SPECTRUM USAGE MONITORING SYSTEM (SUMS)

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ABSTRACT

DoD T&E and Training ranges are under pressure from two sides: externally to share or vacate RF spectrum to make it available for commercial purposes, and internally to increase that usage to support more missions per day, and more data per mission. To appropriately respond to these pressures, the DoD CIO developed the DoD Electromagnetic Spectrum Roadmap and Action Plan. A key recommendation from that plan is to develop a spectrum usage monitoring program at T&E and training ranges. SUMS is being developed in response to that recommendation.

The primary objective of SUMS is to give individual T&E and training ranges, as well as the DoD CIO and other senior DoD leadership, a comprehensive picture of spectrum usage at those ranges. This will enable them to make intelligent decisions about spectrum use, and also give them the tools needed to defend current and future spectrum allocations, or to plan cooperative spectrum sharing with non-Federal users.

This paper will describe the need for a capability like SUMS, some of the challenges of developing SUMS, its overall architecture, and some of the benefits we expect the DoD to realize when SUMS is fully implemented and deployed.

INTRODUCTION

To support a wide variety of mission goals, Department of Defense (DoD) Test and Evaluation (T&E) and training ranges have an ever-expanding need to communicate data between Test Articles (TAs) and systems on the ground. For safety of flight purposes as well as overall mission effectiveness, much of this data must be conveyed in real time, which requires the use of RF spectrum that has been allocated to those ranges. But commercial interests also have an ever-increasing need to use this same spectrum in ways that benefit the public and are willing to pay handsomely for it. Thus, the DoD has incentives to use its assigned spectrum efficiently not only to maximize benefit to test programs but also to justify the need for those spectrum allocations. In some cases, there is an opportunity to share spectrum with commercial interests.

The growing need for T&E ranges to use increasingly more RF spectrum comes from two sources: ranges are attempting to perform more missions per day and more TA data is available to be transmitted for each mission. The additional TA data is generated by more complex TAs that include both improved sensors and a greater number of sensors. These trends show no signs of decreasing in the future.

A first step in ensuring that these allocations are being used efficiently is to measure actual spectrum use. Existing spectrum management systems primarily measure planned usage, without determining how much of that planned usage actually occurred. In fact, the Range Commanders Council (RCC) Frequency Management Group (FMG) document, "Spectrum Management Metrics Standards" (FMG 707-14) [1], defines "Use" as "Denial to Others". While this is a useful definition for the purposes of that document, it ignores any difference between usage that was planned and that which was actually used. Another important step is to document unmet needs for spectrum. In other words, capturing how much *additional* spectrum is required to most effectively support the DoD mission, and the benefits to T&E ranges if this additional spectrum were available.

CHANGES OVER TIME

When wireless telemetry started in the 1920s, only a few measurements could be sent, at a slow rate, and the process was very unreliable. Werner von Braun once claimed that it was more useful to watch the rocket through binoculars. Since then, the number of measurements and the rate at which they are measured have grown exponentially. Transmitting more measurements, and transmitting them more often, requires an increasing amount of RF spectrum. At the same time, commercial use of RF spectrum has also skyrocketed. These two forces compete for the limited amount of spectrum that is available for everyone. In recent years the DoD T&E ranges have lost some of the spectrum that had been allocated to them, in favor of commercial interests that were able to pay tens of billions of dollars for the use of that spectrum.

Ongoing research and development into spectrum efficient technologies and network telemetry are leading to tools and techniques that make better use of the available spectrum, including more efficient encoding of measurements, dynamic configuration of airborne instrumentation, and radios capable of aggregating non-adjacent frequency bands. Two-way communication and improved computing capacity onboard TAs have enabled real-time selection of which data will be transmitted and how often it will be transmitted [2]. These capabilities can increase the amount of useful data that can be transmitted to ground in real time, while reducing the amount of bandwidth dedicated to data less critical to safety and real time analysis. But each of these techniques will only go so far. There is a real need for T&E ranges to understand how the spectrum they have available is being used, to better allocate their spectrum between the missions that are requesting to use that spectrum, and also to assure legislatures and other government entities that they are making efficient use of that spectrum.

UNDERSTANDING SPECTRUM USAGE

T&E ranges must understand their spectrum usage on both short and long time scales. For short time scales, on the order of minutes or seconds, knowing how spectrum is used could allow systems that can change their frequency assignment to move to different frequency bands, to allow systems that are not as agile the use of their previous bands. That type of automatic frequency shifting is rare today, but could be more common if instantaneous spectrum usage information were readily accessible.

For long time scales, on the order of days, months, and years, knowing how spectrum is used can guide mission planning and execution as well as either defending existing frequency allocations or cooperating with other government or commercial entities in the use of those allocations. Each of these is addressed in the following paragraphs.

Mission Planning: While several systems exist to aid T&E ranges in planning for missions, they only look at planned usage, not actual usage. But if actual usage is not measured or considered, mission planners are only working with partial information, and so they risk suboptimal planning.

Defending Existing Frequency Allocations: As has already been discussed, RF spectrum that has been allocated to T&E ranges is a very valuable asset, both to the ranges themselves and to other government and commercial interests. Being able to show metrics highlighting how existing allocations are being used, and being used efficiently, would enable the ranges to more successfully defend the need for those allocations.

Cooperating with Other Government or Commercial Entities: Under some conditions, the same frequency band can be used by both the T&E range and by other Federal or commercial entities. For example, if the band in question is only needed occasionally by each organization, it may be possible to coordinate that use so that only one organization is using it at any given time. Understanding how that frequency band has been used in the past would help the range manage the details of making such a cooperative arrangement.

SYSTEM DESIGN

To measure actual usage, SUMS must aggregate data from various sources. These sources will include Range Instrumentation, such as telemetry receivers; Frequency Monitoring Systems, such as dedicated RF receivers; and Scheduling, Planning, and Visualization tools, often used at ranges to plan RF spectrum usage.

Most ranges already have examples of some or all of these systems in place. One of the technical challenges of the effort lies in integrating spectrum usage information from these myriad sources without interfering with the primary mission of those respective systems. Additional sources of actual spectrum usage information such as from dedicated RF monitoring equipment will also be used to support the SUMS system.

Data from each of these systems will need to be sent to a central database server, stored there, and then processed to produce the outputs described in the next section. A nominal configuration at a typical range will include the data sources mentioned previously, a database server, and systems for configuration and control as well as data analysis.

OUTPUTS

The primary outputs of SUMS will be reports, which can be automatically produced according to a schedule or manually on demand. These will include:

<u>Periodic Reports</u>: Traditional periodic reports will be automatically generated according to a predetermined schedule and automatically delivered electronically to a predetermined distribution list. It will also be possible to have two distribution lists: one to which draft reports are transmitted, and a second one to which reports are transmitted only following approval by the responsible person(s). Reports will also be automatically archived on the Data Servers and will be easily retrievable by report type, date, and any other desirable criteria.

<u>Interactive Reports</u>: Some reports can be requested interactively by selecting the report type and applicable parameters on an electronic form. If desired, the access to various reports may be controlled on a user basis (i.e. not every user may have access to all reports), or location basis. The available technology supports requesting interactive reports from any browser connected to the network by a user with the proper credentials.

<u>Real-Time Reports</u>: The range's SUMS servers may be programmed to maintain a real-time display of predetermined information. Each time the server receives predetermined new data, the server will run a predetermined analysis of the data and update the real-time display. Alternatively, or in addition to these real-time displays, the result of the analysis may trigger the transmission of appropriate messages (such as emails, IM, or SMS, depending on network connectivity) to preconfigured users.

<u>Visualization</u>: For metric and spectrum usage visualization, SUMS will provide several built-in chart formats including pie, line, area, bubble, scatter, and bar. In addition, users will be able to develop custom charts or use third party libraries that provide other forms of data visualization such as 3-D surface plot implementations.

CHALLENGES

We expect there to be several challenges that we will need to overcome during the development of SUMS. Some of these are technical, and others are nontechnical.

In addition to the challenges that are encountered in every software project, such as algorithm selection, database schema design, and user interface design, the development of SUMS will engender less common challenges, such as:

- Multiple system interfaces: SUMS must interface with many different systems on the range, all of which have unique interfaces, and ultimately, SUMS must operate at different ranges, each with its own architecture.

- Non-intrusive access: SUMS interface to the range instrumentation receive chain must not interfere with or slow down range operations.

- Data correlation challenges: With data being ingested from multiple, heterogeneous systems, SUMS must attempt to correlate records of the same spectrum events acquired through these different systems. Since each legacy system maintains its own internal representation of the spectrum event with different identification markers, correlation of data from these different sources may be challenging. Once correlated, data must be captured in a common format.

- Real-time data distribution: Real-time distribution will be important if SUMS is to function as a dynamic frequency management tool. The challenge of real-time distribution is added to the challenge of crossing multiple network boundaries inherent in the architecture of most ranges.

BENEFITS

The main benefit of SUMS is that local range frequency managers will have a more robust picture of spectrum usage, a picture which is both broad in scope but also with enough detail to fine-tune spectrum usage plans. SUMS-generated planned usage versus actual usage reports will help identify areas where mission participants thought they would use certain frequencies, but for whatever reason ended up not using them. A direct product of these reports should be more efficient planning of future missions.

The selection of reports, visualizations, and real-time displays available from SUMS will give local range frequency managers the tools they need to make optimal decisions for mission planning. They can characterize how often RF frequencies in the range's spectrum allocation are being used, and indications of modulation and encoding techniques will indicate how efficiently those frequencies are being used. Finally, by indicating when certain frequencies are being used, these reports can support efforts to share spectrum with other Federal or commercial entities.

In addition to the longer timeframe reports, by monitoring frequency usage on a short-term (seconds or minutes) basis, and providing that data to the range, SUMS can enable frequency-agile RF equipment to be used optimally, changing frequencies in response to real-time events as they happen.

CONCLUSION

The DoD must better understand the use of RF spectrum at T&E ranges, and at the same time optimize its use of that spectrum. The spectrum usage data collected by SUMS can be used to substantiate that the ranges are using their allocated spectrum efficiently in order to better manage its existing allocations, and to take advantage of opportunities to share that spectrum with other government or commercial entities. By leveraging existing information sources, and by taking advantage of some new ones, SUMS can provide the tools to make that understanding possible. By collecting and distributing spectrum usage information in real time, SUMS can also enable RF hardware to make the best use of available allocations as the RF environment changes.

REFERENCES

[1] Range Commanders Council Frequency Management Group, “Spectrum Management Metrics Standards”, Document 707-14, April 2014

[2] Reinwald, Carl, “Telemetry Data on Demand – The Key to Understanding the Telemetry Network Revolution”, paper submitted to ITC 2018