ROBERT ALLAN
Naval Architects & Marine Engineers

Tug's use in Port

Association of Pacific Ports – 111th Annual Conference – 2025: Nanaimo, B.C.

Who we are

Robert Allan Ltd. is world leading Naval Architecture firm, specializing in the design of harbor and escort tugs

Built on history, guided by innovation, and backed up with leading edge analysis tools

Founded in 1928 and led by 3 generations of Robert Allan.

As of 2008, Robert Allan Ltd. became 100% employee owned, with approximately ¼ of our 100 staff members as shareholders.

Innovation in tug design

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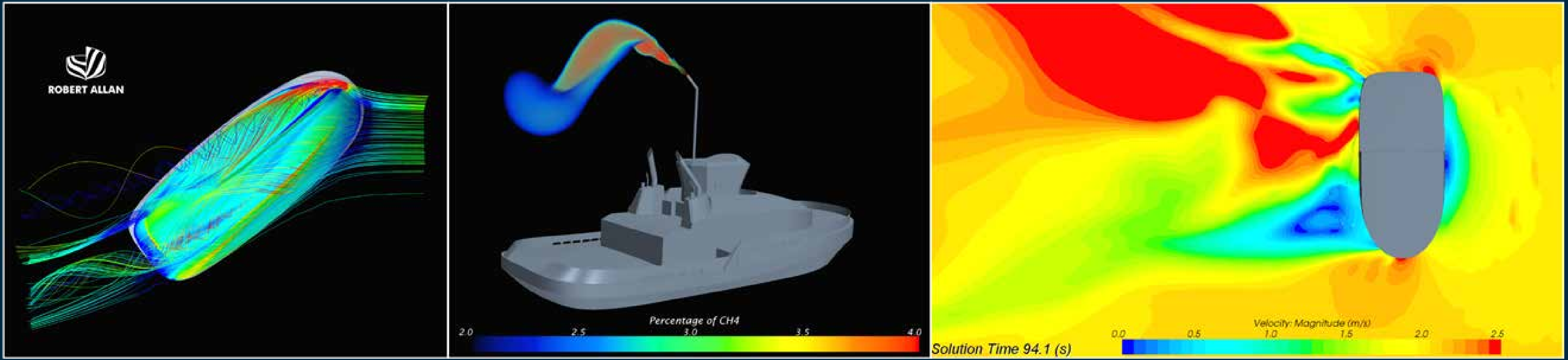
- Z-Tech: Unique sheerline for high-flare vessels
- Rastar: Sponsoned hull for optimal escort performance
- AmpRA: North America’s first electric tug

Pioneers in alternate fuels for tugs:

LNG, methanol and battery-electric

Leading Edge Analysis Tools

- CFD (Computational Fluid Dynamics)



Leading Edge Analysis Tools

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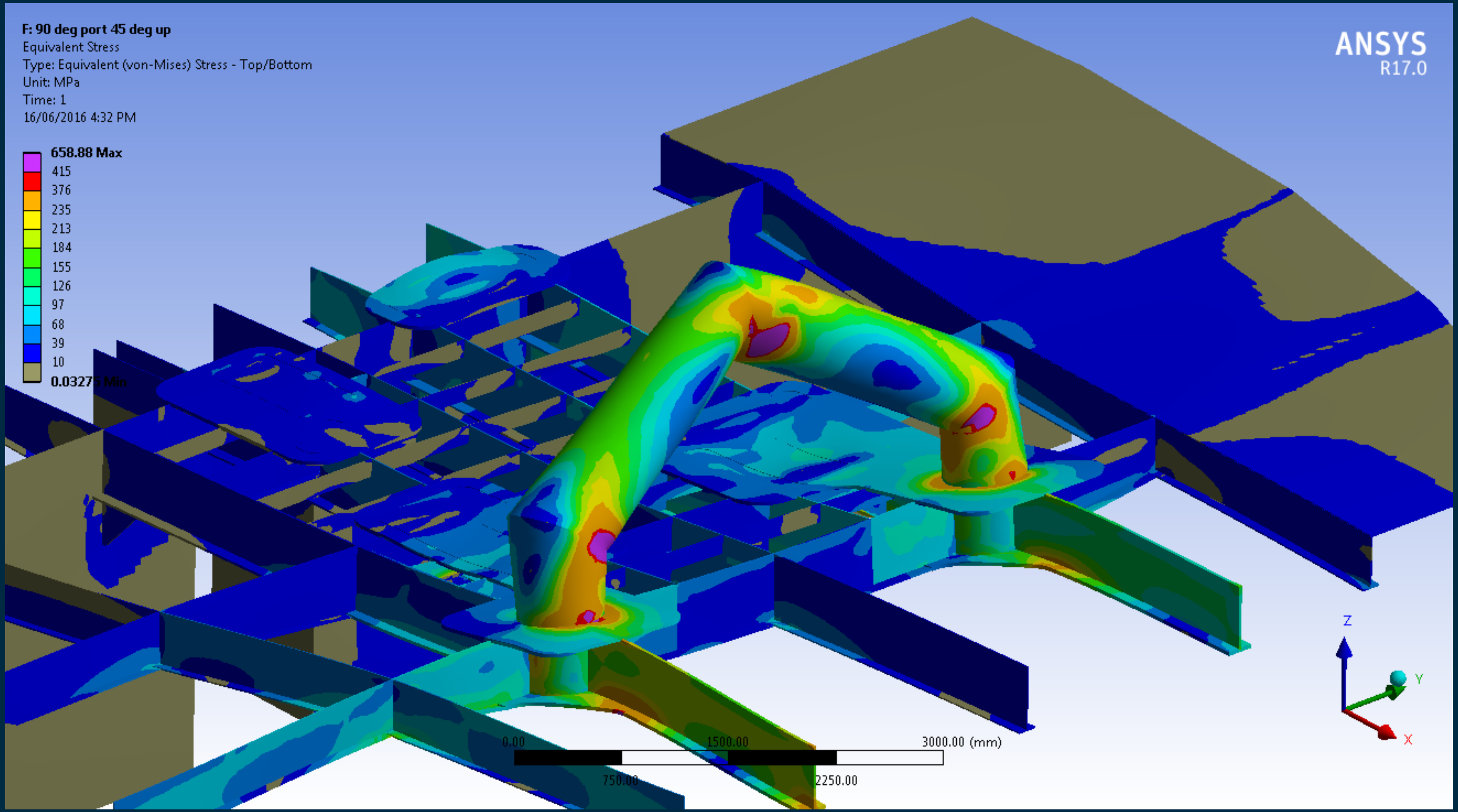
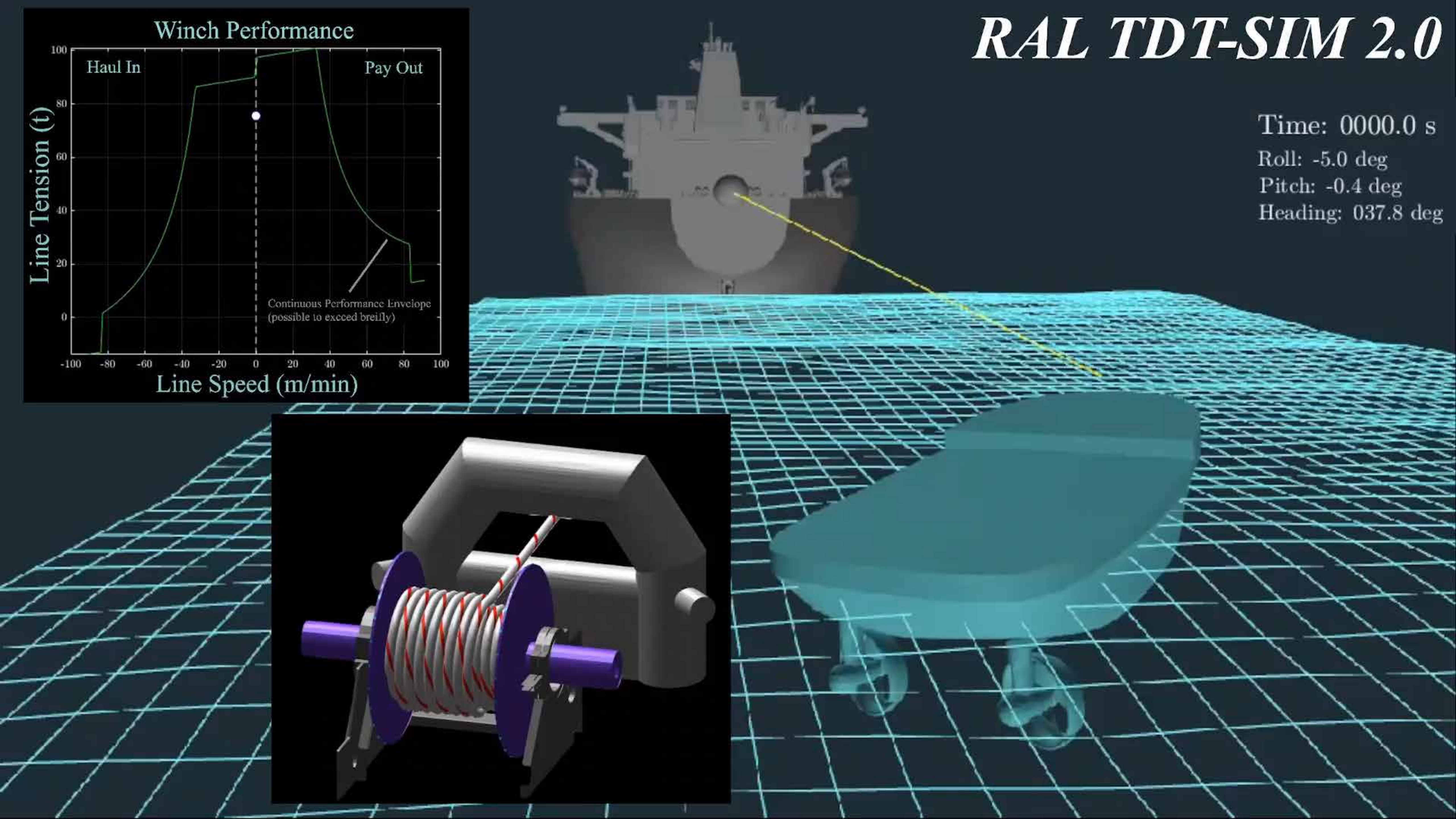
- FEA (Finite Element Analysis)




RAL TDT-SIM 2.0
Winch Performance
Haul In
Pay Out
Line Tension (t)
Line Speed (m/min)
100
80
60
40
20
0
-100
-80
-60
-40
-20
0
20
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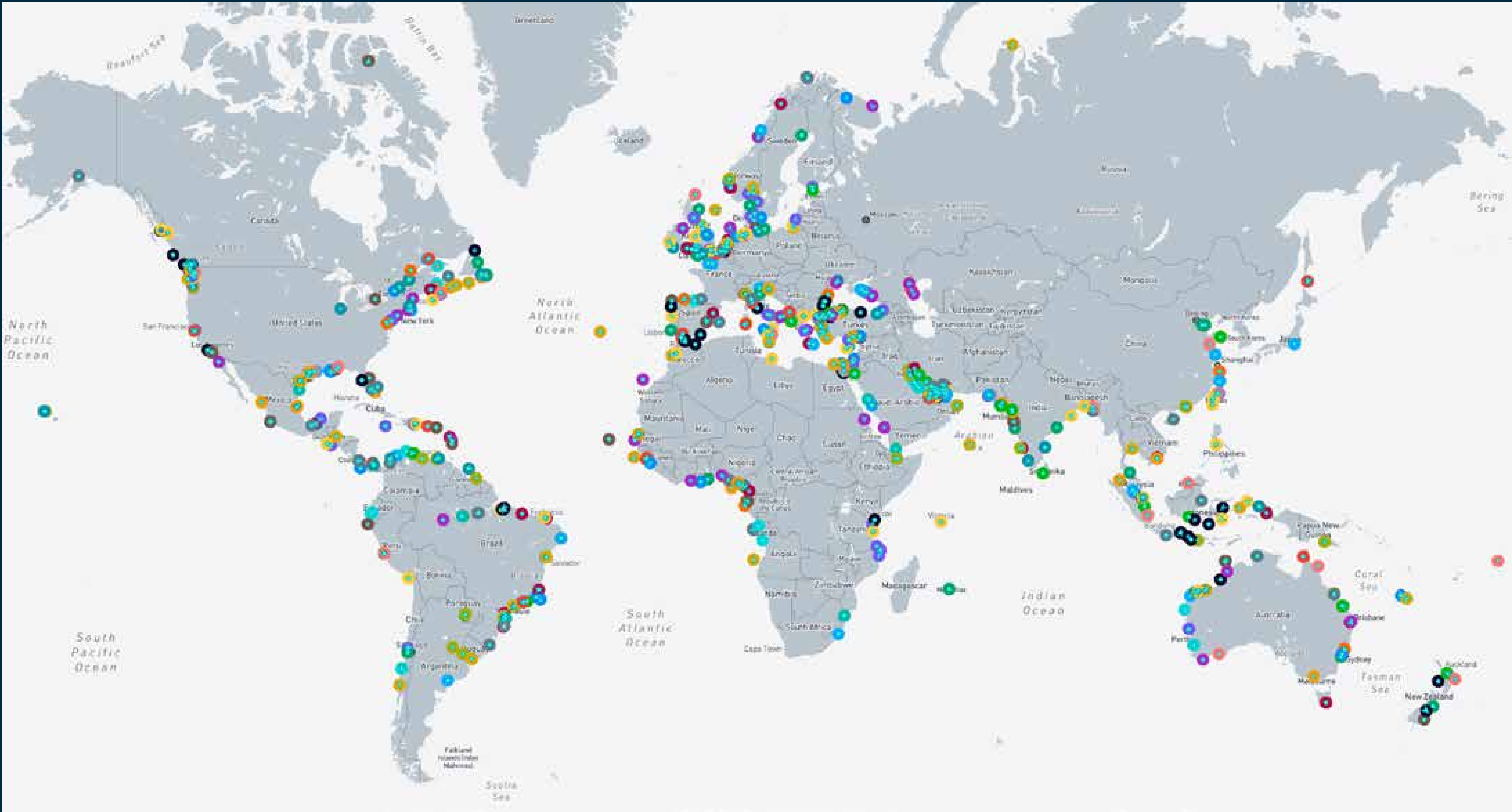
Continuous Performance Envelope
(possible to exceed breifly)
Time: 0000.0 s
Roll: -5.0 deg
Pitch: -0.4 deg
Heading: 037.8 deg



Our tugs get built! Over 1200 in service worldwide.

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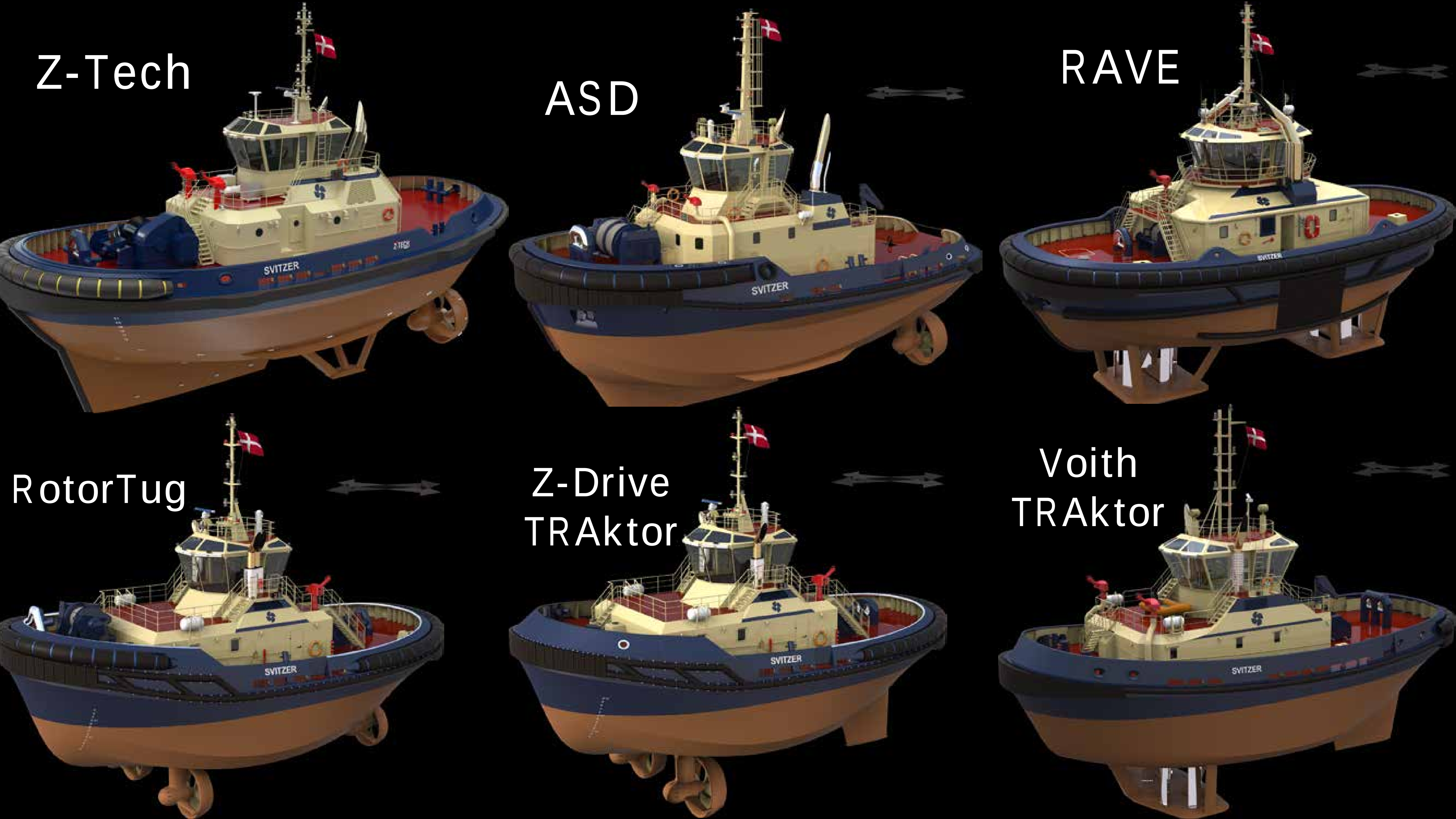
Tug introduction


Z-Tech
ASD
RAVE
RotorTug
Z-Drive TRAktor
Voith TRAktor

TRAnsverse

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There are many different types of tug:

- Anchor Handling / Offshore support
- Ocean / Coastal / Harbour Towing
- River pusher tugs
- Articulated Tug-Barge Systems
- Line Handling
- Ship Assist
- Escort

Supplemental roles:

Icebreaking / ice management, Firefighting, Oil spill recovery, NavAids, Pilot transfer

Tugs working in your port

Two main types :

- Ship assist: Small, simple, maneuverable, powerful


EAGLE VENTURA


ΜΑΡΑΝ ΓΚΑΣ
MARAN GAS
PIRAEUS
IMO 9942988
HAISEA BRAVE
HAISEA BRAVE
VANCOUVER B.C.
HAISEA WEE'GIT

Excellent maneuverability at low speed (<6 knots)
push/pull, direct towing:

Escort Tugs

To provide supplemental steering and braking forces on a ship. Usually as an emergency measure, but sometimes to assist high speed turns in narrow channels.

Escort tugs could have prevented these disasters!

- EXXON VALDEZ = destruction of natural habitat

- DALI (Baltimore Bridge) = loss of life

- EVER GIVEN = Economic hardship

Two ports in Australia standout in the field of escort towage:

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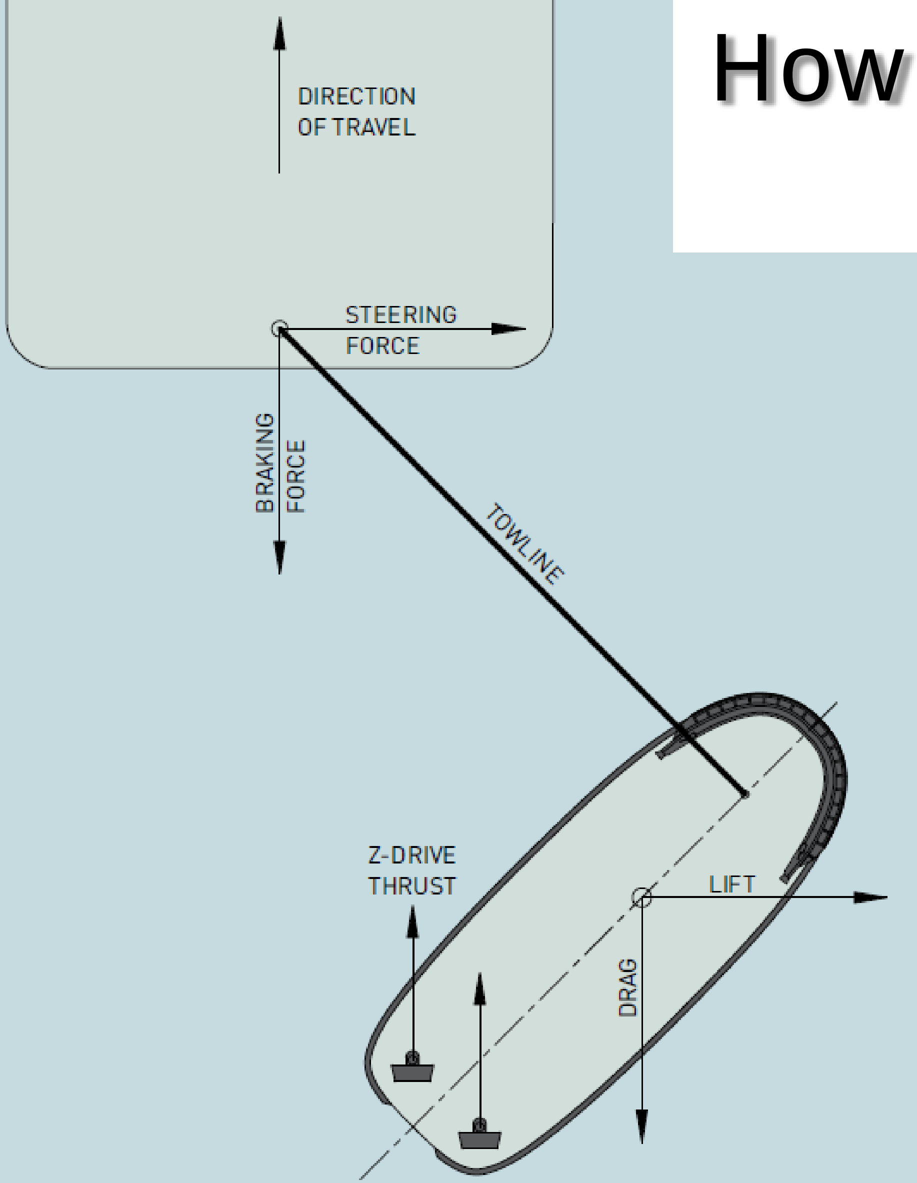
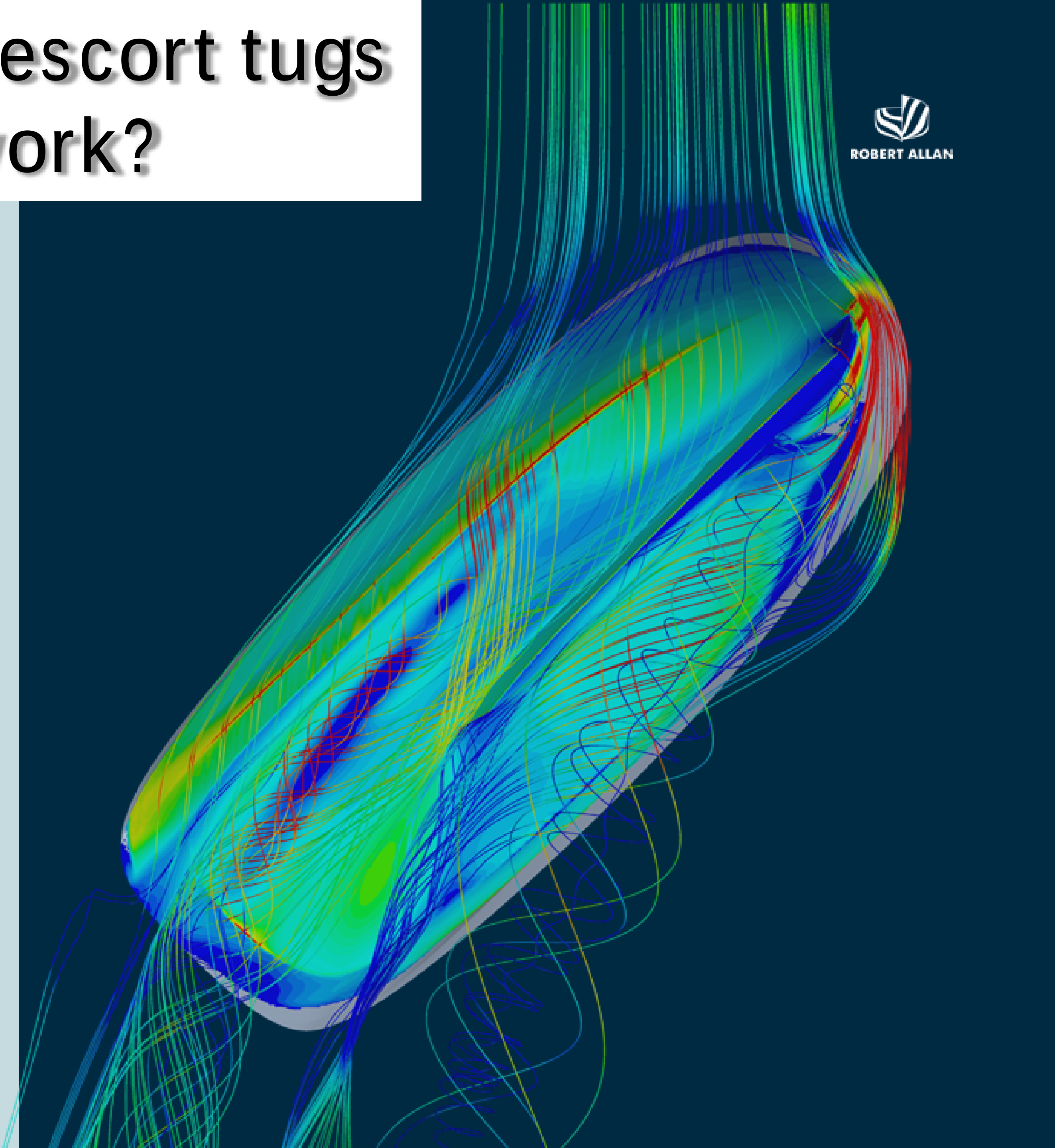
Newcastle, world's largest coal export port

Port Hedland, world's largest iron ore export port

How do escort tugs work?





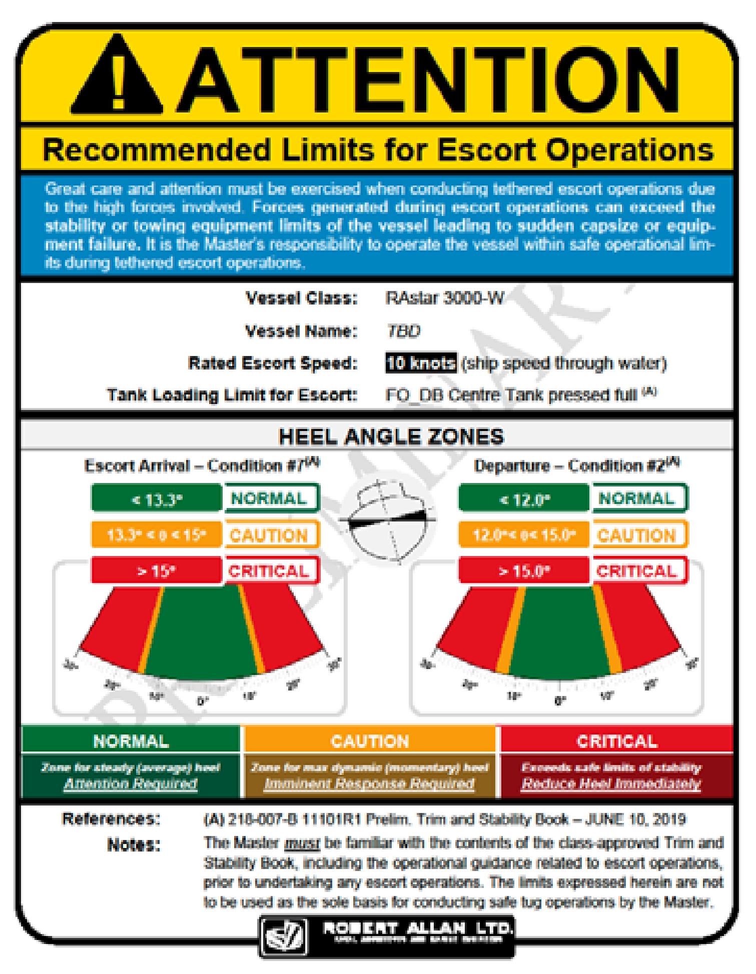
- Do not let Harbour Tugs perform Escort manoeuvres!

- Escort tugs **must** have the proper IACS class designation, not just an operator's validation

- This is very dangerous!
- >>>>>>>>>>>>>>>>>>>>

Harbour vs Escort Tugs

- Stability is the ultimate limitation

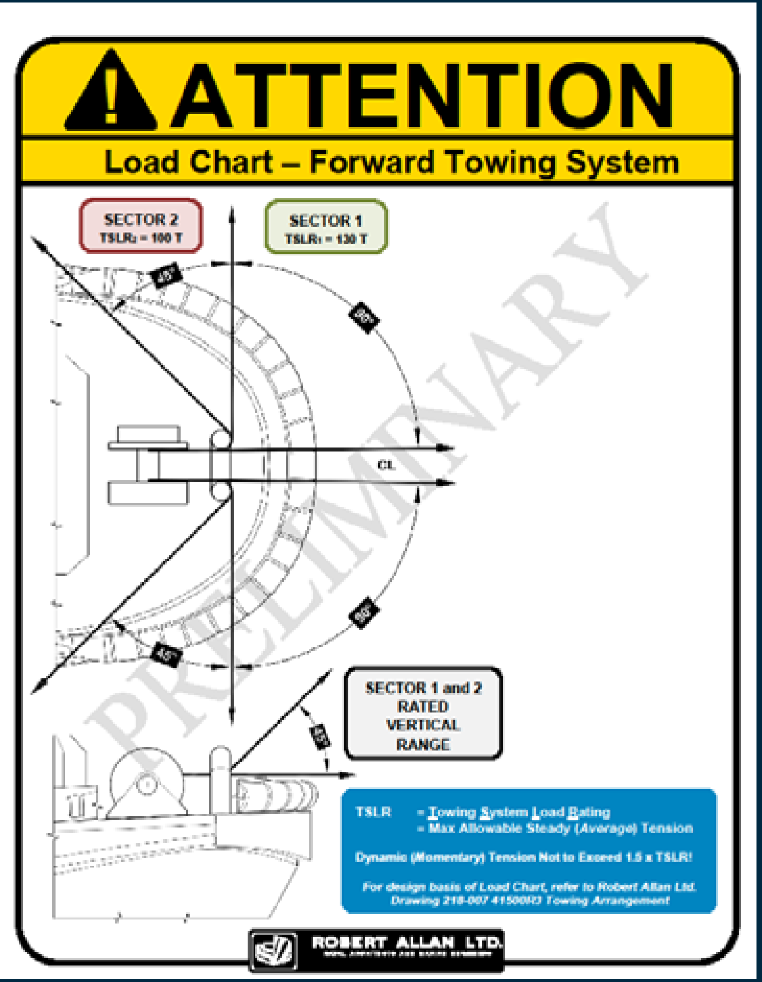


Heel Angle Limits

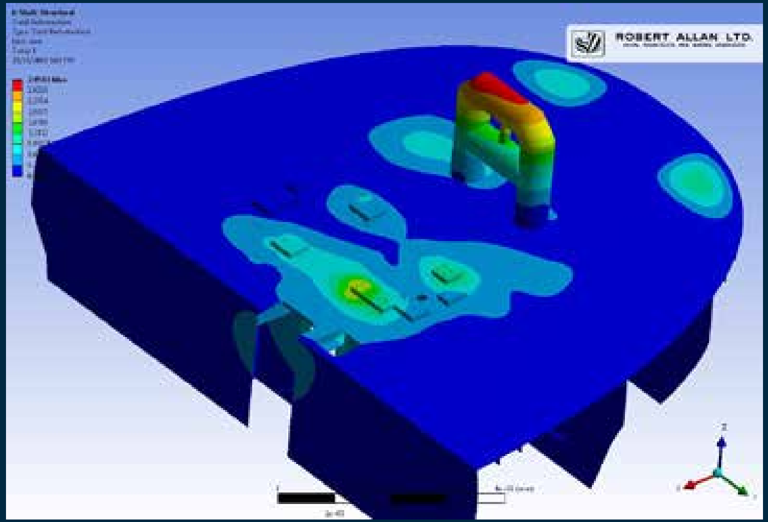
Heel Angle Indicator

Harbour vs Escort Tugs

- Strength of Tow fittings is an important consideration



Towline Angle and Load Limits



FEA of Tow Fittings

Simulator modeling with tugs

Ensuring the accuracy of your tug simulator model

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- Scenarios for new ship types and manoeuvres are normally modeled in a simulator
- Tug selection for BP and Escort forces is based on simulator results
- Simulator models must be accurate
- IMO ship maneuvering test are not applicable to tugs
- Tugs require a unique set of manoeuvres to be modeled
- It must be a requirement that the simulator model is validated and not just based on a tug master's evaluation that it "Feels about right"

Ensuring the accuracy of your tug simulator model

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DNV

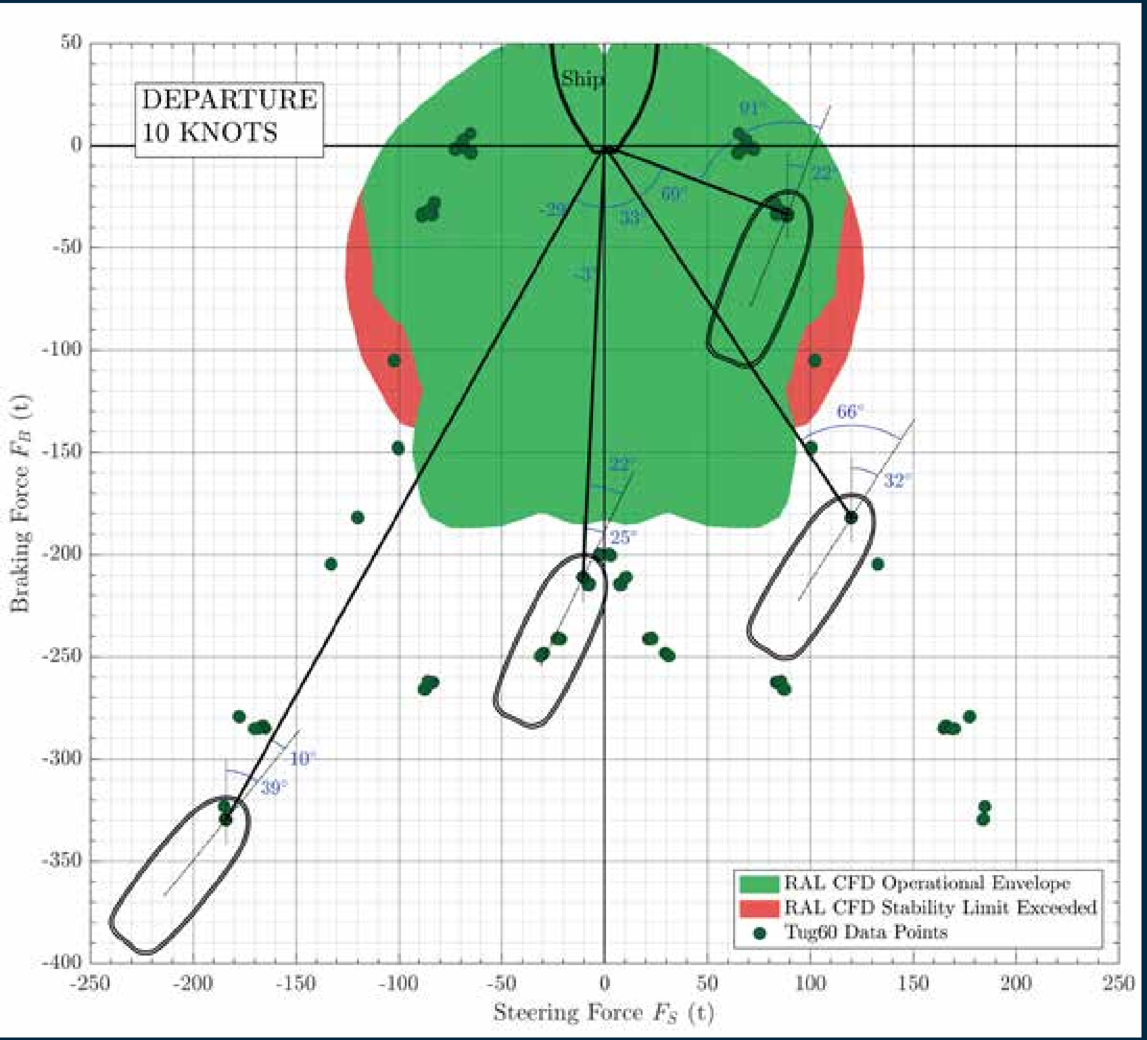
STANDARD

DNV-ST-0033 Edition June 2021

Maritime simulator systems

Ensuring the accuracy of your tug simulator model

- Comparison of CFD values and a simulator model
- Simulator models must be verified according to CFD or real-world measurements
- Non-scientific assessments may be accurate for manoeuvring behavior but are not accurate for tug forces



Alternate fuels

Chicken or the egg dilema

Scalable Zero Emissions Fuels (SZEFs)

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- Relative to Diesel Fuel, all the alternatives have issues with;
- - Bunkering / charging infrastructure
- - Low flashpoint fuels - flammability and hazardous zones for ventilation
- - Equipment Availability
- - Storage Volume
- - Weight / Energy density
- - Toxicity

Scalable Zero Emissions Fuels (SZEFs)

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- There are many paths on the road to De-carbonization

	Zero-carbon energy source					
Energy source	**Methanol**	**Hydrogen**	**Ammonia**	**Electricity**	**Diesel**	**LNG**
NG with CCS		NG-hydrogen	NG-ammonia			
Biomass	bio-methanol				bio-diesel	bio-LNG
Renewable electricity	e-methanol	e-hydrogen	e-ammonia	batteries	e-diesel	e-LNG

Battery Electric Vessels are here!

- Direct pathway to zero emissions
- Tugs have now entered service with more currently under construction

- Use Cases:
  - Predictable operating profile
  - Within a dedicated fleet
  - Shoreside infrastructure is well developed
  - Where power supply is green (ideally)

Ideal for Harbour Tugs

ElectRA 2800

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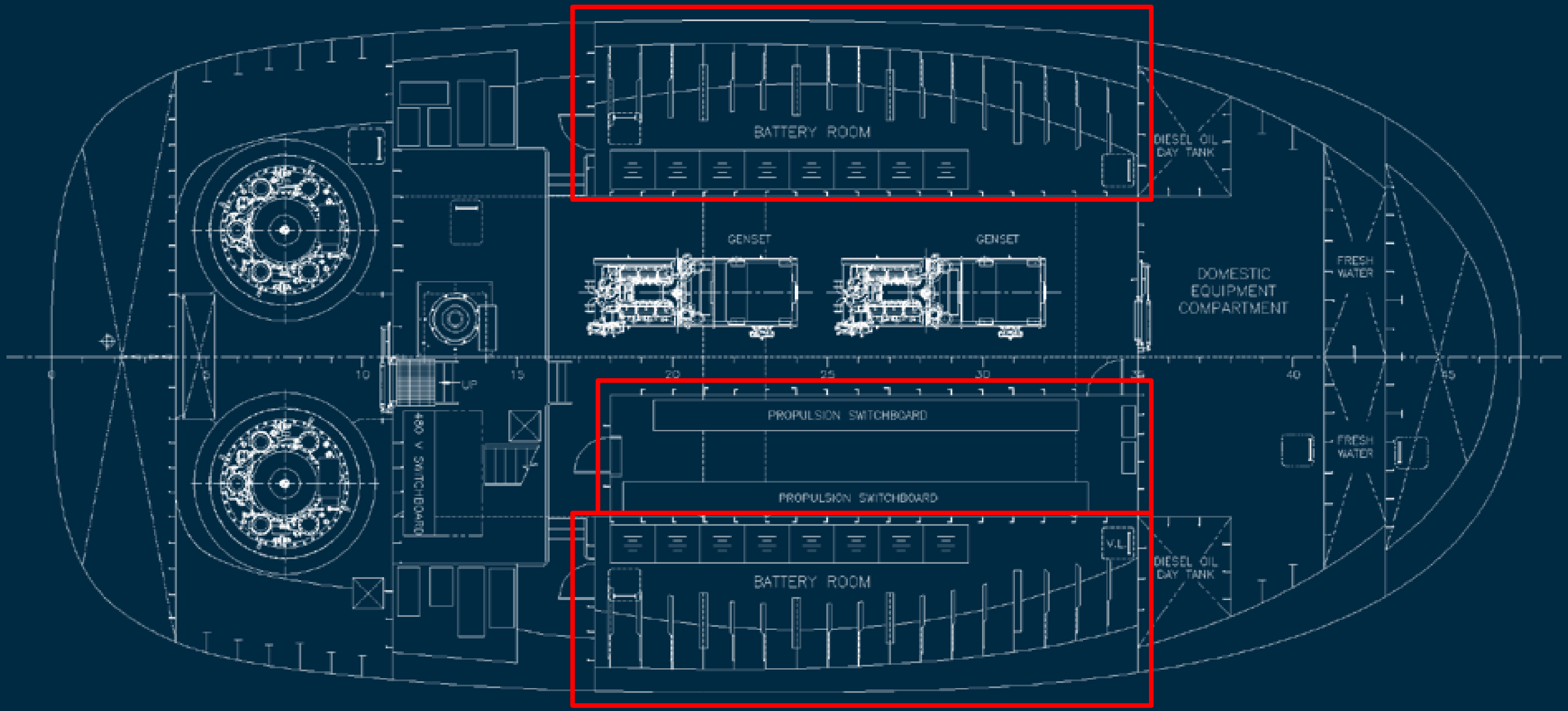
- 70 tonnes Bollard Pull
- Speed: 12 knots
- 5200 kW-hr installed battery energy
- Battery endurance: Up to 6 hrs. for normal harbour tug operations
- Dedicated terminal tug for LNG Canada in Kitimat, British Columbia.
- Backup gensets: 2 x 940 ekW
- Delivered from Istanbul, Turkey to Vancouver Canada on its own bottom. A journey of over 10,000 N.M.

ElectRA 2800 – space consumed by Batteries and Switchboards!



CHINA ZORRILLA – ELECTRIC FERRY

- 14,000 GT
- 40 MW.HR BATTERY

= 2.9 KW.HR / GT

ELECTRA – ELECTRIC TUG

- 400 GT
- 5 MW.HR BATTERY

= 12.5 KW.HR / GT

Battery Electric Vessels – limitations

- Currently unsuitable for
  - Operations which require both high power and endurance
  - Areas where shoreside infrastructure limits charging
- Not well suited to salvage, coastal towing, or long escort operations
- As battery technology and cost improves, battery electric vessels will become more practical for these operations
- Hybrid tugs have potential to bridge the gap
- Larger backup gensets to provide continuous power
- Need to look to alternative fuels for certain operations

Drop in Fuels – Biodiesel / Hydrotreated Vegetable Oil (HVO)

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- Do not require changes to vessel design
- Minor engine modifications
- Small changes to storage and handling procedures
- But is it scalable?

Alternative Fuels

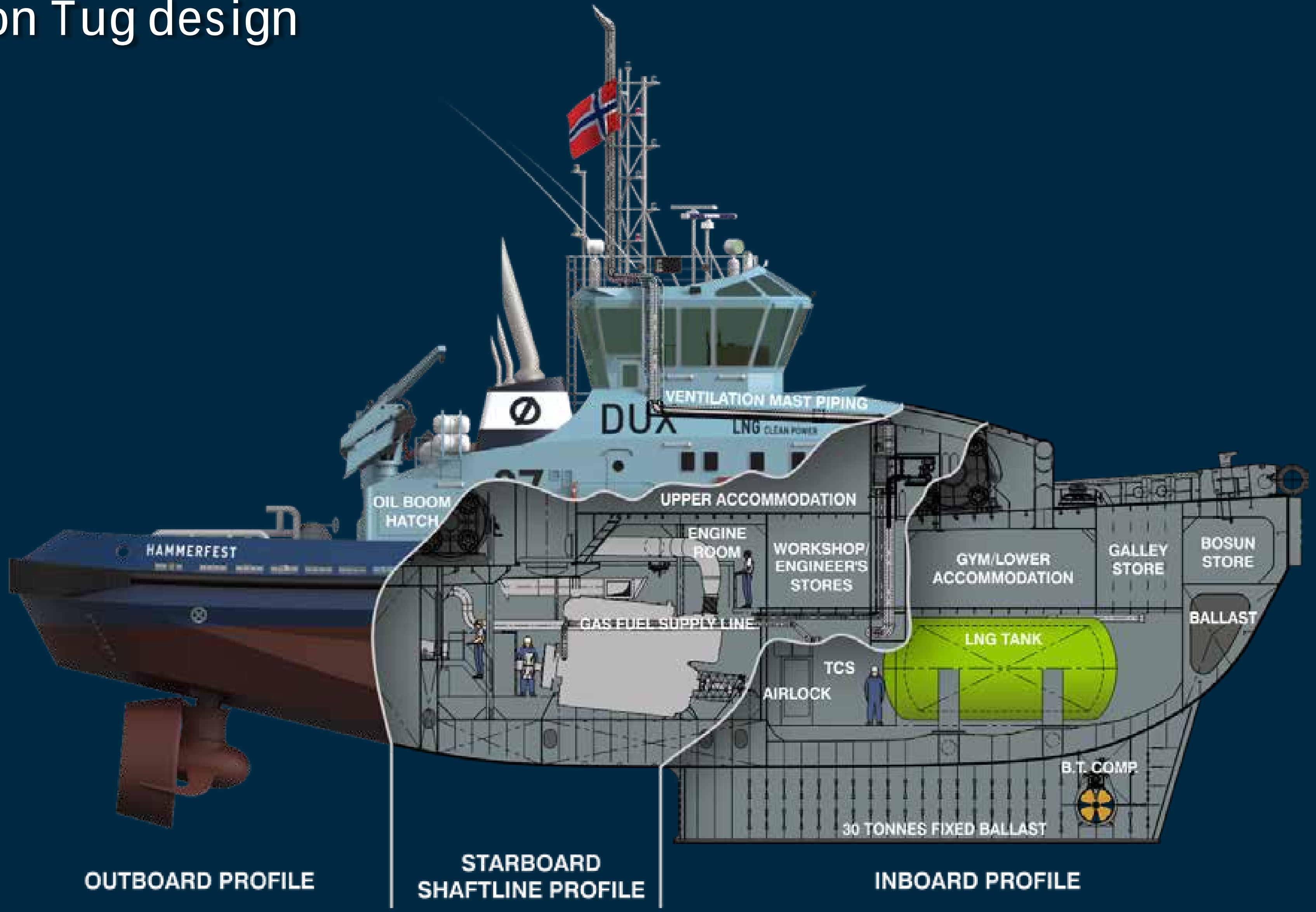
- Liquid Natural Gas (LNG)
  - Low flashpoint, Pressurized, Cryogenic
  - Can reduce CO_2 by 25%
  - Well established designs

- Methanol
  - Low flashpoint
  - Better Storage capabilities
  - Green methanol provides net zero GHG

- Hydrogen
  - No Carbon!
  - Low flashpoint, Pressurized, Cryogenic (in LH2)

- Ammonia
  - No Carbon!
  - Low flashpoint, Pressurized
  - Toxic

Impacts on Tug design

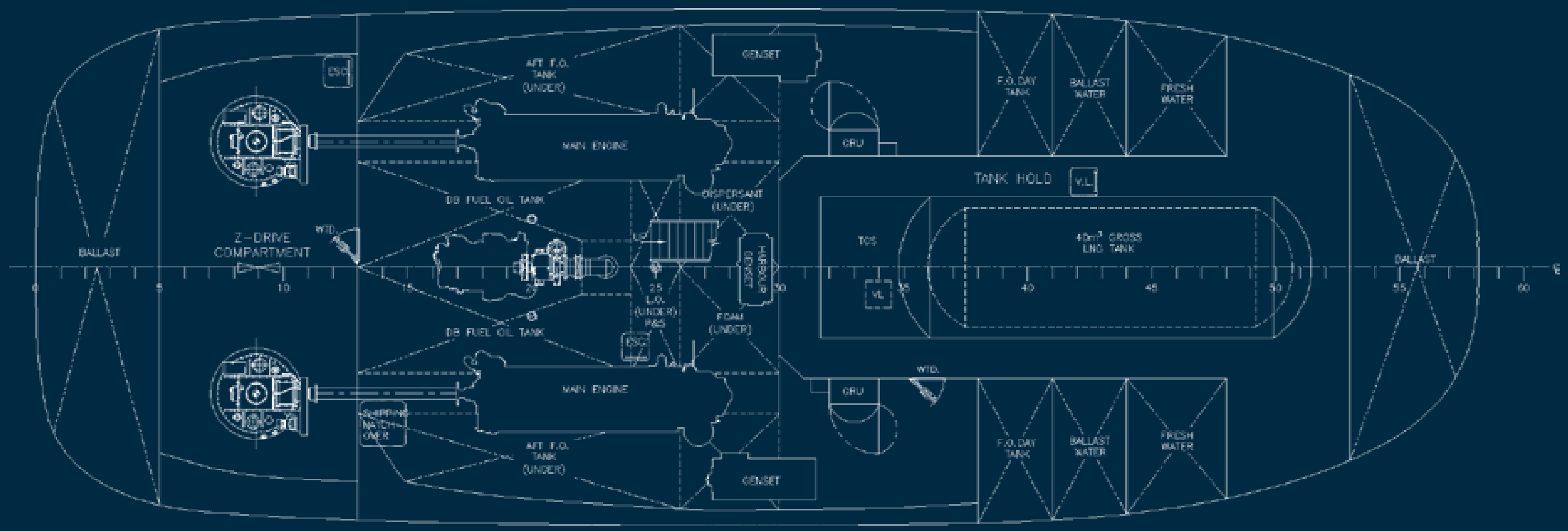


System Effective Energy Density (SEED)

- Volumetric energy density does not account for:
  - Space associated with Fuel system
    - Tank Connection Space (TCS)
    - Bunkering Station
  - Restrictions on Fuel storage Locations
    - Cofferdams
    - IGF Clearance Zones

- The SEED value of a given fuel compares the amount of <u>energy</u> that can be practically stored on a tug.

- For comparison Diesel is assigned a value of 1



500 GT Tug SEED Values

- SEED values below for some typical tug designs
- Referenced vessels are ~32m LOA and have similar accommodation with 80t bollard pull

Tug Fuel	Diesel	Methanol	LNG	Ammonia	LH_2	H_2 (gas-250 bar)
Installed Fuel Quantity	200m3	100m3	40m3	50m3 (estimated)	40m3 (estimated)	45m3
Total Installed Energy (GJ)	7120	1570	830	570	340	125
SEED	1	0.22	0.12	0.08	0.05	0.02

- When considering the fuel system and storage, Methanol moves ahead of LNG in terms of endurance.

Endurance by Fuel Type – Actual fuel capacities

Class Societies – ABS, BV, Lloyds, DNV-GL

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- Rules are written with bigger ships in mind
- Limited experience in the tug world
- Application of the rules require determination of equivalent levels of safety
- All classes have slightly different rules
- Interpretations will change as more tugs are built

Hazardous Zones

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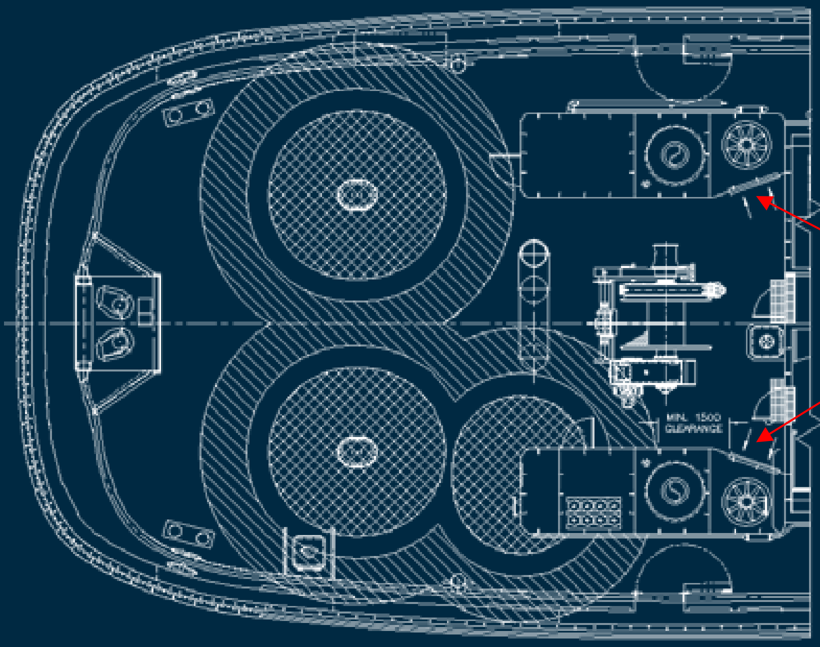
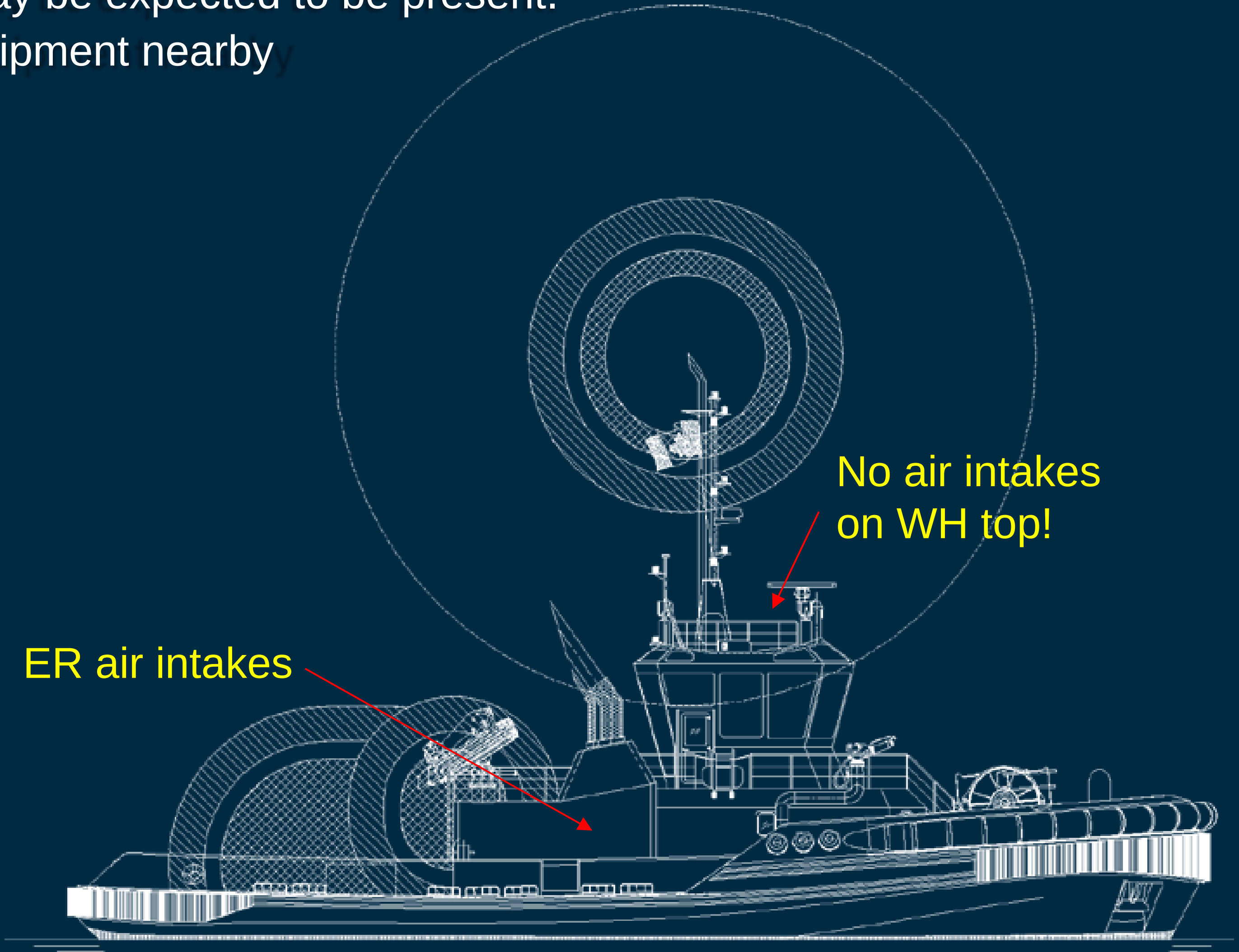
- Any area where an explosive gas is or may be expected to be present.
- Requirements for intakes, entrances, equipment nearby

- Key hazardous zones are:
  - Fuel system vent outlets
  - Bunkering Station (temporary zone)
  - Tank Access points (for methanol tanks)



MAIN DECK PLAN



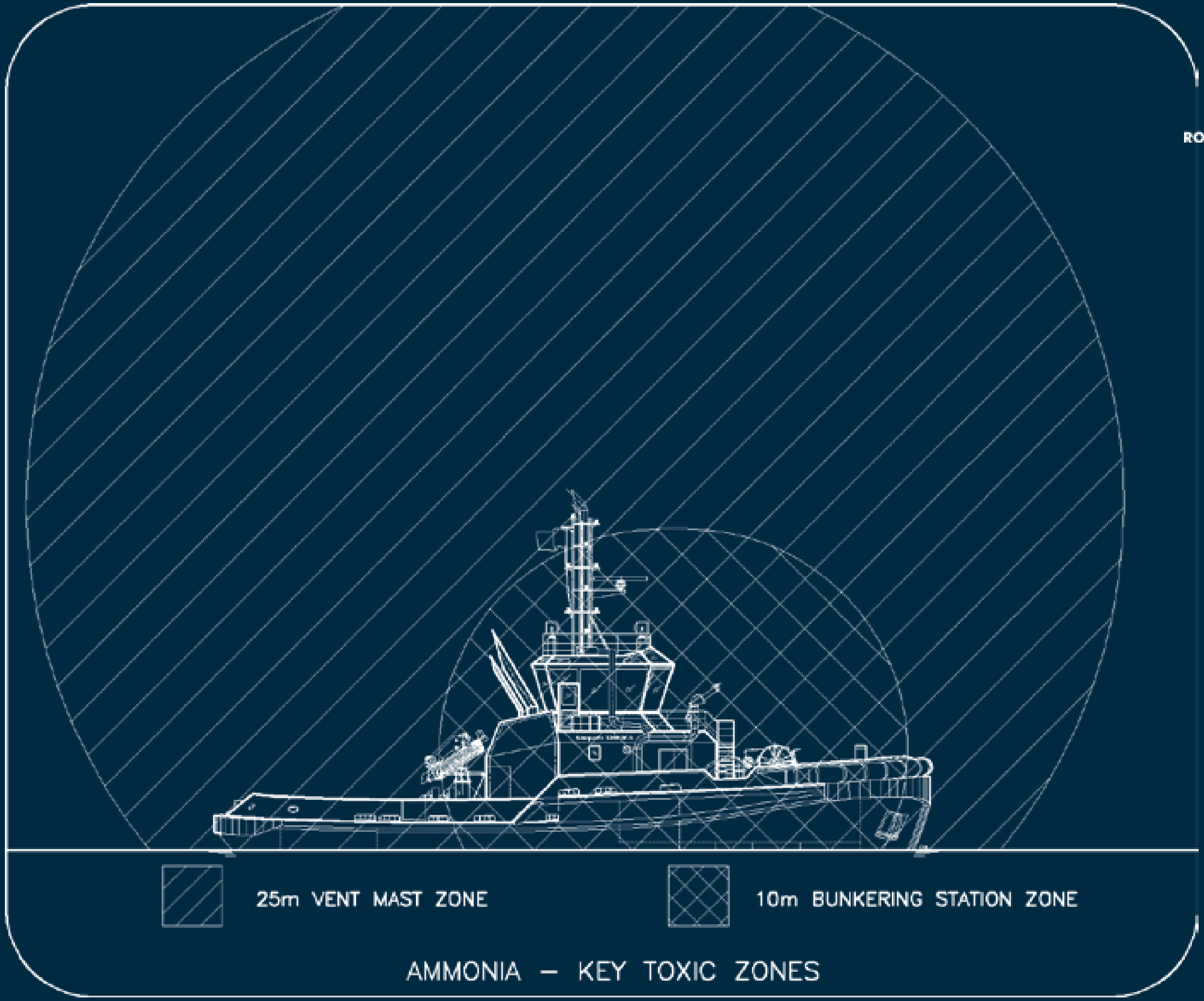
OUTBOARD PROFILE

Toxic Zones

- Only applicable to Ammonia

- 25m around fuel system vent outlets
- 10m around bunkering stations

- Without regulatory changes, Ammonia is unfeasible for sub 500 GT tugs



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Other Considerations

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- Shoreside infrastructure for battery charging and fuel delivery
- Fuel Availability / Scalability
- Beware of the fuel source! Well to Wake vs. Tank to Wake for overall carbon emissions

Equipment Availability

- Currently there are few engines available
- Unclear as to which manufacturer, fuel, or technology will be dominant
- Most engines are medium speed
    - Require deeper hulls and larger engine rooms compared to high speed engines

Conclusions – Fuel Selection

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- LNG
  - LNG will remain an important transitional fuel, though its market share may decline as battery and methanol vessels come online
- Hydrogen
  - A promising solution for the future, possibly 10 -15 years
  - Cost, storage requirements, pose issues for sub 500 GT tugs
- Ammonia
  - Toxic Zones make Ammonia unsuitable for sub 500 GT tugs
  - Could work well on large vessels
- Methanol
  - Best endurance of the group
  - Green methanol will provide net zero GHG emissions
  - Expected to be the dominant fuel in the near future

Underwater Radiated Noise (URN)

Port authority-led ECHO Program launches expanded seasonal measures to support recovery of southern resident killer whales

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Underwater Radiated Noise (URN)

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- How do we reduce the impact?

- - Lower speeds
- - Reduce propeller loading (large and slow)
- - Properly designed propulsion supports (isolation)
- - Electric drive

Shipping is a vital part of the economy:

- No shipping, no shopping

Tugs are a vital part of port operations:

- No tugs, no trade

Thank you for your time