

Innovation Grant (IG) Report

Evaluation of Cellular Push-to-Talk Technology for First Responder Communications

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Abstract

This report presents the initial evaluation of cellular push-to-talk technology and its functionality for enhancing two-way communications for first responders. Cellular push-to-talk (PTT) is a new class of mobile telephony service that enables instant one-to-one and one-to-many half-duplex communications on cellular phones making them work like two-way push-to-talk radios. This report provides a brief overview of push-to-talk systems and service factors of prime concern to public safety users. It presents a detailed discussion of the testing and performance evaluation of three PTT systems with nationwide coverage: Nextel's Direct Connect, Verizon Wireless' Push-to-Talk, and Sprint's Ready Link. The performance evaluation served to identify that PTT is a valuable technology for public safety users who can benefit from easy, instant access to other users nationwide. All three services could stand performance improvement. Key areas of improvement include:

- Use compatible technologies among different providers to enable users on different networks to communicate.
- Reduce call setup latency on Verizon and Sprint networks.
- Provide priority access during network congestion (currently, only Nextel offers first responders special features, available only for public safety users).
- Adopt roaming agreements among carriers to expand coverage areas.

The report presents the outcome of open discussions with officials from the Loudoun County Fire Department about possible applications of cellular Push-to-talk systems. The following include the most important suggestions:

- For large counties that are fully covered by radio systems, PTT can provide back-up communications to their primary radio systems, extending the range of coverage geographically and/or enabling interoperability between agencies.
- Small counties in rural areas with small budgets to cover the high cost of building a private radio system could benefit from commercial push-to-talk technology and infrastructure in their primary operations.
- Other uses include emergent volunteers or certified teams to help during incidents. The emergent volunteers can use commercial PTT service for communications among other volunteer groups who have undergone disaster training sessions that include use of PTT.

The evaluation of PTT solutions will continue as they evolve with the emergence of an open Push-to-talk over Cellular (PoC) standard that will make cellular PTT services work across carrier networks and operate on a variety of handsets and user devices. Building on the PoC standard, next generation of PTT systems will be integrated with presence and availability information of individuals and talkgroup members, offering expanded communication options for public safety users.

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Evaluation of Cellular Push-to-Talk Technology for First Responder Communications

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1. Purpose

This report presents the evaluation of cellular push-to-talk (PTT) technology and its functionality for enhancing public safety interoperable communications. The evaluation effort is supported by the CEM's Innovation Grant (IG) for First Responders Communications. It entails the following activities: (1) understanding the specific needs of public safety communications through holding open discussions with local public safety users, (2) exploring the ability of commercial PTT systems to meet the communication needs of the public safety community by testing a number of commercially available systems and evaluating their performance; (3) identifying the shortfalls of tested PTT systems in meeting the specific needs of public safety communications, such as priority access and communications privacy, and finding ways to overcome these shortfalls, and (4) observing the industry activities for establishing a uniform PTT standard that will enable the next-generation of PTT systems to interoperate across carrier networks and enable communications between phones made by different manufacturers.

The evaluation effort of PTT technology is part of MITRE's continuing investigation of commercial technologies and innovations for improving wireless communications for public safety agencies. The outcome of this investigation will help MITRE build the expertise required to assist Government agencies select wireless services and equipment to improve communications for first responders.

2. Introduction

The public safety market is currently experiencing an increasing demand for mobile systems and for integration of systems that will allow data sharing across a wide spectrum of jurisdictions and government agencies. Public safety is a very significant growth market. Gartner Dataquest, a market research company, expects IT spending for public safety to increase at an average annual rate of 7 percent from \$6.72 billion in 2001 to \$8.77 billion in 2005 [1].

The PTT service is very attractive to first responders because it is relatively inexpensive and works very well under favorable communications conditions. However, there are a number of challenges to its widespread use for public safety communications. The first responders' requirements differ significantly from that of most users because of the safety-of-life implications of their services. Among these unique requirements are: coverage, ability to establish communications in real-time between different public safety organizations involved in managing incidents, access under high volume conditions, guaranteed continuity of conversations, security, and quality of service. This innovation Grant (IG) sponsored by MITRE's Center for Enterprise Modernization (CEM) will make a preliminary investigation of the technology to determine if there is an opportunity

to leverage PTT service for first responder communications to fulfill their public safety-related missions.

The public safety community has been relying on the operation of licensed two-way land mobile radio (LMR) systems for their voice and data communications. Recently, use of cellular telephones has become the standard for most local police department personnel and other public safety officials. The cellular phones provide auxiliary communications systems to the primary LMR service.

Cellular push-to-talk (PTT) is a new class of mobile telephony service that enables instant one-to-one and one-to-many half-duplex communications on cellular phones making them work like two-way push-to-talk radios. Push-to-talk addresses a real need amongst businesses to disseminate or communicate time-critical information quickly and efficiently. Cellular PTT technology is rapidly progressing with an increasing number of cellular carriers in the U.S. introducing PTT services on their networks. An open push-to-talk over cellular standard is emerging under the auspices of the Open Mobile Alliance (OMA), which will make cellular PTT service work across carrier networks and operate on a variety of handsets and user devices

If the PTT service could meet a large proportion of the first responder communications needs, it would significantly reduce the cost of public safety communications and increase the ability of responders from different jurisdictions to talk to each other. MITRE has a good relationship with a number of cell service providers and a good understanding of the fixed and mobile networks. MITRE understands the critical needs of public safety for interoperable communications and has worked closely with a number of local emergency respondents. MITRE has a good chance of being able to advise government and industry on how PTT technology could be leveraged to greatly enhance public safety communications.

3. Overview of Cellular Push-to-Talk Service

This discussion of cellular push-to-talk addresses the characteristics of current systems available from a number of carriers in the U.S. The current PTT services do not work between carriers, that is, a Sprint PCS user cannot push-to-talk with a user on Nextel or Verizon Wireless network, and vice versa. The inability of cross-carrier PTT service means users should carefully analyze coverage in areas where they want to utilize cellular push-to-talk technology in order to realize the service benefits.

Industry efforts are underway to complete a globally interoperable Push-to-talk over Cellular (PoC) standard over both GSM/GPRS and CDMA2000 networks. Building on the PoC standard, the next generation of PTT systems, which is expected to emerge in the U.S. market within one or two years, will enable interoperability among carrier networks and will offer users a competitive handset environment. The next generation of PTT systems will provide improved performance and combine PTT functionality with other applications, such as multimedia messaging and location services. An overview of the next generation PTT systems is provided in Section 6 of this report.

3.1 First Generation PTT Service

There are four PTT systems being offered over commercial wireless networks in the United States. Nextel, Sprint PCS, Verizon Wireless, and Alltel currently offer services that let customers with PTT-enabled phones talk with anyone who is on the same carrier, almost anywhere in the country. Nextel, Verizon and Sprint PTT services are available nationwide but Alltel service is only available in limited market areas. Another regional wireless carrier Cellcom began offering PTT services on its CDMA/AMPS-based network in the upper Midwest in June 2004.

The following describe the system capabilities of the three PTT services with nationwide coverage: Nextel's Direct Connect, Verizon Wireless' Push to Talk, and Sprint's Ready Link. (Alltel's Touch2Talk service is not offered in the Washington Metropolitan area.) These services were subjected to performance tests as part of the MITRE evaluation effort of PTT use for public safety communications.

3.1.1 Nextel Direct Connect Service

Nextel Communications Inc. has been offering "Direct Connect" dispatch services for 10 years through Motorola's Integrated Digital Enhanced Network (iDEN) technology and handsets operating in the 800 MHz band. iDEN technology makes it possible to combine communications and telephony systems in a single device. The service was first limited to specific regions, but since late 2003 has been available nationwide. Direct Connect provides the following services

- **Direct Connect®** – Instant contact with people in your local coverage area
- **Nationwide Direct ConnectSM** – Instant contact with anyone, anywhere on the Nextel national network
- **International Direct ConnectSM** – Instant contact in four countries: Argentina, Brazil, Canada and Peru (through partnerships with wireless operators Telus Mobility in Canada and NII Holdings in South America).
- **Group ConnectSM** – Instant contact with a group of up to 25 people, all together, all at once
- **NextMail** – Use the walkie-talkie feature to email a voice message to anyone, anywhere on the Nextel national network

Direct Connect calls provide instant access and one-to-one conversation capability. Nextel has a separate "Private ID" for Direct Connect. The first 3-number group in a Direct Connect call number is similar to an area code. The second group, the fleet number, is like an exchange in a landline call. The last group of digits is the member number. Each group of digits is separated by an asterisk which the caller keys in along with the numbers.

Direct Connect service enables two modes of initiating contact with other Direct Connect customers on Nextel national network:

- **Direct Connect Call** – A user enters the number of a Direct Connect user and presses and holds the PTT button. User begins talking to recipient after phone emits a chirping sound.
- **Send a Call Alert** – A user contacts another Direct Connect recipient to indicate desire to talk to the recipient on a Direct Connect call, without barging-in and automatically speaking. The recipient's handset emits a series of beeps and display name or Direct Connect number of sender. The Recipient has the option to respond, place alert in queue to Direct Connect back at a more convenient time, or clear the call alert.

Direct Connect calls are shorter than normal cell phone calls and less expensive. The average conversation time of Direct Connect calls is 40 seconds and the average call set up time is less than one second. Nextel adheres to a call setup time limit of no more than one second.

Group Connect service connects up to 25 people all together, all at once. Customers set up talkgroups with Nextel online management tool. Customers can create up to 200 talkgroups (with 3-25 members each) and use the tool to modify and delete talkgroups.

To meet the needs of the Federal market and the Public Safety Community, Nextel offers the First Responder feature set to improve Direct Connect functionality in times of crisis beyond that of commercial users. The First Responders feature set, available only to public safety organizations, includes:

- **Priority Queuing (PQ)** – provides priority access to network for subscribers during times of congestion. PQ subscribers are queued higher than other subscribers thus increasing the speed and likelihood that the call will be completed.
- **Emergency Group Call (EGC)** – provides access to network resources during times of congestion. When an EGC call is initiated, other calls occupying that resource (channel) are preempted to allow for the emergency call to be completed. Members of the talk group receive priority treatment for the duration of the call.
- **Multiple Simultaneous Talk Group Scan (MSTGS)** – allows users to listen for calls on up to four talk groups at the same time. Once a call is initiated the user's handset no longer monitors calls on the other channels in the talk group.

Public safety in several state and local jurisdictions and government officials are familiar with Nextel's Direct Connect service and have been using it in addition to their dedicated radio systems for the transmission of voice messages. Some users are concerned that the cellular telephone systems could be overloaded and ineffective during large scale emergencies or disaster incidents. In the mean time, some users have reported that in areas surrounding various incidents, Nextel's Direct Connect feature worked well for those personnel so equipped. As cellular telephones are now standard issue for most local police department personnel, more jurisdictions are acquiring Nextel PTT phones as auxiliary communications systems.

Nextel services operate in the 800 MHz band and their cell phone towers cause interference to networks used by public safety radio and other trunked radio systems

operating in the 800 MHz band. In July 2004, the FCC awarded Nextel a replacement spectrum of 10 MHz in the 1900 MHz band for reorganization of the 800 MHz band. Nextel will have to retune all its phones to the new band within three years. Other cellular carriers are objecting to the ruling citing claims of non-competitiveness nature to the award.

3.1.2 Verizon Wireless “Push to Talk” Service

Verizon Wireless (VZW) started offering its PTT service, named “Push to Talk”, across the nation in August 2003. Verizon is using equipment from Motorola's Winphoria Division for its “Push to Talk” solution. A Verizon “Push to talk” call is not a standard cell call, but rather runs over the CDMA 1xRTT high-speed data network, equipped with Motorola's Winphoria Division PTT solution gear, and is based on Voice-over-IP. There is currently one “Push to Talk” enabled handset available, the Motorola V60p, which must be activated with one of several business plans. Although Verizon “Push to Talk” system is proprietary, the carrier will at some point upgrade to a standards-based solution that should be interoperable between services and different handsets.

The following highlights the features of VZW's “Push to Talk” service:

- **Coast-to-coast coverage** – within the Verizon Wireless national enhanced service area.
- **Simple Voice Communication** – Connect at the touch of a button. “Push to Talk” customers can talk one-to-one or with groups of up to 20 participants
- **Online Contact & Group Management** - Store up to 150 individual “Push to Talk” contacts and up to 50 “Push to Talk” groups. Customers create and organize contact lists and group lists on the Verizon “Push to Talk” Contact Management Web site: www.vzwpushtotalk.com, without the assistance of customer service.
- **One Number** - One number for both “Push to Talk” service and voice calls
- **Presence** – A presence icon next to the contact name lets users know their contacts are available to receive “Push to Talk” calls.

“Push to Talk” service enables two modes of initiating contact with other “Push to Talk” customers on VZW network:

- **Alert Call** – A tactful method by which a user can contact another “Push to Talk” recipient without barging-in and automatically speaking. The recipient's handset plays an audible tone and displays a message indicating someone wants to speak with them.
- **Barge Call** - The method by which someone receives a “Push to Talk” call by hearing an audible tone immediately followed by the voice of the originator.

Verizon's service uses its 1xRTT high-speed data network that sits on top of its normal cellular network for PTT functionality, providing a large overall coverage area in urban areas but potentially a thin coverage in rural areas. Early industry reviews of Verizon “Push to Talk” service indicate voice latency and call setup times are much longer than

service from Nextel. Calls set up times on the order of 6 to 14 seconds have been reported for Verizon “Push to Talk” calls. Verizon plans to launch an enhanced “Push to Talk” service that would enhance the latency issues in the next few months.

3.1.3 Sprint PCS Ready Link Service

Sprint PCS offered its PCS Ready Link push-to-talk service in November 2003. Like Verizon Wireless, Sprint is using equipment from Motorola's Winphoria Division for its PCS Ready Link PTT solution. Sprint PCS Ready Link offers nationwide coverage and the ability to bundle the Ready Link solution with the company's PCS Vision CDMA 1XRTT data service.

Sprint has deployed its Service Engine to manage call routing, authentication and authorization based on Session Initiation Protocol (SIP)-based communications. The SIP-based services platform will set the stage for a broad array of new services. Sprint plans to transition the SIP platform to the overall IP Multimedia Subsystem (IMS), of which SIP is a part, as the foundation for integrating new IP services.

The service facilitates group calling on a nationwide basis. A Ready Link group call can have up to five participants, but only one person at a time can talk. A user presses and holds a button on the side of the phone to talk, releasing the button when done, which opens the floor for another speaker.

Ready Link uses the same number for Ready Link and traditional PCS phone calls. A separate Ready Link phone book keeps 200 personal and 200 company contact numbers. Ready Link subscribers are able to manage their calling lists through the Web or via the phone. PCS Ready Link calls are terminated when user presses "End" or after 20 seconds of inactivity. While in a PCS Ready Link session, voice calls will go directly to voicemail. When on a voice call, using PCS Vision or out of coverage, PCS Ready Link calls will not be completed.

The Ready Link service was initially available with two Sanyo handsets. One handset is a rugged version intended for the business and enterprise market. Two other Ready Link phones with built-in camera are currently available. Sprint provides one number for push-to-talk and regular calls; real-time access to PCS VisionSM service with web, messaging and Picture MailSM applications.

Early Industry reviews of Sprint's Ready Link service indicate better latency and call setup than service from Verizon Wireless. The setup time for a Ready Link call is less than 4 seconds and the volleys back and forth are instantaneous. However, analysts said such early quality comparisons don't mean much, and both Sprint and Verizon are emphasizing the long-term benefits of having deployed a new infrastructure.

Table 1 highlights the service features offered by the three carriers: Nextel, Verizon Wireless, and Sprint PCS.

Table 1. Comparison of Push-to-Talk Services

Service Details/Functionality	Nextel “Direct Connect/ Group Connect”	Verizon Wireless (VWZ) “Push to Talk”	Sprint PCS “Ready Link”
Voice Point-to-Point Calls	Yes	Yes	Yes
Voice Group Calls	Yes (only regional) Up to 200 talk groups (3-25 members/ group)	Yes Up to 50 talk groups (3-20 members/ group)	Yes Up to 50 talk groups (3-5 members/ group)
PTT-Enabled Phones Used with the Service	All Nextel iDEN phones are PTT-compliant by design	Motorola V60p (more to be added in the future)	Sanyo Phones: SCP-5500, RL-2000, RL-2500, RL-7300
Rugged Phone/Terminal	Yes: for example, r750, i305, i530, i58sr	No	Yes: Sanyo RL-2000, RL-7300
Emergency Button on Phone/Terminal	Yes: provides priority access during heavy congestion, and Emergency Group Connect	No	No
Priority Access	Yes (Note 1)	No	No
Emergency Group Call	Yes (Note 1)	No	No
Talk Group Scanning	Yes (Note 1)	No	No
Encryption & Privacy (adequate security to guard calls from interception)	No	No	No
Presence Information (User and Group)	No	Yes	No
Group Talk Setup via Internet	Original Talkgroups are provisioned by Nextel. Users can add or remove Talkgroup participants using Nextel website	Users must establish, modify, or delete group contacts via VZW “Push to Talk” website (Individual contacts must also be established online)	Users can establish, modify, or remove Talkgroup participants using Sprint phones or website
Group Talk Setup via Phone	No	No	Yes

Flexible Package Plans	Yes	Yes	Yes
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Note 1: This feature is only available to public safety organizations.

3.2 PTT Service Factors of Prime Concern for First Responders

The first responder's requirements differ significantly from those of most users because of the safety-of-life implications of their services. Of utmost importance are the coverage area and the availability of service even during peak periods of congestion over the network. In evaluating the applicability and utility of PTT service for first responder applications, considerations are given to the following factors:

- Availability – Users can acquire service from a provider in a given region.
- Coverage – Communication transmissions can reach users in a given service area. Coverage may be limited or not available in sparsely populated communities or rural areas.
- Accessibility – Service is accessible and usable on demand, even during peak periods or network disruption.
- Security and privacy – Level of inherent security and privacy of a service and capability to add security measures.
- Offerings of PTT-enabled handsets – Number and types of PTT-enabled phones used with the service.
- Addressing functionality – Setting up contact lists and group talks information.
- Cost – Handset and service costs.
- Type of application supported – Range of communication services offered/integrated with PTT.

4. Testing of PTT Systems

We developed a progressive testing methodology for evaluating PTT systems from three wireless providers: Nextel's Direct Connect, Verizon Wireless "Push to Talk", and Sprint's Ready Link. Under this progressive testing methodology, the candidate PTT systems are first evaluated and characterized in a laboratory environment. The equipment is next subjected to controlled, technical field tests with only MITRE staff participating in the tests. After the field tests, a small controlled operational field test would be performed with public safety personnel to determine user suitability.

We acquired at least two phones from each of the three providers and signed up for service on their commercial networks. We conducted a series of laboratory tests to measure performance of the various systems on each network. The PTT-equipped phones used during these tests were:

Carrier	Phone Model
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Nextel	Nextel i730
Verizon Wireless	Motorola V60P
Sprint PCS	Sanyo RL-7300

All phones were equipped with a push-to-talk switch on the side of the unit, and all have speakers for communicating in PTT mode. The Nextel Model i730, the smallest iDEN phone, features a color display, advanced user interface, true GPS, and Java.

The V60p is Motorola's first CDMA push-to-talk phone. It is a variant of the V60 series. Additional features include 1xRTT high-speed data, EMS, and voice dialing. The V60p includes the Binary Runtime Environment for Wireless (BREW) solution developed by Qualcomm for enabling carrier-independent push-to-talk service (not offered initially by Verizon). Although the service uses Verizon's advanced data capabilities, the V60p handset offers no data services, such as e-mail; it also lacks a color display.

The Sanyo Model RL-7300 for Sprint PCS Ready Link is a rugged, black, clamshell phone that offers users many options such as web service, digital voice memo recorder, and a color display.

4.1 Performance Metrics for PTT Solutions

Performance measures/metrics for evaluating applicability of commercial PTT services for public safety communications include:

- Call setup delay over wireless networks (during normal business hours and evening hours; and also during high-capacity events such as near a congested rush-hour highway or at the conclusion of a stadium event)
- Intra-call latency (voice delay within a call)
- Voice quality
- Ease of use, including set up of contact lists and talk groups
- Availability of rugged PTT-enabled handsets
- Availability of specific features for first responders that enhance service availability during times of network congestion

4.2 PTT Test Results

4.2.1 Delay Measurements Results

We ran multiple tests to measure the delay performance of PTT services from Nextel, Verizon Wireless, and Sprint PCS, and averaged the times over the series of tests. We used a digital stopwatch showing hundredths of seconds to measure times, focusing on the following three parameters: call setup time, initial voice delay, and intra-call voice delay.

The call setup time of a PTT call is measured as the time elapsed from the instant a caller presses the push-to-talk button until a beep is heard to start speaking (i.e., the floor is made available for the caller to speak).

The initial voice delay is measured as the time elapsed from the instant a caller presses the push-to-talk button until a beep or the spoken voice is heard at the second phone.

The intra-call voice delay is measured as the time elapsed, within an ongoing call, between the start of an utterance at one phone until the talker's utterance is heard at the second phone.

The measured delay times for the PTT services over the series of tests are provided in Table 2.

Table 2. Measured Delay Performance of PTT Services

	Call Set Up Time (seconds)			Initial Voice Delay (seconds)			Intra-call Voice Delay (seconds)		
	Min	Av	Max	Min	Av	Max	Min	Av	Max
Nextel	0.81	0.92	1.10	1.69	1.82	1.97	0.40	0.58	0.85
Verizon Wireless	3.35	6.32	8.93	7.69	9.18	11.06	1.28	1.54	1.82
Sprint PCS	2.25	4.34	6.91	8.09	10.16	15.38	0.96	1.15	1.34

Nextel was ahead of Sprint and Verizon, providing average call setup time and intra-call voice delay of less than a second. The initial voice delay averaged 1.82 seconds.

For Verizon, the call set up times measured between 3 to 9 seconds with an average of about 6 seconds. An additional delay was observed before a beep and the spoken voice could be heard at the second phone, therefore the average initial voice delay was longer than call set up time by over a second. Once connected, the voice delay improves -- it took about 1 to 2 seconds for a spoken utterance to arrive at the second phone.

For Sprint, the average call set up time measured a little over 4 seconds. We observed that although the measured call set up time on Sprint is less than on Verizon, the caller could not always talk right away after hearing the beep; therefore the initial voice delay on Sprint is longer than Verizon's. In some instances, spoken sentences would not transmit in their entirety and the talker had to repeat what was said, resulting in confusion.

We asked Verizon and Sprint sales representatives about the call set up latency issue. Sprint sales representative confirmed that call set up and delay of Ready Link are longer than Nextel.

Verizon indicated that the call set up and delay will be improved with the launch of the next phase of "Push to Talk" service, which is scheduled within the next few months.

Verizon sales representative offered to upgrade the V60p phones loaned to MITRE with enhanced “Push to Talk” client software.

After upgrading the phones, we repeated the measurements. We noted that the call setup time with the upgraded phones improved significantly, averaging an impressive 1.11 seconds. However, we observed that both the initial voice delay and the intra-call voice delay have remained at about the same level, averaging 8.1 seconds and 1.7 seconds respectively.

4.2.2 Observed Functional Differences between PTT Services

Ease of Use - Push-to-talk service is easy to use on all three carriers’ networks. To begin a connection on Nextel, users first select a user in the phone's contact list or enter a user number on the key pad and press a button to start talking or send an alert. On Verizon or Sprint, users press the PTT button to access contact list, scroll to highlight contact or group name and press the same button again. When the user releases the button, others in the conversation hear a beep indicating that it is okay for someone else to talk. A user would have the floor for as long as he/she holds down the PTT button, and therefore there are no interruptions. Releasing the button after each utterance produces a beep and gives the other person the floor to speak.

During a PTT call, incoming voice calls go directly to voice mail. Conversely, if someone tries to contact a user through PTT while on a voice call, the person sending the PTT alert receives a notice indicating that the user was unavailable. But the user does not get an indication at all that somebody tried to reach him/her.

There are operational differences on PTT services: Sprint's phone screens say "You have floor" or "Floor is open" during a PTT call, which makes it easy for users to know when the floor is available. We observed that if you begin speaking immediately after pushing the button and “You have floor” message is displayed on screen, your utterance is not transmitted to the other end unless you wait until you hear a beep first. Furthermore, the use of similar beeps at the release of button by a distant user and the pressing of button before you talk makes the exchange of conversation somewhat annoying on Ready Link.

Ready Link enforces “inactivity timeouts” that terminates the call after 6 seconds of silence at both ends of the connection, causing the caller to redial to re-establish the connection. Verizon “Push to Talk” service also enforces inactivity timeouts but after a longer interval of silence (about 20 seconds), therefore it is not as restrictive as with Ready Link.

Ready Link enables users to set up calling groups of up to five people on the handset or on the Sprint PCS Web site.

Verizon's phone book icons tell you if your callers are within range with their phones turned on. Users can not add a push-to-talk number to a Verizon phone's address book except through a web site, which is inconvenient.

Group calling is very different too. Sprint Ready Link talkgroups are limited to five people. Verizon “Push to Talk” talkgroups are limited to 10 people.

Nextel talkgroups can include 25 people, but they can be reached simultaneously only if they're in the same home region -- a limitation. Furthermore, Nextel has to provision the group calling and establish the talkgroups, which could take up to two days.

Phones - Almost every Nextel phone is a PTT-capable phone. Any Nextel user can contact any other Nextel user and know without a doubt that PTT functionality exists on both ends. That's not true with Verizon or Sprint. Every person that wants PTT on Verizon or Sprint will need to purchase a PTT-capable phone. Right now, only one PTT-capable phone is available from Verizon: the Motorola V60p. (More models will be available in the near future.) Sprint now offers a choice of four PTT-ready phones. On all of these phones, a single button press shuts off the speakerphone during PTT calls and users have to hold the phone to their ears, making PTT calls much more welcome at social gatherings.

First Responder Features on Nextel - Nextel suite of features for first responders, including priority access, emergency group connect, and rugged handset, work together to enhance public safety communications. (Discussion with Sprint sales representative indicated that Sprint plans to have priority access capability by the end of 2004.)

Presence Icons on Verizon - The Presence functionality on Verizon lets users know their contacts they want to talk to are available to receive "Push to Talk" calls. The Presence icon next to a Contact name or Group name indicates recipient's availability and is updated in real time. We found Verizon's presence icons (for individuals and talkgroups) is a very useful feature. It saves the caller repeated attempts to reach a user who has his/her phone closed or is in an area where the phone is out of service.

Alert Feature on Nextel and Verizon - The Alert feature makes PTT calls less intrusive, enabling the called party to accept or decline the request to talk, if they are engaged in a meeting.

PTT Numbers vs. Cell Numbers - Nextel phones have separate numbers for cell calls and push-to-talk calls. With Sprint and Verizon, users have only one number for both types of calls. This is easy for users to remember. But it does not make a big difference, as users generally dial by name from the address book in the phone.

Coverage - The Sprint and Verizon cellular networks are actually much larger in comparison to Nextel.

PTT Service plans - There are differences among the service plans of the three carriers (Service plans will change with time based on market demands and company policies):

Sprint - Sprint's Ready Link PTT service costs \$10 a month and provides unlimited push-to-talk time on top of any monthly voice calling plan, which can range from \$35 (for 300 minutes) to \$115 (for 2500 minutes). Sprint's push-to-talk prices include group calling. (A caveat: You can not use Ready Link in an area where you have only a roaming signal; you have to be on the Sprint network.)

If you subscribe to the company's \$15-a-month PCS Vision data service plan, you can get Ready Link for \$5 a month. Alternatively, if you choose a plan that costs \$100 or more per month and don't want the Vision data service, you get Ready Link for free.

Verizon - Verizon offers combination voice and “Push to Talk” packages, called America's Choice with Push to Talk. Prices range from \$60 (400 voice minutes) to \$220 (3500 voice minutes) and cover unlimited “Push to Talk” on one-to-one calls only. A “Push to Talk” group call is an additional 15 cents per minute per participant.

Nextel - The company designates Direct Connect calls both locally (which it calls In Market) and nationally (Market to Market). When users subscribe to Nextel's voice plan, which range from \$40 to \$200 (the allotment of minutes varies widely), “In-Market” Direct Connect calls are free. “Market-to-Market” calls cost 10 cents per minute for each participant, which means a user is charged for both inbound and outbound transmissions. What's more, with an a la carte PTT service, Nextel deducts minutes from the user's voice calling plan.

If users prefer to keep the minutes in the voice-plan bucket, they would sign up for the company's unlimited PTT plan for \$10 a month.

Nextel treats Group Connect calling as an extra-cost, a la carte service, and it can get expensive fast.

4.2.3 Summary of PTT Service Evaluation

We tested PTT services from three commercial wireless carriers: Nextel, Verizon Wireless, and Sprint PCS. We measured latency performance on all three services and observed functional differences among the services. Overall, we found that PTT could be a useful technology for public safety users who can benefit from easy, instant access to other users nationwide. All three services could stand improvement, though. First, users can push-to-talk only with subscribers of the same cellular company, a serious issue with respect to interoperability. Second, the latency for call setup and the limited number of PTT-enabled phones on Sprint and Verizon networks make the service less appealing to users. Currently, Sprint PCS has only four Ready Link phones, and Verizon Wireless offers just one phone for “Push to Talk” service. Nextel has an advantage in that all its phone models work with its Direct Connect network. Any Nextel user can contact any other Nextel user and know that PTT functionality exists on both ends. Verizon has more coverage and offers a better value than most other national plans. In general, Verizon's “Push to Talk” service covers more areas than Nextel.

4.3 Issues with First Generation PTT Service

The following summarizes some of the issues with the PTT services currently available from commercial providers:

- Incompatibility of different technologies among different providers which prevent users on different networks from communicating
- Noticeable latency for call setup times on Verizon and Sprint networks
- Lack of priority access during network congestion (Only Nextel offers first responders special features available only for public safety user)
- Lack of security and or communications privacy on commercial networks
- Inability to receive PTT calls/alerts while on a regular voice call

- No roaming agreements among carriers to expand coverage areas
- Inability to rapidly set up talkgroups in the field
- Inability to see call attempts from other groups after completion of a PTT call

5. Open Discussion with Loudoun County Fire Department Officials

We visited the Loudoun County Fire Training Center on June 23, 2004, and met with several officials to discuss the use of Push-to-Talk and commercial services by Loudoun county officials. Attendants from Loudoun County Fire Department included:

Matthew Partlow, Deputy Chief
Department of Fire Rescue Services

Kevin Johnson, Deputy Chief
Department of Fire Rescue Services

Gary McKelvey, Communication System Supervisor
Department of Information Technology

The Loudoun county officials addressed several important factors that wireless commercial systems must satisfy for viable use by public safety agencies:

Coverage: Public safety operation requires full coverage that goes beyond most commercial services coverage. They complain about coverage gaps of commercial services outside of densely covered urban areas and “dead spots” in somewhat difficult terrains that adversely affect public safety operations. Roaming agreements among carriers can effectively enhance coverage areas for users. However the 100 percent coverage sought by public safety operations may still not be attainable since most commercial carriers do not provide service in scarcely populated areas. Furthermore, public safety work requires service penetration inside buildings to enable response to fire and emergency incidents.

Cost of Replacing Current Equipment: Public safety agencies already have significant investment in their communications systems. For example, Loudoun County has an existing inventory of about 1000 pagers that are too costly to replace.

Channel Priority Access: Public safety operations require channel priority functions on commercial systems to enable them high probability access and channel availability even when the network becomes congested.

Recording and Logging of Push-to-Talk Calls: Public safety operations require recording of all participants’ voice exchanges of the push-to-talk sessions. Call loggings are essential for both push-to-talk one-to-one and group talk conversations. Call loggings need to be kept by the public safety agency for a minimum of 90 days and up to a year to enable public safety officials to retrieve vital information.

High Availability: Extremely high availability of the wireless transmission infrastructure is a necessity for public safety operations (with or without PTT services), including towers, transmission media, and switching/call control resources. As this has proved problematic both during 9/11 attack and in natural disasters, use of backup systems

combined with primary communications systems is essential to providing extremely high availability.

Security: Public safety agencies involved in sensitive communications requires appropriate security techniques, such as data integrity, transmission privacy and user authentication, to safeguard voice communications and data from eavesdropping.

System Integration: Public safety officials want to understand how the commercial system can fit into their current communications systems. For example, can simple functions such as contact lists, talk groups that are already stored and available in existing systems, be duplicated on commercial systems? Would commercial systems need to interface with existing systems? Who is going to keep the numbers of the different jurisdiction phones?

Performance: Factors such as voice quality and latency are important. Equally important are the concerns that use of cell phones would tend to make public safety officials talk longer and the cost of accumulated calls would be high.

Reliability: User handsets and carrier networks must meet public safety requirements of high reliability and robustness. Rugged handsets are required in most applications.

We discussed with Loudoun County officials the ways they use to conduct inter-county communications with neighboring counties such as Fairfax and Montgomery counties and for communications with other public safety jurisdictions. They indicated that fire department officials at each county are constantly aware of the radio templates that identify the channels used by the neighboring counties and they set their radios to those channels to enable inter-county communications during incident response. They also said that they have about 500 surplus portable radios stored for special events to loan to personnel from other counties during emergency. They also used the communications/command units to provide interoperability between radios that use different channels using audio "bridge" that interconnects incompatible radios, such as the ACU-1000 Modular Interconnect System, made by JPS Communications.

As for communications with other public safety jurisdictions such as law enforcement and medical emergency staff, the Loudoun County Fire Department officials said that different jurisdictions could not talk with one another with the use of low-band radio systems. Communications with other jurisdictions is possible with 800 MHz systems but it is the responsibility of the incident management team to define who needs to interoperate with one another. The unified incident command is responsible for enabling communications among the different jurisdiction groups. The incident command is a new concept for law enforcement and public health groups.

Loudoun County officials did not think that PTT service is applicable for public safety communications in their local county because it is fully covered by the 800 MHz towers, and because they are capable of carrying inter-county communications with neighboring counties using different interoperability schemes as indicated above. They also indicated that in order for PTT service to be a viable communications option for Loudoun County, it has to be accepted as a regional communications buy-in concept for Loudoun as well as all other neighboring counties in the region.

Loudoun County officials have suggested the following use of PTT service for enhancing public safety communications:

- As a “fail-over” back-up communications capability, or as a temporary substitute for the larger counties, such as Loudoun County, for their primary radio communications systems, extending the range of coverage geographically and/or enabling interoperability between agencies of different jurisdictions. Commercial PTT service would be the back-up system when the primary radios collapse.
- As a primary wireless capability for small counties in rural areas that only have a small group of emergency personnel, where the county budget cannot afford the high cost of building a private radio system. For these smaller counties, the use of commercial wireless systems would be a cost-effective solution. But again the coverage provided by the commercial networks may still be a problem because the providers may not have invested in building enough communications towers to provide full coverage for these scarcely populated areas.
- As a wireless communications system for the emergent volunteers such as Community Emergency Response Teams (CERT) and certified teams organized by joint neighborhood watch groups or volunteer centers to help during incidents. Emergent volunteers are valuable sources of information and technical assistance to agencies engaged in disaster planning. Volunteer centers help agencies prepare to involve emergent volunteers in expanding services to the community following a disaster. The emergent volunteers/certified teams can use PTT service for communications among other volunteer groups who have undergone practice disaster training sessions that include use of PTT. Emergent volunteers would therefore be familiar with the PTT equipment when responding to real emergencies. They could also create PTT databases of pre-planned talkgroups in regional areas or on a national basis for ease of reaching other members in the group when the need arises.

Loudoun County Fire Department officials expressed their urgent needs of high-speed wireless data communications to improve their field operations. They asked for data rates on the order of 256 kbps or 512 kbps to enable their teams to access data on the Internet and obtain information on hazard material while on-scene during emergency response and to be able to send e-mail or instant messages to other personnel. They complained about the shortfalls of their existing vehicular modems that cost \$6,000.00 a unit while providing data speed of only 19.2 kbps. They mentioned that data communications during field operations has very high priority for each function. They would even be willing to participate in a MITRE-supported research program if it can meet their data communications requirements.

6. Next Generation PTT

Most Industry analysts agree that PTT interoperability is the next step once the various carrier PTT systems are deployed. Market participants are working to address the issues of first generation PTT relating to compatibility between different systems. Leading mobile vendors with the support of mobile carriers have been working on an access-independent and globally interoperable standard for PTT over cellular (PoC).

Standardization will achieve interoperability between the PTT solutions from different providers.

Next generation PTT offerings, based on PoC standards, are expected to help network operators in negotiating PTT network interconnection agreements to give their PTT customers broader roaming coverage. Next generation PTT will also have standardized PoC-compatible handsets, offering users a competitive handset environment. The first interoperable products resulting from these standards activities are expected to be available for commercial use in the second half of 2004 or early 2005.

Nextel and Motorola plan to develop a Direct Connect product for global wireless network operators using CDMA platforms based on Qualcomm's QChat software, which would enable Nextel to offer Direct Connect service to CDMA carriers outside of the United States. Nextel subscribers would be able to use their Direct Connect feature to reach other users around the world.

Nextel is also building a presence-and-availability engine into its network that will give corporate users more information about the whereabouts of their workgroup mates, as well as the ability to leave recorded Direct Connect messages. Ultimately, the carrier wants to integrate voice and data applications so tightly that users can do instant voice and data collaboration.

The mobile data networks that provide the platform for interoperable PTT functionality offer broadband speeds that can significantly enhance data services for public safety users. Data services, such as General Packet Radio Service (GPRS), Enhanced Data Rates for GSM Evolution (EDGE), and EV-DO (short for Evolution-Data Optimized) are being deployed nationally on GSM and CDMA2000 networks, offering a range of high-speed data rates from 40 kbps to 500 kbps to and from mobile terminals. Additional enhancements are currently being standardized that will further increase the data rates to 2 Mbps and will support point-to-multi-point multimedia data services. The applicability of the different data service offerings and capabilities to enhancing public safety field operations needs to be examined with care.

6.1 PoC Standard

The technical standard specification for PoC was submitted to the Open Mobile Alliance (OMA) standards body in August 2003. Ericsson, Nokia, Motorola, and Siemens are advancing a final version of the standard. The PoC standard is based on the IP Multimedia Subsystem (IMS). The OMA is defining services like Instant Messaging and presence as part of the PoC standard. The standard is due to be completed soon, enabling communications between phones made by different manufacturers and across different operator networks.

Building on the PoC standard, next generation PTT systems will be integrated with presence information of individuals and group members and will offer multimedia messaging applications and services. The IP architecture supporting PTT service allows network operators to differentiate the service to correspond to the diverse requirements of user groups, assuming such requirements are communicated properly to the standards-setting groups and network operators.

Next generation PTT services can be expanded to incorporate features unique to public safety systems, such as priority access and security, and offered only to first responder users. Other important factors that require special consideration in the standard include: coverage areas, availability, latency, system maintainability and ease of use. The IMS-based services platform will set the stage for a broad array of integrated new IP services.

6.2 Wireless Access Priority for Government Users

Wireless Priority Service (WPS) is a White House-directed National Security/Emergency Preparedness (NS/EP) National Communications System (NCS) program for priority cellular network access. The WPS was approved by the Federal Communications Commission (FCC) for NS/EP requirements on a call-by-call priority basis. The NCS executes the program on behalf of the Executive Office of the President. The NCS provides the day-to-day administration of the WPS. (More information about WPS is available at the program Web site at <http://wps.ncs.gov>.)

WPS is available only to designated leadership at all government levels, national security/emergency responders, and private sector critical infrastructure leaders and decision makers, as approved by the FCC Rules and Requirements and the NCS. WPS has been designed to have minimal impact on regular cellular users, providing priority access to vital decision makers without restricting the public's ability to gain access to those same networks.

When trying to make a call in times of emergency or natural disaster, national security and emergency preparedness users will have the ability to gain priority access to the next available cellular channel to place their call. Together with Government Emergency Telecommunications Service (GETS), available on wireline networks since 1995, WPS service will greatly enhance the ability of public safety users to complete wireless calls during critical times and communicate vital decisions and reports during emergency situations.

The initial carrier for WPS is T-Mobile. Additional Global System for Mobile communication (GSM) carriers (AT&T Wireless, Cingular, and Nextel) will follow later in the 2nd calendar quarter of 2004. Verizon Wireless and Sprint PCS, which use Code Division Multiple Access (CDMA) technology, will be added when modifications can be made, most likely in 2006.

WPS is accessed by dialing * 272 before the destination number using a phone that has been subscribed with the WPS Feature. How WPS can be adapted for push-to-talk type of calls, which do not require dialing the destination number, is subject to investigation.

The emergence of next generation PTT services that offer interoperability across carrier networks in the coming years and the possible adaptation of wireless priority service for push-to-talk calls during emergencies will enhance public safety communications.

7. Conclusions and Future Plans

We evaluated the applicability of push-to-talk technology for public safety communications by testing the capability of commercially available systems and conducting interviews with local public safety officials in Loudoun County to learn about

their wireless communication needs. Based on the outcome of this evaluation effort, we conclude that the push-to-talk technology provides a valuable niche capability for public safety communications. Push-to-talk can be used to provide back-up communications to the primary radio systems used by public safety agencies, extend the range of coverage geographically and/or enable interoperability between agencies. Small counties in rural areas with a small group of emergency personnel and small budgets to cover the high cost of building a private radio system could benefit from commercial push-to-talk technology and infrastructure in their primary operations.

Other uses include emergent volunteer groups to help during incidents. Emergent volunteers are valuable sources of information and technical assistance to agencies engaged in disaster planning. Volunteer centers help agencies prepare to involve emergent volunteers in expanding or expanding services to the community following a disaster. The emergent volunteers/certified teams could use PTT service for communications among other volunteer groups who have undergone disaster training sessions on how to use PTT and would be familiar with the PTT equipment in case of real emergencies.

We submitted a proposal for FY05 to continue investigation activities into interoperable push-to-talk and technologies for enhancing wireless voice and data communications for public safety users. We proposed to test new capabilities of next-generation PTT systems, such as speed, performance and feature richness, and engage public safety users in the tests. We plan to conduct the tests under stress conditions to assess how congestion on the networks would affect PTT delay performance. This will help us determine user suitability and identify PTT problems/shortfalls to support the needs of public safety interoperable communications. To respond to the critical needs of public safety users for high-speed wireless data capabilities, we plan to evaluate the feasibility of emerging wireless broadband data services from commercial operators to enhance public safety's field operations by testing real-time distribution of images and data.

We plan to communicate PTT shortcomings to standards organizations and wireless carriers through technical contributions that address public safety communications needs for next PoC standards release.

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9. Acronyms

AMPS	American Mobile Phone Service
BREW	Binary Runtime Environment for Wireless
CDMA	Code Division Multiple Access
EDGE	Enhanced Data Rates for GSM Evolution
EGC	Emergency Group Call
EV-DO	Evolution Data Optimized-Data Only
FCC	Federal Communications Commission
GETS	Government Emergency Telecommunications Service
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
iDEN	Integrated Digital Enhanced Network
IMS	IP Multimedia Subsystem
IP	Internet Protocol
LMR	Land Mobile Radio
MSTGS	Multiple Simultaneous Talk Group Scan
NCS	National Communications System
NS/EP	National Security/Emergency Preparedness
OMA	Open Mobile Alliance
PCS	Personal Communication System
PoC	Push-to-talk over Cellular
PQ	Priority Queuing
PTT	Push-to-Talk
RTT	Radio Transmission Technology
SIP	Session Initiation Protocol
TDMA	Time Division Multiple Access
VZW	Verizon Wireless
WPS	Wireless Priority Service