SHIPS' LIFE CYCLE: CLOSED LOOP MANAGEMENT

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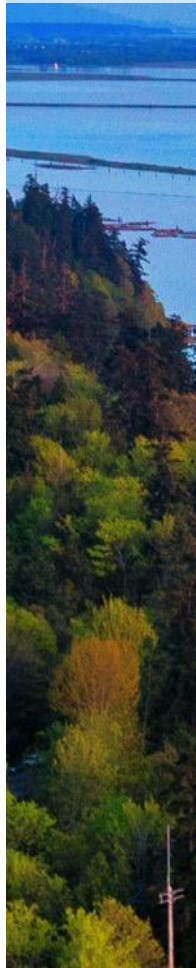
SHIPS' LIFE CYCLE

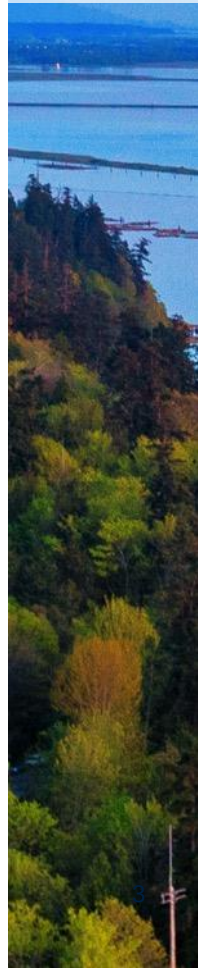
- Life phases: Stakeholders:
  - Design — Designer/builder
  - Construction — Designer/builder
  - Operation — Owner & operator
  - Disposal — Opportunist

- Past/present:
  - Cheap resources / energy → defines the current coupling between the life phases
  - Search for minimum freight rates
  - Recently air & water pollution in focus, primarily in operation
- Future:
  - Energy/materials not perceived cheap anymore (+ CO_2 tax)
  - More profound awareness of the impacts on the environment
  - Cost, environment & society intertwined



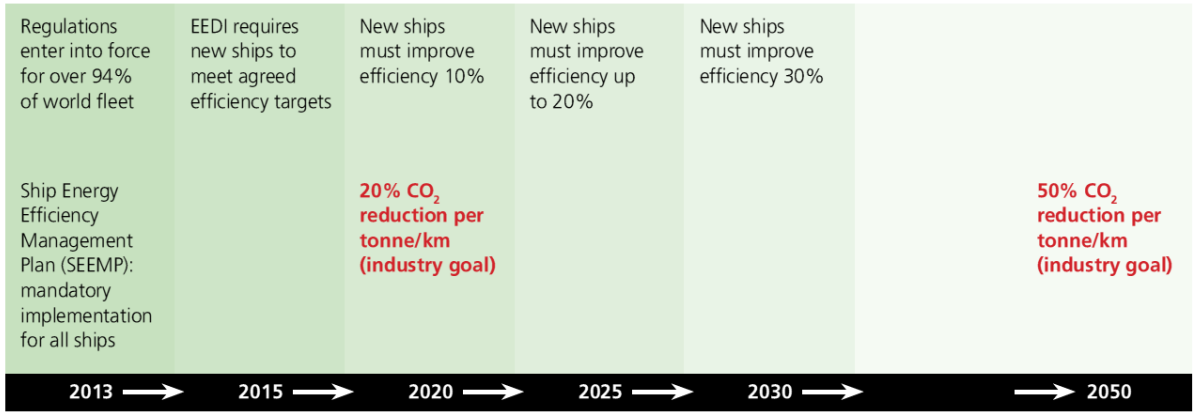
TOTAL SYSTEM THINKING

- Each phase has its own environmental impact
- Currently, the most interest is on the operations phase (IMO, ICCT, independent studies)
- Actions in one phase affect the impact in other phases
- Design phase defines the “range of flexibility” during the life
- Current flexibility (defined in design) is insufficient to react to the changes 20-30 years ahead
- New technologies available or emerging, beyond the ones typically considered



REQUIREMENTS AND AVAILABLE SOLUTIONS FOR EMISSIONS REDUCTION

MARPOL Annex VI, Chapter 4 adopted July 2011, which entered into force in January 2013

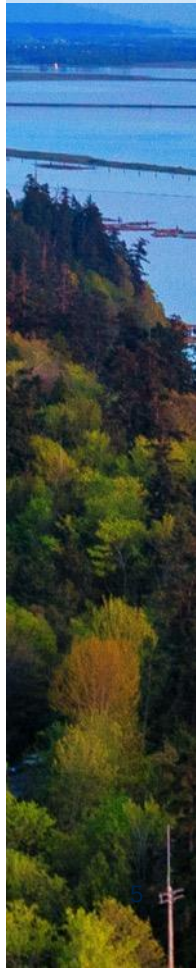


~60% technical solutions available or under development to reach that 50% CO_2 reduction by 2050:

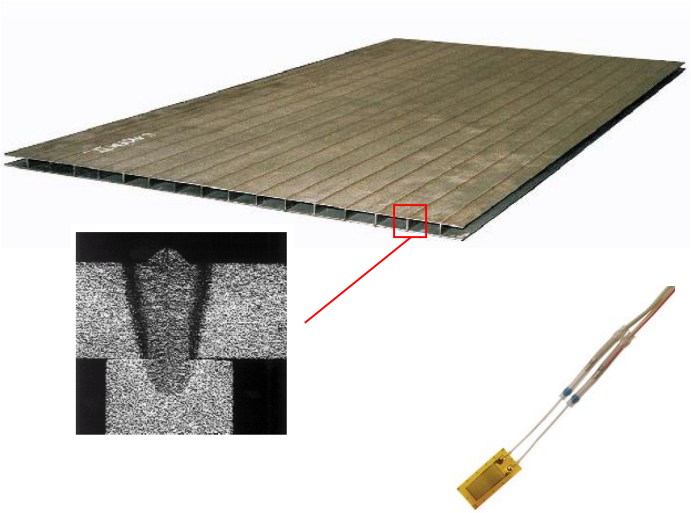
Propeller polishing
Autopilot upgrade
Water flow optimization
Weather routing
Propeller upgrade
Hull cleaning
Air lubrication
Wind power
Hull coating
Waste heat reduction
Speed reduction
Main engine retrofits
High-efficiency lighting
Solar panels

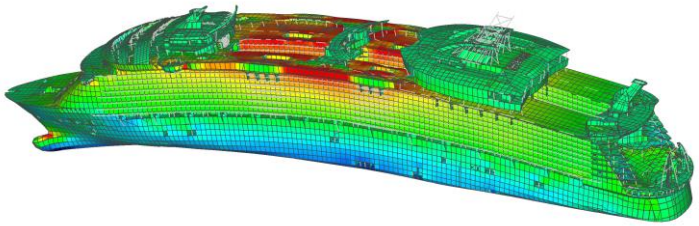
STRUCTURAL DESIGN

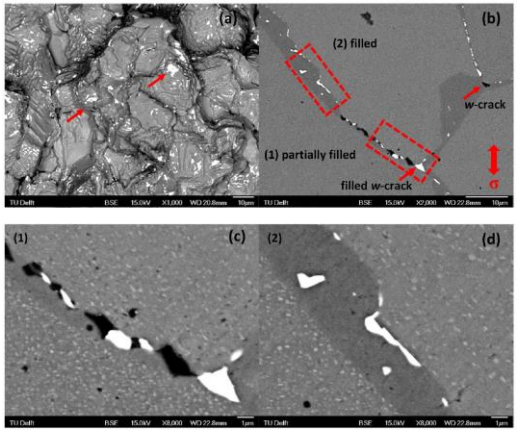
- Ferries, cruise ships, naval ships, container ships:
  - 40-50% of the displacement comes from steel
  - Progress in materials selection, welding techniques, construction methods, structural health monitoring
  - High-quality steel products (or some other)
    - Allowing prolonged life
    - Re-use of structural components (instead of scrapping)
  - Composite materials:
    - Lightweight
    - Not recyclable yet (to be burned in the end, or use toxic chemicals to dissolve)
  - What is the sustainable way to reduce the structural weight?

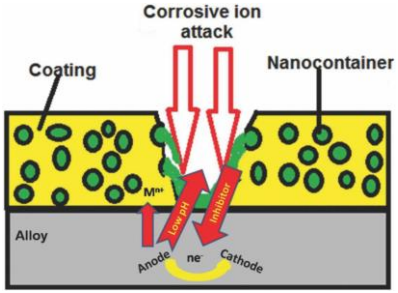


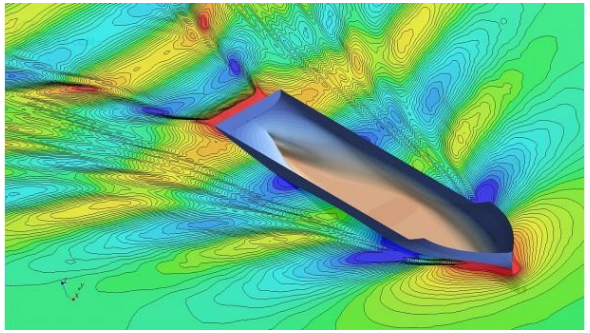
ADVANCES IN STRUCTURAL DESIGN







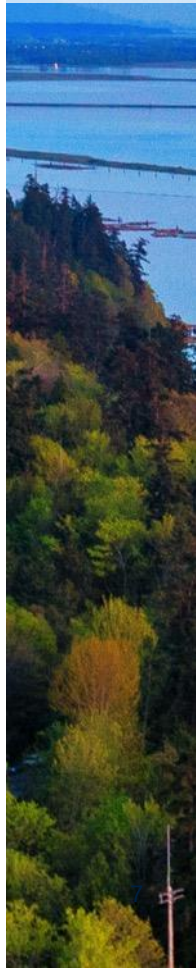




DESIGN FOR FLEXIBLE OPERATION

- Life span of a ship – what is the optimum?
  - Currently 25-40 years
  - Longer lifespan, high quality / shorter lifespan, low quality
  - Given the new opportunities, where is cost optimum, environmental impact optimum? Where will it be in the future?

- If the life span is to increase, how to provide larger flexibility to ship owner / smaller volatility to market conditions:
  - Modular design
  - Re-use of ship systems and materials
  - Anticipation of change (cargo, route, fuel sources, etc.)
  - Adoptable hull shape (resistance, fuel savings)
  - Adoptable machinery system / fuel source
  - Can the additional costs be justified?
  - What is the "CO_2 tax" which would justify the use of new technologies leading to reduction of emissions in the whole life cycle?



- **Given current practices, how to minimize the pollution in other life phases?**
- **What is the optimal life span, given the emerging technologies, to minimize impact on the environment?**