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FACT SHEET

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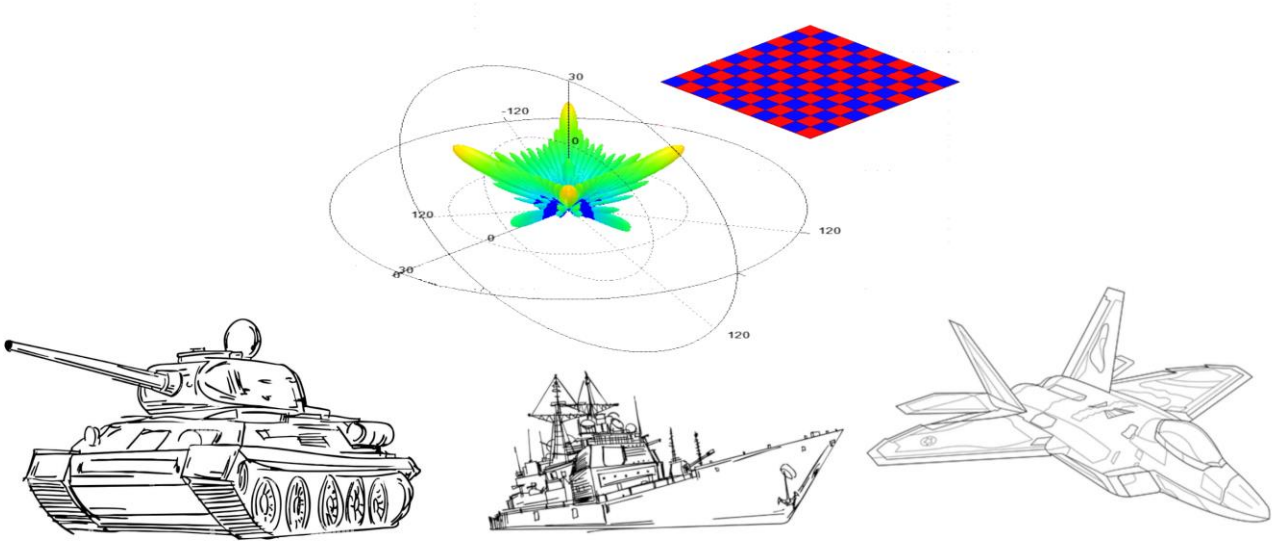

Hybrid Multifunctional Metamaterials for Defence Applications – HiMMODA (2nd phase)

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

The study 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.

Last update: 23 April 2024

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

Each range identified during the 1st phase of HIMMODA has been separately optimized and an associated demonstrator has been optimized and implemented. The optical and Radar range demonstrators have been assembled into a multirange system as described within the requirements identified during the 1st phase.

For the **optical range**, i.e. the laser and thermal imaging, a specific multilayer system was devised, studied, optimised and a multilayer system was fabricated to achieve the required performance. Namely that of low laser visibility (absorption), thermal camouflage (low thermal emissivity within the air transparency IR range) and thermal radiation outside the air transparency window to facilitate cooling. 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 above sea surface maritime applications and has been 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 using negligible power and capable of absorption, anomalous reflection or other responses. 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. A reconfigurable reflection metasurface was developed offering programmable, absorption, reflection or off-axis reflection (anomalous reflection) at the range of 10 GHz. This was achieved by a semiconductor integrated system incorporating a meta atom that is switchable by a programmable switch. The developed Radar demonstrator has been arrayed onto a pcb backbone to achieve a free space compatible size.

For the **acoustic range**, that is interesting particularly for the naval domain, the main goal was to achieve absorption of both impinging (active sonar) and outgoing (passive sonar) acoustic waves. Static camouflage that outperforms typical Alberich tiles 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 demonstrator developed during HIMMODA phase 2 was based on one of multiple designs of phase 1 that shows good static absorption at any angle using readily accessible materials.

Finally, **multirange camouflage** applications require that each range is placed in tandem. Such a solution has been implemented for the terrestrial and airborne use case scenario were optical and Radar camouflage is required at the same time. The resulting multiple range camouflage has been retains the performance characteristics of each constituent thus making it n excellent system for multiple range reconfigurable performance.

From the point of view of military users, the **most promising operational opportunities** for metamaterial camouflage have been addressed by implementing two demonstrators to showcase the metamaterial potential in camouflage applications.

Outlook

This factsheet introduces the HiMMODA study and summarises the results of its 2nd phase, which was implemented between September 15th 2022 and January 2024. The work is continued in the 3rd phase, which focusses on the detailed testing and validation of the fabricated demonstrators and the final exhibition in which overall results of the HIMMODA project will be showcased.