact area of harmful interference being generated from the commercial site, the test procedure was repeated. This time, the field strength meter was tuned to one of Nextel's frequencies (861.7875MHz). Figure 8 on page 26 shows the antenna pattern from the commercial site. The blue area, which indicates an average signal level greater than −38dBm, corresponds roughly to the red area in Figure 6. This is the same area in which the portable radios would stop receiving.

To verify that WCCCA's trunking system actually provided coverage in the area of interference from the commercial site, some extra measures had to be taken. With the assistance of a local Motorola engineer, the measuring equipment was modified, as shown in Figure 9 on page 26.

The field strength meter was surrounded with an aluminum shield. RF filtering was added to all power sources and to data cables that were connected to the meter. Dual-cavity filters were also added to the antenna input. The field strength meter and cavity filters were tuned to WCCCA's control channel #1. Again, the entire area was driven to collect an entirely new set of data points, as shown in Figure 10 on page 26. The RF shielding and filter allowed the field strength meter to operate 90%–95% of the time in close proximity to the Nextel site. This verified that WCCCA's system was actually providing signal in that area. Figure 11 on page 26 is a composite of maps from the three-part measurement procedure. The yellow area shows the area where public safety's portable radios stopped receiving and where mobile radios received substantial interference and had difficulty receiving emergency broadcasts from Fire Dispatch.

Motorola review

An engineering review by Motorola concluded that it was "evident that Nextel's IDEN sites in Washington County are serious communications 'holes' in key urban areas for public safety communications."

The report determined that the initial commercial activation of the first six channels presented heightened interference, but the expansion to 12 channels created the RF environment in which WCCCA's radios ceased to function.

The report also noted that following the short-duration system shutdown that Nextel made at WCCCA's request, Nextel used an HP spectrum analyzer to check the purity of its signals. The tests showed that the site was within specification and that spurious emissions or noise were below the noise floor of the analyzer (−118dBm). Measurements indicated that the 12-channel site produced 600W ERP composite total using 2° downtilted omnidirectional antennas also within specifications.

Bench tests by Motorola to duplicate the problem found that control channel reception was negligibly affected by high levels of interference (+13dBm and more) as long as the interfering frequencies were spaced 1.5MHz or more from the control channel frequency. Spacing tighter than [illegible]MHz caused the control channel to blank in a symmetrical bell curve. Within just a few hundred kilohertz of the control channel a

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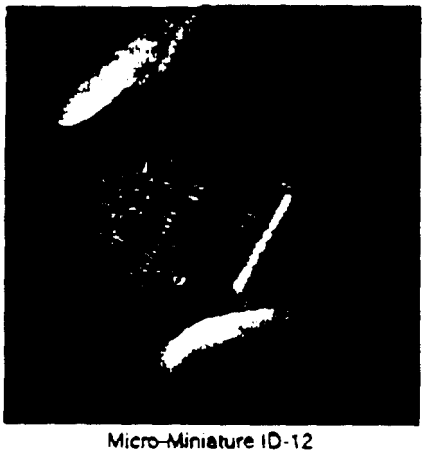

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Circle (27) on Fast Fact Card

Congress calls on FCC to address interference problems

UTC, the Telecommunications Association, has been educating congressional representatives on the dangerous interference problems that many utilities and pipelines currently face. The UTC has described cases in which utilities couldn't dispatch crews in critical emergencies because of interference.

The threat to public safety, therefore, prompted UTC to seek a regulatory solution that would protect the critical communications systems of utilities and pipelines from harmful interference. In December 1998, 11 members of Congress wrote a bipartisan letter to the Federal Communications Commission calling for swift action.

The letter read that "interference from non-public safety-related radio users put at risk the lives and safety of utility and pipeline maintenance and emergency response crews," and threaten public safety. The letter stated that "in one particular case, a utility mobile dispatcher was unable to contact its field crews to shut off gas to a burning building because of continuous interference from a limousine paging service."

The number of cases of harmful interference continues to grow, and reportedly, 12 states have reported interference cases.

H.R. 4813, the "Critical Infrastructure Radio Systems Protection Act of 1998," has been introduced, directing the FCC to adopt rules to "ensure the on-going protection from harmful interference of private land mobile frequencies used by utilities and pipelines to protect life, health and property," according to the letter to Kennard.

The 11 Congressional representatives, including nine members currently serving on the influential House Commerce Committee, warned that should the FCC not move to address the problem, "Congress will be certain to take appropriate action when we reconvene." ■

varying number of interfering frequencies could blank the receiver with as little as −24dBm.

The engineering report concluded that "although the interference-handling capability of Motorola radio receivers is good, the sheer brute strength of the continuous-duty IDEN site transmitters planted in the same immediate vicinity and on the same subband as local public safety communications systems will spell problems for communications reliability in those areas. The issue is further aggravated by installation of IDEN sites in the same heavily populated areas (where) public safety also needs heightened communications reliability."

Moving toward resolution

This was the only site on which WCCCA performed extensive tests. Several other ESMR sites are located in Washington County, and spot-checking has found the same harmful interference. As commercial sites are added to improve coverage, public safety coverage will deteriorate.

Since the testing phase, Nextel has cooperated by cutting its ERP at the site back by half, and reducing the number of active channels from 12 to eight. Some frequencies were also relocated. This has decreased the zone of interference from ¼ mile to ⅛ mile at the local level.

In January, Motorola contacted WCCCA to arrange to send an engineering team assembled from its IDEN and RF design groups. After analyzing the problem in the lab, this team will follow up with real-world field tests.

A wakeup call to the the industry

The commercial mobile radio service in this case, Nextel, cooperated with local public safety in working toward a resolution of the interference issue. However, the same technical conflict is probably taking place all across the country. The national office of APCO has taken an interest in the problem, and Oregon's congressional delegation has expressed concern.

The FCC has looked at the problem, but concluded that because both parties in this case have valid FCC licenses and are operating within engineering specifications, there is nothing the agency can do. Nextel mentioned the band plan that contributed to the problem in the first place.

It's analogous to a shipping channel that is used for critical cargo. The government allows some contractor to build an underwater structure in the middle of the channel just below the surface, and then does not tell the shippers that it is there.

The FCC, manufacturers, commercial service providers and public safety agencies need to examine the consequences to public safety, particularly in populous areas, resulting from certain band plans, power levels and site locations. Improved frequency coordination and RF design are critical in dealing with interference. ■

Circle (13) on Fast Fact Card

Regulations Governing the Use of "Guard Band" Frequencies in the 746-747/776-777 and 762-764/792-794 MHz Bands

§ 27.1001 Scope.

This subpart sets forth the technical and operational standards for all systems operating in the guard bands between 746-747/776-777 MHz and 762-764/792-794 MHz. They are intended to ensure that public safety operations within the 764-776 MHz and 794-806 MHz bands are able to operate free from interference from systems deployed in the 746-747/776-777 MHz and 762-764 /792-794 MHz bands. The rules in this subpart are to be read in conjunction with the applicable requirements contained elsewhere in this part; however, in case of conflict, the provisions of this subpart shall govern with respect to licensing and operation in the 746-747/776-777MHz and 762-764/792-794 MHz bands.

§ 27.1002 Spectrum Blocks and Service Areas for the Guard Bands.

MEA service areas are available for two spectrum blocks. Spectrum block A contains the frequencies between 746-747/776-777 MHz inclusive. Spectrum block B contains the frequencies between 762-764/792-794 MHz. No single entity can hold both licenses in the same MEA. The MEA service areas are defined in Section 27.___.

§ 27.1003 Guard Band System Operations and Band Managers.

Licensees in Spectrum Block A and Spectrum Block B in the Guard Bands shall operate as band managers. The obligations and responsibilities of Band Managers are fully defined in the *Second Report and Order* in WT Docket No. 99-168. In addition to the obligations defined therein, Band Managers shall ensure that:

(1) the Band Manager retains all responsibility to ensure that communications systems deployed under the terms of its license conforms to the technical and operations requirements of the FCC,

(2) the Band Manager shall immediately address any and all instances of interference to public safety systems caused by systems operating under the terms of its license,

(3) the Band Manager shall maintain the ability to immediately terminate any and all transmissions operating under the terms of its license upon notification by the FCC,

(4) the Band Manager shall not use more than 30 percent of the spectrum available under the terms of its license for its own internal communications.

The Band Manager shall not provide more than 30 percent of the spectrum available under the terms of its license to any single communications system in a discrete metropolitan area.

(5) the Band Manager shall abide by any other conditions specified by the Commission in its license.

§ 27.1004 Emissions Limitations

Systems deployed in the 746-747/776-777 MHz and 762-764 /792-794 MHz bands must comply with the ACCP provisions of Section 90.543. Additional attenuation of out-of-band emissions may be required on a case-by-case basis should interference occur. Pending the final decisions in WT Docket 96-86, channel bandwidths in excess of 150 kHz will not be permitted.

§ 27.1005 Transmitting Power Limits

Systems operating in the 746-747/776-777 MHz and 762-764 /792-794 MHz bands must comply with the rules set forth in § 90.541 regarding the transmit power limits applicable to public safety use in the 764-776 and 794-806 MHz bands.

§ 27.1006 Frequency Coordination Required

Notification of all new and modified systems prior to deployment in the 746-747/776-777 MHz and 762-764/792-794 MHz bands must be submitted to all designated frequency coordinating committees for the 764-776/794-806 MHz public safety bands for review, retention and comment. This requirement applies to all transmitting locations including all base and fixed stations and shall include, at a minimum, the site location, frequency or frequencies of use, transmitter height and power, proposed fixed and/or mobile and portable service area, engineering analyses as appropriate that predict service area and adjacent band interference contours, and contact information. Licensees shall retain copies or records of all coordination correspondence and make such records available to the Commission upon request.

§ 27.1007 Cellular Architectures Prohibited

Systems deployed in the guard bands should be of a non-cellular design. For purposes of this section, this means that no more than three interrelated base stations with overlapping 40 dBu [F(50,50)] service contours that reuse the same frequencies, in whole or in part, to cover a discrete metropolitan area.