# What is 3-D Printing?

- 3-D Printing or Additive Manufacturing is a process of making three dimensional solid objects from a digital file.

- Here an object is created by laying down successive layers of material until the object is created.

# Origin of the Concept

- Concept launched in 1984 by Chuck Hull in USA.
- Named as 3D systems.
- After near bankruptcy now worth USD 6 billion.
- Now based in Rock hill, South Carolina.

# Application as of today

- Currently used in Motor Vehicles , Aerospace machinery, Electronics and Medical equipment & products.

Comprised of –

- Motor vehicles :19.5% of Current output , 0.01% Industry share
- Aero Space : 12.1% of Current output , 0.02% Industry share
- Industrial/ Business Machines:10.8 %of Current output, 0.01% Industry Share
- Medical / Dental : 15.1% of Current Output , 0.04% Industry Share
- Govt./ Military : 6.0%of Current output , 0.05% Industry Share.
- Architectural : 3.0%of Current Output , 0.01% , Industry Share
- Consumer Products: 33.6% of Current output , 0.01% Industry Share
- **Market Penetration in 2011** : 8%.

**SO SUFFCIENT ROOM TO GROW !!!**

- 62.8% of all 3D printed commercial/industrial units sold in 2011 were made by **– Stratasys , Z-Corporation and 3D systems.**

- **Wohlers Associates** forecast in 2014- 3-D printing to be USD 4 billion Industry in 2015,
  USD 10.8 billion by 2021.

- Assuming a saturation level between 5%-35% , Industry is forecasted to reach 50% of market potential between 2031-2038 and 100% between 2058-2065.

- $50 billion between 2029-2031 and $100 billion between 2031-2044- **Thomas, Douglas Report**.

- Globally : $967 million collections in Revenue in 2013 .

# Benefit for Maritime Industry ?

- A ship's computer may one day have a a database of 3-D CAD images of spare parts. The 3-D printer can produce made to spec replacement in a matter of minutes to few hours.
- Lower Inventory/ transportation cost along with decreased risk to supply disruption. Thus reduction in overall costs.
- Lighter components, reduced fuel costs, combustion engine with reduced cooling. Thus reduction in total energy consumption of the ships.
- Customized Ship for a Specific Purpose.

- In 2016 , Port of Rotterdam set up Rotterdam Additive Manufacturing(3D printing ) Laboratory- **RAMLAB** to provide large metal 3D printed parts .

- **FOKKER** (Aerospace) and **SIEMENS**( software) participated in the R&D for a pilot project.

- Printed: a Propeller , Cooled Valve Seat ,Space Ring, Hinge , T-Connector, Manifold etc.

- **Maersk** has already installed on few ships.

# Existing processes /technology to be replaced / improved by 3-D Printing.

- Transportation of small value spare parts makes no economic sense.
- Making precision parts is a skilled and labour intensive job.
- Material wastage and discarding of inappropriate parts during research.
- Costly and time consuming during traditional manufacturing.

# Existing processes /technology to be replaced/improved by 3-D printing.

- For Export/Import, Ship's travel across oceans , have to carry large number of spares.
- Armies/Navies worldwide have to carry all vital spares to repair any equipment on the battlefield.

# How 3-D printing improve/replace the existing processes

- Biggest benefit-complexity for free.
- All precision, labour intensive and time consuming jobs handled by 3-D printer. Thus time and cost efficient. Reduce wastage of material as precise product printed.
- Immediate availability of spare parts for repair/replacement. No need to carry large inventory. Shall save space and reduce the amount of money locked in large inventories In 2011, an average of $208 billion ( 14 % of annual revenue) held in inventory for med/high tech manufacturing with an estimated $52 billion as holding cost.(3% of revenue)

- Armies/Navies can change strategy because of immediate availability of spares, on site printing.
- US Navy , Royal Army, British Navy to use 3-D printed unmanned vehicles and ships in next 15 years –Report from Qinetiq Group Plc.– govt. defence research lab
- These features shall transform maritime maintenance and logistics supply chain.
- Lead time cut from weeks to days. HHI estimates saving of USD 1.8 billion to Korean Shipbuilding Industry due to localised manufacturing.

# How much feasible is implementation of 3-D Printing.

- Shipbuilding and maritime industries lag behind in 3-D printing as compared to aviation / automotive and defence.
- Several ships' spare parts are large, non availability of large 3-D printers currently.
- Falling Oil prices and slowing world economy had lead to reduction in R & D and staff.
- Thus investment to commercialize new technology is very low.

- However, continuous technological advancement in 3-D printing, outweigh the above.

- Considering benefits such as lower weight, fewer parts, less labour intensive, less stock, lead time reduction and quicker alterations , the concept of 3-D printing looks promising.

- Complex technological processes combined with 3-D printing technology can be cost effective.

- Higher subsidy in marine sector like aviation industry can push 3-D printing.

- Given the large-scale nature of the parts needed we will expect shipbuilding to be slower to adopt 3D printing than other industries as large scale investment is needed to commercialize the same.

# Biggest challenges to 3-D printing and continued safe use.

- Material:

1. How do you set up?
2. How do you optimise and adopt detailed designs of your spare parts model to printer?

- Technological difficulties

1. Printer works at its own pace; can't do overtime.
2. Challenge especially if very few standardised parts available.

3. Actual printing parts is much complex than to carry data in computers; special softwares needed to give instructions to printer.

4. Printing involves adhesives connecting layers upon layers; Thus printed part may have a different 3-D structure than actual parts and hence strength/durability issues.

Whether they perhaps can be satisfactory for specific application?

5. There can be issues with ability to replace large parts or ones built with different materials. Limited size of print beds.

6. What if any particular part requires two different types of 3-D printers to print. Also stability of printer at sea , fire safety etc.

Perhaps a printer with multiple heads, designed to print with multiple materials simultaneously is the answer.

These are the questions which the industry still needs to figure out but also where the plot thickens. However, with achieved success in other industries, it gives good hope.

# Conclusion

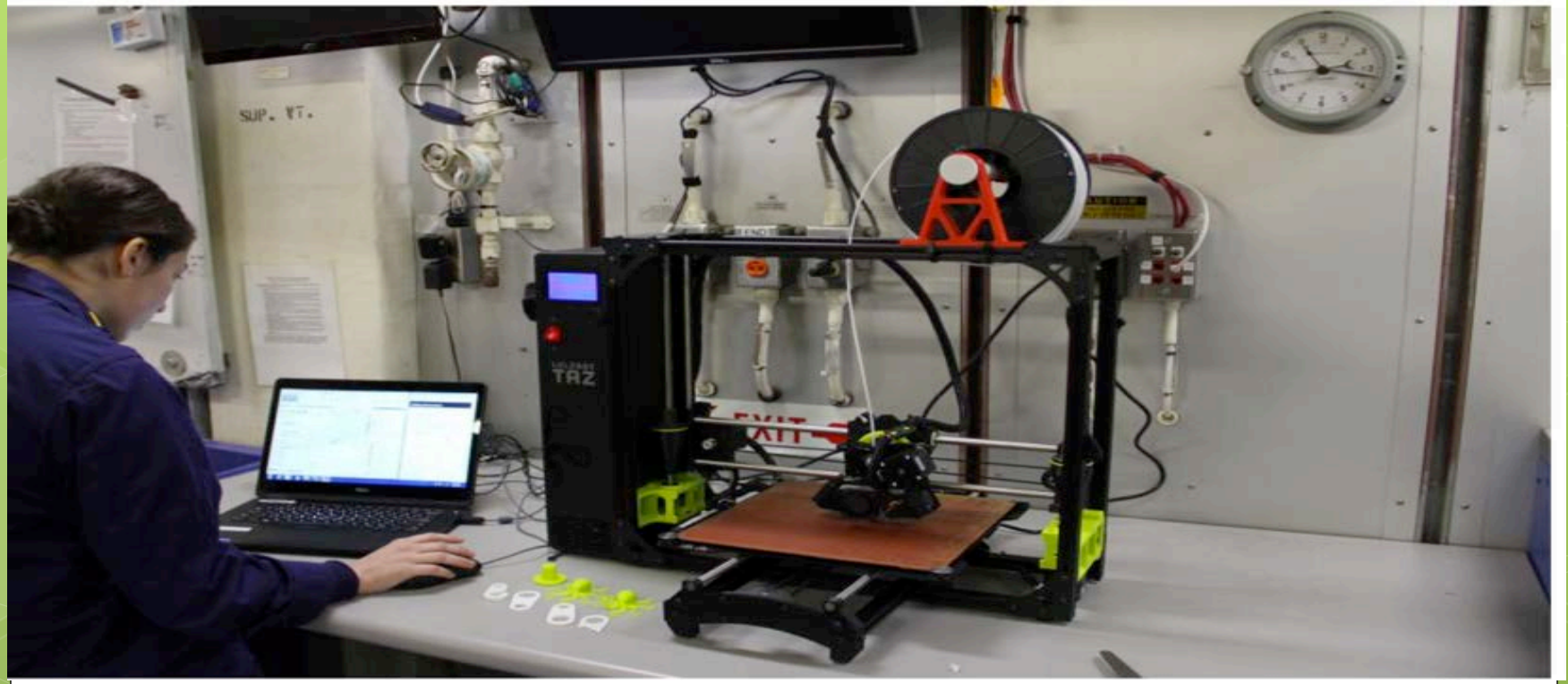
- It's clear that, if this technology is adopted on a large scale, the balance of cargo will shift from container vessels back to bulk cargoes, but that might not be the limit.

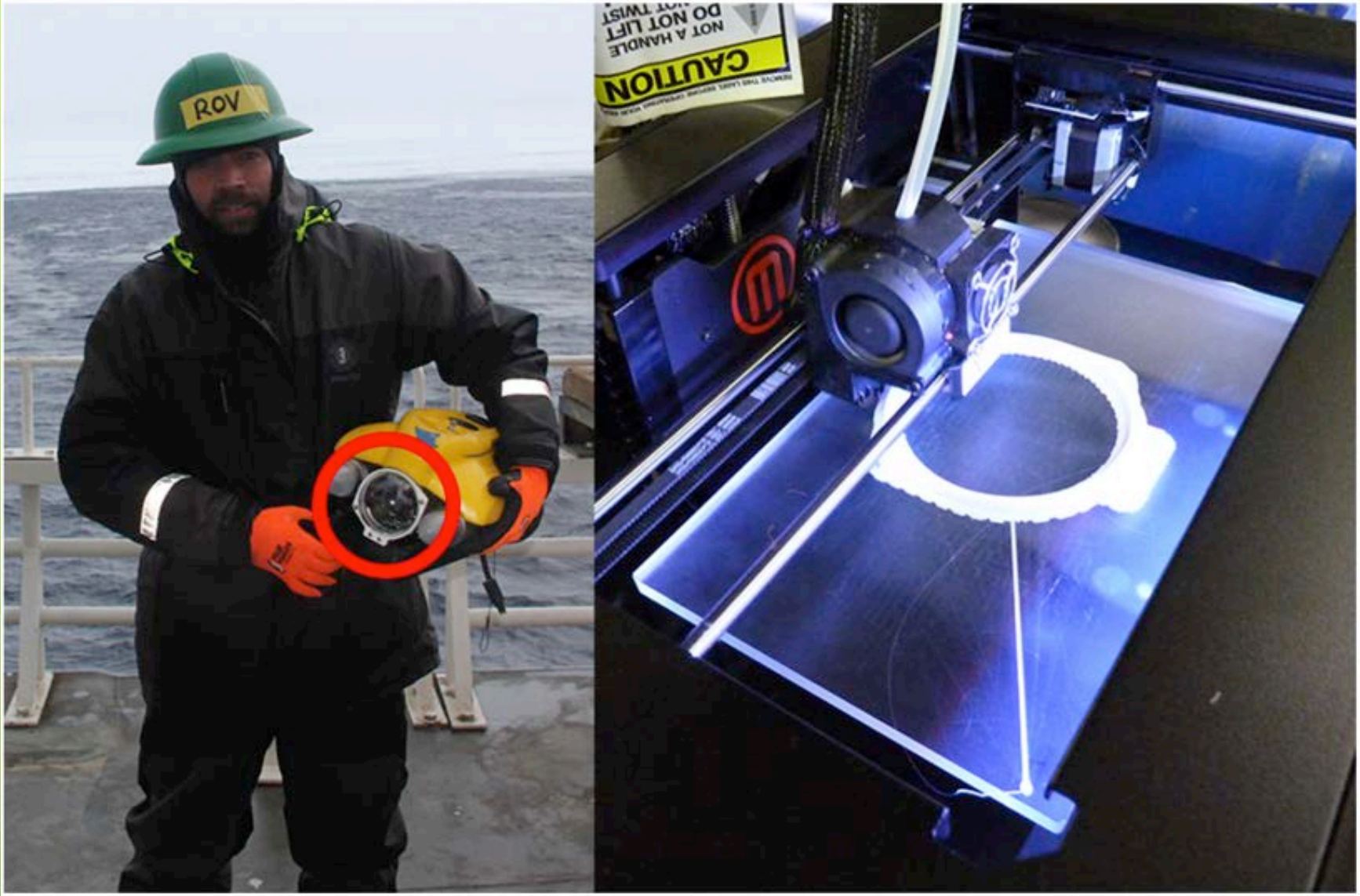
- Ships could conceivably become manufacturing plants. Install a bank of 3D printers aboard ship and the vessel could pick up raw materials overseas and begin manufacturing products during the long voyages.

- Just like the Industrial Revolution, the assembly line, the advent of the Internet and the Social Media phenomenon, 3D Printing will be a game changer.

- Class Approval???----Marine Insurance.....????

# US Coast Guard prints spare parts at sea.






*A replacement part for this remotely operated vehicle was printed in the Arctic aboard Coast Guard Cutter Healy in 2013. U.S. Coast Guard photo.*

*This prototype pump bracket for the H-65 medium range surveillance helicopter was printed by the U.S. Navy in collaboration with the Aviation Logistics Center in Elizabeth City, N.C. U.S. Coast Guard photo by Bill Bryan.*