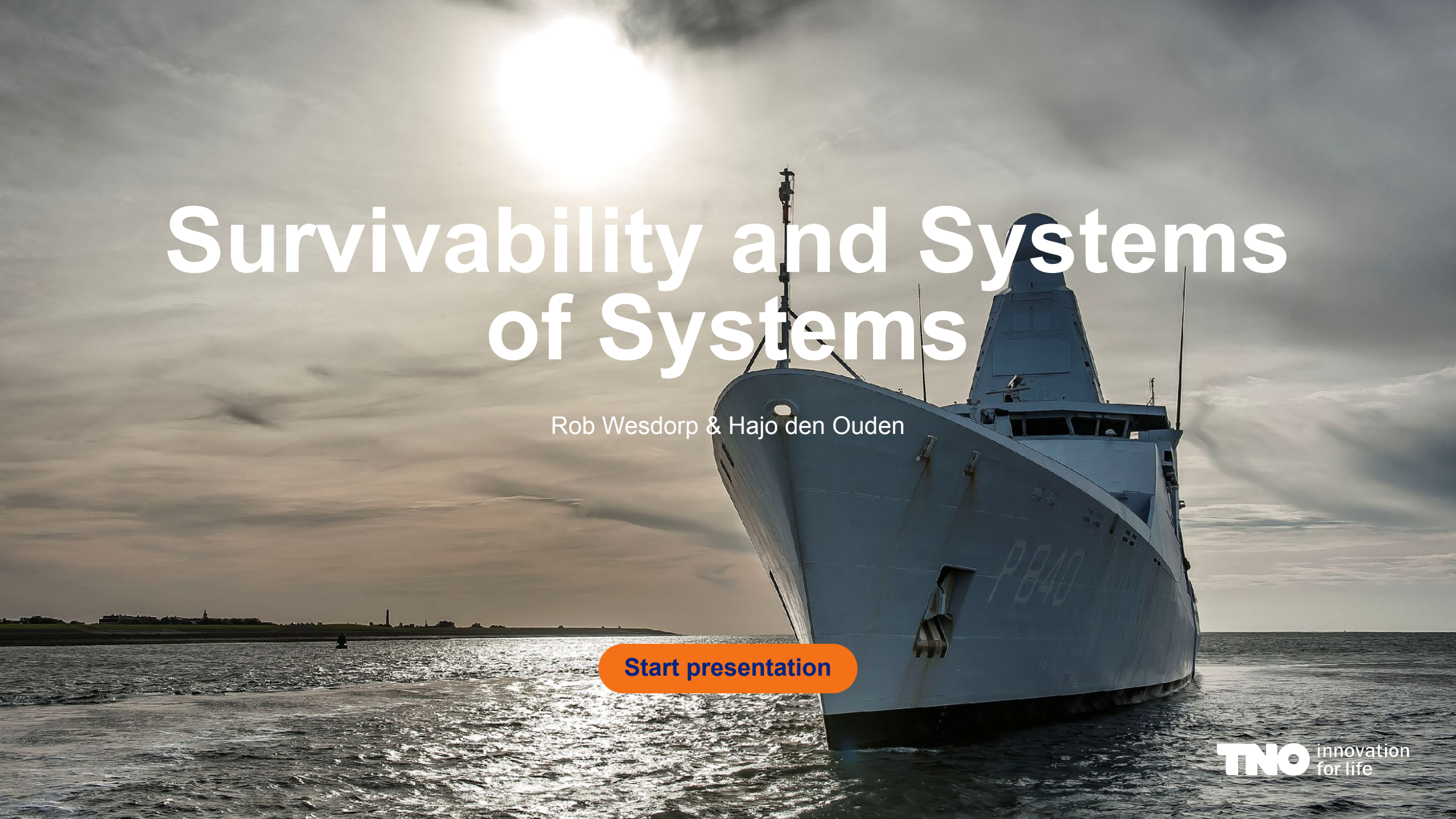


Survivability and Systems of Systems

Rob Wesdorp & Hajo den Ouden

Start presentation

TNO innovation for life

Survivability and Systems of Systems

Navy Tech 2025

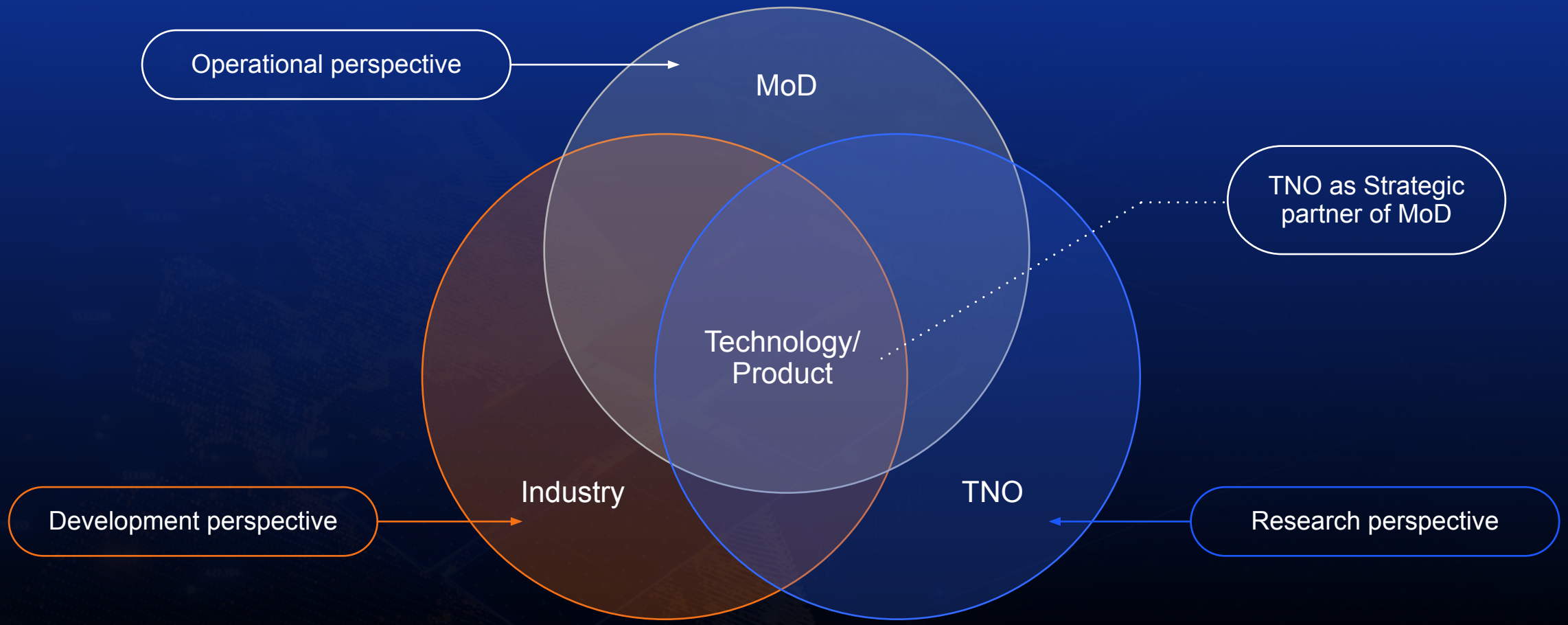
Rob Wesdorp & Hajo den Ouden

TNO innovation for life

Agenda

1. Intro to TNO
2. Challenges for future combatants
3. Integral design and Survivability
4. MBSE and First Time Right

Triple Helix Ecosystem



Units

Defence

Naval and Offshore Structures

Maritime & Offshore

Mission Navy Tech

DSS Divisions

Human & Organisational Effectiveness

- Resilience & Security
- Strategic defence & security analysis
- Human behaviour & collaboration
- Human performance
- Learning & workforce development

Electromagnetics & Military Operations

- Electronic warfare
- Electromagnetic signatures & propagation
- Radar technology
- Compact radar systems
- Surface & aerospace warfare
- Modelling of tactical ops

Acoustics & Underwater Warfare

- Acoustic signatures & noise control
- Underwater operations & seabed security
- Acoustic sensor & sonar systems
- Instrument manufacturing Waalsdorp

Autonomous Systems & Decision Support

- Autonomous systems & robotics
- Intelligent imaging
- Human machine teaming
- Mission simulation & training
- Intelligence & decision support

Protection, Munitions & Weapons

- Energetic materials
- Platform protection & advanced materials
- Personal protection & explosives safety
- CBRN protection
- Instrument manufacturing Ypenburg

Overview of facilities

- Human Factors Research Center
- Protection, Munitions & Weapons Research Center
- Electromagnetics Research Center
- Acoustics Research Center
- DSS AI Research Center
- Interactive Autonomy & Robotics Research Center
- Mission simulation Research Center

Ballistics Test & Research Facility

PPES Large calibre bunker
PPES Small calibre bunker (three units)
PPAM Mobile Measurement Facility
PPES Multifunctional Vehicle Test Hall
ESP High Energy Laser

Additive Manufacturing Research Facility

EBP 3D/ additive manufacturing facility

CBRN Research Facility

CBRN Aerosol Test Chamber
CBRN Ambient Breeze Tunnel
CBRN Analysis Tools
CBRN BioSafety Labs
CBRN High Tox lab
CBRN Radiological Labs

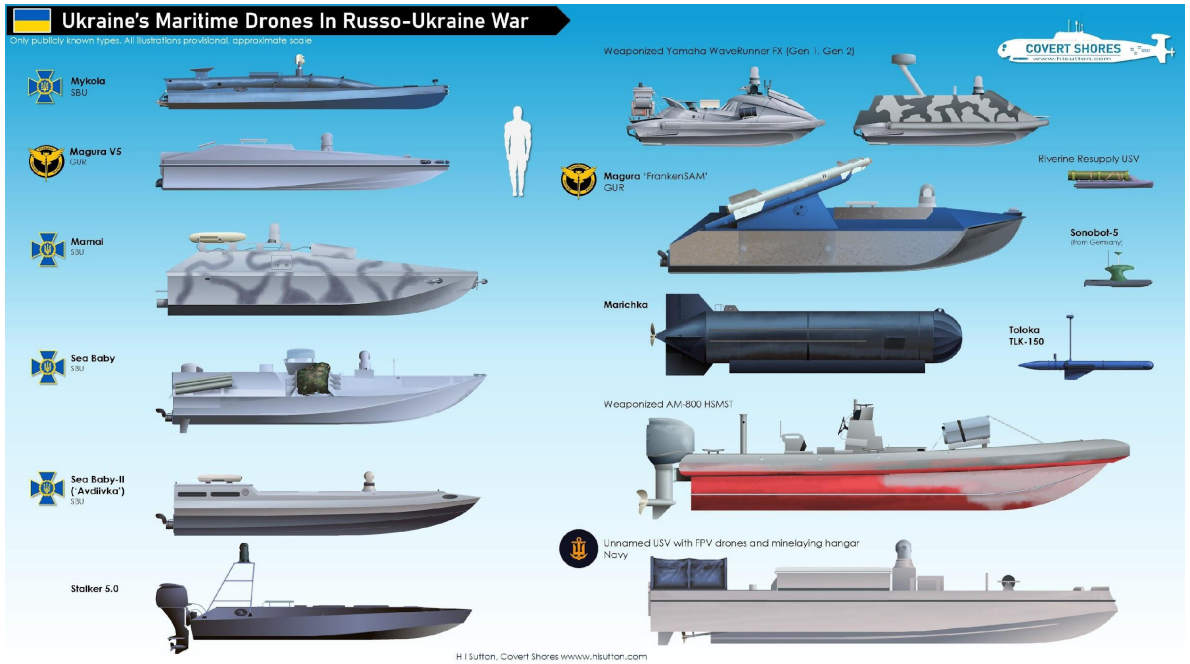
EM Synthesis, Processing and Production Research Facility

EM Pyrotechnics tunnel
EM Bunkers Production of Energetic Materials
EM Laboratory Production of Energetic Materials

EM Characterisation & Testing Research Facility

EM Chemical Laboratory
EM Thermal Laboratory
EM Processing facilities for energetic materials EM Mechanical test facility
EM Explosives storage
EM Materials Research
EM Bunkers Testing Energetic Materials
EM Explosives detection
EM Trace detection
EM Fire test facility
EM Multifunctional test facility
IMY Location Ypenburg

First added challenge for vulnerability: more targeted threats

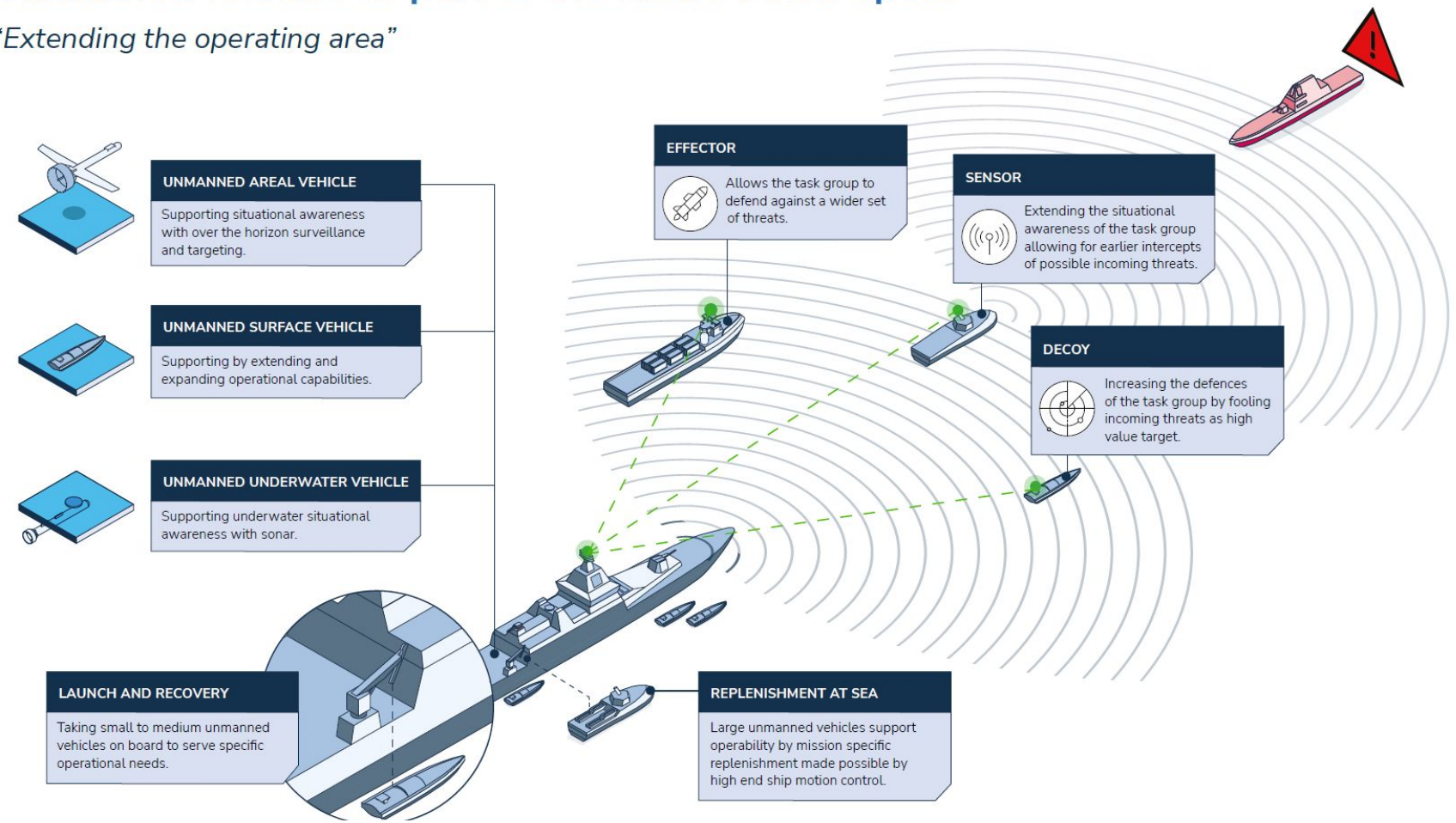


[Russian ship hit in Novorossiysk, Black Sea drone attack, Ukraine sources say (bbc.com)]

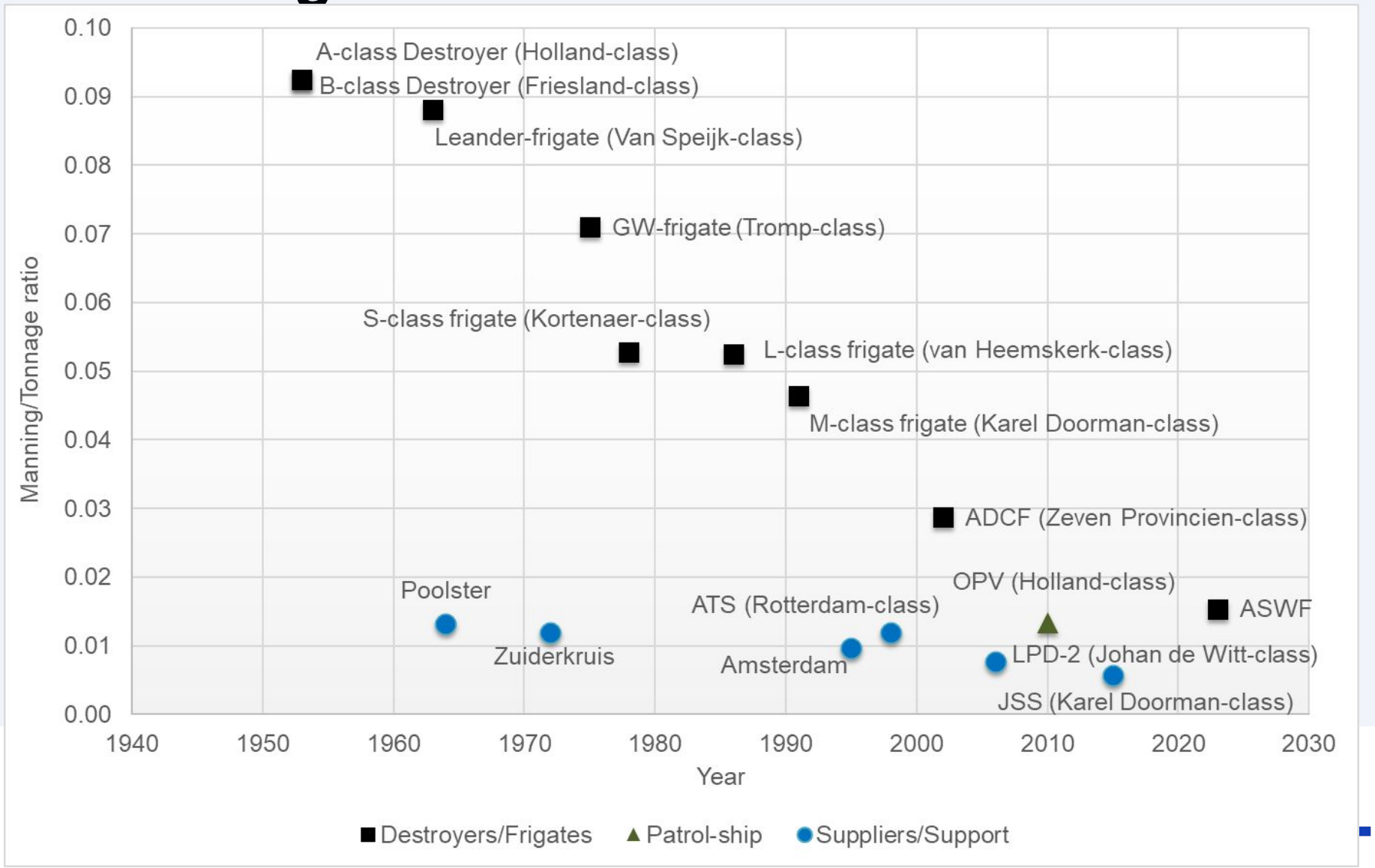
Second vulnerability challenge: going from ship to a small fleet

Unmanned vehicles as part of the future battle space

"Extending the operating area"

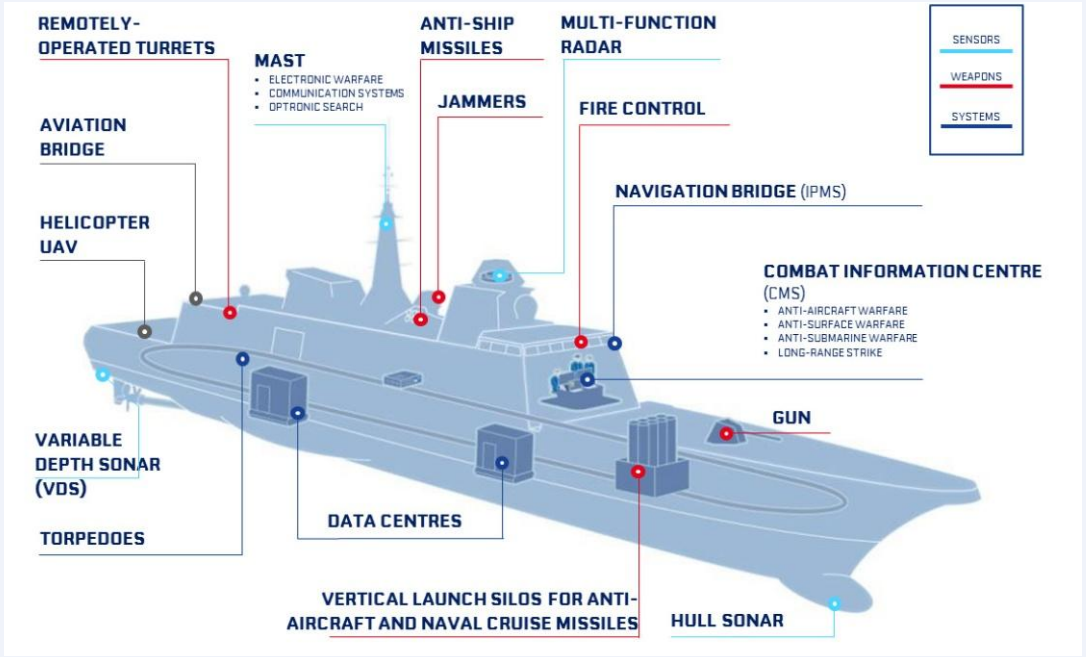


Third Challenge: Crew Size and Modern Vessels



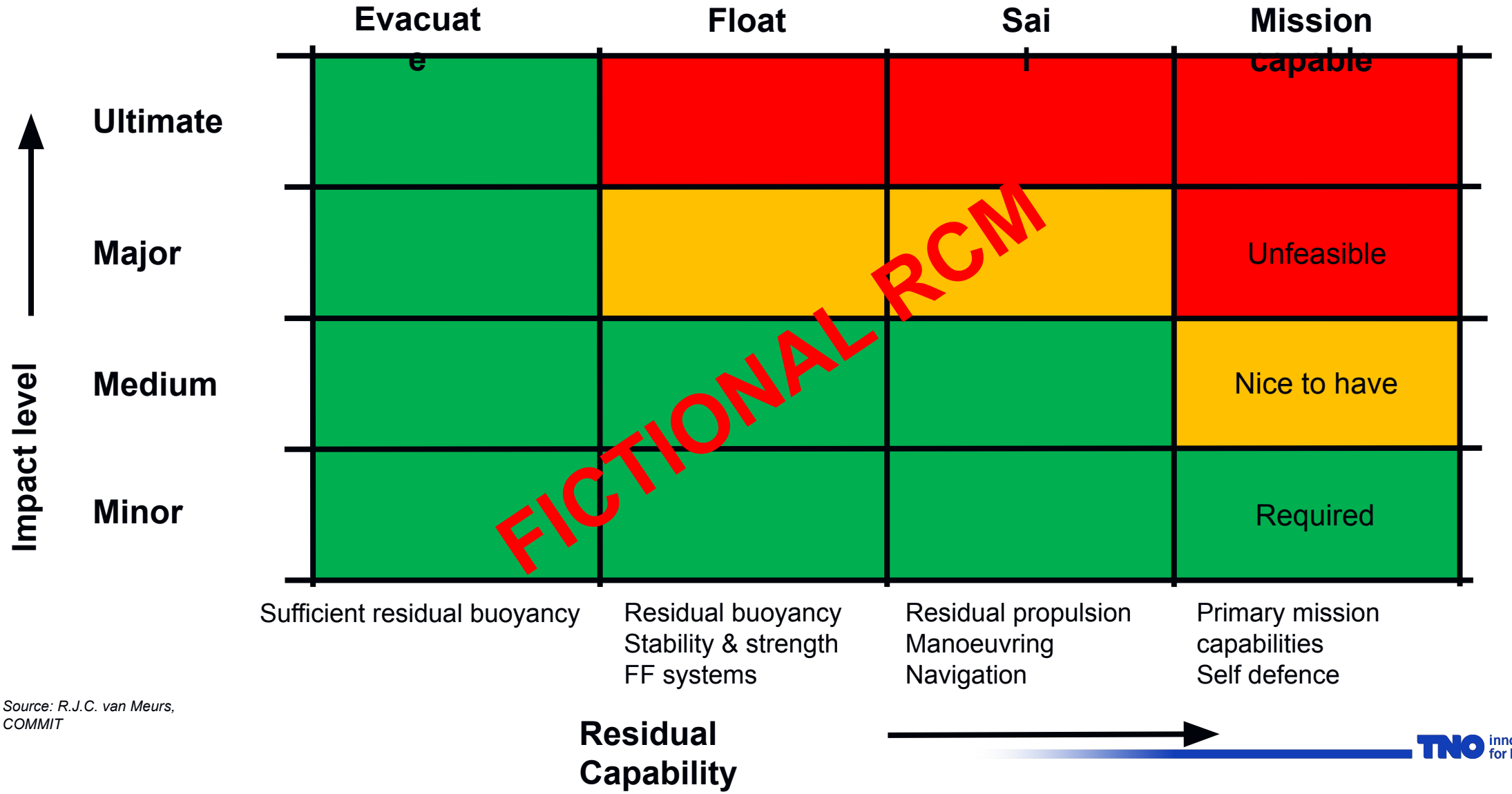
Systems of Systems and Vulnerability

- Vulnerability assessments are only as complete as the systems are represented on board
- To assess the effectiveness of vulnerability measures (with respect to systems) it is therefore important to have a decent representation of a great set of systems
- Therefore, vulnerability and damage control assessments of a ship can only be approached in an integral manner.



A full range of high-performance systems | Naval Group

Requirements Frigate



Source: R.J.C. van Meurs, COMMIT

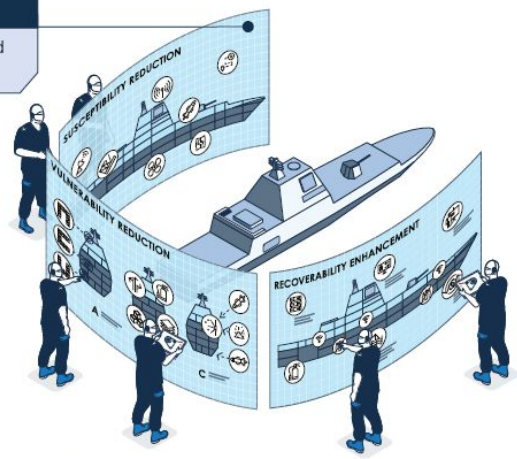
Vulnerability integral within the design

Integral Survivability

"Mission continuity with the most resilient ship and crew"

INTEGRAL SURVIVABILITY IN OPERATION

Including decision support and automated reconfigurability.



A. SUSCEPTIBILITY REDUCTION AND HIT PREDICTION

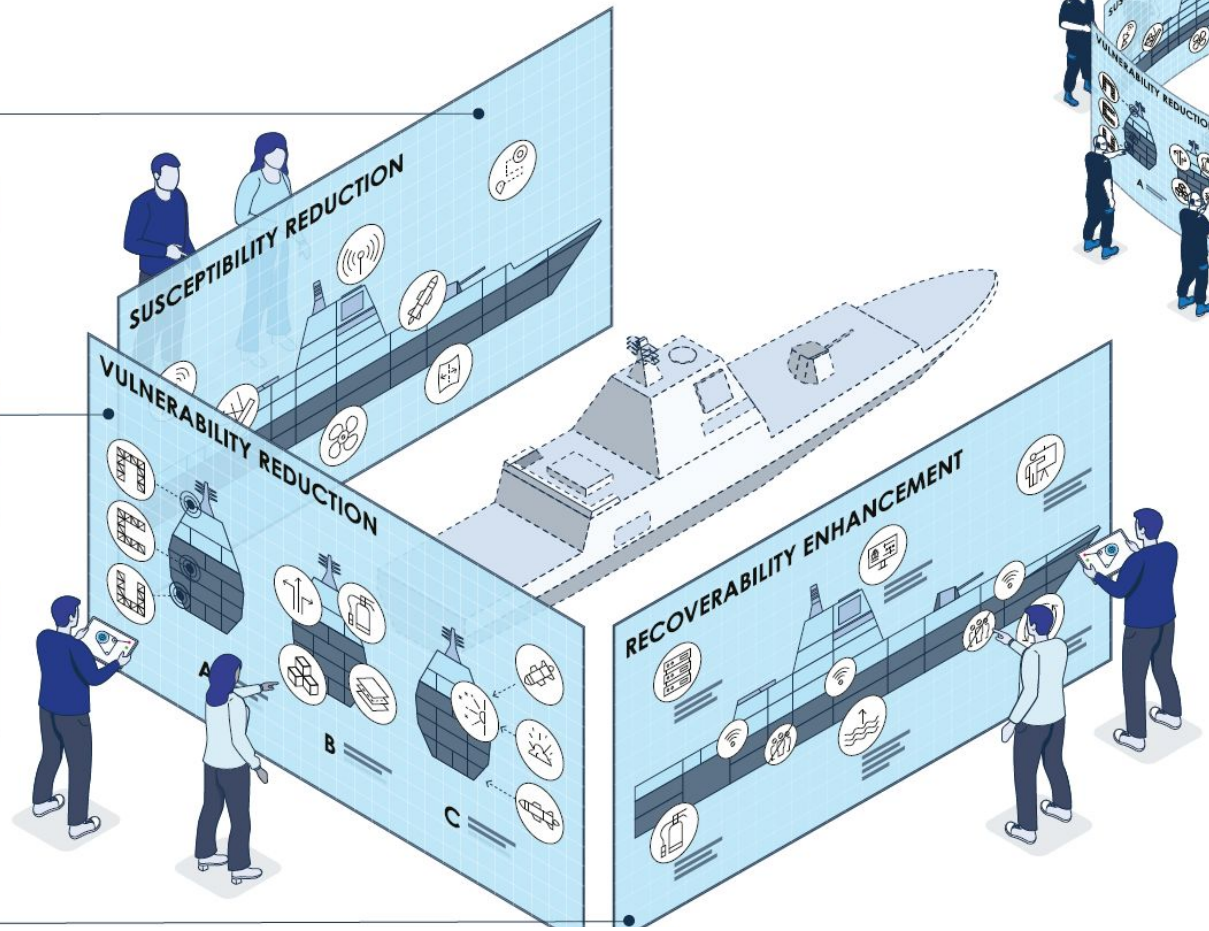
Prevent detection by signature reduction, prevent lock-on by distraction and avoid weapon by seduction.

B. VULNERABILITY REDUCTION

Resist weapon effects through explosion resistant structures, intelligent system lay-out and redundancy.

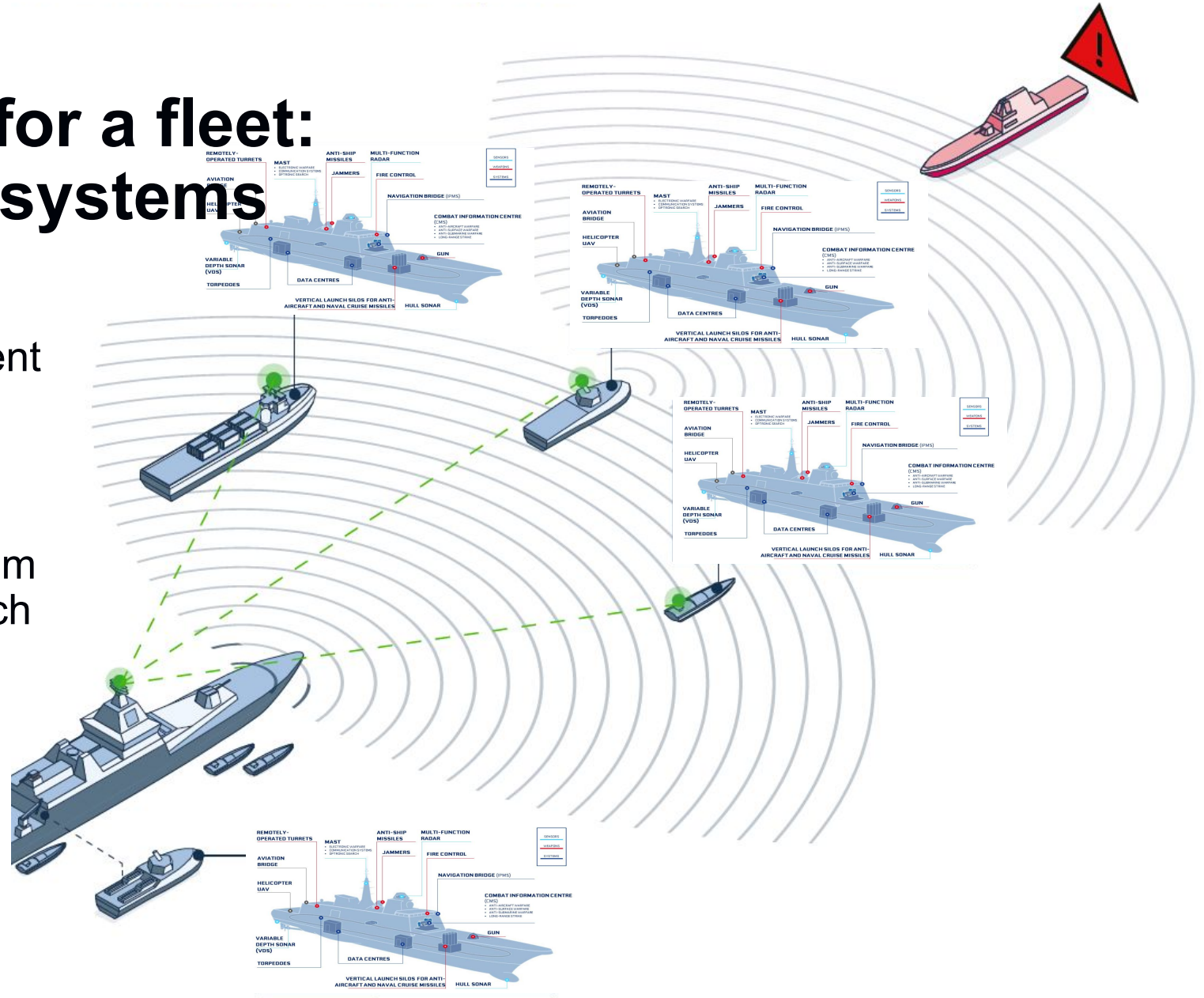
C. RECOVERABILITY ENHANCEMENT

Maximize recoverability of lost systems and functionality of the basis of (automated) damage assessment and command aim.

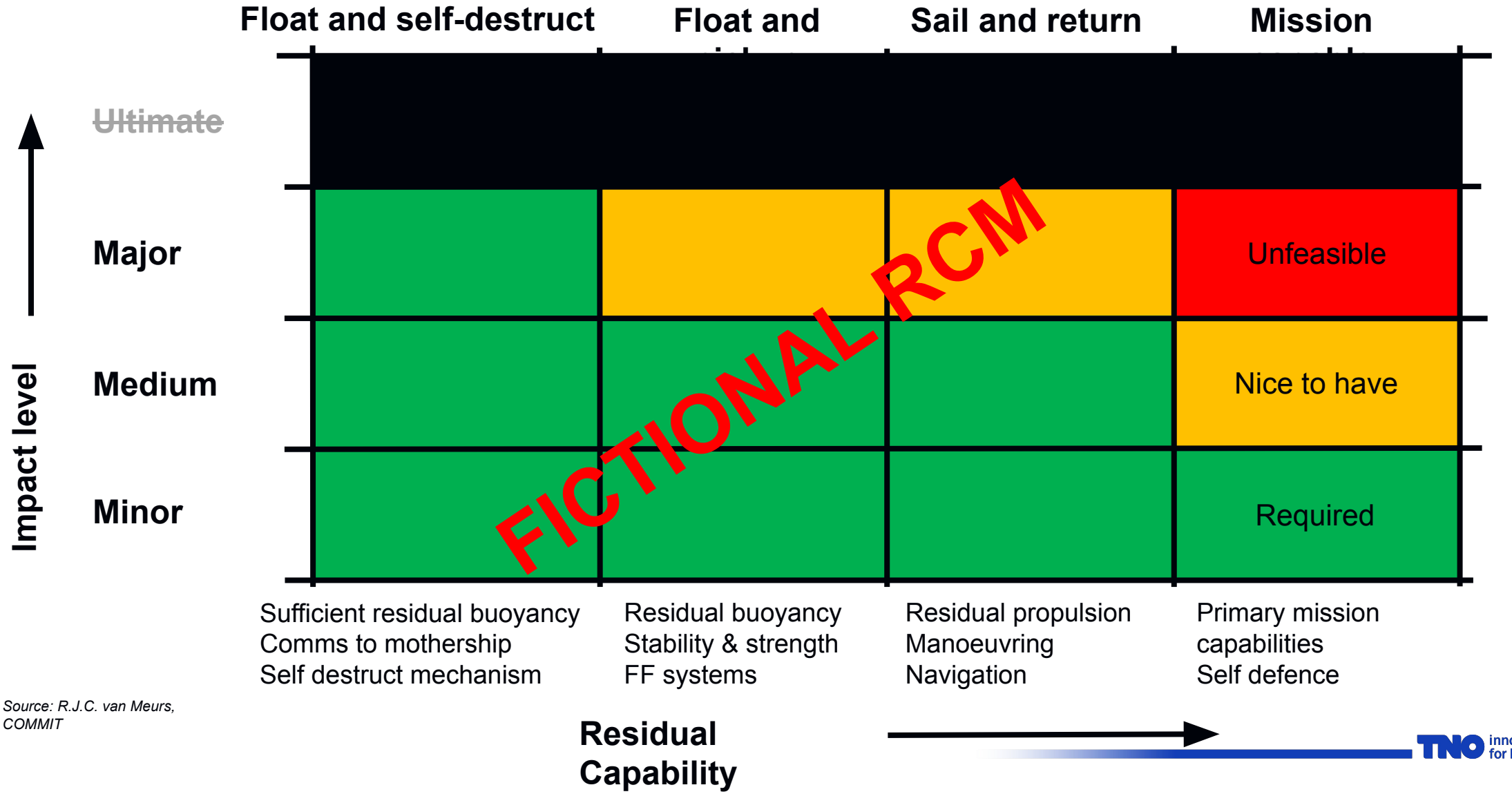


Integral assessment for a fleet: System of system of systems

- While the vulnerability assessment of the a single USV is simple the challenge arises
- However, the problem moves from a single ship to a small fleet which in turn is a system of systems

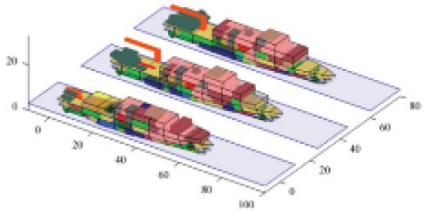


Requirements USV (and potential the full fleet)



Source: R.J.C. van Meurs, COMMIT

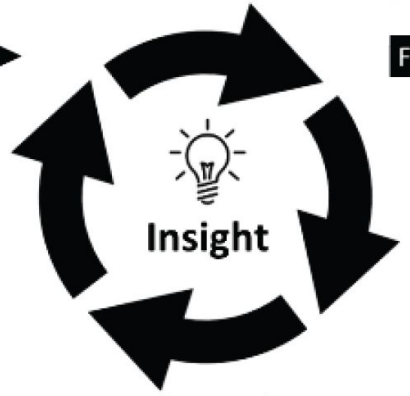
Naval Design Process



1 Generate many alternative concepts
(=platform + SEWACO + crew + CONOPS)

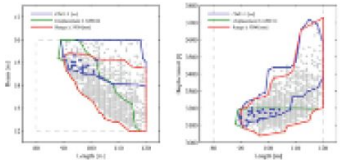
Initial requirements & budget

Final requirements & solutions

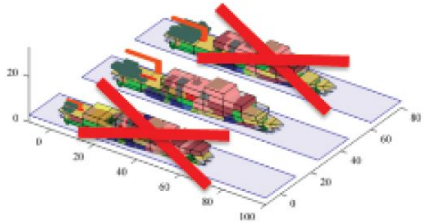


4 Adjust requirements & budget

2 Investigate cost, effectiveness & feasibility

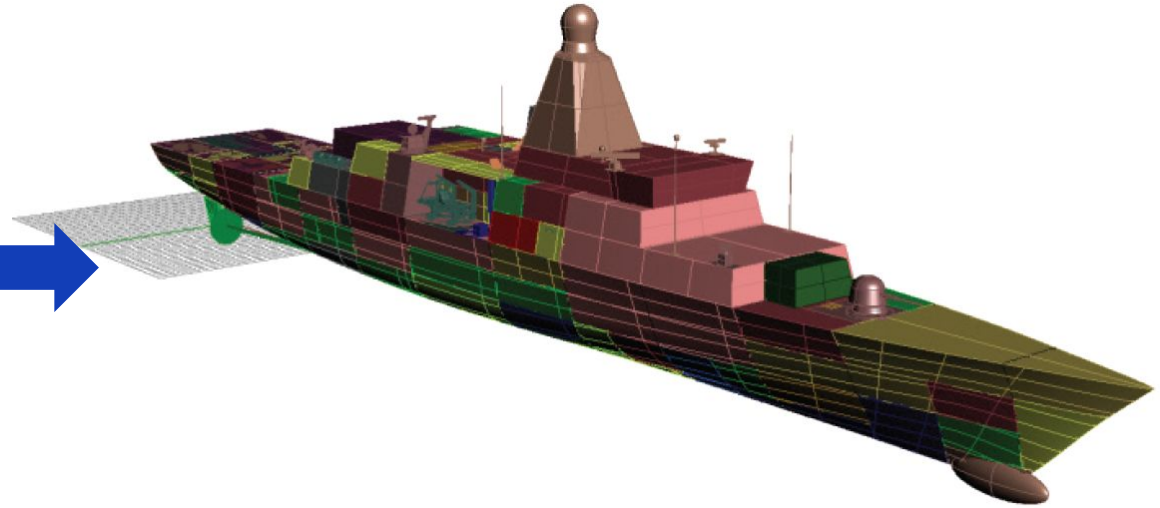


3 Decide & choose



Multiple iterations in which a great amount of concepts are explored and evaluated

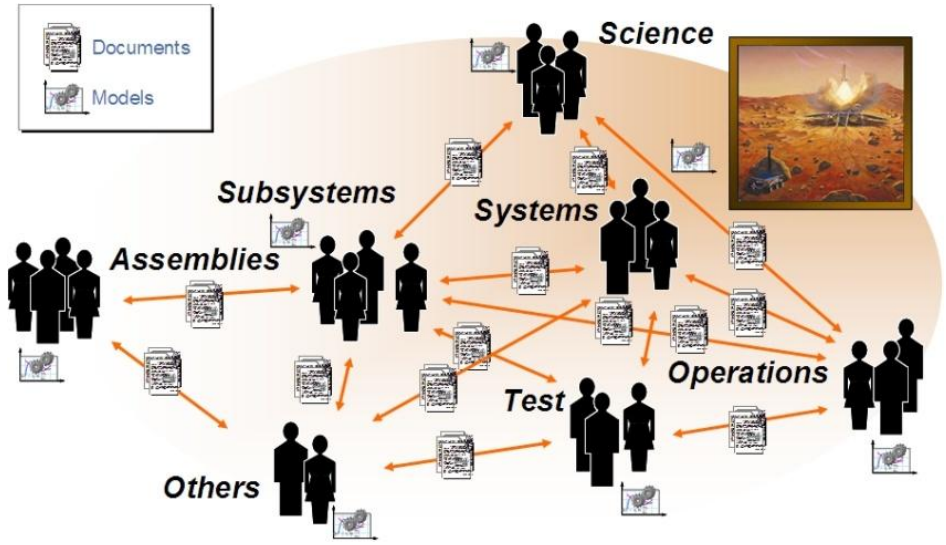
Warship Concept Exploration and Definition at The Netherlands Defence Materiel Organisation – B. van Oers et. al. (2018)



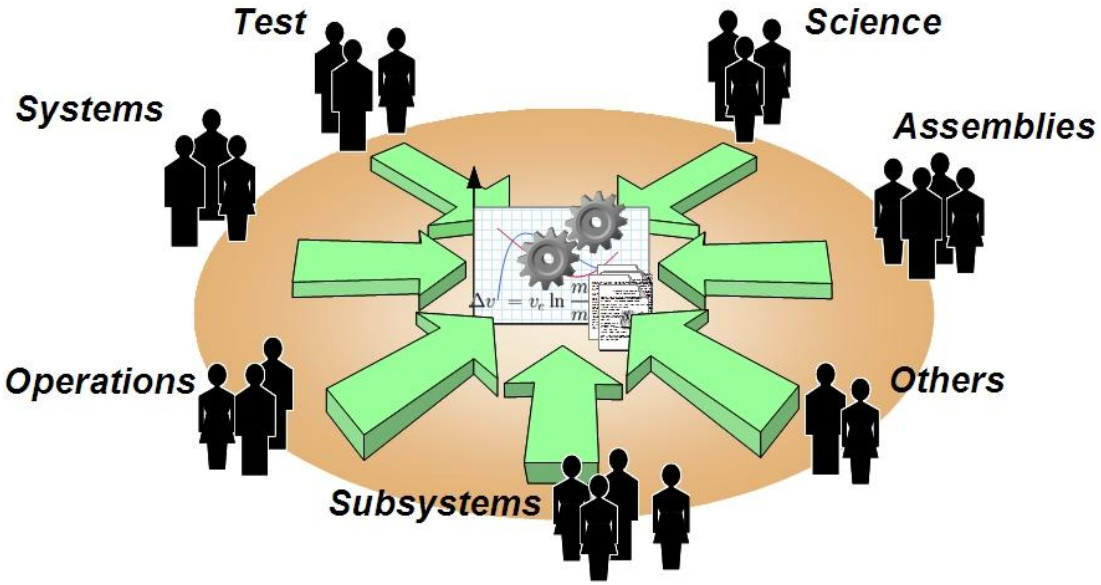
One or multiple concepts in which different design options should be tested in detail

SE VS MBSE

Past: Document Centric

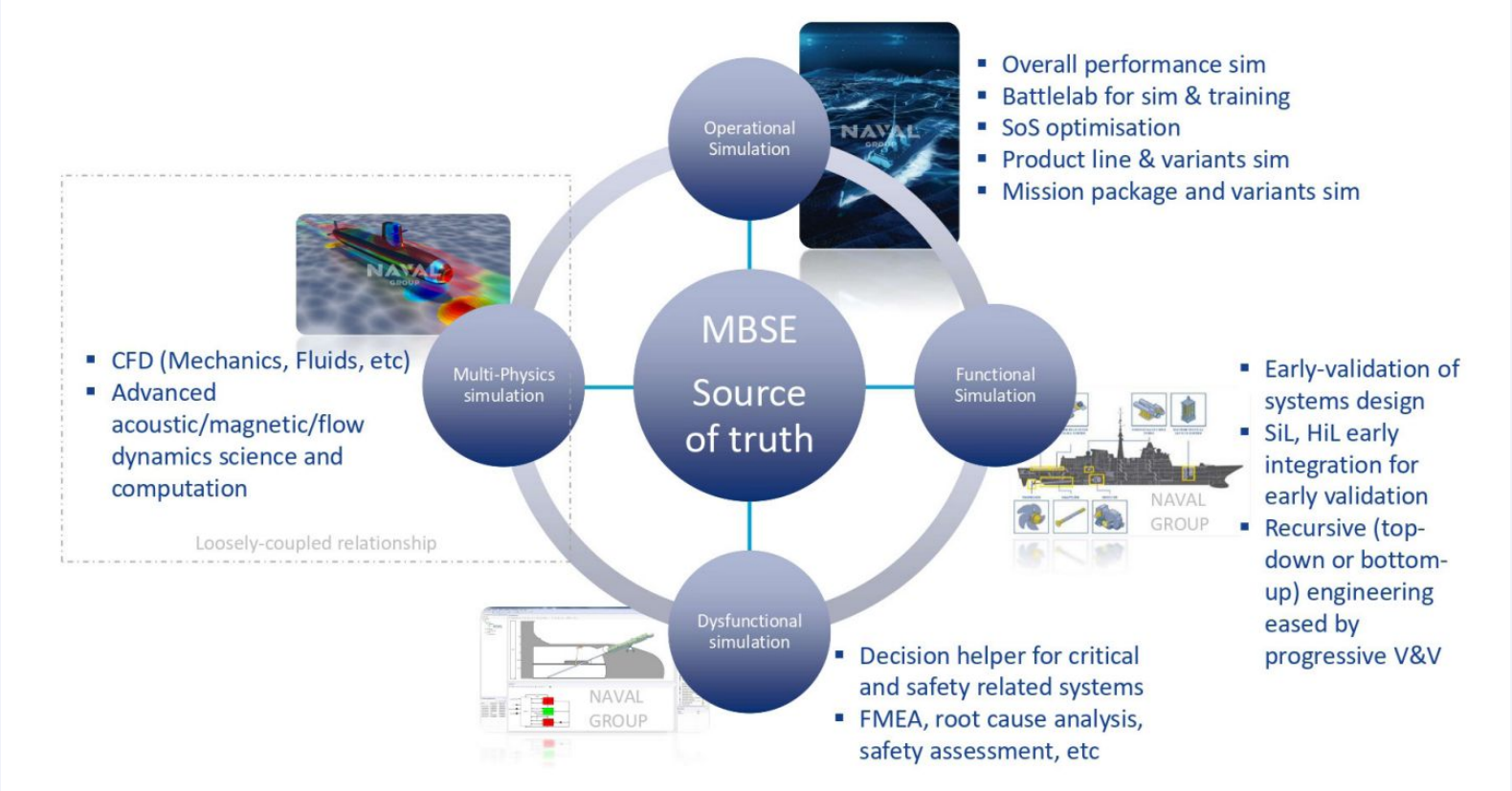


Future: Model Centric



Model-based Systems Engineering (MBSE) 101
Elyse Fosse, Presentation presented on International Workshop 25 Jan -26 Jan 2014, Torrance, CA, USA.

From SE to MBSE



[From Document-Driven to Digital-Native Engineering | Naval Group]

Conclusions

- It is already a challenge to get the ship design right the first time due to the integral nature of ship design
- This in turn with the new complicated threats that arise on the battlefield (multi-hit drones)
- A next layer of complexity is added with the ship design itself, using extra automation and applying USV’s
- Therefore, it is a necessity to move from SE (separate documents determine truth) to MBSE (one model generates the separate documents)