



**Wireless Innovation Forum's Comments to
the FCC regarding the Public Notice on the
Technological Advisory Council (TAC)
White Paper and Recommendations for
Improving Receiver Performance**

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

In the matter of)	
)	
Comments on)	
Technological Advisory)	GN Docket No. 13-801
Council (TAC) White Paper)	
and Recommendations for)	
Improving Receiver)	
Performance)	

**COMMENTS OF THE WIRELESS INNOVATION FORUM ON THE OFFICE OF
ENGINEERING AND TECHNOLOGY REQUEST FOR COMMENTS ON TECHNOLOGICAL
ADVISORY COUNCIL(TAC) WHITE PAPER AND RECOMMENDATIONS FOR
IMPROVING RECEIVER PERFORMANCE**

The Wireless Innovation Forum is a US based international non-profit organization driving technology innovation in commercial, civil, and defense communications around the world. Forum members bring a broad base of experience in Software Defined Radio (SDR), Cognitive Radio (CR) and Dynamic Spectrum Access (DSA) technologies in diverse markets and at all levels of the wireless value chain to address emerging wireless communications requirements through enhanced value, reduced total life cost of ownership, and accelerated deployment of standardized families of products, technologies, and services.

In this response, the Forum offers comments regarding the NPRM on the issues raised in the TAC white paper and recommendations on improving receiver performance. A number of critical issues are addressed in the body of this response and a table in Section 6 is included with specific responses to questions asked by the Committee. In Section 7, we offer a framework to develop a regulatory roadmap enabling successful implementation of shared spectrum using a Multi-Stakeholder Spectrum Advisory Committee (MSSAC).

The work of the FCC TAC on improving receiver performance and interference harm limits is a significant step forward in the conversation to enable receiver performance evaluation and spectral sharing. The Forum is glad to lend its support and advice to the FCC on this topic. The Wireless Innovation Forum has an active agenda to identify innovations that will be necessary to drive future shared spectrum and software defined radios. These innovations are important to the members of the Forum, and include many of the same priorities as the FCC, including the following innovations from the WinnForum Top Ten Most Wanted Wireless Innovations List.

- [Innovation #3](#): Receiver Performance Specifications
- [Innovation #8](#): Interference Mitigation Techniques
- [Innovation #9](#): Standardized Computer Interpretable Policy Language for Cognitive Radio
- [Innovation #10](#): Flexible Regulatory Framework for Temporary, Cooperative and Opportunistic Access

1 On Multi Stakeholder Organizations

The Wireless Innovation Forum (Forum), a multi-stakeholder organization committed to wireless innovation in all areas of commercial, industrial and mission critical communications, enthusiastically supports efforts by the FCC Office of Engineering and Technology to insure the public received the highest value proposition possible from the nation's limited spectrum resources. As articulated in the White Paper on "Interference Limits Policy - The use of harm claim thresholds to improve the interference tolerance of wireless systems" (Version 1.0 February 6, 2013) and OET request for comments (ET Docket No. 13-101), the Committee

clearly understands the underlying complex nature of spectrum sharing and the need for a clear roadmap for deployment of spectrally agile communication systems.

Many of the technical challenges identified by the Committee relate directly to challenges first addressed in tactical communication systems developed by Forum member companies for the Department of Defense. Forum members developed the Software Communications Architecture (SCA) widely used today in ALL modern defense communication systems, and the Forum remains the center of mass for development of SCA for adaptive communications. The Forum also is a pioneer in development of Cognitive Radio (CR) architectures that directly support frequency agile communications and the next generation of spectrally aware transceivers and networks.

The members of the Wireless Innovation Forum believe that the Forum provides the ideal venue to host a multi-stakeholder group as identified in Committee's request for comments. It is important to note that The Forum was originally started in 1996 AS a multi-stakeholder group, supporting the needs of the US Air Force in establishing an ecosystem system of vendors advancing software defined radio technologies in the commercial, civil and defense domains¹. Since that time, the Forum has hosted, and continues to host numerous related stakeholder groups, including those advancing SDR and CR in Public Safety Communications, the Space Telecommunications Radio System architecture (STRS), the Software Communications Architecture (SCA), TV White Space communications, Mission Critical Communications, and Spectrum Innovation^{2,3,4,5,6}. To enhance their ability to act as a multi-stakeholder group, the

1 <http://data.memberclicks.com/site/sdf/meet-arlington-1996.pdf>

2 <http://groups.winnforum.org/d/do/1565>

3 <http://groups.winnforum.org/d/do/1581>

4 http://groups.winnforum.org/SCA_Committee

5 <http://groups.winnforum.org/d/do/5687>

members of the Forum have established a Regulatory Advisory Committee. This group provides a venue for regulators, policy experts and Forum members to exchange information and collaborate, formally and informally on the development and deployment of software defined and cognitive radio technology⁷. Similarly, the members of the Forum established an SCA Advisory Council, allowing government and industry stakeholders to informally exchange information on areas relevant to the advancement of the SCA in defense communications⁸. The members of the Forum have also established collaborative relationships with a wide range of European Union Projects focused on dynamic spectrum access and spectrum sharing, and with industry standards organizations that include IEEE and ETSI^{9,10,11,12,13}. The resources and infrastructure established by the Forum's members in maintaining these multi-stakeholder relationships could be easily adapted to support the FCC's needs in advancing the discussion on Receiver Harm Thresholds.

2 On Spectrum Dashboards

The Forum advocates legacy users augmenting their existing systems, where possible to facilitate cooperative sharing of spectrum. There is an inherent inefficiency of spectrum etiquettes that do not account for the presence or behaviour of other radio systems. To share spectrum, radio systems' operational parameters are implemented so both systems have access to the spectrum. While many radio system parameters such as transmitted power (e.g., transmit

⁶ http://groups.winnforum.org/spectrum_innovation_committee

⁷ http://www.wirelessinnovation.org/Regulatory_Committee

⁸ http://www.wirelessinnovation.org/CC_SCA_Steering_Group

⁹ <http://www.wirelessinnovation.org/assets/documents/qosmos%20mou.pdf>

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<https://sdf.memberclicks.net/assets/documents/acropolis%20winnf%20associate%20member%20agreement%20of%20terms%20of%20involvement.pdf>

¹¹ http://www.wirelessinnovation.org/assets/documents/part-COST_Action_ICO_905_TERRA_MoU.pdf

¹² <http://www.wirelessinnovation.org/assets/documents/IEEEStandards%20and%20WInnForum%20MOU.pdf>

¹³ <http://www.wirelessinnovation.org/assets/documents/ETSI-WINNF%20MoU.pdf>

power control), frequency (e.g., dynamic frequency selection) and time (e.g., predictive scheduling) directly impact coexistence metrics and are obvious candidates for cognitive radio control. Many other parameters can be set to ensure and enhance coexistence such as route selection (choosing routes to minimize interference), network association (preferentially connecting to a network with greater protective measures), and application layer parameters (such as reducing video quality which reduces occupied bandwidth)¹⁴. Conceptually, virtually every parameter, setting, and/or process which influences the transceiver operations of a radio can be controlled to ensure or enhance the coexistence of cognitive radio systems with other users.

Out of necessity, most proposed techniques for gaining information about legacy systems (e.g., TV or satellite) adopt a non-cooperative approach, where the cognitive radio system has to gain relevant information without help from the incumbent. Cooperative techniques such as has been proposed for systems utilizing a Radio Environment Map database are therefore generally limited to use for coexistence between cognitive radio systems accessing available “white space”. However, this need not be the case as with the proper inducements, over time legacy users could augment their existing systems to aid cognitive radio systems’ observation and orientation processes. The inducement for legacy users to embrace, and support cognitive radio behaviours will be based on the value to users and operators to better utilize spectrum. This includes registering accurate transmitter and receiver characteristics for legacy radio systems with the radio environment map database.¹⁵

¹⁴ Working Document Towards a Preliminary Draft New Report on Cognitive Radio in Land Mobile Service, SDRF-08-R-0001-V1.0.0, <http://groups.winnforum.org/d/do/1578>

¹⁵ Wireless Innovation Forum Announces Broad Support of the PCAST Recommendations on Spectrum Sharing, WINNF-12-R-0004-V1.0.0, <http://groups.winnforum.org/d/do/5895>

The members of the Forum endorse this approach, which allows for the design, development and standardization of a “spectrum dashboard” providing a real time or near real time view of the radio environment map at a given location and at a given time. Such a dashboard will be a key tool in determining the etiquettes that the cognitive radio must consider when making its decisions.

3 On Receiver Standards

The Forum believes that the role of receiver parameters in standards and their related consideration in spectrum engineering and management should receive greater prominence in order to enhance spectrum efficiency and to help maximize value to the economy and society.

- The Forum believes much benefit can be achieved in terms of spectrum efficiency through this approach while at the same time reducing risk for new market and new technology entrants¹⁶
- Receiver parameters play a fundamental role in flexible spectrum usage and management because the defined protection approaches are a function of the receiver parameters e.g. sensitivity, blocking, and protection ratios
- Improvements in technology and manufacturing processes have greatly reduced the costs for components designed to improve receiver performance. It is the Forum’s belief that there is now little or no economic penalty for improving receiver performance in new products.

¹⁶Electronic Communications Committee, The Impact of Receiver Standards on Spectrum Management, <http://www.erodocdb.dk/docs/doc98/official/pdf/ECCRep127.pdf>

- Furthermore, the Forum believes that the protection of an existing wireless communications system with a poor receiver performance would hamper the introduction of a new technology.

Receiver parameters included in harmonized standards would have a positive impact on equipment specifications, improving the performance of existing radio systems and further supporting the deployment of new wireless communications products and services.

4 On Interference Limits Policy Approach

The model proposed in the TAC whitepaper for interference harm provides a good foundation, and once matured should provide the basis for reliable and efficient regulatory policy. The Forum believes modifications are required to represent the performance of current systems in the bands of interest. For example, TR-808 defines performance of LMR systems, commonly used in a variety of bands below 1 GHz, and can be evaluated to determine the required harm limit thresholds to provide equivalent protection. The interference rejection performance, as evaluated from adjacent channel protection, intermodulation protection and blocker rejection, yield different levels of acceptable adjacent band interference spectral levels. If the most pessimistic of these is chosen, the band will be overly specified. If the most permissive level sets the interference harm limit, this description will not provide adequate protection of current systems. Stakeholder groups will need some leeway in defining the harm limit mask to both provide a simple representation and an accurate one.

Interference harm limits are useful when applied to a whole band of interest. As most receiver performance measurements today are focused on receivers that only receive one carrier of many possible ones across a band, the application of harm limits may be applied to single carrier use. However, this must be approached with care. Overall interference levels will be

dictated by a multitude of carriers, with resulting aggregate levels and intermodulation products. The aggregation and mutual coupling have caused unintentional interference in the past, and will need to be carefully considered in studies of appropriate interference harm limits.

5 Spectrum Test Beds and Test Cities

The Forum advocates for the establishment and utilization of real world Spectrum Test Beds and Test Cities to mature and validate Cognitive Radio and Network technologies. Industry and academia have been researching techniques that could conceivably improve spectrum efficiency through improved sharing techniques; however, experimentation with these technologies is difficult given the need to protect incumbent operations. In many situations, critical services are using this spectrum and any disruption in service could cause significant harm.

Test-Beds provide an environment in which new technologies can be evaluated to prove their efficacy in improving spectrum utilization. In order to achieve this objective, the Test-Bed should focus specifically on (1) the capabilities of cognitive radios, (2) ways to reliably identify harmful interference, (3) measuring spectrum efficiency, (4) determining ways to increase spectrum efficiency, and (5) investigation of new efficient technologies as well as (6) the potential value to the economy and society. In addition, Test-Bed experiments must be executed in a controlled and repeatable manner in order to reliably detect and report incidents of harmful interference and avoid conflicts between simultaneous uncoordinated experiments. If done properly, these experiments could lead to improved spectrum sharing mechanisms that enhance interference avoidance capabilities while enabling increased spectrum efficiency.¹⁷ The Forum advocates government sponsorship and funding be made available to facilitate real world

¹⁷ Comments of the Software Defined Radio Forum, Creation of a Spectrum Sharing Innovation Test-Bed, ET Docket No. 06-89 (2006); http://www.ntia.doc.gov/files/ntia/sharecomment_007.pdf

Spectrum test beds and overcome existing barriers to spectrum sharing by adjacent and co-channel incumbent spectrum holders.

The Forum advocates Test-Bed concept should allow for the progression from testing in a controlled environment to trial deployments in a “real-world” trial environment that more closely aligns with the intended deployment area and target market. The Forum advocates the development of Corporative Research and Development Agreements (CRADA) to support industry and academic participation in development and deployment of Test-Beds. This approach would provide opportunities for wireless system and applications developers to trial and assess the capabilities of their innovative technologies in more complex environments e.g. a Test City. By adopting this two stage approach, the Forum believes the gaps between experimental development and the release of a new market offering can be narrowed by comprehensively addressing the technical hurdles that need to be overcome thereby reducing the time to market. In addition, the Test City approach would help increase market and investor confidence and serve as a valuable innovation showcase for wireless communications technologies and companies.

6 Wireless Innovation Forum Q&A Responses

OFFICE OF ENGINEERING AND TECHNOLOGY INVITES COMMENTS ON TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE	
ET Docket No. 13-101	Comment: Date: June 21, 2011
<p>Context: Interference Limits Policy Approach – Comments are requested on the viability of the overall interference limits policy approach presented in the TAC white paper. In particular, we invite parties to comment on the viability of the use of an interference limits policy approach among services operating in adjacent frequency bands.</p>	
<p>1. What are the costs and benefits associated with this approach?</p>	
Response:	<p>The Forum fully supports the FCC’s efforts to establish Harm Claim Thresholds as a basis for development of an Interference Policy Approach as outlined in the TAC White Paper. Clearly, the implementation and governance policy developed by the FCC will ultimately determine the balance between cost and benefits of the selected regulatory policies and policy implementation strategy.</p> <p>By providing a framework to specify the expected system performance, the FCC has the ability to reduce the risk for new market and technology entrants, while protecting the existing spectral use cases. This will create significant benefits to wireless users to enable easy entry of new services and connectivity.</p> <p>If the results of the multi-stakeholder group process result in the need for improved performance of future or existing wireless systems in a band, the costs for this transition should be considered. In the view of the members of the Forum, improvements in technology and manufacturing processes have greatly reduced the costs for components designed to improve receiver performance. It is the Forum’s belief that there is now little or no economic penalty for improving receiver performance in new products. Furthermore, the Forum believes that the protection of an existing wireless communications system with a poor receiver performance would hamper the introduction of a new technology.</p> <p>The Forum also believes a system level approach to spectrum management is an excellent foundation to build meaningful regulation that will allow continued innovation in both technology and services for all spectrum managers, suppliers and user.</p>
<p>2. Are there specific frequency bands or services that would particularly benefit from this approach or where implementation is straightforward and would be appropriate for a trial?</p>	
Response:	<p>There are already some significant frequency bands where harm limits analysis could be used to validate the approach. TV White Space trials provide an excellent environment for evaluation of spectral reuse - in a specific case where high power broadcast system are separated by large unused guard band regions. Adjacent channel and intermodulation characteristics testing performed in the rebanding of 800 MHz spectrum for dual use in an excellent environment for evaluation of receiver performance requirements for multiuse mobile operators. Evaluation of C-Band satellite earth stations and WiMax terrestrial communications systems in the 3500 – 3800 GHz band is an excellent system</p>

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RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
	<p>environment for evaluation of the effect of wideband legacy satellite receives and microwave backhaul services.</p> <p>All of these trials are conducted in different environments and with different service. As such they provide good insight to the specific “texture” of spectrum and services to highlight challenges that may or may not require specific regulatory requirements.</p> <p>The forum recommends a workshop be conducted to identifying the specific “textures” that include spectral frequencies, geolocation, services and other environmental and physical properties for a wide range of dual use spectrum applications. Clearly regulations that govern performance characteristics in urban areas and rural areas as significantly different to warrant a full range of trials prior to establishing national receiver standards. The goal of the workshop should be to establish the scope of the trials as well as clearly identify how the “texture” of the trial relates to more general governance policies.</p>
	<p>3. We request comment on any areas where additional technical analysis may be needed to implement an interference limits policy approach, such as the impact of various coding and modulation schemes on interference thresholds, propagation models that should be used in determining the interference thresholds, measurement methods for assessing compliance with the limits in cases of interference, and methods for determining the performance characteristics of currently deployed receivers and systems.</p>
Response:	<p>Development of international, national, regional and local propagation models is a critical factor in development and use of spectrum databases and should be included in the proposed Spectrum Dashboard to support opportunistic use of spectrum. A static limits policy approach (harm claim threshold) applied at a national only level will significantly impede deployment and use of cognitive communication environments.</p> <p>Within the Spectrum Innovation Committee of the Forum, the Cognitive Radio Working Group (CRWG) actively evaluates opportunistic use of spectrum and continues to research and publish important works related to Dynamic Spectrum Access (DSA) and policy development for multi-use spectrum.</p>
	<p>4. In addition, we invite parties to discuss the key implementation issues of the proposed approach that would need to be addressed as the Commission focuses on making additional spectrum available for new mobile and fixed wireless broadband services.</p>
Response:	<p>The Forum believes the Commission should focus on making additional spectrum available for a wide range of services, not just new mobile and fixed wireless broadband services. The Forum believes it is as important for the Commission to support multiuse spectrum in all bands, not just new opportunities for mobile and fixed wireless broadband. This will encourage innovation in all areas of service providers open us the opportunity to move services as technology evolves to support regulatory requirements for static, dynamic and real-time allocation of</p>

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TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
	<p>spectrum. This is particularly important for public safety systems.</p> <p>A short-term regulatory approach should focus on “do no Harm” as a primary consideration in deployment of new services in exiting licensed spectrum. A long-term regulatory approach should include a reasonable roadmap for improvement in legacy systems to permit multi-user operation in all bands, with policy based preemption for a limited number of select user to support mission critical operations.</p>
<p>5. Would proactive attention to establishing interference limits create more certainty in the marketplace for spectrum (re)allocations?</p>	
Response:	<p>The Forum believes proactive attention is necessary to focus industry and government to openly and cooperatively address the spectrum issues. The Commission can act as a honest broker in the evaluation of all elements development of multiuse spectrum and to establish an open framework for all stakeholders to participate in the future of wireless communications.</p> <p>A roadmap with a series of workshops focused on identification of challenges and opportunities in a wide range of wireless system implementations is a critical first step. Collection of legacy receiver specification will be necessary property model the system architectures. Once models specific and meaningful trials can be undertaken that will allow model refinement and eventually provide the appropriate data to formulate governance policy.</p>
<p>6. The TAC white paper makes note that an interference limits policy approach may not be appropriate in all cases. Are there other policy approaches that should be considered?</p>	
Response:	<p>The Forum believes a regulatory requirement for receiver specification for legacy systems is problematic, but documentation of Harm Claim Thresholds, initially based on Harm Claim Threshold is reasonable. As technology advances to allow improved system performance, regulatory standards can be developed to allow enhanced multiuse spectrum.</p>
<p>Context: Interference Limits Policy Approach Continued– Moreover, the GAO report identifies the lack of incentives for manufacturers or spectrum users to incur costs associated with using more robust receivers, and the difficulty of accommodating a changing spectrum environment, such as when spectrum is repurposed for a new use.</p>	
<p>7. Are the incentives in the TAC white paper recommendations for improving receiver robustness to interference sufficient?</p>	
Response:	<p>The Forum believes incentives are sufficient in many bands that will see little or no significant multiuse. Receivers are normally operated as an edge node of a system, and the edge node user will often place a value on improved receiver characteristics, which in turn encourages industry to respond with better performance.</p>

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TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
	Poor performance of legacy receivers is problematic in areas where millions of receivers (GPS) are deployed and are interfered with by newer broadband systems (e.g. LightSquared). It is not unreasonable, however, to establish a timeframe for deployment of newer broadband systems that interfere with legacy receivers as long as an adequate roadmap for receiver replacement with more robust technology is developed by the stakeholders.
8. Are there other incentives not mentioned in the TAC white paper recommendations that should be considered?	
Response:	<p>There are earth sensor systems and sensitive broadband receivers that, because of their high dynamic range and sensitive instrumentation will not, at least in the near future perform well in a multi-use environment. The Commission must account for these systems prior to establishment of receiver regulations, but even many of these systems can support TDMA operation that would allow some level of multiuse of the spectrum.</p> <p>The Forum encourages the Commission to include discussion of these types of communication systems in workshops prior to completion of its regulatory approach. Many of these systems will require unique solutions to allow multiuse of spectrum.</p>
9. Should the Commission consider circumstances unique to each service, such as the diversity of devices available, the cost of replacement devices, typical replacement times, or sophistication of users that may impact the practicality, necessity, or sufficiency of such an approach?	
Response:	We strongly concur. The Forum believes a roadmap for a regulator environment must account for all of these factors. It is likely as time and technology advance, opportunities will continue to present themselves for the Commission to manage.
10. How should the technological evolution of components and receiver design influence the timeframe and evolution of interference limits?	
Response:	<p>Technology is an important element of all communication systems and the Commission and its regulatory guidance should encourage innovation in component, receiver and systems technology.</p> <p>The Forum maintains an updated list of “The 10 Most Wanted Wireless Innovations” it uses for members to drive all its technical committees and working groups. This is the most downloaded document on the Forum’s web site and can be found at: http://groups.winnforum.org/winnforum_top_ten</p>
11. In light of these issues, are there other alternatives, or other options within an interference limits policy approach, that should be considered for further analysis and/or small-scale pilot tests?	
Response:	The Forum strongly supports the creation of a roadmap for the Commission that includes development of propagation models (texture of the communication system in its environment), Spectrum Dashboards (international, national, regional, local) and clear Harm Claim Thresholds.

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TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
	The Forum also supports use of Cooperative Research and Development Agreements (CRADA's) to promote test participation between all stakeholders.
12. What are the cost and benefit tradeoffs of these alternatives?	
Response:	The Forum believes a light regulatory approach that provides guidance to industry and government user of spectrum will ultimately be successful in providing the public with the highest level of service. Innovation is unleashed when both industry and government understand and are included as a part of the regulatory framework. Historically industry also responds well to reasonable changes in regulations that have a clear benefit to the public. Innovation by car manufacturers occurred as a direct result of new EPA regulations, MPG and safety standards. Innovation in communication systems should be positively influenced by light regulatory approach.
<p>Context: Receiver Standards - Industry standards for receiver performance exist for certain federal and non-federal wireless services and technologies. There are also wireless services for which there are no industry guidelines or standards for receiver performance.</p>	
13. Where industry standards exist for receivers, what is the relationship between these standards and the method for determining appropriate harm claim thresholds for receivers?	
Response:	<p>Government spectrum, managed by the NTIA continues to use DD-1492 filings to insure all transceivers operated in government control spectrum have known transmitter and receiver characteristics. The Forum believes this is a good model for the FCC to follow in development of an appropriate database for establishing reasonable industry based Harm Claim Thresholds.</p> <p>A key difference between NTIA controlled government spectrum and FCC commercial spectrum is that many of the transceivers used in government spectrum have mandated performance requirements for operation. Therefore, the transceiver cannot operate in the United States unless it meets "contracted" requirements. In the commercial world, industry invests in development or receivers and transceivers and often consider their internal specification proprietary. However by establishing a Harm Claim Threshold the actual internal performance does not need to be disclosed only that it meet the Harm Claim, and in the case of a receiver, if it does not then it cannot petition the Commission for Harm Claim relief.</p>
14. How do actual receivers perform in relation to existing performance standards?	
Response:	<p>Modern communication system continues to advance receiver performance. Many systems, particularly in public safety and mission critical systems significantly outperform existing performance standards. This is due in part to the fact 1st responders and public safety operators covet performance over cost when lives at stake.</p> <p>Older systems, particularly SATCOM or VSAT systems based on legacy satellite constellations and the need to build millions of receive only earth stations don't</p>

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TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
	meet any published performance standards. It is likely a roadmap for update and/or replacement of these systems will need to be address in the Commission's roadmap.
15. How are receivers evaluated in meeting those industry standards?	
Response:	Many industry groups have established and published standards that provide for interoperability of equipment and systems. This model has worked well in the past and is likely the best model for the future for commercial certification for transceivers and self-certification for receiver only systems
16. Where there are industry standards, how are such standards enforced?	
Response:	In many commercial networks, self-enforcement of standards for performance is a powerful force to insure compliance. The commercial industry is driven by market opportunity and deployment of non-compliant equipment is extremely rare and economically unsustainable. Industry standards are normally governed by standards committees that require you to comply with standards developed by the organizations stakeholder to even obtain a license to develop equipment based on the standard. This license requires you to comply with interoperability with both the standard and often with legacy equipment deployed with under the standard.
17. To the extent standards are voluntary, how do users of receivers know whether equipment meets or exceeds such standards?	
Response:	Compliance with standards is often the most important and powerful element of marketing a product. For example, there are over 10B Bluetooth enabled computing devices in the world today. Most sensor systems are marketed as Z-Wave, ZigBee, Ant+, or BT4. Industry also is the strongest supporter of innovation in commercial wireless industries. The development of WiFi from 802.11 a/b/g/n to ac is a testament of how effective commercial industry standards operate.
18. Where there are no industry standards for receiver performance, how should acceptable thresholds of receiver performance be developed and validated?	
Response:	The Forum believes a light regulatory touch is appropriate. There are very few systems without industry standards and all are unique to specific applications, or of such a basic nature that regulation is not of value to the government, industry or user. For example, you can purchase an AM radio based simply on its ability to receive radio stations regardless of its receive performance. In this case receiver performance may be poor but the radio may have a good antenna that compensates for receive loss. It is likely mandated thresholds of receiver performance rather than simply if a system works or not as a measure of value would result in freezing innovation rather than supporting it.

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TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
19. What are the technical and performance issues among diverse wireless services that need to be understood and analyzed between different stakeholder groups, especially the developers of wireless transmitters, receivers and components?	
Response:	<p>Technical performance issues are highly dependent on system level implementation and support for industry standards groups are the best model for establishing the appropriate understanding between different stakeholder groups.</p> <p>For example, many of the protocols in Home Automation Networks based on 802.15 have independent user (stakeholder) groups but share protocol stacks to insure interoperability and collision avoidance. Again this is a model that works well and does not require regulation.</p>
20. What are the cost and performance trends of key receiver components that determine practical thresholds of system performance?	
Response:	<p>Higher levels of integration and advances in technology are clearly pushing down cost of manufacturing key receiver components. The Forum believes this trend will continue. An additional benefit of higher levels of integration is the proliferation of chips and chipsets that simplify system level implementation and lower cost of products that comply with commercial standards.</p>
<p>Context: Receiver Standards Continued - The TAC recommends that the FCC implement a web accessible repository (e.g., through the FCC spectrum dashboard) of existing receiver standards, and a voluntary repository of receiver specifications for existing receivers. This, the TAC contends, would facilitate technical information sharing among diverse stakeholder groups of wireless system developers who need to know and understand the specifications of systems other than their own</p>	
21. How effective would this method of information sharing be for product developers?	
Response:	The Forum believes this is an effective approach.
22. What are the source documents that would be appropriate for such a repository?	
Response:	<p>The Forum believes a number of important information should be available:</p> <ul style="list-style-type: none"> • FCC Spectrum Dashboard • International, National, Regional and Local Spectrum License information • Geolocation of fixed transmitters and a visual overlay of propagation models • Real Time Spectral Density Maps • White Space Maps • Receiver Sensitive Maps
23. Are there additional and/or more effective methods, perhaps industry-led, to share receiver technical standards and specifications between stakeholder groups that traditionally do not work together in the same industry groups (e.g., standards organizations)?	
Response:	<p>Virtually all commercially available equipment supports a standard and undergoes some level of certification within the appropriate stakeholder groups. Forums, such as the Wireless Innovation Forum which are industry leading</p>

**OFFICE OF ENGINEERING AND TECHNOLOGY INVITES COMMENTS ON
TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
	<p>organizations for markets rather than specific implementation of a communication system are the best organizations to facilitate how to resolve conflicting requirements between stakeholder groups.</p> <p>The membership of the Forum includes a wide range of wireless US based and international communication companies that provide system solutions for the wireless industry that supports mission critical communications that operate in NTIA controlled spectrum. This spectrum has been and continues to be an important region for advance development of Cognitive Radio (CR), Self Optimizing Networks (SON), Dynamic Spectrum Access (DSA) and other technologies that provide the foundation for shared spectrum.</p>
	<p>24. Given the increasing number of devices developed for international use, would an industry-led approach be more effective than a US-specific repository?</p>
Response:	<p>The Forum is an international organization and works in all ITU regions to understand, influence and resolve spectrum issues that relate to its membership. Timing of the Commission is appropriate to influence the international community, and provide leadership that will insure US manufactures can compete internationally and US consumers can benefit from a world market approach to spectrum management.</p>
	<p>Context: Multi-stakeholder Organizations - The TAC recommends that the Commission encourage the formation of one or more multi-stakeholder groups to investigate interference limits policy at suitable high-value inter-service boundaries. We seek comment on such a multi-stakeholder process and solicit interest from candidate participants.</p>
Response:	<p>The Forum agrees with the TAC recommendation that the Commission encourage formation of multi-stakeholder groups to identify and resolve the unique challenges with spectrum sharing. The Forum has many years of experience in this space.</p> <p>All tactical, commercial and industrial wireless communication systems in use today are based on Software Defined Radio architectures developed under the guidance provided by the Forum. The Forum and its membership continuing to push the envelope in system architectures, particularly in development of the underlying technology and processes required for spectrum aware communications based on Cognitive Radios, use of opportunistic spectrum, Dynamic Spectrum Access, Self Optimizing Networks, terminal provisioning and access control, policy base protocols and both terminal and network collision avoidance.</p> <p>The Forum understands the challenges of multiuse spectrum and stands ready to support the Commission by facilitating and participating in meetings, workshops, trials and reports that support the Commissions goals.</p>

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TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No.
13-101

Comment: Date: June 21, 2011

25. What frequency bands would be most appropriate for considering the formation of a multi-stakeholder organization to develop technical parameters and methods for implementing an interference limits policy?

Response:

As commented upon earlier, there are already some significant frequency bands where harm limits analysis could be used to validate the approach. TV White Space trials provide an excellent environment for evaluation of spectral reuse - in a specific case where high power broadcast systems are separated by large unused guard band regions. Adjacent channel and intermodulation characteristics testing performed in the rebanding of the 800 MHz spectrum for dual use in an excellent environment for evaluation of receiver performance requirements for multiuse mobile operators. Consideration of the history and issues around each of these interference environments could provide valuable context for the formation of multistakeholder groups and interference harm limits.

Evaluation of C-Band satellite earth stations and WiMax terrestrial communications systems in the 3500 – 3800 GHz band is an excellent system environment for evaluation of the effect of wideband legacy satellite receives and microwave backhaul services. Portions of this band have been identified for spectrum sharing, providing motivation to apply receiver harm analysis.

The Forum recommends a stakeholder’s workshop be organized to directly address development of technical key technical parameters with the goal to develop industry wide input on the challenges for specific areas of concern. This would permit a survey of exiting (legacy) systems to be developed as a foundation for understanding unique challenges for implementation of shared spectrum in specific terms rather than general principles. The goal would be to facilitate areas of collaborative research and trials between stakeholders to share spectrum.

An approach to facilitate and collaborate through Forum’s and other stakeholder groups will go a long way in opening up industries acceptance of multiuse and repurposing of spectrum.

26. Are there more effective methods of organizing a diverse group of stakeholders for developing such technical parameters?

Response:

Leveraging international Forums that have a demonstrated history of supporting both industry and government communication systems is a critical step in acknowledging the value and importance of shared spectrum, spectral reuse and repurposing to legacy user. Managed properly the consumers, suppliers, operators and regulators will benefit from opening up ALL spectrum for multiple uses (note however provisions for policy based use for Mission Critical Communications priority uses should be developed for any spectrum which supports public safety systems regardless of the location of the spectrum used).

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TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
	<p>The Forum has a long history of serving in this role since its foundation as a multi-stakeholder group in 1996. The Forum’s initial work supported the needs of the US Air Force in establishing an ecosystem system of vendors advancing software defined radio technologies in the commercial, civil and defense domains. Since that time, the Forum has hosted numerous related stakeholder groups, including those advancing SDR and CR in Public Safety Communications, the Space Telecommunications Radio System architecture (STRS), the Software Communications Architecture (SCA), TV White Space communications, and Spectrum Innovation.</p>
27. What is the best way to initiate the formation of a multi-stakeholder group?	
Response:	<p>Forums are multi-stakeholder organizations and should be considered as a prime resource to represent its membership in discussions of spectrum allocation, management and governance.</p> <p>The Wireless Innovation Forum like many actively supports an advocacy agenda for spectrum management. Information on the WinnForum Advocacy Agenda can be found at: http://groups.winnforum.org/advocacy and the Advocacy Agenda itself can be downloaded from the link above.</p>
<p>Context: Multi-stakeholder Organizations Continued - We invite comment and recommendations on applicable governance, issue resolution, and enforcement methods, including but not limited to how stakeholders can coordinate across industry segments, such as those where voluntary standards are needed and/or developed. Also, recognizing that service boundaries and spectrum sharing often involve both non-federal and federal spectrum users, we seek comment on the costs and benefits of a comprehensive approach between the FCC and NTIA to incorporate receiver performance into spectrum management practices.</p>	
28. How should the FCC and NTIA coordinate with government agencies and other stakeholders to address situations where large numbers of users are impacted by changes to adjacent spectrum licenses?	
Response:	<p>The Forum believes an open approach to allow all stakeholders to participate in meetings, reviews and trials is critical to insuring industry and government can avoid unintended consequences of changes in use of public licensed and government owned spectrum. The use of stakeholder Forums, Associations, Federations and Organizations to represent the interest of its members is an excellent way for the Commission to interact with stakeholders.</p> <p>The FCC and NTIA should provide insight to the multistakeholder groups to ensure that the government users participate, and can share relevant information as an active part of the process. The relatively broad characteristics needed to specify the interference harm limits should enable this information to be discussed for secure systems. In the cases where a system’s requirements for interference harm limits cannot be discussed in an open forum, the stakeholders may need to have a working group that can be cleared to discuss these details.</p>

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TECHNOLOGICAL ADVISORY COUNCIL (TAC) WHITE PAPER AND
RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
29. Should the FCC and NTIA perform band assessments to determine where possible future repurposing in a band might impact adjacent bands and develop plans and processes to ensure proper protections?	
Response:	We strongly believe that the FCC and NTIA should conduct band assessments . This planning will go a long way to provide industry clarity of the business case of innovation in the wireless space. In addition, the FCC and NTIA should insure propagation models are developed to support the Spectrum Dashboard and other tools which can help define spectrum of opportunity for shared use.
Context: Role of the FCC - We seek general comment on whether and how the Commission should implement a policy that incentivizes improved interference tolerance of wireless systems.	
30. Specifically, should the FCC adopt a policy of employing interference limits in certain cases of neighboring bands and services?	
Response:	The Forum believes it is appropriate to establish interference limits (harm claim thresholds) for legacy receivers to help industry, and through industry the public, to understand the value of improvement in spectrum use. Even in areas where existing receivers such as GPS have poor performance from an interference limits perspective, new technology will eventually prove the necessary value proposition to user to encourage replacement of existing receivers. A light regulatory touch is recommended to avoid disruption of services and destruction of markets. A roadmap for implementation of multiuse spectrum with reasonable timeframes that avoid harm to existing stakeholders (users) is important. To do this, the multi-stakeholder group should consider both the existing legacy environment as well as the timeline and future performance of receiver technology.
31. Should the FCC adopt specific rules for establishing interference limits that are recommended by one or more multi- stakeholder groups?	
Response:	The Forum believes the FCC should maintain a light regulatory touch in adaption of interference limits. Just as our spectrum requirement have evolved to the point we must consider repurposing and sharing of spectrum today, it is likely technology will allow continued improving in the future. Mandating interference limits would freeze technology and innovation rather than promote it. This would leave the United States in non-competitive position as a supplier in the world market.
33. We envision that the FCC could be a facilitator in a non-directive role with convening stakeholders. Also, the GAO recommends consideration of small-scale pilot tests of options for improving receiver performance.	
Response:	The Forum agrees the FCC should facilitate by convening stakeholders and encourage stakeholder groups to join in multi-stakeholder forums to coordinate development of trials and reports to support FCC governance policies.
33a. What should be the scope of an appropriate pilot test?	

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RECOMMENDATIONS FOR IMPROVING RECEIVER PERFORMANCE**

ET Docket No. 13-101	Comment: Date: June 21, 2011
Response:	Field demonstration of system behavior and correlation to system models for refinement of regulatory guidance is important. The Forum has a robust Systems Modeling Group and strong ties to organizations such as The Object Modeling Group (OMG) and can help the Commission define how these system models can be developed and used.
33b. What role should the FCC play in encouraging and initiating industry action?	
Response:	<p>The FCC should facilitate development of Corporative Research and Developments Agreements (CRADA) between stakeholder groups with a Forum of diverse members supporting development of trials and reports used to provide regulatory guidance.</p> <p>The FCC should operate in an advisory role to the stakeholder groups to ensure that full cross sections of relevant stakeholders are identified for participation in the process.</p>

7 Summary

The Forum strongly supports the Committee’s approach to include all stakeholders in determination of policy development and recommends a series of workshops be held to finalize a regulatory roadmap for multiuse spectrum. The Forum believes a light regulatory touch based on development of a regulatory roadmap best serves the public good by promoting continued innovation in key areas of technology and policy guidance needed in the next decade, while at the same time mitigating disruption to existing public and private infrastructure. The Forum further recommends an advisory panel representing key suppliers of wireless services be formed to provide written reports from these workshops with key recommendations to the Committee to resolve any contentious issues between exiting and evolving stakeholders. Improving utilization of spectrum is critical to support the public good and provide the public necessary telecommunication services.

The Wireless Innovation Forum has a unique position in the wireless ecosystem, with membership covering a broad range of wireless stakeholders in both FCC and NTIA managed

spectrum. This gives the Forum a unique perspective in static, dynamic, and real time management of commercial, mission critical and military systems. The diversity of the Forum's stakeholders make it an ideal organization to host workshops focused on identifying and resolving important issues leading to successful deployment of systems in a multiuse spectral ecosystem to support the public.

7.1 A Multi-Stakeholder Spectrum Advisory Committee

Industry Associations, Organizations and Forums are excellent sources of representatives to provide the Committee the broad set of candidates for formation of a Multi-Stakeholder Spectrum Advisory Committee (MSSAC). Some of the key candidate participants are:

- Federal Communications Commission (FCC): Representing commercial spectrum users and the future of multiuser spectrum.
- National Telecommunications and Information Administration (NTIA): Representing federal spectrum users and the future of multiuser spectrum.
- The Wireless Innovation Forum (Forum): Host for workshops and responsible for generation of final reports for submitting to the Committee, FCC and NTIA. Representing Public Safety markets and federal (DoD) tactical spectrum users.
- Cellular Telecommunications & Internet Association (CTIA): Representing national and international cellular telecommunication stakeholders.
- Satellite Industry Association (SIA): Representing stakeholders from US based satellite industry.
- Global VSAT Forum (GVF): Representing stakeholders from the international satellite industry.

- Department of Homeland Security (DHS): Representing public safety and emergency services.
- Consumer Electronics Association (CEA): Representing home networks and non-cellular wireless.
- National Association of Broadcasters (NAB): Representing radio and television broadcasting.
- IEEE Standards Association: Representing the 802 and DYSPAN standards for wireless networking.

This is just a sampling of the potential MSSAC candidates, and is not meant to be a complete list of the wireless industry stakeholder groups.

7.2 Workshops

The role of the MSSAC is to insure all industry stakeholders are fully represented and all key regulatory issues are covered. A minimum of three focused workshops are recommended:

- Workshop #1: Receiver Specifications and Harm Claim Threshold's
 - Focus:
 - Evaluation of key receiver specifications
 - Development of a multiuse spectrum roadmap
 - Development of required filings for receiver specifications
 - Development of harm claim threshold targets
 - Deliverables:
 - Recommended receiver reporting forms for both new and legacy receivers
 - Recommended regulatory policies for harm claim thresholds.

- Recommended roadmap for filing of receiver performance for use in harm claim threshold regulations.
 - Recommended policy for receivers that lack known receiver performance.
 - Recommended compliance policy
- Workshop #2: Multiuse Spectrum opportunities
 - Focus:
 - Identification of multiuse spectrum opportunities
 - Development of requirements for national, regional and local spectrum databases
 - Determine the role of edge node sensors and opportunities for real time use of spectrum
 - Identification of critical spectrum access policies for edge node sensors
 - Deliverables:
 - Summary primary, secondary and future multiuse spectrum opportunities
 - Summary of national, regional and local spectrum database requirements
 - Recommended policies for real time access by edge node sensing
- Workshop #3: Regulatory Roadmap trade studies and recommendations
 - Focus:
 - Evaluate timing and deployment of multiuse spectrum tools, databases and policies
 - Evaluate the process for driving to multistakeholder consensus
 - Define the methods to update and maintain the regulatory roadmap

- Deliverables:
 - Recommended Spectrum Policy Roadmap

The Forum looks forward to working with the Committee in support and development of a Regulatory Roadmap that will minimize disruption to existing telecommunications, promote innovation in all areas of wireless communications and support the Committee, FCC and NTIA in providing the most valuable use of spectrum for the public good.

Respectfully submitted,

By: _____

Keith Nolan
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Wireless Innovation Forum

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