*Projekt*

**Klastry krytycznych technologii obronnych (*Clusters for Critical Defence Technologies*) oraz motywy dla przełomowych technologii obronnych (*Disruptive Technologies for Defence*) zaproponowane przez Europejską Agencję Obrony (EDA) na potrzeby przygotowania przez Komisję Europejską dokumentu zakresowego dla okna badawczego EDF (Scoping Paper EDF-R)**

1. Clusters for Critical Defence Technologies (CDTs)
2. **Autonomy:** The scope of this cluster isto deal with all aspects of autonomy for platforms (land-air-sea). It will address technologies related to detect, sense and avoid, operation and control of autonomous systems of various levels of autonomy including collaboration with other heterogenous autonomous systems and all aspects related to human operators (trust, teaming, interfaces of collaboration) and the introduction of Artificial Intelligence (AI) to autonomous systems. Additionally, aspects related to multirobot control and cooperation will be analysed. **This cluster is mainly linked with the Cross-Domain Capability of the CDP**.
3. **Guidance, Navigation & Control Technologies (GNC):** This cluster is highly correlated with activities related to technologies that are enhancing the capabilities of armed forces to operate in challenging environments (e.g. underground, or in GNSS denied environments) either through manned or unmanned platforms, technologies that are improving the precision, guidance and control of munitions and missiles, and the improvement of key enabling technologies of GNC such as clocks including signa generation and time references. **This cluster is mainly linked with Air Mobility, Air Superiority, Ground Combat Capabilities, Naval manoeuvrability, the Integration of military Air capabilities in a changing aviation sector, and the Cross-Domain Capability of the CDP**.
4. **New Generation Communication systems:** In this cluster technologies are included dealing with all aspects of communications systems. These technologies are contributing to the development of capabilities in different environments such as underwater or open space and range (e.g. long-range communications) but also investigating new technologies that can be the backbone of the new generation of communication systems such as software defined networks, cognitive radios. **This cluster is mainly linked with the Information Superiority and Cross-Domain capabilities of the CDP.**
5. **Defence aspects of big data and cloud computing**: This cluster is focusing on technologies, systems and architectures stemming from the cloud and big data paradigms. It includes technologies related to the management and processing of information at large scale and from heterogenous resources, including but not limited to big data infrastructure, tactical clouds and defence Internet of Things. Furthermore, it will look into the algorithmic aspects of AI and big data and their impact in decision making, information processing and in health and usage monitoring of platforms and systems. **This cluster is mainly linked with the Information Superiority, Enhanced Logistic and med support capabilities of the CDP.**
6. **Algorithms and Systems for enhanced data fusion:** The scope of this cluster is to identify those technologies that are increasing the capability of the armed forces to analyse huge information data sets. It includes technologies for threat recognition and identification, systems/ networks and algorithms for increased awareness (including self-awareness of systems and platforms), sensor technologies and algorithms such as Terahertz and IR imaging detectors and sources and algorithms for detection, tracking and identification of challenging targets. **This cluster is mainly linked with the Information Superiority, Ground Combat, Naval Manoeuvrability, Air Superiority and Cross-Domain capabilities of the CDP.**
7. **Global Situational Awareness:** This cluster deals with the technologies that increase the potential of forces to operate at a global scale. It is related to the space based situational awareness and includes technologies that are needed for the creation of the Recognised Space Picture and for the improvement of Satellite defence reconnaissance systems. **This cluster is mainly linked with the Space-based information and communication services capability of the CDP.**
8. **Electronic – Cyber Warfare:** The scope of this cluster is to develop technologies that will enhance the capabilities of the armed forces to survive electronic-cyber warfare. It deals mainly with aspect of counter warfare in communications (electromagnetic support measures (ESM), counter detection of systems and platforms (range and signature management), electro-optical counter measure systems and identification and countering of threats (land, air, sea surface and underwater). **This cluster is mainly linked with the Information Superiority, Ground Combat, Naval Manoeuvrability, Underwater Control and Air Superiority capabilities of the CDP.**
9. **Complex Weapons:** This cluster dealswith technologies for the improvement of warheads and penetrators, rail guns, laser weapon systems and less-than-lethal effectors. It is aiming at the introduction of new technologies for the optimisation of effectors. **This cluster is mainly linked with the Ground Combat, Naval Manoeuvrability, and Air Superiority capabilities of the CDP.**
10. **Munition, Missiles and Energetic Materials:** The scope of this cluster is to improve existing capabilities in the area of munition, missiles and its propulsion systems, especially in terms of extend weapons range, increase precision, improve life management, reduce sensitivity and to develop new capabilities (including hyper velocity) compliant with REACH regulation. **This cluster is mainly linked with the Ground Combat, Naval Manoeuvrability, Air Superiority and Enhanced Logistic and medical support capabilities of the CDP.**
11. **Emerging and Smart Materials and Structures:** Thiscluster deals with new and emerging materials and structures for enhancing platforms, systems and individual soldiers in terms of protection, monitoring mobility and performance compliant with REACH regulation. This includes smart textiles, materials passive and active protection for platforms, light weight high performance structures and emerging materials such as programmable materials for future platforms. **This cluster is mainly linked with the Ground Combat, Naval Manoeuvrability, Air Superiority and Cross-Domain capabilities of the CDP.**
12. **Advanced Sensors and Electronics:** The scope of this cluster is to improve the capabilities related to sensor and electronic components for systems and platforms. It deals with technologies related to the new generation of electro-optical systems including active and passive systems, multi/hyper spectral imaging systems and novel optical configurations. It includes also technologies related to RF sensors with emphasis on new concepts for Radar systems including multiplatform RF systems and cognitive radars. For both EO (electro-optic) and RF (radiofrequency) sensors algorithmic aspects are also investigated in terms of increasing the capabilities in imaging and detection, tracking and recognition of targets in all environments and conditions. As far as it concerns the electronics, it looks into technologies for the development of advanced circuit design and production of advanced RF components. This includes technologies such as new ADC and DAC designs, RF and HDI PCBs, packaging technologies and thermal management, RF photonics and advanced antennas and RF receivers. **This cluster is mainly linked with the Ground Combat, Naval Manoeuvrability, Air Superiority and Cross-Domain capabilities of the CDP.**
13. **Technologies to Counter CBRNe (Chemical, Biological, Radiological, Nuclear and explosives):** This cluster deals with technologies related to the improvement of capabilities related to protection of personnel and systems, detection technologies and technologies for the management of CBRNe threats including hazard management (decontamination, specific medical counter-measures (MCM). This includes detection, identification, monitoring and defeat of CBRNe, new personal protective equipment and technologies for the protection of critical infrastructure and systems. **This cluster is mainly linked with the Ground Combat, Naval Manoeuvrability, Air Superiority and Enhanced Logistic and medical support capabilities of the CDP.**
14. **Concealment Technologies and Forensics:** The scope of this cluster is to enhance the capabilities in the areas of camouflage, signature reduction and deception of systems and platforms. It includes technologies such as camouflage and signature management technologies (land, maritime, air), and pryrotechniques for decoying and obscuring. **This cluster is mainly linked with the Ground Combat, Naval Manoeuvrability, Air Superiority and Cross-Domain capabilities of the CDP.**
15. **Human Factor Technologies:** The scope of this cluster is to investigate technologies with the potential to improve capabilities in the domains of human-machine interaction including novel user interfaces and cognitive aspects of human machine teaming and training performance and monitoring including various simulation & modelling technologies. **This cluster is mainly linked with the Information Superiority, Ground Combat, Naval Manoeuvrability, Air Superiority and Cross-Domain capabilities of the CDP.**
16. **Advanced Energy Technologies:** The scope of this cluster is to improve capabilities related to power generation for defence purposes looking into various aspects of propulsion, power generation, power storage and efficiency for land, maritime and air systems, energy management technologies to increase resilience of forces at home and in operations and for technologies enabling the armed forces to use alternative energy sources. **This cluster is mainly linked with the Ground Combat, Naval Manoeuvrability, Air Superiority and Enhanced Logistic and medical support capabilities of the CDP.**
17. **Technologies for Cyber responsive operations:** This cluster addresses technologies that are enhancing existing and developing new capabilities in the field of cyber response. The technologies included are related to defending C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) systems of land, air, maritime platforms and for developing capabilities for cyber situational awareness and response. It includes also technologies and advanced algorithms related to AI enabled capabilities providing secure autonomous and cyber resilient C4ISR systems. **This cluster is mainly linked with the Information Superiority, Enabling Capabilities for cyber responsive operations and Cross Domain Capabilities of the CDP.**
18. Themes for Disruptive Technologies for Defence
19. **Sensorisation, datafication and sense-making of society**: The sensorisation and datafication of society generates a wealth of (near) real-time data on the ‘human condition’ including, more specifically, on security situations and conditions. Advances in automated / algorithmic analysis (through such enablers as machine learning) make it possible to process ‘big data’ into meaningful information on longer-term patterns, developments and trends as well as on short-term events that may act as a ‘catalyst’ (actualisation of underlying, simmering developments) or ‘shock’ (breach of a longer-term trend). This has the potential of substantially increasing our broader situational awareness and understanding, as well as our ability for early warning and anticipation, in particular at the strategic and operational levels. And that, in turn, is the basis for focused and early, even pre-emptive, information-driven (military) action. At the same time, these developments will also affect the situation when a conflict erupts and in the period immediately after. Opponent forces will try to both leverage and attack this ever-expanding mesh of networks and sensors that is likely to become an increasingly critical part of our societies and our armed forces. These (partly civilian, partly military) sensor networks will be used by both European actors and adversaries to achieve superior situational awareness and understanding and to direct various industrial and increasingly post-industrial effectors to high-value targets.
20. **Human-machine teaming and artificial intelligence**: The proliferation of artificial intelligence (AI) into our societies over the past few years is increasingly visible in our everyday lives. AI holds the potential to be a major driver of economic growth and social progress, if industry, civil society, government, and the public work together to support development of the technology with thoughtful attention to its potential and to managing its risks. The literature shows that, in the next decade, AI will be incorporated into virtually every app, application and service. As computers become smarter, the world is moving from an era of automation, where computers support human tasks, to an era in which intelligent machines work together with humans to achieve the full potential of man-machine teaming. As intelligent things such as drones, autonomous vehicles and smart appliances permeate the environment, a shift from stand-alone intelligent things to a collaborative intelligent things model is anticipated. The ‘business case’ for many cheap and small drones, that together exhibit swarm intelligence and may overwhelm expensive high-tech platforms, might become more and more compelling. A new instantiation of the old asymmetric ‘swarming tactics’ can already be observed, with the ‘very cheap and numerous’ taking on the ‘very expensive and scarce’. With an increasing dependence on automated (intelligent) systems, guaranteeing the integrity and ‘cyber’ security of these systems is a crucial challenge.
21. **Influencing and the ‘battle of the narrative’**: Particularly in the context of ‘hybrid war’ – conflicts that are not quite open war but more than regular competition, mixing psychological, media, economic, cyber and military operations – the ‘battle of the narrative’ is an important instrument. It is likely that influencing techniques become more sophisticated in the 2035+ timeframe, in particular through effectively combining various influencing techniques, such as improved fake news and propaganda tools via technological advances in signal intelligence and outreach to societies via internet 4.0. Part of the challenge of integrating strategic communication in a comprehensive approach to deal with ‘hybrid’ threats / conflicts, is to effectively counter the opponent’s influencing activities as well as communicating one’s own narrative (these two are clearly interlinked), while at the same time respecting our (‘western’) norms and values – something the opponent is not necessarily bound to. Another element would be to see how our defence organisations can (better) piggy-back on the enormous expertise there is with branding, affecting messaging, crisis communication, etc. in the private sector.
22. **Globalisation of technology and modularisation of systems**: This theme focuses on the increased accessibility of many forms of technologies with (also) military applications; and on the fact that (military) systems are increasingly designed in a modular way in order to make it easier to scale, upgrade or add new functionalities / technologies throughout the lifecycle of the particular system. The question of how (or even whether) European nations and their allies will be able to maintain technological superiority throughout the tier-1 Generic Military Task List (GMTL) tasks raises many challenges. To make maximum use of technology that can be obtained on the market, military systems must possess a certain amount of ‘openness’. In the world of ‘software’ (and there is now more software than hardware engineers in the developed world), open modularity (e.g. service-oriented architecture) has led to remarkable efficiency gains. Very few of today’s military platforms and weapon systems are truly ‘modular’ in the sense that they can ‘seamlessly’ scale, in other words that functionality can easily be added or subtracted. Open interface standards and open architectures offer great promise here. The concept of modularity, in combination with the contracting of innovation cycles in many technology fields (particularly ICT-related), leads to the traditionally sequential phases of specification, development, acquisition, maintenance and the actual use of more and more amalgamating equipment. This raises the challenge of creating a truly ‘modular’ materiel process, not only in a technical sense, but also in terms of the process itself; and how to effectively combine longer-term innovation cycles (often at the platform level) and fast innovation cycles (at the subsystem and component level). A system engineering and architectural approach is needed to enforce the compliance and traceability of all aspects of the final capability with mission specifications, validated and verified against user requirements.
23. **Flexibility of effects (kinetic and non-kinetic)**: For the entire industrial age, armed forces have primarily endeavoured to achieve their goals through the large-scale application of industrial-age kinetic force. The current portfolio of effectors of all major defence players remain skewed towards that part of the spectrum. Recent armed conflicts (e.g. in Syria) as well as current investment priorities of some of the key global players show that this part of the effector portfolio of defence and security organisations will have to continue to evolve and will require innovative solutions. At the same time, however, it is evident that many key players are increasingly attracted by, and indeed are using, the non-kinetic side of the spectrum. This includes a growing number of cyber, behavioural, algorithmic, knowledge, and other effectors. Armed forces that can skilfully and flexibly blend these various effectors across the entire spectrum are likely to obtain sizeable advantages over their opponents. Of critical importance here is also the ability to more reliably link actual operational (but also strategic) effects to the different types of effectors that are being employed. European armed forces have gained a much more acute understanding of what can, but also cannot, be achieved by predominantly kinetic means. The debate between the relative merits of kinetic and/or non-kinetic effectors will not be satisfactorily resolved until both can be adequately assessed on evidence-based grounds.
24. **Space as a battlefield**: Many business sectors, as well as the military, heavily depend on space-based assets for communication, navigation (GPS) and observation. Space is still largely regarded and treated as a global commons, not owned or regulated by any individual country. Given that great powers such as China, India and the US are trying to establish bases outside earth’s atmosphere (space stations, stations on the Moon, and by 2035+ possibly on Mars), defence of these assets will certainly become an issue. With the contours of the ‘weaponization’ of space already emerging, the transformation of space from a ‘global commons’ to a ‘battleground’ is maybe not inevitable, but certainly conceivable. Nevertheless, with an increasing dependence on space assets, guaranteeing the ‘cyber’ security and electromagnetic protection of these systems (including the ground components) is a crucial challenge.
25. **Digitisation of matter**: 3D and 4D printing are already affecting (military) logistics, including maintenance, repair and overhaul (MRO) processes. But it will also enter the core of military operations. Funding from such organisations as DARPA has accelerated the work in the past years. Engineers are now working towards self-assembling pop-up bridges, uniforms that adjust their insulation to individual biometrics, and camouflage that changes to match its surroundings. Printing objects that transform over time is dubbed ‘4D printing’, and there is a wide range of applications imaginable. Examples include products that can adapt to heat or moisture to improve comfort or add functionality, such as clothes and footwear that optimise their form and function by reacting to changes in the environment. A further possible application is self-deforming materials in healthcare – researchers are printing biocompatible components that can be implanted in the human body. In the future both larger structures that can handle more complex transformations, as well as smaller, miniaturised models that can, for example, be used in the body, are foreseen.
26. **Human enhancement:** Advances in medicine, health and ‘lifestyle strategies’ provide for a number of ways in which the human life form can be supported to perform better, both physically and mentally. This is increasingly done at the level of small groups or individuals, with personalised medicine and treatments tuned to the individual. Human enhancement can be physical, e.g. through artificial limbs and exoskeletons; wearable fitness and health devices, and personalised drugs. On the cognitive side, wearable augmented and virtual reality devices already merge the physical and virtual world. Steps are being made in brain-machine interface technologies to bring cognitive enhancements through implants closer. New techniques, such as CRISPR-CAS9 (selected by the magazine Science as the 2015 Breakthrough of the Year) make human genome editing a routine process.
27. **Renewable energy, all electric vehicles and energy weapons**: Contested energy sources are one important driver that scholars have put forward as a cause of conflict. Within the field of geopolitics, it is recognised that the energy regime of the global system and the energy relations between producer countries, transit countries and consumer countries are important variables. The transition towards more renewable energy sources will likely have major geopolitical consequences. Renewable energy is more decentralised in nature and an interwoven net of renewables combined with smart grids could potentially be more reliant and could empower people and regional authorities vis-à-vis central governments and interests. In terms of impact on military capabilities, the associated trend towards more powerful and compact (electrical) energy storage technology is of importance. This trend is closely linked to electrification generally and specifically to the advent of all-electric automobiles that perform better (to a large extent already achieved) and are cheaper (projected for 2020 and beyond) than combustion engine cars. Also, in the military realm, both hybrid and all-electric vehicles and ships are likely to emerge and in the longer term possibly replace conventionally powered platforms. The combination of possibly more visible (and painful) effects of global warming with further dramatic change in the economics of renewables may even lead to national regulatory changes that prohibit the further use of fossil fuels. This would lead to both a challenge for our current – still heavily fossil-fuel dependent – armed forces, but also to a set of new opportunities for much leaner (in terms of logistics), cheaper and less vulnerable energy provision methods.

# Definitions

1. **Capability Development Plan (CDP)** - The revised 2018 CDP has been developed in the framework of EDA in close cooperation with Member States and reflects key contributions from the EU Military Committee and the EU Military Staff. It benefits from several inputs such as the Headline Goal Process, studies on long-term trends, lessons identified from CSDP operations and missions, as well as information on Member States’ current plans and programmes. As a result, the CDP is a shared EU reference informing national capability planners on capability requirements over time. Member States’ defence planners are encouraged to use it to identify priorities for capability improvement and exploit opportunities for cooperation. The 2018 CDP and the derived EU Capability Development Priorities were approved by Member States on 28 June 2018. The CDP prioritises military capabilities that need to be addressed and developed by Member States and underpins the identification of cooperative activities that can be implemented by Member States in the cooperation framework of their choice, including under PESCO and the EDF. The CDP provides the reference and general orientation for a more coherent development of the European capability landscape and will notably serve as a key reference for ongoing and future activities related to capability development in the EU framework, such as the Coordinated Annual Review on Defence (CARD), PESCO and the EDF.

Plan Rozwoju Zdolności - podstawowy dokument UE określający 11 wspólnych priorytetowych zdolności uzgodnionych przez państwa członkowskie w ramach EDA (przy współpracy z Komitetem Wojskowym UE i Sztabem Wojskowym UE) oraz przyjęte w 2018 r. przez Radę Sterującą EDA w formacie ministrów obrony:

1. Enabling capabilities for cyber responsive operations
2. Space-based information and communication services
3. Information superiority
4. Ground combat capabilities
5. Enhanced logistic and medical supporting capabilities
6. Naval manoeuvrability
7. Underwater control contributing to resilience at sea
8. Air superiority
9. Air mobility
10. Integration of military air capabilities in a changing aviation sector
11. Cross-domain capabilities contributing to achieve EU’s level of ambition
12. According the PADR definition of **Critical Defence Technologies (CDTs)**, CDTs are “*technologies that are considered to be critical for EU Member States in terms of strategic autonomy and/or security of supply*”.
13. **Demonstrators** are meant to demonstrate the suitability of research and technology for capability purposes and can be an important means to hand-over between the two dimensions of the EDF, research and capability and to bridge the so called “valley of death” between research and capabilities. Research demonstrators should not be seen as a (pre-)prototype.
14. **EDTIB** is the European Defence Technology and Industrial Base needed for armament programmes.
15. Accordingthe proposal for EDF regulation article 2, a “*disruptive technology for defence' means a technology the application of which can radically change the concepts and conduct of defence affairs*.”
16. **Key Strategic Activities (KSA):** EDA’s work on KSA aims to identify manufacturing capacities, technologies, as well as skills and competencies from a strategic autonomy perspective. This is to be done through the analyses of European industrial capacities in the areas of commonly agreed capability development and research priorities (CDP and OSRA). Given the nature of the KSA process, it results in a growing knowledgebase, which is built to inform future investment decisions at EU level.
17. **The Overarching Strategic Research Agenda (OSRA)** was launched by the European Defence Agency with the aim of providing a harmonized view of relevant European defence research priorities and the possible paths to achieve them, taking into account different funding mechanisms available. For that purpose, OSRA aligns the Strategic Research Agendas of EDA’s Capability Technology Groups (‘CapTechs’) with military tasks and long-term capability needs agreed by Member States in the Capability Development Plan (CDP). Building on the CapTechs and Member States’ capability development needs, OSRA defines common research and technology (R&T) priorities in the form of so-called Technology Building Blocks (TBBs). OSRA has thus become the EU reference for technological priorities, as the CDP is the EU reference for capability priorities, and both are closely intertwined. The OSRA methodology is at the same time capability-driven/pulled (top-down, based on clearly defined military capability needs) and technology-pushed (bottom-up, driven by new emerging technologies).
18. **Risk** has the meaning of the product of “loss in case of failure” times the “probability of a failure”.
19. **The Strategic Context Cases (SCC)** area set of 11 documents, one for each of the 2018 EU Capability Development Priorities. SCC are designed to facilitate and guide the implementation of cooperative solutions by specifying the strategic environment of each priority and identify collaborative options and roadmaps to develop the expected capabilities in a coherent manner. Each SCC identifies the TBBs potentially linked to the priority explored. The EDF work-programme preparation and the preparation of future EDF projects could benefit from the agreed content of the SCCs.
20. **Technology Building Blocks (TBBs)** within the OSRA framework identify R&T areas in which a cooperative approach at European level would bring an added value to support the development of defence capabilities. In December 2018, EDA Member States’ R&T Directors validated the outcome of the OSRA review, including a total of 139 developed TBBs each of which provides information on the existing technology gap in a given domain, its relevance for defence capability development, the Technology Readiness Level (TRL), links with other TBBs as well as on related projects within and outside the EDA framework. In a second step, EDA CapTechs prepare associated technology roadmaps for each of the TBBs, including plans for appropriate funding instruments. The TBB roadmaps can help Member States’ Ministries of Defence to decide whether to lead or contribute to cooperative ad-hoc R&T projects and will also inform funding decisions taken in the context of the future European Defence Fund (EDF).
21. **TBB Roadmaps** constitute the basic scenario identified by the CapTechs for the development of OSRA TBBs and aim to provide guidance to financial instruments at European and national levels. The TBB roadmaps are notably instrumental for identifying future cooperative projects to be developed within the EU, based on Member States willingness to share information. They could be either directly financed and developed by a group of Member States (EDA ad-hoc projects) or in the frame of cooperative activities funded by European Commission EDF schemes.
22. **TRL** is the Technology Readiness Level according to the following scale:

9 Proven through Successful Missions

8 Qualified for Operational Environment

7 Full Demo in Operational Environment

6 Technology System Demo in Relevant Environment

5 Technology validated in Relevant environment

4 Technology validated in Lab environment

3 Proof of concept in Lab

2 Technology Concept/Application Formulated (Studies only)

1 Basic Principle Reported