EDF-2021-DIS-RDIS: Research for disruptive technologies for defence applications

Proposals are invited against the following topic:

EDF-2021-DIS-RDIS-AMD: New materials and technologies for additive manufactured defence applications

Budget

The Union is considering a contribution of up to EUR 60 000 000 to support proposals addressing the abovementioned topics and their associated specific challenge, scope, targeted activities and main functional requirements.

A lump sum approach will be used. For selected projects, the maximum EU contribution will be based on the eligible costs in the requested funding, but actual payments will be conditioned to the completion of work packages. Proposals should include clear descriptions of the proposed criteria to assess work package completion.

Several actions, addressing different topics, may be funded under this call.

Additive manufacturing (AM) allows producing multi-functional parts and has been introduced into various industry segments over the last decade. For future military applications employing materials that are even more advanced, the AM process still requires significant technology development in order to establish robust and high yield processes to tap its full potential. The complexity of the necessary processes of additive manufacturing requires a profound understanding of material chemistry, metallurgical structures on microstructural level as well as defect detection on the macroscopic level. Research activities[1] could include but are not limited to identification and analysis of material properties, such as (super)alloys or concrete composites, full functional 3D printed electrified structures, new technologies to further improve military propulsion, AM parts or structures for an improved protection of soldiers and equipment, specialized AM-materials for function and structure in next-gen ammunition and missiles or AM technologies for ballistic functional structures as well as new approaches to lightweight applications.

Specific challenge

Additive manufacturing (AM) allows production of parts for various defence-industries segments with various technologies and materials. AM e.g. can improve development processes due to shorter production times, to manufacture obsolete spare parts or parts on-demand, to produce parts with integrated functions or parts of high complexity. There are several topics related to AM that can be addressed in research activities. These activities could include but not be limited to: the identification and analysis of material properties, such as (super)alloys or concrete composites, full functional 3D printed electrified structures, specialized AM-materials for advanced ammunition and missiles or AM technologies for ballistic functional structures.

[1] Materials and products have to be as Safe and Sustainable as possible By Design and during their life cycle (COM(2020) 667 final - Chemicals Strategy for Sustainability; Towards a Toxic-Free Environment, COM(2021) 400 final - Pathway to a Healthy Planet for All; EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil').

- Proposals should in particular address R&T efforts in the areas of:
- Identification and analysis of new materials for AM for defence application
- Innovative AM technologies and procedures, e.g. for the production of multi- functional parts

Proposals should balance R&T efforts in the following areas:

A Additive Manufactured Electronics (AME)

In order to overcome future challenges in defence electronics, the aspects of increased miniaturisation and complexity is of major importance. Furthermore, SWAP-C needs to be considered, too. In case of damage, defence electronics should be replaced as soon as possible and not depend of the availability of spare parts. Therefore, the impact of supply chain management and their impact to the independency from outer EU regions is vital. Finally, classical manufacturing of PCBs is related to significant numbers of harmful substances, like acids or galvanic fluids. This is directly related to RoHS and REACH requirements.

B Additive Manufacturing of Advanced Ammunition

For the next generation of ammunition several challenges need to be addressed, e.g. increased performance, improved reliability and safety, additional functionality, changing requirements and adequate supply. AM can be used to produce ammunition covering both, the production of the body/shell and the high-energetic material. The high degree of freedom in shape, can led to significant improvements in performance as the ammunition can be designed and adopted to several mission-specific requirements. For example, pressure profile in a barrel can be improved by the design of the energetic-material or the fragmentation of a shell can be influenced by the shape of the casing.

C Additive Manufacturing for Protection

Different groups of additive manufacturing technologies provide the opportunity to improve the protection of soldiers and equipment by advanced approaches to avoid or resist threats. Using the flexibility in terms of shape and complexity, AM parts or structures can be manufactured without the restriction of classical technological limits. Particularly for resistance it is important to absorb energy and withstand high-strain rates, where AM structures can show an improved protection quality and/or reduced weight.

D Additive Manufacturing for Lightweight Structural Parts

Lightweight structures can be achieved through a geometrical lightweight design and/or the use of lightweight material. AM offers the opportunity to address both by taking advantage of the freedom in the shape using (new) lightweight materials leading. Additionally, using AM for structural parts leads to the necessity of safe and robust processes leading to high-quality products.

Scope

Proposals should consider the current state-of-the-art including additive manufacturing systems, materials and material properties. Additionally, the entire additive manufacturing

process should be taken into acount in order to evaluate and classify the planned activities within a project.

Proposals are generally intended:

- To improve the understanding of the investigated AM-processes
- To further develop the manufacturing technology
- To evaluate the potential compared to other solutions
- To improve the performance of the products, processes or operations addressed by the proposal

For the previously mentioned areas, this means:

A Additive Manufactured Electronics (AME)

To increase the level of integration regarding electronics and RF-components, multiple physical functions should be integrated in multi-functional parts using AM, e.g. mechanical, thermal and especially the electric function.

Due to the potential design freedom AME can merge mechanical and electrical functions in one multifunctional structure. Future designs could handle concurrent requirements regarding weight reduction, increased complexity, rapid manufacturing and reduced environmental impact.

Challenging factors to get AME in use at defence level are manufacturing process maturity, definition of material properties and population technologies (e.g. soldering, multi-layering). Additionally the ability to create these functional designs is equaly important. Therefore, the education of engineers and definition of design guidelines are therefore the key to implement AME successfully.

B Additive Manufacturing of Advanced Ammunition

Different types of ammunition may be investigated e.g. kinetic projectiles, shaped charges, grenades or high and hypervelocity ammunition. The specialized materials must be characterized and tested with respect to their intended use, e.g. high-density materials needed for kinetic projectiles.

To improve and adopt the behaviour of ammunition items energetic materials may be additively manufactured to affect the time-dependent energy conversion. To affect fragmentation gradients in the material properties within a shell may be investigated as well as a complex design of ammunition bodies/shells. To affect propulsion, complex shaped propellant grains may be investigated.

The quality and accuracy of the AM-process and the AM-processed materials should receive special attention.

C Additive Manufacturing for Protection

To increase protection different combinations of materials and technologies may be used at each stage of manufacturing process. Different densities, internals structures of components

should be considered here, e.g. to optimize the protection quality /mass ratio. AM may be used to exclusively manufacture or just perform the modifications of the existing parts. Multimateriality and multifunctionality of the parts may be additionally implemented.

D Additive Manufacturing for Lightweight Structural Parts

Lightweight structures are to be realized addressing both aspects, an optimal distribution of the material as well as improved (weigh-specific) material properties. Therefore, complex designs are to be addressed as well as the use of new materials. Due to the typically low safety factors used for many lightweight applications, special attention should be paid to process and material quality as well as an substantial database, which should be built up for the processed materials.

Targeted activities

The proposals must cover the following activities as referred in article 10.3 of the EDF Regulation, depending on the topics addressed according to the functional requirements:

- Activities that aim to create, underpin and improve knowledge, products and technologies, including disruptive technologies for defence, which can achieve significant effects in the area of defence.

In order to overcome the aforementioned challenges, projects should include the following activities (if applicable):

- Analysis of available printing technologies and materials in terms of chemical, environmental, mechanical and thermal properties of the additive manufactured parts
- Investigations on long-term behaviour and effects of environmental conditions
- Analysis of parameters and variables affecting the additive manufacturing process
- Investigations at specimen, sub-component and component level
- Investigations on post-processing and post-treatment of printed parts
- Optimization methods and numerical simulations
- Consideration of testing methods (including non-destructive testing)
- Consideration of reliability and quality related issues
- Investigations regarding the overall added value for defence systems and products

For the previously mentioned areas, target activities additionally must include:

A Additive Manufactured Electronics (AME)

- Analysis of material in terms of electrical and RF properties
- Investigations on assembling technologies, e.g. soldering, gluing, beam welding and wire-bonding
- Investigations on new possibilities of three-dimensional routing for electronic parts, integrated shielding and increased packing density of RF structures
- Investigations on the integration of microelectronic components and analysis of thermal management
- Investigations to optimize post-treatment processes, e.g. to reduce post-treatment temperature

B Additive Manufacturing of Advanced Ammunition

- Analysis of specialized materials (or material-combinations) with respect to the intended use of the ammunition, e.g. high-strain-rate or shock driven processes
- Investigation on the performance of additively manufactured ammunition

C Additive Manufacturing for Protection

- Analysis of the material properties and high-dynamic loads and the energy absorbance
- Investigations covering complex or adopted shapes and/or lattice structures
- Ballistic tests of the fabricated resistance structures and components

D Additive Manufacturing for Lightweight Structural Parts

- Investigations on the lightweight potential using optimized designs
- Investigations on the lightweight potential using new material
- Analysis of the process robustness and quality of printed parts during the product life cycle

The proposals must substantiate synergies and complementarity with foreseen, ongoing or completed activities in the field of AM, notably through EU funded actions under Horizon 2020 and Horizon Europe or in the framework of the European Defence Agency.

Functional requirements

The proposed solutions should include in general:

- Build-up and strengthening of European capabilities and resources for equipment and devices related to the additive manufacturing processes
- Proof of concept of the investigated issues on a technology-demonstrator level
- Proof of concept including environmental effects
- Evaluation of the material properties of additively manufactured material on specimen level
- Establishment of a quality-assured AM process chain, including the evaluation of key influencing factors

For the previously mentioned areas, the proposed solutions additionally must fulfil the following requirements:

A Additive Manufactured Electronics (AME)

- Characterization of electronic properties e.g. conductivity and proven RF performance e.g. microstrip lines
- Established design guidelines for AMEs, e.g. conductors, including 3D-routing
- Integrated and assembled generic electronic structure, including microelectronic structures proven on demonstrator level including environmental tests and analyses
- Proof of concept for 3D-routing including integrated shielding with high packing density of electronics components and thermal management using integrated thermal structures

B Additive Manufacturing of Advanced Ammunition

- Proof of concept for ammunition with an additively manufactured body/case and/or energetic material
- Proof of concept for design, e.g. fragmentation
- Evaluation of safety aspects related to AM of energetic materials

C Additive Manufacturing for Protection

- Characterisation of mechanical properties for high strain rates and shock loadings
- Improved protection level and/or reduced weight
- Proven protection level e.g. acc. to STANAG 2280 (if applicable)

D Additive Manufacturing for Lightweight Structural Parts

- Evaluation of lightweight potential due to optimized design and/or new material
- Proven recommendations/ derivations regarding certification aspects for safety-critical parts
- Evaluation of NDT and embedded sensors for health monitoring methods, during production and parts life cycle

Expected impact

In principle the TRL of the technologies will be increased towards usability in defence applications. Improved performance must be achieved by the manufacture of products that were not possible with classical manufacturing technologies. Additionally, more flexibility is created by reduced effort to implement adaptations and by allowing more flexibility in the place and time of manufacture.

For the previously mentioned sub-topics, in particular:

A Additive Manufactured Electronics (AME)

More and different functions can be combined in smaller volumes. Thus, the integration level of electronic assemblies can be significantly improved. Furthermore, new AME technologies offer a reduced ecological impact, allow on-demand production and reduce the dependence on international supply chains.

B Additive manufacturing of Advanced Ammunition

Ammunition will be more flexible and adapted to mission-specific requirements. Scalability will be improved and raw materials as well as resources can be used more efficiently towards a more time-demand-orientated production progress and reduced environmental impact.

C Additive Manufacturing for Protection

The safety of the soldiers will be improved by an advanced protection of persons, systems and/or infrastructure. Improved protection would directly translate to improved resilience and survivability in missions.

D Additive Manufacturing for Lightweight Structural Parts

Improvements in lightweight design affects to overall performance due to improved agility and speed. Additionally weight reduction will lead to a stress reduction and (for systems) will also reduce environmental footprint.