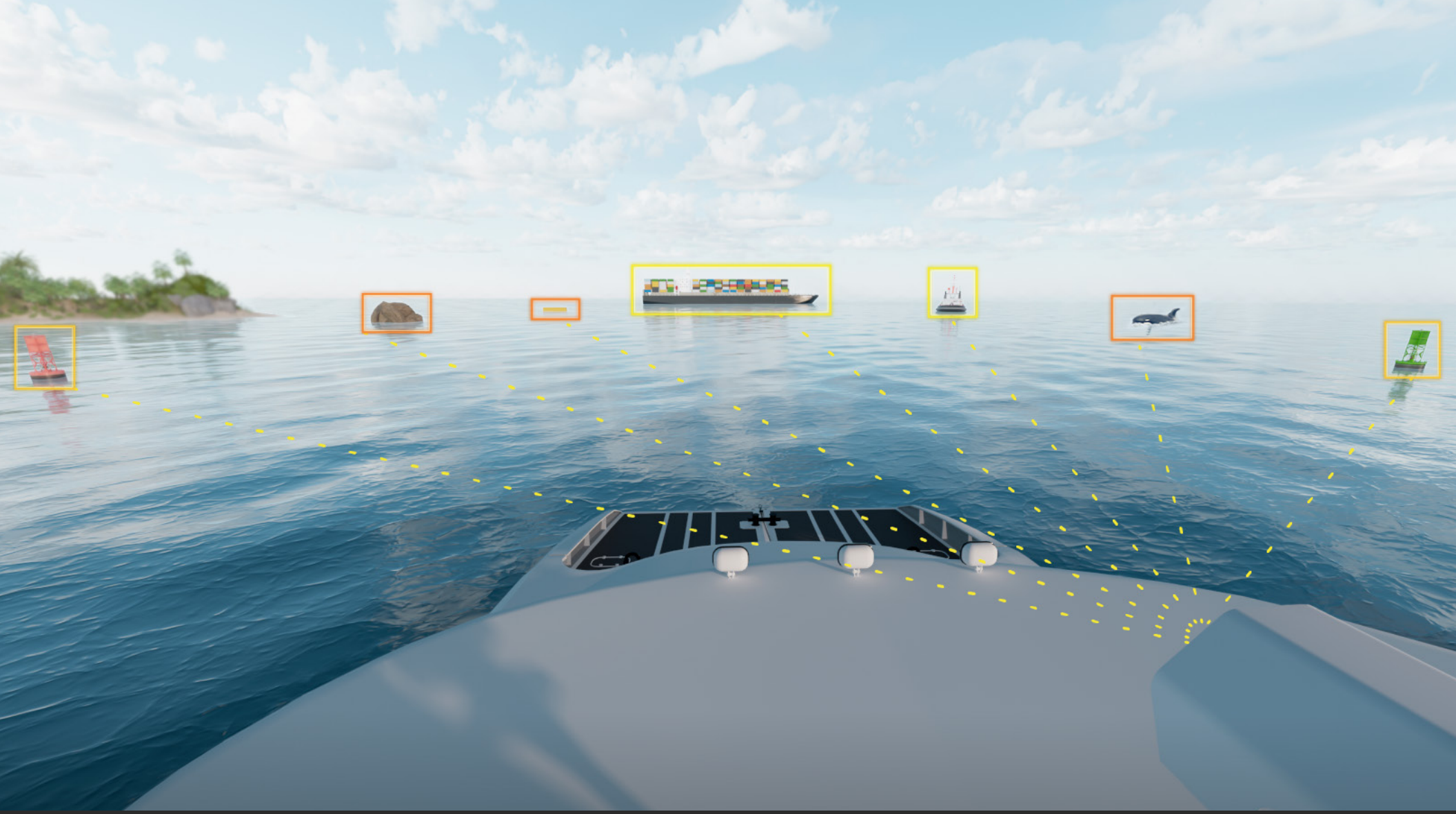


A LOOK INTO THE NEXT GENERATION OF MARINE TECH: AI-POWERED COMPUTER VISION

SEA MACHINES

INTRODUCTION

The global marine ("Blue") industry is responsible for trillions in economic output and is a major driver of jobs and commerce. Despite the sector's critical function in global society, these sectors face significant challenges related to safety, performance and profitability.

The primary purpose of this whitepaper is to educate marine industry leaders, ship and vessel owners/operators, and investors about the potential that emerging vessel technologies have in disrupting and advancing this massive Blue Economy. In this publication, you will learn about the current state of the marine space, the specific challenges it faces today, and how several technologies – specifically Artificial Intelligence (AI), computer vision, and autonomy – are poised to deliver valuable solutions, now and in the very near future. Readers will also gain an understanding of which other industries (such as automotive, manufacturing and agriculture) have already successfully adopted such technologies and what the impact has been.

A secondary goal of this whitepaper is to provide insight into where the marine industries are headed as a result of this technology revolution. As will be explained, technology based on automation and AI can create new types of jobs and significantly shift traditional operations. While these changes will predictably create a future skills gap, these technologies will generate new opportunities that may be more fulfilling and are certainly safer for human workers.

Andrew Ng, computer scientist and technology entrepreneur, summarized it best: "Artificial Intelligence is the new electricity." Just as electricity changed how the world operated more than 100 years ago, autonomy and AI-based technologies will have a similar impact across all industries, and especially within the marine and maritime space.

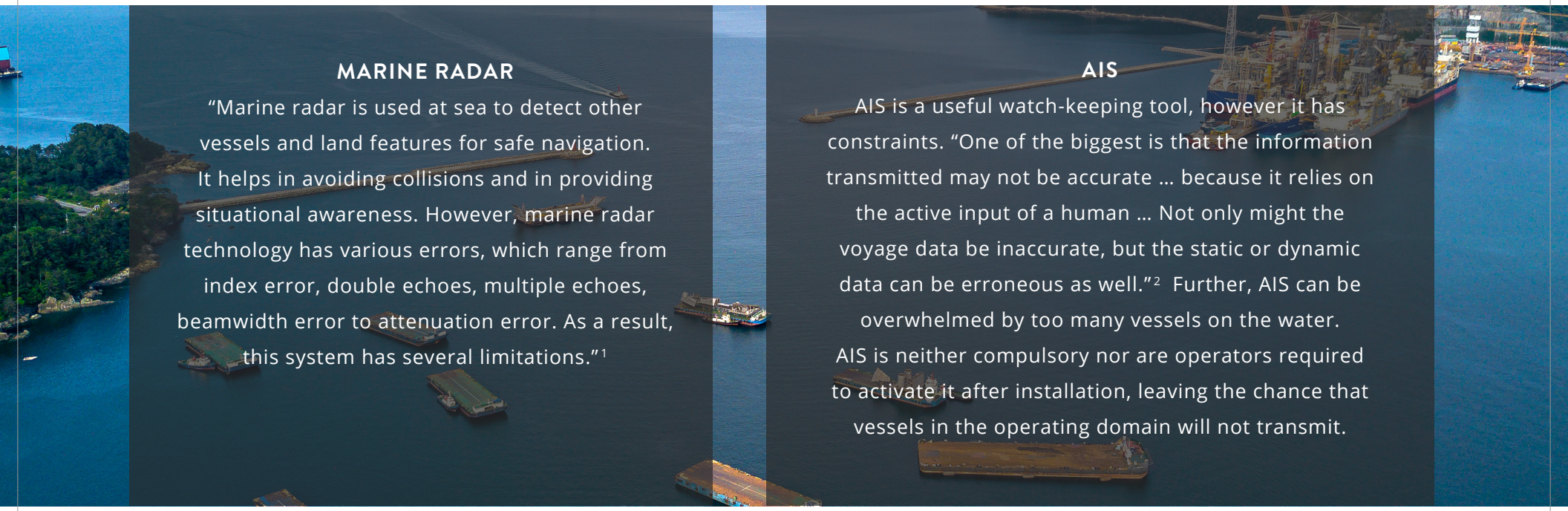
> "Artificial Intelligence is the new electricity."
>
> **ANDREW NG**
>
> **COMPUTER SCIENTIST AND TECHNOLOGY ENTREPRENEUR**

2 STATE OF THE INDUSTRY & CURRENT CHALLENGES

As one of the oldest trade fields in existence, the commercial marine sector today faces significant challenges. Slow to automate, the Blue industry continues to rely on traditional technologies and sensors. This reliance, combined with a heavy dependence on manual operations, contributes to the sector's higher-than-average accident rates when compared to other modes of transportation.

2.1: TRADITIONAL TECHNOLOGY AND SENSORS

Despite working in a sector with significant economic value, mariners are still operating in legacy modes with outdated technologies. The tried-and-true marine systems that provide situational awareness to crews have limitations that leave operators and vessels at risk while operating at sea. These include:



MARINE RADAR

"Marine radar is used at sea to detect other vessels and land features for safe navigation. It helps in avoiding collisions and in providing situational awareness. However, marine radar technology has various errors, which range from index error, double echoes, multiple echoes, beamwidth error to attenuation error. As a result, this system has several limitations."[1]

AIS

AIS is a useful watch-keeping tool, however it has constraints. "One of the biggest is that the information transmitted may not be accurate … because it relies on the active input of a human … Not only might the voyage data be inaccurate, but the static or dynamic data can be erroneous as well."[2] Further, AIS can be overwhelmed by too many vessels on the water. AIS is neither compulsory nor are operators required to activate it after installation, leaving the chance that vessels in the operating domain will not transmit.

While both of these tools offer supplemental support to an operator, they also require human interpretation and training.

In summary, current technologies and operating practices do not allow for optimized situational awareness and therefore safety.

[1] (Errors and Limitations of Marine Radar, 2021)
[2] (What Are The Limitations Of AIS?, 2022)

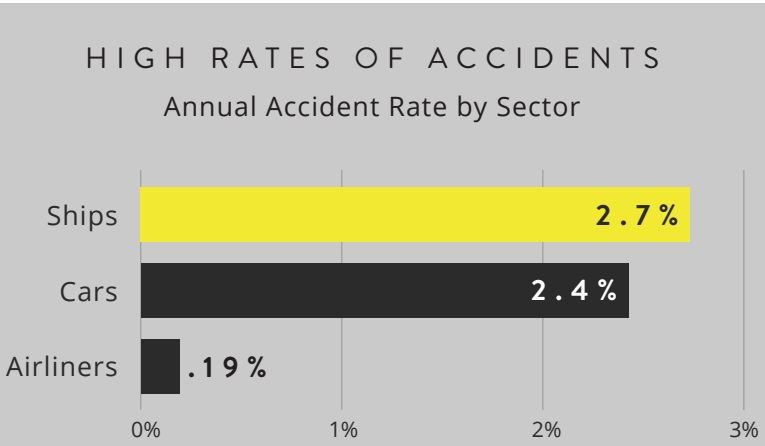
2.2: MANUAL EFFORT

From the wheelhouse of nearly any commercial surface vessel, mariners must interpret multiple sources of data about their surrounding marine domain. In addition to using their natural senses, they understand their at-sea position by referencing physical landmarks, mapping the vessel's course along ECDIS charts and referencing a GPS. They become semi-aware of nearby vessel traffic and patterns via AIS data and radar. If a vessel has been outfitted with cameras for a bird's-eye view or other difficult-to-see angles, they will reference one or more video screens. For mariners who are responsible for the safe transit of marine assets and valuable cargo, these various data sources are not only helpful to operations, but vitally important.

This very active role of the mariner relies on a human's ability to manually aggregate data from numerous dynamic sources, interpret it quickly, with a high degree of accuracy, and make critical decisions, often in rapidly changing environments. Crews are highly trained to execute this task continuously as vessels operate around the world 24/7, but the job comes with inherent risk. Human vision is flawed, and our senses cannot give dedicated attention to all targets at the same time. This is a main reason why human error is the root causes of most at-sea incidents.

2.3: HIGH ACCIDENT RATE

Today's Blue industry reports a high incident and accident rate during at-sea operations. Accidents involving the world's largest machines can be catastrophic, negatively impacting human and environmental health, as well as an operator's bottom line. Vessel incidents also lead to delays in a critical industry that moves around 90 percent of the world's cargo by volume. A significant percentage of at-sea incidents are caused by limitations in conventional perception and situational awareness from the ship's bridge.



The majority of on-water accidents result from inherent human limitations, such as fatigue, tedium and distraction, that cause loss of attention during long transits or confusion in a very open domain without apparent lanes.

Sources for two images/graphs above: Allianz Annual Safety and Shipping Review, US DOT / NHTSA, IATA

~2.7%

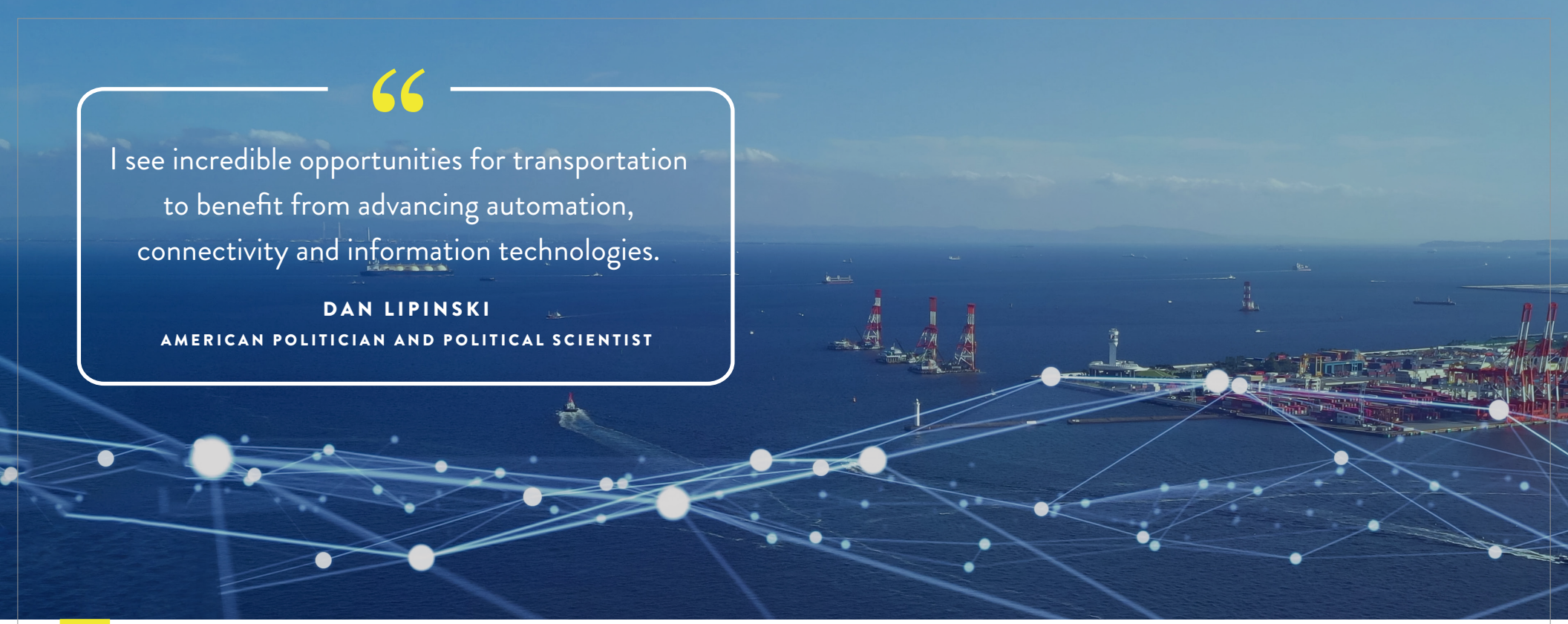
of the world cargo fleet is involved in major incident annually

$2.6B

marine insurance claims in 2020

58%

due to preventable human error (groundings, collisions, allisions, strandings)



> I see incredible opportunities for transportation to benefit from advancing automation, connectivity and information technologies.
>
> **DAN LIPINSKI**
> AMERICAN POLITICIAN AND POLITICAL SCIENTIST

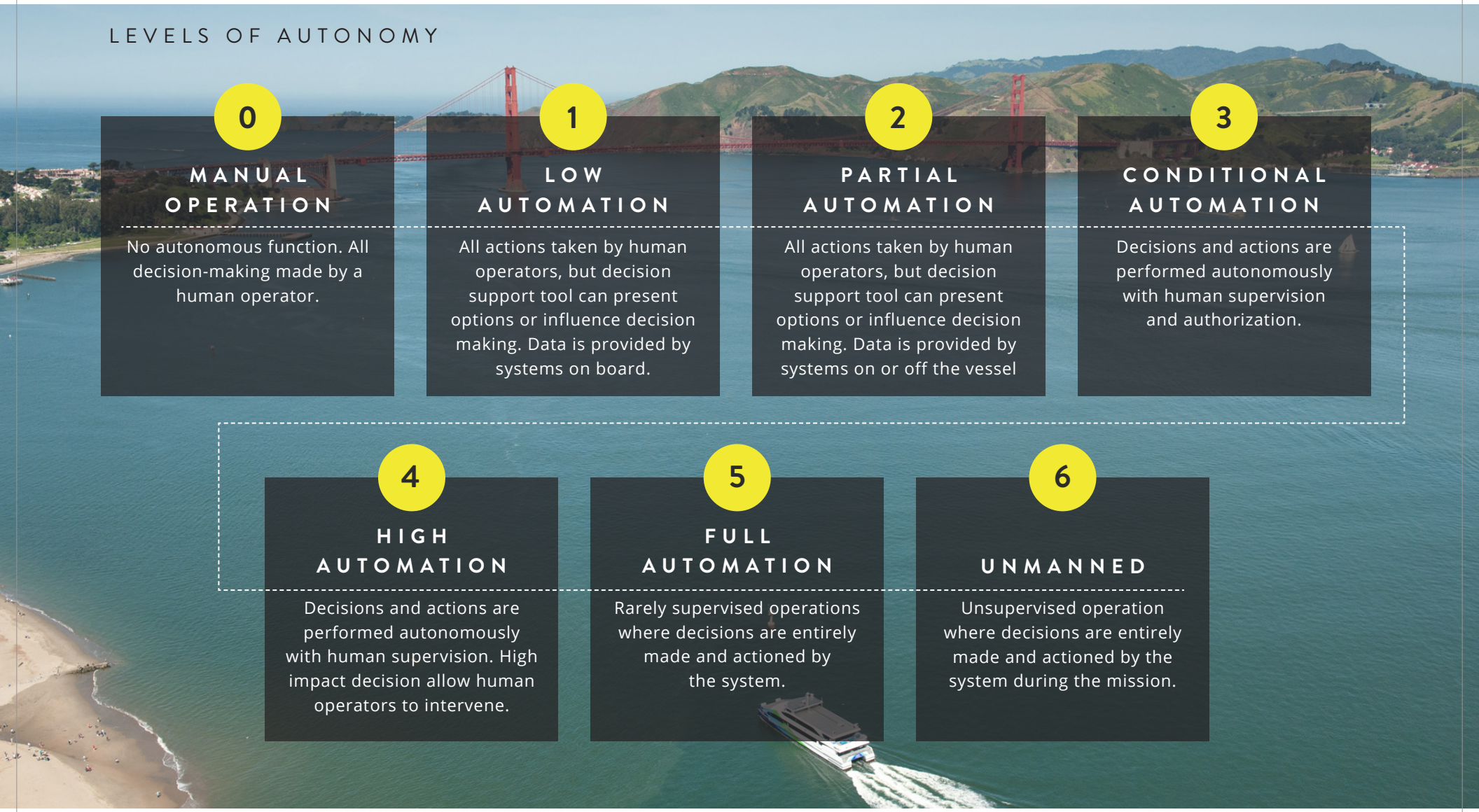
3 CATALYST FOR CHANGE: EMERGING "SMART" TECHNOLOGY

Until recently, the automotive industry faced many of these same challenges. Drivers have historically relied on human vision, physical road signs, maps and GPS technology, odometers, and other data sources to manually operate vehicles. However, with today's Advanced Driver Assistance Systems (ADAS) and available autonomous technologies, society now benefits from reduced risk when using our roadways. Modern-day systems fuse and interpret data from multiple sources – including GPS, LiDAR, ultrasonic systems, cameras, and radar – to instantaneously generate useful information for the driver, such as lane-departure warnings, or automated behaviors, like autonomous emergency braking. These technologies have been trialled since the early 1980s and have proven their value by helping drivers make better and safer decisions on the road.

Similar to the intelligent technologies that automotive innovators (like Tesla or retrofit ADAS providers) introduced, leading marine technology developers, like **Sea Machines Robotics**, are now offering autonomous vessel systems and perception systems that intelligently fuse common and emerging marine data sources in a single view, so mariners have immediate and accurate operational information. The end goal is to in the future enable full autonomous solutions that solve current-day industry challenges.

3.1 AUTONOMY

Today there are currently six accepted levels of autonomy for vessel design and operation, per Lloyd's Register.[3]



[3] (Autonomy Level (AL) for Ship Design and Operation, 2020)

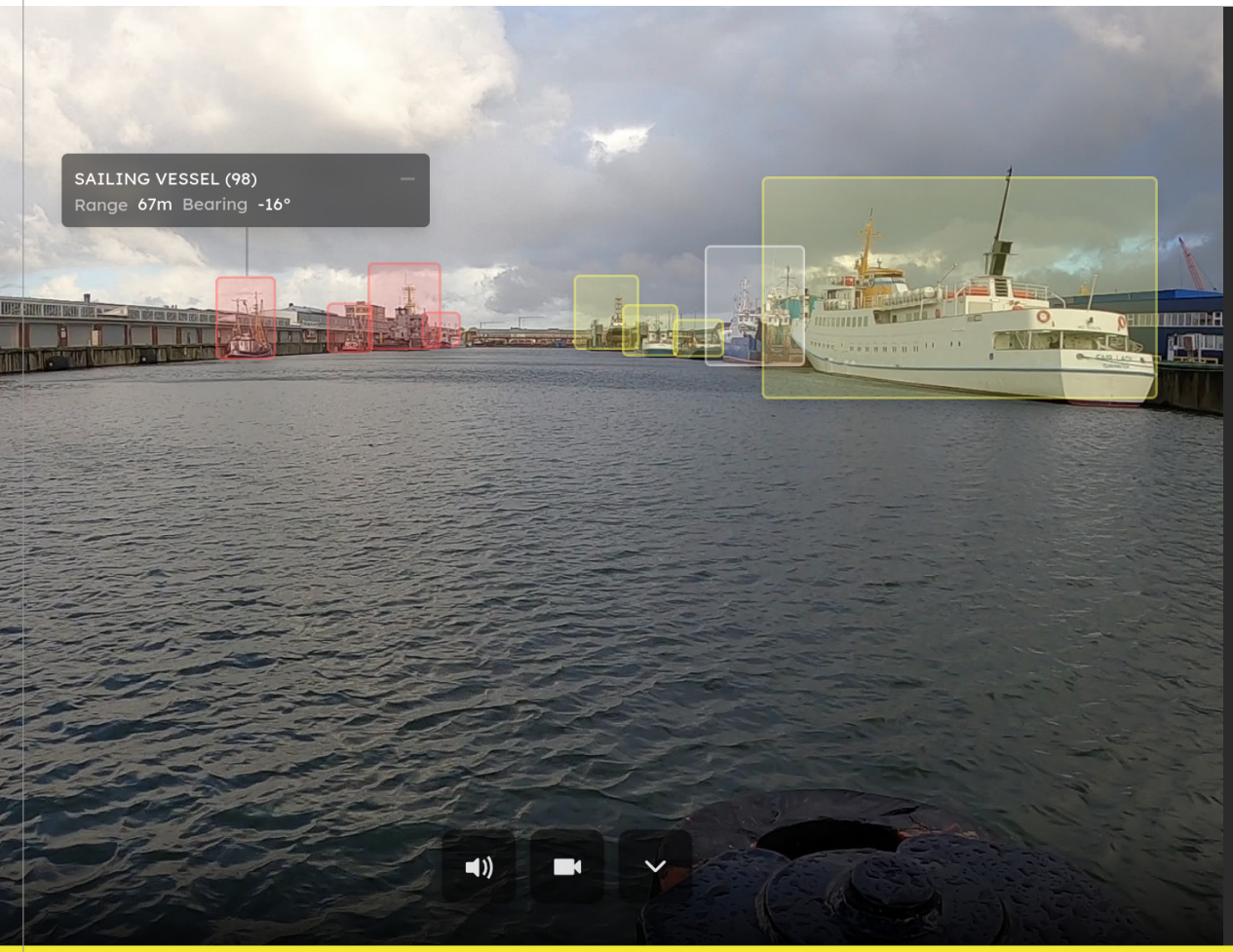
SM300 AUTONOMOUS COMMAND & CONTROL SYSTEM

Leading autonomous marine technologies, like Sea Machines' SM300, install aboard existing or new-build surface vessels and provide operators with immediate new capabilities. Referencing the Levels of Autonomy chart, the SM300 is a Level 4 High Automation system, meaning it automates highly manual, tedious or dull tasks.

The technology can be used to support on-board or remote crews or to provide autonomous man-on-the-loop operations in controlled domains. This relieves crews of navigational tasks as well, allowing machines to focus on the routine and mariners to focus on operational or higher-level tasks.

The SM300 also enables operators to remotely command and monitor multiple autonomous vessels from a shipboard or shore-based center. This enables reduced-crew vessel configurations and mitigates crew risk in dynamic, toxic or dangerous marine operations. To further protect crew, cargo and payloads, the SM300 regulates vessel motions during missions and voyages.

Vessels enabled with Sea Machines' autonomous technology benefit from the system's dynamic obstacle avoidance capabilities, which operators can choose to activate during planned voyages or missions. This system never fatigues, never gets distracted, and consistently operates around the clock, even during times of low light or poor visibility. Sea Machines' commercial systems intelligently fuse data from radar, GPS, AIS, electronic charts, and computer vision into one intuitive display so mariners can make more timely and informed decisions.



However, to achieve autonomous operations with full situational awareness, as described in Levels 5 and 6, a system must also incorporate AI-powered computer vision.

For Sea Machines, the next wave of technology will include sensor fusion and enhanced situational awareness with the utilization of computer vision. This combined technology provides crews with a fuller understanding of the ship's operating domain – including nearby traffic, obstructions and typically undetected objects by traditional sensors – by fusing computer vision with data from conventional marine instruments. It gives the crew the accurate, comprehensive data they need to make informed decisions, while solving common Blue industry challenges.

3.2 ADVANCING AI-POWERED COMPUTER VISION

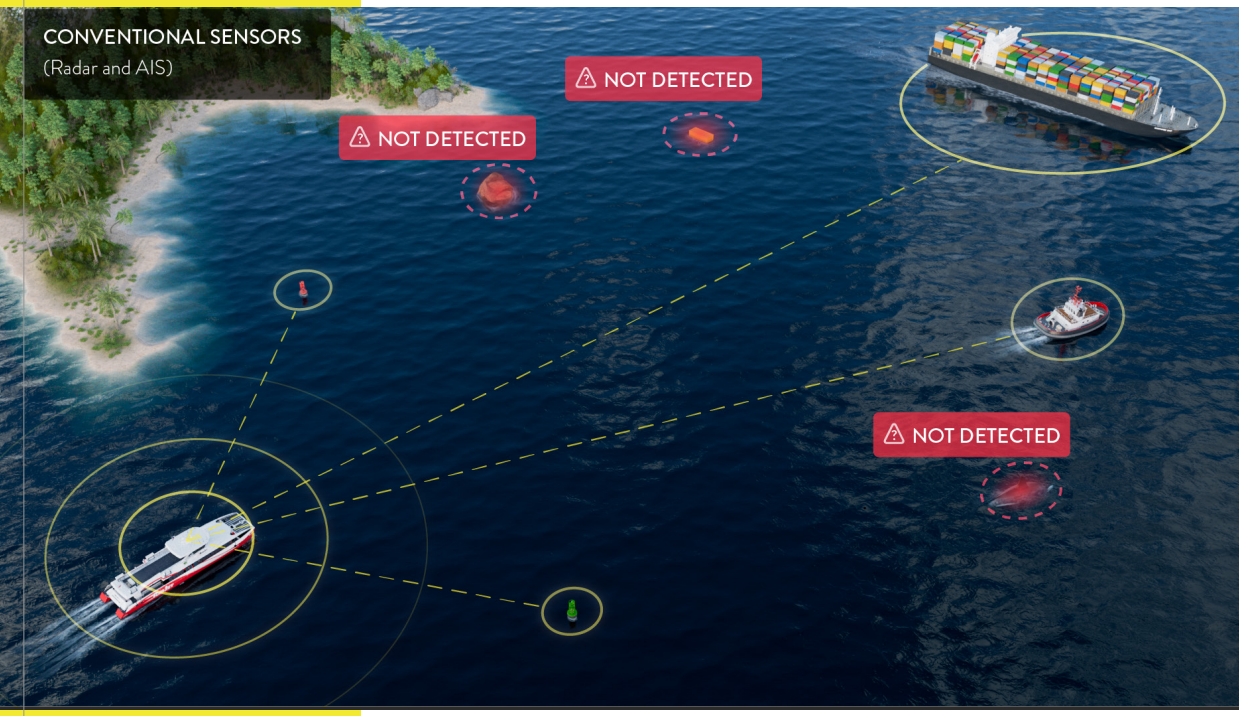
When considering computer vision, understand that it is a subcategory of AI that focuses on building and using digital systems to process, analyze and interpret visual data. Further, "computer vision systems use (1) cameras to obtain visual data, (2) machine learning models for processing the images, and (3) conditional logic to automate application-specific use cases." Computer vision is currently revolutionizing companies across all industries, particularly for rapidly automated AI vision inspection, remote monitoring, and automation.[4]

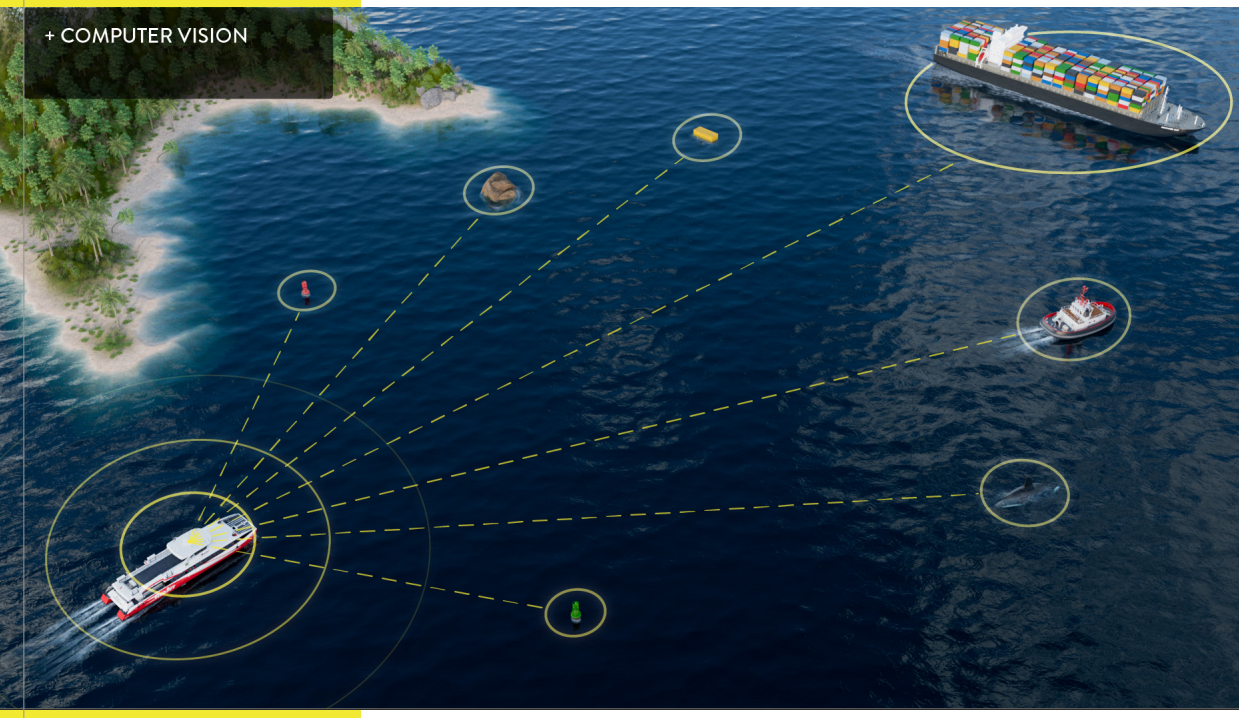
TOP INDUSTRIES BEING TRANSFORMED BY COMPUTER VISION[4]

The following industries are undergoing a technical revolution powered by advanced perception and AI.

- Agricultural
- Education
- Healthcare
- Insurance
- Manufacturing
- Military
- Retail
- Security
- Sports
- Technology
- Transportation

[4] (87 Most Popular Computer Vision Applications in 2022, n.d.)





Capable of delivering transformative change in everyday life, computer vision plays a significant role in enabling digital transformation across different industries. In short order, computer vision has the potential to enhance productivity, efficiency, customer experience, reduce operating costs, minimize defects and improve security.

The reason behind the adaptability of computer vision is its accuracy and precision, far beyond what a human can see.[5] Installation of computer vision technology includes placement of several strategically located cameras aboard vessels. The resulting live footage can play anywhere in the vessel (in or outside of the wheelhouse).

[5] (Saxena, 2019)

INDUSTRY'S MOST EXTENSIVE DATA SETS, 100 MILLION IDENTIFIED TARGETS OVER 10M IMAGES

Based on one of the marine industry's most extensive data sets, comprised of nearly 100 million identified targets over 10M images, Sea Machines marks the operational video footage with AI-generated labels and bounding boxes to clearly indicate vessel and environmental information. Mariners report that these denotations are intuitive, unlike other systems, like radar, which require training before use.

AI-powered computer vision is far more reliable than the human eye, especially when the data is combined and validated by other sensors. Consider the situational awareness mariners have with conventional sensors versus those that also incorporate computer vision.

Offering a wider field of view, AI-powered computer vision technology is indefatigable and maintains a lookout 24/7, without the risk of distraction. In low-light, foggy or rainy conditions, it will one day offer a far more accurate picture of the surrounding domain than humans can. Computer vision also provides redundancy aboard vessels, allowing crew to observe annotated video of the surrounding environment on mounted screens from locations outside of the wheelhouse in real time.

AI-POWERED COMPUTER VISION PROVIDES PROFESSIONAL VISION

Ability to Perceive Domain Obstacles & Attributes	IN DAYLIGHT				IN FOG				IN DARKNESS			
	LV	SV	FL	IL	LV	SV	FL	IL	LV	SV	FL	IL
Human Operator												
Conventional Marine Instruments												
Computer Vision												

LV: Large Vessel SV: Small Vessel FL: Misc Flotsam, IL: Ice Lanes

The use of AI enables computers to learn and "think" using structures modeled on the human brain. This means the technology will become "smarter" and more useful over time. Sea Machines' system intelligently surveys the surrounding environment and isolates targets of interest, such as humans in the water, landmarks and various types of vessels.

Sea Machines' computer vision technology continuously monitors the surrounding environment and identifies, classifies, geolocates and tracks all on-surface objects that may need the attention of the human operator.

All of this collectively gives the crew the data to make informed decisions that can positively improve safety, cargo schedules and operational costs.

> I see incredible opportunities for transportation to benefit from advancing automation, connectivity and information technologies.
>
> **DAN LIPINSKI**
> **AMERICAN POLITICIAN AND POLITICAL SCIENTIST**

3.2 COMPUTER VISION & AUTONOMY SOLVE PERSISTENT CHALLENGES

Across all industries, the embrace of automation and autonomous technologies has improved operational performance, profits, efficiency and safety. When applied to the marine and maritime industry, these benefits will translate to greater operational output and schedule integrity, with lower at-sea risk. When this technology incorporates AI-powered computer vision, the industry will begin to capitalize on solutions to many of the enduring challenges it faces.

Sea Machines is solving many of these challenges now by developing technologies that are helping our established, traditional industries transition into a new era of task-driven, computer-guided vessel operations. These solutions include:

MODERNIZING HELM TECHNOLOGY

Updating helm technology to include autonomy and AI-powered computer vision not only elevates the role of mariners, but also improves their at-sea situational awareness. Sea Machines intelligently fuses AIS, GPS, radar, and computer vision into a single, intuitive display that offers greater confidence for vessel traffic, on-water obstacles, and critical information about the surrounding environment. Easy to use, these advanced technologies require minimal training to use and offer immediate operational benefits.

AUTOMATING MANUAL WORK

Sea Machines' technology automates routine, repetitive and tedious tasks, allowing operators to focus on higher-level work. When data from multiple sources is curated into a single view that provides intuitive and critical navigational information, mariners spend less time guessing about their surroundings and more time operating in productive modes. In addition to helping to reduce the risk of incidents, AI-powered computer vision paired with autonomy has the potential to reduce menial work and improve shipboard life by way of more fulfilling work.

REDUCING THE HIGH ACCIDENT RATE

When mariners have clear and accurate situational awareness, as well as 24/7 watch-keeping redundancy and autonomous collision avoidance, on-water accidents related to human error are minimized. A lowered rate of at-sea incidents will create a safer industry with lower associated costs.

CONCLUSION: THE FUTURE WILL BE SEEN

It has been reported that "worldwide revenues for the AI market … are forecast [for 18.8% growth in 2022 and will] break the $500 billion mark by 2024."[6] This unprecedented expansion will certainly bleed into the Blue industry, helping to soon enable fully connected, self-driving fleets capable of transporting cargo and people from dock to dock safely and at the lowest possible cost.

While fully unmanned ships are still on the horizon, vessels equipped with AI-powered computer vision and autonomy systems are already in use. As the value of computer vision technology is realized, the future may include mandatory use during at-sea vessel operations. The result will be the start of an unprecedented era of safety, increased efficiencies and the introduction of myriad, new skill sets for mariners.

Sea Machines clearly sees the future of our industry and we invite all to get on board.

[5] (IDC Forecasts Companies to Spend Almost $342 Billion on AI Solutions in 2021, 2021)

Learn more about Sea Machines' AI-powered computer vision technology **here**.

REFERENCES

Errors and Limitations of Marine Radar. (2021, January 8). Retrieved from Lidar and Radar: https://lidarandradar.com/errors-and-limitations-of-marine-radar/

What Are The Limitations Of AIS? (2022). Retrieved from Causal Navigation: https://casualnavigation.com/what-are-the-limitations-of-ais/

Autonomy Level (AL) for Ship Design and Operation. (2020, January 22). Retrieved from Marine Insight: https://www.marineinsight.com/wp-content/uploads/2020/01/autonomy-level.jpg

Meel, V. (2022). *87 Most Popular Computer Vision Applications in 2022.* Retrieved from Viso.ai: https://viso.ai/applications/computer-vision-applications/

Saxena, A. (2019, December 10). *Exploring the Potential of Computer Vision Across Industries.* Retrieved from eInfochips: https://www.einfochips.com/blog/exploring-the-potential-of-computer-vision-across-industries/#:~:text=The%20reason%20behind%20adaptability%20of,and%20reduce%20operating%20costs%20significantly.

IDC Forecasts Companies to Spend Almost $342 Billion on AI Solutions in 2021. (2021, August 4). Retrieved from International Data Corporation (IDC): https://www.idc.com/getdoc.jsp?containerId=prUS48127321

Amelia P. Smith, Sea Machines Robotics

SEA MACHINES. SEA BETTER.

For more information,
contact sales@sea-machines.com.

SEA-MACHINES.COM