Technical E-Paper

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Why develop a custom Wi-Fi antenna?

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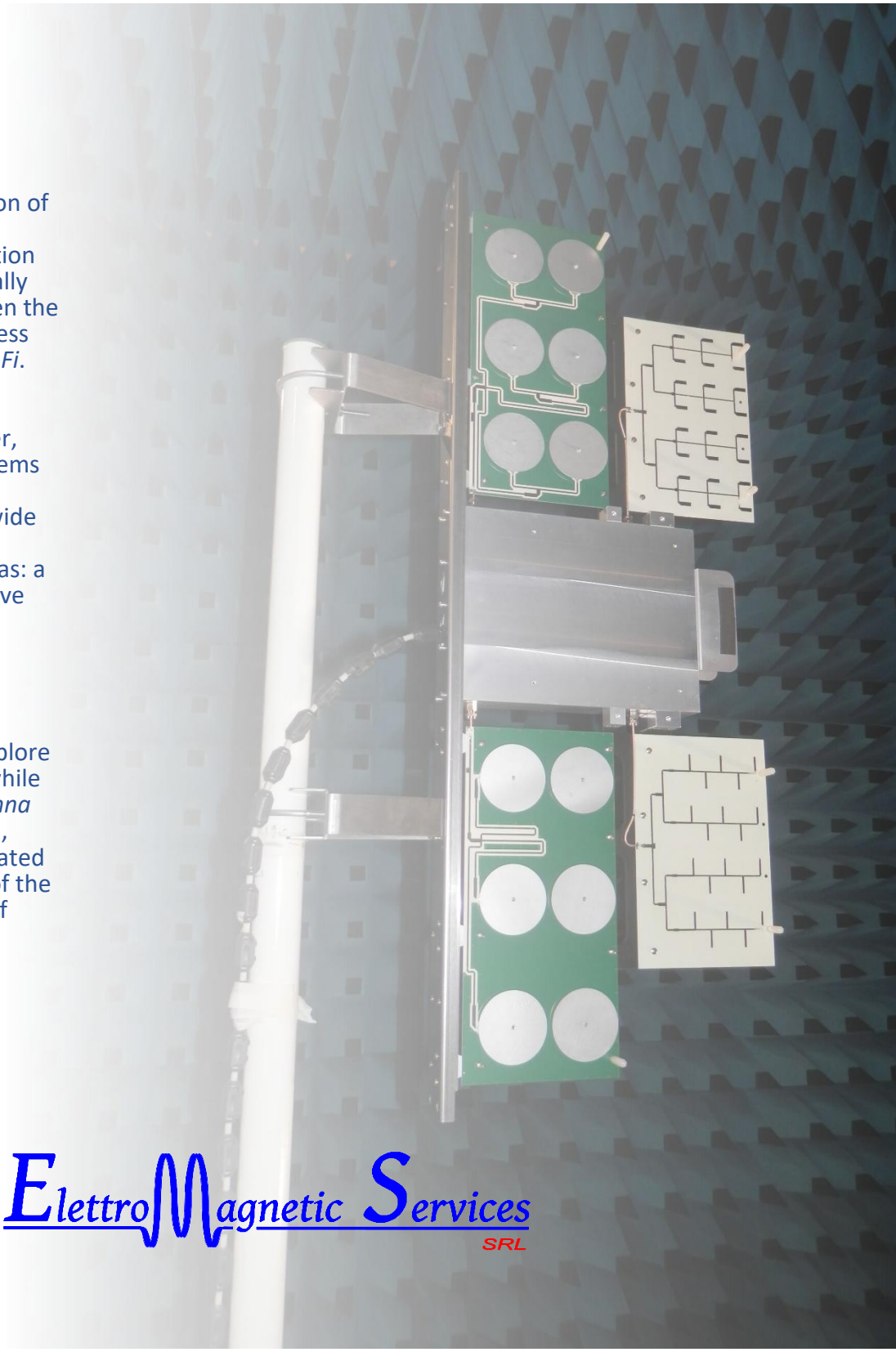
In 1997, the first version of the 802.11 standard was introduced: a communication protocol that would radically change our habits and open the door to the world of wireless connectivity known as *Wi-Fi*.

A quarter of a century later, *Wi-Fi* communication systems appear to be firmly established, relying on a wide range of commercially available standard antennas: a scenario that seems to leave little room for innovative products with high added value.

In this short article, we explore why it may still be worthwhile to develop a *custom antenna* for this field of application, which appears to be saturated with innovation in terms of the electromagnetic aspects of wireless connectivity.



ElettroMagnetic Services SRL

1. Introduction.

A custom antenna is, by definition, an antenna with **unique and exclusive technical characteristics** that are **not available in standard products already on the market**. It is designed with the aim of meeting the **specific requirements** that the **Customer** needs to address in a given situation.

Starting from this assumption, one might come to the conclusion that, **for certain applications**, such as the *Wi-Fi* sector, the **almost infinite range of antennas** available on the market could provide **a solution to all the needs** of an installer.

Based on our **experience**, we can say that **this is not true**.

Even in such **crowded sectors**, there are companies constantly looking for **new solutions**, for which it is necessary to develop **custom antennas** capable of ensuring **maximum performance** for their equipment.

The new antenna must therefore be able to provide the Customer with **a clearly defined added value**, not available in other commercially available antennas, while always keeping in mind the principle **"There must be a valid reason to develop a custom antenna."**

In this technical paper, we will therefore examine **the reasons** that may lead a company operating in this sector **to have a professional custom antenna designed**.

2. Technical specifications.

As we know, **the main goal** of designing a custom antenna is **to optimise the performance of the device** for which the antenna is developed, allowing the Customer to provide its target market with **higher-performing solutions** than those of its competitors.

While, in most common cases, the use of a standard antenna may **fully meet** the needs of those who purchase it, when **more specific requirements** must be addressed, having a product with **unique technical characteristics**, expressly designed for the particular problem to be solved, makes it possible to achieve **a significant advantage** over the solutions already available on the market.

To develop a custom antenna, **the technical requirements** are defined in the form of **electrical, mechanical or environmental specifications**. Most of the time, however, in the *Wi-Fi* sector, the Customer comes to us with **field issues** encountered during tests or installations, and it is the analysis of these problems that lays **the foundations for the design** of a new antenna.

As discussed above, it is important for the Customer or installer **to test the products already available on the market in the field** and assess whether or not they are sufficient to meet their needs.

Below are **some practical cases** in which the design of a custom antenna enabled our Customers in the Wi-Fi sector to offer **exclusive technical solutions**, achieving **significant advantages** over their competitors.

2.1. Wi-Fi coverage in warehouses.

When dealing with **Wi-Fi coverage in warehouses, yards or logistics facilities**, it is often necessary to work with **large metal structures** that divide the environment into a series of **long, narrow aisles.**

These structures **significantly hinder *Wi-Fi* signal transmission**, not only because they represent an **obstacle to its propagation**, preventing the signal from passing through, but also because of a series of reflections that **trigger multipath propagation mechanisms**, creating numerous **shadow areas** in wireless connectivity.

The **technical measures** that can be implemented to improve the situation under these adverse conditions are varied and must be analysed on a case-by-case basis, taking into account **typical installations** in these **challenging environments**.

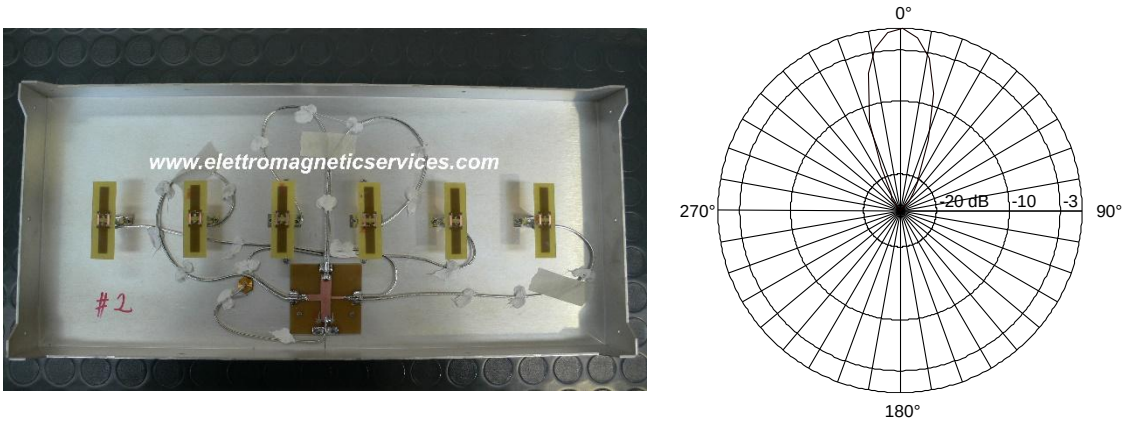


Figure 2.1
Example of a narrow-beam panel antenna, with high side-lobe suppression, and its corresponding radiation pattern in the horizontal plane.

First of all, it is possible to develop antennas with **ad hoc radiation patterns**, typically narrow in the horizontal plane and wide in the vertical plane, allowing power to be transmitted mainly towards **the areas of interest**, namely within the aisles, **thereby increasing the efficiency of the entire system** (Figure 2.1).

In addition to this, in order **to minimise or eliminate service interruptions** caused by *multipath* issues, **diversity reception** can be adopted — or **MIMO technology**, as we will see later — which can be implemented through **spatial diversity** or **polarisation diversity**, depending on the specific characteristics of the system being studied.

It is also important to consider that, in locations of this type, it is often necessary **to prevent antennas from being damaged by forklifts or other vehicles**. This issue is addressed by installing the antennas at **a height considered to be "safe"** and using **a tiltable bracket** to direct the radiation beam downwards.

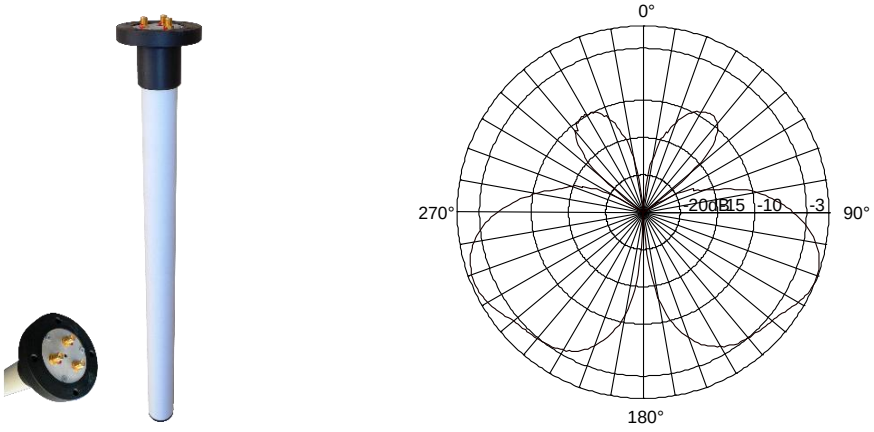


Figure 2.2
Three-port omnidirectional ceiling antenna with independent inputs and corresponding radiation pattern in the vertical plane.

A further alternative involves **installing the antennas on the ceiling** (Figure 2.2).

In this case, it is advisable to design omnidirectional antennas with **a downward radiation beam tilt** or to develop radiating elements with **hemispherical radiation patterns** for signal transmission in the **lower half-space.**

Once a **typical installation configuration** has been defined, it is therefore possible to identify the custom antenna with **unique electrical, mechanical and aesthetic characteristics**, optimised for the specific application and capable of ensuring **the best possible performance**.

2.2. MIMO technology.

MIMO (Multiple Input Multiple Output) technology is often used in this type of installation, as it provides **numerous advantages**. For further information on this technology, we recommend our **TEP No. 21**.

One of its **distinctive features** is the use of **multiple radiating elements integrated into a single housing**, known as a *multi-port antenna*, characterised by a **high degree of mutual decorrelation** so that they can operate independently.

For systems of this type, designing a solution capable of **incorporating all these radiating elements within a single enclosure**, rather than installing multiple individual antennas, makes it possible to achieve **several advantages.**

From a technical point of view, for example, it is possible to design a structure that **optimises the relative positioning of the different radiating elements**, achieving **high levels of isolation** and thereby **increasing the performance** of the entire system in terms of *data throughput*.

From the point of view of **ease of installation**, the possibility of deploying a single structure instead of several different antennas leads to a **significant saving in time and costs**, due both to a **considerable simplification of the procedures** and to a **substantial reduction in overall dimensions**.

In addition, careful design also makes it possible **to achieve savings** in terms of **cables and connectors**, through the use of **appropriately sized *pigtails***.

These are just some of the aspects that can be improved through the development of a professional custom antenna.

Each specific application **must be analysed and studied in depth** on a case-by-case basis, in order to implement solutions with **a level of customisation** capable of driving performance to **optimal levels**.

2.3. Systems for identifying the direction of incoming signals.

Another specific application in this sector concerns the development of **systems for identifying the direction of arrival of certain signals**, for example the direction of arrival of **drones** for the protection and defence of particularly sensitive areas.

These systems are designed **to monitor the space** surrounding a given area, using omnidirectional or sectoral radiation patterns, depending on the specific requirements.

A system of this type consists of multiple antennas, each responsible for **monitoring a specific portion** of the surrounding space. To achieve an **adequate level of accuracy and avoid false detections**, it is necessary to define **an appropriate beamwidth for the various radiation beams**, in order to **optimise coverage** while **avoiding detection ambiguities** between two antennas belonging to adjacent sectors.

To maximise the performance of a system of this type, it is necessary to start from the following considerations:

- the antennas must have **a clearly defined radiation pattern**, specifically designed for the particular requirement, and must be installed in a **fixed and clearly defined relative position**;
- in addition to **the required performance**, a system of this type must be able to ensure **fast and precise installation**;
- the enclosure can also be designed to accommodate **all the electronic equipment** intended for use. In this way, it is possible **to optimise space, further speed up installation and ensure an appropriate IP rating** for the entire installation.

In order to effectively ensure all these advantages, it is necessary to have the **experience and capability** to study in depth the specific application that the Customer intends to implement, so as to develop **the most suitable dedicated solutions.**

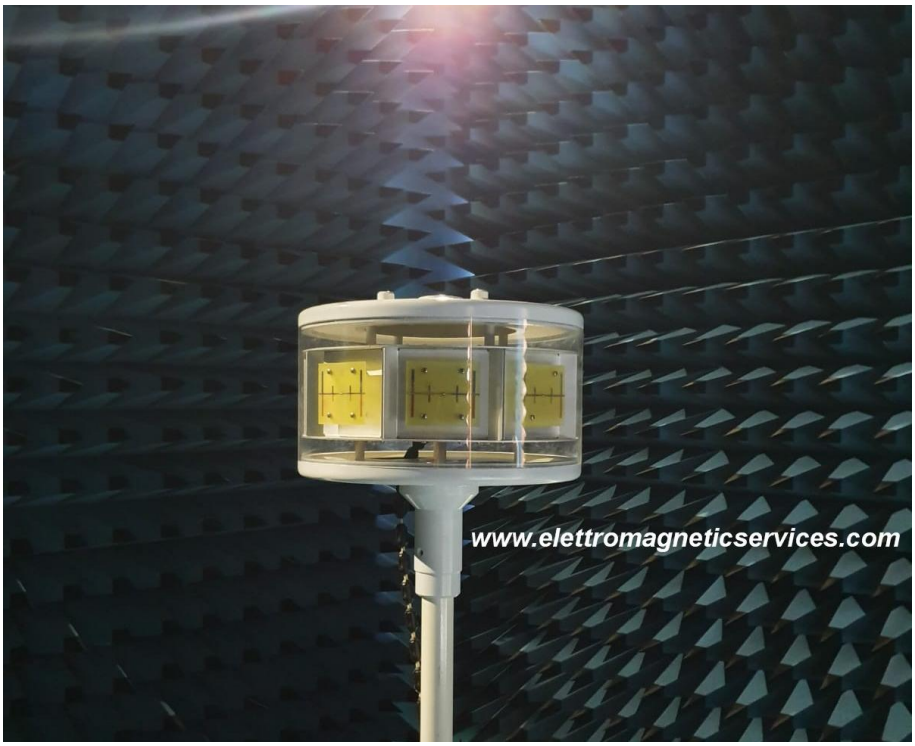


Figure 2.3
Dual-band system (2.4 GHz and 5.8 GHz)
for drone airspace surveillance.

2.4. *High-value* applications.

As shown in the previous paragraph, as well as in the cover image representing a dual-band bidirectional antenna (2.4 GHz and 5.8 GHz) for *Smart Road* applications, there are still **specific *Wi-Fi* applications** in which an antenna with particular electrical characteristics **is justified** and **represents an advantage** for the Customer.

We refer to these areas as **high-value applications**, since the development of an antenna optimised for the specific application **can make the difference** not only in the **performance of the *Wi-Fi* communication** system, but also in its **actual feasibility**.

We will return to this topic in the future, presenting specific *case studies*, as each application would deserve a dedicated article.

2.5. Integrated antennas.

Integrated antennas, already generally described in a previous series of our technical articles (**TEP No. 3**, **TEP No. 4** and **TEP No. 11**), represent **an important aspect of *Wi-Fi* applications**, where the development of a custom antenna is justified not only by **technical reasons**, but also by **commercial requirements**, as will be discussed in the following paragraph.

Although there are commercially available radiating elements, either chip-based or PCB-based, that can be installed inside an 802.11 wireless product in a so-called "universal" configuration, **it is impossible to optimise performance** by relying solely on a "plug & play" antenna installation, since each proprietary device has **different electromagnetic characteristics**.

The modern use of *Wi-Fi* or *Bluetooth* technology **to determine the position of client devices**, for example for access control through a gate or for detecting presence within an indoor environment with numerous workstations, requires the design of antennas that not only meet **mechanical integration requirements**, but also provide **well-defined electrical performance** in terms of **directional gain**, in order to create the "picocells" needed for user recognition.

Figure 2.4
Radiation measurement of a 2.4 GHz integrated antenna, mounted on a *fixture* that simulates its actual operating conditions.

3. Commercial requirements.

In addition to technical requirements, the development of a new custom antenna may be driven by **commercial needs**, which may either **complement the former** or **be decisive** in achieving advantages over competitors.

Below are **some concrete examples** we have encountered in our experience.

3.1. Aesthetics and *family identity*.

The search for a distinctive line and shape in the products to be developed can certainly help when the goal is **to stand out from competitors**, allowing the company to be characterised by **a specific aesthetic identity** and thus define its own ***family feeling***.

In this way, it is possible to become **immediately recognisable** and build loyalty among all those Customers who particularly appreciate our stylistic choices.

The reasons that lead to **the identification of a particular geometric shape** may be related to **the external appearance**, may result from **a very specific technical choice**, or may combine both requirements, thereby achieving an **attractive aesthetic appearance** together with **excellent performance**.

In any case, these choices must provide **concrete benefits** that we know will be **particularly appreciated by the Customers** who will use the product being developed.

3.2. Long-term availability.

How **detrimental** can it be to be told that the antenna selected for a specific application **is no longer in production?**

The consequences of such a situation are certainly **neither easy nor immediate to resolve.**

First of all, time will need to be dedicated to finding **a product capable of adequately replacing** the one that is no longer available. But that is not all…

The new product will certainly not be identical to the previous one, which may lead to **issues related to its dimensions or aesthetic appearance**, making **its mechanical integration** into the already defined system **more difficult**.

Another issue may concern any **certifications** which, due to the replacement of a key component, may need to be repeated, in the hope that they deliver **the expected results**.

Without wishing to overstate the issue, situations of this kind are certainly **unpleasant** and can be avoided **by designing a custom antenna**, which ensures **its future availability**.

3.3. Exclusivity.

The most elegant way we have to move away from the so-called “price war” is **to offer products that are different from, and better than, those of our competitors.**

The ability to ensure **unique advantages and benefits** makes it possible to gain **a clear competitive edge** in one’s target sector.

If we add to all this **the certainty** of being able **to offer an exclusive solution**, then **the result is guaranteed**.

Designing a **custom antenna** makes it possible to achieve all this, with all **the resulting benefits**.

4. Conclusions.

Designing **a new custom antenna** means developing a product with **unique technical characteristics** that cannot be found in standard items already available on the market. These characteristics must be conceived and developed according to **the specific requirements** that need to be met.

As a result, we might think that, for certain sectors considered more **"commercial"** than others, the availability of a **large number of standard solutions** makes the design and development of custom products **unnecessary**.

This line of reasoning is certainly **understandable**. However, based on **our experience**, we can state that even in these sectors it is possible to develop **innovative solutions** with **unique characteristics** that are not yet available on the market.

In this technical paper, we have presented examples of custom antenna requests that have brought **advantages and benefits** even in a **particularly crowded sector** such as *Wi-Fi* installations.

We can therefore confidently state that **any effort** aimed at delivering **novelty and innovation** can be **a source of satisfaction and success** even in markets where, at first glance, this might seem out of reach.

*All the information and experiences presented in this article are the result of the design, development, and production of custom professional antennas carried out by **ElettroMagnetic Services Srl** according to the **AntennaCustomizer** method.*

*For questions, clarifications, or further information on this or other topics related to professional antennas, please contact **bollini@elettromagneticservices.com**.*

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