TRUSTED AUTONOMOUS SYSTEMS

2022

Annual Report
Defence CRC TAS Limited

Trusted Autonomous Systems Annual Report

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Executive Summary
Message from the CEO
Glen Schafer

Australia has an impressive record of innovation and invention and no more so is this exemplified than in the arena of Defence. Whether this is through the outstanding work carried out by the leaders in innovation in the Defence Science and Technology Group (DSTG), our Australian Universities, or in Defence Industry, each one works in partnership with our Defence Forces delivering game-changing technologies to those serviceman and servicewomen of our Forces charged with the most sacred duties of our country.
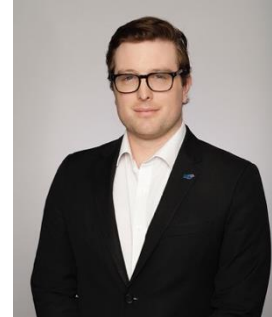
The close of this reporting period marks the fourth full year of Trusted Autonomous Systems' (TAS) operations, and it is my pleasure to report that all milestones and key performance indicators across our Commonwealth funding agreement have been achieved, and in some instances exceeded.

This reporting period has marked some incredibly exciting developments and deliveries, which are set out in more detail in this report. TAS has executed five new projects this financial year, including four publicly announced projects, three under Advance Queensland funding and one funded directly by Defence. This reporting period has also seen the delivery of two projects, being the Joint Autonomous UAS Effects (JAUASE) program and the Human Machine Teaming (HuMT) Geospatial Decision Support project, both of which included delivery through local (Queensland) SMEs.

The JAUASE program was led by Skyborne Technologies and Cyborg Dynamics Engineering, with DSTG and the University of Queensland, and has resulted in the development of a technically mature system using state of the art neural networks, decision support capabilities, and middleware. The Human Machine Teaming (HuMT) Geospatial Decision Support project was delivered by Cyborg Dynamics Engineering and enhances the existing interface being developed under the JAUASE program to include geospatial data and semantic scene AI to enhance mission planning. The technology from both projects is in follow-on development as a Defence Innovation Hub Phase 4 (Commercialisation) Project.

One unifying feature of the projects in which TAS has been privileged to be involved is the collaboration between the technology leaders in innovation across all entities. Such fusion of thought and ideas makes this industry an incredibly exciting and unique environment in which to work, and has led to outcomes far greater than we could have imagined. The successes in this report are the successes of each person across each entity with whom we have been privileged to work. The names leap time and time again from these pages: DSTG, the universities, the big primes, SMEs, and, overscoring it all, the Defence Force. These are the people who put aside the shackles of "it can't be done" and said: let us dream and let us make this dream a reality.

Thank you. From me, and from my team, it is a privilege and honour to work with you.

Glen Schafer
CEO

TAS Chief Engineer
Dr Simon Ng

TAS continues to consolidate its Defence-directed 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 human 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 Chief Scientist
Dr Kate Devitt

TAS is pushing the scientific boundaries of the 'smart, small and many' by leading research into 'Thinking Swarms' including establishing an international Swarming Community of Practice across academia, industry and defence and leading development of an academic monograph.

TAS continues to accelerate the trusted adoption of autonomous systems through the ethics, law, and assurance of autonomy activities. In the last year TAS impact is exemplified by the launch of the Queensland Government-funded Robotics and Autonomous Systems Gateway (RAS-Gateway). RAS-Gateway is a public digital portal providing tools, resources, and access to test ranges in support of the autonomous systems ecosystem.

Throughout the year TAS has worked with stakeholders across Defence, Government, industry, and academia to develop frameworks, guides and resources and make RAS-Gateway intuitive, useful, and relevant to a broad range of users. RAS-Gateway includes TAS initiatives including the new Australian Code of Practice for Autonomous and Remotely Operated Vessels, COLREGs Operator Guidance Framework, Autonomous Systems Demonstration Canvas, Specific Operations Exploration Tool, and research outputs from the Ethics and Law of Trusted Autonomous Systems Activity.

TAS aims to facilitate the growth of the Australian autonomous systems ecosystem, driving innovation and increasingly ambitious use of autonomous technology, while keeping safety at the forefront. RAS-Gateway is a central pillar of that vision, representing an innovative and intuitive experience unmatched worldwide.

Projects and Activities
Work conducted by the Centre in FY2021-2022 included:

Projects: industry-led programmes of work with academic, Defence, and Government partners intended to achieve tangible capability outcomes and create sustainable industry capacity to ensure the resilience of the Defence capability pipeline for robotic and autonomous systems.

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.

TAS has executed five new projects this financial year, including a number under Advance Queensland funding. The Advance Queensland industry-led projects will increase industry capability in robotics, autonomous systems and artificial intelligence hardware and software and have flow-through benefits for broader AI research and Defence.

Trusted Search

The Trusted Search Project is near completion, having delivered all-bar one of its milestones. The final milestone, due in the first quarter of financial year 2022-23, will showcase a multi-drone heterogenous swarm conducted a complex multi-task mission in a representative real-world environment. DefendTex are partnering 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 family of USVs and subsystems). This project was approved by the board in August 2018 and has delivered key technology demonstrations in February and June 2022. You can read more about DefendTex deployable, compact, low-cost UAV systems and the deployment of these technologies overseas to assist reconnaissance functions improving soldier safety.

Distributed aUtonomous Spectrum ManagemenT (DUST)

DUST 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. The project is led by Consunet Pty Ltd with RMIT University, the University of Melbourne, the University of Sydney and DSTG in support. 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 significant commercial outcome with the DUST IP. The project has been a foundation for other significant success for Consunet, announced in April 2022 as a partner with Lockheed Martin on AIR6500, developing 'critical spectrum and manoeuvre technologies'. The project was approved by the board in November 2018 and is due to conclude in mid-2023.

Joint Autonomous UAS Effects (JAUASE)
Concluded in reporting period

Led by Skyborne Technologies and Cyborg Dynamics Engineering with the University of Queensland (UQ) and DST. Approved by the board in February 2019. The 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 has 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. The technology is now in follow-on development as a Defence Innovation Hub Commercialisation Project, underling the ability of TAS to accelerate innovation and transition innovation into capability and commercial success.

Trusted Autonomous Ground Vehicles EW (TAGVIEW)

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, have 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; huma command interfaces that allow single operators to manage complex mission profiles for multiple vehicles. The developed technology will be integrated and demonstrated in late 2022, and will underpin BAE Systems platform development strategy for future Defence land vehicles. Read more about the progress of BAE Systems and Army Robotic & Autonomous Systems Implementation & Coordination Office (RICO) conversion of M113AS4 Armoured Personnel Carriers into Optionally Crewed Combat Vehicles.

Mine-Counter-Measures in a Day

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 solution 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 needed 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. The work is an addition to Thales existing experience in the field of autonomous Mine-Counter-Measures systems, The Project work was on display at IndoPac 22 and received considerable attention.

Gannet Glider

Skyborne Technologies are 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 in June provided clear evidence of the performance of the system. The program has already been accelerated through a Defence Rapid Prototyping Initiative. The final demonstration is due in the first quarter of financial year 2022-23.

Human Machine Teaming (HuMT) Geospatial Decision Support

Concluded in reporting period

Cyborg Dynamics Engineering is enhancing the existing ATHENA interface being developed under 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.

Firefly

Concluded in reporting period

In collaboration with RMIT and a range of industry partners (LUX Pty Ltd, Danfield, Elson Space Australia), and with the 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 basic problems, including the algorithms needed to predict the trajectory of a high-altitude airship using detailed wind models, algorithms for controlling constellations of airships so that 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

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 and assurance and accreditation of autonomous systems. The result is "RAS-Gateway", an online platform providing digital regulatory tools and resources to autonomous systems stakeholders, with an initial focus on the maritime and air domains.

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.

Stakeholders include: ADF, AIMS ReefWorks, AMC Search, AMSA, CASA, Department 13, DSTG, FlyFreely, Frazer-Nash Consultancy, Greenroom Robotics, East Consulting Services, Frazer-Nash Consultancy, Hover UAV, Mirragin, Nova Systems, QinetiQ, QUT Law, UQ Robotics Design Labs, Shoal Group, Revolution Aerospace, RAS Consulting, Scout Aerial, UQ Robotic Design Lab, Vanderkooi Consulting, Warfare Innovation Navy.
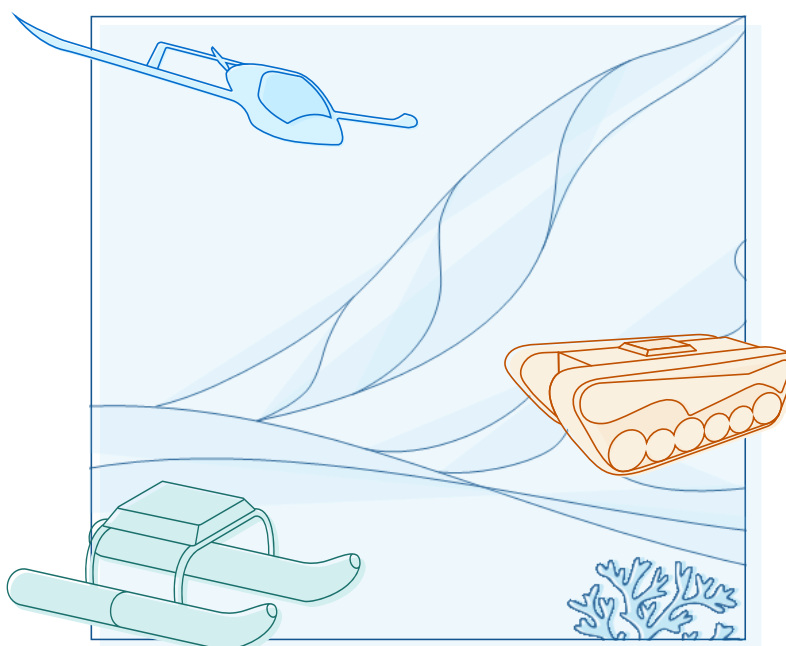
High Altitude Pseudo-Satellite (HAPS) Challenge

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. It is in its final stage, with the participants having progressed towards the final demonstration at Cloncurry, QLD, due to occur in October 2022. 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. Feedback from attendees was strong, and the project is currently being developed for a future phase.

If successfully demonstrated, the HAPS challenge will have delivered a prototype pseudo-satellite and persistent surveillance capability with reliable station-keeping for communications and surveillance tasks, such as bushfire early warning. 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.

Patrol Boat Autonomy Trial

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 Patrol Boat. This will provide a proof-of-concept demonstrator for optionally crewed or autonomous operations and explore the legal and regulatory pathways and requirements.

Austal are 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, are delivering a Regulatory Exemplar Project integrated with the Patrol Boat Autonomy Trial to establish best practice commercial and defence regulatory approaches for autonomous vessels. The Regulatory Exemplar Project will also deliver a comparative resource to assist in navigating between commercial and defence frameworks, enabling greater transparency and supporting dual use.

Hyper-Teaming

'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; it will 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.
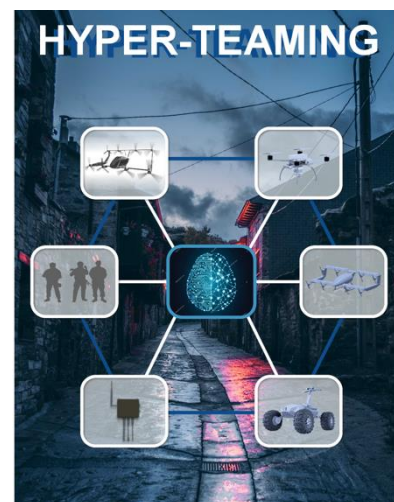
NEW PROJECTS IN REPORTING PERIOD

HuMT – identify & protect high value cultural assets

QLD Government funded

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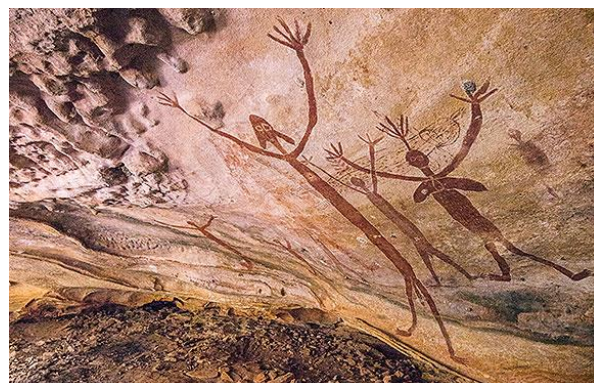
This project will integrate five industry AI products into a semi-autonomous drone platform suitable to navigate and survey remote and rugged terrain as well as a methodology and framework for data and machine learning assurance.

Low SWaP – Cognitive payloads for UAV

QLD Government funded

The Low Size Weight and Power Cognitive Payloads for Small UAV project was executed 28 January 2022. 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.

AI and Automation in Language Tech

QLD Government funded

Pama Language Centre (PLC) and Janet Wiles, Ben Foley, and Ben Matthews at 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 underpin 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 as well as 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.

iDrogue

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.

This pilot project is being conducted over 12-months, through 2022. An iDrogue prototype was the centrepiece of a RAN stand at Indo-Pacific 2022 on a display arranged by TAS. The ultimate aim, with further funding, is to develop an intelligent robot based on biomimicry that can launch and recover 'any AUV, from any platform in virtually any sea state'.
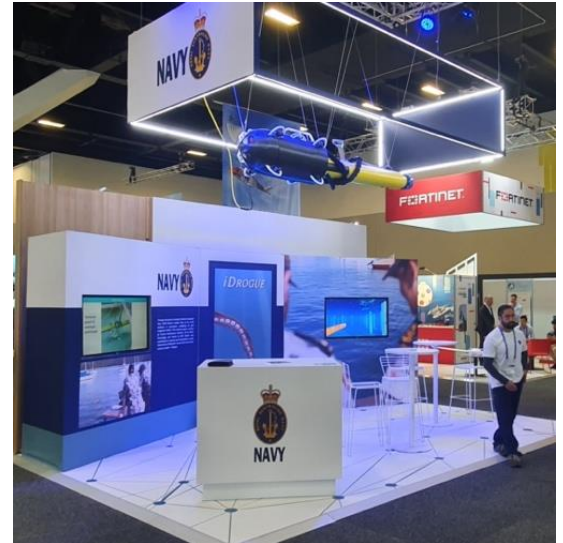
Activity 1.
Ethics and Law of Trusted Autonomous Systems (NGTF Funding)
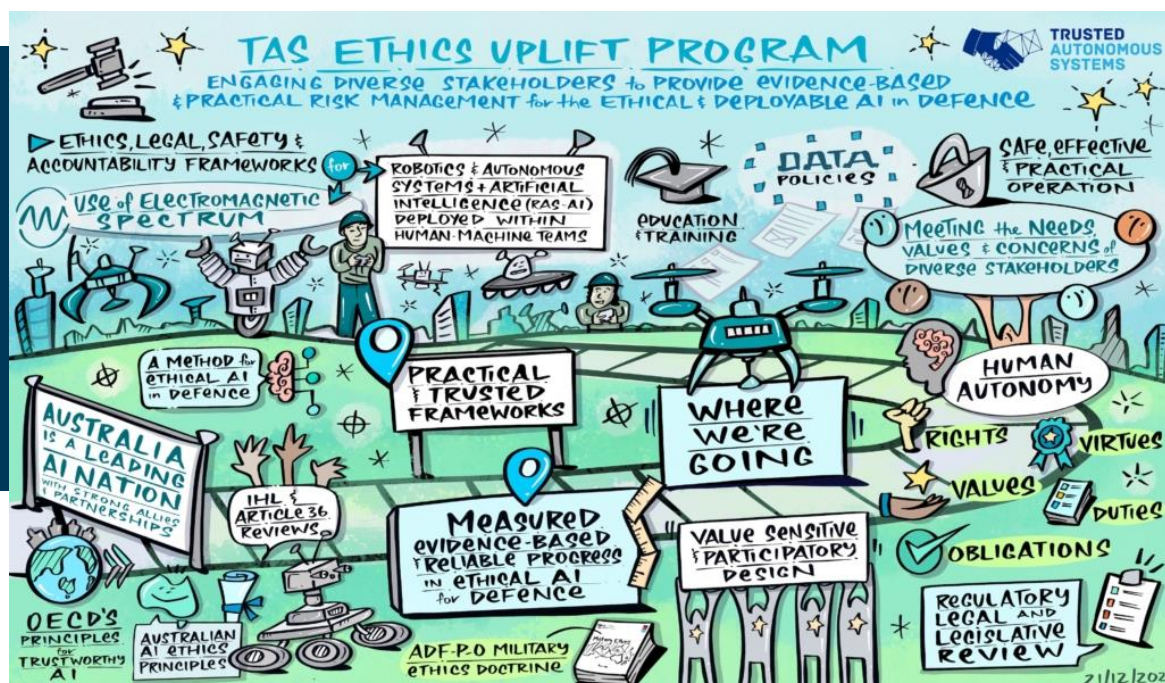
The Trusted Autonomous Systems (TAS) Ethics Uplift Program (EUP) supports theoretical and practical ethical AI research and provides advisory services for industry to enhance capacity for building ethical and deployable trusted autonomous systems for Australian Defence.

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.

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.

Ethics and regulation of AI spectrum technologies: The Ethics and Regulation of AI Spectrum Technologies project researches 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.

A framework of Human Factors methods for safe, ethical, and usable Artificial Intelligence in Defence: TAS is supporting Human factors (HF) research with the University of the Sunshine Coast to assist with the evaluation of ethical and legal factors on autonomy projects (e.g. Athena AI emerging from the JAUASE project).

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

The Ethics Uplift Workshop Q4 2021 on the Ethics of Autonomous Systems brought together ethics researchers, consultants, Defence, Government, and industry to discuss current best practise approaches to ethics for robotics, autonomous systems, and artificial intelligence (RAS-AI) in Defence. It also showcased recent work from the TAS Ethics Uplift program. The workshop aimed to increase awareness of Australian artificial intelligence governance frameworks in civilian and military applications; share practical tips and insights on how to ensure ethical AI in Defence projects; and connect our ethics, legal, and safety experts.

Published MEAID case studies: Two case studies have been published using A Method for Ethical AI in Defence (MEAID) led or co-authored by TAS staff:
1. Case study on the TAS JAUASE project led by TAS and published in the Journal of Responsible Technology on the application of MEAID for Athena AI.
2. Case study using MEAID to analyse the TTCP Allied IMpact research system led and published by DSTG with accompanying Defence press release.

Videos on ethical AI for Defence (TAS for CDLE): Ten new ethics videos completed for Centre for Defence Leadership & Ethics Australian Defence College (CDLE/ADC) on Ethics of RAS-AI for ADF on the topics of responsibility, governance, trust, law, and traceability based on 'A Method for Ethical AI in Defence' (MEAID) released on TAS YouTube. There are now 14 videos available for professional military education on RAS-AI ethics in Defence.
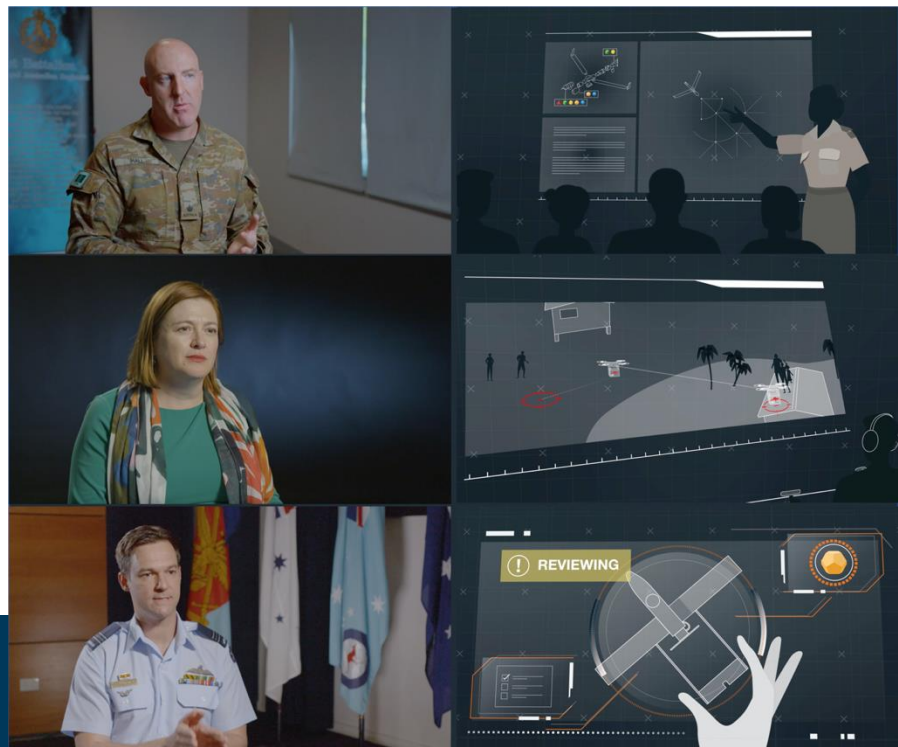
Law

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. They have contributed to international discussion on the use of autonomous systems by Defence, e.g. 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 out for expert contributions, e.g. they have acted as expert reviewers for multiple NGO reports on IHL and LAWS. They have extensive connections with international organisations such as ICRC, SIPRI, UNIDIR, UNODA. They 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; this appointment promotes regular engagement with DFAT lawyers and policy officers on arms control issues, this includes discussion on AWS.

The UQ Law team have 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 create 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 collaborate with domestic and international industry, academia, Government, regulators, 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 continue to elicit feedback on the Code from operators with the intent of informing future iterations.

- **COLREGs Operator Guidance Framework:** The TAS team, supported by Frazer-Nash Consultancy, have 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 have 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.

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.

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 this reporting period 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 Buurken	UNSW ADFA	Ethical Design of Trusted Autonomous Systems in Defence

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 $160 million dollars of investment from the initial Next Generation Technologies Funds grant of $50 Million, providing an expansion ratio of 2.4:1. Co-investment has come from across our stakeholder group, including the Queensland State Government ($51M), the ADF services (over $17M), and from our DST, academic and industry Participants (over $55M).

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 2022 for Centre wide investment	KPI	Notes (excludes data for projects executed after June 30 2022)
# Projects	23	Includes common good activities A1 and A2
Total Value of Program	$186.5M	Cash and In-kind from all sources
Cash Funding to Industry	$47.5M	Direct cash funds to Industry from NGTF, Qld Government or Defence (excludes Cash contributions from Industry and academia)
Cash Funding to Academia	$19.75M	Direct cash funds to Academia from NGTF, Qld Government or Defence (excludes Cash contributions from Academia)
Full Time Equivalent Employment Created	235	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	36	
# Academic Participants	12	
Leveraged Funds	$135.8 M	Funds (cash and in-kind) attracted by leveraging the NGTF investment
Events hosted by TAS: 27 webinars/online workshops	612 Attendees	
Symposium in Brisbane	154 Attendees	
Thinking Swarms Workshop	50 Attendees	

National Funding, Distribution by Sector

Diagram flows left to right

SME	Small to Medium Enterprise
PFRA	Publicly Funded Research Organisation

Cash Leverage (cf. NGTF): 1.9

Total Leverage (cf NGTF; excl. Acquisition and DIH): 3.6

Direct contributions to participants

Total distribution by participant

Services: $26.7M

Cash & In-Kind: $94.1M

Cash input into Centre

Qld Gov Funding: $15M

Centre: $65.5M

Next Gen Tech Funding: $50M

Acquisition: $37M

Defence Innovation Hub: $9.8M

Primes: $25.4M

PFRAs: $78.2M

Academia: $36.6M

SMEs: $92.9M
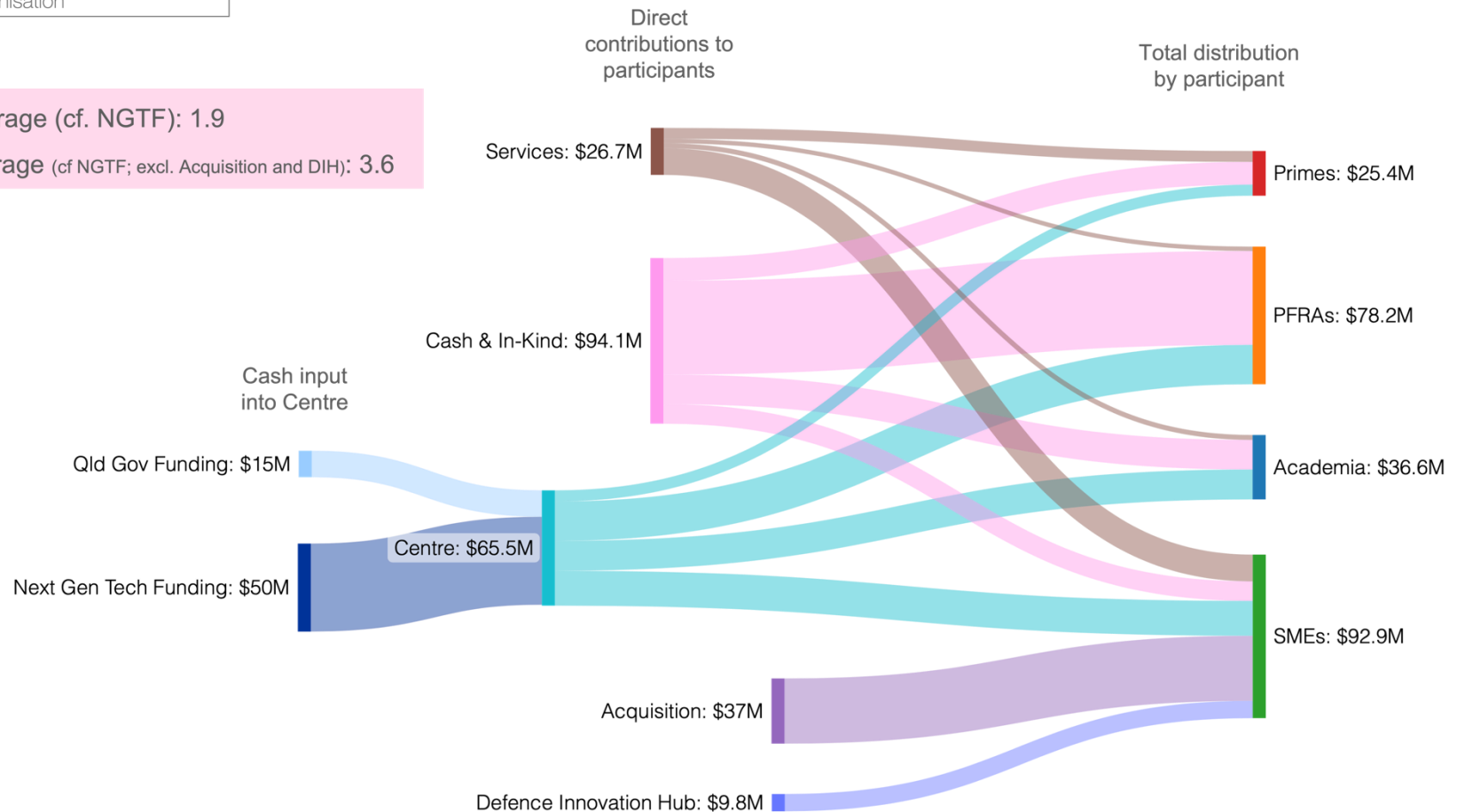
Participants and Third Parties

The Centre 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

Collaboration, Engagement & Education

Networking Event

On 29 July 2021, TAS hosted a networking event, following a briefing on opportunities for new Queensland funded projects. This was held at the Advance Queensland facility *The Precinct* in Fortitude Valley with 152 people were registered to attend. Follow-up processes for new projects received 30 expressions of interest after the event.

Symposium

On 15 June TAS delivered the 2022 Symposium – 'Accelerating cross-domain autonomy' at Customs House in Brisbane. Minister Stirling Hinchliffe (Minister for Tourism, Innovation and Sport and Minister Assisting the Premier on Olympics and Paralympics Sport and Engagement) provided a video-taped opening message for delegates. There were 154 registered in-person attendees on the day, very positive feedback received with a formal survey underway. There were 26 presenters on the day representing each ADF service, Joint functions, Industry and Researchers. Delegate affiliations included Defence 60, Industry 59, Research 32. Queensland attendees numbered 75. The assistance of the Queensland Strategic Defence Advisors as session chairs was a welcome addition to the program and flow of the Symposium. Queensland Government supported up to 20 SMEs to attend with some late attrition due to COVID isolations.
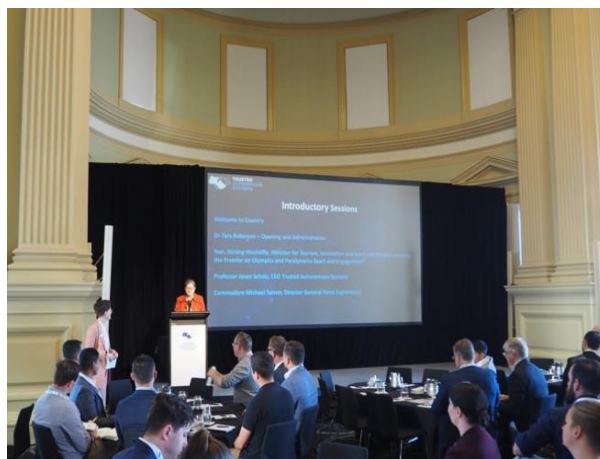
Deputy Director-General Michelle Bauer introduces Minister Hinchliffe (L)

Thinking Swarm Workshops

Between 13-14 June, TAS delivered the Thinking Swarms Workshop in partnership with UNSW Canberra. 50 attendees were present at the Thinking Swarms workshop from academia, industry and Defence including DSTG and ADF. The workshop represented the culmination of 10 weeks of weekly online discussions with a growing community of practice in swarming technologies. TAS and UNSW intend to publish an academic book from the research.

A visual artist scribed the Thinking Swarms workshop. This image is an example from this series.

Webinars

TAS hosted or arranged the following webinars in the reporting period to continue engagement:

- Initial Briefing on Code of Practice for Autonomous and Remotely Operated Vessels (July 21)
- Six Workshops on the Code of Practice for Autonomous and Remotely Operated Vessels (July 21)
- HAPS Challenge Phase 2 Entry Information Seminar (August 2021)
- Project FireFly Live Demonstration (August 2021)
- Series of four Queensland Project Workshops (September 2021)
- Assurance of Machine Learning for use in Autonomous Systems (AMLAS) with University of York, Activity 2 – Queensland (October 2021)
- Don't make machines learn, educate them (October 2021)
- University of York AAIP – A principled ethical assurance argument for the use of AI (February 2022)
- Mergeable nervous system for robotic swarms (April 2022)
- Series of Thinking Swarms Workshops (May – June 2022)

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, undergrads, and Centre Fellows.

Research Fellows

Two Centre Fellows were appointed in the last reporting period appointed in the TAS Ethics Uplift program. This makes 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 as part of working closely with the Centre and continue their original research independent of Projects to address fundamental challenges in areas pivotal to realising trusted autonomy.

New NGTF Fellows – TAS Ethics Uplift

Dr Zena Assaad, TAS Ethics Uplift Fellow (NGTF)
Zena's TAS project will explore 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 will explore the development of appropriate safety requirements and frameworks, including appropriate methods to manage and communicate these, for HUM-T operations.

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.

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

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 modeling 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.

Publications

The following publications were distributed by TAS in the reporting period.

- TAS Assurance of Autonomy Activity Report: Development of an Australian Code of Practice for the Design, Construction, Survey and Operation of Autonomous & Remotely Operated Vessels (2021)
- TAS Assurance of Autonomy output: Australian Code of Practice for the Design, Construction, Survey and Operation of Autonomous and Remotely Operated Vessels, Edition 1 (2022)
- TAS Assurance of Autonomy output: COLREGs Operator Guidance Framework (2022)
- TAS Ethics Output: Autonomous Systems Demonstration Canvas, Version 1.1 (2022)

An additional series of five short and five longer videos Facets of Ethical AI for Defence, contracted by the ADF Centre of Defence Leadership & Ethics (CDLE).

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

2022

- Devitt, S. K., Scholz, J., Schless, T., & Lewis, L. (2022). Developing a Trusted Human-AI Network for Humanitarian Benefit. *The Journal of Digital War,* Special Issue 'My War'. *[under peer review]*
- Laird, R.F, ed (2022). Defence XXI: Shaping a Way Ahead for the Unites States and its Allies
- 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, 100036, ISSN 2666-6596, https://doi.org/10.1016/j.jrt.2022.100036
- Various (TAS contributors, Chapter 9 (Defence), Robotics Australia Group, A Robotics Roadmap for Australia 2022

2021

- Back, Andrew D., and Janet Wiles. 2021. "Entropy Estimation Using a Linguistic Zipf–Mandelbrot–Li Model for Natural Sequences" Entropy 23, no. 9: 1100
- Devitt, S. K (2021) 'Does Australia's commitment to Ethical AI give our adversaries the edge?' W.A. Defence Review 2020-21 Annual Publication, pps 216-217.
- Devitt, S. K. (2021). Normative epistemology for lethal autonomous weapons systems. In J. Galliott, D. MacIntosh, & J. D. Ohlin (Eds.), Lethal Autonomous Weapons: Re-Examining the Law and Ethics of Robotic Warfare. Oxford University Press.
- Horne, R. (2021). Autonomous and remotely operated vessels 2021 to 2040. MIAL Future Leaders White Paper. Predictions for the Australian Maritime Industry 2040. Maritime Industry Australia Limited. pp.12-27
- Liivoja, R., Väljataga, A. (eds.) (2021), 'Autonomous Cyber Capabilities under International Law' NATO CCDCOE Publications.
- Massingham, E. (2021). Automation of the Spectrum, Automation and the Spectrum: Legal Challenges When Optimising Spectrum Use for Military Operations. Law, Technology and Humans, 3(1).
- Massingham, E (2021), 'Navigating to autonomy: legal questions in the use of autonomous aerial vehicles by the Australian military', Australian Journal of Defence and Strategic Studies, AJDSS Volume 3 Number 1 (2021).
- Massingham, E (2021), An AI-flown military aircraft is being designed in Australia. Are our laws equipped to protect us?, The Conversation, (Subsequently reposted on ABC News)
- Scholz, J.B. (2021) 'Disruptive AI for Defence', Invited Keynote speech, IEEE Symposium Series on Computational Intelligence (SSCI), Orlando Florida and online, presented on 6 Dec.

A number of other proposed outputs have been submitted for review and future publication.

Commercialisation

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

- **DefendTex** has made additional overseas sales of the Drone D40 UAS connected with their TAS project.
- **Athena AI,** a Queensland Based Company and an outcome of TAS NGTF funded Project 3 JAUASE has gone from a 4-6 FTE project completed in May 2022 to a 17 FTE company employing world leading data scientists, software and hardware engineers. The project has resulted in a 4+ mil AUD follow on commercialisation project sponsored by the DoD and the preferred AI solution for a number of US major RASAI providers. Both the vision and geospatial capability (both funded by TAS) were also accepted as part of UK Army Warfighting Experiment (AWE) which will be demonstrated in November 2022. The company has also now supported a number of other SME AI projects and also submitted into major ADF acquisitions programs as part of a Prime lead bid.
- The **Gannet Glide Drone** program, Project eight, that began with TAS sponsorship is anticipated to finalise in Q4 2022 after a number of successful flight tests. The Gannet program has had keen interest from other elements of the ADF and has secured a follow-on program approximately three times the size of the original. This will enable Skyborne to upsize the Gannet team from approximately 3 FTE to 6 FTE.

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 by means of each Project Lead (that is, those companies leading the various projects and activities), consolidating and submitting each quarter a list of IP generated. The IP is protected and managed by the Project Lead using typically 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. TAS continues to create and distribute to around 150 participants on an opt-in mailing summary of Autonomy and Robotic articles of interest to research, industry and Defence on (generally) a weekly basis. The TAS Blog 'Game-Changer' 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 2022. The Centre has implemented robust financial processes to ensure prudent financial management and oversight on milestone and progress reporting to third-party Participants. BDO were appointed auditors for FY2021-2022.

Annual Report 2022
Defence CRC TAS Limited

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TRUSTED AUTONOMOUS SYSTEMS