A datum in the ocean

Marine robots
Interview with Eamon Carrig, chief roboticist at Autonomous Marine Systems, which aims to provide continuous data about the world's oceans

The total surface of Planet Earth spans some 510 million square kilometres, and the ocean accounts for more than 70 per cent. If there's one man who would be familiar with these kind of numbers it's Eamon Carrig, co-founder and chief roboticist at Autonomous Marine Systems (AMS), a US robotics startup which could scarcely have more compelling origins.

AMS was started by three aerospace engineers – Carrig, T.J. Edwards, and Walter Holemans, although Holemans has since left the company.

"We had all been working together on spacecraft mechanisms – TJ and Walt mostly mechanical, me mostly electrical and software – since 2006," says Carrig in an exclusive interview with RoboticsandAutomationNews.com.

"Specifically we worked on satellite separation systems, which are the last systems that have to work to get a satellite on orbit. In my career as a sep system engineer, we produced about 15 systems for flight. I would have bet my life on every single system we delivered."

> **"Our grand vision is centered around using networks of heterogeneous robots to collect big ocean data"**
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> Eamon Carrig (left), chief roboticist, AMS

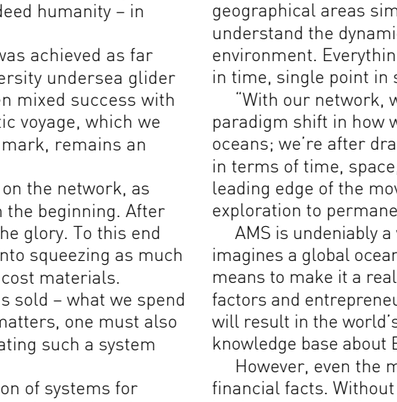
AMS has built small robotic vessels it calls "Datamarans" which act as data collectors for meteorology and oceanography. In the simplest form, think of them as self-guided buoys that happen to look like futuristic sailboats. The company is offering custom surveys of the world's oceans for the defense, energy, shipping, fishing, and research sectors. Although accurately summarized on its website as a "marine data service", the description doesn't quite sum up the epic scale of the task AMS has taken on and the potential benefits to a variety of sectors.

The company says it is building the world's first global water-borne, intelligent sensor network and data distribution channel. Such a system, had it been available in the past, may have helped find aeroplanes that crashed at sea but were never found, such as Malaysia Airlines' flight MH370, which is believed to have crashed in the Indian ocean last year, with 239 people lost.

Despite months of intense searching, using satellite technology as well as civilian and naval vessels, and ships and planes from a multitude of countries, nothing has been found of MH370. Recent discoveries of plane wreckage on the coast of Reunion Island, in the Indian Ocean, have not yet been conclusively proved to be from MH370. With a persistent network permanently installed on the ocean, it seems unlikely that such a long search would have been necessary, and it's equally unlikely that it would have ended in failure to find the plane.

Carrig tells the story of how AMS came about. "We decided to try to this wacky idea of building an infinite duration surface vessel after learning about the needs in the scientific community for co-local simultaneous measurements of partial pressure of CO2 above and below the surface.

"These measurements are critical to our efforts to understand carbon transport and climate change. There is no good remote sensing solution – you have to be there. This project is our best effort to get sensors out to the middle of the ocean as cost-effectively as possible. We see the oceans as the most important area on which to concentrate our stewardship efforts in the coming century."



Main picture and circle inset: the AMS Datamaran is a solar-powered small vessel which acts as a metocean data-collection device and a node in a network of AMS Datamarans on the ocean, connected by satellite and other networking systems

In the not-too-distant past, some might have dismissed it as an impossible dream, or at least slightly eccentric, and may have been reluctant to back it with money. But with robotics and communications technology advancing and proliferating as they have, combined with Carrig and his team's skills, the "wacky idea" became an ambitious but realistic goal.

"In the very beginning AMS was self-financed," explains Carrig. "As the project took on more steam, we did a kickstarter campaign, and completed an F&F round. Last year we were selected for and completed the #1 ranked energy accelerator Surge in Houston. We were able to raise a seed round coming out of that program that allowed us to service our first commercial pilot programs. We are currently raising a series A and building out our manufacturing capabilities."

F&F refers to friends and family, and Series A funding is simply a formal term to mean a startup company's first significant phase of venture capital financing.

Although AMS is by no means the only company in the marine robotics market, in Carrig's judgment, the market is yet to see a technically capable system offered at the right cost.

"There are several technologies at various levels of maturity being deployed and evaluated in marine robotics," says Carrig. "However, no commercially available systems meet the needs of industry – and indeed humanity – in terms of price and performance.

"Notable development success was achieved as far back as 2009, when a Rutgers University undersea glider crossed the Atlantic. There has been mixed success with surface vessels, but the transatlantic voyage, which we have chosen to focus on as a benchmark, remains an open problem.

"Our approach has been to focus on the network, as opposed to the individual boats from the beginning. After all, it is the utility that matters, not the glory. To this end we have chosen to pour our efforts into squeezing as much performance as possible out of low-cost materials.

"But it is not just the cost of goods sold – what we spend on materials to make a boat – that matters, one must also consider the logistical costs of operating such a system over its entire lifetime."

The Datamaran uses a combination of systems for power, including a rigid sail to harness the wind, and onboard solar panels to charge the battery to operate the electronics. AMS is planning to use a number of communications networks to connect the Datamarans: the Iridium satellite constellation, GSM (cell phone), Wi-Fi, and RF (like an RC airplane).

The company says each Datamaran acts as a node in the network. Using peer-to-peer communication, and redundant host systems on land, swarms of Datamarans can self-organize for maximum efficiency in carrying out their mission. This capability allows for ocean surveillance of unprecedented richness and responsiveness to changing conditions, says AMS.

AMS has concentrated on developing a system that makes the most of the burgeoning components market in robotics without packing too much into it; and the company has developed the system in a way that allows for future expansion and augmentation.

The small vessel it has developed that will serve as the data points is claimed by the company to be the world's first self-righting catamaran, which has been named a "Datamaran". The vessel offers savings and performance unmatched by any other vehicle in its sector, says AMS.

"Many of the claims in our first patent, granted several months ago, focus some clever tricks to get the most performance out of a system composed of low-cost materials and scalable construction methods.

"A craft is not credibly commandable if it cannot overcome surface currents, yet we believe that the returns on speed drop off sharply soon thereafter. We don't want to make the best boat; quixotically, we want to make the least boat that satisfies the need.

"Keeping the individual node costs as low as possible allows us to deploy the technology as widely as possible. Distributed networks are the only way to address this global requirement."

What may actually have been an impossible dream in the past is now possible largely because of the advent of the Internet and networking technology, which, like components, is coming increasingly within reach of many companies' budgets whereas in the past it may have been the preserve of the few.

"It has never yet been been plausible to effectively measure millions of data points across massive geographical areas simultaneously, which is critical to understand the dynamic properties that control the global environment. Everything [in the past] has been single point in time, single point in space measurements.

"With our network, we're introducing a whole new paradigm shift in how we're exploring and studying the oceans; we're after drastic increases in data density in terms of time, space, and precision. We're on the leading edge of the movement from expeditionary ocean exploration to permanent longitudinal ocean monitoring."

AMS is undeniably a visionary company which not only imagines a global ocean monitoring system, but also has the means to make it a reality. A perfect storm of technological factors and entrepreneurial ideas is being harnessed and will result in the world's first real-time encyclopaedic knowledge base about Earth's watery nature.

However, even the most noble of ideas have to face financial facts. Without being able to demonstrate a viable business model, it's unlikely that AMS would have got off the ground, so to speak. And while Carrig may be intensely interested in the scientific and engineering aspect of the

company, he indicates that the company has identified clear gaps in the market and has strong backers who will help AMS to bridge those gaps.

"Our initial customers are from the US – primarily the energy and defense sectors," says Carrig. "Our first missions are concerned with data collection and exfiltration. Metocean data collection in particular is a global problem – the amount of data currently being collected is sparse, and the tools being used are inadequate.

"The nice thing about these mission sets from a business development perspective is that the needs look the same all over the world. We will earn our stripes so to speak by delivering the highest quality product to marquee customers in the US, and expand from there.

"Currently there are only about 650 [conventional/traditional, non-robotic] metocean buoys deployed in the entire world. The bottleneck here is largely due to the exorbitant costs of deployment and recovery. In many cases the buoy itself is a mere rounding error compared to the logistical costs of getting it on station.

"Nearly all of these buoys are moored near North America and Europe. As industries move to frontier markets, the data from buoys like these is critical to the development and operations of their billions dollar assets. As a senior scientist from a super major recently told us, 'What I need is a self-deploying buoy'. We are pleased to oblige."

AMS is all set with its fleet of Datamarans to achieve its objective of networking the world's oceans, but as enormous as that enterprise sounds, it is actually just the beginning for the company.

"Our grand vision is centered around using networks of heterogeneous robots to collect big ocean data. We hope to reach a critical density of proprietary data, and reap the added value of an integrated longitudinal data set. Nothing like this has ever been achieved.

"By making each node in our network – surface, air, and under water – as flexible as possible, we are able to rapidly integrate advanced sensors and flex to customer needs.

"We anticipate a panoply of specially outfitted Datamarans working in concert to cover the spectrum of sensing needs. Any such network needs to employ a multitude of physical channels, data protocols, and command and control structures.

"Fortunately we have a leg-up on building these tools from our experiences in the spacecraft industry, and prior work in bandwidth constrained environments. Surface vessels are critical to any such network because they are uniquely able to access to ample environmental energy and both satellite and acoustic comms.

"We do our best to be data driven, and are focused on addressing the largest unmet needs first. That said, we have lots of wacky ideas, both derivative and tangential, floating around (pun intended).

"The best part of a technology like this is that it opens up possibilities that no one has thought of, or if they have, have done so only in theory without a direct, plausible, pathway to achievement.

"Our power-positive, persistent, affordable platform is a necessary condition to building the next generation of ocean observation tools, and rising to the global challenge of ocean stewardship.

"In general, I think very few working roboticists truly understand the implications Moore's Law (myself included!). We're seeing startups rise with truly impressive technologies only to be overtaken by even more impressive technologies that come around five years later. This is true across the board.

"At AMS we're trying to get to the time-and-computation-independent heart of the problem – the algebra if you will. It's tough to build a strong stable business around something that may ultimately become a commodity, which is why the Datamaran is only the beginning.

Surge, a startup consultancy which has advised and supported AMS since the early days of the business

"The world needs cheap reliable boats, but more to the point, the world needs low-cost tools to garner ocean intelligence. We will not rest until that goal is achieved."

Naturally, on a project of such magnitude, there are many complex issues to resolve, and many of the most difficult dilemmas have been presented by Earth itself.

"We've certainly had our share of challenges," says Carrig. "The largest come from the ocean itself – it is not an exaggeration to say that the environment in which our boats are operating is the most hostile on the planet – violent storms, caustic ions, even pirates. In many ways, ocean transects make spaceflight look like a breeze.

"We have this enormous technical challenge on top of the typical issues faced by any early stage high-tech startup.

"One thing I'm very grateful for is that we learned relatively early on to seek help. We are not too proud to leverage the wonderful cosmos of investors, inventors, and professionals working in ocean science."

Carrig elaborates on the support AMS has received, in particular from Greentown Labs (GTL). "I can't resist the temptation here to shout out Greentown Labs in Somerville, MA, our home for the last seven months or so. Greentown is an amazing community of people working on big ideas that are instantiated in real things. Being accepted there, and getting to move to the heart of the robotics ecosystem, has been invaluable."

"GTL affords startups real lab space in addition to business enrichment services. This heady combination is very special and cannot be found anywhere else. And, of course, Surge, we would be nowhere without la familia. The sage counsel, and access to capital and customers truly accelerated our growth."

Looking back to the beginning, Carrig says he and his colleagues are indebted to the NSF I-Corps DC, a US government programme to nurture innovative startups. "The mentors there opened our eyes; from babes to businessmen in a few short weeks (feels like a lifetime ago). We could never have imagined that our participation in these programs would have had such a profound effect on our company, our lives, and our ability to engage the problems on which we are so lucky, and thrilled, to work."

AMS recently received a $1.7 million innovation grant from the Virginia research and development program. The money will enable AMS to "scale and refine" its Datamarans. The company says it will keep its manufacturing operations in the US.

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