



HYBRID MULTIFUNCTIONAL METAMATERIALS FOR DEFENCE APPLICATIONS – HIMMODA (1ST PHASE)

In April 2021, EDA commissioned an in-depth study to investigate and assess hybrid multifunctional metamaterials for defence applications of camouflage technology, focusing on use of metamaterials and metasurfaces. The aim is to deliver a roadmap of the capabilities and potential this technology could offer to the defence area in future, thereby informing capability development as well as research & technology (R&T) planning of recommendable options for future action in this field.

Objectives

Metamaterials are materials engineered to have properties that cannot be found in naturally occurring materials. HIMMODA includes a comprehensive collection of concepts of metamaterial technology, working principles and key components, an assessment of the key technology and scientific challenges associated with the development of future metamaterial camouflage, together with an overview of the related European design and fabrication capabilities, the identification of suitable metamaterial camouflage concepts and relevant operational scenarios, and a series of designs for three different ranges, namely optical, radar and acoustic, for follow-on activities. Four key questions are answered:

- Which technologies for metamaterial camouflage may contribute to achieve enhanced performance?
- Which are the main metamaterial use cases to consider and their vulnerability assessment?

- Which are the most suitable concepts for multifunctional metamaterial camouflage and for which scenarios?
- Which are the metamaterial requirements from a user point of view?

Methodology

The contract was awarded to a consortium spanning several key players within Europe led by the multinational company THALES. All involved institutes conducted key desk research based on publicly accessible sources of information, namely scientific publications, complemented by exploiting their knowledge relevant to HPEM and related camouflage technology derived from own applied research in these fields, supported by an advisory board comprised of EU key players.

The creation of a European Community of Interest in Metamaterials was initiated by the execution of a large (virtual) project workshop in October 2021, with wide participation of Defence industry and research entities from several EU Member States.

Key findings

Integration of a series of metamaterial structures in a camouflage solution or anti detection solution is possible and should be divided into three main components or camouflage **technology building blocks**:

- Optical range,
- Radar range,
- Acoustic range

For the **optical range**, i.e. the laser and thermal imaging, a series of existing technologies are available to achieve absorption, thermal camouflage and heat management without resorting to active solutions, thus creating a simple, static membrane type solution based on readily available materials processed by conventional techniques. The technology is capable of providing a compact, yet high performance, anti-detection solution.

The **Radar and radio wave range** can be interesting for aircraft, terrestrial and naval applications and could for instance be realized with carefully crafted surfaces that offer re-configurability. The complex response that metamaterials offer results in a highly adaptable camouflage solution, reconfigurable on the field and capable of absorption, anomalous reflection or other responses such as Doppler block. All solutions are based on the simple concept of a craftable meta-antenna structure that is repeated over a surface and can be tuned by specific elements incorporated within the structures. Depending on the implementation frequency, technology may vary significantly.

For the **acoustic range**, that is interesting particularly for the naval domain, but can also be applied in terrestrial application, the main goal is to achieve absorption of both impinging (active sonar) and outgoing (passive sonar) acoustic waves. Static camouflage that outperforms typical Alberich tiles is readily available and could potentially offer a series of benefits compared to existing acoustic solutions. Such benefits include broadband absorption for a thinner structure and excellent surface characteristics that result in lower maintenance and better marine drag penalty. The resulting designs show good static absorption at any angle using typical materials.

Finally, multirange camouflage applications require that each range is placed in tandem. Such a solution has been investigated for different use scenarios either in naval or in airborne and terrestrial applications and possible **multirange** solutions have been proposed. The main technical challenges are related to better performing compact designs, to enhance the performance metrics with smaller structures and the reconfigurability control over larger surfaces.

From the point of view of military users, the **most promising operational opportunities** for metamaterial camouflage has been identified. This assessment was based on criteria such as likely detection scenario and potential environment characteristics. A series of demonstrators were proposed to showcase the metamaterial potential in camouflage applications.

Outlook

This factsheet introduces the HiMMODA study and summarises the results of its 1st phase, which was implemented between April 2021 and September 2022. The work is continued in the 2nd phase, which focusses on the design and fabrication of several demonstrators the aim of which is to prove multi-range camouflage, based on the findings of the 1st phase. Beyond this, a 3rd phase of HiMMODA is envisaged. The 3rd phase will include the testing and validation of the demonstrators, as well as a final exhibition in which the overall results of HiMMODA will be showcased.