Surface Effect Ships (SES)
Technology Briefing

EUREKA NAVAL CRAFT
BENGAL - Module Carrier

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NAVSEA | PEO USC | PMS 406
Product Service Code 1905
Modular Attack Surface Program (MASC)
August 14, 2025

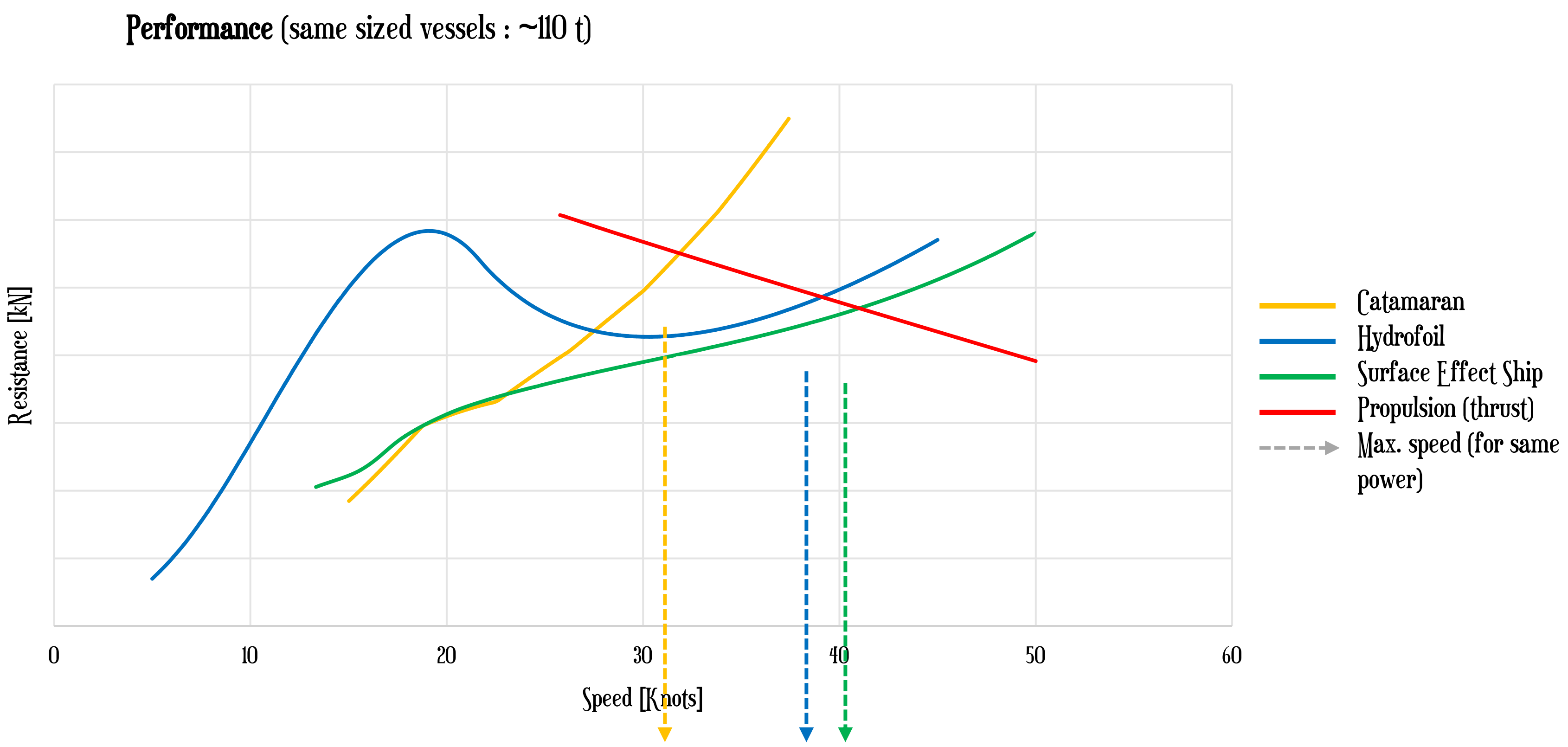
SES Systems Overview

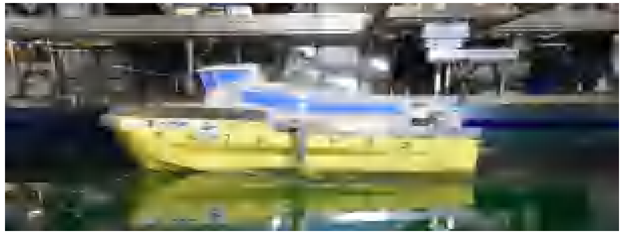
- A Surface Effect Ship (SES) is a type of vessel that combines an air cushion, similar to a hovercraft, with twin hulls like those of a catamaran. They are essentially the offspring of a Hovercraft and a Catamaran – with all their best attributes.
- SES ships are also known as Air-Cushioned Catamarans.
- Despite some similarities, they are not hovercraft.
- In fact, air-cushioned catamarans differ significantly in many ways, including:
  - Their ability to operate in rough sea conditions
  - Greater efficiency of their waterjet propulsion
  - Absence of noise generated by propellers
  - Enhanced maneuverability and agility
  - Stronger and more resilient hull structure

SES Systems Overview

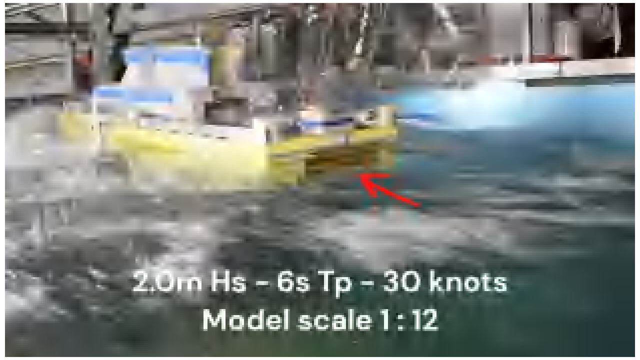
- Two side hulls designed to minimize wetted surface area
- An air cushion positioned between the two side hulls
  - The air cushion refers to the rectangular, box-shaped space between the side hulls
  - Equipped with bow and bag skirt systems at the front and rear between the side hulls
  - Lift and bag fans maintain the air cushion pressure
    - SES control system regulates pressure consistently in waves
    - Includes motion damping
- Other systems function similarly to those on conventional surface vessels
    - Standard auxiliary systems with seawater cooling
    - Efficient high-speed water jet propulsion systems
- Thanks to their air cushion and reduced hydrodynamic drag, SES vessels have a higher speed-to-power ratio, lowered fuel consumption, and improved ride comfort

SES Hydrodynamic Performance





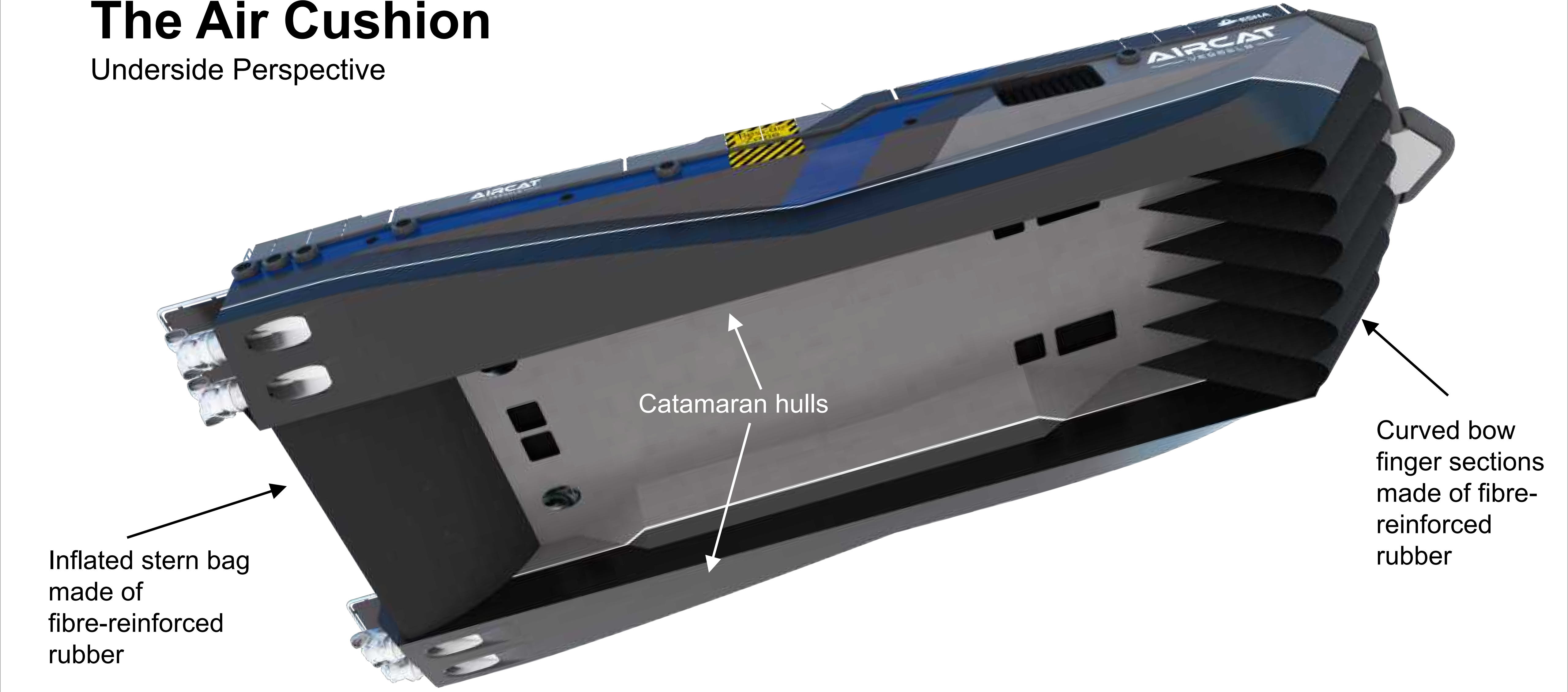
Towing Tank Tests – Stadt Towing Tank (Norway)



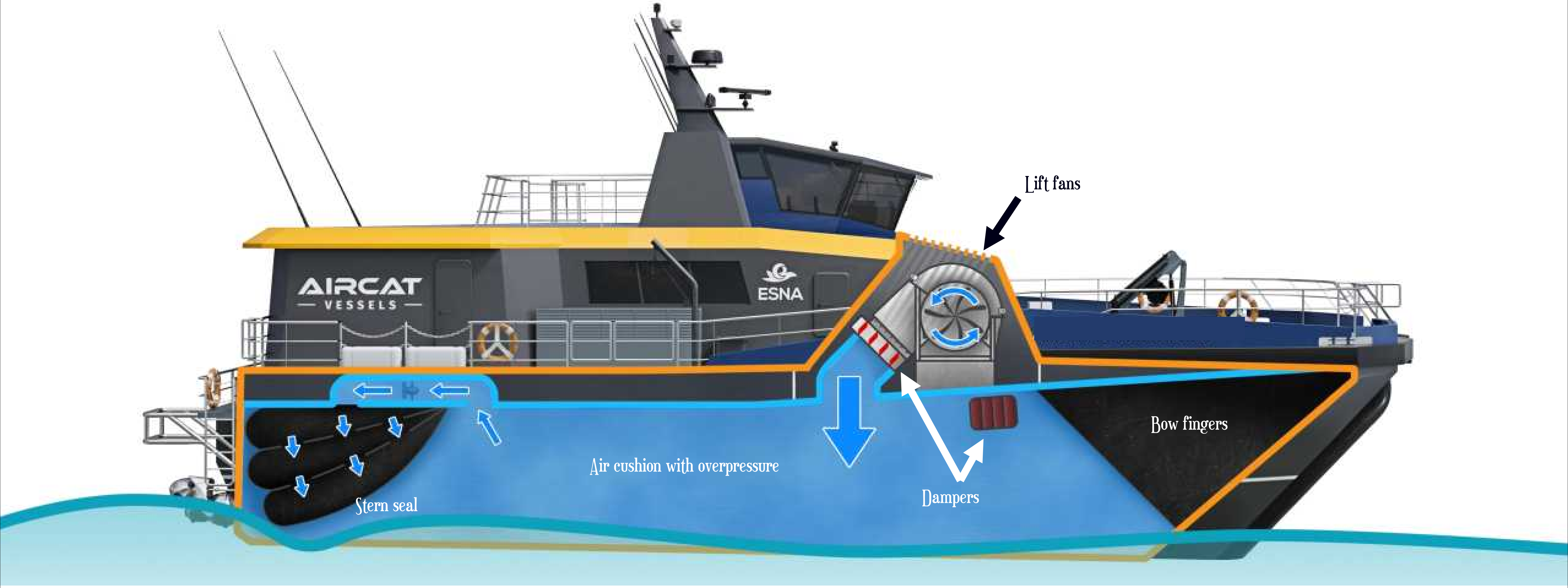
Oil & Gas Tested and Class Approved

The Air Cushion

Underside Perspective



SES Systems

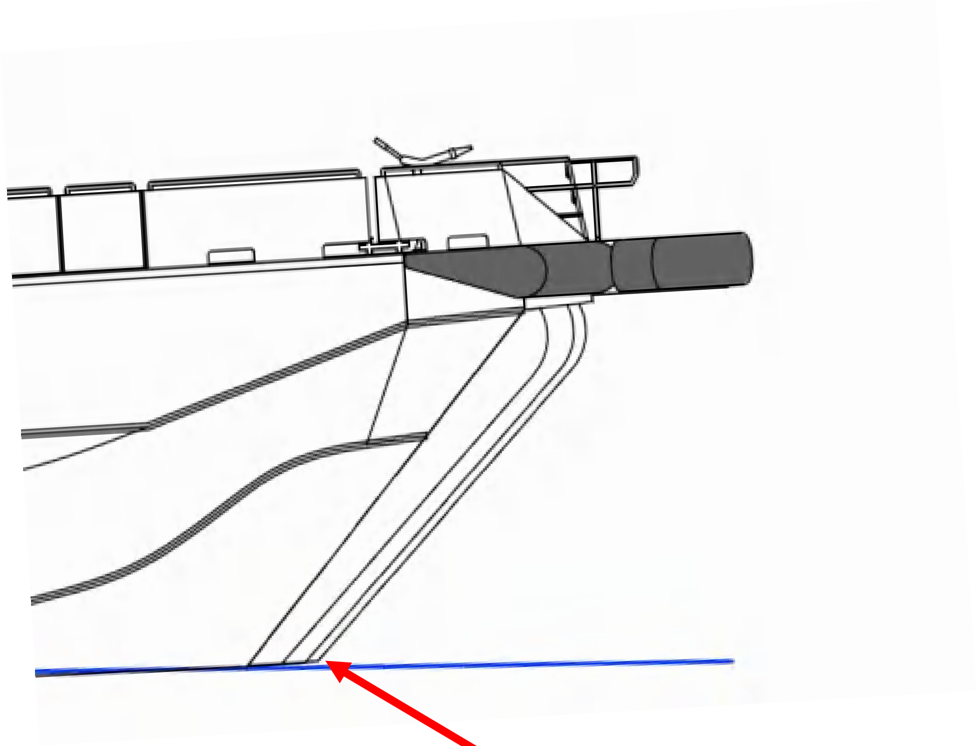

AIRCAT
VESSELS
ESNA
Lift fans
Bow fingers
Air cushion with overpressure
Stern seal
Dampers

BOW SKIRT (FINGERS)

Threaded into rails in wet deck

Attachment to flat bar welded to wet deck

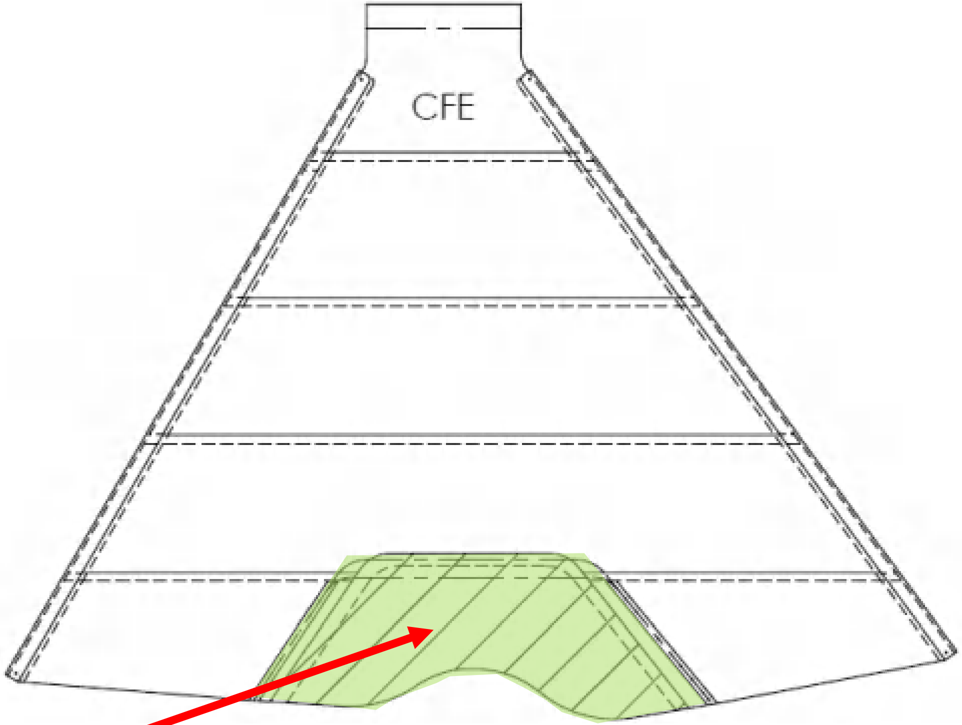
BOW SKIRT (FINGERS)



Inside air-cushion view, looking forward

Wear on the bow fingertips caused by flapping against the water at high speed (similar to the wear on a flag during a storm)

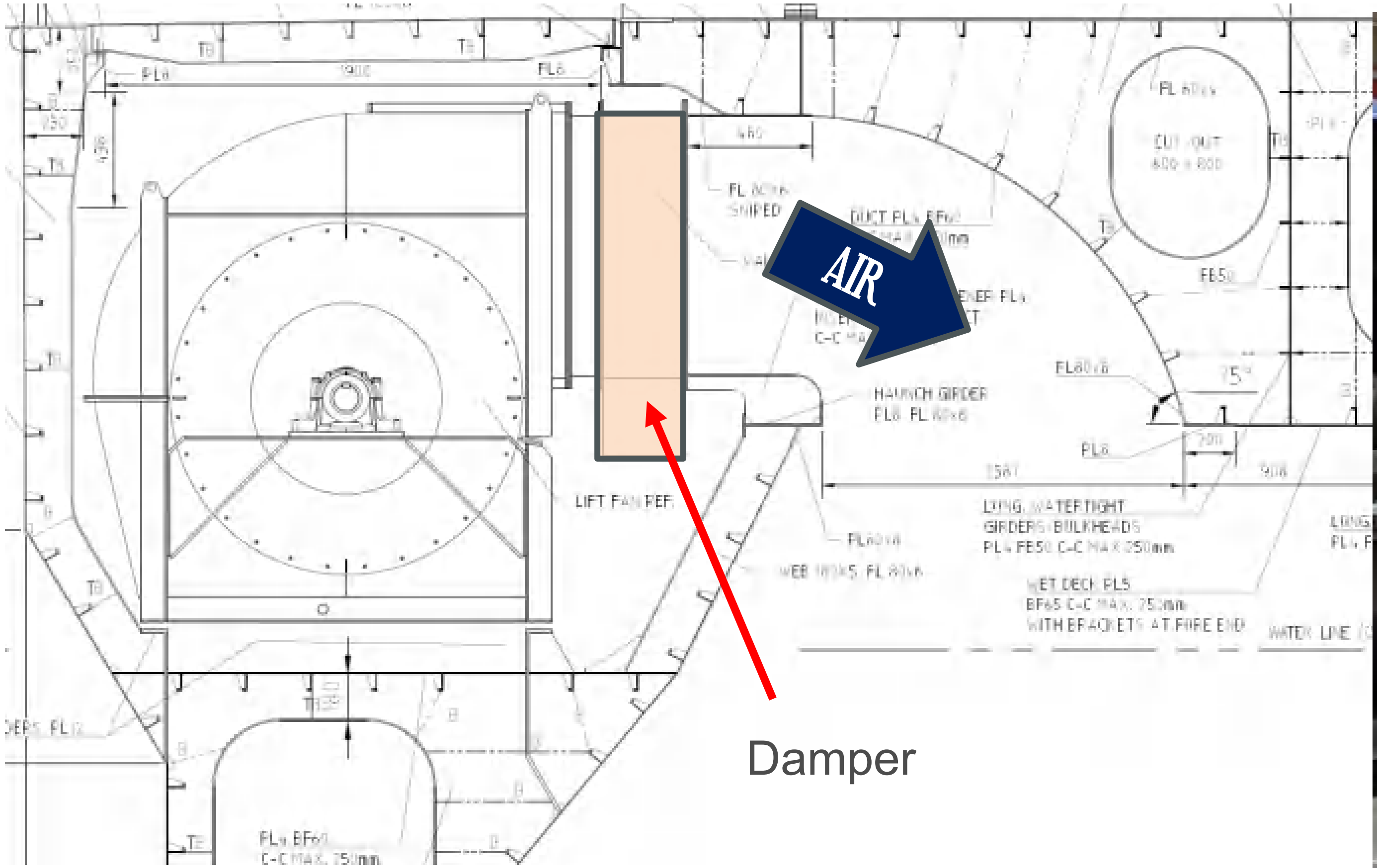
BOW SKIRT (FINGERS)



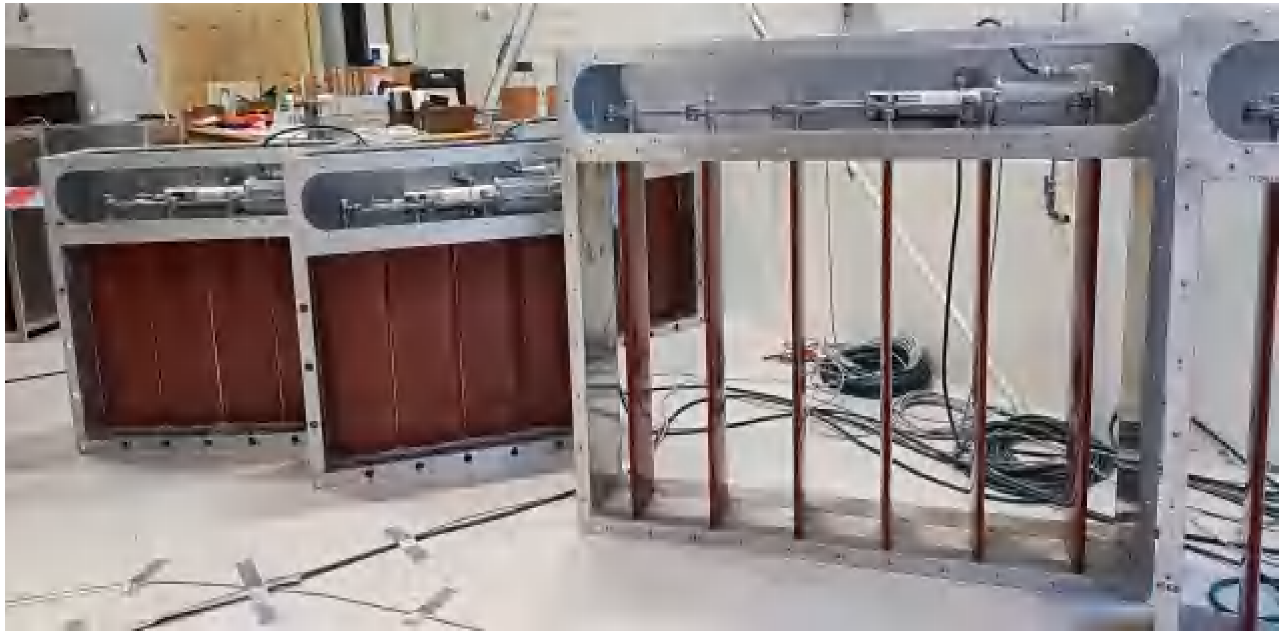
Replaceable bow fingertip, with bolt attachments
(Replacement can be done with the vessel afloat in the field)

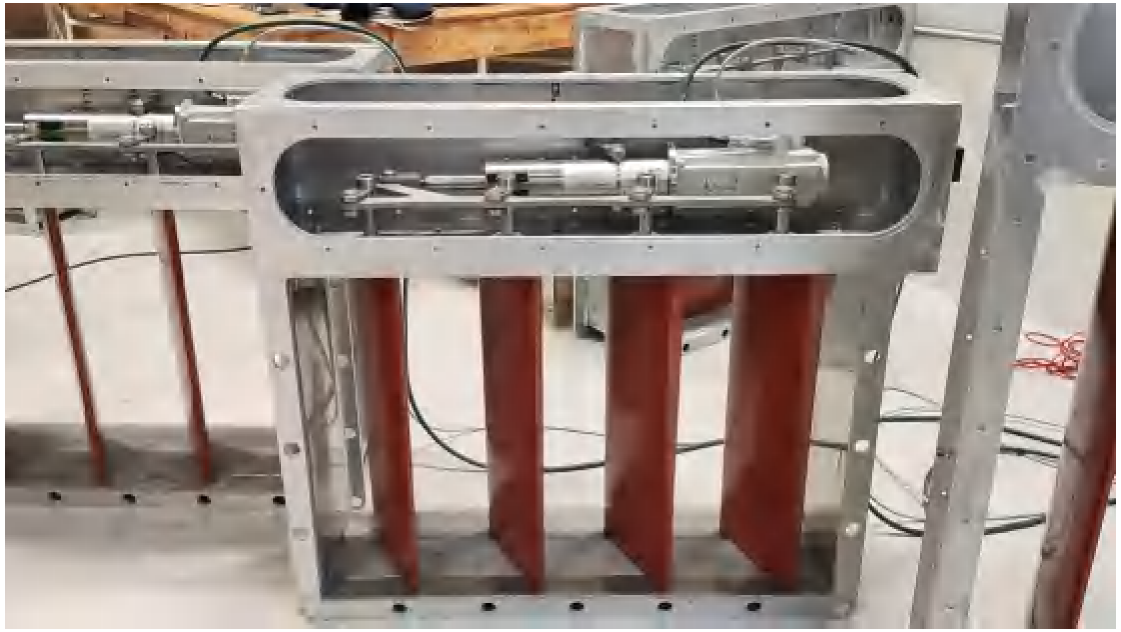
LIFT FANS

High-Reliability with Redundancy

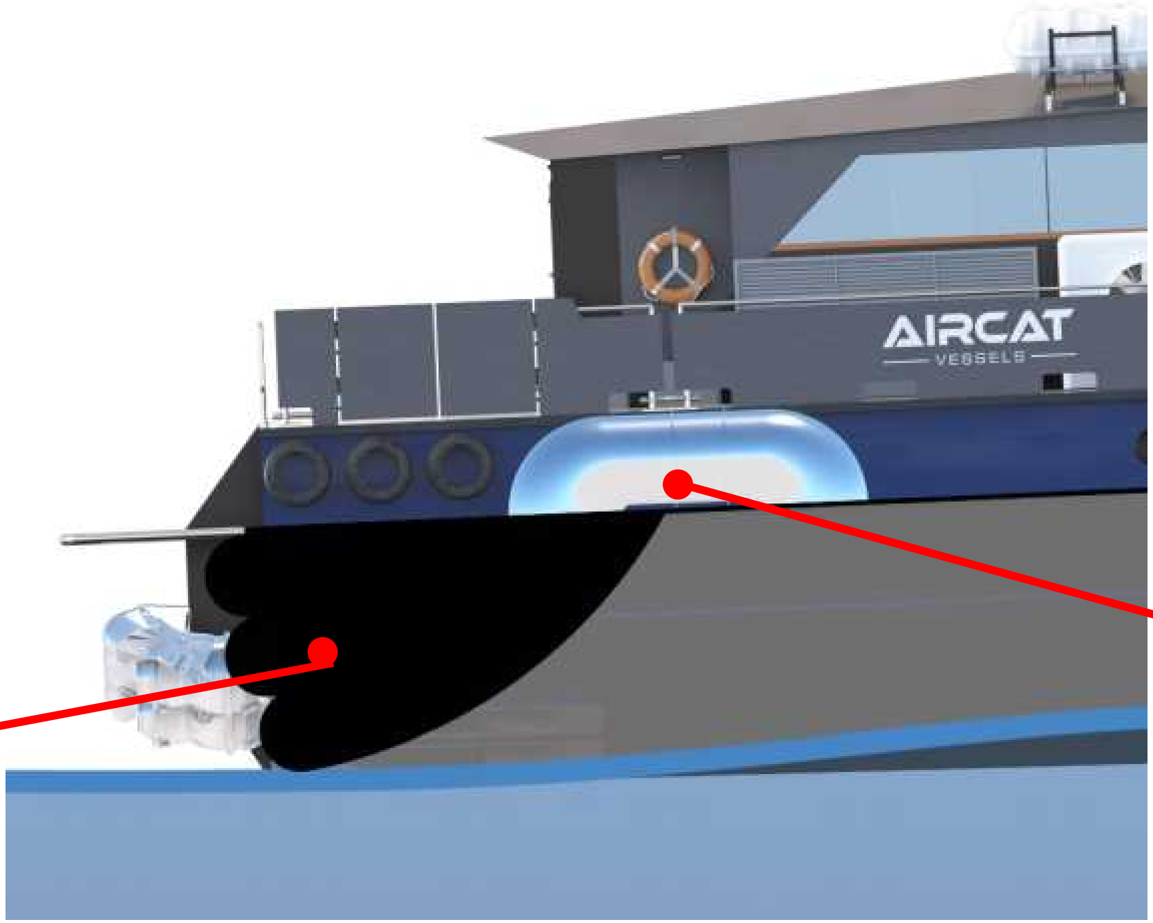


ACTUATED DAMPERS
ENHANCING RIDE CONTROL





AFT BAG + FANS

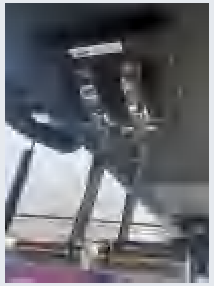


3-lobe rubber bag

SES EQUIPMENT – CONTROLS

Wheelhouse

Controls touch screen



Lift fan
throttle joystick

Technical spaces

Beckhoff PLC
SES control system

Actuator drives in a separate cabinet

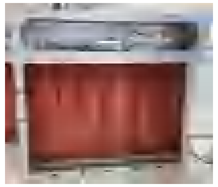
Drives for bag fans

SES ARRANGEMENT

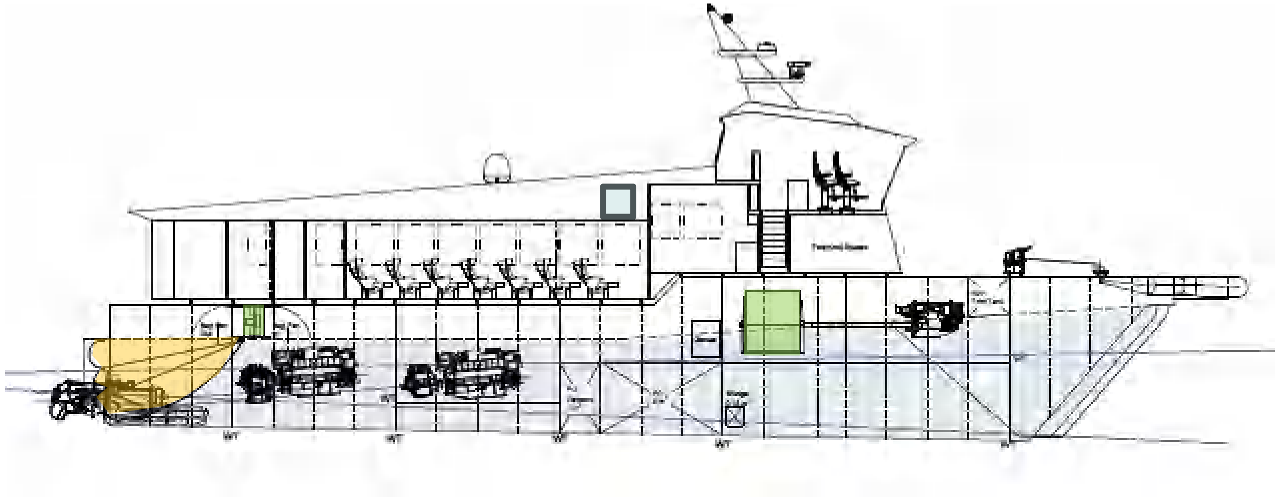
Pressure transmitters

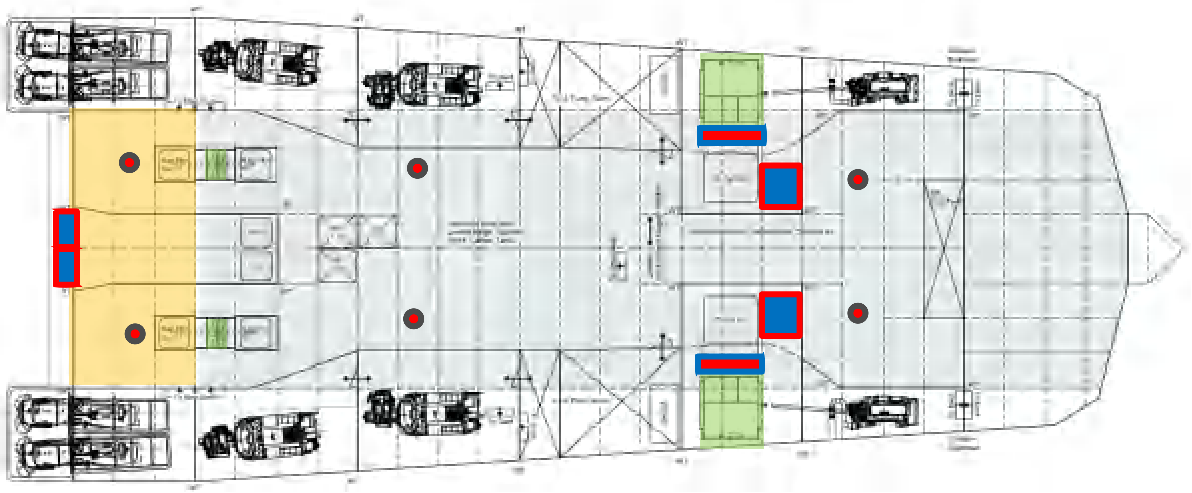
MRU

RCS dampers



Lift fan dampers





COMBINATION

Lift fan damper

RCS damper

SES Air Cushion Wave Resistance Dominates for Lower Speeds

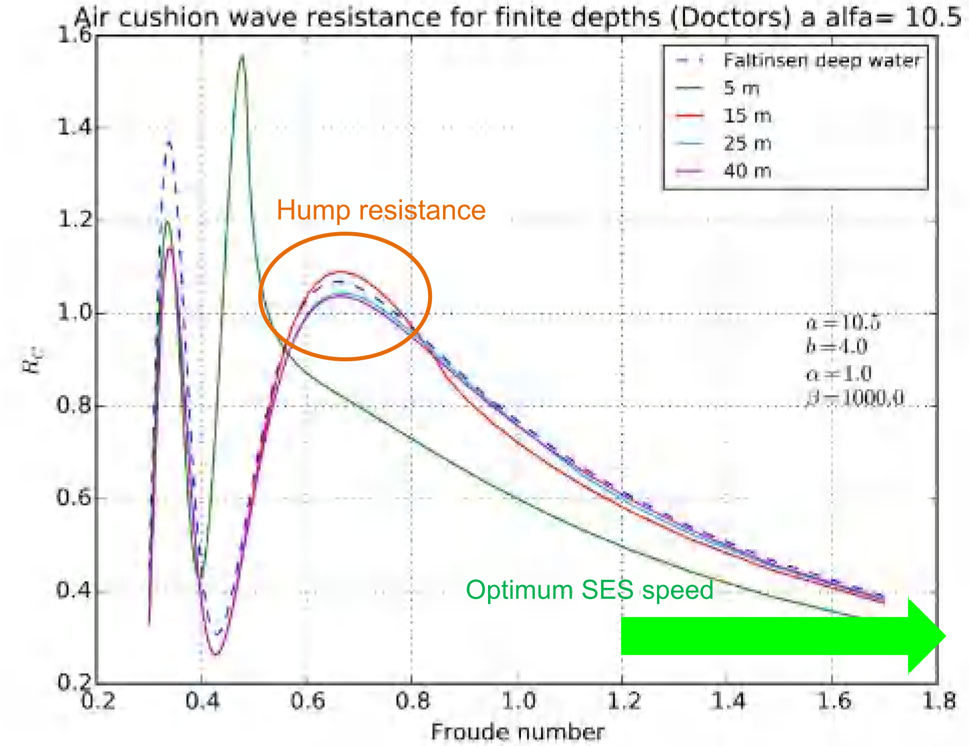
The wave resistance behavior of a SES is theoretically well comprehended and is controlled by the Froude number.

In simple terms:

$$F_n = \frac{U}{\sqrt{Lg}}$$

U – Vessel speed in m/s
L – Vessel length in m
g =9.81m/s²

- Speeds near the hump speed *Fn = 0.7 should be avoided
- The operating speed should exceed *Fn = 1.2



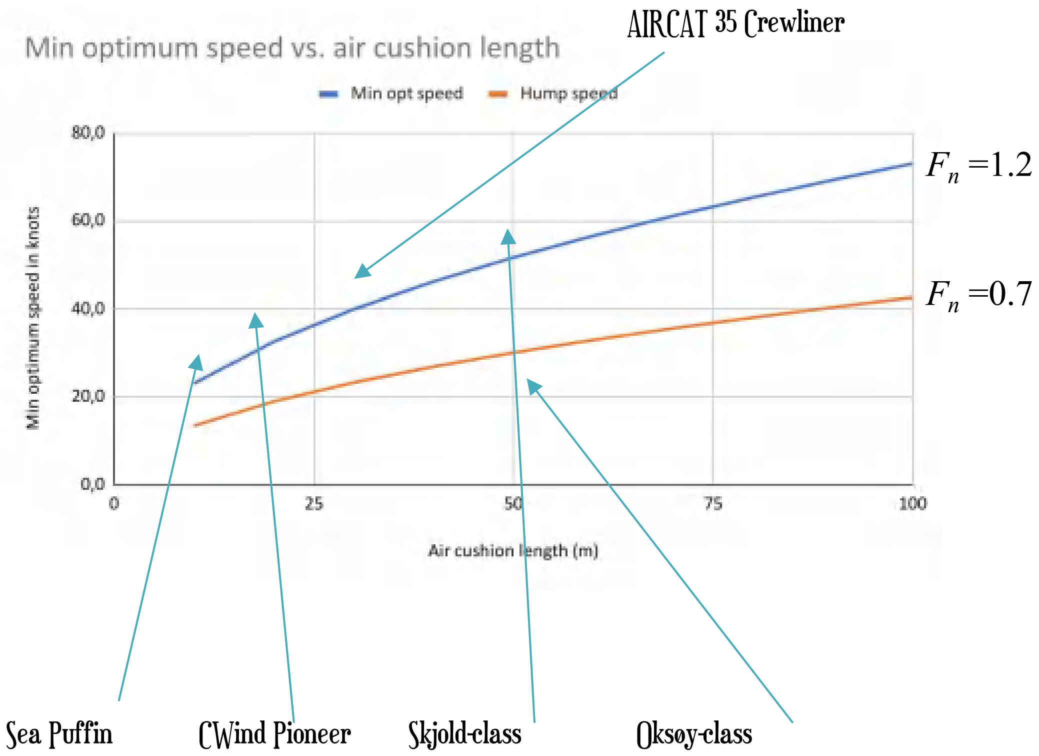
When traveling at speeds exceeding a Froude number of 1.2, a SES is notably more fuel efficient than other types of vessels.

Optimum Speed for a Surface Effect Ship (SES)

- The competitive speed (F_n >1.2) and the hump speed increases with the length of the vessel
  - At F_n >1.2 a SES has significantly lower resistance than catamarans and monohulls (including wave piercing)
- A larger SES is therefore best suited for very high-speed applications

For best overall performance:

- Low *L/B* for high speeds
- High *L/B* for near hump speed



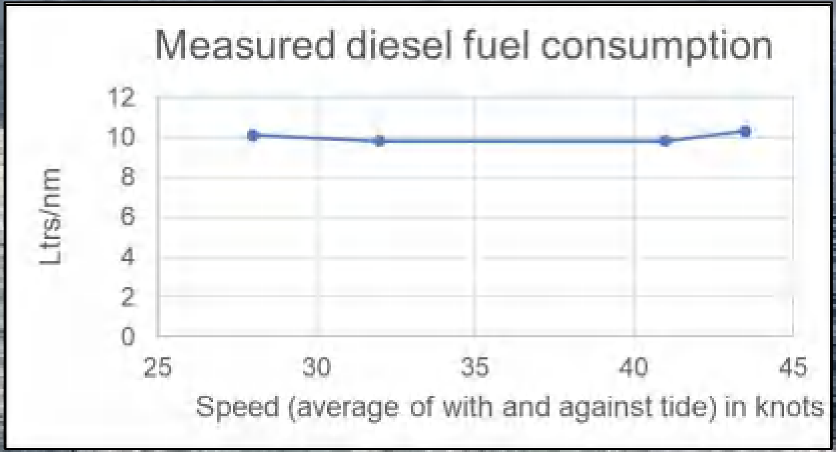
(The Oksøy-class SES is optimized for low signatures, seakeeping, and high shock resistance - not for high speed)

SES and Range

CWind Pioneer is a SES Crew Transfer Vessel (CTV) for Offshore Renewables
- **~20m air cushion length**
- **Optimum fuel-efficient speed 30-45 kts**

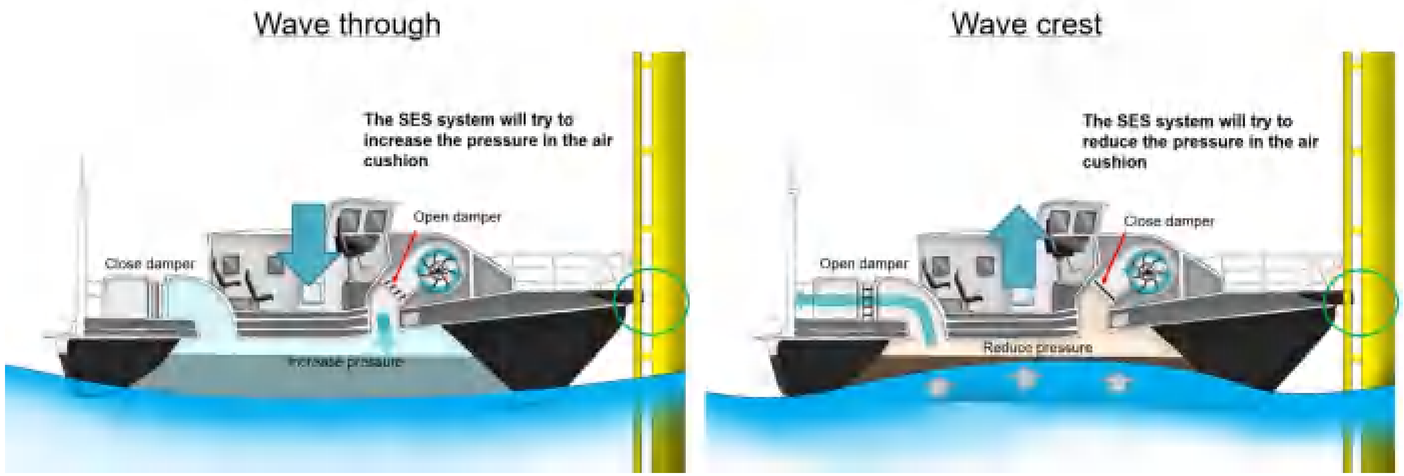
CWind Pioneer's fuel savings when compared to catamaran CTVs:
- **30-50% for speeds greater than 25 kts**

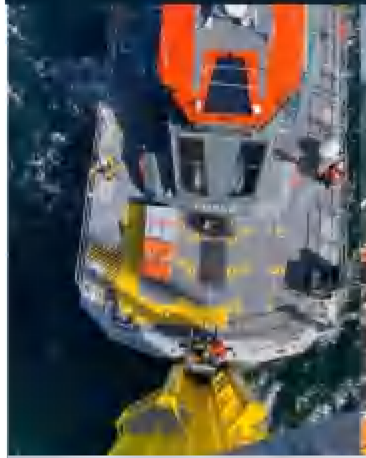
- A SES has a flat energy/nautical mile curve for speeds well above the hump speed
- All high-speed vessels (wave-piercing, catamaran, swath, SES, etc.) have limited range capability
  - Typical range < 20-30 hours of operation at full power
    - 20 hrs x 40 knots = 800 nautical miles
- When a longer range is required
  - Increase length and/or reduce speed
  - In such instances, while SES efficiency may drop off, it still exceeds the figures of other vessels operating at similar speeds over distance



Motion Control Systems
Proven In Offshore Operations

- A secure platform for offshore cargo transfer
  - Reduced wave-induced vibrations – decreased water contact
  - Utilizes active air cushion technology for motion reduction





COMFORT & SAFETY = ENHANCED OPERABILITY

ACTIVE MOTION DAMPING – 3M HS
(CLICK ON VIDEO TO SEE IN ACTION)

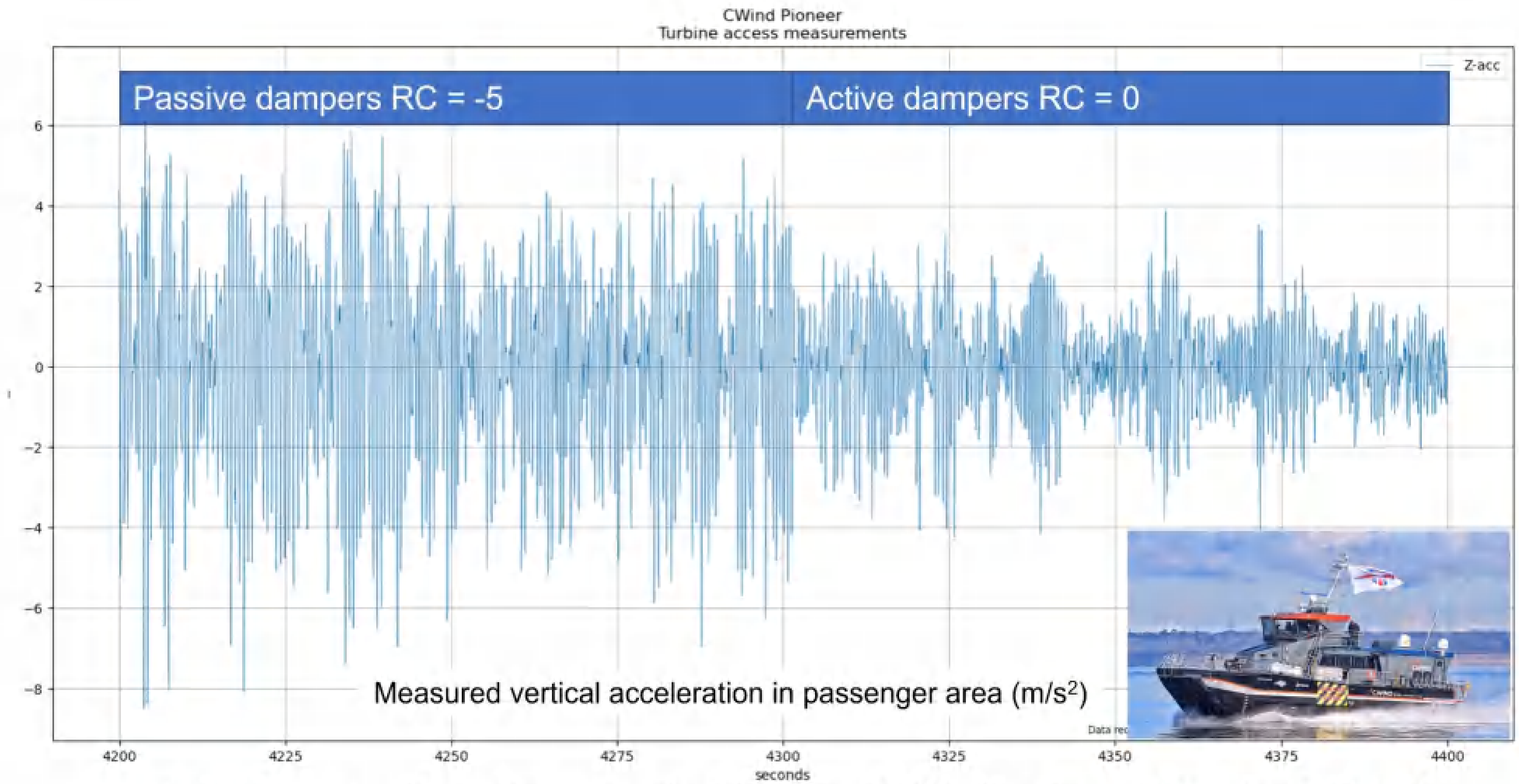
COMFORT – LESS PITCH MOTIONS

Thanks to the vessel being partly lifted from the water, the waves induce **less heave and pitch motions** compared to other vessel types.

In addition, the **air cushion** acts as a large shock absorber, providing a high-speed **comfortable** ride.

SES = REDUCED VERTICAL ACCELERATIONS

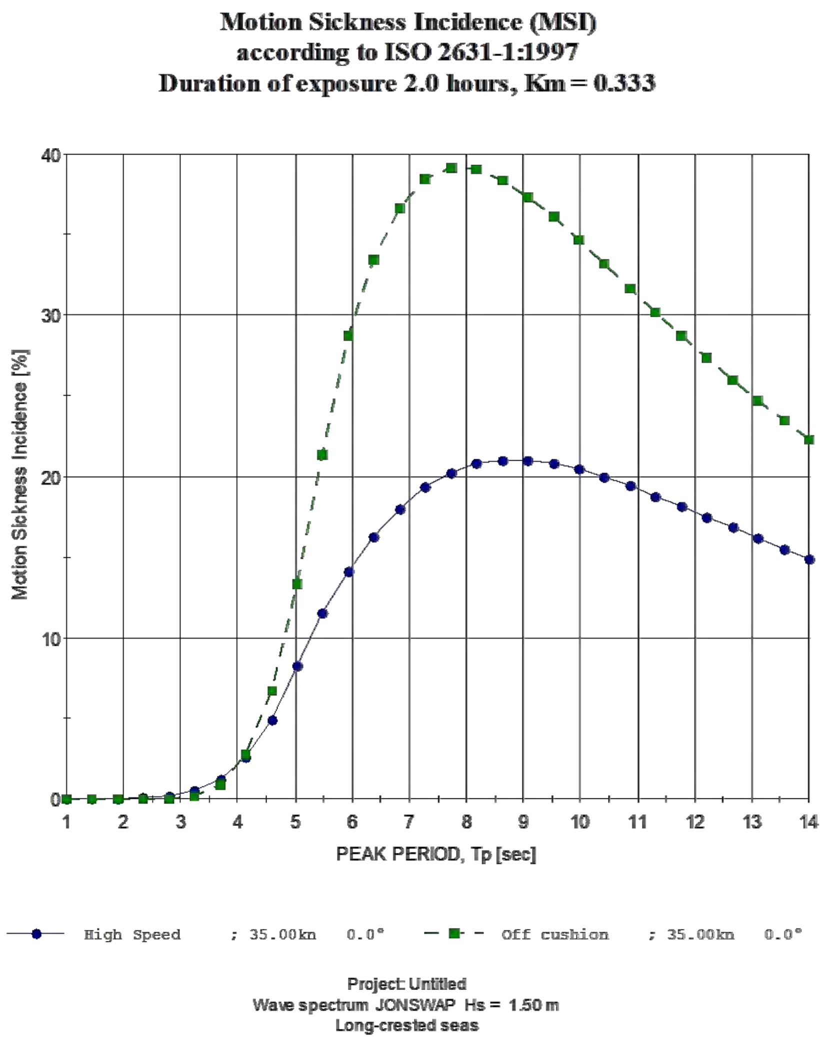
(Translates to Less Wear and Tear on Key Systems, i.e. Mission Modules)



Cwind Pioneer with passive and active high speed RCS - **Head sea, 35 knots, 0.75 m H_s**

COMFORT = REDUCED SEASICKNESS

(In Naval Defense, this Translates to Increased Weapons Accuracy and Combat Performance)



The primary cause of **seasickness** is a combination of **vertical movements** and **accelerations**.

The **air cushion reduces** both the **amplitude** of the **vertical movements** and their **accelerations**.

BENGAL-MC

Based on a Design In Active Use by Oil & Gas

https://youtu.be/aAs9phSwx3Y

Advantages of SES Vessels In Naval Defense
Compared to Monohulls and Catamarans

- Exceptional service speed ranging from 35 to 45 kts, combined with notably low fuel consumption
- Improved seakeeping abilities in rough sea conditions
  - Reduced heave, roll, and pitch movements
  - Provides a stable platform for sensors and targeting systems
- Highly flexible platform suitable for multiple missions
  - Proven effectiveness in offshore renewables and oil and gas industries
  - Well-suited for loading/discharging cargo from sea bases
- Minimized sea sickness and enhanced crew comfort
- Strong shock resistance, including protection against underwater explosions (referencing Oksøy-class MCM Vessels)
- Low acoustic and magnetic signatures
- Broad beam offering generous deck space
- Shallow draft while on cushion
- Less affected by weight changes compared to catamarans

Oksøy-class MCM Vessel – Clearing Mines Off Norway

Eureka's Team - Includes World-Leading SES Experts

- Eureka has teamed up with ESNA, the leading Surface Effect Ship (SES) experts
  - ESNA's SES experience dates back to the 1980s - prior work with ONR
- Experience, in addition to working on Eureka projects, includes leadership roles in the following SES projects:
  - Skjold-class, Naval Missile Corvettes
  - Oksøy/ Alta-class, Naval MCM Vessels
  - T-Craft, ONR Project for High-Speed Amphibious Naval Transport
  - LCAC / SSC, Naval Amphibious Hovercraft Landing Craft
  - Wavecraft-class, Offshore Renewables Crew Transfer Vessels
  - CWind Pioneer, Offshore Renewables Crew Transfer Vessel
  - Sea Puffin, Offshore Renewables Daughter Craft
  - AIRCAT 35 Crewliner-class, Oil and Gas Fast Crewboats
  - Fremtidens hurtigbåt, Electric and H2 Fast Ferries
- Eureka's extensive experience is strategically utilized to deliver exceptional SES designs for MASC, ensuring maximum efficiency and performance.

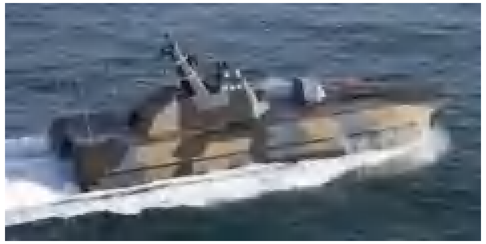
MASC Solutions - 6th-Generation SES
High-Speed Naval Gamechanger

- An essential requirement for a high-speed vessel is its "ocean crossing capabilities.“
- The Navy’s stated MASC requirement of a range of 2,500 nm at a speed of 25 kts in high sea states translates to approximately 4 days or 100 hours of at-sea transit time.
- Achieving this range is challenging for most high-speed vessels. However, if the combination of high speed and long range is desirable, then SES (Surface Effect Ship) technology is the most cost-effective solution.
- Eureka’s BENGAL-MC can carry a relatively large weight compared to its size, thanks to the air cushion SES technology it utilizes.
- SES technology enables the BENGAL-MC to operate in a fuel-efficient manner at speeds ranging between 35 and 45 kts.
- BENGAL-MC also features a reduced size, power, and fuel consumption compared to other high-speed solutions, such as wave-piercing mono-hulls, catamarans, swath, and hydrofoils.
- The SES technology also enables the BENGAL-MC to reduce the adverse effects of motion on any embarked personnel and systems, resulting in better mission effectiveness versus other vessel types.

BENGAL-MC Aligning with US Navy Combatant Needs

- The table below outlines the main dimensions of potential BENGAL-MC vessel platforms that meet the specified range requirements. It includes the desired payload container capacity for each platform.
- All of Eureka's BENGAL-MC vessel platforms are highly fuel-efficient and capable of achieving high speeds utilizing proven 6th-generation SES (Surface Effect Ship) technology. They have service speeds ranging from 30 to 45 knots, which exceed the MASC thresholds.
- Additionally, they can reach sprint speeds of up to 50 knots in good weather conditions.
- Refer to the BENGAL-MC **Capability Table**

For Comparison:
Norway's Skjold-class Corvette is 47m x 13.5 m, 300 tons total displacement, 800 nm range in 40 kts with some weapons & munitions payload.



EUREKA NAVAL CRAFT

Capability Table

AIRCAT BENGAL-MC

Modular Attack Surface Craft (MASC)

		BENGAL-MC	BENGAL-MC (L)	BENGAL-MC (M)	BENGAL-MC (H)
LOA	ft	118	131	144	157
Beam	ft	46	58	79	79
Draft (On Cushion / Off Cushion)	ft	2.3 / 7.9	2.3 / 7.8	2.3 / 7.8	2.5 / 7.9
Air Draft (Off Cushion)	ft	35	36	36	36
Capable of Fitting in Well Deck (LHD/LHA, LPD, LSD)	(Y/N)	Y	N	N	N
Capable of Fitting on ESD	(Y/N)	Y	Y	Y	Y
Maximum Speed	kts	50+	50+	50+	50+
Maximum range with specified payload					
Mission Payload for maximum range	tons	24	24	25	145
Fuel load for maximum range	tons	35	58	185	100
SS0 Service Speed	kts	40	45	45	45
SS0 Range (10% Fuel Reserve)	nm	1060	1200	3800	1600
SS4 Avg Service Speed (1.5m Hs)	kts	33	35	35	35
SS4 Avg Range (1.5m Hs, 10% Fuel Reserve)	nm	830	940	3100	1400
SS4 High Service Speed (2.5m Hs)	kts	27.5	30	30	30
SS4 High Range (2.5m Hs, 10% Fuel Reserve)	nm	650	740	2600	1100
Range with 1 x FEU @ 36.3 t					
Container payload	tons	36.3	36.3	36.3	
Fuel load	tons	22.7	37.7	173.7	
SS0 Service Speed	kts	40	45	45	
SS0 Range (10% Fuel Reserve)	nm	690	900	3570	
SS4 Avg Service Speed (1.5m Hs)	kts	33	35	35	
SS4 Avg Range (1.5m Hs, 10% Fuel Reserve)	nm	540	710	2910	
SS4 High Service Speed (2.5m Hs)	kts	27.5	30	30	
SS4 High Range (2.5m Hs, 10% Fuel Reserve)	nm	420	560	2440	
Range with 2 x FEU @ 36.3 t					
Container payload	tons			72.6	
Fuel load	tons			137.4	
SS0 Service Speed	kts			45	
SS0 Range (10% Fuel Reserve)	nm			2820	
SS4 Avg Service Speed (1.5m Hs)	kts			35	
SS4 Avg Range (1.5m Hs, 10% Fuel Reserve)	nm			2300	
SS4 High Service Speed (2.5m Hs)	kts			30	
SS4 High Range (2.5m Hs, 10% Fuel Reserve)	nm			1930	
Range with 3 x FEU					
Container payload	tons			108.9	
Fuel load	tons			101.1	
SS0 Service Speed	kts			45	
SS0 Range (10% Fuel Reserve)	nm			2080	
SS4 Avg Service Speed (1.5m Hs)	kts			35	
SS4 Avg Range (1.5m Hs, 10% Fuel Reserve)	nm			1630	
SS4 High Service Speed (2.5m Hs)	kts			30	
SS4 High Range (2.5m Hs, 10% Fuel Reserve)	nm			1420	
Range with 4 x FEU					
Container payload	tons			145	145
Fuel load	tons			64.6	100
SS0 Service Speed	kts			45	45
SS0 Range (10% Fuel Reserve)	nm			1330	1800
SS4 Avg Service Speed (1.5m Hs)	kts			35	35
SS4 Avg Range (1.5m Hs, 10% Fuel Reserve)	nm			1090	1400
SS4 High Service Speed (2.5m Hs)	kts			30	30
SS4 High Range (2.5m Hs, 10% Fuel Reserve)	nm			810	1100

Also available in MS Excel format

Microsoft Excel Worksheet