Zero Emission Fleet Study Update

WETA Board of Directors
October 7, 2021

WETA

ARUP

aurora marine design

Study Goals

"Develop a plan to transition ferry operations on San Francisco Bay to zero-emission vessels"

How much power do we need?

Where will it come from?

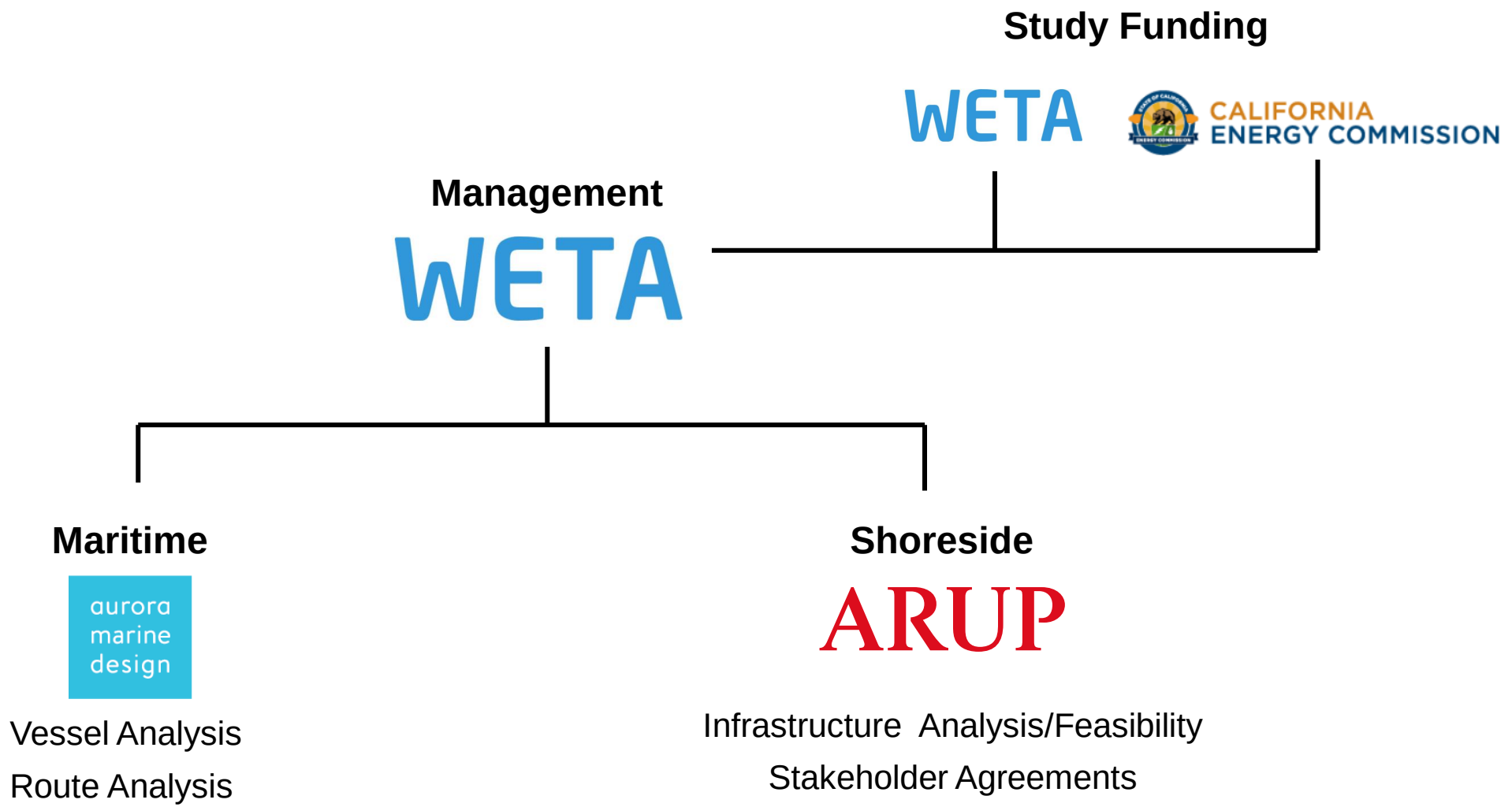
When do we need it?

How much will it cost?

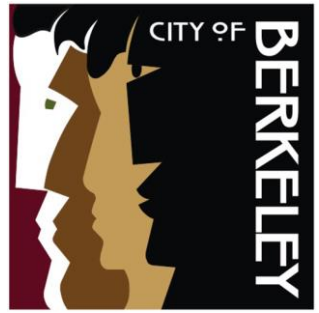
How do we pay for it?

Emphasis on the use of electric propulsion systems and resolving the technical and regulatory barriers for the shore side infrastructure

Study Responsibilities



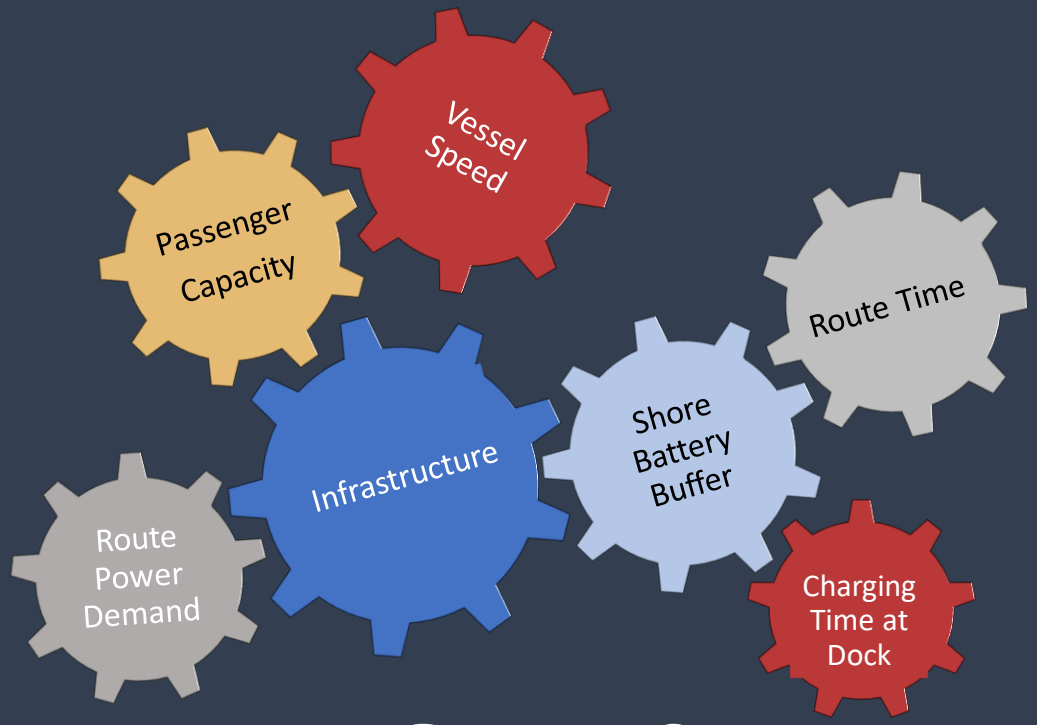
Stakeholders Engaged



Workflow

Stage 1
Baselining

Collect and process data on operations, vessels and terminals to define their constraints and opportunities



Stage 2
Optioneering

Develop solutions and assess their attributes and drawbacks to select optimal direction

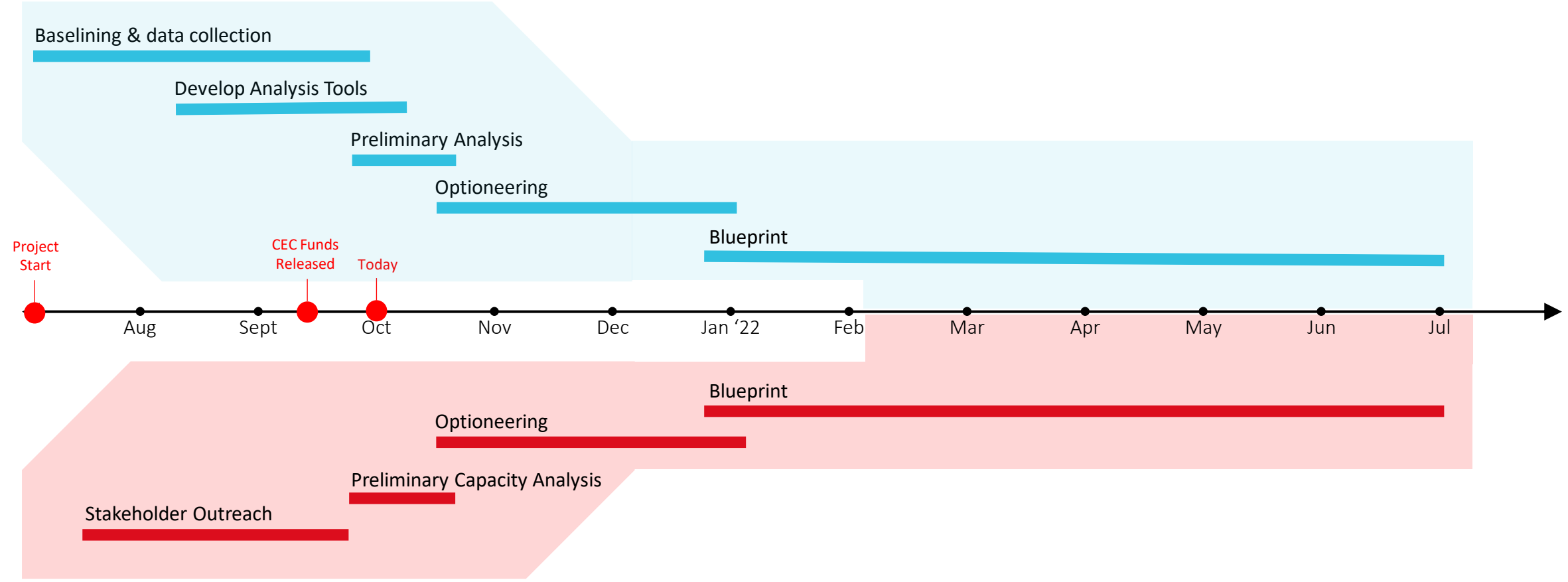
Stage 3
Blueprint & Strategy

Lay out an actionable path to progress to procurement, design and delivery of electrified ferry service

Project Timeline

aurora marine design

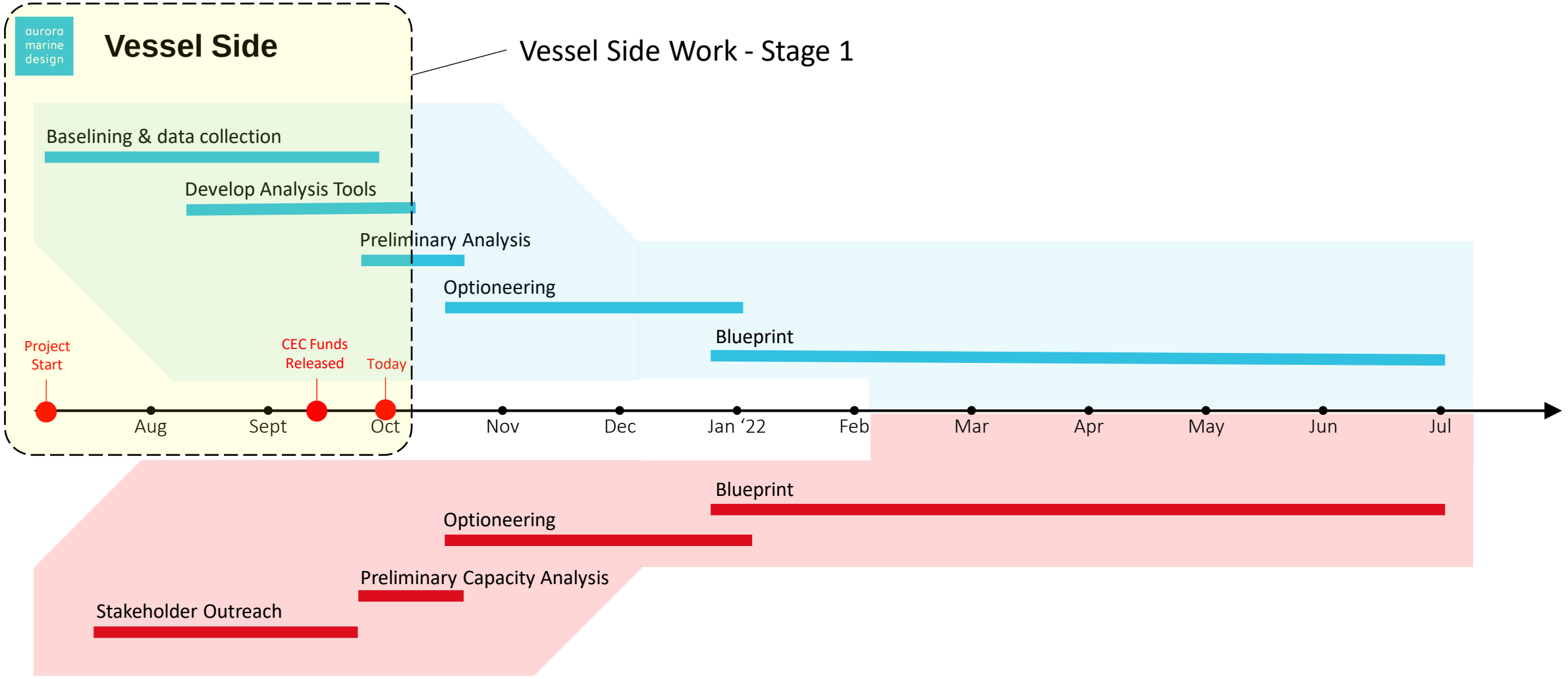
Vessel Side



ARUP

Shoreside

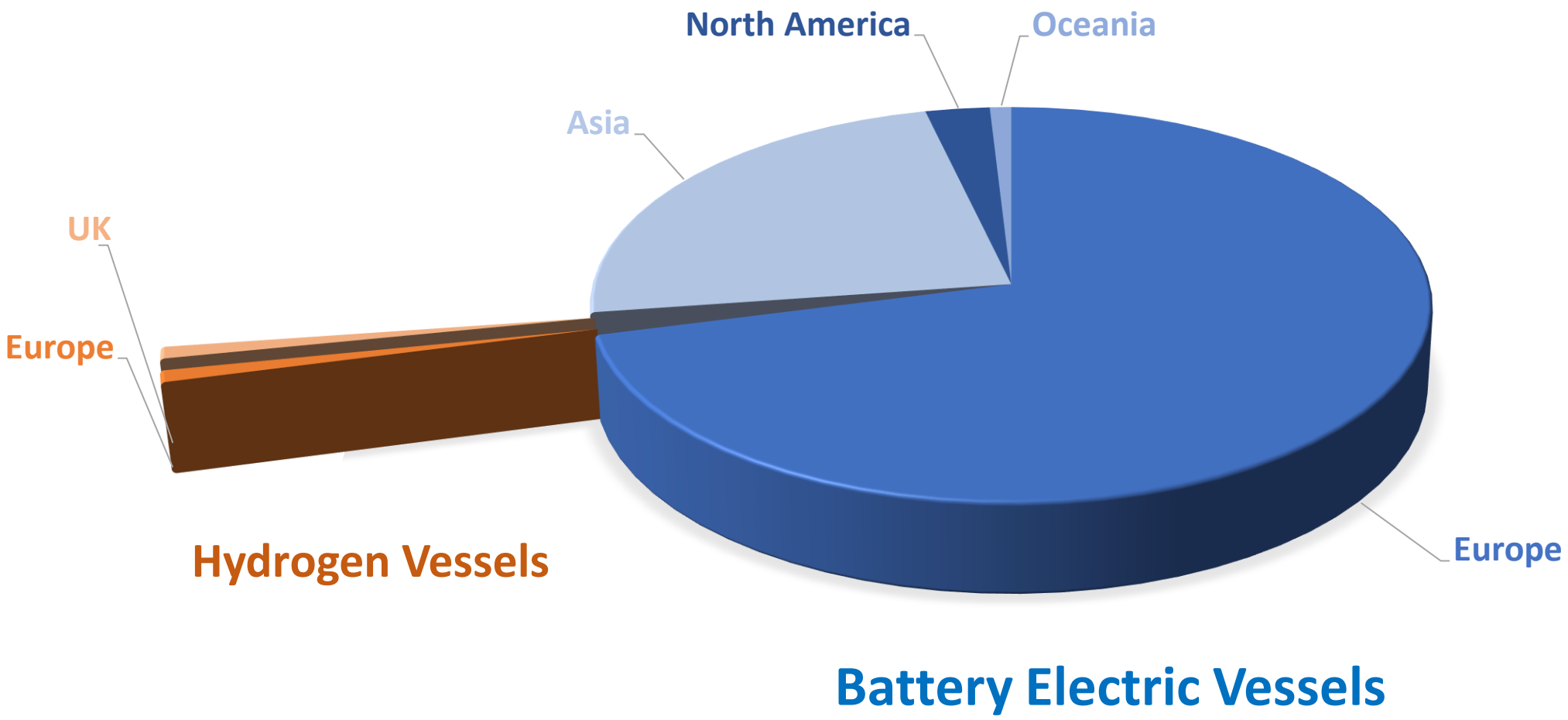
Vessel Side Progress Update



ARUP **Shoreside**

Global Zero Emission Ferry Fleet *

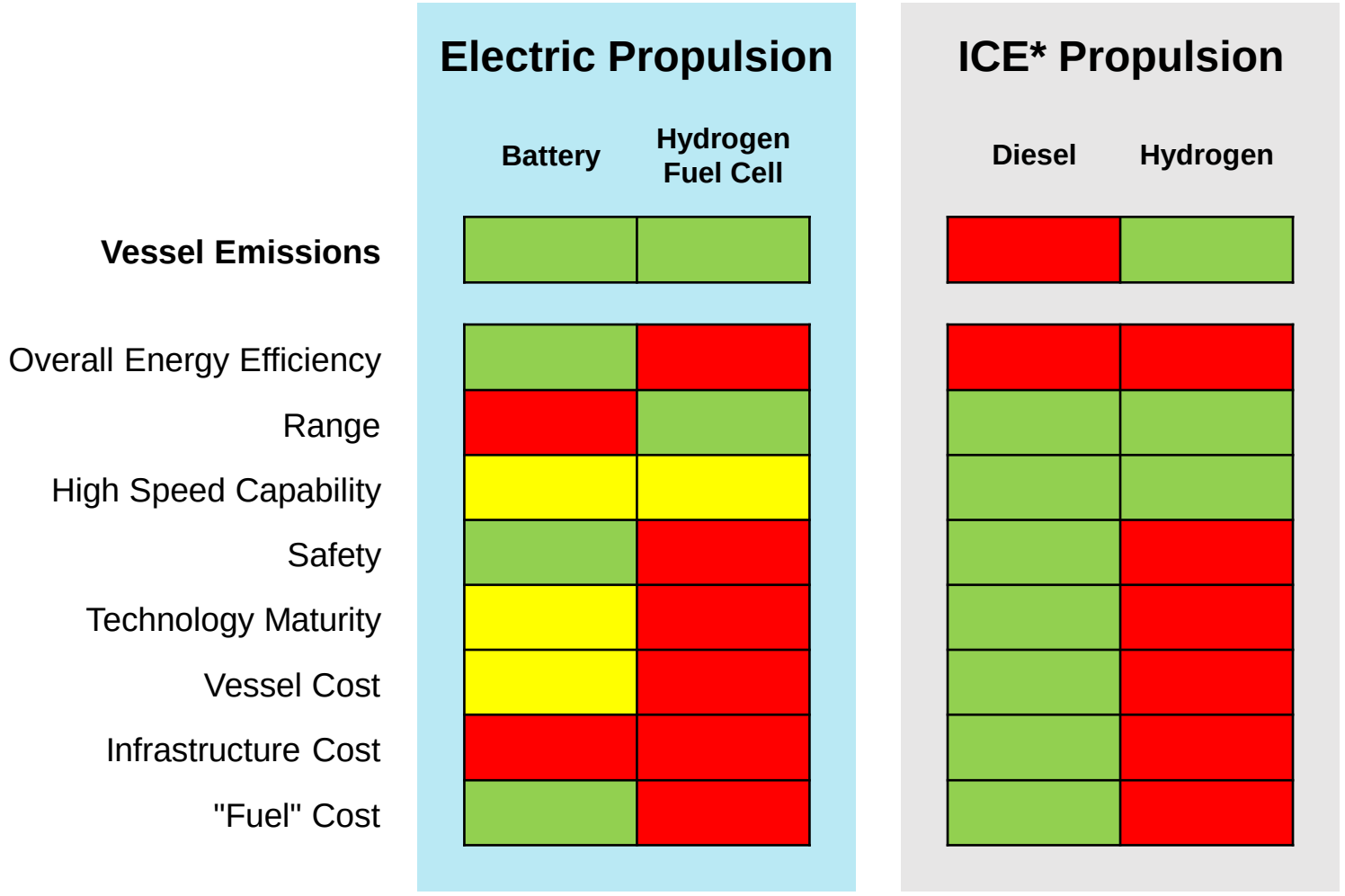
** Vessels currently in service based on readily available information*



Energy Sources

aurora marine design

- **All propulsion options have strengths and weaknesses**
- **Careful route definition and analysis is required to determine the best match**
- **Battery Electric is initial focus per the CEC Study**
- **Hydrogen Electric provides a zero emissions "bridging" solution where Battery Electric is impractical**



** Internal Combustion Engine*

The above chart is a general representation of propulsion tradeoffs

Data Collection

aurora marine design

Vessel Data Collected

- Detailed Vessel Metrics
- Performance characteristics, speed vs power vs weight vs fuel burn
- Viability of Electric Conversion:
  - Remaining Lifespan
  - Structural Design Limits (How much weight and space margin do we have to install this equipment?)

Route Data Collected

- Develop a database of existing and planned routes. For each route, determine:
  - Load Profile
  - Daily Timetables
  - Route Constraints
  - Expected Growth
- Assess operational profiles for energy usage, speed sensitivity, and timetable sensitivity

WETA Ferry System Analysis

aurora marine design

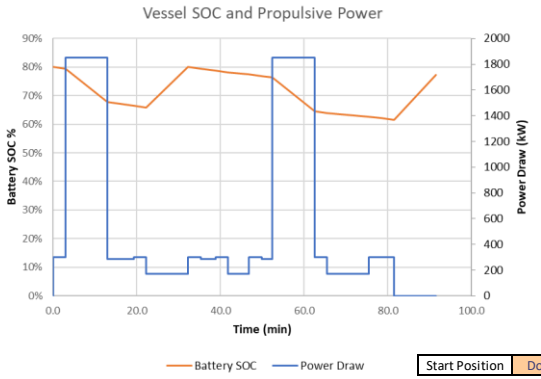
WETA's complex service involves **A LOT OF VARIABLES!**

- How much energy is currently consumed on each route segment and what is the sweet spot for speed vs. power consumed vs passengers moved?
- What is the impact of extended dockside charging time?
- Is interlining possible or practical during a transition to electric?
- What impact does speed vs passenger capacity have on power consumed?

This required the development of some WETA specific **RAPID ANALYSIS TOOLS**

Route Analyzer Tool

aurora marine design



Start Position: Downtown

			Outputs									
		Route Segment	Length mi	Speed kts	Time min	Propulsive Power Required kW	Fuel consumption gal	Battery Consumption (Electric) kwh		Cumulative Time min	Time	SOC
		-	-	-	-	-	-	-		0.0	14:00	80%
Leg 1	Total Distance: 6.4 mi	Leave Downtown	0.1	3.0	3.0	298	1.1	18.6		3.0	14:03	79%
Oakland	Unrestricted Transit Speed 26 kts	Unrestricted Transit	5.0	26.0	10.0	1851	21.1	350.6		13.0	14:13	68%
	Inner Harbor Transit Speed 10 kts	Inner Harbor Transit	1.2	10.0	6.3	285	2.3	37.2		19.3	14:19	66%
	Number of Passengers 250	Enter Oakland	0.1	3.0	3.0	298	1.1	18.6		22.3	14:22	66%
		Subtotal	6.4		22.3		25.6	424.9		22.3	14:22	
Docked-Oakland	Time Docked 5 min ☐ Charging ☑ Under Power At	Docked	0.0	0.0	5.0	171.5	1.2	19.2		27.3	14:27	
		Docked- Charging						0.0				
		Subtotal	0.0		5.0		1.2	19.2		27.3	14:27	65%
Leg 2	Total Distance: 0.9 mi	Leave Oakland	0.1	3.0	3.0	298	1.0	18.6		30.3	14:30	65%
Alameda Main Street	Inner Harbor Transit Speed 10 kts	Inner Harbor Transit	0.7	10.0	3.5	285	1.1	21.1		33.8	14:33	64%
											14:33	64%
	Number of Passengers 250	Enter Alameda Main Stre	0.1	3.0	3.0	298	1.0	18.6		36.8	14:36	63%
		Subtotal	0.9		9.5		3.1	58.2		36.8	14:36	
Docked-Alameda Main Street	Time Docked 10 min ☑ Charging ☑ Under Power At	Docked	0.0	0.0	10.0	171.5	2.3	38.4		46.8	14:46	
		Docked- Charging						-480.0				
		Subtotal	0.0		10.0		2.3	38.4		46.8	14:46	78%
Leg 3	Total Distance: 5.7 mi	Leave	0.1	3.0	3.0	298	1.0	18.6		49.8	14:49	77%
Downtown	Inner Harbor Transit Speed 10 kts	Inner Harbor Transit	0.5	10.0	2.6	285	0.8	15.5		52.5	14:52	77%
	Unrestricted Transit Speed 26 kts	Unrestricted Transit	5.0	26.0	10.0	1851	20.6	350.6		62.5	15:02	65%
	Number of Passengers 250	Enter Downtown	0.1	3.0	3.0	298	1.0	18.6		65.5	15:05	65%
		Subtotal	5.7		18.6		23.4	403.2		65.5	15:05	
Docked-Downtown	Time Docked 10 min ☑ Charging ☑ Under Power At	Docked	0.0	0.0	10.0	171.5	2.3	38.4		75.5	15:15	
		Docked- Charging						-480.0				
		Subtotal	0.0		10.0		2.3	38.4		75.5	15:15	79%
		Trip Summary:	13.0				58.0	982.4		75.5	15:15	79%

Create a user-friendly tool to rapidly configure and optimize energy used on each route

Enables user to:

- Build a route from a dropdown library of route segments
- Select a vessel (current fleet and user defined)
- Adjust route parameters (speed, dock maneuverability, leg distances)

Output :

- Energy used
- Battery sizing
- Charging power required at each stop
- Transportation Efficiency metrics
- Diesel used - *for calibration*

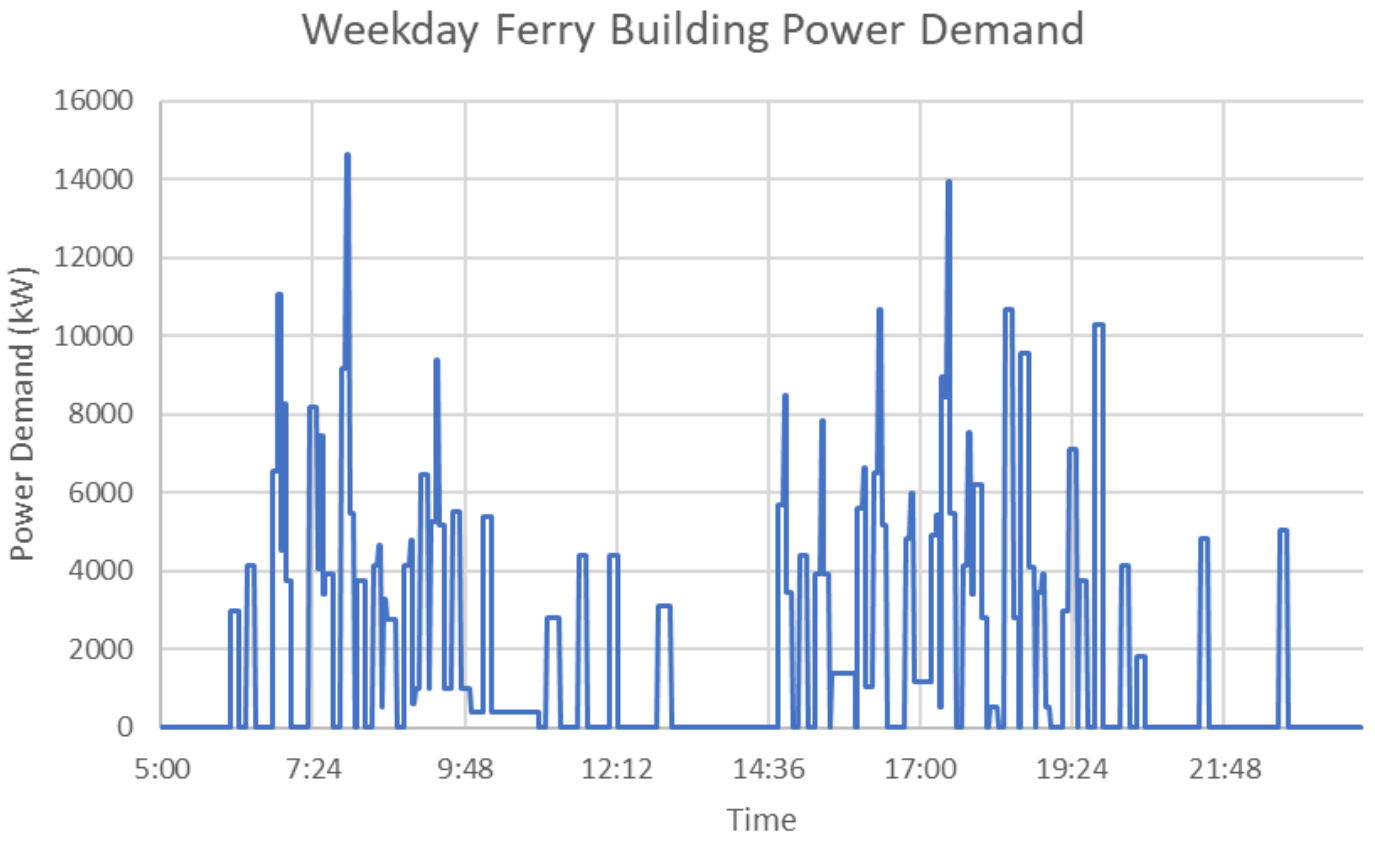
Fleet Analysis Tool

aurora marine design

Rapidly determine the power required at each terminal

Receives inputs directly from the Route Analyzer tool

- Contains a graphical schedule builder
- Automatically updates real time systemwide energy demands at any given minute
- Exports an energy demand profile at each terminal to support shoreside infrastructure analysis

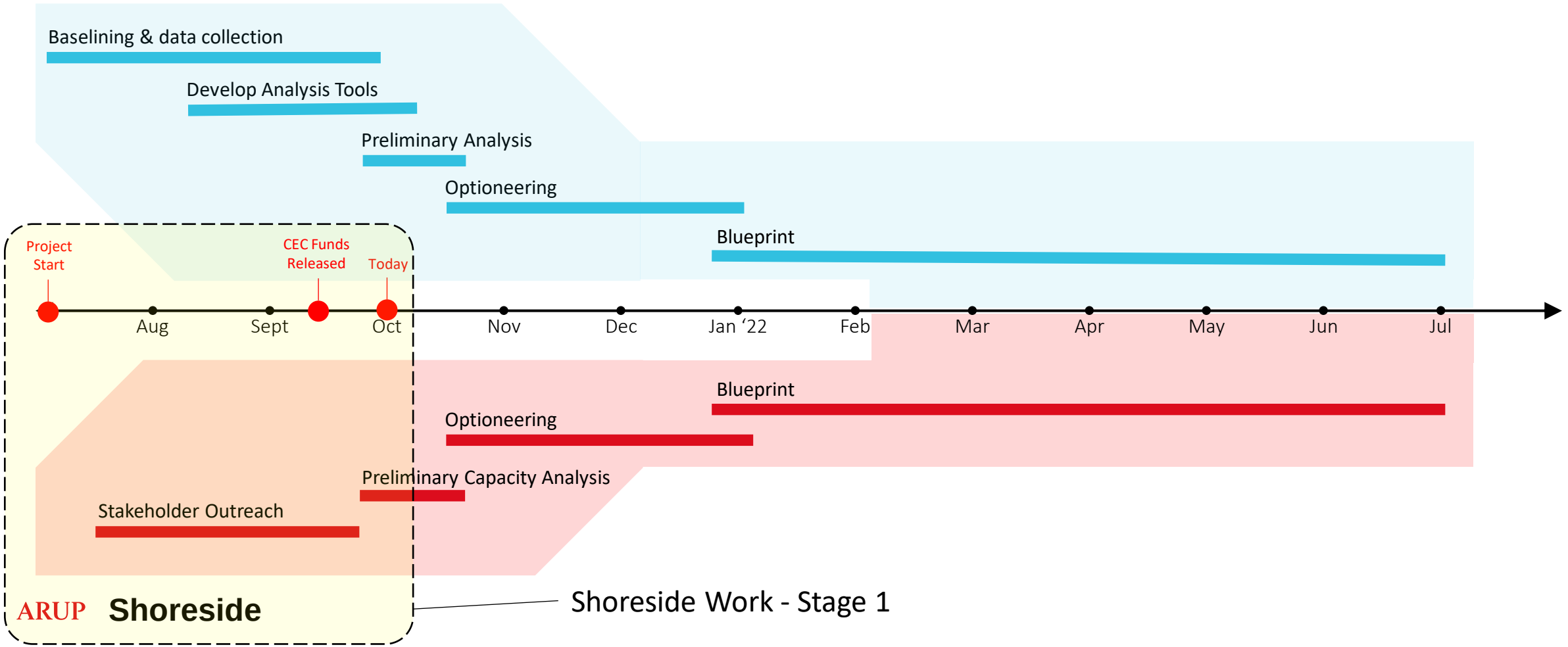


Shoreside Progress Update

ARUP

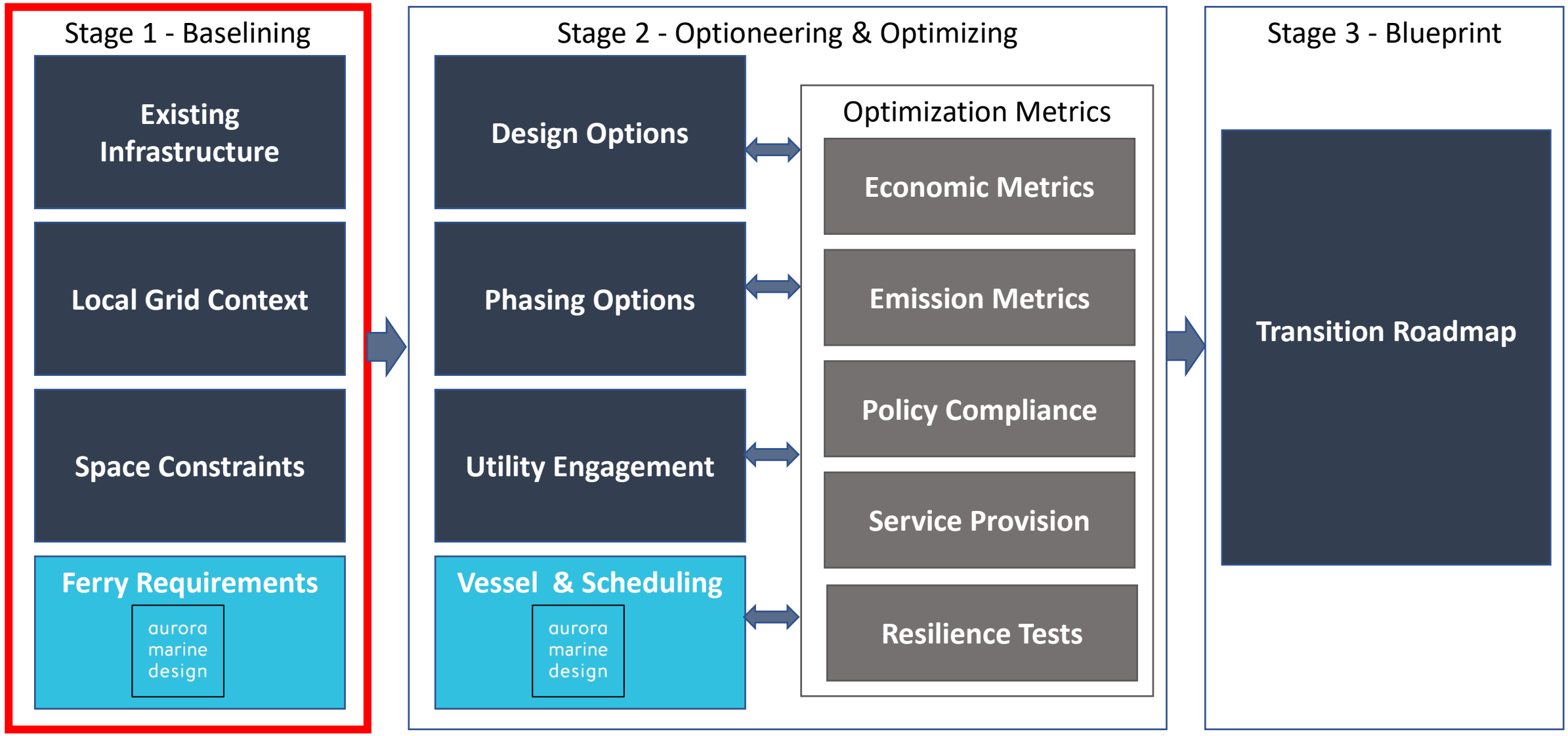
aurora marine design

Vessel Side

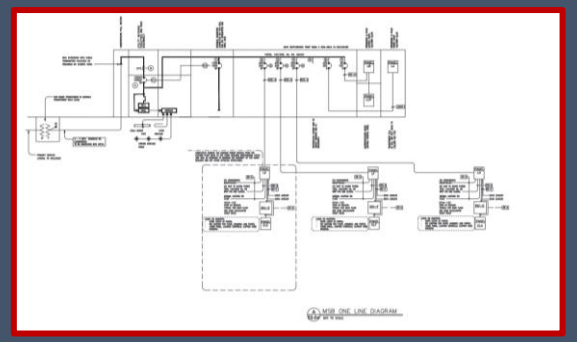


Shoreside Overview

ARUP

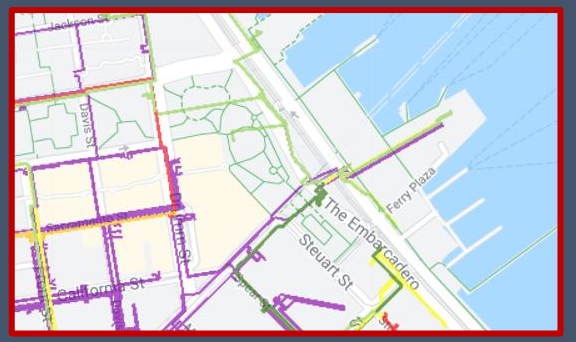


Baselining – Terminal Assessment



Existing Electrical Connections and Design

Excluding central bay all terminals predicted to require substantive grid connection upgrades and the addition of resilience measures for transition. These will be costly



Local Grid Context

High variability in the grid context of the different terminals. In particular Downtown is of high concern.

Space constraints assessment

Opportunities for solar, batteries and back up power reserves are being assessed by evaluating space availability

Baselining – Terminal Assessment

ARUP

Highly constrained grid with costly upgrades

Constrained grid with reasonable cost upgrades

Unconstrained grid with opportunities

Potential Solar

Uncertain

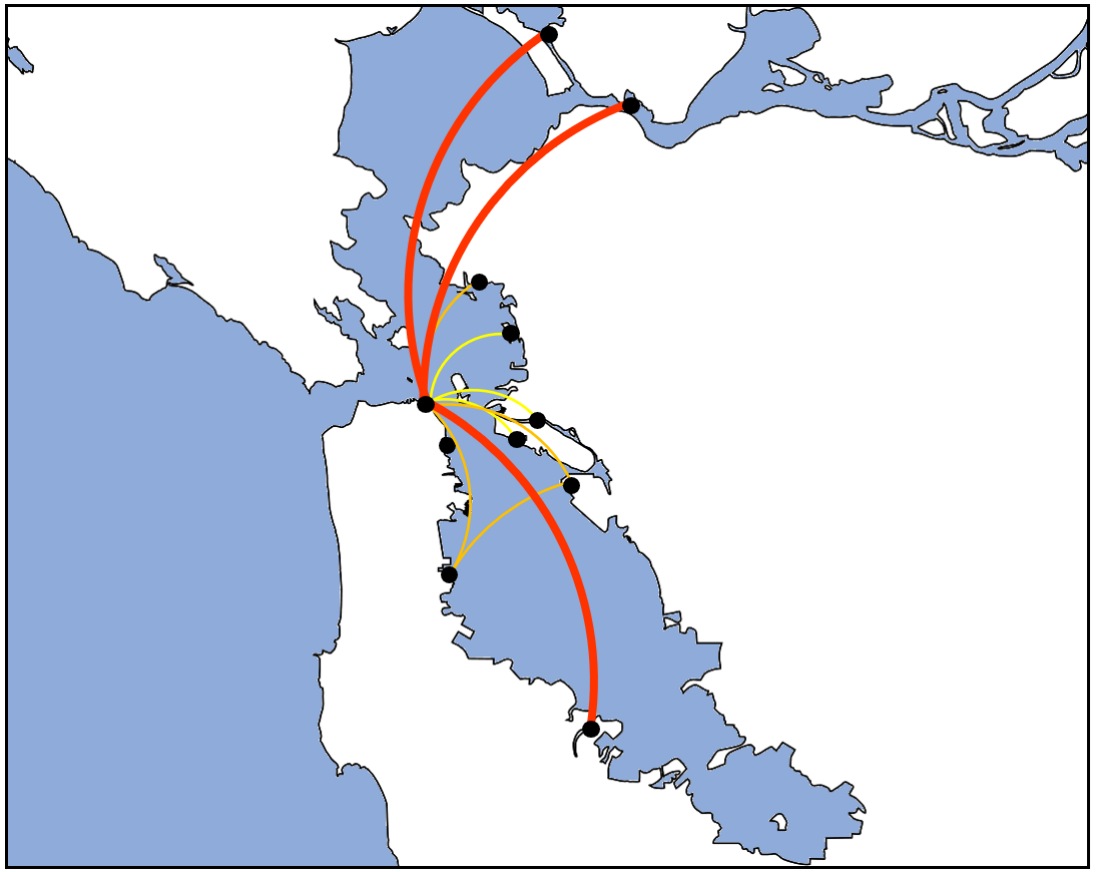
SF Ferry Building	Richmond	Alameda Seaplane
Oakland	South SF	Central Bay Maintenance
Alameda Main Street	Mission Bay	Berkeley
Harbor Bay	Treasure Island	Redwood City

Preliminary Roadmap

Phased Implementation

aurora marine design

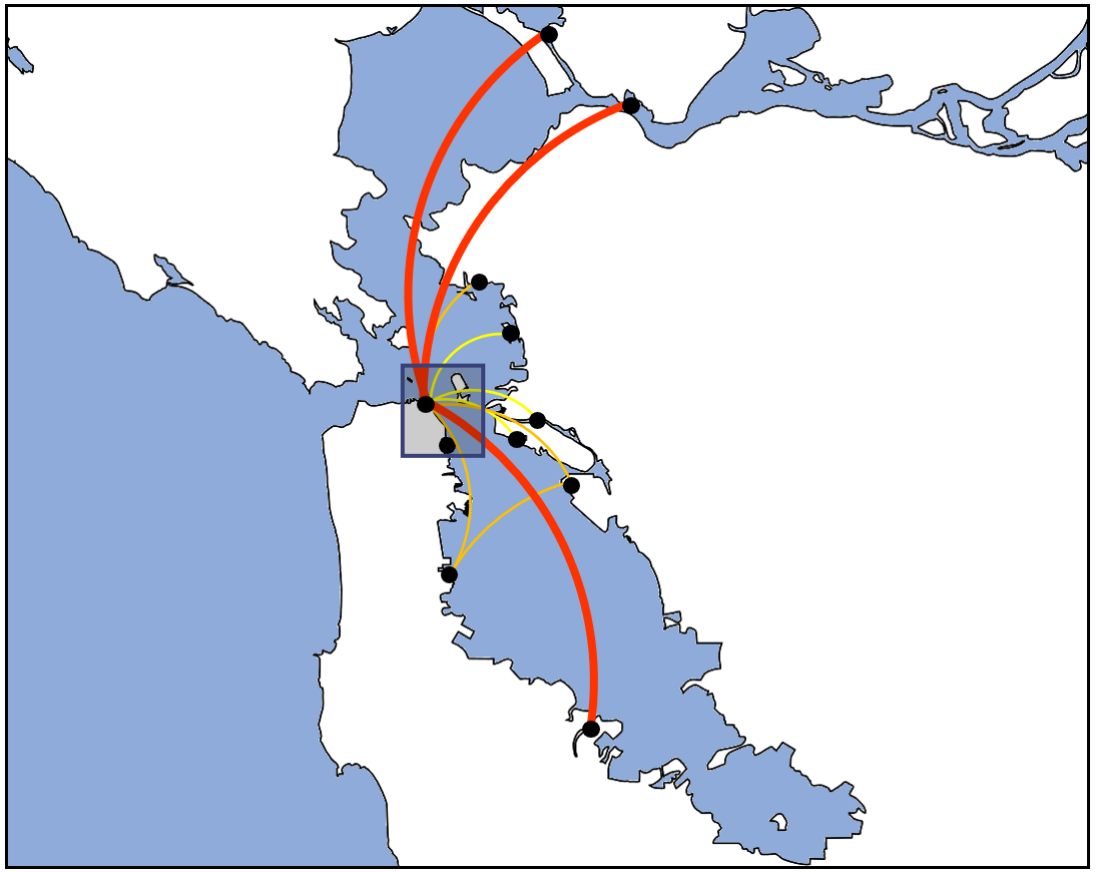
Initial analysis points to four phases, which will be refined during the analysis:



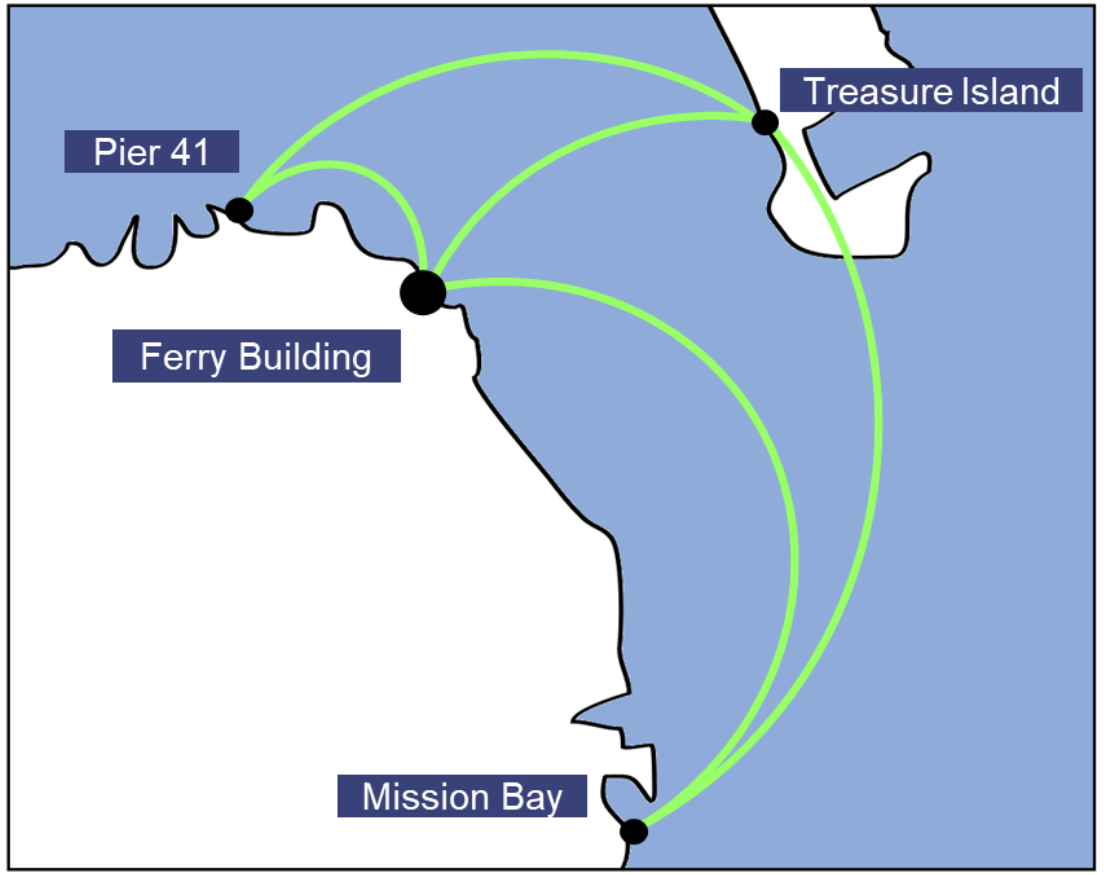
Phased Implementation

aurora marine design

Initial analysis points to four phases, which will be refined during the analysis:



Phase 1 – Inner Central Bay – TI, Mission Bay, Pier 41, SFFB

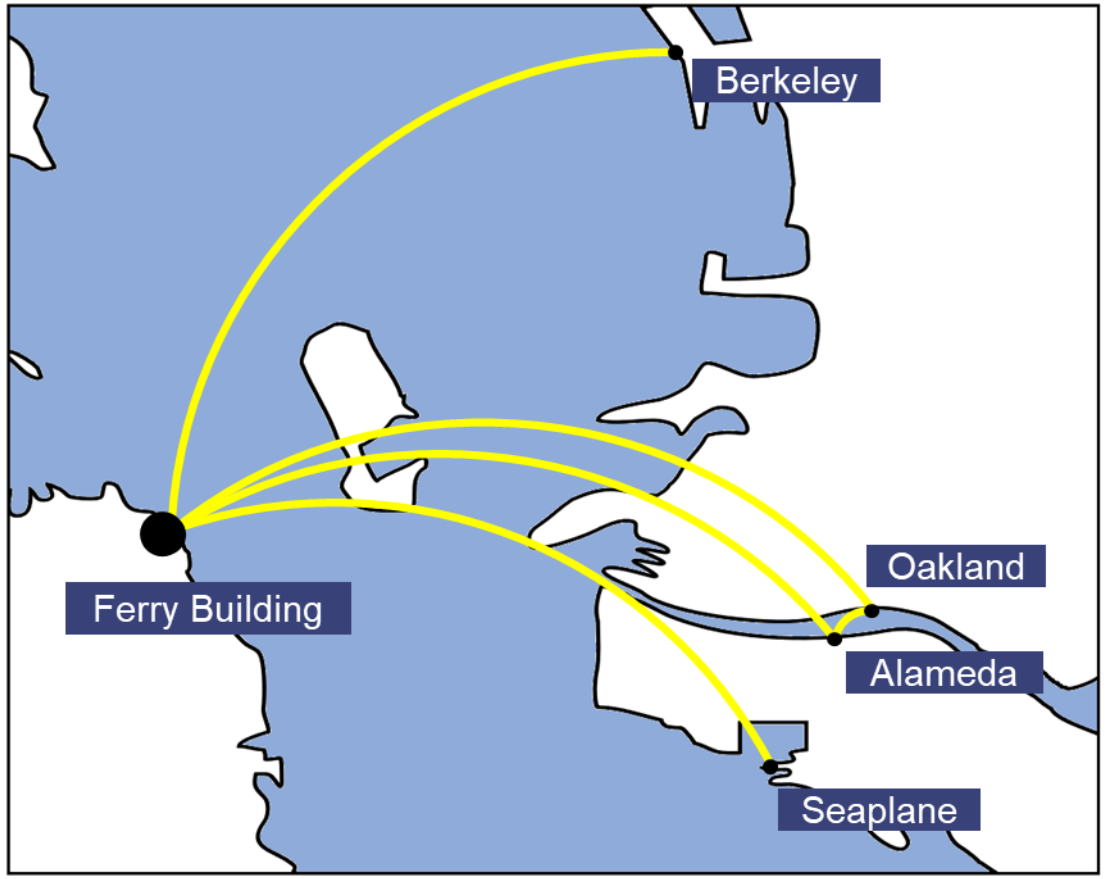


Phased Implementation

aurora marine design

Initial analysis points to four phases, which will be refined during the analysis:

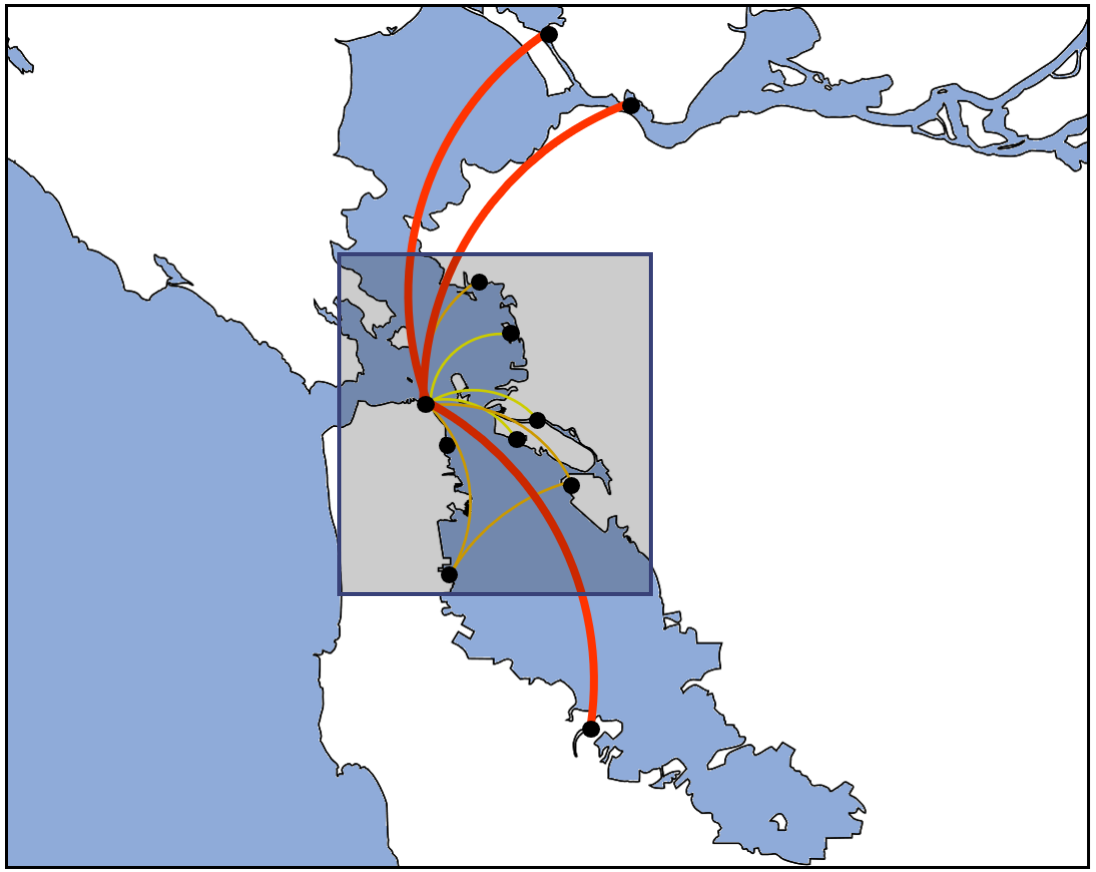
Phase 2 – Central Bay – Oakland, Alameda, Berkeley



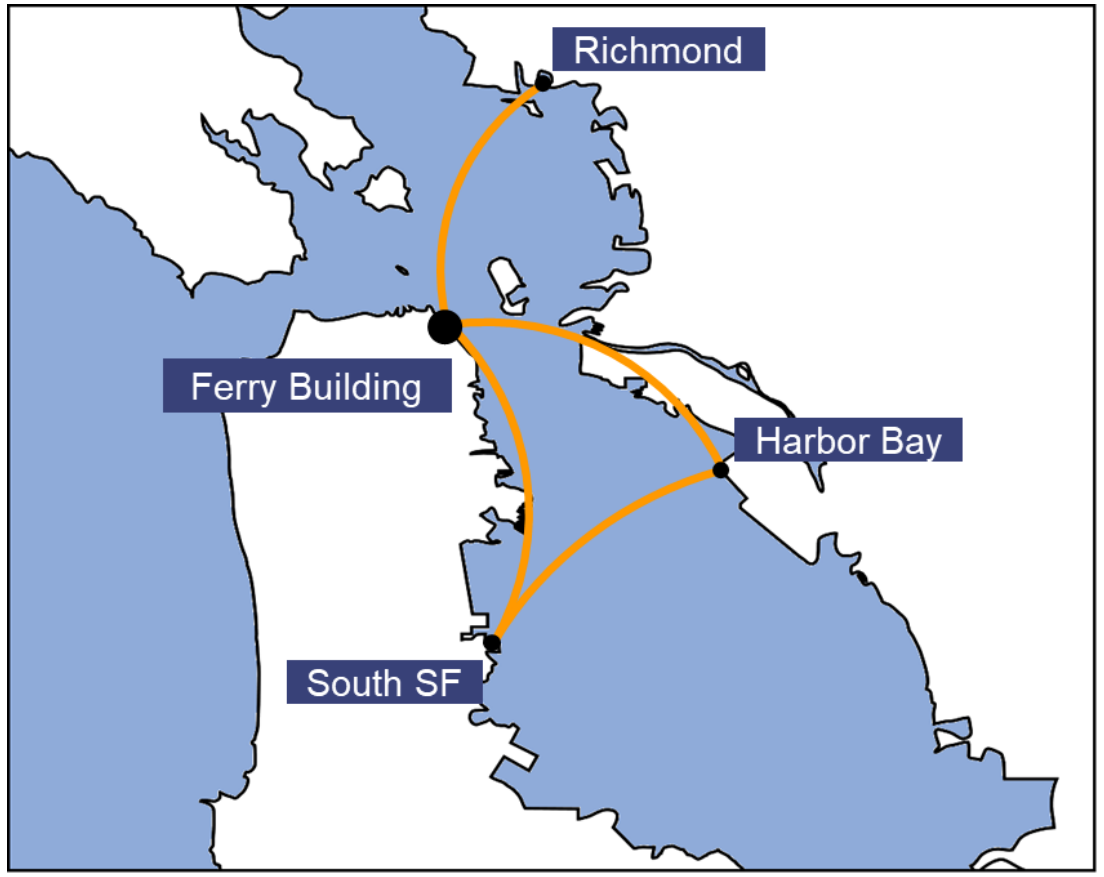
Phased Implementation

aurora marine design

Initial analysis points to four phases, which will be refined during the analysis:



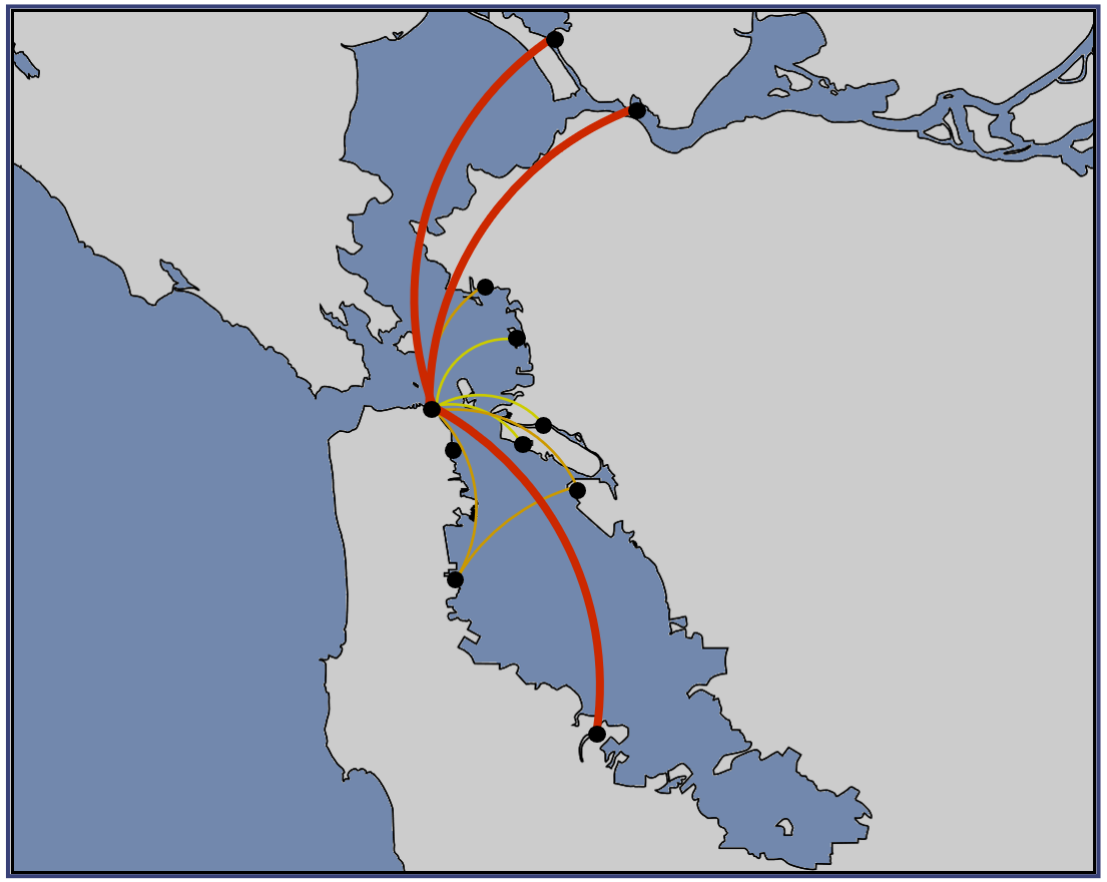
Phase 3 – Long Run Central Bay – South SF, Richmond



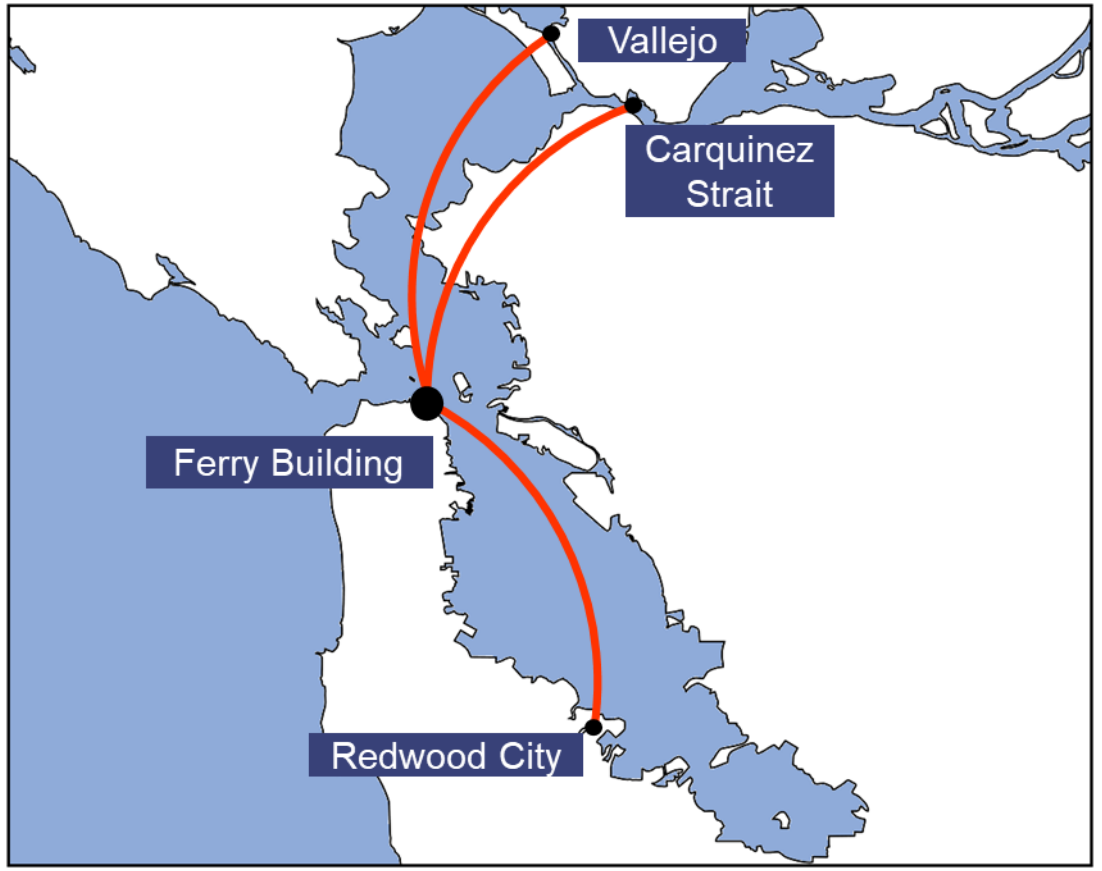
Phased Implementation

aurora marine design

Initial analysis points to four phases, which will be refined during the analysis:



Phase 4 – Vallejo / Cartequenez / Redwood City

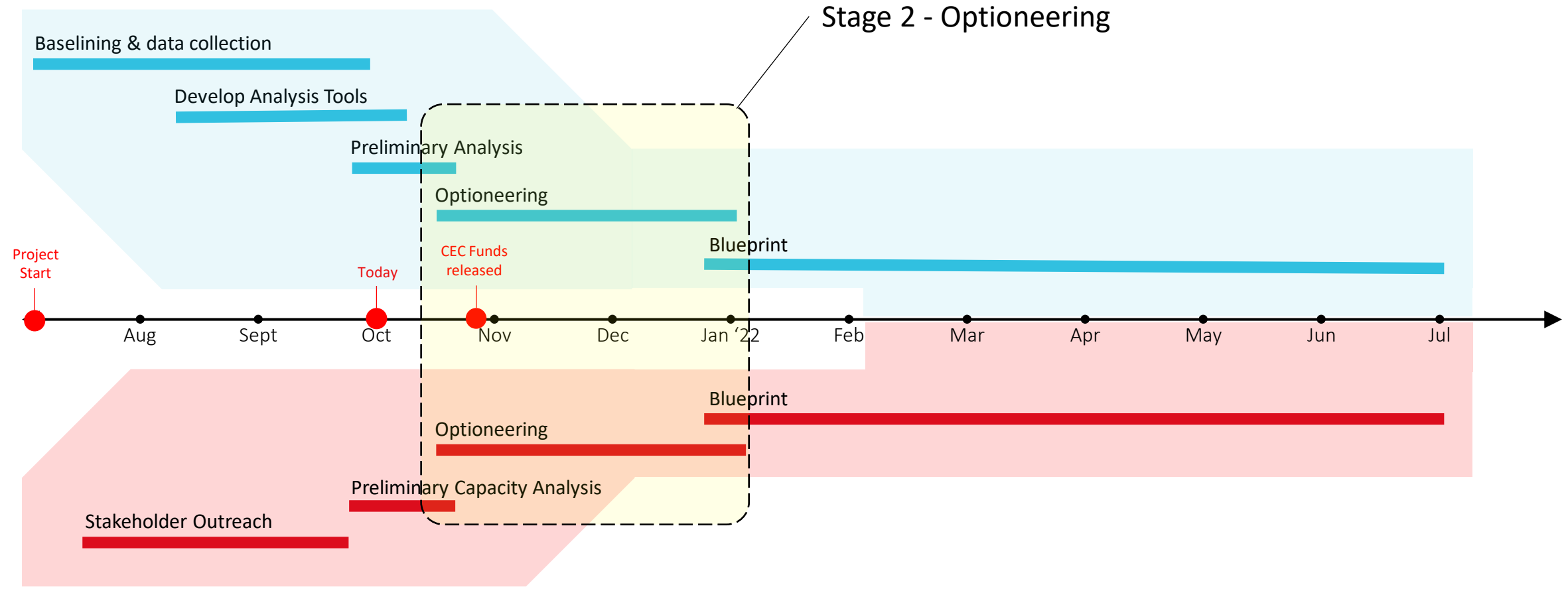


Next Steps

Next Steps

aurora marine design

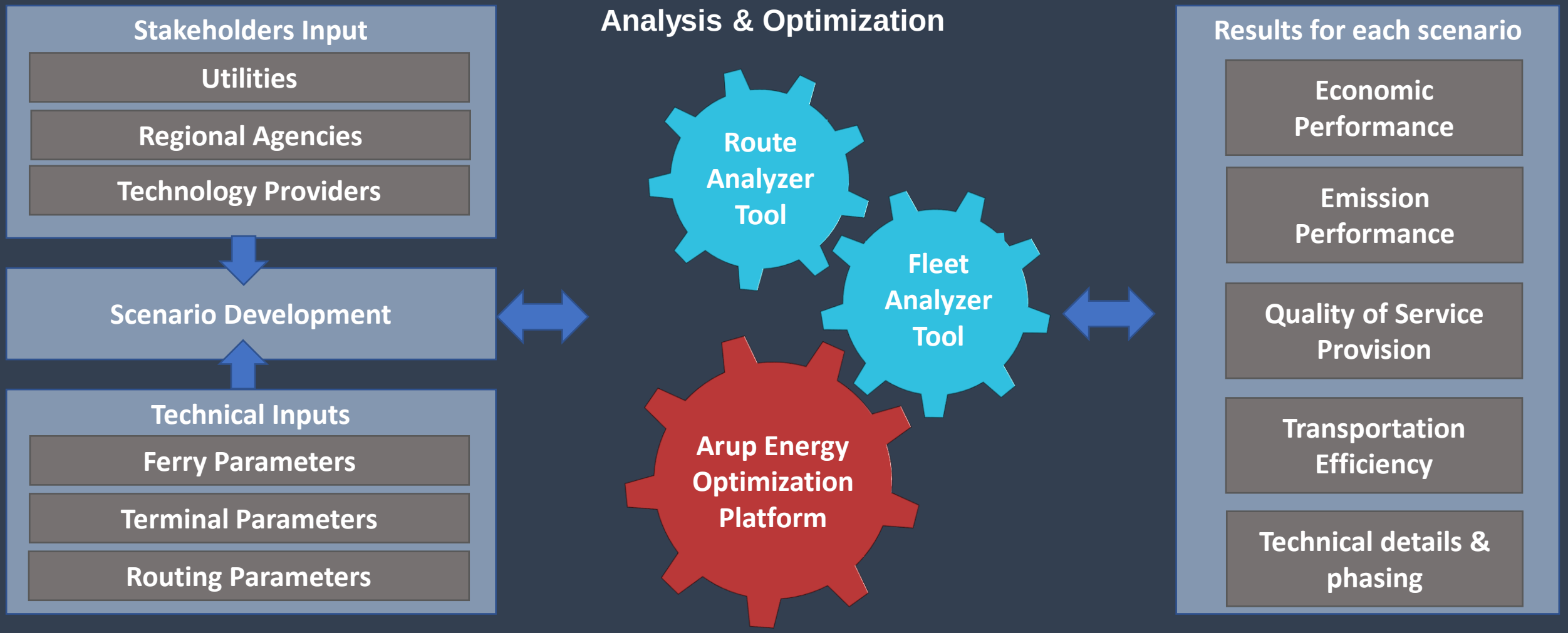
Vessel Side



ARUP

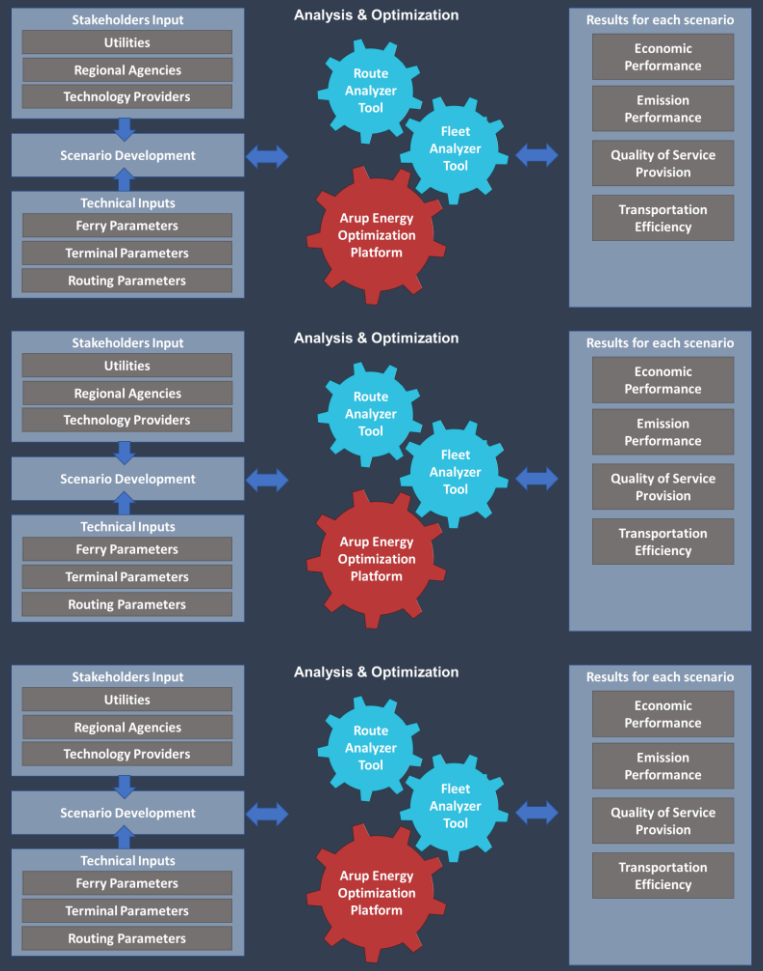
Shoreside

Next Steps – Iterative Optioneering & Optimizing



Next Steps – Iterative Optioneering & Optimizing

Rerun multiple scenarios for each phase



Answers to our study questions

How much power do we need and where?

What is the phasing for implementation?

How much will it cost year by year?

How do we pay for it?