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DIGITAL TRANSFORMATGION IN THE MANAGEMENT AND MONITORING OF THE RADIO SPECTRUM

(Item on the Agenda: 3.3)

(Document submitted by TES AMERICA)

Impact on the sector:

The incorporation of cutting-edge technologies from the fourth industrial revolution poses a paradigm shift in the management and enforcement of the radio spectrum. Such technologies include cloud computing, edge computing, the use of compact digital receivers that perform continuous monitoring and generate large volumes of data on spectrum occupancy, machine learning, and artificial intelligence. Additionally, software as a service (SaaS) mode adds to this transformation. These innovations facilitate more effective and rapid decision-making, at lower costs, and with simple implementation.

Executive Summary:

An efficient spectrum management system is essential for economic development, technological innovation, access to communication services, and improving the quality of life in every country. It helps maximize the use of a limited resource and builds a robust and competent communication infrastructure.

In this regard, the consolidation of the TES Monitor Planning® (TMP) suite with a modular, web-responsive structure focused on information for action and tailored for non-expert users becomes an important alternative to modernize and/or enhance existing spectrum management and monitoring systems. It improves cost-effectiveness, and it's easy and quick to implement and use.

This approach can bring significant benefits to the administrations of the member countries of the Inter-American Telecommunication Commission (CITEL). Furthermore, these approaches and experiences can provide valuable contributions to the work of Study Group 1 on Spectrum Management of the Radiocommunication Sector of the International Telecommunication Union (ITU), which could be reflected in future versions of National Spectrum Management and Monitoring Handbooks.

Objective

To present the benefits that the administrations of Colombia, El Salvador, and Uruguay have obtained through the adoption and integration of 4.0 technologies and the software as a service model, resulting in increased capabilities and versatility, ensuring the security, confidentiality, and integrity of information, accommodating new approaches that significantly improve spectrum management practices and may be useful to CITEL member administrations.

Background:

Given its ethereal nature, the radio frequency spectrum is difficult for political sectors and the general public to interpret. For the agencies involved and experts, it has been complex to convey its importance as a scarce and strategic national resource that requires special attention and efficient management. Additionally, for developing countries and emerging economies, the following challenges arise:

- **Limited number of experts**: Most developing countries and emerging economies have a limited number of experts, making it difficult to establish and maintain an efficient spectrum management system. This affects the scope of supervision, assignment, and control of frequencies for any administration. Similarly, the cost of traditional monitoring equipment has limited the number of monitoring stations available in countries with smaller budgets, leading to the proposal of using low-cost devices to support monitoring tasks (ITU-R Recommendation SM.2039-0 and ITU-R Report SM.2355-2).

- **Inherent complexity:** Traditional management and monitoring solutions deployed in most countries in the region have required a significant amount of time for implementation, on average two to three years. They are complex and not easily updated due to the new investments they require. For monitoring systems, national coverage is limited by the costs of fixed-type ITU stations, and it is also necessary for the personnel involved to have specific training on the acquired platforms, limiting their exploitation and widespread use.

- **Regulation and legal framework:** The absence of a clear and competent legal framework for spectrum management can hinder its efficiency. Lack of adequate regulation can lead to difficulties in enforcing regulations, which can result in interference between telecommunications services and conflicts in the assignment of the radio frequency spectrum.

- **Unauthorized spectrum use:** In most cases, poor frequency control and monitoring lead to interference between different communication services, caused among other reasons by unauthorized emissions that illegally use the spectrum or fail to comply with authorized technical parameters. This has been equated to the same impact as a cyber-attack, as it can block communications in the worst cases and, in more common cases, affect the quality of services and limit the capacity to meet the growing demand for communications.

- **Lack of coordination among government entities:** Spectrum management often involves multiple government entities, such as telecommunications agencies, regulators, planning authorities, and entities that use the spectrum for non-commercial purposes (aeronautical, maritime, scientific). The lack of platforms that facilitate coordination and collaboration between these entities can hinder the coherent implementation of a spectrum management system.

- **Political and economic factors:** In some cases, decisions about spectrum allocation may be influenced by political and economic pressures. If the spectrum management system is not robust or transparent, frequencies may be allocated that negatively affect efficiency and equity in spectrum use.

• **Rapid technological changes:** The rapid evolution of communication technologies makes it difficult and complex for administrations to keep up with changes. It also makes it even more challenging to keep their systems updated and effectively adapt their spectrum management policies and regulations.

Technologies used to overcome the challenges presented.

The challenges in spectrum management and monitoring are addressed through a combination of technology, collaboration, regulation, and education, with the aim of ensuring optimal and sustainable use of this vital resource. Below is a description of the model developed and the technologies used.

Intelligent Algorithms

In line with the recommendation to improve efficiency in spectrum management, in the management, and enforcement model an intelligent layer has been added, it simplifies tasks using Software Robots (RPA's) for complex and repetitive analysis. This allows for automation and simplification of decisions for spectrum assignment and/or enforcement using intelligent algorithms without the need for constant intervention by an expert operator. With the use of these capabilities, a greater number of professionals are efficiently enabled for planning, spectrum assignment and enforcement, allowing for better management, in line with the quality-of-service objectives established in the ITU's National Spectrum Management and Monitoring Handbooks.

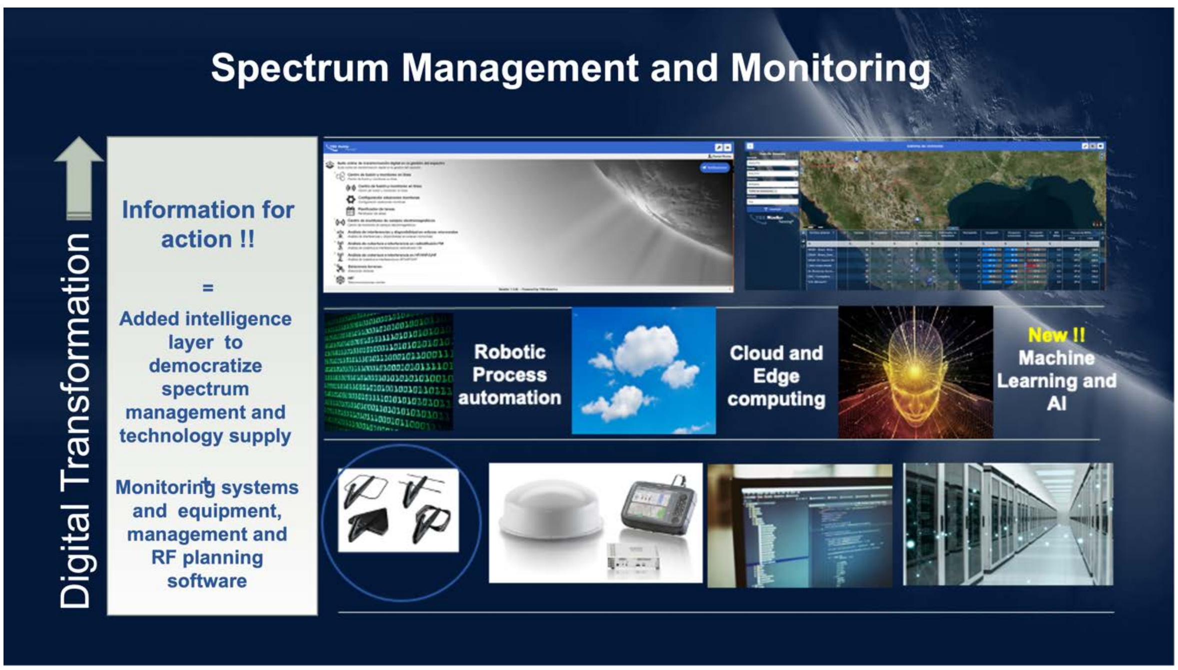


Illustration 1. Management Model Using 4.0 Technologies

Cloud Computing:

The operation of the cloud solution fosters collaboration and coordination among stakeholders by providing access from a web browser, with no user limits, all accessing a single repository of information, with high standards of security and availability. It follows recommendations for flexibility and adaptability for easy customization by country. The adoption of these technologies reduces infrastructure costs (CAPEX) and IT personnel costs (OPEX), improves accessibility, provides a better user experience by experiencing shorter response times, and facilitates interconnection between different governmental and regulatory entities.

Compact Digital Receivers and Energy Efficiency:

Aligned with the global push for sustainability, compact digital monitoring sensors are utilized, prioritizing the continuous monitoring of high-demand services like FM, TV, and IMT within the VHF & UHF bands. These sensors, operating on low-cost, low-power consumption, are based on software-defined radio (SDR) architecture incorporating Digital Signal Processing (DSP). This dual approach not only slashes monitoring expenses but also enhances energy efficiency in spectrum management and monitoring infrastructures, echoing the imperative to address environmental and sustainability concerns.

Machine Learning and Artificial Intelligence (AI):

The implementation of 24/7 monitoring sensors generates large volumes of systematically organized data (Big Data) on the effective use of the radio frequency spectrum. This enables the application of data analysis techniques and machine learning in various directions. Within the implemented platform, machine learning models have been developed that have led to adaptive propagation models, which adjust and refine to identify the location of authorized and unauthorized broadcasting FM radio stations. This innovation paves the way for future work focused on the use of AI for dynamic spectrum allocation, among other possibilities that are still being explored.

Case Studies:

In alignment with the call of the ITU Handbooks to offer practical guidance, this contribution showcases the systems deployed in Colombia, Uruguay, and El Salvador as case studies. These instances demonstrate the effective adoption of cutting-edge technological trends in spectrum management, offering concrete examples that can serve as invaluable best practice references within both the National Spectrum Management and Monitoring Handbooks of the International Telecommunication Union (ITU).

TES Monitor Planning® (TMP):

TES Monitor Planning® (TMP) has been the implemented platform, comprising a suite of various modules that overcome different challenges faced by administrations and strengthen processes driving their sustainable digital transformation. The way in which the various challenges were addressed is detailed below:

Awareness:

Through the "Spectrum Occupancy Analytics and Statistics" module, the utilization of the spectrum by various services is presented in a straightforward manner. This includes the geographical distribution with the visualization of microwave links, coverage areas, and population covered by gender and age groups. It encompasses fixed services across different bands, as well as FM radio broadcasting, television, and mobile services in the VHF and UHF bands, considering the geographical and administrative segmentation of each country.

This is achieved by synchronizing the platform with the existing spectrum management system database. In case there is no updated spectrum management system with a database, existing Excel files and/or information in databases such as Access can be uploaded. Additionally, it's possible to digitize PDF files. This way, the information is unified and made visible to all stakeholders through the platform.

Through this functionality, useful information for spectrum usage planning is easily obtained. Accompanied by media outreach campaigns, it becomes possible to highlight the magnitude of authorized systems, thus emphasizing the importance of spectrum management.

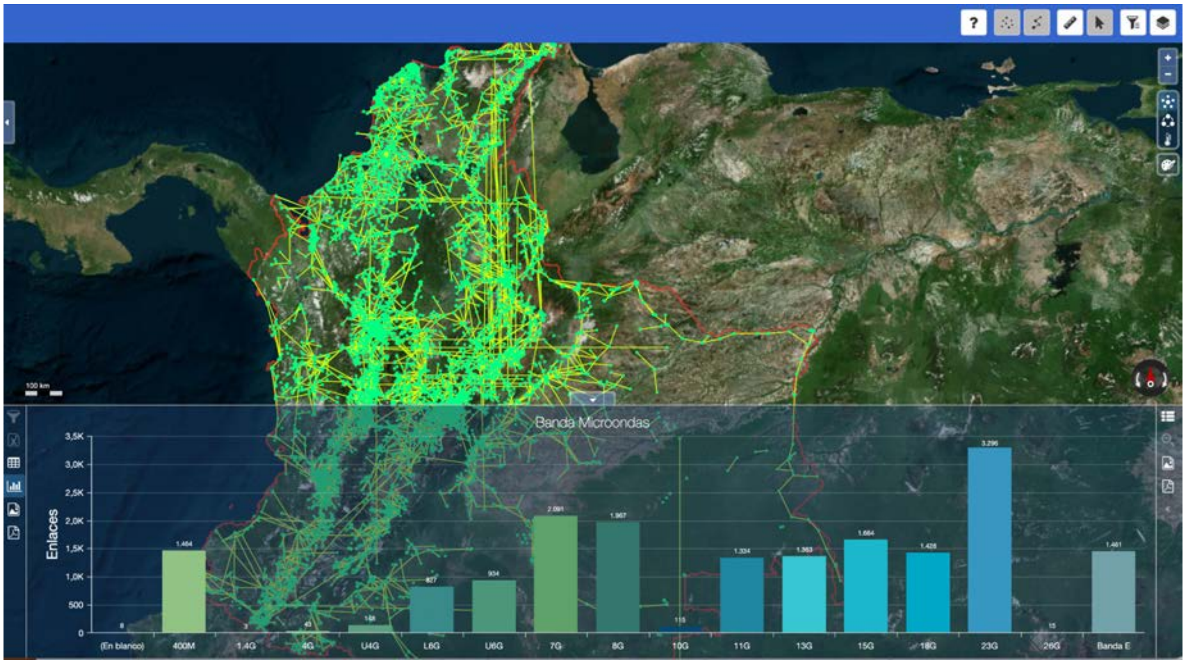


Illustration 1. Authorized microwave links in all bands[1]

***Capacidades técnicas**:*

En colaboración con los expertos de cada administración, utilizando RPAs y algoritmos inteligentes se han logrado automatizar análisis de coberturas e interferencias con solo unos clics del mouse para enlaces de Microondas, y estaciones FM, TV, e IMT en banda VHF y UHF con lo cual se logran superar las limitaciones técnicas y de recurso especializado. La interfaz intuitiva y el acceso basado en la nube de la plataforma, permite que operadores y concesionarios en general y de manera concurrente sin límite de accesos puedan realizar análisis de prefactibilidad antes de solicitar frecuencias reduciendo la carga a la administración de manera importante.

Existe un módulo para cada uno de los servicios, lo que permite una configuración modular de acuerdo a las necesidades. En las siguientes ilustraciones se presentan resultados de dichos módulos.

[1] Source: Spectrum Viewer of the National Spectrum Agency of Colombia (ANE)

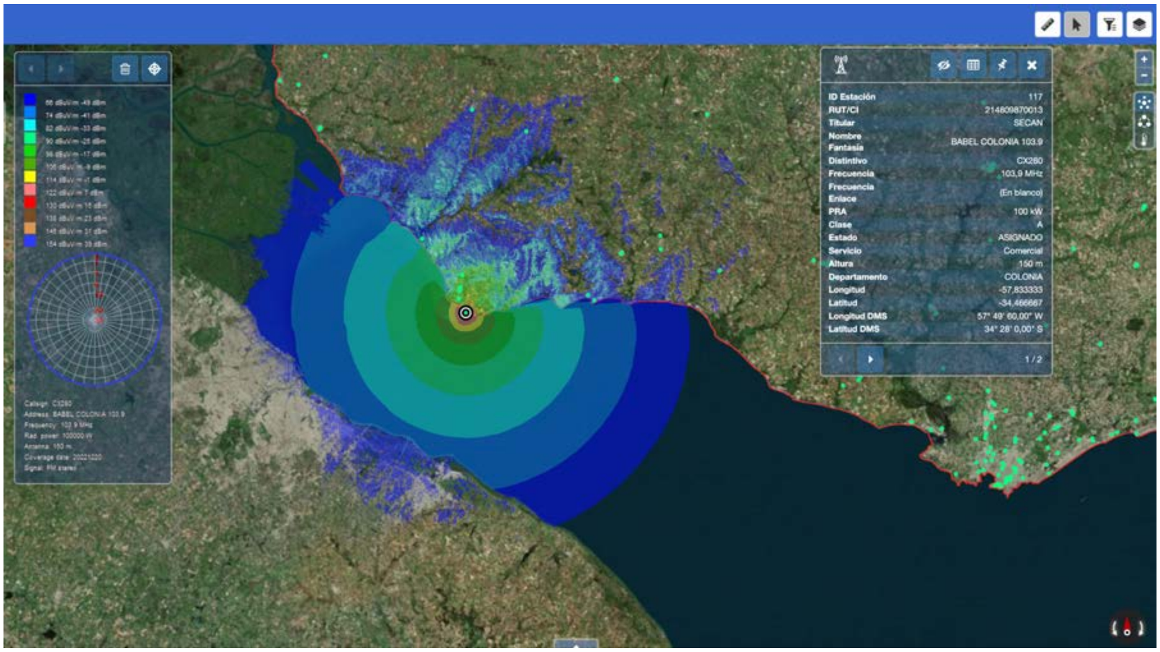


Illustration 2. FM broadcasting simulation with three clicks[2]

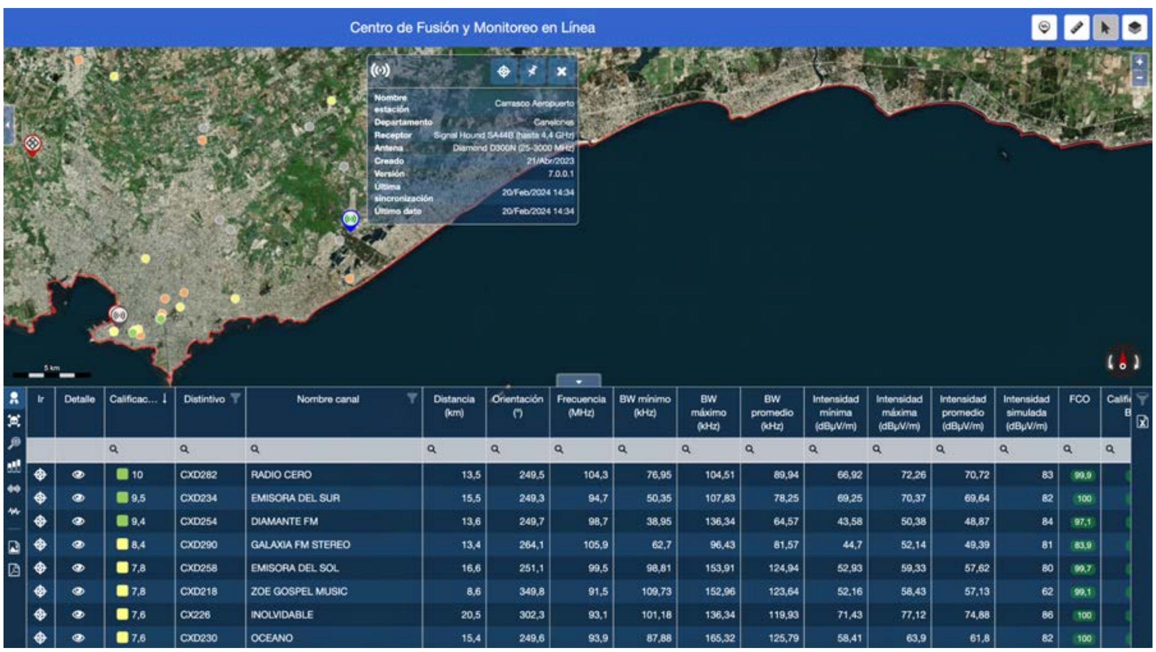


Illustration 4. Continuous Measurement of FM Broadcasting Service [3]

It is worth noting that in the case presented in the previous illustration, the sensors allow for the automatic detection of FM stations with weighted qualification.

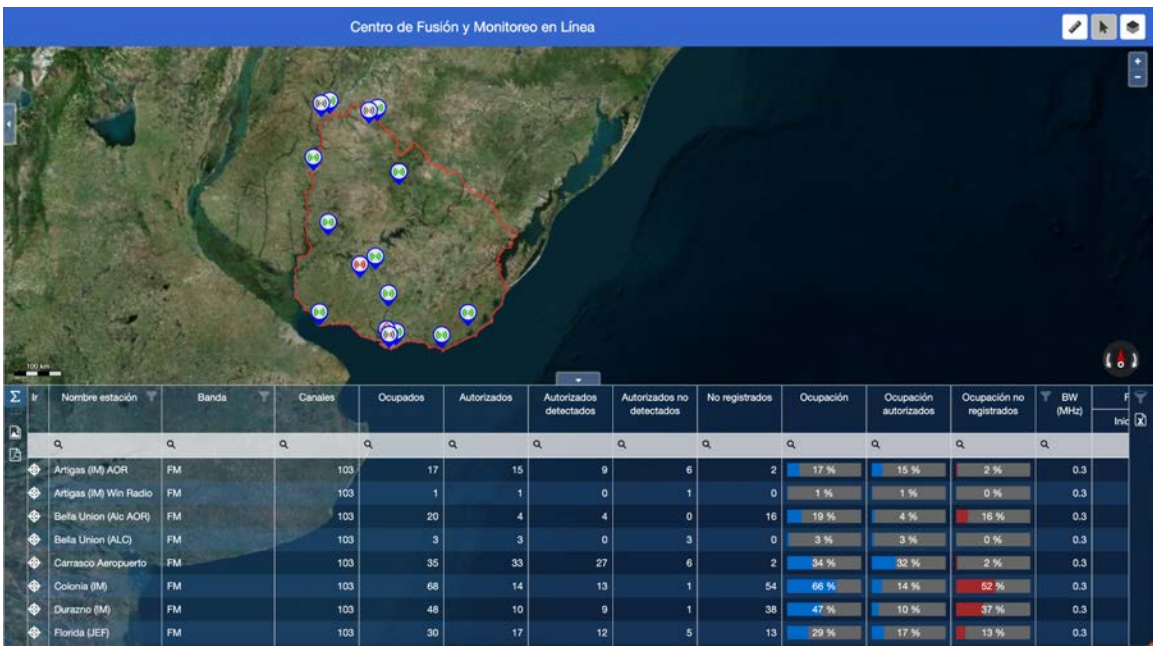
[2] Source: Spectrum Viewer of the Regulatory Unit of Communication Services (URSEC), Uruguay
[3] Source: Spectrum Viewer of the Regulatory Unit of Communication Services (URSEC), Uruguay

Much lower monitoring costs.

The monitoring module known as the Fusion and Monitoring Center (CFyM) represents the evolution of the model proposed in 2017 in contribution 4408/17 and is the realization of the new paradigm formulated in 2021 in contribution 5363/21, both presented to the CCPII of CITEL.

The CFyM enables the automatic identification of unauthorized emissions, synchronizes with existing monitoring systems, and allows for the connection of compact remote sensors that simultaneously measure FM, TV, and IMT services in the VHF & UHF bands 24/7, generating big data on spectrum occupancy in these bands. This has led to the development of adaptive propagation models using AI for emission localization.

Regardless of the manufacturer or provider of existing radio spectrum management and monitoring systems, the platform dynamically complements and updates them by adding an intelligent layer that standardizes processes, simplifies and automates analysis, and transforms the monitoring system into an open platform focused on data rather than hardware. This allows for greater network monitoring coverage.



Ir	Nombre estación	Banda	Canales	Ocupados	Autorizados	Autorizados detectados	Autorizados no detectados	No registrados	Ocupación	Ocupación autorizados	Ocupación no registrados	BW (MHz)
	Artigas (IM) AOR	FM	103	17	15	9	6	2	17 %	15 %	2 %	0.3
	Artigas (IM) Win Radio	FM	103	1	1	0	1	0	1 %	1 %	0 %	0.3
	Bella Union (Alc AOR)	FM	103	20	4	4	0	16	19 %	4 %	16 %	0.3
	Bella Union (ALC)	FM	103	3	3	0	3	0	3 %	3 %	0 %	0.3
	Carrasco Aeropuerto	FM	103	35	33	27	6	2	34 %	32 %	2 %	0.3
	Colonia (IM)	FM	103	68	14	13	1	54	66 %	14 %	52 %	0.3
	Durazno (IM)	FM	103	48	10	9	1	38	47 %	10 %	37 %	0.3
	Florida (JEF)	FM	103	30	17	12	5	13	29 %	17 %	13 %	0.3

Illustration 5. National Monitoring Network of Uruguay [4]

The presented result combines a Rohde & Schwarz station with 18 sensors from 3 different providers.

Regulation and Legal Framework

The platform adapts to both local and international regulations. By including non-wireless telecommunication infrastructure such as fiber optic nodes, digital service centers, and postal service points, among others, a National Infrastructure Integration and Visualization Center can be established. This serves as the necessary input for defining or improving regulatory frameworks that respond to the needs for bridging the digital divide and enhancing service quality. This can lead to dynamic regulation that interprets the status of national connectivity in each country.

[4] Source: Spectrum Viewer of the Regulatory Unit of Communication Services (URSEC), Uruguay

Proactive enforcement

By integrating ITU-type monitoring stations and deploying multiple compact sensors operating 24/7 with storage capacity of up to one year, spectrum occupancy can be verified by regions with traceability down to days and hours. This allows for the automatic identification of unauthorized emissions, enhancing the capacity for control and surveillance. Administrative resources can thus be focused on proactively resolving interference and unauthorized spectrum use issues, ensuring service quality.

Illustration 6. Automatic Detection of Discrepant FM broadcasting Emissions [5]

The National Monitoring Network of El Salvador integrates 19 TCI monitoring stations and over 50 sensors in the process of deployment.

Coordination Among Government Entities

The use of cloud computing and the web-based nature of the solution enables global access without user limits. By using the browser of a mobile device or laptop/desktop computer, any involved and authorized entity can access the same information, leading to automatic synchronization through data and information unification, thereby facilitating coordination.

Political and Economic Factors

With the implementation of the platform, transparent use of information from authorized systems and actual spectrum occupancy, distribution, and automatic identification of unauthorized emissions are enabled. Therefore, spectrum assignment under this framework will make equity in frequency assignments evident and visible, adhering to technical criteria and minimizing political and economic pressures.

[5] Source: General Superintendence of Electricity and Telecommunications (SIGET), El Salvador

Technological Upgradation

The Software as a Service (SAAS) model enables platform and functionality updates as part of the roadmap without additional costs to the administration, ensuring relevance with the rapid evolution of communication technologies and effectively adapting to new spectrum management policies and regulations.

Considering all the features, it can be validated that TES Monitor Planning® is a results-oriented and user-centric solution, significantly simplifying management and monitoring processes by harnessing the potential of technology to drive real digital transformation.

Real Impact

The National Spectrum Agency (ANE) of Colombia spearheaded the open data policy regarding spectrum usage, which includes the necessary technical data for interference analysis and coverage of each service. Since 2019, it has implemented the analytics and spectrum occupancy statistics module of TMP, which, in addition to visualizing all authorized services georeferenced, allows users to download information in Excel format that can be filtered by the user. Additionally, online statistics are obtained by political division, frequencies, and number of assignments.

In 2020, the microwave module was implemented, allowing an operator to upload their frequency request for up to 500 new links in Excel, and the module returns viable frequencies for each link within seconds. In subsequent years, the FM, DTT, and private VHF&UHF network modules were implemented.

In February 2024, ANE publicly shared part of the impact of adopting TMP under the name "Spectrum Viewer". [Agencia Nacional del Espectro | Noticias (ane.gov.co)]

“Assignment of radio spectrum usage permits 2024

February 14, 2024

The Ministry of ICT has issued a Call for Proposals for the Objective Selection Process granting radio spectrum usage permits for 2024. As an allied entity, the ANE has processed 16,231 link requests and 4,566 frequency requests over the past 4 years.

Bogotá, February 14, 2024. (@ANEColombia). The National Spectrum Agency (ANE) will support the Ministry of ICT in the radio spectrum assignment process in 2024. Through an Objective Selection Process (PSO), the ANE will ensure that the networks to be deployed do not interfere with existing permits.

Over the past four years, there has been a significant increase in point-to-point link requests, with 16,231 processed, marking a rise from 4 to 9 admissions annually. This enhancement has streamlined spectrum technical management, resulting in a notable reduction in processing times from "49 to 17 days.

Similarly, in the case of Coverage Systems, there has been an increase in processed frequency admissions, totaling 4,566, representing a rise from three to seven admissions per year. This improvement has led to a reduction in processing times from 44 to 36 days, indicating a more efficient acceptance of requests within the designated time frame.

One of the tools that facilitates and speeds up these tasks is **Visor de Espectro,** a web application that enables massive analysis of service areas. This allows operators to design, pre-validate their designs, request spectrum permits, and deploy their networks more quickly.

These significant actions have been carried out in coordination with the MinTIC and benefit surveillance companies, ambulances, taxis, among others, to keep their vehicles and organization members connected through coverage systems in HF, VHF, and UHF bands, and to enable mobile operators to properly interconnect their networks for microwave or point-to-point links in SHF and EHF bands.

With its experience and technological advancements, the National Spectrum Agency will support the Ministry of ICT during the technical evaluation stages following the Call for the assignment of radio spectrum usage permits in 2024. “

Asignación de permisos de uso del espectro radioeléctrico 2024

14 de Febrero de 2024

El Ministerio TIC publicó Aviso de Convocatoria para el Proceso de Selección Objetiva que otorga permisos de uso del espectro radioeléctrico para el 2024.

La ANE como Entidad aliada, ha atendido 16.231 solicitudes de enlaces y 4.566 solicitudes de frecuencias en los últimos 4 años.

Bogotá D.C., 14 de febrero de 2024. (@ANE_Colombia). La Agencia Nacional del Espectro (ANE) apoyará al Ministerio TIC, en el proceso de asignación de espectro radioeléctrico en 2024.

A través de un Proceso de Selección Objetiva (PSO), la ANE se encargará de revisar que las redes que se van a desplegar no interfieran ni sean interferidas por permisos existentes.

En los últimos cuatro años, para enlaces punto a punto, se han atendido 16,231 solicitudes, pasando de atender cuatro a nueve solicitudes por año, agilizando la gestión técnica del espectro y reduciendo los tiempos de atención de 49 a 17 días.

Por su parte, para Sistemas de Cubrimiento, se han atendido 4,566 solicitudes de frecuencias, pasando de atender tres a siete por año, y reduciendo los tiempos de atención de 44 a 36 días.

Una de las herramientas que facilita y agiliza estas labores es el Visor de Espectro, un aplicativo web que facilita el análisis masivo de áreas de servicio. De esta manera, los operadores pueden diseñar, pre-validar sus diseños, solicitar el permiso de espectro y desplegar sus redes más rápidamente.

Estas importantes acciones se han desarrollado en coordinación con el MinTIC y benefician a empresas de vigilancia, ambulancias, taxis, entre otras, para mantener comunicados sus vehículos y las personas de sus organizaciones a través de sistemas de cubrimiento en las bandas HF, VHF y UHF y para que los operadores móviles realicen adecuadamente interconexiones en sus redes para enlaces microondas o punto a punto en las bandas SHF y EHF.

Con su experiencia y avances tecnológicos, la Agencia Nacional del Espectro respaldará al Ministerio TIC durante las etapas de evaluación técnica posterior a la Convocatoria de la asignación de permisos de uso del espectro radioeléctrico 2024.

On the other hand, the General Superintendence of Electricity and Telecommunications (SIGET) of El Salvador dramatically reduced the analysis and report generation times for spectrum occupancy in the VHF & UHF bands, going from months to minutes using TMP. Additionally, advanced functions were implemented to address the requirement of integrating the occupancy results from all nationwide monitoring stations to automatically generate online reports of all assigned channels, including statistical graphs of their usage.

The online reports allow for instant visualization of assigned and unused channels for the period defined by the user. Similarly, discrepant emissions and the stations detecting them are identified, facilitating the identification and location of illegal emissions.

With this new dynamic, SIGET transitions from reactive to fully proactive and prospective enforcement, with the capability to add sensors to increase its reach and control, towards dynamic spectrum allocation.

Finally, the Regulatory Unit of Communications Services (URSEC) of Uruguay has been at the forefront of monitoring systems, as it has been using low-cost compact sensors for spectrum occupancy monitoring for over 10 years, in combination with a fixed ITU-type station. With the implementation of TMP, edge computing has been incorporated into each sensor for continuous and simultaneous monitoring of multiple services, integrating them into a single platform with the fixed ITU-type station, taking its monitoring network to the next level with the update and expansion of compact sensors.

At the request of experts, URSEC implemented the functionality of reporting the status of the sensors, which is sent by email reporting the status of each one with the periodicity decided by the administrator.

URSEC has also been a pioneer in proposing the simplification of international frequency coordination (for example, for the coordination of point-to-point radio links, IMT system base stations), for which it requested the extension of the coverage analysis area and evaluation of interference of all its services on average 300 km beyond its borders, while being able to timely assign special accesses to the Administrations with which it borders so that they can enter the platform and verify online if a potential emission causes interference to their existing networks, avoiding unnecessary procedures and giving a more efficient dynamic to international coordination.

The implementation of the platform by more countries in the region will standardize data management and automate and simplify engineering and international coordination processes, projecting de facto regional integration for real and projected visualization of spectrum usage that allows for the identification of regional uses of different bands for better decision-making in spectrum allocation and assignment.

Conclusions:

The incorporation of cutting-edge technologies from the Fourth Industrial Revolution, such as cloud computing, edge computing, the use of RPAs, compact digital receivers, machine learning leveraging large volumes of data, and Artificial Intelligence, as well as the software as a service (SAAS) and monitoring as a service (MAAS) modalities, represent a paradigm shift in the management, monitoring, and enforcement of the radio frequency spectrum, facilitating informed decision-making more effectively, quickly, at lower costs, and with simple implementation.

These solutions are being adopted by CITEL member administrations, and their implementation will increase over time due to the advantages they offer. Therefore, administrations are encouraged to explore and consider implementing functional pilots of the platform to validate its functionalities and the impact they have. Additionally, it is an efficient and low-cost solution for spectrum management, which also simplifies international frequency coordination without compromising compliance with all applicable technical requirements and standards.

We believe this new approach will offer valuable insights for refining the ITU National Spectrum Management and Monitoring Handbooks, contributing to their ongoing evolution and enhancement.

Acknowledgements

TES Monitor Planning® (TMP) is the result of joint work and cooperation with the administrations of Colombia, Uruguay, and El Salvador, stemming from nearly two decades of work and learning through participation in both the CITEL CCPII and regional workshops and conferences of the ITU, and from the insights gained at world radio communication conferences.

Special recognition goes to Diana Paola Morales Mora from ANE and her team, Hector Bude, Leslie Green from URSEC and their teams, and Carlos Valle, Rafael Arbizu from SIGET and their respective work teams.

We highlight the joint work carried out for over a decade with ICESI University (Colombia), under the leadership of Mr. Andrés Navarro and his research group. Their invaluable contribution has been fundamental in the development of prototypes for both sensors and the conceptualization of the fusion center. Similarly, we emphasize the fruitful collaboration with Pontifical Bolivarian University (Colombia), led by Leonardo Betancur and his research team, who have significantly contributed to the development of specialized competencies in analytics, machine learning, and AI.

It is important to note that some of these collaborations have led to contributions to the CITEL CCPII, underscoring the relevance of dynamic participation by the academic sector in CITEL's efforts.

We acknowledge the presentation spaces and advice provided by Mr. Oscar León, Executive Director of CITEL, and his entire team. Likewise, great recognition goes to colleagues from the ITU Radiocommunication Bureau, particularly to its director, Mr. Mario Maniewicz, Mr. Sergio Buonomo, Mr. Philippe Aubineau, and Mr. Joaquin Restrepo, who have provided valuable insights and recommendations within Study Group 1.

Finally, we acknowledge the effort and dedication of TES America and its entire team in achieving autonomously the development and realization of the platform and its functionalities.

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ITU Recommendations compliance

TES Monitor Planning® (TMP) is aligned with the best practices established by the ITU and takes a quantum leap in simplifying engineering analysis and unauthorized emissions detection. TMP complies with the following recommendations:

RADIO PROPAGATION SIMULATIONS		
UIT-R* RECOMENDATIONS		
P.525-4	(08/2019)	Calculation of free-space attenuation Note - This version of the Recommendation is incorporated by reference in the Radio Regulations.
P.526-15	(10/2019)	Propagation by diffraction Note - This version of the Recommendation is incorporated by reference in the Radio Regulations.
P.530-18	(09/2021)	Propagation data and prediction methods required for the design of terrestrial line-of-sight systems
P.838-3	(03/2005)	Specific attenuation model for rain for use in prediction methods Note - This version of the Recommendation is incorporated by reference in the Radio Regulations.
P.1546-6	(08/2019)	Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4 000 MHz

ASSIGNMENT		
UIT-R* RECOMENDATIONS		
F.382-8	(04/2006)	Radio-frequency channel arrangements for fixed wireless systems operating in the 2 and 4 GHz bands
F.383-10	(02/2021)	Radio-frequency channel arrangements for high-capacity fixed wireless systems operating in the lower 6 GHz (5 925 to 6 425 MHz) band
F.384-11	(03/2012)	Radio-frequency channel arrangements for medium- and high- capacity digital fixed wireless systems operating in the the 6 425-7 125 MHz band
F.385-10	(03/2012)	Radio-frequency channel arrangements for fixed wireless systems operating in the 7 110-7 900 MHz band
F.386-9	(02/2013)	Radio-frequency channel arrangements for fixed wireless systems operating in the 8 GHz (7 725 to 8 500 MHz) band
F.387-13	(11/2019)	Radio-frequency channel arrangements for fixed wireless systems operating in the 10.7-11.7 GHz band
F.497-7	(09/2007)	Radio-frequency channel arrangements for fixed wireless systems operating in the 13 GHz (12.75-13.25 GHz) frequency band
F.595-11	(02/2022)	Radio-frequency channel arrangements for fixed wireless systems operating in the 17.7-19.7 GHz frequency band
F.635-7	(02/2013)	Radio-frequency channel arrangements based on a homogeneous pattern for fixed wireless systems operating in the 4 GHz (3 400-4 200 MHz) band
F.636-5	(11/2019)	Radio-frequency channel arrangements for fixed wireless systems operating in the 14.4-15.35 GHz band
F.637-5	(02/2022)	Radio-frequency channel arrangements for fixed wireless systems operating in the 21.2-23.6 GHz band

ASSIGNMENT		
UIT-R* RECOMENDATIONS		
F.1099-5	(02/2013)	Radio-frequency channel arrangements for high- and medium-capacity digital fixed wireless systems in the upper 4 GHz (4 400-5 000 MHz) band
F.1242-0	(05/97)	Radio-frequency channel arrangements for digital radio systems operating in the range 1 350 MHz to 1 530 MHz
F.1496-1	(02/02)	Radio-frequency channel arrangements for fixed wireless systems operating in the band 51.4-52.6 GHz
F.1497-2	(02/2014)	Radio-frequency channel arrangements for fixed wireless systems operating in the band 55.78-66 GHz
F.2006-0	(03/2012)	Radio-frequency channel and block arrangements for fixed wireless systems operating in the 71-76 and 81-86 GHz bands

MONITORING AND ANALYSIS		
UIT-R* RECOMENDATIONS		
BS.412-9	(12/98)	Planning standards for terrestrial FM sound broadcasting at VHF
SM.328-11	(05/2006)	Spectra and bandwidth of emissions
SM.377-4	(02/2007)	Accuracy of frequency measurements at stations for international monitoring
SM.1268-5	(08/2019)	Method of measuring the maximum frequency deviation of FM broadcast emissions at monitoring stations

MONITORING AND ANALYSIS		
UIT-R* RECOMENDATIONS		
SM.1537-1	(08/2013)	Automation and integration of spectrum monitoring systems with automated spectrum management
SM.1880-2	(09/2017)	Spectrum occupancy measurement and evaluation
UIT-T* RECOMENDATIONS		
K.83	(01/2022)	Monitoring of electromagnetic field levels

INTERFERENCES		
UIT-R* RECOMENDATIONS		
P.530-18	(09/2021)	Propagation data and prediction methods required for the design of terrestrial line-of-sight systems

* TMP has incorporated the latest versions of the publications mentioned above. Every quarter, revisions are made to update or generate new versions of the platform, as needed.

ITU Publications considered.

TES Monitor Planning® (TMP) se ha guiado por los siguientes documentos:

NATIONAL SPECTRUM MANAGEMENT		
Radio Regulations	Edition 2020	Volume I CHAPTER II - ARTÍCLE 5 - Frequency Allocations
National Spectrum Management Handbook	Edition 2015	CHAPTER 5 – Spectrum engineering practices
		CHAPTER 7 – Automation for spectrum management activities
		ANNEX 1 – Spectrum management training
		ANNEX 3 – Best practices for National Spectrum Management
Spectrum Monitoring Handbook	Edition 2011	CHAPTER 3 – MONITORING EQUIPMENT AND AUTOMATION OF MONITORING OPERATIONS
		CHAPTER 4 – MEASUREMENTS
		CHAPTER 5.2 Broadcast monitoring
Computer-aided Techniques for Spectrum Management (CAT)	Edition 2015	CHAPTER 1.3 The benefits of automation of the spectrum management process
		CHAPTER 2.4.3 System design