Glosten

CONCEPT DESIGN
PROPULSION SYSTEM TRADE-OFF
ENGINEERS COST ESTIMATE
WORK TO COMPLETE
KEY TAKEAWAYS
Q&A

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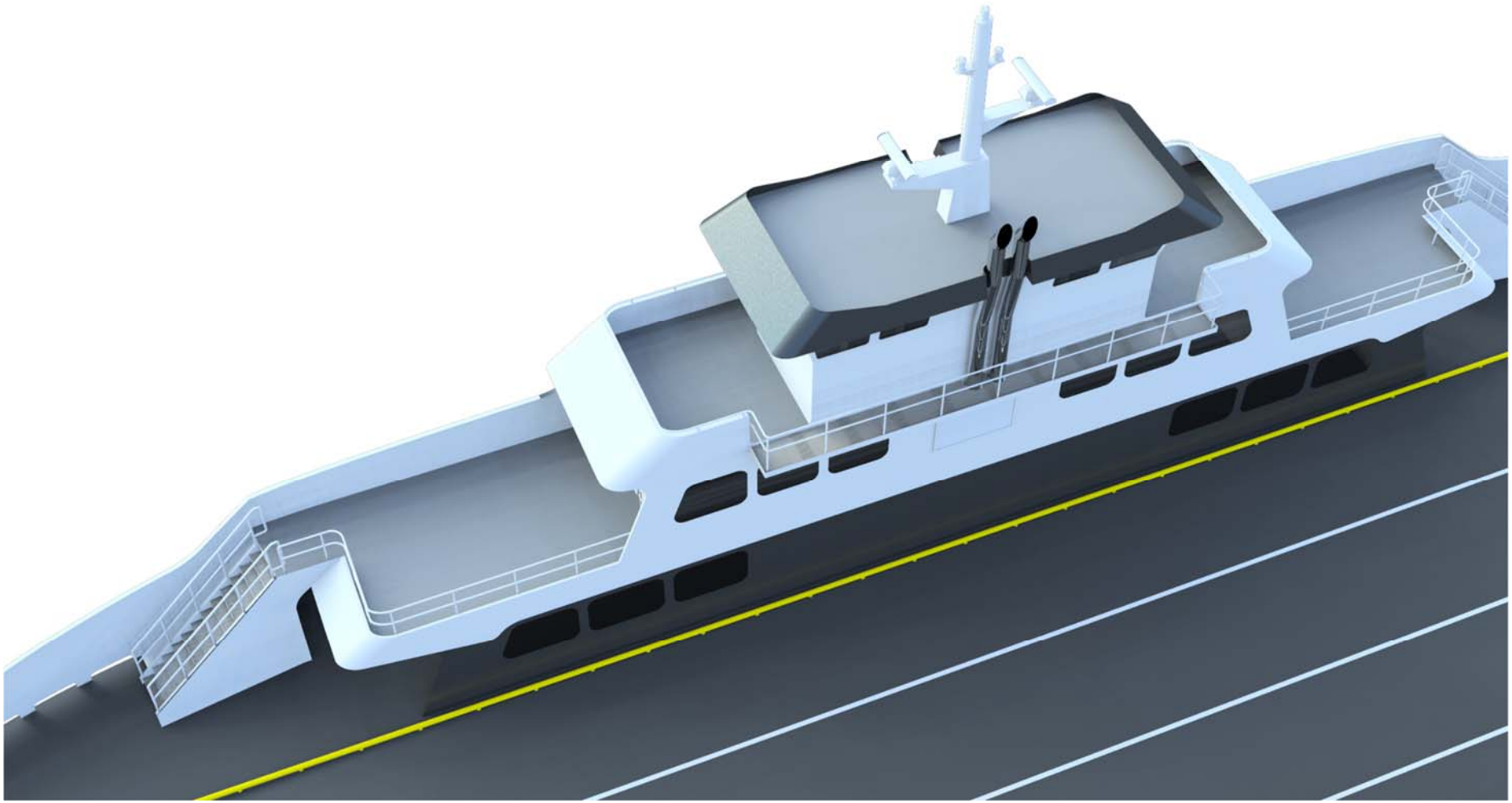


CONCEPT DESIGN

32 Vehicles, 150 Passengers

178' length x 53' beam

Deckhouse sized for growth

- 40 seats on ADA-accessible main deck, breezeway to improve mobility
- 20 seats on upper deck
- Single off-center pilothouse

Wider vehicle lanes

- Improves loading speed

Same regulatory system

- <100 Gross Registered Tons
- Master + 2 Deckhands

CONCEPT DESIGN

Steel hull

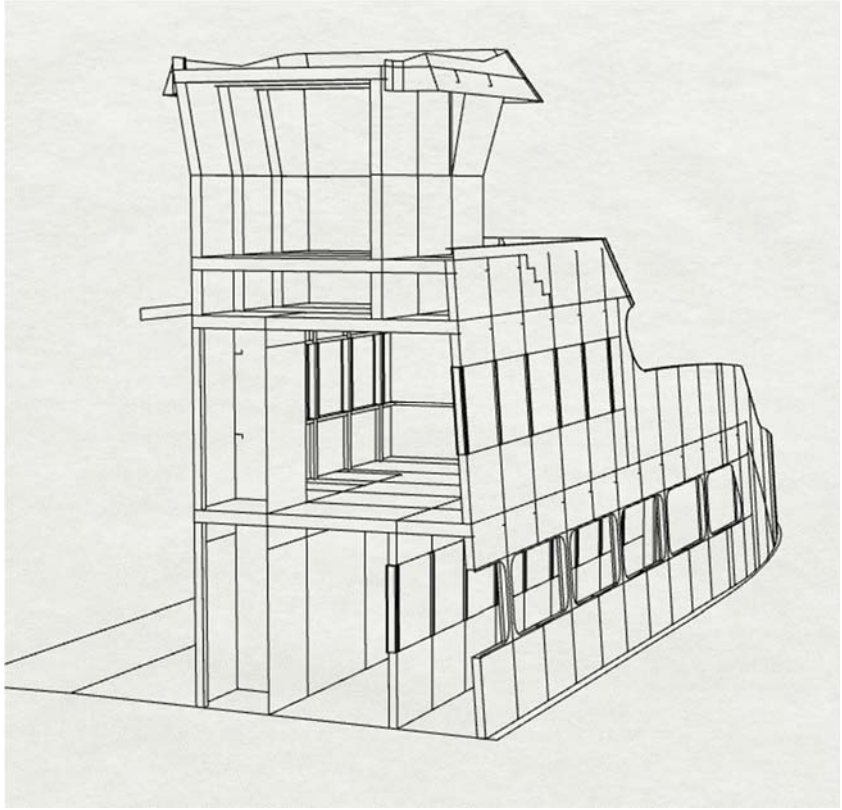
- Framing to handle truck wheel loads
- Corrosion resistant main deck
- High strength steel to reduce weight

Aluminum deckhouse and bulwarks

- Lightweight and low maintenance
- Reduces amount of fixed ballast

Z-drive thrusters

- Modern drives with high reliability
- No drydocking to remove
- Nozzles to increase efficiency



DESIGN DRIVERS

Terminal interface

- Governs shape at ends, restricts beam
- Dolphins have limited capacity

High tidal currents

- Installed power dictated by maneuvering requirements
- Short and steep waves means greater freeboard

Vehicle capacity

- Drives overall length of vessel
- Projected to increase 74% over next 40 years

Two round trips per hour

- Charging designed around tempo and adverse weather

Emergency services

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PROPULSION SYSTEM STUDY

Five propulsion options

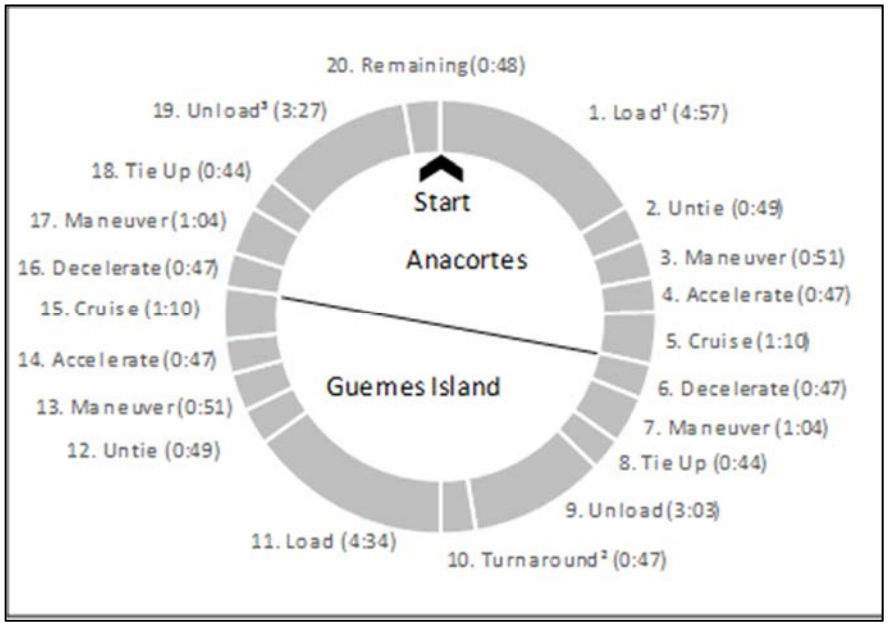
- Geared Diesel (baseline)
- Diesel Electric
- Series Hybrid
- All-Electric
- Plug-in Hybrid

Operational profile is key

Shore power infrastructure

- Charging Anacortes only
- Major driver in capital cost

OPERATING PROFILE



Assumptions

- 32 car ferry
- Maintain 2 round trips per hour

One-Way Profile

- Load/Unload – 70%
- Maneuver – 6%
- Accelerate – 5%
- Cruise – 8%
- Decelerate – 5%
- Maneuver – 7%

OPERATING PROFILE

Operation	Delivered Power, Pd (kW)
Load / Unload	150
Maneuver	556
Accelerate	798
Cruise	743
Decelerate	524
Maneuver	476

Operation	Delivered Power, Pd (kW)	Notes
Load / Unload	800	Current vessel maximum observed
Maneuver	834	1.5 multiplier on average power
Accelerate	1,196	1.5 multiplier on average power
Cruise	1,114	1.5 multiplier on average power
Decelerate	786	1.5 multiplier on average power
Maneuver	1,450	Max installed power

Normal Operation

- Average annual loads
- 21% MCR time-weighted average
- Compared to current fuel consumption

Worst-Case Run

- 5% of time annually
- Particular challenge for all-electric and plug-in hybrid
- Dictates shore-side equipment ratings

SHORE POWER DESIGN

Automatic Battery Charging

- Automatic charging system likely necessary to meet vessel turnaround times (8 min charging)
- Investigated multiple technologies/systems
- Components must be sized to meet peak demand

One versus two-side Charging

- Two-side charging reduces vessel energy consumption by 60%
- Infrastructure upgrades on Guemes Island prevent feasibility

Vacuum Mooring

- ROI greater than 20 years

UTILITY CONNECTION – PUGET SOUND ENERGY

	Power		Total Shore Energy (kWh)	Vessel Battery Energy (kWh)
	No Shore-side Batteries (kW)	Shore-side Batteries (kW)		
All-Electric Average	1500	400	200	150
All-Electric Peak	**4000**	1050	525	350
Plug-in Hybrid Average	1400	375	200	150
Plug-in Hybrid Peak	**2600**	700	350	200

Connection Feasibility

- Connection is feasible, 12 kV connection
- Shore-side batteries will be required

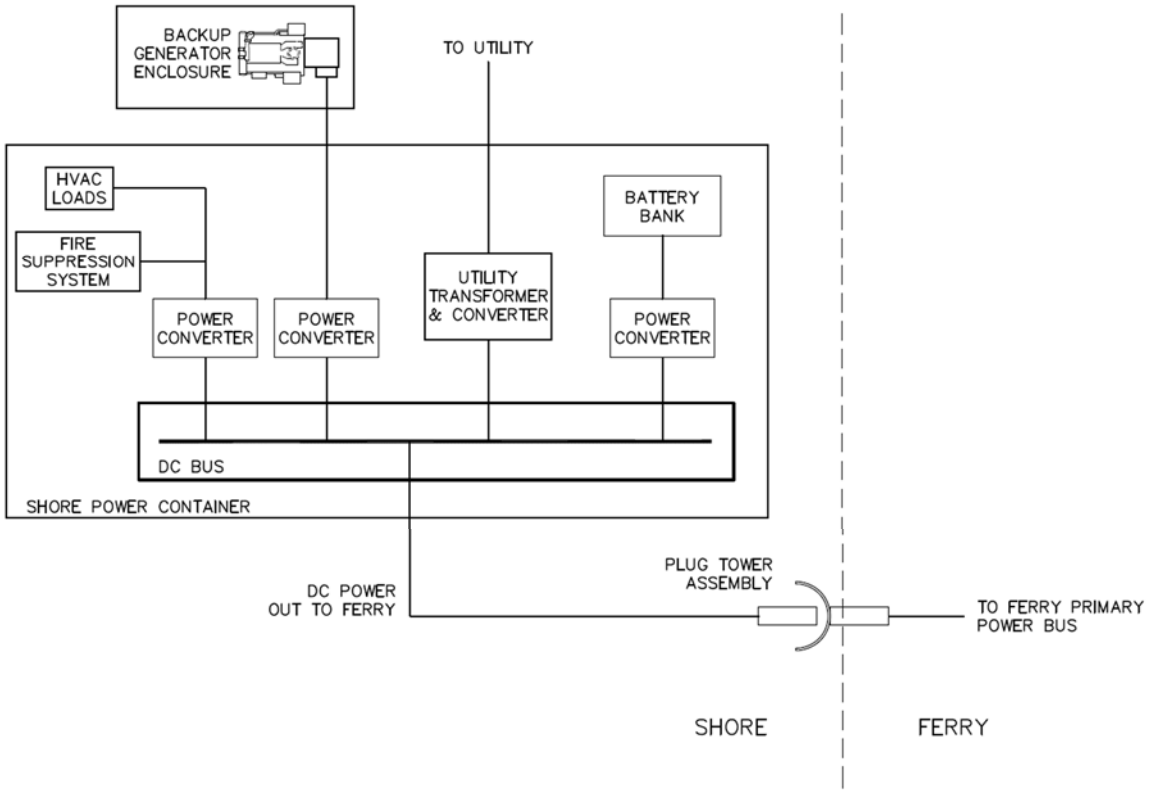
Cost

- Demand charge based on peak power, accounts for 40-50% of annual cost
- ROM estimates for utility connection included in shore-side costs

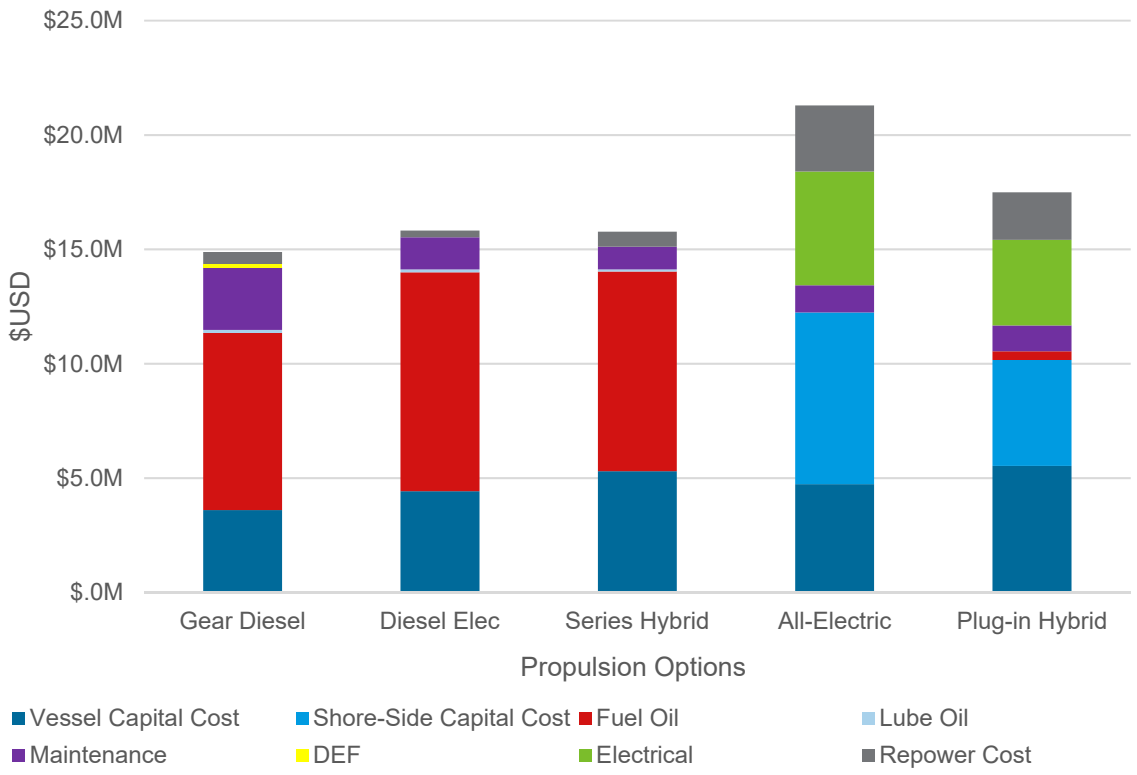
SHORE POWER DESIGN

Infrastructure

- Plug assembly
- Shore power house w/ switchboard
- Battery bank with converter
- Transformer
- Backup generator (all-electric)



LIFE CYCLE COST – PROPULSION SYSTEM



- 40 year life
- 3% real discount rate
- Net present value
- Only includes propulsion system costs
- Capital costs versus operational costs

CAPITAL COST – PROPULSION SYSTEM

	Gear Diesel	Diesel Electric	Series Hybrid	All-Electric	Plug-in Hybrid
Vessel Capital Costs (M USD$)	$3.7	$4.6	$5.5	$4.9	$5.7
Shore-Side Capital Costs (M USD$)	$0	$0	$0	$7.7	$4.8
Total Capital Cost (M USD$)	$3.7	$4.6	$5.5	$12.6	$10.5

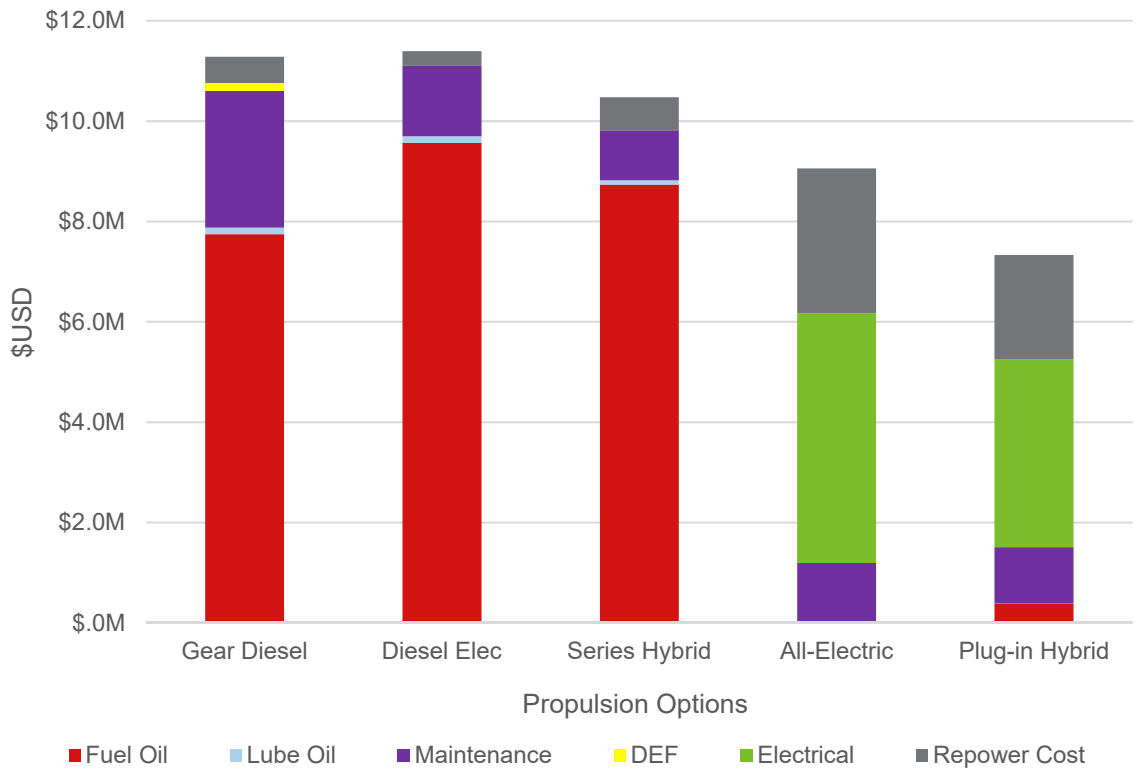
Vessel Costs

- Similar for all propulsion system options
- Includes required equipment for emergency services

Shore-Side Costs

- Equipment ratings are sized for worst-case run
- If schedule requirements are relaxed in poor weather, shore-side capital costs could be reduced
- Includes required equipment for emergency services

OPERATING COST – PROPULSION SYSTEM



Consumables

- Annual consumption of Fuel, DEF, Electrical, and Lube Oil
- Propulsion efficiency affects consumption

Maintenance

- Includes oil changes to engine overhauls

Repower

- Mid-life engine repower
- 8 year battery replacement

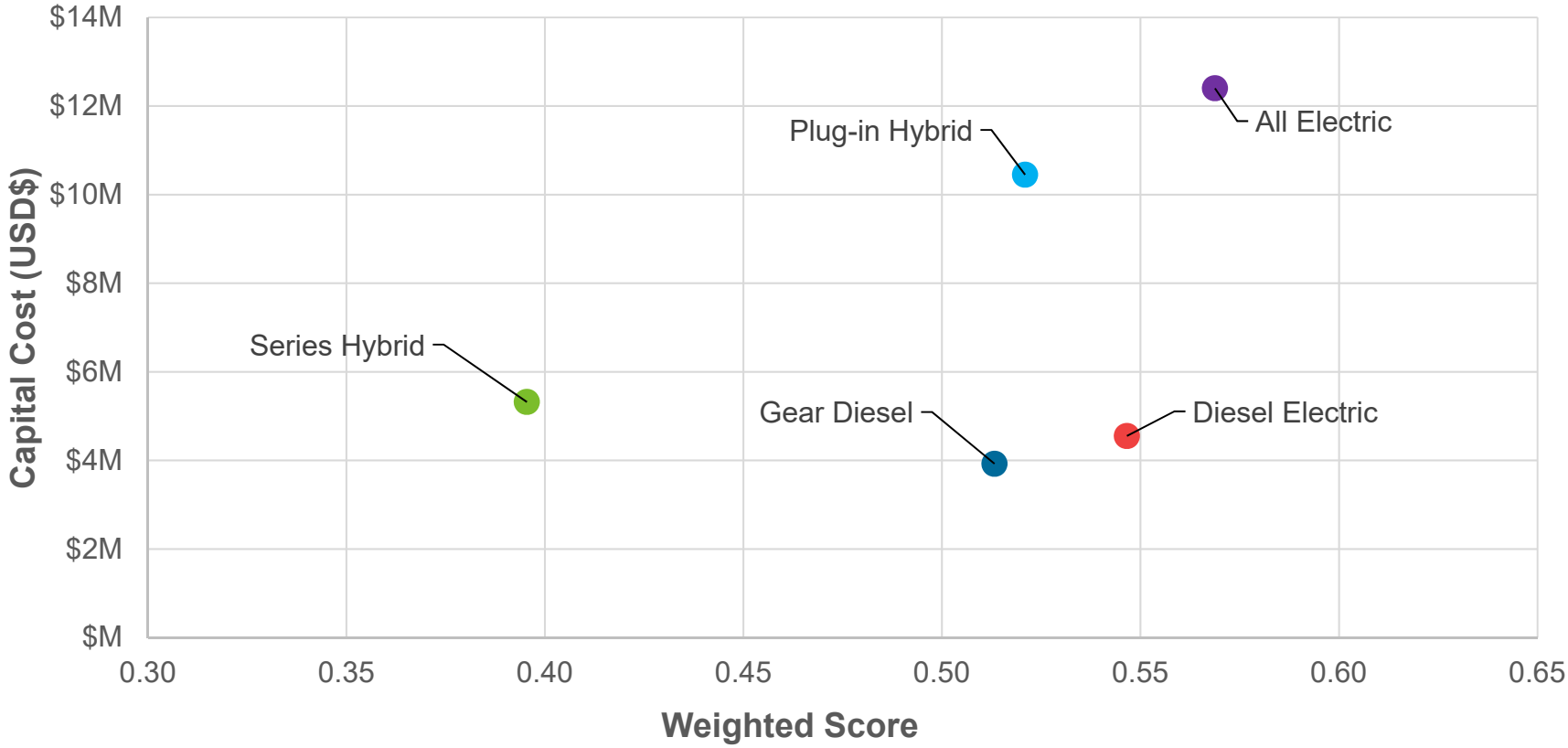
SCORING SYSTEM

- **System Weight** – Weight of all propulsion equipment installed on vessel
- **Design and Build Complexity** – May affect cost of engineering to complete design as well as cost to build the vessel and shore-side infrastructure
- **Reliability and Availability** – Probability of failures based on risk assessment
- **Airborne Noise** – Noise created from vessel engine operation
- **Vessel Air Emissions** – local engine exhaust, measured in particulate matter

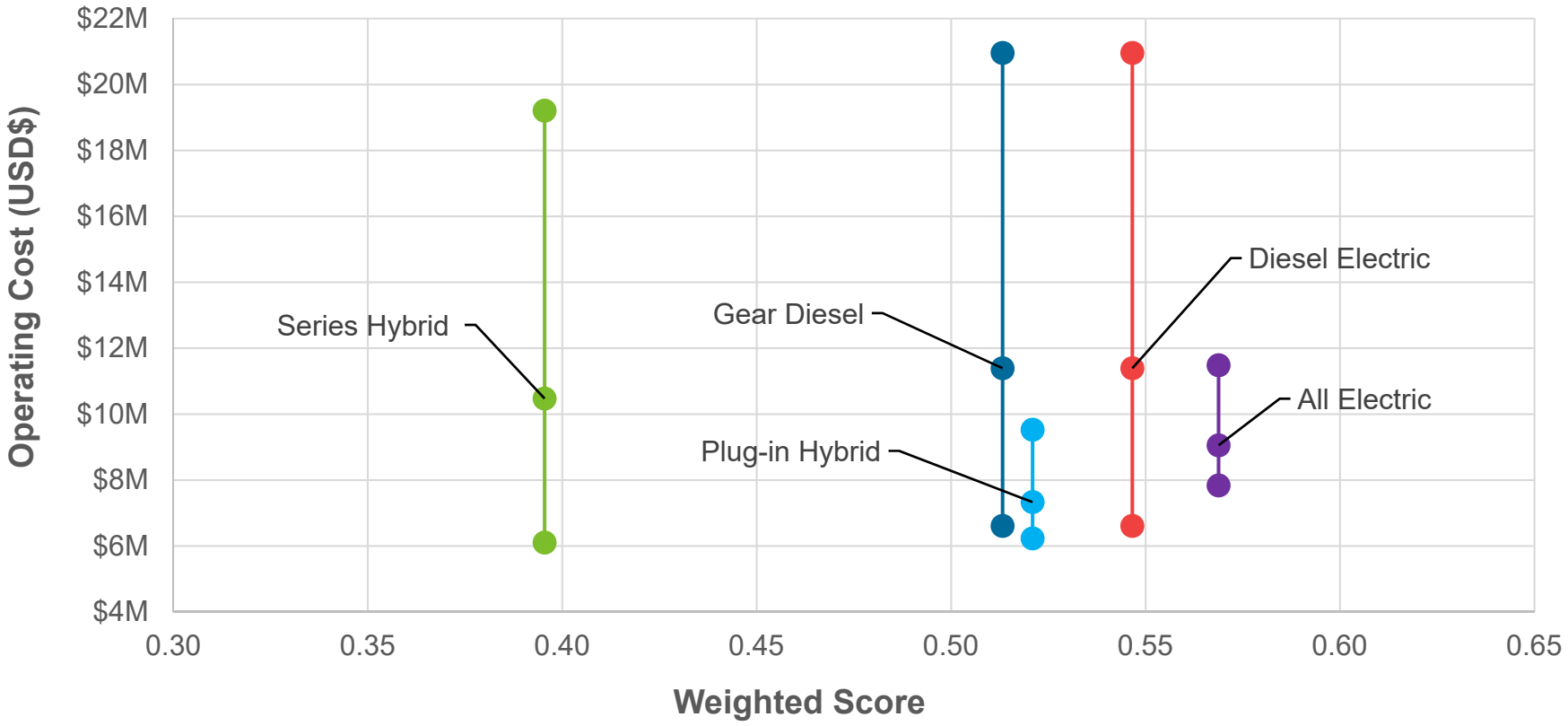
Scoring Category	Weighting Factor
Capital Cost	0%
Operations and Maintenance Cost	0%
System Weight	10%
Design and Build Complexity	20%
Reliability and Availability	35%
Airborne Noise	10%
Vessel Air Emissions	25%

Total must equal 100%

CAPITAL COST – PROPULSION SYSTEM



OPERATING COST RANGE – PROPULSION SYSTEM



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ENGINEER'S COST ESTIMATE

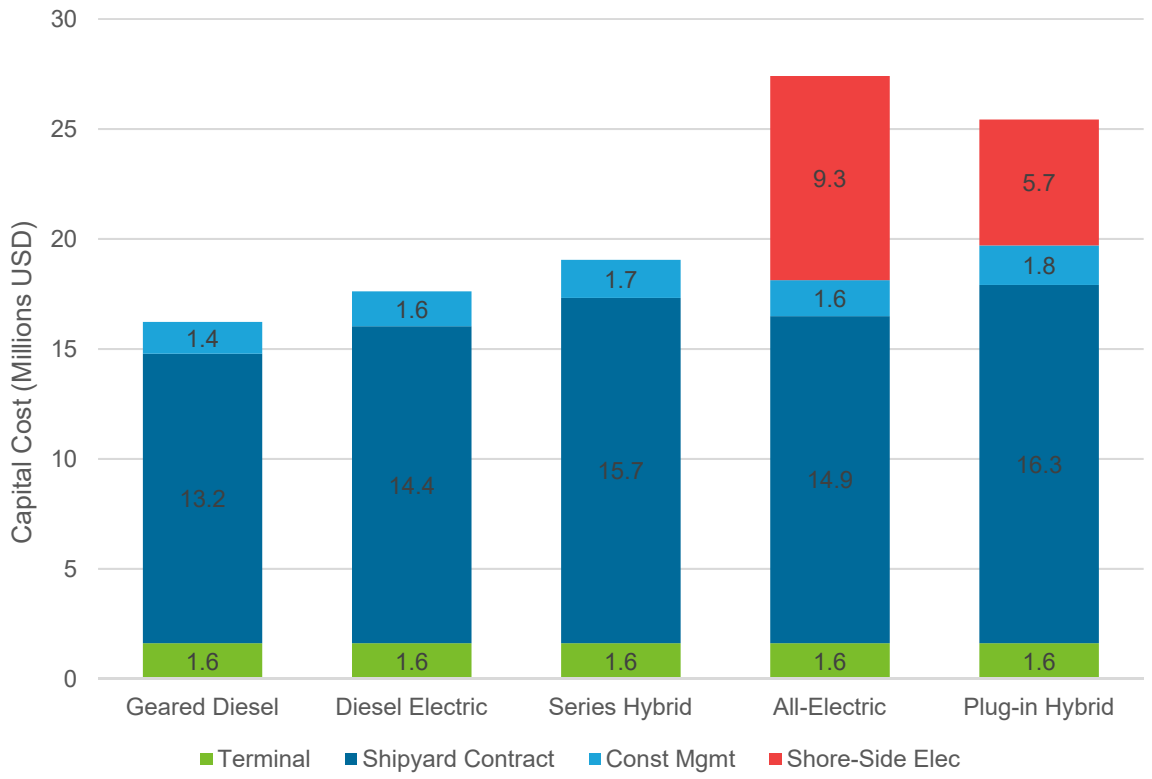
20% contingency

Vessel is tax exempt

8.5% tax for shore

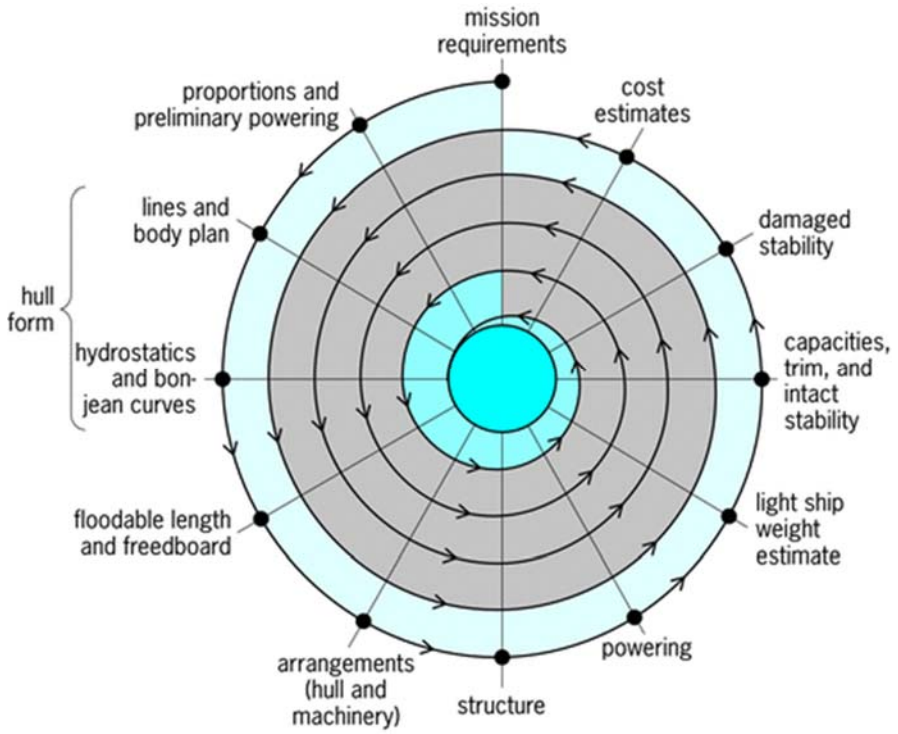
Included:

- County oversight
- Design
- Const. Management



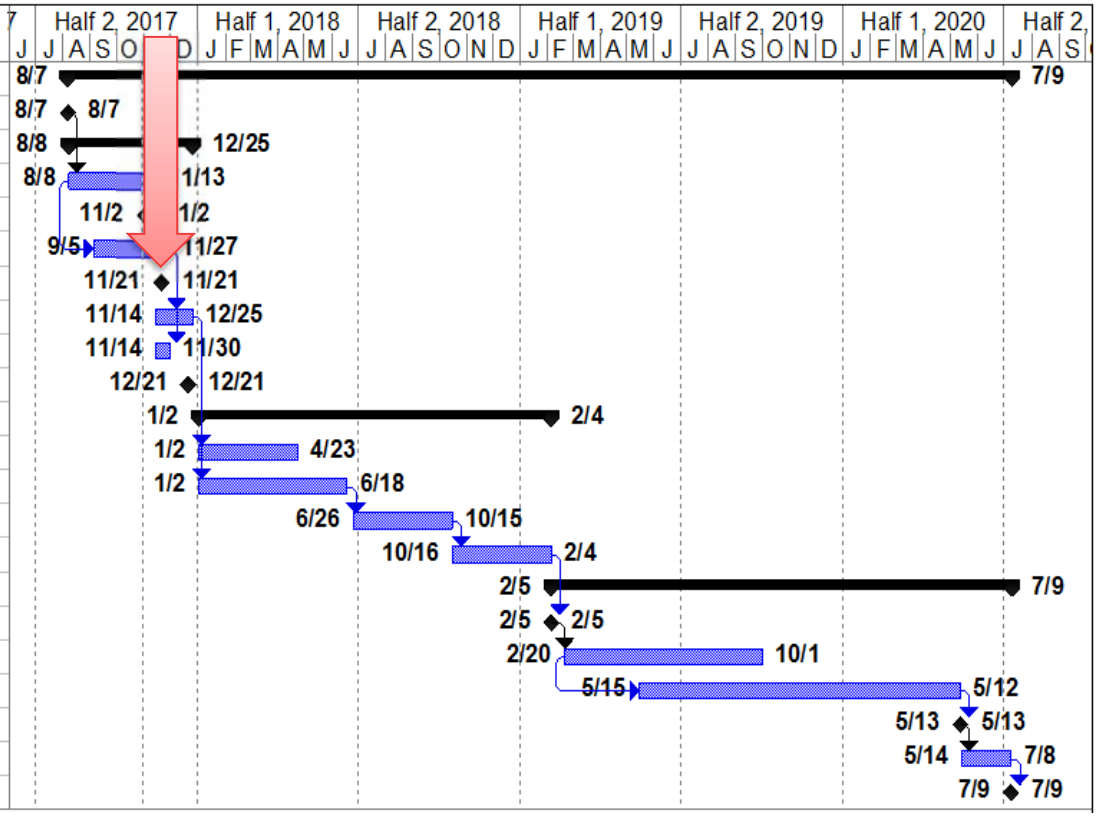
WORK TO COMPLETE

1. Finalize concept design report
2. Finalize engineer's cost estimate
3. Progress shore-side infrastructure
4. Refine general arrangement
5. Develop renderings
6. Prepare binder for CRAB



LONG-TERM SCHEDULE

ID	Task Name
1	**Guemes Ferry Replacement**
2	NTP
3	**Phase 1 Design**
4	Design Studies
5	Public Meeting
6	Concept Design
7	Concept Design Review
8	Design to 30%
9	Cost Estimate
10	Submit CRAB Funding Request
11	**Phase 2 Design**
12	CRAB Funding Support
13	Preliminary Design
14	Contract Design
15	IFB and Negotiation
16	**Construction**
17	Shipyard NTP
18	Functional and Production Design
19	Construction
20	Delivery
21	Crew Training
22	Vessel In Service



KEY TAKEAWAYS

- Shore side charging infrastructure adds 6 to 9 million in capital cost
- All-Electric and Plug-in Hybrid will likely have lower operating expenses than diesel options
- Plug-in Hybrid offers the lowest operational costs and a reduced capital cost over the All-Electric option.
- Capital costs can be reduced if the frequency of service or vessel capacity is reduced

Q&A

- Can the board provide a set of weighting factors?
- Is the Board able to recommend a propulsion system?
- What other information can we provide?

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