

PAXSTREAMLINE



Streamlining the Industrial World

Corporate Background
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52 Leveroni Court
Novato, CA 94949 USA
(P) 415-883-2300
(F) 415-883-2301
www.paxstreamline.com

STREAMLINING THE INDUSTRIAL WORLD

Streamlining Understood

Thirty years ago, inventor Jay Harman, a naturalist who served with the Australian Department of Fisheries and Wildlife, began observing the patterns of natural fluid flow in ocean and air currents. He encountered the impressive energy efficiency of natural fluid systems and discovered that these systems share common geometries. Harman speculated that if fluids always tend to follow a certain optimized path in nature, there must be a way to design technology that takes advantage of this fact.

“Nature has already solved the problem of friction reduction. To build more efficient industrial equipment, we must take full advantage of nature’s remarkable engineering solutions.”

*Jayden Harman, CEO,
PAX Scientific*

Out of his initial research came a series of all plastic, seamless watercraft. Based entirely on natural design, these boats were extraordinarily navigable, lighter, and stronger than comparable boats, and yielded 30 percent greater fuel efficiency, according to tests performed by Bombardier Recreational Products. Building on this success, Harman theorized that specific surface geometries naturally match the underlying streamlines of vortical flow in fluids (liquids or gases). By designing surfaces that mimicked this vortical structure, superior energy efficiency and performance might be possible for a wide variety of industrial equipment.

In fluid-handling equipment, poor drag management can result in high energy usage, low or unmanageable output, unwanted heat, component wear, harmful cavitation, and excessive noise. For example, in 2007, more than 339 million metric tons of fuel was used to drive 60,000 cargo vessels carrying 5.1 billion tons of international goods. The cost of bunker fuel—which accounts for 79% of the 339 million ton total—reached \$143 billion dollars. A 5% reduction in bunker fuel usage translates into *\$7 billion* annually—and reduces CO₂ emissions by 41.7 million metric tons.

Streamlining Applied

Employing the Streamlining Principle, PAX’s designs consist of compound curves in multiple axes. This is distinctly different from other rotational equipment on the market, which typically consists of either a planar surface or surfaces with a simple curvature in only one axis. The company’s patented design methodologies streamline fluid movement, manage turbulence, and reduce friction, drag, wear, and heat. These improvements in turn offer numerous potential performance benefits, including:

- Improved energy efficiency
- Significant noise reduction
- Superior directional thrust
- Decreased manufacturing and maintenance cost
- Reduced damage to organic fluids

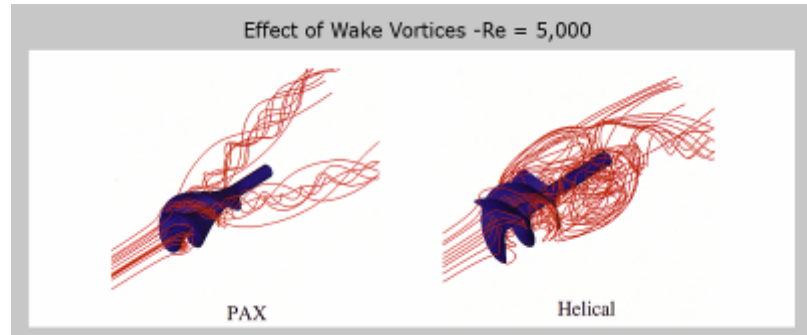
*Conventional technology creates shapes to induce flow;
PAX technology derives shapes from ideal flow.*

Independent testing of PAX fans, pumps, and propellers, performed in collaboration with international research facilities, demonstrates that PAX’s streamlining effect can provide energy efficiency and other benefits. For example, for fans, PAX technology can reduce energy requirements from between 10% and 75% and decrease noise by up to 75%.

PAX Core Research

In 2003, PAX Streamline's parent company, PAX Scientific, entered into a research relationship with Cascade Technologies and Stanford University to validate the scientific foundations of the Streamlining Principle. This group of nationally recognized fluid dynamicists analyzed the Streamlining Principle as it applied to PAX fan blade and mixer/impeller designs.

Employing detailed Particle Image Velocimetry (PIV) techniques coupled with numerical simulations using state-of-the-art CFD (computational fluid dynamics) codes, Cascade's scientists confirmed the principles underlying Harman's discoveries. Side-by-side testing with traditional counterparts identified a number of substantial improvements provided by PAX technology in the areas of pressure loading, vortex generation, and flow conditioning.



PAX mixer flow compared to traditional helical rotor.

PAX Companies

PAX refers to a family of companies launched to promote the natural streamlining strategies that Harman observed and termed the Streamlining Principle. Founded in 2007, **PAX Streamline** was spun off from parent company PAX Scientific in 2008 with lead funding from Khosla Ventures, the Menlo Park firm founded by respected venture capitalist Vinod Khosla. Khosla Ventures' capital comes entirely from its own partners and a portion of all profits is donated to charitable causes. PAX Streamline is a logical inclusion into Khosla Ventures' portfolio of cleantech firms, as PAX shares Khosla's mission of reducing dependence on foreign energy reserves. The company was given a mandate to develop and bring to market products in specific market areas that employ the energy efficiency benefits of PAX's streamlining methodologies.

The PAX companies include **PAX Scientific**, founded in 1997. **PAX Mixer** develops industrial mixing technologies. **PAX Water Technologies** commercializes water and wastewater management applications. **PaxFan** markets PAX's fan designs.

Commercial Approach

In addition to those mentioned above, many applications can benefit from PAX's streamlining methodologies, such as:

- Turbines (wind and water) and compressors
- Marine propellers and other propulsion equipment and components that reduce drag

- Heat exchangers, heat sinks, refrigeration technologies, and duct designs and components
- Pumps, jet pumps, and vacuum pumps
- Low shear bioreactors and biomedical equipment such as mixers and pumps
- Other fluid-handling equipment, surface profiles and hulls, and structural design.

PAX has several commercial strategies:

- **Manufacturing:** PAX's product development engineers design applications for OEM manufacturers.
- **Licensing:** PAX will consider master and other types of licenses on a case-by-case basis.
- **Strategic alliances, joint ventures, and subsidiaries:** When appropriate, PAX will create subsidiaries to exploit selected market opportunities; the company will also consider strategic alliances and joint ventures in selected market sectors.

Patent portfolio

PAX holds numerous US and international patents and patent applications on its technology, and engages in continuous patent development. In addition to the applications now being commercialized, PAX holds international patent applications for an even wider range of products and design tools.

PAX Streamline: Improved Industrial Equipment

While other PAX companies focus on fan, water, and mixer commercialization efforts, PAX Streamline is developing heating, ventilation, and air conditioning (HVAC) and refrigeration products and actively analyzing other markets for development opportunities, including wind turbines and aerospace. PAX's engineers perform studies using both CFD numerical methods and accepted engineering analytical methods to ensure the validity of the results. The optimized performance of the resulting designs are verified using in-house and external experimental testing.

Sonoma Cool

PAX Streamline uses patented geometries to develop proprietary components that enable more energy-efficient heat transfer and improve the performance of air conditioners and refrigeration units. In 2009, the company began commercializing low-flow liquid desiccant air conditioning (LDAC), for use in HVAC and refrigeration applications. LDAC is a new technology developed with the support of the Department of Energy's National Renewable Energy Laboratory (NREL).

Traditional air conditioning cools and reduces humidity by chilling the air *far below* the human comfort zone of 72 °F (23 °C) to condense out the water, and then re-heats the air to a comfortable temperature. This roundabout process is extremely energy intensive: in warm, humid climates, dehumidification can account for as much as 80% of the total electricity used by the air conditioning system. LDAC systems chemically dehumidify the



Sonoma Cool

air, removing moisture *before* cooling, to *significantly* reduce the electrical energy needed to maintain a cool, dry environment.

PAX's new HVAC solution, **Sonoma Cool**, combines reliable, low-cost components with low-flow liquid desiccant to make a commercial LDAC system that is simple, dependable, affordable, and competitive. A cleantech product, the system can employ solar or waste heat to regenerate (dry) the used desiccant, further reducing energy costs. **Sonoma Cool** is applicable to most commercial environments, including supermarkets, office buildings, shopping malls, movie theatres, hospitals, process industry facilities, and any interior challenged to manage heat and humidity.

Wind Turbine Program and Exploratory Activities

PAX's wind turbine program focuses on blade optimization and streamlining winglets to reduce drag and noise while maximizing power production.

The core R&D team explores other application areas that can benefit from biomimetic methodologies. To this end, PAX works with fluid dynamics experts at leading universities and consulting companies to study efficient fluid flow for a variety of applications. The team also develops tools employed by all PAX companies to design blades and rotors that generate efficient flow.

Management and Team

PAX's technology is developed and tested by a skilled team of mechanical, aeronautical, electrical, and chemical engineers using state-of-the-art CAD (computer-aided design), CFD (computational fluid dynamics), Particle Image Velocimetry (PIV), and experimental test facilities targeting specific applications such as heat exchangers, pumps, and HVAC. PAX tests aerodynamic prototypes on flow meters and operates an anechoic chamber designed to extract refined data from the aerodynamic and mechanical reverberations. The company performs its own SLS (selective laser sintering) rapid prototyping and machining. In addition to the company's own facilities, PAX has consulting relationships with a number of universities and research and testing firms.

PAX Management

John Webley (CEO) founded and held various executive positions at Advanced Fibre Communications, which he grew (along with his two co-founders) to 300 employees and a market capitalization of \$6 billion. John later founded Turin Networks, an optical networking company. Six years later, when he retired as CEO, Turin was a \$50 million business with 250+ employees.

Jayden Harman (Chairman and Chief Inventor) has founded a number of profitable companies, including ERG Australia Ltd, which he took to a highly successful IPO. Jay has extensive experience in the licensing of new technologies, and is the author of numerous patents in marine craft design, and in friction and cavitation reduction technologies. He is also CEO of PAX Scientific, and of PAX Water Technologies.

Francesca Bertone (Chief Operating Officer) has 20 years of experience in program administration and education. Before founding PAX, Francesca served as director of operations for Tank & Pipe Welding Pty Ltd in Australia. She is a member of the PAX Scientific Board of Directors.

Laura Bertone (Chief Financial Officer) has 18 years of experience in the banking industry. She is a Chartered Bank Auditor and a member of the Institute of Internal Auditors. At Bank of America, she managed the Global Capital Markets/Investment Banking Group, Retail Audit Group, and Development and Training Teams. She is a member of the PAX Scientific Board of Directors.

Michael May (Vice President of Engineering) brings to PAX his extensive experience in new product development. At Carrier Corporation, he served as engineering director of both commercial refrigeration NA and global bus engineering. At UT Power, Michael led the automotive cell stack engineering team in developing a new fuel cell power section for Nissan, and also served as engineering business manager.

Tom Gielda (Vice President of Advanced Research) has held a variety of technical leadership positions in diverse industries, including aerospace, automotive and consumer appliances. Before coming to PAX, he was the global mechanical systems director for Whirlpool Corporation, leading a team of more than 600 engineers in new product development and product innovation. Prior to joining Whirlpool, Tom was a distinguished technical fellow for Visteon/Ford.

Kasey Arnold-Ince (Director of Communications) has helped Fortune 100 firms, multimedia providers, innovative startups, and nonprofit organizations such as the Martin Luther King Papers Project, NASA, and the Exploratorium define their identity and message through a variety of media.