ATLANTIS RESOURCES

For more than a decade, Atlantis has pioneered the development of tidal current power as a predictable source of reliable, economic and secure renewable energy.

JANUARY 2015 **NEWSLETTER**

AR1500 TIDAL TURBINE SYSTEM UPDATE

Building on a rich heritage of designing, constructing and testing market leading tidal turbine generation systems over the past decade, the first of the new Atlantis 1.5 megawatt flagship AR1500 tidal turbine systems will be delivered to MeyGen project in Q1 2016. The AR1500 project combines ten years of research and development at Atlantis with the engineering experience of Lockheed Martin Corporation, one of the world's largest and most sophisticated global systems integrators. The design intent of the AR1500 is simple; the delivery of the lowest cost of energy through military specification reliability and intelligent simplicity.

The AR1500 is an active pitch, full yaw, horizontal axis tidal turbine with a rated power output of 1.5 megawatts achieved at flow rates of three meters per second. Lockheed have been engaged by Atlantis to compete the detailed design of this turbine, which has been undertaken by Ocean Energy, a division of Lockheed Martin Mission Systems and Training (MST) which provides systems engineering, software development, complex program management, supply chain solutions and logistics, and training and simulation technologies for global security, civil and commercial markets.

INTRODUCTION BY DREW BLAXLAND, CHIEF TECHNOLOGY OFFICER

"Our efforts to develop tidal generation projects at good economic returns to project investors has driven internal focus on holistic marine energy solutions that include integration of fit-for-purpose infrastructure such as turbine foundations, nacelle deployment systems, power export cables and grid conversion equipment. Our intimate understanding of these interface requirements and challenges will ensure that the AR1500 design is fully optimised, enabling lowest cost of energy for the developer over the life of the project."

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"We have focused on a synchronous approach to component integration to produce this best-in-class product. Our partnership with Lockheed Martin is testament to our commitment to excellence. Lockheed were awarded the engineering contract for the design of the AR1500 in 2013 and having just completed a crucial design stage, will complete final production engineering in Q1 this year, meaning we are well on target for delivery of the first AR1500 to the MeyGen project on time. I expect to unveil the first AR1500 at the end of this year prior to hand over to the MeyGen Project. Both the Lockheed Martin and Atlantis Technology team members deserve high praise for leaving no stone unturned throughout this process. In my opinion, we have now developed a product offering that is second to none in the fully submerged tidal power sector." Mr Blaxland adds.

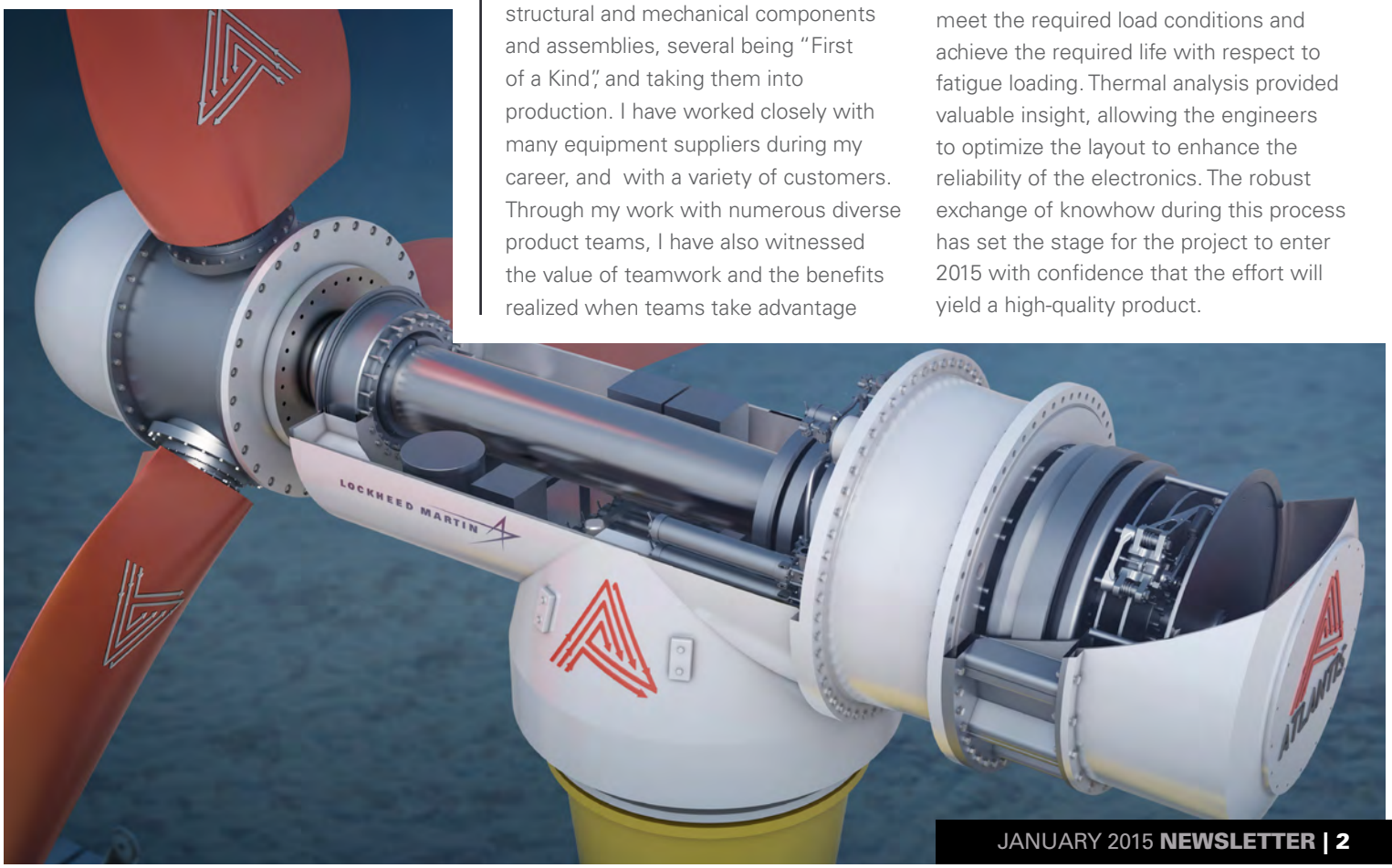
INTERVIEW WITH DOREEN NIXON, OCEAN ENERGY CHIEF ENGINEER FOR LOCKHEED MARTIN

Doreen, tell me a little bit about yourself and what experience you are bringing to the AR1500 turbine development with Atlantis

Sure. I am the Chief Engineer for Ocean Energy at Lockheed Martin with over 30 years of engineering design and management experience.
I hold a Master's degree in Mechanical Engineering and am a registered Professional Engineer. I spent the first few years of my career working in a steel mill so am quite familiar with huge steel structures and challenging environments. The remainder of my career has been with Lockheed Martin where I have had the opportunity to design numerous structural and mechanical components and assemblies, several being "First of a Kind", and taking them into production. I have worked closely with many equipment suppliers during my career, and with a variety of customers. Through my work with numerous diverse product teams, I have also witnessed the value of teamwork and the benefits realized when teams take advantage of diversity of thought and blend that into an optimized design. The last half of my career has been in management where I have led Hardware and Systems engineering organizations of over 1600 engineers. The experience gained from managing such a talented group of people, as well as programs, has also greatly enhanced my network of experts within Lockheed. Seeing a design evolve from concept to production is a passion of mine. I am excited to be part of the AR1500 program and look forward to continuing to work with Atlantis to bring the AR1500 turbine into high volume production.

A critical juncture for the design of the AR1500 is just being completed and is the gating process before moving into final engineering and placement of supply orders. How does Lockheed feel that this has gone and how is the project now set to enter the next stage?

We just completed a very comprehensive review of the AR1500 design, which we believe was valuable, successful and positions us very well for the transition into 2015 where Atlantis plans to start placing orders for time critical components. Extensive structural analysis provided confidence that the design will meet the required load conditions and achieve the required life with respect to fatigue loading. Thermal analysis provided valuable insight, allowing the engineers to optimize the layout to enhance the reliability of the electronics. The robust exchange of knowhow during this process has set the stage for the project to enter 2015 with confidence that the effort will yield a high-quality product.



How does Lockheed Martin feel about the quality of the design work and the interaction that has been achieved between the Lockheed and the Atlantis teams?

The Atlantis team is a talented group with excellent experience in the operating environment that the AR1500 will see. We established a strong communication with them , which includes regular status meetings and one-on-one communication amongst the engineers to discuss the design and resolve design details on an ongoing basis. Getting to this level of comfort took effort from both Atlantis and Lockheed Martin, as our internal processes are very different, and extra effort was expended to ensure details that drove priorities were thoroughly understood. We are now working as a team totally focused on, and committed to delivering a turbine that is reliable, producible and will be an industry leader. As we work through the final engineering and pre-production phase, I expect this interaction to continue.

The Atlantis turbine team is regarded as one of the most experienced currently operating in the tidal turbine sector; what specific skills and experience has Lockheed been able to bring to complement and enhance this capability?

We believe that the long-term success of tidal energy requires collaboration and shared expertise. I think it is very safe to say that the combination of Lockheed Martin and Atlantis on the AR1500 design is a powerful one, resulting in a better turbine than either of us could have designed on our own. While this has sometimes proved challenging to both companies it is having very good results. Lockheed Martin's design team brings a broad talent base with expertise in designing and fielding first-in-class systems. We bring a rigorous design process, advanced mechanical and electrical analysis skills and tools, and the ability to reach across a very large corporation to apply talent where needed with the skills to solve very specific problems. Our team is primarily mechanical engineers but also includes highly skilled electrical engineers with expertise in electrical design, power systems, I/O and control. Our systems engineering expertise has provided an overarching structure to the program to ensure overall system performance and verification methods are front and foremost in the decision making process. Our specialty engineers are experts in reliability, maintainability, availability and system safety. They develop system level reliability models and ensure that personnel and system safety are assessed throughout the design process. Our team is highly skilled in designing complex systems that provide high reliability in harsh operating environments. We also have extensive experience working with a diverse set of suppliers that are engaged throughout the process to ensure competitive and highly producible designs. In addition to our core AR1500 team, we have also used our extensive LM Engineering Fellows network and other experts across our very large corporation to provide expertise in design details as well as serve as independent reviewers of our designs.

Two of the most critical components of the turbine are the yaw and variable pitch systems. How do Lockheed assess that these components are progressing and how do they think that they will compare to competing products?

Both designs matured significantly over the last couple of months, in parallel with maturing the overall AR1500 design. The yaw design is very compact and highly integrated. A clear advantage of Lockheed Martin designing both the nacelle and yaw is that the engineers worked closely together to optimize the overall turbine load path resulting in designs that showed significant weight savings and enhanced accessibility for assembly and maintenance.

The Variable Pitch System (VPS) takes a lot from existing systems to reduce risk, but we have designed a unique pitching mechanism, optimized for the AR1500. In addition to our own mechanical engineering team, we are working closely with industry recognized leaders in components and VPS manufacturing. We performed an extensive industry evaluation to select the best company to successfully manufacture and test our variable pitch system. We selected Schottel, an industry leader, and they are currently under contract to Lockheed Martin. They are also continuing to provide our team design-for-manufacturing recommendations as we advance towards the build of the unit this year. The combination of Lockheed Martin and Schottel positions us well to provide a highly competitive, reliable and robust variable pitch system for the AR1500 turbine.

How is Lockheed contributing into the AR1500 delivery for MeyGen Phase 1a and other Atlantis projects?

Lockheed Martin is making a significant investment to fund the design and first-of-class manufacturing of the AR1500 Yaw Drive System and Variable Pitch System as part of our technology partnership teaming agreement with Atlantis. For MeyGen Phase 1a, it is planned that those first-of-class systems funded by Lockheed be made available for use by Atlantis. Under a contract to Atlantis which we are currently finalising, it is planned that we will also lead the nacelle manufacturing, nacelle integration and the integration of the yaw and pitch systems to the nacelle. So, we lead the manufacturing and integration of the main elements that we are designing, which we believe is a very good approach. We are also planned to serve as the overall Systems Integration Assurance lead and to provide Quality Management oversight of the manufacturing and assembly processes, which is a key part of ensuring a successful turbine delivery. In Lockheed Martin, Quality Assurance is an independent, disciplined group with expert knowledge of manufacturing processes and a proven track record of implementing proper controls to ensure that program processes are adhered both internally and at suppliers.

We are also working with Atlantis on developing a tidal energy project in the Bay of Fundy in Nova Scotia, Canada. In 2014, we, along with Atlantis, continued to advance this project, and we were instrumental in securing a grant for Atlantis that will help to keep the project moving forward. Nova Scotia is demonstrating real support for tidal energy, and we are looking forward to continuing to work closely with Atlantis to have our technology also fielded in a Canadian project.

Rotor blade testing, Bristol, 2014

The successful execution of the AR1500 design programme during 2014, aligned to a manufacturing strategy making use of modularised OEM components, means that the ordering of long lead time items has now commenced in January 2015.

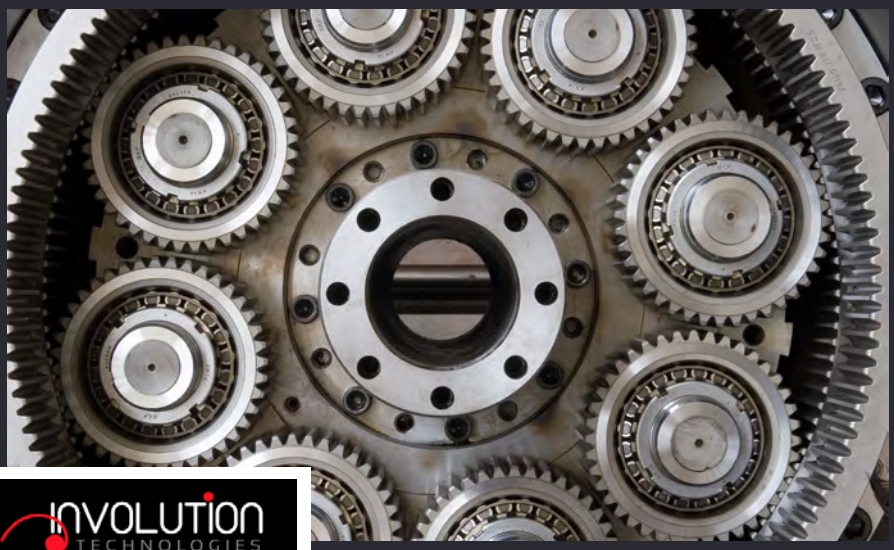
Mr Dave Rigg, the project director at Atlantis entrusted with the delivery of AR1500 turbine systems to the MeyGen project, explains that "the AR1500 manufacturing strategy is another key enabler to the design intent. Each of the key system modules has been designed to allow for manufacture at separate locations facilitating greater supply chain flexibility, less complex assembly and more efficient sub-systems testing. For example, the front section of the nacelle (Module 1) will be procured, assembled and tested by a single supplier before being delivered to a central assembly facility. This facility will receive and assemble all of the various turbine modules, which will all have undergone their own testing at their respective factories. As the Systems Integrator, Lockheed will be responsible for managing the assembly, testing and commissioning of the world's most advanced tidal power generation system, the AR1500".

AR1500 DRIVETRAIN - PERMANENT MAGNET GENERATOR

THE SWITCH

The AR1500 utilises a highly efficient Permanent Magnet Generator designed and manufactured by The Switch in Finland. The Switch have a long standing history of providing highly efficient permanent magnet generators to the wind industry and to the marine sector. They have a wealth of experience designing medium speed generators such as the one which will be used on the AR1500 turbine drive train. The Switch also have a significant role to play in the design of the gearbox and generator mating interface. By integrating the generator and gearbox as a pre-tested module, we are reducing assembly risk, reducing cost and improving reliability through the reduction of the number of assembly stages required prior to full commissioning of the nacelle.

Permanent Magnet Generator, The Switch, Finland



Flexible Pin Gearbox, Involution Technologies

AR1500 DRIVETRAIN – GEARBOX

The design-manufacturing partnership of Involution Technologies Ltd (UK) and HAGG (Hangzhou Advance Gearbox Group, China) were selected through a tender process in 2013 to provide the gearbox. Involution Technologies have significant experience in providing gearbox solutions for both wind and tidal turbines. HAAG currently produce flexible pin wind turbine gearboxes to Involution design and see a natural fit for high torque tidal turbine gearboxes in their well established production facilities. The gearbox design incorporates proven flexible pin technology with a self-aligning low speed shaft, eliminating the need for flexible couplings. This, in addition to the fact that the gearbox unit is passively cooled reduces cost and failure risk.

AR1500 CONTROL SYSTEM

Development of the AR1500 Turbine Control System (TCS) is well under way. DNV GL (Garrad Hassan) are nearing completion of a detailed design contract focusing on optimisation of the rotor speed and power control algorithms, with respect to performance and minimisation of extreme loads. The next stage is to deploy and test these algorithms on the Beckhoff PLCs that will sit in the MeyGen substation – a process that will be significantly de-risked through trials using demo hardware in the coming months. These trials will also involve demonstrations of the Safety System and Supervisory Controller designs.

AR1500 SUBSEA CONNECTION MANAGEMENT SYSTEM (CMS)

The AR1500 Connection Management System (CMS) has evolved from the electrical connection systems used on our previous tidal turbines and is the culmination of four years of research and development work. It provides a means of electrically connecting the turbine to the subsea cable as the turbine is landed onto its subsea foundation. Achieving a simultaneous mechanical and electrical turbine connection without any ROV or diver assistance in a single operation enables us to minimise the construction time required on site, and as such is a major advantage. This reduces the operational cost but more importantly it reduces our exposure to weather risk.

Over the next few months this system will be tested in a purpose made rig to confirm that the connectors mate correctly even when the turbine landing exceeds impact and misalignment limits.

INTERVIEW WITH DAVE RIGG, HEAD OF OPERATIONS AT ATLANTIS

How long have you been at Atlantis and what do you do there?

I started with Atlantis in 2009, working as the Project Manager responsible for building and installing our first 1MW tidal turbine. I am now Head of Operations and lead the team that will deliver the AR1500.

What is a CMS and a NIT and why are they important?

Marine construction in extreme tidal conditions is challenging. The challenge is exacerbated by the fact that our projects tend to be based in regions that are subject to extreme and unpredictable weather conditions. We have mitigated the risk of weather related delays by designing a turbine intervention system that minimises the required on-site construction time. The CMS (Connection Management System) and the NIT (Nacelle Intervention Tool) are two innovations that we have developed over the last four years to enable us to install and recover turbines in swift single operations without ROV or diver intervention. The CMS enables the electrical connection between the turbine and the subsea cable. The NIT is a hydraulically operated lift frame that incorporates spotting cameras and a passive alignment system to enable the remote docking of the tool with the turbine.

INTERVIEW WITH DAVE RIGG, HEAD OF OPERATIONS AT ATLANTIS CONT.

How is the AR1500 delivery program coming together?

With the design nearing completion we are now in final negotiations with various suppliers to provide the major elements of the turbine. Much of the turbine will be procured in Scotland and the turbine is also due to be assembled at a Scottish location.

Why do you think that the AR1500 turbine system will be best in class?

Over the last five years we have acquired a core team of engineers who have more experience in the design, build and operation of this technology than any other organisation in the world. We have enhanced this expertise with the might of Lockheed Martin, a company who have a long history of designing and building innovative machines for very challenging environments.

The tidal environment is very unforgiving and requires a right-first-time approach. As a result we have developed a bespoke quality control system. The Quality Control Map (QCM) captures every quality control activity in the manufacturing and assembly process. This tool is driven by a database and enables us to plan, monitor and audit the quality control process with great precision. Much of the quality control will be based on sub-system and system testing, the most significant of which will be the full drive-train testing at the National Renewable Energy Centre (Narec).

I am confident that this combination of core engineering expertise, unparalleled tidal experience and a surgical focus on quality control will produce the world's leading tidal turbine.

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