

Marine Nuclear Propulsion

Presentation to KIVI-NNS Symposium 3/11/17

Aidan Goldsworth

Chief Engineer – Capability and Sustainment

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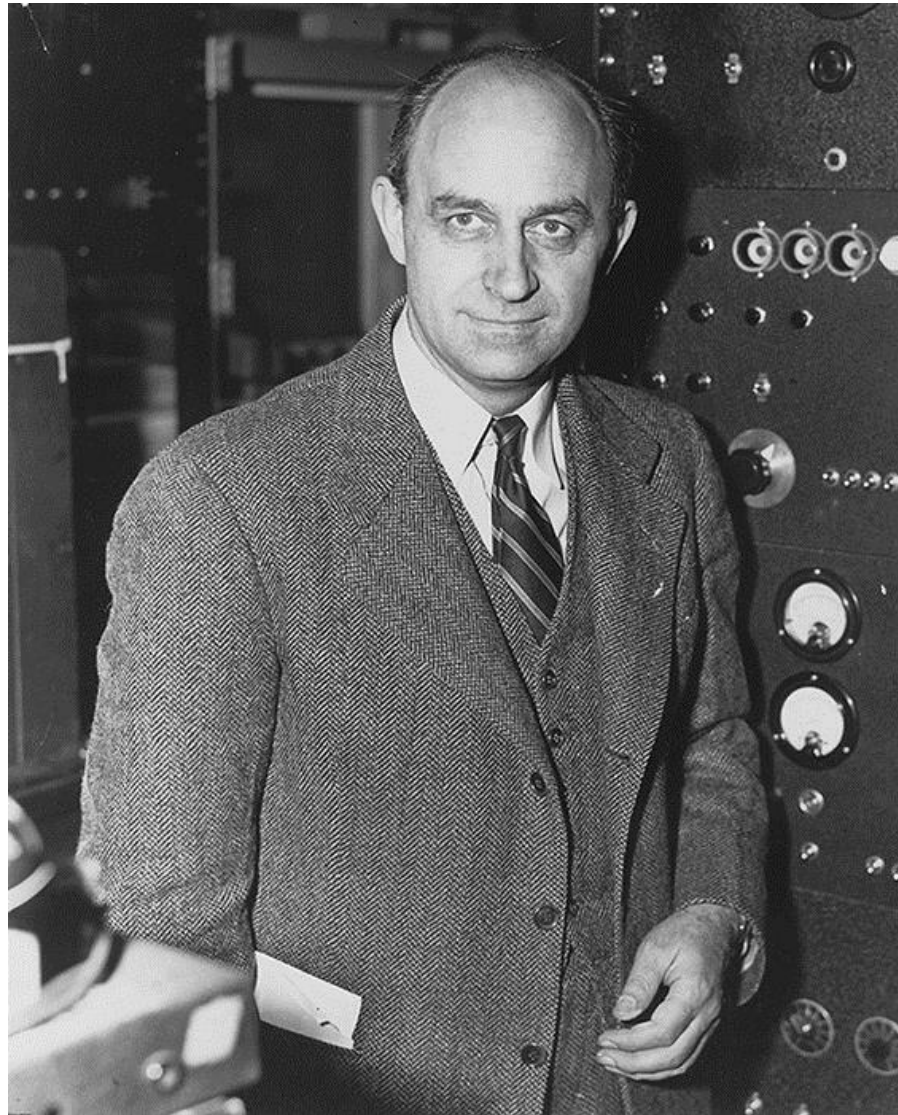
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Outline of Presentation

- Nuclear propulsion for Submarines
- Nuclear propulsion for surface shipping
- Where could we go in the future?



Fermi



Courtesy National Archives and Records Administration



Early Submarines



[flickr.com/photos/divemasterking2000/](https://www.flickr.com/photos/divemasterking2000/)



Early Submarines



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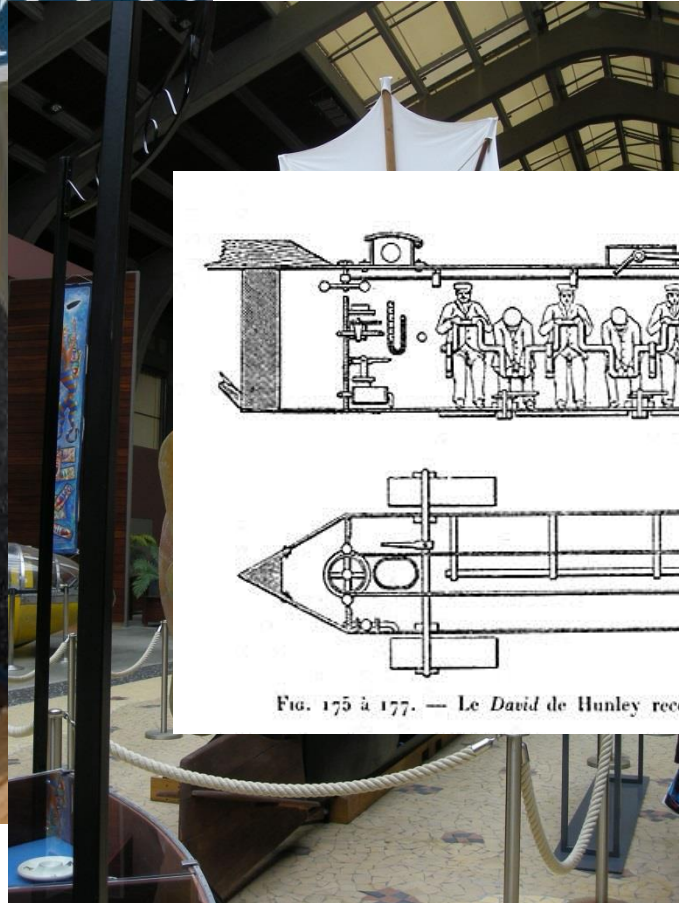


By Ji-Elle - Own work

Early Submarines



flickr.com/photos/divemasterking2000



By Ji-Elle - Own work

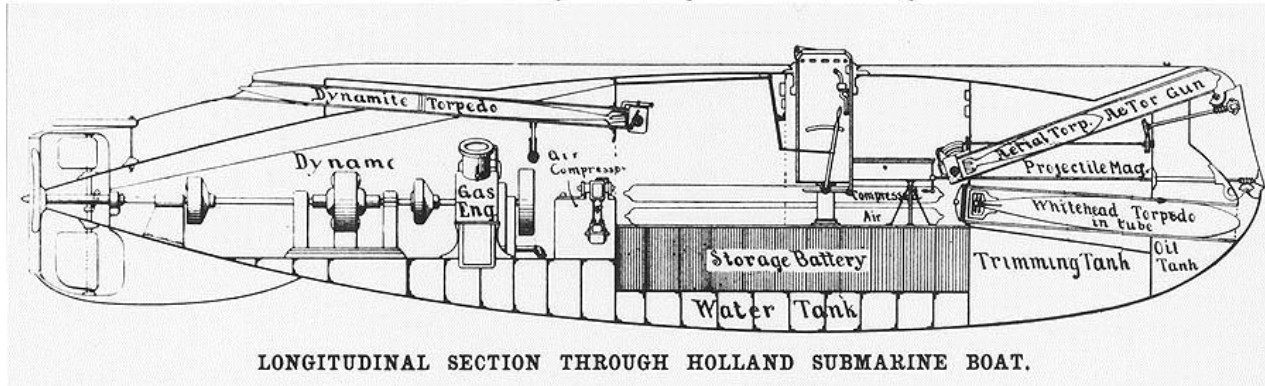
Fig. 175 à 177. — Le David de Hunley reconstitué d'après les dessins de M. William-A. Alexander (1863).

U.S. Naval Historical Center Photograph #: NH 58769



Later Submarines

Photo # NH 53474 Inboard profile drawing of submarine Holland, published 1898



U.S. Naval Historical Center Photograph #: NH 53474



Courtesy Imperial War Museum (collection no. 8308-29)

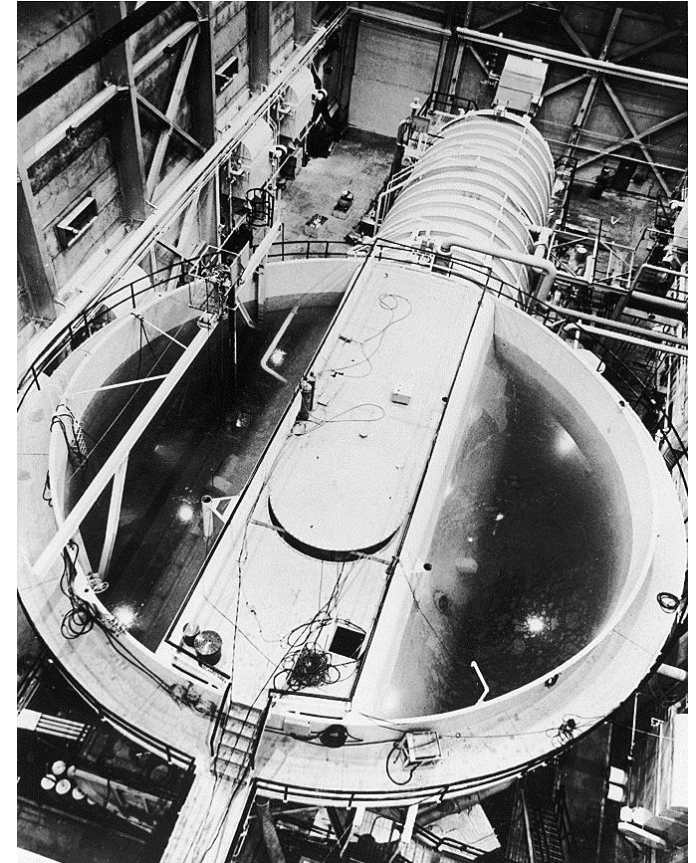
Rickover



Courtesy U.S. Naval Historical Foundation



Nautilus Prototype



Photos courtesy Idaho National Engineering and Environmental Laboratory

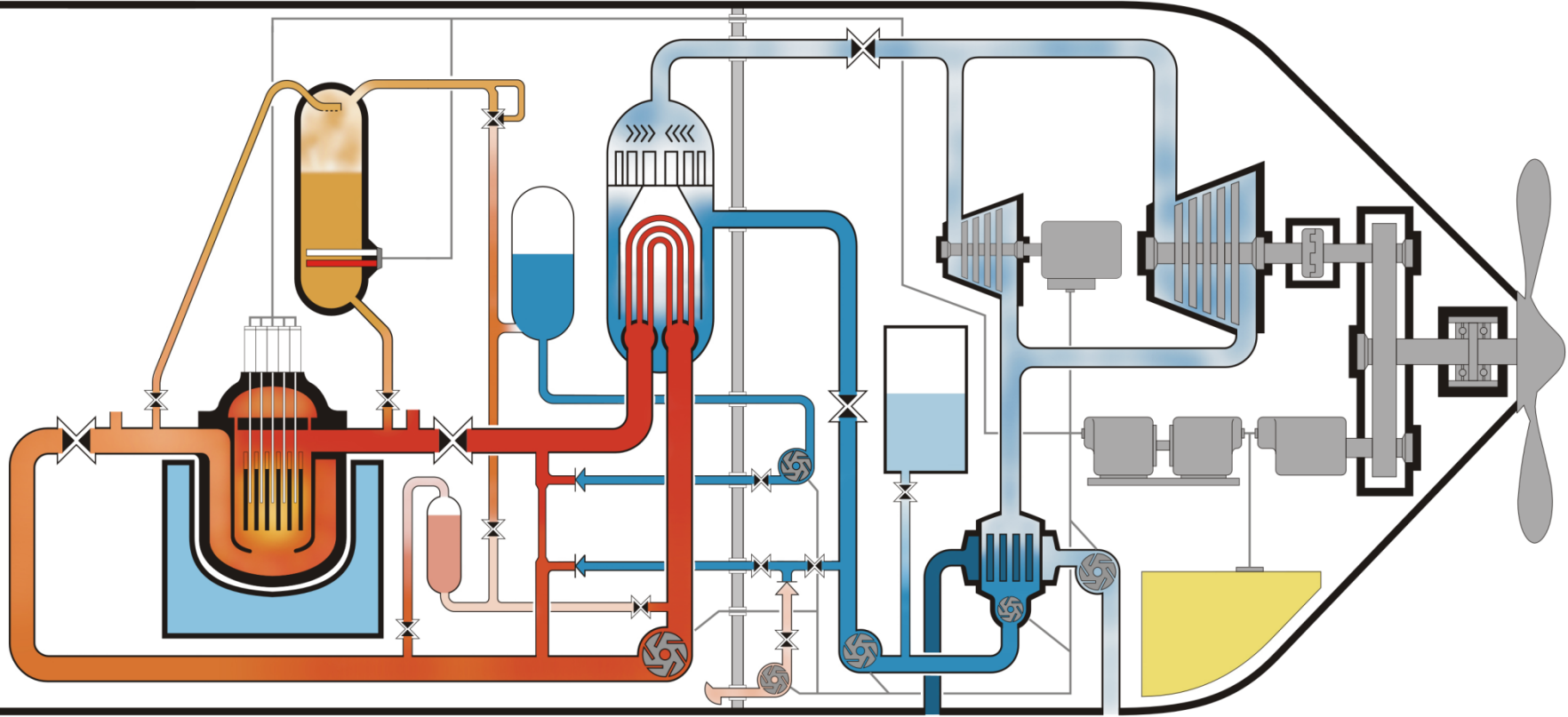
“Underway on Nuclear Power”



Courtesy U.S. Naval Historical Foundation



Typical Dispersed PWR



UK Experience

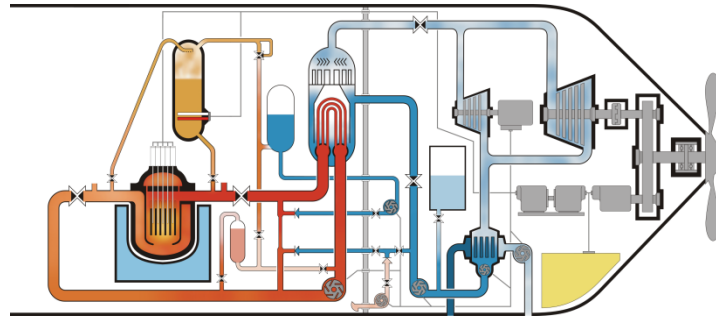


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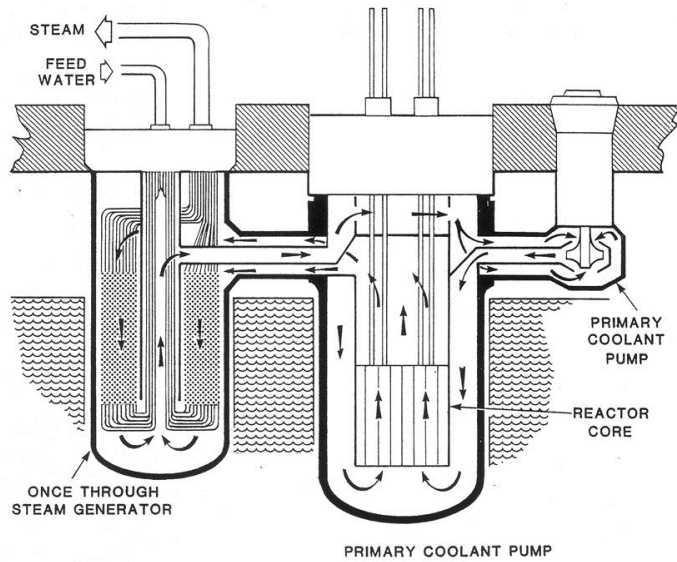


Marine PWR Options

Dispersed

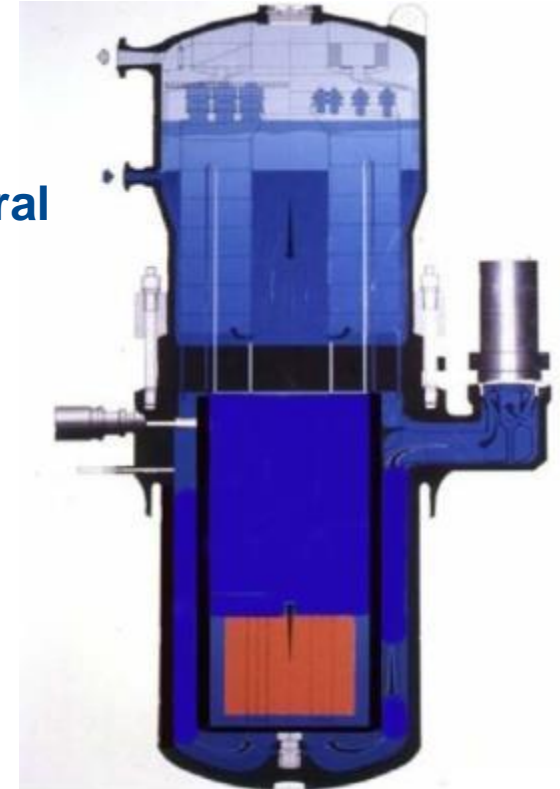


Close Coupled



Source untraceable

Integral



Source untraceable



Other Reactor Types

- **Liquid Metal Fast Reactors (LMR)**
 - Na
 - Pb-Bi
- **Heavy Water Reactors**
- **Boiling Water Reactors (BWR)**
- **Gas Cooled Reactors**
 - GTMHR
 - GFR
- **Molten Salt Reactors**



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commons.wikimedia.org/wiki/File:Alfa_class_submarine_2.jpg

Naval Surface Ship Nuclear Propulsion

Aircraft Carriers

US - 11

France - 1



USN – U.S. Navy VFA-146 official website



commons.wikimedia.org/wiki/File:US_Navy_110129-N-3885H-158

Cruisers

US - (9 decommissioned 1995-1998)

Russia - 1 (3 decommissioned)



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Communications Ship

Russia – (1 decommissioned)



United States Department of Defense

Merchant Ship Nuclear Propulsion

Ice Breakers

Russia - 10 including Sevmorput (3 decommissioned)



commons.wikimedia.org/wiki/File:Yamal.jpg



commons.wikimedia.org/wiki/File:Sevmorput.jpg

Cargo/ Passenger

US - 1 Savannah
(decommissioned 1972)



commons.wikimedia.org/wiki/File:Ns_savannah.jpg

Germany Otto Hahn
(decommissioned 1979)



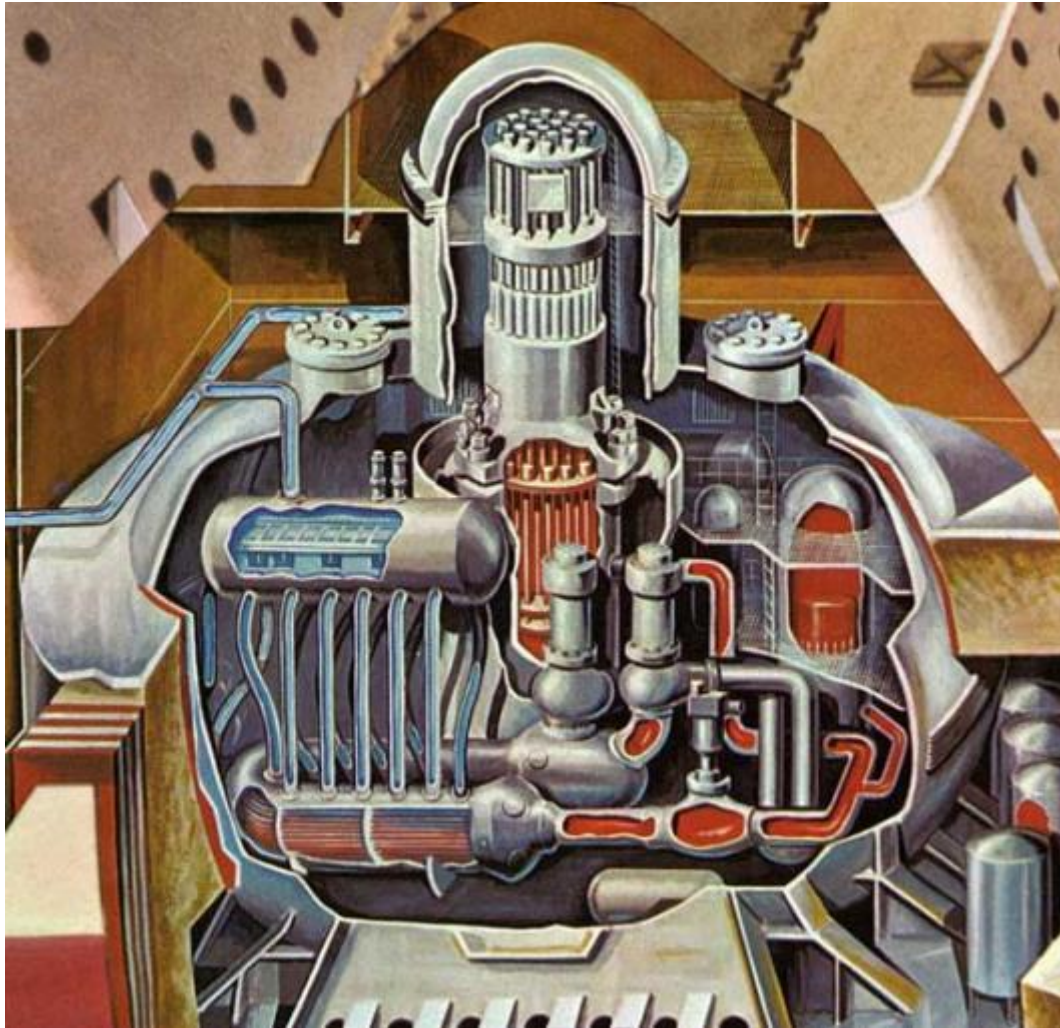
Bundesarchiv, B 145 Bild-F031999-0006 / Engelbert Reineke

Japan - Mutsu
(decommissioned 1992)



jolifukyu.tokai-sc.jaea.go.jp/fukyu/tayu/ACT95E/06/0601

NS Savannah



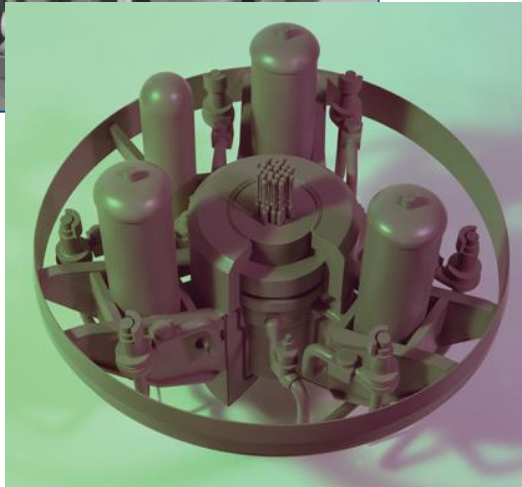
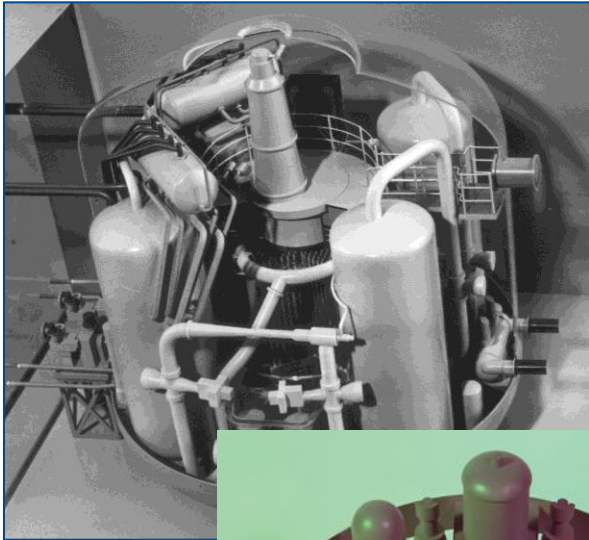
With permission: Maritime Park Association



Merchant Ship Nuclear Propulsion

Design – 1970's

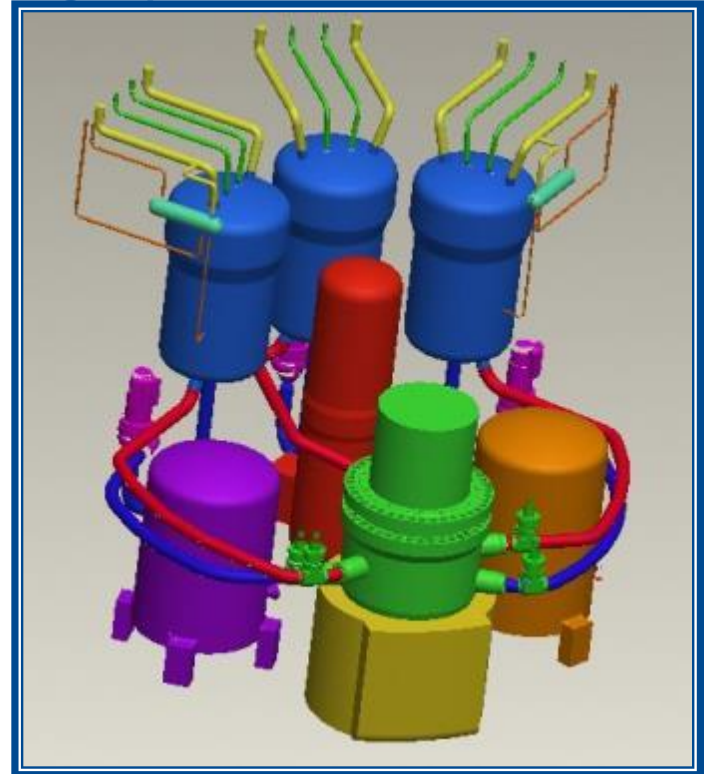
Merchant Ship Reactor



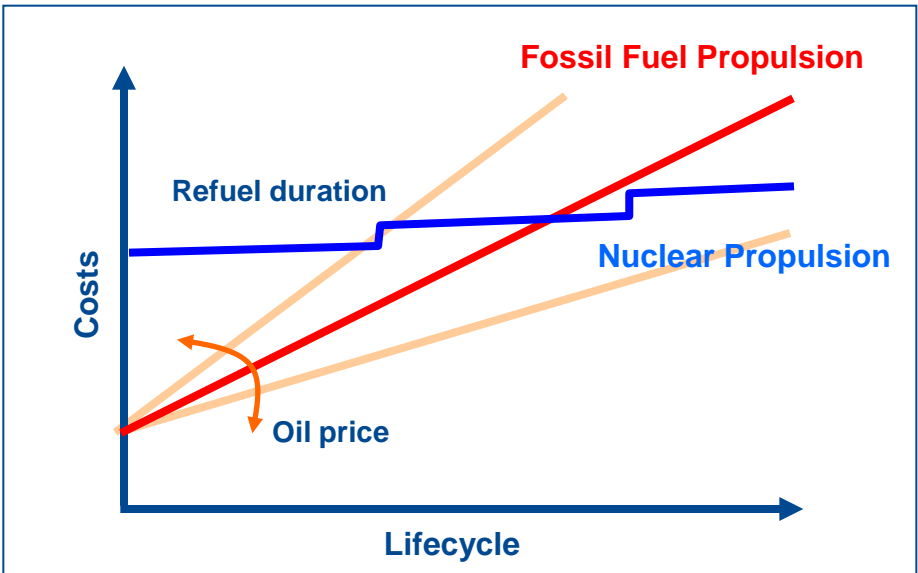
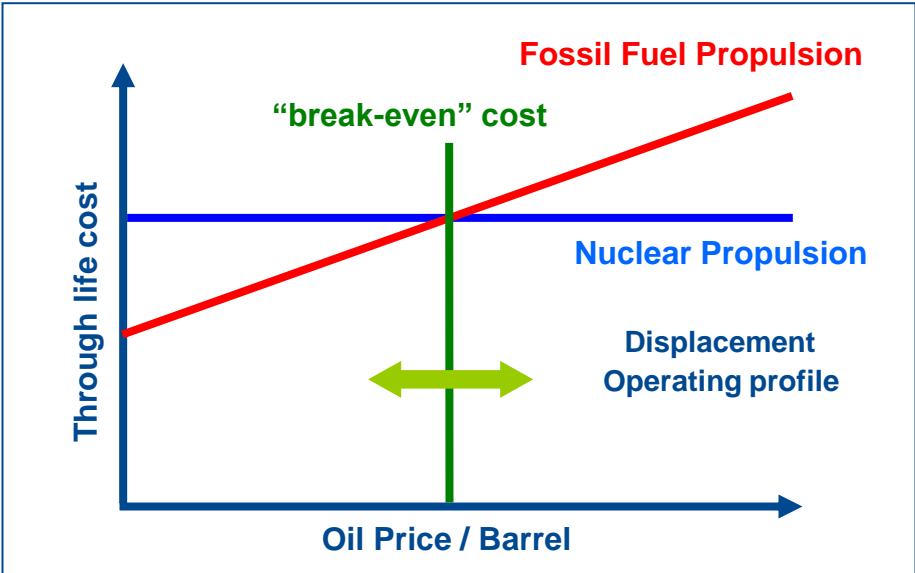
3 Loop PWR Icebreaker

Design – 2000's

High Speed Sea Lift

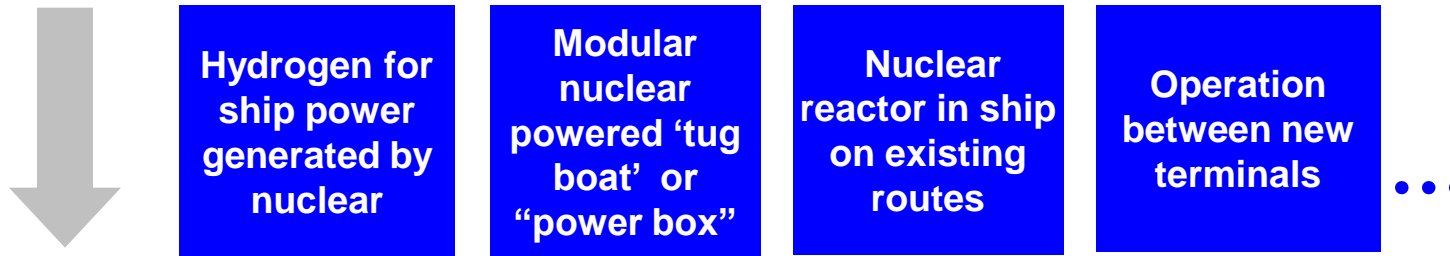


Business case



System level options

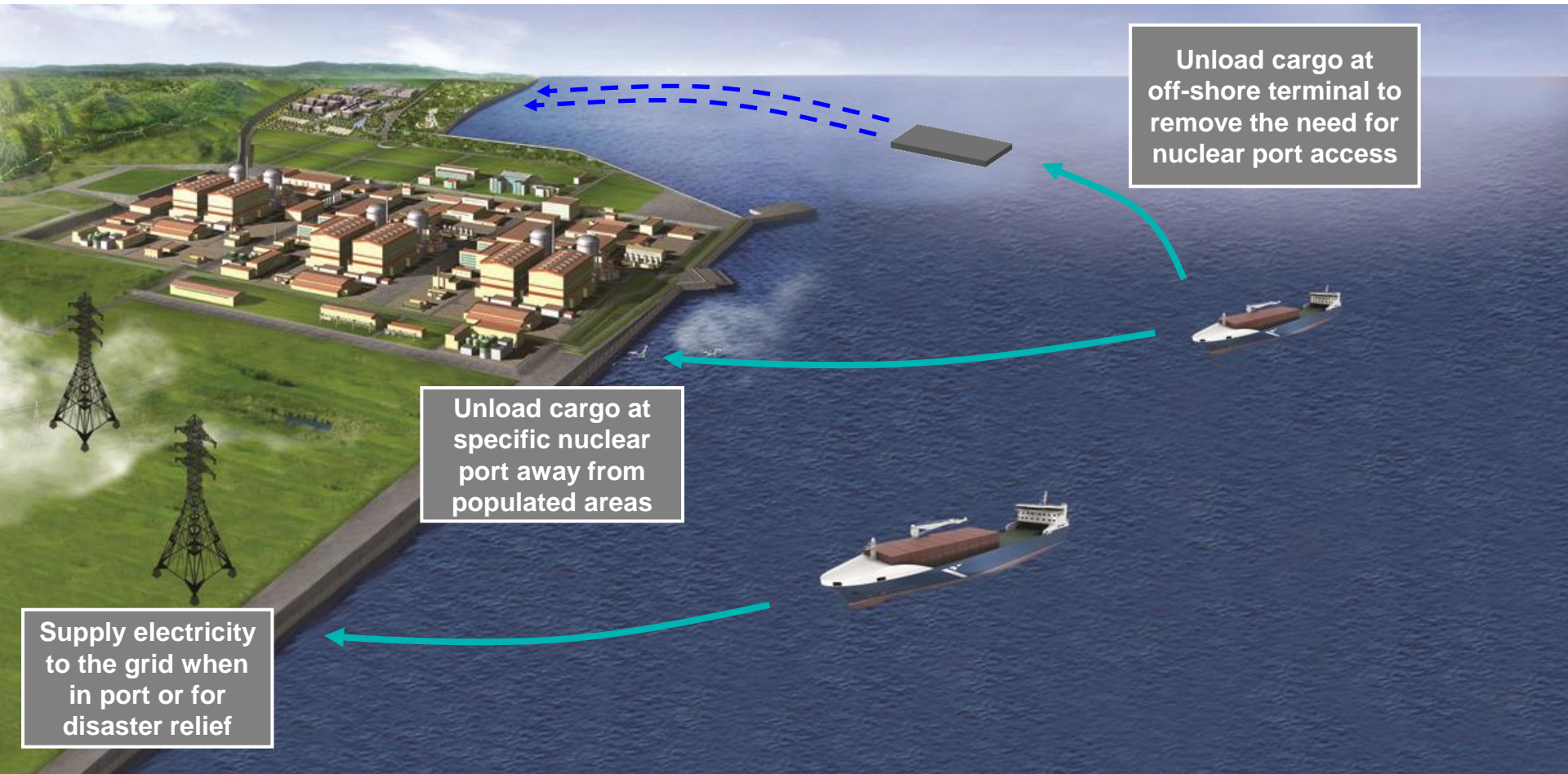
Super-system level



System level



A Super-System Concept



Supply electricity to the grid when in port or for disaster relief

Unload cargo at specific nuclear port away from populated areas

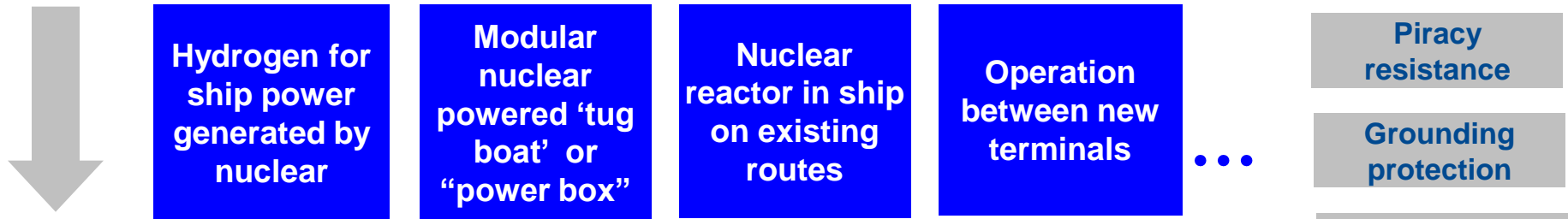
Unload cargo at off-shore terminal to remove the need for nuclear port access



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System level options

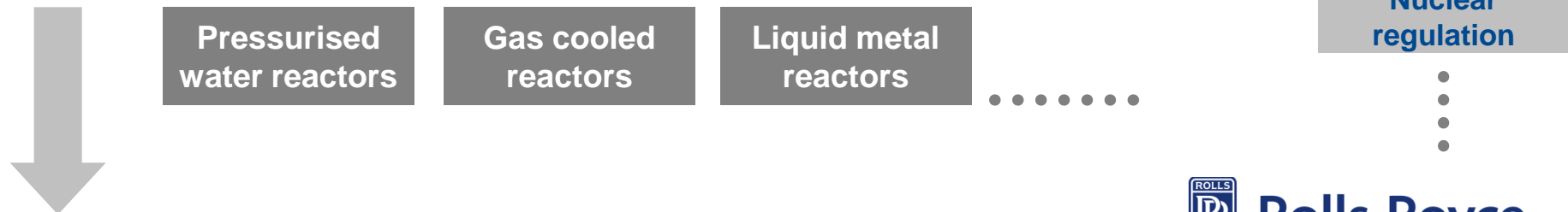
Super-system level



System level



Sub - system level: power generation



Regulatory and Safety Challenges

- Regulatory framework for licensing
- Definition of design basis
 - Collision
 - Grounding
 - Sea conditions
- Link to Class Societies
- Automation policy



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commons.wikimedia.org/wiki/File:Msc.napoli.beforesnapping.190707

There are many stakeholders



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Most Recent UK Study



FUTURE SHIP POWERING OPTIONS

Exploring alternative methods
of ship propulsion

July 2013



Thank you for your attention

