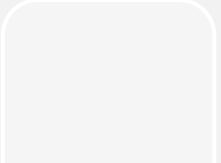
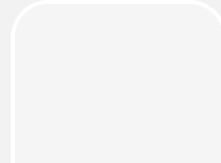
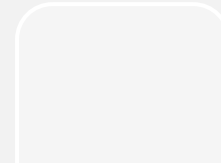
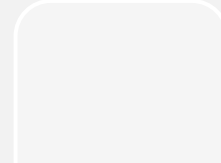
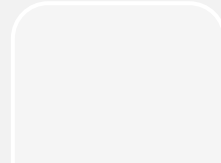
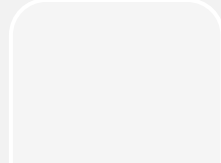
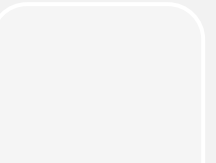
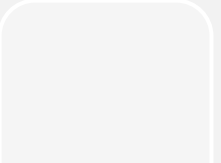
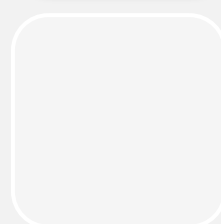
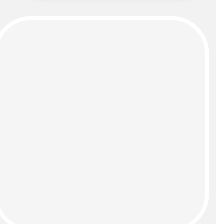
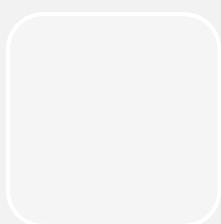
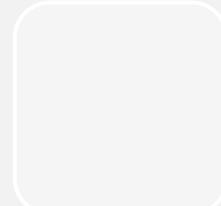
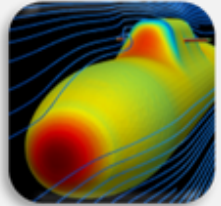
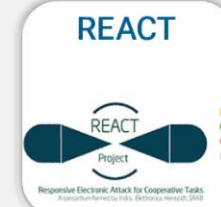


Near Future Submarine (NFS) programme: Human Factor Engineering (HFE) and it's technological challenges

Farnborough 22 May 2024

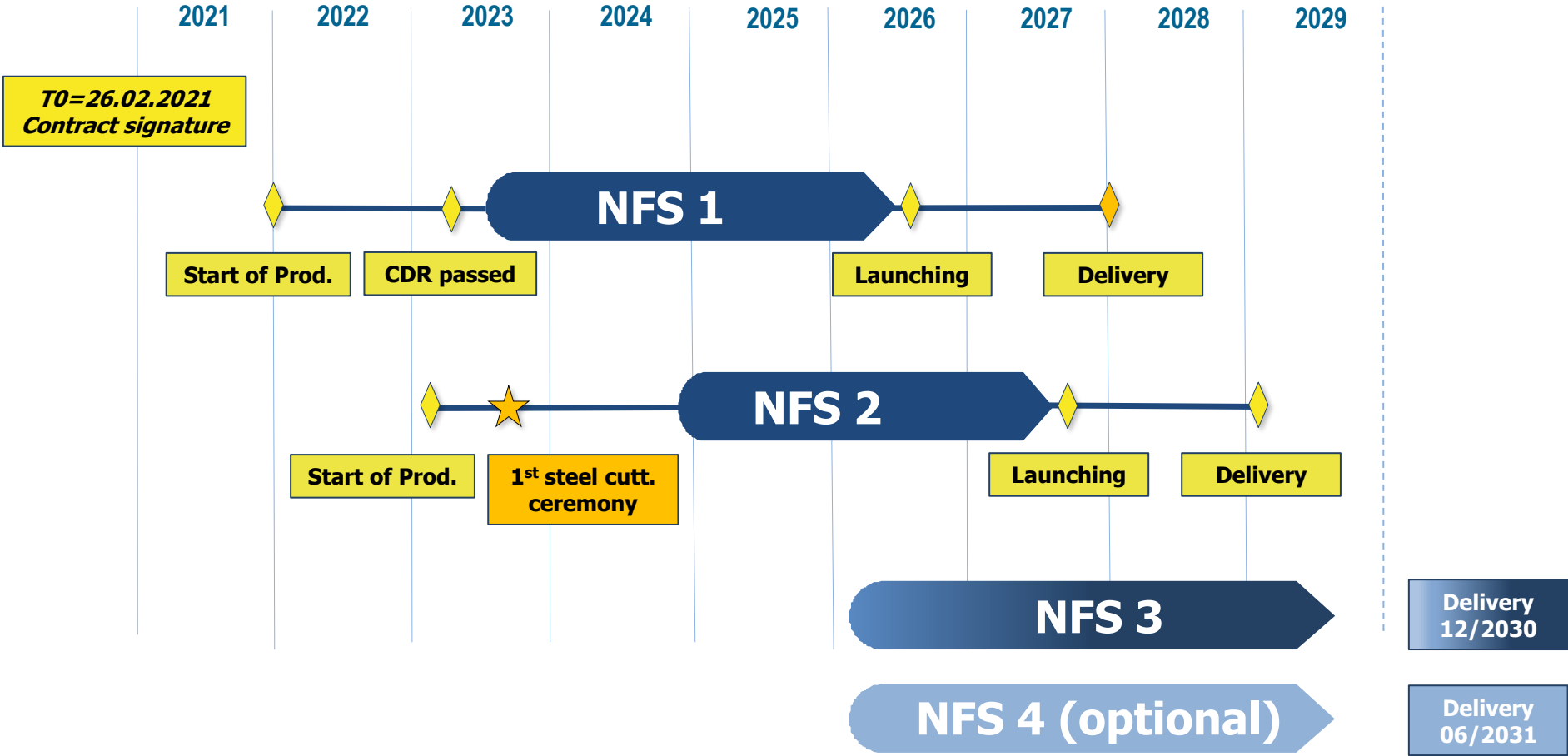


Agenda

- ❖ NFS Programme overview update
- ❖ HFE design & analysis
- ❖ NFS HF overview - Focus on:
 - New development systems
 - On the horizon technologies
 - Over the horizon needs and technological challenges

U212 NFS Programme overview

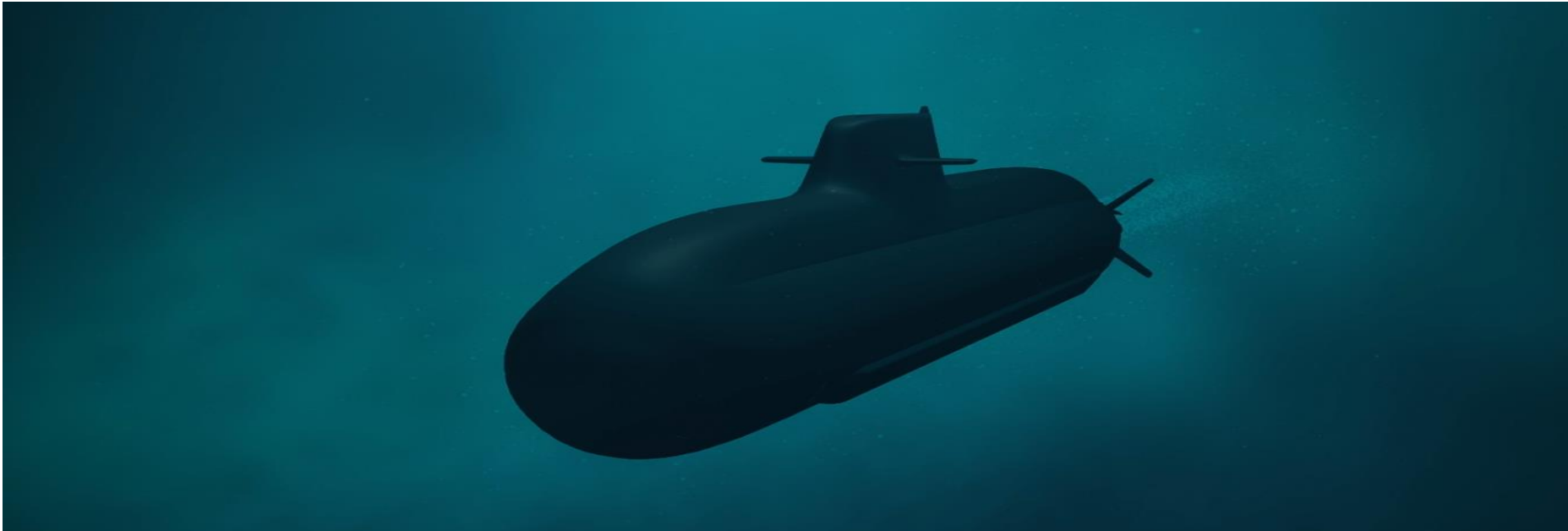
Programme schedule



U212 NFS Programme overview

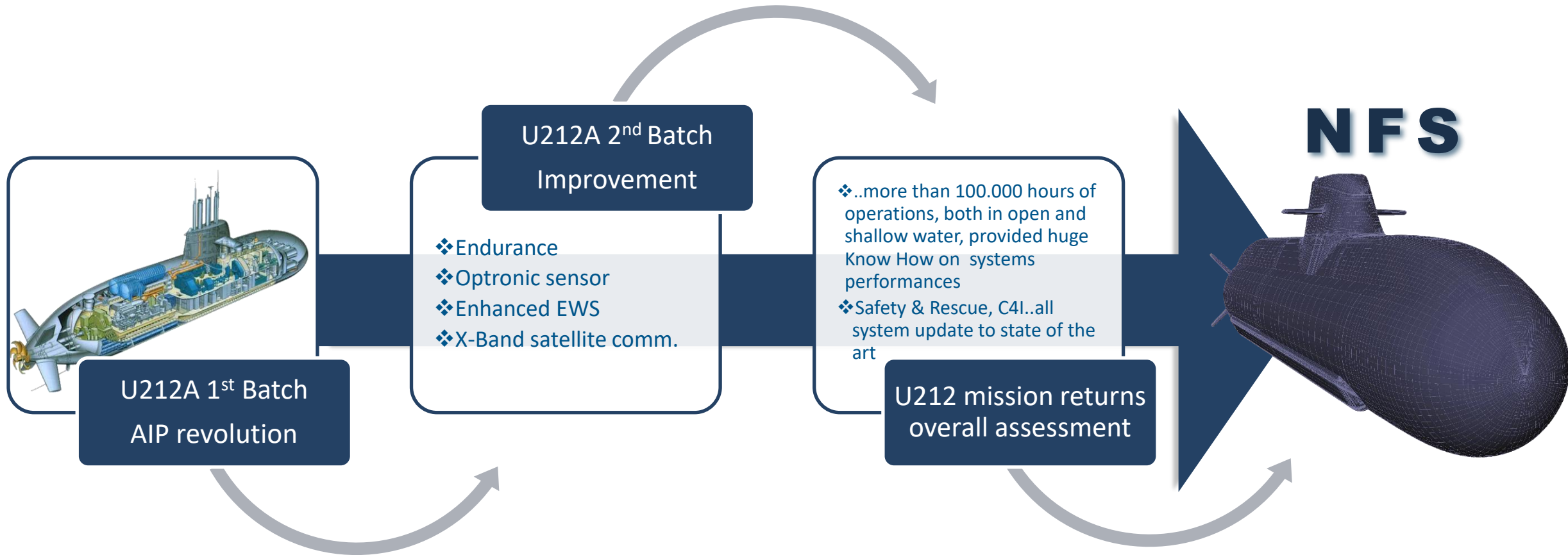
WHY NFS

...to maintain the consistency and update of the Italian Navy submarine fleet, in order to ensure adequate underwater domain surveillance and control capability, taking into account the future complex scenarios of underwater operations



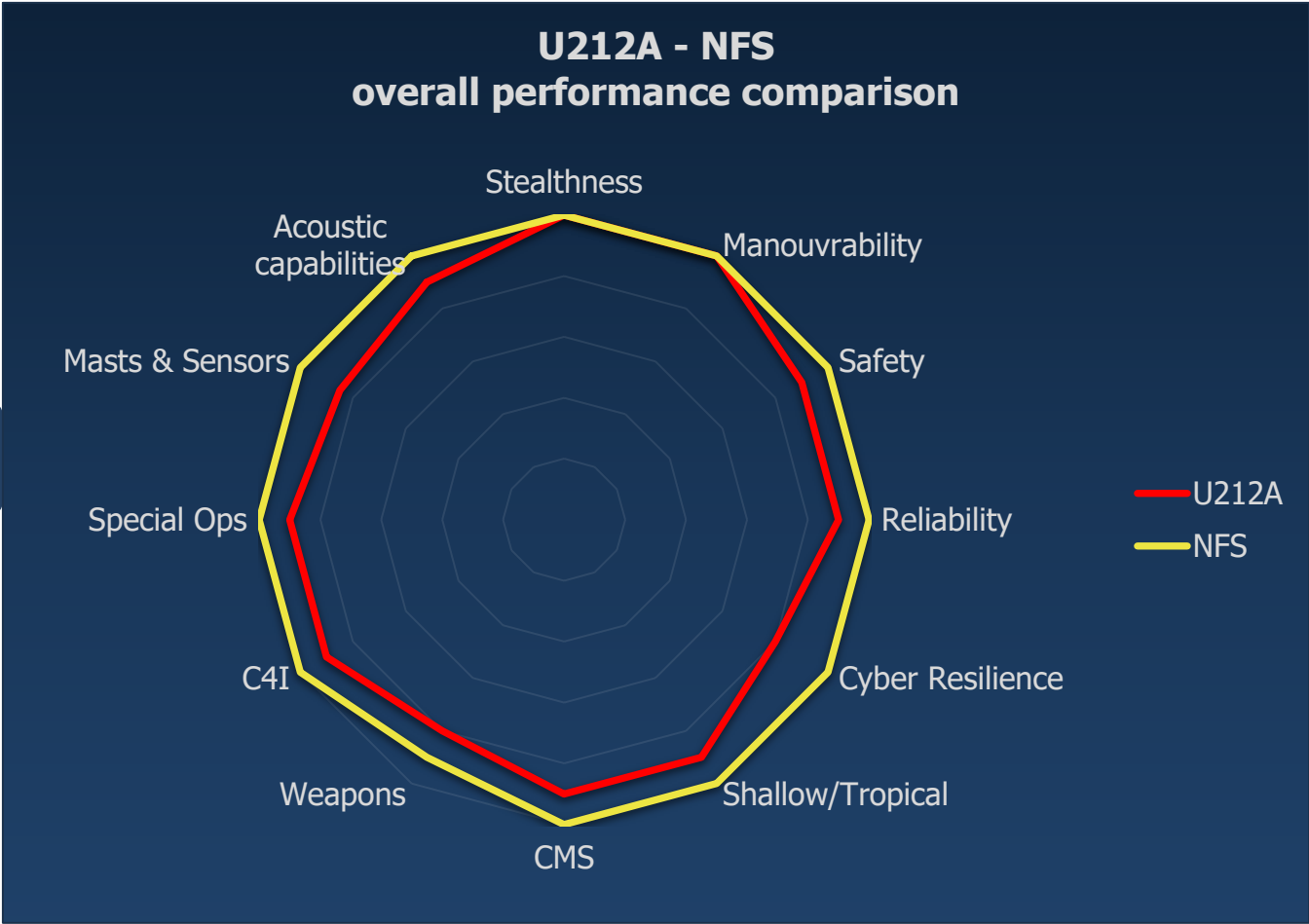
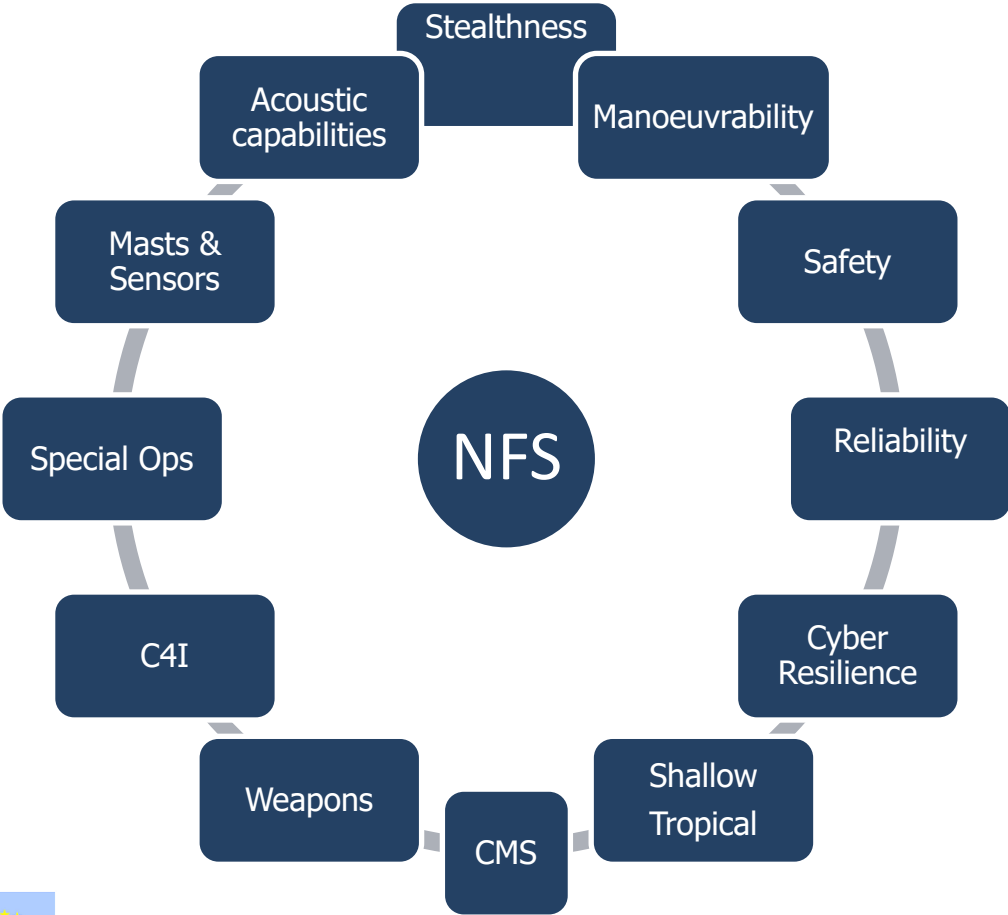
U212 NFS Programme overview

NFS approach: evolution



U212 NFS Technical overview

U212 DESIGN MODELS MAIN FEATURES COMPARISON



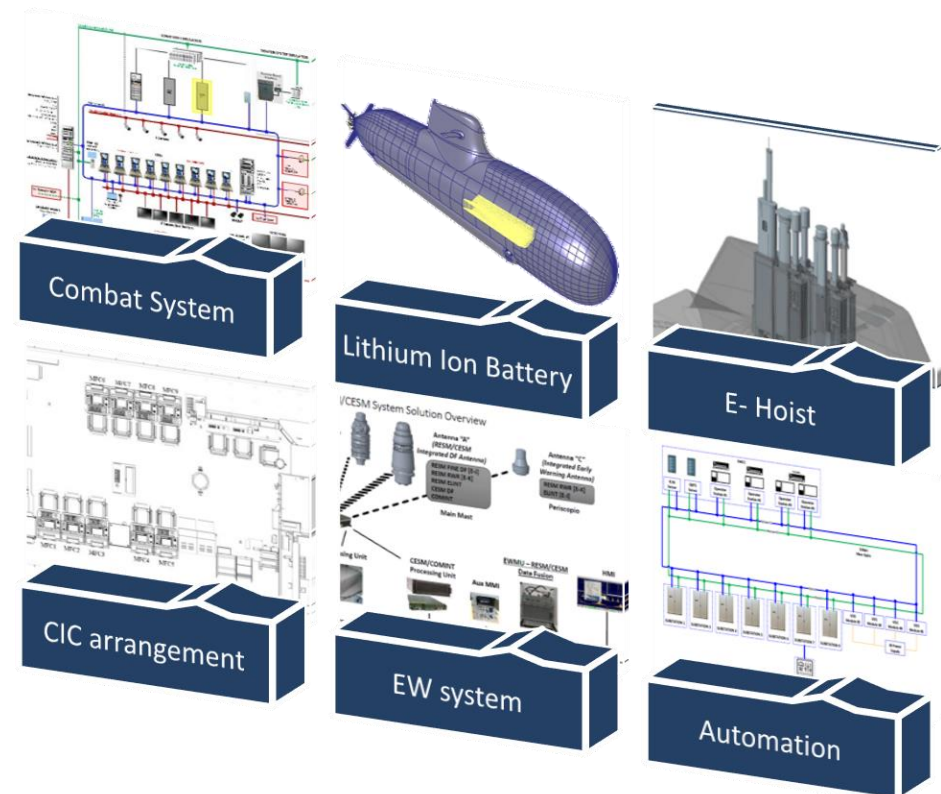
U212 NFS technical overview

ENHANCE OPERATIONAL FLEXIBILITY AND OVERALL STATE OF THE ART CAPABILITIES

Main Features

- ❖ Length overall approx. 59
- ❖ Height above sail approx. 12 m
- ❖ Maximum diameter approx. 7 m
- ❖ Surface Displacement approx. 1600 ton
- ❖ Crew members approx. 29
- ❖ Propulsion Engine Permasyn
- ❖ Propeller 7 blades
- ❖ Diesel Generator 970 kW
- ❖ Battery System Lead Acid/R&D Li-Ion
- ❖ Fuel Cell 8+1 modules

Main Features



Human Factors Design & Analysis



Human Factors Design & Analysis

Increased Underwater Capability - Technological Payload

Remotely Operated Vehicles

Special Force

Autonomous Underwater Vehicles

Extremely Large
Unmanned Underwater Vehicles

New Power Generation

New Hydrodynamic Shape

New Communication Systems

New Propulsion System

Cyber Defence

New Combat Systems



Human Factors Design & Analysis

Evolution - Increased Underwater Capability - Technological Payload

New Capability

- Remotely Operated Vehicles
- Autonomous Underwater Vehicles
- New Power Generation
- New Communication Systems
- New Hydrodynamic Shape
- Special Force Systems
- New Propulsion System

LEAD



Main Features

- Increase density of technological systems
- Saturation living space
- Numerous visual stimulus
- Numerous auditory stimulus
- High man-machine activity
- Microclimate
- Safety

Human Factors Design & Analysis

What is Human Factors ?

Human Factors Engineering is the science related to understanding the properties/work interaction/condition of human capability and their interaction with environmental around

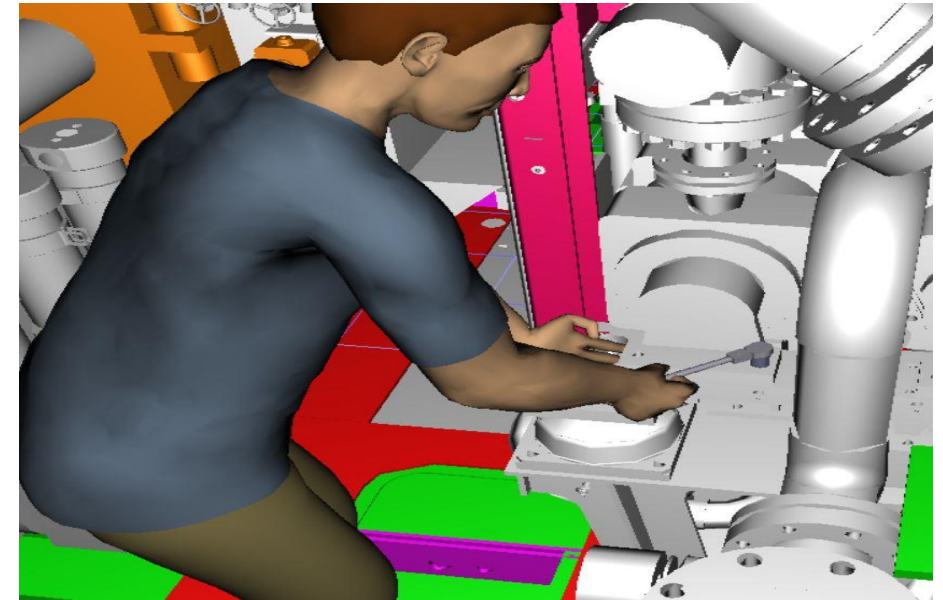
main factors about Human factors engineering and their interaction are:

- engineering design;
- psychology (clinical/experimental);
- environment (especially work);
- system design;
- anthropometry;
- R&D;
- statistical study applied to engineering design;

Human Factors Design & Analysis

Why Human Factors ?

- Increase crew comfort and wellness during the mission
- Improve operators' performance and safety
- Verify usability and the adequacy of the equipment
- Optimize communication and interactions with other crew members in operative rooms.
- Focalize the attention on the user in order to increase comfort onboard
- Propose a set of improvements to the on-board rooms aimed at increasing comfort
- Verify the biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities.



Human Factors Design & Analysis

Main Objectives

Describe/evaluate and manage the main interaction of crew with:

- Systems
- Equipment
- Facility
- Procedures
- Managements system
- Environment
- and each other



Human Factors Design & Analysis

Main Related Documentation

MIL-DTL-16377H Lighting: Shipboard Use;
MIL-STD-882E System Safety
MIL-HDBK-759C Human Engineering Design Guideline
MIL-STD-46855A HFE Requirements for Military Systems
MIL-STD-1474E Design Criteria Noise Limits
MIL-STD-1472H Human Engineering
MIL-G-2874 Gloves, Anti-flush, Flame Resistant
MIL-STD-1473C Color and Marking of Army Material
MIL-DTL-7788 Integrally Illuminated Panels
NAVSEA T9640-AC-DSP-010/HAB Shipboard Habitability Design
DOD-HDBK-743A Anthropometry of US Military Personnel
NEHC-TM-OEM-6260.6 Prev & Treat of Heat & Cold Injury
EU Parliament Directive for Safety & Health at Work 2002/44/EC - Vibration



NFS Human Factor overview

Ergonomics and HMI guidelines - Habitability analysis

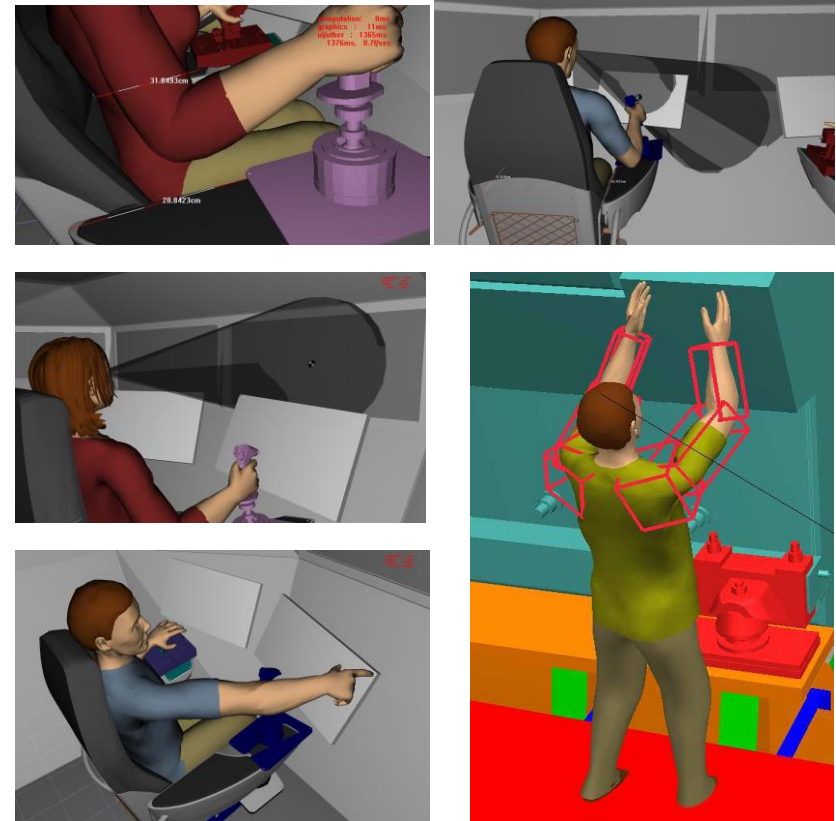
- The **Ergonomics and Human Machine Interfaces (HMI) guidelines** study purpose is to identify guidelines that can support the designer in a functional layout of the spaces, furnishings and equipment on board.
- **Habitability studies** analyzes the environment in which the crew lives and works in order to increase the comfort on board and to improve the design.



NFS Human Factor overview

Reachability and Visibility analysis

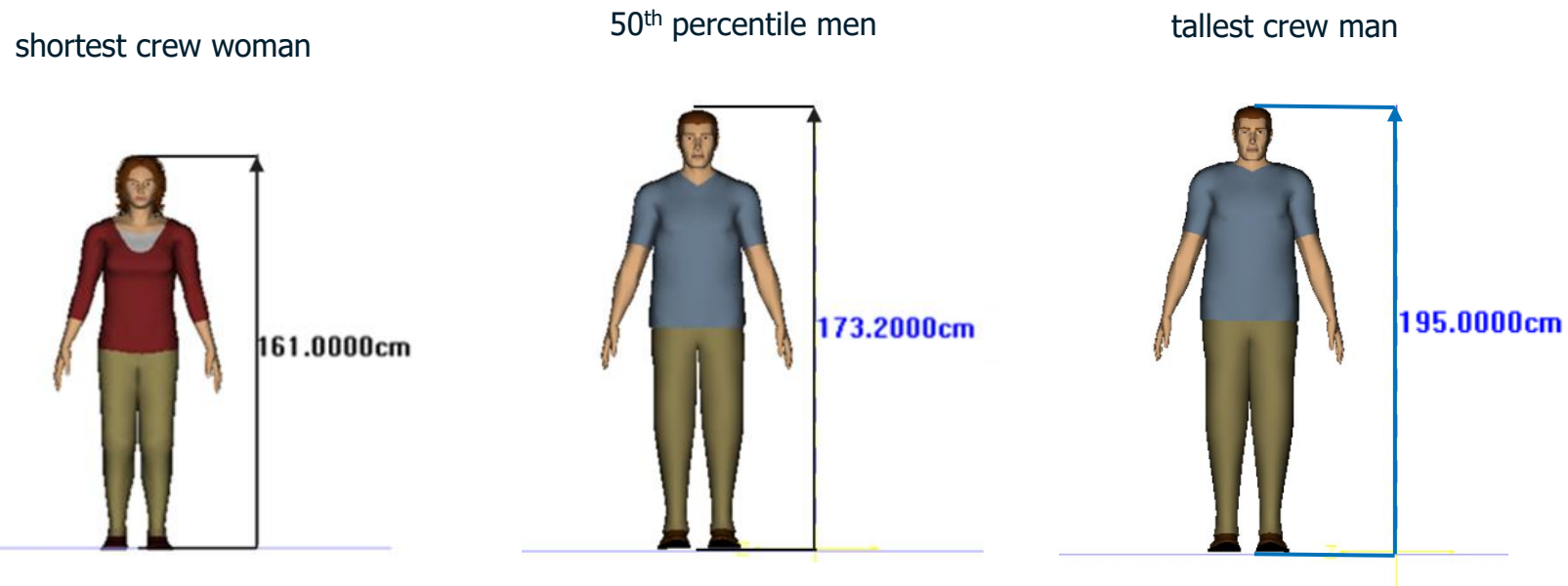
- **Reachability** analysis verify how and if the operator can reach the tools and if their position can create fatigue or incorrect postural position of the operator
- **Visibility** studies have a great relevance when designing consoles and rooms. The fields of view of the operator is important in the definition of optimal values combining eyes and head movement.



NFS Human Factor overview

New Development System - Ergonomics analysis of Console

The measures of the shortest crew woman, the 50th percentile men and the tallest crew man have been considered for the studies.

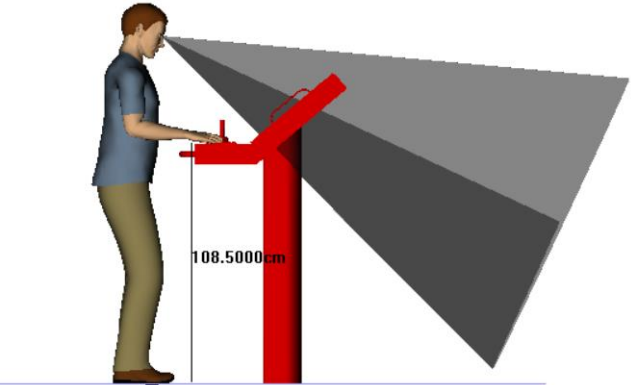


NFS Human Factor overview

New Development System - Commander Console

View Cones

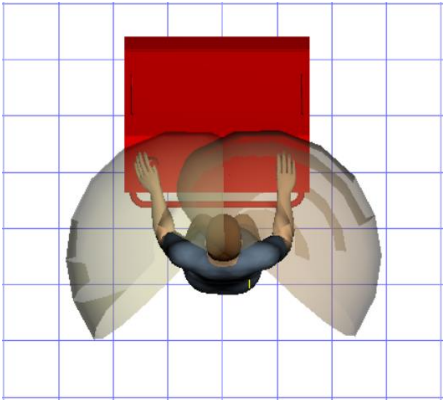
The 50th percentile man has his neck bent 24 degrees



Body Group A Posture Rating		Body Group B Posture Rating	
Upper arm:	1	Neck:	1
Lower arm:	1	Trunk:	1
Wrist:	1		
Wrist Twist:	2	Total:	1
Total:	2		
Muscle Use:	Normal, no extreme use	Muscle Use:	Normal, no extreme use
Force/Load:	< 2 kg intermittent load	Force/Load:	< 2 kg intermittent load
Arms:	Not supported		
Legs and Feet Rating			
Standing, weight even. Room for weight changes.			
Grand Score: 2			
Action: Posture acceptable if not maintained or repeated for long periods.			

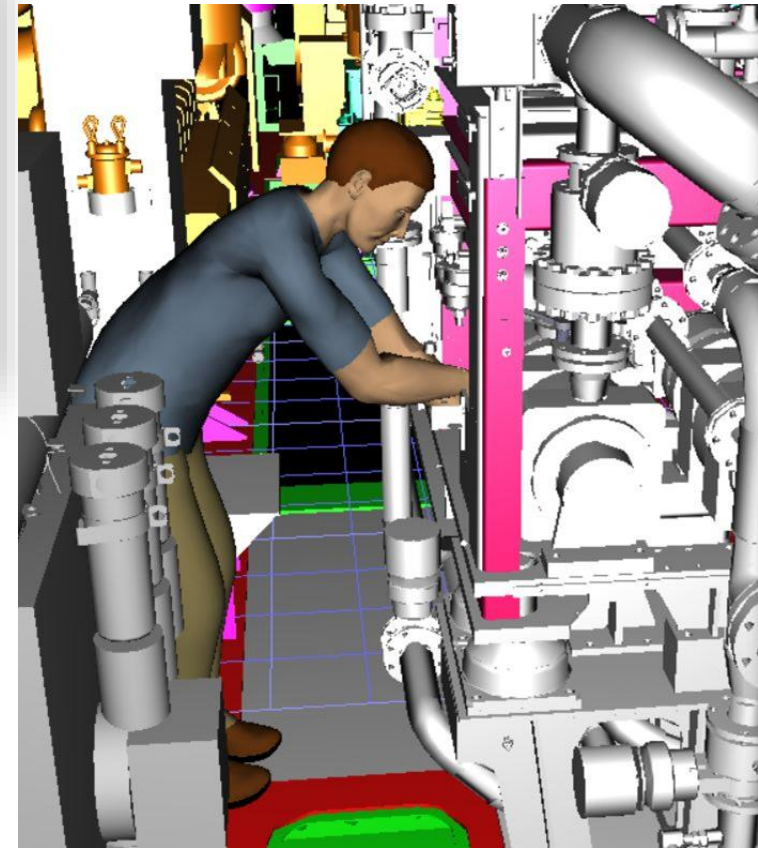
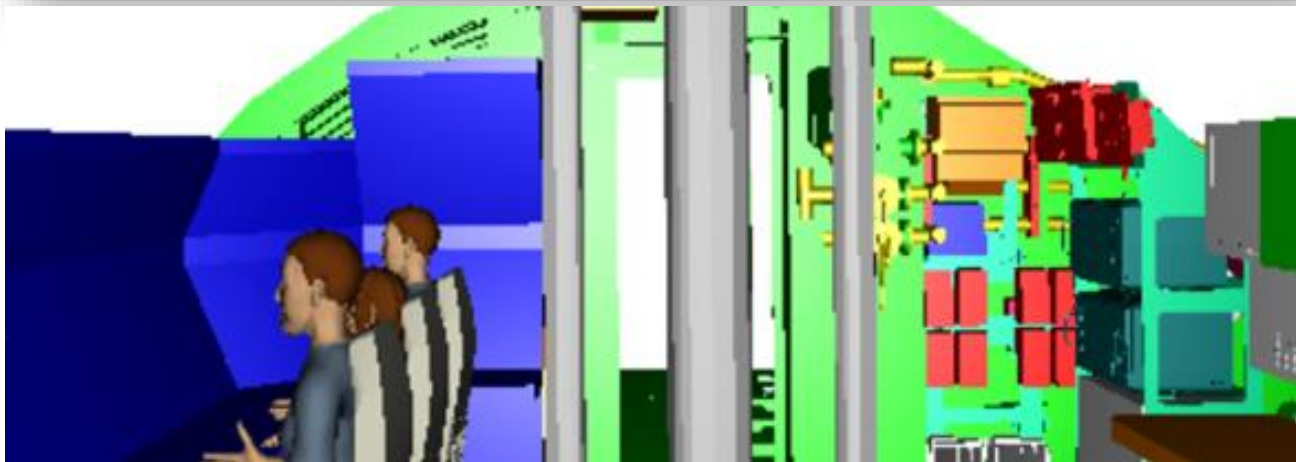
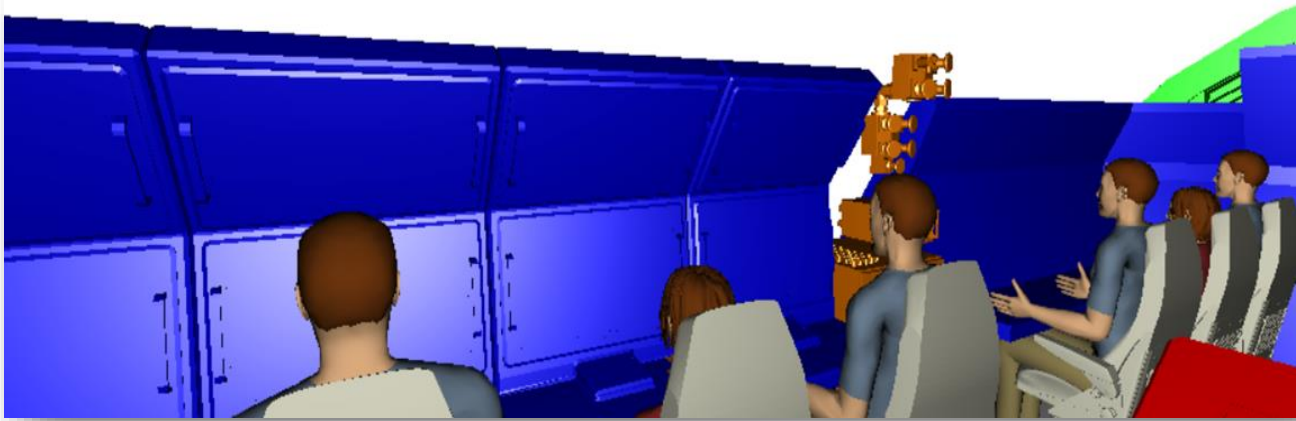
Reach Zones

the 50th percentile men has their elbow joint bent 87 degrees.



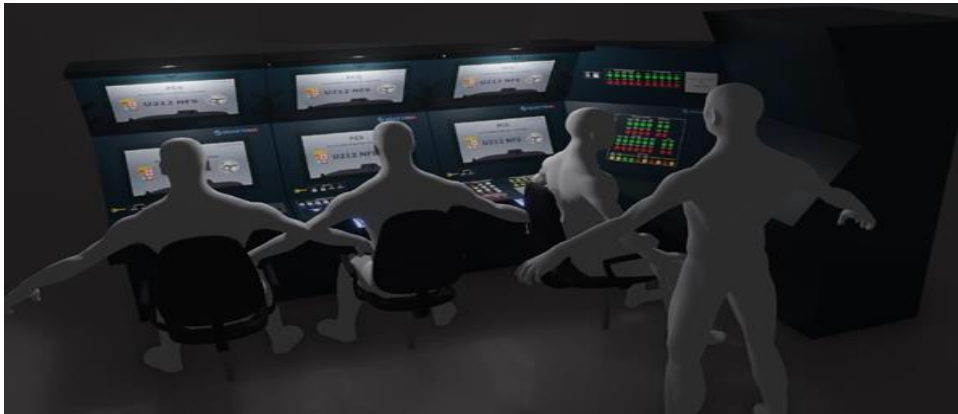
NFS Human Factor overview

New Development System - Ergonomics analysis of Consoles – Maintenance – Living Space



NFS Human Factor overview

New Development System - Ergonomics analysis of Consoles – Maintenance – Living Space



Human Factor Analysis

New Procedures for systems

Vigilance effect during watch performance (6 hours)

during watch performance the submariner have to conduct systems and detect every anomalies;

assumed that human efficiency is in line with tasks in the first 45 minutes (about) of the watch especially when stay seated at consoles



investigating an active system in order to evaluate eye movement and create different (not repetitive procedure) to regenerate the nervous system activity and reset the time of best performance

NFS Human Factor overview

New Procedures for systems

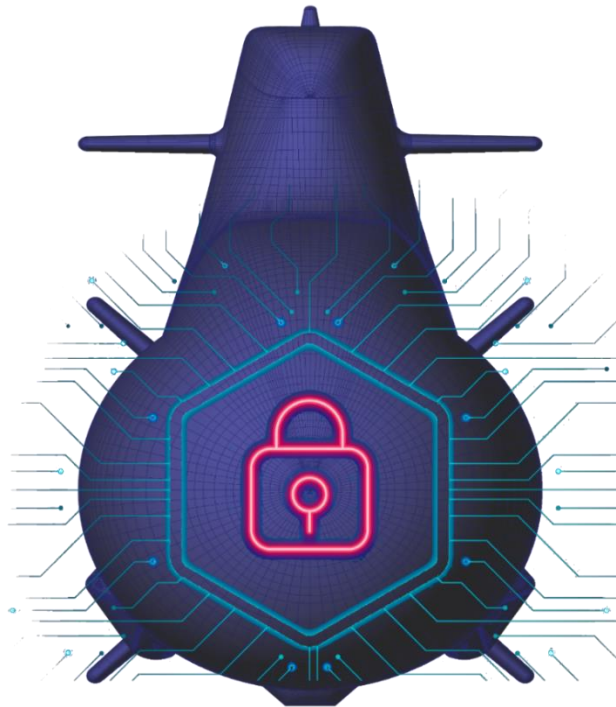
- Power Reverse Manoeuvre
- Former Procedure: need to press several times different buttons
- New Procedure: push one time PR AHEAD



NFS Human Factor overview

New Development System Cybersecure by design approach as part of Human Factor design

IT Navy cybersecurity guideline have been applied for all digital systems in the unclassified domain



- 1 Assess cyber risks during the preliminary design phase
- 2 Evaluate residual cyber risks
- 3 Verify the application of selected cybersecurity requirements
- 4 Assess the cyber resilience via penetration test activities

NFS Human Factor engineering

upcoming needs & technologies

Propulsion & Manouvrability

- Rim-Driven Prop.
- Electric actuators
- Positioning systems

Structures & materials

- Composites
- Nano-Structure
- SMART Materials

Energy

- New Battery Sys
- Storage Sys.
- New FC
- Micro Genset
- Underwater grids

AI & Computing

- Quantum computing
- Machine learning

Modularity

- Modular sensor set
- Modular payload management
- UW Interfaces

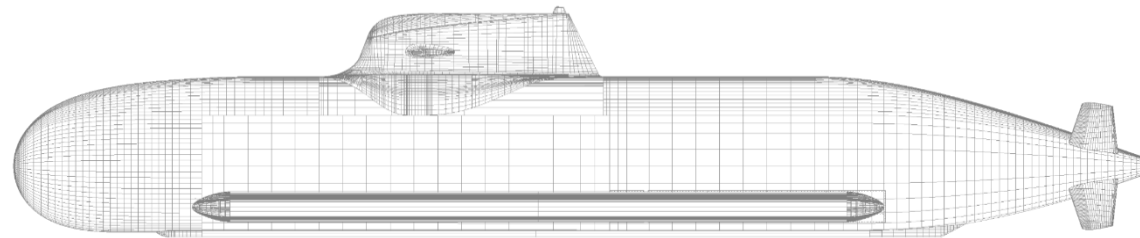
Unmanned & UW Comms

- UUV
- UAV
- UW infrastructures
- SF support systems

Target Strenght

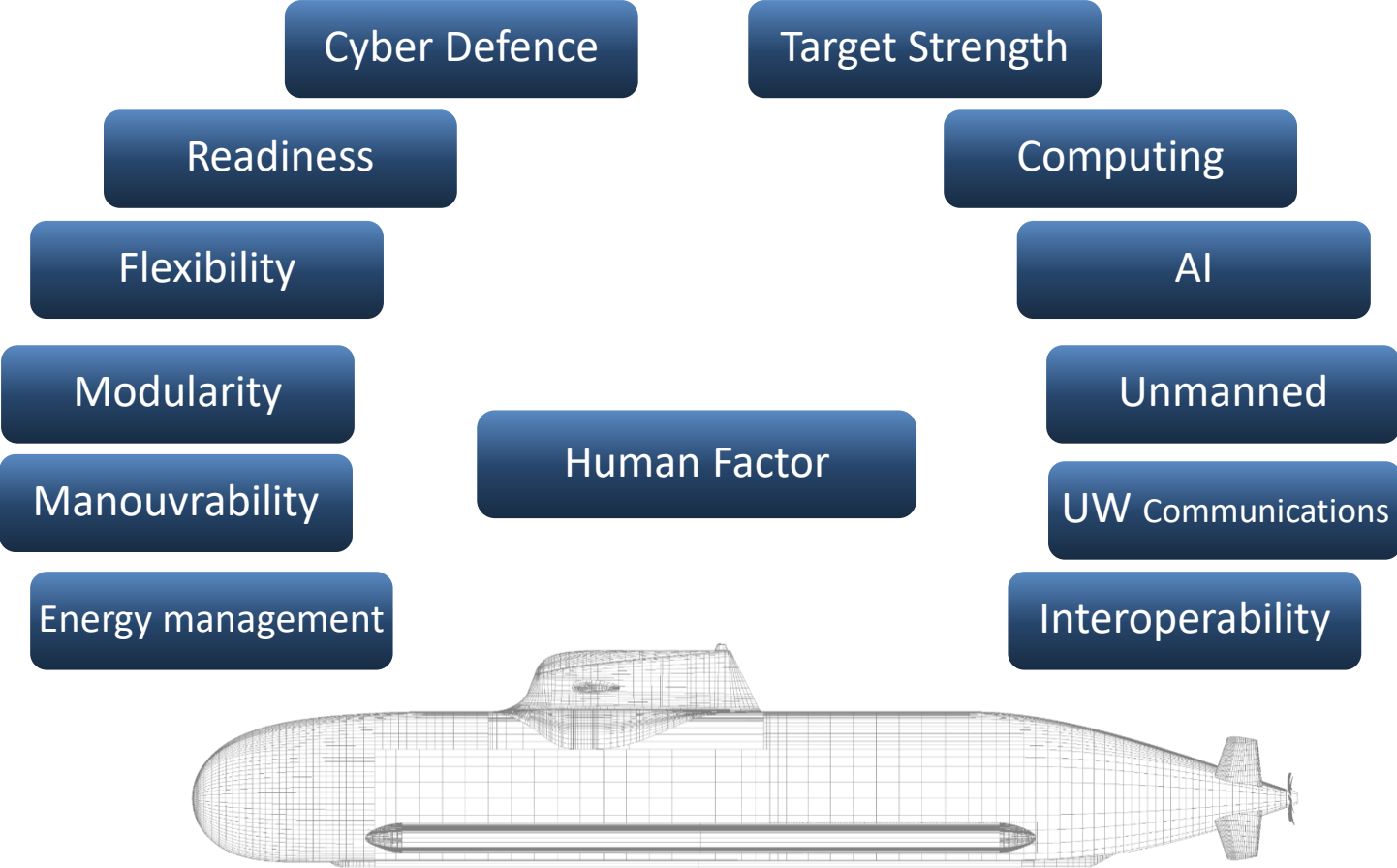
- Hull design
- Smart Metamaterials
- Energy control

worldwide investments in those transversal R&D field can substantially impact Submarine technologies and Human machine interaction



NFS Human Factor engineering

upcoming needs & technologies



NFS Human Factor overview

upcoming needs & technologies

Biodynamic lighting

The use of **Biodynamic lighting**, in environments without natural lighting, would make possible to modify the light characteristics during the day/night hours in order to not alter the circadian rhythm and to improve the comfort and well-being on board.

Benefits of biodynamic lighting on Submarine:

Circadian Rhythm Regulation

It regulates the sleep-wake cycle and various biological functions.

Enhanced Mood and Well-being

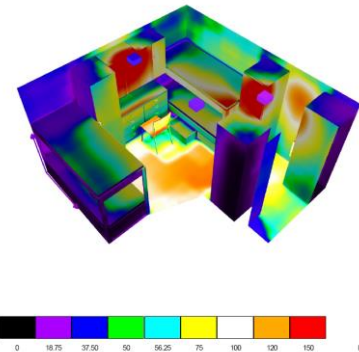
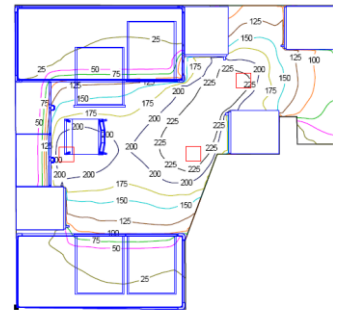
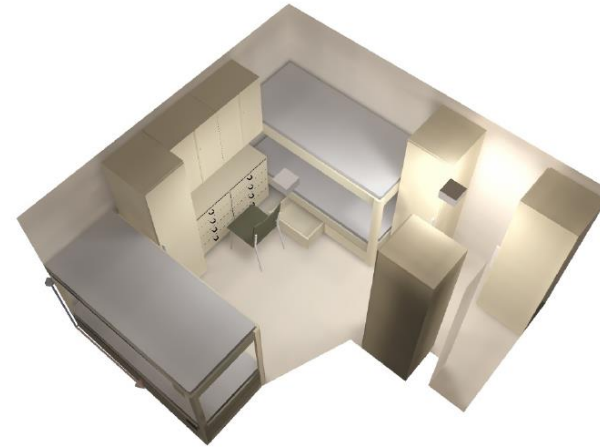
It positively impact mood and overall well-being, leading to increase alertness, reduced stress and improved comfort.

Increased Productivity and Performance

Optimal lighting conditions provide enhance concentration, focus, and productivity.

Support for Visual Comfort

It adjust lighting parameters to provide optimal visual comfort and reducing eye fatigue.



NFS Human Factor engineering

upcoming needs & technologies

Augmented Reality

Innovative tool that supports the operational activities by making the technical assistance and training and easier and faster

- Increase the workforce
 - Efficiency
 - Productivity
 - Safety
- Reduce Human Errors
- Reduce Costs



NFS Human Factor engineering

upcoming needs & technologies

Helmet

- AR and MR supports
- 3D laser scanner
- Hand Tracking
- Eye Tracking
- Safety compliance
- Bone conduction audio

Wearable Application

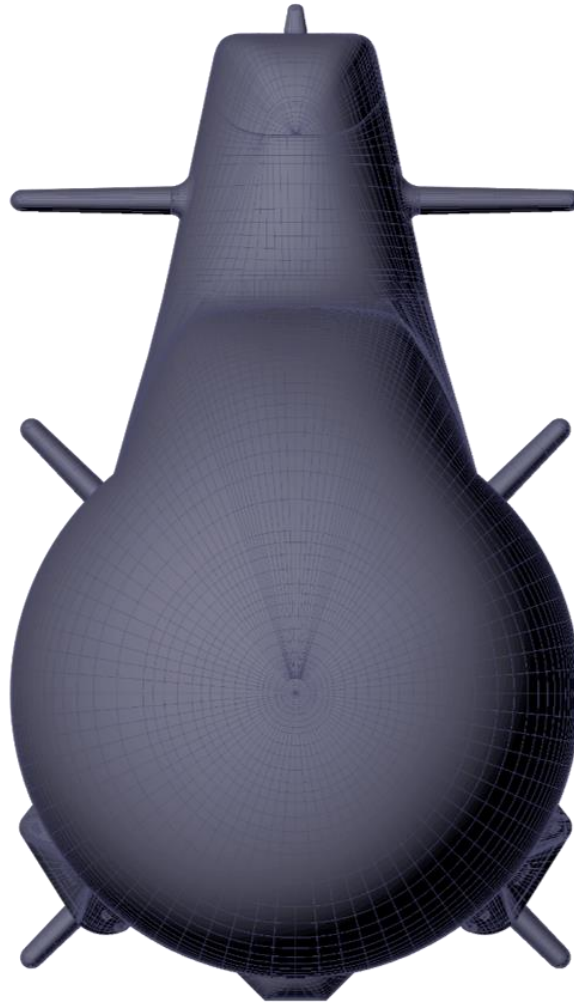
- Ordinary and extra ordinary maintenance management

Desktop App

- Operators' management
- Helmets management
- Contents management



Thank You



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