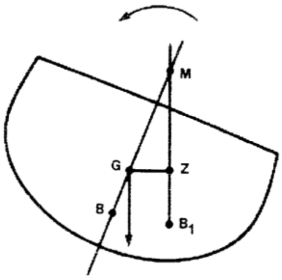
1 ai) With the help of diagrams, illustrate the various stability conditions of a vessel at rest

Positive Stability

* M is ABOVE G

* Righting Lever (GZ) brings vessel back

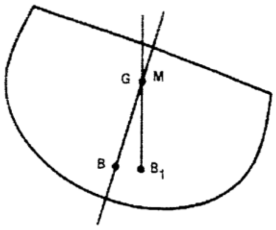


Neutral Stability …………(Cross Over CAUTION !!!)

* M CO-INCIDES G

- NO Lever (GZ)

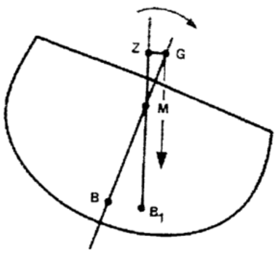
- Vessel remains @ ANGLE OF LOLL



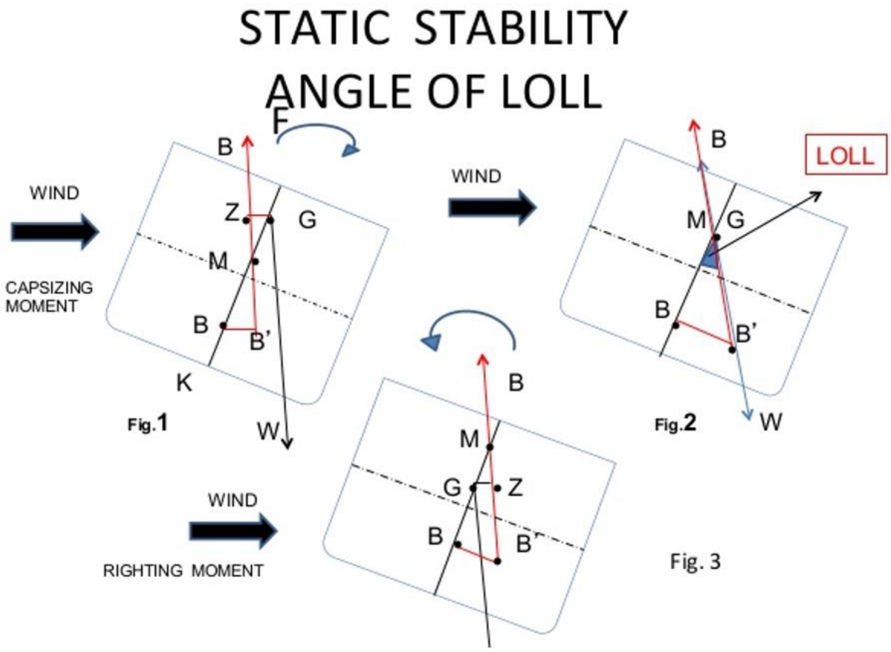
Negative Stability (Unstable)

* M is BELOW G

* Upsetting Lever (GZ) brings vessel further / Capsize !!!



ii) What is meant by an angle of loll, and how do we correct this condition?



Actions to correct .....

- Need to LOWER centre of gravity of the ship:

1. Lowering existing weights
2. Loading/adding weights at locations below the CG of the ship.
3. Discharge weights at locations above the CG of
   the ship.
4. Remove all Free surfaces Effects (FSE)
   – Top up slack tanks etc w

1b) Discuss the differences between Length Overall (LOA), Length Between Perpendiculars (LBP) and Registered Lengths along with their practical applications.

Length Overall (LOA) – Length of vessels as measured over all extremities; used for commercial use – stowage for cargoes

Length Between Perpendiculars (LBP) – Distance between the forward and aft perpendiculars measured along the summer load line; stability calculations

Registered Lengths – measured from head of the stem (FWD) to the head of the stern post (AFT). It is the official length in the ship registration by flag states. Used in documents relating to the ownership and matters related to ship business – ie. Taxes

2a) The shipping industry is making significant headway towards greener marine environment. As prevailing, the maritime industry is taking advantage of the latest technologies to target lowest possible zero global pollution.

Discuss any two technologies as related to the above

Technologies towards green shipping

1. No ballast system
2. LNG Fuel for propulsion & Aux
3. Scrubber system
4. Propeller/Rudder system
5. Waste Heat recovery system
6. Exhaust gas recirculation system
7. Water in fuel system
8. Wind Propulsion
9. Solar Propulsion

Explain any two above

b) Discuss the following statement: “For autonomous shipping to gain regulatory and societal acceptance, this technology must be at least as safe as traditional ships”

Regulatory Barriers …..

- COLREGS
- SOLAS
- STCW
- ISM
- VARIOUS NATIONAL LEGISLATIONS

Challenges Ahead for Autonomy Vessels :

1. Definitions issues:

- As of now …no well set definition of what an autonomous or unmanned ship is on the global front.
- An autonomous ship is a ship by international law ???

2. Absence of crew issues:

- UNCLOS defines that all ships must be "in the charge of a master and officers who possess appropriate qualifications". SOLAS, MARPOL, STCW and the Paris MoU as well as the EU directive 16/2009 on PSC all presume that the master will be present onboard…….This is a BIG Question !!

3. Issues of navigation rules:

- Capability to timely and effective execution of manoeuvres to avoid collisions in accordance to Regulations as per COLREGS.

4. Issues of seaworthiness and error in navigation:

- Implied warranty that the vessel is “reasonably seaworthy in all respects” ?????
- This warranty fundamental and basis of all policies in marine insurance at the commencement of a voyage. As per Hague Visby Rules, all ships to be seaworthy (Clearly requires ship to be properly manned !!!)

=

5. Issue of cyber risks:

- Environment of HIGH Dependency on computers and other robotic equipment, which could escalate in a cyber attack.

6. Issues of liability and its limitation:

- In general, civil liability in shipping is regulated , and most jurisdictions require a fault-based standard.

- For ships with a degree 3 or 4 autonomy, Big challenge when required to determine human fault …….As ships are navigated without any real-time human intervention, relying only on pre-programmed algorithms operated by AI or by remote operators.

c) The maritime industry is experiencing rapid advancements in technological innovations with significant impacts on ports and terminals. List down four port technologies in this respect

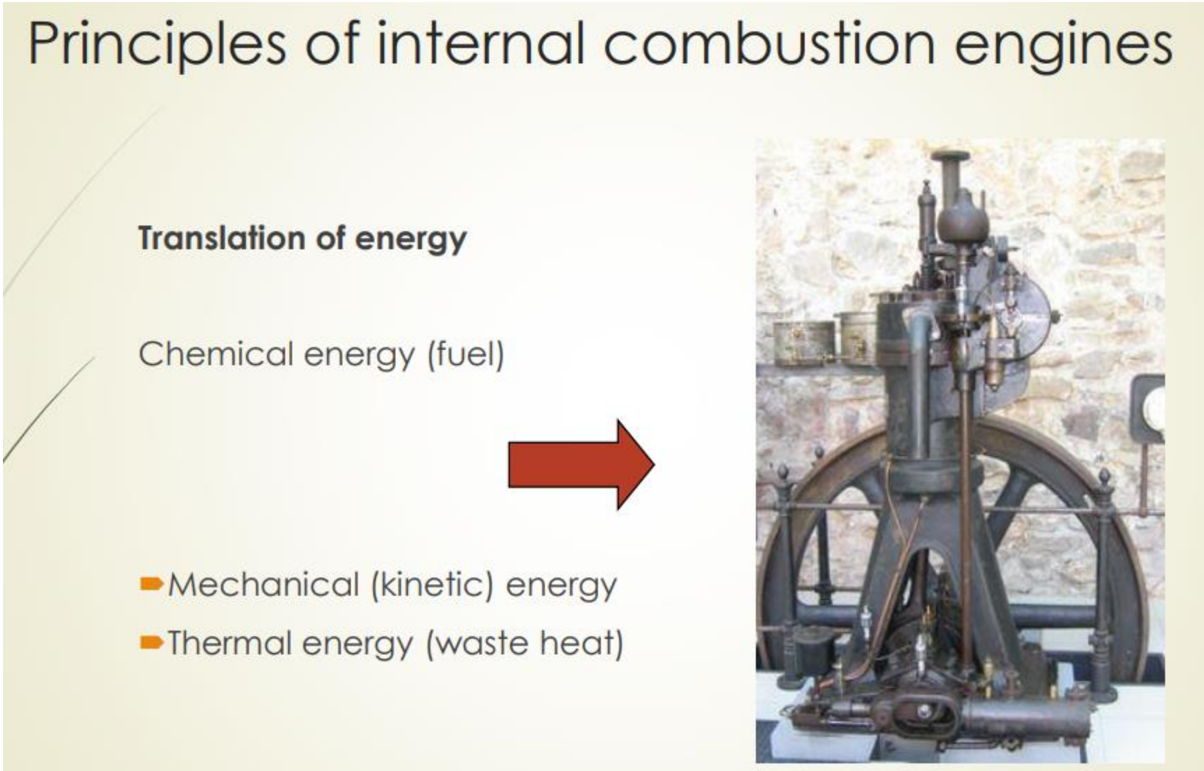
1) Drone technology

2) Internet-of-Things (IOT)

3) 5G

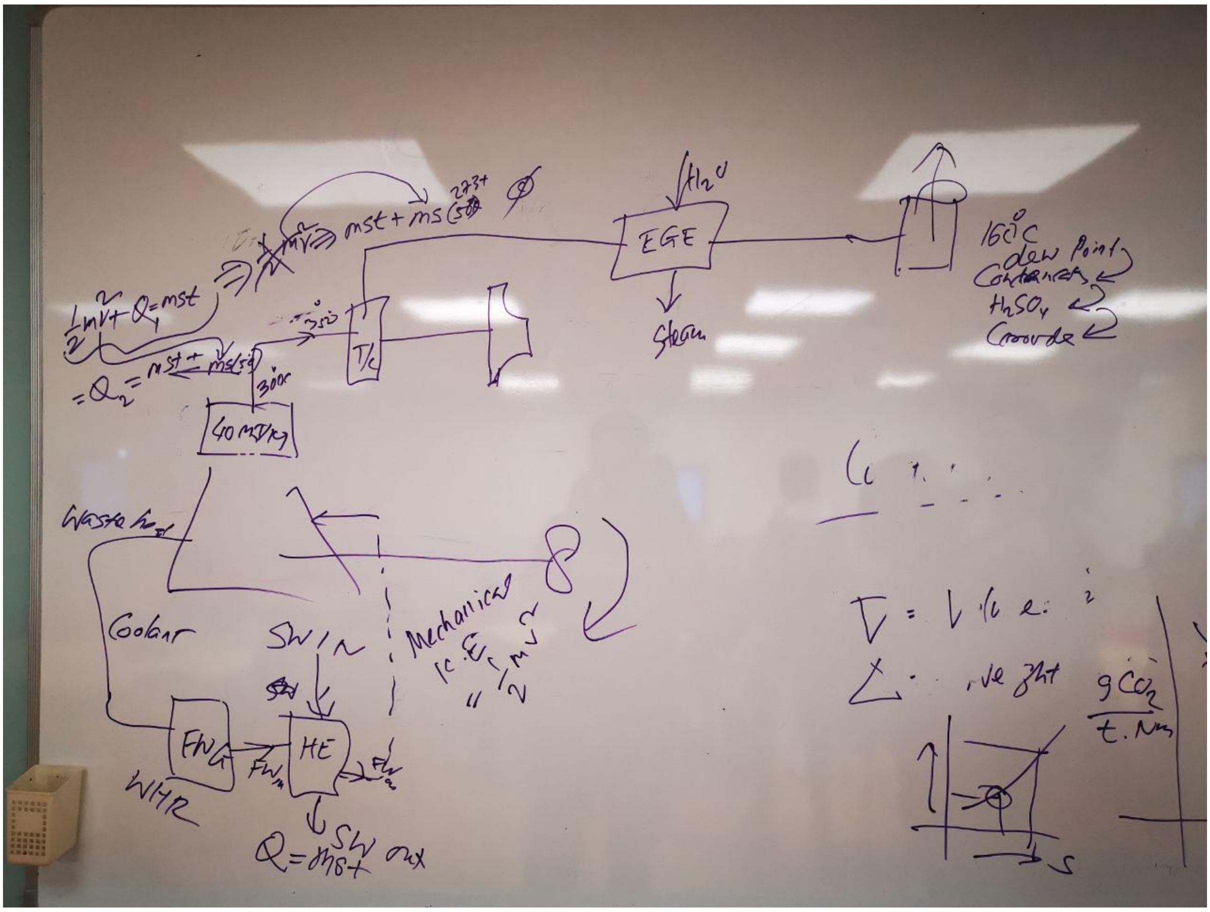
4) Augmented Reality

3a) Explain the principles of an internal combustion engine. What is the overall efficiency of a marine diesel engine and the typical value of energy content of marine fuel?



48-55% efficiency

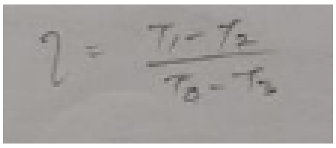
3b) Describe with a schematic diagram how the chemical energy of marine fuel is transformed into other useful energies including the WHR (waste heat recovery)

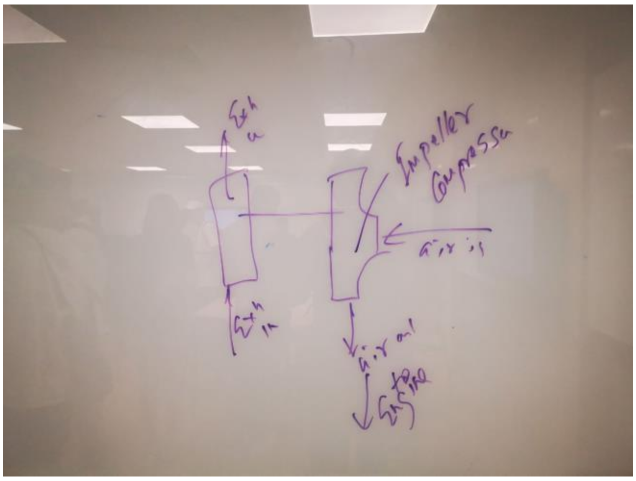


3c) The average temperature of all the units of an engine is 300 degC. The same exhaust before the turbocharger registers temperature of 350 Deg C. Explain the reason.

The gas that leaves the exhaust valve is 300 degC and it gets blocked by the turbocharger fan blade. Since energy cannot be destroyed or created, the kinetic energy converts into heat energy – thus increasing its temperature to 350 degC.

d) The temperature difference of exhaust gas inlet of two turbochargers of the same engine is 350degC and the gas outlet temperature of turbocharger A is 250 deg C and that of turbocharger B is 300 deg C. Which turbocharger is running more efficiently? Explain the reasons of lower efficiency of the turbocharger in question.





Turbocharger A is running more efficiently as it converted more heat energy into kinetic energy; thus the lower temperature

4a) The operation cost of a ship (OPEX) is comprised of various expenses. What typical percentage of the OPEX is attributed to the fuel?

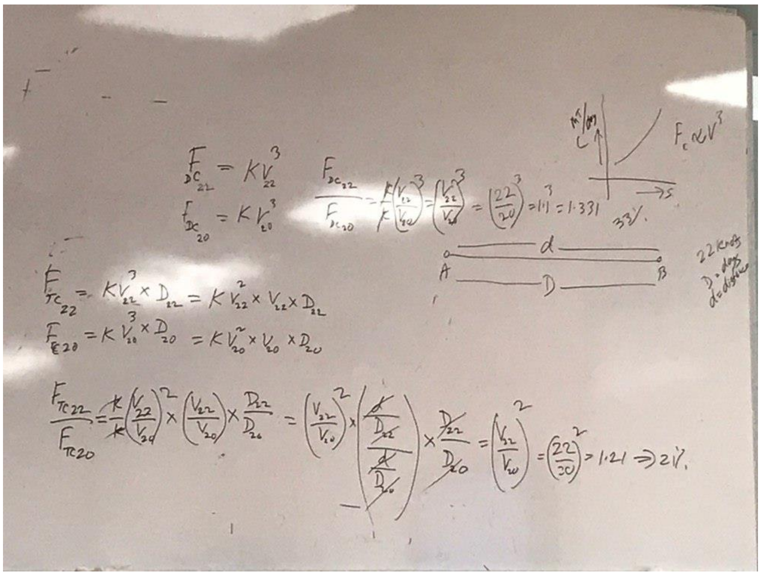
50-60%

4b) Every ship has an SEEMP, which sets a goal of reducing emission as per EEOR. To reduce EEOI, the plan is made of various energy efficiency savings initiatives called energy saving levers. Describe at least two operational energy saving initiative with appropriate mathematical equations and graphs where applicable.

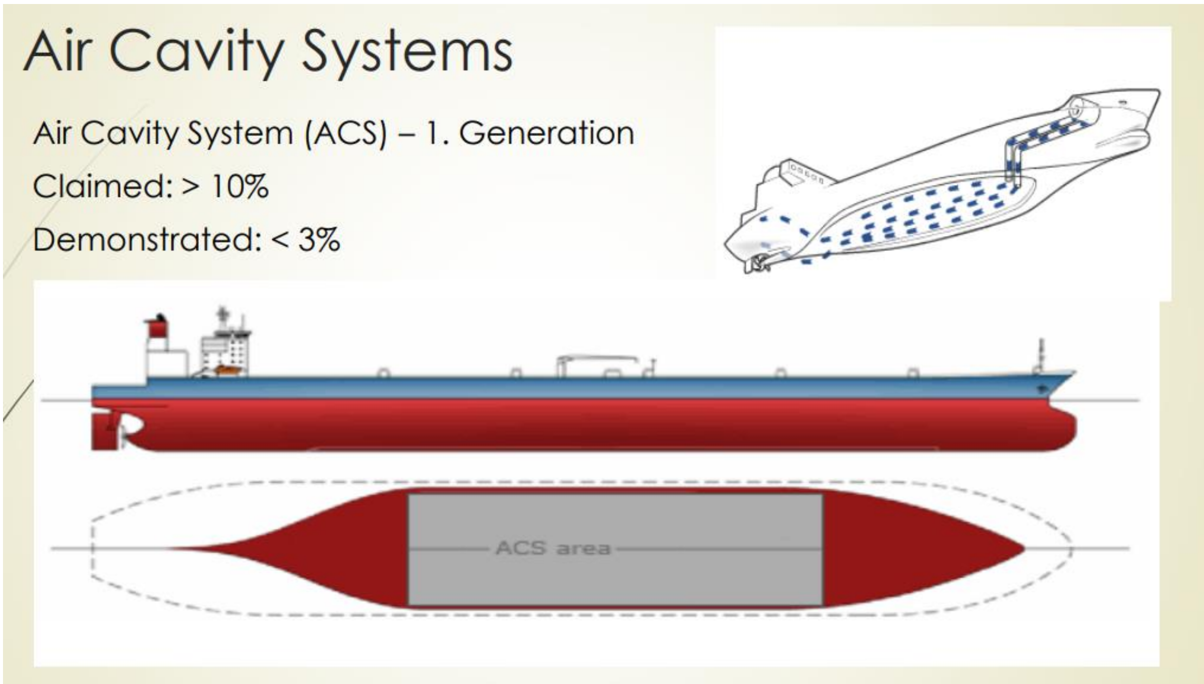
Slow-steaming

Hull Cleaning

4c/d) Show with the mathematical formula, what percentage of reduction of the daily fuel consumption of a ship would be, if the speed is reduced from 22 knots to 20 knots.



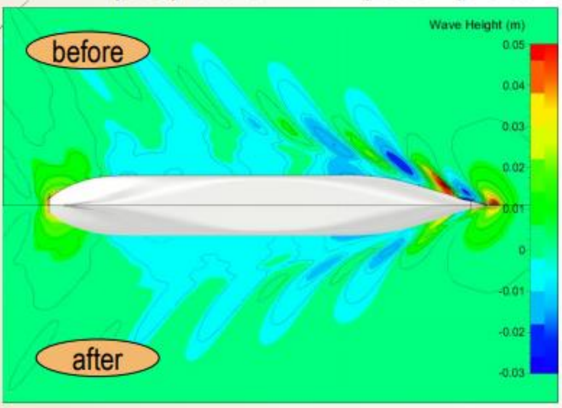
4e) Every newly built ship must have an EEDI. Ships with lower EEDI are more efficient, have lower consumption and are in good demand in the charter market. Describe two features, fittings and/or PIDs of the ship which could contribute to the lower EEDI.



Wave resistance

bulbous bow refit - optimized for speed (range)

- formal optimization may gain 2-5%
- re-fit should be considered (~ 250,000 €)
- payback < 1 year possible



CLT propeller

CLT = Contracted and Loaded Tip

- **noise and vibration reduced**
- **better propeller efficiency for highly loaded propellers**
- up to 16% fuel savings claimed for retrofitted tankers/bulkers
- claims doubted unanimously in survey with propeller experts

same idea

PBCF = Propeller Boss Cap Fins

Boss Fins changes flow at hub

No hub vortex with PBCF

Associated energy recovered

Installation cost ~$100,000

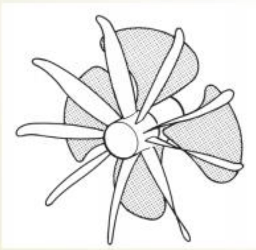
- fuel savings up to 6% claimed (?)

(independent model tests gave 0.5%)

- can be retrofitted
- reduces vibrations and noise

Grim Vane Wheel

- rotates behind propeller
- has larger diameter
- generates additional trust
- fuel savings of 7-10% reported
- mechanically delicate



5a) Explain the advantages and disadvantages of 2 stroke and 4 stroke diesel engines

Principles of internal combustion engines

Advantages of 4-stroke engines for marine use:

- better gas exchange, efficient combustion
- good power to weight ratio
- compact design
- blowers or turbochargers not required

Mainly used as auxiliary engines or small / medium sized main engines.

Principles of internal combustion engines

Advantages of 2-stroke engines for marine use:

- Firing every revolution
- high degree of efficiency, up to 55%
- Simple, robust design
- Low speed engines => no reduction gear required

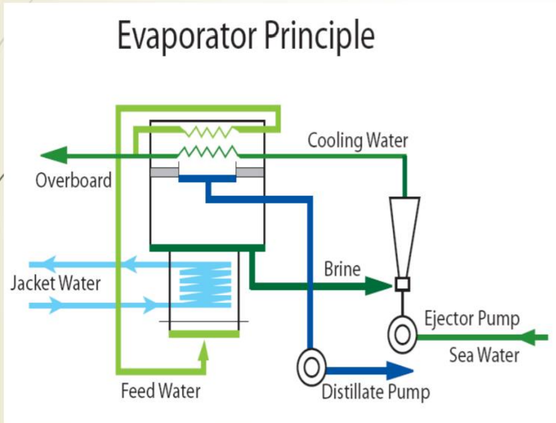
Mainly used as big main engines

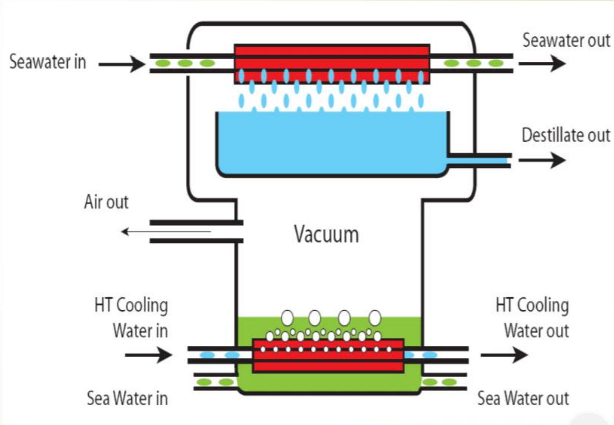
b) sketch and describe the principle of a freshwater generator

Fresh Water Generator:

- Evaporator:
  - Ejector creates vacuum evaporation temperature ca. 60°C
  - Heated by HT / jacket cooling water or steam

Fresh Water Generator:





c) identify and describe two applications of digitalization in shipping

Digital Twin

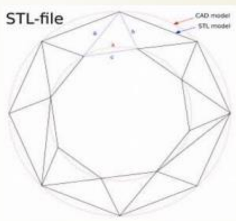
- The Digital Twin is a virtual image of an asset, maintained throughout the lifecycle and should be easily accessible at any time
- It is a central part of digital asset ecosystem and it will enable a new generation of advanced analytics and understanding of the product
- A Digital Twin should be able to integrate data from many different software products and handle them in a managed environment throughout the whole lifecycle
- The concept of the Digital Twin will potentially enhance information management, understanding and collaboration, to prevent costly mistakes and rework
- The combination of holistic design and Digital Twin has the potential to revolutionize the ship eco system from early design & planning to design & operation and demobilization

Potential of Digital Twin in the design & building phase

- Many yards and ship designers are now challenging their way of doing ship design and are looking on new process and supporting systems
- Legacy processes can involve as many as 15 to 25 different systems across the different design disciplines from early planning to fabrication
- Data consistency and changes are hard to drive through and manage when the data definition and information is kept in so many different systems
- To avoid failure, many costly efforts are spent on non- value adding processes. It is also pricey to secure that relevant people can access the correct data in the required time span
- In a demanding digital and disruptive world [with focus on cost cutting, improved innovation and fierce competition] yards and ship designers needs to be challenged to look for a novel approach for designing vessels for the next decades

3D Printing (additive manufacturing)

- In Additive Manufacturing (AM) or 3D printing, as is known is consist of 4 fundamentals
  - **INPUT**
  - MATERIAL
  - METHOD
  - APPLICATION



- **INPUT**
  - A model or component is modelled on a CAD/CAM system. CAD files are **digitalized representations of an object**. They're used by engineers and manufacturers to turn ideas into computerized models that can be digitally tested, improved and most recently, 3D printed.
  - The model is then converted into **"STL" (STereoLithography) file** format which approximates the surfaces of the object by polygons
  - A computer program analyzes the .STL file and **"slices"** the model into cross sections
  - The cross sections slice by slice are systematically recreated to form the real 3D object

3D Printing Technology

- There have been several 3-D printing processes invented till date but very few are commercially affordable and sustainable
- Currently, this technology is used in industries to produce scientific equipment, small structures and models for various applications
- For shipping, recently, a ship's **propeller** has been built through 3D printing
- Further developments in this process can lead the industry to use this technique to build complex geometries of ship; e.g. **bulbous bow** easily
- 3-D printers are also currently being used, in a limited scale, for quick replacement of ship's parts for **repairing purpose**