Comments of the SDR Forum on the 2nd Notice of Proposed Rulemaking in the Matter of Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band

Document SDRF-08-R-0005-V1.0.0

18 June 2008

Comments of the Software Defined Radio Forum on Federal Communications Commission Second Further Notice of Proposed Rulemaking

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

In the Matter of	)	
	)	
Service Rules for the 698-746, 747-762 and 777-792 MHz Bands	)	WT Docket No. 06-150
	)	
	)	
	)	
Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band	)	PS Docket No. 06-229
	)	
	)	
	)	

COMMENTS OF THE SOFTWARE DEFINED RADIO FORUM ON SECOND FURTHER NOTICE OF PROPOSED RULEMAKING

I Introduction

The Software Defined Radio Forum (SDR Forum) is pleased to see the FCC continue to explore innovative approaches to maximize spectrum utilization and meet Public Safety's need for a Nationwide Broadband Network (NBN) that allows nationwide interoperability. We believe that Software Defined and Cognitive Radio technologies are key enablers to meet this vision. The SDR Forum is an international, non-profit organization dedicated to promoting the development, deployment and use of Software Defined Radio (SDR) technologies. More than 110 organizations throughout the world are members of the SDR Forum.[1] Participants in Forum activities are decision-makers, planners, policymakers, technologists, educators, and managers from a wide variety of commercial, educational, scientific and government organizations.

[1] See http://www.sdrforum.org/pages/currentMembers/currentMembers.asp.

The Software Defined Radio Forum also works closely with a number of national and international organizations working in our areas of interest. It participates in technology development and standards development activities.

The SDR Forum has worked closely with the FCC for a number of years. Forum members view this association as a valuable conduit for information, and one of the benefits of Forum membership. We are pleased to offer these comments on the subject proposal.

This document has been prepared by the Regulatory Committee of the Software Defined Radio Forum and has been approved by the Board of Directors of the Forum in accordance with its procedures. The Board believes that the position taken herein represents a consensus view of the Forum's membership, but the Board also realizes that individual member organizations may not have participated in its preparation and might offer differing opinions in their own submissions to the Commission.

Comments of the Software Defined Radio Forum on
Federal Communications Commission Second Further Notice of Proposed Rulemaking

Table of Contents

II SDR Forum Activities in Public Safety Communications

The SDR Forum has, for several years, analyzed and advocated the role of Software Defined Radio (SDR) and Cognitive Radio (CR) technology in addressing critical issues and enhancing capabilities of public safety communications systems. To focus attention and activity within the SDR Forum on such issues, a Public Safety Special Interest Group (PS SIG) was chartered in 2004. The focus of this Public Safety SIG is to consider the technical, operational, and regulatory challenges and approaches to harnessing SDR and Cognitive Radio technology to improve Public Safety communications capabilities.

As the SDR Forum noted in comments on the NPRM for Docket 03-108:

> Software defined radio is a rapidly evolving technology that will bring enormous benefits to the providers and consumers of wireless services. The potential of SDR technology is well known to this Commission, which has aggressively reformed its rules in a way that has helped allow SDR technology to become a reality. As it continues to develop, SDR technology will also play an important role in the development of cognitive radios and in the fullest possible exploitation of the spectrum resource. Thus, the SDR Forum supports the Commission's effort to promote the development of cognitive radio technology.[2]

The Public Safety SIG was created specifically to provide a focus on activities in which the Public Safety community has an interest and to bring together Public Safety users, vendors, researchers, and regulators to identify requirements, establish research challenges, and support relevant standards development in the deployment of SDR and Cognitive Radio technology into the Public Safety community. The first major output of

[2] SDRF response to ET Docket No. 03-108, 1 May 2004, pg. 2, SDR Forum Report No. SDRF-04-A-0004-v0.00. Available at www.sdrforum.org.

the Public Safety SIG was the report titled *SDR Technology for Public Safety*[3], released in April, 2006. One of the key conclusions of that report is that:

> SDR also has significant potential for both life cycle cost reduction and enabling cognitive applications that allow a radio to adjust operating parameters automatically to improve performance or better utilize spectrum that enhances performance.

The Report also included several recommendations:

- That SDR researchers investigate cognitive applications to enhance interoperability and performance;
- That SDR researchers investigate quantitative data on spectrum usage across all services including Public Safety, commercial services, and other services during major events and incidents; and
- That regulatory bodies modify existing regulations to support the capabilities listed above, including rules for accommodating evolving cognitive applications.[4]

The Public Safety SIG has also been actively working with the SDR Forum Cognitive Radio Working Group to develop use cases and explore prospective application of cognitive techniques and concepts to Public Safety.

The SDR Forum also has provided inputs to the regulatory process to highlight the role of SDR/CR technology in enhancing communications. Our primary position, stated in the response to the initial NPRM regarding the matter of Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band (the 9th NPRM for Docket WT 96-86), has not changed, namely that "SDR and Cognitive Radio technologies have significant potential for enabling life-saving applications and improving radio performance and spectrum efficiency, recognizing that they must be proven to meet Public Safety's robustness and reliability requirements, and not to cause

[3] SDR Forum, *Software Defined Radio Technology for Public Safety*, SDR Forum Report No.SDRF-06-P-0001-V1.00, 14 April 2006. Available at http://www.sdrforum.org/.
[4] Op. Cit., Table 0-1.

interference nor be subject to received interference prior to deployment for mission critical communications."[5] Since then, many of the ideas of the national broadband network have evolved and SDR/CR technology continues to advance and reach the market. To specifically highlight the potential contributions of SDR/CR technology, the SDR Forum released a report in December, 2007, entitled *Considerations and Recommendations for Software Defined Radio Technologies for the 700 MHz Public/Private Partnership*[6], which concluded the following:

> The public/private partnership to utilize new 700 MHz spectrum is an innovative attempt to provide public safety with a needed nationwide broadband network funded by sharing resources with a commercial system. This is clearly uncharted territory for public safety and presents a number of challenges. Emerging software defined radio and cognitive radio technology provide near-term and longer-term solutions to these challenges. Thus it is paramount that the stakeholders in the system account for the benefits that can be gained by this technology in the system design and implementation, negotiation of agreements among the PSBL and the D-block awardee, and the governance structures that are developed for the network. Otherwise the options for providing an economically viable network that meets public safety requirements are unnecessarily, and significantly, curtailed.

Based on the evolution of the concepts of the proposed public/private partnership, and to provide greater detail for some of the concepts raised in that report, the SDR Forum Public Safety SIG continued their analysis of the role of SDR/CR technologies and have released a new report; in this response we draw heavily from that report to provide comments on this topic.

The SDR Forum has consistently encouraged the exploration of SDR technology and Cognitive Radio technology to address the critical challenges facing Public Safety

[5] SDRF response to PS Docket No. 06-229 & WT Docket 96-86, 23 February 2007, pg. 21, SDRF Forum Report No. SDRF-07-R-0005-V1.0.0, 23 February 2007, available at www.sdrforum.org.
[6] SDR Forum, *Considerations and Recommendations for Software Defined Radio Technologies for the 700 MHz Public/Private Partnership*, SDR Forum Report No. SDRF-07-R-0024-V1.0.0, 5 December 2007, available at www.sdrforum.org.

communications. This NPRM has far-reaching implications for business models and licensing that must be worked out for successful implementation. While the SDR Forum acknowledges the importance of those issues, the focus of the SDR Forum's comments is on the capabilities and current technology maturity of SDR and Cognitive Radio to support the proposed rules changes.

This response is organized around discussion of specific paragraphs of the NPRM. As the focus of the Forum's comments are on technology issues, comments are provided on a selected subset of the overall questions.

III SDR Technology Supports Interoperability (Response to NPRM Paragraph 34)

The Commission seeks comment on the extent to which the public safety broadband network will or should be interoperable with existing voice and data networks. The SDR Forum believes the public safety broadband network should be a communications system capable of providing the state-of-the-art technologies available in the commercial world to public safety and it should foster interoperability. Interfacing legacy narrowband voice and data to a broadband network will involve scalable methodologies. These should be nothing new to the commercial sector since they must routinely interact with multiple carriers. We also believe that providing the performance of the broadband network should take precedence over incremental enhancement of data facilities on legacy networks. Present narrowband data systems are on the order of tens of kilobits per second at best. We believe that cognitive technologies can be employed that will foster interoperability without sacrificing network performance on either the broadband or

legacy network. There will undoubtedly be limitations imposed due to differences in performance between the broadband network and legacy systems. Fostering interoperability between the two systems will require the ability to mitigate bandwidth differences and manage access to media types available on each network. Pushing audio or video traffic to and from a legacy network should be consistent with the policy of the legacy network. On the broadband network interface to the legacy network, we feel cognitive capabilities can effectively manage appropriate interfaces to prevent bottlenecks from occurring, scaling traffic load. An example would be scaling video traffic using advanced compression schemes to map with the legacy network bandwidth limitations.

The question was posed by the Commission on how they could encourage interoperability with legacy systems and if they should make mandatory interoperability with existing voice and data networks with the new broadband network. To the first question the SDR Forum believes interoperability should be encouraged with legacy systems. Such interoperability will be particularly important to agencies lacking capital resources to invest in new equipment. In addition, SDR technology provides flexibility that facilitates a migration path for agencies that need to gradually transition to new systems and features.

The Commission posed a question on the use of multimode hand sets that support legacy networks and whether the new public safety broadband network could enhance interoperability. The SDR Forum replies in the affirmative that if backward compatibility were provided into newer handsets used on the broadband public safety

network, it would promote system acceptance, aid migration to the new network, and encourage interoperability. The second part of the question asked by the Commission was how could they encourage or mandate the use of such handsets. The SDR Forum believes the answer to the question depends on a number of factors. First, the handset must support multiple bands of operation. Second, the voice or data protocol will need to be licensed at a fair and reasonable cost to permit the programming of handsets to communicate by multiple vendors. Because of the potential cost of multi-band and multi-service handsets, we do not recommend that the FCC mandate their use, and that could preclude some agencies from accessing the network. We anticipate that the value of such handsets to end users will motivate the necessary research and development to drive down their cost over the lifecycle of the network. The third part of the question is how any proposed policies in this regard would affect the cost of handsets and network construction/operation. The Forum believes the Commission policies should encourage solutions that allow capabilities that are programmable by manufacturers or third parties. If distinct modes are required for multiple proprietary protocols, the cost of the device will be escalated. Therefore it would be beneficial keeping prices down to allow manufacturers to permit the capability for radios to be software configurable by other than the manufacturers

The Commission also posed the question inquiring how the use of 10 or 20 megahertz of shared spectrum could affect the throughput of the broadband network and the functions it can support. The SDR Forum believes that there does not have to be any impact on the broadband network's ability to sustain performance levels for *public safety* if proper

safeguards are imposed. The Forum believes the model that should be used is for public safety to have priority access to the network when needed. We also believe if additional capacity is necessary, public safety may either purchase additional capacity on the network or pay for additional features. We also believe that cognitive technologies that can manage priority and capacity should also be employed to more efficiently use available spectrum resources.

In response to the question of what throughput should be expected with the amount of spectrum envisioned, we reply that it should be consistent with what the industry provides for commercial wireless services. We also believe if additional bandwidth is necessary it should be an additional feature that can be procured or provisioned. The provisioning of additional bandwidth can utilize cognitive technologies that enable using other spectrum resources outside of the broadband network and aggregation techniques to achieve higher throughput.

The Commission also requested comment on the functionalities that can only be supported on a network with additional spectrum. The Forum believes the functionalities should be consistent with what the industry provides for commercial use and provide a subset for public safety. It is difficult to predict at this point what services public safety would find most useful once the network is in place; anecdotal experience suggests that as such capabilities have been deployed, potential applications evolve quickly. Given a decades-long life cycle for the network, it is more important to design the network to accommodate new functionalities than to enumerate the functionalities today.

IV SDR Technology Must Be Considered in Assessing the Economic Viability of the Network (Response to NPRM Paragraph 58)

In paragraph 58, the Commission introduces a series of questions around "changes to the network that the D Block licensee is required to construct, and whether to modify the construction schedule." We comment on several detailed questions in the paragraphs that follow. However, we note in response to this paragraph that the SDR Forum has conducted an analysis of the technological feasibility of meeting the divergent requirements of commercial and public safety users. The results of this analysis have been published as SDR Report SDRF-08-0004-R-V1.0 entitled "Utilization of Software Defined Radio (SDR) Technology for the 700 MHz Public/Private Partnership" dated June 2008. The report concludes that SDR technology is sufficiently mature that multi-waveform base stations and network management capabilities can facilitate a network that supports public safety and also supports sufficient commercial use to be commercially viable. We do not recommend specific language in the rules requiring SDR, as we believe that the D Block licensee should not be constrained to specific technical solutions. However, we think any argument against the economic viability of the shared network that does not account for the flexibility provided by SDR technology is not complete.

V The NPRM Technical Appendix Provides a Useful Baseline But Should Address Capability to Evolve (Response to NPRM Paragraph 61)

The NPRM Technical Appendix provides a reasonable and realistic framework for designing the Shared Wireless Broadband Network (SWBN). The SDR Forum endorses

the existing document and notes that SDR and cognitive radio capabilities are useful in meeting the defined requirements. (For a more detailed discussion of specific SDR/CR capabilities, see the SDR Forum's recently published report on SDR technologies for the SWBN.[7])

The SDR Forum, however, notes that network evolution should be addressed by the Technical Appendix to ensure that the system is designed to accommodate the anticipated growth and evolution of both public safety and commercial applications. Applications, radio access technology, and operational policies and procedures will evolve significantly over the life of the NBN. While the SDR Forum understands that initial emphasis is on the near-term challenges of establishing the network, we believe that it is critically important to ensure that the effort undertaken to establish the network includes sufficient foresight to keep the network from premature obsolescence or from continual shortfalls of technology with respect to competing systems. We specifically recommend the following language be added as another section entitled "Network Evolution":

> "The Nationwide Broadband Network should be designed to allow cost-effective introduction of revised protocols and standards for radio access without negatively impacting existing users. Revised radio access capabilities should be able to be used by a class of users (e.g., commercial users) and/or by users in a defined geographic area. Note that introduction of new capabilities cannot negatively impact operability (e.g., reliability, coverage) and interoperability among public safety agencies."

[7] SDR Forum, *Utilizing SDR Technology for 700 MHz Spectrum*, SDR Forum Report No. SDRF-08-R-0004-V1.0.0, June 2008, available at www.sdrforum.org.

VI Appropriate Leveraging of SDR/CR Technology can Achieve Economies of Scale While Accommodating Divergent requirements (Response to NPRM Paragraph 64)

The SDR Forum believes that economies of scale can be achieved, given that appropriate standards are in place and common ground can be defined among public safety and commercial users (particularly with respect to hardware). The key is leveraging SDR/CR technologies as recommended herein to enable flexibility, adaptability, and scalability of the system that accommodates those requirements that are not common across both user communities.

The ideal solution from an economy of scale standpoint would be to have common hardware platforms (hand-held devices, mobile devices, base stations, and network routers, switches, and controllers) that are usable by both public safety and commercial users. Such a solution would achieve economies of scale of the hardware platform, and possibly share a great deal of software as well. These platforms would utilize

- SDR to enable software-configurable options tailored to each type of user[8], and
- Scaling of *quantities* of devices such as the number of base station sites and frequency channels for meeting the divergent coverage and probability of queue (GOS)/latency requirements respectively.

To achieve a common hardware platform, the presently divergent requirements between public safety (PS) and commercial systems must be harmonized in several areas,

[8] For example, commercial entities could even use different modulations and operating modes than public safety, with the latter designed for improved coverage reliability, perhaps at the expense of reduced data rate than demanded by the former.

including, but not limited to, harmonization of coverage topologies, relaxing traditional PS transmit and receive spectral purity and receive adjacent channel rejection requirements, and compromises on ruggedness specifications.

A cost driver for a traditional public safety handheld is power output, which is typically 3 watts or greater for a portable and 30 watts or greater for a mobile. This output power is also divergent from typical cellular radios, which are 600 milliwatts maximum. As a step toward harmonization which would further enable economies of scale and cost reduction, it would make sense that the broadband 700 MHz system RF coverage requirements, protocols, and topologies be chosen[9] to be compatible with using PS radios with lower power output approaching or equaling cellular radios. A key consideration in this tradeoff is that the broadband data communications predominately—if not exclusively—should use individual "one to one" calls and not use "one to many" (i.e., group) calls that dominate present-day public safety voice communications. Group calls drive present-day public safety voice systems away from cellular's sectorized antennas, low tower heights, and low power operation. Perhaps the cause of an even greater divergence of coverage topologies is the *signal energy density* that has traditionally been required for public safety LMR systems in the coverage area. Typically, public safety has demanded coverage to a high reliability (typically >95% area coverage) and often for handheld coverage in buildings with 30 dB signal loss or greater, whereas a typical cellular provider is not *required* to meet requirements even three orders of magnitude more lenient.

[9] Since we understand that the broadband technology and protocol have not been decided , the eventual system parameters (power outputs, antennas, tower heights, site spacings, etc) for achieving RF coverage for the 700 MHz broadband system are unknown at present.

For further harmonization, the stringent traditional/typical public safety requirements for transmit spectral purity and receive adjacent channel rejection—both major cost drivers and divergent from cellular systems—will need to be relaxed from traditional values presently associated with the narrowband public safety LMR frequency bands, via action from both regulators (e.g., FCC) and standards bodies such as TIA.

To help enable the harmonization discussed above for enhancing economies of scale cost savings, the SDR Forum recommends that the following standards be considered:

- "Standard" common interface of the hardware platform to the software so that the software developers can design their specific software as a "drop in" to the common hardware.[10]

- Standard definition of the capabilities and minimum performance for the shared hardware elements

VII SDR/CR Technology Support Key Characteristics Specified for the Proposed Network (Response to NPRM Paragraph 65)

The Commission invites comments on other specifications required of the network, including a mechanism to automatically prioritize public safety communication over commercial uses on a real-time basis; operational capabilities consistent with features and requirements typical of current public safety systems; operational control of the network by the PSBL; and at least one handset that includes an integrated satellite solution.

[10] However, previous consideration by the SDR Forum of the Military's SCA (Standard Communications Architecture) for public safety use deemed it not practical, and so a "scaled-down" version that is less complicated and requires less overhead is deemed preferable.

The SDR Forum strongly endorses the concept of automatic prioritization. Mechanisms exist today to assign priorities to devices, and to invoke a prioritization scheme under policy-defined circumstances. The SDR Forum recommends that those circumstances be determined by negotiation in a Network Sharing Agreement, and include manual invocation by an authorized individual. We also note, that having extensively reviewed the 7/7/05 bombings in London[11] that decision making procedures for determining invocation of priority access must be clear and unambiguous. This study, from which the SDR Forum derived use cases for cognitive technology in public safety systems, carries the concept of prioritization even further. There is significant operational value in providing the capability to dynamically change priorities of devices based on their user and the role that the user has in the incident response. This approach allows network resources to be devoted to the most critical public safety communications involving safety of life and property and homeland security. The SDR Forum recognizes that the technology for dynamic prioritization is not fully proven and therefore should not be included as a requirement in the initial system. However, the system design should not preclude dynamic prioritization, and it should be identified as a desired capability during the life of the system.

With respect to operational capabilities consistent with current public safety system features, the SDR Forum analysis[12] noted how SDR and cognitive radio technology could help a national broadband network provide operation in adverse conditions, dynamic

[11] SDR Forum, *Use Cases for Cognitive Applications in Public Safety Communications Systems*, Volume 1: Review of the 7 July Bombing of the London Underground, SDR Forum Report No. SDRF-07-P-0019-V1.0.0, November 2007, available at www.sdrforum.org.

[12] SDR Forum, *Utilizing SDR Technology for 700 MHz Spectrum*, SDR Forum Report No. SDRF-08-R-0004-V1.0.0, June 2008, available at www.sdrforum.org.

resource management, network control, and support a system of system concept, as described below:

Operation in adverse conditions: SDR/CR cannot directly repair physical damage. It can, however, augment the traditional techniques of physical hardening, replication, and redundancy of equipment by providing new and innovative ways to fill gaps in capability during disasters and emergencies. SDR/CR can recognize when degraded capabilities and traffic loading may impact access for mission critical communications (via traffic monitoring and geolocation capability) and perform dynamic reallocation of channel capacity throughout the network to support higher traffic volume in the disaster area. Another potential capability is to shed traffic to lower power consumption and extend fuel operating time if a base station is operating off a power generator. The system could also perform an area-wide optimization of fuel reserves to direct higher traffic volumes to radio sites with the most kilowatt-hours of power availability. In the event that a site is completely lost, SDR/CR capabilities are applicable for coverage re-optimization and extension into the coverage gap from nearby sites, so that users in their coverage areas are provided connectivity. SDR/CR mobiles with multi-service capabilities could allow use of alternate service in the area where the primary service is down.

Dynamic resource management: The mission critical nature of public safety communications requires more complex bandwidth management than is required for non-critical communications, particularly to meet competing public safety requirements when capacity limits are approached. Public safety networks are designed with the ability to manage network resources on a per-user priority basis. Network resources are assigned

based upon the priority level that each user or talkgroup has been assigned in the network. Commercial networks, while providing users with different pricing schemes, generally do not implement the real-time per-user prioritization that is required by public safety. There are a number of SDR/CR techniques that can provide more efficient resource management, including:

- Adaptive Assignment of "Just Enough" Bandwidth per Data Transfer Path
- Per User Capacity Adjustments by means of:
  - Start limiting users
  - Adjust Per User Capacity
  - Dynamic Bandwidth Allocation
- Intelligent Routing
- Dynamic Prioritization

Network control: A policy-based radio architecture provides operational controls to meet disparate needs and requirements. Perhaps the most important contribution a policy-based architecture can make is its ability to dynamically adjust the use and configuration of network assets to ensure both spectral efficiency and network performance—especially in disaster management and emergency conditions. The concept of policy-based radio networks is described in more detail later in this section in the context of operational control of the network.

System of systems: The flexibility of SDR/CR capabilities provides advantages for incorporating the national broadband network into the system of systems concept. As a national broadband network it fits the definition of Extended Area Network (EAN). But consistent with the system of systems concept, it may also provide capabilities that are incorporated into, or interface into, an Incident Area Network (IAN). IANs, by definition, are temporary networks established for the purpose of providing communications support to a specific incident. The flexibility provided by SDR technology provides tools for reconfiguring the national broadband network to fulfill as needed requirements of the IAN. In other cases, an IAN may be established using licensed 4.9 GHz spectrum; in this case the national broadband network may need to establish gateways that provide an interface between the 4.9 GHz network and the national broadband network at 700 MHz. Rapidly reconfigurable gateways implemented using SDR technology can facilitate this process as well. Reconfigurability at the subscriber device level is another potential application of SDR technology. Ideally a responder would not require different devices to access the different networks that are being used; SDR and cognitive radio technology can facilitate single devices that operate seamlessly on multiple networks.

In addition, we note that SDR allows economical implementation of multiple waveforms in both base station and subscriber units, facilitating the co-existence of several capabilities in the network and in a device.

With respect to operational control of the network, the SDR Forum analysis[13] identified policy based systems as an evolving technology that can facilitate operational control of the network. The PSBL should have a responsibility to ensure that network operations are meeting the needs of the public safety users both in terms of routine operations and in support of major incidents.

It may not cost effective for the PSBL to be responsible for real time day to day decisions relating to public safety use of the network on a continuous basis.

One approach to providing control in a cost effective manner is for the network (both at the infrastructure and subscriber level) to operate on the basis of user defined machine interpretable policies that specify network behavior and constraints.[14] Policies can be developed, tested, and invoked as needed as part of network operations management. Also note that policies could be developed that allow for local or regional variations in network use. Policy based system technology is still evolving, so the SDR Forum does not recommend that such capability be initially required. However, the system architecture should not preclude eventual incorporation, and such capabilities should be identified as desirable for implementation during the life of the system.

Finally, with respect to integrated satellite capability, the SDR Forum notes that SDR technology is making cost-effective multiple band, multiple protocol devices a reality and

[13] *Ibid.*
[14] Policies here are defined as a set of rules that govern the behavior of a radio. Policies are envisioned to be written by humans but in a language that can be interpreted and executed by a radio. Policies may reflect regulatory rules (such as only transmitting when the radio is in specified geographic locations) or network management rules.

should be considered as a potential enabling technology in meeting this requirement during the life cycle of the network.

VIII SDR Technology Facilities Network Evolution (Response to NPRM Paragraph 71)

The Commission seeks comments on the services and applications that should be available on the network and the responsibility of who makes that decision. The SDR Forum begins by noting that the prevailing practice of exchanging cell phones every year or two shows how fast technology is evolving in wireless communications. Advances in system capability are moving along, with new data services emerging every few years. There is little precision in technology forecasts five years out (with the possible exception that Moore's law hasn't broken yet), and the ten-year view is highly speculative.

In contrast to those observations, Public Safety organizations have historically purchased systems with at least a ten-year service expectation. Parts for some legacy systems are routinely sold on eBay because the OEMs no longer provide them.

The new system needs a smooth upgrade from existing commercial systems to get started. Then, as new technology emerges, it must be integrated into use without breaking existing facilities. Software Defined Radio is key to this non-trivial problem. For example, multi-waveform basestations can simultaneously support multiple protocols to facilitate migration of new technology, and SDR implementation facilitates rapid reprogramming to deploy new and/or enhanced technology.

There is a PSBL control center in several of the high-level system diagrams, with that comment that they are to ensure appropriate delivery of Public Safety services. As noted in Section VIII and the response to NPRM Paragraph 65, the SDR Forum recommends that a cost–effective approach to ensuring appropriate delivery of public safety services can be accomplished with support to the commercial carriers operations combined with definition of human readable and machine interpretable policies that govern network and subscriber behavior as needed. The PSBL could implement such policies through a Policy Board that determines the policies on which the system bases its Public Safety support operations, and monitors compliance.

The Commission also seeks comments on the specification of services in the network. As we note in Section III, the potential public safety applications for this network are substantial. Agencies are only beginning to develop ideas on how to leverage broadband technologies. Ongoing pilots and early deployments have moved from submitting of reports from the field to transmission of driver license photos and BOLO pictures to streaming video, building plans, and a variety of sensors. But certainly over the lifespan of the network one can envision other potential applications placing different demands on the network—point of view walkthroughs of buildings for SWAT or fire teams prior to building entry; updated in real time; complex plume models in HazMat incidents; holographic displays, and so on.

The actual applications that interact with the network, and the nature and requirements for information communicated over the network, from a public safety perspective, should be driven not by the latest fad (as might be the case in the commercial market) but by the

real operational requirements to improve incident response. But that information will only come from training, exercises, and in-depth analysis of lessons learned from operational events. In summary, the most important characteristic of the network is not what applications it will carry today, but what it is capable of carrying in the future. Since such applications are not able to defined today, it is critical to the longevity of the network and the return on investment of all parties to ensure that the network is designed to accommodate new technologies and applications and that there are procedures in place to encourage innovation and deployment of new capabilities while respecting the mission critical nature of the public safety requirement for network use.

Finally, with respect to integrated satellite capability, the SDR Forum notes that SDR technology is making cost-effective multiple band, multiple protocol devices a reality and should be considered as a potential enabling technology in meeting this requirement.

IX SDR/CR Technology Should be Adopted as Part of Any Broadband Platform Solution (Response to NPRM Paragraph 72)

In paragraph 72, the Commission requests detailed information regarding any proposed broadband solution. While not a product specification, the SDR Forum report[15] provides an extensive analysis of specific ways in which SDR and cognitive radio technology can help meet requirements that meet public safety's needs while constructing a system that is economically viable, and provides flexibility regarding network design. A summary of key challenges and capabilities is included in Table 1.

[15] [15] SDR Forum, *Utilizing SDR Technology for 700 MHz Spectrum*, SDR Forum Report No. SDRF-08-R-0004-V1.0.0, June 2008, available at www.sdrforum.org.

Comments of the Software Defined Radio Forum on Federal Communications Commission Second Further Notice of Proposed Rulemaking

Table 1, Key Challenges and SDR/CR Capabilities[16]

	Challenge	SDR Capabilities	CR Capabilities
1	A national broadband network must be created that is commercially viable while simultaneously meeting public safety needs.	SDR provides flexibility to meet diverse requirements.	CR techniques can further leverage that flexibility to improve coverage and mitigate interference for critical communications on a system compatible while accommodating commercial coverage requirements.
2	The national broadband network infrastructure will need to adapt and change over time as operational experience is gained, as technology changes, and as commercial and public safety user-requirements evolve.	SDR provides flexibility and cost-effective approaches to adapting the network to meet evolving requirements and technologies.	Cognition capabilities can further leverage that flexibility by providing tools to automatically or semi-automatically configure devices and/or the network as needed.
3	Network features designed to meet unique requirements of the public safety users may not be optimal solutions for commercial users.	SDR provides capabilities to reconfigure devices and infrastructure to meet specific public safety needs as needed.	CR capabilities leverage that capability to provide robustness and dynamic real-time resource management that can be tailored to specific public safety needs.
4	Based on the build-out schedule, there may be other 700 MHz networks that will need to interoperate with the national broadband network.	SDR provides a cost-effective means to work with legacy systems and adapt to an evolving network architecture.	CR capabilities provide additional capabilities for seamless operation across multiple networks and transition/integration of new capabilities.
5	Meeting the technical and operational challenges for building a national broadband network should not add significant cost or detract from the usability of the subscriber equipment.	SDR can reduce costs by providing over-the-air reprogramming and approaches to managing varying technology refresh cycles.	CR provides user interfaces that hide the technical details of the radio system so that the user interface is based on user job functions rather than the details of the radio system.

[16] *Ibid.*

X SDR/CR Technology Helps Improve System Reliability (Response to NPRM Paragraph 73)

In paragraph 73, the Commission invites comments on the reliability requirements. The SDR Forum defers to other stakeholders as to appropriate specifications, but notes that Section 3.3.1 of the SDR Forum report on the application of SDR/CR to the proposed network[17] identifies SDR and CR technology that can improve system reliability. While use of SDR technology would not likely be justified strictly on the basis of reliability, this comment provides other justification and reliability enhancements can then be realized as well.

For example, one effect of a localized disaster or emergency in a public safety system's service area is increased traffic load for the base station sites that provide coverage to that location. If the sites do not have sufficient bandwidth to accommodate the additional traffic load, the Quality of Service could be degraded to the point of precluding rapid channel access required during life critical situations. SDR/CR can recognize when such a situation occurs (via traffic monitoring and geolocation capability) and perform dynamic reallocation of channel capacity throughout the network to support higher traffic volume in the disaster area. Such reallocation may be accomplished by a priori frequency coordination, with a number of preplanned resource reallocations established to respond to a variety of disaster scenarios. With SDR/CR the response may be extended to dynamic solutions, whereby the system recognizes in real-time sites with low volume or lower priority traffic from which to "borrow" additional resources for the duration of the disaster response.

[17] *Ibid.*

SDR/CR technology can also facilitate intelligent load shedding, power resource management (for example, reallocating load where feasible to minimize drawdown of emergency power supplies), network reconfiguration, graceful degradation, and leveraging of multiple services or radio access technologies to provide redundant communications capabilities.

The time schedule for buildout will undoubtedly defer installation in low-density areas where the Public Safety need and economic potential are low. Some mechanism for permanent local variations in the coverage requirement could have substantial economic benefits without unduly compromising needed facilities. Alternate coverage means should be considered for remote areas. Mobile base stations, satellite links, balloons, aircraft, and UAVs all have potential for providing emergency access to the network.

XI SDR/CR Technologies Facilitate Network Management and Quality of Service

In paragraph 77, the Commission invites comments on network management and quality of service. Section 3.3.2 of the SDR Forum Report on Technologies for the National Broadband Network[18] identifies SDR and CR technology that provides tools for network management and quality of service. SDR/CR techniques that can provide more efficient resource management include:

- Adaptive Assignment of "Just Enough" Bandwidth per Data Transfer Path—adaptive modulation and/or error rate control can achieve a given capacity by allocating less bandwidth to communications paths with high signal-to-noise

[18] *Ibid.*

ratio; intelligent bandwidth allocation can yield greater capacity or support more users.

- Start limiting users—denying access to some users; a simple implementation of this approach is the limitation on commercial use during an emergency condition, but more sophisticated approaches could ensure that available capacity is allocated to the most critical public safety users.

- Adjust Per User Capacity—bandwidth can be allocated depending on the nature and criticality of the user and their role in the response.

- Dynamic Bandwidth Allocation—bandwidth can be allocated dynamically based on the nature and criticality of the data being transmitted.

- Intelligent Routing—align routing as needed to optimize resources while meeting data transmission requirements (e.g., a man-down alarm is routed through the most robust channels while administrative data may be routed through the least reliable or lowest throughput channels.)

- Dynamic Prioritization—dynamically adjust the priority of communications based on evolving incident response requirements.

XII SDR/CR Technologies Provide Tools for Flexible Spectrum Utilization (Response to NPRM Paragraphs 78 and 80)

In Paragraphs 78 and 80 of the NPRM, the Commission seeks comments on the alternative approaches to allocating the 20 MHz of spectrum (combined public safety and

D-Block) and on how that would impact applications on the network. The SDR Forum recommends that leveraging SDR/CR technologies provides a great deal of flexibility in configuring the network to meet needs, whether in real-time to meet an evolving incident response need or over a longer term to accommodate technology development. Such technologies will be more effective when working with the entire 20 MHz as a unified whole.

4th Generation technology has the potential to live up to the expectations of public safety and provide network services for applications stalled by the current generations of mobile networks. In particular, high throughput applications such as video are becoming an increasing desire and are moving towards requirement status for future public safety operations. The 700MHz spectrum is being heralded for public safety to provide the promise of a true broadband multi-megabit wide-area network, more cost effectively than 4.9Ghz. With 4th generations technologies the 700MHz network could be able to accommodate video and other throughput intensive applications, not readily supported by 3rd generation technologies. SDR and cognitive radio can play a pivotal role in managing the network to squeeze every available bit out of the 20MHz of available spectrum.

There are physical limitations to the amount of throughput available on the network using current commercially available technology. The 700MHz broadband network cannot accommodate all public safety applications, for example multiple streams of high definition MPEG2 video would fill the network to capacity for other commercial and public safety applications. Other fixed wireless services may be more appropriate in

some situations. Traditional traffic engineering and network load balancing techniques are applicable in this scenario. It is also important to develop cognitive abilities at the application level for video, potentially working with the cognitive abilities of the network to adjust frame rate and compression level to balance available network capacity and importance of the video information.

SDR and CR technologies enable the ability to build the broadband network around 20MHz of spectrum, creating one unified network. SDR and CR technologies have to ability to manage the network's capacity available users by correlating traffic types and traffic priorities to network capacity and communications requirements. Dynamic allocation of channel bandwidth and modulation/error correction schemes can be based on source, destination and other factors. When SDR/CR technologies are used in that manner and cognitive actions are defined based on a set of negotiated parameters, spectrum can be managed to most efficiently and effectively meet communications requirements.

SDR/CR enables the design engineers to combine the 10 megahertz of D Block spectrum and the 10 megahertz of public safety broadband spectrum into a single and integrated 20 megahertz pool of spectrum that may be assigned to users without regard to whether a public safety user is being assigned frequencies in the D Block or a commercial user is being assigned frequencies in the public safety broadband spectrum, so long as the network provides commercial and public safety users with service that is consistent with the respective capacity and priority rights of the D Block license and Public Safety Broadband License and with the rules. This allows much more flexibility for capacity

planning. It also allows theuse of intelligence control of SDR/CR to more effectively balance the bandwidth and throughput requirements of different user classes enabling the respective capacity and priority rights of the PSBL to be preserved in a combined network. Negotiations between the commercial provider and the PSBL can focus at the application level, knowing that the network will automatically reconfigure based on the spectrum parameters. Specifically, SDR/CR technologies enable the network to provide commercial and public safety users with service that is consistent with the respective capacity and priority rights of the D Block license and Public Safety Broadband License.

XIII SDR/CR Technology Could Still Be Useful, and Benefit Public Safety, Even Without the Partnership (Response to NPRM Paragraph 191)

Throughout this response we have highlighted significant benefits of SDR/CR to the public safety community that can be realized within the context of the proposed NBN, and that SDR/CR technologies hold great promise not only for meeting public safety requirements but also for doing so in a commercially viable manner.

However, in response to the FCC questions regarding alternatives if the partnership is unable to be realized, we recommend that D-Block be granted as a nationwide license.

The rationale for that recommendation is based on the view that there will be a number of major applications needing nationwide broadband support. One such prospect is Intelligent Traffic Systems (ITS), digital control of highway traffic. The dual impact of this capability is a substantial improvement in fuel economy and deferral of billions of dollars of highway construction. It is but one example of many others that cannot emerge until network support is available.

Reliable digital broadband wireless communication, with requirements similar to those of Public Safety, is essential to the safety and effective operation of such a system. Because that is the case, Public Safety organizations might choose to use this commercial service as a supplement to their dedicated networks even though it might not have features tailored to their requirements. Public Safety purchase of services would, of course, benefit the business case. Such a network might also be beneficial for interoperability between Public Safety and other organizations and agencies.

As is the case with a number of the comments above relating to the NBN, Software Defined Radio and Cognitive Radio technology will enhance the flexibility and utility of a network operating in D-Block independent of the Public Safety spectrum. It will aid implementation of new applications, ease introduction of new technology, and facilitate interoperability.