

EXPERT PAPER



THE PROMISE OF NEXT-GENERATION BROADCASTING

Delivering more: Capacity, coverage and new services

ROHDE & SCHWARZ

Make ideas real



EXECUTIVE SUMMARY

A NEW ERA FOR BROADCAST NETWORKS

The future of terrestrial broadcasting is shaped by the need for greater spectrum efficiency, improved reception robustness, and flexible IP-based services. This Expert Paper examines the challenges broadcast network operators are facing, including the increasing demand for UltraHD content, the need for robust signals in both dense areas and large regions, and the requirements for new services such as personalized advertising and interactive applications.

We introduce ATSC 3.0 and DTV+ (Digital Television +) as key technologies to address these challenges.

ATSC 3.0, combined with innovative transmission mechanisms such as layered division multiplexing (LDM), multiple-input multiple-output (MIMO), and transmitter identification (TXID), enables a new generation of broadcasting services. Specifically, this means the ability to increase the capacity of broadcast channels, significantly improve indoor coverage and reliability, and enable new, data-intensive services. TXID also promises precise location determination and efficient troubleshooting.

Rohde & Schwarz is a pioneer in next-generation broadcasting. Our experts specialize in designing robust ATSC 3.0 transmitters and help customers implement and set up complete broadcasting infrastructure, from planning and installation to operation and optimization.

ABBREVIATIONS

ATSC 3.0 = "Advanced Television Systems Committee 3.0"; a broadcast standard for digital television, also known as "NextGen TV"

DTV+ = Digital Television Plus; refers to features on top of digital TV broadcasts

GNSS = Global Navigation Satellite System

LDM = Layer Division Multiplexing; a technique which allows the transmission of multiple streams of data within a single broadcast signal

MIMO = Multiple Input Multiple Output; a technology for stronger and more reliable TV signal reception

OFDM = Orthogonal Frequency-Division Multiplexing; a technique for efficiently transmitting digital TV signals over the airwaves

PLPs = Physical Layer Pipes; a technology for delivering multiple services – like different TV channels, radio, or data – simultaneously within a single broadcast signal.

SFN = Single-Frequency Network; multiple transmitters broadcast the same program simultaneously

TXID = Transmitter Identifier; a unique identifier for each TV broadcast transmitter



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THE FUTURE OF BROADCASTING



CHALLENGES AS OPPORTUNITIES

Nowadays, viewers demand an exceptional viewing experience in ultra high definition (UHD) with reliable reception everywhere and including innovative digital services that enhance the television offering.

Broadcasters not only have to deliver the highest quality content but also invest in significant technological upgrades. They are expected to fulfill a crucial societal responsibility, i.e. ensuring reliable information transmission, particularly during crisis situations. Prioritizing a robust network for emergency notifications is paramount.

Simultaneously, the increasing scarcity of radio frequency resources presents a growing challenge for broadcasters and network operators. These developments are driving a profound transformation in terrestrial broadcasting, creating exciting new opportunities alongside these challenges.



FOR THE EVOLUTION OF BROADCASTING: POTENTIALS FOR GROWTH AND INCREASED EFFICIENCY

- | **New business models:** Datacasting, targeted advertising, first responders as well as automotive and interactive applications offer significant revenue potential, necessitating investment in advanced technologies and network upgrades to maximize channel availability and capacity, including approaches like DTV+.
- | **The UHD revolution:** Delivering ultra high definition (UHD) content demands a significant increase in bandwidth and the adoption of more efficient transmission technologies.
- | **Robust reception in challenging environments:** Ensuring stable reception within buildings and densely populated urban areas remains a key technical challenge.
- | **Safety and reliability:** Maintaining a robust broadcast signal for public alerts is of paramount importance.
- | **Spectrum optimization:** Preparing networks for frequency reuse and maximizing the efficient use of available spectrum are crucial for the long-term viability of terrestrial broadcasting.

This shift toward IP-centricity is exemplified by DTV+ (the evolution of Brazil's TV 3.0 standard), which represents an architectural transition from traditional 'broadcast-first' models to an 'app-centric' framework. By utilizing an all-IP transport layer, DTV+ treats the Connected TV (CTV) as a high-performance execution environment where the user interface serves as a web-based gateway for all content.

This architecture facilitates seamless hybrid delivery: the system can pull high-bitrate UHD video via over-the-air (OTA) terrestrial signals while simultaneously integrating personalized data, such as targeted advertising or interactive 'T-commerce' modules, via a broadband return channel. In this context, the broadcast signal is no longer a passive linear stream, but a high-efficiency data pipe feeding a sophisticated, interactive application ecosystem.

ATSC 3.0

THE FOUNDATION FOR NEXT-GENERATION BROADCASTING



ATSC 3.0 significantly enhances the efficiency of existing frequencies. Improved compression and advanced transmission methods enable broadcasters to deliver more high-quality

programs, including UHD content, within the same channel bandwidth – similar to increasing the volume of water transported through a fixed-size pipeline.



Simultaneously, the new radio technology improves reception within homes and in densely populated areas. It exhibits greater robustness against reflections and multipath effects, ensuring more reliable

indoor and mobile reception. Techniques such as MIMO and adaptive transmission control further extend range and enhance reception reliability.



ATSC 3.0 unlocks new network planning capabilities through support for single frequency networks (SFNs). SFNs enable synchronous operation of multiple transmitters on the same frequency, minimizing

interference. This simplifies channel management by facilitating more flexible frequency allocation and redistribution. Notably, during frequency repacking scenarios, ATSC 3.0 aids in maintaining full coverage by enabling increased transmitter density and optimized range.



The benefits extend to significant cost savings. Robust basic services, such as emergency alerts, and high bit rate content can coexist within a single channel, eliminating the need for additional

transmitters or dedicated channels. This reduces infrastructure and operating costs while promoting more flexible use of scarce spectrum.

However, the true value of adopting ATSC 3.0 extends beyond improved picture quality and spectrum efficiency.

The ATSC 3.0 standard leverages IP based data transmission – mirroring the architecture of the internet – and unlocks entirely **new possibilities for datacasting, personalized content delivery and interactive programming.**

This includes applications such as targeted advertising, over-the-air software updates for receivers, and more broadly, the rapid distribution of large amounts of data to a wide audience.

ATSC 3.0 significantly **enhances the reliability and prioritization of emergency alerts.** This can be achieved through the employment of advanced transmission techniques – including robust signal modulation and repeated broadcasts – and the leveraging of network redundancies, ensuring critical information is delivered even under challenging reception conditions.

IP datacasting and enabled devices further ensure delivery and display with alarm functions. Unlike bidirectional networks, broadcasting scales without relying on user resources and is therefore more resilient during severe weather or network overload.

ATSC 3.0 enables broadcasting of **position, navigation and timing information (PNT)** through a terrestrial transmitter network. By synchronizing multiple transmitters, critical infrastructure – including first responders, financial markets and telecommunications – can be equipped with reliable time information. Logistics companies and rescue services also benefit from

precise location data available independently of satellite systems. This capability could create a comprehensive GNSS backup solution, maintaining time and position measurements when satellite signals are disrupted.

Advanced transmission techniques—like MIMO, LDM and TXID—can elevate the infrastructure provided by ATSC 3.0, enhancing signal robustness, transmission efficiency and interference mitigation. These techniques are explored in detail in the following sections.

CHALLENGE	IMPACT	ENABLING TECHNOLOGY	BENEFIT
Limited spectrum availability	Constrains data rates and the number of services offered per channel.	Divides each channel into a robust layer (low bit rate) and a high-capacity layer (UHD).	Maximizes spectrum efficiency, allowing for more programs and services.
Poor indoor and mobile reception	Weak signals and multipath interference cause signal dropouts and unreliable service.	The robust layer employs simpler modulation, stronger error correction and optional repetition for reliable reception even with weak signals.	Ensures consistent service quality in challenging reception environments, including buildings and while mobile.
Frequency repacking and network density	Risk of coverage gaps and reduced capacity during spectrum re-allocations.	Layer separation enables localized optimization of coverage and capacity. Combining with SFN mitigates service gaps.	Maintains a comprehensive service footprint even after frequency re-allocations.
High infrastructure costs	Separate networks for robust services and high-definition content increase investment and operational expenses.	Utilizes a single channel and existing transmitter infrastructure for both layers.	Reduces costs associated with network duplication, streamlining operations and frequency planning.
Critical communications reliability	Assurance of timely and widespread delivery of emergency alerts is essential.	Prioritizes emergency information on the robust layer with frequent repetition.	Maximizes the probability of reception, even when the high-capacity layer is unavailable.

APPLICATION

A regional broadcaster delivers live UHD sports alongside standard definition broadcasts on the same channel.

Commuters and residents in high-rise buildings receive a stable TV signal via the robust layer, with UHD available where reception is optimal.

Following a repacking, operators strengthen the robust layer in areas with poor coverage.

A broadcaster delivers emergency alerts using the robust layer of an existing channel, avoiding the need for a dedicated network.

During severe weather, authorities broadcast evacuation instructions via the robust layer, ensuring warnings reach viewers with weak signals.

LDM

LAYERED DIVISION MULTIPLEXING

Layered transmission – for maximum power

Layered division multiplexing (LDM) is a transmission method that simultaneously broadcasts two distinct service layers within a single radio channel: a highly robust, low-bit-rate layer for reliable indoor and mobile reception, and a high-capacity layer for ultra high definition (UHD) video. This is comparable in certain respects to two lanes on the same highway: One lane is dedicated to basic, essential transport, and the other is used for high-bandwidth, data-intensive transmissions.

CHALLENGE	IMPACT	ENABLING TECHNOLOGY	BENEFIT
Limited capacity for UHD content	Insufficient bandwidth to deliver high-resolution content ubiquitously.	Spatial multiplexing allows multiple independent data streams to be transmitted simultaneously over the same frequency, increasing the usable data rate per channel.	Increases spectrum efficiency, enabling the delivery of more UHD content.
Poor reception in buildings and on mobile	Signals are disrupted indoors and while traveling due to obstacles and reflections.	Diversity reception utilizing multiple antennas reduces dropouts caused by reflections and multipath effects by transmitting /receiving signals over different paths.	Improves signal reliability and stability in challenging reception environments.
Demand for datacasting and interactive services	Increasing data rate requirements for new applications.	Higher throughput and improved link robustness enable large-volume datacasting and parallel, customizable services.	Facilitates the delivery of bandwidth-intensive data services, opening opportunities for DTV+ and personalized content.
Robustness for public safety and emergency alerts	Emergency alerts must be reliably received even under difficult conditions.	Spatial diversity increases the availability of critical connections, so warnings are more likely to reach recipients, even in weak reception areas.	Improves the reliability of emergency communications.
Interference mitigation and capacity enhancement in dense networks	Optimizing network performance in environments with high radio density and during frequency changes.	Beamforming and directed transmission reduce interference and enable targeted capacity utilization in congested or densely populated areas.	Improves network performance and allows for efficient spectrum reuse.

APPLICATION

In suburban areas with good reception, additional UHD programs can be broadcast in parallel without requiring new frequencies.

In densely populated urban areas or on trains, picture and sound remain more stable due to multiple antenna paths compensating for signal gaps.

Multiple receivers at events can simultaneously access infostreams and on-demand content without interrupting main TV broadcast

Evacuation messages reach households in shadowed areas because multiple antenna paths improve the probability of reception.

Following channel re-allocation, service quality is maintained because directed transmission minimizes local interference and allows for more data to be provided where needed.

MIMO

MULTIPLE INPUT MULTIPLE OUTPUT

Optimizing network performance

Multiple input multiple output (MIMO) utilizes multiple transmit and receive antennas to either increase data throughput within the same frequency band (higher capacity) or enhance signal reliability through path diversity (higher stability). This is similar to deploying multiple delivery personnel: They can either split up the mail to deliver more packages per route (spatial multiplexing) or deliver the same mail via different routes to ensure delivery even if one route is disrupted (diversity).

For broadcast networks like ATSC 3.0, this translates into increased ultra high definition (UHD) capacity where channel conditions are favorable and significantly more stable reception in challenging urban or mobile environments. Combined with OFDM, PLPs, LDM and SFN, MIMO provides an additional mechanism to strategically balance capacity and robustness.

CHALLENGE	IMPACT	ENABLING TECHNOLOGY	BENEFIT
Interference management and network optimization	Difficulty identifying and resolving network issues.	TXID clearly identifies which site delivers which signal and which layer/power level, allowing interference sources, misconfigurations or SFN/LDM fine tuning to be quickly identified and targeted for resolution.	Facilitates rapid identification and resolution of network issues.
Warning authenticity and reliability	The need to ensure the authenticity and trustworthiness of emergency alerts.	TXID-transmitted information can provide a verifiable origin and broadcast proof for alerts, enabling quality assurance and tamper protection.	Enhances the trustworthiness and accountability of emergency alerts.
User experience (mobile reception and roaming)	Demand for stable and consistent reception during mobility.	TXID could provide receivers and apps with additional information about the signal's origin, allowing them to automatically select the optimal transmitter or appropriate layer (robust vs. high-capacity).	Improves mobile reception quality and user experience.
Regulation, billing and operator transparency	Requirements for transparent documentation and traceability of network information.	TXID can provide traceable logs of transmission time, location and reported performance, which can be used as evidence for regulatory reports, SLAs or shared infrastructure billing.	Streamlines regulatory reporting, billing processes and infrastructure audits.

APPLICATION

Drive tests using TXID can reveal which transmitter has excessive power or incorrect antenna alignment; corrections can be made precisely, reducing downtime and incidents.

Authorities can demonstrate which sites broadcast an evacuation warning; receivers can identify missing or unsigned alerts as unauthenticated.

A mobile app could use TXID information to recognize which transmitter currently provides better reception or the robust layer, and automatically switch before users experience dropouts.

With shared transmitters, TXID can accurately document which party provided which transmission times and performance, simplifying audits and billing.

TXID

TRANSMITTER IDENTIFICATION

Transmitter ID

Transmitter identification (TXID) is a unique identifier embedded within the RF signal transmitted from each location. It can optionally include site coordinates, transmit power, layer information and a digital signature. A simple analogy: TXID functions like an identity card – clearly indicating which transmitter generated the signal. In practice, TXID provides immediate operational and regulatory transparency, enabling quick identification of interference and illegal transmissions, supporting troubleshooting based on measurement data, and facilitating precise configuration of transmitter networks (SFN/LDM).

TXID also delivers reliable information for alerts and billing related to shared transmitter infrastructure. Signal authenticity is verified through digital signatures. Optimal TXID implementation requires standardized data formats and support by receiving devices and measurement tools.

MAXIMIZING BROADCASTING POTENTIAL



The adoption of ATSC 3.0 unlocks a new era of broadcast capabilities, but realizing its full potential requires a holistic approach to network design and operation. Building upon the foundational technologies of MIMO, LDM and TXID, broadcast network operators can achieve significant gains in spectral efficiency, service quality and operational streamlining. This discussion explores how these advancements translate into tangible benefits – from unlocking new revenue streams and enhancing the viewer experience, to optimizing spectrum utilization and ensuring regulatory compliance.

INCREASING EFFICIENCY IN THE BROADCAST NETWORK

Broadcast network operators are continually challenged to maximize spectral efficiency while maintaining – and improving – service quality and coverage. To meet evolving demands, the network architecture must incorporate advanced modulation techniques. LDM and MIMO are pivotal in enabling these improvements.

LDM allows a single channel to deliver both **robust coverage and high throughput**, making the most of existing spectrum. MIMO further enhances performance by **increasing network capacity or improving signal reliability** – crucial for a consistently high-quality viewing experience. This approach also leads to more efficient single frequency network (SFN) planning, improving coverage in challenging urban and indoor environments without the need for additional

frequency allocations.

Operational efficiency benefits from features like TXID, providing rapid identification of transmission sites and interference sources, **minimizing downtime and simplifying troubleshooting**. Precise control over transmitting power and layer assignments optimizes resource allocation and reduces the need for redundant infrastructure.

Broadcast network operators require deep expertise in core technologies to maximize performance and future-proof their infrastructure. Rohde & Schwarz delivers this through a dedicated team of specialists, optimizing network resources, ensuring high broadcast quality, and providing expert guidance on operational efficiency.

NEW BUSINESS MODELS AND MONETIZATION THROUGH TECHNOLOGICAL PROGRESS

Securing return on investment through innovation is paramount for broadcast network leadership and their strategic direction. Next-generation broadcast technologies, powered by advancements in modulation techniques, offer a pathway to **unlock new revenue streams and maximize value**.

The capacity to deliver UHD content, support multichannel broadcasting, enable targeted

advertising and facilitate datacasting services opens doors to diversified revenue models beyond traditional broadcasting. Concurrently, increased spectral efficiency allows for the delivery of more services without proportionate increases in frequency or transmitter costs, lowering long-term capital expenditures and improving operational margins.

Additionally, these advancements enable **product differentiation**. Offering tiered quality of service (QoS) levels – from robust basic coverage to premium UHD experiences – creates opportunities for customized service packages and premium subscriptions, appealing to a broader audience and increasing customer lifetime value.

A strategic migration path is crucial for successful deployment. Tiered rollouts and pilot strategies allow for phased implementation, thorough testing and minimal disruption. Rohde & Schwarz supports this with comprehensive planning, expert consultation and flexible deployment options for a controlled transition to a future-ready broadcast infrastructure.

IMPROVED TV EXPERIENCE AT HOME AND ON THE GO

Advances in broadcast technology promise a noticeably improved viewing experience. These improvements focus on enhancing picture quality, ensuring reliable reception and expanding content options.

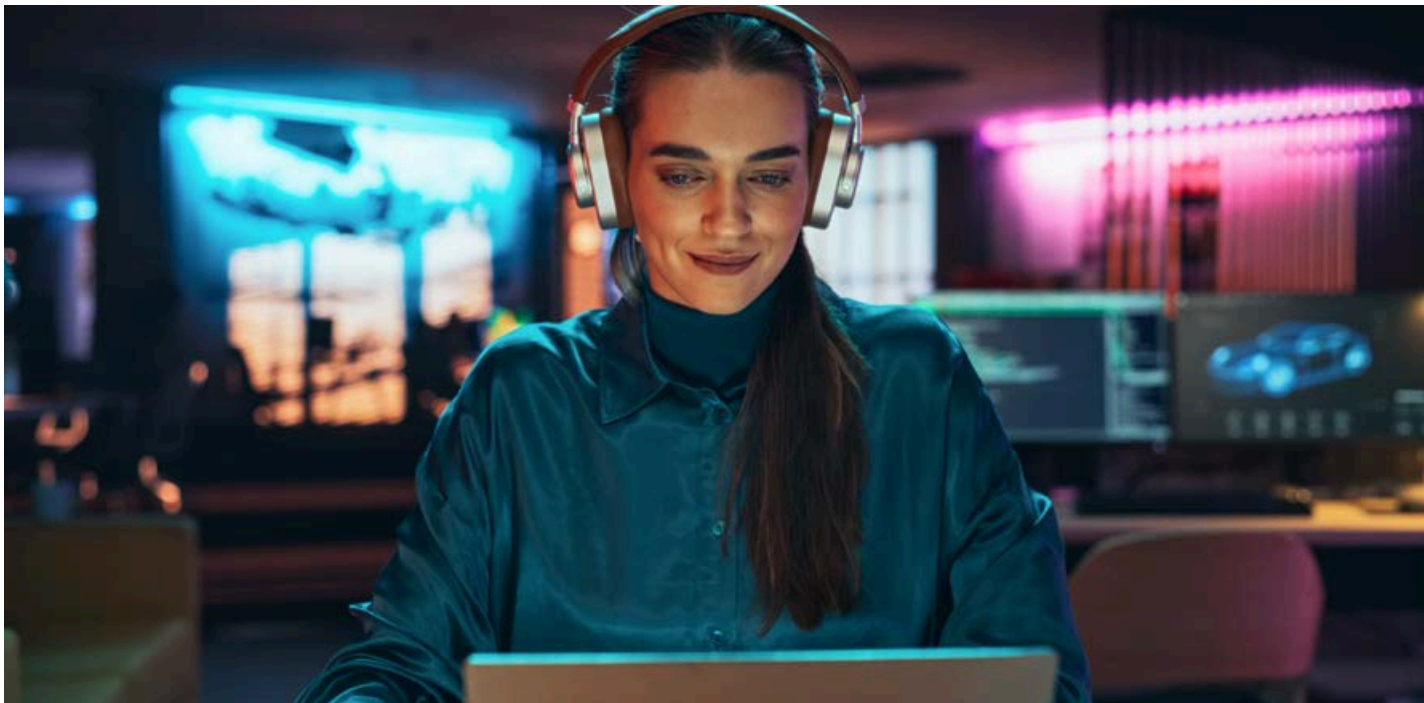
Viewers could enjoy increased access to stunning UHD programming, resulting in **sharper images** and a more immersive visual experience, particularly within the home and in urban environments. MIMO and LDM minimize signal dropouts, providing more consistent viewing experience.

Beyond picture quality, these advancements facilitate the delivery of advanced interactive services and personalized content, increasing the diversity and appeal of broadcast offerings. Furthermore, critical emergency notifications can reach a wider audience reliably, with verification capabilities **enhancing**

public safety, even during network disruptions caused by events such as severe weather or natural disasters.

Increased channel selection, enabled by these technologies, also provides viewers with a greater range of content choices.

Looking ahead, leveraging expertise in modulation and transmission technologies is crucial for realizing these benefits. Rohde & Schwarz provides a unique software based exciter platform supporting ATSC 3.0 and offers upgrade options for existing transmitters through exciter replacement, enabling broadcasters to deliver a richer consumer experience.



OPTIMAL SPECTRUM UTILIZATION AND ENHANCED COMPLIANCE IN BROADCASTING

Building on the advancements in broadcast technology discussed previously, LDM and MIMO offer significant opportunities to **optimize spectrum utilization and strengthen regulatory oversight**. Higher utilization of available bandwidth through the delivery of more services simplifies frequency management and auctioning processes, maximizing the value of public spectrum assets.

Furthermore, TXID enables rapid and precise pinpointing of transmission sources, simplifying interference analysis.

By recording performance data and logs, transparent compliance with coverage obligations is demonstrated and service quality is assured. This data-driven approach supports informed and efficient regulatory decision-making.

Through TXID and advanced transmission modulation techniques, Rohde & Schwarz can equip broadcast networks with technology that streamlines regulatory oversight through precise signal identification and optimized spectral efficiency.



As broadcasters navigate the evolution of ATSC 3.0, embracing innovation in modulation, transmission and network management will be key. The combined power of technologies like MIMO, LDM and TXID, coupled with expert guidance from Rohde & Schwarz, enables a future-proof broadcast infrastructure capable of delivering superior performance, unlocking new business opportunities, and serving the evolving needs of viewers. Successfully implementing these advancements is a crucial step for those seeking to maintain leadership in a dynamic broadcast landscape.



YOUR PARTNER FOR TRANSFORMATION: ROHDE & SCHWARZ

Rohde & Schwarz empowers network operators to deliver exceptional customer experience and future-proof their broadcast infrastructure through a comprehensive portfolio of robust solutions and a commitment to long-term partnership.

At the heart of our offerings is our software based exciter platform, providing unparalleled flexibility and scalability for broadcast transmission. Integrating seamlessly with advanced technologies like LDM, MIMO and TXID, it unlocks the full potential of ATSC 3.0 by enabling support for evolving modulation schemes, streamlined upgrades and optimized resource allocation.

Understanding the significant investment involved, Rohde & Schwarz leverages detailed return on

investment (ROI) analysis to inform strategic investment decisions, allowing operators to confidently plan network upgrades and expansions. We complement our technology with expert system integration, detailed network planning, and ongoing service and support to ensure optimal performance throughout the network lifecycle. We provide expert guidance on navigating evolving regulatory frameworks, ensuring compliance and optimizing network performance within established guidelines.

Ultimately, our goal is to provide not just technology, but a complete ecosystem that empowers broadcasters to thrive in a dynamic and competitive landscape.



Ready to transform your broadcast network?

Partner with Rohde & Schwarz to future-proof your business with resilient and flexible systems. Contact our team to request information, or arrange a technical consultation.



AS BROADCASTERS NAVIGATE ATSC 3.0 AND BEYOND, THEY NEED MORE THAN EQUIPMENT—THEY NEED A STRATEGIC PARTNER. ROHDE & SCHWARZ DELIVERS THE TECHNOLOGY, LIFECYCLE SUPPORT, AND LONG-TERM COMMITMENT THAT ALLOW BROADCASTERS TO INVEST WITH CONFIDENCE AND BUILD FOR THE FUTURE.

Erik Balladares, Vice President, Broadcast Sales, North America

CONTROL THE SPECTRUM

KEEP CRITICAL INFRASTRUCTURE RUNNING



SECURITY
SCREENING



COUNTERING
DRONES



TERRESTRIAL
BROADCASTING



MONITORING
SOLUTIONS



CYBERSECURITY
AND NETWORK
PROTECTION



SATELLITE
COMMUNICATIONS



CELLULAR
NETWORK AND
IP ANALYTICS



TEST &
MEASUREMENT



MOBILE
NETWORK
TESTING



AIRBORNE
COMMUNICATIONS



Critical infrastructure is under increasing pressure. As systems become more interconnected and dependencies deepen, disruptions can spread rapidly across services, organizations and sectors. At the same time, cyber risks, interference and hybrid threats are raising demands on resilience, continuity and accountability.

Keeping essential services running requires a stable operational foundation in which signals, communications, networks and trusted data are unassailable. When this foundation is compromised, the effects are immediate – safety, infrastructure availability and decision-making capability can be crippled within seconds.

With decades of experience across numerous disciplines, Rohde & Schwarz makes these hidden operational layers visible, controllable and dependable. By combining technology leadership with in-house development and manufacturing, high vertical integration and global support, we deliver reliability where continuity is mission critical.

INSIGHT

Understand what matters

Detect risks early, assess their impact and maintain situational awareness across essential operations. Rohde & Schwarz provides visibility across the electromagnetic spectrum, signals and networks – enabling operators to identify anomalies, understand dependencies and act before disruptions escalate.

CONTROL

Keep operations running

Maintain business continuity and resilience amid disruptions, attacks, evolving threats and growing operational complexity. Rohde & Schwarz provides control through secure communications, monitoring and protection capabilities that help sustain essential services under pressure.

TRUST

Decide with confidence

Rely on trusted information and auditable evidence to support accountable, compliant and legally defensible decisions. Rohde & Schwarz provides decision security backed by measurement-grade data and documentation – supporting operational security, long-term reliability and confident decision-making.

Service at Rohde & Schwarz You're in great hands

- ▶ Worldwide
- ▶ Local and personalized
- ▶ Customized and flexible
- ▶ Uncompromising quality
- ▶ Long-term dependability

Rohde & Schwarz

The Rohde & Schwarz technology group is among the trailblazers when it comes to paving the way for a safer and connected world with its leading solutions in test & measurement, technology systems and -networks & cybersecurity. Founded more than 90 years ago, the group is a reliable partner for industry and government customers around the globe. The independent company is headquartered in Munich, Germany and has an extensive sales and service network with locations in more than 70 countries.

www.rohde-schwarz.com

Sustainable product design

- ▶ Environmental compatibility and eco-footprint
- ▶ Energy efficiency and low emissions
- ▶ Longevity and optimized total cost of ownership

Certified Quality Management

ISO 9001

Certified Environmental Management

ISO 14001

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