EDF-2021-NAVAL-R: Smart ships

Proposals are invited against the following topic:

EDF-2021-NAVAL-R-DSSDA: Digital ship and ship digital architecture;

Budget

The Union is considering a contribution of up to EUR 43 500 000 to support proposals addressing any of the above mentioned topics and their associated specific challenge, scope, targeted activities and functional requirements, while considering a contribution of up to:

- EUR 29 000 000 to support an individual proposal addressing the topic EDF-2021- NAVAL-R-DSSDA

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

Digital technologies evolve at a very high pace, with civilian markets as key driver for innovation. The mastery of the data cycle, from capture to management and exploitation, is now considered as a key element for ship superiority at sea (combat capabilities, improved maintenance, enhanced crew training...). To ensure the adequate integration of innovative digital capabilities and the development of advanced data-based services, it is necessary to define a data-centric IT infrastructure, based on principles that offer resilience, high level of native security, availability and performance as well as computing and storage scalability – while considering the specific requirements of European navies (duration of the mission at sea, low connectivity, sea conditions and environment, interoperability...). This topic is a structuring one. It aims to help the development of fundamentals for digital ship: digital architecture and data/interface standards and ask for the studies of a concrete demonstration on ship and ship systems health monitoring.

Specific challenge

The specific challenge is directed towards the definition of shared digital architecture of naval surface vessels and data/interface standards, against which innovative data management solutions will be tested and selected. This architecture will in particular include a modelling and simulation environment (including digital twinning) that allows for intelligent predictive maintenance based on sensor technology, crew training, training, continuous upgrades of naval capabilities and on-board assessment of the impact of degraded systems on critical functions and ship capabilities, assisted by on-shore experts. A model based systems engineering design approach that represents a realistic testing environment for the continuous integration of evolving digital technologies (processing, data storage capacities, Industrial Internet of Things (IoT)...) to ensure the openness and scalability of ships' digital architecture.

Strategic importance is identified as the overarching goal to increase the level of automation and support to the ship crew in order to be able to reduce the crew, obtain higher speed in the OODA-loop (observe–orient–decide–act), ensuring high value military tasks, increase safety, operational efficiency, operational readiness (training on real data) as well as decreasing the total life cycle cost of the ship.

Scope

The proposals must aim at obtaining higher degrees of automation in ship and combat systems using big data analysis, data fusion, Artificial Intelligence (AI), including machine learning and multi-agent technology and other technologies to obtain higher speed in the OODA loop, including digital twinning. This objective will be achieved through the definition of a data-centric digital architecture and shared data/interface standards, allowing for new services.

The proposals must address some of the following elements:

- Identification of the specifications for warships' digital architecture such as European navy needs and specific constraints (operational, environmental, energy-related, connectivity-related...);
- Definition of a ship digital architecture and of smart processes in order to optimise sharing, pushing, pulling, selection, collect, enrichment, exploitation of data, whether for optimising the functioning of systems or for constituting data bases of knowledge or data bases for machine learning or both;
- Development of a limited set of interface and implementation standards in order to ensure interoperability and the integration of future data-based solutions and services in various ships.
- A modelling and simulation environment based on Model Based Systems Engineering (MBSE) principles;
- The combination of IoT technologies, sensors, data lake infrastructures to improve data collection and management, and AI based analysis capabilities to be able to provide services as to assess a platform's health status and develop predictive and corrective maintenance strategies;
- The capability to introduce novel technology or functionality on an existing design and demonstrate impact on Requirements, Functional, Logical and physical domains;
- The definition of the best application of digital twinning aiming both at product development and lifecycle management.

Targeted activities

The proposals must cover the following activities as referred in article 10.3 of the EDF Regulation, not excluding possible upstream activities eligible for research actions if deemed useful to reach the objectives:

- studies, such as feasibility studies to explore the feasibility of new or improved technologies, products, processes, services and solutions;
- the design of a defence product, tangible or intangible component or technology as well as the definition of the technical specifications on which such design has been developed which may include partial tests for risk reduction in an industrial or representative environment.

The targeted activities must in particular include:

- definition and demonstration of principles for implementation of a standardised on-board naval IT infrastructure, which may integrate computing, storage, networking, and virtualization resources to be able to run on commodity hardware and/or withstand country-specific choices of technical solutions, but also standards to allow for the joint development of new services and data-based solutions;

- identification, evaluation, test and selection of classes of solutions/services to address data management issues of data integrity, data and user's confidentiality and data traceability;
- MBSE implementation in existing design environment. Availability of physical-mathematical models for system behaviour;
- select and design new (AI based) functionalities aiming at increasing the level of automation and support for operational crew on-board, increasing the efficiency and effectiveness of the OODA loop;
- SPDM (simulation process and data management) and PLM (product life cycle management) integration for platform and combat system development;
- IIoT standards, data infrastructure solutions and AI based algorithms. Component and system failure modelling;
- modular design principles to reduce interfaces among systems and facilitate upgradability of system.

Definition and demonstration of ship and ship systems health monitoring:

- design, development and realization of an engineering environment using MBSE for the design of 2 till 5 complete systems (e.g. power and propulsion system, pumps, heating, ventilation and air conditioning (HVAC) system, combat system capability);
- definition of a model based systems engineering design approach that represents the ships' functions and capabilities for advising the crew on remaining functions and capabilities if systems are degraded;
- design of a condition monitoring method for selected systems and develop component and system failure models. Development of AI and/or physics-of-failure based algorithms to predict remaining useful life of critical components. Development of AI based algorithms to predict remaining critical functions and ship capabilities in case of damage, failure or anomalies;
- implementation of modular design principles in a state-of-the-art IT-architecture to be able to upgrade and or to replace components or part of systems and assess impact on requirements, functional performance, logical architecture and physical integration.

A detailed planning of potential subsequent phases must be generated, including the identification of implementation priorities, according to the operational needs.

Functional requirements

The proposals must include a technological demonstrator for the proof of concept. The proposed solution should provide a collaborative environment with the capability:

- To provide and demonstrate a basic functions representative infrastructure framework including all main aspects of storage, processing, communications hardware and protocols, administration and supervision, etc. Taking into account the specific constraints and requirements of naval warfare;
- To apply mbse allowing for the simulation of behaviour modelling while demonstrating impact on requirements, functional, logical and physical domains;
- To demonstrate the design of 2 till 5 systems including physics based modelling of these systems;

- To demonstrate iiot technologies, sensors, operator interfaces, data lake infrastructures and ai based analysis capabilities to be able to assess a platform's health status and develop predictive and corrective maintenance strategies;
- To demonstrate condition monitoring for selected systems and develop component/system failure models, as a demonstration of the service provided by digital ship;
- To demonstrate upgradability by using mbse and modular design principles and the capability to assess operational effectiveness;
- To demonstrate continuous deployment of (software) systems in the digital twin integrated system environment and on board;
- To demonstrate easiness and effectiveness of adding new functionalities and digital capabilities, without altering the existing system, on the basis of shared standards for data and interfaces.

The digital architecture solutions should comply with the following functional objectives:

- Resilience: To identify architectural principles against undesirable events (e.g. combat damages resulting in decreased capabilities, loss of power, cyber-attack, etc.) that allow fast recovery, core functions in degraded mode, etc.
- Security: To define and select common architectural principles that maximize security against cyber and physical threats. The safety of the infrastructure for the ship itself is also to be considered.
- Sustainability: Focusing both on the ability to maintain the architecture's operational availability at reasonable costs (e.g. maintainability, obsolescence management, etc.) and as the optimization of resource-usage (e.g. lean architecture, energy optimization, etc.). The ability of the architecture to evolve and integrate future technologies and architectural patterns is another key aspect of sustainability.

In particular, these solutions should define the optimal allocation of operational functions to systems or subsystems and the mutualisation of hardware capabilities (processing, data storage capacities). To support this optimal allocation, a review and evaluation of digital architecture models currently used in the civilian world is to be conducted against requirements. Models to be evaluated should include cloud computing (Iaas/PaaS/SaaS[1]), edge computing, service-oriented architectures (SOA) or micro-services architectures. Selected infrastructure must offer centralized and mutualized technical services such as management, policies, security, mobility, data collection using IoT technologies, which can be shared by applications and which must contribute to reduced effort in development, shortened time for integration and qualification of incremental capabilities.

For the purpose to seek for interoperability between actions under the two topics considered in this call for proposals, it is encouraged that the proposal addresses possible linkages to the other actions under the topic EDF-2021-NAVAL-R-SSHM (Ship Structural Health Monitoring).

Expected impact

- The definition of a data-centric IT infrastructure to ensure the adequate integration of innovative digital capabilities and the development of advanced data-based services,

[1] Infrastructure as a Service/Platform as a Service/Software as a Service

while considering the specific requirements of European navies, to provide ship superiority at sea.

- The implementation of an MBSE systems of systems digital architecture in a connected environment on-board and on-shore (digital twinning), integrating the various platform's systems will allow for several breakthroughs inter alia, in terms of integrated mission management and systems diagnosis, predictive maintenance facilitating mission planning and mission planning adaptation, simulation and training scenarios, reduced manning and/or autonomous operations.
- The full digitalization combined with the data assimilation of the different sensors will provide safer platforms, increase reliability of equipment and systems, increase endurance and lower maintenance and logistic support cost.
- Establish a collaborative framework for standardization in terms of data & models.
- Facilitate platform adaptability. Facilitate the validation and incorporation of new technologies in the platform during its lifecycle. Navies can remotely configure customized platforms and assess operational effect.
- The possibility to work in cooperation will extend the surveillance and operational capabilities of the platforms.