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Silverstream Technologies and the successful scaling of its proven air lubrication technology, the Silverstream® System



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Abstract

This paper presents an update on Silverstream Technologies and its journey in the delivery of its proven air lubrication system (ALS), the Silverstream® System, to the global shipping industry. Silverstream's technology deploys a bubble carpet along a ship's hull which reduces its frictional resistance, thus lowering the vessel's fuel burn and resulting CO2 emissions by an average 5-10% net. Silverstream's insistence on third-party verification of its system's performance in sea trials and in operation, as well as its transparency in the market around those savings and how they are achieved, has underpinned the company's exponential growth in recent years. Silverstream's continued commitment to innovation, research and development has kept it at the forefront of maritime clean technology innovation and has cemented its reputation as a respected thought leader.

Introduction to Silverstream Technologies and the Silverstream® System

Over the past 13 years, London-headquartered Silverstream Technologies has developed, patented, verified and commercialised the Silverstream® System, an innovative air lubrication system (ALS) which releases a uniform carpet of microbubbles along a ship's flat bottom to reduce its frictional resistance. This in turn lowers the vessel's fuel burn and resulting CO2 emissions by an average 5-10% net, depending on vessel type.

Silverstream has developed its technology to enable a simple installation on both newbuild vessels and retrofits, and it is available to all of shipping's major segments including LNG carriers, tankers, containerships, cruise ships, Ro-Ros and ferries. The system is fuel agnostic which means it is well-suited to vessels using existing fossil fuels and future transformational fuels such as ammonia and hydrogen; it is also complementary to all other available efficiency technologies including high-performance coatings.

Silverstream has experienced rapid commercial growth in recent years, aided in part by vessel efficiency regulations imposed by the International Maritime Organization (IMO), including EEXI, EEDI and CII, which have mandated shipowners and charterers to decarbonise their fleets in both the near and long term. Silverstream is well-placed to meet the exponential demand for its proven technology from the world's ship owning community, with a team of 120 maritime experts located across its London and Shanghai offices, who are focused solely on the development and scaling of its core technology.

Silverstream® System in detail



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The Silverstream® System is a patented air lubrication technology that consists of four components: compressors, pipes and valves, Air Release Units (ARUs), and a control and automation system. Air is delivered through oil-free compressors that are dimensioned based on the specific vessel's operational profile and requirements (including specification of the number of compressors). The piping and valve system, including a custom y-piece for air distribution in 1-to-2 compressor to ARU layout, is further designed for each specific vessel.

Air is introduced into the water from the patented ARUs through fluid shearing, a unique feature of the system, requiring less energy than expulsion-based systems and producing a high 'quality' bubble carpet without disturbing the boundary layer on the ship hull. System performance is manifested by a decrease in the shaft power and an increase of the ship speed, shifting the ship's speed-power curve between system on and off, an effect which can be quantified through a variety of methodologies.

The open water interface inside the ARU allows for generation of microbubbles through the so-called Kelvin-Helmholtz instability effect. The stability of the microbubble carpet will depend on the ship speed and draught and is controlled through the airflow provided. A row of ARUs is arranged along the flat bottom line at the front of the ship, maximising the affected surface area to achieve maximum frictional resistance reduction. The solution was developed through extensive experimental testing over a 10-year period at HSVA's HYKAT cavitation tunnel, allowing evaluation and validation of the design at full scale (avoiding the need for Reynolds scaling, essential when considering frictional resistance reduction applications like air lubrication).

Based on the experimental testing, the control and automation system controls and optimises the airflow delivered as governed by the ship's operational conditions. An important aspect of air lubrication systems as an energy saving solution is the fuel agnostic character of the technology. Because alternative or transformative fuels are less energy dense, and generally more expensive, the system can achieve energy savings independent of the fuel type used. Addressing energy consumption (and related emissions) on a fundamental level by tackling the ship's resistance provides a clear competitive advantage and is agnostic to all decarbonisation strategies. Additionally, owners are offered a flexible solution as the installation is simple and straightforward for both newbuild vessels and retrofits.

First-movers and growing orderbook

Silverstream Technologies has been a pioneer in the air lubrication space since 2010. The initial uptake of the technology was driven by 'first movers' like Shell, Carnival, Grimaldi, Vale and MSC, and accelerated by companies like Maersk, ADNOC L&S, Knutsen OAS and others



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embracing a 'close second' strategy. The 'first mover' strategy successfully secured thought leaders in each industry segment (e.g. cruise, tanker, roll-on-roll-off, container, etc.). Additionally, the first movers re-affirmed their trust in both the company and the technology through repeat orders and fleet deals. Over the past decade, Silverstream showed that air lubrication technology can be offered beyond the theoretical, prototype stage, on a truly commercial scale.

Since its conception, key to the success of Silverstream and the uptake of its Silverstream® System, has been a clear, open and honest communication strategy. From the prediction of realisable and realistic savings to demonstrating the savings in real world scenarios, Silverstream has always prioritised transparency. Through external verification, for example, the customer can be reassured that the savings promised will be the savings delivered. The best indicator of the success of the outlined strategy is seen in the exponential growth the company is experiencing, both in terms of the orderbook and the scale-up of the company to deliver the orderbook. As of August 2023, a full order roster highlights that the company has contracted for 175 systems, of which 41 are in-service, leading to the realistic ambition of reporting 500 contracted systems by 2025.

Innovation, Research & Development

Innovation is fundamental to all research and development activities at Silverstream Technologies. The continued efforts of the Innovation, Research & Development (IR&D) team are driven by the need to achieve a deeper understanding of the product, but also by the desire to continuously develop and improve the technology further. Focus is placed on benefits that directly impact existing customers by the optimisation of the system performance in a cost-efficient manner, through upgrades and retrofits of, for example, the airflow control system. Deeper understanding of the concept and technology will help Silverstream to remain the air lubrication technology innovator and thought leader.

Silverstream's IR&D roadmap envisions continued thought leadership in the maritime clean tech space, extending efforts through both internal and external collaborative projects. Additionally, the aim is to grow university collaborations further and invest in PhD and post-doc projects. Besides academic collaboration, more industry involvement is being sought through the design and engagement in publicly funded research programmes and Joint Industry Projects. In general, future projects will expand the focus of the programme beyond upgrades of the current system and push for even further innovation.

Summary and Conclusions



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Silverstream Technologies has successfully developed and commercialised the Silverstream® System, an air lubrication system (ALS) that deploys a uniform carpet of air bubbles along a ship's flat bottom. The fuel agnostic nature of the system helps a ship owner / operator comply with the ever-increasing regulatory pressure aimed at reducing the environmental footprint of the maritime industry.

Over the past 13 years, Silverstream showed that air lubrication technology can be offered beyond the prototype stage, on a truly commercial scale. The importance of measuring and demonstrating the performance of the Silverstream® System has been essential in ensuring the further development of the product, as well as achieving its widespread adoption within shipping. Silverstream's rapidly growing orderbook, spanning all of shipping's main segments, highlights the commitment to technology and service excellence the company has strived for since its conception, earning it the status of ALS market leader today.

Finally, Silverstream places innovation at the forefront of all research and development activities within the company. Driven by the need for a deeper understanding of the product, but also by a clear desire to continuously develop and improve the technology further, continued research and development is undertaken with rigour. By never standing still in its pursuit of ALS innovation, Silverstream is safeguarding itself from future competition by continually improving its offering to customers.