RINA MARITIME INNOVATION COMMITTEE

Theme: Design and Manufacturing

Version: 2

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Design & Manufacturing

This theme covers processes, tools and technologies that may be used in the design and manufacture of marine vehicles and offshore structures, to improve the efficiency of the process or to improve the capability of the end product.

Objectives

- Key objectives related to technology and innovation within design and manufacturing are:
  - Improved efficiency of design and manufacturing processes
  - Through improved design and analysis methods:
    - Improve capability of end product
    - Improve safety / survivability of end product
    - Improve environmental protection through more efficient products, less wastage, reduction in greenhouse gas emissions etc

Technology Priorities - Design

Technologies that we believe will have the most significant impact on the marine industry

Technology	Technology Description
Use of Robotics (influence on ship design)	Robotics may replace human operators or other mechanical systems onboard ships and offshore structures to improve the effectiveness of the ships operations or to remove operators from dull, dangerous or dirty environments.
Unmanned Systems - impact on marine vehicle design	Unmanned systems can be used to remove the human from dull, dirty or dangerous environments and / or reduce operational costs. Marine vehicle and offshore structure design is impacted by unmanned system technologies either such that they can be operated as an unmanned system or to cater for the stowage, launch, recovery and support of unmanned systems on-board (Refer to Autonomy Theme).
Modularity (influence on ship design / operations)	Modularity in ship and offshore structure operations can be used to provide flexibility of a marine vehicles use, allowing re-role of a marine asset or easy upgrade of the modular capability as required without major modification work to the vessels structure or systems. Modularity can potentially result in reduced whole of life cost.

Technology Priorities - Design

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Concept Design Process	This is the exploratory phase which should converge to an outline balanced design solution. The complexity of this process is extremely variable dependent on the coherence of the need and affordability, that complexity may be precise (and quick) or require a complex requirements elucidation process (and be protracted). The latter benefits from an architecturally driven design process such as the Design Building Block Approach. Design trade-offs conducted and initial cost estimates produced for Unit Production Cost (UPC) and through life costs.
Systems Practice (Systems Engineering Approach)	The use of systems theory and practice, which can be very systems engineering based or the adoption of Systems Architecture practice, which is seen to be more appropriate to very complex systems, both for software and large scale physical systems, or systems of systems.
Human Factors Integration / Ergonomics	Design of marine vehicles and offshore structures considering the 'human factor', to maximise the effectiveness of the operation. Requires consideration to workflow, task analysis, level of automation, human machine interface, design of compartments and equipment with consideration for human size and abilities (see also simulation tools for design).

Technology Priorities - Design

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Technology	Technology Description
Design for Survivability & Safety	This topic covers the application of new design processes or new technologies into a marine vehicles and offshore structures to enhance their survivability (including susceptibility, vulnerability and recoverability for warships) and safety, thereby reducing the risk of damage to, or, loss of the asset and enhancing the safety of personnel and protecting the environment.
Design for Support	Design for support activities aim to reduce support and maintenance requirements through life to increase operational availability and reduce costs. Includes designing in maintenance envelopes and removal routes, system diagnostics and monitoring, materials and equipment selection etc. Needs to be addressed from the concept stage to gain most benefit.
Simulation tools for design	Simulation in design can be used to assure the product can meet the user need, to improve operability or efficiency of a process and to de-risk introduction into service. Simulation can potentially replace expensive full scale testing or physical model testing thus saving time and cost. Simulation in design benefits greatly from graphics based computer aided design.

Technology Priorities - Design

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Digital Twin	Digital Twin is a virtual representation of a physical product or process. From a design perspective the aim is to design, test and build a marine vehicle in a virtual environment before manufacturing commences to reduce time and risk.
CFD modelling	Computational Fluid Dynamics (CFD) can be used to simulate fluid flows and fluid / solid interactions. It can be applied in marine vehicle design to optimise hullforms and appendages and assess their performance. CFD can also be used in wider fluid flow applications in support of design.

Technology Priorities - Manufacturing

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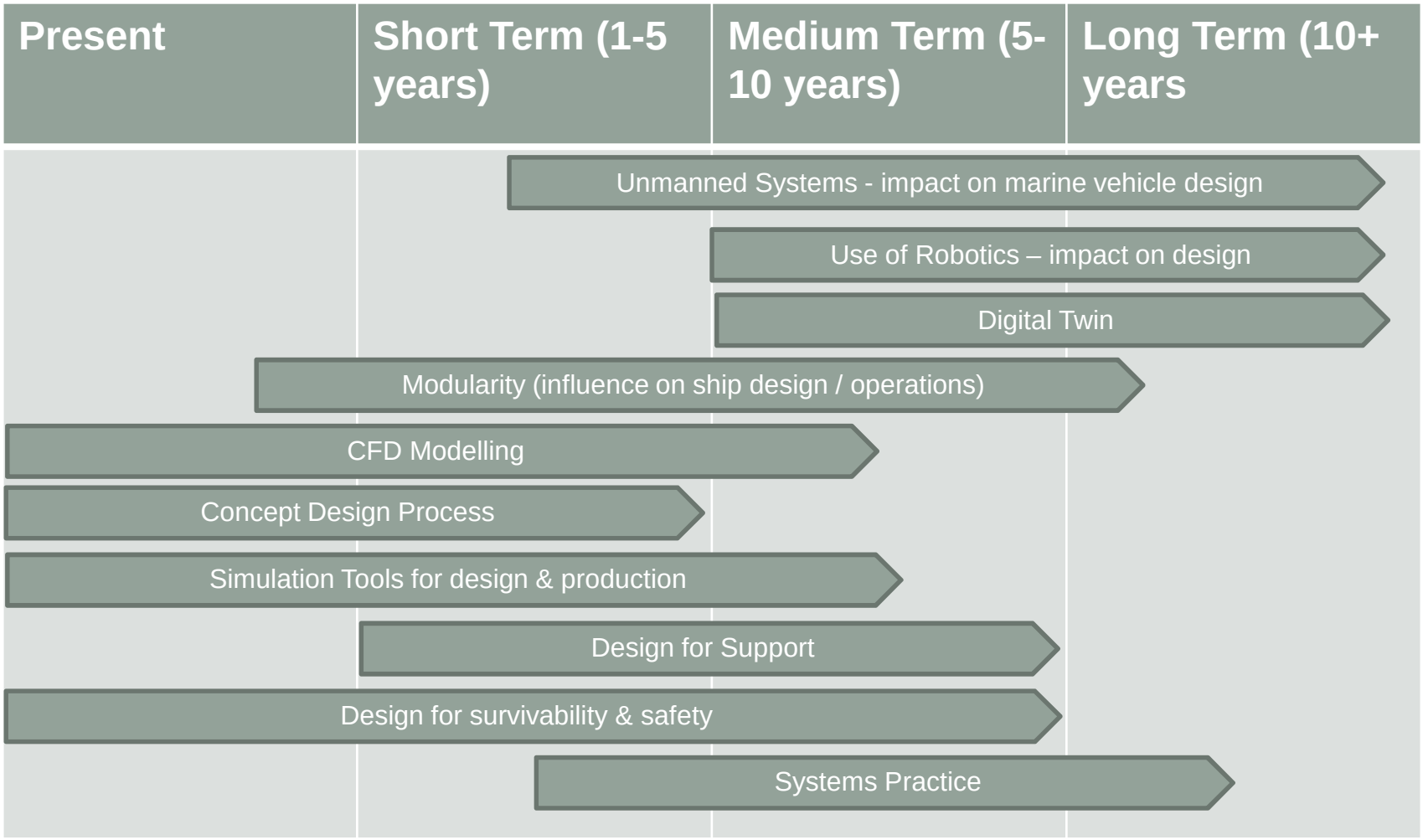
Technology	Technology Description
3-D Printing	3-D Printing sometimes known as 'Additive Manufacturing' can be used in the design process to make scale prototypes of products to aid understanding and to test ideas prior to manufacture, or, can be used in manufacturing to make real parts.
Use of robotics in manufacturing	Robotics can be implemented in a manufacturing environment to replace humans to improve efficiency / accuracy or to remove humans from dull, dangerous or dirty environments.
Modularity (in build)	Modularity in ship construction can be used to improve the shipbuilding process by allowing more outfitting work to be undertaken earlier in the process in more efficient ways to reduce overall build cycle times and save manhours and cost.

Technology Priorities - Manufacturing

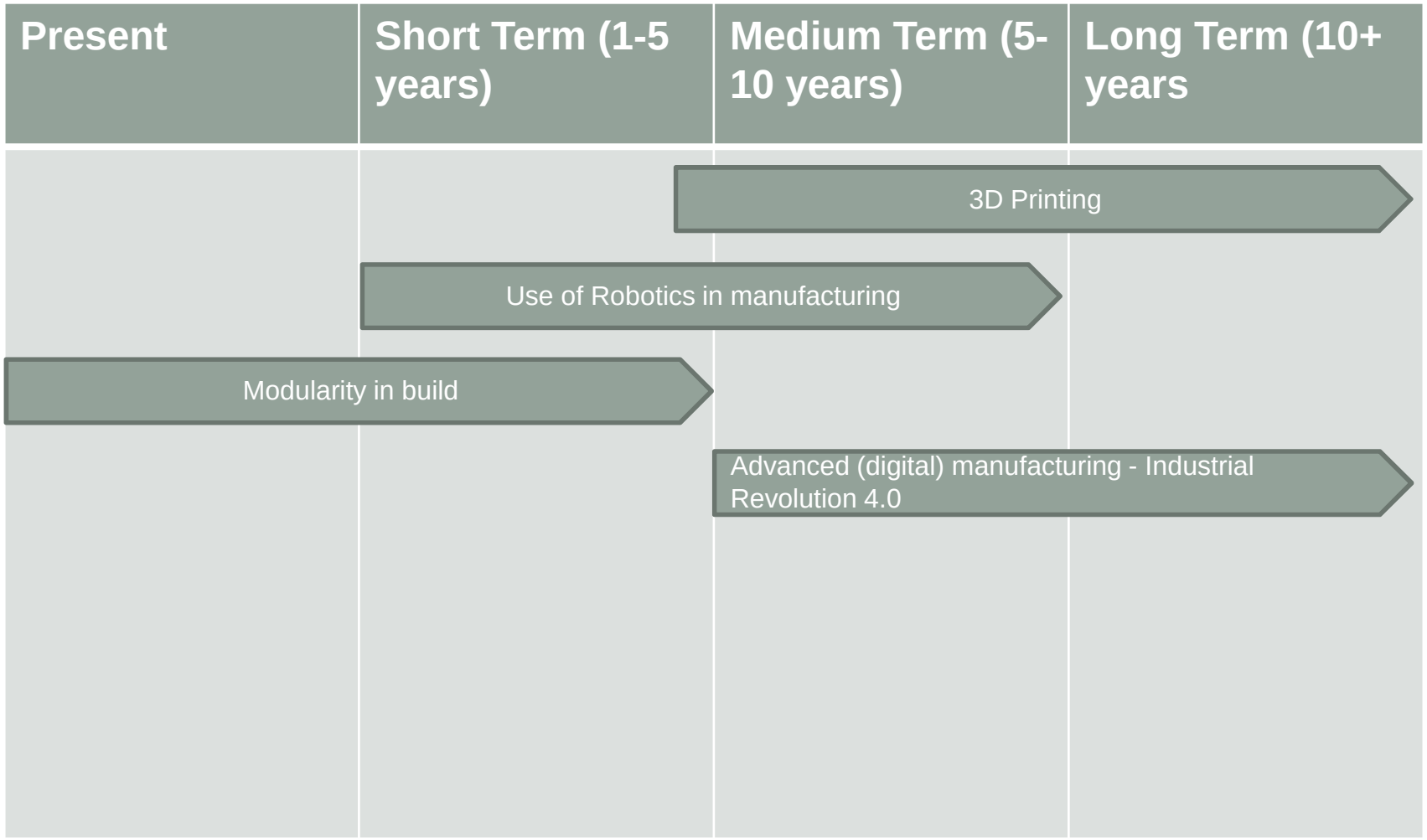
Technologies that we believe will have the most significant impact on the marine industry

Technology	Technology Description
Advanced (digital) manufacturing - Industrial Revolution 4.0	Industry 4.0 is a term used to describe the automation and data exchange in manufacturing. It includes cyber-physical systems, the Internet of things, cloud computing and cognitive computing. Industry 4.0 creates what has been called a "smart factory". Within the modular structured smart factories, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services, both internal and cross-organizational services are offered and used by participants of the value chain.

Exploitation Timescales - Design



Exploitation Timescales - Manufacturing



Challenges & Risks

- Key challenges and risks within design technology:
  - Rate of change of technology is a significant challenge for marine designers
  - The naval architect needs to become even more broad in his/her understanding
  - Products are becoming more complex, so the processes and tools used by designers will need to recognise this complexity
  - Understanding of the role of humans within a system will become more important as autonomy increases, and could add risk where they become the fail-safe mode due to loss of operating experience
  - More reliance on computational modelling requires greater levels of verification and validation, operators need to understand the applicability of the results

Examples

- Modularity in ship design: https://www.usni.org/magazines/proceedings/2014-01/modular-warship-2025
- Unmanned Ships http://www.unmanned-ship.org/munin/about/the-autonomus-ship/ , https://spectrum.ieee.org/transportation/marine/forget-autonomous-cars-autonomous-ships-are-almost-here
- Digital Twin https://to2025.dnvgl.com/shipping/digitalization/
- CFD in ship design https://www.ship-efficiency.org/onTEAM/pdf/14-Ship%20efficiency%20seminar%20-%20CMA%20CGM-%20HydrOcean%201.%20CMA%20.pdf
- Survivability in ship design http://survivability.co.uk/
- 3D printing https://www.sculpteo.com/blog/2015/10/12/3d-printing-maritime-military-vessels-cargo-shipping-and-more/ , https://3dprint.com/9021/maersk-ships-3d-printers/
- Robotics https://spectrum.ieee.org/robotics/industrial-robots

Conclusions

- New technologies including autonomy, digitalisation and robotics will have a significant impact on the design and the designer of marine vehicles and offshore structures in the coming decade. The rate of change is a significant challenge.
- 3D printing is likely to revolutionise the manufacture of components used in the construction and support of marine vehicles and offshore structures; propellers are one example.
- The human factor will become even more important as digitalisation and autonomy / semi-autonomy become a reality most specifically HMI considerations. The human is likely to remain in the loop for some time to come, especially in more complex operating environments including Naval applications.
- Robotics and automation in construction will continue to improve efficiency.
- The digitalisation of shipyards (Industry 4.0 or industrial revolution 4) will add further benefits.

Conclusions – Design

- The design processes used to design marine vehicles and offshore structures are evolving as new technology and computing power allows greater levels of simulation, analysis and optimisation, for example CFD and simulation of human or machine tasks. Machine learning will allow greater levels of automation in support of design.
- Products are becoming more complex, so the processes and tools used by designers will need to recognise this complexity including ‘system of systems’. This will require greater use of ‘systems practice’.
- Concept design will need to account for the use of rapidly changing technologies which could significantly disrupt the solution space. The naval architect needs to become even more broad in his/her understanding.
- Complex systems will benefit from the use of architecturally driven design processes e.g. design building block approach at the earliest stages to test the feasibility of diverse solutions
- VR and AR technologies will enhance design understanding / optimisation and may add benefits during manufacture.