Research and Technology Challenges and Opportunities (Commercial Ship Design Perspective)

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Public Meeting – June 10, 2010
R&D in the Commercial Industries

Who innovates in the maritime and offshore industries? Who does the basic and applied research?

- Commercial shipping and the offshore oil & gas industries are competitive, free market industries. Equipment suppliers, designers and shipowners all have interest and need to innovate to remain competitive.

- There is little basic research. Some at the university level, some funded by governments (Japan, EU), and occasionally by class societies & design companies.

- The commercial industries concentrate on applied research with 3 to 10 year horizon of application.
Innovative Concept Design is Traditionally Initiated by Shipowners

- Concept design innovation has traditionally been the realm of shipowners. Especially true for novel ship types. Shipyards are effective at optimizing the design for construction – rarely at exploring and developing new concepts.

- Owners are continuously assessing their competitiveness vs. other owners. Owners understand the cost of transport – where improvement can be achieved.

- Examples of new ship concepts developed by shipowners and their design firms in the 2nd half of the 20th century include containerships, specialized bulk carriers, ro-ro vessels and car carriers.
Shipowner Loss of Expertise Inhibits Innovation and R&D

Trend away from owner design expertise has further reduced pathway to innovation

- Reduced capacity of owners to design ships or even develop ideas in house and reduced capability of design firms that work for shipowners.

- Concentration of design work at shipyards. Shipyards tend towards parametric design rather than beginning with “clean sheet”, and are even more risk averse than shipowners.

Exceptions include

- A few of the largest shipowners.

- The major oil companies – participate in concept design development of offshore structures and novel ships.
Regulatory Barriers to Innovation

Commercial ship design regulations have historically been prescriptive in nature, which limits the designer’s ability to innovate. There has been a trend toward performance-based and risk-based design criteria.

- Rules for design of ship structures on 1st principle basis introduced by class societies in the 1970’s.
- IMO introduced probabilistic damage stability in the 1970’s. Performance based criteria now include oil outflow; intact and dynamic stability; collision and grounding prevention; fire and explosion risk.
- IMO established Formal Safety Assessment (FSA) guidelines to support its decision-making.
- IMO is introducing “goal based” standards for assessing adequacy of ship structural requirements.
Other Barriers to Innovation and R&D

Obstacles to developing innovative technologies include:

- Ocean shipping is a fragmented industry with many players. Few shipping companies are large enough to initiate R&D and testing of innovative solutions.

- Dynamic nature of international shipping creates market uncertainties. Shipowners are hesitant to make investments requiring long-term payback.

- Environmental performance and energy efficiency are not fully accounted for in the second-hand market.

Partnerships, government participation, and effective regulation will be needed to foster innovation.
Driver for Improvements in Efficiency

Proposed International Maritime regulations call for reductions in CO₂ emissions, with the reduction factors becoming more demanding over time. Reduction factors being considered by IMO are shown below.

Although these reductions can be achieved through speed reduction, industry prefers to reduce emissions through cost effective innovative technologies.

<table>
<thead>
<tr>
<th>Year of Contract</th>
<th>Reduction Rate</th>
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<tbody>
<tr>
<td>Phase 1: 2013 – 2017</td>
<td>10%</td>
</tr>
<tr>
<td>Phase 2: 2018 – 2022</td>
<td>15% to 25%</td>
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<tr>
<td>Phase 3: 2023 – 2027</td>
<td>30% to 35%</td>
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Rates proposed by Japan at MEPC60
Hull & Propulsion Optimization

Examples of solutions with near term maturity. These technologies will receive significant attention from ship designers and equipment manufactures.

- **Hull Resistance Improvements**
  - Low friction coatings (polymers, nanotechnology, …) (0 – 10 years)
  - Stern Duct (0 – 5 years)
  - Surface technologies (ribblet films, surfactants, polymer injection (5 – 20 years)
  - Air Lubrication (5 – 20 years)

- **Propulsive Efficiency Improvements**
  - Pre-swirl fins (0 – 5 years)
  - Counter rotating propellers (0 – 10 years)
  - Hybrid Pods (0 – 10 years)

- **Hull Form Optimization**
  - Focus on optimization in waves and wind
Ship Propulsion Plant Effectiveness

![Diagram showing the progression of ship propulsion plants from sailing ships to motor ships with a shift towards natural gas and the next generation of non-fossil fuels.]

Effectiveness

Year

1800 1900 2000

Wind

Sailing Ships

Coal

Steamships

Oil

Motor Ships

Natural Gas

The Next Generation
(Non-Fossil Fuels)

Bio-Fuels?
Nuclear Propulsion?
Fuel Cells?
Low Carbon Fuels

- Natural Gas: DFDE propulsion is currently applied for LNG carriers. LNG propulsion has likely applications for coast-wise vessels, and potentially for long haul vessels. GI-DE and CoGES are possible alternatives to DFDE.

- Bio-Fuels: Shipping industry will not be a driver for bio-fuel application. Land-based operations will have first priority for bio-fuels; shipping will likely wait for efficiently produced “second generation” fuels.

- Nuclear propulsion: Will become competitive at higher fuel prices (oil > $100/bbl). Technology is available – key barrier is public acceptance.

- Hydrogen: Technology development is slower than expected. Viewed as a possible future solution.
Trends towards using natural gas as fuel

- **Dual Fuel Diesel Electric Plants (DFDE)**
  - Can operate either on liquid fuel (HFO or MDO) or gas
  - Natural gas is supplied at 6 bar pressure
Trends towards using natural gas as fuel

- **Gas Injected Diesel Plants (FI-DE)**
  - Can operate simultaneously on natural gas and liquid fuel (HFO or MDO)
  - Natural gas is supplied at 250 bar pressure
Trends towards using natural gas as fuel

- Combined Gas, Steam Turbine, Electric
  - Can operate on MGO or natural gas
  - Natural gas is supplied at 25 to 46 bar pressure
Hull Structure

Use of composites and other non corrosive materials. R&D needed to bring cost of construction down; maintain fire safety; re-cycling, etc.)

- **Sandwich Construction**
  FRP laminates with light weight core material. (applied for high speed craft, superstructures, etc.) offer 30% to 70% weight savings

- **Sandwich Plate System (SPS)**
  metal plates with polyurethane elastomer core. (applied in superstructures, hatch covers, etc.) potential for cost savings

Manufacturing.
Ex: New techniques for joining and forming pieces (Automation of design and parts generation)
Operations (Minimum Manning)

Trends
- Reduced steadily over the last 150 years. Has bottom out in last 15 years. Typical ocean-going ships have 18-25 complement, and coastal ships have 8 to 20 complement.
- This reduction in manning means crew costs are a relatively small part of total operating costs (2%-4%)

Therefore, there has been no concerted effort to further reduce manning in recent years.

Further reductions in manning on ships will come with further enhancements in automation and remote monitoring, but will not be a focus of the commercial shipping industry.
Ship Systems and Operations (R&D)

R&D for ship operations may include

- Goal of zero ballast discharge
- Goal of zero VOC emissions
- Goal of zero emissions in port from all ship-based sources
- Enhanced weather routing & voyage optimization.
- Shifting equipment to terminal (ex: mooring equipment)
- Enhanced remote monitoring of ship operations, efficiency, and condition.
- Shore based pilotage
- Remote operated tugs
Cargo Operations (R&D)

R&D for more efficient cargo operations may include

- Tracking and intelligence.
- Aggregation into larger load components, pre-assembled before arrival
- Light weight containers
- Load-discharge automation & optimization (ex: automated crane operation)
- Shoreside automation (cargo movements, stacking, etc.)
- Reduced emissions from cargo handling
Offshore Terminals

R&D for offshore and remote terminals:

- Existing offshore terminals were developed primarily due to shallow water restrictions (ex: LOOP)
- Use of offshore terminals will be further considered for reasons of efficiency, security, and public perception. Especially suited for:
  - LNG & Oil, import/export and production
  - Ships with nuclear propulsion plants
- May be combined with alternative energy production (wind; OTEC, tides; etc)
Summary

- In the near term, R&D efforts in the commercial ship design communities will concentrate on ship efficiency and minimizing GHG emissions, both in design and operations.
- Trend will be towards use of cleaner fuels including natural gas. Further R&D on GI-DE and CoGES plants is needed.
- Longer term, alternative propulsion plants (nuclear power, fuel cells, etc.) will be the natural progression.
- Trend towards remote monitoring of ship operations and condition will continue.
- Increased cargo handling efficiency has been a key component in the dramatic reduction in the cost of shipping over the last 50 years. There are many opportunities for further R&D in this area.
Summary (continued)

- Offshore terminals offer certain advantages related to efficiency and security, and will likely be employed for specific trades.

- Most research in the maritime industry is applied research, with expected near term maturity.

- There is very little basic research and virtually no “curiosity driven” research in the maritime industry. Basic research in the commercial industry requires partnering or support from government.