One World Trade Center: Broadcasting is back with Rohde & Schwarz

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Executive summary

One World Trade Center is the tallest building in New York City and the most prestigious address for broadcasters in the United States of America. Six out of seven national broadcasters, such as WPXN (ION Media), WNET (PBS), and WWOR (FOX), have chosen to deploy the R&S®THU9evo for their primary broadcasts from One World Trade Center in New York City, but WNJU was the first station to move in.

On June 23, 2017, Telemundo's WNJU launched its over-the-air (OTA) broadcasting from the broadcast center on the 90th floor using the largest Rohde&Schwarz transmitter ever built. Its sister station, WNBC, the New York flagship for NBC, decided to share its transmitter before the end of last year.

Rohde&Schwarz is proud to be an integral part of the innovative 1WTC broadcast center. Our advanced transmitters feature liquid cooling systems to minimize noise and heat, and a custom liquid cooling solution we designed manages the heat produced by additional equipment in the room.

The new broadcast center was a truly collaborative effort led by The Durst Organization that included a number of vendors and equipment manufacturers. During construction, there were significant logistical hurdles, from delivery schedules to storage restrictions, but the results speak for themselves. The dedicated broadcast space can support several television and radio stations, while the unique ring platforms around the roof antennas accommodate equipment for broadcasters and other commercial and government agencies. Plus, the infrastructure was designed to support the upcoming ATSC 3.0 standard. With 1WTC, OTA broadcasters have a new benchmark for quality and efficiency.

Bringing back broadcasters to 1WTC

By John M. Lyons, Assistant Vice President, Director of Broadcast Communications, The Durst Organization

After 9/11, there was a desire to re-establish broadcasting in Lower Manhattan. Nothing happened immediately, of course, but after considering several sites, stations became interested in the new World Trade Center. Originally, the Port Authority of New York and New Jersey worked with the Metropolitan Television Alliance (MTVA) to bring broadcasting to 1WTC.

When those efforts stalled, and The Durst Organization, after forming a joint venture with the Port Authority, worked together to make it happen. Durst has a history with broadcasting. After all, our tower at 4 Times Square houses primary and backup transmitters for several TV and FM radio stations, as well as an armada of other telecommunications.

It's fair to say 1WTC has been a labor of love, but it was a long, seven-year process. We didn't even get the first full broadcast licenses signed until December 2015, and that was only after we conducted tests earlier in the year with UHF and VHF signals. Broadcasters needed to confirm they wouldn't lose coverage to Brooklyn and areas of New Jersey if they relocated from the Empire State Building.

The broadcast center on the 90th Floor of 1WTC was designed to support all 11 TV and 21 FM radio stations in the market. While WNJU was the first, we will have at seven TV stations in the building by mid-2018.

That's a lot of electronics in a relatively small area, but the facility temperature will stay comfortable even at maximum capacity, because the broadcast center is almost com-

pletely liquid-cooled. There are three loops of liquid moving around the facility, with supply and return loops already in place where transmitters are expected to be installed.

Durst is a very green organization, and we maintain a strong emphasis on sustainability. There are 13 cooling towers on the top of the building that feed the entire building, including a closed loop secondary system just for the broadcast center, with its own heat exchangers and redundant pumps. Even the AC system that services the Broadcast Center is liquid-cooled, and we installed shades around the entire facility to eliminate solar heat from the windows during the day hours. In fact, the only things cooled by ambient air are the terminal equipment racks that house monitors, switches, servers, etc., which is a relatively minor load.

We don't expect any of the liquid cooling systems to leak, but the broadcast center´s floor is waterproofed. There's also a pre-action fire sprinkler system to minimize loss in case of a fire. The broadcast center´s floor plan is open, with no cages and no interior walls. Stations can lock their equipment racks, of course, but we designed the area to create an airy, clean look.

There is a 13.8 kV generator for electric power, but the feed system is greatly reduced for better efficiency. One feeder brings the higher voltage, but we convert it to 480 V through dual-ended substations on the 90th floor. WNJU also invested in a flywheel uninterruptible power supply to make sure its transmitter stays on the air even if the building has to transition to emergency power.

Installing the world's largest solid-state UHF transmitter on one of the highest floors of the tallest building in New York City was no easy feat. I was involved with the project from the beginning, even visiting Rohde&Schwarz and other manufacturers as plans progressed. The biggest engineering challenge we faced with the WNJU installation was the coordination and staging, which I thought went fairly smoothly. WNJU dealt with the minor "growing pains" associated with being the first station back – while other tenants were moving into the building, no less – but the experience laid the ground work for future installations.

Engineering 1WTC: a coordinated effort

By Ted Collora, Senior Vice President, Hanson Professional Services, Inc.

Hanson is the engineer of record for broadcasters at 1WTC. As broadcast consultants working with the builder, Tishman Realty & Construction, we were tasked with coordinating and managing the base building's broadcast infrastructure for the broadcast center, housed on the 90th floor; the antennas on the roof, and ancillary radio equipment on the 104th floor. We handled all the construction documents for the broadcast systems in cooperation with The Durst Organization, the base building's engineers and various vendors, contractors and equipment manufacturers.

From an engineering standpoint, the 1WTC project was different from many other broadcast areas housed in tall buildings. 1WTC was a very carefully planned facility, a replacement for the original World Trade Center. The project began with the Metropolitan Television Alliance (MTVA), a consortium of television broadcasters in New York City organized after 9/11, but The Durst Organization fulfilled the concept and developed the centralized broadcast facility that is in use today.

The antenna mast is equipped with a master broadcast antenna system consisting of main and backup UHF antennas and a VHF antenna, as well as microwave and ENG equipment located on the antenna ring platforms on the roof at the base of the mast.

Most other broadcast locations have individual antennas for each station (or small groups of stations), but 1WTC allows any broadcaster to come in and operate from the broadcast center without installing a new broadcast antenna and individual combiner. Three rings built at different levels surround the broadcast antennas. The ring platforms provide space for additional antennas and equipment for various agencies, including government and law enforcement. Some broadcasters have installed cameras on the rings to shoot beauty shots of the city, sending the images back to their respective stations via the microwave.

Durst wanted thebroadcast center designed to accommodate all the UHF and VHF television broadcasters in the market. It can also handle all the FM radio stations, if necessary, though additional equipment would have to be installed. Hanson will continue to work with broadcasters moving to 1WTC and other broadcast facilities. Six of the seven broadcasters at 1WTC have selected Rohde&Schwarz transmitters. There are no offices in the broadcast center; all transmitters are remotely controlled, so a full-time staff is not required.

The Port Authority of New York and New Jersey was very helpful and cooperative. Before we started on the project, we had to submit drawings and specifications on behalf of the broadcasters to make sure our design documents were up to code and fully coordinated. The Port Authority continued to work with us throughout the process, inspecting various phases of the work and performing the final inspections.

We were very successful in coordinating all the components of the base building's infrastructure and integrating them into the building. Because we worked both with the building's staff and the broadcasters, coordination was much easier. In fact, we had very few engineering changes in the field. We modeled the facility in 3D with Autodesk's Revit Building Information Modeling (BIM) software, integrating the broadcast system with the base building and avoiding issues with electrical equipment, air conditioning, plumbing and other building systems. Using a model from the roof to the broadcast center, we mapped multiple runs of transmission lines. During the actual installation, we only needed a few minor field cuts.

Solid-state UHF reaches new heights with 1WTC

By Cornelius Heinemann, Vice President, Transmitter and Amplifier Systems and File-Based Media Solutions,

Rohde&Schwarz

The WNJU transmitter housed at 1WTC is the biggest solid-state UHF transmitter ever constructed, and the largest transmitter ever produced by Rohde&Schwarz. Built with our R&S®THU9evo liquid-cooled UHF transmitter, the six-rack unit has 72 amplifiers (1.7 kW per amplifier) to deliver a strong signal throughout the top DMA in the United States.

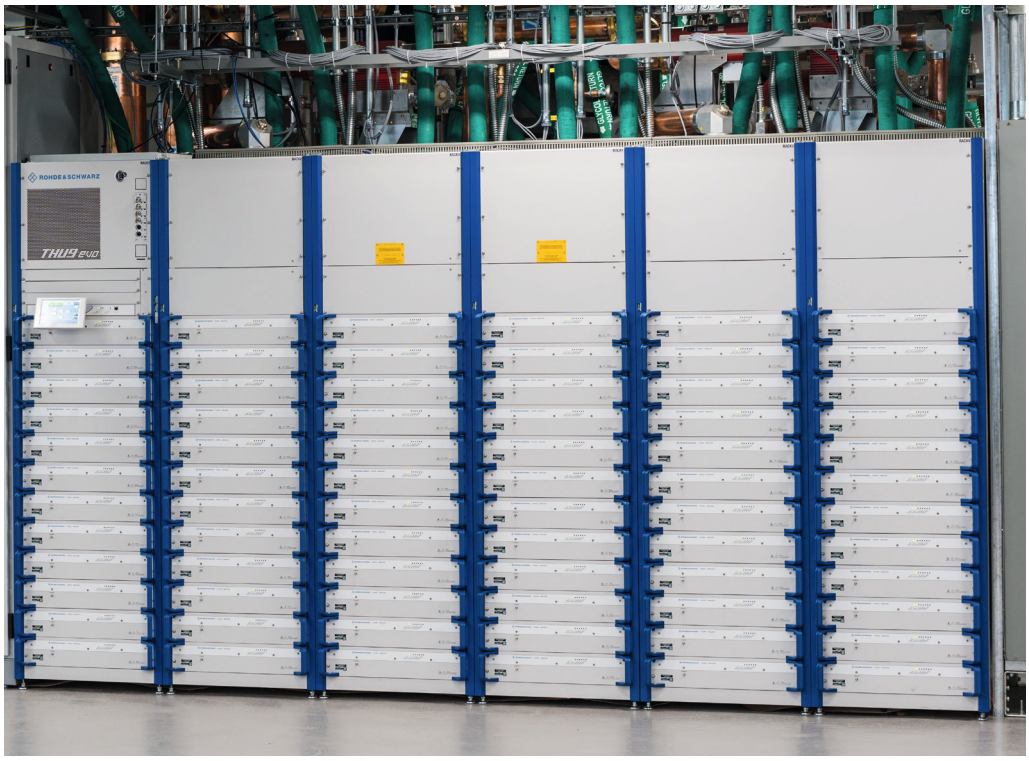
For WNJU, the approach was high power for a high tower. The station wanted coverage throughout the metropolitan area with enough power to get the signal to the streets and into buildings.

One thing you notice in the broadcast center is how quiet it is. In the old days, transmitters made a lot of noise. The superior design of the R&S®THU9evo's liquid cooling system eliminates noisy fans. Plus, because the system's heat is minimized, the AC system isn't blasting the room, which means less expensive utility bills. 1WTC is a great example of quiet efficiency for broadcasters.

Other equipment in the broadcast center, such as power supplies and dummy loads in case power can't get through to the antenna, are air-cooled (through fans) and produce

heat. In many facilities, that heat dissipates into the room and requires excessive use of air conditioning, however, that kind of excess heat is not permitted in 1WTC. While the WNJU transmitter has its own liquid cooling system, Rohde&Schwarz designed a custom standalone liquid cooling solution for the broadcast center to control the temperature of all the additional equipment in the room.

We expect to see several more Rohde&Schwarz transmitters installed on the 90th floor of 1WTC for other broadcasters in the near future.



Top of the world: the 1WTC antenna

By Todd Loney, RF Consultant

I had a unique perspective on the 1WTC project from the inside and outside of the building. WNJU contracted me to project.manage the transmitter installation and commissioning, and Radio Frequency Systems contracted me to provide installation supervision, testing and commissioning of the antenna and combiner systems.

Given the location and the history of the site, security at 1WTC is paramount, and transporting equipment into the building is a complex task. We scheduled the transmitter components to arrive on a Saturday, when the loading dock was not as busy. Within one long workday, we were able to stage the equipment on the 87th floor, then position it properly in the broadcast center on the 90th floor.

Over the next four months, we were able to complete the complex installation. The advances in solid-state transmitter technology are just remarkable. WNJU's transmitter is the largest solid-state UHF transmitter ever built, yet it's only about 1/3 the footprint of an inductive output tube (IOT) transmitter with the same power density.

Unlike the transmitter, we didn't start from scratch with the antenna. The 1WTC spire had been installed while the building was under construction – and while the massive tower crane was still installed. Thankfully, it's a future-friendly panel antenna with a very flex-

ible architecture designed to support anything from horizontal to full circular polarization. WNJU opted for full circular polarization, which outputs the same power on horizontal and vertical polarization. When ATSC 3.0 is formally adopted, a circular polarization signal will allow broadcasters to deliver better reception to mobile devices, particularly in urban environments like New York City.

Two UHF antennas are located on the 1WTC spire. The top antenna array has eight levels with five sides for a total of 40 panels. The second array, larger because it is closer to the base, is eight panels high with 12 sides, so it holds 96 panels. Each panel has two 7/8-inch inputs and is fed from the combiners in the broadcast center via dual seven-inch rigid lines for PEP40 (top array) and dual eight-inch lines for PEP96. At the base of the spire are three massive communication rings, which house smaller antennas and equipment for law enforcement and other agencies, as well as broadcaster microwave links for STL/TSL and ENG shots.

Work began on the antenna in July 2016 and lasted through April 2017. We had significant delays due to bad weather and windy conditions. It's unsafe to work on the antenna in high winds, which can be prevalent at such heights during the winter months. Extremely cold temperatures and wind chill also make it almost impossible to work with the small fasteners on an antenna.

There are two separate combiners in the broadcast center that will eventually be shared by all broadcasters in the building. WNJU's broadcast transmissions are split evenly between the combiners but with different phase relationship to achieve desired polarization. From there, transmissions are fed to the panel antenna +45 and –45 degree inputs. With the split signal, each broadcaster can not only select its own polarization ratio, but can change the ratio later as needed. The 1WTC broadcast center provides a formidable and flexible transmission facility for stations in the nation's largest broadcast market.

Transmission equipment installation requires careful cooperation

By Philip Cindrich, President, Myat, Inc.

As a system equipment manufacturer and supplier based in Mahwah, New Jersey, Myat was designated the equipment consolidation point for the antenna, transmission lines and combiners shipping into the 1WTC project. For us, as a local company, it was exciting to be part of the process to return broadcasting to downtown New York City. Not only did we supply the antenna, which was purchased from Radio Frequency Systems (RFS). We also manufactured and assisted with the system layout for the transmission line runs from WNJU's Rohde&Schwarz transmitter to the combiner, as well as from the combiner to the antenna.

One of the design team's biggest challenges was trying to "future-proof" the site. While it has not yet been officially adopted, we know ATSC 3.0 is on the way – and it requires a much higher voltage capacity than the current ATSC standard. When it comes to voltage, size does matter; any significant increase in voltage handling requires a larger transmission line. We worked with The Durst Organization and RFS to make sure the 1WTC system functions as designed when ATSC 3.0 is adopted, even with the anticipated increase in voltage capacity.

The 1WTC build was a multi-year, multi-vendor process. Myat's first proposal related to the project was submitted in 2012, and the antenna orders were received in December 2015. Because the FCC repack was not yet complete when we started the 1WTC project, it was not known with certainty what channel WNJU (or other potential broadcasters) would be assigned. In fact, we couldn't assume the FCC repack would in fact happen, so Durst decided to install an antenna that supports the 14-52 UHF spectrum, though by design it delivers better performance at the low end. (WNJU ultimately remained on digital channel 36.)

Equipping the broadcast center, which was to be constructed after the building itself was completed, also had its own unique set of logistical hurdles that required careful planning. All the components for the project had to be broken down to fit in the elevators, as 90 flights of stairs, or a roof crane pick, were not feasible transport options. Typical elevators, for example, will not accommodate 20-foot transmission line sections. The 1WTC elevators are no exception, and could handle only up to 10-foot line sections. Then we needed to plan how to move equipment through the building to the combiner room and to the roof.

Deliveries to the building also required advanc planning. With all the trucks that service 1WTC, scheduling and security are key factors. Every truck and each driver had to be cleared prior to delivery, with manifests reviewed at checkpoints before the vehicle would be allowed to proceed to the loading dock. Most deliveries had to be scheduled at least a week in advance. We worked very closely with The Durst Organization, their construction management team and all the trades to deliver the required materials on time.

Storage was another issue. For most projects, all materials required for the build are stored at site and used as needed. Not so with 1WTC. As you might expect, floor space was very limited and incredibly expensive, so our approach had to change. We carefully coordinated storage, limiting on-site material deliveries to equipment that would be required within the next week or two. Meanwhile, manufacturing worked the anticipated requirements four to eight weeks out on the schedule.

The Rohde&Schwarz transmitter for WNJU was shipped to us on schedule, and it was held at our facility until 1WTC told us that they were ready for it. It's always great working with Rohde&Schwarz. The company has very knowledgeable people who deliver great products. Myat will continue to work with all the broadcasters who join WNJU at 1WTC, so we will continue to be involved with the logistics when it's time to install other Rohde&Schwarz transmitters at the site.

Rohde&Schwarz: transmitter of choice

By Glen Hurst, Transmission Systems Engineer/AE, Rohde&Schwarz

WNJU's new transmitter at 1WTC is the largest solid-state digital transmitter in the world, a six-rack R&S®THU9evo that delivers 106 kW transmitter power output. As a result of the FCC repack, WNJU and WNBC will eventually share the transmitter, multicasting both HD channels within the same 6 MHz bandwidth.

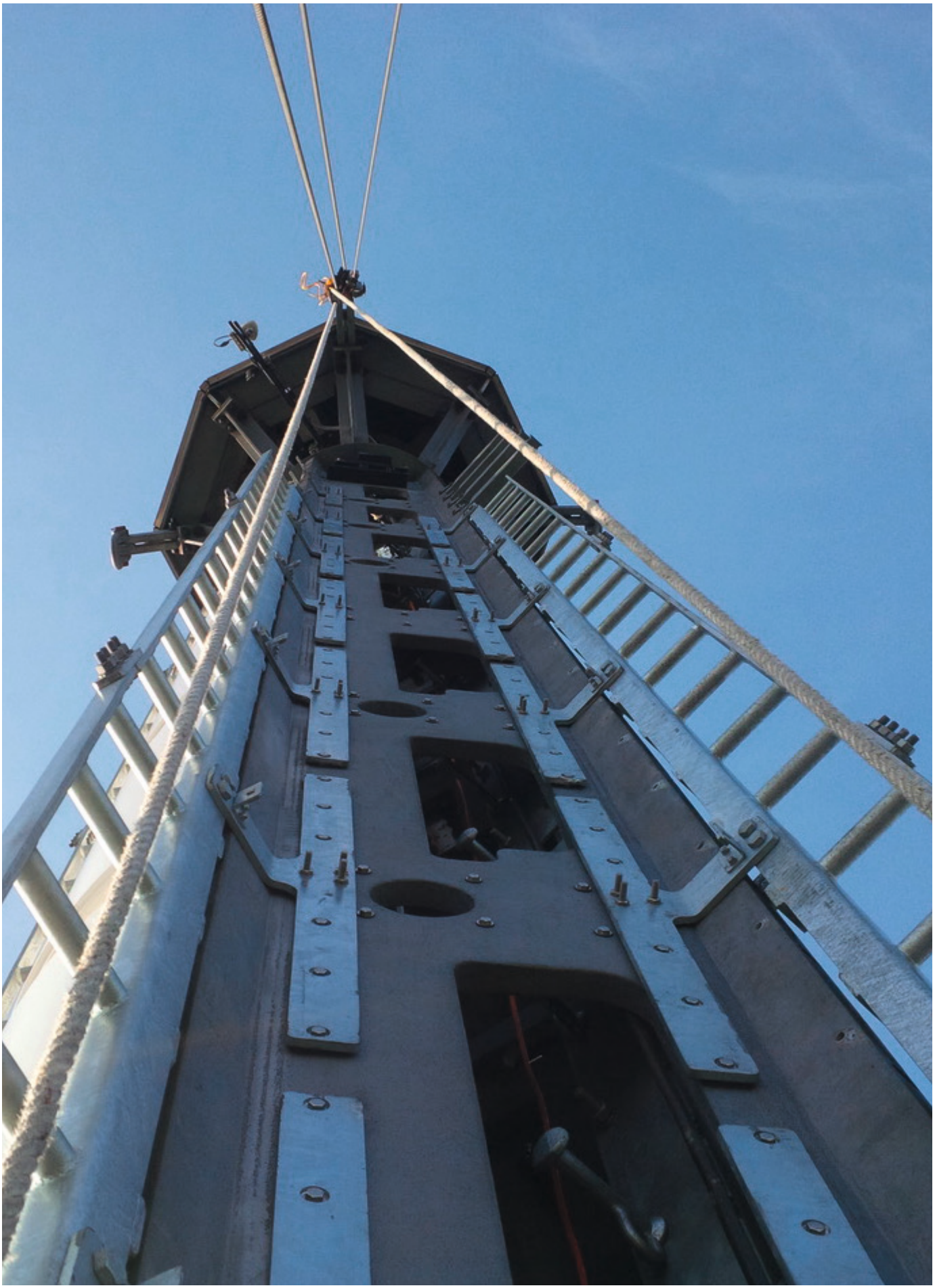
I don't think there was any question 1WTC would house solid-state digital transmitters instead of inductive output tube (IOT) transmitters. Solid-state transmitters now have the same or better efficiency than IOT models, the architecture is much more reliable and stable, and annual maintenance costs are significantly less. With a solid-state transmitter, if you lose a transistor, you lose some output but still have a signal. IOT technology is more hazardous because it requires more voltage. Plus, when you lose a tube, you lose significant output power, so failures are catastrophic for the broadcaster.

The installed R&S®THU9evo includes an R&S®TCE901 exciter, 72 R&S®PHU903 amplifiers that are field replaceable, and three redundant power supplies in each amplifier. WNJU has also included an unusual amount of programming redundancy, as it accommodates up to six different inputs from different locations via fiber, wireless, and IP. The transmitter delivers more than 40% efficiency, with modulation error ratio (MER) greater than 44 dB and shoulder attenuation over 60 dB.

Beyond energy efficiency, the WNJU transmitter excels at site efficiency, distributing minimal heat load to the room because of its 100% liquid-cooled technology. In fact, because of our expertise, Rohde&Schwarz was selected to provide the broadcast center's liquid cooling system for ancillary equipment. Based on the proven technology used in our transmitters, the center's system can handle the cooling needs for the combiners, filters and almost every other piece of RF equipment in the room (except the transmitters, which have their own systems) for all stations that will reside in the facility.

1WTC needed a way to remove heat from the room while maintaining a small footprint, so we installed a liquid-to-liquid cooling system. The system is significantly smaller than a liquid-to-air system, which would have required an outside fan source. The system features two loops circulated by separate pumps – the liquids don't mix. The cooling loop is coupled to the equipment loop in part, where plate heat exchangers remove the heat from the transmitter. It's a very efficient system with built-in redundancy.

WNJU's transmitter can produce outputs of 50 kW for vertical and 50 kW for horizontal polarization, which is higher than what is typically seen in today's solid-state devices. Not only does the transmitter produce a signal strong enough to navigate through the concrete jungle of the largest U.S. local television market, but the vertical component positions WNJU and WNBC to deliver innovative services to handheld devices when ATSC 3.0 is adopted.



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