# TRUSTED AUTONOMOUS SYSTEMS

# 2023
# Annual Report

Trusted Autonomous Systems Annual Report
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# Executive Summary
## Message from the CEO
### Glen Schafer

This year brings clarity on Defence priorities through the Defence Strategic Review (DSR), AUKUS Pillar II and the formation of the Advanced Strategic Capabilities Accelerator. Trusted Autonomy remains a high priority in all three, placing Trusted Autonomous Systems at the thematic forefront.

TAS is presently in its final year of operation and thus I reflect on the effect it has had for its partners and Defence. The TAS entity was purposefully designed as a fast, lean, consortium focused vehicle for the delivery of capability into the Australian Defence Force. The result of this innovation experiment has been a success, with a significant number of our programs translating into Defence capability and commercial outcomes. This result is even more impressive given that TAS is a core team of eight people supported by the superb work of our partner organisations and our Board of Directors.
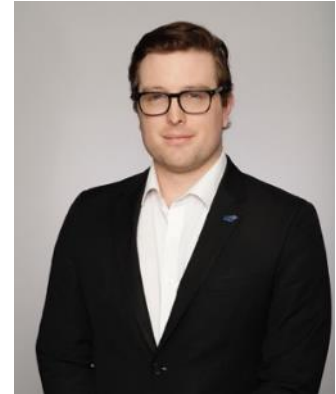
The TAS model has been referred to as a disrupter and, like any successful disrupter, we have at times challenged the status quo on how things are or could be done. Fundamentally, most disruptors are all in one way or another led by a purity and clarity of mission, supported by a common series of lean processes. In this sense the environment that tends to foster innovation is repeatable; what is left then is intuition, talent and bravery. The innovation challenges faced by Australia and Defence are significant. TAS remains ready and willing to continue operations beyond 2024 bringing to bear its model, people and experience, accumulated over our seven years of operation.

It has been my great privilege to lead Trusted Autonomous Systems this year and to work with our remarkable universities, fellows, industry partners and TAS team members all of whom are instrumental in its success.


Glen Schafer
CEO

# TAS Chief Technology Officer
## Dr Simon Ng

TAS continues to consolidate its Defence-directed and industry-led innovation program built on world-class research from Australia's publicly funded research ecosystem.

In the last year, TAS has partnered directly with Defence, industry, and academia to develop a new system for supporting launch and recovery of autonomous underwater vehicles, to develop core technologies that will allow humans to team with heterogenous teams of air and ground robots, and to deliver a prototype system for high-altitude (stratospheric) persistent surveillance.

These projects support Defence's vision to deploy robotic and autonomous systems at scale across air, land, and sea. The technology we are investing in represents best of breed in robotics and autonomy; the industry and research partners occupy the forefront of robotics and autonomous systems innovation nationally and internationally; and we have now generated well over two hundred items of individual IP to be exploited by sovereign industry and government.

# TAS Deputy Chief Technology Officer
## Katherine Head

In addition to the continued facilitation of Defence-focussed capability development, TAS provides support across functions that enable industry-led projects. TAS provides best-practice guidance in the application of lean systems engineering processes tailored to rapid research and development projects, direction in the effective test and evaluation of RAS-AI systems, and advice on the effective communication of deep technical concepts and project outcomes to end users. These critical functions aim to ensure that TAS-led projects deliver results with a ready ability to translate to mission-ready capabilities.

# TAS General Manager – Law, Regulation and Assurance
## Rachel Horne

TAS has collaborated with the Australian autonomous systems ecosystem to produce practical tools, resources and standards supporting navigation of regulatory pathways.

In the last year, TAS has worked directly with government, Defence, industry, and academia to develop a new centralised access point for regulatory tools and resources: RASGateway.com.au. This free online platform supports designers, manufacturers, operators and regulators of autonomous systems used in the air, maritime and land domains to understand the Australian operating environment, including the systems in use, the regulatory requirements that apply, and available pathways. Improving access to information via this sort of innovative approach will have far-reaching and positive impacts for TAS stakeholders, enabling more efficient and certain regulatory engagement.

TAS activities in Law and Ethics, and Assurance of Autonomy, support the Australian autonomous systems ecosystem to design, manufacture and operate safe and trusted autonomous systems. The projects we are investing in, supported by the Queensland Government, are addressing long-standing regulatory and related hurdles, and driving innovation and business domestically and internationally.

# Projects and Activities
## Work conducted by the Centre in FY2022-2023 included:

**Projects**: industry-led programmes of work with academic, Defence, and government partners intended to deliver capability and create sustainable industry capacity to ensure the resilience of the Defence capability pipeline for robotic and autonomous systems. TAS attributes its industry-led nature to the success of these projects.

**Activities**: centre-wide and aim to deliver a common good to projects, participants, and key stakeholders, as well as the wider national and international community. Any IP generated by activities is available to all projects and participants.

There is not a hard barrier between the Projects and Activities.  Instead, our ethics, law, and assurance activities inform and support the trajectory of research towards adoption. In turn, this approach increases the practicality and applied nature of the activities' work.



Leverage and impact from TAS operations to end FY 22-23

# Ongoing Projects

TAS has executed two new projects this financial year. These new projects are subject to confidentiality provisions as are some projects continued from previous reporting periods.

## Trusted Autonomous Ground Vehicles EW (TAGVIEW)
### Ongoing – NGTF funded

TAGVIEW delivers core technologies relevant to fielding of multi-vehicle autonomous ground platforms to support tactical ISR and EW. BAE Systems, working with researchers at the Universities of Melbourne and Adelaide, has developed advanced AI techniques to deliver a next-level trusted autonomous platform capable of robust and persistent operation in complex, contested land environments. In this reporting period, core subsystems have been developed and demonstrated in the field, including: a novel method for combining both overhead and real-time ground imagery that allows a machine to recognise important features in its environment; adaptive dynamic tasking of multiple vehicles undertaking complex missions; and human command interfaces that allow single operators to manage complex mission profiles for multiple vehicles. The technology has been integrated into three of the M113AS4 optionally crewed combat vehicles (OCCVs) with the assistance of RICO.


BAE Systems image from OCCV testing.

## Mine-Counter-Measures in a Day
### Ongoing – NGTF funded

Thales is partnering with DST, Academia (Flinders University, University of Sydney, University of Technology Sydney and the Western Sydney University) and Australian SMEs (INENI Realtime, Mission Systems) to develop and demonstrate autonomous technologies and training solutions that will revolutionise mine clearance in littoral operations. The four-year, A$15 million innovation project delivered its first significant milestone earlier this year: a fully integrated simulation of a multi-robot underwater rapid environmental assessment mission that would normally be undertaken by a team of divers. The demonstration highlighted core simulation and modelling techniques that will underpin broader innovation programs for Navy and Thales. This first

demonstration was attended by representatives from across Navy and provided proof of the underlying physics engines need to allow a team of underwater robots to operate in the most demanding underwater conditions.

This new autonomous approach has the potential to support a significant operational step-change to the Royal Australian Navy by removing ADF members from harm's way and accelerating the speed of mission execution.

Progress continues on development of the core system elements, with integration testing conducted on individual systems and subsystems through until June 2023. A full system integration trials program is scheduled for the second half of 2023. The most recent Thales public update on the project is available here.


Thales Australia image November 2022.

# Patrol Boat Autonomy Trial
## Approaching trial phase

The Patrol Boat Autonomy Trial led by Austal, partnering with L3 Harris on behalf of the Royal Australian Navy Warfare Innovation Navy (WIN) Branch will establish robotic, automated and autonomous elements on a decommissioned Armidale Class Patrol Boat (formerly HMAS Maitland). This will provide a proof-of-concept demonstrator for optionally crewed or autonomous operations and explore the legal and regulatory pathways and requirements.

Austal is uniquely placed to undertake this project as the original designers and builders of the Armidale-class Patrol Boat vessels. This project presents a significant opportunity to inform current and future maritime capability acquisition, and to build sovereign Australian capability in the autonomous maritime platform domain. It will pave the way for further work to achieve sustained and sustainable optimal crewing, to improve safety of Australian Defence Force (ADF) personnel and expose the Naval workforce to these technologies and other elements of the Navy RAS-AI Strategy 2040 including normalising human-machine teaming.

TAS, supported by East Consulting, is delivering a Regulatory Exemplar Project integrated with the Patrol Boat Autonomy Trial to establish best practice regulatory approaches for autonomous vessels. The most recent Austal public release on the project is available here and sea trials are planned for second half 2023.

Image of the PBAT Sentinel

# Hyper-Teaming
## Ongoing

'Hyper-Teaming', an Australian Army project being delivered by Trusted Autonomous Systems in partnership with Mission Systems, the University of Technology Sydney, the  Defence Science & Technology Group and AMSL Aero, exploits new robotics technologies and AI techniques to develop a prototype cooperative robotic system suited to high-tempo land operations. 'Hyper Teaming' will enhance the future Joint Land force by prototyping new solutions for air-ground robotic teaming, human command and machine control architectures, trusted autonomous behaviour that is dependable and context aware and can provide a critical enabler for human-machine multi-domain teams to respond cooperatively to emerging threats in their operating environment.

The Project is sponsored by the  Australian Army Robotics and Autonomous Systems Implementation Coordination Office (RICO) in accordance with the Army Robotic & Autonomous Systems (RAS) Strategy, nested within a broader portfolio of Army innovation and concept exploration of future autonomous systems that will drive broader advances across multiple industry and research partners to build sovereign capability in and for Australia, ensuring supply chains and acquisition agility and resilience relevant to Army's future capability needs.

Mission Systems provided a briefing at the Army Robotics Expo (ARX) in 2022 with a video summary available here and field demonstrations will continue in second half of 2023.

Mission Systems team pictured with Chief of Army, LTGEN Simon Stuart at ARX 2022 (Image Mission Systems).

# Low SWaP – Cognitive payloads for UAV

## QLD Government funded - ongoing

The Low Size Weight and Power Cognitive Payloads for Small UAV project was executed 28 January 2022. Led by Revolution Aerospace and working with Queensland University of Technology, the project will prototype a revolutionary low-cost package for a small drone (nominally sub-10kg) leveraging commercial components incorporating advanced sensing and processing methods.

TAS separately engaged with Revolution Aerospace on a Detect and Avoid (DAA) project that has now been extended through the Commonwealth's Emerging Aviation Technology Partnerships Program (EATPP), program Phase 1. TAS is supporting Revolution Aerospace through provision of a range of subsidies for use of the Queensland Flight Test Range. More on Revolution Aerospace ongoing work here.
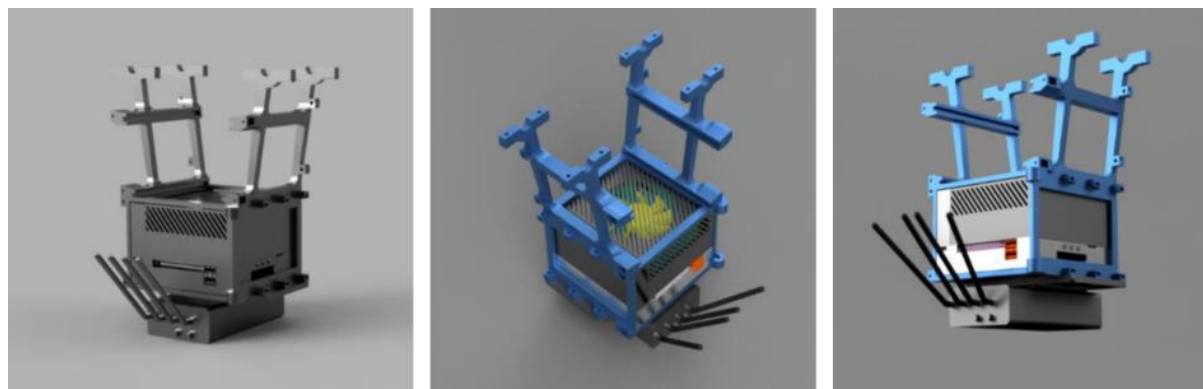


RevAero's low-cost cognitive EW payload

# AI and Automation in Language Tech

## QLD Government funded - ongoing

Pama Language Centre (PLC) and Janet Wiles, Ben Foley, and Ben Matthews at the University of Queensland (UQ) will collaborate on a series of projects with speech communities. This project will develop secure, confidential, onshore AI processing of speech and language data making it practical, widely available and integrated with the digital asset manager that underpins AI language technologies. It will identify requirements for AI systems to achieve data sovereignty for onshore language technologies, achieve participatory design framework for AI and case study, as well as producing AI-enabled Augmented Reality language tools and learning resources for First Nations custodians to create and manage their own AI language assets.

This project will enable career development and professional practice for First Nations Language professionals and will also increase the viability of fragile languages across Queensland and Academic publications in AI for languages and participatory design. The project is also conducting surveys of novel technology designs and data sovereignty models to identify novel technology design possibilities for creating meaningful AR learning experiences for First Nations languages, and the range of data sovereignty models that could be applicable to PLC language assets, asset sharing and longer-term data/asset management.

The project continues to develop a data model and has matured augmented reality educational and learning technologies relevant to effective language engagement for speakers of endangered languages. A workshop aimed at supporting broader community use for this technology is planned for second half 2023.

# HuMT – identify & protect high-value cultural assets

## QLD Government funded - ongoing

KJR and partners (Western Yalanji Aboriginal Corporation, Athena AI, Emesent, Flyfreely, MaxusAI, World of Drones Education Pty Ltd, and Griffith University) will develop a secure multi-platform human-machine teaming capability in Queensland through using semi-autonomous drones for data capture and machine learning for image classification to identify and protect Western Yalanji rock art.

This project will integrate five industry AI products into a semi-autonomous drone platform suitable to navigate and survey remote and rugged terrain as well as a methodology and framework for data and machine learning assurance.



Autonomous detection of rock art sites and specific rock art instances by KJR and the team.

# Completed Projects

Since inception, TAS has realised significant leverage of funding towards capability. These concluded projects are examples of TAS success.

# Trusted Search

## Concluded in reporting period – NGTF funded

The Trusted Search Project is now concluded. The final milestone showcased a multi-drone heterogenous swarm conducting a complex multi-task mission in a representative real-world environment. DefendTex partnered with RMIT University, the University of Melbourne, and the Defence Science and Technology Group (DSTG) to develop key algorithms (dynamic task planning, swarm

formation and flocking control, terrain collision avoidance), key sensing technologies (rotating synthetic aperture radar) and platform technologies (including the Drone-40 family of USVs and subsystems). This project was approved by the board in August 2018 and has delivered key technology demonstrations. A key platform from the project, the Drone 40, is now in operational use in defending Ukraine.

# Distributed aUtonomous Spectrum ManagemenT (DUST)
## Nearing completion – NGTF funded

DUST (led by Consunet Pty Ltd with RMIT University, the University of Melbourne, the University of Sydney and DSTG in support) aims to research, develop and demonstrate near real-time autonomous spectrum management to deliver orders of magnitude increase in agility and efficiency cost savings for Australian Defence and commerce. This year, the DUST Project has not only developed and demonstrated key advances in large-scale spectrum prediction and exploitation, but Consunet has also achieved a significant commercial outcome with the DUST IP, with the technology transitioning into capability as part of both JP9321 and AIR6500. The project has been a foundation for other significant success for Consunet. The video on this link provides an overview of the system that is now being integrated into emerging ADF capability, including Lockheed Martin's AIR 6500.

# Joint Autonomous UAS Effects (JAUASE)
## Concluded in reporting period – NGTF funded

Led by Skyborne Technologies and Cyborg Dynamics Engineering with the University of Queensland (UQ) and DST, and approved by the board in February 2019, this project aims to research and develop autonomous live reconnaissance effects assessment using AI and machine vision for day and night UAS operations over land. The system aims to advise operators on the legal and ethical aspects of fire support missions in near-real time.

The project developed a technically mature system using state-of-the-art neural networks, decision support capabilities, and middleware. The project outcome is now referred to as Athena AI and you can read more here about the system and its progression into capability. The technology is now in follow-on development with significant investment as a Defence Innovation Hub Commercialisation Project, underling the ability of TAS to accelerate innovation and transition innovation into capability and commercial success for sovereign industry. Commercial sales for ATHENA AI continue to grow, marking this as a success story for Australian industry.

# Gannet Glider
## Concluded in reporting period

Skyborne Technologies is working with DSTG to develop a glider that can be carried by the Cerberus UAV in a rotating launcher to provide long-range effects for lightly equipped soldiers. The Gannet Glider uses independently sweeping wings to provide stable, accurate glide control to a target location after command for release is received by the UAS operator. A series of flight tests and drop tests conducted

late in the previous reporting period provided clear evidence of the performance of the system. The program has already been accelerated through a Defence Rapid Prototyping Initiative. The final project demonstration was conducted in early 2023.

# Human Machine Teaming (HuMT) Geospatial Decision Support
## Concluded in reporting period

Cyborg Dynamics Engineering is enhancing the existing ATHENA interface being developed under the Justified Autonomous UAS Effects Program to include geospatial data and semantic scene AI to enhance mission planning.

The project will integrate a complex AI-driven path planning algorithm using autonomous 3D terrain analysis derived from on-board and external sensor data into Athena (see JAUASE below) to aid approach planning for Army in complex terrain, demonstrating an approach to enhancing lawful targeting by enabling a UAS system to classify natural and man-made terrain features that impact targeting considerations and mission planning/execution. A demonstration of the route planning and terrain analysis visualisation is available here. As with ATHENA AI above, the technology from this project is in follow-on development as a Defence Innovation Hub Commercialisation Project, further demonstrating TAS' success at accelerating innovation and transitioning innovation into capability and commercial success. The technology has always been integrated into other development programs as a key AI enabler.

# Firefly
## Concluded in previous reporting period

In collaboration with RMIT and a range of industry partners (LUX Pty Ltd, Danfield, Elson Space Australia), and with support from the Defence AI Centre, TAS invested in an exploratory research project aimed at developing and testing key components of a stratospheric airship capability that could provide Defence and other civil and commercial users with a persistent surveillance and communications capability with strategic mobility.

The Firefly Project focussed on core enablers, including the algorithms needed to predict the trajectory of a high-altitude airship using detailed wind models, algorithms for controlling constellations of airships so they can manoeuvre in concert, and core simulation and modelling tools needed to support both real-time autonomous flight and more robust development. The project delivered its key findings and a full flight demonstration in Q3 2021, providing compelling insights into the underlying technologies.

# RAS-Gateway (previously Agile AI)
## QLD Government funded – concluded in the reporting period

The Robotics and Autonomous Systems (RAS) Gateway project is led by the Trusted Autonomous Systems Assurance of Autonomy Activity with support from a Queensland-based agile software developer Aginic. The project set out to investigate and build digital tools to support assurance and accreditation of autonomous systems. The result is "RAS-Gateway", an online platform providing centralised access to digital regulatory tools and resources for autonomous systems stakeholders in the air, maritime and land domain.

The project has leveraged strong stakeholder engagement from a broad range of defence, government, academic and industry participants to inform the iterative build of RAS-Gateway, ensuring maximum

applicability, usefulness, and buy-in. While the project to develop the RAS-Gateway has concluded, the site remains live and updates will be provided where required.
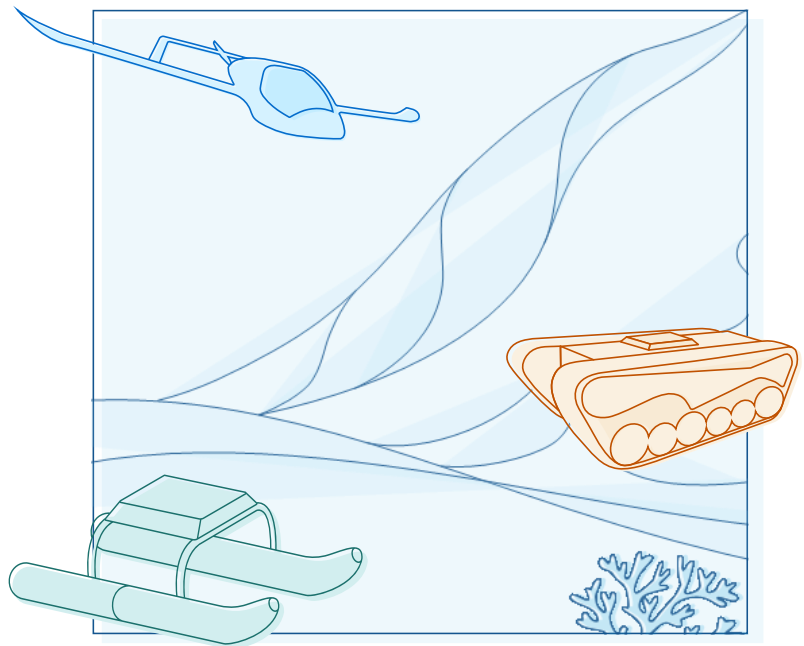


# High Altitude
# Pseudo-Satellite (HAPS) Challenge
## Concluded in reporting period

The HAPS Challenge is exploring high-altitude technologies including balloons that provide a range of lower-cost mechanisms to deploy payloads to areas of interest. The work of the participants was showcased in mid-2022 to DSTG, Air Force (a major sponsor) and a senior US delegation in Brisbane, where the industry partner PACITS inflated the full envelope and put subsystem technologies on display.

The DanField Stratoship team picture in front of inflated envelope during demonstration to US delegation.

The HAPS Challenge Phase 3 took place between November 2021 and 2022, with the sole participant in this phase, Power and Control in the Stratosphere (PACITS), led by DanField Stratoship Pty Ltd.

Despite numerous challenges, PACITS undertook development, regulatory and operational activities over the period of Phase 3, with key achievements including:

- platform and sub-systems construction
- securing CASA exemptions for the flight trials in collaboration with QinetiQ and the Cloncurry Range (Queensland Flight Test Range)
- two envelope inflation tests in May and July, providing confidence in the integrity of the envelope and helping to refine inflation procedures
- development and testing of individual systems, including buoyancy control, flight termination, mission avionics, propulsion, flight control

- achievement of key operational milestones, including pilot training, insurance, range and stakeholder engagement.

The PACITS syndicate and partners mobilised to Cloncurry in October 2022 with payloads and the Stratoship platform developed through the HAPS Challenge. After a period of flight preparation PACITS awaited a flight window that would meet meteorological conditions and flight approvals. Ultimately a launch was undertaken but the flight was terminated due to flight performance and airspace constraints. The system was recovered in full, and while not achieving the full objectives, provided rich lessons for the future.

The Challenge format allowed a diverse group of stakeholders to work together on a problem of mutual interest, providing a springboard for the PACITS consortium to achieve the performance targets with further time and investment. This establishes the basis for further development of a capability that would provide persistent surveillance and services at a cost well below the conventional fixed wing solutions being considered, providing an opportunity to operate at a scale and at an investment level that could provide a transformative capability option for the nation.

PACITS was led by Danfield Stratoship and supported by a team The Stratoship Group including its sibling company Skysite, SuperSky Engineering, SmartSat Services and the Australian National University.

HAPS Challenge management incorporates Sir Lawrence Wackett Defence & Aerospace Centre – RMIT, SmartSat CRC, Trusted Autonomous Systems and RAAF Air Warfare Centre, supported by the Bureau of Meteorology.

# iDrogue
## Concluded in reporting period

Through disruptive innovation, Warfare Innovation Navy (WIN) Branch enables the Royal Australian Navy to be at the forefront of asymmetric warfighting for joint integrated effects. The iDrogue project, initiated by Trusted Autonomous Systems, led by Ocius Technology, and funded by WIN Branch, was established to develop and demonstrate a novel Autonomous Underwater Vessel (AUV) launch and recovery system. Ocius, a leading Australian innovator, is partnered with the Australian Maritime College and University of New South Wales on this exciting project.

In March 2023, this pilot project concluded with a successful demonstration to Navy of the iDrogue AUV launch and recovery system at various depths and an autonomous control loop to automate main phases of the recovery. Future research remains under discussion.
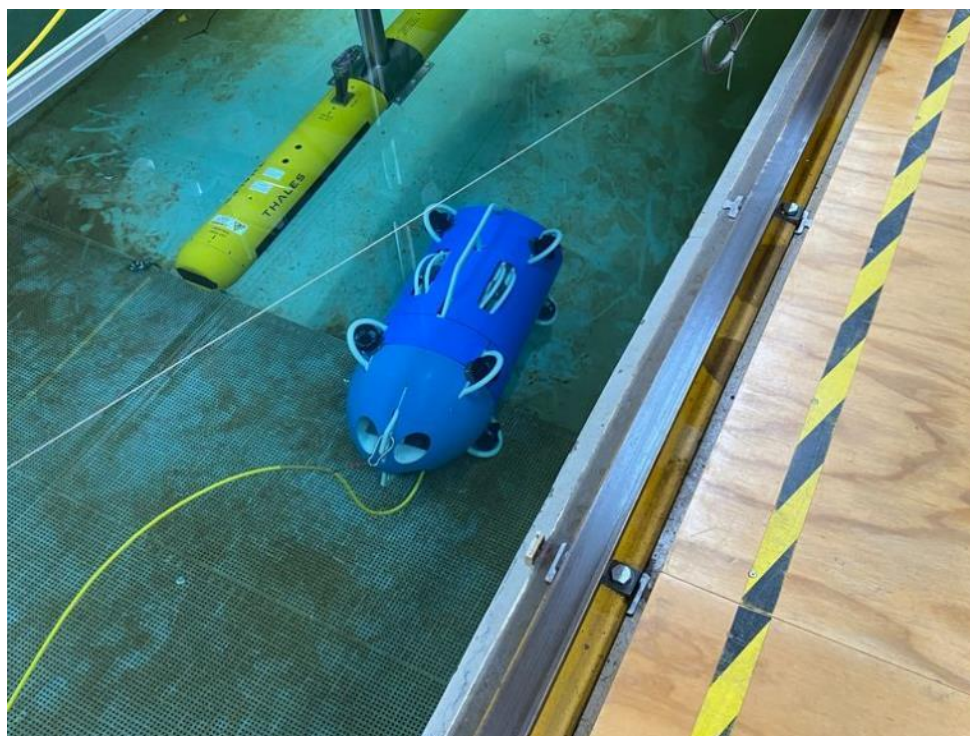
Image of iDrogue (Ocius).

# SeaWolf
## Concluded

While funding for this project was revised prior to initial demonstrations TAS, with a consortium including Cellula Robotics Ltd (Canada), successfully deployed a large AUV system (Solus-LR) in Australia in early 2023, conducting a week of at-sea trials in a bay and deep water. The system was hybrid powered by a hydrogen fuel cell, a first in Australia for this type of platform and demonstrating the range and viability of this propulsion system. Further, this project refined and demonstrated core AI and autonomy software developed by Mission Systems Pty Ltd relevant to future autonomous underwater vessels. Following the cessation of this pilot program, Cellula Robotics has continued to develop the Solus-XR and is now undertaking sea trials with a range of partners. More detail on continued Cellula initiatives is available on the Cellula News site.



12m Solus-XR prototype.

# Activity 1.
## Ethics and Law of Trusted Autonomous Systems
### NGTF funded



The Trusted Autonomous Systems (TAS) Ethics Uplift Program (EUP) supports theoretical and practical ethical AI research and provides advisory services for industry to enhance capacity for building ethical and deployable trusted autonomous systems for Australian Defence.

## Ethics research projects

**Responsible AI for Defence (RAID) toolkit:** TAS and International Weapons Review with Defence consultation and engagement is developing a toolkit to help Defence industries. The toolkit draws on A Method for Ethical AI in Defence (MEAID), ADF-0-P Military Ethics, and other relevant Australian and International ethical and legal commitments and frameworks. A consultation draft is available on the TAS Resources site.

**Autonomous Systems Demonstration Canvas:** The Canvas is designed to optimise design, planning, and management of autonomy technology demonstrations for capability impact and investment. TAS is working with Evaluation Partners and TAS stakeholders to develop support materials for Defence Industry using the Canvas as a planning tool for demonstrations. Version two of the Canvas is available on the TAS Resources site.

**Ethics and regulation of AI spectrum technologies:** The Ethics and Regulation of AI Spectrum Technologies project research existing and emerging regulatory environment and ethical aspects in relation to use of AI in spectrum products and capabilities domestically and internationally. The project identifies regulatory pathways for Defence industries in Australia to test, trial and use advance spectrum management technologies.

**TAS Ethics Uplift fellows** (see below) are developing *A Value-Sensitive Design Framework for Trusted Autonomous Systems* (Dr Christina Boshuijzen-Van Burken) and *A Human-Machine Team (HUM-T) Safety Framework* for cross-domain networked autonomous systems in littoral environments (Dr Zena Assaad).

# Law

TAS law research is led by A/Prof Rain Liivoja's UQ Law and the Future of War Research Group. With an established international reputation, the UQ team's work has informed NGO reports on the use of autonomous weapons systems and academic papers on Article 36 reviews of LAWS. The team has contributed to international discussion on the use of autonomous systems by Defence by outlining how engagement with industry can ensure increased compliance with IHL for new technologies on the International Committee of the Red Cross blog, and highlighting relevant legal standards for autonomous systems on the Lieber Institute's Articles of War platform.

Their researchers are consistently sought for expert contributions. For example, they have acted as expert reviewers for multiple NGO reports on IHL and LAWS, have extensive connections with international organisations such as ICRC, SIPRI, UNIDIR, UNODA, and contribute to the dialogue at the UN CCW GGE LAWS forum. Domestically, they engage with the Attorney-General, Defence Legal, DFAT, and other organisations. A/Prof Rain Liivoja is currently a Visiting Legal Fellow at DFAT, an appointment that promotes regular engagement with DFAT lawyers and policy officers on arms control issues including discussion on AWS.

The UQ Law team has published influential papers and books on diverse subjects, including the legal challenges associated with autonomous navigation, liability for autonomous systems when unintended harms occur, and cyber autonomy and international law. Their research papers are accompanied by policy briefs that provide an executive summary of the papers. They also produce a podcast which interviews experts from diverse fields to explore how new military technology and international law interact. Their podcast has reached over 15500 downloads with up to 850 listens per episode on Apple, Spotify, Google, Overcast, and Buzzsprout.

# Activity 2.
## Assurance of Autonomy
### Queensland Government Funding

The Assurance of Autonomy activity aims to unlock Australia's capacity for translating autonomous system innovation into operational capability, leveraging regulatory and technical expertise and strong stakeholder relationships to support the Australian autonomous systems ecosystem.

The Assurance of Autonomy team collaborates with domestic and international industry, academic, government, regulatory, and defence stakeholders to identify and address key barriers to smooth regulatory pathways. The team delivers initiatives including technical standards, frameworks, and guidance material that better equip the Australian autonomous ecosystem to accelerate innovation in a way that meets a clear and coherent regulatory framework and enhances efficiency without compromising safety.



## Assurance of Autonomy projects:

- **RAS-Gateway:** The Robotics and Autonomous Systems (RAS) Gateway project is delivered by the Assurance of Autonomy Activity team, supported by Queensland-based agile software developer Aginic. More details provided above.
- **Australian Code of Practice:** the TAS team, supported by Vanderkooi Consulting, Frazer-Nash Consultancy and AMC Search, and engaging closely with AMSA, have delivered the first Australian-centric Code of Practice for Design, Construction, Survey, and Operation of autonomous and remotely operated vessels. This project fills a gap in the regulatory framework and provides a benchmark for good practice for autonomous and remotely operated vessels which are domestic commercial vessels. The TAS team continues to elicit feedback on the Code from operators to inform future iterations.
- **COLREGs Operator Guidance Framework:** The TAS team, supported by Frazer-Nash Consultancy, has tackled the worldwide issue of identifying how COLREGs (collision avoidance requirements set out by international convention) apply to autonomous vessels. The COLREGs Operator Guidance Framework translates COLREGs for vessels without crew on board, and supports users to identify when rules apply, the capabilities on and/or off-board the vessel required to comply, and the means of providing evidence to the regulator. This project will have international impact in both commercial and defence industries and supports the ongoing use of increasing levels of autonomy in the maritime domain. The framework has been converted into a digital tool, in partnership with Aginic, and is available for use on RAS-Gateway.
- **Autonomous Systems Body of Knowledge:** the team has consolidated a body of knowledge on the assurance and accreditation of autonomous systems in the air, maritime and land domains. The Body of Knowledge is published on RAS-Gateway.
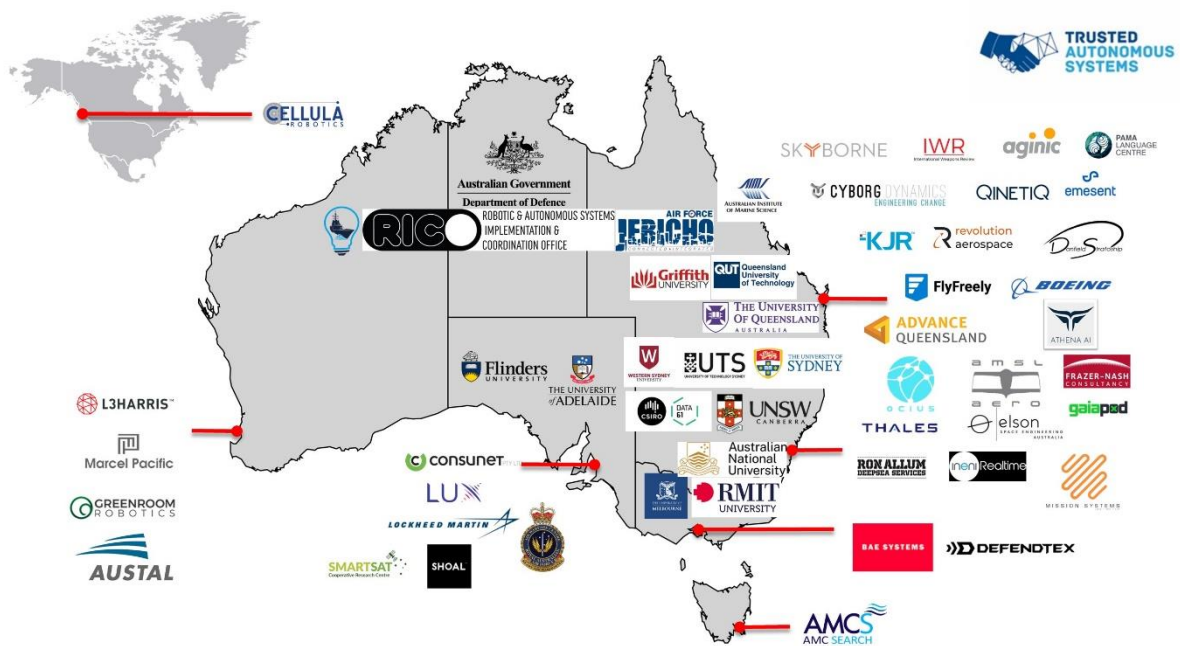
Trusted Autonomous Systems collaborators.

# Governance and Key Staff

The Centre is an unlisted public company limited by guarantee, incorporated, and domiciled in Australia. Its national office is in Brisbane, Queensland. The board conducts activities of TAS through the Chief Executive Officer (CEO) and delegates specific powers and responsibilities to the CEO.

The Board's role is to govern the Centre by:
- providing appropriate leadership
- contributing to and approving the strategic plan
- approving operational plans and budgets to ensure consistency with the goals and objectives
- monitoring performance and management
- assessing risks and ensuring that appropriate risk management strategies are in place
- setting and promoting appropriate values and standards.

The Board has met on seven occasions over the reporting period.

## Research Fellows

Four Centre Research Fellows were appointed in the 2020-2021 financial year as part of the Queensland Government-funded research. Two further Fellows were appointed in 2022-2023 to support Commonwealth Ethics Uplift activities.

### Queensland-funded TAS Research Fellows

| Fellow | Affiliation | Project |
| --- | --- | --- |
| **Dr Andrew Back** | University of Queensland | Synthetic Language and Information Topology (SLAIT) AI |
| **A/Prof Pauline Pounds** | University of Queensland | Embodied Autonomy for Dynamic Control of Unmanned Systems |
| **Dr Jessica Korte** | University of Queensland | Australian Sign Language (Auslan) Communication Technologies Pipeline |
| **Dr Beth Cardier** | Griffith University | Tipping Points: Modelling Emergent Trust in Narrative |

### Commonwealth-funded TAS Research Fellows

| Fellow | Affiliation | Project |
| --- | --- | --- |
| **Dr Zena Assaad** | Australian National University | Human-Machine Team (HUM-T) Safety Framework for cross-domain networked autonomous systems |
| **Dr Christina Boshuijzen-Van Burken** | UNSW ADFA | Ethical Design of Trusted Autonomous Systems in Defence |
| **A/Prof Csab Veres** | Deakin University | Multi-agent reasoning for lawful autonomous action |

# Performance Against Activities and Research outcomes
## Milestone Performance

The reporting period has two relevant sets of performance milestones. The initial set has been successfully completed and is set out below. The detailed performance milestones, the subject of milestone 7 below, have been submitted, agreed, and successfully varied into the funding agreement. They are principally reflections of the research outcomes of the industry-led projects outlined below.

| Milestone | Description | Due Date | Status |
|---|---|---|---|
| 1 | Preparation of the Activity Plan for the Defence CRC | 18 October 2018 | Submitted & accepted |
| 2 | Submission of the Defence CRC TAS Budget | 18 October 2018 | Submitted & accepted |
| 3 | Submission of a list of Participants in the Defence TAS CRC | 18 October 2018 | Submitted & accepted |
| 4 | Initial Research towards delivery of the formation research plan | 18 October 2018 | Submitted & accepted |
| 5 | Submission of the initial security plan | 18 October 2018 | Submitted & accepted |
| 6 | Establish the controlled content register | 18 October 2018 | Submitted & accepted |
| 7 | A variation to the funding agreement to incorporate detailed milestones | June 2019 | Complete |

# Delivering results through strong collaboration

The Centre continues to create a vibrant community of collaboration between universities, Defence and industry through industry-led projects and centre-led activities. Co-investment and engaged stakeholders provide strong evidence of the Centre's success against this overarching objective.

The Centre has leveraged more than $139 million dollars of investment from the initial Next Generation Technologies Funds grant of $50 Million, providing an expansion ratio of 4.1.[1] Co-investment has come from across our stakeholder group, including the Queensland State Government ($51M), the ADF services (over $29M), and from our DST, academic and industry Participants (over $95M).

The Centre is also generating significant workforce capacity, with a projected level of effort of nearly 240 person-years invested in Projects and Activities across the Centre's term, and with 71 individual students (undergrad, masters, and post-grad) and post-doctoral positions created and/or employed. Strong participation from Defence primes and SMEs, and from academia and DST, has been achieved, generating significant intellectual and technical outcomes through collaborative effort. Combined with the workforce achievements, the Centre's efforts are producing an enduring capacity in autonomous systems expertise across industry and academia.

| Key Metrics to June 30, 2023, for Centre wide investment | KPI | Notes (excludes data for projects executed after June 30, 2023) |
|---|---|---|
| **# Projects** | 25 | Includes common good activities A1 and A2 |
| **Total Value of Program** | $189.7M | Cash and In-kind from all sources |
| **Cash Funding to Industry** | $49.5M | Direct cash funds to Industry from NGTF, Qld Government or Defence (excludes Cash contributions from Industry and academia) |
| **Cash Funding to Academia** | $19.8M | Direct cash funds to Academia from NGTF, Qld Government or Defence (excludes Cash contributions from Academia) |
| **Full Time Equivalent Employment Created** | 238 | Total FTE created as a result of the Centre's contracted investments over the life of the Projects and Activities (includes Centre staff and Fellows) |
| **STEAM Impact** | 71 | Number of PhD students, post-docs, senior fellows, Centre Fellows and undergrads engaged. |
| **# Industry Participants** | 28 | |
| **# Academic Participants** | 14 | |
| **Leveraged Funds** | $139.1 M | Funds (cash and in-kind) attracted by leveraging the NGTF investment |
| **Networking Event** | 85 Attendees | |
| **Symposium in Brisbane** | 113 Attendees | |

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[1] Calculated as total funds including NGTF funds (cash and in-kind) divided by NGTF funds.

# National Funding, Distribution by Sector
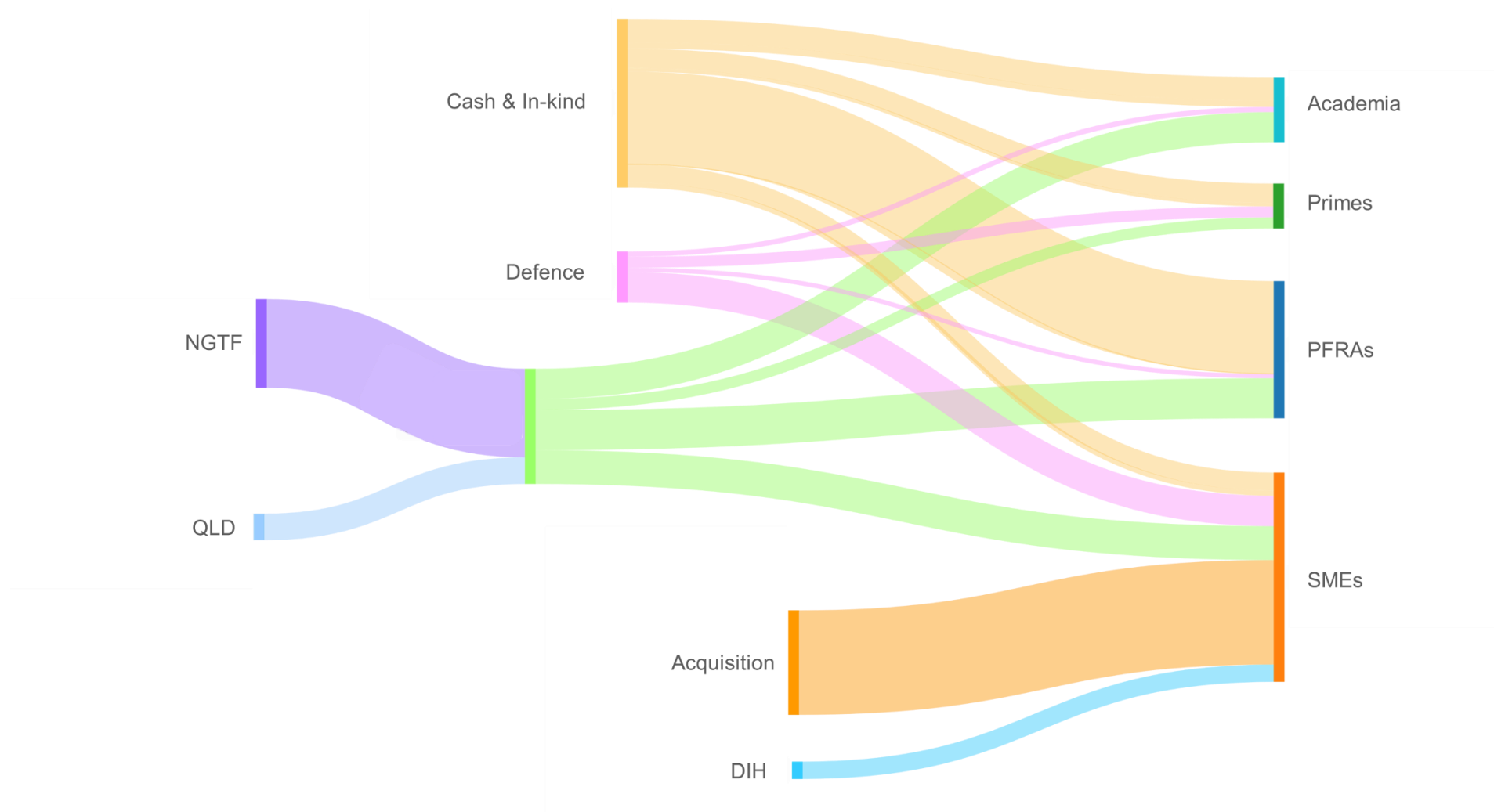
# Participants and Third Parties

Trusted Autonomous Systems continues to add industry and research participants as the portfolio of projects expands and further funding is injected into the Centre.

Founding members, participants and third parties:

| No. | Organisation | Participant Type | Company Member | ABN/ACN |
|---|---|---|---|---|
| 1 | Department of Defence represented by the Defence Science & Technology (DST) | Third party | Yes | 68 706 814 312 |
| 2 | RMIT University | Research | Yes | 49 781 030 034 |
| 3 | BAE Systems | Industry | Yes | 29 008 423 005 |
| 4 | DefendTex | Industry | Yes | 45 602 887 098 |
| 5 | Flinders University | Research | | 65 542 596 200 |
| 6 | University of Melbourne | Research | | 84 002 705 224 |
| 7 | University of Sydney | Research | | 15 211 513 464 |
| 8 | University of NSW (UNSW) | Research | | 57 195 8731 79 |
| 9 | Skyborne Technologies | Industry | | 55 604 5641 41 |
| 10 | Lockheed Martin | Industry | | |
| 11 | Data 61 | Research | | |
| 12 | Consunet | Industry | | 45 101 066 059 |
| 13 | Cyborg Dynamics Engineering | Industry | | 50 621 757 248 |
| 14 | University of Queensland | Research | | 63 942 912 684 |
| 15 | The University of Adelaide | Research | | 61 249 878 937 |
| 16. | Mission Systems Pty Ltd | Industry | | 74 618 922 740 |
| 17. | Boeing | Industry | | |
| 18. | Thales | Industry | | |
| 19. | Ineni Realtime Pty Ltd | Industry | | |

| 20. | Biarri Optimisation Pty Ltd | Industry |
|-----|------------------------------|----------|
| 21. | Queensland University of Technology (QUT) | Research |
| 22. | Griffith University | Research |
| 23. | University of Western Sydney (UWS) | Research |
| 24. | University of Technology Sydney (UTS) | Research |
| 25. | The State of Queensland | Third Party |
| 26. | QinetiQ | Industry |
| 27. | Elson Space | Industry |
| 28. | Danfield Stratoship Pty Ltd | Industry |
| 29. | Green Room Robotics | Industry |
| 30. | GAIAPOD | Industry |
| 31. | Australian Institute of Marine Science (AIMS) | Research |
| 32 | Nova Defence Pty Ltd | Industry |
| 33 | Shoal Group Pty Ltd | Industry |
| 34 | Ron Allum Deepsea Services | Industry |
| 35 | Austal Ships | Industry |
| 36 | Cellula Robotics | Industry |
| 37 | Ocius | Industry |
| 38 | Lux | Industry |
| 39 | KJR | Industry |
| 40 | Revolution Aerospace | Industry |
| 41 | Marcel Pacific Pty Ltd | Industry |
| 42 | Deakin University | Research |

# Collaboration, Engagement & Education

## Networking Event

In November 2022, TAS hosted a networking event, following a briefing from several Defence and Robotic, Autonomous and AI (RASAI) related presenters. This was held at the Queensland Government 1 William Street facility attended by 85 TAS guests.



TAS CEO Glen Schafer addressing the Networking Event.

## Symposium

The annual TAS Symposium was held on 31 May 2023 on the grounds of QUT, with the theme 'Accelerating Asymmetric Advantage through Autonomy'. There were 113 registrations with attendees and presenters from Defence, Industry and Research. Queensland Government continued its ongoing support, facilitating a number of SMEs attending the Symposium.



TAS Symposium May 2023, an opportunity for Defence, industry and researchers to mix and share ideas (Image CCM).

# TAS workshops, demonstrations, and events

TAS has hosted a range of outreach activities as part of Centre Activities and Projects. These events brought together a range of stakeholders to explore specific issues such as defence regulation of autonomous systems, to provide technical demonstrations, and to provide an opportunity for in-person collaboration and networking.

## TAS Maritime Showcase

On 28 September 2022, TAS hosted the TAS Maritime Showcase for 60 participants and attendees at ReefWorks in Townsville, Queensland. This event demonstrated how COLREGs can be conducted via simulation and live trials, together with showcasing Australian industry and providing an opportunity to connect members of the Australian autonomous systems ecosystem. With four live and four static autonomous vessels taking part in the event, this was the largest commercial demonstration of autonomous vessels in Australia to date. Further information can be found here Reflecting on the TAS Maritime Showcase Demonstration, September 2022 – Trusted Autonomous Systems (tasdcrc.com.au)



TAS contributed to Maritime Showcase at AIMS September 2022 (Images AIMS).

## Autonomous Vessel Forum 2022

On 28-29 September 2022, TAS hosted the Autonomous Vessel Forum 2022 for 70 delegates in Townsville, Queensland. Drawing on the outcomes of the inaugural AMSA-led AV Forum in 2019, this TAS event focused on identifying (1) the status of autonomous vessel development and regulation in Australia, and (2) areas of focus for improving assurance and regulatory pathways into the future. Further information can be found here, Reflecting on the Autonomous Vessel Forum 2022 – Trusted Autonomous Systems (tasdcrc.com.au).

## Detect and Avoid Flight Trials

In December 2022, TAS, supported by Revolution Aerospace and QinetiQ, hosted Detect and Avoid flight trials at the Queensland Flight Test Range in Cloncurry, Queensland. These trials showcased a

Detect and Avoid (DAA) system developed by Queensland SME Revolution Aerospace and demonstrated how crewed aircraft can be detected by a DAA system allowing remotely piloted aircraft to manoeuvre to a safe position. The trials were developed as part of a TAS initiative seeking to produce a DAA guideline – a suite of documents that will provide a critical stepping stone to enable Remotely Piloted Autonomous Systems (RPAS) developers to design and build DAA systems with a regulatory-aligned safety assurance process. Further information can be found here: Detect and Avoid flight trials at the Queensland Flight Test Range – Trusted Autonomous Systems (tasdcrc.com.au).

Workshop on Responsibility for Military Autonomous Systems

On 21-22 November 2022, TAS and the UQ Law and the Future of War Research Group hosted a Workshop on Responsibility for Military Autonomous Systems in Canberra, Australian Capital Territory. This Workshop brought together subject matter experts and stakeholders from academia, Defence, government and industry to discuss responsibility for military autonomous systems in an Australian context. The Workshop considered autonomy in cross-domain command, human-machine teaming, trust, Article 36 reviews, export controls, and the future regulation of autonomous systems.

# Education & Training
## TAS Research and Education Activity

The STEAM impact across all Projects and Activities is the creation and maintenance of 71 positions, including PhD students, postdocs, senior fellows, undergraduates, and Centre Fellows.

### Research Fellows
Two Centre Fellows were appointed in the last reporting period in the TAS Ethics Uplift program. This increases the total number of TAS Fellows to six. The other four were appointed as part of the Advance Queensland TAS Fellowships programme.

The selected candidates have been supporting projects through working closely with the Centre and continuing their original research independent of Projects to address fundamental challenges in areas pivotal to realising trusted autonomy.

TAS Research Fellows (L-R) Drs Jessica Korte, Andrew Back, Pauline Pounds and Beth Cardier.

## Advance Queensland Fellows

### Dr Andrew D Back (Advance Queensland)
AI systems are currently unable to interpret the meaning of utterances or solve simple tasks. Andrew's research introduces a new approach to AI called Synthetic Language and Information Topology (SLAIT) AI, which combines information theory with topological data analysis to derive symbolic, probabilistically framed 'words' for individual dynamical systems using new entropy-based models.

### Dr Beth Cardier (Advance Queensland)
Beth models narratives and dialogue to show how implicit information can be included in reasoning systems. She was originally an award-winning fiction writer and media analyst, when, in a plot twist, she learned knowledge modelling for a US Navy-funded research program to demonstrate how writers communicate unexpected events.

### Dr Jessica Korte (Advance Queensland)
Jessica's TAS Fellowship project on the Auslan Communication Technologies Pipeline looks to foreground the visual-gestural language expertise of Deaf signers in the creation of technologies for the recognition, production and processing of Auslan (Australian Sign Language) communication and a modular pipeline for artificial intelligence

### Dr Pauline Pounds (Advance Queensland)
Pauline's TAS project involves exploring robotic whisker technology and finding ways of using them to allow drones to fly through interior spaces and around objects and obstacles without needing to use heavy cameras or complex, expensive lidar systems.

# NGTF Fellows – TAS Ethics Uplift

**Dr Zena Assaad, TAS Ethics Uplift Fellow (NGTF)**

Zena's TAS project [explores the safety implications of human-machine teaming (HUM-T) operations for Australian Defence](#). HUM-T needs to be safe, to be trusted in deployment, and to enable flexible operations without undue operational restrictions. This project explores the development of safety requirements and frameworks, including appropriate methods to manage and communicate these, for HUM-T operations. A draft safety assurance framework for human machine teaming being developed by Dr Assaad was applied to the Army's Leader-Follower trials in June 2023.

**Dr Christina Boshuijzen-Van Burken, TAS Ethics Uplift Fellow (NGTF)**

Christina's TAS project aims [to build an ethical framework](#), based on the value-sensitive design method, that assists developers of autonomous systems in Defence with thinking through the ethical aspects of their technologies. Designing with an eye to ethical values ultimately leads to 'better' technologies, not only in a technical or cost-efficient sense, but also with a view to societal acceptance. Dr Van Burken designed and released an online survey in March 2023, *Autonomous Systems for Australia's Defence* which gathered data from 2000 Australians regarding societal values related to autonomous technology.



TAS Ethics Uplift Research Fellows (L-R) Drs Zena Assaad and Christina Boshuijzen-Van Burken

# Publications

The following publications were distributed by TAS in the reporting period.
- [Responsible AI for Defence (RAID) Toolkit - Consultation](#) (TAS)
- [Autonomous Systems Demonstration Canvas](#) (TAS)

The following publications arose from TAS funded research in the reporting period.

## 2023

- Austrade [Australian Defence Industry Report and RASAI Matrix](#) (TAS assisting Austrade)

- Bijjahalli, S, Pizarro, O, and Williams S.B (2003), [A Semi-supervised Object Detection Algorithm for Underwater Imagery](#), ArXiv (intended for IEEE)

- Boshuijzen-van Burken, C (2023), [Value Sensitive Design for autonomous weapon systems – a primer](#). *Ethics Information Technology* 25, 11 (2023).

- Boshuijzen-van Burken, C, Spruit, S, Fillerup, L and Mouter, N (2023), [Value Sensitive Design Meets Participatory Value Evaluation for Autonomous Systems in Defence](#), EasyChair Preprint 9891

- Devitt, K (2023), [Meaningful Human Command: Advance Control Directives as a method to enable moral and legal responsibility for autonomous weapons systems](#), ArXiv

- Huang, Z, Pemasiri, A, Denman, S, Fookes, C & Martin, T (20023), [Multi-task learning for radar signal characterisation](#), ArXiv

- McFarland, T and Assaad, Z (2023). [Legal reviews of in situ learning in autonomous weapons](#). *Ethics and Information Technology 25* (1) 9

- McKenzie, S & Massingham, E (2023), [AUKUS: The Regulation of the Ocean and the Legal Dangers of Working Together](#), Ocean Yearbook Online, [Volume 37: Issue 1](#)

- Walker-Munro, B & Assaad, Z (2003), [The Guilty (Silicon) Mind: Blameworthiness and Liability in Human-Machine Teaming](#), 8 Cambridge Law. Vol 8, Issue 1

### 2022

- Cardier, B & Hancock, M (2022), [Visualizing Cumulative Risk Across Work Contexts](#), [2022 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE)](#)

- Copeland, D, Liivoja, R, and Sanders, L (2022) [The utility of weapons reviews in addressing concerns raised by autonomous weapon systems](#), *Journal of Conflict and Security Law*

- Liivoja, R, Massingham, E & McKenzie, S (2022), [The legal requirement for command and the future of autonomous military platforms](#), 99 *International Law Studies* 638–675

- Massingham, E & Stephens, D (2022), [Autonomous systems, private actors, outer space and war: lessons for addressing accountability concerns in uncertain legal environments](#), *Melbourne Journal of International Law,* 276-305, 23(2)

- McKenzie, S (2022). The challenge of automated and autonomous technologies to Australian Defence Force compliance with workplace health and safety laws. *Australian Journal of Defence and Strategic Studies* 4(1), 23-38.

- McFarland, T (2022) Reconciling trust and control in the military use of artificial intelligence, *International Journal of Law and Information Technology*, Volume 30, Issue 4, Winter 2022, Pages 472–483.

- McFarland, Tim (2022). Minimum levels of human intervention in autonomous attacks. *Journal of Conflict & Security Law 27* (3) krac021 387-409.

- Roberson, T, Bornstein, S, Liivoja, R, Ng, S, Scholz, J, Devitt, K(2022) A method for ethical AI in defence: A case study on developing trustworthy autonomous systems, Journal of Responsible Technology, Volume 11, 2022.

- Selvaratnam, D, Cantoni, M, Davoren, J.M. Shames, I (2022), MITL Verification Under Timing Uncertainty in 'Logic in Computer Science'.

- Walker-Munro, B (2022), 'Exploring manufacturer strict liability as regulation for autonomous military systems. Who is liable when an autonomous military drone causes unintended harms?' in *Torts Law Journal, Vol 27, Part 3* (available on subscription Lexis Nexis).

- Walker-Munro, B (2022), 'Do Androids Dream of a Duty of Care: Arguing for Civil Liability for Autonomous Military Systems in Australia' in '*University of Western Australia Law Review'* Vol 49(2):239

A number of other proposed outputs have been submitted for review and future publication. The UQ Law team papers are also accompanied by policy briefs that provide an executive summary of their research.

# Commercialisation

Progress has already been made in translation to commercialisation, as follows:

- **Athena AI,** a Queensland Based Company that had grown through the NGTF JAUASE project investment employing world leading data scientists, software and hardware engineers. As mentioned previously, the technology is now in follow-on development with significant investment, over $4M AUD, as a Defence Innovation Hub commercialisation project, underling the ability of TAS to accelerate innovation and transition innovation into capability and commercial success for sovereign industry. Athena AI has also reported their first export sales to the US Department of Defence in conjunction with Tomahawk Robotics.
- As mentioned previously in this report, elements derived through the Consunet DUST project are now being integrated into emerging ADF capability, including Lockheed Martin's AIR 6500.
- Elements conducted under the TAS program with Boeing have formed key parts of the Boeing Ghost Bat program.

Uptake by industry of research outputs is ensured by early engagement with Defence to better match outputs with needs.

# Intellectual Property Management

A key component of the TAS program is that the relevant Project Lead owns the intellectual property. Throughout the reporting period, intellectual Property (IP) is identified through each Project Lead (that is, those companies leading the various projects and activities) consolidating and submitting a list of IP

generated each quarter. The IP is protected and managed by the Project Lead using well-established internal procedures relevant to the relevant company. There are also fallback provisions whereby if the IP is not taken up ownership reverts to Defence.

# Communications

Project achievements are reported to the ADF clients quarterly and through DSTG, being Defence's corporate representative. Publicity for a number of projects' achievements is limited by the requirement for protection of IP and security considerations, in addition to ADF consultation not seeking to highlight some capabilities. This can result in unbalanced communication in relation to public-facing activities. TAS continues to create and distribute to around 150 participants an opt-in mailing summary of Autonomy and Robotic articles of interest to research, industry and Defence on (generally) a weekly basis. The TAS News along with social media on Twitter, LinkedIn, and YouTube provide additional Centre outreach.

# Risks

The Centre continues to maintain a comprehensive risk register that is reviewed annually by the Centre executive and the Board. A progress report on strategies to mitigate any risks which maintain a high residual impact is reported to the Board as required at each meeting.

# Financial management

TAS is in a sound financial position as of 30 June 2023. The Centre has implemented robust financial processes to ensure prudent financial management and oversight on milestone and progress reporting. BDO were appointed auditors for FY2022-2023.

TRUSTED
AUTONOMOUS
SYSTEMS