1

Introduction:
Let's start with the last maritime revolution.

- The **LAST** sea transport revolution started 200 years ago, and was driven by two new technologies:-
  - Sail: was replaced by fossil fuels.
  - Digital communications: made global trade possible.
- In the NEXT sea transport revolution two things are likely to happen:-
  - Fossil fuels will be replaced by zero emission fuels.
  - Digital technology & communications will transform ship operation & trade.

2

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The transition from sail to steam took over a century

- The three-masted, square rigged sailing ship was "probably the most important vehicle in human history" said Basil Greenhill in *The Last Tall Ships*
- For 300 years, these sailing ships made it possible to develop global trade.
- By the 18th century shipbuilders and naval architects were very skillful at refining the design.
- But when steam and iron hulls arrived in the 1790s, new technical questions needed answers.

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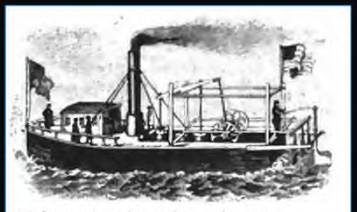
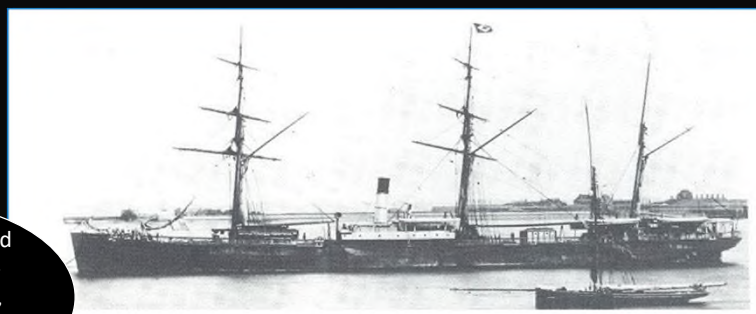
LAST REVOLUTION – developing steam ships capable of global transport took 70 years…



60-foot steam boat driven by stern-mounted oars. Ran between Philadelphia and Burlington. John Fitch 1790.



…fred Holt's Agamemnon 1866 – first steamship capable of trading globally – 2,280 GT, 60 lb boilers, 10 knots, cost £52,000. In 1869 loaded 2,516,000lbs of tea at Hankow, the largest a single ship cargo with record freight of £28,087!!

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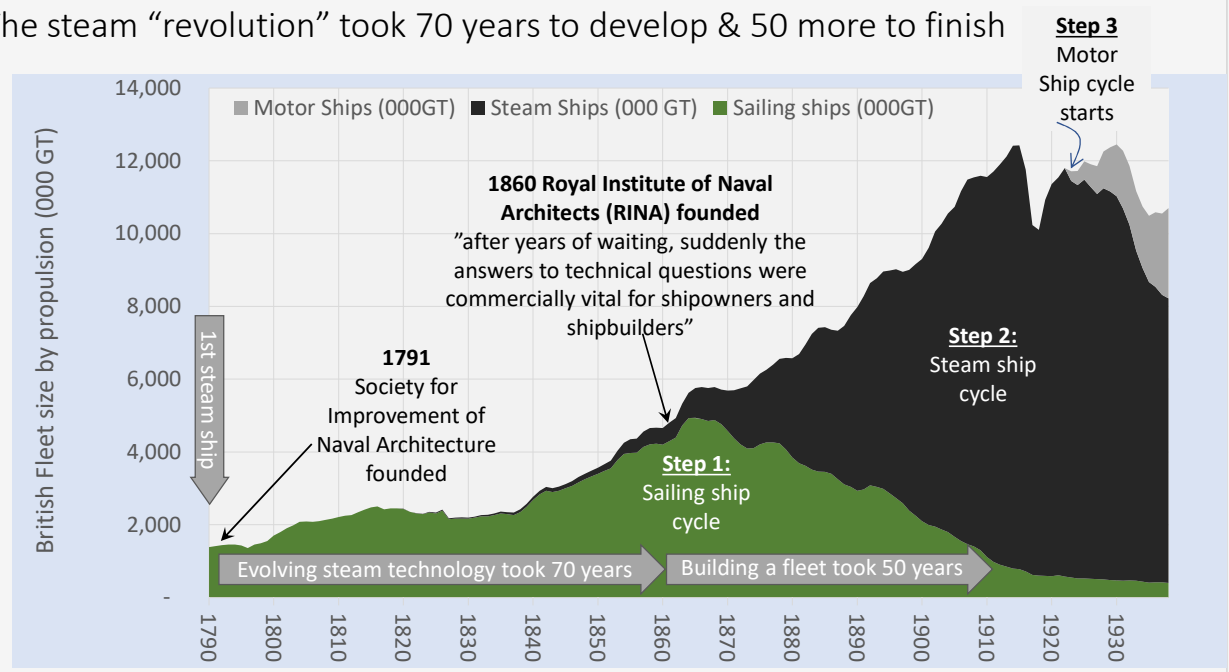
The steam "revolution" took 70 years to develop & 50 more to finish



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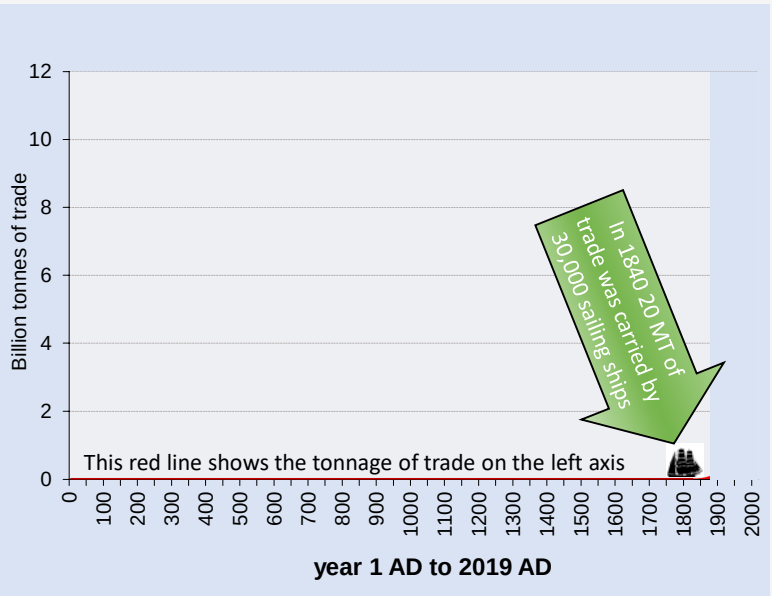
World Sea Trade in 1840 AD – before fossil fuels

- In 1840 shipping relied on the wind for power and the average ship did two voyages a year
- There were about 30,000 sailing ships averaging 200 tonnes



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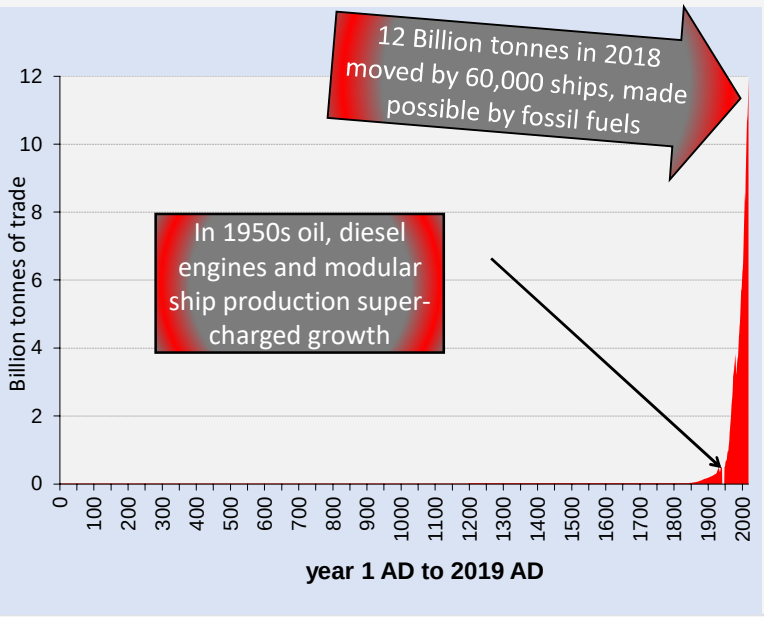
World Sea Trade 1840 to 2019 AD – after fossil fuels

- In 2019 we carried 12 billion tonnes. This was made possible by fossil fuels, first coal then oil.
- Today's world economy could not exist without the raw materials and manufactures shipped by sea.



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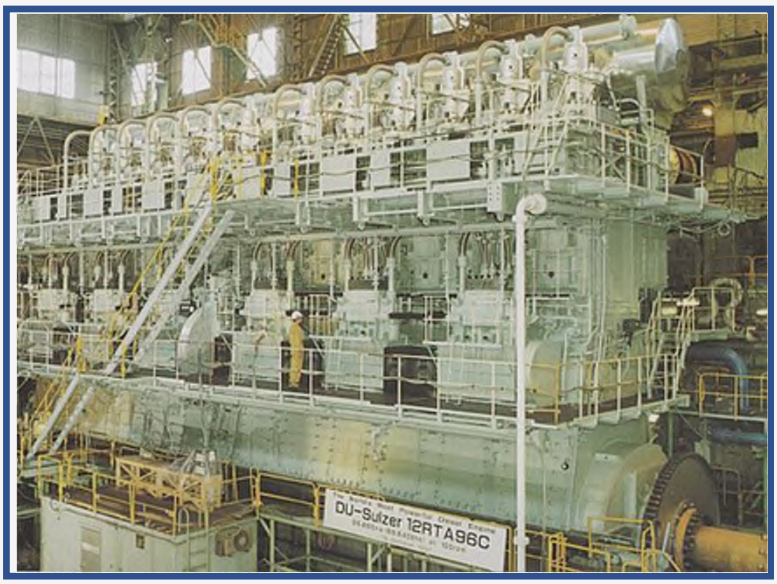
Oil was the energy source that made today's trade volume possible: -

- Thanks to fossil fuel, this engine generates 109,000 HP (82 MW)
- It does the work of about 3 million people (working 8 hour shifts)
- The people powering it would need a town the size of Athens to live in
- They would eat about 9 billion calories a day (3,000 tonnes of grain)!
- Every tonne of oil bunkers produces 3.3 tonnes of carbon
- This is the ELEPHANT in the room.



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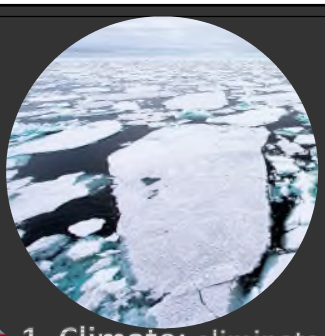
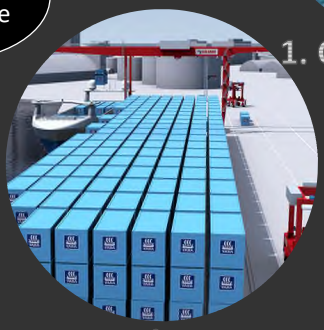
THE THREE BUILDING BLOCKS OF FUTURE SEA TRANSPORT

Now, let's see how to do all these things



1. Climate: eliminate emissions



2. Sea trade: add more value, with less volume

3. Technology: the information & automation revolution

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Issue 1 Climate Crisis: Meet IMO Carbon 2050 carbon target (& much more)

THEME

"Today's revolution is about de-carbonizing an industry built on fossil fuels"

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IMO's Vision for eliminating greenhouse gas emissions – April 2018

- "IMO's vision is to reduce GHG emissions from international shipping.
- Emissions should peak as soon as possible and fall by at least 50% by 2050 compared to 2008.
- At the same time, the industry should pursue efforts towards phasing out GHG emissions entirely".

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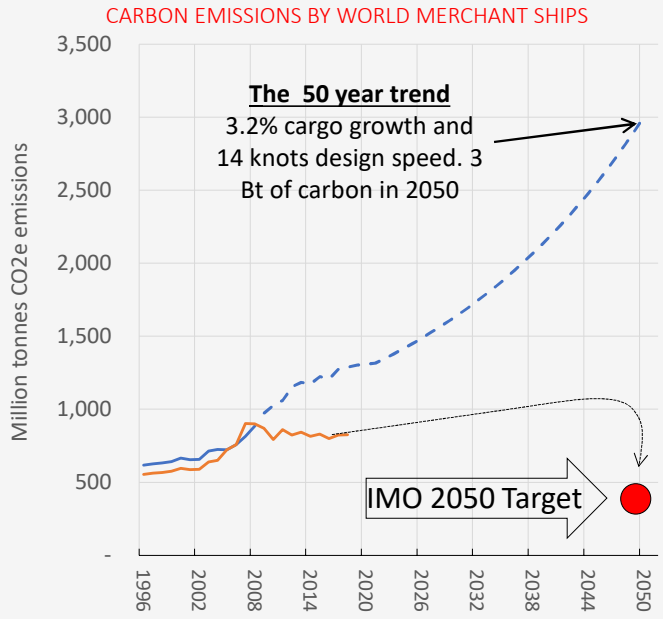
Four ways to implement IMO's vision of a 50% cut in carbon by 2050

Method 1: Less cargo: Transport less cargo by a) new trading patterns, b) new transport policies, c) pricing and d) information systems for better decisions.
Method 2: Slow down etc: Cut carbon emissions/ship km by a) slowing down to 10 knots; b) use bigger (small) ships; c) better designs; d) LNG fuel, e) retrofitting for safe operation at slow speeds etc.
Method 3: Zero carbon power: develop new propulsion systems but tricky. a) Electric fuel cells look the best bet for volume and performance, b) maybe nuclear?
Method 4: Management: Put methods 1-3 to work by re-thinking of the industry's organization and personnel.



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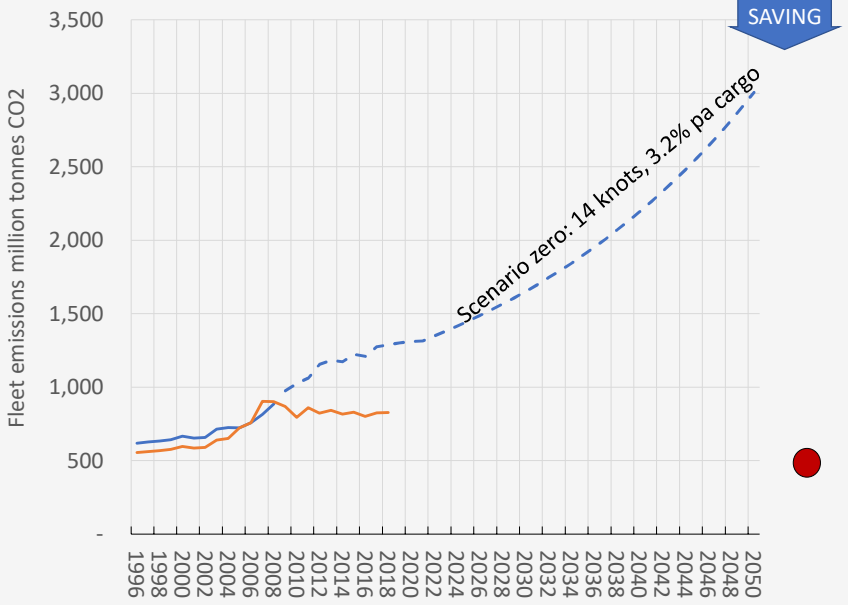
World cargo fleet CO2 Emissions – "Business as usual" Scenario

- "Do nothing" Scenario zero is based on 3.2% cargo growth, and the fleet trading at 14 knots.
- This scenario produces 3,000 Mt of emissions in 2050, six times the IMO limit.



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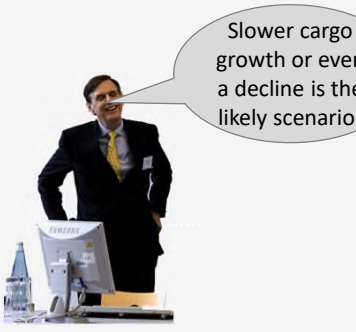
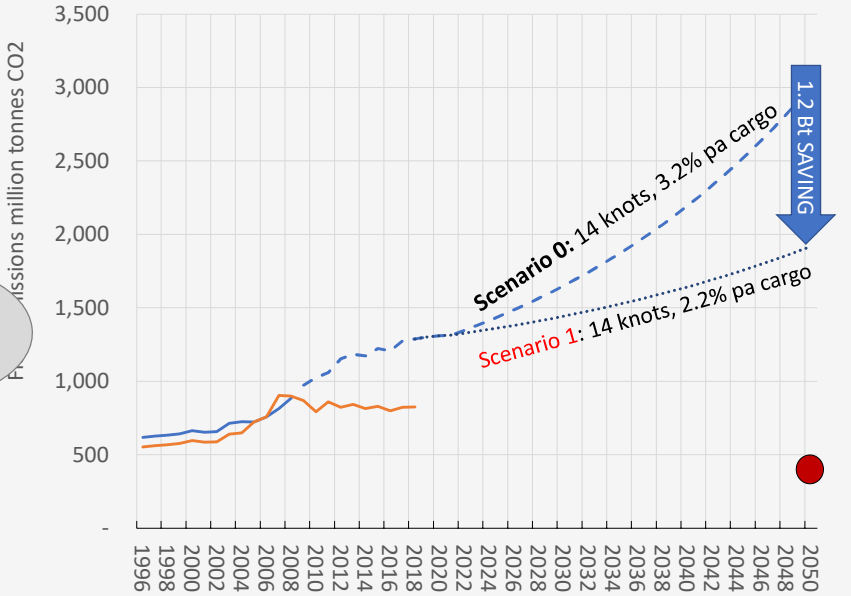
World cargo fleet CO2 Emissions – Scenario 1, cut trade growth to 2.2%

- Scenario 1 cuts trade growth from the 50 yearn average of 3.2% to 2.2% per annum
- Carbon emissions fall to 1.8 billion tonnes, a 1.2 billion tonne reduction.





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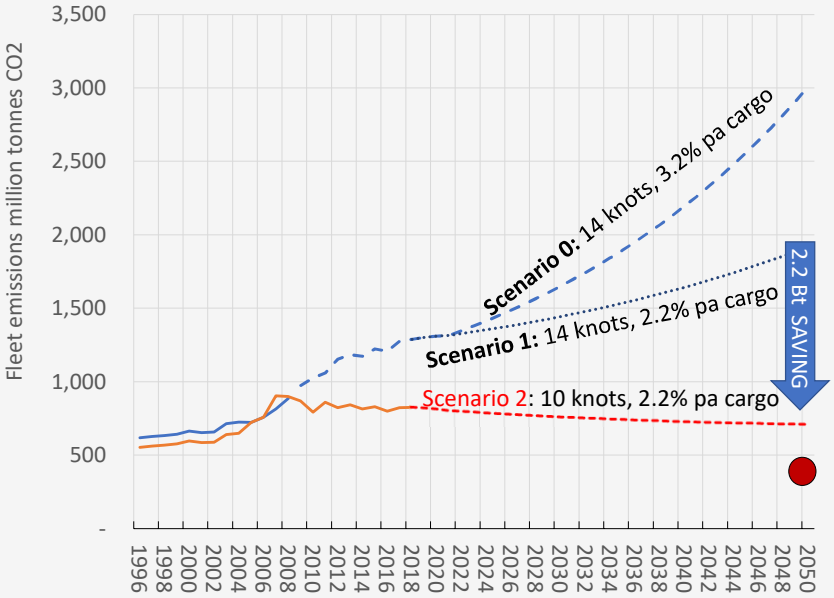
World cargo fleet CO2 Emissions – Scenario 2, slow fleet to 10 knots etc

- Scenario 2 cuts trade growth and slows the fleet to 10 knots average operating speed
- Carbon emissions fall to 0.8 billion tonnes in 2050, a 1 billion tonne reduction.
- We are 75% of the way to IMO's target, without relying on new technology



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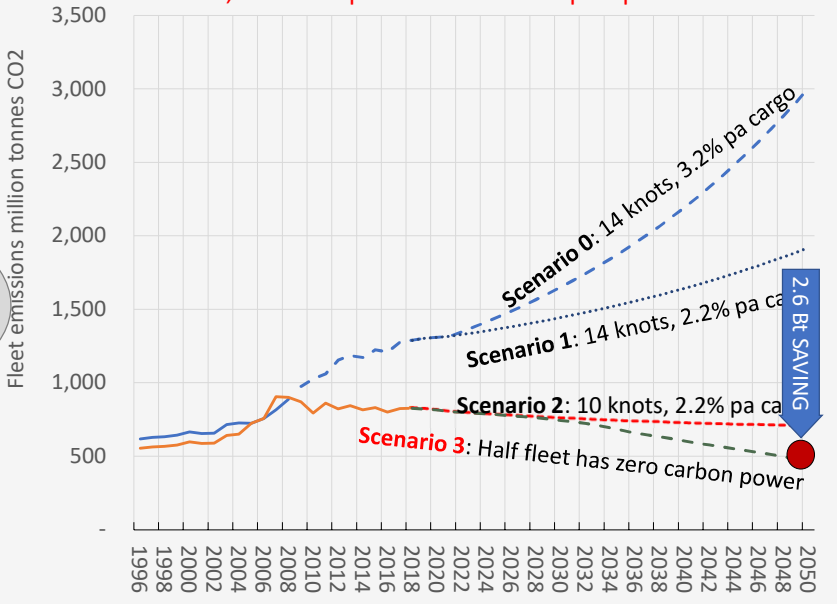
World fleet CO2 Emissions – Scenario 3, develop zero carbon propulsion unit

- Scenario 3 introduces zero carbon propulsion e.g. all electric ship using green fuel. Half the fleet is zero carbon in 2050
- Emissions fall to 480 Mt in 2050, in line with IMO's target.
- Depends on how technology develops



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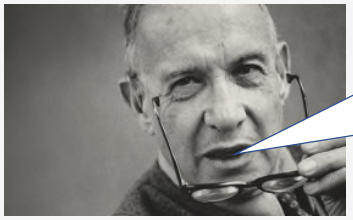
World cargo fleet CO2 Emissions – The three steps to cutting carbon

New organization structures play an important part in making the new technology work….



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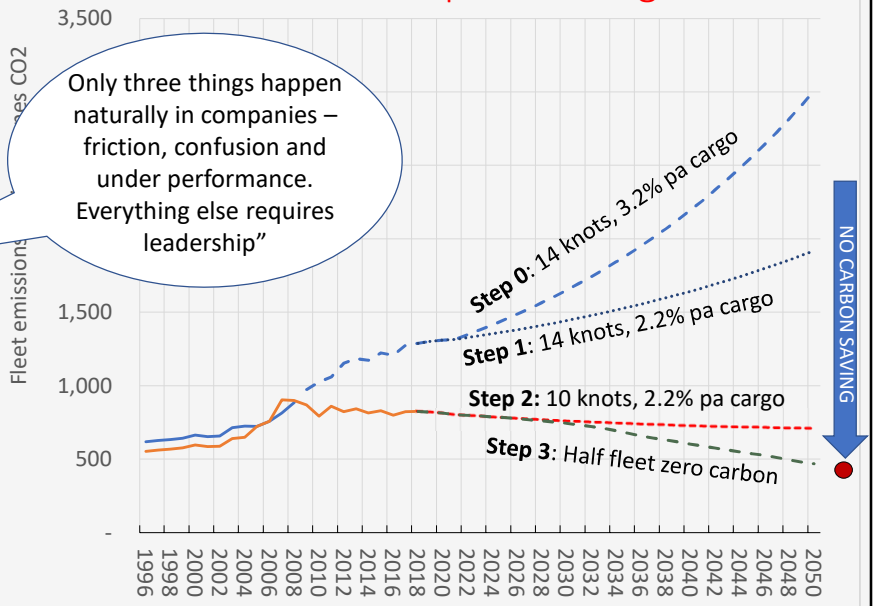
Only three things happen naturally in companies – friction, confusion and under performance. Everything else requires leadership"



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Issue 2: Seaborne trade: Find new ways to manage sea transport & cut emissions 2020- 2050

THEME

"There are two goals: a) ensure that cargo transported *adds economic value* and b) *minimize* door to door emissions"

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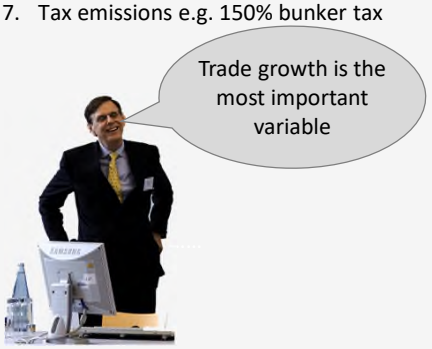
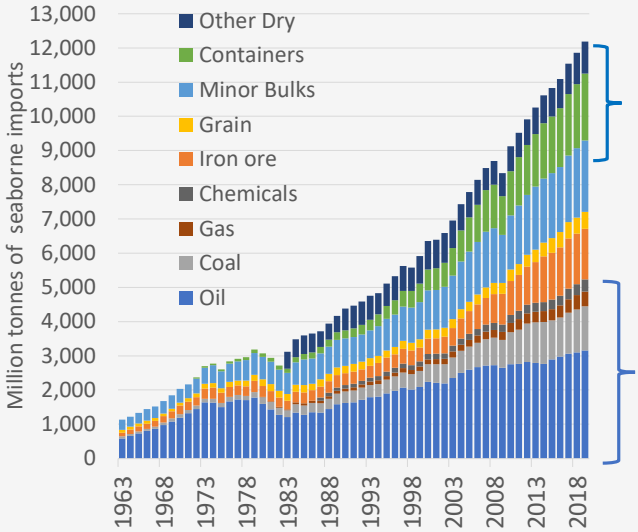
Two questions we should ask ourselves about managing sea trade:-

Seven ways to change trade volumes:-

1. Tell customers their carbon footprint
2. Improve logistics services & options
3. Process cargo before shipment
4. B2B direct sea transport where viable
5. Charge more for zero carbon transport
6. Use local suppliers where possible
7. Tax emissions e.g. 150% bunker tax





Question 1: 27% Growth since 2008. How can we reduce growth without losing value?

Question 2: 37% of sea trade is fossil fuel – What should we plan for in 2050?

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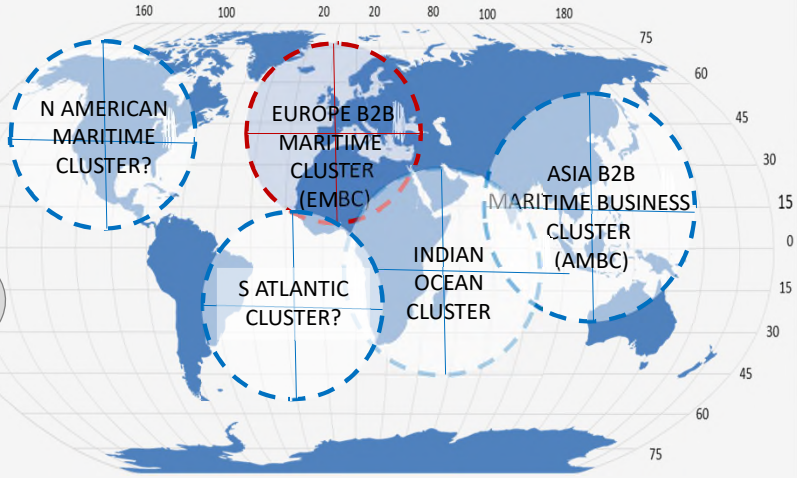
Use short sea shipping to improve B2B commerce & cut CO^2

The revolution should include much more short sea transport



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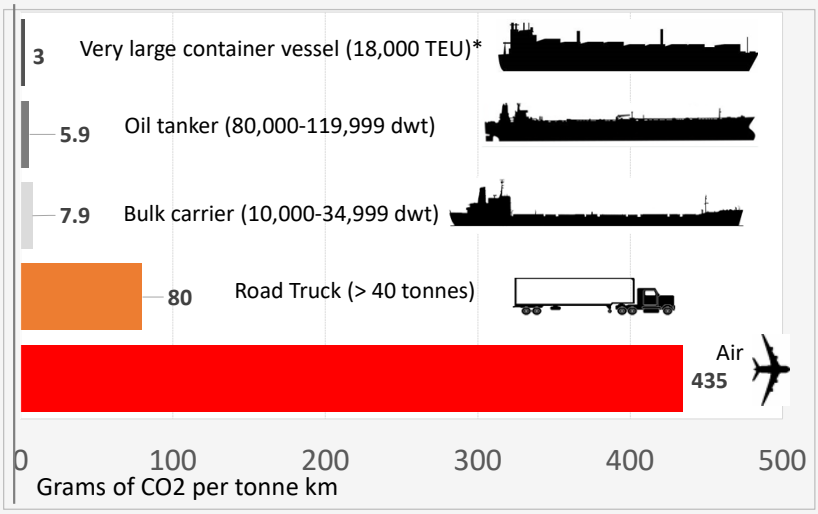
EXPLOIT SEA TRANSPORT'S LOWER CO2 EMISSIONS:-



Source: IMO GHG Study 2009, (* AP Moeller-Maersk 2014)

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Issue 3 Smart Shipping: Develop ships, companies & people to deliver low carbon B2B transport

"Smart technology is about smart organization as well as telematics, deep learning and autonomy."

Martin Stopford

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Next year computer technology will be 70 years old, the same as steam technology in 1866

1951: LEO was the first commercial computer It had 8.75 k of memory (using mercury tanks) and many wires

1966: CDC 6600 super-computer had 10 MHz clock speed (10x other machines) & 980k memory. Cost $7 m.

2019: Intel 9700 I7 processor has 8 cores with 12 MB cache, 3.6 GHZ clock speed $393 from Amazon

Digital technology is falling into place. Computers are massively powerful; others are tiny, efficient and very cheap! Drawing on all this power, systems like deep learning are shooting ahead. Data gathering, and storage are cheaper and more powerful, thanks to the cloud. Marine satellites offer better band width. I

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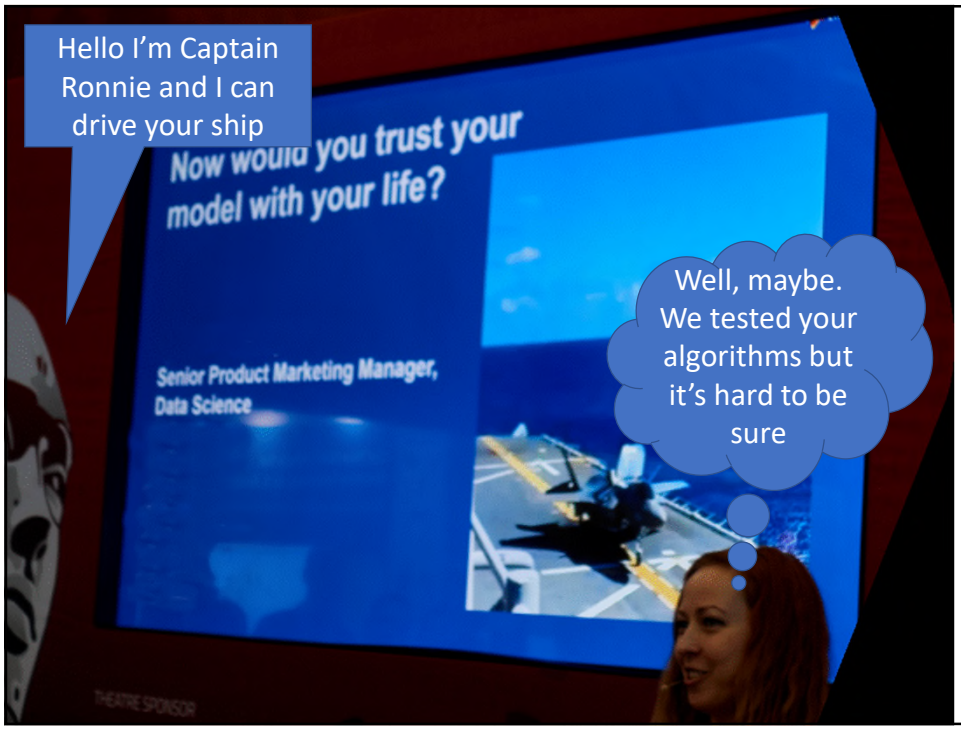

Today's digital technology is fantastic, but it must be developed by experts, with commercial understanding

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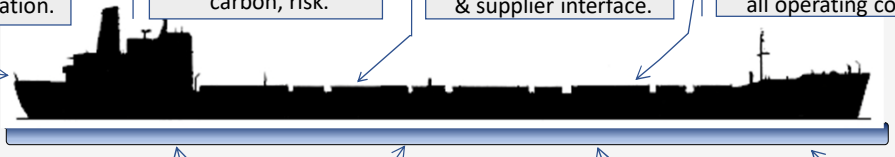
Ship's functional systems are where it is all happening, but..

1. Propulsion. Integrated control systems with real time diagnostics and in service optimisation.

2. Auxiliary power Ship wide power management systems optimising cost, carbon, risk.

3. Auxiliary machinery Systems managing operations, maintenance, efficiency & supplier interface.

4. Ballast & trim Integrated digital management system optimising performance in all operating conditions



Next-generation ships need integrated systems that communicate with each other.

5. Navigation Navigation on network with ability to view on shore as well as ship (e.g. Sperry system)

6. Cargo handling Cargo handling systems with cargo management and sharing key data between ship & shore

7. IT & comms Ship systems hosting and managing on board systems. Also rolling out upgrades & providing.

8. Maintenance Ship condition based maintenance system, integrated with company system

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Chart 15: Vehicle industry moved to digital networks 30 years ago

"It's the CANbus backbone that turned cars into computers on wheels. It can do the same for ships" Martin Stopford


1967 BMW (source: History of cars.com)


2017 BMW (source: Autocar)


2022 all-electric BMW?

50 Years change in car technology – "Modern BMW is a computer on wheels" (The Economist 17th Oct 2018)

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CANbus is the stepping stone to smart "ship" designs

1. The information and electrical loading on the ship will escalate as installed "smart" technology develops
2. As systems will become more complex, communication and control become priority issues
3. The CANbus derivative backbone (NMEA 2000) systems will help deal with many ship design issues:-
   - ✓ **Low cost** – single interface replaces point to point wiring.
   - ✓ **Centralised** - error diagnosis & configuration are made routine
   - ✓ **Robust** – against electrical disturbances
   - ✓ **Efficient** – priorities and traffic flow optimised
   - ✓ **Flexible** – easy to modify ECUs within the protocol

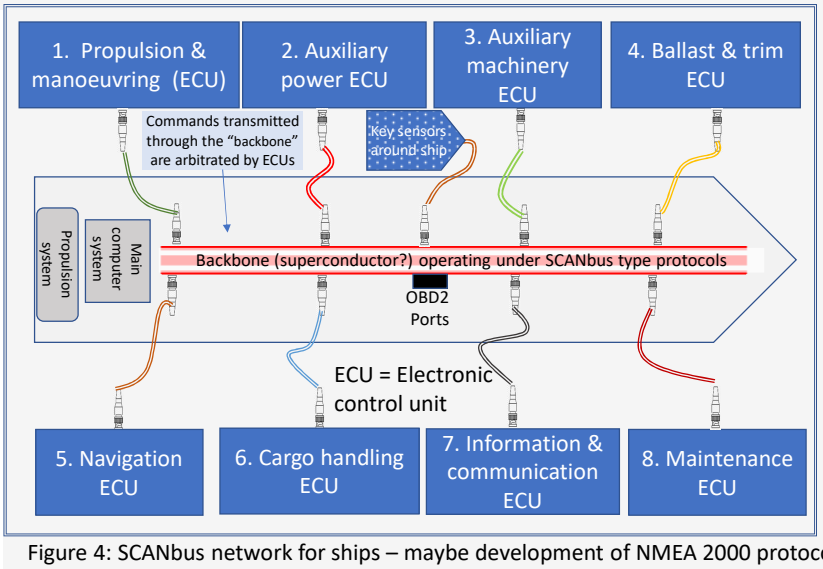

Figure 4: SCANbus network for ships – maybe development of NMEA 2000 protocol

CAN – Controller Area Network

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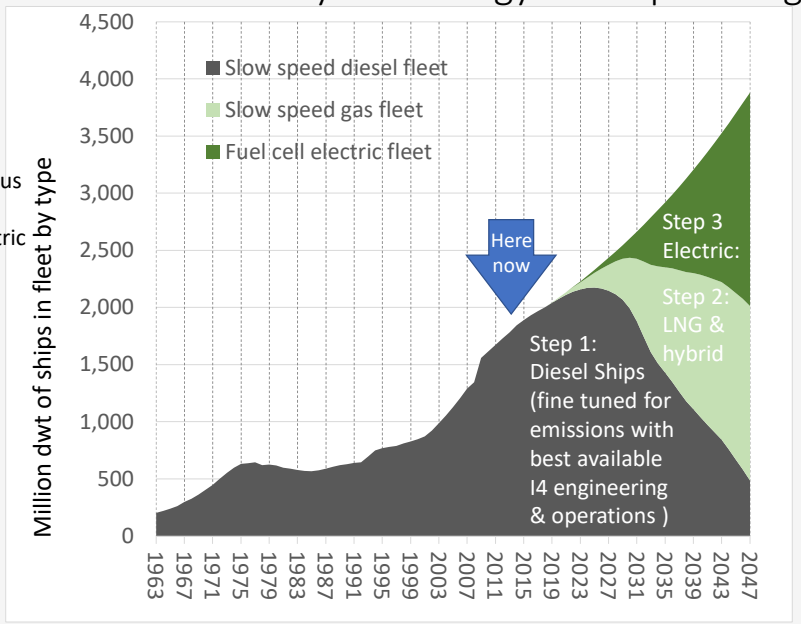
Developing a world fleet with revolutionary technology– 3 Step Strategy

- Focus on available technology, and decision related information.
- **Step 1** apply I4 technology & related innovations to existing designs.
- **Step 2** adopts gas and develops intermediate platforms including CANbus type protocols & batteries.
- **Step 3** introduces the zero carbon electric ship in some form, though we do not know yet what will work best.



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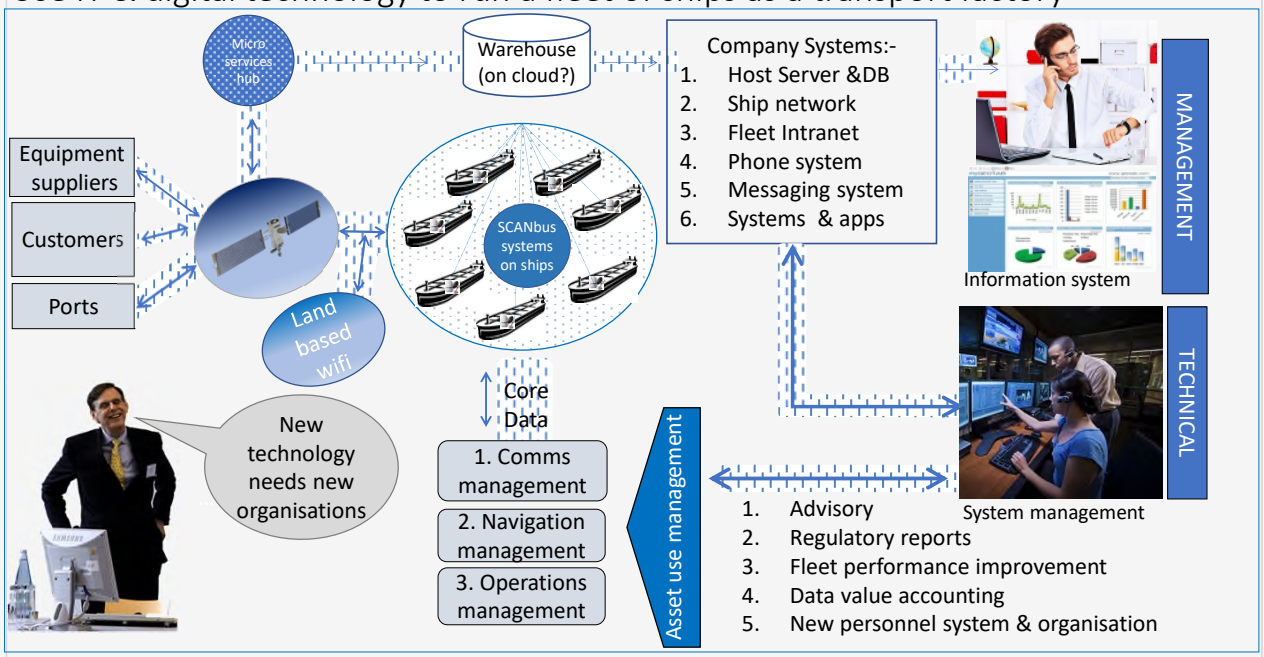
Use IT & digital technology to run a fleet of ships as a transport factory



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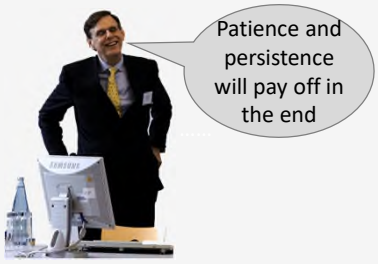
CONCLUSION: in the decades ahead the maritime industry faces 6 challenging tasks: -



1. Meet IMO carbon emission targets, door to door!
2. Focus on increasing the VALUE of sea transport rather than the volume.
3. Fine tune existing designs, while developing zero carbon propulsion
4. Focus on integrated ship systems which communicate robustly (SCANbus F2 etc)
5. Develop "sea transport factories".
6. Develop professional associations, education, training and personnel.

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