Creating RF Predictable Environments for In-Building Wireless Applications

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Creating RF Predictable Environments for In-Building Wireless Systems

Market Demand Scenario

The confluence of current market conditions is creating a huge demand for in-building wireless (IBW) systems over the next five years. These market conditions include:

- 53% CAGR in mobile data traffic in the 2015-2020 period[1],
- 80% of mobile usage is indoors[2],
- U.S. IBW systems market opportunity estimated at US$19 billion through 2020 involving nearly 128,000 commercial buildings in the 100,000-500,000 sf range[3].

The Problem

Building construction materials such as concrete, steel and composite materials act as barriers to RF signals from outdoor macrocells from getting inside buildings in a uniform manner. How often have you had to go to the nearest window to get a strong enough cellular signal to make or take a call?

Wireless capacity and coverage issues can be solved with available in-building wireless systems such as a distributed antenna system (DAS), small cells, and bi-directional amplifiers (BDAs) or signal boosters. Such IBW systems are intended to provide uniform cellular coverage and capacity in high-traffic areas throughout the building.

The problem is that nearly every commercial building is 'touched' by a macrocell. The result is that the outdoor signal does not penetrate the entire building but rather causes interference with the indoor signal, thereby reducing the IBW system effectiveness and resulting in poor signal reception.

When faced with this situation, RF engineers resort to high-power indoor amplifiers to mitigate or otherwise combat the effects of the outside interfering signals so that mobile devices will 'see' a stronger indoor signal connect to the IBW equipment rather than connecting to the nearby macrocell.

This approach, however, generally results in extensive engineering costs, more expensive IBW equipment, and higher installation and testing costs.

[1] Cisco Visual Networking Index (VNI), 2016
[2] AT&T Mobility, 2014
[3] Skyline Marketing Group, LinkedIN Post, June 2015

The Solution

What if the indoor environment could be made 'RF predictable' by insulating it from any interfering RF signals from outside?

With a 'clean' and predictable RF environment, designing IBW systems becomes less complicated and use of lower power amplifiers may be feasible.

DAS Shield™ from Signals Defense is a purpose-built RF attenuation material that is applied to windows, either as a film or as a complete replacement window.

DAS Shield is designed to attenuate any outside signals by more than 30 dB over the 100 MHz to 12 GHz frequency range. This wide range encompasses public safety, TV white space, cellular and Wi-Fi applications.

Application Modeling

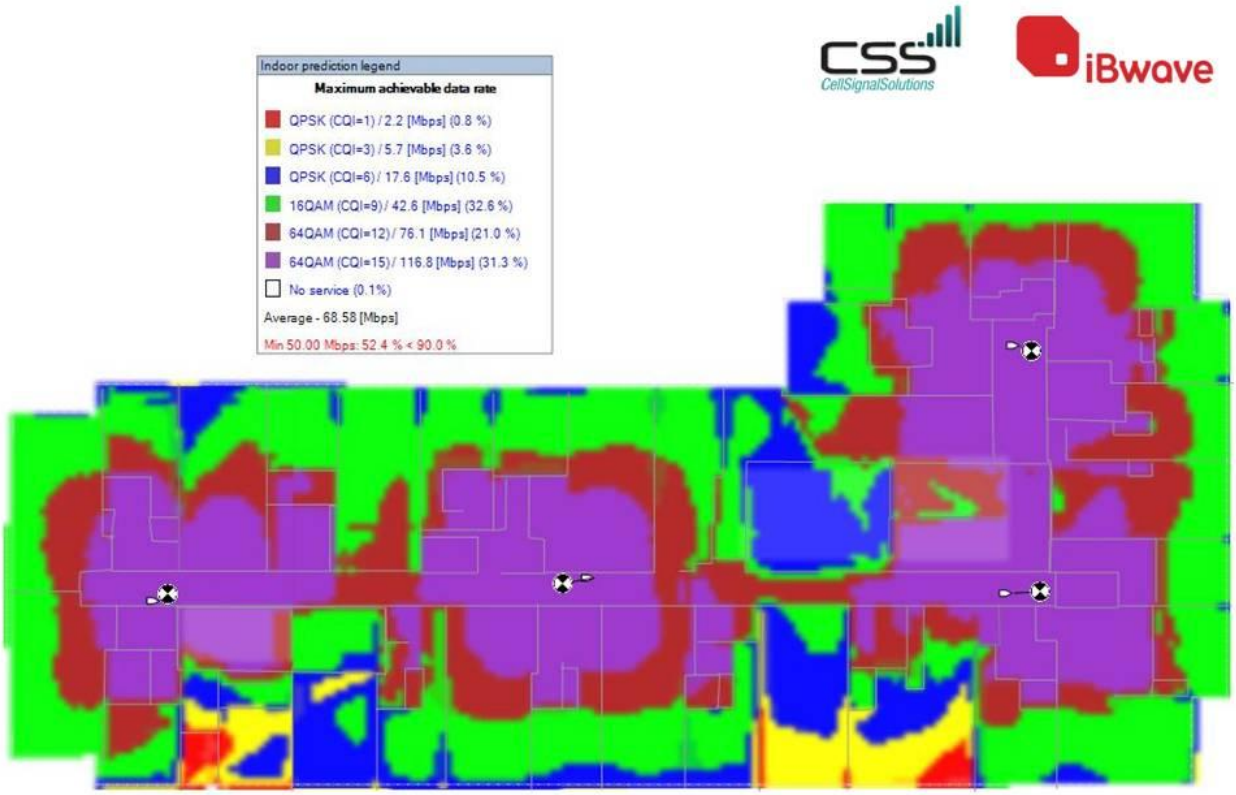
The proof of concept was tested with the support of an established IBW systems integrator, Cell Signal Solutions (CSS), that operates in the New York-New Jersey market, and who is an iBwave licensee.

CSS was asked to model the DAS Shield in an IBW system design to determine expected RF performance in both 'before' and 'after' scenarios using iBwave Design.

Model 1

- A new 35-story building with approximately 300,000 square feet of floor space, located in the New York-New Jersey market.
- Entire building exterior is glass panels.
- The IBW system is a commercially-available DAS.
- IBW system design called for three DAS remote units with 20 dBm output to feed the antennas throughout the building.
- The interfering outside LTE signal varies with floor height. For example, it was measured to be -75 dB at 20th floor.
- The goal is to have Maximum Achievable Data Rate (MADR) to be at least 50 Mbps over at least 90% of the floor plan.
- The 'Before' MADR map is shown Exhibit 1. It is evident that the signals emanating from the antennas only deliver the desired throughput over a portion of the floor plan before being diminished by outside interfering signals along the perimeter of the building.
- Clearly, the goal is not achieved, since only 52 percent of the target area has MADR equal to or greater than 50 Mbps.

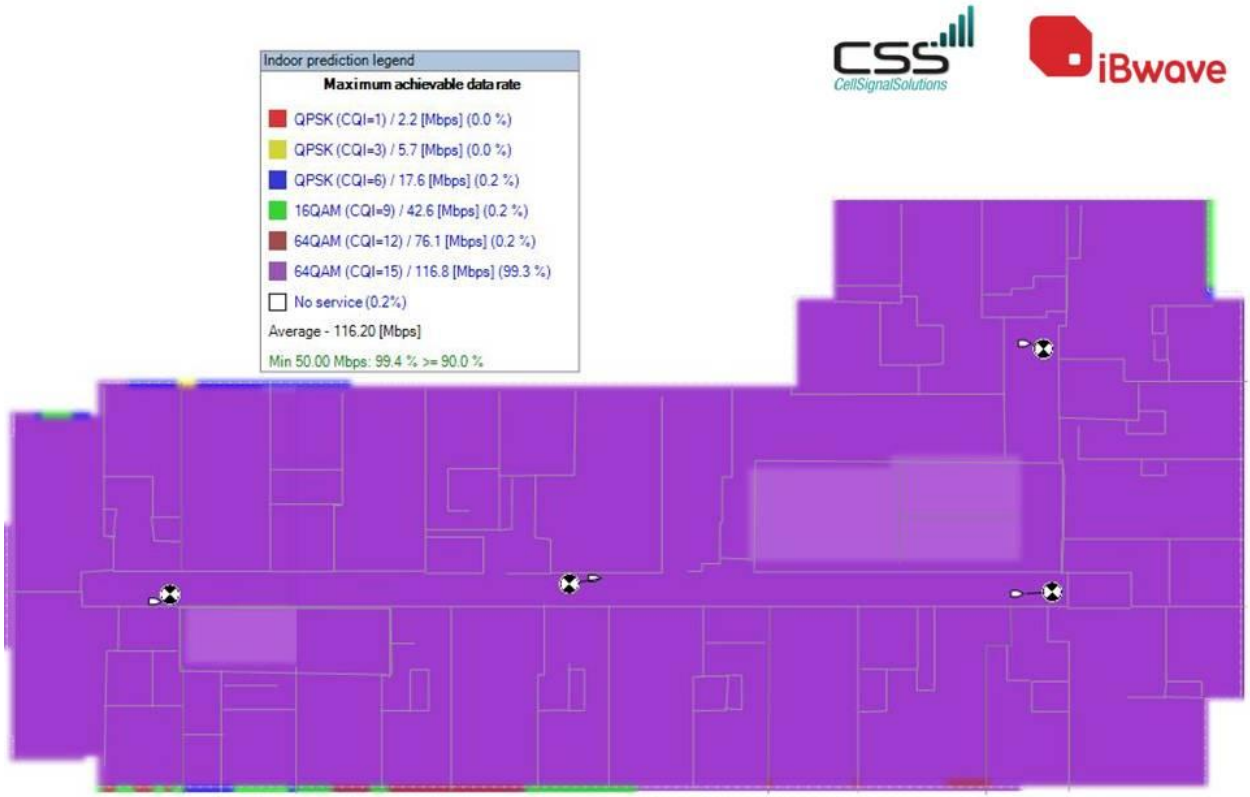
Exhibit 1



Applied Solution

- DAS Shield is applied to all sides of the building in iBwave Design.
- Exhibit 2 shows that, after applying the DAS Shield, outside interference is significantly reduced or eliminated so that 99 percent of the target area has MADR of greater than 50 Mbps now.
- So the throughput target is met.

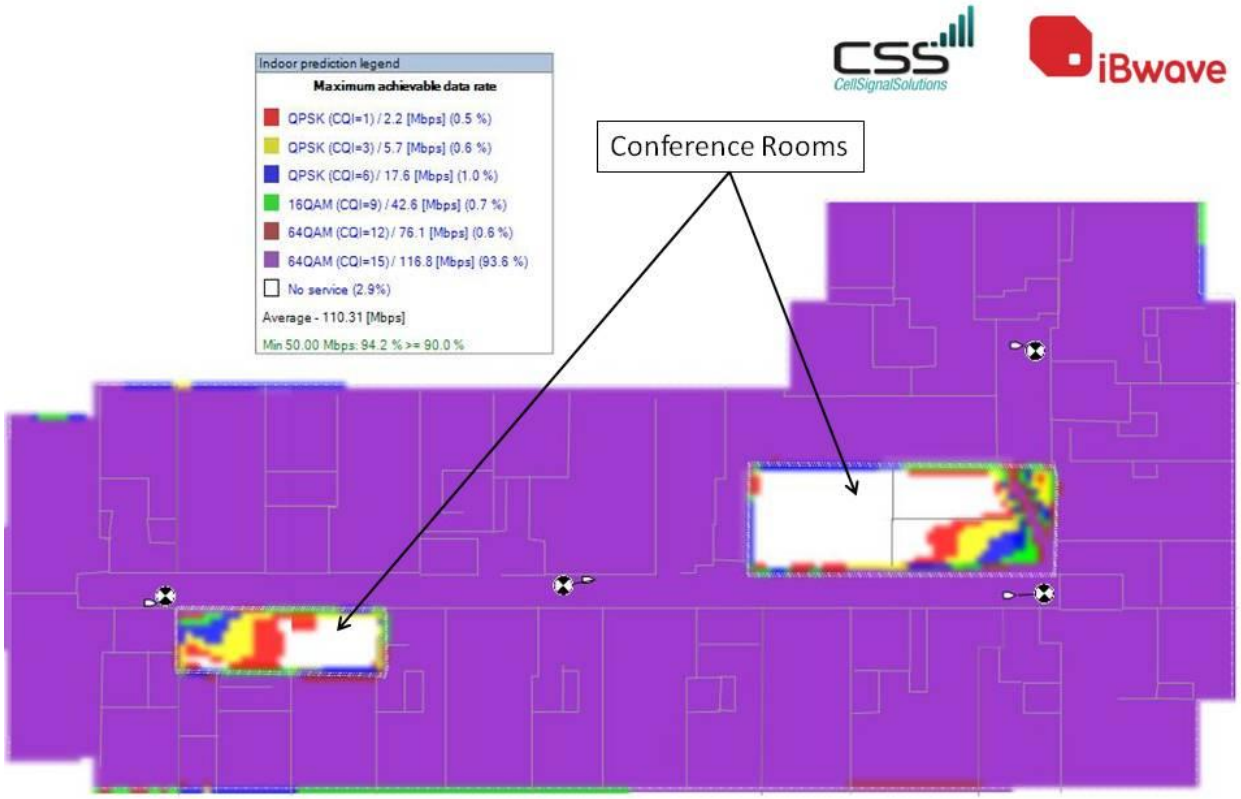
Exhibit 2



Additional Considerations

- Two conference rooms are located in the middle of the floor.
- Both of these are used regularly by executive level managers, and as such, require an extra level of security for wireless transmissions, either over cellular or Wi-Fi frequencies.
- So both conference rooms additionally must be shielded, or isolated, from RF signals being transmitted around the floor plan.
- With the 20 dBm remote units, DAS Shield is applied in iBwave Design to all sides of each conference room to attenuate the RF signals covering the floor plan.
- The ‘After’ MADR map is shown in Exhibit 3.

Exhibit 3

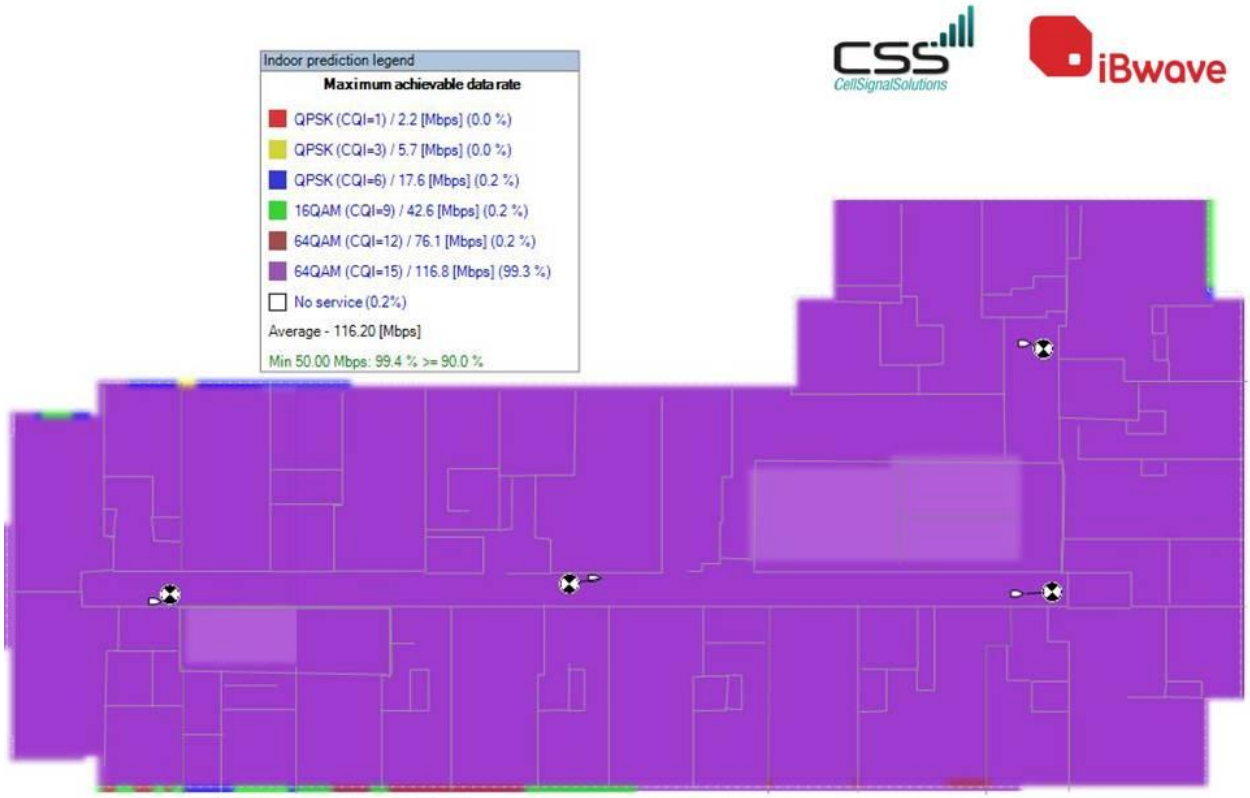


Model 2

- To solve the interference problem shown in Exhibit 1, DAS Shield is applied to all sides of the building in iBwave Design but the output power at the DAS remotes was maintained at 20 dBm.
- In this model, tests were conducted to determine results remote units that transmit at lower power levels.
- Transmit power at each DAS remote is reduced from 20 dBm to 0 dBm.
- Results show that at 0 dBm, the interfering outside LTE signal was kept at -75 dB at 20th floor.

- The 'After' MADR map is shown Exhibit 4.
- Even at 0 dBm, the Maximum Achievable Data Rate averaged out over the whole floor plan increased from 69 Mb/s (Exhibit 1) to 116 Mb/s (Exhibit 4).
- Target coverage (MADR > 50 Mb/s) increased from 52 percent (Exhibit 1) to 99% (Exhibit 4), again meeting the objective.
- This outcome means that the 20 dBm DAS remote unit can be replaced by a much lower power unit resulting in lower equipment costs and lower power consumption while still achieving the desired performance.

Exhibit 4



How DAS Shield Benefits Building Owners and CIOs

The models demonstrate that with application of DAS Shield both mobile data throughput is increased significantly, and DAS equipment and installation costs can be reduced.

Improved, predictable RF performance means that building owners can assure their tenants of uniform, sustained wireless operation throughout the building, thereby adding to the building's appeal.

On existing buildings, DAS Shield is applied as a film on the inside face of all exterior windows. For new buildings, DAS Shield can be installed as a complete window unit.

While DAS Shield material and installation costs must be added back to the total project cost, building owners can realize additional benefits and substantial operating cost savings, as follows:

- **Security/Wireless Invisibility** – "If one can't see the network, one can't attack the network". In addition to creating a quieter and more RF predictable environment on the inside of the building, the 'visibility' of the indoor DAS and other wireless networks from those on the outside will be significantly reduced by using DAS Shield.

  Wi-Fi is a prime example. With DAS Shield, the Wi-Fi signal from inside a building is no longer 'visible' outside the building. This reduction in the emanating RF footprint means there is less access to the indoor Wi-Fi networks by anyone intending on making rogue or unauthorized connections, or wirelessly penetrating the network.

  DAS Shield can also be applied to interior walls to create secure conference rooms or workspaces for wireless local area networks (WLANs). This capability is a significant benefit to IT managers responsible for ensuring the integrity and protection of their proprietary indoor wireless data networks.

- **RF Shielding** - DAS Shield works in both directions. That is, it provides shielding both from the interior and exterior of the building's windows. Thus the occupants and equipment on the inside of the building will have additional sheltering from the active and ambient RF energy and transmissions on the outside of the building.

  Aside from macro-cellular communications, there are many other (possibly unwanted) RF communications and transmissions in urban environments that may interfere with the people and equipment inside the building.

- **LEED Certification** DAS Shield can help building owners qualify for LEED credits towards achieving LEED certification.

  LEED, or Leadership in Energy and Environmental Design, is a 'green building' certification program that recognizes best-in-class building strategies and practices. To receive LEED certification, building projects satisfy prerequisites and earn points to achieve different levels of certification. For more information on the LEED program visit, www.usgbc.org/certification

- **Energy Savings** - With DAS Shield window treatment, infrared (IR) is less than 17%, ultraviolet (UV) light is less than 1% and the visual light transmission (VLT) is about 70% clear and non-reflective while the total solar energy rejected (TSER) is greater than 50%.

  This means that visibility through the windows is relatively unchanged while IR, UV and solar energy coming into the building is significantly rejected. With IR, UV, and solar energy reduced substantially, building owners will see much less glare inside the building and experience less fading of organic materials (floors, furniture, artwork).

  Even though each building is different in construction and location, and must be assessed on its own merits, preliminary estimates suggest that DAS Shield may help lower overall building heating and cooling costs by an average of 5-10% per year.

  Energy simulation software can show how installing DAS Shield yields monthly utility cost savings, based on current consumption. Depending on the utility company and jurisdiction, building owners may qualify for partial energy cost reimbursements for the upgrade.

Conclusions

DAS Shield is a breakthrough in IBW system design.

More important, it can set a new paradigm for IBW systems in achievable RF performance and deployment costs.

The system design can be simplified, overall system equipment costs can be lower and installation and testing time can be reduced.

The DAS Shield parameters already are built into iBwave Design-Materials so the learning curve for designers to incorporate DAS Shield into their designs is minimal.

DAS Shield can help building owners to lower their overall operating costs while delivering a superior, secure in-building wireless experience to their tenants and occupants.

About Us

iBwave is the power behind great in-building wireless experience, enabling billions of end users and devices to connect inside a wide range of venues. As the global industry reference, iBwave software solutions allow for smarter planning, design and deployment of any project regardless of size, complexity or technology. Along with innovative software, iBwave is recognized for world-class support in 90 countries, industry's most comprehensive components database and a well-established certification program. www.ibwave.com

Cell Signal Solutions (CSS) offers in-building wireless solutions that are planned by the industry's most innovative and skilled engineers and architects, installed by accomplished technicians, and maintained by diligent operators. The CSS team consists of extensive wireless technology and industry experience that works to deliver turnkey solutions and best-in-class services to wireless carriers and enterprise clients. www.cellsignalsolutions.com

Signals Defense (SD) produces an innovative, optically-clear window film technology that provides high radio frequency (RF) and infrared (IR) attenuation for RF shielding and thermal imaging defense purposes. SD's patented window technology has been engineered to meet stringent US Intelligence community security requirements for facilities handling classified information. SD's technology is the *de facto* written standard for the US Government and for organizations desiring to properly secure locations handling sensitive and/or classified information. SD's window films meet the TEMPEST requirement for the Intelligence Community Directive ICD 705 and the DoD IR and RF Emanation Protection Standards. SD technology has been deployed on over 1,300 locations providing our clients (including Government Intelligence agencies, DOD, and Fortune 100 companies) with US DoD strength physical, IT and emission security systems. SD technology also provides safety and energy benefits to its clients with UV and glass fragmentation/spall control window films, and SD glass and polycarbonates. www.signalsdefense.com

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