

The PROTOTYPING phase in the design of professional antennas.

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Unlike projects that begin with an extensive feasibility study—postponing any operational decision to an unspecified future date—the development of custom antennas requires a mandatory and decisive **prototyping phase**, essential to achieving a result that truly justifies the Customer's investment.

Starting product development with a clear understanding of both the **timeline** and the **tangible results** to be achieved is a crucial driving factor for reaching a satisfactory outcome.

In this short article, we examine the **prototyping phase**, that is the creation of the first real, tangible object whose aesthetic and functional features closely resemble those of the final product.

Concluding a design activity with the delivery to the Customer of one or more **prototypes of the requested custom antenna** represents the strongest proof of the supplier's professionalism.

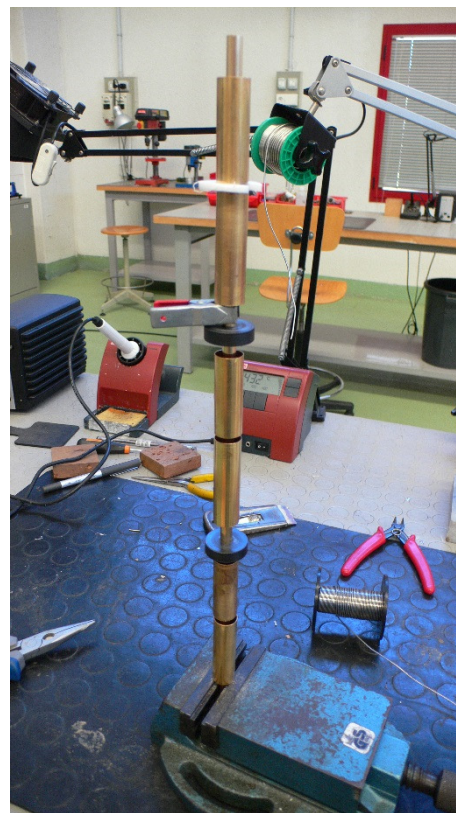
1. What the prototyping phase is.

The **prototyping phase** consists in the realization of one or more antenna samples intended for **validation testing and/or field trials**, and it is certainly among the most important stages in the design of **custom professional antennas**.

In fact, only by carrying out this activity properly can the Customer who commissioned the project be guaranteed not only the **confirmation of the agreed specifications**, but also the delivery of a **tangible, truly manufacturable product**, one featuring the **mechanical, electrical, and environmental characteristics** required for the intended application, rather than merely a virtual object resulting from an electromagnetic simulation.

In particular, approaching the **prototyping phase** without adequate **experience** and **preparation** may lead to issues that are **difficult to resolve**, such as:

- **Failure to achieve the mechanical and electrical requirements** for which the prototype has been developed;
- **Errors in evaluating the most suitable materials**, which may have significant consequences on the subsequent industrialization and production phases;
- **Lack of proper provision for potential modifications and optimizations**, thus requiring the production of a new prototype and resulting in increased costs and development time.



It is therefore clear that the guarantee of a correct design cannot rely solely on the use of simulation software, no matter how advanced it may be. It also depends on the ability to anticipate, from the very first stages, the most **practical** and **constructive aspects** of the antenna, in order to ensure an **efficient** and **reliable production phase**.

Let us now examine the main aspects to consider in order to develop a **prototype** that fully meets **professional standards**.

2. The purpose of the prototype.

The **purpose** for which the prototype is to be used at the end of the project represents an important aspect to consider for its proper realization and must be clearly defined from the **earliest stages** of development.

The **reasons** why the construction of a **prototype** is necessary can vary.

Here are some examples:

- **electrical validation or certification activities;**
- **environmental testing;**
- **field tests or on-site verifications;**
- **pre-series prototypes;**
- **prototypes for system or equipment integration;**
- **very limited production runs, in which the prototypes essentially coincide with the final product.**

It is therefore quite clear that this aspect has a decisive influence on both the **methods of prototype development** and its **characteristics**.

This is especially true when the process involves several **intermediate stages**, during which different **prototypes** must be developed and specific **goals** achieved before proceeding to the next steps.

For example, in the early stages of a project, it may be necessary to ensure the **integrability** of the prototype within a specific system before proceeding with the **electrical design**. In this case, maximum attention must be paid to defining the **dimensions** and the **mechanical interface** with the Customer's device, while the electrical part will be optimized later. Of course, even at this stage, it is essential to **anticipate and consider electrical design choices** that comply with the dimensional constraints being defined, in order to avoid potential difficulties later on.

Experience and the ability to **anticipate the consequences** of specific design choices are therefore essential to successfully complete the development process and avoid **problems or complications**.

In addition to the **purpose of the prototype**, the **characteristics of the final product** are another factor that influences the methods of realization. In particular, this refers to the **selection of materials** and **technologies** to be used.

3. The choice of materials.

As throughout the entire design process, during the **prototyping phase** it is also necessary and appropriate to consider the **characteristics** that the product will need to have in **production**.

Specifically, there are **two main aspects** that should be taken into consideration:

- the **target price** and the **reference market** for which the product is intended;
- the **number of units** to be produced.

Having a **clear understanding** of these two requirements allows us, first of all, to make **appropriate choices** regarding the **materials** to be used.

Let's consider an **example**.

Let us imagine a project in which maintaining a **low target price** during the production phase is required. If, for the realization of some **insulating components** of the prototype, I choose to use an expensive material such as **Teflon®**, it will hardly allow me to guarantee compliance with the **price requirement** later on.

As a result of this incorrect choice, I would probably be forced to **redesign** certain parts of the antenna due to the different ϵ_r of the newly selected dielectric material, leading to **higher costs**, **longer delivery times**, and, in the worst cases, the need for **additional testing** to revalidate the prototype.



This is just one example of an error that may seem trivial, yet it clearly shows how important it is to approach the **selection of materials** with great care, and how a small oversight can lead to **serious issues** and **additional costs**.

Still regarding the **selection of materials**, it is advisable to take into account any **variations in their technical properties** that may occur between different **production batches**.

Here too, an **example** can help clarify the concept.

If we need to design a **radiating element on a PCB**, it is clear that achieving the desired **electrical performance** strongly depends on the **technical specifications** of the substrate used. Choosing a supplier unable to guarantee sufficient **consistency in the dielectric constant** of the selected material across different production batches will inevitably lead to discrepancies between the **electrical characteristics** of the prototype and those of the production antennas. These differences may easily result in the **failure to meet required specifications**, along with all the serious challenges such a situation entails.

It is therefore advisable to take all the necessary time to carefully verify both the **characteristics of the material** selected for the prototype's construction and the **reliability of the chosen supplier**.

In addition to material-related choices, the **characteristics of the final product** also influence the decisions regarding the **technologies** to be employed.

In this regard, it is necessary, for example, to carry out a careful **evaluation of the non-recurring costs** associated with the creation of **production tooling**.

In the next paragraph, we will examine other **important considerations** related to this topic.

4. The available technologies

The selection of the **most suitable technologies** to be used is undoubtedly influenced by both the **number of units** to be produced and the **target price** established.

As mentioned in the previous paragraph, an **in-depth analysis** of the **costs** associated with the realization of possible **tooling and moulds** is certainly advisable. However, there are **other aspects** that are **equally relevant**. Let us examine them below:

- ***possible modifications to be implemented during the process;***
- ***the availability and ease of access to the selected technology;***
- ***suppliers' availability;***
- ***in-house experience accumulated with a specific technology.***

When developing a prototype, it is first essential to define the **level of optimization** achieved, in order to have a clear understanding of how many and what **modifications** may still be required. This approach makes it possible to build the prototype using **technologies** that can simplify and shorten the time needed to implement such adjustments.

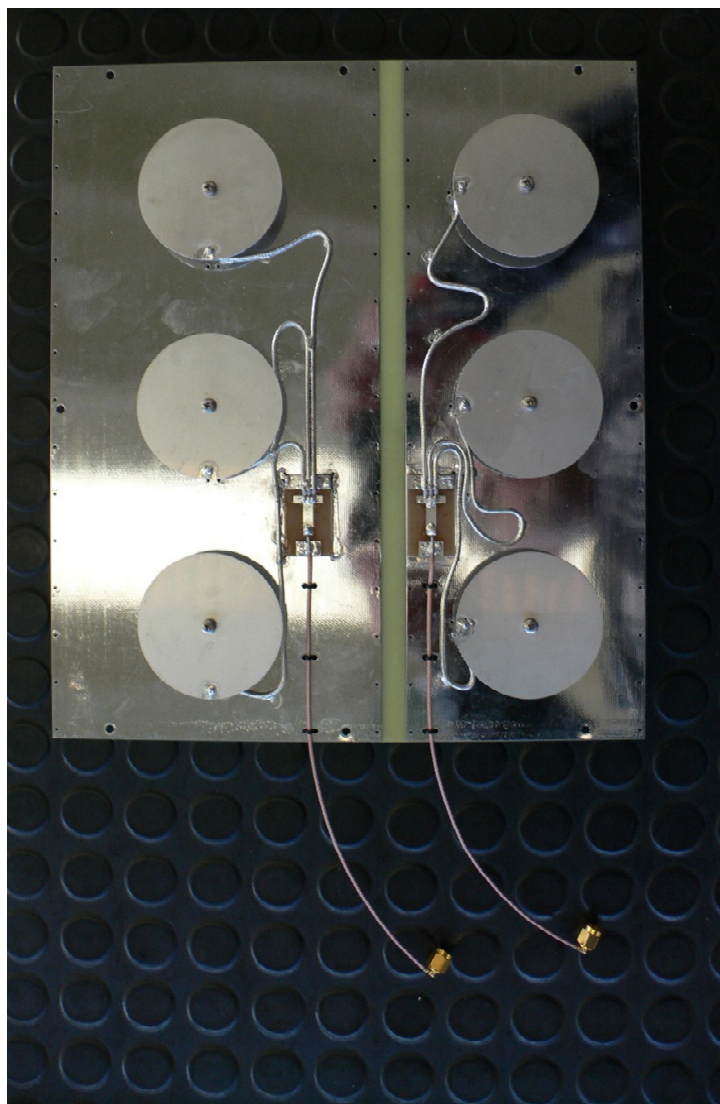
Furthermore, by preparing the **prototype** so that such improvements can be implemented directly on the same unit, we can avoid **additional costs** resulting from the construction of new samples and save **valuable time**, especially when facing predefined **deadlines** and **scheduled deliveries**.

The **time and cost** of realization are also influenced by how easily a given **technology** can be accessed. Having the capability to produce a specific component using **in-house resources** can be undoubtedly advantageous. Conversely, if every modification during the **prototyping phase** requires the involvement of an **external supplier**, obtaining the final prototype becomes considerably more **time-consuming** and **expensive**.

In essence, our recommendation is to maintain a **clear and comprehensive understanding** of the various **technologies** available on the market, so as to determine, case by case, which solution is **most suitable** for the specific project being developed. The greater the **in-house know-how** regarding the technologies applicable to a given realization, the higher the likelihood of selecting **the one that best fits** the intended purpose.

This also allows for a more accurate **evaluation of the supplier** with whom we choose to collaborate, providing greater assurance of their **competence** and **reliability**.

For this reason, the **continuous research and experimentation** of new manufacturing techniques provide a clear advantage over those who struggle to update their **production methods** and **processes**.

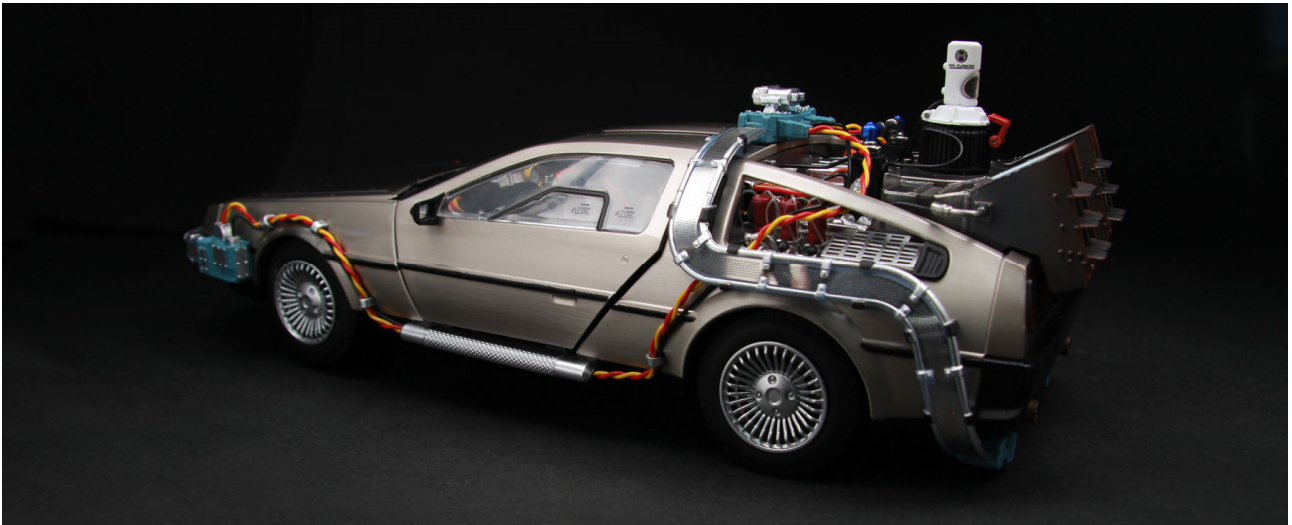


5. The prototype is not meant to be a work of art.

The **prototyping phase** should therefore be regarded as a **crucial and delicate step** in the design process, helping to **properly plan and organize** the subsequent **industrialization** and **production stages**. To avoid **unpleasant surprises** and **unnecessary waste** in terms of both **costs** and **timing**, it is essential to approach this phase with the appropriate **attention, expertise, and preparation**.

To make sound decisions regarding the **required characteristics** and the **manufacturing approach**, it is necessary to **thoroughly analyze** the project's **specific requirements**, defining and fine-tuning the **prototype** most suitable for the particular **application** for which the **antenna** is being developed.

Along with this, we would like to give one last but essential recommendation: the **prototype is not meant to be a work of art**, but it must be built in such a way that **identical copies** can be produced, allowing the Customer, if desired, to carry out the **measurements, tests, and verifications** necessary for the **validation of the designed antenna**.



6. Conclusions.

At the end of this brief overview on the key aspects of **prototyping**, let us summarize the **characteristics** that a **properly developed prototype** should have:

- *full functionality, meaning compliance with the required electrical, mechanical, and environmental specifications;*
- *compatibility with the target production price;*
- *the prototype must be fully known and characterized;*
- *the measurements must be repeatable and verifiable by the Customer;*
- *the prototype must be easily reproducible and compatible with the subsequent engineering phase;*
- *the prototype must be built using materials and technologies that are similar to, if not identical with, those planned for the subsequent production phase.*

In conclusion, assessing—already during the initial meetings—how the person or team responsible for the **design** of the new **antenna** intends to address the most critical **construction aspects** can serve as a reliable indicator of the **supplier's professionalism** and **trustworthiness**.

*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** using the **AntennaCustomizer** method.*

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

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