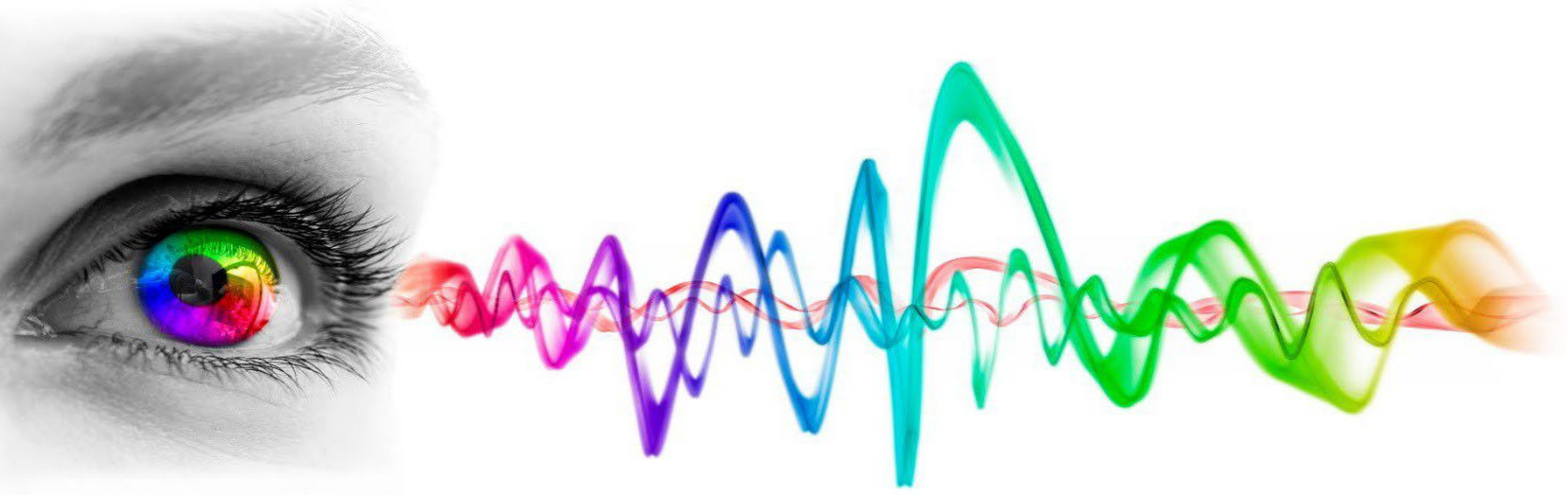
Development of National Spectrum Strategy
Request for Comment (RFC) 230308-0068

Department of Commerce /
National Telecommunications and Information Administration

Attn: John Alden



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Executive Summary

Protecting and facilitating optimal use of Electromagnetic Spectrum (EMS) resources is integral to both the national security and the economy of the United States. Internationally, dominance of the Electromagnetic Spectrum is the key element of maintaining lines of communication and winning on the battlefield. Developing the National Spectrum Strategy for Electromagnetic Spectrum moving forward requires a plan and an approach that delivers across both domestic and international priorities while making the most optimal use of the spectrum available. The strategy must be built on a foundation of technology that is capable to deliver on the requirements of today but also adjust to the changing landscape of spectrum in the future.

Over the past two decades, the exponential growth in broadband wireless technologies experienced both within the United States and around the world has put a strain on available spectrum resources. As the Spectrum Operating Picture (SOP) has become increasingly crowded, the low hanging fruit of reorganizing frequency bands and compressing channel bandwidths to free up spectrum has been taken. The work ahead to establish a viable National Spectrum Strategy will require the establishment of a spectrum management infrastructure that is able to automate the allocation of spectrum and the assignment of frequencies based on the combination of operational capabilities, deployed technologies, and monitoring data to oversee the usage.

For this effort, LS telcom has to produced the following responses to address many of the key questions and requests made in the RFC document. The information provided and the systems and technology described can be leveraged as the baseline for the NTIA National Spectrum Strategy moving forward.

LS telcom US, a RadioSoft Operation, is the dba of RadioSoft Inc. We have offices in Maryland and Georgia, and are a wholly owned subsidiary of LS telcom AG headquartered in Lichtenau, Germany. LS telcom AG has been listed on the German stock exchange since 2001. LS telcom operates with global subsidiaries and affiliates. For over thirty years, LS telcom has been a worldwide provider of integrated, scalable, automated Spectrum Management solutions and strategic consulting services for radio spectrum management and radio spectrum monitoring. Our system solutions (SPECTRA and OBSERVER) comply with global ITU standards and integrate regional and national coordination agreements.

Included below is our response to the *Development of a National Spectrum Strategy Request for Comment (RFC)*. We ahave responded to Pillar one and Pillar three questions as well as have included the brochure for mySPECTRA, the LS OBSERVER and the full suite of directly relevant spectrum services provided by LS telcom.

The LS telecom team recommends that as NTIA sets its National Spectrum Strategy that it consider the benefits of leveraging an existing, proven spectrum management product that can dramatically reduce risk in the implementation, both domestically as well as in support of deployments of resources around the world. mySPECTRA is an ideal starting point to build the foundation for the National Spectrum Strategy to come.

We look forward to potential further discussions with NTIA to provide input for the development

of a National Spectrum Strategy, as well as to demonstrate to the Government team the proven automation of mySPECTRA for spectrum sharing, as well as supporting NTIA's efforts to implement a robust, dynamic, autonomous solution.

Introduction

Pillar #1—A Spectrum Pipeline To Ensure U.S. Leadership in Spectrum-Based Technologies

1. What are projected future spectrum requirements of the services or missions of concern to you in the short (less than 3 years), medium (3–6 years) and long (7–10 years) term? What are the spectrum requirements for next generation networks and emerging technologies and standards under development (e.g., 5G Advanced, 6G, Wi-Fi 8)? Are there additional or different requirements you can identify as needed to support future government capabilities? What are the use cases and anticipated high-level technical specifications (e.g., power, target data rates) that drive these requirements? How much, if at all, should our strategy by informed by work being performed within recognized standards-setting bodies (e.g., 3GPP, IEEE), international agencies (e.g., ITU), and non-U.S. regulators or policymakers (e.g., the European Union)? What relationship (if any) should our strategy have to the work of these entities? Are there spectrum bands supporting legacy technology (e.g., 3G, GSM, CDMA, etc.) that can be repurposed to support newer technologies for federal or non-federal use?

>> LS telcom Response 230417 – Both current and future of technology point to every increasing requirements for efficiency of utilization and optimized reuse and re-farming of spectrum resources as technologies are introduced and older technology generations sunset and ultimately rotate out of required capabilities. What is most important in this evolution of spectrum requirements is that the foundation is established today to support not just the current generation of usage and sharing but the management of transition, new sharing regimes as well as the introduction of new technologies and frequency bands. The optimization of the use of spectrum resources moving forward is imperative as the pace of technology evolution and transition increases.

With this in mind the implementation of configurable Spectrum Management such as LS telcom's mySPECTRA delivers automation and consistency to the frequency allocation process that must be a foundational requirement for any National Spectrum Strategy that is established. The mere implementation of automation can produce a tangible spectrum dividend through the consistency of process, optimization of assignment and the monitoring of use. Current processes supporting weeks or months for requests or demands for exclusive licenses for low use spectrum resources must be reviewed for potential optimization and can be transitioned to automated and dynamic procedures that increase efficiency and consistency thereby increasing the availability of spectrum resources.

Additionally, it is imperative that the next generation spectrum management processes be configurable and changeable based on the changing spectrum requirements. When driven by business process and technical analysis that is configurable, changed to processes to introduce

optimization, or new allocation methods can easily be implemented without software modification. Additionally, the configurations can be implemented based on user group, spectrum band, radio zone location, and time.

2. Describe why the amount of spectrum now available will be insufficient to deliver current or future services or capabilities of concern to stakeholders. We are particularly interested in any information on the utilization of existing spectrum resources (including in historically underserved or disconnected communities such as rural areas and Tribal lands) or technical specifications for minimum bandwidths for future services or capabilities. As discussed in greater detail in Pillar #3, are there options available for increasing spectrum access in addition to or instead of repurposing spectrum (i.e., improving the technological capabilities of deployed systems, increasing or improving infrastructure build outs)?

>> LS telcom Response 230417 – In review of the insatiable market appetite for spectrum, and operating as a resource that will always be limited, the ideal approach for the optimization of its use is to identify where process improvements can be made to current systems to produce a dividend. Reviewing the current spectrum operating picture and the frequency licensing processes, there is an immediate opportunity to gain access to additional spectrum resources through the implementation of basic automation. The foundation of a system like LS telcom's mySPECTRA that delivers consistency for both business process and technical analysis alone will show an immediate dividend of available resources. As these processes are further enhanced with spectrum utilization data, additional spectrum can be identified between usage periods that can become tangible spectrum resources to be used.

3. What spectrum bands should be studied for potential repurposing for the services or missions of interest or concern to you over the short, medium, and long term? Why should opening or expanding access to those bands be a national priority. For each band identified, what are some anticipated concerns? Are there spectrum access models (e.g., low-power unlicensed, dynamic sharing) that would either expedite the timeline or streamline the process for repurposing the band?

>> LS telcom Response 230417 – Spectrum Bands that are currently exclusively licensed should be reviewed to determine the benefits of automating the frequency licensing process. When timing, location, user, technology, and frequency band can be accurately represented through configured steps of an automated process, in most cases a tighter tolerance can be implemented resulting in a spectrum dividend that can be used by additional users without impacting the current usage of the exclusive license holder. By factoring in the different parameters, usage zones and other demarcation points can be established that do not compromise the usage requirements of the current licensee.

4. What factors should be considered in identifying spectrum for the pipeline? Should the Strategy promote diverse spectrum access opportunities including widespread, intensive, and low-cost access to spectrum-based services for consumers? Should the Strategy promote next-generation products and services in historically underserved or disconnected communities such as rural areas and Tribal lands? Should the Strategy prioritize for repurposing spectrum bands that are internationally harmonized and that can lead to economies of scale in network equipment and devices? How should the Strategy balance these goals with factors such as potential transition costs for a given band or the availability of alternative spectrum resources for incumbent users? How should the Strategy balance these goals against critical government missions? How should the Strategy assess efficient spectrum use and the potential for sharing? What is an ideal timeline framework suitable for identifying and repurposing spectrum in order to be responsive to rapid changes in technology, from introduction of a pipeline to actual deployment of systems?

>> LS telcom Response 230417 – As stated in the previous response, with the proper foundation of spectrum management automation in place, bands with exclusive licensing access (that do not impact national security) should be reviewed to determine the benefit of automating the spectrum allocation process. Concerning the harmonization with international bands, LS telcom has dealt with this extensively in cross border coordination. The automated processes can be configured to accommodate harmonization as well as automate the processing of any different allocation regimes between each side of the border. As an example, LS telcom's mySPECTRA system was able to automate the entire US-Canadian frequency allocations for ISED (Canadian regulator) across frequency band, service, location, equipment type, and user group taking what was a months long process to minutes.

5. Spectrum access underpins cutting edge technology that serves important national purposes and government missions. Are there changes the government should make to its current spectrum management processes to better promote important national goals in the short, medium, and long term without jeopardizing current government missions?

>> LS telcom Response 230417 – Configurable automation is key to the spectrum management processes moving forward. The implementation of changes to the current processes cannot be accomplished with siloed systems that are not compatible or applicable across frequency band, service, user group, location, and technology. Additionally, the system must accommodate the multiple levels of spectrum management from the business process through to the technical analysis and factor in the impact of the current allocation.

The mySPECTRA platform provides the necessary foundation for the automation of the spectrum management process. With configurable business process and technical analysis, a spectrum management procedure can be configured to accommodate the specific circumstances (location, user, technology, etc).

6. For purposes of the Strategy, we propose to define ''spectrum sharing'' as optimized utilization of a band of spectrum by two or more users that includes shared use in frequency, time, and/or location domains, which can be static or dynamic. To implement the most effective sharing arrangement, in some situations incumbent users may need to vacate, compress or repack some portion of their systems or current use to enable optimum utilization while ensuring no harmful interference is caused among the spectrum users. Is this how spectrum sharing would be defined? If not, please provide a definition or principles that define spectrum sharing. What technologies, innovations or processes are currently available to facilitate spectrum sharing as it should be defined? What additional research and development may be required to advance potential new spectrum sharing models or regimes, who should conduct such research and development, and how should it be funded?

>> LS telcom Response 230417 – To address the overarching question of dealing with the existing technology baseline, a new approach to spectrum management must be implemented. The current efforts to implement sharing have focused exotic allocation algorithms based on the needs and requirements of the incumbents and then the allocation of the spectrum to the "new" users. While there have been a few workable solutions implemented, these are stove pipe implementations driven by the specific requirements and not based on a general approach that can be applied across frequency bands, services, or different incumbent users. A change in the spectrum management system to allow the implement automation through configurable business processes and technical analysis across services, frequency bands, user groups, locations, and time is the logical approach.

The implementation of allocated spectrum licensing processes can deliver an immediate dividend. Through configurable business process and technical analysis, efficiencies of utilization and allocation can be realized. Additionally, with the incorporation of spectrum utilization information, automated processes can leverage the usage patterns to further optimize frequency assignments.

7. What are the use cases, benefits, and hinderances of each of the following spectrum access approaches: exclusive-use licensing; predefined sharing (static or predefined sharing of locations, frequency, time); and dynamic sharing (real-time or near realtime access, often with secondary use rights)? Are these approaches mutually exclusive (i.e., under what circumstances could a non-federal, exclusive-use licensee in a band share with government users, from a nonfederal user point of view)? Have previous efforts to facilitate sharing, whether statically or dynamically, proven successful in promoting more intensive spectrum use while protecting incumbents? Please provide ideas or techniques for how to identify the potential for and protect against interference that incumbents in adjacent bands may experience when repurposing spectrum.

>> LS telcom Response 230417 – The allocation of spectrum for services will be a mixture of licensing regimes. While some may be applicable on a nationwide basis, there are a number of frequency allocations that can be optimized on a regional basis. Regarding the protection from

interference, this requires multiple capabilities starting with the ability to calculate technical analysis for frequency allocations across services based on current allocations and their operational characteristics and also must include the ability to calculate across services to determine any cumulative impacts to other spectrum.

8. What incentives or policies may encourage or facilitate the pursuit of more robust federal and non-federal spectrum sharing arrangements, including in mid-band and other high priority/demand spectrum? For example, does the current process for reimbursement of relocation or sharing costs adequately incentivize the study or analysis of spectrum frequencies for potential repurposing? Are there market-based, system-performance

based or other approaches that would make it easier for federal agencies to share or make spectrum available while maintaining federal missions? At the same time, what mechanisms should be considered to meet some of the current and future federal mission requirements by enabling new spectrum access opportunities in non-federal bands, including on an ''as needed'' or opportunistic basis?

>> LS telcom Response 230417 – One avenue that can be pursued to open the sharing spigot is the ability for the federal user to monetize the spectrum over time through temporary licensing through a defined sharing regime. Rather than an all or nothing reallocation or repack to a condensed area of licensed use for a one-time payment, the ability to have a recurring use model that can be monetized over time and changed/modified (through configurable automated business processes and technical analysis) provides a new level of flexibility in use that opens access to spectrum for non-federal users without the federal user giving up the use of the frequencies. Additionally, further to the previous question raised on how to prepare for the future spectrum needs and allocation, federal spectrum that is monetized based on a part time usage by non-federal users, also opens the possibility for the federal use to change (though configuration) in the future to support either an increase federal usage or an increase or change in the availability of the spectrum for non-federal use to increase the monetization.

9. How do allocations and varying spectrum access and governance models in the U.S. compare with actions in other nations, especially those vying to lead in terrestrial and space-based communications and technologies? How should the U.S. think about international harmonization and allocation disparities in developing the National Spectrum Strategy?

>> LS telcom Response 230417 – While the harmonization of spectrum use can have benefit on a global scale in the use of equipment and technology, the coordination at the borders through automated spectrum management processes can produce an immediate spectrum dividend and savings in time for the allocation of border frequencies.

Looking at where spectrum can be optimized with the international community, there are prime examples of a spectrum dividend at the border. The US and Canada share a border that is governed bv hundreds of agreements, rules, and regulations that dictate the frequency licensing on each side of the border across spectrum and services. The cross-border coordination is a process that takes months and many times numerous application attempts to gain approval. This is a situation where automation can take a process from months to minutes.

Pillar #3—Unprecedented Spectrum Access and Management Through Technology Development

1. What innovations and next generation capabilities for spectrum management models (including both licensed and unlicensed) are being explored today and are expected in the future to expand and improve spectrum access (and what are the anticipated timelines for delivery)?

>> LS telcom Response 230417 – The key to the National Spectrum Strategy is to establish a baseline system that can support the size, scale, and scope of a national regulator requirements. Siloed solutions that solve a single band or technology do not provide the mySPECTRA system is being implemented at most regulators around the world to provide the baseline for automation. With integrated business process and technical analysis that both work through configuration, the foundation for automation is in place. As spectrum needs and requirements change with a band or technology, the configuration of the allocation model either at the

2. What policies should the National Spectrum Strategy identify to enable development of new and innovative uses of spectrum?

>> LS telcom Response 230417 – The key to the path forward is automation. Without automated processing of spectrum allocations, the policies and procedures of the NTIA will remain antiquated.

3. What role, if any, should the government play in promoting research into, investment in, and development of technological advancements in spectrum management, spectrum dependent technologies, and infrastructure? What role, if any, should the government play in participating in standards development, supporting the use of network architectures, and promoting tools such as artificial intelligence and machine learning for spectrum coordination or interference protections? What technologies are available to ensure appropriate interference protection for incumbents in adjacent bands? What spectrum management capabilities/tools would enable advanced modeling and more robust and quicker implementation of spectrum sharing that satisfies the needs of non-federal interests while maintaining the spectrum access necessary to satisfy current and future mission requirements and operations of federal entities? How can data collection capabilities or other resources, such as testbeds, be leveraged (including those on Tribal lands and with Tribal governments)?

>> LS telcom Response 230417 – The government, as the regulator, should provide a leadership role in the implementation of not only the spectrum management policies but also in the implementation of the business processes and technical analysis. By leveraging a platform like mySPECTRA that provides these capabilities through configuration not software modification, the government is in a position to change system policies, procedures, and sharing mechanism as technology evolves.

4. NTIA is pursuing a time-based spectrum sharing solution called the incumbent informing capability (IIC) to support spectrum sharing between federal and non-federal users. What are some recommendations for developing an enduring, scalable mechanism for managing shared spectrum access using the IIC or other similar mechanism, with the goal of increasing the efficiency of spectrum use? What challenges do nonfederal users foresee with potentially having limited access to classified or other sensitive data on federal spectrum uses and operations as part of the IIC or similar capabilities, and what recommendations do users have for ways to mitigate these challenges? What are the costs and complexities associated with automating information on spectrum use?

>> LS telcom Response 230417 – If the NTIA implements a system with configurable business processes and technical analysis, the implementation of sharing mechanisms can be tuned to provide optimal performance. This type of system can promote implementations based on user groups, locations, coverage vectors, time, and frequency band. With a system like mySPECTRA, the foundational elements of the system (configurable business process and technical analysis) provide the baseline to support numerous sharing mechanisms from the same platform.

Additionally, the mySPECTRA system supports charging mechanisms that can be used for alternate methods of sharing. If there are changes in the current rules and regulations to support NTIA charging for spectrum sharing, this can open a new federal revenue stream to assist in financing the spectrum management efforts.

5. What other technologies and methodologies are currently being, or should be, researched and pursued that innovate in real-time dynamic spectrum sharing, particularly technologies that may not rely on databases?

>> LS telcom Response 230417 – Real time spectrum monitoring can provide key input for the decision mechanism. By incorporating real time measurements that define the usage patterns of the spectrum, automated allocation processes can be optimized to allocate frequencies. The mySPECTRA system allows for technical analysis that accounts for usage information and allocates frequencies based on the usage patterns and other access rights.

LS telcom
Smart Spectrum Solutions

Unleashing the Full Potential of Your Radio Spectrum

Global Spectrum Experience

Spectrum Regulation

System solutions for spectrum management & monitoring, spectrum consulting & engineering, training

LS telcom Worldwide

LS telcom subsidiaries and offices

LS telcom provides world-leading system solutions for spectrum management and radio monitoring, spectrum consulting and capacity building services

Our solutions enable regulatory authorities and other spectrum users to manage the radio spectrum in an optimal and cost-efficient way so that everyone receives the best from communications services.

Founded in 1992, LS telcom draws upon nearly 30 years of experience in the radio communications market. Over that period, LS telcom, an ISO 9001:2015 certified company, has become a member of many industry associations and organizations and cooperates with leading technology universities. We are also an active sector member of the ITU-R and ITU-D. This ensures we are up-to-date on market and technology developments, standards and regulatory practices.

We are pushing for innovation on all fronts. We were the first company to:

- develop a fully integrated web-based e-licensing solution in spectrum management and apply professional workflow engines to automate process flows in spectrum management,
- enable direction finding and geolocation based on historical measurement data,
- apply the techniques of data mining to spectrum management and radio monitoring.

Today, regulators in over 100 countries worldwide rely on our significant investment in research and development and trust in our products, skills and experience.

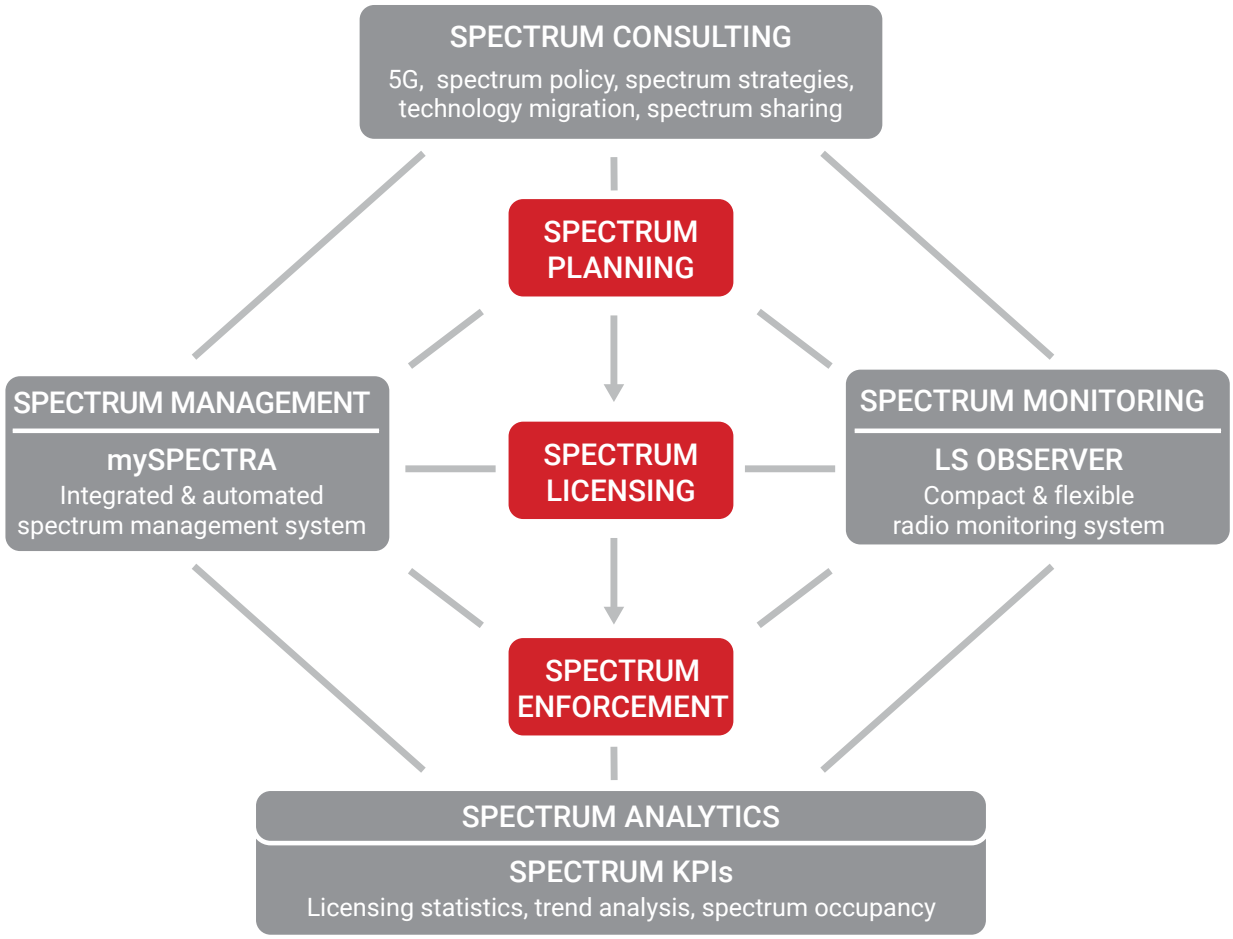
LS telcom is headquartered in Lichtenau, Germany, and operates worldwide with subsidiaries and partners on all continents.

From the right spectrum strategy to spectrum efficient operational processes

LS telcom assists all spectrum users, including government ministries and regulatory authorities, with strategic and operational spectrum management. In order to enact efficient operations in spectrum management and radio monitoring, regulators first have to define their goals for spectrum allocation, assignment methods, and pricing policy. Our consulting experts assist regulators with spectrum strategy, master planning, sector policy development and renewal, pricing, demand assessment, guideline development and technology planning.

When defining operational processes, we deliver value through integrating spectrum management and spectrum monitoring. Instead of delivering isolated solutions for spectrum management or radio monitoring, we deliver combined systems that can provide a unique view on licensed, used and under-utilized spectrum.
Monitoring data supports efficient licensing, re-farming and spectrum policy making. Spectrum management data is the basis for more precise monitoring to answer questions such as "Is the licensed spectrum really in use in a particular area?"

Spectrum management and radio monitoring systems store and handle terabytes of data, which begs the question "It's all at hand, but how do we exploit the data to its full potential?"
Our advanced techniques for data mining and analysis leverage huge volumes of spectrum data in a purposeful way. The data can be displayed in many target- and task-oriented ways, so that it can be interpreted by anyone familiar with the radio spectrum – be they management, business analysts, policy makers, engineers or administrative staff.

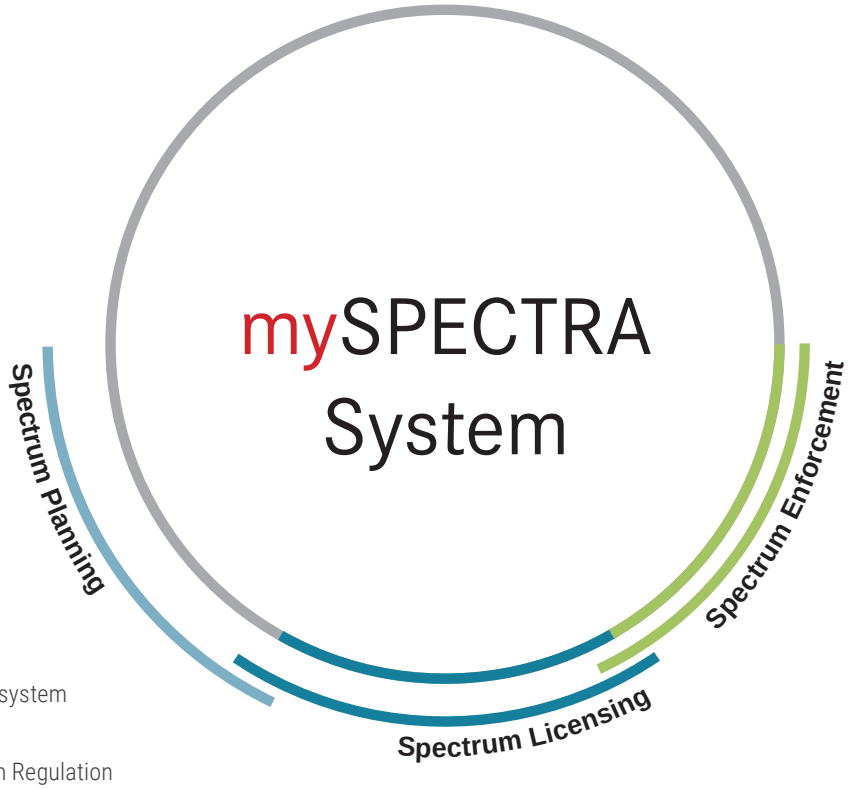


Integrated and Automated Spectrum Management System mySPECTRA

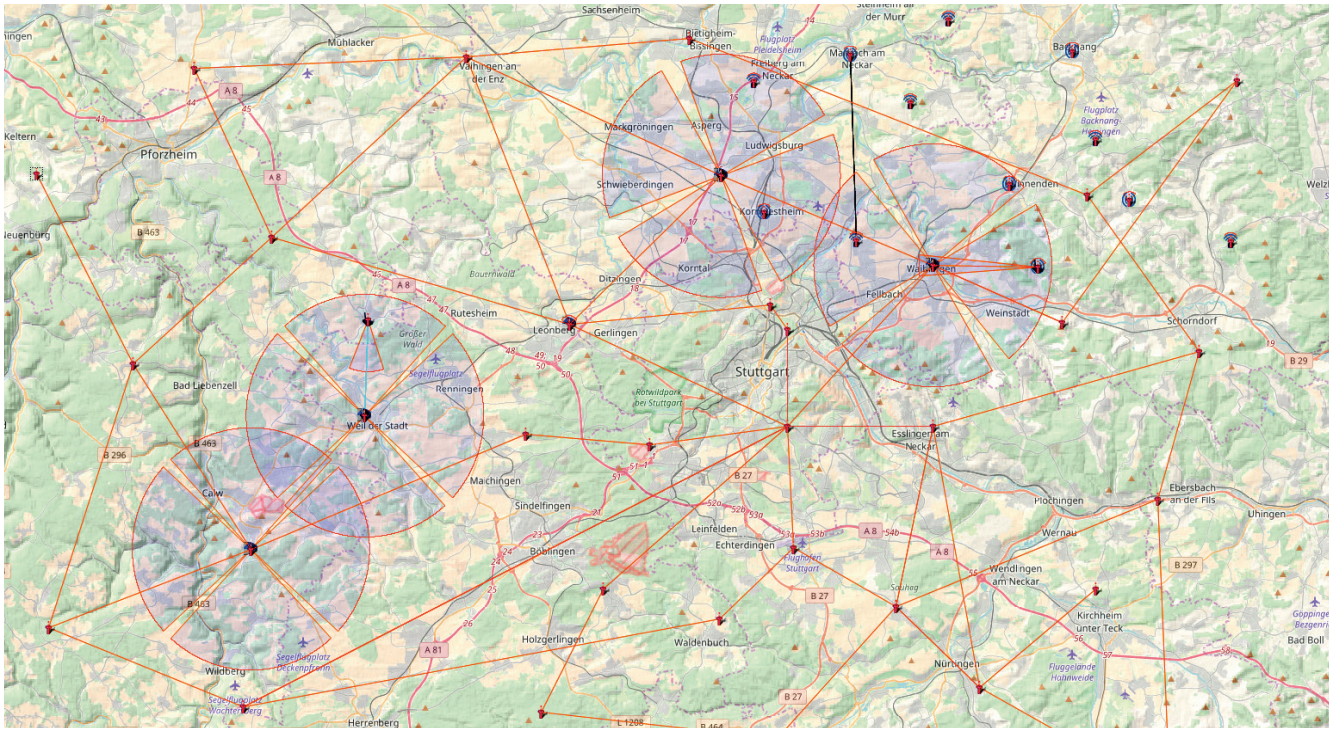
The highly innovative enterprise IT System mySPECTRA is an end-to-end spectrum planning and licensing solution based on a professional workflow engine

Its fully automated workflows guide the user through all the processes of spectrum management, from receiving applications, frequency assignment, international coordination, to issuing licenses, all the way to keeping check on the receipt of payment.

The central data repository stores the mandatory frequency and licensing information for all radio services for instant and easy access by regulatory staff.



The mySPECTRA system



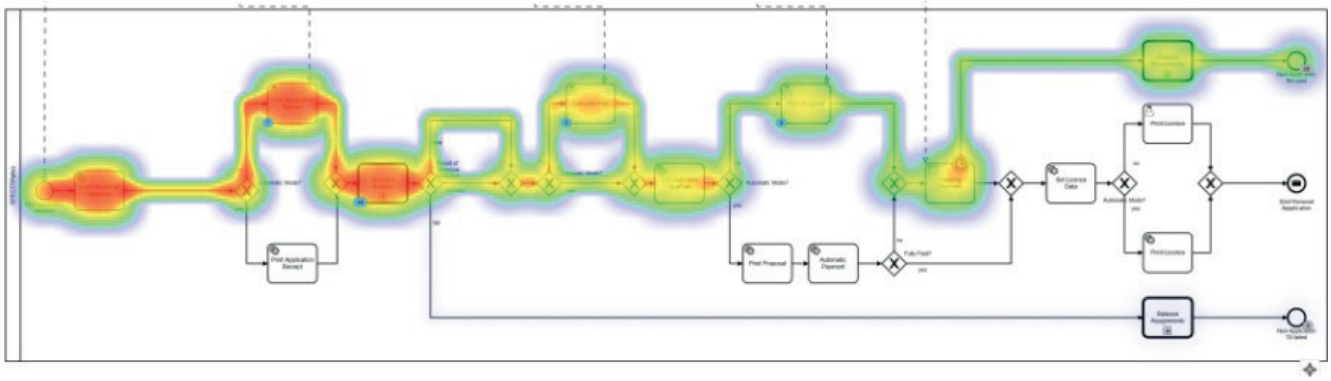
Graphical display of radio links

Regulators face continuous pressure to issue more licenses and reduce license issuing periods to a minimum, as license applicants expect prompt replies to their applications

mySPECTRA handles the increasing number of incoming applications and the associated data volumes with ease and brings structure and clarity into all spectrum management processes.

A lot of different licenses of all types of radio services follow their way through the web-based system automatically and solicit action from the user only when necessary. Workflows automate and streamline the handling of the numerous licensing products in a regulator's general service-catalog. Users are guided through complex processes to ensure consistency and compliance with national regulatory laws.

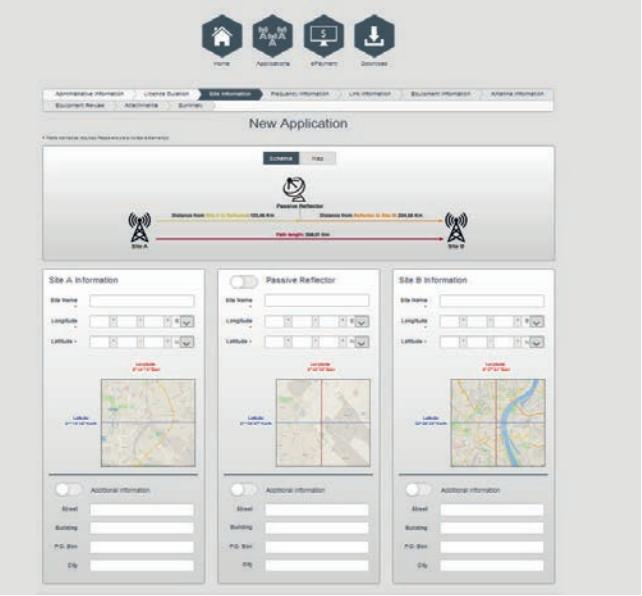
Visualization of workflows: „heatmaps" show bottlenecks in operational processes



Applicants can log in to an online license portal to trigger their license request and manage their profile and application data

They can apply for a new license, amend, renew or cancel an existing one and may view online the status of the application being processed.

Once the application (or renewal request) is submitted, it follows predefined workflows until the receipt of the license and request for payment.

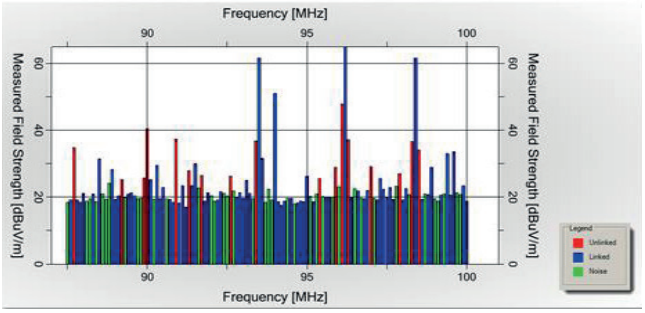


Online licensing portal

Automation of spectrum management processes

There are dedicated workflows available for administrative spectrum management processes such as application, license and invoice processing but also for technical spectrum management processes such as frequency assignment, coordination and notification processes.

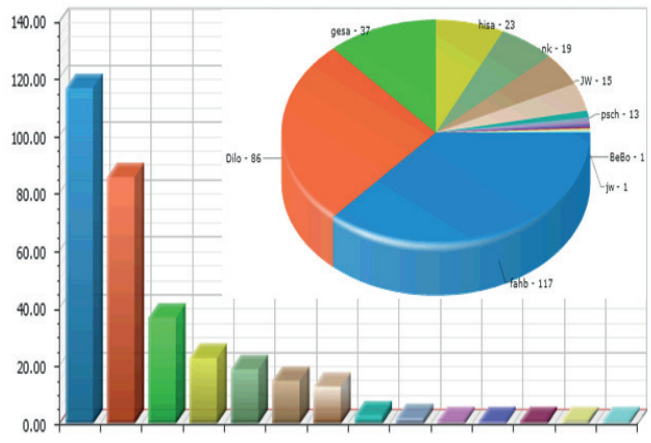
Furthermore, mySPECTRA bridges the gap between spectrum management and radio monitoring. It correlates license data with measurement data to optimize spectrum assignments.



Correlation of license and monitoring data

mySPECTRA brings regulators to the next level when it comes to data and trend analysis

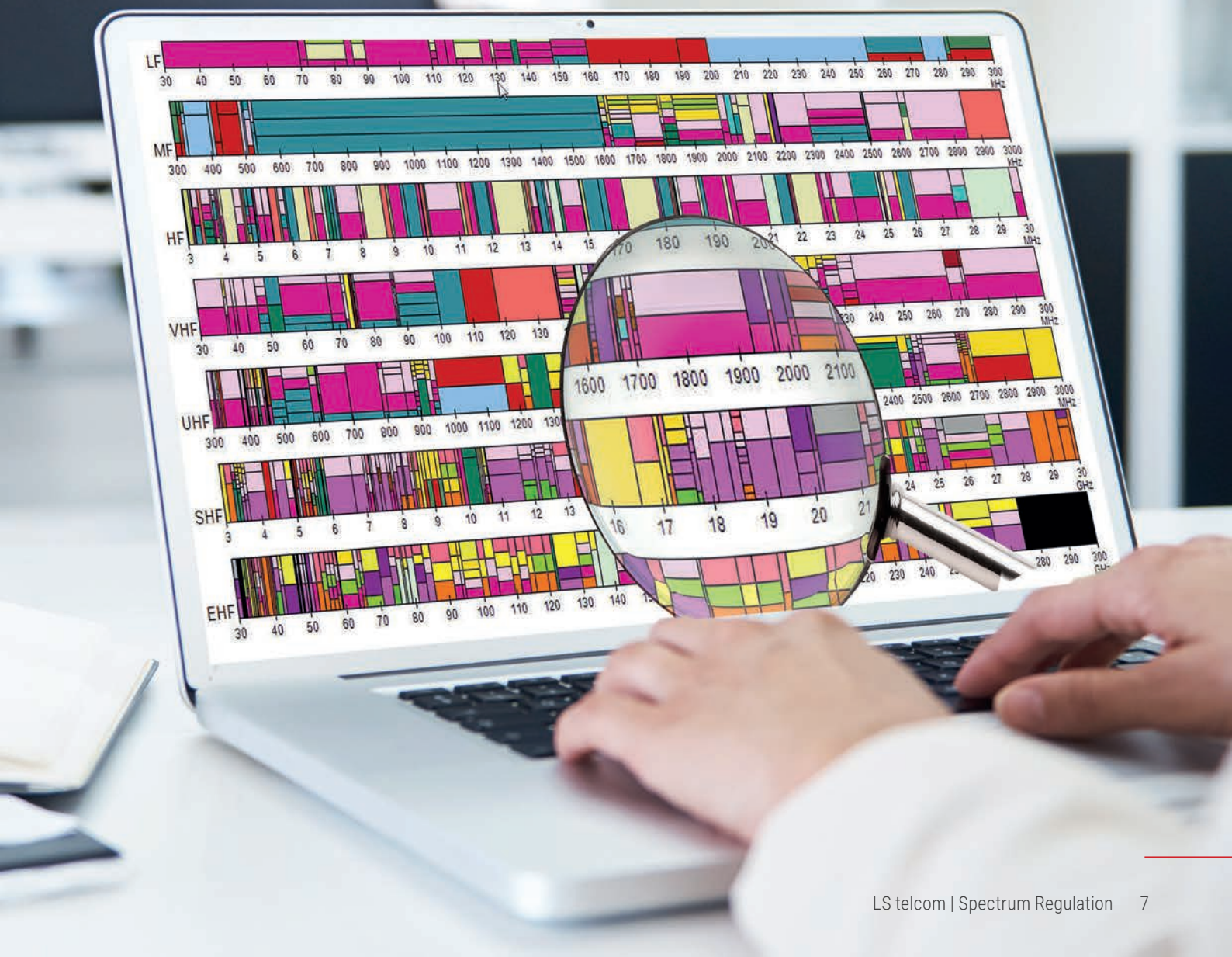
What is the number of license requests per year? How do the figures evolve over time, with the introduction of a new service? How does the licensing revenue evolve? How do I optimize fee calculations? mySPECTRA enables regulators answer these questions by configuring their reports for detailed analysis and by extracting key performance indicators (KPIs) to plan ahead.



Key performance indicators

mySPECTRA:
a host of features and benefits

- Increased user-friendliness through intuitive data entry masks and data management
- Improved data quality through data completeness and plausibility checks
- Open interfaces to ensure smooth data exchange with third party systems
- Workflow-based business processing for consistency in licensing
- Higher operational efficiency through automated frequency assignments, coordination and notification
- E-licensing platforms allowing license applicants to enter, modify or cancel their applications online
- 24/7 access to application and license data
- Spectrum analytics for improved decision making



Compact and Flexible Radio Monitoring System LS OBSERVER

Data collection, data storage & data analysis

Many regulators are dealing with policy making for 5G and IoT these days and spectrum allocation is becoming more complex. Regulators need to know now more than ever, whether the assigned spectrum is really in use and if it is used in the optimal way.

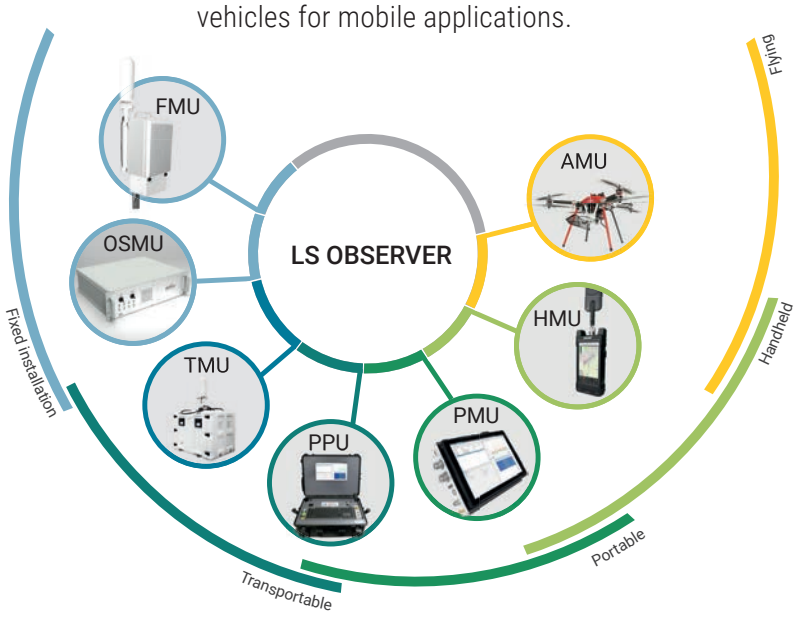
LS OBSERVER supports you in your day-to-day business and on a strategic and operational level. LS OBSERVER promptly delivers the data you need for complaint management and enforcement, and is your foundation for evidence-based regulation and policy making.

LS OBSERVER is a radio monitoring, intelligent data collection and analysis system. It features uncontested data storage capacities and several geolocation and direction finding techniques.

The LS OBSERVER system consists of the central monitoring software and various types of remote monitoring units.

The central monitoring software controls the monitoring stations and is the hub where all data strings come together. The software analyses the data from all the monitoring units and correlates the measurement data with the licensing data. Automatic violation detection, geolocation, direction finding and all other results are displayed and visualized with the software.

Each remote monitoring unit is an intelligent system, which consists of one or several receivers that can perform radio monitoring and direction finding in parallel. Each unit also includes data processing, data analysis and long-term data storage capacities. Choose from a wide array of different monitoring units, such as handheld, portable, transportable, fixed and airborne devices. Our experts can also integrate the monitoring units into vehicles for mobile applications.



Optimize frequency use and react immediately to illegal use with automatic violation detection in LS OBSERVER

Automatic violation detection software in LS OBSERVER automatically alerts the operator, when the measured signal strength does not correspond to the reference or "wanted" signal strength at a given location. The reference signal strength that should be received by a given monitoring station is either calculated based on licensed transmitters' parameters in the spectrum-licensing database, or is extracted from historic measurement data. A logbook registers all the alerts; and emails, text messages or other events can be triggered, depending on the customer's needs.

Other criteria based on power level or bandwidth can also trigger alerts. This information can also be used to correct data in the licensing database, which may lead to an optimized overall frequency re-use.

Geolocation and Direction Finding

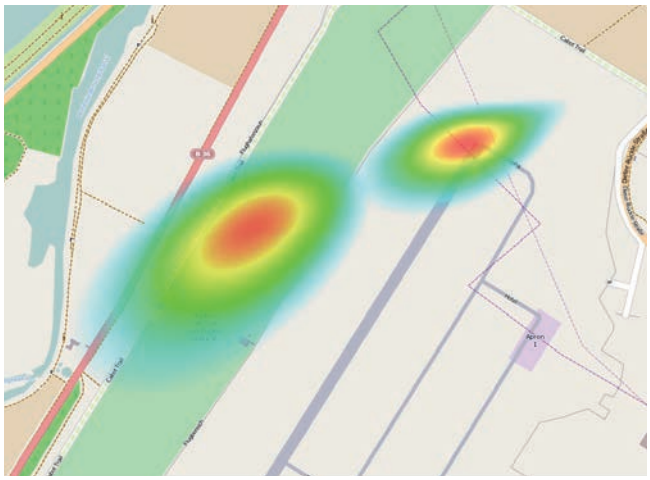
With LS OBSERVER DF Time Travel® there is no need to wait for a transmitter to go on air again in order to locate it

You receive an interference complaint that occurred an hour ago? The day before? There is nothing you can do about it now… unless you have LS OBSERVER DF Time Travel®.

DF Time Travel® is a unique technology, which enables you to locate transmitters based on recorded data. LS OBSERVER scans the radio frequency spectrum continuously and provides the required information for the unique DF Time Travel® technology. Based on the recorded frequency/level/time information, LS OBSERVER together with DF Time Travel® can determine the direction of a signal that occurred in the past. The monitoring operator simply enters the center frequency and the bandwidth of the signal to be located for a certain timeframe and is provided with the line of bearing. The system covers a much larger frequency range than other systems that provide geolocation in post-processing.

DF Time Travel® technology integrated vehicle

Cross section AoA / heatmap AoA



Multi-spot geolocation

Locate a transmitting source with even more precision by combining heatmaps based on several DF and geolocation techniques

An LS OBSERVER system containing several monitoring stations enables you to combine direction finding with geolocation. Using a hybrid direction finding approach based on both power difference of arrival (PDoA) and angle of arrival (AoA) will guarantee even better results.

Our heatmap and multispot AoA take into account reflections and the possibility of several signals being on the same channel. The overlapping of different direction finding techniques allows the consideration of both the main beam and side beams too. The joint display and visualization of beams and heatmaps provides a more accurate and more precise location of transmitting sources.

Integrate inspection processing with your monitoring units

A dedicated Inspection App for Android devices facilitates inspection processes. The inspection plan is directly loaded into the App. Inspection measurements and documentation can be entered in a highly user-friendly environment. Violations are detected and documented on the spot and send back to the central spectrum management and monitoring system.

Inspection App on a Handheld Monitoring Unit

With our unique set of intelligent monitoring hardware and software products, regulators can

- Measure the complete frequency range on a permanent or temporary basis wherever needed
- Store all the measured data and have it available whenever needed
- Identify interference and locate transmitters at any time; even when the transmitter is no longer on the air
- Analyze huge amounts of data for the purpose of spectrum re-farming, evidence-based spectrum policy making and regulation
- Visualize the data in a clear manner, understandable for everyone in the regulator's organization

Data Mining, Big Data Analysis & Data Display

SpectrumMap™ for top level strategic decision making

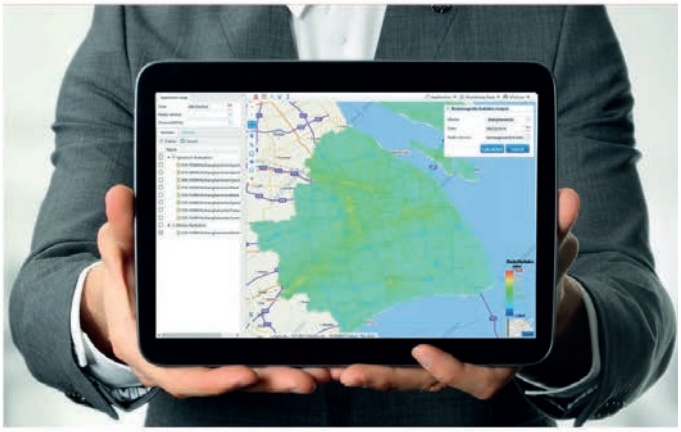
SpectrumMap™ is a cloud-based data mining and analysis system, which gathers real spectrum usage data from multiple sources, such as fixed monitoring sites, mobile, handheld and portable devices, no matter from which provider or manufacturer.

The easy to use interface allows staff not qualified as engineers such as policy makers, band planners, licensing teams, as well as skilled engineering teams, and enforcement, to use a range of analytical tools via web apps. Users can zoom in on a map and display the monitoring data in a way that makes sense to them. The data can be visualized for the area of interest by band, channel or service type.

Key applications, which are available as web apps, include:

- Field strength of single frequencies to whole bands for all users
- Selectable coverage analysis of user selectable bands
- Band occupancy
- Spectrum utilization
- Electromagnetic radiation hazard analysis
- Dynamic band analysis where the display steps through user selectable frequency steps

In contrast to conventional monitoring system control tools, SpectrumMap™ focuses on presenting the data in a geographical area rather than needing to identify monitoring sites and individually calculating the coverage of each site. The system interpolates results between measurement points for complete and accurate coverage. It offers new and exciting opportunities for regulators to take fast, effective and well-informed decisions on spectrum management.



Display of accumulated coverage measurements

Spectrum & Technology Consulting

Regulators across the world rely on our expert spectrum and technology consulting to make the right spectrum policy decisions...

...and create the most appropriate technology environments and legal frameworks for wireless services to prosper - to the benefit of everyone. Many regulators are now looking to pave the way for 5G with a sound regulatory framework. Many questions need answering: Which spectrum is, and should be made available for 5G? How will authorization for new 5G spectrum bands be made, in particular, at frequencies in the millimeter wave bands?

Regulators have to prepare for WRC-19 and beyond. Licensing options will need to go beyond the exclusive, individual rights approach, most commonly used for mobile assignments today and incorporate more spectrum sharing. Beside pricing, auctions and trading; secondary markets, licensed shared access (LSA), dynamic spectrum access (DSA) and other techniques will play an increasing role to accommodate existing spectrum users and enable new, innovative players to emerge. Many more end-user devices and different methods of interaction between devices, arising with 5G and the Internet of Things (IoT), add to the complexity of developing an efficient licensing framework.

LS telcom's consulting team guides you through the jungle of new licensing, access and connectivity methods as well as current and future technologies. We help you set up a technical and legal environment that supports national growth and greater economic efficiency.

Over the last 25 years, LS telcom has assisted over 100 regulators across the world with policy making, capacity building, spectrum strategy and planning, technology studies and spectrum inventories.

LS telcom is already assisting governments and regulators with developing their spectrum policy and regulations towards 5G. For example, we have assisted the UK government with a report on 5G infrastructure requirements, and undertook a project that examined approaches to spectrum assignment in the EU with a view to enabling the future availability of 5G. As a member of the UK's 5G Innovation Centre (at the University of Surrey), we are at the leading edge of 5G developments.

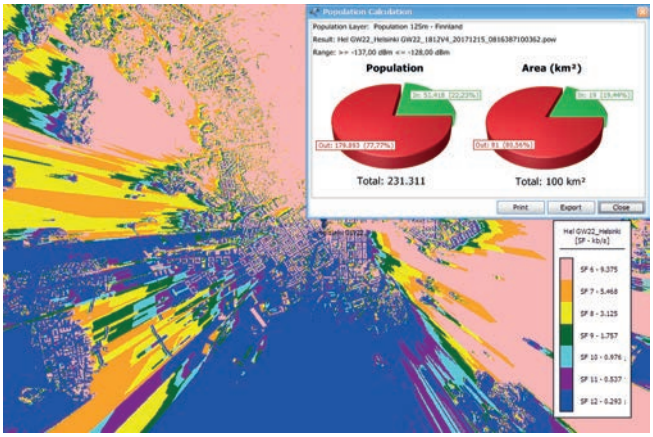
While the drive for spectrum efficiency is global, the answers and solutions for efficient spectrum use vary from country to country. As a member of the ITU, we have unrivalled visibility of global developments and at the same time, we draw upon our huge "case-by-case" experience having worked with numerous regulators on all continents.

LS telcom's consultants and radio engineers assist regulators with:

- Sector policy development and renewal (telecoms, broadcasting, transport, government, utilities)
- Spectrum strategy, policy, master planning and guidelines
- Spectrum planning, re-planning and re-farming (including key bands such as 600 and 700 MHz and 3.5 GHz)
- Implementation of spectrum pricing and use of economic tools
- Assessment of spectrum supply and demand
- Spectrum and technology developments (5G, IoT and M2M, white spaces, cognitive radio)
- Technical analysis of wireless networks and network planning
- Spectrum audits and inventory
- Technology migration (DVB-T to DVB-T2, analog to digital, 3G to 4G)
- Technical sharing, spectrum re-farming and compatibility analysis
- Training and capacity building

Spectrum engineering

Technical issues remain at the heart of efficient spectrum management. Assessing coverage, compatibility and co-existence whether between national or cross-border services is essential to avoid harmful interference. More and more users are looking at sharing as a way to retain their spectrum allocations whilst encouraging new and efficient uses. But sharing brings increased risk of interference. LS telcom has always been at the forefront of spectrum technology and our technical experts routinely solve complex engineering problems; analyze, plan and optimize networks; and model costs, capacity and coverage. Our radio engineers have a vast experience of working with regulators in countries across all regions and continents.



Coverage analysis assessing population and area covered

LS Training Academy

We offer an enormous range of training courses designed for regulators and spectrum users on topics including spectrum management and radio monitoring technologies as well as spectrum regulation and policy.

Our courses address professionals at all skill levels and seniorities, whether technical, managerial, administrative or engineering.

In addition to our standard courses, we offer customized training as well as complete capacity building programs tailored to the needs of your organization. From a training needs analysis to the design and delivery of bespoke courses, LS telcom can ensure that your organization is fit and ready to tackle the increasingly complex issues of spectrum management today.


Home of the LS Training Academcy

Trust in

30

years of know-how and experience

ITU-R

and

ITU-D

sector member

An

ISO 9001:2015

certified company

System solutions and consulting services for

- Spectrum management
- Licensed shared access
- Radio monitoring
- Geolocation and direction finding
- Radio network planning and optimization

Customers in more than

100

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