# RFS In-Building Solutions

Your unrivaled partner for high-performance indoor solutions

# Bringing wireless networks closer to people

Two major trends drive the need to deploy a dedicated wireless in-building communications solution:

- **Peoples' behaviors**
- **New network technologies**

## People are in buildings, consuming more data

Today, people spend most of their time in buildings — at home, at work, in shopping malls and entertainment venues. Even when traveling, people spend much of their time in buildings.

While indoors, people are constantly using smartphones and tablets to stay in touch, entertain themselves and complete work tasks. The increasing demand for wireless services — particularly data services — from within buildings is pushing macro networks to exhaust.

Wireless in-building solutions bring the network inside the buildings where people spend their time. People enjoy access to uninterrupted wireless services and operators can address network challenges. Dedicated in-building solutions:

- Improve capacity and coverage indoors
- Offload the outdoor macro network
- Enable more efficient use of the available spectrum
- Support commercial and mission-critical communications requirements

## Networks and buildings are evolving

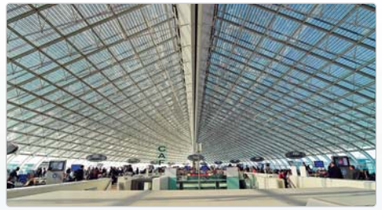
Advanced wireless technologies such as UMTS and 4G LTE give people access to the speeds needed to consume vast quantities of data. However, they are often delivered at high frequencies that don't penetrate buildings well. Adding to the challenge, modern buildings are often constructed with reinforced concrete and steel that resist wireless signal penetration.

Wireless in-building solutions solve these challenges by taking network technologies within building walls. However, in-building solutions only make technical and financial sense if they:

- Support multiple frequency bands, network technologies and operators
- Reduce total cost of ownership (TCO)
- Provide highly reliable communications
- Comply with safety regulations

**More than 80% of all wireless voice and data communications begin indoors.**

Passive distributed antenna system (DAS) solutions from Radio Frequency Systems (RFS) deliver all of the capabilities needed to give people better access to wireless services in buildings while meeting technical and financial requirements.



Paris Charles De Gaulle airport

## Multi-band, multi-technology, multi-operator support

Solutions are transparent from a radio frequency (RF) perspective:

- A single passive DAS solution can be shared by multiple operators that deliver different commercial and mission-critical wireless services using different technologies and frequency bands.
- Operators and frequencies can be added or changed to support new macro network providers or technologies, including 4G LTE.
- DAS solutions are radio access network (RAN) vendor-agnostic.

## High quality and reliability

All solution components deliver high-quality and highly reliable commercial and mission-critical wireless services in buildings:

- RF cables combine flexibility and strength with low attenuation and high power ratings.
- Non-cable components maintain overall system performance and key performance characteristics such as passive intermodulation (PIM) performance.
- RF-over-fiber repeaters can be used to reamplify signals over long distances.

## Built for compliance and safety

Cable materials and construction are all thoroughly tested to ensure they meet national, regional and local fire and flame-retardant specifications.

## A complete partner

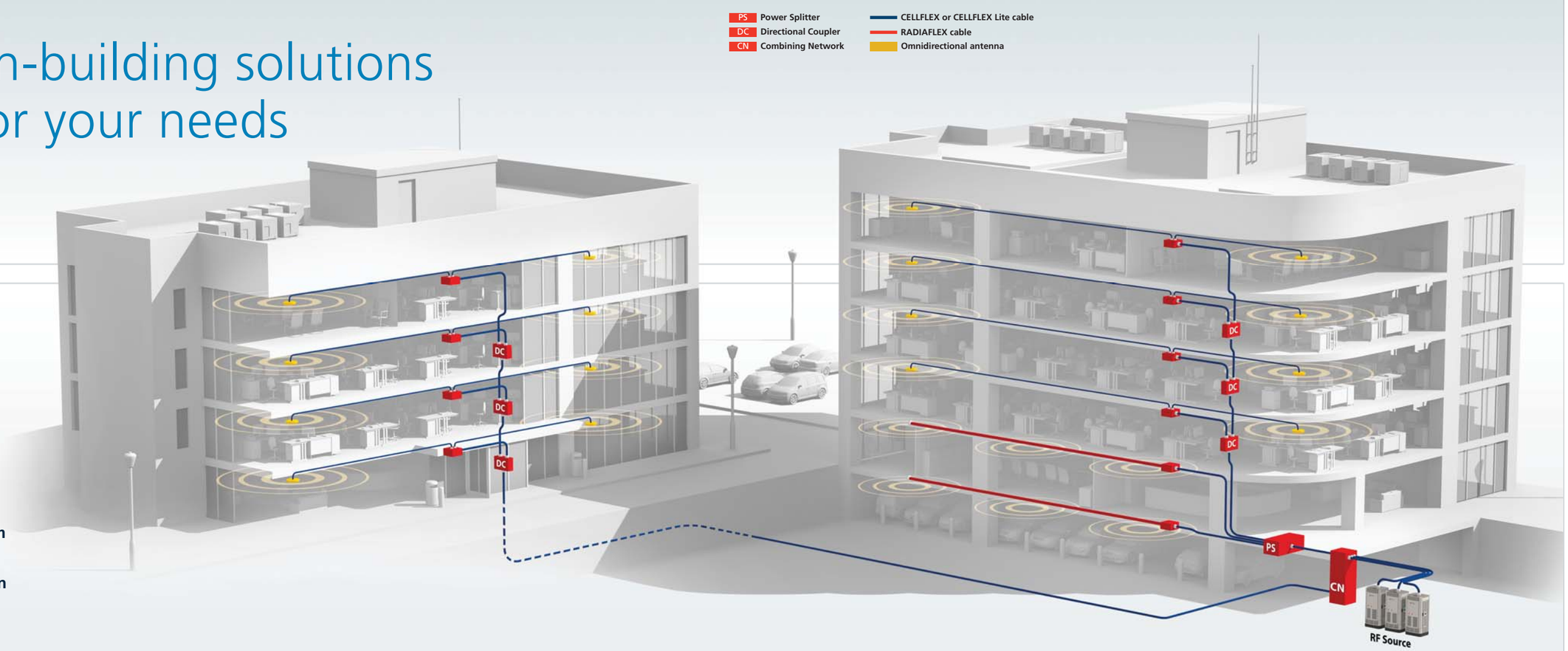
RFS provides professional services to help customers deploy passive DAS solutions that are optimized for cost and performance. RFS can assist customers with specific stages of design and deployment or provide a turnkey solution.

### Low TCO

Once installed, solutions require almost no maintenance and consume no electricity.

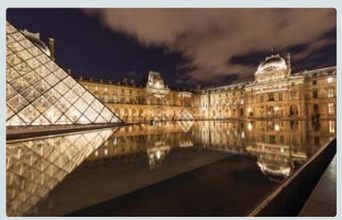
This keeps costs down and ensures error-free operation and high system availability — key requirements for mission-critical services.

# Wireless in-building solutions tailored for your needs




RFS passive DAS solutions are ideal for mid and large-sized buildings of all types, including:

- **Apartments, condominium buildings and hotels**
- **Airport terminals and train stations**
- **Office and industrial complexes**
- **Shopping malls**
- **Stadiums and arenas**
- **Hospitals**
- **School campuses**
- **Conference centers**
- **Public buildings such as museums, art galleries, concert halls and libraries**



The Louvre Museum

## Flexible designs for commercial and mission-critical communications

Every RFS passive DAS solution is purpose-built to match business objectives, application requirements and physical environment.

- **Any complexity, any business model.** Solutions can be designed to support simple environments with a single operator, service and frequency or highly sophisticated environments with multiple operators, services and frequencies. Services supported can include any combination of:
  - **Cellular wireless services based on 2G, 3G and 4G technologies**
  - **Analog and digital security and emergency services**
  - **Wireless LAN (WLAN) services based on 802.11 standards**
  - **Paging services**

## Frequency bands and mobile standards

RFS offers the widest range of 2G (GSM/TDMA/CDMA), 3G (UMTS/cdma2000) and 4G (LTE/WiMAX) antenna solutions for network deployment, designed for greenfield players and existing operators alike.

- **Any population, any capacity trend.** Solutions can be designed to meet capacity requirements ranging from peak-time requirements in apartment buildings to large bursts of simultaneous communications at event venues to consistently high volumes of data traffic in office buildings.
- **Any room size, any layout.** Solutions can be designed for buildings with different room sizes, numbers of floors and layouts, including underground areas. Whatever the physical environment, RFS combines antennas and radiating cables in the way that best optimizes the technical solution and the cost.

## Complete wireless in-building solutions

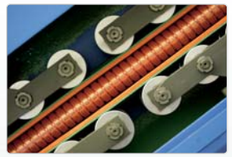
RFS wireless in-building solutions include all of the components needed to deploy an end-to-end passive DAS:

- CELLFLEX® and CELLFLEX® Lite low-loss foam dielectric coaxial cables
- High-performance RADIAFLEX® radiating cables
- Broadband and ultra-broadband indoor antennas
- High-quality connectors that maintain system performance
- Broadband and ultra-broadband indoor combiners, couplers and splitters with low insertion loss

# Designed to address the toughest technical challenges


RFS is recognized around the globe for its dedication to designing and manufacturing reliable, high-performing and long-life products.






## Truly broadband solutions

RFS solutions support services in frequency bands ranging from 380 MHz to 6 GHz. They are particularly well suited to distribution of cellular services in the 698 MHz to 2700 MHz frequency range.


## Low PIM in all in-building products

Low PIM is crucial for high performance in passive components and clear signals across passive DAS solutions.

RFS focuses on keeping PIM values as low as possible in every area of the RF chain:

- **Solution components are designed with corrosion-resistant materials, water-tight sealing, and multi-threaded connectors for fast and easy tightening.**
- **Stringent manufacturing processes ensure high-quality welds, robust connections and no contamination.**
- **PIM performance in finished components is validated against international standards.**
- **Solution components are subjected to harsh environmental tests to ensure corrosion resistance.**
- **Installation processes are straightforward to reduce errors and vulnerabilities.**
- **Installation tools enable precise, repeatable installations.**

## Flame and fire-retardant cables

All RFS cables meet International Electrotechnical Commission (IEC), European Standard (EN) and Association for Electrical, Electronic and Information Technologies (VDE) standards for:

- Halogen-free and non-corrosive jacket tests
- Flame tests
- Cable bundle tests
- Low-smoke emission tests

RFS plenum-rated cables for the North American market are CATVP-rated, with low flame-spread and low-smoke characteristics. They are also tested according to US National Fire Protection Agency (NFPA) testing method 262, ensuring they meet the most stringent flame-retardant and smoke-suppressant requirements.

## High-performance head-end combining networks

Combining network performance strongly influences the quality of up-link and down-link transmissions.

RFS provides the expertise, experience and technical components required to combine a single service per frequency band or multiple services per frequency band and multi-band applications with the highest quality levels. For complex combining networks, we offer customized components that are developed or adapted to meet the unique requirements of particular applications.

## LTE and MIMO support pave the way for network evolution

Multiple input multiple output (MIMO) antenna technology increases LTE capacity. However, due to its electrical characteristics, MIMO can also create signal propagation challenges in buildings.

RFS passive DAS solutions are LTE-ready and designed to support MIMO technology. Our technical experts understand:

- When, where and how to install transmit antennas for continuously high signal integrity
- What levels of signal-to-noise ratio (SNR) are needed for improved data rates
- How to cost effectively scale the solution to ensure a high-performing solution does not break the budget

## Fiber-optic extensions for the most demanding in-building requirements

To ensure highly reliable and available wireless services in all areas of the building, RFS provides RF-over-fiber repeater systems where needed. These high-capacity signal distribution systems support 2G, 3G, 4G and TETRA communications in bands ranging from 380 MHz to 2700 MHz.

"There are a number of cable manufacturers; the challenge is finding one that offers consistent technical performance and reliability, while also providing an economical solution. RFS excelled in all of these areas."

**Joe Mullin, Vice President of Engineering and Operations at InSite Wireless**

# Cables and connectors for every in-building application

RFS coaxial and radiating cables are designed to meet in-building communications requirements today and tomorrow. High-quality connectors maintain signal integrity end-to-end.

## CELLFLEX® low-loss copper cables

CELLFLEX® foam dielectric cables combine flexibility with strength and electrical performance to ensure uninterrupted communications throughout buildings.

**Low attenuation**
Low attenuation enables extremely efficient signal transfers.

**Complete shielding**
The solid outer conductor creates a continuous shield against radio frequency and electromagnetic interference (RFI/EMI) to minimize system interference.

**Low VSWR**
Special low voltage standing wave ratio (VSWR) CELLFLEX® variants help maintain system integrity.

**Outstanding intermodulation performance**
The solid inner and outer conductors virtually eliminate intermodulation.

**High power rating**
Low attenuation, excellent heat transfer properties and temperature stabilized dielectric material ensure a safe long-term operating life at high transmit power levels.

**Wide range of applications**
CELLFLEX® cables support frequency bands up to 6000 MHz to enable a wide range of in-building applications.

## CELLFLEX® Lite lightweight aluminum cables

CELLFLEX® Lite aluminum cables are the lightest RF transmission cables on the market today. They are specifically designed for fast, easy and cost-effective cable installations. CELLFLEX® Lite cables combine an innovative corrugated aluminum outer conductor design with:

- Single and multiple bending radii as per industry standards
- Robust construction
- Advanced electrical performance
- An attractive entry price point

## Choosing the right cables and connectors for your in-building applications

| Markets and applications | Cable types | Cable models | Connector options |
|---|---|---|---|
| **In-building** (all countries, except in North America) | Low coupling-loss radiating | RLK series | RADIAFLEX® connectors |
| **In-building with stringent fire codes** | Plenum-rated air dielectric | ICA12-50JPL, ICA12-50JPLW | Standard and premium CELLFLEX® connectors |
| **In-building with no plenum requirements** | Flame-retardant foam dielectric | LCF12-50JFN | Standard and premium CELLFLEX® connectors |
| **Mining safety and Mine Safety & Health Administration (MSHA)** | Flame-retardant foam dielectric<br>Corrugated, milled radiating | LCF12-50JFN, LCF78-50JFN<br>RCF12-50JFN | Standard and premium CELLFLEX® connectors<br>Standard and premium CELLFLEX® connectors |
| **In-vehicle** | Flexible, corrugated radiating | RSF series | Standard and premium CELLFLEX® connectors |
| **In-tunnel** | Flame-retardant radiating | RLK series, RLF series, RAY series | RADIAFLEX® connectors |
| **Metro and railway stations** | Low coupling-loss radiating | RLK series | RADIAFLEX® connectors |
| **Oil and gas platforms** | Corrugated, milled radiating | RCF12-50JFN | Standard and premium CELLFLEX® connectors |
| **Ships** | Low coupling-loss radiating | RLK series | RADIAFLEX® connectors |

## RADIAFLEX® high-performance radiating cables

RADIAFLEX® is the world's leading "leaky feeder" cable solution. Designed to deliver contoured indoor RF coverage, RADIAFLEX® cables provide a scalable and practical means of tailoring RF coverage in even the most confined in-building spaces. Where required, corrugated outer conductors and small bending radii provide the flexibility needed for easy installation in any indoor environment.

**Broadband solution**
RADIAFLEX® cables support all major services up to 6 GHz, making them ideal for multi-operator and multi-band applications in challenging locations such as parking garages, tunnels and mines.

**Extensive application support**

- Wireless telephony, including 2G, 3G, and 4G LTE
- WLAN
- Mission-critical communications
- Trunked radio

**Flame and fire retardant**
RADIAFLEX® cables are low-smoke and halogen-free to meet all major international flame- and fire-retardancy standards.

**Low loss**
RADIAFLEX® cables offer low longitudinal loss and are available in low coupling-loss variants that are specifically designed for building and tunnel applications.

## Clearfill® Line Plenum-rated cables for North America

RFS plenum-rated wideband cables for the North American market deliver outstanding electrical performance and support all wireless in-building applications. These air dielectric coaxial cables are thoroughly tested for safe use within the "environmental air handling space" in ceilings as well as in more traditional plenum applications.

RFS plenum-rated cables:

- Support technologies and applications in bands ranging from 380 MHz to 6000 MHz.
- Feature conductor designs that create a continuous RFI/EMI shield to minimize system interference and virtually eliminate intermodulation.
- Offer low attenuation, outstanding heat transfer properties and temperature-stabilized dielectric materials.

## Plenum-rated and flame-retardant, factory-fit jumpers

RFS in-building jumpers are pre-terminated in the factory instead of manually terminated in the field to increase performance, save installation time, reduce human error and, ultimately, save money. Our in-building jumpers feature:

- Factory-fit, soldered on connectors for the best possible PIM and VSWR performance.
- Plenum-rated, flame-retardant, low-flame spread, low-smoke jackets that comply with the highest in-building standards for flame and fire retardance.
- A continuous star-dielectric spline for uniform support and fewer electrical and mechanical bending challenges in tight bending situations.

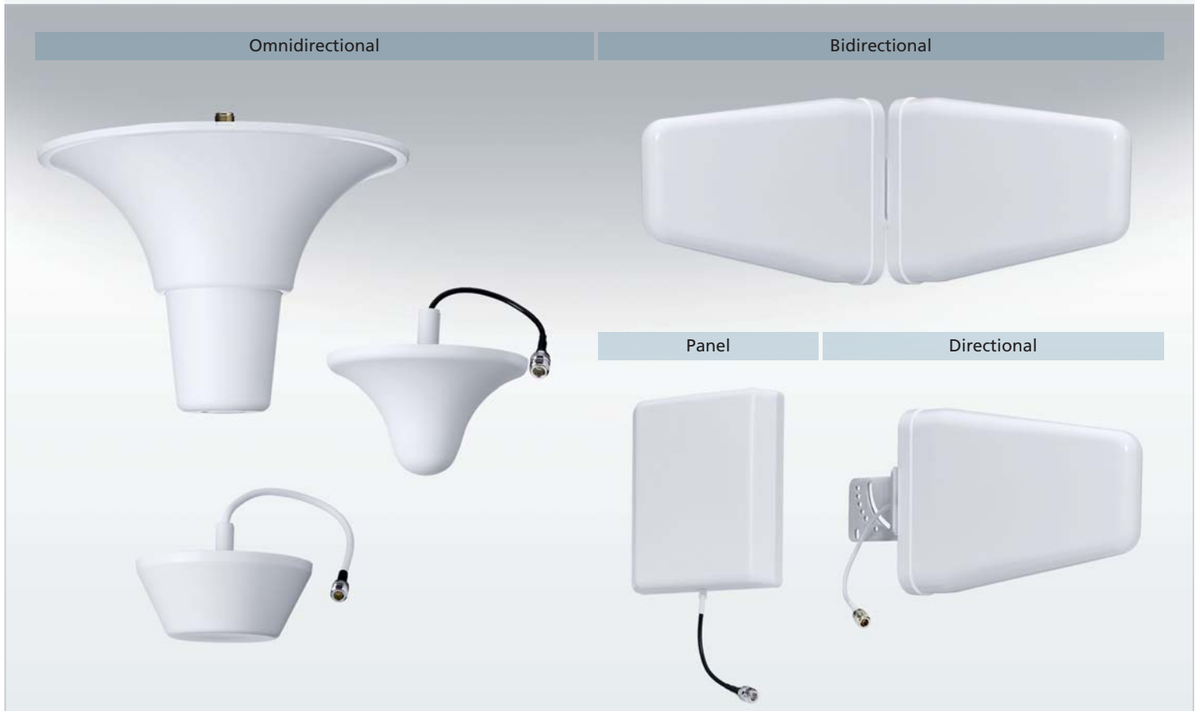
## Standard and premium- performance connectors

The RFS line of OMNI FIT™ connectors includes premium connectors for PIM-critical applications and standard connectors for typical requirements and optimized rollout costs.

For convenience, RFS OMNI FIT™ connectors can be used with CELLFLEX®, CELLFLEX® Lite and corrugated RADIAFLEX® cables. In addition, single-piece, easy-to-install RADIAFLEX® connectors are available for RADIAFLEX® cables with flex foil outer conductors.

Cable preparation tools are available to ensure easy and precise installation; connectors can be re-installed when necessary to avoid waste.

# Broadband and ultra-broadband indoor antennas




RFS passive DAS solutions incorporate indoor antennas that support 2G, 3G and 4G cellular, Wi-Fi, WLAN, TETRA, DVB-H and WiMAX services in frequency bands ranging from 350 MHz to 6000 MHz. Broadband, ultra-broadband and PIM-rated indoor antennas are available for long-life solutions.

## Performance, design, versatility

All RFS indoor antennas are designed for high performance and low visual impact. Antennas can be mounted on walls or ceilings. Antennas and the cables connecting them can also be painted to match surrounding colors and blend into the building aesthetic.

RFS indoor antennas feature:

- Sealed, UV-stable radomes
- Low VSWR, high gain, stable performance
- Compact, lightweight designs

RFS provides four types of indoor antennas to meet every in-building requirement:

- Omnidirectional
- Panel
- Directional
- Bidirectional



# Passive system components, accessories and tools

A complete portfolio of passive system components and accessories completes your wireless in-building solution.

## Passive system components

RFS passive system components provide maximum flexibility and optimum electrical performance.

- **Combiners** support one service per frequency band, multiple services per band, and multi-band applications. RFS also offers standardized combiner modules in 19-inch rack technology.
- **Hybrid combiners and hybrid couplers** combine multiple signals in the same wireless band to a common feeder cable.
- **Directional couplers and tappers** uniformly distribute RF signals.
- **Diplexers and triplexers** combine and separate signals in different wireless bands.
- **DC blocks** prevent the flow of direct current and low-frequency current surges along the inner and outer conductors of a transmission line, while permitting the unimpeded flow of RF signals.
- **Power splitters** evenly split input signals with minimal reflections or loss.
- **Loads** terminate all types of open RF ports.
- **Attenuators** adapt RF power levels to meet different system requirements.

## Cable accessories

RFS cable accessories ensure installation integrity and safety over the long term:

- **Clamps and cable ties** hold cables securely without affecting cable performance.
- **Cable hangers** ensure each cable type is installed the right distance from the wall or ceiling.
- **Grounding kits** provide secure, low-resistance contact to the cable outer conductor for reliable overvoltage protection without mechanical deformation to ensure the electrical transmission is not degraded.

## Installation tools

RFS installation tools simplify installation procedures and reduce the risk of errors:

- **Automated trimming tools** designed specifically for RFS cables ensure cables are properly prepared for connector attachment.
- **Stripping tools** ensure outer conductors are properly prepared for connection to grounding kits.
- **Cable tie adjustment tools** accelerate cabling procedures.

# Leading organizations around the world rely on RFS wireless in-building solutions

## Venetian Macau Resort bets on RFS for large-scale in-building coverage

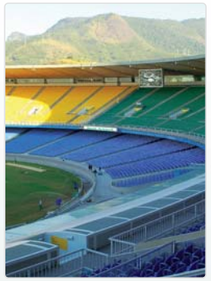
RFS designed and supplied a distributed antenna network for both the 3000-room hotel and the 50,000 square meter (538,000 sq ft) casino and gaming space within the opulent Venetian Macau Resort. The RFS solution consisted of 3,000 point-source antennas and 500 indoor antennas linked together with CELLFLEX® foam dielectric coaxial cable. The expandable system currently supports CDMA 800 MHz, GSM 900 MHz and GSM 1800 MHz commercial services, as well as TETRA service for internal and security communications.

## Dublin stadium takes multi-operator, multi-technology coverage indoors

RFS delivered a turnkey shared distribution system for use by the multiple operators providing wireless services to Aviva Stadium in Dublin, Ireland. The solution, which includes omnidirectional and panel indoor antennas, supports GSM 1800 and UMTS services with multiple carriers per sector. It can be easily upgraded to provide GSM 900 and WLAN services in the 50,000-seat stadium.

## A turnkey, multi-operator solution for “indoor city” in Brazil

Thanks to RFS, the 17,000 employees and 5,000 to 10,000 daily visitors to the 5-buliding Minas Gerais government complex in Belo Horizonte, Brazil, now enjoy uninterrupted wireless coverage indoors. Spanning more than 800,000 square meters of office space, the RFS solution takes 2G and 3G wireless coverage within the reinforced concrete walls of the well-known complex. The solution is shared among four operators and supports GSM and UMTS technologies in the 850 MHz, 1800 MHz and 2100 MHz frequency bands.



## Indoor coverage for major Pan Am Games sites in Rio de Janeiro

RFS supplied the RF distribution system for five major sites used in the 2007 Pan American Games in Rio de Janeiro — the Maracanã complex, the Riocentro Exhibition and Convention Center, the Miécimo da Silva complex, the Autódromo and the João Havelange complex. The turnkey project provided GSM 900, GSM 1800 and UMTS 2100 coverage for two Brazilian operators. It included a triple-band, fiber-fed solution and remote management and supervision for fiber-fed repeaters.


## California stadium reuses existing network for cellular communications

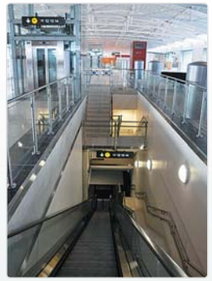
To keep the costs of deploying in-building coverage at California’s Home Depot Center Stadium down, RFS helped Verizon Wireless engineer a solution that takes advantage of the radiating cable network used for the stadium’s UHF-based security system. With a high-performance, band-specific bidirectional amplifier (BDA) from RFS added to the existing solution, visitors to the 50-hectare (125-acre) stadium complex now enjoy signal quality exceeding 80 dBm in 99.9 percent of stadium locations.

## European Central Bank brings 3G coverage to its two new towers

RFS’ CELLFLEX® low-loss foam dielectric cables, splitters and accessories are being used to bring 3G communications to the new European Central Bank (ECB) premises in Frankfurt am Main, Germany. The in-building solution spans the two 45-floor ECB towers and will be used by multiple German operators. Because CELLFLEX® cables are highly flexible and easy-to-install, they were the ideal solution for the buildings’ limited installation space. Installation training from RFS ensured smooth deployment.

## Quinnipiac University in the US enables anytime, anywhere communications

With wireless in-building design services and coverage solutions from RFS, Quinnipiac University in Hamden, Connecticut, was able to bring seamless wireless communications to students and staff. The neutral-host solution provides in-building cellular coverage across the academic buildings, residence halls and sports facilities on the 109 hectare (270-acre) campus. The University buildings now feature excellent cellular reception, location-based services and support for community applications for class work and faculty-student messaging.

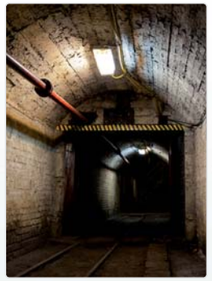


## Cyprus airport brings wireless services to ultramodern airport terminal

RFS provided mobile operators MTN Cyprus and Cyta with a complete active indoor wireless solution that ensures Larnaca International Airport’s travelers and personnel can connect to world-class mobile services. A vital element of the ultramodern airport terminal, the sophisticated wireless in-building system provides GSM and UMTS coverage and is ready to deliver TETRA, Wi-Fi and WiMAX access.


## Fully passive in-building solutions for Brazil’s two busiest airports

Brazilian operators chose RFS to design, implement, test and project manage solutions for in-building GSM 1800, GPRS, EDGE and UMTS 2100 wireless coverage in Guarulhos International Airport and Congonhas Airport, São Paulo, Brazil. The fully passive solutions are also ready to support Wi-Fi in the 800 MHz to 2500 MHz range.



## Leading underground communications specialists rely on RADIAFLEX

Mining communications specialists Pillar Innovations and Becker Electronics based their turnkey wireless communications system on RFS’ RADIAFLEX® radiating cable. As one of the first radiating cables to obtain US Mine Safety and Health Administration (MSHA) certification, RADIAFLEX® is ideal for below- and above -ground mining environments. RADIAFLEX®-based communications systems have been deployed in major mines in the US and South Africa.

# Services to complement your in-building solution

In addition to supplying all of the products and solutions needed to enable a broad range of wireless in-building communications, RFS has extensive experience providing professional services — from a single service to full turnkey solutions for mission-critical and commercial wireless services in buildings. RFS' turnkey solutions include all of the essential services described here.

**Consulting**
Helping customers choose the right technologies, deployment strategy and products for each application.

**Site survey**
Setting the stage for successful deployments.

**System design**
Leveraging our broad experience and deep technical expertise.

**Project management**
Keeping complex, multi-provider deployments on-schedule and on-budget.

**Supervision**
Ensuring sub-contractors meet stringent specifications for quality and timeliness.

**Installation**
Focusing on efficient and cost-effective deployments.

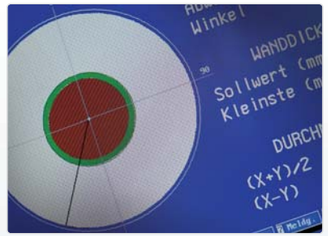
**Commissioning**
Getting new solutions up and running without delay.

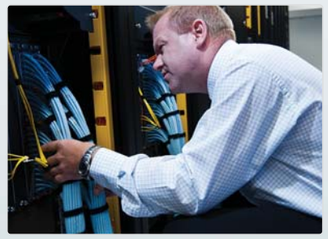
**Acceptance testing**
Proving new solutions meet specific requirements and KPIs.

**Training**
Providing personnel with the knowledge required for smooth daily operations.

**Maintenance**
Reducing the risk of failures and system downtime.

With RFS as their strategic partner, customers enjoy the freedom and flexibility to choose the product, solution and service combination that best meets their business objectives.





# Why RFS?

## An experienced partner with a proven track record

**Radio Frequency Systems (RFS) is a global designer and manufacturer of cable, antenna and tower systems along with active and passive RF conditioning modules, providing total-package solutions for wireless and broadcast infrastructure.**

**RFS serves OEMs, distributors, systems integrators, operators and installers in the broadcast, wireless communications, land-mobile and microwave market sectors.**

**As an ISO-compliant organization with manufacturing and customer-service facilities that span the globe, RFS offers cutting-edge engineering capabilities, superior field support and innovative product design.**

RFS has more than 40 years of experience delivering reliable in-building solutions to customers around the world. As one of the major players in the marketplace, RFS has the portfolio, strength and size to become a long-term partner

**Argentina**
- Torre Madero building

**Belgium**
- Brussels International Airport

**Brazil**
- Congonhas Airport
- CAMG complex
- Guarulhos International Airport
- Maracaña Stadium
- Petrobras oil platforms

**China**
- East China Sea oil platforms

**Cyprus**
- Cyprus Airport

**France**
- Alcatel-Lucent headquarters
- Orly Airport
- Roissy Charles de Gaulle Airport

**Germany**
- Berlin International Airport
- Frankfurt Airport
- Tübingen Hospital
- Volkswagen plant

**Hong Kong**
- Convention and Exhibition Center

**Iceland**
- Icelandic Dam Water Plant

**Mexico**
- Princess Hotel Acapulco

**Netherlands**
- Leiden Hospital

**Norway**
- North Sea oil platforms

**Saudi Arabia**
- Oil caverns

**Singapore**
- Metropolitan Area Network

**South Korea**
- KOEX exhibition building

**South Africa**
- Gold mines

**Spain**
- Madrid Airport

**United Kingdom**
- London Olympic Village
- Ireland Intel plant

**USA**
- Americas Mart
- Beaumont Hospital
- Boston Marriot Hotel
- Bridgestone Arena
- Coal mines
- Dallas Cross Center Building
- Grand Ole Opera Hotel
- Home Depot Stadium
- LP Field
- Lucas Oil Stadium
- M & T Bank Stadium
- New Orleans CTIA Exhibition
- Princeton University
- Qualcomm Stadium
- Quinnipiac University
- SNET Headquarters

**For more information, please contact the nearest RFS sales office:**

**Southern Europe, Middle East, Africa & India**
www.rfsworld.com/sales/semeai

**Northern Europe**
www.rfsworld.com/sales/euno

**Latin America**
www.rfsworld.com/sales/latam

**North America**
www.rfsworld.com/sales/na

**Asia Pacific**
www.rfsworld.com/sales/apac

**www.rfsworld.com**

RADIO FREQUENCY SYSTEMS
The Clear Choice®