Silicon Flatirons
A Center for Law, Technology, and Entrepreneurship at the University of Colorado

Risk Assessment in Spectrum Policy:

A report on a Silicon Flatirons conference, held October 23, 2015**

Jeff Ward-Bailey†

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** More information, including slide presentations and video records of the conference may be found at http://www.silicon-flatirons.org/events.php?id=1598. The event speakers are listed at the end of the document.

†Jeff Ward-Bailey is a Master's degree candidate in the Interdisciplinary Telecommunications Program at the University of Colorado College of Engineering and Applied Science.

Summary

- Probabilistic risk assessment, also known as quantitative risk assessment, is well established among many government agencies.
- Probabilistic risk assessment – which takes into account events, the consequences of those events, and how likely those events are to happen, known together as the "risk triplet" – generally yields a more realistic picture of harms or risks facing the public.
- Traditional engineering analyses of interference concerns that use deterministic, often worst-case, methods may result in overly-conservative final rules. Risk assessment is a useful tool for balancing the potential benefits of allowing a new wireless entrant to operate against the harms that a new service could cause to spectrum incumbents.
- When possible, risks should be communicated to decision makers and to the public as possibility ranges (commonly depicted as bell curves), rather than as extreme scenarios.
- An agency cannot move overnight from deterministic to quantitative risk assessment, since it takes time to build expertise and confidence with a new method of analysis. Nevertheless, the Federal Communications Commission can and should begin moving in this direction.
- Probabilistic risk assessments should be transparent about their assumptions and the methods by which they arrive at conclusions.
- Specifying the burden of proof for spectrum interference issues will be very important for the wireless industry and the FCC going forward.
- Skilled staff and the commitment of agency leadership are both needed for good risk analysis. It is important that decision makers and risk analysts have distinct roles, but maintain good communications.

Introduction and background

"Everybody wants more radio," conference organizer Pierre de Vries told participants by way of introduction to the Risk Assessment in Spectrum Policy conference hosted by the Silicon Flatirons Center on October 23, 2015 at the University of Colorado Law School. Spectrum access is hotly contested, De Vries explained, since there are practical limits on the number of radio devices that can operate concurrently in close proximity in time, place and frequency. The main question confronting a spectrum regulator, therefore, is whether to allow new wireless entrants to operate in frequency bands with incumbents. To answer that question the regulator must balance the potential gains to be realized from new services against possible harm that those services would cause to incumbents.

Interference analysis is important in determining the costs and benefits of allowing new entrants into the spectrum field. However, spectrum engineering risk analyses have traditionally been deterministic, which is to say that they calculate interference by using single values for all the relevant parameters, often with many or all being extreme values – a worst case analysis. "It tends to be conservative as a method," De Vries told the audience. "It easily leads to rules that provide incumbents with more protection than they need, while at the same time not allowing the new services to realize their full value."[1]

"Real people have been the winners here."
– Gary Marchant, Arizona State University

Worst-case analysis made sense when spectrum rights were not in such great demand, De Vries explained; but as wireless services are packed ever more tightly together, over-conservative protection rules will not maximize the economic and societal value of the spectrum use. For example, worst-case analysis may lead to the establishment of unnecessarily wide guard bands for a particular incumbent service.

Risk-informed analysis – also known as Quantitative Risk Assessment (QRA) or Probabilistic Risk Assessment (PRA) – is gaining traction in the spectrum community as a complement to the deterministic, often worst-case, analysis described above. Probabilistic risk assessment takes a

[1] For more information about risk analysis and spectrum issues, see J. Pierre de Vries, "Risk-Informed Interference Assessment: A Quantitative Basis for Spectrum Allocation Decisions," *TRPC 43: The 43rd Research Conference on Communication, Information and Internet Policy Paper,* Sep. 2015, *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2574459.

range of values as inputs, rather than single worst-case values, and attempts to give a more complete picture of risk by addressing three questions, the “risk triplet”:[2]

1. What can happen? (That is, what can go wrong?)
2. How likely is it to happen?
3. What are the consequences of it happening?

The Silicon Flatirons Conference on Risk Assessment in Spectrum Policy gathered experts in the currently distinct fields of risk assessment and spectrum policy to discuss how engineering risk analysis is being applied to public policy, how risk assessments inform government regulation generally, and what the major challenges and opportunities are for applying quantitative risk assessment to spectrum regulation specifically.

This conference report is organized thematically. Each of the four sections that follows identifies a major topic of discussion from the conference, summarizes the views expressed on each topic, and records selected quotes from panelists.

Theme 1: What is Risk Assessment?

Paul Fischbeck, Professor of Social and Decision Sciences at Carnegie Mellon University’s Engineering and Public Policy department, pointed out in his introductory keynote that risks permeate mechanical systems and human activities alike. To reduce risk, he said, we can either reduce the likelihood of an initiating event, or we can attempt to eliminate the consequences of that event through prescriptive or performance-based standards. In either case, it’s important to acknowledge and bound the risk by determining how much is acceptable. This will depend on a number of factors including who might be affected by an event, how likely the event is to happen, and how severe the consequences of the event would be.

Gary Marchant, Executive Director of the Arizona State University Center of the Study of Law, Science, and Technology, and another of the conference’s keynote speakers, noted that probabilistic risk assessment can be roughly divided into two types: event tree or fault tree analysis, which multiplies single-valued probabilities at the nodes of a fault tree to estimate the deterministic probability of a specific initiating event; and probabilistic analysis, which uses a range of values for each input and provides a probability distribution (loosely speaking, a “bell curve”), rather than a single probability, as an output. The Environmental Protection Agency (EPA) follows the National Academy of Sciences’ “Blue Book” (1994), Marchant added, which

[2] *See* S. Kaplan and B. J. Garrick, “On the Quantitative Definition of Risk,” *Risk Analysis,* vol. 1, no. 1, pp. 11-27, Jul. 1980.

recommends acknowledging and attempting to quantify the uncertainty involved in risk predictions.[3]

The EPA defines probabilistic risk assessment as "a group of techniques that incorporate variability and uncertainty into the risk assessment process. It provides estimates of the range and likelihood of a hazard, exposure or risk, rather than a single point estimate. It can provide a more complete characterization of risks, including uncertainties and variability, to protect more sensitive or vulnerable populations and lifestages."[4] The EPA employs a tiered approach in which simpler problems are tackled with a deterministic risk assessment, while more complex problems – especially those for which the consequences of using point estimates of risk are unacceptably high – are addressed using probabilistic techniques.

"The statistics are beginning to enter into analyses."
– Julius Knapp, FCC

Marchant noted that worst-case or deterministic assessments aren't unreasonable *per se,* especially where human health is a concern, since "we favor lives over dollars." And since worst-case assessments tend to be quicker and easier to perform, he said, they can be useful as initial screening analyses to see whether certain activities or materials are generally safe or unsafe. Deterministic risk assessment can give a rough order-of-magnitude estimate that may indicate that an activity is totally safe, or that it needs to be examined more closely with a more nuanced and accurate risk assessment based on probability distributions. Marchant added, however, that deterministic risk assessment often grossly exaggerates risk, because adding together worst-case assumptions in analysis tends to create a compounding effect.

In addition, Marchant said, because the predictions based on deterministic risk assessment can be so inaccurate, the resulting regulations often end up being aimed at "hypothetical, made-in-computer people," as opposed to the actual affected population. Probabilistic risk assessment, therefore, is not only more nuanced, but also more accurate than deterministic risk assessment – and when regulators know the distribution of risk they are empowered to make better policy decisions. Deterministic risk assessment is based on average values, Fischbeck said, and should be treated with "suspicion," because "it's the tails [of the probability distribution] that are going to create unintended consequences." Probabilistic risk assessment, therefore, doesn't always lead to less protection, but rather to more accurate protection, since agencies will be

[3] National Academy of Sciences, *Science and Judgement in Risk Assessment ("Blue Book"),* 1994, *available at* http://www.nap.edu/catalog/2125/science-and-judgment-in-risk-assessment.

[4] EPA, *Probabilistic Risk Assessment Methods and Case Studies,* EPA/100/R-14/004, July 2014, *available at* http://www2.epa.gov/sites/production/files/2014-12/documents/raf-pra-white-paper-final.pdf.

less likely to spend resources guarding against risks that may not actually affect real-world populations. "Real people have been the winners here," Marchant concluded.

Several panelists pointed out that performing risk analysis is not only about identifying or quantifying harms, but also about identifying benefits. Francisco Zagmutt, Managing Partner at EpiX Analytics, a Boulder-based risk consulting firm, said that in the food-safety sector, risk assessments are used to quantify the extent to which a change in policy could reduce the incidence of food-borne illnesses in society. And in the pharmaceutical industry, he added, risk assessments are often used to decide whether or not to advance a particular drug to the next stage of study. In both the public and private sectors, Zagmutt said, there is often "no A-to-Z process for doing a risk assessment." Instead, regulators or managers must formulate the risk question to be answered, and work with an in-house or third-party risk assessment group to identify the data needed to be able to create an accurate risk model for that question.

Fischbeck pointed to the Nuclear Regulatory Commission (NRC) as another good example of how probabilistic risk assessment can work. NRC engineers have used probabilistic risk assessment and fault tree analyses since the 1970s to measure the likelihood of initiating events and to judge measures such as the size of Emergency Planning Zones around nuclear reactors. Probabilistic risk assessment employs tools such as Monte Carlo analysis to combine probability distributions by calculating thousands of trials with different values of random variable, and showing the range of possible outputs. The result is a graph showing the probability of risk which yields statistics such as mean risk and 95th percentile risk; by comparison, a deterministic (e.g. worst case) analysis yields a single "magic number" indicating whether a given risk is acceptable or unacceptable.

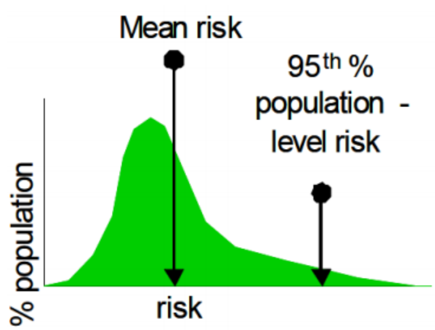

Figure 1. A simplified risk distribution diagram with lines indicating mean and 95th percentile risk. Source: Environmental Protection Agency, Probabilistic Risk Assessment to Inform Decision Making, EPA/100/R-14/004, Jul. 2014, p. 9.

Panel moderator Rob Alderfer, Vice President of Technology Policy at CableLabs, commented that since the federal government already uses quantitative risk assessment in various areas, including quantifying risks in the environmental and nuclear sectors, regulators could and should apply it to spectrum concerns.

Fischbeck pointed out that the public's perceptions of risks vary dramatically, and that there is often a mismatch between what scientists identify as the biggest risks to a community, and what the public thinks the biggest risks are. This is especially true when the risks in question affect health and safety, such as whether the water we drink contains carcinogens or whether the paint in a child's toy contains chemicals. The EPA, therefore, has to spend comparatively more time on risk communication than the FCC does, Marchant said, because the public perceives environmental risks more acutely than they do spectrum risks.

Gregory Rosston, Deputy Director and Senior Fellow at the Stanford Institute for Economic Policy Research, noted that in the future, risk analysis will need to be applied to engineering questions in areas such as self-driving cars. Managing the public's perception of safety and accident rate, he said, is a big part of successfully implementing a major new technology.

Theme 2: Conceptions of harm and burdens of proof

At the heart of spectrum risk analysis is the concept of "harmful interference."[5] As keynote speaker Julius (Julie) Knapp, Chief of the FCC Office of Engineering and Technology, pointed out, the Commission has used different means over the decades of determining whether or not interference is "harmful," "unacceptable," or "objectionable." In the days of analog television, experts used to carefully examine the received picture to judge its fidelity, describing the interference qualitatively with phrases such as "so bad, you could not watch it." In today's digital world, by contrast, such determinations are based on figures such as data speed and bit error rate.

Quantifying interference risk is more difficult today than in decades past, Knapp said, because digital systems are capable of switching bands and modulating their data rate on the fly when they encounter adverse conditions – which means that evaluating the real-world impact of interference can be quite difficult. This difficulty can be partially overcome, he said, through the development of better statistical models and a better institutional understanding of the baseline performance of wireless systems. Knapp also noted that the FCC cannot realistically eliminate all interference, but that good rules can decrease overall interference to a point where the agency need only deal with a handful of big disputes.

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[5] Regulators generally use "harmful interference" as their criterion for making decisions, but sometimes use related but distinct concepts such as "unacceptable" or "objectionable" interference. Harmful interference is defined in 47 CFR 2.1(c) as "Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations." Definitions of "unacceptable" and "objectionable" interference are given only for very limited and specific purposes: *see, e.g., Public Safety Communications in the 800 MHz Band,* WT Docket No. 02-55, Report and Order, Fifth Report and Order, Fourth Memorandum Opinion and Order, and Order (adopted July. 8, 2004), *available at* http://800ta.org/content/fccguidance/FCC_04-168_08.06.04.pdf, *and* 47 CFR 90.187(b)(2)(iii).

Knapp noted that spectrum interference analyses have generally been conducted using worst-case assumptions, such as setting the emitter at the maximum power of which it is capable and assuming that the receiver picks up only a weak signal. Advocates also tend to describe risk itself in extremes, painting dire scenarios of emergency public-safety alerts that do not get through, 911 calls that are dropped, and so on. Because policymakers must make subjective judgements and grapple with shades of grey in conducting interference analyses, Knapp said, they tend to err on the side of writing overly conservative rules. As an example of overprotective rules, Knapp spoke about an FCC analysis of ground-penetrating radar. The risk assessment predicted that the radar would interfere harshly with GPS and other services in the areas where stations were located. But the FCC opted to allow the radars to operate, and, Knapp said, "as near as I can tell, they haven't bothered a soul."

"The parties often describe the risks in extremes."
– Julius Knapp, FCC

Later in the conference Peter Tenhula, Deputy Associate Administrator for Spectrum Management at the National Telecommunications and Information Administration (NTIA), argued that the Commission's definition of harmful interference should take into account the *effects* of interference on how federal agencies are able to carry out their missions. For example, he said, quantifying layers of risk could help vindicate a policy of giving public safety agencies a higher degree of protection – or, conversely, it might offer support for a policy of more intensive coexistence on certain bands.

The discussion of harm definitions at the conference also brought up the concept of the burden of proof. Who has the burden of showing that a new wireless entrant will not cause "unreasonable harm" to the incumbent – the new entrant, the incumbent, or the regulator?

William Boyd, a historian of risk assessment and public safety institutions and an Associate Professor of Law at the University of Colorado, noted that this burden of proof falls in different places in various sectors. Within the world of food additives, for example, the burden falls to manufacturers to demonstrate that their products meet the Food Safety Act's "reasonable certainty of no harm" standard, and the Environmental Protection Agency (EPA) has the authority to hold them to this standard through rigorous testing.[6] The opposite is the case with industrial chemicals such as formaldehyde: the Toxic Substances Control Act (TOSCA) states that the EPA must prove that the chemical poses an unreasonable risk to human safety before it can require additional testing or other regulation. And while the EPA completes thousands of

[6] For more information about this standard, see e.g. D. M. Freedman, "Reasonable Certainty of No Harm: Reviving the Safety Standard for Food Additives, Color Additives, and Animal Drugs," *Ecology Law Quarterly,* vol. 7, no. 2, Sep. 1978, *available at* http://scholarship.law.berkeley.edu/cgi/viewcontent.cgi?article=1139&context=elq.

small risk assessments each year, Boyd added, major risk assessments under TOSCA may take decades to complete, which means that the EPA must be very careful in choosing what chemicals to focus on.

The legal burden of proof is still up for debate in many areas, as was demonstrated in *Industrial Union Department v. American Petroleum Institute (1980)*, also known as “The Benzene Case,” in which the Supreme Court held that the Occupational Safety and Health Administration (OSHA) had the responsibility to demonstrate that a carcinogen posed an unreasonable risk to human health before it could set an exposure limit for the substance.[7] All panelists agreed that specifying the burden of proof for spectrum interference issues will be very important for the wireless industry and the FCC going forward.

Rosston recommended moving the burden of proof, in a general way, from lawyers to engineers, to ensure that ambiguity in analysis is replaced with quantification of risks to the greatest degree possible. This suggestion was echoed by other panelists such as Shawn Jackman, the Founder and CEO of healthcare IT company Clinical Mobility, who noted that engineering transparency allows us to clearly articulate a risk model’s assumptions and input parameters, and to “dimension” risk problems as well as possible. “Scientists live by transparency of assumptions,” he concluded.

Knapp sounded a note of caution, however, noting that tasking engineers with performing spectrum analyses doesn’t necessarily mean they’ll come up with a single answer. “For anybody who thinks that the engineers sit down and all come up with the same answer, you haven’t been in a room full of engineers,” he joked. Knapp acknowledged that there may still be ambiguities and grey areas in the results of probabilistic risk analyses and in the policy responses to those analyses. “Policy makers want binary choice, but get shades of grey,” he concluded. Knapp recommended that lawyers and engineers work together to communicate risks to decision makers, since lawyers are often more comfortable with ambiguity than engineers are.

Theme 3: Implementation – Challenges

Panel moderator Tom Power, Senior Vice President and General Counsel for CTIA–The Wireless Association, introduced the discussion of implementation challenges by saying, “The benefits of risk assessment are obvious; it’s implementation that’s the problem.” Paul Fischbeck agreed, noting that while tools to perform sophisticated risk assessment, such as Monte Carlo simulation software, are widely available, in many cases “the ease of use has greatly exceeded the knowledge of the users” in the public and private sectors. Francisco Zagmutt said that although software tools are easier to use than they were 20 years ago, this can sometimes impede well-thought-out, robust risk assessments. In addition, he said, there has been a

[7] *Industrial Union Department v. American Petroleum Institute,* 448 U.S. 607 (1980).

proliferation of statistical models that attempt to simulate highly detailed risk scenarios, but it's often unclear how to validate those complex models.

Greg Rosston acknowledged that risk analysis is very difficult to do properly, because input probabilities and cost/benefit magnitudes can be exceptionally difficult to estimate correctly. But, he said, obtaining accurate value ranges for inputs is very important, because otherwise decision makers end up crafting policy based on values that are partially made up.

In addition to performing engineering risk assessments, risk managers must also communicate risks in different ways to decision makers, stakeholders, and the public. When it comes to risk assessments that inform spectrum policy, panel moderator Anna Gomez, a Partner at Wiley Rein LLP, said, "I have a hard time picturing the [Federal Communications] Commissioners having the time to dig through a lot of risk analysis." Panelists recommended that rather than delivering full analyses to policymakers, risk managers should present the final result in visual form (see Figure 1). Policymakers will be able to draw accurate conclusions from a final graph with a line drawn on it to show the mean risk, said Marchant, and this simple but nuanced summary will inform their policy decisions.

"The benefits of risk assessment are obvious. It's the implementation that's the problem."
– Tom Power, CTIA

Marchant acknowledged that it can be difficult to communicate risk in a succinct yet accurate way to decision makers. They often prefer a precise number to a range of values, he said, but "life is messy." Giulia McHenry, a former Senior Associate at The Brattle Group and now Chief Economist at NTIA, added that risk analysts need to be flexible in their work, and to accept that they might not have all the relevant information at the time an analysis is being performed. Risk analysts have to be able to incorporate new information over time, she concluded, since there will always be unknowns. Earlier in the conference, Rosston explained spectrum "unknowns" by quoting a statement made in 2002 by former Secretary of State Donald Rumsfeld regarding things "we don't know [that] we don't know."[8] Rosston said that although commentators at the time mocked Rumsfeld's statement, he was correct that calculations of risk may sometimes be thrown off by factors not previously known to exist.

[8] "Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know." (Donald Rumsfeld, DoD news briefing, Feb. 12, 2002, *available at* http://archive.defense.gov/Transcripts/Transcript.aspx?TranscriptID=2636.)

Several panelists noted that probabilistic risk assessments can take months or even years to perform. Francisco Zagmutt mentioned that EpiX Analytics might spend as long as a few years on a risk assessment, depending on the level of complexity needed by the agency or company for whom the assessment is being performed, though most of the company's risk assessments take a few months. Gary Marchant said that the EPA performs thousands of smaller risk assessments each year, often to obtain an order-of-magnitude estimate of whether a given policy or activity is risky or not. William Boyd pointed out that the EPA has only completed one probabilistic risk assessment under the Toxic Substances Control Act: an analysis of trichloroethylene that was begun in 1986 and released in June 2014, 28 years later.[9]

All panelists substantially agreed with Julius Knapp's assessment that "while the statistics are beginning to enter into [spectrum] analysis," there is a need "to develop better statistical models" for calculating interference risks. Knapp also concluded that while no agency, including the FCC, can shift overnight from deterministic to probabilistic risk assessment, since "change is not going to happen overnight," the Commission can begin embracing probabilistic risk assessment in limited ways today to begin building a base of institutional expertise. Gomez added that it takes time for any organization to get "staffed up" with employees who understand how to perform probabilistic risk assessment; Jackman added that expert groups can help to educate agency personnel in risk management issues.

"I think there is enormous benefit to going down this road [of transparency in risk analysis]."
– Joan Marsh, AT&T

Joan Marsh, Vice President Federal Regulatory for AT&T, conceded that no organization has the right to expect a totally interference-free environment, and that companies and government have to coordinate their use of wireless frequencies. She argued that the wireless industry as a whole needs to be more data-driven and transparent, relying on objective measurements to inform spectrum policies and sharing data with others to promote healthy coexistence. She also argued in favor of "starting with some small, concrete steps" at AT&T, and at other companies, to promote institutional comfort with probabilistic risk assessment. She said that establishing objective tolerable levels of interference could help spectrum disputes to be argued on engineering terms, rather than political ones. "As soon as you politicize interference, you've lost," she said. "You're no longer searching for solutions." Marsh and Bob Weller pushed for more transparency in the overall discussion of spectrum sharing, and Marsh averred that she sees "enormous benefit to going down this road."

[9] After the conference, Greg Rosston noted the irony that even though the event was focused on probabilistic risk assessment and moving away from worst-case analysis, a lot of time was spent discussing the "28 years" figure – essentially a worst-case scenario for the length of a risk assessment.

Several panelists spoke about the importance of having top administrators in federal agencies and companies committed to the idea of probabilistic risk assessment. Peter Tenhula also argued that the government could serve as a neutral "honest broker" collecting data and evidence about where and when spectrum is actually being used, and facilitating spectrum sharing. For example, he said, collaboration between government and industry earlier in 2015 had allowed exclusion zones around transmitters in the 3.5 GHz band to be reduced, allowing greater use of that spectrum band. Giulia McHenry echoed this assessment, and suggested that funding be made available for a neutral government agency or other third party to perform trusted, objective interference analysis. Earlier in the conference, Fischbeck noted that a neutral broker can be vital in cases where parties with different goals produce conflicting estimates of harms or risks, since that broker can help the regulator to understand what's causing the differences.

Theme 4: Implementation – Lessons and recommendations

Many panelists argued that processes should be designed in such a way that probabilistic risk assessments can be carried out in a reasonable time frame. Proper institutional design, they agreed, allows expert agencies to perform both forward-looking analyses of risks to the public and retrospective analyses of assumptions of harm based on anecdotes. Gary Marchant argued that top administrators in agencies need to be committed to performing transparent, probabilistic risk analyses. William Boyd and Susan Fox, Vice President for Government Relations at The Walt Disney Company, both agreed, saying respectively that "good civil servants" and "strong administrators" are needed for good analysis.

"Risk-informed spectrum sharing is the future of spectrum policy."
– Bob Weller, NAB

Panelists agreed that the shift from deterministic to probabilistic risk assessment has been largely successful in federal agencies so far. The EPA, for example, began moving in the 1990s from using point estimate "inference options" – worst-case default assumptions to be used in risk analyses when data were missing – to a more nuanced probabilistic approach that accounts for uncertainty in estimates.

The EPA has never *required* a probabilistic approach over a deterministic one, but has encouraged it heavily since the 1990s. Marchant noted that an agency self-evaluation of 16 probabilistic risk assessments had been very favorable, and that he has been unable to find any criticisms from the wider scientific community of the agency's shift from deterministic to probabilistic risk assessment. In addition, Marchant said, the EPA has developed at least three major internal proposals regarding risk assessment, and all have been supportive of probabilistic assessment. A 1997 EPA guideline document, for example, stated that probabilistic techniques have "the advantage of allowing the analyst to account for relationships between input variables and of providing the flexibility to investigate the effects of different modeling assumptions."[10] And a 2014 document noted that "Stakeholders inside and outside of the Agency have recommended a more complete characterization of risks, including uncertainties and variability, in protecting more sensitive or vulnerable populations and lifestages. [Probabilistic risk assessment] can be used to support decision-making risk management by assessment of impacts of uncertainties on each of the potential decision alternatives."[11]

Probabilistic risk assessments are a "win-win-win" tool in that they appeal to all three major EPA stakeholders, Marchant said:

- Environmentalists support more-accurate assessments because they realize that they lead to better regulations.
- Industry groups support probabilistic risk assessment because it can lead to a relaxing of burdensome regulations that may not actually be protecting real people.
- The EPA likes probabilistic risk assessment because more accurate results allow the Agency to spend its resources more wisely and effectively.

Furthermore, Marchant argued, shifting from deterministic to probabilistic risk assessment has lessened the probability that the agency will be sued. Deterministic risk assessment provides a "cookbook" of rules, Marchant explained, and the agency can be held legally accountable for failing to abide by one or more of those rules. By contrast, probabilistic risk assessment relies to a greater degree on expert agency judgement, rather than on a prescriptive process, and it's very unlikely that a judge would see fit to second-guess an agency's determination.

"Risk managers might want a precise number [quantifying risk], but even though it's messy, we have to try to give them a range."
– Gary Marchant, ASU

However, William Boyd argued a counterpoint: that courts are complicit in making risk assessments take a lot of time by being too deferential. If courts held agencies to stricter standards regarding how probabilistic risk assessments are to be performed, he said, the process might be quicker overall. And, he said, if the burden falls on a regulatory agency to prove "no unreasonable risk," for example of a particular chemical to public health, the company selling that chemical may fight the risk assessment or try to drag the process out.

[10] EPA, *Guiding Principles for Monte Carlo Analysis,* EPA/630/R-97/001, March 1997, *available at* http://nepis.epa.gov.

[11] EPA, *Probabilistic Risk Assessment to Inform Decision Making: Frequently Asked Questions,* EPA/100/R-14/003, July 2014, *available at* http://www2.epa.gov/sites/production/files/2014-11/documents/raf-pra-faq-final.pdf.

Tenhula added later in the conference that since the FCC has exclusive jurisdiction to resolve spectrum disputes, agency reliance on probabilistic risk assessment isn't likely to cause lawsuits. He also said that it would be helpful for the FCC to restate the law of harmful interference in a way that defines who has burden of proving that harm.

All panelists agreed that probabilistic risk assessment is achieving its goal of providing a more accurate picture of risks in those agencies where it's being implemented, and that it could transform the way spectrum policy is crafted. Weller went so far as to conclude that "risk-informed spectrum sharing is the future of spectrum policy," adding that because there are strong economic incentives for commercial parties to share, the market could drive the shift toward more intensive spectrum coexistence with government facilitating, rather than mandating, spectrum sharing.

Weller argued that the best opportunities to employ probabilistic risk assessment are when new services are being introduced into the market, when existing services are being introduced into secondary markets, or when regulators want to study well-engineered systems that already use probabilistic metrics, such as point-to-point microwave.

"Add-ons to [Microsoft] Excel allow anyone to do Monte Carlo analysis, but … the ease of use has greatly exceeded the knowledge of the users."
– Paul Fischbeck, CMU

Francisco Zagmutt urged federal agencies to "start small" in their implementation of probabilistic techniques, and not to separate decision makers from risk analysts. He cited the European Food Safety Agency as example to learn from, since at its inception the Agency tried to fully separate risk assessment from risk management in an attempt to make unbiased scientific judgments, whereas today the Agency's emphasis is evolving to a model of "independence with interdependence" between analysts and decision makers.

Julie Knapp argued that in order to apply probabilistic risk assessment to spectrum and interference concerns, policymakers must "better understand the baseline performance of systems," meaning that they should understand the interference environments in which those systems typically operate and other constraints within which the systems must be designed to operate. Knapp also said that the best solution when it comes to making spectrum available is for engineers among various factions to reach a consensus and move away from worst-case scenarios.

Susan Fox concluded that current industry approaches to risk, especially where electronics are concerned, are "anecdote-driven rather than bell curve-driven," meaning that people tend to fixate on a few worst-case scenarios when equipment or service didn't work as expected. She said that in interference analyses, the FCC should push industry groups for data in order to "get to the science behind" the question of harmful interference. This data-based approach can take a while to yield conclusions, she said, but in some cases "more time would have been better." For example, she argued that the electronics industry rushed in the 1990s to coalesce around a digital television (DTV) standard that is still being debated and reevaluated today. "Maybe it would have been wise to slow down and do a little more data-driven analysis that looked at the different inputs," she concluded. "There are many avenues by which you can get to the wrong decision quickly."

Joan Marsh agreed with Fox's characterization of industry approaches to risk, saying that regulators should be trained to focus on "the bell curves between the extreme cases," and that risk analyses should be transparent about the data on which they are based and how conclusions were reached. Fox and Marsh agreed that spectrum interference cases could be greatly clarified by probabilistic analysis, and that because advocates in such cases tend to describe risks in extremes, they should have to back up their claims with engineering rationale.

Speakers

Session 1: Risk Analysis in Engineering and Public Policy

Paul Fischbeck (keynote speaker)
Professor, Social and Decision Sciences, Engineering and Public Policy
Carnegie Mellon University

Tom Power (moderator)
Senior Vice President and General Counsel
CTIA-The Wireless Association

William Boyd
Associate Professor of Law
University of Colorado

Gregory Rosston
Deputy Director and Senior Fellow
Stanford Institute for Economic Policy Research (SIEPR)
Director, Public Policy Program
Stanford University

Francisco Zagmutt
Managing Partner
EpiX Analytics

Session 2: Risk-Informed Regulation

Gary Marchant (keynote speaker)
Director, ASU Center for the Study of Law, Science and Technology
Lincoln Professor Emerging Technologies, Law and Ethics
Arizona State University

Anna Gomez (moderator)
Partner
Wiley Rein LLP

Susan Fox
Vice President for Government Relations
The Walt Disney Company

Shawn Jackman
Founder and Chief Executive Officer
Clinical Mobility

Giulia McHenry
Former Senior Associate**,** The Brattle Group
Currently Chief Economist, NTIA

Session 3: Risk Analysis in Spectrum Policy

Julius Knapp (keynote speaker)
Chief, Office of Engineering and Technology
Federal Communications Commission

Rob Alderfer (moderator)
Vice President of Technology Policy
CableLabs

Joan Marsh
Vice President Federal Regulatory
AT&T

Peter Tenhula
Deputy Associate Administrator for Spectrum Management
National Telecommunications and Information Administration (NTIA)

Robert Weller
Vice President of Spectrum Policy
National Association of Broadcasters