

Application Note

# Safely Maintain Cell-Site Performance

Expedite Service and Minimize Tower Climbs with CellAdvisor™ and RFoFiber™

Modern cell sites have a distributed architecture where the radio has two main elements: the base band unit (BBU) performs radio functions on a digital baseband domain and resides at the base of the cell site; and, the remote radio head (RRH) performs radio frequency (RF) functions on an analog domain and resides next to the antennas at the top of the cell tower.

These two elements communicate via an interface standardized as the Common Public Radio Interface (CPRI) or the Open Base Station Architecture Initiative (OBSAI).

Distributed cell-site architectures provide the benefit of practically replacing coax-based feeders with fiber-based feeders, significantly reducing the problems of signal loss, reflections, and intermodulation.

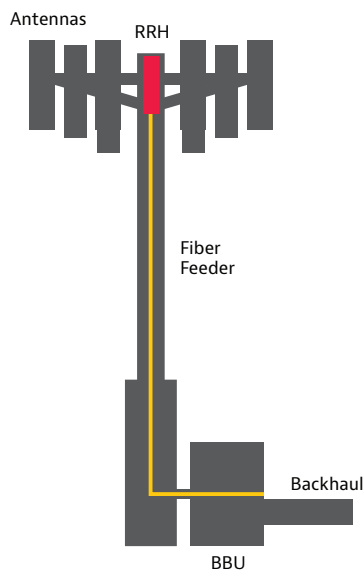
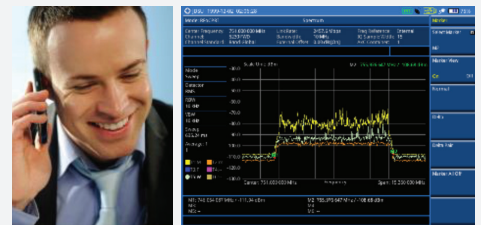


Figure 1. Distributed cell site



A centralized management system continually monitors the radio access network (RAN) to provide key performance indicators of cell sites. In case of service degradation, further analysis identifies the cell site or cluster of cell sites that are experiencing problems. The management system then generates a work order or trouble ticket to conduct localized maintenance.

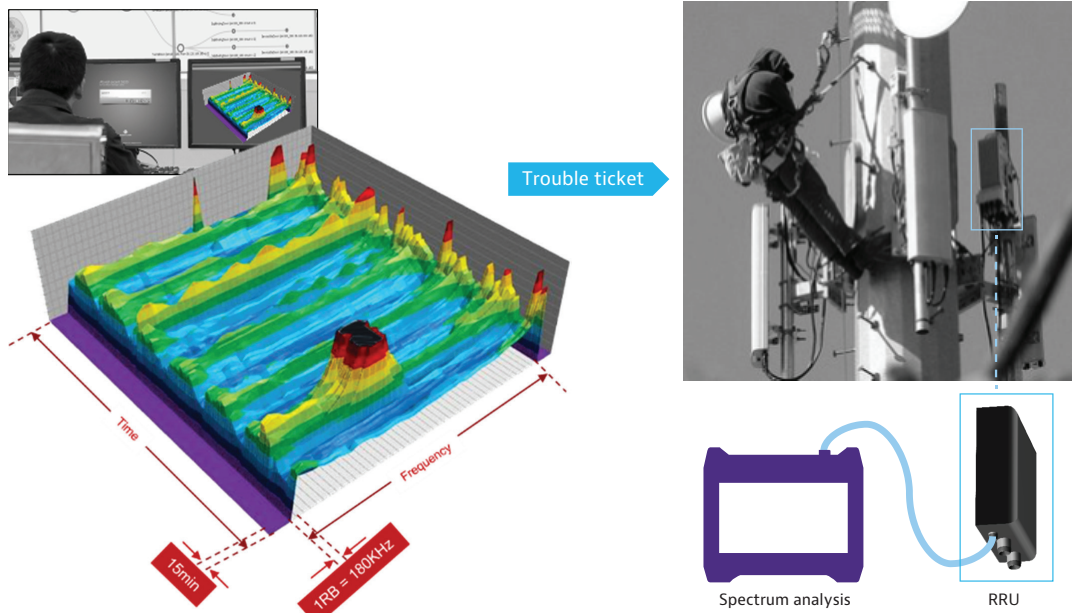


Figure 2. Cell-site management and service

However, since all the RF functions reside on the RRH, any RF maintenance or troubleshooting such as interference analysis requires reaching the top of the cell tower to get access to the RRH. This represents a high operational expense due to the need to hire a tower crew, and there is an implicit security risk.

VIAVI Solutions™ has worked closely with mobile service providers to make the CellAdvisor base station analyzer the industry's most comprehensive test solution for cell-site installation and maintenance. CellAdvisor was one of the first integrated solutions to characterize both RF and fiber. It substantially refined signal quality testing to ensure quality of experience of mobile users. Most recently, CellAdvisor added RF over fiber (RfOverFiber) technology to perform RF analysis from CPRI or OBSAI links on the ground instead of the top of the tower. This innovation has significantly lowered maintenance costs and minimized security concerns.

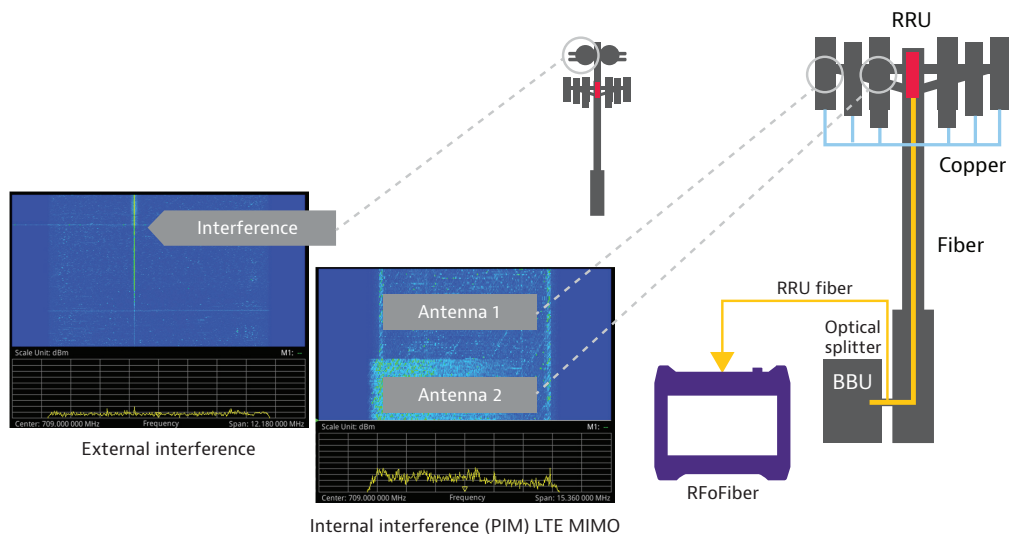


Figure 3. CellAdvisor with RfOverFiber technology

## RFoFiber Technology

RFoFiber verifies a CPRI or OBSAI fiber link and extracts user-plane traffic or RF data transmitted between the BBU and RRH. This enables monitoring and analyzing interference signals on mobile devices (uplink) as well as the performance of a radio's signal (downlink).

RFoFiber also enables de-mapping and analyzing user-plane data so technicians can maintain and troubleshoot RF at ground level via fiber coupling at the BBU. This yields significant benefits including:

- Eliminating cell tower climbs and improving safety
- Minimizing the number of instruments needed to maintain cell sites
- Significantly reducing maintenance time and operational expenses

Figure 4 illustrates two common service processes. In the first, the cell site problem is continuous: for example, signal reflections, loss in the coaxial jumpers, or a constant interferer signal that a single tower climb and verification can resolve. The second and most common process is for intermittent problems: external interference or intermodulation that requires extended testing and verification.

In both cases, RFoFiber technology enables rapid problem assessment right next to the BBU rather than up the tower next to the RRH. This avoids scheduling the time and expenses of a tower crew. A prompt service resolution avoids reducing ARPU and minimizes churn due to poor service quality.

## RFoFiber Interference Analysis

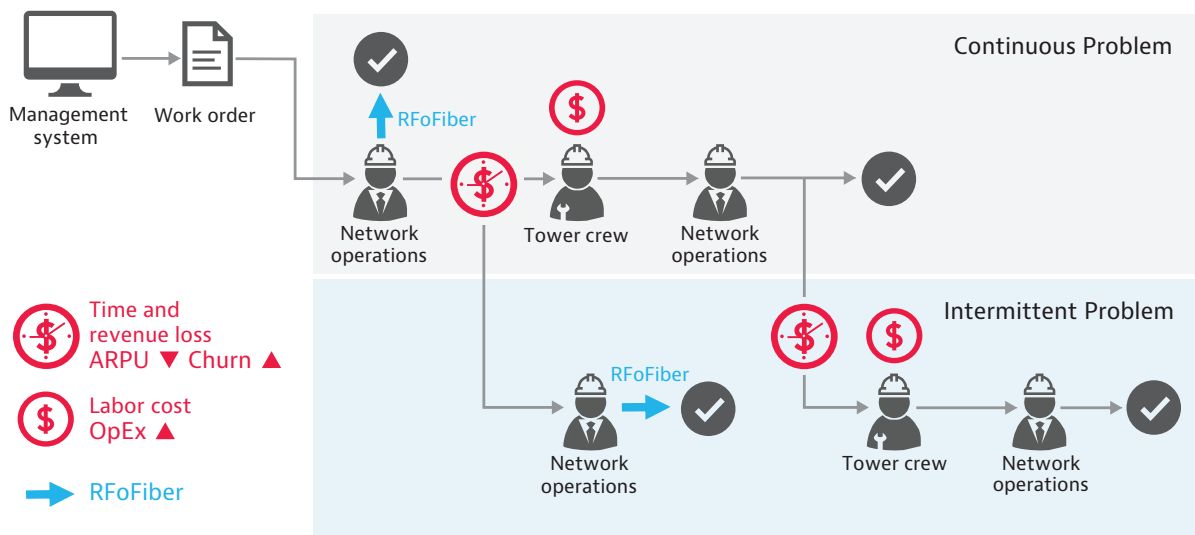


Figure 4. Service processes with RFoFiber

RF interference mainly affects the transmitting signals of mobile devices (uplink) due to their limited transmission power. This interference may come from external sources or from the cell site as passive intermodulation (PIM) products from the radio's signal (downlink).

CellAdvisor with RFoFiber technology analyzes interference without disrupting service by monitoring CPRI or OBSAI signals derived from a passive optical coupler installed next to the BBU. This coupler can support multiple fiber channels: Figure 5 diagrams a cell site transmitting in three sectors: alpha ( $\alpha$ ), beta ( $\beta$ ), and gamma ( $\gamma$ ).

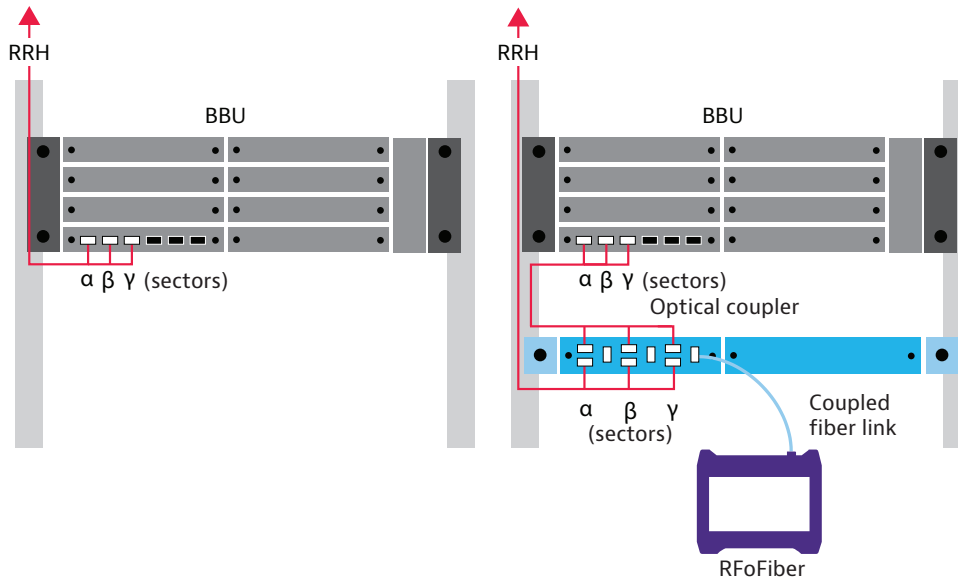


Figure 5. BBU serving sectors (α, β, γ)

Figure 6. BBU serving sectors (α, β, γ) with CellAdvisor

With the flexibility of setting either CPRI or OBSAI profiles, RFoFiber enables conducting interference testing on all RF signals transmitted, including multiple signals from the same carrier such as multiple input multiple output (MIMO) and multiple signals from different carriers.

Impairments in conductivity in the cell site's infrastructure (from sources such as loose jumpers, bent cables, different metals used in jumpers, or corrosion) can generate interference that affects mobile devices (uplink). This intermodulation occurs when signals transmit through these impairments in the cable system and create different products or multiples of the transmitted signals.

Intermodulation can be present in single-carrier LTE cell sites because the LTE signal transmitted by the radio is composed as an aggregate of subcarriers (15 kHz) that together constitute a wideband signal. For example, 600 subcarriers make up a 10 MHz LTE signal. Therefore, an LTE signal transmitting over a cable system with conductivity impairments can create multiple products of the signal's subcarriers. These products may occupy the same frequency as the band assigned to uplink transmission, causing a wideband interference that alters the flatness of the uplink noise floor.

The RFoFiber spectrum analysis example in Figure 7 is from a cell site transmitting LTE signals of 10 MHz over two antennas (MIMO) where the uplink branches exhibit power imbalances.

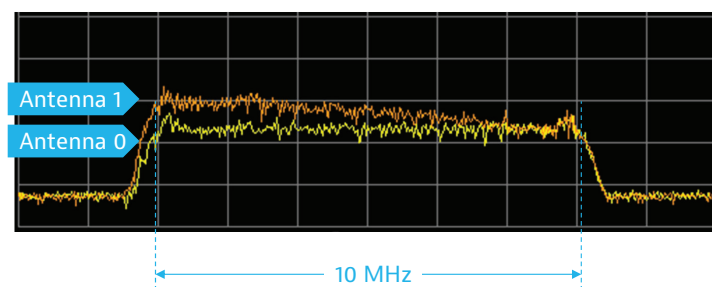


Figure 7. RFoFiber spectrum analysis — LTE uplink 10 MHz MIMO with intermodulation

In addition to the higher power level exhibited by antenna 1 compared to antenna 0, its power level is higher at lower frequencies and gradually decreases with lower frequencies. This is a key characteristic of intermodulation.

Spectrum analysis can also detect interference from sources external to the cell site. However, due to the different nature and unique characteristics of interferers, the parameters of the spectrum analysis must be properly adjusted. Effective interference detection and analysis requires filtering (resolutions bandwidth and video bandwidth) and power adjustments, including attenuation, averaging, and pre-amplification.

External interferences are sometimes intermittent—active for short periods, making them difficult to detect. In this case, it is important to continuously record spectrum measurements, either as spectrum analysis or spectrogram measurements.

Spectrogram measurement is perhaps the most common technique used to detect intermittent interference since it enables continuously monitoring and recording the spectrum through time. Power variations can display with different color codes, facilitating the detection of interference in time, and capturing its spectral characteristics.

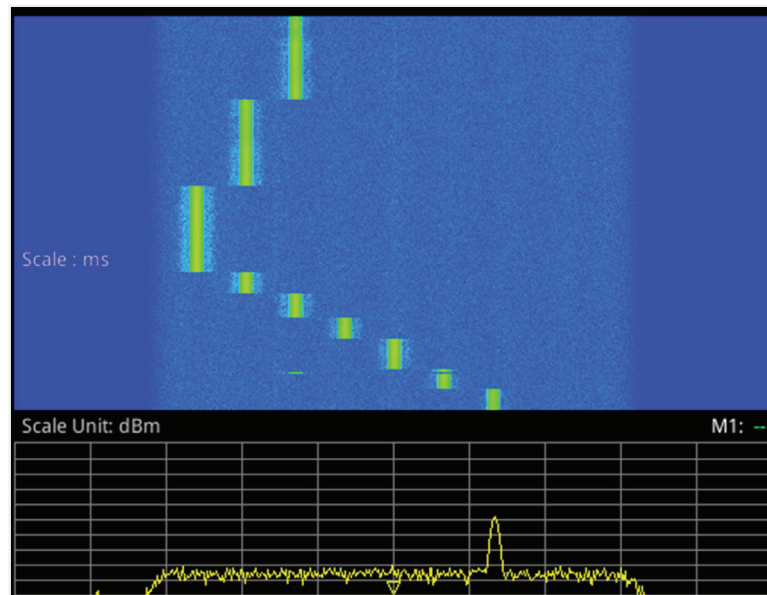


Figure 8. RFoFiber spectrogram measurement with intermittent interference

Interference is a significant problem for mobile transmission (uplink) regardless of the type of cell site providing service. For example, interference can be present in metropolitan areas that typically have many small cells or cloud RANs, as well as in venues such as stadiums or shopping malls with DAS and macro cells serving urban and suburban areas.



Figure 9. Small cell and CellAdvisor with RfFiber

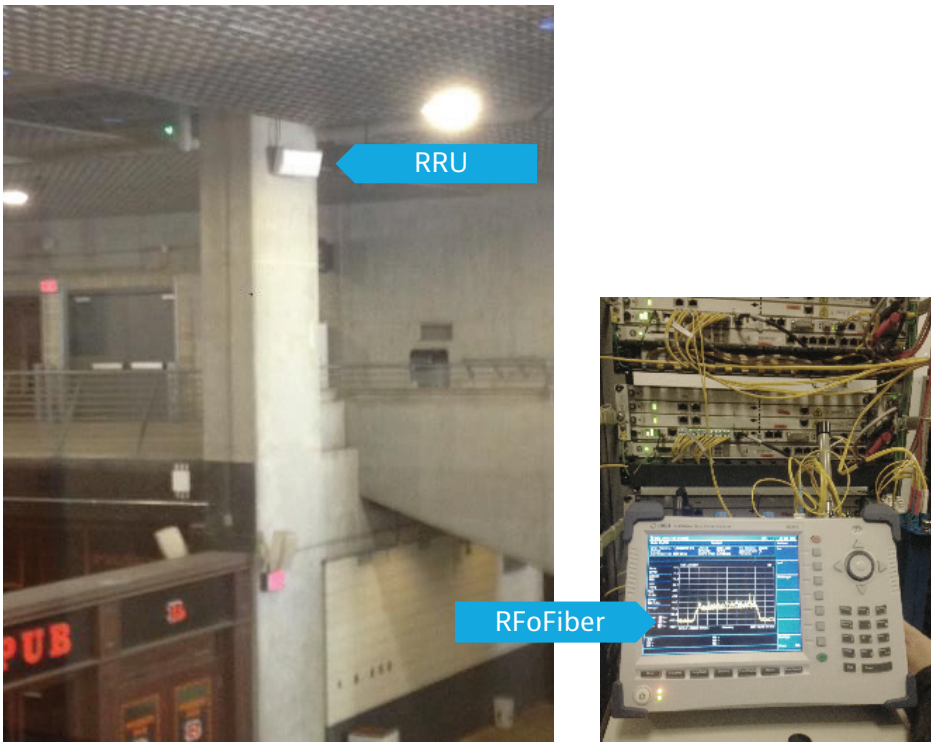


Figure 10. DAS and CellAdvisor with RfFiber

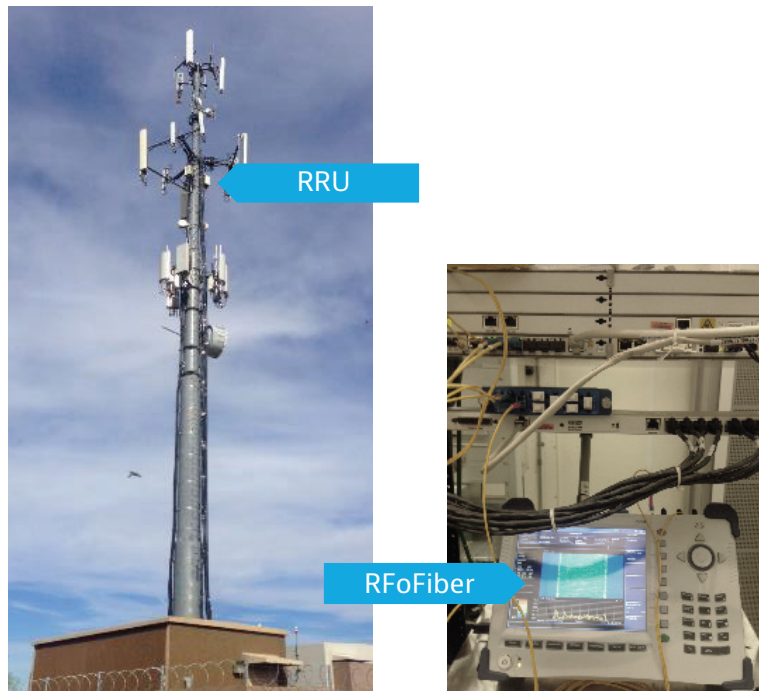


Figure 11. Macro cell and CellAdvisor with RFoFiber

## Conclusions

The increasing number of active transmitters on the RF spectrum is making interference artifacts in cellular networks more prevalent. These transmitters belong not only to licensed services such as mobile networks, paging systems, wireless local networks, and digital video broadcasting, but also belong to unlicensed or malfunctioning devices that generate external interference to licensed systems.

In addition, improper conductivity at the cell site itself can generate intermodulation products that interfere with the transmitting signals of mobile devices.

Detecting interference has been a challenging and expensive task on distributed cell sites. RF access was removed from the core of the radio to remote radio heads that are installed close to the transmitting antennas. RFoFiber technology solves these challenges. It measures RF through CPRI links from the BBU on the ground. This efficient interference analysis minimizes tower climbs, reducing safety concerns and reducing maintenance costs.

The VIAVI CellAdvisor is the most advanced and complete portable test solution for installing and maintaining conventional and distributed cell sites. It supports all wireless technologies (GSM/GPRS/EDGE, CDMA/EVDO, WCDMA/HSPDA, LTE-FDD/LTE-TDD) as well as LTE-MBMS and LTE-Advanced. And, it detects PIM, inspects fiber, tests and analyzes cloud services, and makes cell-site work safer and faster with RFoFiber.

## References

1. Common Public Radio Interface (CPRI); Interface Specification v 6.0
2. Open Base Station Architecture Initiative (OBSAI) – BTS System Reference Document Version 2.0
3. ETSI GS ORI 001. Open Radio Equipment Interface (ORI); Requirements for Open Radio Equipment Interface (ORI)
4. ETSI GS ORI 002. Open Radio Equipment Interface (ORI); ORI Interface Specification; Part 1: Low Layers
5. *Interference in Cellular Networks; Intermodulation and Frequency Refarming*, VIAVI
6. *Radio Access Networks; Interference Analysis*, VIAVI
7. *RF Analysis in Fiber-based Cell Sites*, VIAVI



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