A zero-emission hydrogen fuel cell research vessel

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Presentation Overview

- Research vessels at Scripps
- Project background and goals
- Science mission requirements
- Vessel particulars
- Hydrogen systems & fueling
- Emissions: Well-to-waves

Sandia National Laboratories
MARAD Maritime Administration
Glosten
DNV·GL
UC San Diego

Research Vessel
Robert Gordon Sproul

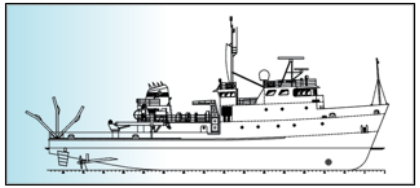
Built: 1981
Length: 125 feet (38 m)
Crew: 5
Scientists: 12
Endurance: 14 days
Owner: UC

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC SAN DIEGO

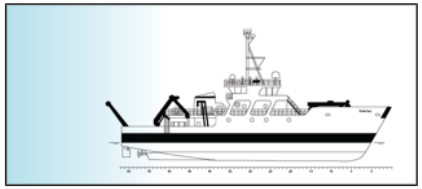
UC San Diego

CALIFORNIA-BASED INTERMEDIATE CLASS & SMALLER SHIPS

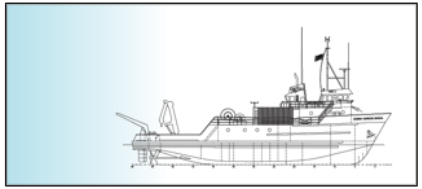
Research vessels able to carry out California's local research and education needs have decreased from 3 to 1, with the last remaining ship approaching the end of its service life. A new vessel is needed.



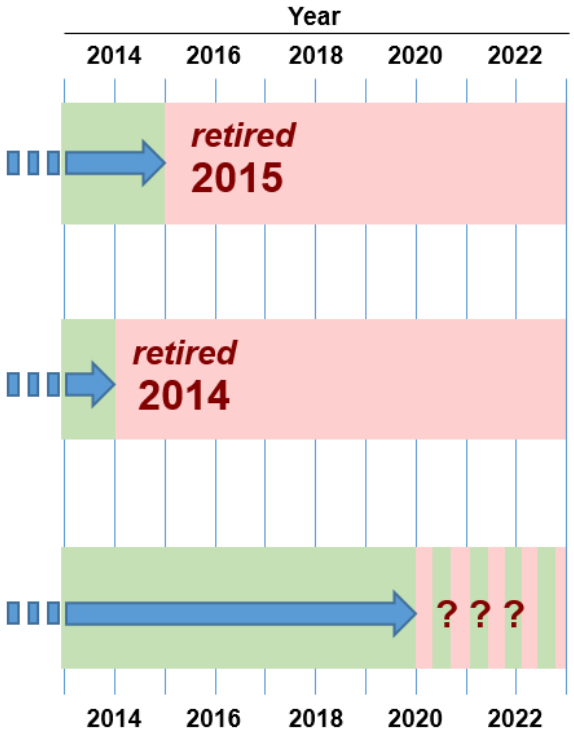
INTERMEDIATE
R/V *New Horizon*
170 feet / 40-day endurance
12 crew / 19 scientists



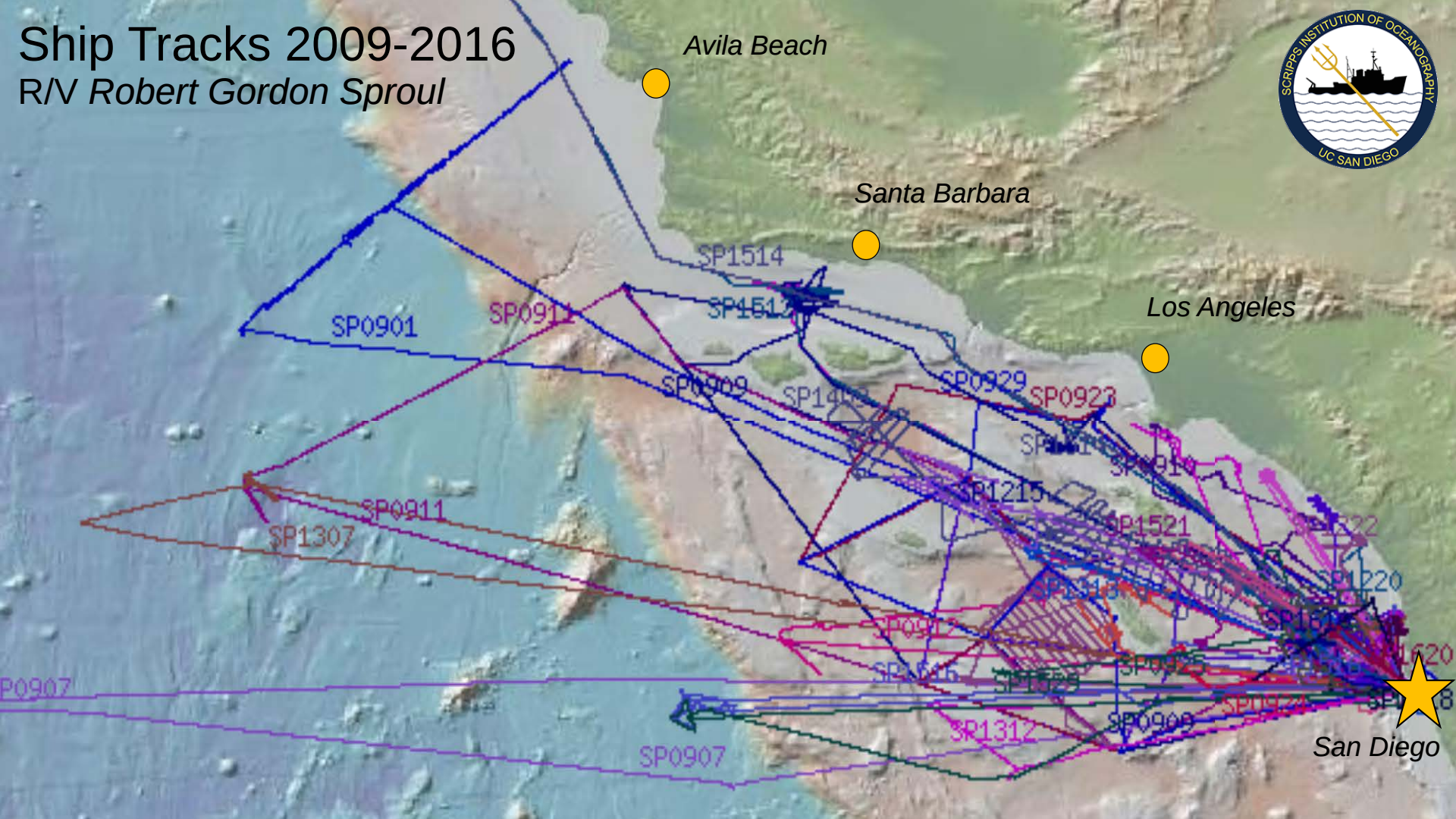
REGIONAL
R/V *Pt Sur*
135 feet / 21-day endurance
8 crew / 12 scientists



LOCAL / COASTAL
R/V Robert Gordon Sproul
125 feet / 14-day endurance
5 crew / 12 scientists



Needed


Ship Tracks 2009-2016
R/V Robert Gordon Sproul
Avila Beach
Santa Barbara
Los Angeles
San Diego
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC SAN DIEGO
SP1514
SP0901
SP0911
SP0909
SP0929
SP0923
SP1215
SP1521
SP1307
SP0907
SP1312
SP0908

PROJECT BACKGROUND & GOALS

Feasibility study: Is it possible to build a capable non-polluting coastal research vessel that does not use fossil fuels, with existing technology that is available commercially now?

Zero-V Project Goals

- Assess technical feasibility of LH2 fuel cell research vessel
- Evaluate technical feasibility of marine LH2 fuel cells
- Evaluate refueling feasibility
- Assess criteria pollutant and CO2 emissions
- Resolve the economics to build & operate
- Understand the regulatory framework
- Evaluate the ability of a hydrogen-powered vessel to fulfill desired scientific missions

Sandia National Laboratories

MARAD Maritime Administration

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DNV·GL

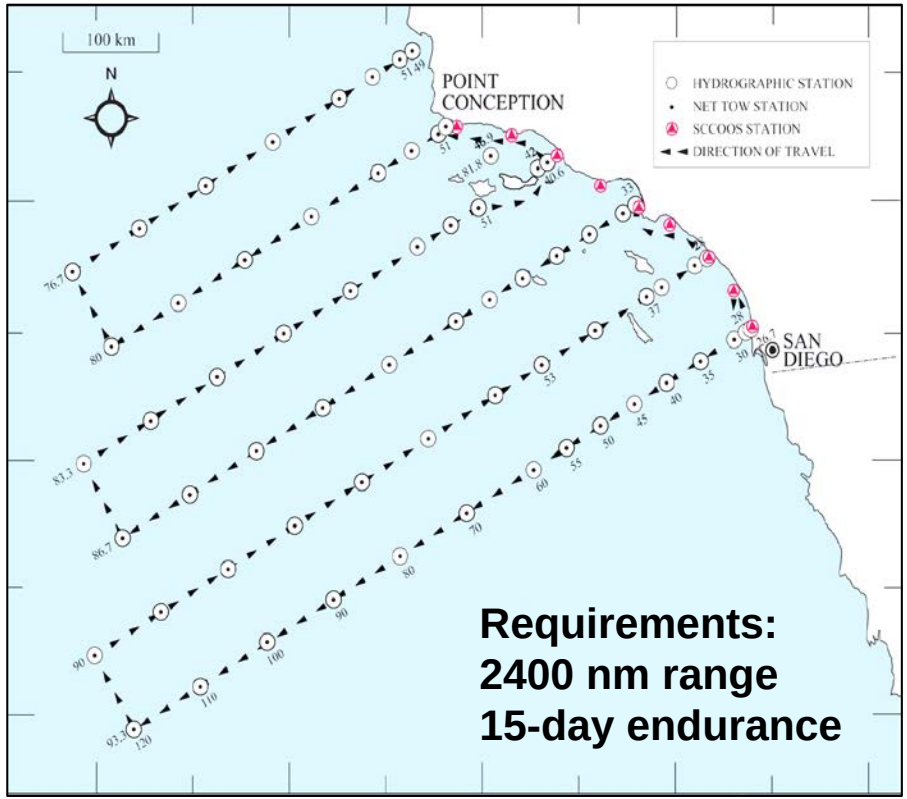
UC San Diego

ZERO-V SCIENCE MISSION REQUIREMENTS

Primary Vessel Requirements

Cruise	10 kts, calm water	Portable Vans	2
Speed	12 kts, calm water (sprint) 9 kts, SS4 7 kts, SS5	Crew Berths	11
Range	2400 nm	Scientist Berths	20
DP	2 kts beam current, 25 kts wind at best heading	A-Frame	12,000 ST SWL
Endurance	15 days	Main Crane	8,000 lbs @ 12' over the side
Main Lab	800 sq ft	Portable Crane	4,000 lbs SWL
Wet Lab	500 sq ft	Side Frame	5,000 lbs SWL
Computer Lab	120 sq ft	Trawl Winch	10,000m 3/8 3x19
Aft Deck	1200 sq ft	Hydro Winch	10,000m 0.322 EM, 10,000m 1/4 3x19

Benchmark Mission: CalCOFI Survey



VESSEL PARTICULARS – GENERAL

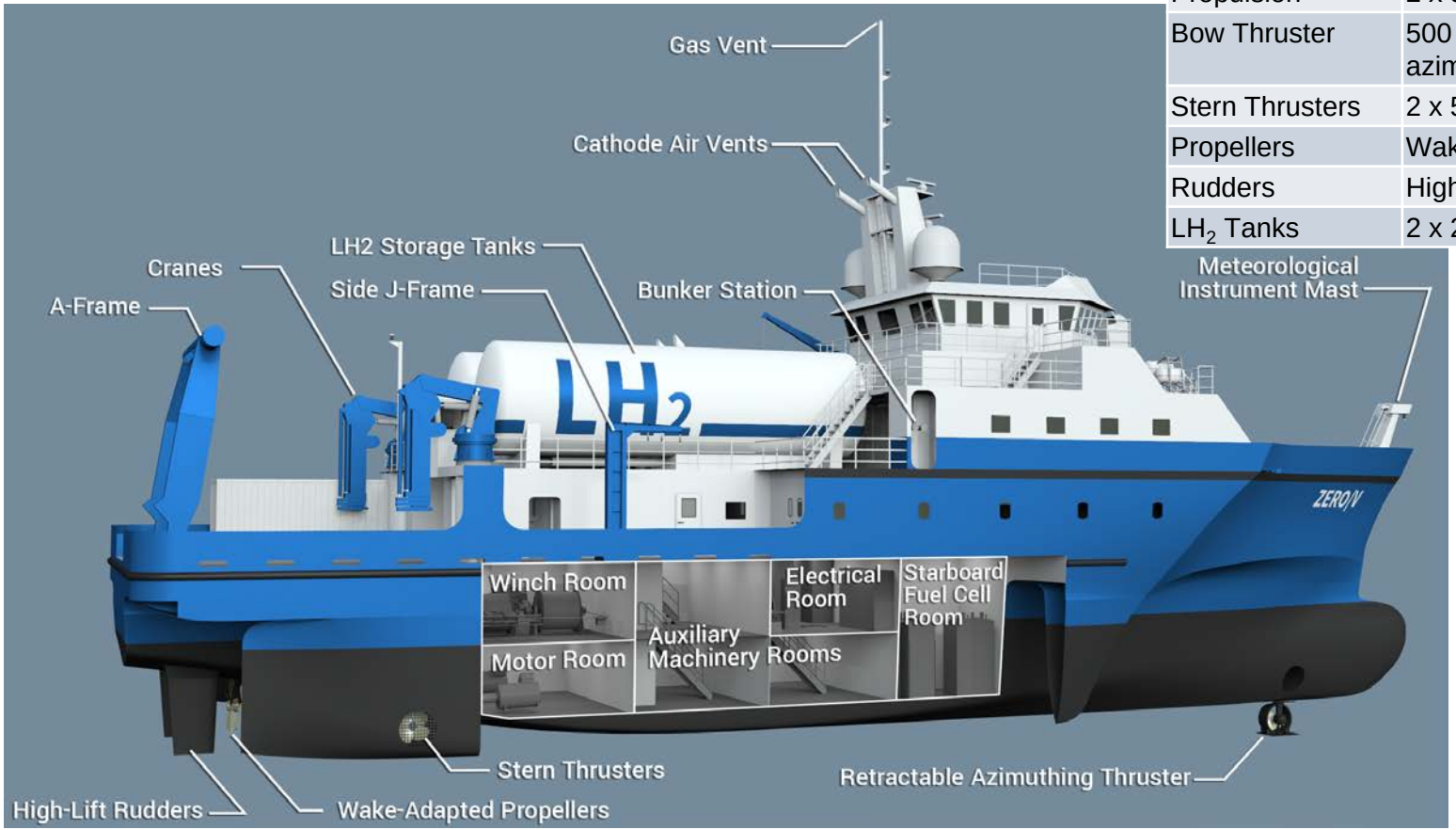
Hull Type	Trimaran
Material	Aluminum
Length	170 ft.
Beam	56 ft.
Draft	12 ft.
Freeboard	9 ft.
Displacement	1,175 LT
Cruise Speed	10 knots
Range	2,400 nm
Endurance	15 days
Station Keeping	Dynamic positioning
Berths	20 Science (double) 11 Crew (single)
Air Emissions	Water vapor

VESSEL PARTICULARS – SCIENCE

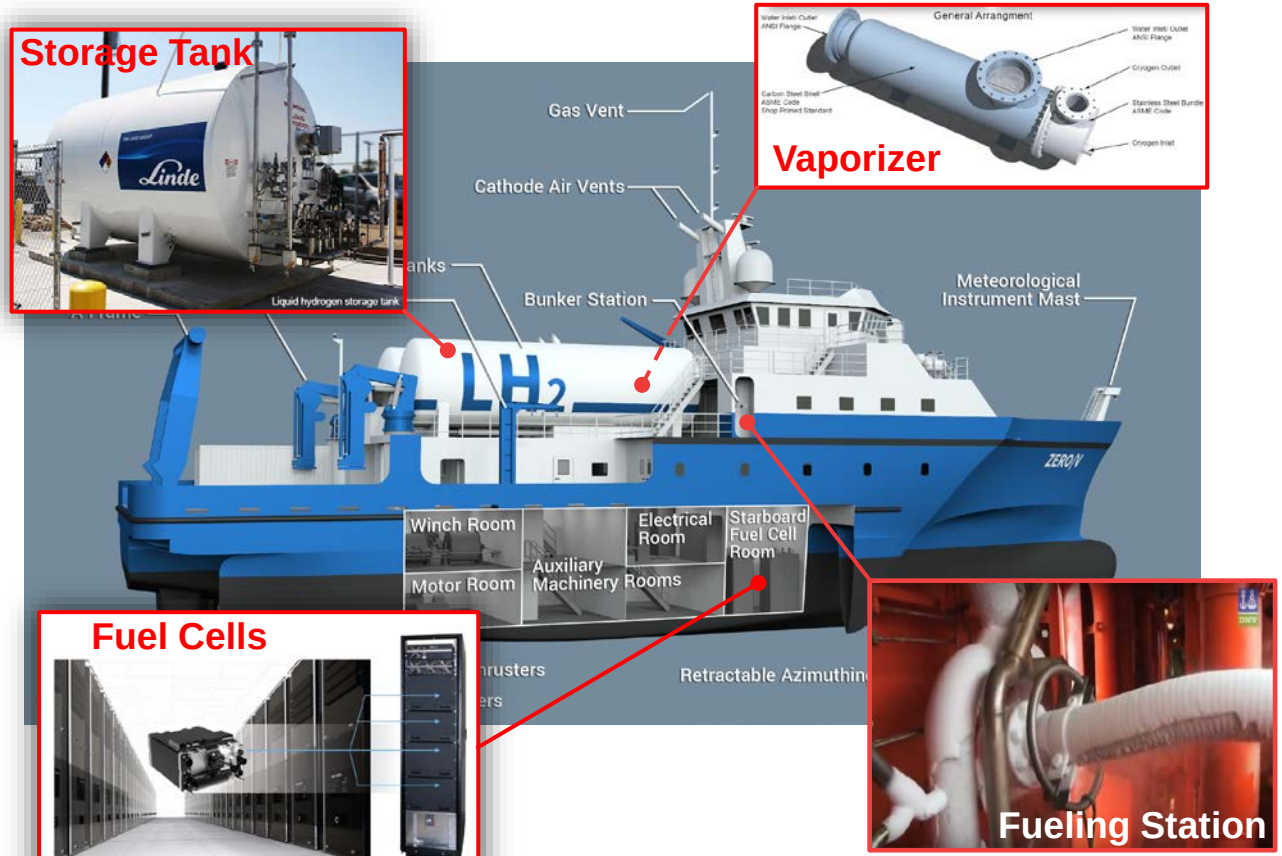
A-Frame	20,000 lbs SWL 20′ vertical clearance 12′ outboard reach
Main Cranes (2)	8,000 lbs SWL over the side
Portable Crane	8,000 lbs SWL
Side Frame	5,000 lbs SWL
Trawl Winch	10,000m 3/8 3x19 wire
Hydro Winch	10,000m 0.322 EM 10,000m ¼″ 3x19 wire
Multi Beam Sonar	Kongsberg EM712
Underwater Noise	ICES up 8 knots
Main Lab	825 ft^2
Wet Lab	575 ft^2
Computer Lab	175 ft^2
Aft Deck	1,775 ft^2
Side Deck	525 ft^2
Van Spaces	2
Science Payload	50 LT

VESSEL PARTICULARS – PROPULSION

Power	10 x 180 kW hydrogen fuel cell racks
Propulsion	2 x 500 kW PM motors
Bow Thruster	500 kW, retractable azimuthing
Stern Thrusters	2 x 500 kW tunnel
Propellers	Wake-adapted fixed pitch
Rudders	High-lift
LH_2 Tanks	2 x 28,800 gal type C



H_2 GAS SYSTEMS



- **(2)** Type C vacuum insulated LH_2 tanks (5,830 kg / tank)
- **(10)** Power racks with 6 Hydrogenics HyPM HD 30 fuel cell modules (180 kW/rack)
- **(2)** Thermax cryogenic cold water evaporators
- Gas system full redundancy
- Fuel cell room has redundant ventilation and gas detection for each rack and emergency shutdown upon any failure
- Water deluge system protects areas around tank
- NOVEC clean agent fire extinguishing in fuel cell rooms

FUELING LIQUID HYDROGEN (LH_2)

Fueling procedures were informed by commercial vendors

Bunker from trucks

- No shore infrastructure
- Currently used for filling LH_2 storage tanks across US
- Trailer delivers approximately 4,000 kg of LH_2
- 3 trailers to fully fuel. Typical bunkering with 1-2 trailers (most missions <8,000 kg)
- Full trailer deliver take 3.5 to 4 hours
- Use 2 trailers simultaneously, one bunkering each tank

REGULATORY REVIEW

DNV·GL

STATEMENT OF CONDITIONAL APPROVAL IN PRINCIPLE

Glosten/Sandia National Laboratories
Zero-V Hydrogen Research Vessel

This is to certify that Zero-V Hydrogen Research Vessel is granted *Conditional Approval in Principle (CAIP).*

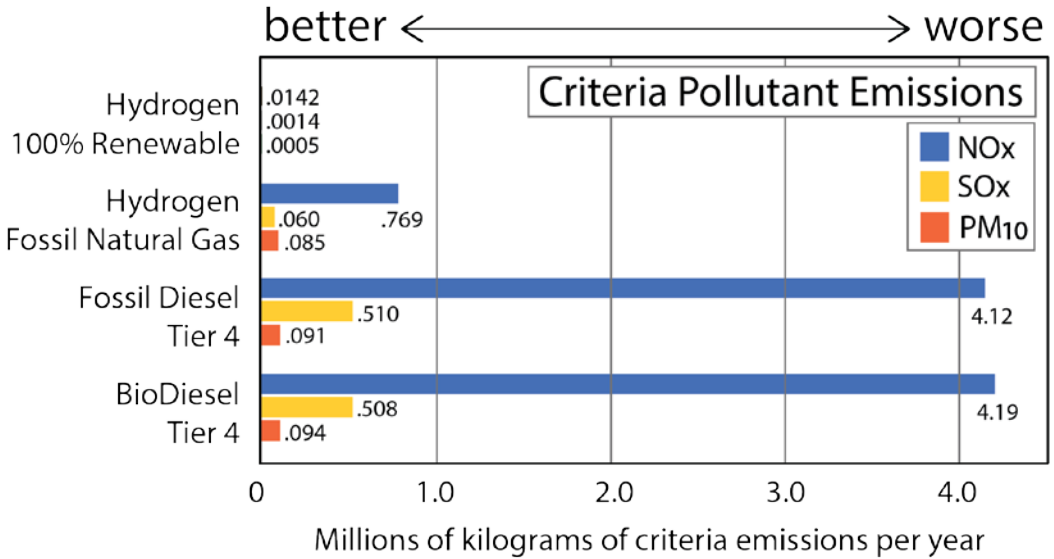
No show-stopping red flags were identified in the regulatory reviews

Received a Conditional Approval In Principle (CAIP) from DNV GL.

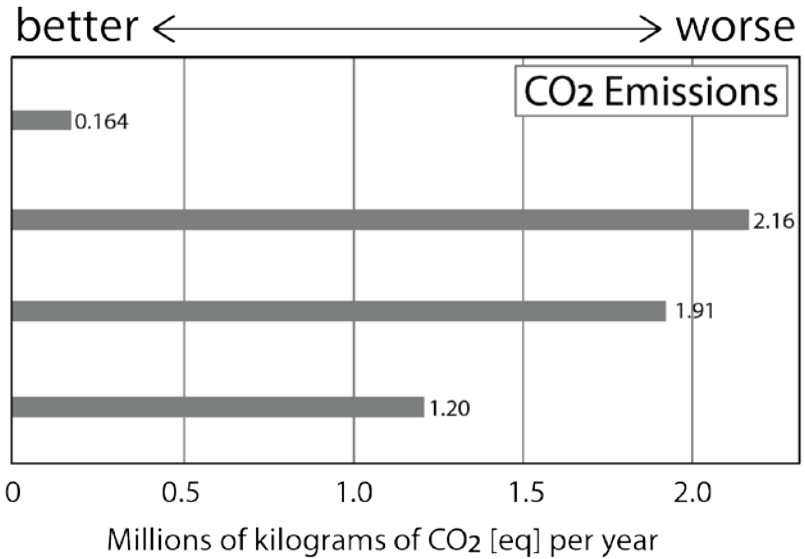
- The regulatory regime for a hydrogen fuel cell powered vessel is developing
- No current US or international regulations specific to hydrogen fuel cell vessels
- Regulatory basis:
  - Extend the regulations applicable to LNG fueled vessels to hydrogen fuel
    - DNV GL Rules for Classification: Ships
    - IGF Code: International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuel
    - 46 CFR Subchapter U: Oceanographic Research Vessel
  - Give consideration to differences hydrogen may present.
- Submitted to the US Coast Guard and DNV GL for review to identify any significant regulatory or safety concerns with the fundamental design.

EMISSIONS: WELL-TO-WAVES

Well-To-Waves Criteria Emissions (1,000 MT / year)



Well-to-Waves Greenhouse Gas Emissions (1,000 MT CO_2 equivalent / year)



Criteria pollutant emissions can be reduced using LH_2. Dramatic reductions in GHG can be achieved with ***renewable*** LH_2. Renewable LH_2 is available now from commercial gas suppliers.

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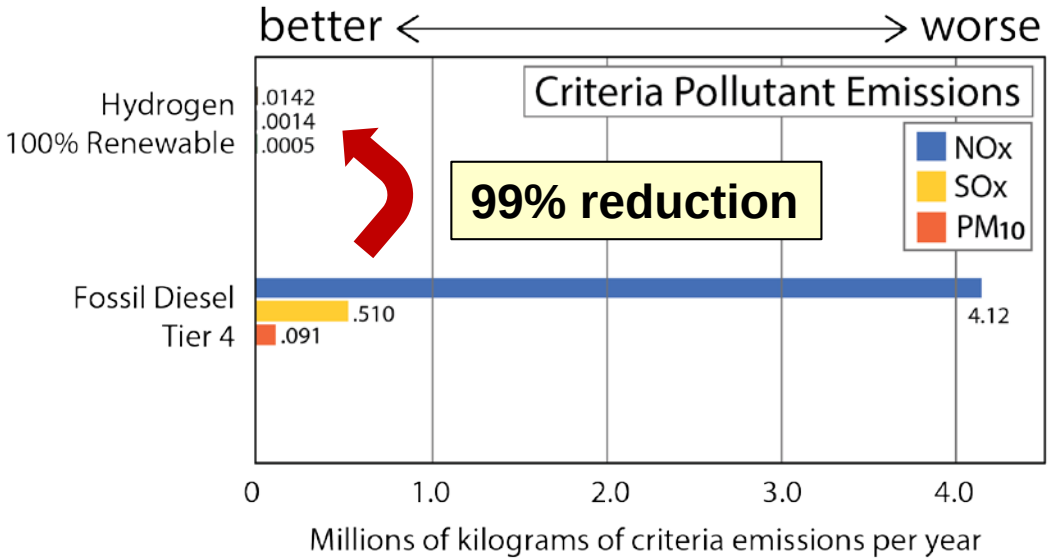

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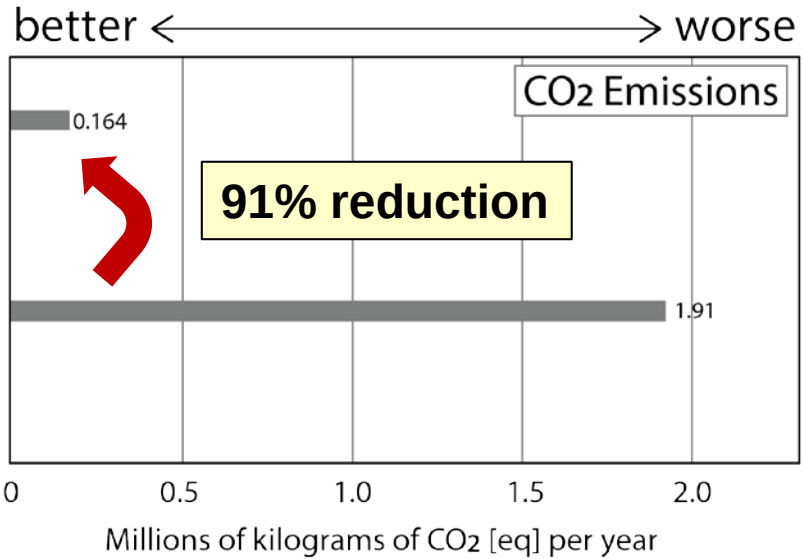
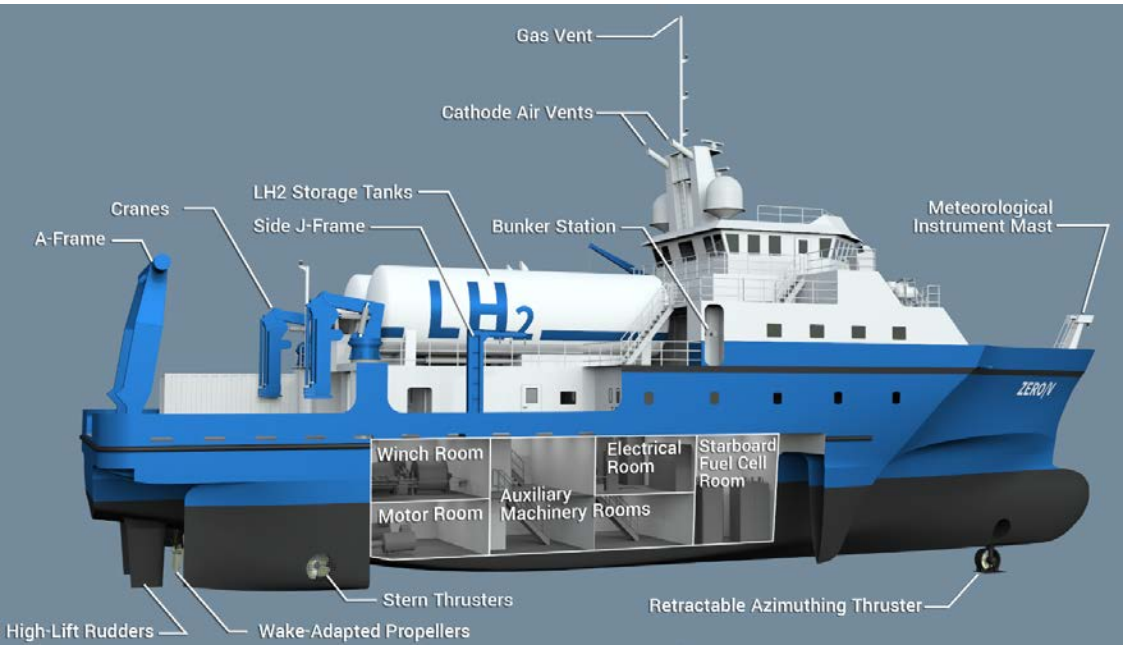


Criteria pollutant emissions can be reduced using LH_2. Dramatic reductions in GHG can be achieved with ***renewable*** LH_2. Renewable LH_2 is available now from commercial gas suppliers.

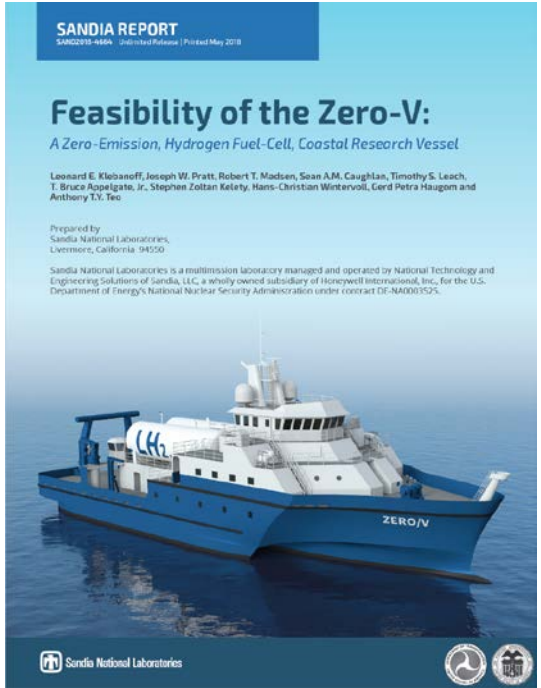
A zero-emission research vessel is feasible NOW using existing technology



- Oceanographic research vessel for coastal / regional operations
- Uses clean hydrogen: **No fossil fuels!**
- Zero emissions: **Clean / no GHGs!**
- Carries no diesel: **No oil spills!**
- All-electric propulsion: **Quiet!**
- **FEASIBLE** with existing technology
- Outstanding scientific capabilities
- Advanced instrumentation
- Designed for California's educational and R&D needs

PROJECT RESULTS

Feasibility study: Is it possible to build a capable non-polluting coastal research vessel that does not use fossil fuels, with existing technology that is available commercially now?



Yes

Download the full report:
energy.sandia.gov/transportation-energy/hydrogen/market-transformation/maritime-fuel-cells/

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Sandia National Laboratories

MARAD Maritime Administration

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