ISART 2022 – Evolving Spectrum Sharing Regulation Through Science and Engineering

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***Abstract*—ITS seeks input for ISART™ scheduled for early summer 2022. The goal of ISART 2022 is to chart a roadmap and gain consensus for data-, science-, and technology-driven means to evolve and expedite spectrum sharing analyses and decision-making. To assist in planning, ITS seeks input. This paper provides context and instructions for submitting input.**

***Index Terms*—Spectrum management, interference analyses, feasibility studies, spectrum sharing, spectrum repurposing, propagation**

I. About ISART

The International Symposium on Advanced Radio Technologies (ISART)™ is a U.S. government-sponsored conference hosted by the National Telecommunications and Information Administration's Institute for Telecommunication Sciences (NTIA/ITS). ISART is a science and engineering discussion-based conference that brings together government, industry, and academic leaders (both domestic and international) for the purpose of forecasting the development and application of advanced radio technologies and the application of careful engineering and research on radio technologies within the context of spectrum management, policy, and regulation. NTIA serves as the executive branch agency principally responsible for advising the President on communications and information policies. NTIA also manages U.S. government use of the spectrum.

A. Background for ISART 2022

A little over a decade ago, in 2010, President Obama set a goal of making 500 MHz available for sharing within 10 years. [1],[2] Later that year, NTIA released a ten-year plan and timetable to make 500 MHz of spectrum available for wireless broadband. [3] ITS conducted technical research to underpin the spectrum sharing and repurposing efforts and focused three consecutive ISART symposiums on how to develop forward-thinking rules and processes to fully exploit spectrum resources. The emphasis of ISART 2010 was spectrum sharing technologies to improve spectrum utilization. ISART 2011 [4] provided an evaluation of radar spectrum usage and management and ISART 2012 explored approaches to real-time sharing with Federal systems. These discussions provided technical foundations for regulatory advances that resulted in a real-world radar-band development environment worthy of private investment, e.g., Citizens Broadband Radio Service (CBRS).

Significant progress—far outreaching the goal set by the Obama Administration—has been made since 2010, with 7,513 MHz of spectrum across all bands, including over 1130 MHz of mid-band spectrum repurposed for sharing in the U.S. [5] Domestically, NTIA and the Federal Communications Commission (FCC) continue to pursue efforts to identify new candidate spectrum bands for potential sharing and repurposing. Mid-band spectrum is also the focus of an agenda item at the International Telecommunications Union (ITU) 2023 World Radio Conference (WRC-23).[6],[7]

A decade into the increased emphasis on spectrum sharing, many lessons have been learned from multiple spectrum repurposing and rule-making proceedings. Broadly generalizing, to achieve the successful repurposing of thousands of megahertz to date, a relatively linear process (see Fig. 1) has been used: band prioritization (often driven by industry demand); feasibility studies (based on incomplete technical parameters for new commercial systems[1] and deployment assumptions); rule-making for the service rules (based on the feasibility studies, and often lacking agreed upon models used in engineering studies); and auction/licensing/certification (often with ten-year rights and renewal expectancy). Post commercial deployment, enforcement is the primary conformance tool.

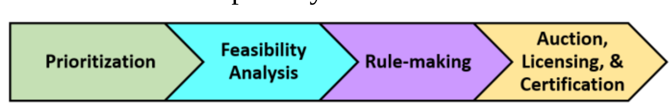

Fig. 1. Broadly generalized graphic depiction of the current linear spectrum sharing regulatory process.

[1] In its place worst case assumptions are typically used.

Many factors align to suggest this linear process could be reformulated into an improved iterative and flexible process.

- The pace of innovation for hardware is significantly faster—and for software is exponentially faster—than the current regulatory process. Regulatory processes that take years or decades to complete can stifle innovation, optimization, and international leadership opportunities.
- Critical engineering studies to identify interference potential to incumbent Federal systems are needed before the sharing parameters are set, not after, when transition and relocation funds are finally available. Late-stage engineering studies that establish real-world obstacles—often related to out-of-band emissions and inadequate receiver filtering—undermine the regulatory certainty the linear rule-making process may have initially achieved and add unexpected costs to the entire ecosystem.
- Unlicensed or non-licensed bands have proven a boon for innovation, but with spectrum relocation funds for Federal systems tied to auction proceeds, spectrum repurposing to share with unlicensed services is not a practical option for Federal systems.
- Conflicting self-interests and goals cause trust and information-sharing asymmetries that result in sub-optimal rules and spectrum inefficiencies.
- Commercial interests pay billions of dollars for well-defined spectrum rights during spectrum auctions. Once post-auction commercial licensing and certification occurs, there is limited opportunity for regulatory revision or optimization. Over time, this model limits the advance of new technologies to commercial optimization.

Thus, the current process, while intending to foster market and regulatory stability, affords little opportunity to revisit regulatory analyses, share deployment and ground-truth data, validate or update assumptions, test local interference management techniques and technologies, and adjust the rules on a timely and ongoing basis with well-engineered justifications. We wish to examine how the regulatory processes might be updated to address these concerns.

B. ISART 2022

The goal of ISART 2022 is to chart a roadmap and gain consensus for specific data-, science-, and technology-driven means to evolve and expedite spectrum sharing analyses and decision-making. In particular, we will explore options for reform where: rules could build upon lessons learned from prior proceedings; assessments and iterative reassessments of the rules for specific bands could occur on a regular shorter-time basis; rules could evolve over shorter-time periods; and incentives could exist for collaboration among industry, Federal incumbents, regulators, and equipment manufacturers to (1) update information, models, requirements, and assumptions underlying regulatory feasibility analyses, (2) test new technologies and concepts, and (3) consider economic cost-benefit tradeoffs.

Fig. 2 illustrates a proposed continuous regulatory improvement model. The interior circle regulatory elements include key components of the linear process, but within an iterative and evolving context: (1) prioritization and planning, (2) feasibility analysis (and development of coexistence parameters), (3) rule-making (through auctions and certifications), and (4) reassessments based on real-world ground-truth data (including any interference instances). The exterior circle represents system evolution, and likely touchpoints for ongoing cross-sector dialogue related to industry deployment, optimization, standards and community development, and test and demonstration to establish a pipeline for proven new science and technology.

This model represents a potential future regulatory process that could be more responsive to the rapid pace of technical evolution and more reliant on applied engineering analysis. It extends the regulatory horizon from initiation and the first set of regulatory rules, through early implementation and deployment stages of a new technology—which might trigger reassessment of aspects of the rules—through the process of scaling up and expanding deployments and using lessons learned and data from those efforts to tweak the rules, to market maturity and full system deployment—at which time the ecosystem can be studied, the models and interference protection criteria validated, and lessons learned can be applied to other sharing scenarios.

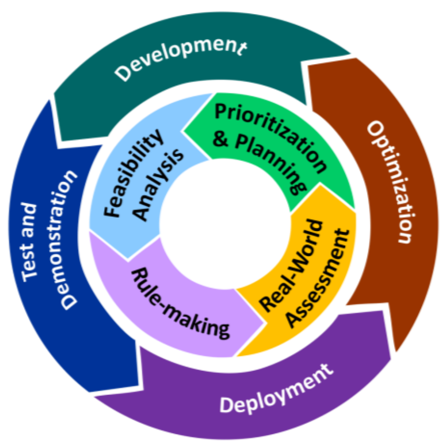

Fig. 2. Continuous regulatory improvement model.

During ISART 2022, panel discussions, technical presentations, and breakout sessions will examine options to evolve spectrum sharing rules through examination of specific use cases and issues. These may include retrospectives on recent spectrum sharing proceedings and applying lessons learned; reducing margins within the technical aspects of spectrum sharing feasibility analyses; incentives for enhanced data sharing and transparency for continuous improvements and shorter timeframes, driving for stakeholder community involvement and acceptance of models; application of risk-based interference prevention to spectrum sharing; and opportunities for continuous improvements and developments beyond the current linear spectrum sharing process.

II. Possible Topics

To assist in planning, ITS seeks input, particularly in the form of abstracts, recent publications, articles, or papers, relevant to the ISART 2022 theme as outlined above, and possible topics, and use cases as expanded upon within the following subsections. Ideas for creative solutions needn't be fully developed to be submitted in an abstract form. Submissions could lead to an invitation to participate or present in some fashion at ISART 2022, or to have a publication, article, or paper included in a bibliography for the symposium.

A. Retrospectives on AWS-3, CBRS and AMBIT

The ISART 2022 agenda will include a retrospective on spectrum sharing developments through the different phases of its life cycle, i.e., (1) prioritization, (2) feasibility analysis, (3) rule-making, (4) auction and certification, (5) commercial deployment and ecosystem optimization. What lessons learned can be drawn from the Advanced Wireless Service 3 (AWS-3) [8], CBRS [9]-[16], and America's Mid- Band Initiative Team (AMBIT) [17] case studies? How can rigorous engineering analysis make possible regulatory process improvements? Would AWS-3, CBRS, and/or AMBIT be a good candidate for testing an iterative regulatory process model as proposed here?

B. NTIA Spectrum Sharing Feasibility Analyses

Regulatory feasibility analyses, underpinning spectrum sharing rules, are interference prevention analyses based on Frequency Domain Rejection (FDR) [18], area-mode statistical propagation models, mean-power interference protection criteria (IPC) [19], and assumptions about the current and planned state of spectrum technologies based on incomplete information. What technical parameters of the transmitters are most determinative of IPC? What assumptions cause the greatest margins in interference prevention analyses? What information about victim receivers is most critical for determining FDR? Can cost-effective modifications to government systems be achieved that improve coexistence? Can planned engineering to promote coexistence be made part of the industry technology standardization process?

C. Data Sharing and Transparency

Insufficient data on planned uses of repurposed spectrum can lead to conservative technical and inaccurate deployment assumptions in regulatory feasibility studies. Further, insufficient data on actual uses of shared spectrum (e.g., locations of service nodes, base stations, and transmitters) leads to inaccurate coverage assumptions and predictions, and thwarts opportunities for data-based reassessments of sharing rules. Feasibility studies would benefit from enhanced data sharing. What means and incentives exist or could be developed to encourage industry participants, including network operators, manufacturers, entrepreneurs, and innovators, to share more accurate, granular, and detailed, but potentially proprietary or competitively-sensitive data with regulators? [20] What impact would information on receiver performance have on feasibility studies?

D. Model Standardization

Propagation models are a critical element to interference analyses. Today, we live in a data-rich world. We have access to resources ranging from high fidelity environmental data (i.e., LiDAR, meteorological, etc.) to advanced and dispersed measurement systems that can provide the means to develop data-driven predictions that produce more accurate results. Combined with open-source software development, this allows models to be developed with transparency. What validation requirements are needed for community/stakeholder acceptance and trust of new models? What open-source data-driven propagation models are available? What limits of a model's capabilities should be clearly and transparently identified? Is there incentive for the community to work together toward standardization of propagation models? How significant an impact on interference margins would improved path loss predictions create? How should the time statistics for the propagation models be handled? In addition to propagation models there are models for clutter and building loss that need to be defined.

E. Risk-Based Interference Prevention

NTIA [20], FCC [22], and ITU [23] generally define harmful interference as interference that endangers the functioning of a radionavigation service or other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service. Is a new quantifiable definition of harmful interference needed? In lieu of worst-case interference analyses, is it practical for regulatory feasibility studies to adopt a risk-based approach, where the probability (e.g., in time and space) and consequences (e.g., performance degradation versus harmful interference) are considered? Could risk-based interference criteria be developed to set a percentage of time and locations that systems must not create or encounter harmful interference? Can economic analyses (e.g., cost-benefit trade-offs) related to spectrum sharing decisions be modeled in a consistent way across all bands and services, even in light of government spectrum-dependent missions such as defense, public safety, weather forecasting, or scientific passive sensing?

F. Ex Post Developments

A possible means to keep pace with innovation would be for the rules to be revisited by the regulator. In addition to improving interference prevention requirements in current rules, how could the iterative process proposed in this paper generate post-rule-making (ex post) actions by industry and government to improve spectrum management, enforcement, and respond to unforeseen interference scenarios? Are there opportunities for ex post data, science, and technology advances to benefit AWS-3, CBRS, and AMBIT spectrum management? Can the community addresses interference ex post, through rapid response embedded processes? Can advanced interference assessment algorithms be proactive, anticipate interference, and adapt cross-layer wireless network technologies to avoid interference to and from government systems? Would a risk-based approach to defining and quantifying interference criteria provide flexibility for ex post software changes in radios and communications systems? What level of laboratory and real-world demonstration, testing, and validation should be required to prompt a regulatory feasibility reassessment related to future technology?

III. Submission Guidelines

All submissions must be made via email to ISARTcontact@ntia.gov. Please provide an abstract, not to exceed four pages, if submitting a lengthy publication or paper. Please use IEEE conference paper format guidelines, limit length to four pages, and be aware of the following important dates:

- Submission window opens: 24 January 2022
- Submission window closes: 21 February 2022
- Notifications and invitations expected to begin: 14 March 2022
- ISART 2022 tentative dates: week of June 13, 2022.
- ISART 2022 is now expected to be virtual.

IV. Questions

For any queries, please contact the General Chair Rebecca Dorch or Technical Chair Michael Cotton.

References

[1] *Presidential Memorandum: Unleashing the Wireless Broadband Revolution*, (June 28, 2010).

[2] FCC National Broadband Plan, March 17, 2010,

[3] NTIA, *Plan and Timetable to Make Available 500 Megahertz of Spectrum for Wireless Broadband*, (Oct. 2010).

[4] M. Cotton, M. Maior, F. Sanders, E. Nelson, D. Sicker, "ISART 2011 Proceedings - Developing Forward Thinking Rules and Processes to Fully Exploit Spectrum Resources: An Evaluation of Radar Spectrum Usage and Management," NTIA Special Publication SP-12-485, Mar 2012.

[5] NTIA, "Second Annual Report on the Status of Spectrum Repurposing," NTIA Special Publication, Jan 2021.

[6] "Agenda for the 2023 World Radio Conference," Resolution 811 (WRC-19), Mar 2020.

[7] "Studies on frequency-related matters for the terrestrial component of International Mobile Telecommunications identification in the frequency bands 3300-3400 MHz, 3600-3800 MHz, 6425-7025 MHz, 7025-7125MHz, and 10.0-10.5 GHz," Resolution 245 (WRC-19), Mar 2020.

[8] "An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220 MHz, 4380-4400 MHz Bands," NTIA Report, Oct 2010.

[9] President's Council of Advisors on Science and Technology, "Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth," Report to the President, Jul 2012.

[10] FCC, "Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, Notice of Proposed Rule-making, GN Docket No. 12-354," FCC 12-148, 27 FCC Rcd 15594, Dec 12, 2012.

[11] FCC, "Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, Further Notice of Proposed Rule-making, GN Docket No. 12-354," FCC 14-49, 29 FCC Rcd 4273, Apr 23, 2014.

[12] FCC, "Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, Report and Order and Further Notice of Proposed Rule-making, GN Docket 12-354," FCC 15-47, 30 FCC Rcd 3959, Apr 21, 2015.

[13] E. Drocella, J. Richards, R. Sole, F. Najmy, A. Lundy, P. McKenna, "3.5 GHz Exclusion Zone Analyses and Methodology," NTIA Technical Report TR-15-517, June 2015.

[14] Letter from Paige Atkins, Associate Administrator, Office of Spectrum Management, NTIA to Julius Knapp, Chief, Office of Engineering and Technology, FCC re Commercial Operations in the 3550-3650 MHz Band (GN Docket No. 12-354), Mar 24, 2015.

[15] Spectrum Pipeline Act of 2015, Pub. L. No. 114-74, Sec. 1008, 129 Stat. 621, 625, 2015.

[16] FCC, "Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, Second Report and Order and Order on Reconsideration, GN Docket 12-354," FCC 16-55, 31 FCC Rcd 5011, May 2, 2016; FCC, "Promoting Investment in the 3550-3700 MHZ Band," Report and Order, GN Docket No. 17-258, FCC 18-149, 33 FCC Rcd 10598, Oct. 24, 2018.

[17] E. Drocella, R. Sole, and N. LaSorte, "Technical Feasibility of Sharing Federal Spectrum with Future Commercial Operations in the 3450-3550 MHz Band," NTIA Technical Report 20-546, Jan 2020.

[18] ITU-R, "Frequency and Distance Separations," Recommendation SM.337-6, Sep. 2008.

[19] A. Paul, et al., "Interference Protection Criteria: Phase 1 – Compilation from Existing Sources," NTIA Report 05-432, Oct 2005.

[20] See e.g., Commerce Spectrum Management Advisory Committee (CSMAC) Report of the Future Spectrum Requirements of Non-Fedral Users Subcommittee, July 30, 2020

[21] NTIA, "Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook),", Sections 6.1.1 and 8.2.3, Sep 2017.

[22] 47 C.F.R. Section 2.1.

[23] International Telecommunication Union, Radio Regulations, Chapter 1, Section 1.169, Chapter 1, Section 1.169.