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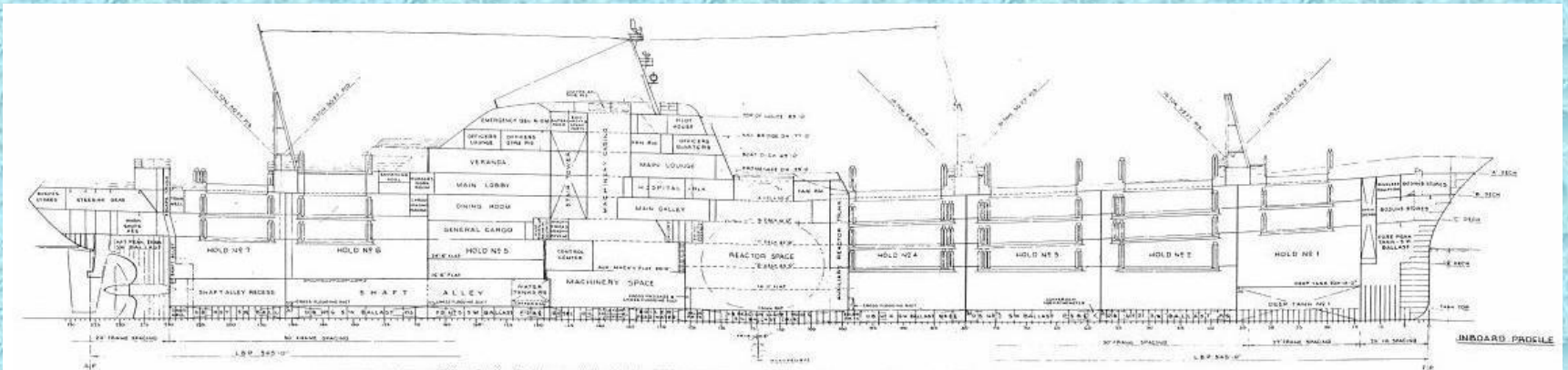
# Nuclear Merchant Ships

- NS Savannah 1962-1972
- NS Otto Hahn 1968-1979
- NS Mutsu 1990-1995
- NS Sevmorput 1988-to date

# NS Savannah

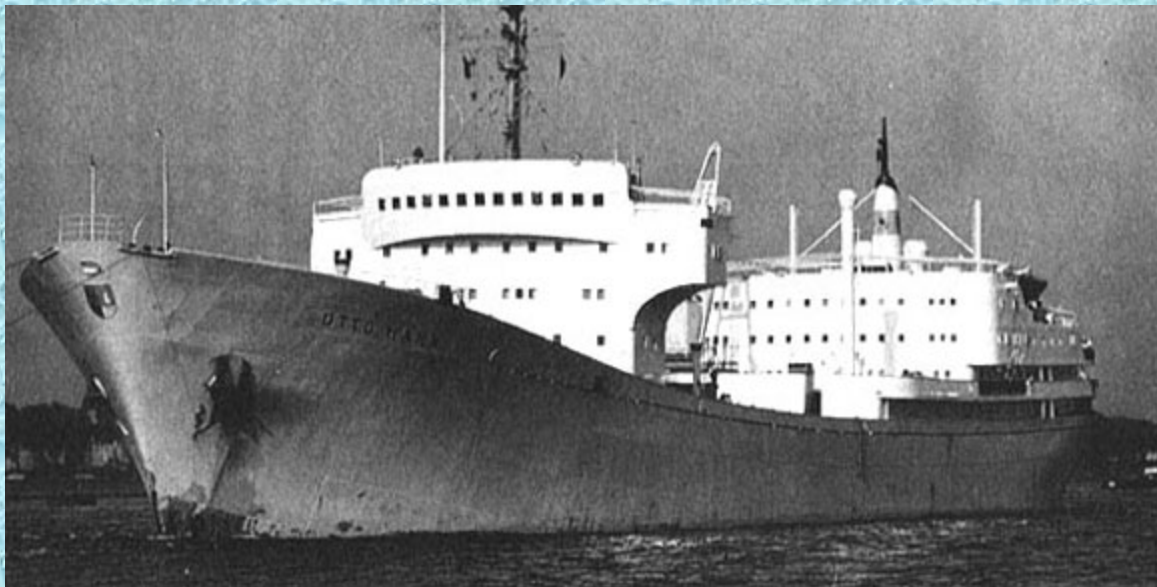


# NS Savannah

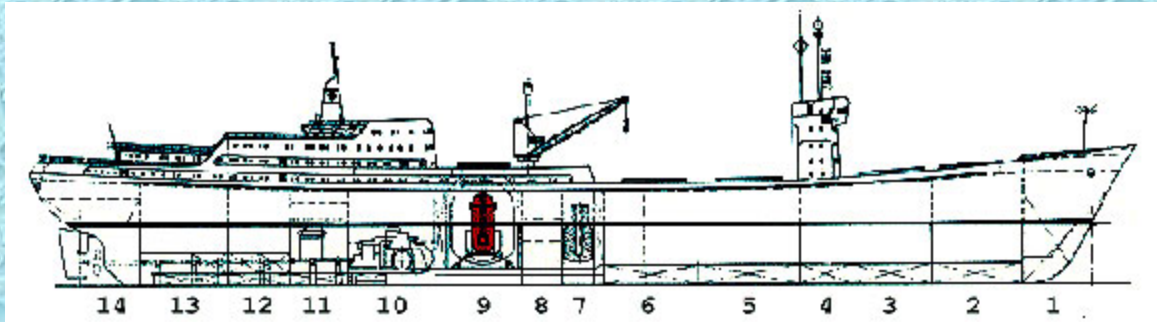


- LOA 181.6 m
- Beam 23.8 m
- Deadweight 9,900 tons
- Passengers 60
- Speed 21 Knots
- Propulsion Power 20,300 SHP
- Reactor 74 Mw

# NS Otto Hahn



# NS Otto Hahn



- LOA 172 m
- Beam 23.4 m
- Displacement 25,795 tons
- Deadweight 14,040 tons
- Speed 17 knots
- Reactor 38 Mw
- Reactor Volume 35 m<sup>3</sup>

# Nuclear Navy

- Aircraft Carriers
- Submarines
- Cruisers
- Destroyers



# Nuclear Navy

- US Navy has over 5400 Accident Free “Reactor Years”
- US Navy Operates over 100 Nuclear Powered Ships
- 11 Nuclear Powered Aircraft Carriers
- US and Russian Cruisers and Battle Cruisers
- Nuclear Powered Submarines:
  - US and Russia have over 100 each
  - UK and France have about 20 each
  - China: 6
  - India: Building 1 and Leasing 2

# Russian Nuclear Icebreakers



- Ocean Class: 6
- River Class: 2

# Russians to Build a Barge Mounted Nuclear Power Plant



- Named “Akademik Lomonsov”
- Two 60-Mw KLT-405 Reactors
- \$200 Million Cost
- Construction Started 2007
- Construction to be Completed 2010

# Nuclear Electrical Power Production

- 15% of World Electricity Production
- 31 Countries
- 439 Nuclear Power Reactors Worldwide
- 78% of France
- 30% of Japan

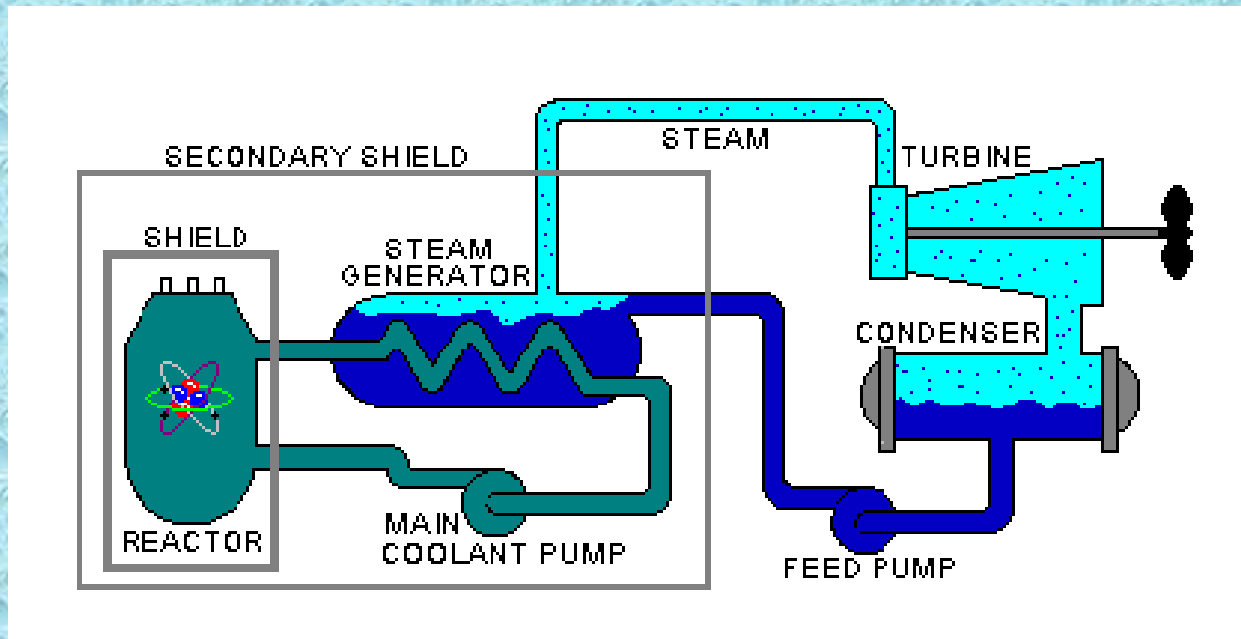
# Revival of US Power Plants

- 35 Year Lull (Last Oct. 1973)
- 21 Companies
- 34 Plants
- AREVA (France) and Northrop Grumman Newport News Teaming to Build Reactors<sup>1</sup>

# Revival of US Power Plants

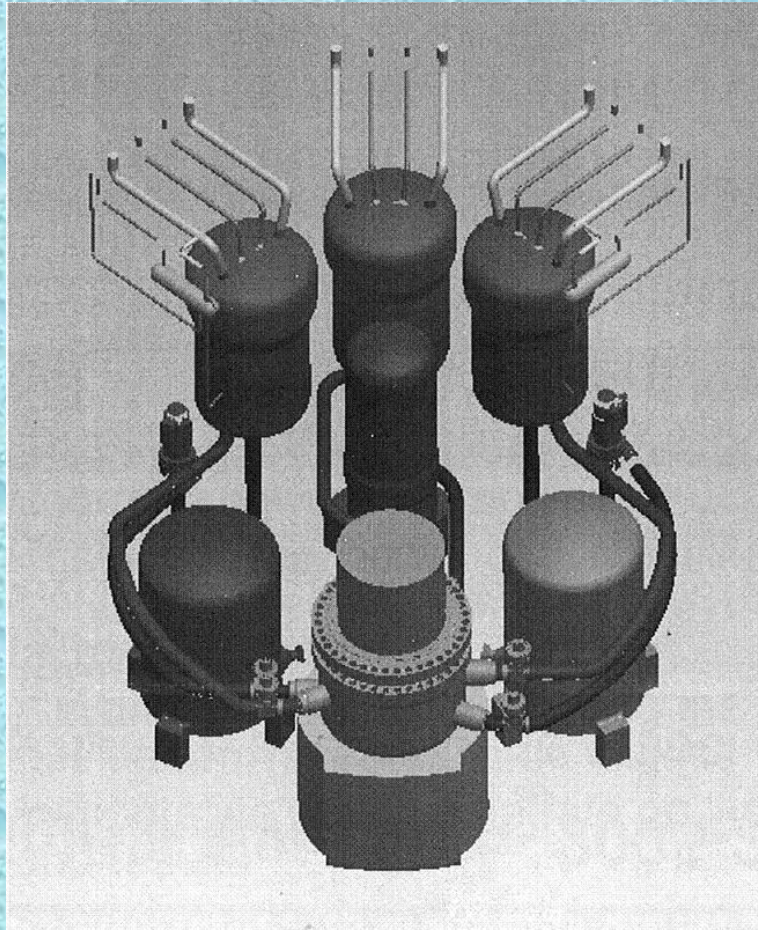
- Support in Congress Growing
- Protests Waning
- Environmentalists Spending Their Energy and Resources Fighting New Coal-Burning Plants

# Nuclear Propulsion



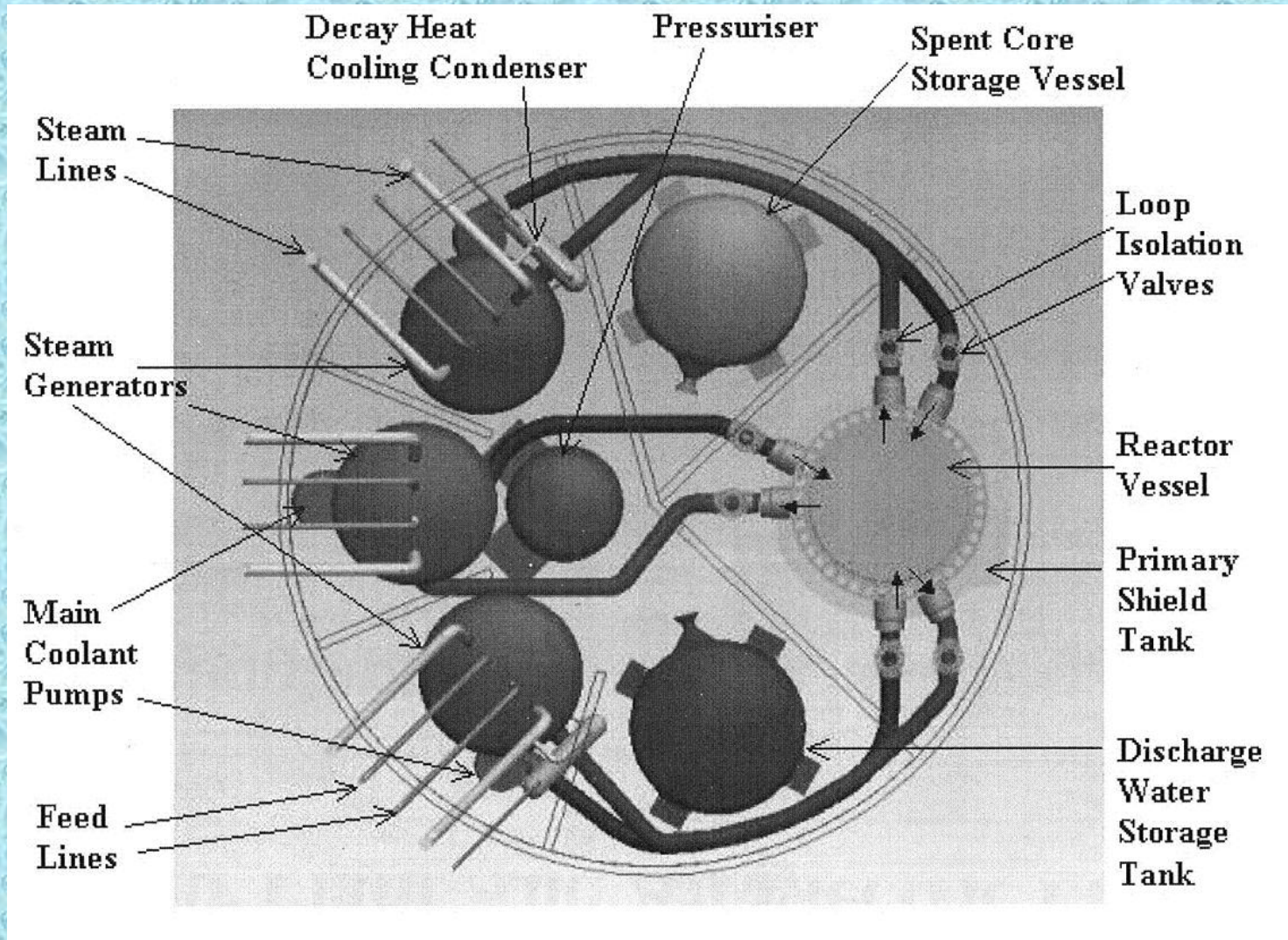
Electric Motor  
or Propeller

# Nuclear Steam Supply



- 3 Loop Pressurized Water Reactor

# Nuclear Steam Supply



# Reactor Compartment Size

| Vessel          | Weight (tons) | Length, ft | Width, ft | Height, ft | Diameter, ft |
|-----------------|---------------|------------|-----------|------------|--------------|
| Pre-Los Angeles | 1130          | 38         | -         | -          | 33           |
| Long Beach      | 2250          | 38         | 37        | 42         | -            |
| Other Cruisers  | 1400          | -          | -         | 37         | 31           |
| Los Angeles     | 1680          | 42         | -         | -          | 33           |
| Ohio            | 2750          | 55         | -         | -          | 42           |
| CCDoTT          | 3724          | -          | -         | 49         | 62           |
| USMMA           | -             | -          | -         | 50         | 67           |

# Why Nuclear?

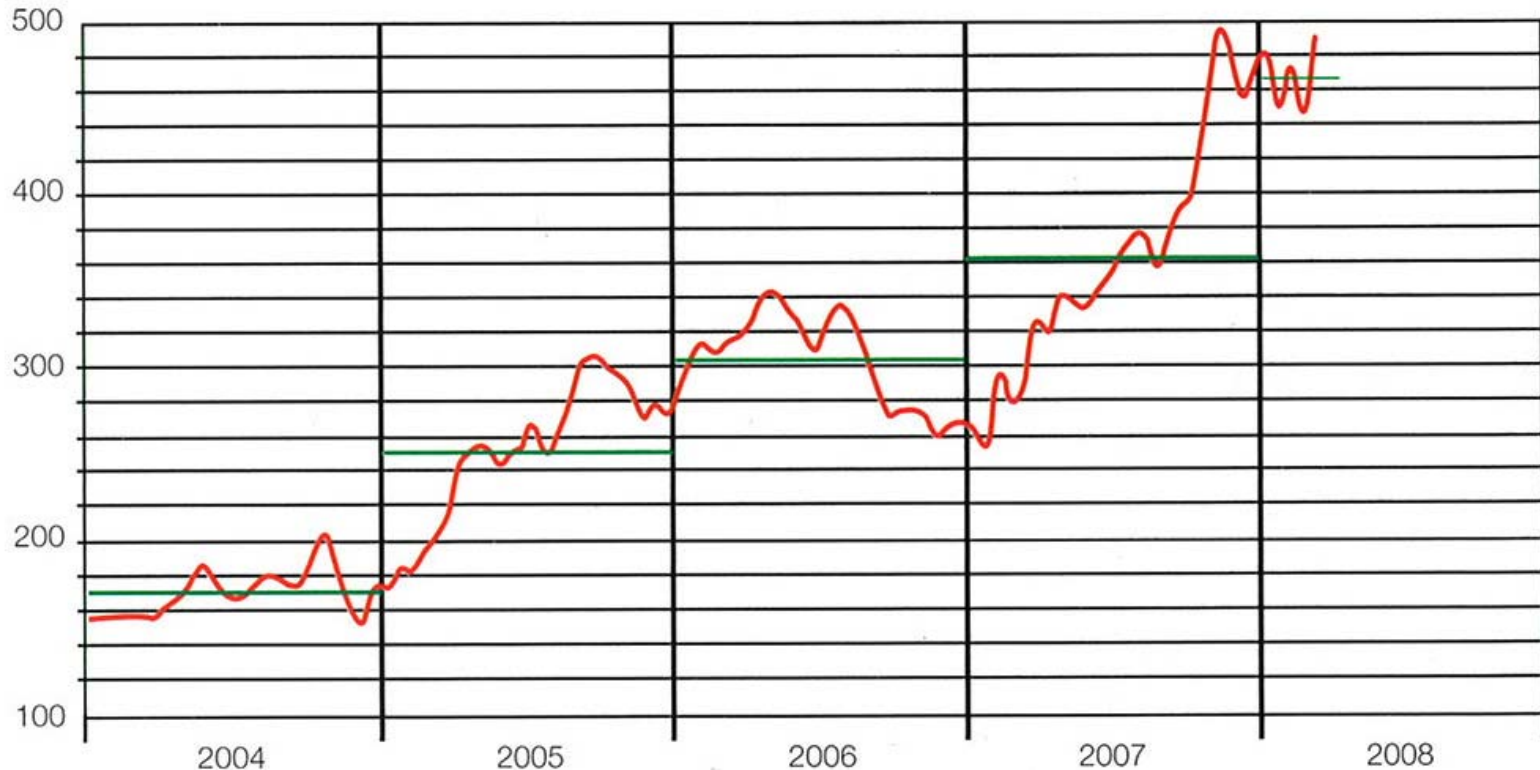
- Economics
  - Rising cost of oil
- Environment
  - No Carbon Footprint
- Reliability of Supply
  - 6 Year Fuel Life
  - 40 Year Service Life
  - Not Oil Dependent

# Nuclear Fuel Costs

- Nuclear Plant: \$2500 / kW
- Initial Fueling:
  - Operating Fuel Cost: \$0.005 / kW-Hr
  - Maintenance & Repair: \$0.001 / kW-Hr

# Rising Cost of Oil

Bunker price, US\$/tonne  
380cSt HFO



*The significant rise in bunker prices in recent years is illustrated on this chart, which shows the average price of 380 cSt heavy fuel oil at various ports around the world from 2004 to 2008; the green bars indicate the mean price for each year*

*Source: Marine Propulsion, August/September 2008*

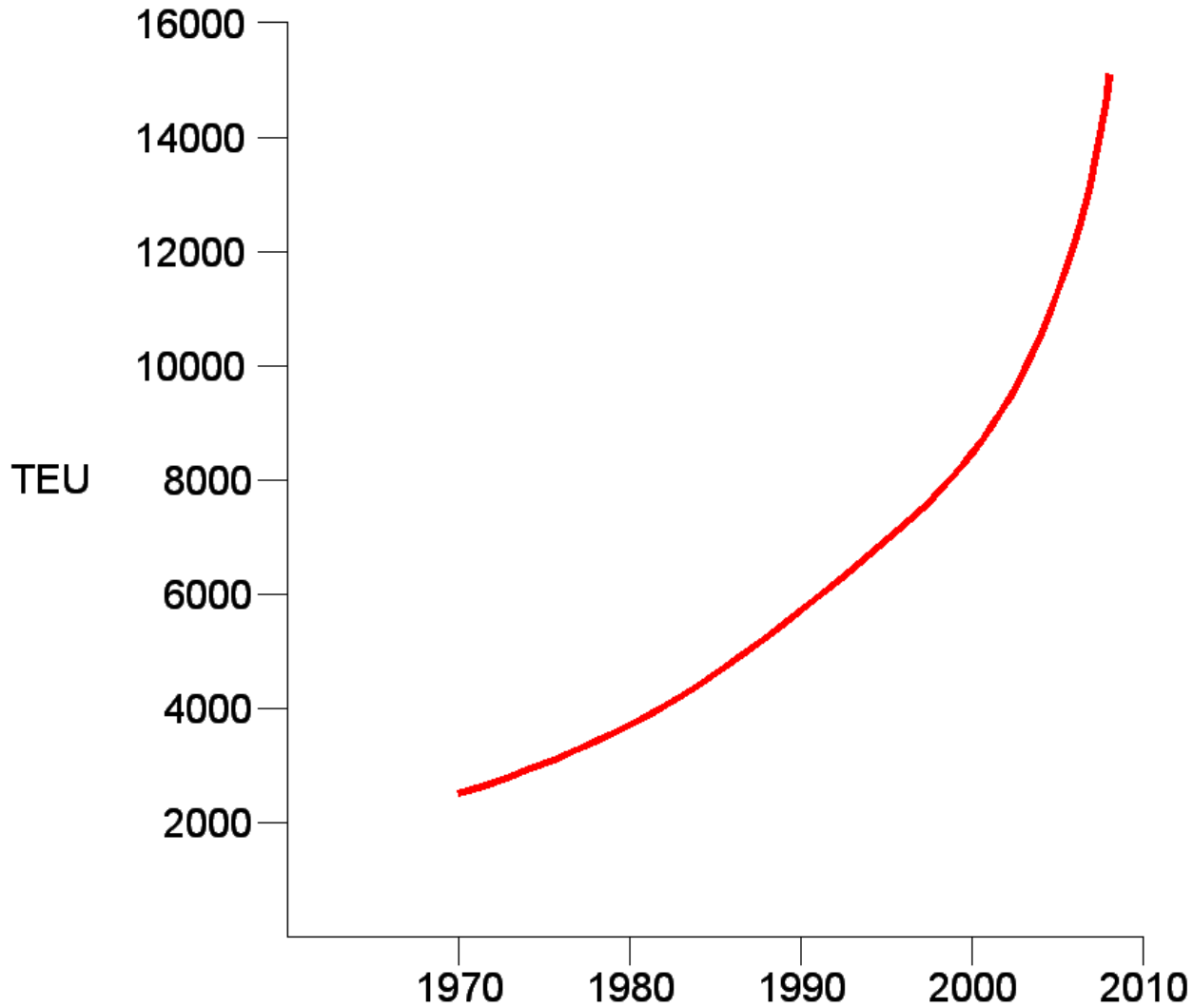
# Increase in Size and Speed of Container Ships



# M/V Emma Maersk

- Capacity 13,500 TEU
- LOA 397 m
- Beam 56 m
- Depth 30 m
- Speed 26 knots
- Power 80 Mw (109,000 HP)

# Growth in Size - TEU



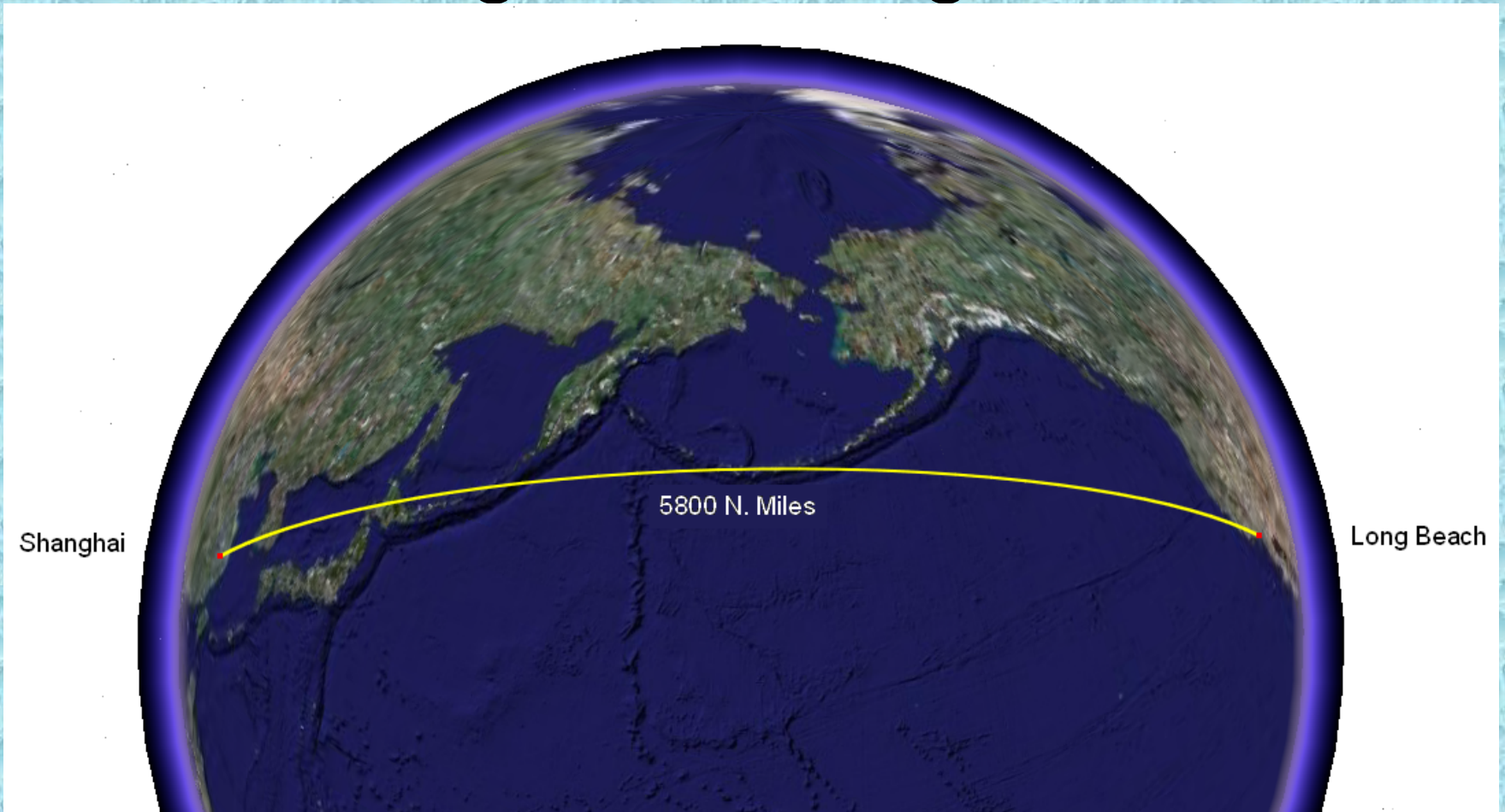
# Size

- 34% of World Fleet is Post-Panamax (Over 5000 TEU / 32.3 m Beam)
- Largest Ship to Date: 15,100 TEU
- As of May 2008, 62% of all Containerships on order are Post-Panamax
- Growth from 6000 TEU to 12,000 TEU Produces 25% Reduction in Slot Costs.<sup>1</sup>

# Example Nuclear Containership

- Capacity 15,000 TEU
- Length 405 m
- Beam 60 m
- Draft 15.5 m
- Speed 32 knots
- Power 150 Mw (200,000 SHP)
- Propellers 2

# Trans-Pacific Example: Shanghai to Long Beach



- At 32 Knots – 7 ½ Days

# Economic Issues

## Capital Costs

150,000 kW (200,000 HP)

1. Assumes Nuclear @ \$2500 / kW
2. Assumes Diesel @ \$800 / kW
3. Assumes Plant Life 40 Years
4. Assumes Interest Rate 10%

# Economic Issues

## Capital Costs

|                   | Nuclear        | Conventional  |
|-------------------|----------------|---------------|
| Plant Cost        | \$375,000,000  | \$120,000,000 |
| Annual Plant Cost | \$38,360,000   | \$10,230,000  |
| Difference        | + \$28,140,000 |               |

# Economic Issues

## Operating Costs

|                  | Nuclear        | Conventional |
|------------------|----------------|--------------|
| Security         | \$3,000,000    |              |
| Insurance        | \$10,000,000   |              |
| Personnel        | \$1,200,000    |              |
| M&R              | -              | \$2,000,000  |
| Reactor Disposal | \$2,000,000    |              |
| Difference       | + \$14,200,000 |              |

# Economic Issues

## Fuel Cost

|                  | Nuclear         | Conventional |
|------------------|-----------------|--------------|
| Fuel             | \$0.005 / kW-Hr | \$500 / Mt   |
| SFC              | -               | 165 kg/kW-Hr |
| Operating Hours  | 9000            | 9000         |
| Annual Fuel Cost | \$6,750,000     | \$89,100,000 |
| Difference       | -\$82,350,000   |              |

# Economic Issues

## Summary

|            | Nuclear       | Conventional         |
|------------|---------------|----------------------|
| Capital    | +\$28,140,000 | -                    |
| Operating  | +\$14,200,000 | -                    |
| Fuel       | -             | +\$82,350,000        |
| Total      | +\$42,340,000 | +82,350,000          |
| Difference |               | +\$40,000,000 / Year |

# Environmental Considerations

- Eliminates Emissions
  - Carbon Dioxide
  - Nitrous Oxides
  - Sulfur Dioxide
  - Particulate Matter
- Eliminates Risk of Oil Spill
- Eliminates Consumption of Petroleum Resources
- Potential Electricity Supply in Port

# Safer Reactor Designs

- Passive Safety Systems



- Westinghouse AP 1000

Source: Technology Review, Nov/Dec 2008

# Objectives

1. Economically Justifiable
2. Environmentally Preferable
3. High-Speed Transport of Time Sensitive Cargo
4. Secure Source of Power

# Tasks

- Support
- Finance
- Research
- Development
- Design
- Construction
- Acquisition
- Deployment
- Training
- Operation
- Support
- Disposal

# What to Do Next?

1. Find Sponsor
2. Refine Design
3. Refine Economics
4. Present Case

# Special Thanks to:

- Stan Wheatley, Technical Director, Center for the Commercial Development of Transportation Technologies
- Jose Femenia, Professor of Maritime Engineering, US Merchant Marine Academy