Brief Product Description

The current focus of the business is a high-quality underwater communications technology that offers superior connectivity for wireless communication with the underwater robots (also known as Autonomous Underwater Vehicles, AUVs), oil&gas pipeline and marine farm monitoring, image transmission from the trawl to bridge, underwater surveillance, oceanographic instrumentation, and military missions. Our current product, termed “ROAM (Robust Acoustic Modem)”, has been shown to provide 10 to 100 times faster connectivity with significantly enhanced reliability than commercial acoustic modems in the market.

ROAM is founded on the outcome of a scientific breakthrough which has enabled us to combine all desirable properties of three main wireless communication waveform techniques in a single waveform, which is merged with a novel set of receiver algorithms. ROAM owes its superior performance to its ability to extract instantaneous and accurate information on the state of the propagation medium and adjust itself to the changes in the environment on-the-fly with unprecedented granularity.

In addition to producing “ROAM”, Marecomms Inc. is also poised to research, design and develop intellectual properties, algorithms and hardware implementations in the broader area of wireless communication and remote sensing systems for maritime environments.

Business Model

Our business model is based on the production of software executing our proprietary signal processing and wireless communication algorithms, and purchasing hardware from third parties to offer integrated software/hardware solutions embodying our underwater acoustic communication product.

An underwater acoustic modem is mainly comprised of three fundamental components: Underwater sensors (*i.e., hydrophones and transducers*), electronics (*i.e., power amplifiers, analog-to-digital and digital-to-analog converters, processing devices*), and transmission and reception software that executes the algorithms. At Marecomms, our strength is in our ability to produce state-of-the-art solutions that are executable on software. In that regard, our solutions are **hardware-agnostic** as they can be executed on multiple various hardware configurations, but they are **hardware-dependent**, as our solutions require specific hardware for successful implementations.

Therefore if we were to rely solely on software licensing as our main revenue stream, we would be able to appeal only to the underwater sensor manufacturers or other underwater modem manufacturers in the market as our customers. This follows from the fact that our software requires the integration of underwater sensors, and the end users (e.g., AUV manufacturers or trawlers) would not typically have the necessary expertise to perform the integration on their own. Following from that, we take the alternative approach, and produce a fully integrated product. By virtue of purchasing sensors and hardware from third parties, and combining those with our own software, we will sell the end-user the complete package that they can readily use, without the aid of any other apparatus.

Such “B2B-disintermediation” business model will enable us to address various vertical markets as we can tailor our software/hardware integrated products for different use cases. Since the software is our main technology driver, selling annual software maintenance packages to existing customers will also bring us recurring revenue.

We have prioritized the AUV market due to the significant growth in the use of AUVs for many different underwater missions and the apparent need for a robust and high-speed connection, which is lacking at present. Evidently, AUV manufacturers either rely on tether cables when large data need to be transferred in real time, or they access their data only after the fact. Our one-on-one conversations with multiple AUV manufacturers (*including Cellula Robotics, Kraken Robotics, Thales France, Kongsberg, ISE Limited and BAE*) made it clear that the present underwater modems in the market fall significantly short of delivering a robust and high-speed communication link for AUVs.

We note, however, that in the future, we may consider software licensing mainly for those jurisdictions that may be lucrative markets, but that place high barriers of entry due to import regulations. There may also be some exceptions to the “disintermediation” business model for a full-scale remote maritime network in the future as we will elaborate in the sequel. We will also have more to say on the supply chain considerations in what follows.

Value Proposition

A major factor impeding the growth of global underwater communication devices is that current communication devices by key market players work only under ideal ocean conditions (*low wind, low shipping activity, low ambient noise, deep water, vertical channel*). A small amount of nonideality (*such as a rough ocean surface in a shallow water environment for horizontal transmission*), however, is enough to break down a typical underwater acoustic communication device produced by competitors.

ROAM distinguishes itself from what is available in the market in providing communication with significantly enhanced reliability even in the harshest ocean conditions. ROAM has been tested and shown to deliver up to 100 times the user data rates offered by competitors in the same environments where off-the-shelf underwater acoustic modems have been shown to lead to significant outages and very slow connection speeds. More information on ROAM and our promotion and demonstration videos are available at www.marecomms.ca

In its current implementation, ROAM is comprised of Marecomms' proprietary algorithms executed on software, underwater sensors (supplied by Geospectrum Technologies as our solution partners) and processing devices including a Central Processing Unit (CPU), and a Graphical Processing Unit (GPU). The hardware-agnostic nature of our solution leads us to consider various other firmware options in the future including the use of Field Programmable Logic Arrays (FPGAs) when viable.

Use of ROAM in a typical AUV use case is illustrated in Figure 1. As seen in the figure, a ROAM transmit unit is embedded in an AUV. The data (*whether they be a sonar image, a photograph, or diagnostic information*) captured by the AUV are translated into a sound wave and emitted by the ROAM transmit device, as depicted in the bottom-right of Figure 1. As seen on top-left portion of Figure 1, a ROAM receiver unit is placed on a support vessel. The receiver unit comprises of a hydrophone array towed by the vessel and a top-end unit. The data obtained by the hydrophone array are brought to the top-end unit, which, as depicted in this illustration, is a computer allowing the human operator to inspect and store the received data in real time.

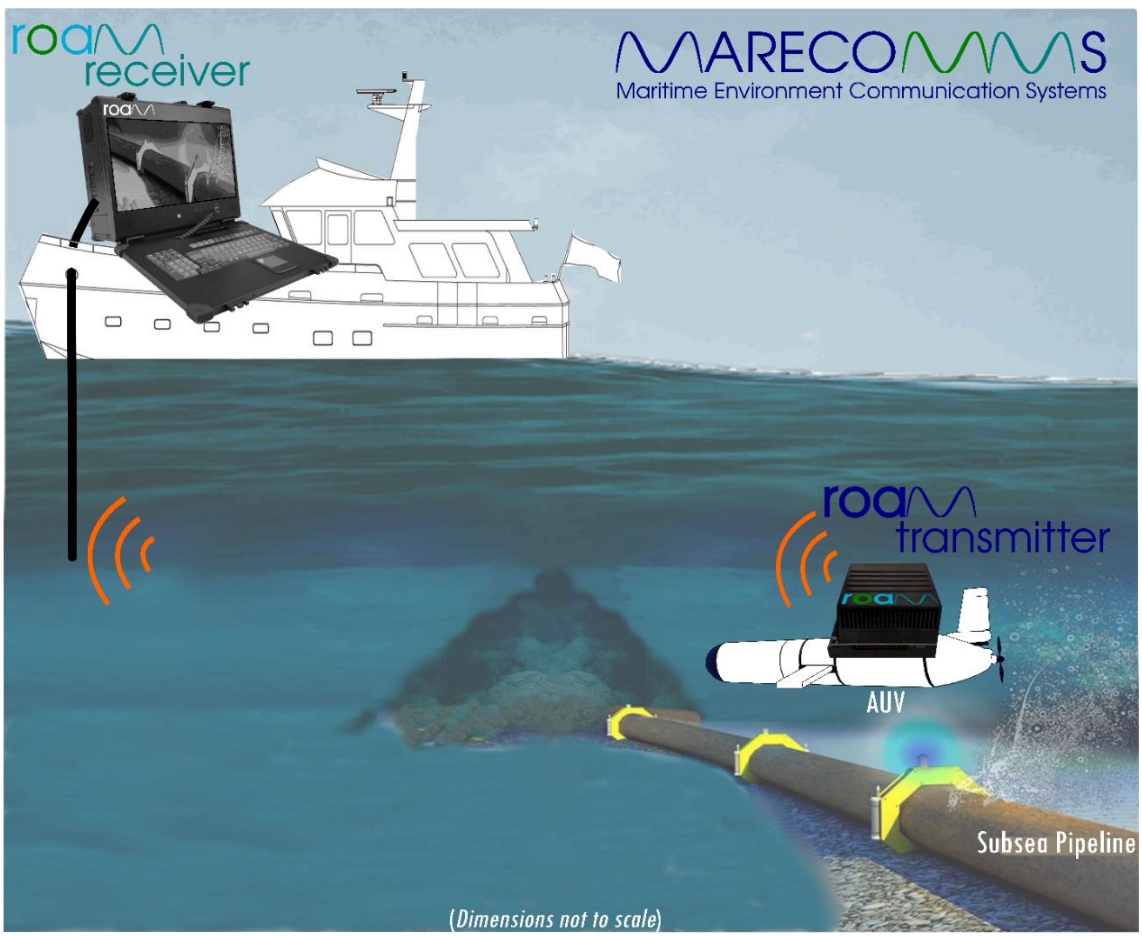

Figure 1. A depiction of ROAM for AUV use cases. The ROAM transmit and receiver components are enlarged for convenient visualization, and dimensions are not to scale.

Addressable Market Pain

The MarketsandMarkets (www.marketsandmarkets.com) forecasts that the global underwater acoustic modem market will grow to $2.86 Billion by year 2023. While this figure can be considered as a forecast on the growth of existing market, ROAM will leverage untapped opportunities thanks to its image transmission capability. Therefore, with ROAM, AUVs will be significantly more capable to be employed in those missions that are considered infeasible with the current underwater acoustic communications technology. More specifically, the total market opportunity for ROAM as a combination of present market and untapped potential amounts approximately to **$5 Billion** (*Military market not included*) as we will elaborate. The use cases in this market estimate include the AUV missions, Commercial Trawl Fisheries and Offshore Aquaculture.

The AUV market itself is expected to grow into a $5.2 Billion market. Note, however, that not all AUVs are equipped with an underwater acoustic modem, as tether cables are still the preferred method of large data communication with AUVs. Given the fact that nearly a quarter to half of AUV apparatus is spared for communications equipment, we estimate that **$1.3 Billion to $2.6 Billion** market opportunity will arise in this domain.

One specific area of AUV use cases where a reliable, broadband underwater acoustic communications system as ROAM would alleviate a significant pain is the inspection of underwater oil&gas pipelines and distribution infrastructure. This is currently a labor-intensive task, where a crew of 5-6 employs AUVs to gather inspection data along the pipeline (*typically chemical sensor readings as well as images*) and those data are analyzed by data analysts in an offline fashion after the AUVs have been rescued, since current underwater communications technology falls short of stringent reliability requirements. It costs approximately $300,000 to inspect 35 km of pipelines (*Estimate offered by Former Slumberger Scientist*). It is estimated that there is nearly 600,000 km of offshore pipelines around the globe including existing and under construction infrastructure. Hence the cost per inspection cycle amounts, approximately, to a $5 Billion pain. If a ROAM transmit device is installed in the body of an AUV that moves at 1 knot velocity, a week-long job can be reduced to a 1 to 2 day job. A faster and more expensive AUV can further shorten this duration. Considering the size of the pipelines, we anticipate that this use case can accommodate us to sell 5,000 to 6,000 modems as a conservative estimate. Therefore, this creates an untapped market opportunity of **$0.5 Billion to $0.6 Billion** for ROAM. Eventually, a $5 Billion pain will be reduced to $0.5 Billion to $0.6 Billion thanks to ROAM.

Let us next quantify the Commercial Trawl Fisheries market. The Food and Agriculture Organization (FAO) of the United Nations estimated that the worldwide fishing fleet consisted of about 2.86 Million motorized fishing vessels in 2018. FAO also estimated that 3% of these motorized vessels (*i.e., approximately 85,800 vessels*) have a length of 24 m or larger with the greatest proportion located in Oceania, Europe and North America. Then if we equip each vessel with a ROAM system, we have a potential market size of $8 Billion for this use case. We note, however, that markets other than North America and Europe may present a very high barrier of entry. Therefore our realistic market size estimate is one quarter of large vessels, amounting to approximately 85800/4=21450 vessels in North America and Europe. That creates an untapped market opportunity of **$2.145 Billion** in North America and Europe.

Smart technologies for aquaculture farms are still at their infancy due to the fact that regulations still allow fish farms to be located inshore. This, however, will change in the near future. Evidently, more and more fish farms are being moved to open-ocean sites in Panama, Mexico and Norway. In an open-ocean farm, without a remote monitoring system, daily inspection and feeding cycles are still a labor-intensive effort performed manually. Open-ocean fish farms are typically 15-50 Km away from the nearest shore. Feeding and monitoring activities require staff to drive to farm on a daily basis, and the infrastructure observation is performed by divers who physically monitor the state of fish pens. This amounts to nearly **$100,000** per day (*Estimate offered by Cooke Aquaculture*). Incorporation of wireless technologies that use cameras and other sensors such as ROAM can automatize a significant portion of those tasks. In particular, feeding can be automatized using silos installed in the centre of each pen, and continuous infrastructure monitoring means that real time information on the health of fish and infrastructure is remotely accessible. As a result, human intervention can be minimized to renewing the feed stock, transportation of fish, and maintenance. If visits per day can be reduced to visits 2-3 times a week, then 2-3 fold savings in operational costs can be achieved. Although it is difficult to speculate on the total number of offshore fish farms that will emerge in the near future, nearly 53% of seafood will be farmed in offshore aquaculture facilities globally by year 2030 based on the data published by FAO.

Consequently, the combination of AUV and Fisheries markets alone presents up to a **$4.7 Billion** market opportunity, whereas a significant increase in this amount should be expected when the Military market and future offshore aquaculture markets are also accounted for, which are difficult to estimate as of today.

Competitive Landscape

Herein we compare the competitors' AUV modems in terms of price, range (communication distance) and the throughput (net data rate). We note that the competitor devices are typically tested in calm and cooperative ocean conditions, and consistently reported to break down when exposed to more challenging and realistic environments. Hence the chart refers to the competitors' best case data rates. The vast amount of real time end user experience, however, reveals that those data rates are almost never achieved in practice. For instance, Kraken is presently using EvoLogics modem, and the net throughput that they have measured is around 100 bits per second, which is 150 times less than the catalog info. The same is true for Teledyne modems based on the personal experiences of our colleagues including Dr. Mae Seto from Dalhousie University, DRDC-Atlantic, Kongsberg, and Geospectrum Technologies.

Company	Price	Data Rate (bits per second)
LinkQuest Inc.	Approximately $35,000 US	14,000
TELEDYNE MARINE Everywhereyoulook	Approximately $30,000 US	140 – 15,360
EvoLogics	Approximately $25,000 US	Up to 13,900
DSPComm	Approximately $16,000 US	Up to 1,000
MARECOMMS Maritime Environment Communication Systems roam	$60,000 - $100,000	72,000 achieved in June 2021 as a combination of acoustic link speed and our proprietary image compression ratio. 108,000 and 144,000 bits/s will be trialed on Stella Maris in late June – early July 2021

As seen in the chart, our maximum data rates are already significantly higher than the competitor products' best case scenarios. It should also be noted that our prices will depend on the selected hardware configuration. We will assist our customers on the most suitable hardware selection (*including the length of an array, which will determine the required computational power*) based on the environment that they want to use ROAM in.

Current Status

The core communication technology in ROAM has been rigorously tested and it is currently in TRL7 level. Our current prototype is working in real time, and the latest real time experiments took place on June 4, 2021 on Stella Maris platform in the presence of third parties for our H2O demo day presentation.

In order to address AUV customers, ROAM will need to be presented as an integrated package. This will require the inclusion of a cooling and pressuring system at the transmit side, and a presentable top-end unit for the receiver side. The receiver top-end unit will contain the analog receiver components and our processing device in a single case (*e.g., a pelican case*). Once this integration has been completed, we will install ROAM on a test AUV for use-case ready demonstrations in a pilot project. For this, we have approached Kraken Robotics first, and they are interested in working with us for such joint tests. Additionally, we talked with Cellula Robotics of B.C., as well as BAE Systems of UK to discuss a pilot project. These discussions are presently ongoing. We anticipate that in the next 9-12 month period, we will have completed the production of our first commercial unit and it will have been mounted and tested on an AUV, and we will be ready for marketing, promotions and sales.

Supply Chain

At present, ROAM encompasses a Transmit Computer, a Power Amplifier, a Step-Up Transformer, and a Transducer at the transmit side. The Transmit Computer that we deployed on Stella Maris platform is a Raspberry Pi computer. For high power applications, we will use a PC-based platform using a power-efficient mother card. We will purchase the Power Amplifier (PA) and Step-Up Transformers from Benthowave Systems in Ontario. After examining various PA options, we decided that Benthowave would be an adequate supplier both in terms of the capabilities of their PAs and the ease of supply logistics. We design the Step-Up Transformers ourselves based on the transducer characteristics and outsource the manufacturing of the transformers to Benthowave as well. Our transducers are supplied by Geospectrum Technologies (GTI), from whom, we also receive significant technology assistance on the details of transduction methods.

At the receiver side, we have a Hydrophone Array (supplied by GTI), an Analog Receiver (GTI), a multi-channel Data Acquisition Board (DAQ) and a receiver computer. The receiver computer that we have deployed at Stella Maris Operations Centre is a GPU-CPU based custom-built computer. The DAQ unit is supplied by a General Standards of Houston, TX.

Following from the supply chain model, the only item that is supplied from an international manufacturer is the DAQ board. This is a highly specialized apparatus that can sample data from multiple sensors at a very high rate in a synchronous fashion. It is, therefore, expensive, and one of our future goals is to build this unit in-house. Other than that, we anticipate that once COVID restrictions are lifted, our supply chain will be dependable enough to support our growth.

Growth Strategy

Our immediate goal is to address the AUV market, and start generating revenue both in selling new units and software maintenance in the next few years following commercialization. In the near future, we will also address the Commercial Fisheries use case, which brings some additional difficulties, but at the same time presents a significant market opportunity. In order to address multiple verticals simultaneously, we will create internal divisions at Marecomms where each group will have a common platform to build on, but will specialize in addressing the particular use case requirements.

Once we have launched ROAM successfully as a point-to-point communication link, we will also deploy an underwater internet of things building and expanding on ROAM. We believe that this product will be a significant asset allowing us to penetrate deeper into the AUV market by leveraging the military use cases.

In order to create a fully autonomous remote maritime network, one of the items on our future agenda is merging ROAM with a Radio Frequency (RF) link to relay the data obtained under the water to remote land stations. We have a US patent on an invention of ours in the development of a low-cost mobile wireless receiver that is optimized for battery efficiency (https://patentimages.storage.googleapis.com/3a/89/ae/6ca3ba3ae083d3/US10374853.pdf). We will leverage this invention by leasing either a satellite link (such as future Starlink) or an existing High Frequency (HF) link for relaying data to remote locations.

As mentioned previously, the core technology underlying ROAM is capable of detecting and tracking the environmental variations with very high accuracy and resolution. This motivates us to use the foundations of ROAM to serve as a communication and a remote sensing system at the same time. In other words, one of the future goals will be addressing a joint sonar/acoustic modem platform.

In light of the above growth strategy, our goal is to become a team of 100 in less than a decade by hiring engineers, scientists, technologists and business, marketing and sales personnel.

Future Subscription Based Model

For the future fully integrated RF remote maritime network that we conjecture, our objective is to establish permanent communication facilities, and charge the users per Kilobyte of data usage. Our own maritime communication networks will serve for multiple purposes including gathering data from open-ocean aquaculture farms, mammal monitoring systems, wind turbines as well as future autonomous shipping fleets. Subscribers will have access to our relaying networks that may include a satellite link, an HF link, or combination of both.