X-BOW® & X-STERN™ HULL LINES

STUDIES, DOCUMENTATION AND EXPERIENCES



The first X-BOW® ship, 'Bourbon Orca', delivered from Ulstein Verft in 2006.

ULSTEIN®

INTRODUCTION

The IP-protected and patented ULSTEIN X-BOW® is a rounded but pointed bow, normally with no bulb. For ships operating at higher speed, an integrated or conventional bulb can be arranged to optimise the calm water resistance of vessels at constant draft.

The extra space in the fore part of the vessel leads to higher buoyancy. The vessel cleaves the waves, and slamming and vibrations are reduced, even eliminated in most cases.

In bad weather there is normally no need to reduce speed, and time tables are more easily held. Even with medium engine capacity installed, the X-BOW® vessels can keep higher speed than comparable vessels with a conventional bow when in heavy seas.

The vessel will have more capacity in the bow area, space which can be used for causes such as accommodation or extra storage. An X-BOW® vessel will normally free up more hull space for cargo and/or equipment, compared to a more conventionally designed vessel. Hence, more revenue making capability and capacity.

Of importance to many cargo owners is also the protection and integrity of cargo and equipment carried on deck.

A most efficient speed-power relationship of a ship design solution when at sea is paramount.

Comfort is crucial, not only to crew's and passengers' welfare, but also when safety is concerned. Quality sleep before starting to work is a critical feature before taking on demanding operations.

Also, for a vessel on a mission, it is of high importance to keep the time schedule. With the X-BOW®, the vessel can retain speed, even in adverse weather, while maintaining comfort. The X-STERN™ feature also improves the infield mission operability.

If speed and time tables are not the issues, but fuel consumption is, the vessel can slow down speed and save more fuel than comparative conventional-hull vessels, and at the same time reduce emissions to air.

FROM 1 TO 100 X-BOW® VESSELS IN 10 YEARS

The X-BOW® was introduced to the market in 2005, and after ten years the bow has been implemented on a wide variety of vessels for an even wider variety of ship owners. The first vessels were vessels in the Offshore Oil & Gas segment, such as anchor handling tug supply, platform supply, rescue, seismic research, subsea construction, heavy lifters, inspection-maintenance-repair. In later years, there has been a rise in demand for other types of vessels, including ultra-long-distance towing vessels, walk-to-work service operation/construction sup-port vessels, subsea rock installation, exploration cruise vessels, RoPax ferries and yachts. Designs for fishing trawlers, and short sea vessels, including smaller general dry cargo carriers, open hatch carriers, container feeders, heavy lifters, car carriers, and chemical and gas carriers, have also been launched.

X-STERN™

The X-STERN™ is inspired by the X-BOW® performances to achieve the same benefits for the aft ship in following seas. The sloping, higher stern allows for a sharp stern shape in which the traditional flat transom plate is replaced by a tapered stern shape. The X-STERN™ was developed for vessels that can benefit from operating with their stern pointed towards the forces from the currents, waves and wind. The first deliveries in 2016 and 2017 were for two Service Operation Vessels for the offshore wind industry and have since received excellent feedback for their operability. The X-STERN™ feature can also significantly reduce ship motions of any vessel transiting the high and harsh seas.



'Windea La Cour', the first vessel featuring an X-BOW® as well as the novel X-STERN™, was ordered by Bernhard Schulte Shipmanagement, and delivered in 2016. The sister vessel, 'Windea Leibniz', delivered one year later, is X-BOW® vessel number 100.

KEY BENEFITS X-BOW®

Smarter ships

The wider space in the fore part of the vessel increases the cargo carrying capacity and opens up to more flexible vessel solutions. The X-BOW® hull leads to a significant reduction in spray, noise, vibrations and slamming. This increases the comfort for people on board, and leads to uninterrupted rest for crews and passengers. Additionally, it allows the work to continue uninterruptedly even in rough sea states. From a production perspective, the single curvature of the X-BOW®, in contrast to conventional bulbous bow shapes, reduces the labour inputs. Reduced resistance leads to reduced fuel consumption. There will be more revenue-making per cubic metre vessel. If speed is needed to carry out operations, the X-BOW® vessels will not need to slow down even in fairly rough weather, which makes it easier to complete mission in scheduled time.

Safer ships

There will be less sea spray and green sea on deck due to the X-BOW®, also resulting in reduced risk of ice or slippery decks. The X-BOW® hull makes it possible to get to the very forward of the vessel, the most attractive viewing spot, and still be well protected. The deck load, cargo and equipment are sheltered and protected. Reduced accelerations and slamming mean less wear and tear on people and equipment. Vibration and consequent noise are also reduced.
The X-BOW® with its shell structure and little double-curved hull plates represents a very robust and simplistic forward hull. The intrinsic strength of a single-curved hull form makes it lighter, consequently requiring less internal stiffening structure and leaving more space for protected mooring and anchor handling systems. This structure makes it easier for passage through ice-infested waters without extra ice-strengthening.

Greener ships

With the reduced pitch and heave accelerations and speed loss in waves, power consumption can be substantially reduced. This improves fuel efficiency and reduces harmful emissions.
The X-BOW® is one of Ulstein's contributions to cleaner and more sustainable shipping operations.


Heavy lift


Cable lay


Seismic research


Rock installation



Long-distance tow


Expedition cruise


Offshore oil & gas


Offshore wind / W2W

WHY ARE VESSELS WITH THE X-BOW® MORE EFFICIENT?

Due to the different distribution of volume, the vessel will not be exposed to the heavy slamming forces observed on vessels with flared bows in waves. This makes the motions more gentle, increasing crew comfort and their work efficiency whilst also conserving energy by not decelerating as much as flared, bulbous bow solutions.

An X-BOW® vessel is less sensitive to changes in the vessel's draught and speed with respect to its power-speed potential than a conventionally flared, bulbous bow solution. This is an advantage for vessels which have large variations in displacement, trim and speed over the duration of their operational profile. A conventional flared, bulbous bow is typically optimised for a specific loading condition and narrow speed range.

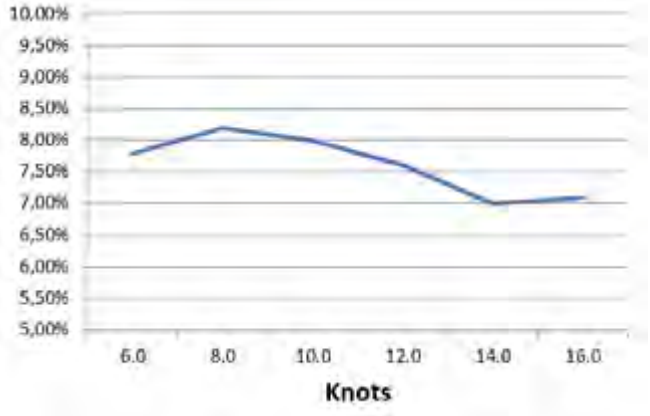
RESISTANCE

The differences in power requirement for an X-BOW® featured vessel compared to an equivalent conventional, bulbous bow vessel at sea are significant and in favour of the X-BOW® vessel.

Two large platform supply vessels (PSVs) of identical size were tested. The graph to the right reflects that at slow steaming speeds, 6 to 10 knots (typically, 12% of vessel's operational life), an X-BOW® PSV vessel has a power demand which is 8% lower than the conventional bulbous bow vessel. At higher speeds, 14 to 16 knots (typically, 1% of vessel's operational life), the power difference will be around 7%.

The advantage of the X-BOW® vessel will vary with sea state conditions and speed. For sea states above 2 metres significant waveheight (Hs), the X-BOW® vessel outcompetes conventional ones. This situation (Hs above 2 m) occurs typically, 7% of the time in the Gulf of Mexico, typically, 77% in the North Atlantic (coast of Ireland), typically, 36% in the South Atlantic (coast of Brazil), typically, 60% in the Norwegian Sea (outside Lofoten) and typically, 13% in the Mediterranean Sea (outside Egypt).

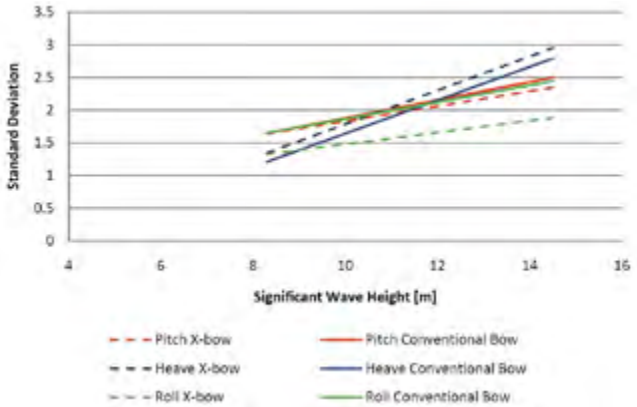
Power reduction,
PSV with and without X-BOW®

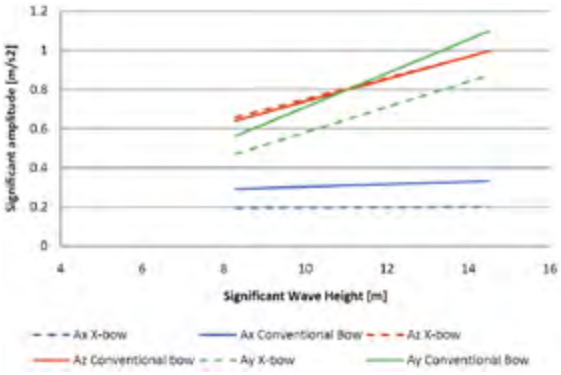


RELATIVE MOTIONS AND ACCELERATIONS

The graphs below present the results of a tank test comparison of two 208 m drillship units with X-BOW® and conventional bow, respectively. The two graphs represent motions and acceleration of both units in bow quartering seas at zero speed. Because of the nature of its operations, drillships spend most of their operational time in dynamic position, hence, zero speed.

Motions (left graph) and acceleration (right) in bow quartering seas at zero speed





Motions:
Overall, the motion behaviour of both vessels is comparable. However, the roll of the X-BOW® is considerably less, where heave is slightly higher. For higher waves, the pitch motions for the conventional bow become also higher.

Accelerations:
The longitudinal acceleration levels are considerably lower for the X-BOW®. The explanation can only be found in the bow shape, giving less wave impact. The transverse accelerations are also lower for bow quartering sea states. The lower acceleration levels in the horizontal plane lead to a higher comfort level on board. The accelerations in the vertical direction are equal to a conventionally flared bow solution.

DOCUMENTED ACHIEVEMENTS

MORE EFFICIENT AT NO EXTRA COSTS

The X-BOW® vessels have been tested in most weather conditions by crews world-wide.

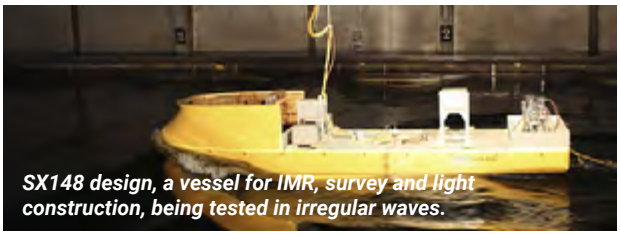
Quote from the Master of the AHTS vessel 'Bourbon Orca': 'Less shaking, it also means less vibration, less noise and less splashing. There was no slamming and, therefore, no loss of speed. We could easily tow in bad weather conditions without the high dynamic tension variations. In transit in head seas we kept high speed, floating on top of the waves, with substantially reduced heave movements and stamping.'



The PSV vessel 'Bourbon Mistral' in rough conditions in the North Sea.

X-BOW® TANK TESTS

2004	Comprehensive resistance and seakeeping testing of first X-BOW®, for AHTS vessel, tested at Marintek.
2006-14	The above has been followed up with several more tank tests of various offshore vessels (PSVs, AHTS, seismic research and offshore construction vessels)
2015	Offshore wind (SOV) SX175, tested at HSVA, Germany
2017	Cruise vessels, CX103/CX104, with/without an integrated bulb, tested at SSPA, Sweden
2017	Yacht, tested at HSVA, Germany
2018	Factory stern trawler FX101, tested at Marintek, Norway
2025	Stun & bleed FX501, tested at Marintek, Norway



SX148 design, a vessel for IMR, survey and light construction, being tested in irregular waves.

TANK TESTS X-BOW® VS. BULBOUS BOW

Ulstein has carried out three model tests comparing the performance of the X-BOW® with an equivalent conventional bulbous bow. The tests included calm water and seakeeping analyses.

2007	Short sea container vessel DX541 vs D541, tested at Centrum Techniki Okretowej SA, Poland
2009	Platform supply vessel PX105 vs P105, tested at Stadt Towing Tank AS, Norway
2010	Drillship XDS3600 vs DS3600, tested at MARIN, the Netherlands
2010	General cargo carrier DX127 vs D127, tested at Istanbul Technical University (ITU), Turkey

FULL SCALE TESTING

Ulstein has been a pioneer in the use of the facilities of Møre Ocean Lab in Storfjorden. These facilities include buoys for real time measurement of wave and current, and wind measurement towers. These facilities create a natural environment where Ulstein has run full scale tests of their vessels to calibrate initial predictions and CFD calculations.
So far, Ulstein has carried out four full scale tests on vessels within the areas of platform supply, offshore wind service, cruise and RoPax. These analyses have been carried out to enhance Ulstein's design capability and build up knowledge on how internalities and externalities affect the performance of vessels in operation.

CONSTRUCTION-WISE

Documented statements from the Zaliv Shipyard:

"The labour inputs for producing parts and sections are reduced by 15% compared to conventional bulb-bows of other projects.

The costs for assembly, welding and bending rigging are halved, since large numbers of bending templates, checking and marking works are not necessary.

Opens up to a wide application of advanced methods of assembly and welding.

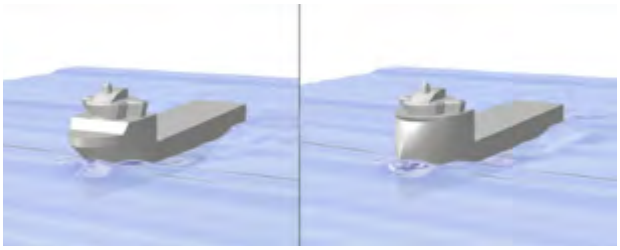
15% reduction in adjustment and fitting works when aligning in the dock during forming of the hull owing to simplification of the form of the outer shell butt joints."



CFD ANALYSES

Tank tests are a significant investment and availability of model test slots in the basin do not always match project deadlines. For many purposes, CFD simulations become a powerful complementary approach, allowing the designer to understand the hydrodynamic effects of a design change by analysis.

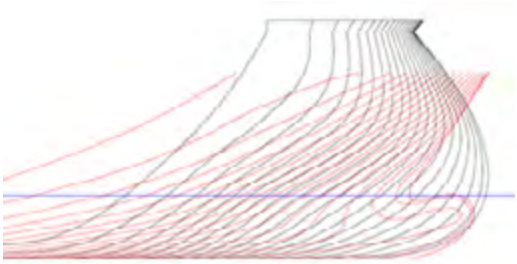
Comprehensive correlation verifications have been carried out with tank tests as well as CFD analyses.

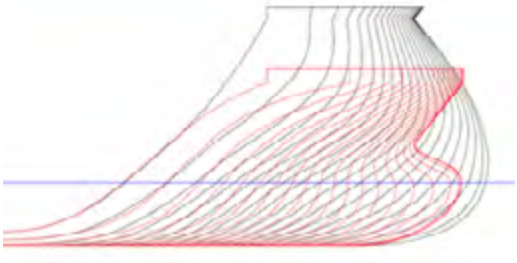


A BETTER INVESTMENT

MORE REVENUE MAKING FOR THE SAME INVESTMENT

The X-BOW® design allows a larger volume allocation in the forward area of the vessel which, without penalising the resistance of the vessel (it is mostly above waterline), increases the revenue making capability of the vessel. This revenue making capability may be the result of larger cargo carrying capacity for a given length of the vessel (more container carried, larger cargo holds, or larger accommodation areas on a cruise vessel).
For a container vessel of 2000 TEU, an X-BOW® design provides a 4 to 10% higher cargo carrying capacity compared to a vessel of equivalent size (LOA x B x D), depending on the size of the vessel.





GREENER VESSELS BY SMARTER SHIP DESIGN

Ulstein has carried out tank tests for two equivalent container vessels of 188 m length. The tests were carried out for multiple vessel speeds in the range of 11 to 20 knots and at several sea states, from calm water (Hs = 0 m) to fresh-gale conditions (Hs = 6,5 m).

In nearly all conditions, the X-BOW® vessel outperformed the conventional bulbous flared bow vessel in terms of power requirement and little or no green sea on deck. The difference between the two vessel increases as the speed and or wave height increases.

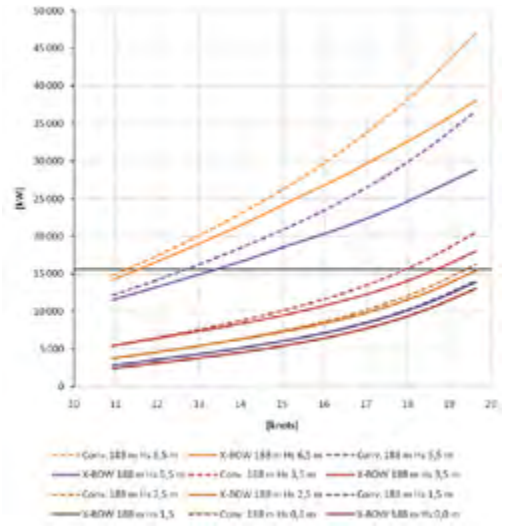
Based on the tests performed, the benefits may be estimated as follows:

i) For a given average transit speed, the X-BOW® yields 6-8% reduced powering needs; or corresponding to 6-8% reduced fuel consumption

ii) For a given powering, the X-BOW® yields 3-5% higher end revenue capability per year, or 3-5% higher average transit speed, corresponding to 2-3% increased transport capacity

The result is that an X-BOW® vessel may be designed with less installed power, but still achieve the same average speed and annual transport work as a conventionally bowed vessel.

Speed/Power at various Hs as Function of Speed (LOA 188 m)



SMARTER VESSELS = BETTER INVESTMENTS

The combination of higher revenue making capability with lower propulsion resistance and a better seakeeping performance results in a better investment for the ship owner.

The overall annual revenue capacity of an X-BOW® vessel, a container vessel in this case, is increased by 6 to 13% (4 to 10% due to larger cargo areas, and 2 to 3% due to higher operational speed at sea in waves.)
In 2018 daily rates, this represents 570 to 1235 USD extra per day (average dayrate for 2018 = 9500 USD/day).







SEAKEEPING PERFORMANCE

Seakeeping performance relates to the ability of a vessel (or floating unit) to respond to the environmental conditions (waves, wind and current) while performing operations at sea. Vessels are designed to operate for different missions and operational environments. Seakeeping criteria are therefore different from ship to ship and situation to situation.

Choosing a cruise vessel with the X-BOW® means more room for hotel and cabin spaces, making your journey more comfortable and enjoyable. Unlike traditional hull designs, the X-BOW® also allows for safer and easier access to the bow, so you can fully enjoy excursion views.

When it comes to seakeeping, cruise vessels focus on the comfort and safety of passengers, while construction vessels are built to stay steady and minimise motion during long operations at sea.

OPERABILITY OF OFFSHORE VESSELS

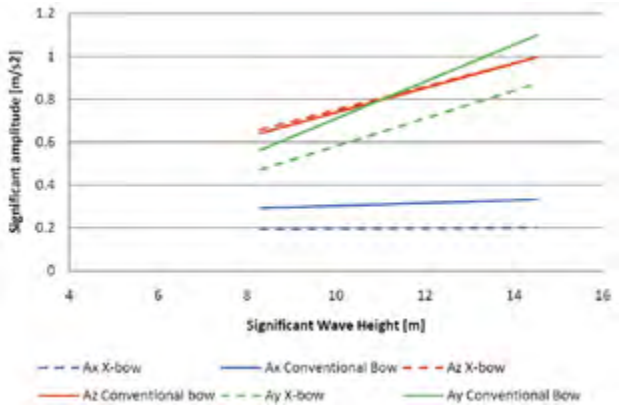
Vessel operability in the design and operation of offshore vessels relates mostly to the ability of a vessel to retain its position and carry out operations given a set of limiting criteria.

Ulstein has evaluated the performance of the X-BOW® in a drill ship vessel. The results shown in the figure represent the finding from a tank test carried out for a 208 m drillship.

The longitudinal acceleration levels (blue lines) are considerably lower for the X-BOW® . The explanation for this can only be found in the bow shape, giving less wave impact.

The transverse accelerations (green lines) are also lower for bow quartering sea states. The lower acceleration levels in the horizontal plane lead to a higher comfort level on board. The accelerations in the vertical direction (red lines) are almost equal.

Accelerations in CoG in bow quartering seas at zero speed

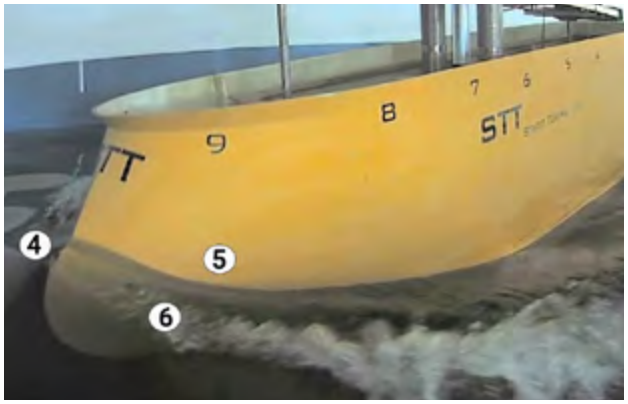


OPERABILITY OF SEA-GOING VESSELS

CONVENTIONAL BOW (PHOTO BELOW, LEFT)
1. High bow impact forces and slamming, inducing excessive accelerations, vibrations and risk of structural fatigue, causing frequent voluntary speed reductions
2. Waves reflected forward, absorbing energy and causing speed loss
3. Waves inducing excessive heave motions, absorbing energy and causing speed loss.

ULSTEIN X-BOW® (PHOTO BELOW, RIGHT)
4. No spray and green seas, offering better cargo protection and safer deck operations
5. Reduced bow impact forces and slamming.
6. Waves gently deflected around the hull, reducing impact loads, minimising speed loss and enhancing fuel efficiency





A CASE STUDY

Ulstein has, among other studies, carried out a case study on a 160 m container feeder vessel, and proven that the X-BOW® allows for reduced powering, or higher transit speed, or a combination of the two.

Considering the sample vessel (Loa 160 m, 9,000 kW, 18 kts) and taking into account the wave probability distribution for the North Atlantic and World-Wide trade respectively, the commercial benefits may be estimated as such:

REDUCED POWERING

For a given average transit speed, the X-BOW® will allow for reduced powering:
- North Atlantic: 1,100 kW less (~11%)
- World Wide: 600 kW less (~6%)

HIGHER AVERAGE TRANSIT SPEED

For a given powering, the X-BOW® would allow for higher average transit speed:
- North Atlantic: 0.7 knots higher transit speed (~5%)
- World Wide: 0.4 knots higher transit speed (~3%)

REDUCED FUEL CONSUMPTION

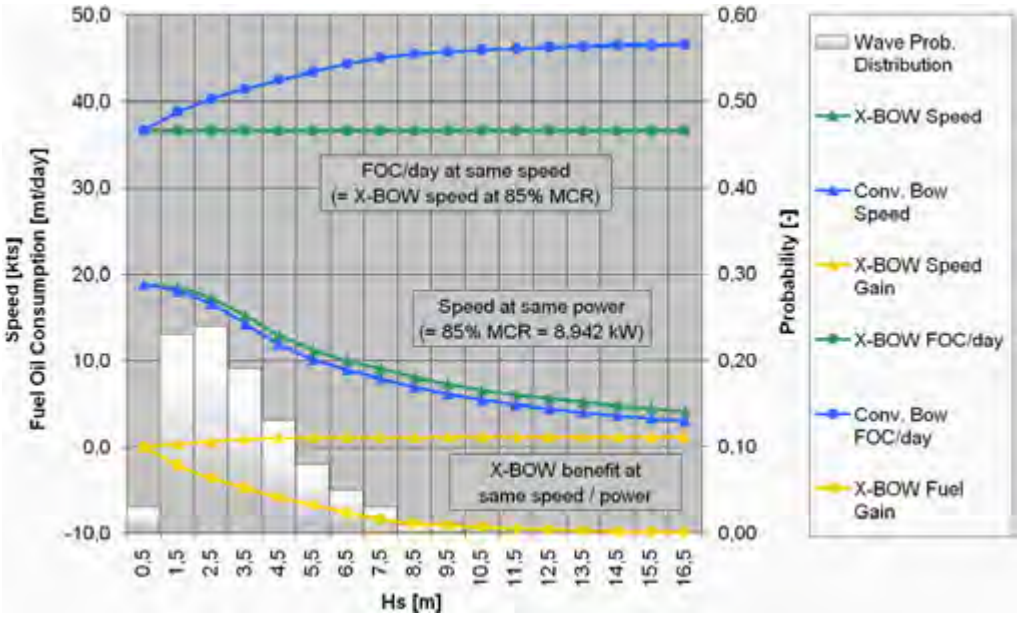
Reduced powering would provide for reduced fuel consumption:
- North Atlantic: 4.4 t less per 24 h (~11%)
- World Wide: 2.4 t less per 24 h (~6%)

INCREASED TRANSPORT CAPACITY

Higher average transit speed will correspond to increased transport capacity:
- North Atlantic: 12.3 days equivalent per year (~3%)
- World Wide: 6.2 days equivalent per year (~2%)

ULSTEIN X-BOW ® - Commercial Benefits (sample vessel)

The diagram below shows X-BOW® benefits in North Atlantic trade (Loa 160 m, 9,000 kW, 18 kts vessel).



Converting these benefits into monetary figures yield the following results:

	X-BOW fuel benefit at given speed		X-BOW revenue benefit at given power	
	Low fuel price	High fuel price	Low TC rate	High TC rate
World-Wide	**Annual = 155,000 USD**	Annual = 310,000 USD	**Annual = 50,000 USD**	Annual = 100,000 USD
North Atlantic	Annual = 280,000 USD	**Annual = 565,000 USD**	Annual = 100,000 USD	**Annual = 195,000 USD**

The following parameters have been applied:

- Lower – upper fuel oil price: 300 – 600 USD/t.
- Lower – upper TC rate: 10,000 – 20,000 USD/day.
- Vessel value = 30 mUSD, annual off-hire 10 days, port time 40%, discount rate 7%, calculation period 25 years.

X-STERN™ FEATURES

INSPIRED BY THE X-BOW®

The X-BOW®, introduced in 2005, has been implemented in more than 100 vessels of various types. All features related to the X-BOW® are equally relevant to the X-STERN™, a similar solution for the aft end of the vessel, and introduced in 2015.

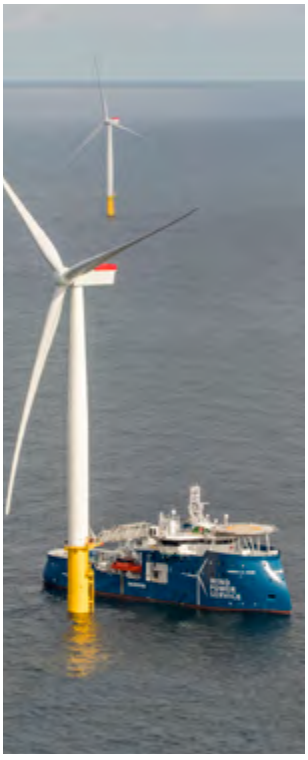
FIRST X-STERN™ FEEDBACK

Quote from the senior DP operator on the SOV vessel 'Windea La Cour':

'This is the very first vessel with the X-STERN™ aft solution.

If the weather is not too adverse, the ship will stay on the spot at site with two thrusters running, which leads to substantial reduction in fuel consumption, instead of keeping the vessel in full DP.

With the stern towards the weather, we experience absolutely no slamming and vibrations, not even when we are in transfer, and people love it. They get complete rest in between their maintenance shifts.'





The X-STERN™ has been successfully introduced into the offshore wind energy market. Offshore wind service vessels need to operate in a flexible, controlled and comfortable manner for their clients. The X-STERN™ has also been implemented in other vessel design segments, such as exploration cruise and cable laying.





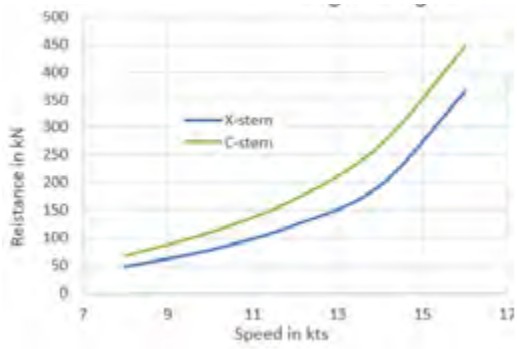


X-STERN™ DOCUMENTATION

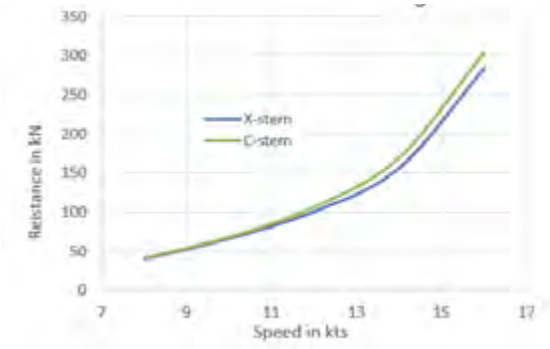
The X-STERN™ shape and its high freeboard design provides less spray and probability of green water on deck, and enables safe operations in higher waves, increasing operability while stern to weather. Directional stability astern is better and less manoeuvring is needed, hence less fuel consumption and emissions. The resistance of the vessel when in transit is up to 28% lower at certain relevant loading conditions. Operating stern to weather requires 60% less power than for a conventional, transom stern arranged vessel. The main reason is the fact that the most powerful thrusters of the vessel are located here.

The X-STERN™ feature also contributes to the reduction of the rolling motion of the vessel. A CFD analysis indicated a roll motion reduction on the range of 7%.

Resistance at design draught



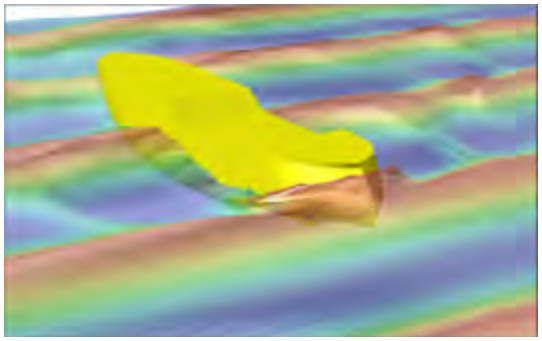
Resistance at trial draught



Based on the results of a CFD analysis on a service operation vessel (SOV), the resistance in calm water is 28% lower hull resistance in forward sailings and 60% in astern sailing for an X-STERN™ vessel compared to a conventional, transom stern vessel.

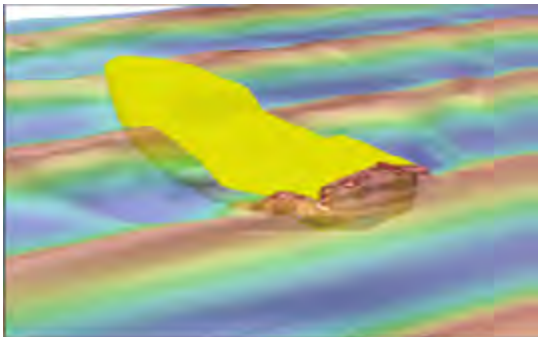
THE X-STERN™ WILL INCREASE:

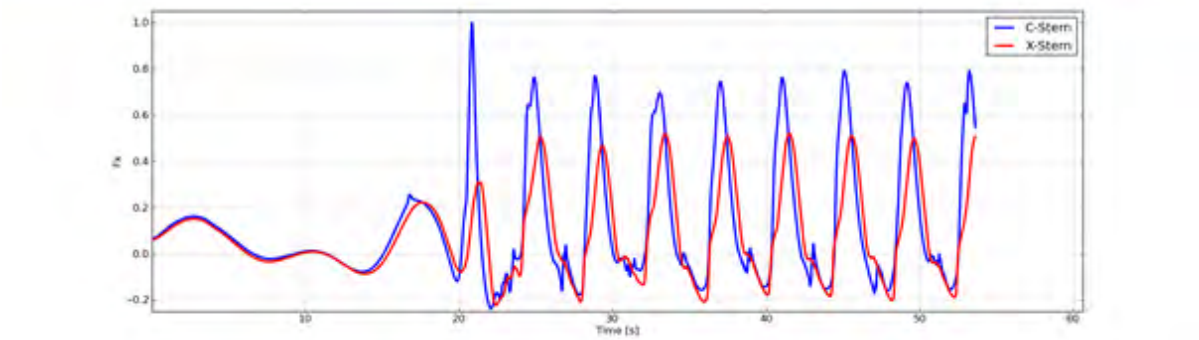
Vessel operability
Vessel flexibility in heading
Safety and crew comfort



THE X-STERN™ WILL REDUCE:

Wave response
Fuel oil consumption
Environmental footprint





HOW CAN WE HELP?

- Project making
- Analysis and business case development
- Ship design - Norwegian design & quality - portfolio of designs
- Shipbuilding - Where to build? How to build?
- Design & equipment packages - Pre-qualified and proven technology
- Site support and commissioning services
- Vessel life cycle support
- Engineering consultancy









TURNING VISIONS INTO REALITY

Ulstein Group is a family owned group of companies offering a wide range of ship designs, equipment packages, shipbuilding and maritime solutions.

We deliver award-winning vessels of Norwegian quality designs and standards. We have a solid, 100-year experience in shipbuilding, and are renown for punctual deliveries of high-quality vessels to the agreed price.

We offer a portfolio of designs and equipment packages for a wide range of segments. Our thorough marketing and vessel concept design solution analyses make a solid foundation for developing outstanding adventures and performances in an ever more competitive market.

Contact us for a consultation and get your specific market review.

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ULSTEIN®

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