FULLY ELECTRIC (BATTERY/FUEL CELL) POWERED SUBMARINE

and its performance compared to other submarine designs

Sven Los

Nevesbu

Naval Architects & Marine Engineers

CONTENT

- Introduction
- Power plant design and Hydrogen storage
- The H_2MORAY concept
- Power plant performance comparison
- Future outlook & discussion
- Conclusion

INTRODUCTION

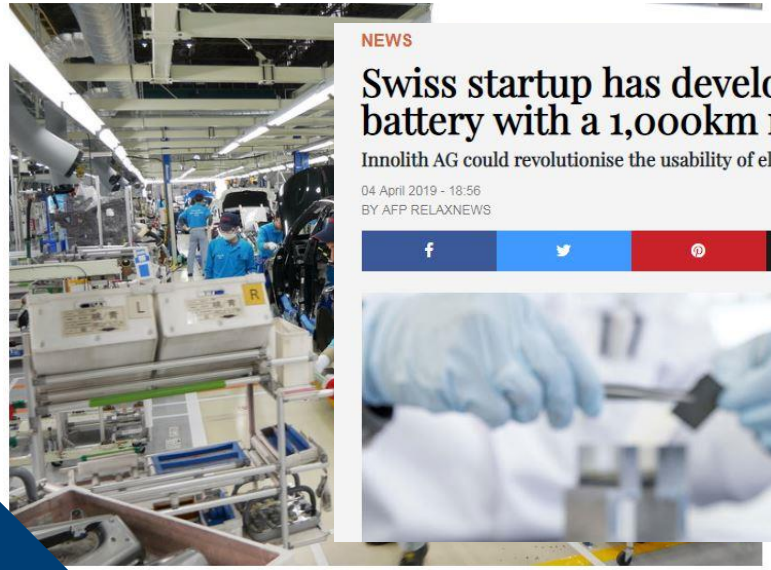
Development of alternative power plant solutions in civil industries

Japan Is Betting Big On The Future Of Hydrogen Cars

March 18, 2019 · 4:19 PM ET
Heard on All Things Considered

SUSAN PHILLIPS

FROM WHYY



CNN travel

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BUSINESS TRAVELLER

EasyJet plans electric planes by 2030

Lianne Kolirin • Updated 30th October 2018

NEWS

Swiss startup has developed an EV battery with a 1,000km range

Innolith AG could revolutionise the usability of electric vehicles going forward

04 April 2019 - 18:56
BY AFP RELAXNEWS

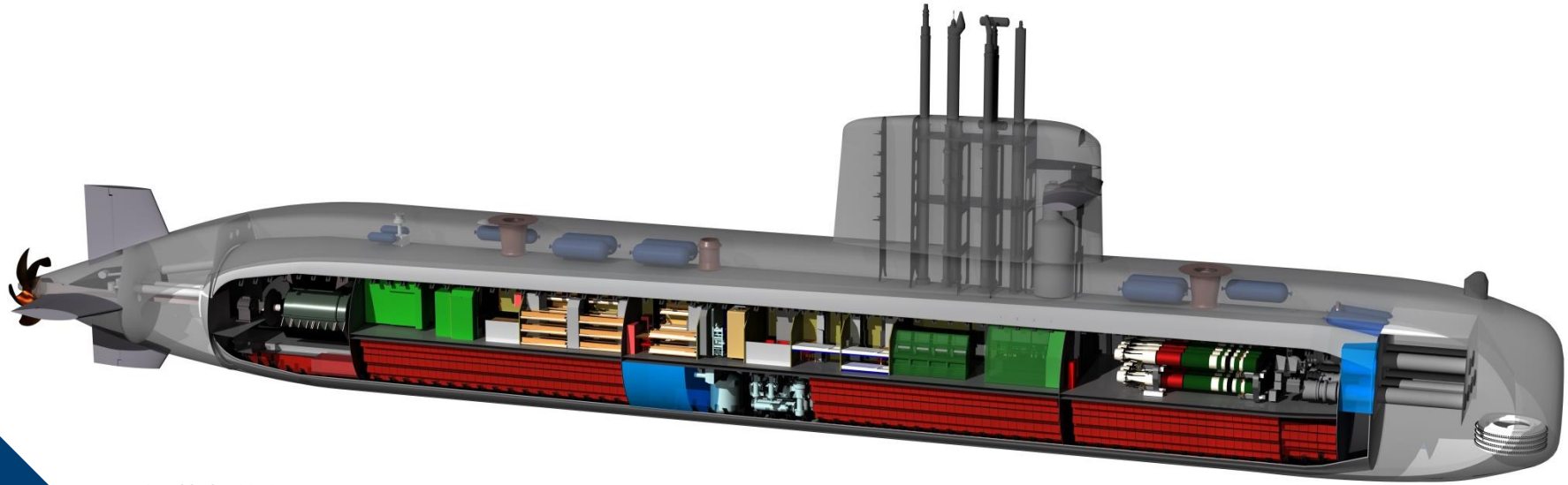
2019 Hyundai Nexo Review: 380 Miles (on Hydrogen). Can Your EV Go That Far?

By Bill Howard on November 14, 2018 at 12:33 pm | 62 Comments

64 SHARES

INTRODUCTION
UDT 2018: The E-MORAY

- Totally battery powered concept: The E-MORAY
  - Range of 2000 nm
  - Endurance of 24 days
  - Potential expected to increase
- Potential benefits
  - Air-independent power plant
  - Reduction in signatures
  - Decrease in design complexity



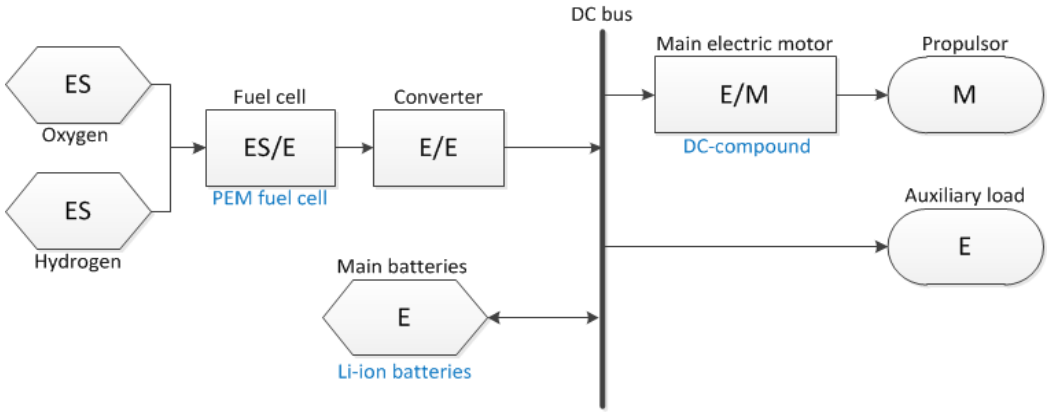
INTRODUCTION
Research objective

- Fully Electric (battery/Fuel cell) powered submarine concept
- Impact on submarine design and operational capabilities currently unknown
  - Creation of a concept design; The H_2MORAY
  - Performing an operational capability study
- Power plant comparison between E-MORAY, H2MORAY and conventional Diesel-electric MORAY1800

POWER PLANT DESIGN

Power plant layout H_2MORAY

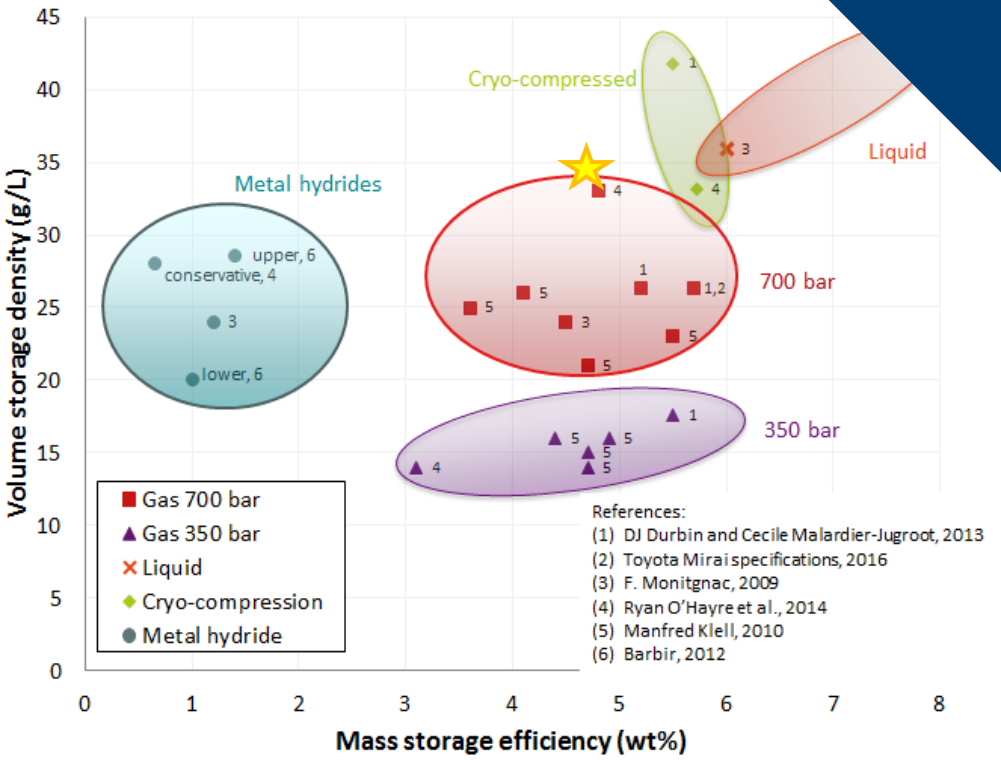
- Proton Exchange Membrane Fuel Cell
  - Proven technology
  - Designed for transit speed
- Lithium-ion as main batteries
  - Designed for high speed sprints
- Oxygen storage; LOX tanks
  - Proven technology



POWER PLANT DESIGN
Hydrogen storage selection

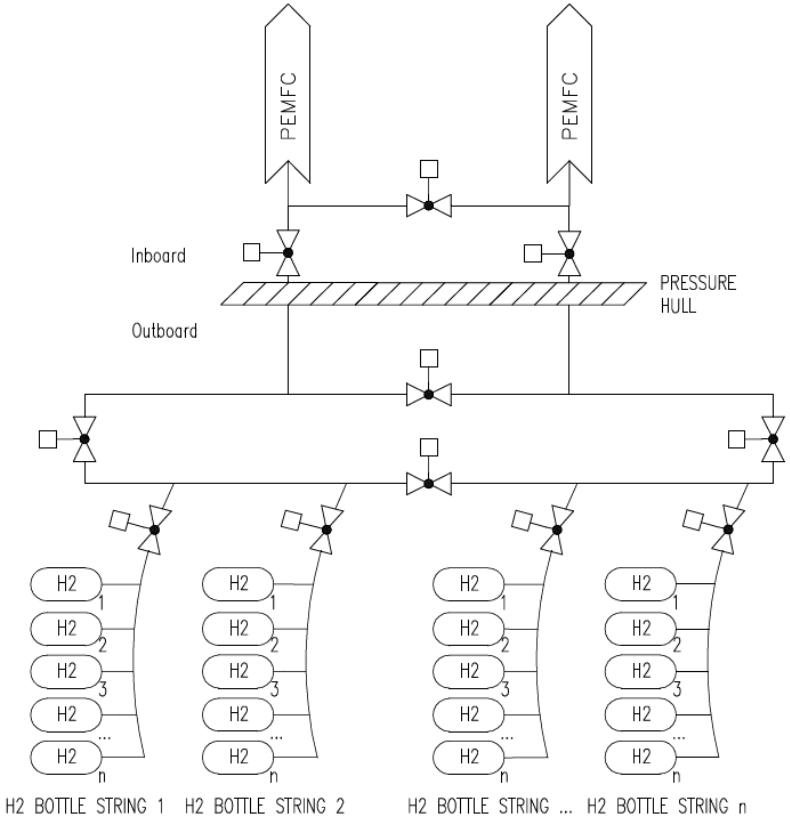
- Hydrogen storage selected over hydrogen reforming
  - Design complexity
  - No impact on signatures
  - Outside pressure hull solutions possible

- High pressure hydrogen storage
  - 700 bar storage
  - Proven technology in car industry



POWER PLANT DESIGN

High pressure hydrogen storage outside the pressure hull



POWER PLANT DESIGN

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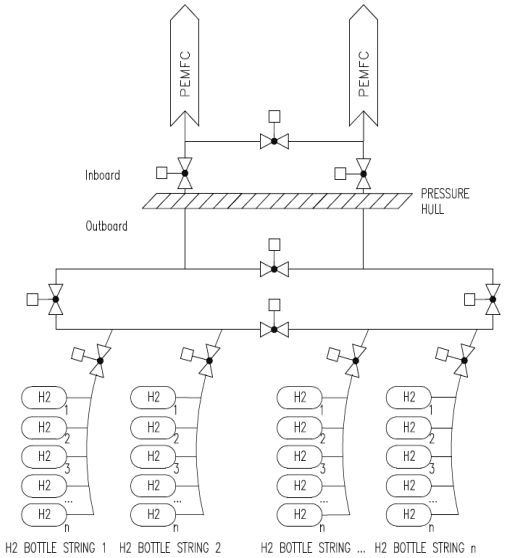
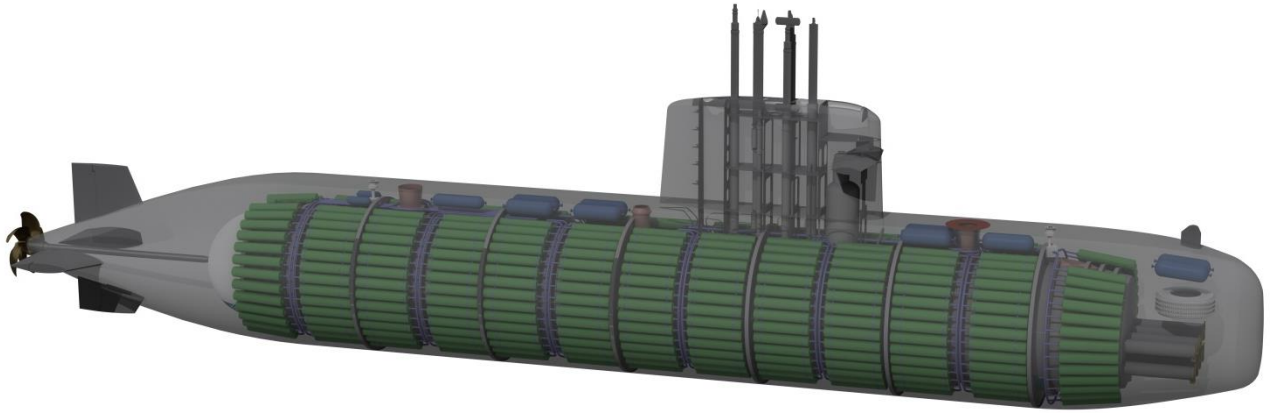
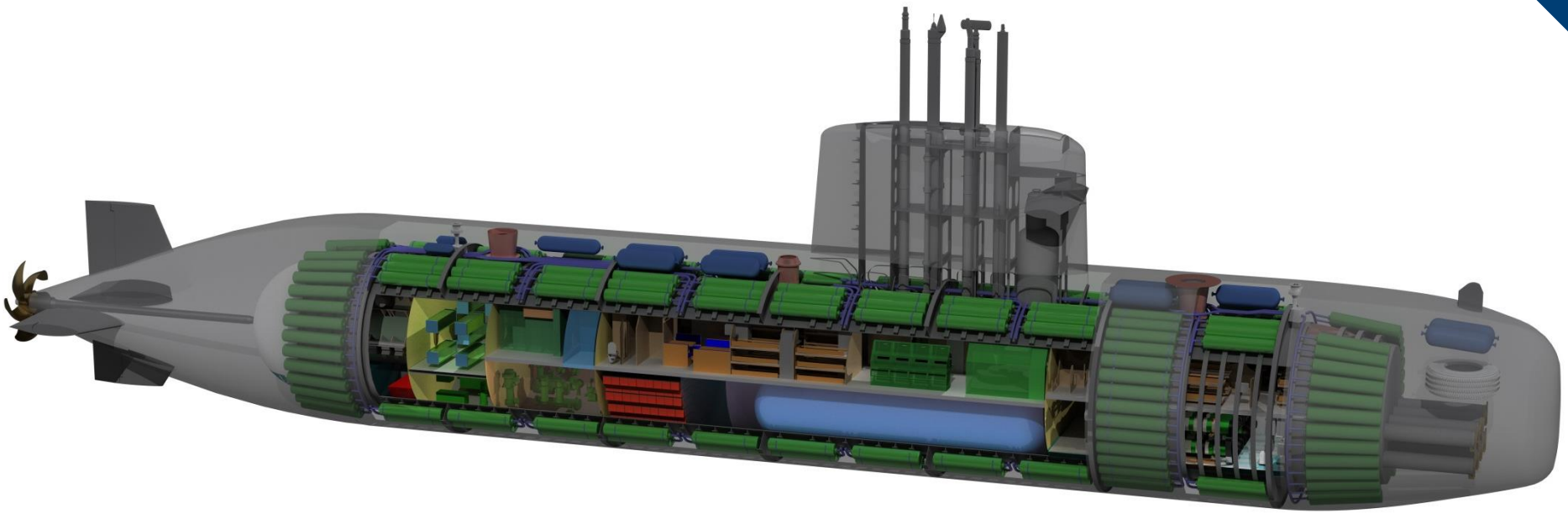


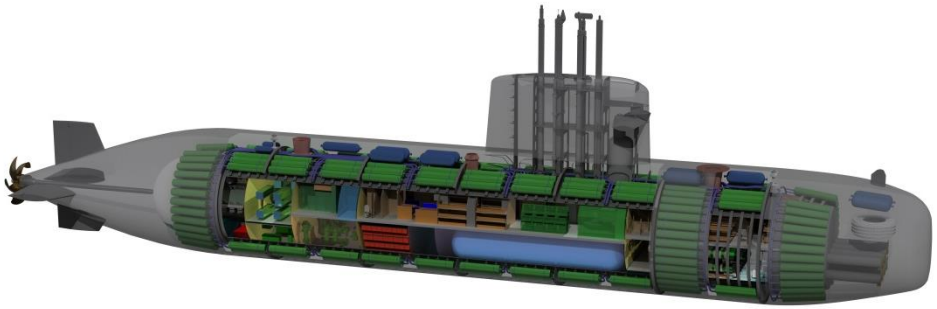


THE H_2MORAY

Fully Electric (battery/Fuel cell) powered submarine concept



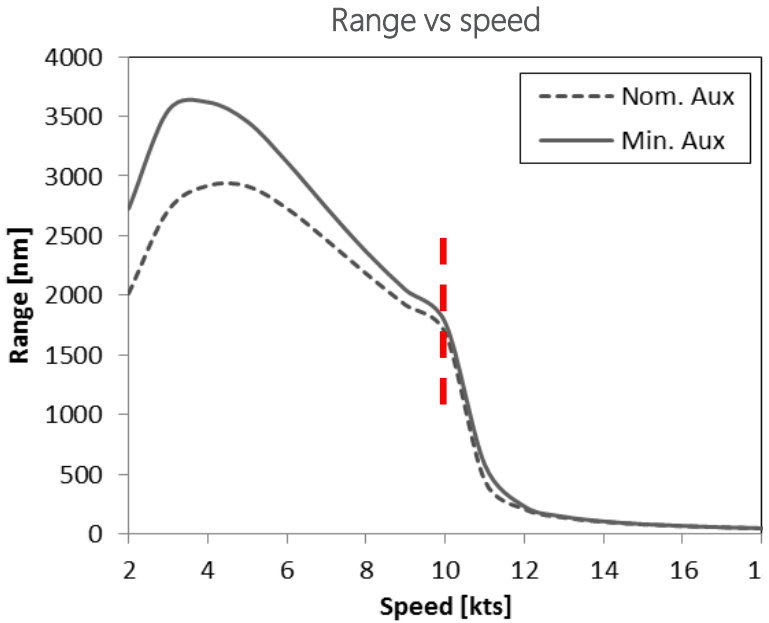
THE H_2MORAY
Submarine main concept

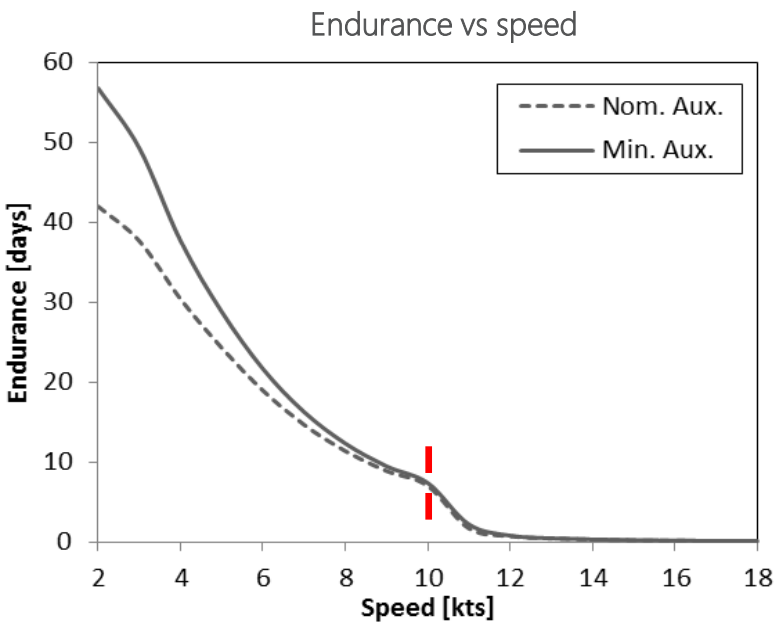


Dimensions	Length	64.4 m
	Hull diameter	6.4 m
Displacement	Surfaced	1700 ton
	Submerged	1900 ton
Diving depth	Max. operational	300 m
Combat	Launching tubes	6
	weapons	20
Speed	Max for one hour	20 kn
	Burst	21.5 kn
Fuel cells	Installed power	800 kW
Hydrogen	Number of bottles	382
	Storage capacity	7.7 ton
Oxygen	Storage capacity	68 ton
Batteries	Installed capacity	7.4 MWh
Accommodation	Crew & trainees	34+4

OPERATIONAL CAPABILITIES

Range and endurance



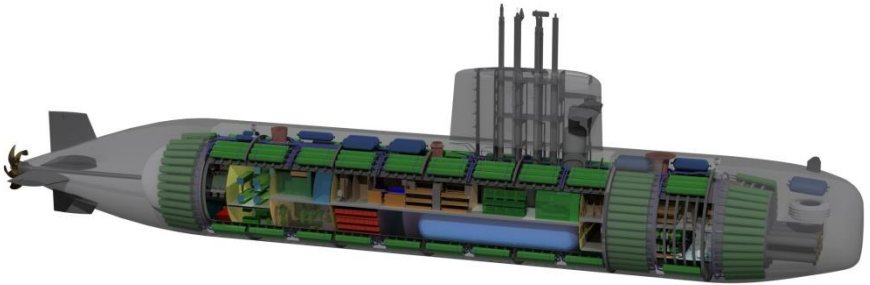


MISSION CAPABILITIES

- Indication of a four week round trip of 2500 nm
- Operational advantages
  - Air-independent power plant
  - Low signatures
- Mission capabilities
  - Local to medium range mission
  - Sea control/denial
  - Intelligence gathering
  - Special forces/equipment deployment
  - Coastal defense

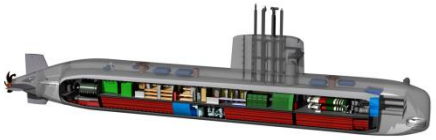
CONCLUSION H_2MORAY CONCEPT

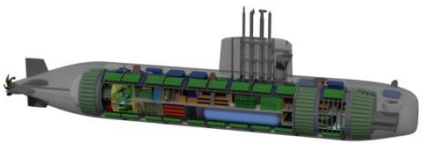
- Battery/Fuel cell powered submarine is a feasible concept
- Local to medium range missions feasible with a high level of covertness
- High operational flexibility due to self charging capacity fuel cells
- LOX tanks limiting design factor



COMPARISON WITH DIESEL-ELECTRIC AND TOTALLY BATTERY POWERED SUBMARINE

Overview of designs

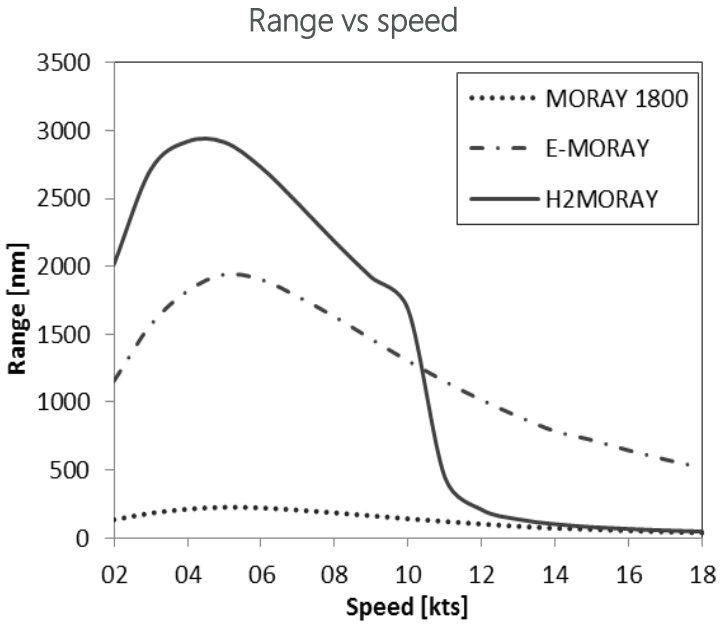


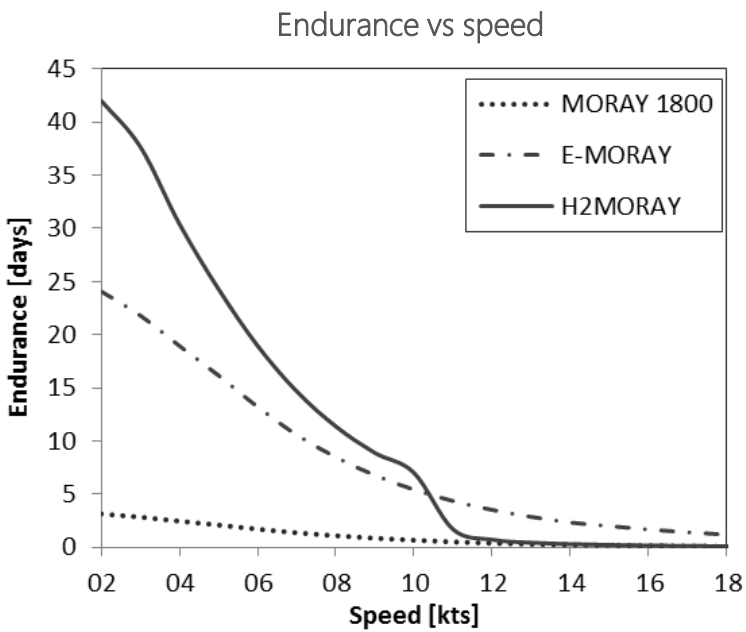


		MORAY 1800	E-MORAY	H_2MORAY
Submerged displacement	[ton]	1900	1900	1900
Accommodation	[-]	38	38	38
Combat (tubes & weapons)	[-]	6 & 20	6 & 20	6 & 20
Maximum speed	[kn]	20	20	20
Power plant	[-]	DG-set & lead-acid batteries	Li-ion batteries	Full cells & Li-ion batteries

COMPARISON WITH DIESEL-ELECTRIC AND TOTALLY BATTERY POWERED SUBMARINE

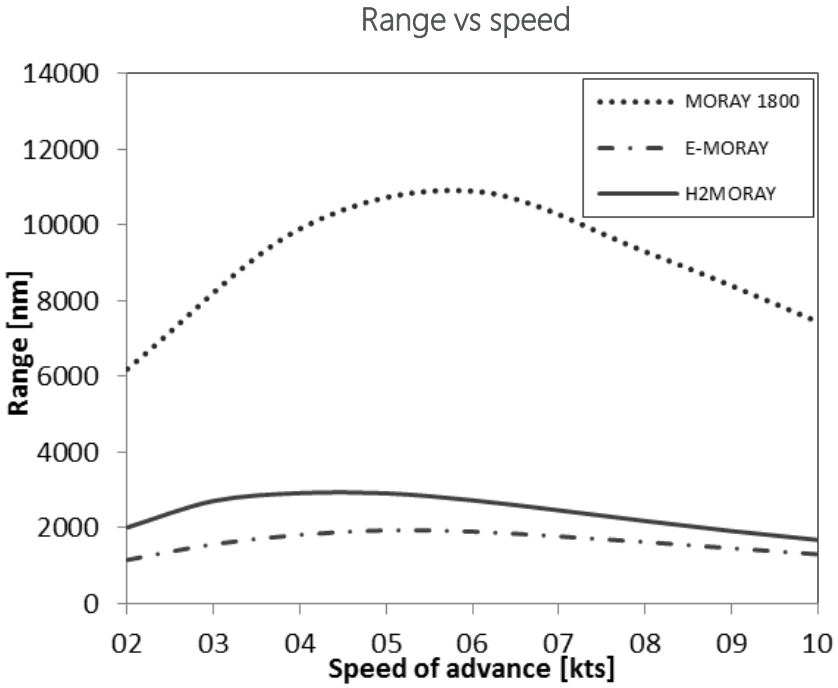
Submerged range and submerged endurance





COMPARISON WITH DIESEL-ELECTRIC AND TOTALLY BATTERY POWERED SUBMARINE

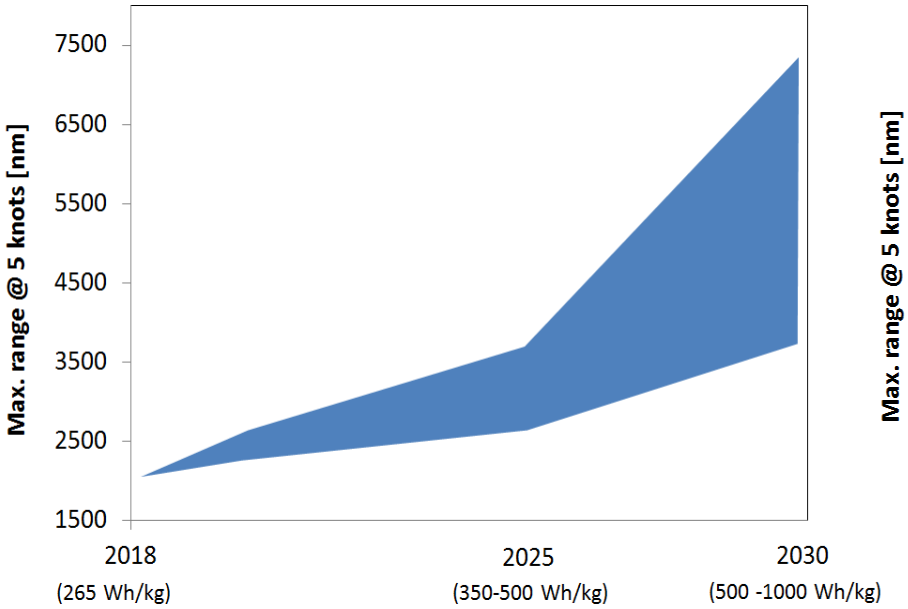
Total range and endurance



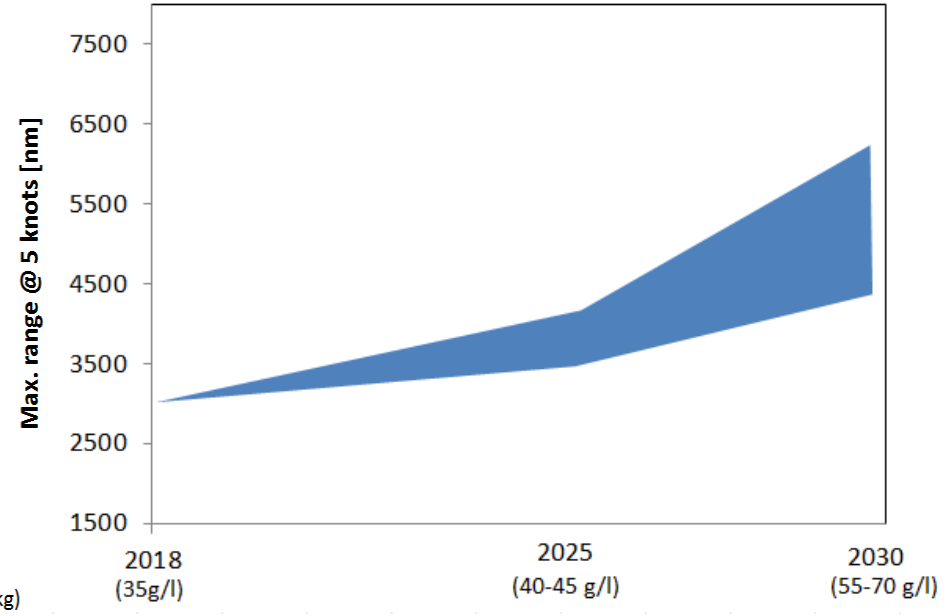
FUTURE OUTLOOK

Impact of expected technical developments

Potential of E-MORAY



Potential of H_2MORAY



DISCUSSION

- Development speed & applicability of new technology difficult to estimate
- Increase of design space
- Importance of power plant selection based on Navies CONOPS
- Important to analysis new commercially developed technologies and the knock-on effects of their (large scale) application in submarine designs
  - Safety
  - Design complexity
  - Crew size

CONCLUSION

- Potential of alternative power plant solutions for submarines will increase in the nearby future
- Totally battery powered submarines and battery/fuel cell power submarines will become realistic design options
- Design space exploration in early design phases will become of greater importance
- Commercially driven developments will impact submarine design considerations

CONTACT

Nevesbu b.v.

Kelvinring 48

2952 BG Alblasserdam

The Netherlands

+31 88 943 3400

sales@nevesbu.com

www.nevesbu.com