# Risk-informed interference assessment

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**Summary:** Quantitative risk assessment can complement worst case interference analysis and lead to more intensive coexistence of radio systems.

Should a spectrum manager allow a new radio service if it might introduce interference to an existing service? This question is at the heart of spectrum regulation. It has traditionally been answered by doing a worst case analysis that can lead to overly-conservative decisions. There is an alternative, though: risk-informed interference assessment.

Quantitative risk assessment has been used in other regulated industries for decades but has not yet been applied to spectrum management. A working group of the FCC's Technological Advisory Council (TAC) examined the potential of risk-informed interference assessment last year, and recently published a paper on the topic (see references; I was a member of that working group). This column note the state of play and sketches the way ahead.

## Worst case analysis vs. quantitative risk assessment

A worst case analysis considers the single scenario with the most severe consequence, regardless of its likelihood. However, there are many kinds of radio interference, and their impacts vary. A common but moderate effect may be more problematic overall than the worst case. Selecting a single value of a single interference mode—typically a worst case—doesn't represent reality accurately and can lead to false confidence that the resulting rules has averted any harm. For example, the rulemaking in the early 2000's to protect GPS from ancillary terrestrial transmissions in an adjacent band focused on out-of-band emissions, and the risk of adjacent band interference wasn't realized until a decade later when LightSquared's deployment loomed.

A worst case approach is intrinsically conservative; it leads easily to rules that limit the benefits of new services while giving incumbents more protection than they need.

This approach made sense when spectrum rights were not in such great demand. It is not tenable when high value services have to be packed in more tightly.

There are exceptions where a conservative approach remains appropriate, such as services where interruption is absolutely unacceptable and spectrum protection is the only way to guarantee it. (Every incumbent will argue that it belongs in this category.)

In engineering practice, risk is often defined as the combination of likelihood and consequence for multiple hazards, known as the risk triplet: What can go wrong? How likely is it? What are the consequences? By contrast, a worst case analysis focuses on a single scenario with very severe consequences, regardless of its likelihood.

In general, the purpose of risk assessment is to provide evidence-based information and analysis that can inform decisions on how to deal with risks and choose between options. In spectrum management, the risk is that of harmful interference and the selection is between various possible service rules (including the option of not allowing a new service at all). Applying this technique to spectrum yields risk-informed interference assessment.

## Quantitative risk assessment in other regulated industries

Quantitative risk assessment has been used around the world for decades in regulated industries from finance to food safety, including cases where safety of life is paramount:

- In 1967, Reg Farmer of the U.K. Atomic Energy Authority advanced the idea of probabilistic risk assessment for nuclear reactor safety analyses. The U.S. Nuclear Regulatory Commission adopted quantitative risk assessment in the Seventies. Its 1995 policy statement on probabilistic risk assessment (PRA) encouraged greater use of this technique to improve safety decision-making and regulatory efficiency, and in 2009 it published guidance on the use of PRA to support licensee requests for changes to plant licenses.

- The U.S. Environmental Protection Agency (EPA) uses risk assessment to characterize the nature and magnitude of health risks from chemical contaminants and other environmental stressors. The EPA first issued a cancer risk assessment in 1976, followed by a series of guidelines based on a 1983 risk assessment paradigm developed by the U.S. National Academy of Sciences. Risk assessment practices are now well established at the agency and are widely used for public and environmental health protection.

- The U.S. Food and Drug Administration (FDA) uses risk analysis to ensure that regulatory decisions about foods are science-based and transparent. It has developed FDA-iRisk, a publicly accessible online tool to estimate the health burden of microbial and chemical hazards in food.

Risk assessment methods are also used by other U.S. government agencies and departments including the Offices of Management and Budget and Science and Technology Policy; the Departments of Homeland Security, Health and Human Services, and Transport; and the Federal Aviation Administration, NASA and Occupational Safety & Health Administration.

## A three step method for risk-informed interference assessment

The FCC TAC spectrum & receivers working group has suggested a three step method for analyzing radio interference hazards: (1) make an inventory of all significant harmful interference hazard modes; (2) define a consequence metric to characterize the severity of hazards; (3) assess the likelihood and consequence of each hazard mode, and aggregate them to inform decision making.

Making an inventory of all interference hazard modes (co-channel, out-of-band and adjacent channel interference, intermodulation, etc.) is straightforward, and has been described in industry documents such as IEEE 1900.2.

Selecting a consequence metric is more challenging since there are many plausible candidates, while decision makers prefer to focus on a few at a time. Possibilities include RF metrics like interference-to-noise and carrier-to-interference ratios; service metrics like unavailability or throughput degradation; and organizational metrics like profitability or mission success.

Once hazards and metrics have been defined, the likelihood-consequence profile for each hazard can be calculated by using Monte Carlo methods, and then aggregated into a risk assessment that combines low likelihood/high impact risks like malicious jamming with high likelihood/low impact ones like an increase in the noise floor.

## The way forward

Achieving widespread use of risk-informed interference analysis will take time, not only to work through spectrum-specific technical issues but also to shift the management culture from worst case to a risk-informed world view.

Regulators can get the ball moving by using quantitative risk assessment in their own work and publishing the analyses and results; and by piloting risk-informed interference assessment in site-specific license waiver proceedings or assignment requests. Operators can help regulators—and their own bottom lines—by applying risk assessment to their own spectrum allocation and technology deployment questions.

There's no need to start with headline-grabbing initiatives; limited applications will build expertise and confidence. However, the sooner we start applying these methods, the sooner society and industry will reap the benefits of more intensive spectrum coexistence. In other words: *Start small, but start soon.*

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