MONASH University

WOODSIDE FUTURELAB AT MONASH UNIVERSITY **ANNUAL REPORT 2018**

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I am pleased to share this annual review as the end of 2018 marks the third year of our groundbreaking, innovation partnership between Woodside and Monash. The Woodside FutureLab at Monash University is setting the benchmark for industry-university collaborations in Australia.

By working side-by-side with Australia's most progressive oil and gas company we are applying breakthrough thinking, best-in-class expertise and novel solutions that are shaping the future of the resources and energy sector. I have witnessed this first-hand having visited Woodside operations in Karratha and Perth as well as the Woodside FutureLab related facilities across Monash in Melbourne.

The partnership continues to build on our foundational strengths, transcending traditional approaches through cross-disciplinary and cross-organisational teams focused on rapid prototyping, advanced materials and information technology.
A fantastic aspect of this collaboration is that it is not just the missions of both organisations that align, but the people. When I have been in rooms with Monash and Woodside people together, the organisational boundaries fade and an excited, common purpose to change it for good takes over. I have to admit the excitement of those rooms is hard to resist.

The world of work is also changing and we continue to draw on the fresh thinking our students bring individually and in teams as they get exposed to the challenges faced by the resources and energy industry, suggest answers not anticipated previously and propose new models for doing business. From a national and international perspective, both Woodside and Monash remain committed to leading technological innovation to optimise existing approaches and, more importantly, to be at the forefront of the new energy challenge. Monash is the first Australian university to commit to an energy reduction target of net carbon zero emissions by 2030 and working together with Woodside, we look forward to sharing new and exciting developments.

Mr Ken Sloan
Deputy Vice-Chancellor and
Vice-President (Enterprise)

The Woodside-Monash partnership is built upon a deep sense of trust and respect between the two institutions, and upon the shared values of progress through collaboration. This is clearly reflected in the inherent freedom given to our research; a freedom that allows innovation to flourish, unfettered from the constraints common to most contract research. The partnership is highly dynamic and the interactions with Woodside personnel very frequent. This gives both Monash and Woodside staff an incredible opportunity to connect with the innovation and the real-world impact of the work, which in turn opens up the path to new ideas and opportunities for collaboration.

2018 saw the maturation of this relationship, with many of the projects within the FutureLab at Monash moving from concept and prototype stage into reality. It is extremely rewarding to see projects such as the use of STOPAQ for corrosion management of stainless steel, deliver hundreds of millions in savings to Woodside. Commercialisation options are also starting to reach new readiness levels with the development of the auto layout software and the corrosion detection probe.

We would like to acknowledge and thank Professor Nick Birbilis for his exceptional contributions in the set up and development of the FutureLab, making it an exemplar for collaboration in Australia. We are proud to continue the work he has begun and are delighted to see it accelerating into 2019.

Indeed, new projects continue to grow as we engage further and wider within Woodside. The areas of Bayesian networks, optimisation and visualisation continue to grow in interest for Woodside, and will be a source of significant collaboration in 2019. Growing the network beyond Woodside, with key industry collaborators in the areas of additive manufacturing, is a particularly exciting prospect. Importantly, the FutureLab continues to prioritise external impact on the broader community, as well as public engagement.

Crucially, the FutureLab remains a strong magnet for talent and good ideas. Woodside's philanthropic support has been significantly leveraged, allowing the continued growth of a considerable team within the first three years of operations. The Woodside FutureLAB team at Monash is comprehensive and interdisciplinary, with all researchers focused on direct industry needs. We hope this 2018 report reflects what has been an exceptional year of achievement between Woodside and Monash.

Prof. Christopher Hutchinson
Acting Woodside Innovation Co-Chair,
Associate Dean of Research,
Faculty of Engineering

Prof. Maria Garcia de la Banda
Acting Woodside Innovation Co-Chair,
Faculty of Information Technology

Dr Lee Djumas
Research & Innovation Manager,
Woodside FutureLab

2018 HIGHLIGHTS

- Translation of the Woodside FutureLAB at Monash from proof-of-concept lab to practical application in areas including:
  - Additively manufactured (AM) service-ready components that included monoflange and IP washers. These components were prepared using a variety of material types. New agreement with Anderson Greenwood and ProChem to deliver, in partnership with Monash, an additively manufactured monoflange for Woodside.
  - Advanced automated corrosion detection and monitoring techniques utilising machine learning (ML).
- Pilot system tested of additively manufactured heat exchanger with large scale system in development for early 2018.
- Realisation of superior additively manufactured super duplex stainless steel and development of additively manufactured metal-glass composites.
- Development of large scale multi-metal printing process with applications in cladding, coatings, multi-metal components and advanced repair and maintenance.
- Implementation of a 2D User Interface for plant layout that supports dynamic nozzles and HYSYS-style equipment, which is more familiar to (and thus practical for) plant engineers.
- Development of a 3D visualiser for plant layout to create images dynamically, rather than from a fixed palette.
- Development of a new search process to significantly improve the scalability of the plant layout system, which now consistently produces near optimal equipment allocations.
- Creation of a workflow for plant layout on a virtual machine accessible by Woodside. It can run on “modular” or “whole plant” modes, using a plant back-bone in 3 configurations.
- Completion of a model of the NextGenIII plant together with its backbone.
- Development of effective monitoring and protection strategies related to materials durability, such as corrosion under insulation and the deployment of STOPAQ for stainless steel assets.
- Development of a decision support tool for risk management based on Bayesian Network models. Two cases studies are being explored: pipe walking and an umbilical control.
- Designed and printed prototype carbon fibre bicycle frame in 6 months, demonstrating the capability of additive manufacturing to produce metal-replacement components.
- Maturation of research themes to align to significant cost savings and innovations spread across various Woodside groups.
- Continued growth of the Woodside FutureLAB at Monash with new areas of explored interest including wind tunnel modelling and testing and risk modelling and assessment.
- Provided significant Innovation and Design training to various partners and collaborators.
- Continued acquiring and developing talented individuals as part of the Woodside FutureLAB at Monash team.
- Supported Woodside Technology Group by delivering feasibility and operability study for the deployment of a Pop-Up FutureLab based in Karratha.
- Strengthening of relationship between the two institutions via exploration of affordable energy and profitable carbon themes.
- A senior delegation of Monash personnel including multiple Dean’s and Provost, visited Karratha plant.
- Information exchange with voestalpine, material supplier to Geographe (Woodside OEM), around the topic of additively manufactured.

PUBLIC ENGAGEMENT

Close engagement with the community around us — within Woodside, Monash and the broader public — is critical to the success of the FutureLab as a space that can influence change through innovation.

- Attended the NAMIC (National Additive Manufacturing Innovation Cluster, Singapore) Maritime and Energy Summit, presenting overview of the collaboration between Woodside and Monash.
- Attended CP 2018 (24th International Conference in Constraint Programming) to present the equipment allocation component of the Plant Layout application, co-authored by Woodside Engineers.
- Supported the NextAero team in their participation at the In the Zone Conference, highlighting the capabilities of Additive Manufacturing (AM) and LNG in the aerospace sector.
- FutureLAB members joined Team Woodside to participate in the Ride to Conquer Cancer.
- Supported Muscular Dystrophy Australia's Little Miracles 2018 campaign, printing and donating 2000 ornaments which were sold for charity with the proceeds used to help fund research into a cure for muscular dystrophy.
- Supported Woodside in various endeavours to develop and grow collaborative relationships with various partners, both within the resources industry as well as outside.
- Began an ongoing engagement with Local Peoples and Matters Journal to highlight and promote the world-leading research and development taking place within Monash Materials Science and Engineering and the Woodside FutureLAB.
- Hosted more than 30 industry delegations, including Halliburton, Safran, BCG, Maclaren, Bluescope, Bosch, Dassault Systemes, Stryker and Voestalpine.
- Hosted Therese Rein, leading social entrepreneur and wife for former PM, Kevin Rudd.
- Engaged with local secondary schools to deliver information sessions and workshops, including mentoring John Monash Science School students working on various projects to be judged at nationwide and international competitions.
- Explored an industry engagement relationship with XBlades.
- Supported Woodside Technology Group by delivering feasibility and operability study for the deployment of a Pop-Up FutureLab based in Karratha.
- Supported Woodside's Graduate Recruitment Program by connecting Woodside staff to Monash' Undergraduate and Posgraduate students, including meetings with our top female students.

2018 PROJECT SNAPSHOTS AND SUMMARIES

The projects conducted within the FutureLab in 2018 underwent both growth and maturation, whereby existing projects reached an advanced level of completion, and new projects were seeded for 2019 and beyond.

FUTURELAB OPERATIONS

- Commissioned the design and build of high-temperature polymer printer, with the aim of utilising high-performance engineering thermoplastics to produce end-use components for service within Woodside.
- Purchased and installed a large format Selective Laser Melting (SLM) 3D printer (Sisma MySint300) to be utilised in support of FutureLAB expansion, with the aim to qualify stainless steel AM components for service within Woodside.

DESIGN, FABRICATION AND QUALIFICATION OF AM COMPONENTS

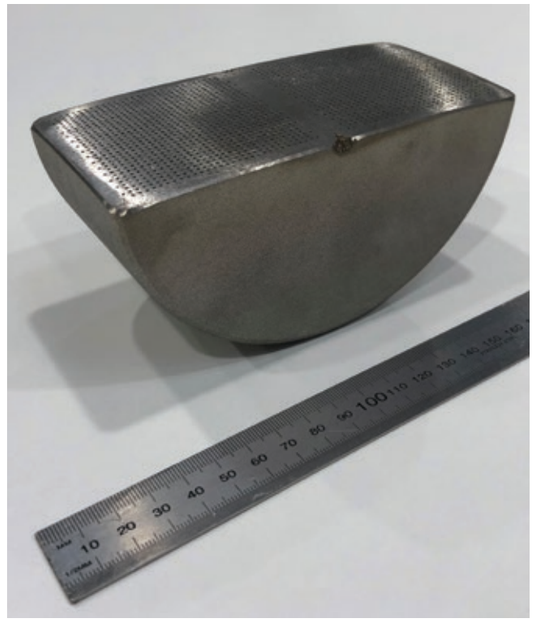
- Printed (3) redesigned monoflanges for deployment into Woodside.
  - The design was successfully tested to 100MPa nominal pressure (right).
  - An agreement was established with Anderson Greenwood and ProChem to support machining and finishing of the monoflange for deployment in Q2 2019.
  - Began investigations into AM of an inducer.
  - Trial components were printed to determine any geometry-based limitations.
- The AM Qualification Plan was adopted into the Woodside MoC system.

LARGE FORMAT MULTI-METAL FABRICATION VIA ADDITIVE MANUFACTURING

- Continued investigations into 3D printing of multiple metal combinations in an effort to understand the interfacial and material properties.
- 3D printed stainless steel pad flange examples directly onto mild steel pipe, demonstrating the viability of utilising Direct Laser Deposition (DLD) AM to perform high-precision cladding and component builds directly onto existing non-planar surfaces.

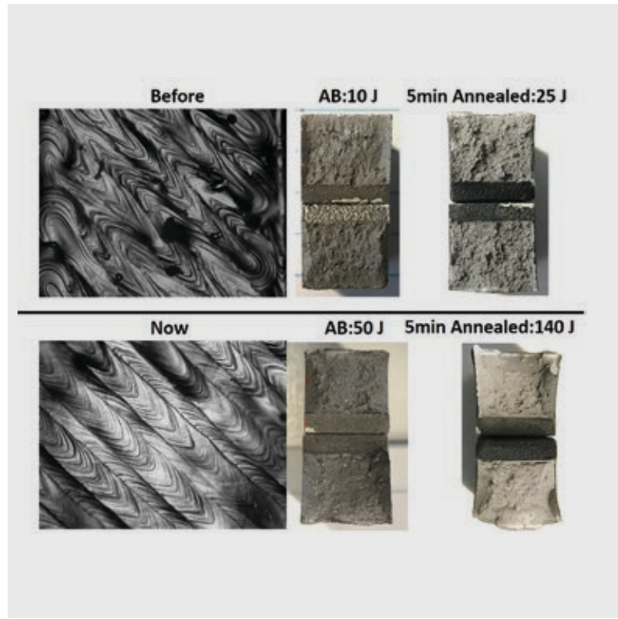
CARBON FIBRE BICYCLE

- Successfully designed, printed, and assembled a bicycle frame using carbon fibre-nylon composite material, showcasing the potential for utilising composite material as a metal replacement and the capability of the FutureLAB team to take an idea from concept, through design, to final production.
- The bicycle went on display at Mia Yellagonga to challenge Woodside personnel to consider alternative materials as potential solutions to various engineering challenges.



ADDITIVELY MANUFACTURED HEAT EXCHANGER

- Printed an all-in-one larger scale heat exchanger with headers.
  - An increased length of 220mm was used to allow for thermal testing.
  - Thermal testing was performed successfully with approach temperatures of 30deg C.
- Printed an alternative U-bend specimen for comparison.
  - The difficulty of powder removal was significantly increased versus the straight channel design despite having access to all channels.

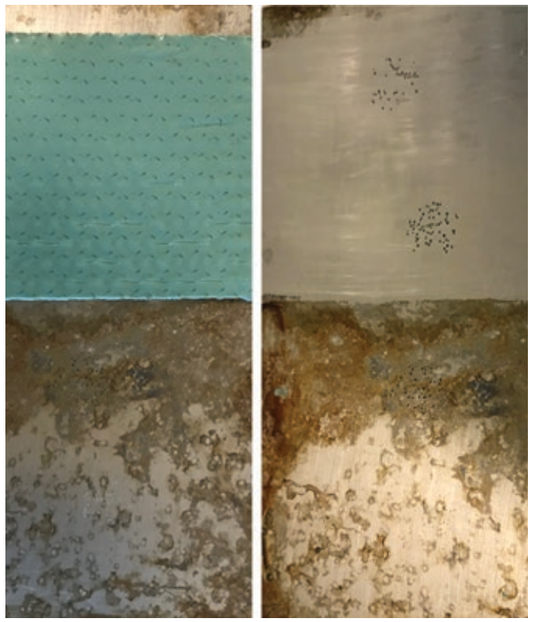


ADDITIVELY MANUFACTURED CORROSION RESISTANT ALLOYS (CRAS)

- Optimised the printing parameters for duplex and super duplex stainless steels.
  - Impact strength was improved versus the previous parameters which yielded good tensile strength, but poor impact strength.
- Performed U-bend testing of AM and wrought duplex and super duplex stainless steel specimens, immersed in a Ferric chloride solution.
  - After 7 days , microcracks were found in the wrought specimens while no cracks were found in the AM specimens.
  - After 10 days, pits began forming in both the AM and wrought.
- Performed U-bend testing of AM and wrought 316L stainless steel specimens.
  - Due to the lengthy nature of the experimental procedure testing is ongoing with results expected in Q2 2019.
- Corrosion resistance of AM duplex and super duplex stainless steels was found to be equal to that of wrought material.

MONITORING AND PROTECTION STRATEGIES FOR CORROSION UNDER INSULATION (CUI)

- Modified the design of the CUI probe, including the addition of a connection cap to facilitate data collection by an intrinsically safe multimeter.
  - The probe design has been proven in a lab setting.
  - Refinement is ongoing for intended field use.
- Project completion is scheduled for Q3 2019.

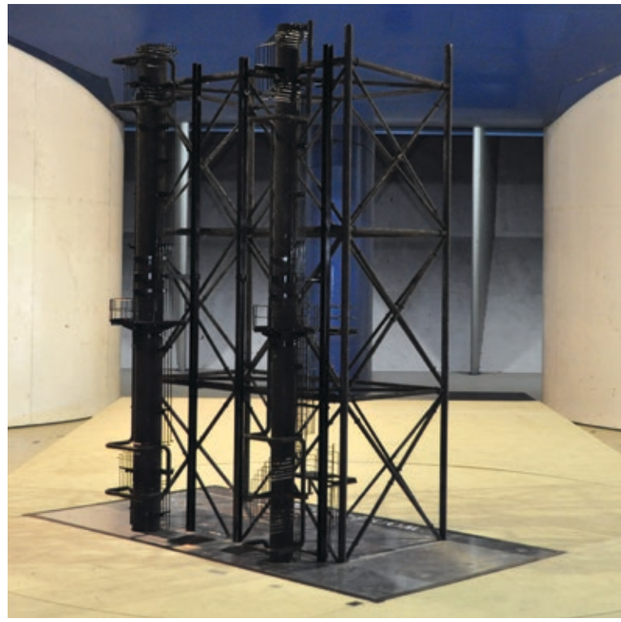


STOPAQ EVALUATION

- Using state-of-the-art high-resolution CT imaging techniques, combined with the latest in corrosion science theory, the FutureLab successfully demonstrated the capability of STOPAQ to arrest sustained pit growth in austenitic Stainless Steel for the first time.
- This has enabled the Q2 2019 deployment of STOPAQ on existing stainless steel assets to extend their service life, as such avoiding replacement and saving the business tens of millions of dollars.

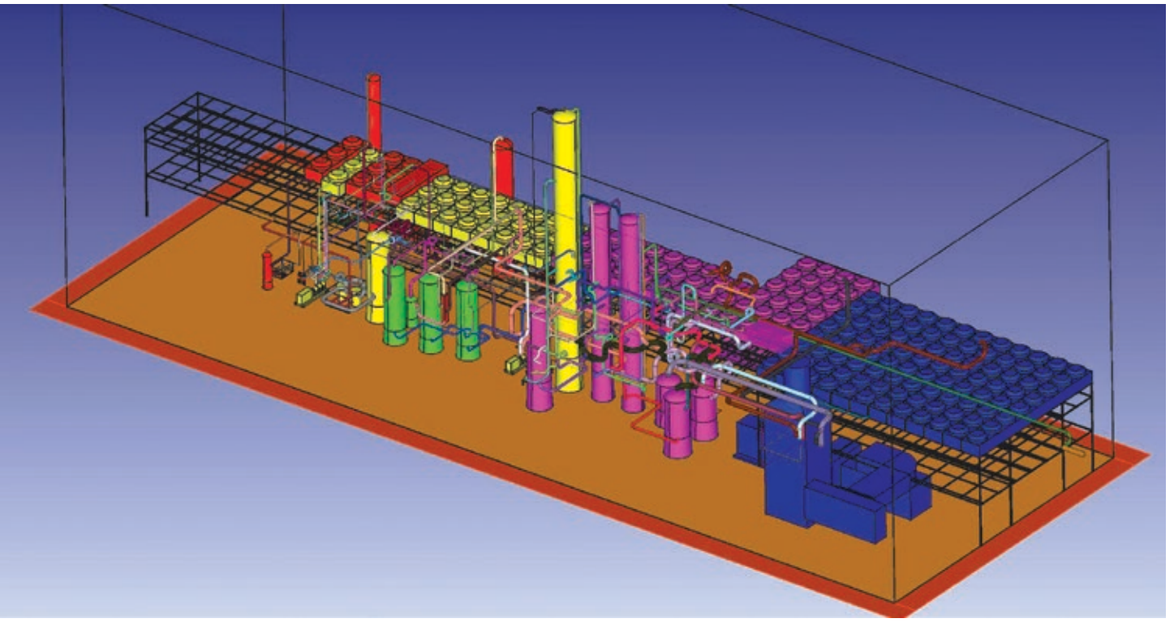
AUTOMATED CORROSION DETECTION USING ARTIFICIAL INTELLIGENCE

- Assessed the quality versus quantity of datasets for deep learning models to provide semantic segmentation of corrosion. The research indicates that to achieve the level of performance (>80% accuracy) we require a dataset of roughly 60,000 images.
- Launched corrosion detector website to raise awareness and build a classification dataset. Analysis of the responses highlighted some of the difficulties with relying on novice labelling of images for dataset creation. This is the subject of a paper currently being drafted.
- Coded a capsule net semantic segmentation model. It is limited to processing in 128 x 128 pixels due to memory constraints of current GPUs.
- Next step is to use multi-task learning to enable the model to learn contextual clues (e.g., what is steel, what is a person, etc.). This requires secondary labelling of the dataset and coding a multi-task model, which is currently ongoing.



WIND TUNNEL TESTING AT MONASH WIND TUNNEL RESEARCH PLATFORM (MWTRP)

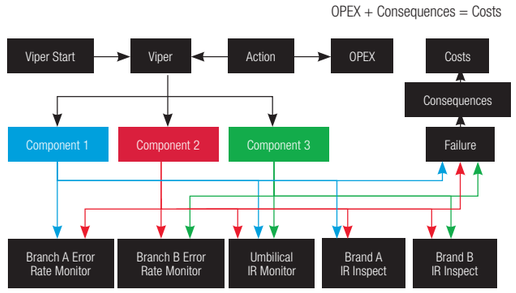
- Focus of continued collaboration was on the aerodynamic analysis of multiple high riser structures at the Karratha and Pluto Gas Plants.
  - The challenge was to predict wind loads experienced by the structures in the event of cyclones.
  - The work required advanced model making, wind tunnel testing and computational fluid dynamics (simulation) to estimate loads that can be coupled with a structural analysis software.
- Submitted joint Australian Research Council (ARC) Linkage Grant application. If successful, the project will commence in the first half of 2019.
  - Project aims to address the challenge of predicting the impact of extreme cyclonic winds on complex engineering structures.
  - By applying advanced computational and experimental techniques, we can develop new insight into turbulent flows at a sub-cyclone scale and how these produce aerodynamic loads on closely spaced cylindrical structures and elements.
  - Expected outcomes include enhanced simulation techniques leading to better understanding of structural vulnerability to cyclones. This should provide significant benefits, such as improved structural design and cyclone mitigation strategies applicable to both high-value engineering structures and vulnerable communities in cyclone regions.



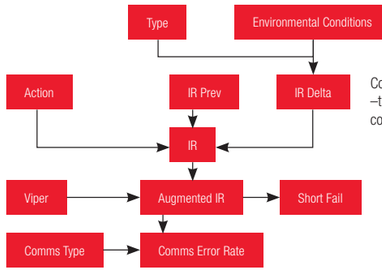
PLANT LAYOUT OPTIMISATION

- Considerably extended the 2017 optimisation and visualisation prototype by adding:
  - 2D User Interface to support dynamic nozzles and HYSYS-style definition of equipment
  - 3D visualiser to create 3D images of the objects “on the fly” (rather than from a fixed palette)
  - New equipment: pumps, separate fin-fans, plateHX and multi-compressor units
  - New constraints: on-boundary, direction-specific min/max distances, groups and sequences
- Significantly improved scalability. The system now consistently produces new optimal layouts.
- Built a workflow (2D » Optimisation » 3D » Sage) on a virtual machine accessible by Woodside. It runs on “modular” or “whole plant” modes, using a plant back-bone in 3 configurations.
- Developed a 2D UI model that integrates Pluto’s units 1100, 1300-1400 (propane section) and 1500.
- Developed a 2D UI model of the NextGenIII plant, together with its backbone.
- The system has been fine-tuned to consistently produce near-optimal layouts.
- The consolidation phase to start in 2019, to allow better understanding and control of the layouts.
- Submitted joint Australian Research Council (ARC) Linkage Grant application.

UMBILICAL INSULATION RESISTANCE



Monitor/inspect variables at system level (aggregation of components) will inform the next step action

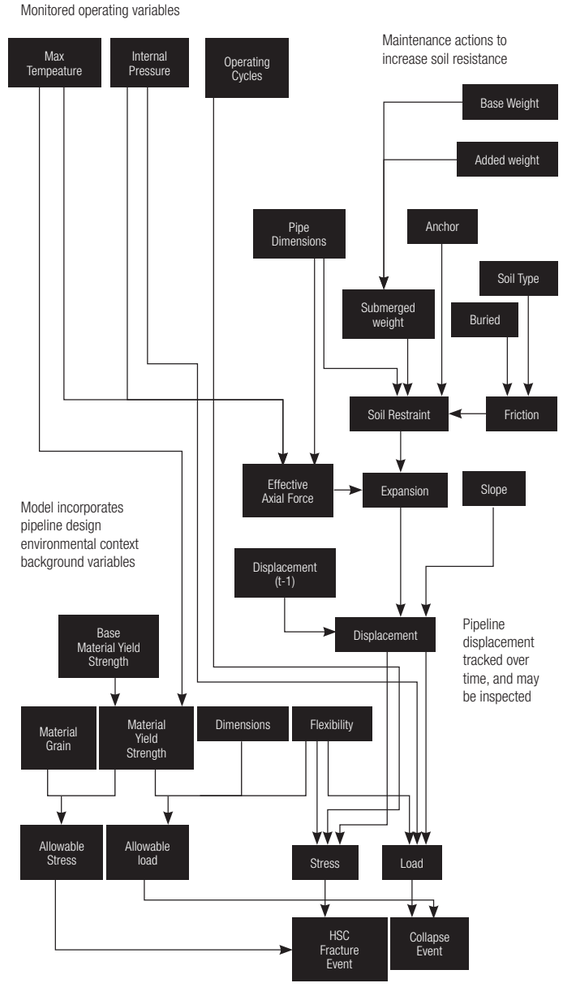


Component sub model –tracks change in component IR

RISK MODELLING

- Investigated how Bayesian Network (BNs) can be used as the modelling and reasoning engine in a risk management tool (RMT), using 2 case studies: Pipeline Walking, Umbilical Control system.
  - BNs were used to model the relationship between Inspection, Monitoring, Maintenance, Repair (IMMR) Plan actions and failure events, with the aim of defining an optimum IMMR plan.
  - Completed the design and implementation of the decision support tool.
  - Continued working with Woodside domain experts to parameterise and validate the BNs.
- Project is scheduled for completion in Q1 2019.
  - The BN models for the 2 case studies will be finalised and then integrated into the prototype decision support tool.

PIPELINE WALKING STATUS SUB MODEL



Two failure mechanisms modeled

PERSONNEL

Members of the FutureLab Team supporting Muscular Dystrophy Australia by making 3D printed Christmas ornaments to raise money for charity.

The core Monash team at Woodside's FutureLAB has grown in 2018 and continues to leverage researchers, technicians, students and professionals to add value to the Woodside/Monash partnership. We are incredibly proud of our people and want to acknowledge the fantastic contributions they make.

NAME	ROLE	PROJECT
Prof. Chris Hutchinson	Acting Woodside Co-Chair & Professor MSE	Physical metallurgy; Additively Manufactured (AM) corrosion resistant alloys (CRAs); fatigue and fracture
Prof. Maria Garcia de la Banda	Acting Woodside Co-Chair & Professor IT	Maria serves as the senior point of contact for research with the Faculty of Information Technology. She has oversight on the projects related to Bayesian risk, optimisation and visualisation.
Prof. Nick Birbilis	Former Woodside Chair	Nick oversees the FutureLAB activities and the interface between numerous Monash departments and faculties. He also is an active researcher contributing to materials engineering, materials durability, and AM.
Ms. Malaika Ingram	FutureLAB Manager	Malaika is the FutureLAB manager, with oversight of operations and capability. She also is a Mechanical Engineer who contributes to research themes in design and additive manufacturing.
Dr. Lee Djumas	Innovation Lead, Woodside Engagement	Lee is the Innovation lead, scouting and integrating new technologies, along with the development of novel technologies. He has a joint appointment with Woodside and Monash, allowing effective integration of the FutureLAB to the field.
Dr. Gleb Belov	Senior Research Fellow	Plant layout optimisation
Dr. Ilankaikone Senthooran	Research Fellow	Plant layout optimisation
Dr. Michael Wybrow	Senior Lecturer	Plant layout visualisation and interaction
Prof. Mark Wallace	Professor IT	Plant layout optimisation
Dr. Tobias Czauderna	Research Fellow	Plant layout visualisation and interaction
Mr. Matthias Klapperstueck	Software Engineer	Plant layout visualisation and interaction
Mr. Zhe Chen	Undergrad Intern	Parameter tuning for plant layout optimisation
Mr. XinRui Wei	Undergrad Intern	Conflict resolution in pipe routing for plant layout optimisation
Mr. Yin-Lee Ho	Undergrad Intern	Parametric 3D modelling for plant layout visualisation
Mr. Mathew Baker	Undergrad Intern	Extraction of 3D info from Navisworks for plant layout
Mr Nathan Truong	Undergrad Intern	Improving 3D interaction for plant layout visualisation
Dr. Sebastian Thomas	Research Fellow	Coatings; Corrosion; Materials, including CUI and STOPAQ
Dr. Ruifeng Zhang	Research Fellow	Materials science with a focus on materials degradation
Mr. Derui Jiang	PhD student	3D printing of stainless and duplex steels
Ms. Qing Cao	PhD student	Corrosion under insulation
Mr. Will Nash	PhD student	Artificial intelligence for corrosion monitoring
Ms. Abirami Babu	PhD Student	AM alloy development
Mr. Darren Feenstra	PhD student	AM of multi-materials fabrication via direct laser deposition; Lead researcher in glass printing development
Mr. Guilherme Sander Malab	PhD student	Corrosion of 3D printed metals; Lead AM engineer for 316L SS components
Mr. Marten Jurg	PhD student	Design for AM; in-situ process monitoring for quality assurance
Mr. Tim Murray	PhD student	AM of iron-based alloys
Ms. Courtney Powell	Undergrad Intern	Machine learning and HTML coding for corrosion detection
Mr. Timothy Herzog	Undergrad Intern	Machine learning for corrosion assessment
Mr. Cristian Costa	Undergrad Intern	Large-scale, high resolution 3D scanning and imaginG; STOPAQ imaging
Ms. Georgia Hunter	Undergraduate Intern	AM and qualification
Mr. Ken Aui	MGP Intern	Glass printing
Ms. Roseann Chan	Casual Innovator	CAD; AM design
Mr. James Bott	Casual Innovator	CAD; AM design
Ms. Vaishali Haria	Casual Innovator	Pop-Up Futurelab development
Mr. Aryan Faghihi	Casual Innovator	Pop-Up Futurelab development
Mr. Michael Widjaja	Casual Innovator	CAD, AM design
Ms. Gabrielle Newman	Casual Innovator	CAD; AM of polymers
Mr. Paul Hendy	Casual Innovator	CAD; AM design
Mr. Calvin Vong	Casual Innovator	CAD; AM of composites
Mr. Juan Nicklaus	Honours Project	Corrosion of AM alloys; AM of metal-glass composites
Dr. Andrey Molotnikov	Senior Lecturer	Materials; Design; CAD
Prof. Ann Nicholson	Professor	Bayesian networks and risk modelling
Dr. Owen Woodberry	Research Fellow	Bayesian networks and risk modelling
Prof. Jon McCormack	Professor	Human-Computer Interaction
Mr. Elliott Wilson	SensiLab Manager	Human-Computer Interaction
Dr. Sam Gao	Research Fellow	Characterisation and testing of new materials; Microscopy; Physical testing, including strength, fatigue and fracture
Mr. Andreas Hamacher	Research Fellow	Visualisation, scanning and imaging
Mr. David Burton	Manager	Wind Tunnel; Fluid dynamics
Mr. Daniel Curtis	Technician	Materials; Technician
Mr. Enrico Seemann	Technician	Electrical and mechanical systems
Mr. Jono Wilson	Technician	Mechanical systems

PERSONNEL EXCHANGES / VISITS

A significant factor in the success of the FutureLab to date has been the frequent (planned and unplanned) visits of both Woodside staff to Monash, and Monash researchers to Woodside. The dynamic nature of these working visits contributes enormously to the success of the FutureLab.

- The Woodside Technical Sabbaticals have continued to add to the success of the Woodside FutureLab at Monash. This face-to-face involvement allows for the successful integration of Monash into Woodside's core business and technical units, spreading the message of Monash capability and the innovation. Woodside employees who have spent time at Monash have acquired key skills and relevant experience in the areas of AM, advanced CAD, data science and materials engineering. Additionally, the visiting Woodside staff have provided Monash with an improved understanding of issues and realities of Woodside operations. The Woodside staff who visited in 2018 include:
  - Ms. Ellie Beurteaux (Graduate Mechanical Engineer)
  - Mr. Josh Goyder (Graduate Data Scientist)
  - Ms. Sarah Summerscales (Graduate Materials Engineer)
- Numerous Woodside personnel have visited the Woodside FutureLAB at Monash to gain an understanding of our capabilities as well as present us with strategic challenges that require an innovative solution. The personnel who visited in 2018 include:
  - Mr. Brian Haggerty (Vice President, Innovation Capability)
  - Mr. Shaun D'Monte (Senior Development Engineer, Brownfield Development – Onshore), Mr. Steve Sheen (Senior Structural Engineer)
  - Mr Solomon Faka (Principal Development Engineer), Michelle Frayne (Graduate Process Engineer)
  - Mr. Eric Chen (Lead Drilling Engineer), Ms. Emil Puzey (Graduate Process Engineer)
  - Mr. Travis Baensch (Senior Client Coatings & Insulation Inspector)
  - Ms. Emily Puzey (Graduate Process Engineer)
  - Mr. Darren Shanahan (Production Technology Portfolio Manager)
  - Mr. Paul Henderson (Graduate Inspection Engineer)
  - Mr. Iain Mackenzie (Chief Electrical Engineer, Development Engineering), Mr. Stephen Brown (Principle Engineer, Electrical)
  - Ms . Nicole Magill (Resourcing Manager, People and Global Capability), Jackie Connolly (Vice President, People & Capability), Theo Anderson (General Manager, Organisational Development)
- We continued to actively engage with Woodside through regular visits from our counterparts Neil Kavanagh (Chief Science & Technology Manager), Mike Brameld (Chief Materials and Inspection Engineer), Voula Terzoudi (Technology Manager), Wendy Gibbons (Technology Manager), and Mahesh Raghvani (Geophysicist Technology).
- We have continued sending Woodside FutureLAB at Monash personnel to Woodside for site/industry visits, with an aim of improving their understanding of the challenges encountered in the Oil & Gas industry. The numerous visits in 2018 include:
  - Senior Delegation of Monash Academics and leaders to Perth and Karratha incl. Prof. Marc Parlange (Provost & Senior Vice-President), Prof. Elizabeth Croft (Dean of Engineering), Prof. Jordan Nash (Dean of Science), Prof. Jon Whittle (Dean of IT), and Mr. Marcus Ward (Chief Philanthropy Officer) in July
  - Prof. Birbilis to Perth
  - Prof. Chris Hutchinson and Prof. Elizabeth Croft to Perth and KGP
  - Delegation of New Energy Researchers to Perth for 2-day workshop incl. Prof Damon Honnery, A/Prof. Jacek Jasieniak, Prof. Doug Macfarlane, Dr Akshat Tanksale, Mr. Scott Ferraro, Prof. Maria Garcia de la Banda, Dr. Dinh Phung and Dr. Matthew Nussio.
  - Prof. de la Banda, Dr. Belov, Dr. Czauderna, Mr. Klapperstueck, Dr. I. Senthooran to Perth, Curtin and KGP
  - Ms. Ingram and Ms. Cao to Perth and KGP
  - Dr. Djumas to Perth and KGP on multiple occasions
- Monash MSE Undergraduate Mr. Juan Nicklaus has taken up a position in the Woodside Graduate Program in the Materials Engineering Function after contributing over 2 year to the Woodside FutureLab.
- Mr. Paul Hendy spent a fortnight embedded in the Woodside Mechanical Engineering function, progressing key projects as well as gaining valuable exposure to the Woodside working environment.
- Ms. Wendy Gibbons (Technology Manager) and Dr. Tejas Bhatelia (Senior Research Fellow – Curtin University) visited the Woodside FutureLAB at Monash for in-depth discussions of current and future collaboration opportunities.
- Monash Industry Team Initiative (MITI) – Woodside hosted a multi-disciplinary team of Monash students over the Dec 2017-Feb 2018 period.
- Monash MSE Undergraduate Georgia Hunter participated in the Woodside Summer Internship program over the Dec 2017 – Feb 2018 period.

As a result of these exchanges and visits, Woodside has gained a better understanding of the calibre of engineers available at Monash. Woodside has first access to Monash Engineering talent as evidenced by recruitment of Woodside FutureLAB at Monash casual researchers and Monash undergraduates into various internship programs.

2019: THE YEAR AHEAD

Continuing to build the project portfolio is a key focus of Woodside FutureLAB at Monash moving into 2019. This includes:

- (i) recruiting additional personnel, as they are the foundation of what we are able to do;
- (ii) diversifying research initiatives to maintain our status as an industry leading, world-class research facility;
- (iii) identifying areas where we can become innovators; and
- (iv) growing the size and scope of the FutureLab to include new themes and projects. The chart below details all of these.

Denotes within present FutureLAB scope
** Denotes future work
(XX) Denotes focal contact

ADDITIVE MANUFACTURING

MATERIALS

AM 316L SS, incl. upscaling. ***(GSM)***

AM of Duplex and Super Duplex CRAs.***(DJ)***

Multi-metal printing, large format printing, cladding. ***(DF)***

Metal Replacement, polymers and composites. ***(LD, MI)***

DESIGN

> Carbon Fibre Bicycle. ***(LD, CV, MI)***
> 316L SS Monoflange. ***(LD, PH, GSM)***
> Pad Flange. ***(DF)***
> Automated, high throughput 3D scanning. ***(LD)***

MATERIALS DURABILITY

Addressing Corrosion Under Insulation ***(CUI, QC)***

Corrosion of additively manufactured ferrous metals. ***(GSM, ST)***

Repair, organic coatings and pitting arrest (STOPAQ) in metals. ***(ST, GSM)***

Machine Learning for corrosion detection. ***(WTN)***

Multi-metal coatings/claddings. ***(DF)***

Hydrogen effects on corrosion. ***(ST)***

DATA SCIENCES

Automated plant layout. ***(MGDLB, GB)***

Plant layout optimisation and visualisation. ***(TC, MW)***

Risk Modelling, Management & Visualisation ***(AN)***

Artificial intelligence, Neural networks and Machine learning. ***(WTN, AN)***

Artificial Intelligence partnership. ***(IITB)****

ADDITIONAL PROJECTS

Glass Printing. **(DF/NB)**

Structural/Wind Tunnel investigations. **(DV)**

Pop-Up FutureLab

Qualification of on-demand AM components for O&G

FUTURELAB EXTENSION

Affordable Hydrogen

Useful Carbon

EMERGING THEMES

> Joining and integration of AM produced components
> AM Process/Materials Modelling
> Subsea exploration and drilling exploration
> Micro-climate Modelling
> Subsurface Visualisation
> Drilling Optimisation
> Sustainable Manufacturing
> Seismic Data Interpretation
> Inventory Management
> Integrated Planning Visualisation
> Subsea Pipe Routing

TECH TRANSFER & OPPORTUNITIES

Training, exchange, sabbaticals and immersion

SPIN OFFS AND SPIN OFF PROSPECTS

> Corrosion detection software
> Technology consultancy
> Probes and corrosion solutions
> Automated plant layout software
> AM for O&G

LEVERAGING OF FUNDS

> IMCRC
> ARC Linkage
> Opportunities & Partnerships

Monash University 2019

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FURTHER INFORMATION

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