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A Systems Approach to Wireless RF Transmission Lines

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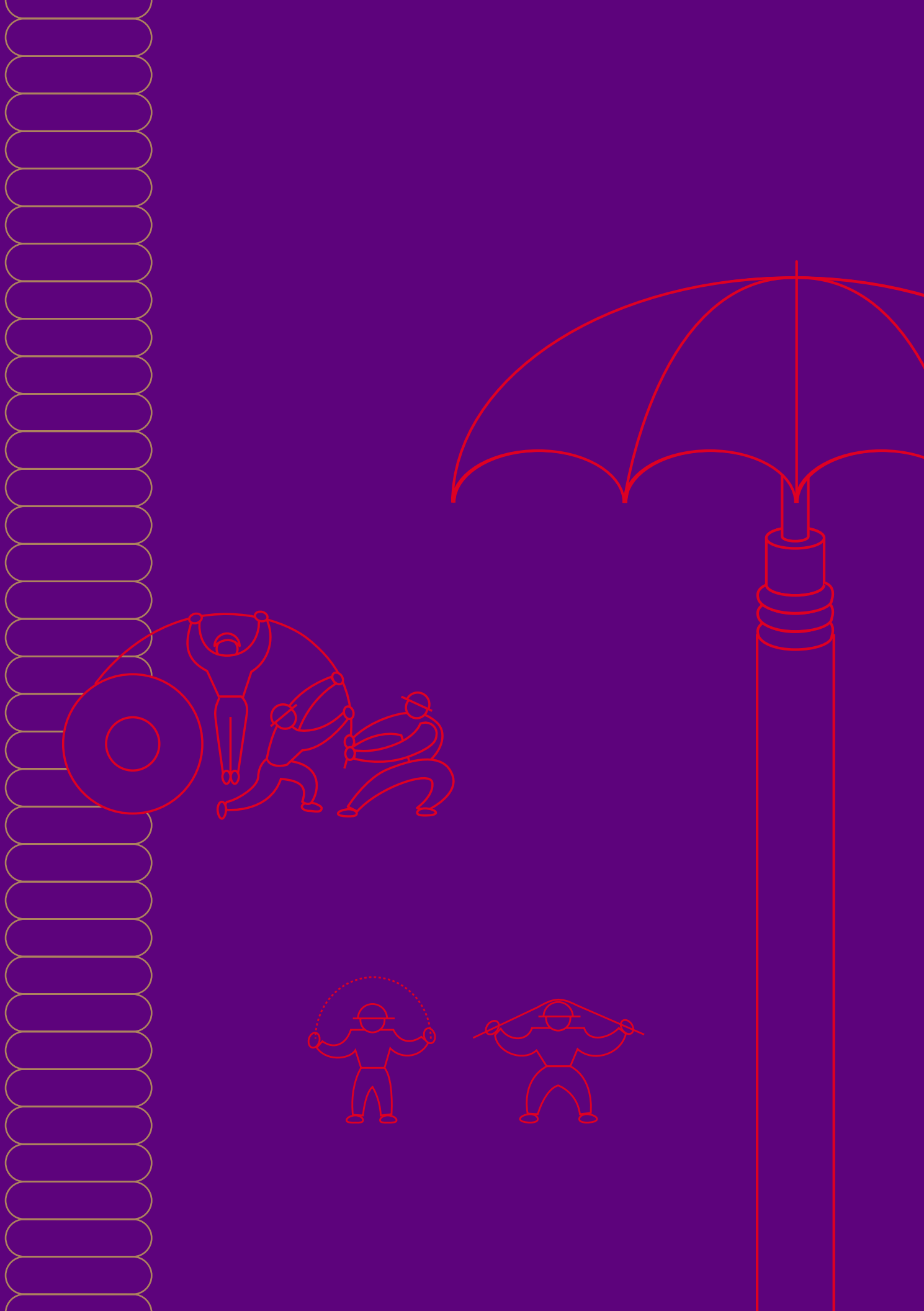

A Systems Approach to Wireless RF Transmission Lines

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2. **Transmission Line Cable** — an overview.
3. **Water** — it's all or nothing.
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10. **Performance:** electrical, mechanical, system and supplier.

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1 The bottom line is system performance, and system performance is about system integrity

Until they're assembled into an operating system, RF transmission line components are no more than copper tubing and plastic foam. In the field, the best individual component specs in the world don't matter if, when put together, the system doesn't play as it should, day in and day out.

Success in the wireless communications business is about systems, not components. Wireless RF system managers and designers can maximize performance by taking a systems approach—selecting components designed to team together.

Integrity:
Electrical (integrity) + Mechanical (integrity) = System Integrity

System electrical and mechanical integrity are interdependent: poor mechanical connections lead to poor electrical connections, increased system VSWR, intermodulation, and attenuation. Poor electrical performance may be a symptom of poor mechanical integrity (loose or ill-fitting parts that allow electrical connections to degrade with time or exposure to the environment).

Indicators of System Electrical Integrity:

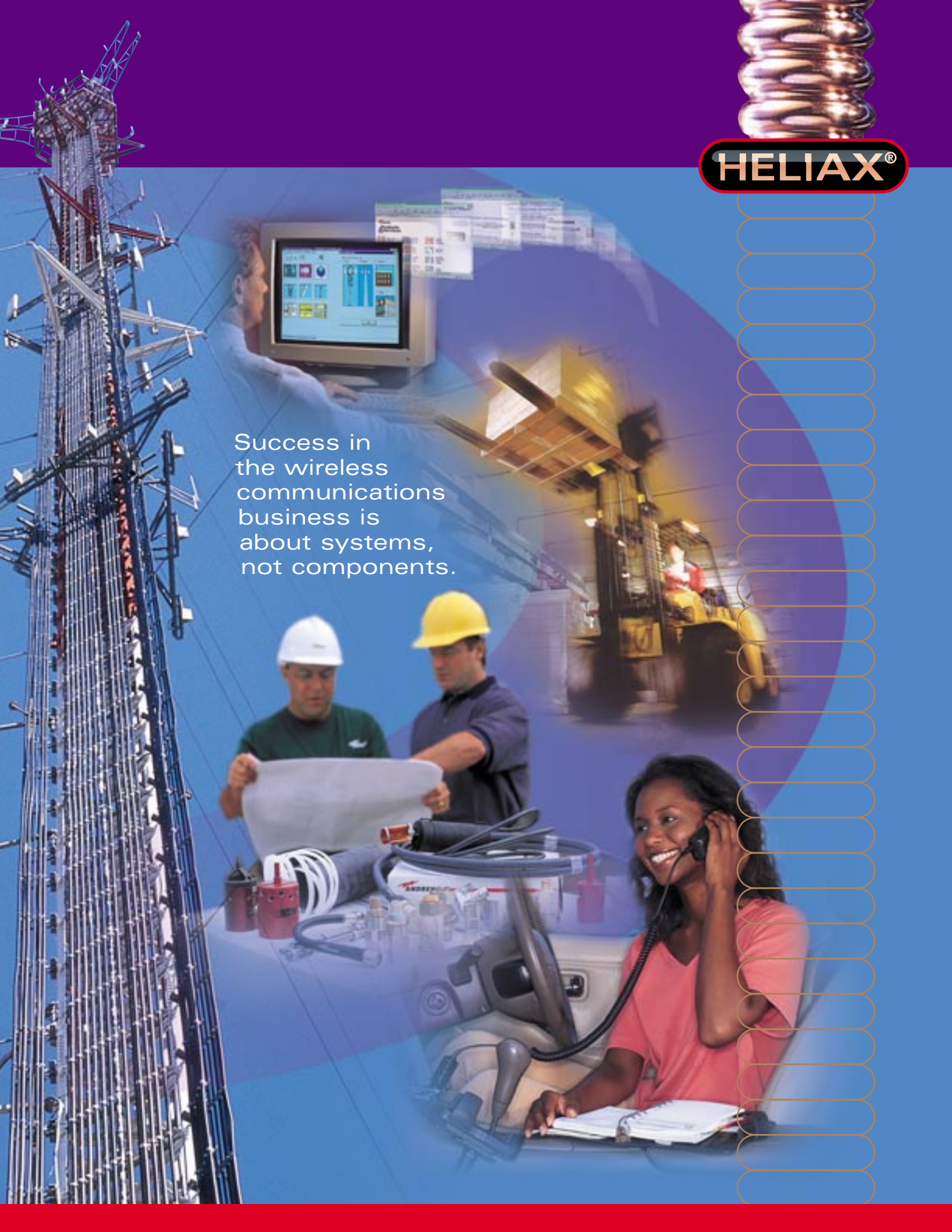
- Connectors, arrestors, antennas, cable all match electrically
- Cable conductors are solid
- Impedance is a 'tight' 50 ohms
- Components mate tightly with minimum parts and with proper compensation
- Consistent signal flow
- Low insertion loss, low impedance values, and low VSWR values
- All platings are compatible

Indicators of System Mechanical Integrity:

- In the overall match and fit of everything to the cable and the cable to the tower, components fit perfectly, with tight tolerances
- There are no field fabrications or adjustments to compensate for mismatched parts
- The system withstands the environment without deterioration
- Components stay in place
- Water migration is prevented
- No call degradation from system components
- Connectors, grounding kits, hangers, and weatherproofing fit the cable tightly without deforming or denting it

Transmission line system integrity is more than just the sum of its components' specifications—it's how those components work together, day in and day out. When all considerations for choosing a transmission line are factored in, Andrew HELIAX® cables, connectors, accessories, and assemblies are clearly superior — in value, performance, reliability, customer support, and breadth and depth of product line.

Andrew offers the broadest array of RF transmission line products in the industry, so there's always the right combination available to meet unique design needs and optimize a specific system's performance.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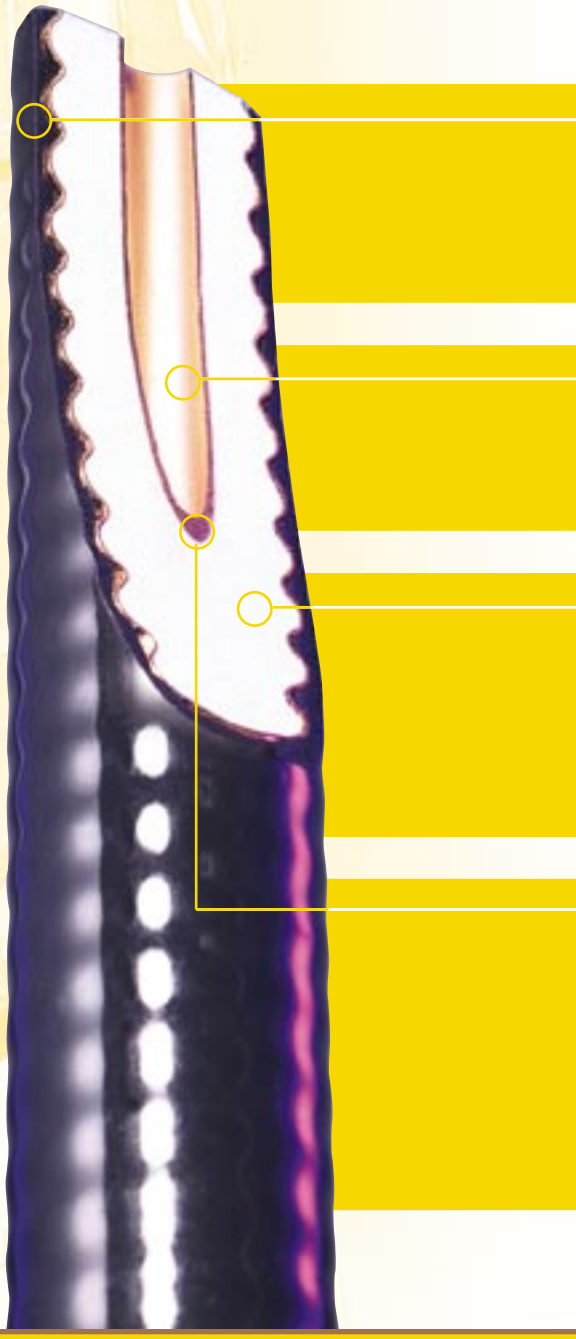
Success in the wireless communications business is about systems, not components.

2 Transmission Line Cable – an overview

When selecting a cable for wireless RF systems, it's crucial to match the electrical, mechanical and environmental requirements of the application to the cable's characteristics.

The shielding, dielectric properties, flexibility, mechanical characteristics, and temperature range as well as power ratings, attenuation, VSWR, IM, and tensile and crush strengths are all considerations when choosing the proper cables for receive or transmission.

Deeply corrugated cable.
Corrugated cable was introduced in the early 1950s. Since then, only Andrew has significantly developed and refined the technology to develop deeply corrugated cable. The most technologically advanced design in the industry, deeply corrugated cable requires significantly greater precision in design, engineering, and manufacturing.



When an installation requires...

either a few relatively tight bends or multiple bends, or when the cable will be exposed to the environment, deeply corrugated cable has proven to be the best choice. Deeply corrugated cable offers a superior combination of electrical performance, ease of system integration, configuration options, installation flexibility, and weather resistance.

As the recognized leader in wireless communications systems, Andrew has developed and refined RF transmission line system technology to a greater extent than anyone else in the industry. Andrew has sold more solutions providing long-term performance to a more diverse set of customers worldwide than any other company in the business.

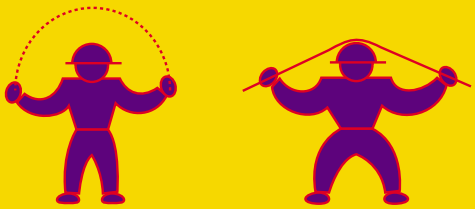
When quality, cost effectiveness, and system performance over time are important considerations, system designers would do well to specify Andrew HELIAX® coaxial cables.

Jacketing: Cable jacketing should be weatherproof, durable, abrasion resistant, and ultraviolet stabilized. Jacketing should be suitable for direct burial. Specific jacketing may be required for indoor or fire retardant applications.

Copper: To avoid nonlinearities and minimize attenuation distortion, the highest quality copper (> 99.9%) is required in both the inner and outer conductors.

Foam: To obtain the lowest dielectric loss along the length of the transmission line, cable manufacturing and processing should result in the lightest possible foam. Foam should be consistent for fewer fluctuations in electrical power. The closed cell foam will prevent water migration.

Adhesive: The composition of the adhesives used can impact electrical performance. Use of multiple layers of adhesives can make cable preparation more difficult, with the potential for dust and debris to be left inside the connector, potentially resulting in higher intermodulation distortion. In general, the less adhesive used in a cable design, the better.



Andrew: over 60 years of innovation

1938 Andrew introduces smooth wall air dielectric 70 ohm cable.

1953 Andrew introduces HELIAX corrugated air dielectric cable.

1958 Andrew introduces smooth wall air dielectric 50 ohm cable.

1963 Andrew patents flexible corrugated waveguide.

1965 Andrew patents corrugated foam dielectric cable.

1969 Andrew introduces FSJ Series superflexible, helically corrugated foam dielectric cable.

1971 Andrew patents helically corrugated, deeply corrugated foam dielectric cable (HELIAX®).

1972 Andrew patents radiating coaxial cable (RADIAX®).

1978 Andrew introduces LDF Series annularly corrugated foam dielectric cable.

1983 Andrew introduces state-of-the-art "A" series low density foam cables, incorporating further advances in materials selection and processing technology.

1983 Andrew patents high temperature foam dielectric cable.

1996 Andrew introduces EFX Series extraflexible, annularly corrugated foam dielectric cable.

1999 Andrew introduces VXL Series flexible, annularly corrugated foam dielectric cable.

WHY ANDREW CORRUGATES HELIAX® CABLE SO DEEPLY

Andrew HELIAX® cable features the deepest corrugations and lightest foam in the industry.

Why?

The answer is simple: to obtain the best combination of simplified installation and superior electrical performance. Andrew teams the mechanical advantages of corrugation—such as greater flexibility and improved crush strength—with superior cable processing. The result is an unmatched combination of mechanical and electrical performance.

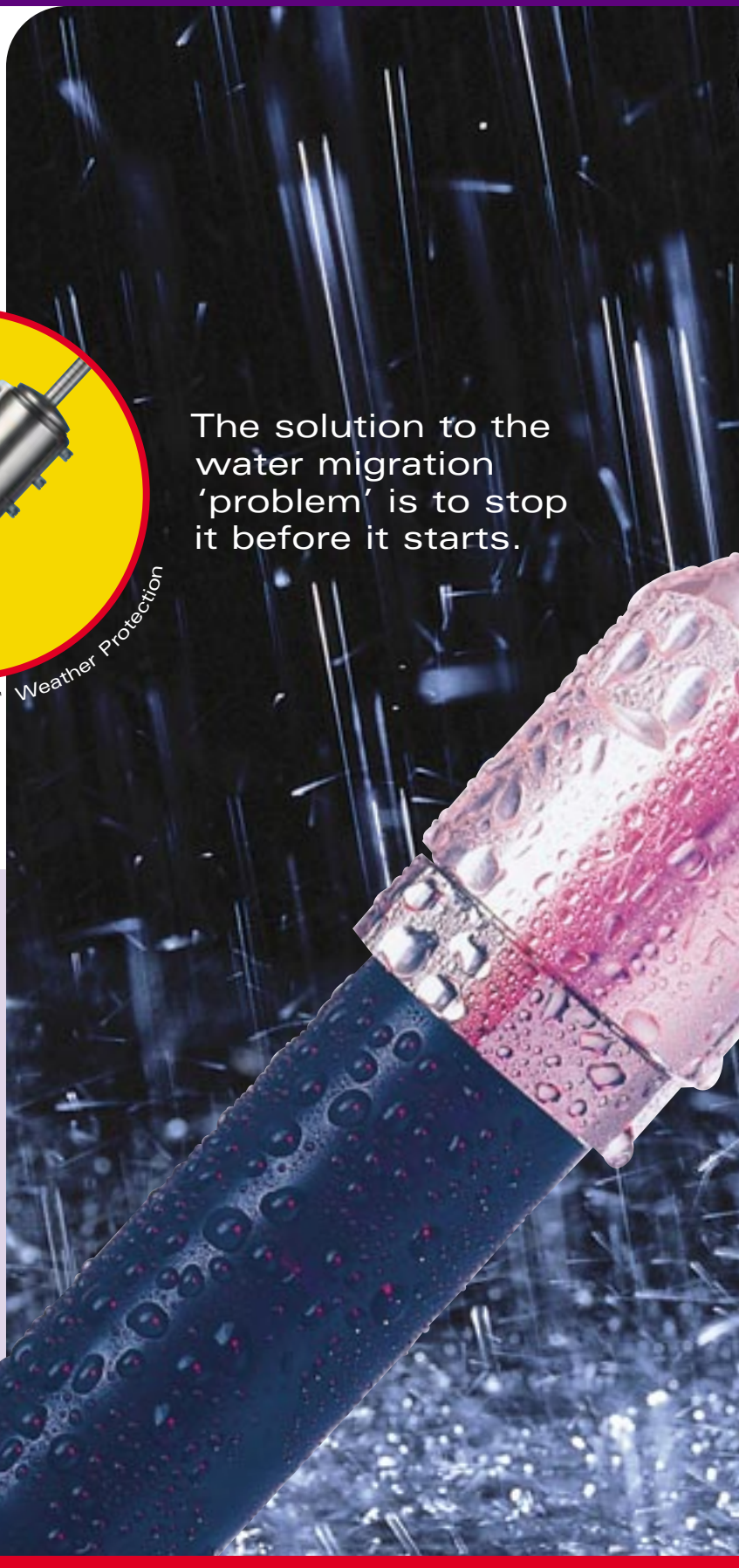
3 Water – it's all or nothing

When it comes to water migration, it's about prevention, not the cure.

Water is not electricity's friend—there is no 'safe' amount. If only minute amounts —drops— enter a RF system, things go wrong fast. Return loss increases significantly. Performance drops. The line becomes inoperable. System alarms go off. Technicians scramble to find the problem. And customers are calling.

The solution to the water migration 'problem' is to stop it before it starts. Keep the system fully operational by maintaining system integrity—lock water completely out of the system.

Learn more about protecting a system from the environment and maintaining electrical integrity—learn more about connectors…

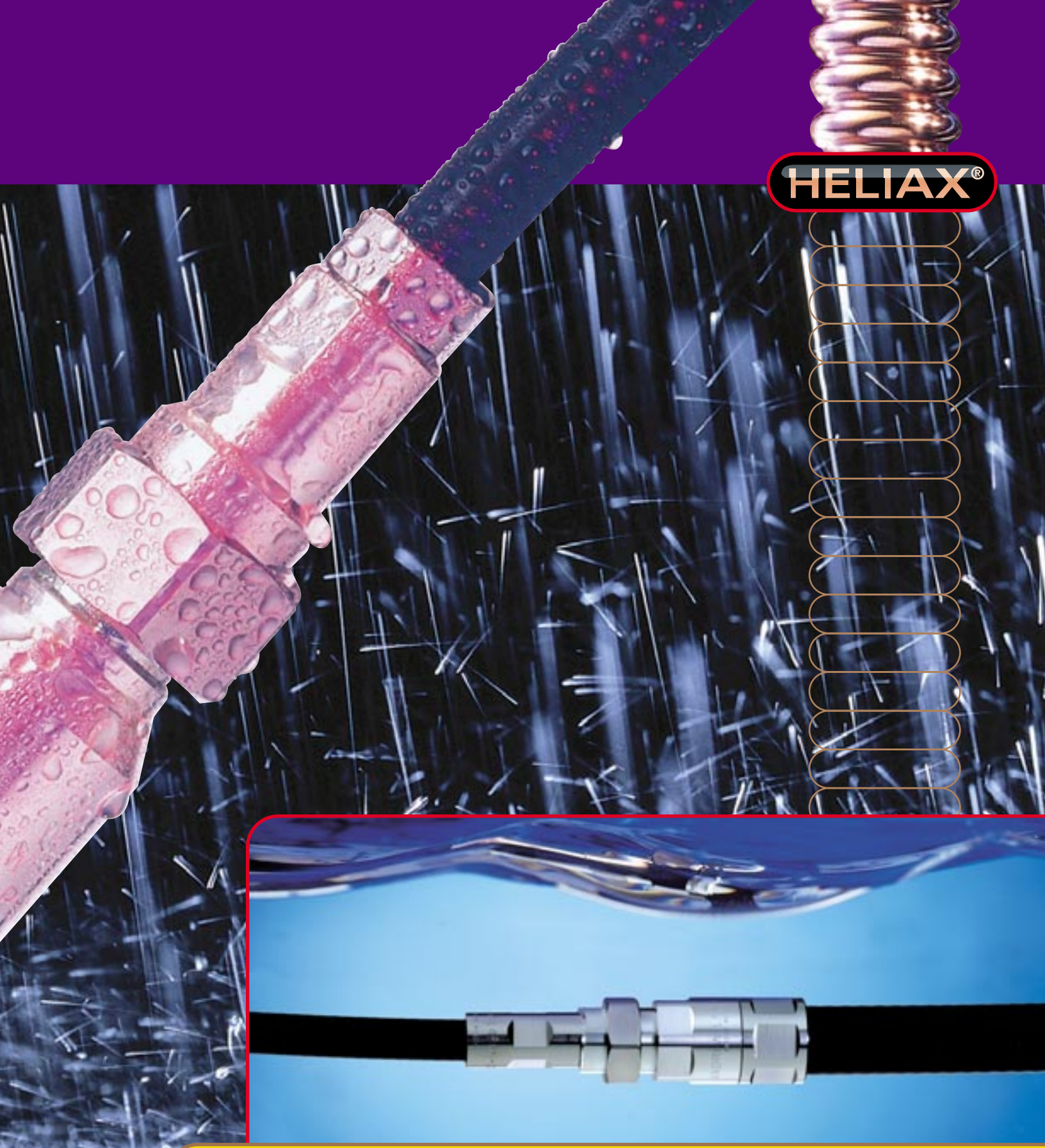


Why Andrew Recommends Secondary Weatherproofing

Industry-leading HELIAX® connectors are proven to lock out the environment, yet Andrew recommends secondary weatherproofing, such as its patent-pending WeatherShield™.

Why?

Even in moderate climates, cables and connectors take a beating from a host of environmental forces. Secondary weatherproofing provides a low-cost measure of insurance that minimizes vibrations that can loosen connectors. Since the costs of 'unscheduled maintenance' and lost airtime far outweigh the cost of secondary weatherproofing, it just makes good sense to add this measure of protection.



Andrew knows how to prevent water from entering a transmission line system. In the last ten years alone, hundreds of millions of meters of Andrew HELIAX® cable have been installed worldwide in some of the harshest environments imaginable, without a water migration problem.

4 Connectors: where performance comes together

If cables shoulder the load of carrying the wireless RF system's signal, then connectors are the heart and soul of the transmission line system.

Consider:

- Connectors are critical points for system electrical integrity and performance
- Connectors are critical points for system mechanical integrity and performance
- Connectors are the most common points for water entry into the system
- Connectors are the components that take the greatest beating from environmental forces
- Connectors are the components that receive the greatest handling during installation

Why Andrew Offers EASIAX® Cable Preparation Tools

Secure connector attachment is critical to system electrical performance, and quality cable preparation is key to connector attachment. Burrs, residue, and non-uniform preparation of the cable can contribute to increased system VSWR and IM. While no special tools are required to prepare HELIAX® cables or attach HELIAX connectors, Andrew offers its EASIAX® cable preparation tools to make the cable preparation process faster (10 seconds!), simpler, more uniform, and more repeatable – all in one step! Attention to this detail during installation means improved system performance during operations.

Connectors— What to look for:

Method of maintaining contact pressure
Look for solid, all-metal parts that maintain a constant and uniform contact pressure. Constant and uniform contact pressure helps minimize system VSWR and IM.

Number of parts
To improve system performance, simplify installation, and lower labor costs, look for connectors with fewer parts.

Tools required for installation
To maximize the probability of a successful installation, connectors should not require special tools.

Optimized for performance with specific cables
Look for connectors designed to specifically match the electrical and mechanical specifications of the coaxial cable design. Connectors should be electrically compensated to minimize mismatch at the connector-to-cable interface. Minimizing this mismatch will help lower system VSWR.

Designed for quality installation
Look for a simple design that facilitates precision and repeatability in installation.

Quality materials
Look for all-metal construction to maintain mechanical and electrical integrity over time. For performance and durability, choose connectors with silver plating on the connector body within the RF current path and silver- or gold-plated inner contacts.

Captivated inner pin
Look for captivated (solderless) inner conductors to reduce installation time and improve the quality of the connection.

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Connectors will be one of the first things field techs check if the system goes down.

Andrew HELIAX® connectors provide worry-free, long term system performance. HELIAX connectors are electrically compensated to minimize mismatch at the connector-to-cable interface for lower VSWR, excellent system electrical performance, and long term reliability. The solid metal components keep constant pressure on the inner conductor, maintaining uniform contact and preventing gaps and nonlinearities for lower intermodulation.

Preferred by installers, HELIAX connectors require no special tools. Andrew has continuously refined the design of HELIAX connectors for the fastest, most precise, and easiest installation.

HELIAX connectors feature tough, solid metal components to prevent the ingress of water— and are tested under a meter of water for over 24 hours. In thousands of installs around the world, HELIAX connectors are standing up to the toughest weather—snow, wind, sleet, salt water, dust, broiling heat—maintaining mechanical integrity, locking the environment out, and keeping systems operational.

5 Electrical Performance – it's the system that counts

The electrical performance of the wireless RF transmission line system has a direct bearing on the performance of the larger communications system. Link budgets, transmit power, receive sensitivity, and system noise figures for any given site all contribute towards the system manager's and designer's ultimate goals: improved coverage and quality of service.

There are three critical elements of wireless transmission line system electrical performance:

Attenuation is the loss of signal strength usually related to the distance the signal must travel. Electrical attenuation is affected by the resistance of the conductors, the density and quality of the dielectric, and the quality of the connections. Minimizing attenuation must be balanced against system costs and against desirable cable mechanical characteristics such as flexibility and crush strength. These must be traded off to some extent against attenuation in the design. System designers and engineers may be able to specify smaller, lighter, less expensive cable (and still meet a given link budget) if the cable, connectors, and jumper assemblies are optimized to minimize system attenuation.

To minimize attenuation:

- Reduce insertion loss by reducing the number of components in the RF path (for example, use jumperless feeder cables)
- Specify cable, connectors, and accessories that are specifically designed to work together
- Specify cable with the lowest attenuation consistent with optimal mechanical characteristics, for trouble-free installation, and consistent with the required link budget

Calculating System VSWR: Vector Mathematics *System VSWR is an important specification, but it's often difficult to predict. Unlike attenuation, individual component return loss doesn't simply add up. Because there is a phase component to VSWR, it's impossible to calculate an absolute value. Adding all the reflection coefficients in phase produces a highly unlikely worst case scenario. A more accepted way to predict system VSWR is to determine the root of the sum of the squares of the individual reflections.*

For a more detailed discussion of attenuation, calculating system VSWR, and other system electrical performance issues, visit our web site: www.andrew.com

Voltage standing wave ratio (VSWR) is a measure of the efficiency of the signal reflected by a component or system. All transitions in a system generate some level of VSWR. High levels of VSWR contribute to increased distortion and an increased system noise figure.

To minimize system VSWR:

- Reduce the number of components in the RF path
- Specify integrated surge arrestors
- Specify cable with excellent mechanical characteristics
- Insist on uniformity and repeatability in cable preparation and connector attachment during installation
- Specify accessories that fit and hold cables tightly and securely but do not deform or dent the cable
- Specify connectors specifically designed and electrically compensated to minimize the electrical mismatch at the cable-to-connector interface

Intermodulation (IM) is a mixing of two or more signals resulting in the generation of new interfering signals. Passive components, including (but not limited to) coaxial cables and connectors, that exhibit even slightly nonlinear responses can generate IM at significant levels. IM is a potential problem in multichannel communication systems, where IM products generated by high power transmit signals can fall into receive bands and cause increased noise or reduced capacity.

To minimize IM:

- Reduce the number of components in the RF path
- Specify solid, all-metal connectors that provide constant, uniform contact pressure to minimize nonlinearities
- Insist on quality and precision in cable preparation and connector attachment during installation
- Specify connectors using non-magnetic materials for component parts, and for platings and underplatings of RF current-carrying surfaces

Andrew offers documented superior electrical performance: optimized transmission line system solutions with the lowest attenuation, the lowest system VSWR, and the lowest IM.

6 Installation Issues – some assembly required

Long years of experience have demonstrated how critical installation issues are to system performance. Airtime, quality of service, system alarms, midnight field service calls, customer complaints, revenue, and reports to management are all a function of how well the installation team is able to perform its difficult task.

System managers, designers, and specifying engineers can maximize the probability of a successful installation and minimize system costs by:

- Specifying transmission line cables that are easy to bend and route around obstacles
- Specifying connectors with simplified installation procedures
- Specifying connectors that do not require special tools for attachment
- Specifying accessories (such as hangers and lightning protection) that will fit tightly and hold the cable securely but will not dent, abrade, or deform the cable

Compatibility issues can be minimized by:

- Choosing a supplier offering an 'installer-friendly' integrated system of cables, connectors, accessories, and assemblies
- Selecting accessories and assemblies optimized for system performance

QA/QC and reliability issues can be addressed by:

- Selecting system components with a proven track record of worldwide successful installs and a reputation for high quality.

Quality transmission line, connectors, accessories, and assemblies help add up to a quality installation. For every HELIAX® cable, connector, accessory, and assembly, Andrew designs with installers in mind. Cable that's easier to route on crowded towers, roof-tops, and monopoles. The fastest, simplest, and most accurate connectorization process in the industry. And ergonomically designed, patent-pending, system-essential accessories. HELIAX products have proven they'll maintain your system's electrical and mechanical integrity the day they're installed and every day thereafter.

7 RF Systems – each one is unique

In a textbook world, site build-outs are in perfect locations. Towers are brand new, cable runs are all straight, and your system is the only system installed on the tower. The temperature stays a comfortable 68°, the wind never blows, the air is pure, and the worst moisture is an occasional heavy dew.

In the real world, zoning laws and tower real estate shortages mean trying to get one more cable run on a tower that's already overcrowded. Perhaps trying to bend transmission line onto a rooftop or install it in a monopole that's already erected. Maybe the antenna has to go on top of a water tower, meaning the cable has to conform to an odd-shaped structure.

In reality, transmission line systems are regularly doused by downpours, broiled by the sun, and beaten by wind, ice, and man-made airborne corrosives.

Ensuring system integrity for optimal system performance is difficult. Wireless RF transmission line systems face location challenges different than those in any other industry. To meet those challenges, wireless RF system managers, designers, and engineers should specify cables that bend and install easily in cramped site locations and that are designed for use with multiple connector interfaces and jumpers. Connectors, accessories, and assemblies must be manufactured with the highest quality materials to withstand temperature changes, ice, and wind gusts over time. All system components should come from a manufacturer with expertise in wireless RF transmission line, and there should be a large installed base in varying, harsh environments.

In the field where site conditions, system performance, and system revenues are driving factors, the best choice is wireless RF transmission line system solutions that meet the unique — often harsh — demands placed on system components.

Andrew HELIAX® cable is specifically designed to meet the needs of wireless RF transmission line systems. Andrew is a long-time, acknowledged leader in the wireless communications industry. HELIAX cables, connectors, assemblies, and accessories are known for their ease of installation in difficult situations, long term reliability, optimal system performance, and component quality. For the many different and varied wireless RF applications, Andrew offers a broader range of system solutions than anyone else in the industry. Whatever your challenge, you'll find the right combination of HELIAX transmission line components, optimized for your system and providing you with superior system performance.


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8 Quality: turn it on, walk away, don't come back

Quality means cost effective, reliable performance. The most cost effective wireless RF transmission line system is one that's installed once and has the fewest return trips for 'unscheduled maintenance.'

Quality can be quantified. For example, a site build-out to handle increased user demand and expanded services is projected at around $150k. Approximately $5k is budgeted for the transmission line system.

A low materials quote comes in at $4500, but it's not Andrew HELIAX® cables and connectors.

That may appear to be a 10% savings. However, there are other considerations:

$500 savings as percentage of total tower build-out ($150k): .03%

A $500 short term savings may lead to higher long term costs.

Utilize the appropriate local cost figures, then consider some other costs that may have an effect on that anticipated savings:

- *Additional installation crew-days: # days x $ rate per day:* _____
- *Field crew to troubleshoot site: # hours x $ rate per hour x # of crewmen:* _____
- *Materials to be replaced due to quality: materials cost + expedited delivery fees:* _____
- *Field crew to fix problem found: # hours x $ rate per hour x # of crewmen:* _____
- *Lost revenue: average rate, off-peak, x # minutes:* _____
- *Lost revenue: average rate, peak, x # minutes:* _____

Andrew HELIAX® transmission line systems control system costs by performing to specification today, tomorrow, and years into the future, saving installation days and dollars, and locking the elements out.

The quality and reliability of Andrew HELIAX products has been documented over time and in countless installs around the globe. Andrew has sold more solutions providing total system integrity and reliable longterm performance to a more diverse set of customers than anyone else in the industry.

Save yourself some money. Specify Andrew HELIAX.

9 Options– there's more than one right answer

On paper, the build-out plan looks good. On the ground, things change...

Three of the towers covering a growing suburb turn out to be monopoles, not K-braced…A rural site turns out to be covered by a county's zoning laws mandating increased lightning protection…A rooftop pass-through install now requires plenum-rated cable…New policy mandates the use of tower-top electronics… The field tech at another site says they'll need round member adapters for installation…A call comes in that the shelter for another site will need to be relocated an additional 55 feet from the tower…

Staying competitive in today's wireless communications business means staying up with changing situations. Staying up with changing situations means having a resource to draw on. Look to a supplier with a complete line of wireless RF transmission line system solutions to find answers for those 'unique' challenges that crop up every day. Find the supplier who can offer cables, connectors, assemblies and accessories that are manufactured and optimized to work together for a system performance solution specifically designed for the problem.

Andrew provides a HELIAX® transmission line solution that fits individual site designs—even when those designs change. The breadth and depth of our product line—from a single cable to prepared kits—means that whatever your build-out needs, there's a combination of HELIAX products that will provide superior system performance.

10 Performance: electrical, mechanical, system and supplier

Wireless RF system designers and engineers often talk in terms of electrical performance. Or mechanical performance. Or total system performance.

Equally critical is supplier performance.

With many suppliers competing for your business, how can you measure supplier performance? All suppliers make the best case for their products' superiority. But you have to make a choice.

Consider the following:

- Is the supplier's primary business the RF business —is it where the expertise lies?
- Can the supplier offer referrals from satisfied wireless RF system customers around the world?
- Is the supplier preferred by installers and field techs?
- Does the supplier state product performance relative to a competitor's latest specs and using accepted industry definitions and measurements?
- Can the supplier demonstrate how its products meet the realities of system installation, system, electrical, and mechanical integrity and long term performance?
- Can the supplier provide a track record—evidence that you can depend on performance to specification the first time and over time?

Andrew has been serving the needs of wireless RF communications professionals around the world for over 60 years. With installations worldwide, we've built our reputation as the industry leader on a solid foundation of technologically advanced, high quality, superior-performing, and cost effective system solutions, products, and services—all backed by solid warranties and responsive customer service.


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