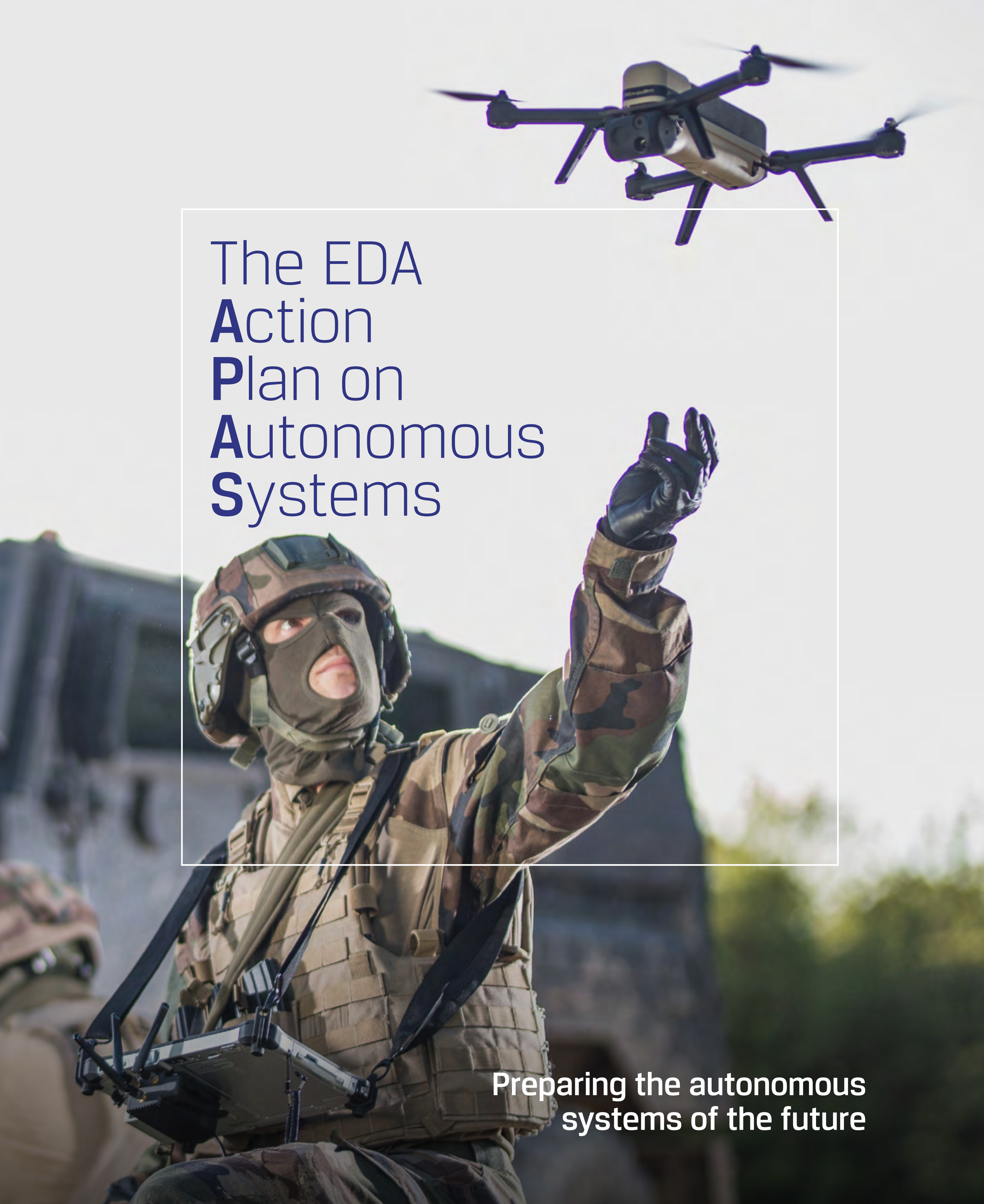
EUROPEAN DEFENCE AGENCY



The EDA Action Plan on Autonomous Systems

Preparing the autonomous systems of the future

More information on the European Defence Agency is available at www.eda.europa.eu

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HIGHLY AUTONOMOUS, EFFECTIVE,

Context

Autonomous systems (AS) are increasingly shaping our world, driving significant societal transformations. In today's fast-evolving and challenging international landscape, where Europe and its Member States (MS) must maintain a technological edge to strengthen defence capabilities, advances in areas such as robotics, artificial intelligence (AI), networked systems-of-systems, renewable energy, microelectronics, advanced computing, human-machine interfaces, and big data are enabling the development of highly capable AS. These advancements offer significant advantages to those who can leverage them.

There is significant evidence that autonomy provides substantial military value, offering benefits such as reducing personnel exposure to operational risks, accelerating decision-making in time-critical operations, and improving performance through enhanced precision, speed, persistence, endurance, and scale. Additionally, AS reduce cognitive load on soldiers and enable missions in environments that are "dull, dirty, dangerous, and dear" — scenarios that would otherwise be unfeasible or unaffordable.

In military context, AS have the potential to deliver operational benefits across a wide range of missions. These range from intelligence, surveillance, target acquisition, and reconnaissance (ISTAR), utilising distributed and persistent vehicles and sensors, to logistics and resupply, where autonomous platforms can transport supplies and ammunition to soldiers and offer in-theatre mobility. Moreover, AS can provide stand-off precision effects against sophisticated threats, ensuring mission success in complex battle environments.

AS also present a solution to the decreasing size of fleets of advanced manned platforms, a trend that persists due to the high costs associated with developing next-generation manned combat systems. Autonomous systems offer greater flexibility by allowing the creation of task-specific systems while keeping costs manageable. Furthermore, AS can help mitigate the shortage of manpower, particularly addressing the declining availability of highly skilled military personnel, such as pilots of manned combat air platforms.

Given their force-multiplying capabilities, it is no surprise that EU stakeholders are actively pursuing the development of AS for military applications. Most EU Member States are investing in autonomy-related projects, aligned with the EU Capability Development Priorities, which identify the need for cooperatively developing AS across a wide array of defence capabilities.

Recognising the growing importance and added value of military AS, MS tasked EDA to develop a comprehensive Action Plan on Autonomous Systems (APAS), to accelerate the development of highly effective, efficient, and reliable autonomous systems for land, air, maritime, and cross-domain operations.

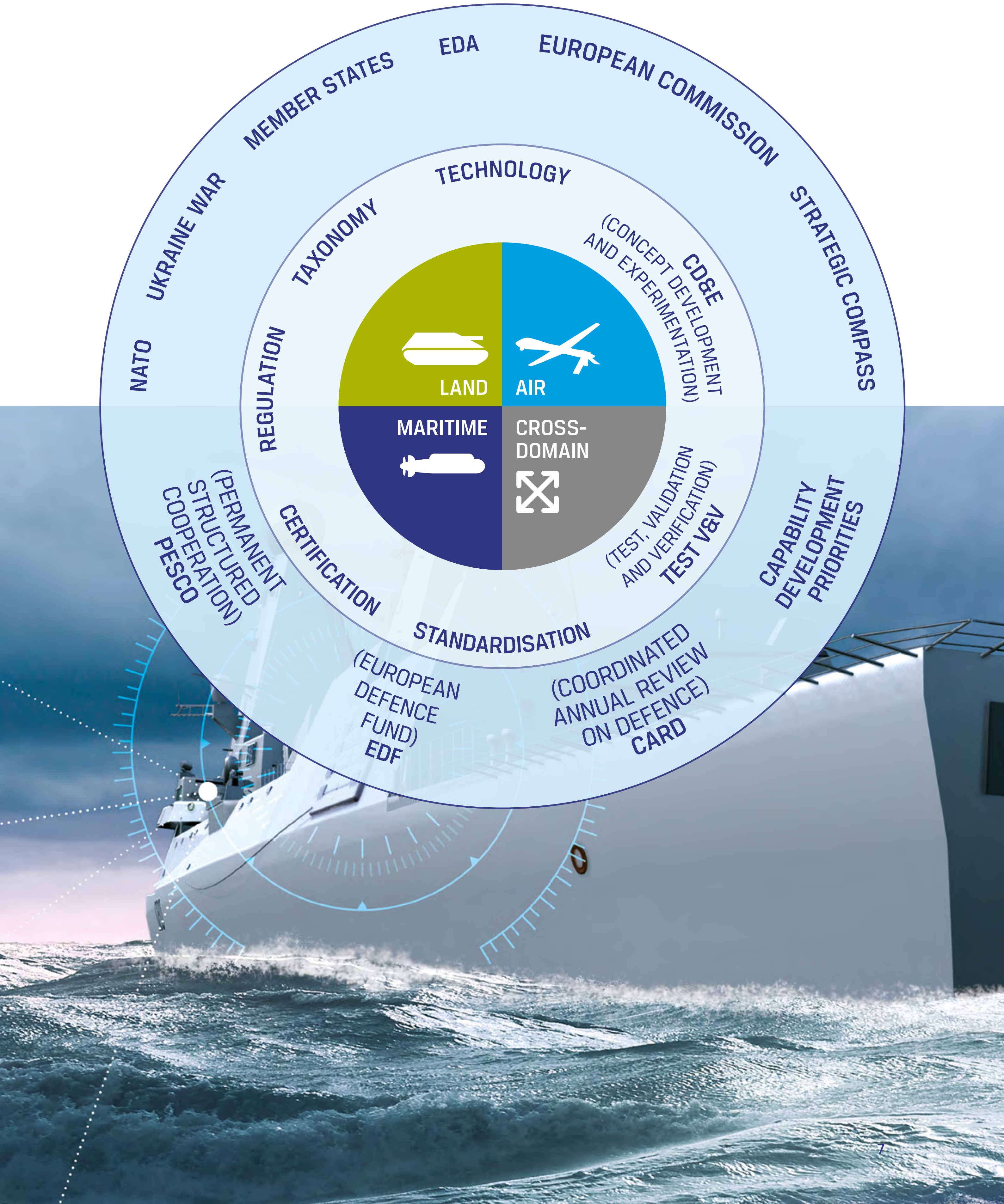
Approved on 11 January 2024, the APAS establishes priorities and fosters complementarity among EU programmes and entities, including the European Defence Agency (EDA) and the European Commission. Furthermore, it contributes to enhance efficiency of investments, accelerate the transition of innovations into military capabilities, and promote cross-fertilisation between civil and defence industries.

EFFICIENT, AND RELIABLE SYSTEMS

The APAS ecosystem

The ecosystem of the APAS is a dynamic and interconnected framework designed to support the development and integration of AS within the European defence landscape. It comprises a diverse network of stakeholders, including the MS and their respective defence industries and research and technology organisations (RTOs), EDA, and the European Commission. This ecosystem fosters collaboration between the civil and defence sectors, leveraging emerging technologies such as artificial intelligence, robotics, and networked systems.

The APAS ecosystem emphasises the importance of a holistic approach, integrating different domains (land, air, maritime and cross-domain) to enhance military capabilities while ensuring interoperability, standardisation, and ethical considerations. By aligning with EU programmes and NATO initiatives, the ecosystem aims to streamline innovation, avoid duplication, and accelerate the transition of technology from research to operational use. This collaborative environment is essential for maintaining the EU's technological edge in AS, ensuring strategic autonomy, and responding to the rapidly evolving global security landscape.


NATO
UKRAINE WAR
MEMBER STATES
EDA
EUROPEAN COMMISSION
STRATEGIC COMPASS
CAPABILITY DEVELOPMENT PRIORITIES
CARD (COORDINATED ANNUAL REVIEW ON DEFENCE)
EDF (EUROPEAN DEFENCE FUND)
PESCO (PERMANENT STRUCTURED COOPERATION)
TECHNOLOGY
CD&E (CONCEPT DEVELOPMENT AND EXPERIMENTATION)
TEST V&V (TEST, VALIDATION AND VERIFICATION)
STANDARDISATION
CERTIFICATION
REGULATION
TAXONOMY
LAND
AIR
MARITIME
CROSS-DOMAIN

The APAS relevance

The APAS is critical for shaping the future of European defence, directly aligning with the strategic priorities set out in the Strategic Compass, the EU Capability Development Priorities, and the CARD. These key EU initiatives underscore the urgent need for AS to address emerging security challenges and enhance military capabilities across various domains. The Strategic Compass calls for the rapid development of cutting-edge technologies to ensure the EU's strategic autonomy and resilience. Similarly, the EU Capability Development Priorities identify AS as essential for future capabilities, particularly in enhancing intelligence, surveillance, target acquisition, reconnaissance, logistics, and precision strike capabilities.

The CARD Report 2022 recommends MS to increase the incentives to boost defence innovation, including Research and Technology (R&T), reinforce the use of R&T cooperation platforms and frameworks to stimulate defence innovation and to engage in collaborative research projects, particularly by fully utilising EDA's Capability-Technology Groups (CapTechs) and the Hub for Defence Innovation (HEDI). It also reaffirms the commitment to developing capabilities to counter low-speed/low-visibility Unmanned Aerial Systems (UAS) (Counter-UAS) and advancing related R&T activities in AI, unmanned systems, and robotics.

STRATEGIC COMPASS

EU CAPABILITY DEVELOPMENT PRIORITIES

COORDINATED ANNUAL REVIEW ON DEFENCE (CARD)

LESSONS FROM UKRAINE

The lessons observed from the Russia's war of aggression against Ukraine have further highlighted the operational value of AS, demonstrating their effectiveness in complex and contested environments. Autonomous systems have proven to be force multipliers, enabling more efficient and effective responses in warfare scenarios by reducing the cognitive load on soldiers, accelerating decision-making, and conducting operations in hazardous areas where human presence would be too risky.

In this context, the APAS is not just a technological roadmap but a strategic necessity. It provides a coordinated and coherent framework for EU Member States to invest in and develop AS that are interoperable, reliable, and aligned with European ethical standards. The APAS ensures that the EU can rapidly transition from technological innovation to operational capability, addressing the demands of modern warfare and maintaining a competitive edge in global defence.

APAS

TECHNOLOGY
CONCEPT DEVELOPMENT & EXPERIMENTATION
TEST, VALIDATION & VERIFICATION
REGULATION
CERTIFICATION
STANDARDISATION
TAXONOMY

EU Capability Development Priorities – the primary driver of the APAS

The EU Capability Development Priorities are the cornerstone of the APAS, guiding its strategic direction and defining its priorities. The EU Capability Development Priorities set out the EU's capability needs and identify the key areas where AS will be essential for future defence operations. As the main driver of the APAS, the EU Capability Development Priorities ensure that the development of AS is aligned with the overarching goals of enhancing Europe's defence capabilities and achieving strategic autonomy.

The EU Capability Development Priorities emphasise the critical role of AS in several priority areas, including intelligence, surveillance, target acquisition, and reconnaissance; precision strike capabilities; and logistics operations, among others listed below. These systems are highlighted for their potential to significantly enhance operational efficiency, reduce risks to human personnel, and provide superior decision-making tools in complex environments.

EU CAPABILITY DEVELOPMENT PRIORITIES GOALS FOR AUTONOMOUS SYSTEM

- UAVs and UGVs for MEDEVAC (Medical evacuation) and CASEVAC (Casualty evacuation).
- Unmanned systems (UxS) for strike, interdiction, ISR and ISTAR.
- Modular, open, and scalable architecture for MUM-T (manned-unmanned teaming) joint fires.
- UxS for personnel recovery, including CSAR (combat search and rescue).
- Remotely and safely disarm or destroy IEDs.
- Tactical air transport with unmanned solutions.
- UAS swarms through MUM-T concepts.
- Counter UAS and drones swarms.
- Armed RPAS with fixed and rotary wing.
- Loitering munitions.
- Autonomous air-to-air refuelling.
- Fixed/rotary wing collaborative wingmen for Air Combat

By following the priorities set by the EU Capability Development Priorities, the APAS is designed to ensure that the EU develops the autonomous capabilities needed to maintain a competitive edge in modern warfare. This alignment not only justifies the focus of the APAS but also ensures that investments in AS directly contribute to enhancing the EU's overall defence posture. The EU Capability Development Priorities's guidance thus provides a clear, strategic framework that underpins the entire APAS, driving forward the development of AS that are crucial for the future of European defence.

- **Long endurance at sea through unmanned maritime systems (UMS).**
- **Maritime situational awareness through UAVs.**
- **Mine warfare through unmanned underwater systems (UUS).**
- **UMS to counter physical obstructions.**
- **Anti-submarine warfare with unmanned vehicles.**
- **Harbour protection through UxS.**
- **Autonomous systems for cross-domain logistics.**
- **Unmanned engineering systems.**
- **Saturation tactics.**
- **Anti-Access/Area Denial (A2/AD) capabilities.**
- **Autonomous maintenance.**
- **AS for integrated air defence.**
- **Modular UxS teaming with dismounted soldiers.**

The starting point of the APAS

The starting point of the APAS was defined through a comprehensive analysis of various sources that collectively represent the state of play of AS in Europe. This analysis involved integrating data and insights from multiple critical areas, beginning with extensive contributions from the EU defence industry – key players in the European defence sector who are at the forefront of developing and deploying cutting-edge technologies. Their input provided a detailed understanding of the current technological landscape, including the capabilities, limitations, and strategic directions of AS.

Additionally, the APAS leveraged information from a range of projects funded and supported by EU programmes and mechanisms, such as the European Defence Fund (EDF), the Preparatory Action on Defence Research (PADR), and the European Defence Industrial Development Programme (EDIDP). The data from these projects offered valuable insights into the ongoing and completed efforts, highlighting both successes and areas needing further attention.

Furthermore, the APAS took into account the challenges identified throughout these analyses, which include technological, regulatory, operational, and ethical barriers to the widespread adoption and deployment of AS. Key challenges such as interoperability, validation and verification (V&V), standardisation, and certification were scrutinised to understand their impact on the development process. The identified challenges not only framed the APAS's objectives but also ensured that the action plan is rooted in the real-world complexities of bringing autonomous systems to operational maturity.

Objective and end-state

The APAS is a plan designed to support the MS to speed up the development of highly autonomous, effective, efficient, and reliable autonomous systems for Land, Air, Maritime, and cross-domain operations.

The primary objectives of the APAS are to foster technological advancements that enhance individual unmanned systems and promote interoperability and collaboration between manned and unmanned platforms, while addressing challenges on Concept Development and Experimentation (CD&E), test, validation & verification, certification, taxonomy, regulation, ethics, and standardisation.

The desired end state of the APAS envisions a comprehensive and integrated autonomous defence capability across the EU. This includes the successful development and deployment of cross-domain autonomous systems capable of performing a variety of military functions, from combat, combat-support or logistics. This will be achieved through flagship projects focused on advancing technology to technology readiness level (TRL) 6 in the areas of (i) cross-domain swarms for persistent ISR, (ii) cross-domain swarms for logistics operations, and (iii) manned-unmanned teaming for joint fires (MUM-T). These projects will later be expanded into additional flagship initiatives to further increase the TRL in the same areas.

With this, the APAS seeks to establish a robust, interoperable framework where AS operate seamlessly with existing and future EU defence, soldiers, systems, and infrastructures.

Concept, phasing and work-strands

The APAS is structured around a strategic, multi-layered concept designed to guide the development and deployment of AS from foundational research to full operational capability. To this end, the action plan proposes three cumulative phases with a 5-year duration each, which will implement three complementary and parallel work-strands.

At the core of its strategy, the APAS recognises two key foundational elements:

- **Domain-Specific Maturity Levels:** The Land, Air, and Maritime domains are at different maturity stages regarding AS. For example, unmanned aerial vehicles (UAVs) have reached a high level of performance while unmanned ground vehicles (UGVs) are less mature and require additional efforts to match the autonomy and performance of UAVs.
- **Cross-domain operations:** Developing highly heterogeneous and autonomous swarms capable of participating in complex cross-domain operations will require significant time, expertise, and investment for development, testing, validation, certification, and deployment.

Transitioning R&T results into high TRL demonstrators, prototypes and capabilities requires continuous and enduring efforts of technology development and integration, and extensive experimentation campaigns to identify suitable solutions that provide operational benefit. Rapid innovation is a continuous cycle, crucial to the technology transition process. Experiments at different technology levels, and feedback from end-users early and often will support a "learn by doing" approach and be important to find and fix inconsistencies and adjust or cancel solutions that prove non-beneficial.

The APAS proposes an agile methodology to bring together incremental innovation and short-cycle innovation, which differ in pace, industry, and technology types. It also proposes an extensive use of CD&E to speed up the conversion of ideas and concepts to high TRL solutions, foster end-user involvement with researchers and developers, and create a more vibrant ecosystem by adding new partners to the existent collaboration base. This approach will provide opportunities for rapid learning through iterative testing and development, contribute to build operational trust on AS, and bridge the "valley of death" between low TRL demonstrators and high TRL prototypes and capabilities.

- **WORK-STRAND 1** – Focuses on enhancing isolated unmanned systems and improving their interactions with humans.

- **WORK-STRAND 2** – Supports the development of cooperative autonomous systems and the enhancement of machine-machine interactions, with an emphasis on semi-autonomous systems.

- **WORK-STRAND 3** – Aims to enable manned-unmanned teaming (MUM-T) within and across operational domains, through larger, more mature swarms of autonomous systems, focusing on close-to-fully autonomous systems for different applications, excluding lethal autonomous weapons.

Overview of the APAS action lines

The APAS proposes the following action lines:

- **Technology discovery, development, and integration:** Focused on enhancing the abilities of autonomous systems to sense, think/decide, move, act, team, self-protect, and self-monitor.
- **Enhancement of enabling technologies:** Prioritise the advancement of key technologies such as AI, network infrastructure, and modular, open system architectures to guarantee interoperability, cost-effectiveness, and compatibility with legacy equipment.
- **Addressing non-technological challenges:** Focused on non-technological issues impacting technology, such as test, V&V, certification, taxonomy, regulation, ethics, standardisation, and concept development.

The APAS action lines aim to enhance coherence between EDA activities on AS and other European initiatives, including the EDF, PADR, EDIDP, PESCO, the European Defence Technology and Industrial Base (EDTIB), as well as NATO activities. Recognising the relevance of the EDF Multi-Annual Perspective (MAP), the action lines incorporate MAP AS-related topics for future implementation without explicitly noting

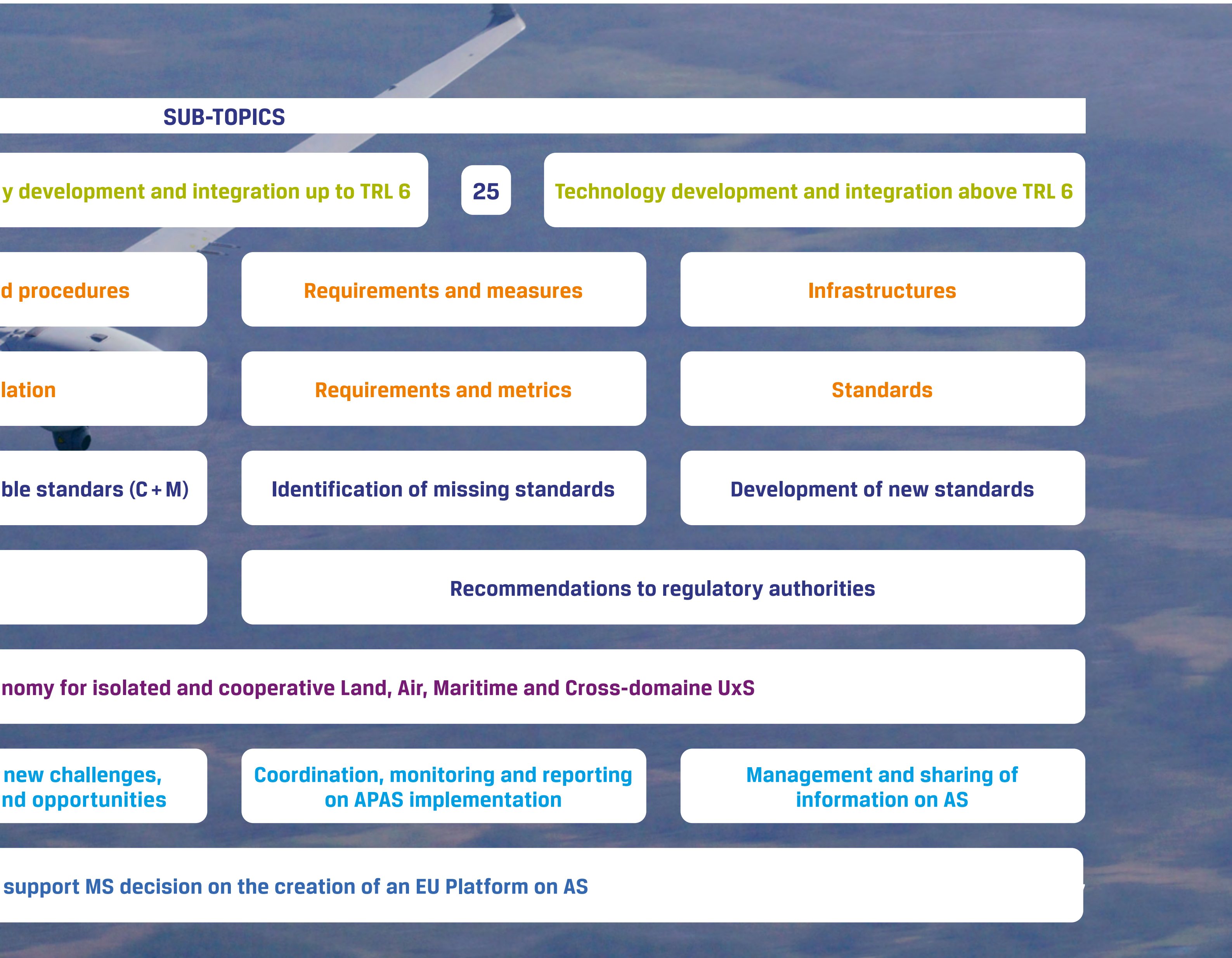
TOPICS, SUBTOPICS, AND NUMBER OF ACTION LINES

TOPICS	NUMBER			
TECHNOLOGY	11	Technology discovery	30	Technolog
TEST, V&V	8	Tools and models		Process an
CERTIFICATION	6	Tools and methodology		Regu
STANDARDISATION	9	Standardisation needs		Mapping of applica
REGULATION	2	Gaps and inconsistencies		
TAXONOMY	1	Comprehensive and unified taxo		
AD HOC WORKING GROUP ON AS (AHWG AS)	1	AS Community of interest		Identification of critical factors, a
EU PLATFORM OF AS	1	Business case to		

their origin. This approach ensures that MS retain the flexibility to translate MAP AS-related topics into future EDF work programmes or implement them through other mechanisms, such as EDA-led projects.

Given the paradigm shift where civilian innovation drives most technological advancements, action lines reflect the need to engage the private sector. This will help capitalise on emerging technologies, foster cross-fertilisation between civilian and defence industries (spin-ins and spin-offs), leverage dual-use technologies for military applications, strengthen innovation, and reduce fragmentation in the civil-defence innovation landscape.

Moreover, to bridge the «valley of death» between low TRL demonstrators and high TRL prototypes and capabilities, the action lines propose a combination of traditional and non-traditional methods for design, development, and testing. This approach integrates incremental innovation (e.g., ad hoc projects) with short-cycle innovation (e.g., scouting, experimentation, challenges, proof-of-concepts). It enables the long-term maturation of defence technologies while allowing for the quick adoption of mature technologies, maximising the potential of autonomy for defence applications.



Technological challenges

Current unmanned systems, while autonomous to some extent, still increase manpower demands and cognitive load on soldiers. They are typically operated in a «one operator-per-asset» configuration and are primarily designed for non-combat tasks such as logistics, training, and explosive ordnance disposal (EOD), limiting their operational effectiveness. Military environments, present unique challenges like unstructured terrain, communication limitations, and a diverse set of threats, requiring an appropriate autonomy with the ability to interact with its surroundings, precise control, advanced situational awareness, and robust AI-driven systems.

In more complex, multi-domain operations, the need for coordinated, multi-asset systems becomes essential. Collaborative AS (swarming) can enhance mission responsiveness and flexibility but require

HIGHLIGHTS OF KEY TECHNOLOGICAL CHALLENGES

SENSING

- Multi-mission, multi-function sensors with software reconfiguration for different user needs; and advanced multimodal fusion systems.
- Lightweight, high-resolution, enhanced passive or non-detectable sensors.

THINKING/DECISION

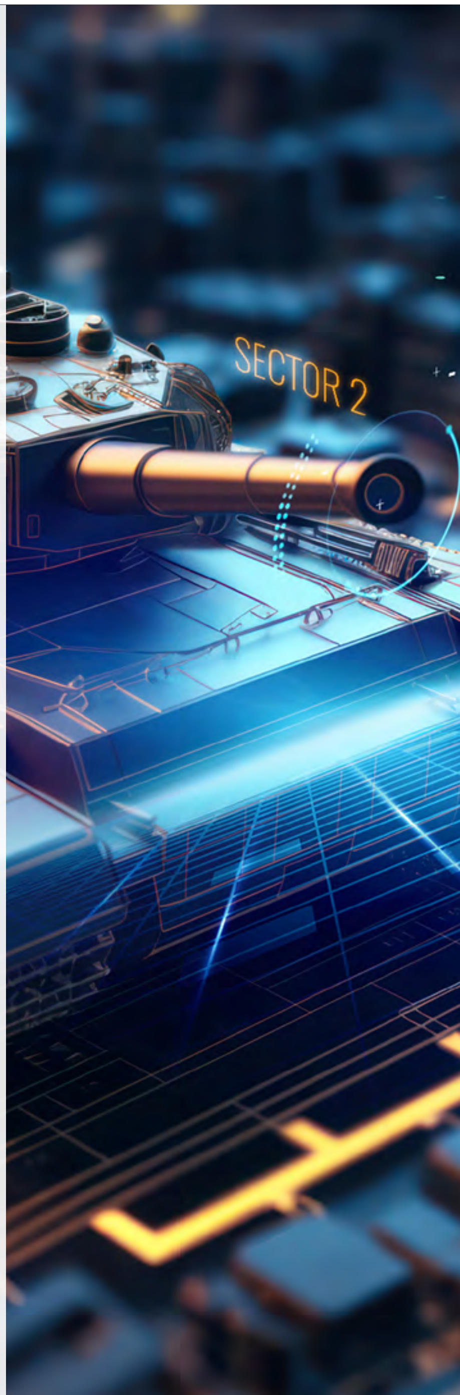
- Intelligent autonomy with embedded AI for advanced value- and ideas-based reasoning and decision-making.
- High-performance computing to transform large data volumes into actionable insights.

ACTING

- Advanced AI for detection, identification, classification, and tracking.
- Explainable AI to build trust in AS for multiple applications.

MOBILITY

- Smart navigation in GNSS-denied/degraded environments and unstructured terrain.
- Propulsion systems for high-speed, autonomous mobility in varied conditions.



significant research to ensure effective coordination and human-machine interaction.

Autonomous systems must be capable of sensing, decision-making, movement, acting, teaming, self-protection, self-monitor, and, ideally, self-repair, supported by enabling technologies like data networks and modular architectures to ensure interoperability and compatibility with legacy equipment.

While fully autonomous systems are a long-term goal, enhanced remote-controlled and semi-autonomous systems will play a critical role in operations in the short and medium term, necessitating steady technological advancements in this transition.

TEAMING

- Collaboration-centric systems with intuitive human-machine interfaces (HMI).
- Algorithms for collaborative detect-and-avoid manœuvres between manned and unmanned systems.

SELF-MONITORING AND SELF-PROTECTION

- Autonomous cyber defence and cyber-resilience by design with intelligent intrusion detection and recovery.
- Reduced platform signatures and passive modes for enhanced stealth and protection.

COMMUNICATIONS AND NETWORKING

- Self-healing mesh networks with onboard data processing for faster, secure communication.
- High-bandwidth, low-latency tactical networks (5G/6G) for stable, robust connectivity.

SYSTEM ARCHITECTURE

- Modular, open architectures for interoperability and cross-domain integration.
- Miniaturisation of components and low-cost systems for large-scale, mass applications.

Technological action lines

The technological action lines are carefully structured to drive the development of AS across different levels of technological readiness. They are designed to be complementary, each targeting specific phases in the technology development lifecycle to ensure continuous advancement from conceptualisation to deployment, and include three different types:

- **Technology discovery** – focused on the earliest stages of technology development, primarily involving activities at low TRLs. The objective is to explore innovative ideas and concepts that could potentially transform future capabilities. This includes fundamental research, concept studies, innovation prizes, technology foresight activities, challenges, and proof-of-concept projects.
- **Technology development and integration up to TRL 6** – involve the development and testing of technologies up to TRL 6, where systems are validated in relevant environments. The focus is on demonstrating that the technology can work in near-operational conditions, refining the designs, and solving integration challenges. It can be done through EDA's R&T ad hoc projects and/or through EDF research projects.
- **Technology development and integration above TRL 6** – these action lines cover higher TRLs, focusing on transitioning technologies from a demonstrated state to being fully operational. It includes extensive validation in operational environments, final adjustments, and preparations

for production lines. Such activities could be implemented through EDA's research and development (R&D) ad hoc projects and/or through EDF development projects. One of the latest additions to the toolbox of enablers for these action lines are operational experimentation (OPEX) campaigns, such as those performed within the HEDI framework. OPEX campaigns are specifically designed to assess systems at TRL 5 and above, targeting the readiness of these technologies across the DOTMLPFI (Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Interoperability) spectrum. These tests ensure that systems are not only technologically advanced but also operationally feasible and aligned with military needs.

The complementarity between these different types of action lines is crucial for maintaining momentum in technology development. This tiered approach ensures that technologies are not only invented but also iteratively improved and adapted to real-world military needs. By systematically addressing different TRLs, APAS ensures that innovations are not just theoretically feasible but are also practical and effective in enhancing capabilities and align with strategic military requirements of EU defence forces.

Standardisation challenges and action lines

STANDARDISATION CHALLENGES

The application of common standards across defence and civilian sectors enhances interoperability, drives innovation, creates synergies, reduces costs, and improves operational performance. However, the variety of competitive solutions in unmanned military systems developed by different manufacturers using distinct navigation, control methods, and interfaces hinders system interoperability and lifecycle management.

A key challenge in standardising AS is selecting relevant standards and creating new ones when necessary, adhering to the principle: "use civilian standards as much as possible, military standards when necessary". Defence efforts should align with civilian standards to expedite adoption and avoid duplicative standards. However, for critical military-specific elements, new standards may be required to ensure interoperability across MS.

Fragmentation of the defence market, differing approaches, and lack of R&D standardisation complicate the development of a global standardisation strategy for AS. Harmonising MS positions is crucial for establishing a common method for developing and implementing standards. Collaboration across industries, academia, governments, and EU institutions is essential, using platforms like European Defence Standards Reference System (EDSTAR) as a reference.

KEY TOPICS ADDRESSED BY STANDARDISATION ACTION LINES

- **Levels of interoperability and standardisation needs across all phases.**
- **Applicability of civilian and military standards.**
- **Reference AS standards in EDSTAR and document their implementation.**
- **Identification of standardisation gaps.**
- **Development of standards in collaboration with EU institutions, European Standards Organisations, industries, and NATO.**
- **Foster standardisation through collaboration between EDSTAR Expert Groups and other EDA bodies.**
- **Apply the Project Standardisation Management Plan (PSMP) in all AS-related projects.**

Test&Evaluation challenges and action lines

VALIDATION AND VERIFICATION CHALLENGES

Test&Evaluation (T&E) are crucial to validation and verification ensuring that AS meet operational requirements and perform safely, effectively, and provide interoperability in military operations, while also building trust in their autonomy.

V&V challenges are largely software centric due to the reliance on AI, and like other military systems, AS must undergo specific qualification and certification before battlefield use.

As AS evolve with higher autonomy, traditional T&E procedures – covering all possible scenarios – become unfeasible as these AS adapt and learn with each interaction, making it nondeterministic for legacy V&V approaches based on a test case situation. AS, being the test subject, create dynamic test environments while being tested. Their expanded autonomy increases the difficulty of evaluating risks and validating and verifying correct behaviour under diverse conditions.

Traditional V&V means of compliance are apparently inadequate for testing AS and present non-evaluated environments. New T&E processes, infrastructure (test ranges, labs), and tools are essential to encompass complexities of autonomy relevant for evaluation.

Member State Test Centres represented at the Defence Test and Evaluation Base (DTEB) and the Test Centres Networks of Excellence could facilitate more inclusive coordination of testing activities aimed at contributing to the definition of developing harmonized T&E procedures and respective means on emerging (non-legacy) technologies in support of future uptakes with built-in interoperability and exchangeability.

KEY TOPICS ADDRESSED BY TEST, VALIDATION AND VERIFICATION ACTION LINES

- Methods and tools to test AI algorithms.
- Modelling and simulation strategy for AS.
- Design and experimentation methods for AS.
- Test procedures, models and database for AI model training.
- Lessons from multinational exercises on V&V processes and tools.
- Specialised test and evaluation infrastructures for AS.
- Coordination with certification bodies and training organisations.

Certification challenges and action lines

CERTIFICATION CHALLENGES

As AS become more advanced and operate with greater independence, their complexity and unpredictable behavior pose significant challenges for certification and regulatory authorities. The need to update traditional V&V methods, combined with the lack of universal certification standards for AS, results in inconsistent criteria across different regions. This inconsistency makes it particularly difficult to obtain approvals in multiple jurisdictions, especially within the diverse landscape of the European Union.

Certification processes for AS can encompass design, production, and ongoing maintenance, which, in turn, encourages valuable discussions about the inclusion of "learning" and "continuous surveillance" in the certification framework. Certification plays a vital role in demonstrating that AS are safe and reliable according to defined requirements. It is essential to ensure that certification supports development, fostering a favorable environment for innovation in a rapidly evolving global landscape. Exploring risk-based approaches can provide effective alternatives for specific applications and environments. While looking forward to the establishment of regional or internationally accepted regulatory frameworks in the future, the current focus should be on developing best practices that enhance safety and promote progress in the field of AS.

Finding experts capable of integrating diverse disciplines – data, AI, control algorithms, mechanics, and electronics – is another challenge. As the development of AS accelerates, it is essential to strengthen the interconnection between several disciplines beyond today's frontiers in the context of AS certification. Safety and trust are paramount, and a major hurdle is the explainability of AI.

Certifying collaborative unmanned and/or AS with varying sensors and domains adds complexity, posing limitations to the certification process and timelines. Lastly, it's crucial that certification evolves side by side with technology following a step-by-step approach.

KEY TOPICS ADDRESSED BY CERTIFICATION ACTION LINES

- New "out-of-the-box" certification methodologies for AS.
- Mechanisms for safety assurance and risk mitigation in AS certification.
- Agile certification-related regulatory framework.
- Unified framework for AS certification standards and methodologies.
- AI, machine learning, and explainable AI to automate certification processes and enhance explainability.
- Certification of collaborative AS.

Regulation challenges and action lines

REGULATION CHALLENGES

The regulation of autonomous systems presents several challenges, arising from the need to establish comprehensive regulatory frameworks that can effectively govern the development, deployment, and use of AS within the European defence context.

Regulatory constraints for AS include:

- **Fragmented regulatory frameworks** – the existing regulatory landscape across MS is highly fragmented, with varying national regulations and standards. This fragmentation complicates the development of a unified regulatory approach for AS, leading to inconsistencies in how these systems are governed across different countries.
- **Rapid technological advancement** – the fast-paced evolution of autonomous technologies outstrips the current regulatory frameworks, which are often unable to adapt quickly enough, creating gaps that hinder effective oversight and deployment.
- **System complexity** – the complexity of integrating AI, robotics, and other technologies into AS poses challenges for creating comprehensive regulations that can adequately cover all aspects of these multifaceted systems, particularly when ensuring they meet safety, ethical, and operational standards.
- **Ethical and legal issues** – regulating AS also involves addressing complex ethical and legal issues, particularly those related to the use of lethal force and decision-making autonomy. Ensuring that regulations account for these considerations is critical to maintaining compliance with international law and ethical norms.
- **Interoperability** – ensuring that AS can interoperate with existing military infrastructure and other systems across the EU requires regulatory frameworks that promote standardisation and compatibility.

KEY TOPICS ADDRESSED BY REGULATION ACTION LINES

- Regulation constrains, inconsistencies, and needs for AS with different levels of autonomy.
- Regulation impact on development, certification, and deployment of AS.
- Coordination with relevant EU regulatory bodies.

Taxonomy challenges and action lines

TAXONOMY CHALLENGES

To establish effective standardisation, certification, and regulation for AS, a common terminology is crucial, as MS and international organisations often have differing definitions and understandings of automation, automated, unmanned, autonomous and related concepts. However, several challenges arise in creating a taxonomy for AS:

- **Rapid technological evolution** – the fast pace of technological advancement and growing complexity of AS make system classification difficult and constantly evolving.
- **Lack of consensus on autonomy** – definitions of autonomy vary significantly across organisations like US/DoD, NATO, and the Joint Authorities for Rulemaking on Unmanned Systems (JARUS), creating inconsistencies and complicating taxonomy efforts.
- **Diversity of AS** – AS operate across multiple domains (air, land, maritime), each with unique subsystems, characteristics, applications, and autonomy levels, complicating their classification.
- **Balance between specificity and flexibility** – a taxonomy must be flexible enough to adapt to evolving technologies but specific enough to be practical and concrete.
- **Over-discretisation of autonomy** – many taxonomies focus too much on levels of machine autonomy, neglecting human-machine collaboration and treating autonomy as static, rather than a continuum.

Despite these challenges, creating a robust taxonomy for AS is essential for ensuring their safe, responsible development and deployment across diverse domains, applications, and environments.

KEY TOPICS ADDRESSED BY THE TAXONOMY FOR AS

- Engagement with all relevant stakeholders, including industry, researchers, regulators, EU organisations, and NATO, to ensure the taxonomy is comprehensive and widely accepted.
- Autonomy levels, operational environments, and task capabilities.
- Flexibility to accommodate the evolving nature of AS and AS-related technologies.
- Include standardisation aspects to ensure alignment with broader AS standards.
- Tools (e.g., databases, documentation, training…) to facilitate the use of the taxonomy.
- Wide dissemination of the taxonomy to ensure broad adoption.

EU Platform of autonomous systems (EUPAS)

EUPAS

As AS evolve in complexity and application spectrum, rapid technological advancements will drive changes in doctrines, use cases, Concept of Operations (CONOPS), testing, validation, certification, regulation, and ethical considerations. In this demanding context, MS cannot develop 21st-century AS using outdated, fragmented, or poorly articulated equipment, policies, methods, or structures. To create effective AS-reliant capabilities, foundational investments and proper organisation are essential. AS must be tested and validated under realistic conditions, which is currently challenging.

Modernising physical and digital infrastructure is crucial to support the development and testing of new concepts, technologies, and capabilities, while systematically collecting and analysing data for knowledge sharing. Such infrastructure should be developed cooperatively, allowing MS and their close partners to share resources and expertise.

This collaborative infrastructure(s) should also facilitate the creation of best practices, standards, and protocols, and provide input for updating AS regulations.

These shared infrastructure(s), named in broad sense "platform", enable MS to test and validate AS using common standards, measures of effectiveness, use case scenarios, and V&V tools and procedures, fostering interoperability. The proposed EU Platform for Autonomous Systems (EUPAS) aims to support the entire lifecycle of Land, Air, Maritime, and cross-domain AS, ensuring cross-domain interoperability and optimised resource use.

The EUPAS-related action line, includes the development of a comprehensive business case to analyse all important aspects such as the mission, resource needs, organisational structure, location(s), implementation timeline, etc, to support MS' decision on the creation of the EUPAS.

Interaction with stakeholders

AUTONOMOUS SYSTEMS COMMUNITY OF INTEREST

A key feature of the APAS is the creation of the Autonomous Systems Community of Interest (ASCI), bringing together a diverse range of governmental and non-governmental experts, including decision-makers, planners, military personnel, and technical experts. The primary goal of the ASCI is to foster collaboration, facilitate the exchange of knowledge, and accelerate the EU's efforts in AS development in a coordinated and cohesive manner. This will be achieved through a cross-functional, cross-domain approach, ensuring a comprehensiveness and transversal exchange of information. This initiative will complement, without duplicating, the ongoing and future work on air, land, and maritime autonomous systems by existing EDA communities and bodies.

ASCI members will have access to key activities via a dedicated EDA webpage. They will also participate in and co-organise thematic events such as conferences, seminars, and workshops, to discuss sector-specific issues, emerging challenges, and potential solutions. Additionally, the ASCI will be offered the opportunity to provide insights for future reviews of the APAS.

Events involving ASCI will be organised on an ad hoc basis, tailored to support APAS implementation and discuss key aspects of future AS. These events will engage a wide audience, covering topics such as:

- Technology for AS (Land, Air, Maritime, cross-domain, enablers)
- CONUSE, CONOPS, and training
- Test, Validation and Verification
- Certification
- Standardisation
- Regulatory and ethical considerations
- Taxonomy

EDA'S AS WEBSITE

Given the multitude of technologies and fields of expertise required for developing future AS across Land, Air, Maritime, and cross-domain operations, the APAS must engage with a wide range of communities. This necessitates clear, simple, yet highly effective and organised communication strategies to ensure smooth collaboration and alignment.

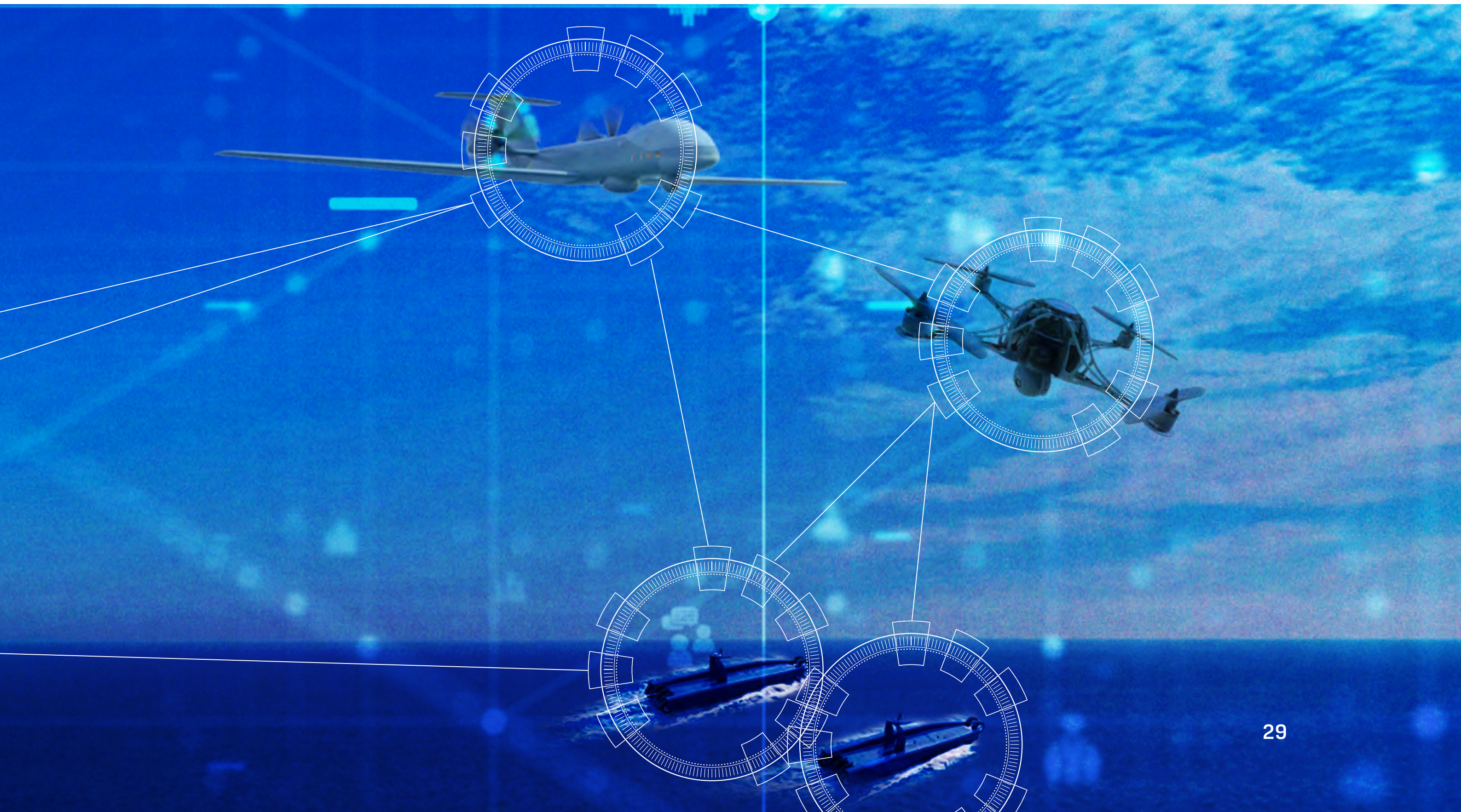
Effective communication is essential to provide timely updates to stakeholders on relevant activities, ensuring transparency, accountability, and proper alignment between all parties. It also fosters active engagement and participation from stakeholders. Equally important is the ability to receive and incorporate feedback from these stakeholders, which will support EDA and MS in making informed decisions about new initiatives and refining processes to meet evolving needs and challenges.

To ensure robust and efficient communication with APAS stakeholders, the EDA has created a dedicated AS website aimed to:

- Centralise all relevant AS information, including links to sector-specific sites when appropriate.
- Provide real-time updates and feedback on the APAS implementation to the ASCI.
- Receive feedback from internal and external stakeholders, allowing for continuous improvement of AS-related activities, processes, and best practices, and guiding future reviews of the APAS.
- Facilitate the dissemination of key documents (e.g., event invitations, publications, reports, communications).
- Collect and share open-source documentation from EU entities, NATO, and others, to enhance cross-organisational cooperation and knowledge sharing.

This approach will streamline communication and ensure the APAS remains adaptive and responsive to the needs of its diverse and dynamic stakeholder base.

EDA's AS website



The Ad Hoc Working Group on Autonomous Systems (AHWG AS)

To ensure effective coordination, implementation, monitoring, and reporting of APAS activities, EDA has created a cross-Directorate Ad Hoc Working Group on Autonomous Systems (AHWG AS), through a phased approach.

Phase 1 – The AHWG AS was established on 26 February 2024 as an EDA internal body to coordinate, monitor, and report on APAS implementation.

Phase 2 – The responsibilities and structure of the AHWG AS will be reassessed and it may be expanded with MS' representatives and other relevant external entities to enhance collaboration and accelerate the development of AS in a coordinated manner.

The AHWG AS was created as a management body, in full respect to the European Parliament resolutions, MS's legislation and normative guidelines, European values, and respect for the fundamental rules and principles of international humanitarian law, including in what it concerns Lethal Autonomous Weapon Systems (LAWS).

Key responsibilities of the AHWG AS include:

- Monitoring APAS activities and providing annual reports to MS and the EDA Management Board.
- Establishing and managing an AS Community of Interest to interact with a diverse group of experts from all MS and share expertise to enhance AS development.
- Organising thematic events to discuss AS technology, test, V&V, standardisation, certification, regulatory frameworks, ethical considerations, and military applications.
- Managing the EDA AS website for information dissemination.

AHWG AS – STRUCTURE AND RESPONSIBILITIES

- **AHWG AS (main body)** – overall coordination of the APAS, with a focus on the technological development of AS.
- **Subgroup 1 (SG1)** – AS activities related to testing, validation & verification, standardisation, and certification.
- **Subgroup 2 (SG2)** – AS activities related to taxonomy, regulation, and ethical considerations.
- **Subgroup 3 (SG3)** – AS activities related to operational requirements, CONUSE, CONOPS, and training.

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