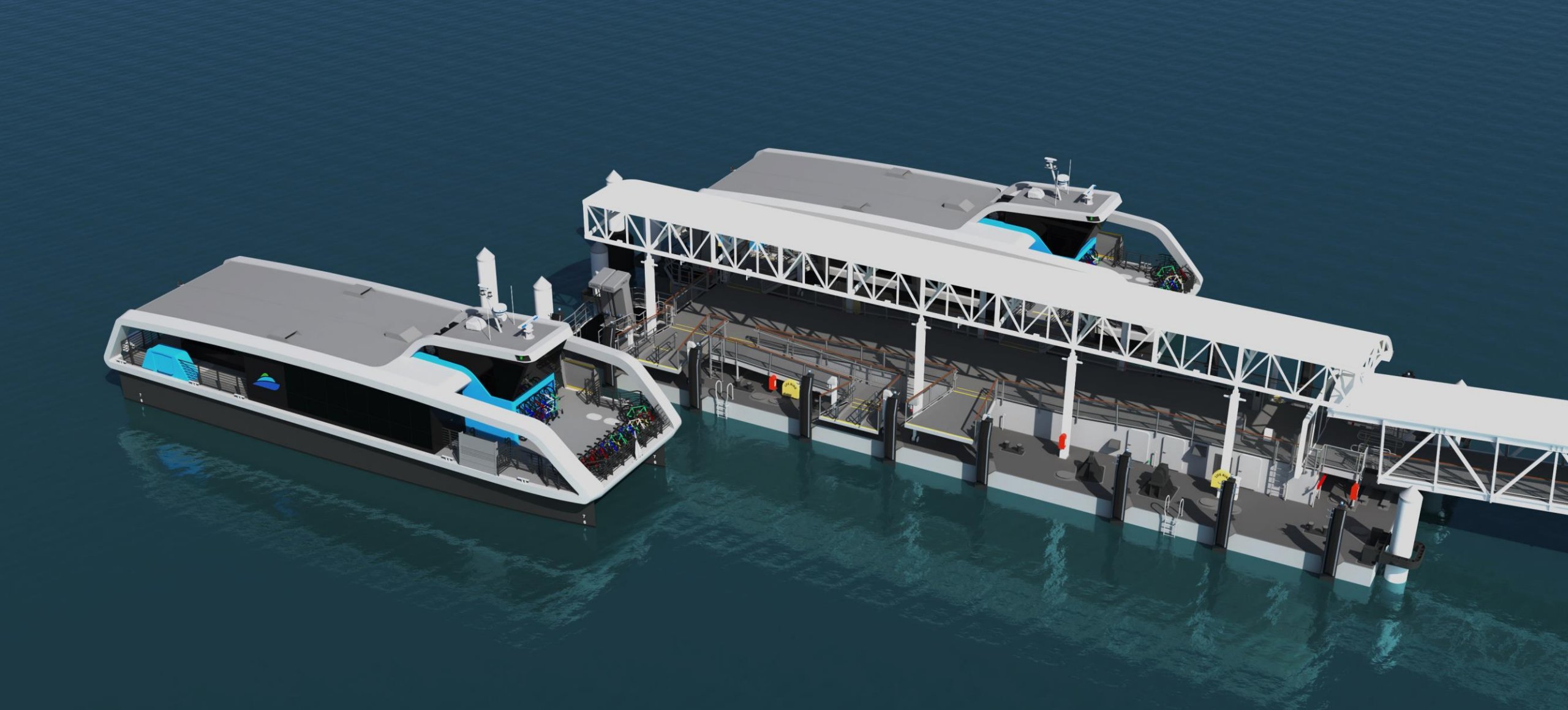


REEF Program

Board of Directors Progress Update

9 January 2024

SF Bay Ferry

aurora marine design

Jan Rybka
Senior Project Manager

Shaun Green
Principal

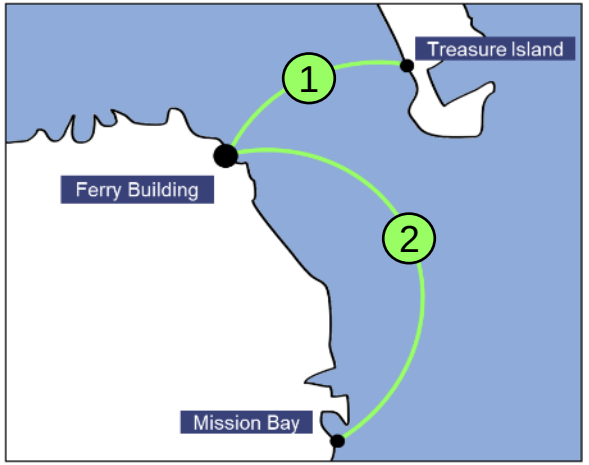
Agenda

1. Project Status Update - Jan
2. Challenges & Solutions - Jan
3. WETA Standards - Jan
4. Evaluation Process - Shaun
5. Next Phase Considerations - Shaun

Water-Side Project Status Updates

Electrification Phasing

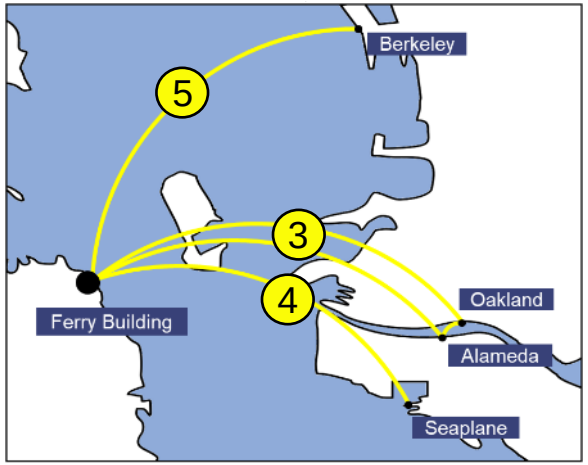
Phase 1 - Inner Central Bay



1 Treasure Island

2 Mission Bay

Phase 2 – Central Bay



3 Oakland/Alameda

4 Seaplane

5 Berkeley

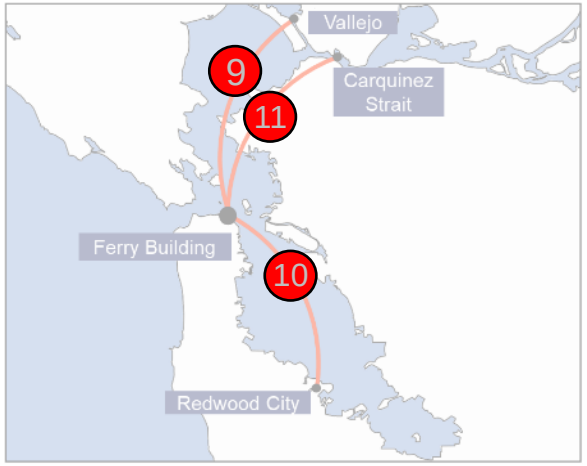
Phase 3 – Long Run Central Bay

6 Richmond

7 Harbor Bay

8 South SF

Phase 4 – Long Runs



9 Vallejo

10 Redwood City

11 Carquinez

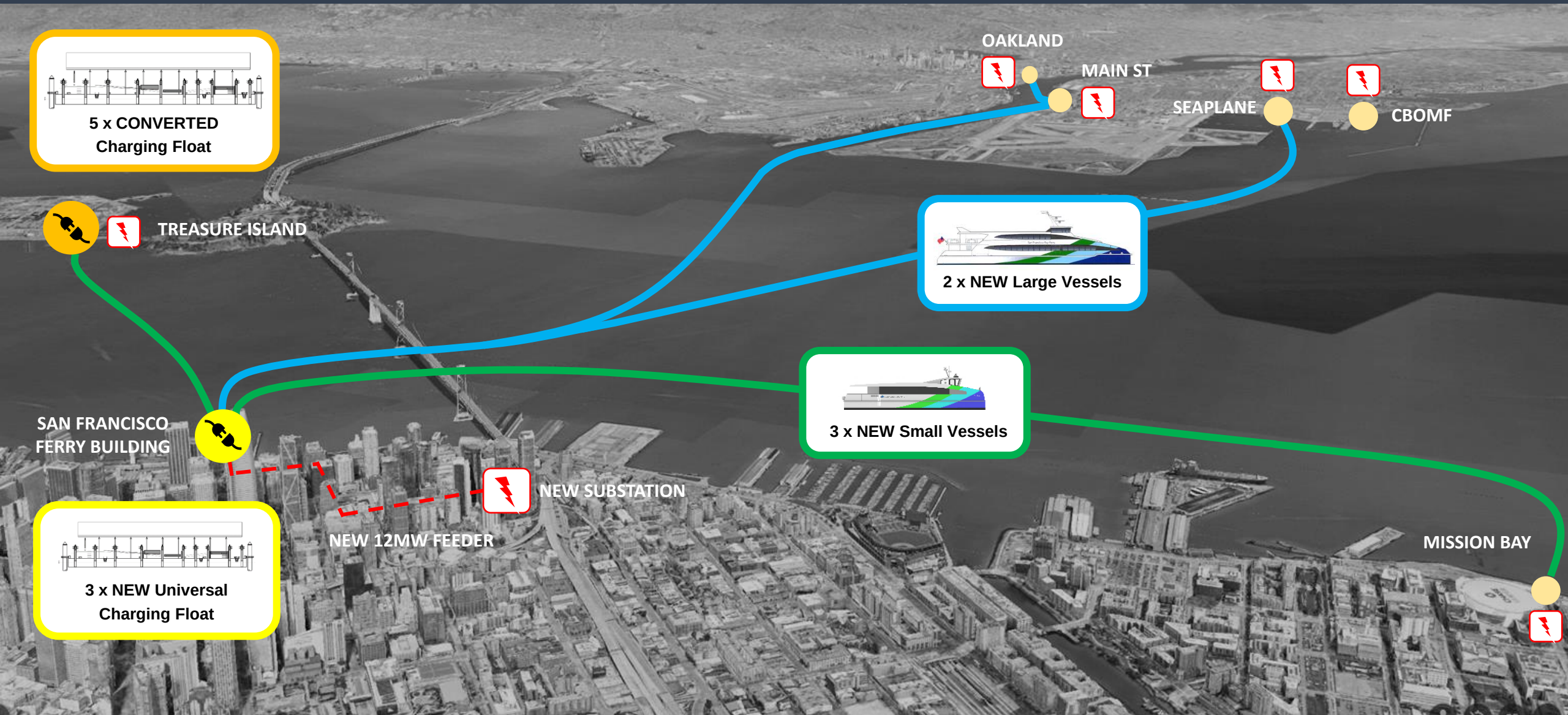
Feasible with Current Vessel Technology

Feasible with Current Vessel Technology - Operational Changes Required

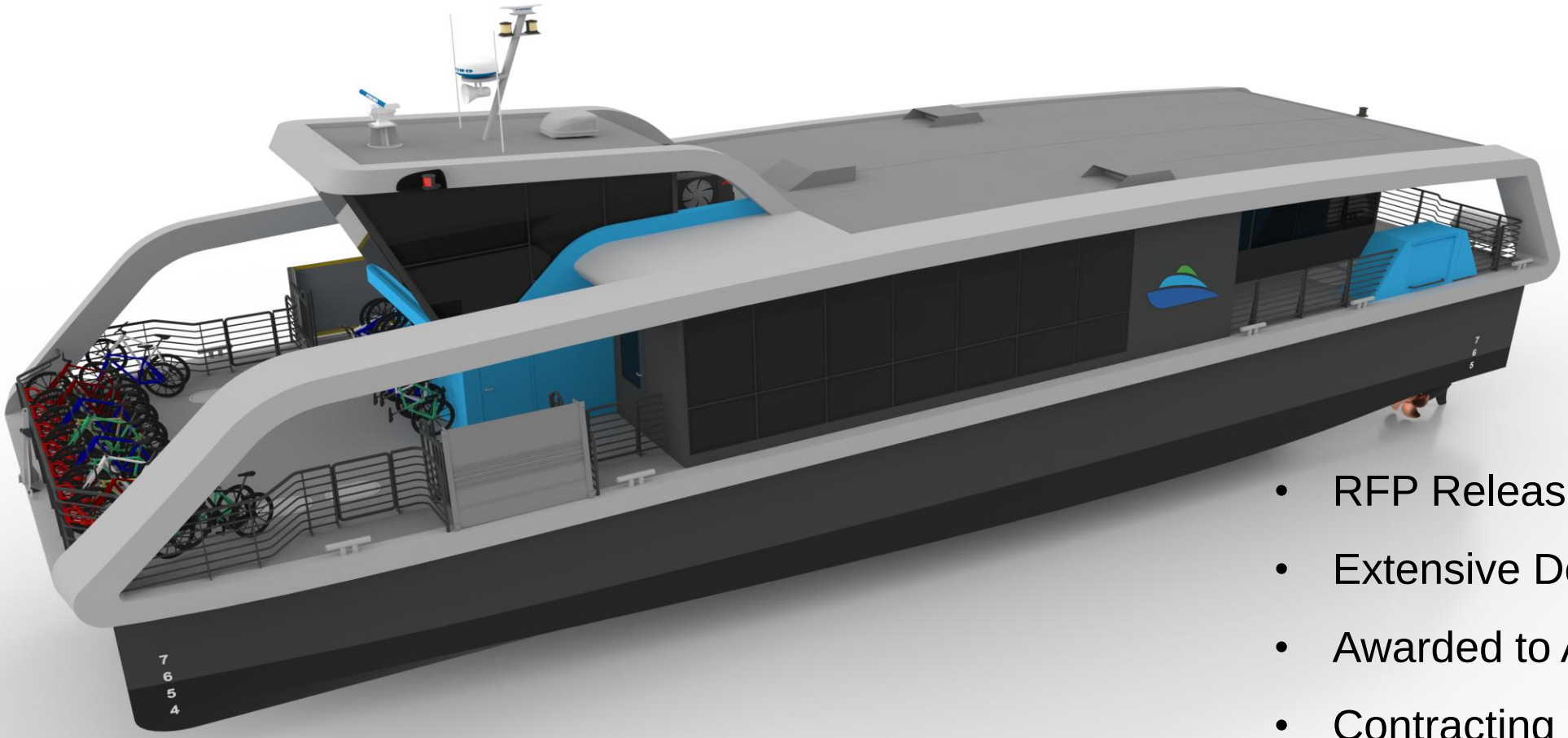
Feasible with Current Vessel Technology - Significant Operational Changes Required

Not Currently Feasible – TBD Future Technology Required

REEF Phase 1 and 2

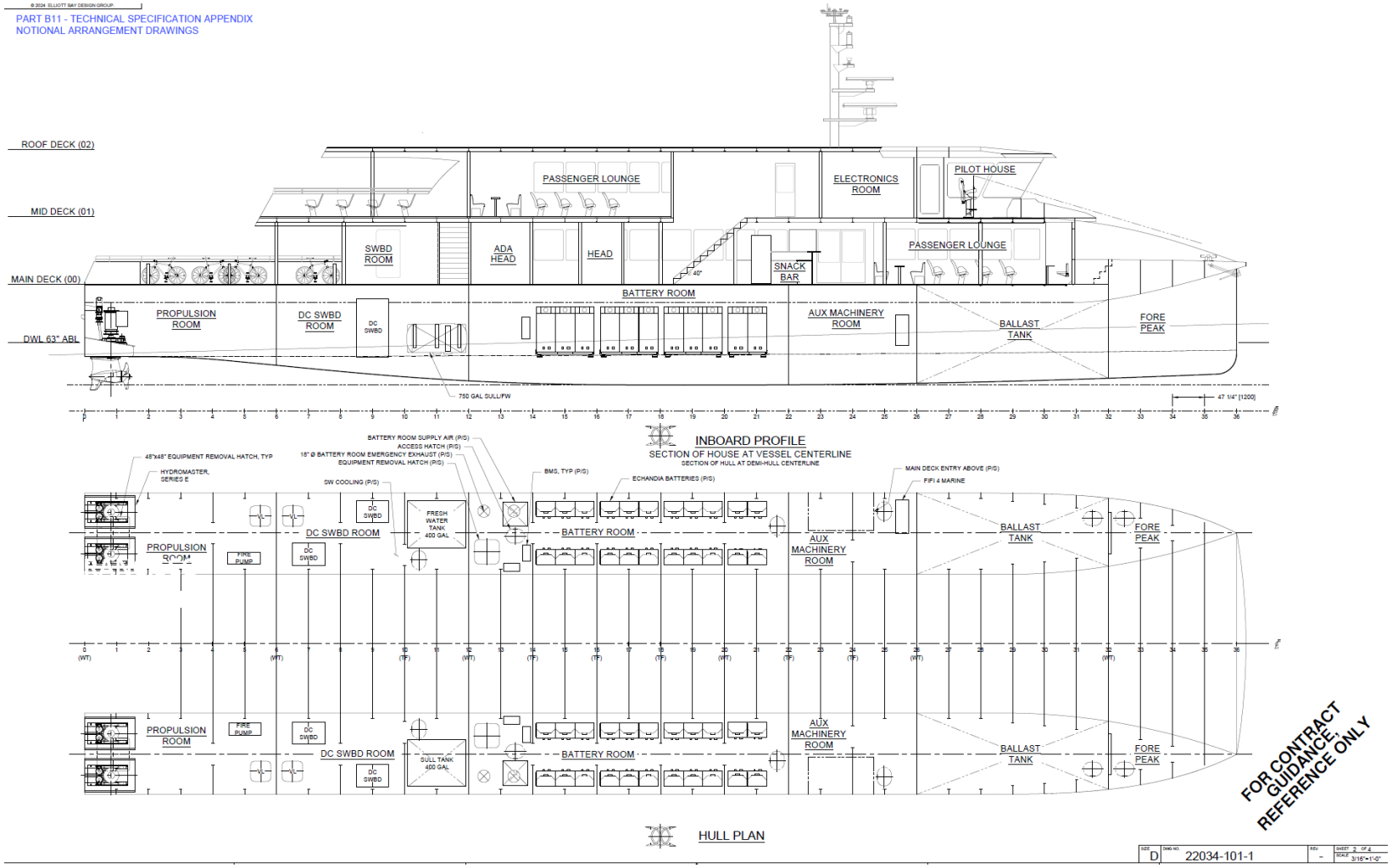


150 Pax REEF Vessel



- RFP Released July 2024
- Extensive Design Pre-RFP
- Awarded to AAM Dec 2024
- Contracting In Progress
- 1st Vessel Delivery Q1 2027

400 Pax REEF Vessel



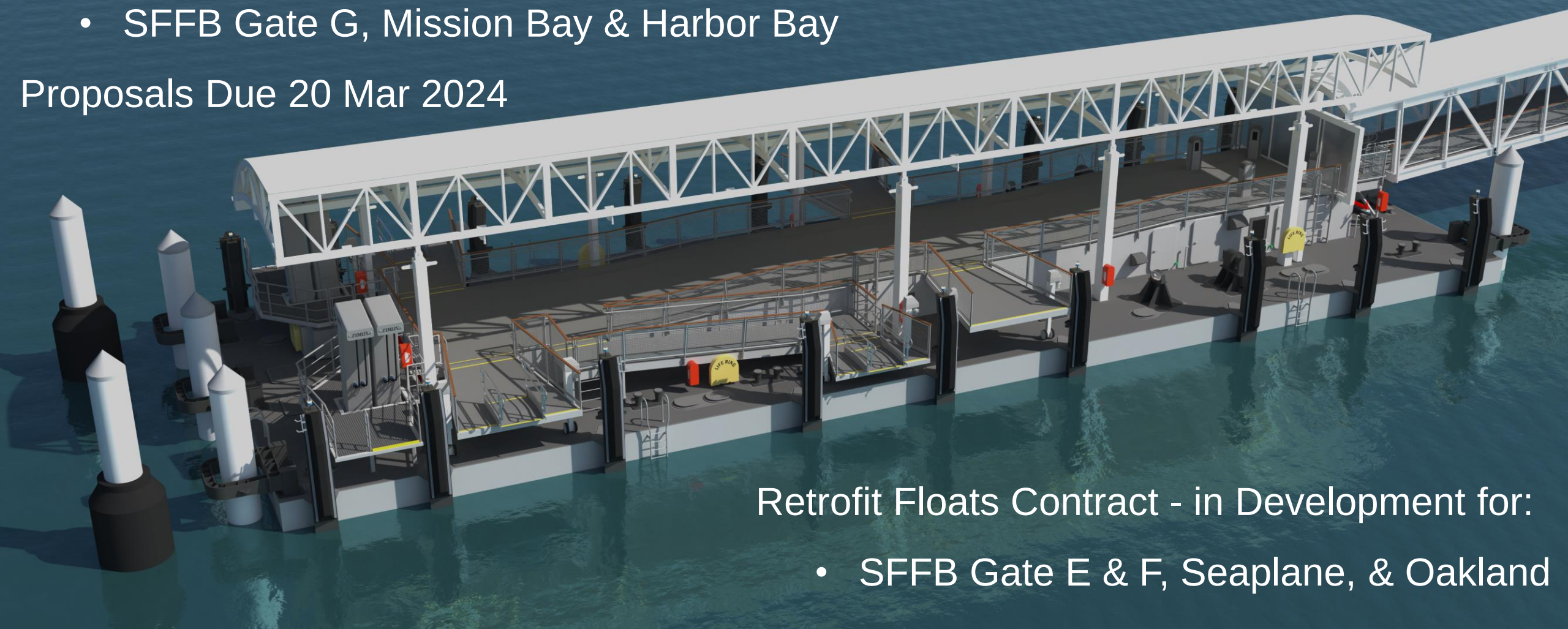
- RFP Released July 2024
- Notional Design Pre-RFP
- Proposals Rcvd Oct 2024
- Currently Under Evaluation

Universal Charging Float

New floats RFP Released 27 Dec 2024

- SFFB Gate G, Mission Bay & Harbor Bay

Proposals Due 20 Mar 2024

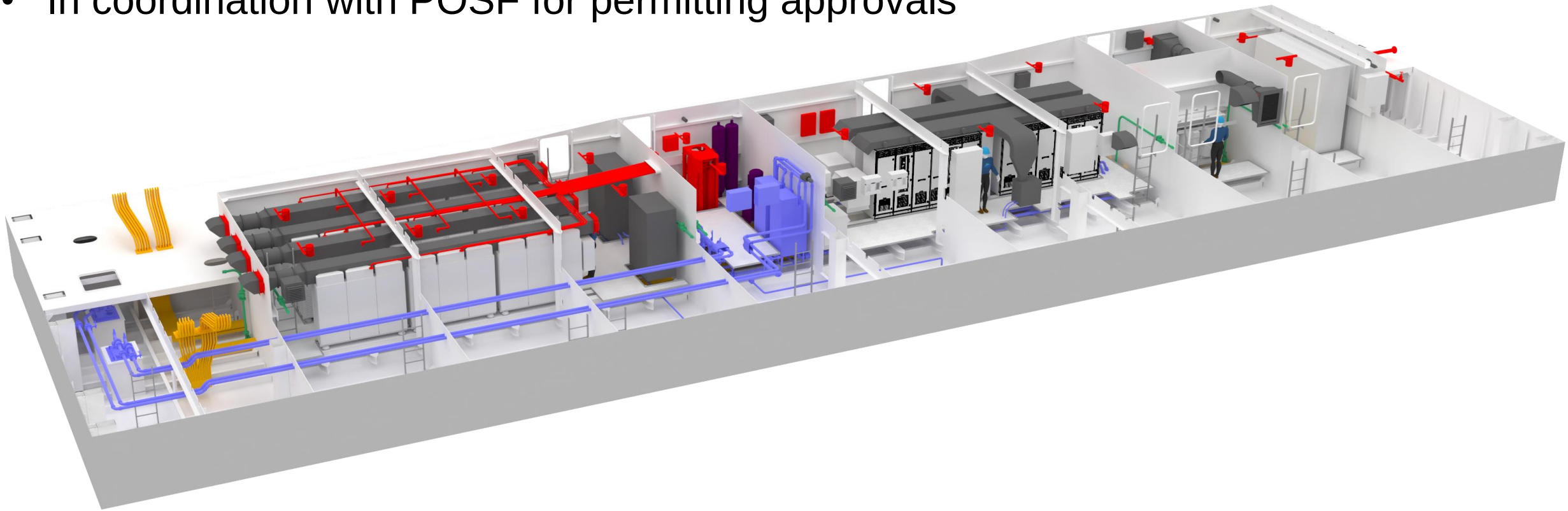


Retrofit Floats Contract - in Development for:

- SFFB Gate E & F, Seaplane, & Oakland

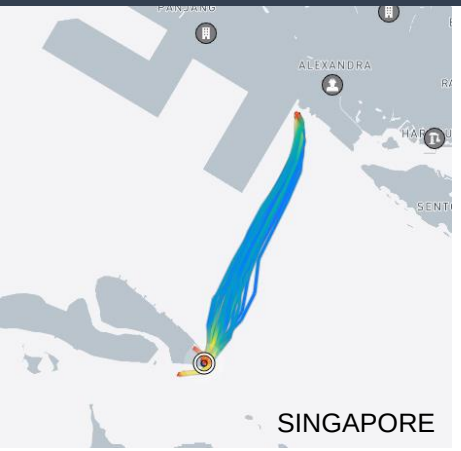
Universal Charging Float

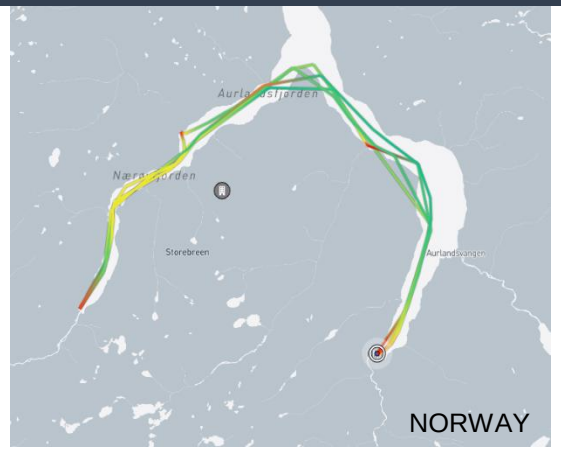
- Heavily Designed Pre-RFP Release
- Heavily specified charging system and support systems
- In coordination with POSF for permitting approvals

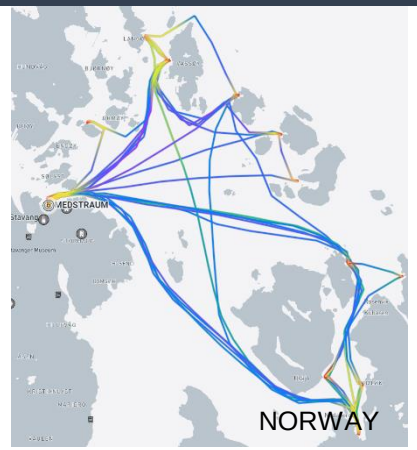


Challenges

WETA System Complexity







ELECTRIC FERRIES ARE OPERATING DAILY WORLDWIDE

WETA's Project is a World First

What makes WETA's Transition so complex?

- Need to support **AT LEAST 3 classes of vessel** – each with unique capacity, speed & range requirements
- Need Common charging, mooring, and passenger access at multiple locations in different cities
- Need to **sustain current service operations and support legacy diesel vessels** during the transition

Asset Regulatory Risk

VESSELS

- US Rules are still evolving from European rule “trickle down”
- Recent regulatory changes in Europe may impact our core propulsion systems

SHORESIDE / FLOATS

- Universal charging floats are **uncharted territory**
- USCG has no jurisdiction
- Recently adopted building code now has provisions for floating structures
- Building a “ship” to landside building regulations
- **SAFETY** first and foremost

Asset Operational Risk

VESSELS

- High Technical complexity in electrical power management systems
- Heavy reliance on interoperability of novel systems

PERFORMANCE

- New propulsions systems
- New docking procedures

Sustainment Risk

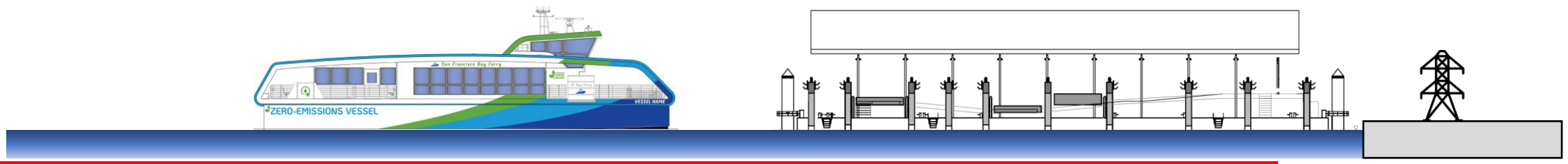
- An overwhelming response from Industry
  - New Products and Solutions constantly entering the market
  - Bespoke vs. “One Size fits all” Solutions
  - How to “Crystal Ball” the future
- European vs. US equipment certifications a challenge
- Buy America Challenges

- Novel systems require new technician expertise for sustainment
- New Sparing requirements

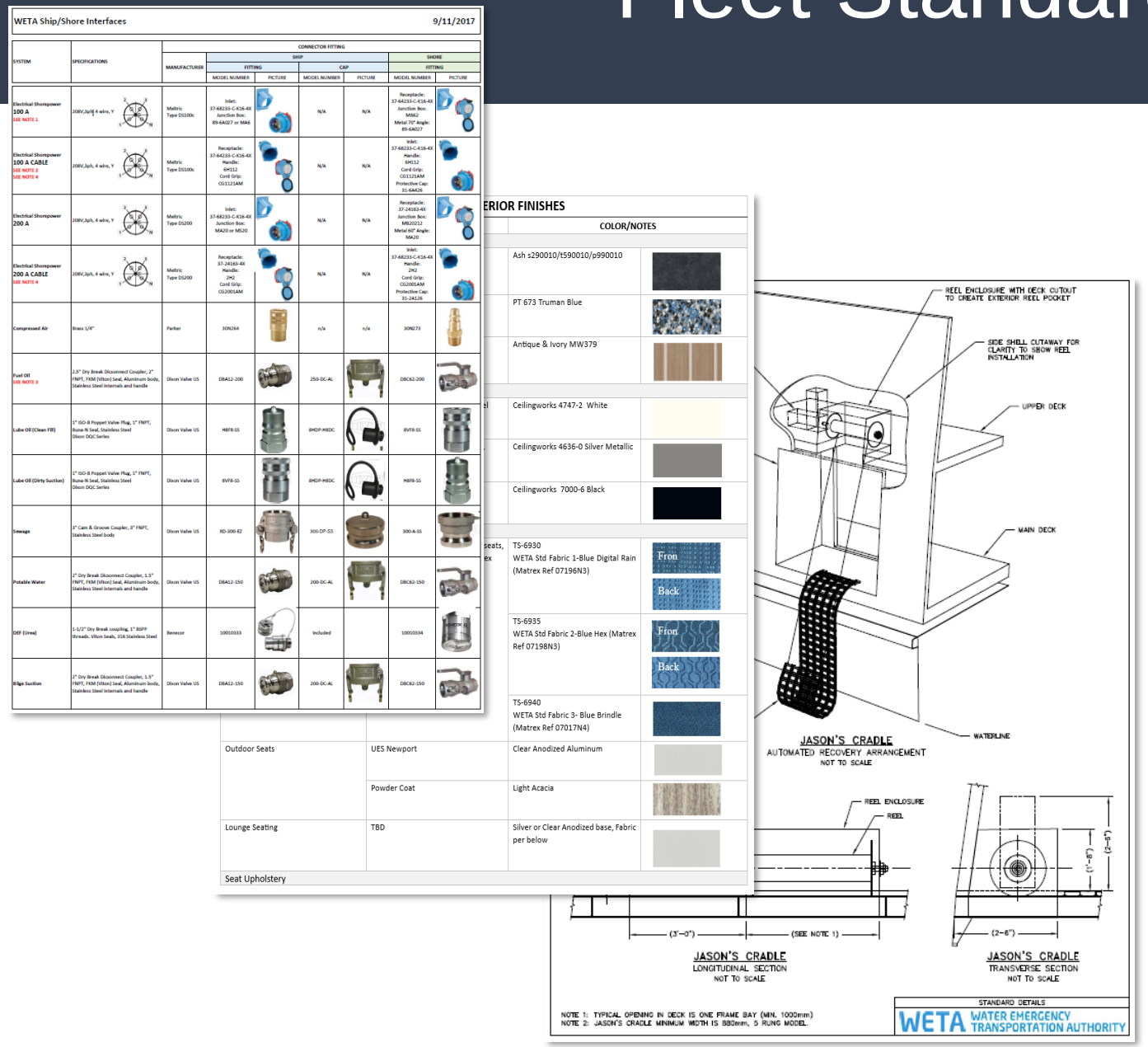
Standardization

Dedicated Electrical System Integrator

- Responsible for specifying the vessel charging and electrical propulsion system
- Selects appropriate components (batteries, motors, power electronics)
- Ensures complete compatibility of the components
- Ensures the vessels and floats are constructed accordingly



Fleet Standardization



- Continue the standardization work
- Long Term Benefits:
  - Operational Safety
  - Maintenance Cost Savings
  - Reduced Inventory
  - Branding
  - Passenger Experience

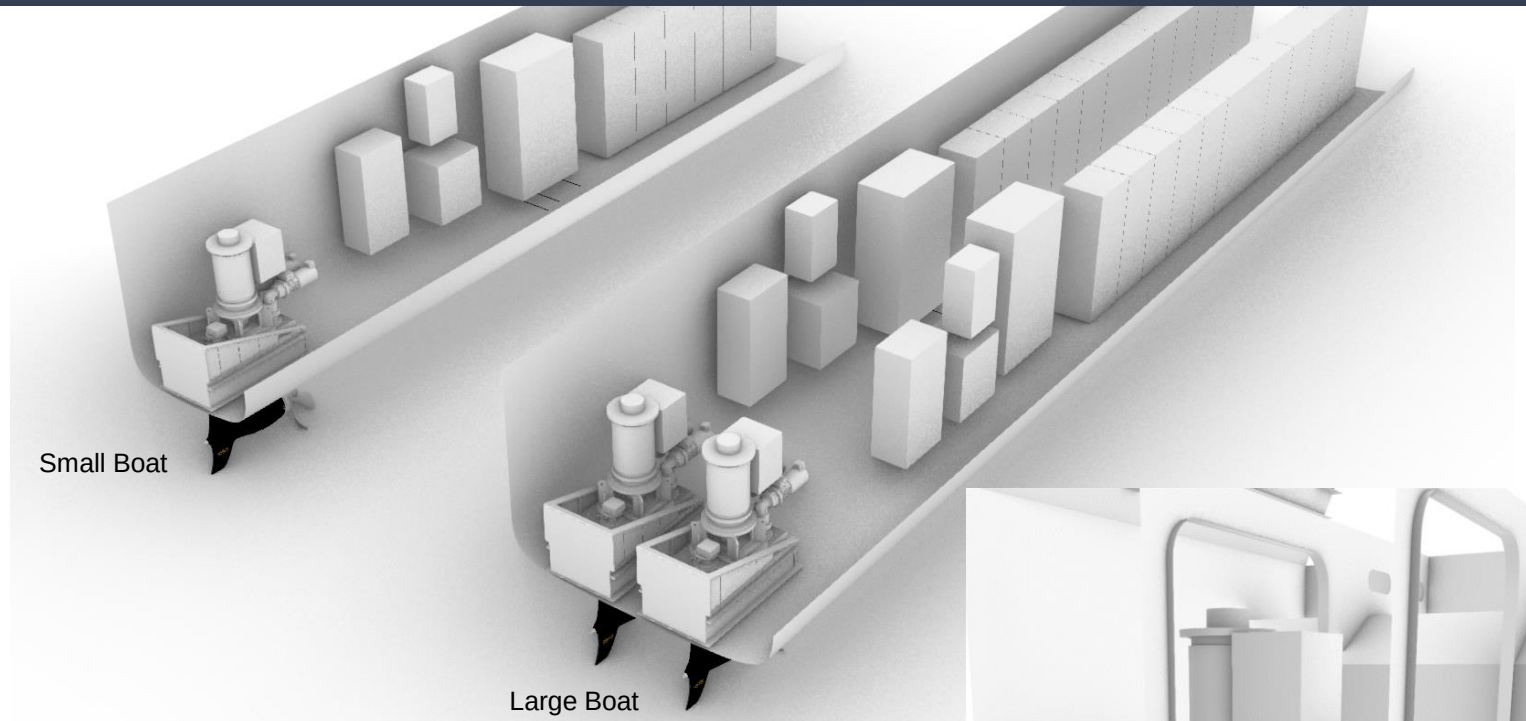
Examples:

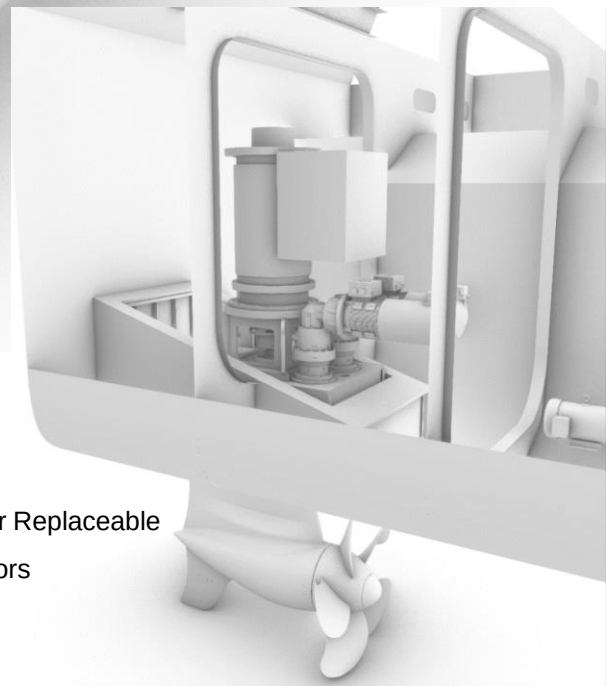
Standardized seating – Saves $150k/yr, Improved Branding

Jasons Cradle – instant Man Overboard response time

Standard Propulsion Power Package

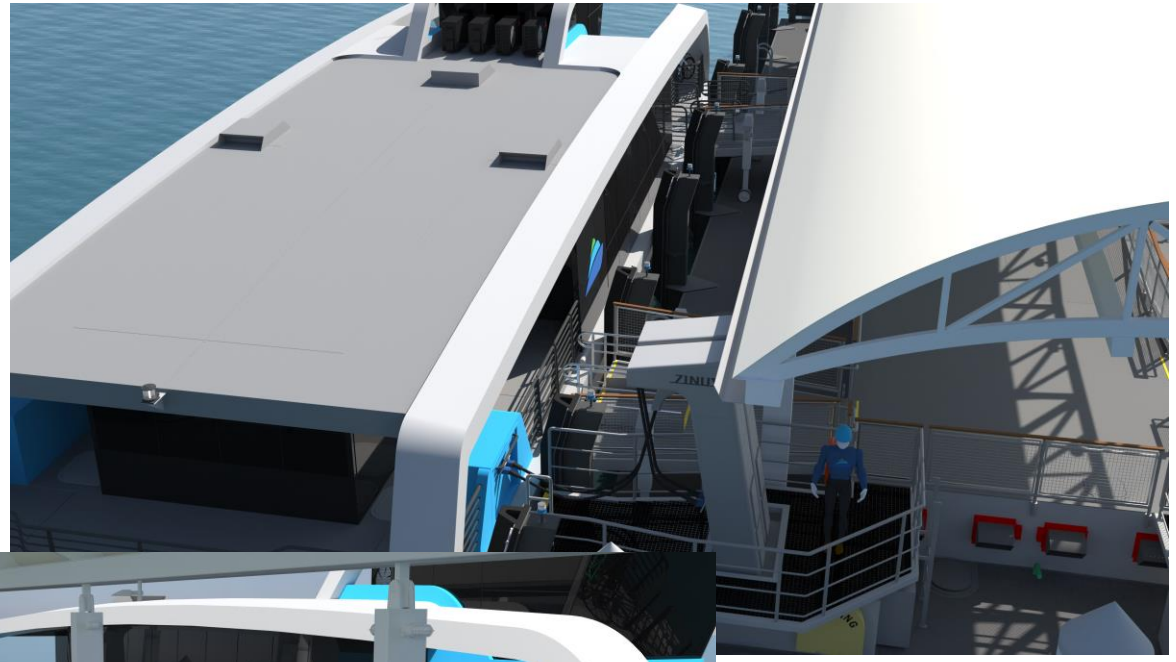
- 100% Modular
- 2 x Propulsion Systems for Small Boat
- 4 x Propulsion Systems for Large Boat
- Scalable Energy Storage
- Same Components Shoreside in Float

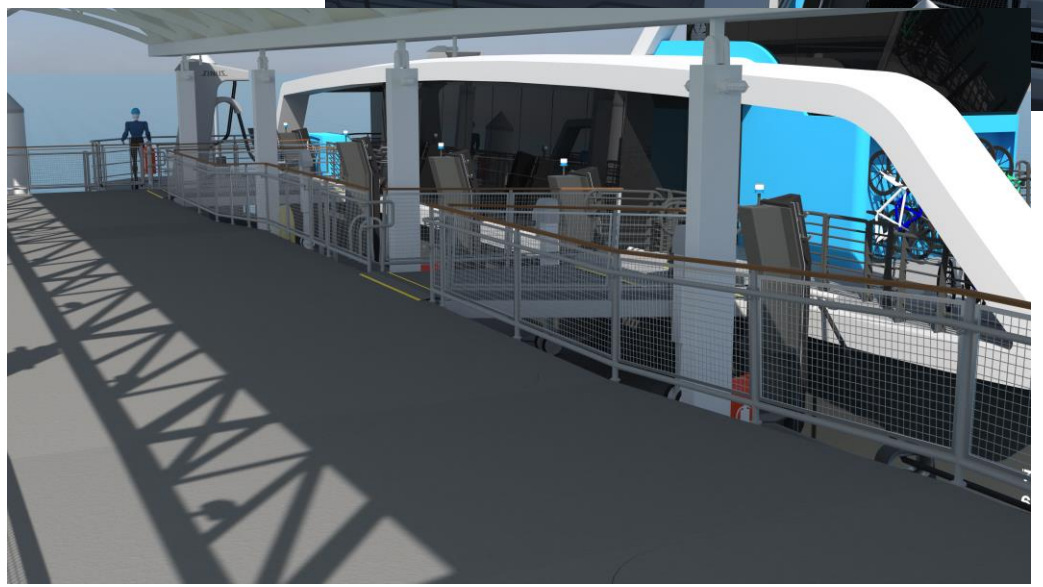




Universal Charging Float

- Designed around Standard Mooring configurations for all WETA vessels
- Standard Charging Plugs – Match current commercial standard
- Ramp systems match access for all WETA vessels and additional bay area ferries
- Battery and power systems interchangeable with vessel configuration
- Currently planned for all terminals except:
  - Alameda Main St
  - Richmond
  - Vallejo
  - South San Francisco





Evaluation Process

How do we Evaluate the new Concepts?

Industry is evolving rapidly

- **Route Specific Optimization** - What works well on one route may not work well on another
- **System Optimization, not Component Optimization** - Evaluate all Vessels / Shoreside together
- **Analysis Tools** – Spend time developing the Analysis Tools to provide unbiased data

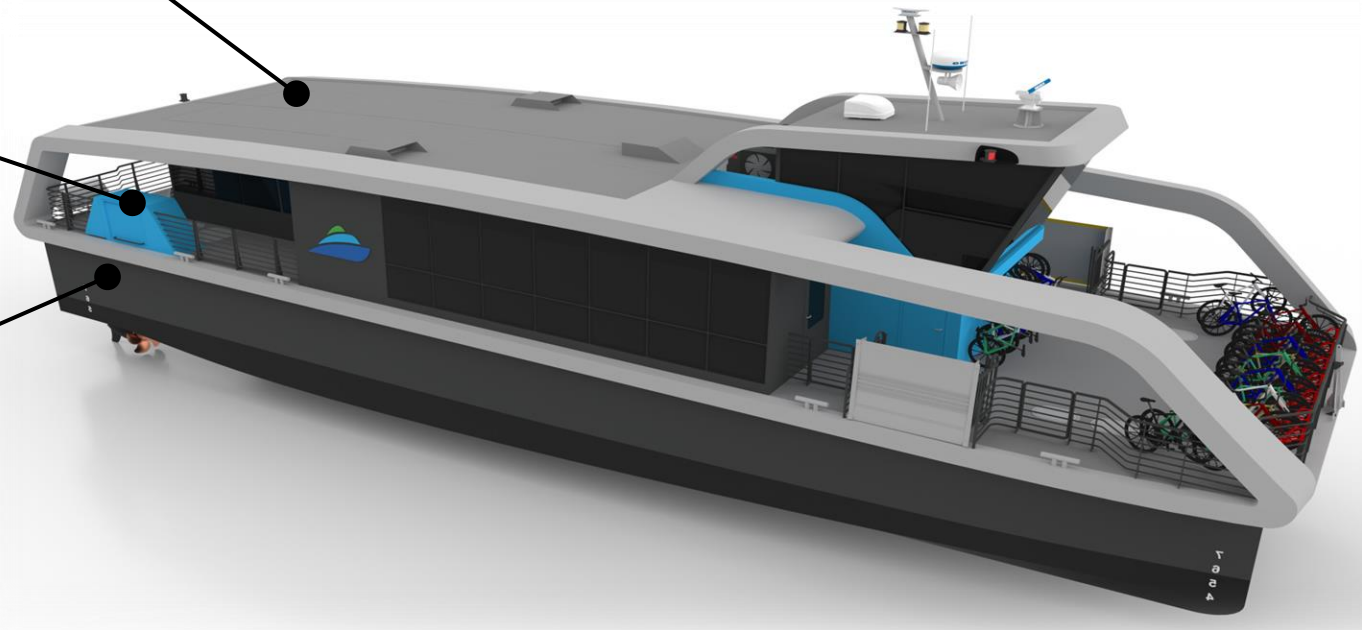
Components

Materials

Batteries

Propulsors

- All key components are evaluated
- Vendors provide specs and performance data
- Stated performance is independently validated from existing vessels (wherever possible)



Component Selection

Scoring Formula Evaluates Numerous Factors:

- Efficiency
- Performance
- Operation
- Maintainability
- Cost – Capital and Lifecycle
- Maturity
- Schedule
- Buy America
- Safety

High Score is the result of several key factors, not just a single attribute

Examples:

- Carbon fiber Composite vs. Aluminum
- Azimuthing thrusters vs. typical propulsors

FACTORS

VENDORS

Propulsion Evaluation- Small Vessel

FACTOR	CATEGORY	POSSIBLE POINTS	Hydromaster	Volvo Penta	Traditional Propeller with gearbox	Traditional Propeller without gearbox	Hamiltonjet
A	**Cost**	45	36.0	21.0	39.0	45.0	19.5
	Capital Cost	15	7.0	10.0	7.0	10.0	7.0
	Maintenance Cost	15	8.0	2.0	9.0	10.0	3.0
	Lifecycle cost	15	9.0	2.0	10.0	10.0	3.0
B	**Efficiency**	50	50.0	20.0	35.0	40.0	10.0
	Overall Efficiency, Weighted for weight, additional appendages, and propulsive coefficients	50	10.0	4.0	7.0	8.0	2.0
C	**Operational Considerations**	30	21.5	18.5	13.5	14.5	22.0
	Efficient Maneuverability Score	10	10.0	6.0	4.0	4.0	3.0
	Walkability Score	10	10.0	9.0	5.0	5.0	9.0
	Control System WETA Operator Familiarity	5	2.0	2.0	10.0	10.0	10.0
	Navigable Draft	5	1.0	1.0	1.0	1.0	10.0
D	**Naval Architecture/ Integration**	35	30.5	24.5	18.5	19.5	17.5
	Arrangement Impact Score	10	10.0	4.0	5.0	5.0	6.0
	Integration Required (total system) score	5	9.0	10.0	3.0	4.0	8.0
	Installation Simplicity Score	5	10.0	10.0	5.0	6.0	6.0
	Commonality Score	10	10.0	2.0	5.0	5.0	2.0
	Historical Performance Low Risk Score	5	9.0	9.0	9.0	9.0	5.0
E	**Maintenance**	35	23.0	18.5	31.0	31.0	29.0
	Serviceability	5	9.0	6.0	10.0	10.0	8.0
	Service Network	5	1.0	8.0	8.0	8.0	9.0
	Repairability	5	9.0	6.0	10.0	10.0	8.0
	Perceived Robustness	5	8.0	1.0	8.0	8.0	8.0
	Control System Service Network	5	2.0	9.0	8.0	8.0	9.0
	subtotal- small vessel	195	161.0	102.5	138.0	150.0	98.0

Propulsor Evaluation Example

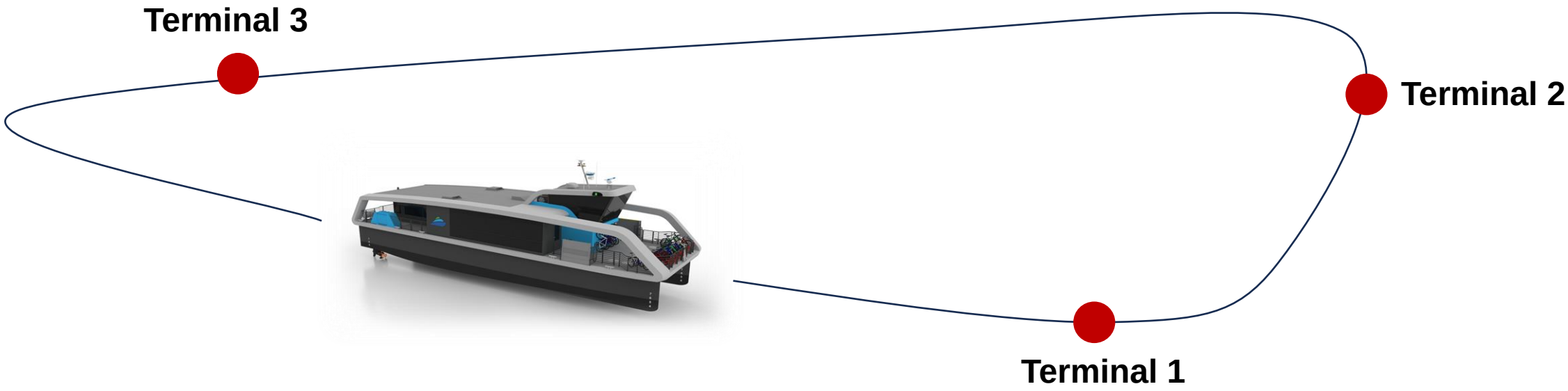
Propulsion Evaluation- Large Vessel

FACTOR	CATEGORY	POSSIBLE POINTS	Hydromaster	Volvo Penta	Traditional Propeller with gearbox	Traditional Propeller without gearbox	Hamiltonjet
A	**Cost**	45	31.5	22.5	36.0	45.0	21.0
	Capital Cost	15	9.0	9.0	9.0	10.0	9.0
	Maintenance Cost	15	4.0	1.0	7.0	10.0	1.0
	Lifecycle cost	15	8.0	5.0	8.0	10.0	4.0
B	**Efficiency**	50	50.0	40.0	45.0	45.0	40.0
	Overall Efficiency, Weighted for weight, additional appendages, and propulsive coefficients	50	10.0	8.0	9.0	9.0	8.0
C	**Operational Considerations**	30	23.5	20.0	15.0	14.5	24.0
Qualitative	Efficient Maneuverability Score	10	10.0	7.0	4.0	4.0	5.0
Qualitative	Walkability Score	10	10.0	9.0	5.0	5.0	9.0
Qualitative	Control System WETA Operator Familiarity	5	2.0	2.0	10.0	10.0	10.0
Qualitative	Navigable Draft	5	5.0	6.0	2.0	1.0	10.0
D	**Naval Architecture/ Integration**	35	32.0	21.5	17.0	16.5	17.5
	Arrangement Impact Score (least impact on arrangement)	10	10.0	8.0	4.0	3.0	6.0
	Integration Required (total system) score - Need Explanation	5	10.0	9.0	3.0	4.0	8.0
	Installation Simplicity Score	5	10.0	10.0	6.0	5.0	6.0
	Commonality Score (between large and small vessels)	10	10.0	2.0	5.0	5.0	2.0
	Historical Performance Low Risk Score	5	4.0	4.0	7.0	8.0	5.0
E	**Maintenance**	35	21.5	23.5	29.0	29.5	29.5
	Serviceability	5	9.0	6.0	10.0	10.0	8.0
	Service Network (Propulsor only)	5	1.0	8.0	8.0	8.0	9.0
	Repairability	5	9.0	6.0	10.0	10.0	8.0
	Perceived Robustness	5	8.0	1.0	8.0	8.0	8.0
	Control System Service Network	5	2.0	9.0	8.0	8.0	9.0
	Control System Component Replacement (Wartsila or MFR?)	5	4.0	7.0	6.0	7.0	7.0
	Steering Control System	5	10.0	10.0	8.0	8.0	10.0
	subtotal- large vessel	195	158.5	127.5	142.0	150.5	132.0
Grand Total			319.5	230.0	280.0	300.5	230.0

System Analysis

Simulate the Route

- Combine the highest scoring equipment into a virtual vessel configuration
- Simulate that vessel on actual routes using the Route Analysis Tool



Route Analysis Tool

WETA Route Analysis Tool - 150 PAX SF-TI 2024-0708.xlsm

Notes and Description

Date: 7/8/2024
Description: Small Electric Vessel, San Francisco Ferry Building to Treasure Island
Notes: All charging on the Trasure Island side

Vessel Particulars

Vessel Selection: 149E

Vessel	Vessel Class	Service Status	Length m	Beam m	Draft m	Passenger Capacity	Bicycle Capacity	Engines	Installed Power kW	Propulsion	Service Speed kts	House Load Est. kW
149E	Small Vessel	Conceptual	28	7.9	1.1	149	25	2x 625kW E-Motors	1250	Propeller	23	48

Route Parameters

Start Position		Route Segment	Distance NM	Speed kts	Time min	Propulsive Power Required kW	Equivalent Fuel Consumed gal	Battery Consumed kwh	Cumulative Time min	Real Time hh:mm	SOC
Treasure Island		-	-	-	-	-	-	-	0.0	6:30	90%
Leg 1	Total Distance: 1.6 NM	Leave Treasure Island	0.10	3.0	2.0	141	0.4	6.8	2.0	6:32	88%
Downtown	Unrestricted Transit Speed: 24 kts	Unrestricted Transit	1.41	24.0	3.5	1189	4.8	80.3	5.5	6:35	70%
										6:35	70%
		Enter Downtown	0.10	3.0	2.0	141	0.4	6.8	7.5	6:37	68%
		Subtotal	1.61		7.5		5.7	94.0	7.5	6:37	
Docked at Downtown	Time Docked: 5 min ☐ Charging ☐ Under Power At Dock	Docked	0.00	0.0	5.0	0.0	0.3	4.0	12.5	6:42	
		Subtotal	0.00		5.0		0.3	4.0	12.5	6:42	68%
Leg 2	Total Distance: 1.6 NM	Leave Downtown	0.10	3.0	2.0	141	0.4	6.8	14.5	6:44	66%
Treasure Island	Unrestricted Transit Speed: 24 kts	Unrestricted Transit	1.41	24.0	3.5	1189	4.8	80.3	18.0	6:48	48%
										6:48	48%
		Enter Treasure Island	0.10	3.0	2.0	141	0.4	6.8	20.0	6:50	46%
		Subtotal	1.61		7.5		5.7	94.0	20.0	6:50	
Docked at Treasure Island	Time Docked: 11 min ☑ Charging ☐ Under Power At Dock	Docked	0.00	0.0	11.0	0.0	0.6	8.8	31.0	7:01	
		Docked- Charging						-200.8			
		Subtotal	0.00		11.0		0.6	8.8	31.0	7:01	90%
Leg 3	NM									7:01	90%
None										7:01	90%
										7:01	90%
										7:01	90%
		Subtotal	0.00		0.0		0.0	0.0	31.0	7:01	
	☐ Charging ☐ Under Power At									7:01	
		Subtotal	0.00		0.0		0.0	0.0	31.0	7:01	90%
		Trip Total	3.22		31.0		12.2	200.8	31.0	7:01	90%

WETA Route Analysis Tool - 150 PAX SF-TI 2024-0708.xlsm

Charging & Battery Parameters

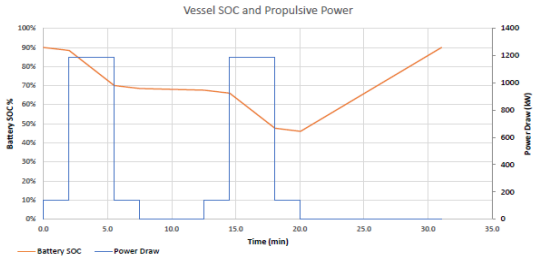
Efficiency- Battery to Propulsor: 90%
Efficiency- Shore to Battery: 90%
Time to Connect Charger: 1.0 min
Time to Disconnect Charger: 1.0 min

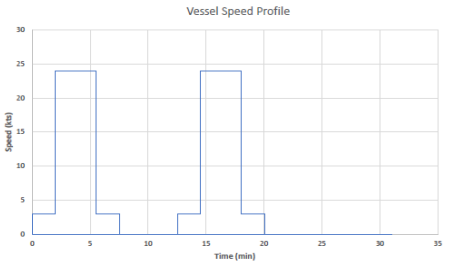
Vessel Battery Size: 437 kwh
Initial Battery SOC: 90%

Suggested Battery Size (NMC)- 1004 kwh

	Dock Location	Charging?	Power Available at Dock kW	Time at Dock min	Vessel Energy Deficit (including consumption while docked) kwh	Available Charging Time min	Dock Energy Required for Replenishment kwh	Dock Power Required for Replenishment kW	Dock Power Provided for Replenishment kW	Dock Energy Provided kwh	Battery Charging Energy kwh	Vessel Energy Deficit After Charging kwh	SOC Before Docking %	SOC After Docking %	C-Rate- Charging	C-Rate - Discharge
Leg 1	☐ Charging Downtown	No	2000	5	-98.0	3.0	108.9	2178	0	0.0	0.0	-98.0	68%	68%	0.00	2.72
Leg 2	☑ Charging Treasure Island	Yes	1500	11	-200.8	9.0	223.1	1487	1487	223.1	200.8	0.0	46%	90%	3.40	2.72
Leg 3	☐ Charging None	No	0	0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	90%	90%	0.00	0.00
Leg 4	☐ Charging None	No	0	10	0.0	0.0	0.0	0	0	0.0	0.0	0.0	90%	90%	0.00	0.00

Output Summary





Vessel Battery Size kwh	Service Speed (kts) kts	Vessel RT Time (min) min	Passenger Point-to-Point time, Treasure Island to Downtown min	Time at Dock-Downtown min	Passenger Point-to-Point time, Downtown to Treasure Island min	Time at Dock-Treasure Island min	Passenger Point-to-Point time, Treasure Island to None min	Time at Dock-None min	Charging Locations	Total Charge Time min	Total Energy Usage (vessel-side) kwh	Total Energy Usage (grid-side) kwh	Charge Power Required (shoreside, balanced between charge locations) kW	Max Propulsive Power Required kW
437	24.0	31.0	7.5	5.0	7.5	11.0	0.0	0.0	1.0	9.0	201	223	1487	1188.6	1188.6

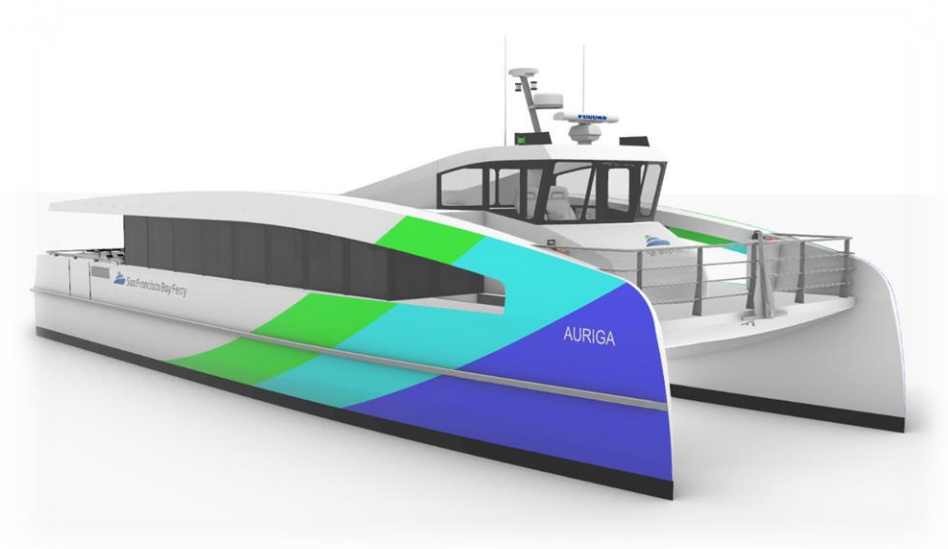
- Rapid evaluation of proposed vessel configurations
- Evaluates vessel **and** shoreside power delivery and use

Highest Scoring equipment may not always be the best choice for the "system"

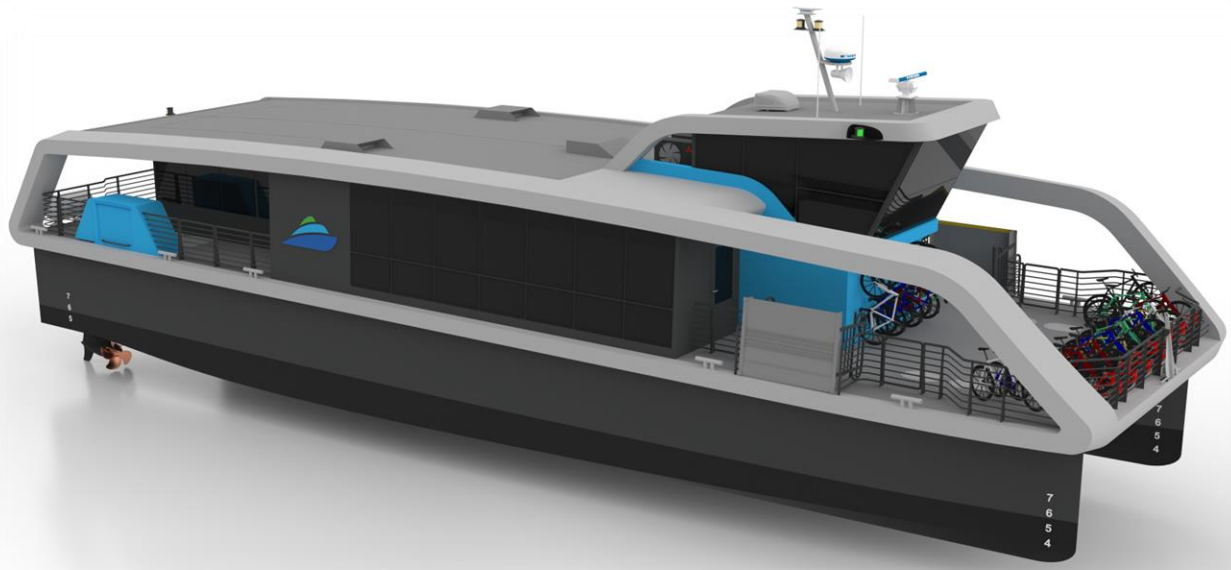
Next Phase Considerations

Lessons learned from Phases 1 & 2

- Added 15 Tons of weight in Concept Design to incorporate WETA's constraints
- Mooring, Boarding and Terminal Interfaces largely dictate and constrain the design
- Route Performance analysis quickly identified issues to be addressed
- Engage the operators, maintainers early in the concept design to limit changes later



Initial concept - 2021



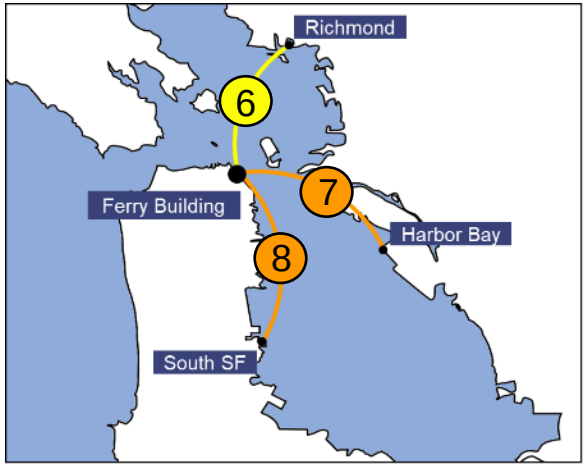
Final concept - 2024

Phase 3 & 4 Considerations

New Technology Almost Certainly Required

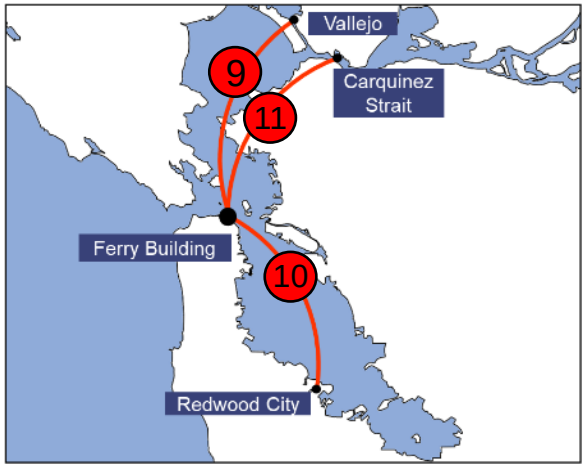
- How do we maintain the fleet commonality we've worked so hard to develop?
- How do we effectively analyze these new technologies?
- How do we adapt our approach to achieve the same level of system integration?

Phase 3 – Long Run Central Bay



6 Richmond
7 Harbor Bay
8 South SF

Phase 4 – Long Runs



9 Vallejo
10 Redwood City
11 Carquinez

Feasible with Current Vessel Technology

Feasible with Current Vessel Technology - Operational Changes Required

Feasible with Current Vessel Technology - Significant Operational Changes Required

Not Currently Feasible – TBD Future Technology Required

Advanced Technologies

New Technologies present new risks

Will require <u>new, additional</u> evaluation factors

- **Safety**
- **Legal**
- **New Regulatory (FAA, Marine Life etc.)**
- **Supply chain robustness**

Foiling

Green Fuels – Traditional Vessel


Wing in Ground Effect

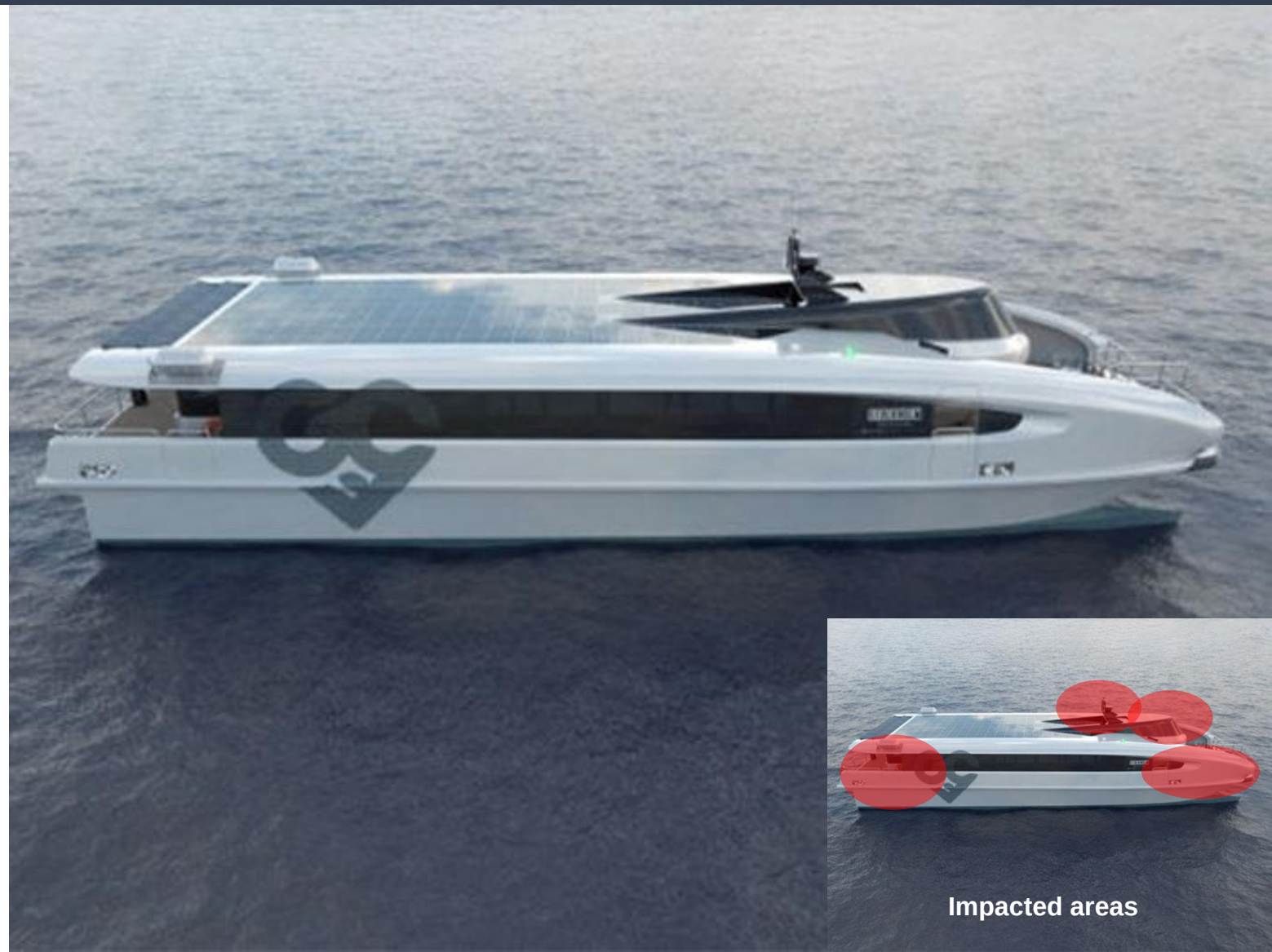
Case Study – Green City Ferries

To make the vessel WETA Compatible:

- New bow openings
- New Stern openings
- External Mooring / boarding provisions
- USCG Regulatory
- ADA Head
- New Pilothouse with forward raked windows
- Increased Bicycle storage

Impacts:

- Aesthetics
- Performance (added weight)
- Passenger count (reduced interior space)



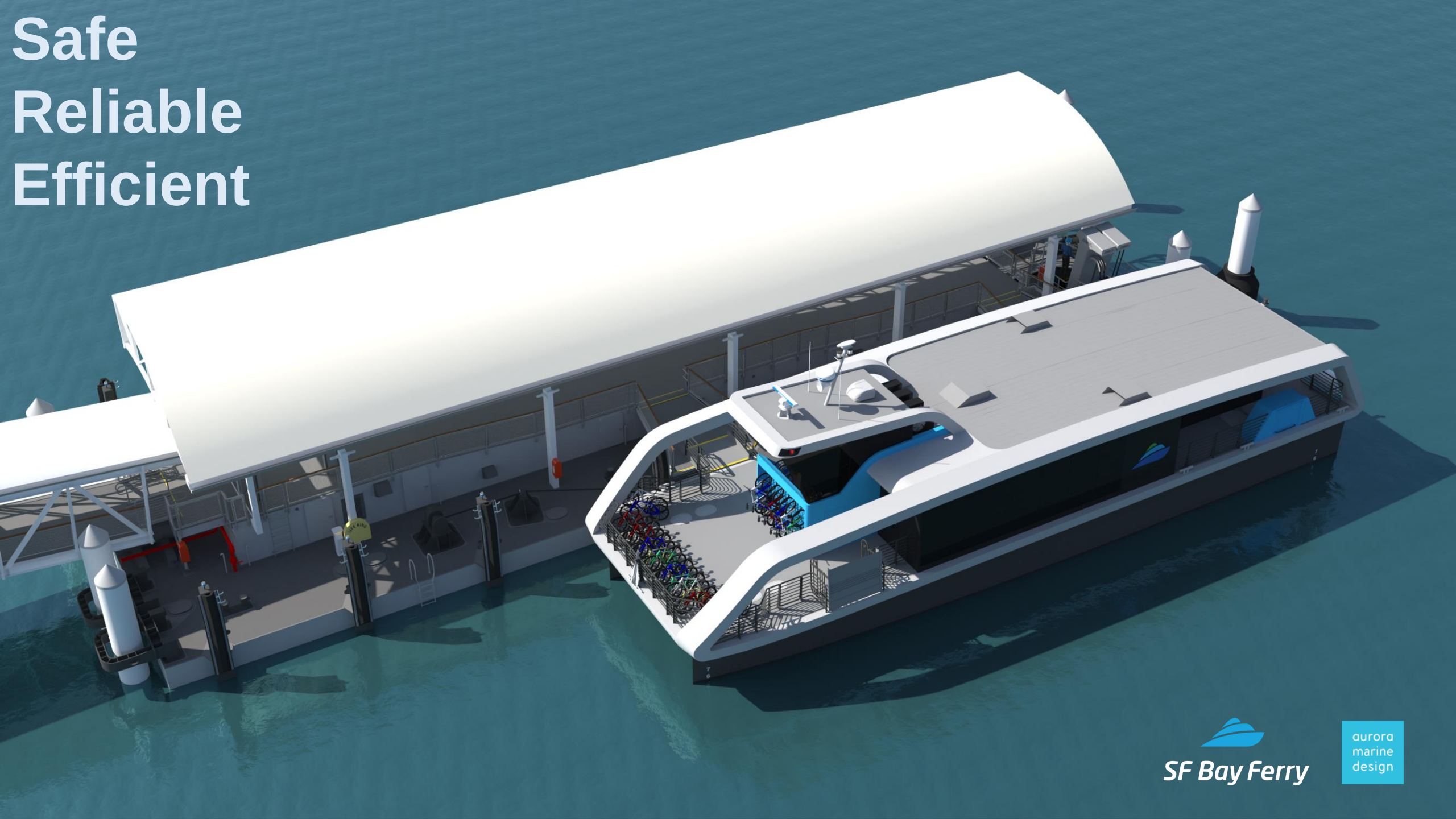
Key Takeaways

- **“Apples to Apples” – ensure any new vessel concept has been adapted to meet WETA’s constraints before evaluating and analyzing**

- **“Plan for the Worst” - leave space / weight reservation in the vessel design for alternate equipment selection to hedge against industry attrition**

- **“Consistency” - Have the same team of operators assigned to evaluate any new technology**

Safe
Reliable
Efficient



SF Bay Ferry

aurora marine design