Post-Conference Report

Written by Allan Devlin, SUT Phoenix Committee Chair (Sub-Committee of the SUT Perth Branch)

Approved by: Session Chairs: Ian Hobbs (Fugro) & Peter Wademan (Woodside Energy)

Rex Hubbard, SUT Perth Chair, opened the conference welcoming the delegates & exhibitors and thanking the Major Sponsors **Fugro Survey Pty. Ltd. and Woodside Energy Pty. Ltd.** that, with their support made the 11th AUT conference possible, the Coffee Cart Sponsor **Subsea Technology & Rentals**, and the Lunch Sponsors **Western Advance, Unique Group and Seafloor**. Rex also gave a special acknowledgement to the members of the **2019 AUT Conference Organising Committee: Stuart Higgins (Curtin University), Mark Casey (Santos), Shuhong Chai (AMC UTAS), Steve Duffield (AHS), Pat Fournier (Neptune), Ian Hobbs (Fugro), Graeme Moya (UTEC), Brendan Reid (Innovative Solutions Plus), Anurag Saxena (TMT), Chris Saunders (INPEX), Wademan (Woodside Energy) and Phil Wells (Neptune)**. Rex also thanked the **SUT Staff**, and Ice breaker event sponsors **Seismic Asia Pacific Pty. Ltd.**

Delegates at Ice Breaker Event

Session A1 AUT – "Opening our Eyes"

The programme commenced with Rex welcoming the session chair **Ian Hobbs (Fugro)** who introduced the keynote speakers.

The keynote presenters **Commodore Chris Smith, Director General Littoral, Royal Australian Navy (RAN) and Commander Paul Hornsby, Navy Lead – Autonomous Warfare Systems, RAN** presented "Sail, Steam… Autonomy? AUT's & 21st century Naval Operations".

The Royal Australian Navy's transition toward Maritime Autonomous Systems (MAS) for naval operations is comparable to the transition from sail to steam. This Warfare Revolution is also underway throughout the world's militaries, and the application of MAS today is already shaping future warfare. Australia is a world leader in the transition to AUVs and USVs. This evolution is forcing a paradigm shift in the way business is done. There have been paradigm shifts historically with new technologies such as anti-ship missiles. The latest paradigm shift involves the introduction of MAS including Autonomous Underwater Vehicles (AUVs), Unmanned Surface vessels (USVs) and Unmanned Arial Vehicles (UAVs). In Australia, the RAN is currently looking at "Off-The-Shelf" solutions, and also supporting innovations in MAS technologies. This is deliberately blurring the lines between Defence and civilian MAS expertise, whilst also opening the door to countless opportunities for collaboration and cooperative improvement. The presentation explored some of the RAN's experimentation with, and integration of MAS. Ships, Submarines and Aircraft are becoming nodes in a network that includes these MAS, operating in all domains (i.e. air, surface, sub-surface, ground and cyber / Artificial Intelligence (AI)) concurrently on one system. As part of this technology development and deployment, trust in autonomous systems will be required, and this involves cultural change within the RAN. MAS operators must test the logic, or AI, that meets the expectations of regulators and the public. Protection of people, the environment and property is paramount in the development and deployment of MAS. Quoting Benjamin Franklin "Well done is better than well said", **Commodore Chris Smith** handed over presentation duties to **Commander Paul Hornsby**.

System integration will be critical, to digitally integrate unmanned systems across multiple domains. Trends (& Threats) include MAS as a Force Multiplier, Interoperability, Integration and Agility. The presentation explored how the future may unfold for MAS-related partnerships between RAN, industry and academia. Specific examples examined deployment of MAS for countering sea mines and conducting hydrographic survey, and more broadly, the challenges faced when delivering and supporting such radically different capability. Future developments include a greater focus towards AI, including software, Robotic Process Automation (RPA) and Machine Learning (ML) to support Combat Management Systems decisions. AI applications in Robotic & Autonomous Systems include Context Awareness, On-board Payload Analysis, Network Independence and progression towards Trusted Autonomy. Littoral is the most complex area to deploy MAS. If RAN can successfully deploy MAS in the Littoral area, it can be deployed in all areas.

Keynote presentation

Richard Mills (Kongsberg Maritime) presented **"**Building on the X-Prize: Collaborative Unmanned Survey Capabilities". The presentation gave an overview of the Shell Ocean Discovery X-Prize, where Kongsberg Maritime (KM) supported the winning Nippon Foundation-GEBCO Alumni team. The winning technology involved a collaborative USV and AUV System with Kongsberg at the core. The drivers to develop collaborative systems include improved area coverage, better data quality, better positioning, enabling concurrent activity, reduced cost per bit of data and improved environmental performance. Challenges to operating AUVs and USVs include weather, endurance, data handling, fault management, and trust in autonomous systems. The presentation introduced the KM Sounder USV System, a unique multi-purpose USV platform, optimal for hydro acoustic applications. The Sounder USV System provides exceptional manoeuvrability and directional stability, which is important for data quality. The Sounder features a state of the art scene analysis system for situational awareness that enables collision avoidance. AI influences the control system K-Mate for The Sounder. A Case Study example was provided of KM using K-Mate with collaborative systems to support Swire Seabed complete an Unmanned Pipeline Survey for Equinor in 2019.

Mark Evans & Alex Mosnier (RHUM Forum) presented **"**Optimizing Hull, Mooring and Riser ROV/UAV Inspections – An Industry Position". The Risers, Hull, Umbilicals and Moorings (RHUM) Forum is a structured forum to enable informal sharing of new (public domain) technologies, best practices, lessons learned and identification of key topics that require formal collaboration. The RHUM Forum facilitated a dialogue between Suppliers and Operators on the focus topic: Optimisation of ROV/UAV inspections. It was determined that Operator key drivers included safety, economics, data capture & use, and technology risk. An overview was provided of the Operator vision for the next 5 year horizon in terms of vehicles & tooling, navigation/location, data and manning. The presenters then led a panel discussion with invited members: **Chris Saunders (INPEX)**, **Mark Casey (Santos)** and **Graham Merrey (ConocoPhillips)**. This included a discussion on where their organisations were with Optimisation of ROV/UAV inspections on the 5 year horizon (i.e. Now, 1-3 Years, 4-5 Years). A key lesson learned shared was that Technology Qualification inherently involves failure, and learning from the root causes of a failure to eventually succeed in developing new technologies.

Panel session

Session A2 AUT – "Bites"

Gilles Gardner (i-Tech 7) presented "Dawn of the Drone: A new method for delivering IRM services subsea". The presentation provided an overview of the "Snorre A" development in the "Tampen" area of the North Sea, and a Subsea Hybrid Vehicle Concept Study to investigate deployment options for an Underwater Intervention Drone (UID). The Snorre Expansion Project chose a Subsea7 Pipeline Bundle solution, with a carrier pipe to contain flowlines, umbilicals, and towheads including power and communications for UID "Docking Stations". The Operational requirements of the UID included an ROV system for the Snorre A Tension Leg Platform area, and a Hybrid autonomous vehicle for the In-field area. The study recommended a battery powered Hybrid ROV/AUV with infrastructure including Docking stations with subsea charging, intelligent power distribution & fibre cable network communications connected to an onshore control centre. The key findings of the study include: There are no technical show stoppers for UID service by 2020; the Hybrid Vehicle solution would provide Autonomous Inspection with human-in-the-loop intervention capabilities; the Docking stations can be deployed in various configurations; and careful management of the Power and Communications network is essential. The key benefits of the UID Concept include: a savings in vessel days; reduced operational footprint offshore; reduced HSE exposure; and reduced carbon footprint.

Geoffry Lawes (iXblue) presented "Long-Term Robust AUV Control using a Gyro-compassing Inertial Navigation System". The presentation gave an overview of principles of inertial navigation which involves initial state, rotation, acceleration and integration. Gyroscopes are used for inertial navigation, but have error types including systemic (biases) and random errors (noise) that can reduce accuracy. The principles of Gyro-compassing, north sensing accuracy limits, and the effect of bias on INS position error were outlined. To achieve long-term robust control in an AUV it requires a gyro-compassing INS that provides: Pitch and roll reference to an external fixed orientation (up) with predictably distributed measurement errors; Non-drifting heading, not derived from external sensors, continually referenced to an internal computation of true north; Positioning output with predictable uncertainty distributions; and Lowest possible bias instability (preferably at or below 10^{-3} ^{0}/hr).

Richard Mills (Kongsberg Maritime) presented "HUGIN Superior: Increased Survey Productivity". HUGIN Superior AUV was introduced, providing Superior data, navigation and endurance. The HUGIN Superior provides industry leading data quality and superior area coverage with the HISAS 1032 Dual Receiver. For example, a 0.35km^2 IKEA Store could be surveyed in 4 minutes and 40 seconds. Micro-Navigation aids the in-situ navigation processors and Sunstone to generate a position estimate. Improved navigation accuracy combined with greater energy density batteries, reduces the need for regular supervision and enhances mission durations enabling operators to conduct concurrent activities. The HUGIN Superior AUV can carry and operate an unrivalled sensor package (e.g. imagery, bathymetry, environmental assessment), providing better than ever data positioning, and reducing the total cost of ownership.

Morning Tea/Coffee break & Exhibition

The morning break enabled the delegates to discuss the presentations, ask a few more questions of the session A1 & A2 presenters, visit the stands of the exhibitors (**Woodside Energy, Fugro Survey, Oceaneering, Seismic Asia Pacific Pty Ltd, Offshore Unlimited, Metocean Services International/ecoSUB Robotics, Western Advance, Neptune Geomatics, Ocean Floor Geophysics/Cellula Robotics, and Unique Group and Seafloor**) while networking and sipping on a fine coffee sponsored by **Subsea Technology & Rentals**.

Session A3 AUT – "Survey Operations & Subsea Inspection"

David Donohue (iXblue Pty Ltd) presented "DriX, The mapping tool of the future". The presentation showed Australia's Exclusive Economic Zone (EEZ) and maritime area of charting responsibility extending south to the Australian Antarctic Territory, east to include Norfolk Island, Papua New Guinea and the Solomon Islands, and west half-way across the Indian Ocean. This survey task would take too long and be too expensive with current technologies. How does industry increase output and reduce cost? The solution is to automate the vessel and everything onboard. Using multiple autonomous vessels from a single host vessel offers significant efficiencies if allowed to operate for long periods of time. iXblue considered several USV's for offshore surveys, but remained unsatisfied. Therefore iXblue decided to develop their own USV called DriX, designed for offshore surveys with high speed, high endurance and versatile payload support. The DriX hull is a ballasted wave-piercing round-bilge design, providing stability for optimal coverage and sensor performance. Compared to other USV's and ships tested, DriX generates low noise optimising sensor range and accuracy. A 2018 DriX Case Study was presented of a large offshore survey in the Kingdom of Tonga, for the client Land Information New Zealand. The survey vessels included the MV Silent Wings (fitted-out as mothership and as a survey ship) and DriX, operated within 3.5km of one-another. A single operator was used for both the DriX and MV Silent Wings survey systems. DriX lowered the cost per Nautical Mile, reduced project duration and improved the environmental footprint for the project. DriX utilizes a davit launch and recovery system that can be installed on a vessel or platform. The conclusion is that unmanned survey vessels have the potential to significantly increase the rate of effort of EEZ seabed survey at significantly reduced cost. Assuming a budget of $100M per annum, there exists the potential for Australia's EEZ to be fully surveyed within 50 years.

Craig Donald (ISES) & Ray Smith (DOF Subsea) presented "AUV Pipeline Inspection: now with OFG iCP". The presentation demonstrated how AUV pipeline inspection reduces OPEX in comparison to historic ROV pipeline inspection. The Ocean Floor Geophysics (OFG) integrated Cathodic Protection (iCP) system enables an AUV to become a viable alternative to an ROV for pipeline inspection. Since 2018 industry has used non-contact iCP for pipeline inspection. In-field system trials occurred in early 2018 over an operational pipeline. The first commercial project was with DOF in 2019 for an AUV with an Updated Payload including OFG/ISES iCP, OFG Magnetometer, CH4 (Methane Sniffer), Cathx Laser and 4K Cathx Colour Camera. A case study of iCP results was presented. iCP can accurately detect and quantify Field Gradient (FG) and current flow along a pipeline route at significantly higher speeds than historic ROV surveys. iCP can detect and quantify pipeline electrical fields (i.e. from anodes, damaged areas, and/or areas of current drain) to an unprecedented level (variations of ~0.02uV/cm), from which currents can be calculated and mapped. This determines the level of cathodic protection, activity of anodes (e.g. estimate of remaining anode life, disconnected or passivated anodes) and leakage currents in the pipe indicating coating or pipe damage, or current drain to a structure/wellhead. Remedial action can then be planned well in advance. Signal accuracy is not reduced by either vertical or horizontal standoff distances between the AUV survey position and the pipeline. The OFG iCP system can add significant value in efficiency and cost savings when used as part of an integrated pipeline inspection management strategy.

Conference Presenters

Leiv Erling Grytten (FORCE Technology Norway) presented "FiGS® - Contactless CP on AUV". Predictive CP survey predicts risk, reduces cost and improves HSE through detailed knowledge about the integrity of the asset, elimination of the use of divers and reduced carbon footprint. A FiGS non-contact CP survey maps potential, life expectancy and coating damages of buried & exposed pipelines/structures without contact. FiGS reduces vessel time, as a FiGS survey can be done at up to 12km/h and enables continuos mapping without calibration stops. The FiGS system is compatible with all main ROV & AUV platforms, and can be run simultaneously with most standard survey equipment. Examples were shown of FiGS tests with a SAAB Sabertooth AUV and a HUGIN AUV with Kongsberg. A Baseline, FiGS inspection of a pipeline provides the following benefits: sensitivity to observe all activity (even cathodic anodes); provides current drain to connected structures and remaining life; and confirmation of anode connection. A Periodic FiGS inspection of a pipeline provides the following benefits: Provides current drain between connected structures and remaining life; can be used on buried pipelines; enables risk-based inspection planning (with focus on high risk areas); extends inspection intervals; detects even small coating damage; provides a full CP integrity report. A Life extension, FiGS inspection of a pipeline provides the following benefits: early prediction of end of life (to avoid a costly retrofit); establishes steel current density for the asset; reduced retrofit cost (with design based on measured steel current densities); and allows determination of retrofit scope. A case study of a FiGS survey for an Operator pipeline system was presented, including management decision summary, reporting, imagery and graphs of anode current, potential profile and anode consumption along the pipeline length. FiGS system use with a Digital Twin provides 3D mapping of the CP system, and a full integrity assessment (e.g. for pipelines, subsea structures, FPSOs, platform jacket structures) with a focus on hotspots to optimize inspection frequency. FiGS is field proven, with Global Technology Approval as a "Proven Technology" with operators Equinor, BP, AkerBP, Chevron and Shell. Many other operators and contractors (e.g. INPEX, ConocoPhillips, Total, Technip, Subsea7, DOF Subsea, Fugro, Oceaneering) use FiGS.

Lex Veerhuis (Fugro) presented "A Cloud-Based Solution to AUV Pipeline Inspection". Advances in technology have resulted in AUV acquisition speeds that are four times faster than traditional methods, and laser point cloud data that is seven times denser than MBES sensors. Acquiring more data, quicker, makes vessel-based processing unmanageable. Increased data resolution means that an average project now requires several terabytes of storage. These factors have driven the need for a cloud-based solution to AUV Pipeline Inspection. Performing an AUV Pipeline Inspection requires state-of-the-art AUV and survey grade sensors, optimised and robust VSAT connections, bespoke automated machine learning algorithms, and web-based delivery to the client while the vessel is infield. Cloud-Based processing provides faster delivery, zero IT footprint, centralised storage & security, scalable on-demand computing resources, distributed flexible teams, and process auditability. Statistics from previous Fugro campaigns show that manual QA is five times more efficient, and machine learning has 97.8% accuracy. Offline eventing allows imagery to be fully orthorectifed and projected onto 3D visualizations to provide spatial context, dynamic overlay on images, and a full audit trail within the eventing system. Various online client delivery formats are provided for near real-time delivery, and final deliverables.

Lunch break & Exhibition

The lunch break represented another significant opportunity for delegates and exhibitors to continue their networking and mingle with the presenters, while enjoying great food offered by Lunch sponsors **Western Advance, Unique Group and Seafloor**, before heading for the afternoon sessions.

Session B1 AUT – "Power & Communications"

The session Chair **Peter Wademan (Woodside Energy Ltd)** recognized the morning presenters of the AUT conference for the exceptionally high quality of their presentations and positive feedback received from delegates over the lunch break.

Darren Burrowes (Blue Zone Group) presented "Subsea Power Enabling New Autonomous Technology Applications". The demand for subsea power and energy storage is being driven by subsea technology developments including rapid advances in miniaturisation, Resident AUV's, and All Electric Field Developments. Enabling technology development areas include navigation, communication, connection and energy. An overview was provided of established and emerging battery technologies. Lithium-Ion batteries are an established technology today, for example on the Japanese Navy Soryu-class diesel-electric submarine. An emerging battery technology area is Advanced Light Metals, such as improved Lithium-Ion, Lithium-air, Lithium-sulphur and sodium-ion. Similar challenges for power and energy storage exist in Deep Space and Deep Sea, and there exists opportunities for technology transfer. For example Fuel Cells are used on the Mars Rover. Examples of Fuel Cell battery technology were shown, including the Subsea Power Node (100kWh), Energy Node (600kWh) and Fuel Cell System combined with Reactant Storage (2MWh, 10MWh or 20MWh). This range of Fuel Cell battery options can power subsea operations, from an ROV (1 to 2kW) to a Hydraulic Pressure Unit (4 to 80kW), for months to many years. Fuel Cells provide lower capital cost for energy > 600kWh compared to Li-Ion batteries. Fuel Cells can operate at very low temperatures and have no "shelf-life" as degradation is based on hours of operation not date of manufacture. Aluminium-Air is an emerging battery technology that can provide significantly more subsea energy (e.g. 10MWh) and power (e.g. 500kW). Aluminium-Air battery technology allows storing clean energy, transporting clean energy and discharging of clean energy. The chemical reactions involve Alumina charged into Aluminium (energy storage), Aluminium discharged into Aluminium hydroxide (energy discharge), and Aluminium hydroxide then recycled into Alumina for re-use. Future technologies that have the potential to further increase subsea energy and power include Aluminium-Air batteries using an aqueous-electrolyte circulating in the cells, and Aluminium-Water batteries that can provide a ten-fold increase in energy density and are inherently safer. Subsea resident AUV and All-electric field development are driving the need for subsea power and energy storage. Many subsea applications are coming soon.

Morgan McDermont (Advanced Navigation) presented “Bi-directional wireless power transmission for underwater robotics and sensing”. Issues with traditional subsea connectors include degradation and failure of sealing surfaces without periodic lubrication, galvanic corrosion from dissimilar metals, expensive and complex true underwater mating capability, and an unreliable supply chain due to incompatibility between manufacturers. Wireless power provides interconnect freedom with no exposed metal contacts, potential for all system components to be permanently sealed for life, proximity mating easily performed by robotic systems, and device interoperability ensured by internationally recognized standards. Energy transfer occurs between coils in close proximity (<10mm). Galvanic isolation exists between transmitting and receiving devices. Foreign object detection and thermal safety features are mandated. 5W and 15W power levels have been released (Qi), while 200W and 2kW power levels are proposed. Bi-Directional power transfer is possible to reverse the direction of power flow between two devices, utilising the same physical coil, power switching electronics and software control strategy. Subsea electronics demand high reliability of interconnections between devices and interoperability between equipment from different suppliers. Strong growth in wirelessly charged consumer electronics is driving technology improvements and standardisation that can also benefit industrial products. A Design Study of the Subsonus Tag was presented, a modern, low cost acoustic positioning transponder. The Subsonus Tag can be deployed for up to 18 months in a low-power endurance mode, with 2000m depth rating, sensor and modem data capability and a high reliability, connector-less design. The technology required includes wireless charging, Bluetooth configuration and hermetical sealing with no connectors or pressure housing. Examples were provided of the Subsonus Tag in two applications: Powering a process monitoring sensor for data gathering; and Providing back-up power & communications for a subsea manifold. A comparison of communication methods for subsea data transfer was provided: WPC Qi; Bluetooth; WiFi; Optical; VLF Radio; and Acoustic. No single data transfer method is suitable for all subsea communication applications. Development of well managed standards is required for manufacturer interoperability. The future of wireless power for robotics includes coil arrays. An overview of Advanced Navigation products and customers was provided.

Do Won Kim (Curtin University) presented "An Inductively-coupled Wireless Power Transfer Application for Autonomous Underwater Vehicles". Wireless Power Transfer (WPT) Systems, originally introduced by N.Tesla in 1898, can be classified as Non-radiation methods (Near field) or Radiation method (Far field). The Non-radiation method can utilities Inductive Coupling or Capacitive Coupling. The Radiation method utilises Microwave WPT for long transfer distances. Recent examples of Inductive Coupling for Inductive Power Transfer (IPT) were provided, including EV battery charging and a Korean high speed train. The most recent example in Norway in 2017 was for IPT wireless charging of a hybrid coastal ferry (Transfer power 1MW, Gap 10cm-50cm, Efficiency 97%). Recent examples of Underwater WPT were provided, including Underwater Vehicle Charging in the USA and China for transfer power up to 1kW and efficiencies up to 92.41%. The principles and equipment for research into Underwater WPT were described. The results of experimentation was presented for WPT design with variables including distance of gap between coils, transfer power, frequency, Air vs. Water vs. Seawater in the gap, and sea water pressure. The WPT Coil Design for AUT was presented, including equipment, electronic circuits, mathematical models, electromagnetic field study results, and frequency response analysis. A Prototype experiment was outlined, including experimental setup, transfer power measurement, and calculation of efficiencies of the prototype. Considerations for AUT WPT systems include size, purpose, housing, frequency, gap, voltage and maintenance. For the extension of WPT technology in AUTs, it is recommended that the standards (e.g. rated power, voltage, frequency, gap) for AUT WPT be established, joint research (e.g. Marine, Electrical, Mechanical) be conducted, and clarification on how implementing WPT practically affects AUTs.

Technical Conference Committee

Session B2 AUT - "Bites"

Rachel Koch (Blue Ocean Monitoring) presented "The use of highly economic, lighter class AUV's for shallow water infrastructure surveys". Blue Ocean Monitoring develop, own and operate autonomous technology including AUV and ASV. Autonomous vehicles are proven to positively impact offshore projects by reducing cost, risk, schedule duration and logistics requirements. Most subsea pipelines exist in less than 200m of water depth. The presentation gave an overview of Light class AUVs to service these conditions, including the L3HARRIS and OCEANSERVER IVER-3 AUV. A Proof of concept was presented for shallow (i.e. 0-20m) pipeline surveys at Varanus Island, Western Australia in September 2019. The objective was to assess free spanning, submergence, movement or deformation of pipeline and compare the results of previous surveys (vessel based, ROV and larger AUV conducted at this site). The Light class AUV required reduced resources, providing cost and schedule reduction compared to previous surveys. The Survey Methodology involved running surveys from shore to depth & return, Side Scan Sonar (SSS) & Bathymetry 2x – offset pipeline, Camera Runlines 1x – directly over pipeline, and position correction surfacing at regular intervals. The Project Outcomes included: AUV handles well in shallow coastal conditions; Launch & Recovery from vessel or shore was efficient and safe; Resolution, Accuracy, Data Quality (e.g. SSS, PDBS Bathy, Camera, Positioning) and Accessibility were all good; and the speed of fast data download was good. The recommendations include further test to determine the optimal survey methodology for data acquisition in a variety of environments. Research and Development for 2019/2020 includes Non-Contact Cathodic Protection and 3D Laser Scanning with industry partners Force Technology, OFG and 2GRobotics.

Aaron Leather & Hema Gunasagaran (Oceaneering) presented "The Freedom Hybrid AUV/ROV - An Autonomous Underwater Vehicle with Remote Piloting Using 4G Satellite Technology". The Freedom is a Hybrid ROV and AUV which can be operated in tethered or untethered mode as a Resident Vehicle subsea. Freedom is based upon a "plug and play" operational philosophy, providing a low-maintenance; field-configurable vehicle optimized via interchangeable payload packages and sensor suites to meet work scopes. Freedom is a modular concept for different missions, for example as a Work Class ROV, Observation ROV or Survey AUV. Freedom can be configured for Autonomous or Real-Time Control, Free Swimming or Tethered, Long Range or Resident, Inspection or Light Intervention. Freedom has the following benefits: Reduction in vessel days; Improved service quality and decision making; Reduced cost for IMR; Potentially reduced insurance premiums; and reduction in carbon footprint. Freedom is equipped with a Subsea Tool Changer for various subsea applications. Freedom applications include: Leak detection monitoring; Subsea inspection and intervention; pipeline survey and offshore windfarm survey. Connectivity for Freedom video & data communications is provided from a 4G Coms Buoy mooring via a Wireless 4G / Internet Network, to a 24/7 operated Onshore Mission Support Center. The Freedom Resident Vehicle concept including a 4G Coms Buoy significantly reduces the need for a surface vessel, reducing the CO^2 footprint by 98%. The Freedom Hybrid AUV/ROV and Living Lab is currently undergoing a Qualification Program in Norway, with customer trials and operations expected in 2020.

Daniel Kruimel (Teledyne Caris) presented "Process Automation for Autonomous Survey Operations". Automation with CARIS Onboard, a web application based processing service that can be installed on autonomous or staffed survey platforms. Sensor data processing is automated during the survey. CARIS Onboard allows processed survey results to be viewed and remotely monitored through a web map interface for QC, reducing risks and costs. Real-time QC allows for problems to be identified and corrected during the survey, providing a single point of access for quality checks between vessels. An example was presented of a CARIS Onboard 2.1 trial of AUV operations for JAMSTEC and their deep-sea AUV "URASHIMA". Automated bathymetry processing on the AUV during the trial allowed access to processed results immediately following AUV recovery, with survey quality and coverage confirmed within 15 minutes rather than the hours required for traditional methods. This resulted in significant time and operational cost savings. In 2019, CARIS will offer an AI solution to automatically classify and reject common types of noise in sonar surveys, providing further operational cost savings for marine surveys, improving utilization of resources, and increasing production rates. Machine Learning can be applied to noise removal. For example Convolutional Neural Networks (CNN) are used. An example of using AI Classification Workflow was provided, using AWS. The performance accuracy was >99% for "real" points and ~92% for noise points. An example of a 2015 Shallow Survey Demo Dataset was provided, showing AI reduced processing times from 6 hours (manual) to 1 hour (CNN). Multi-vehicle and autonomous surveys increase the availability of high resolution data. Through automation we can improve data quality and achieve operational efficiencies. Utilization of human resources can also be improved by automating objective and repeatable processes. By applying automation we can increase the rate of ocean information, survey faster and with greater confidence.

Afternoon Tea/Coffee & AUT Bites Q & A in Exhibition

Once again, this break was a constructive social gathering with the exhibitors and a great networking opportunity.

Perth Branch Office Bearers at Morning Tea

Session B3 AUT – "Realising the Opportunities"

Gilles Gardner (i-Tech 7) presented "Enabling Autonomous Inspection Technologies to Transform IRM Operations". Inspection, Maintenance & Repair (IMR) today relies on surface vessels, which incur additional schedule duration and costs due to mobilisation, transit and weather. There exists the opportunity for a step change in schedule and cost performance with the introduction of Autonomy. Examples of new technologies include Seabed Hosted EROV, Seabed Hosted Caretaker, and Unmanned Surface Vessels with communication links to Remote Onshore Control. Todays trends and enabling technologies include access to high bandwidth 4G communications offshore, secure Wide Aread Network (WAN) connectivity, electrification of underwater systems and autonomy. Autonomy Underwater involves the application of intelligent behaviours that enable underwater systems to operate independently or remotely supervised, reducing the dependency on surface vessel support & required resources, which increases efficiency. Examples of Autonomous Technology Solutions were provided. A Qualification Case Study for Docking was provided. Every single element of the docking system is assessed, tested and validated in water offshore to achieve API 17N System Qualification. The Next Generation of Autonomy for IRM service delivery will include field wide capability, seabed hosted vehicles with 365 day presence, analytics driven methods with predictive asset integrity methods to maximise uptime and lower the total cost of ownership, with the right data captured and delivered for actionable insights. The benefits include reduced cost & HSE exposure, more efficient use of skilled personnel, operational flexibility, and reduced environmental impact.

Delegates within Exhibition Area

Christine Devine (Fugro) presented "Using Simultaneous Operations of AUV and Seabed Sampling to Optimize Marine Mineral Exploration Programs". The presentation provided an overview of Seabed Mineral Resources including Seafloor Massive Sulphides, Manganese Nodules and Cobalt Rich Crusts. Since 1982, 27 seabed mineral exploration contracts have been granted globally by the International Seabed Authority (ISA), as many resources are located the Exclusive Economic Zones of coastal countries globally. An overview was provided of the 2018 DeepGreen Survey in the East Pacific Ocean, to collect high-resolution AUV geophysical data, collect seabed samples by a box corer, select a collector test area for additional geophysical surveying, to support an updated mineral resource estimation. A HUGIN Echo Surveyor VII (ESVII) AUV was used for the survey, with payload sensors including Bathymetry and Backscatter, Side Scan Sonar, Subbottom Profiler and Camera Imagery. Fugro also deployed a large-form 0.75m^2 Box Corer to obtain samples from the seabed. Underwater Transponder Positioning (UTP) was used to optimize offshore time and data acquisition. Transponders were set on the seafloor at 1,800m intervals. The AUV worked autonomously performing the survey, while the vessel moved to other locations to conduct box coring operations. AUV Data Acquisition and Processing involved 14TB of data and over 15 different software applications. Geophysical Data included Bathymetry (at 22/35m Altitudes), Backscatter (at 35m Altitude), Side Scan Sonar (at 6m Altitude), and Camera Imagery (at 6m Altitude). Nodules were classified based on Photogrammetry Data as Type 1, Type 2 or Type 3. Seabed samples and geophysical data were then integrated into a combined model and map. Box coring results included various nodule shapes, which were classified in groups. Interestingly, three Megalodon teeth (i.e. from prehistoric giant sharks) were found in the seabed samples. The DeepGreen 2018 campaign was Fugro's first commercial simultaneous operations survey consisting of AUV and seabed sampling). The successful collection of data and interpretations provided the client with sufficient information to decide the location of the optimal collector test site during the survey. Successful SIMOPS allowed for the collection of 45 box cores and ~150km^2 of geophysical data acquisition. Services that added value to the survey included the ability to process and interpret over 14 TB of camera imagery and geophysical data, building a high-quality interpretational GIS database, as well as systematically processing box core sample while offshore. Data collected during this successful campaign, along with subsequent onshore work and interpretations, were included in the recently released NI 43-101 Technical Report for "NORI Area D Clarion Clipperton Zone Mineral Resource Estimate".

William J. Kirkwood (Monterey Bay Aquarium Research Institute (MBARI)) presented "Shearwater – A Homogenous Platform for Ocean Applications". Multi-Vehicle Operations are needed for Military, Oil & Gas and Resource extraction, management and protection. The presentation discussed the current status of Autonomy for AUV systems, including pros and cons of each, and Range/Speed relationships. The concepts of The Grid Survey and Survey Envelope were shown mathematically and graphically, leading to a comparative look at vehicle options including ships, gliders, IIB and AUVs. A hybrid can offer a significantly increased Survey Envelope; this is the dream of the Shearwater concept. The concept has been around for over 50 years, with various concepts built by Russia and the USA historically. The concept of operations includes launch from water, flight with Wing in Ground (WIG) effect, landing on water, submerge underwater, perform subsea operations, return to surface, take-off from water, flight with WIG, and retrieval from water. Re Number calculations indicate that the propellers and flow over the body will work in air and water. Funding has been provided by the Office of Naval Research, USA. Three concepts have been identified. Computational Fluid Dynamics (CFD) Simulations have been created, allowing CFD analysis of lift and flight stability. Model testing occurred at Monterey. An RC model of the Shearwater has been built and an early prototype flight tested. Part 2 of the Office of Naval Research Award involves doing the background calculations and detail concepts for the structure, energy, payload and endurance.

Steve Duffield (Guardian Geomatics) presented "Unmanned Surface Vessels: A recent example of the Force Multiplier effect". The presentation described a Project that successfully mobilised the vessel Seabed Constructor and three Marine Autonomous Surface Ships (MASS) units for sea acceptance trials. The scope of work included deployment and recovery of four bottom mounted tide gauges, bathymetric survey of the area to IHO S-44 requirements, contour delineation out to the 40m contour, box-in surveys for features identified by the Client, demobilisation, and final reporting & processing. The working area was 800km^2, and numerous shipwrecks. The Project was successful in mobilising the vessel and MASS units, passing sea acceptance trials and deploying the gauges. Only 61.8% of the bathymetric survey was completed due to the large number of fishing boats in the survey area. The rest of the project scope of work was completed, including 7460 line km in 20 days and the identification of 13 unknown wrecks and 94 additional features. Vessel & MASS Operational Timeframes were presented for the 20 days operations, demonstrating the Force Multiplier Effect. The overarching document was the UK Code of Practice. The Captain had overall responsibility, and the MASS units were operated on the basis of 'ships equipment'. Control of Operations used a Matrix of Permitted Operations – Seabed Constructor. The Launch and Recovery System (LARS) utilized a davit system on the vessel. Major Lessons Learnt were in the areas of MASS Unit Survey Operations, MASS Unit Operations and Data Transfer. USV's as a Force Multiplier dramatically increased the rate of effort achieved per day, significantly reduced fuel usage, minimally increased the headcount and reduced the risk of shallow water work. However, the there are diminishing returns from the number of MASS units. The presenter concluded that four MASS units with the mothership would have been optimal.

Closing remarks

Phil Wells (AHS Representative) concluded the conference by thanking the sponsors, exhibitors, session chairs, panellists and delegates. Phil recognized the invaluable contribution of **SUT Perth personnel** including **Branch Manager Jennifer Maninin** in helping to affirm the AUT conference as an event of high international standard. Thanks also to **Stuart Higgins** and the **2019 AUT Conference Organising Committee**.

Phil encouraged attendees to enjoy some drinks and further networking opportunities, thanks to Closing Drinks sponsors **Guardian Geomatics** and **Neptune Geomatics**.

Further photos of the conference can be found at https://www.sut.org/branch/australia-perth/events/event-photos/aut-conference-oct-19/

Delegates at Closing Drinks