2021

Annual Report

TRUSTED AUTONOMOUS SYSTEMS

Trusted Autonomous Systems Annual Report

Table of Contents

EXECUTIVE SUMMARY 3

PROJECTS AND ACTIVITIES 4

GOVERNANCE AND KEY STAFF 22

PERFORMANCE AGAINST ACTIVITIES AND RESEARCH OUTCOMES 24

COMMERCIALISATION 30

INTELLECTUAL PROPERTY MANAGEMENT 30

COMMUNICATIONS 30

FINANCIAL MANAGEMENT 30

Executive Summary

Message from the CEO

Above: TAS CEO Professor Jason Scholz, 2020 recipient of the Australian Naval Institute McNeil Award

Trusted Autonomous Systems (TAS) is Australia's first Defence Cooperative Research Centre and is uniquely equipped to deliver world-leading autonomous and robotic technologies to enable trusted and effective cooperation between humans and machines. Our objective is to improve the competitiveness, productivity, and sustainability of Australian industry by:

- developing highly self-sufficient and survivable systems
- developing highly self-determining and self-aware systems
- developing human-autonomy systems that are human and context aware
- increasing the speed to reach a deployable state for trusted autonomous systems
- increasing the scalability and reduce the cost of autonomous systems technology solutions
- educating in the ethics and legal aspects of autonomous systems
- advocating and shape national policy and regulations.

Our vision is for smart, small and many systems, capable of overmatch of large and exquisite crewed platforms and other robotic systems – enabled by dynamic composition of modular sensor, weapon, and human command components from national, allied, and regional coalition partners. To deliver this new kind of asymmetry, a layered approach is advocated where large crewed and optionally crewed or uncrewed and pre-deployed platforms provide stand-off delivery of "small, many and smart" systems to hold adversaries at risk at long range. This layered approach is illustrated by the below graphic.

We have continued to increase support from Defence, industry, government, and academia in the program, creating employment and investment opportunities with participants. The Centre is presently in discussion with participants on several exciting new Projects, to be finalised in the next reporting period. Throughout the reporting period Trusted Autonomous Systems (TAS) has continued delivery of industry-led Projects and two Centre-run Activities of common-good. TAS formalised new industry-led Project agreements with the support of our principal client, the Australian Defence Force. During the reporting period, TAS has continued to mitigate risks imposed by COVID-19 to delivery and has worked closely with participants to ensure continuity and achievement.

In December 2020, I was proud to be awarded the Australian Naval Institute McNeil Award by Chief of Navy VADM Michael Noonan. This award named in honour of Rear Admiral Percival McNeil CB RAN (1883-1951) is awarded to "…an individual from Australian defence industry who have made an outstanding contribution to the capabilities and sustainment of the Royal Australian Navy (RAN)".

The TAS Symposium, delayed from 2020 due to COVID, was delivered in hybrid form in Townsville in April 2021 and was highly successful. Around 190 people from Defence, industry and academia attended with over 150 physically present. The Symposium also offered an opportunity to showcase some of the TAS Participants work, with presentations from Athena AI (previously Skyborne Tech and Cyborg Dynamic Engineering) and Boeing, senior representatives from the Royal Australian Navy (RAN), Army, Royal Australian Air Force (RAAF) and the Defence Science & Technology Group (DSTG).

The key work of the Centre is delivered through not only through our industry-led Projects but also our common-good Activities. I therefore commend to the reader, a summary of those prior to the other elements of the corporate reporting.

TAS vision

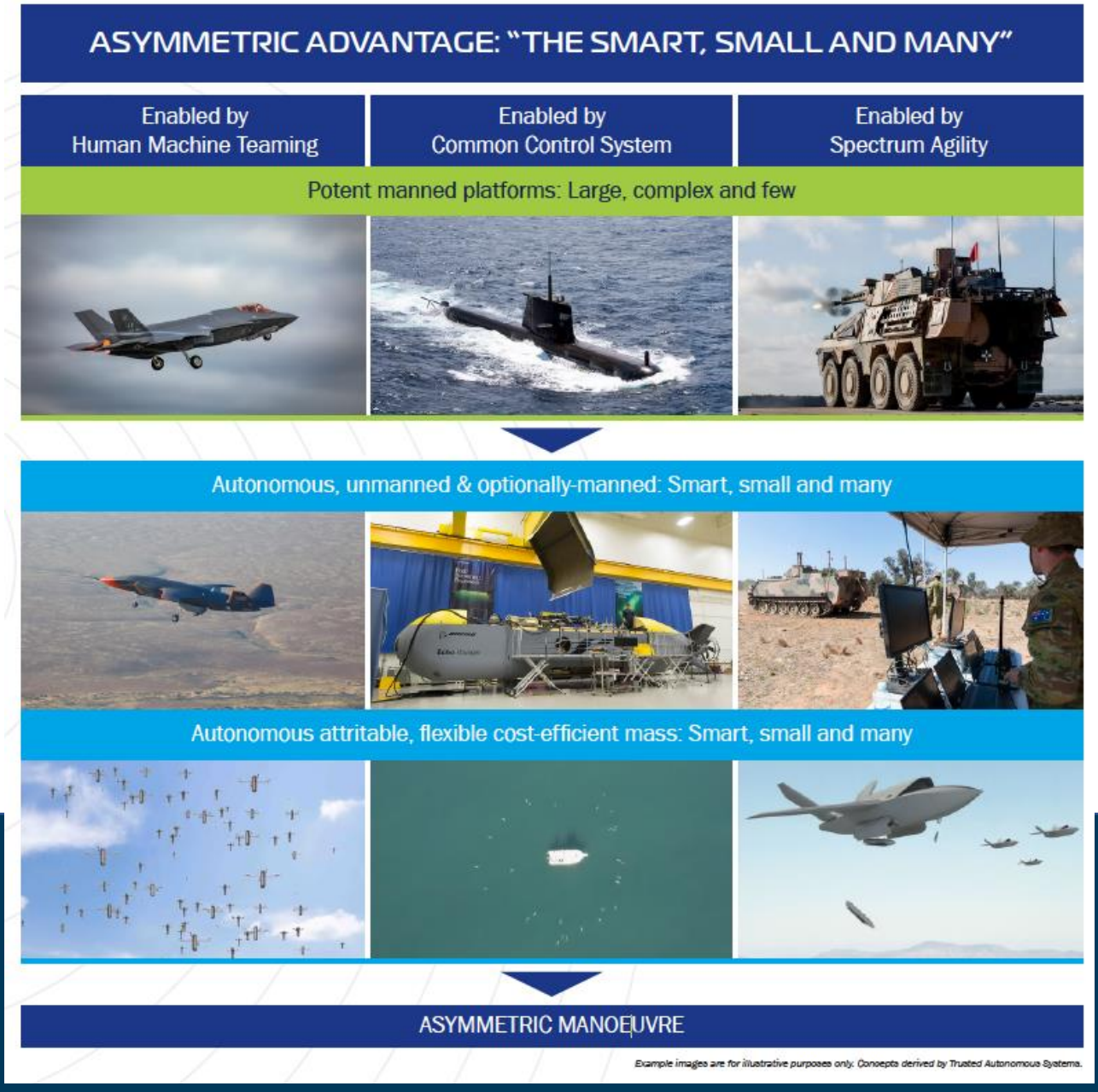
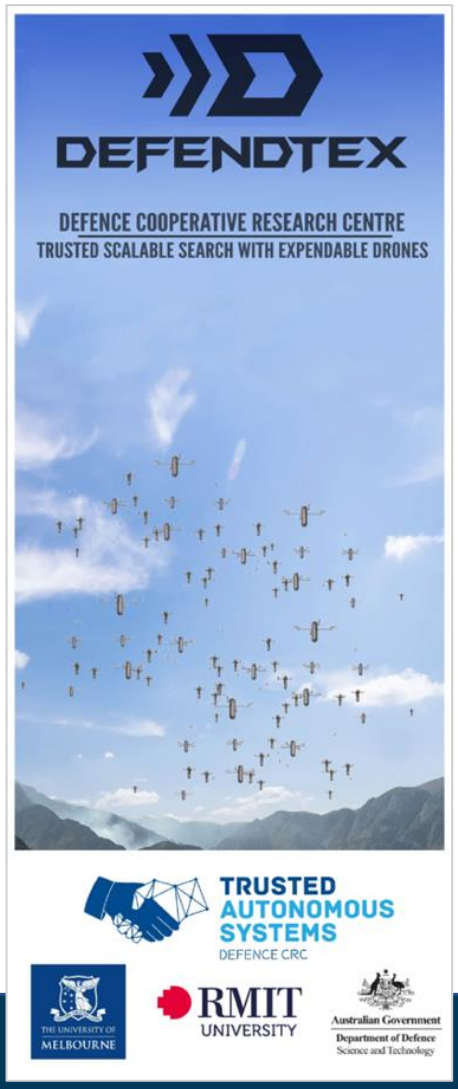


Image: Robotic Roadmap for Australia for 2022 (p. 148), Concepts derived Trusted Autonomous Systems

Projects and Activities
Work conducted by the Centre in FY2020-2021 included:

Projects: industry-led programmes of work with academic and Government partners.

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.



Trusted Scalable Search with Expendable Drones

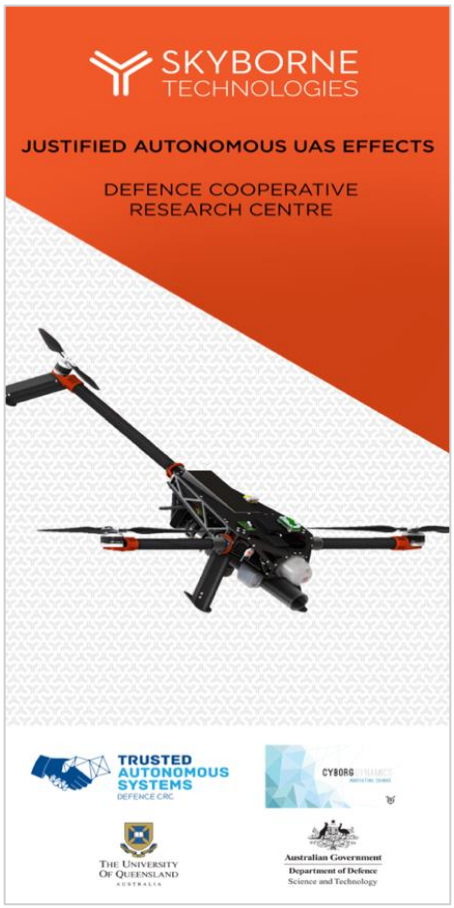
DefendTex-led with RMIT University, the University of Melbourne, and the Department of Defence Science and Technology (DST). Approved by the Board in August 2018. The project is conducting a sequence of demonstrations, culminating in a multi-node swarm conducting ISR operations in both complex semi-urban and underground environments.

DefendTex conducted demonstrations in the reporting period showing progress on their research. The DefendTex Drone 40 platform has been deployed operationally with British Army's Royal Anglian Regiment in Mali and early in the 2021-22 Financial Year was evaluated by US Marine Corps.

Distributed aUtonomous Spectrum managemenT (DUST)

Led by Consunet Pty Ltd with RMIT University, the University of Melbourne, the University of Sydney and DSTG. Approved by the board in November 2018. 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.

Consunet's DUST was successfully involved in commercial demonstrations to ADF in the period. The project has recently demonstrated distributed dynamic spectrum allocation algorithms that significantly improve spectrum use and communications resilience.



Justified Autonomous Unmanned Aerial System (UAS) Effects

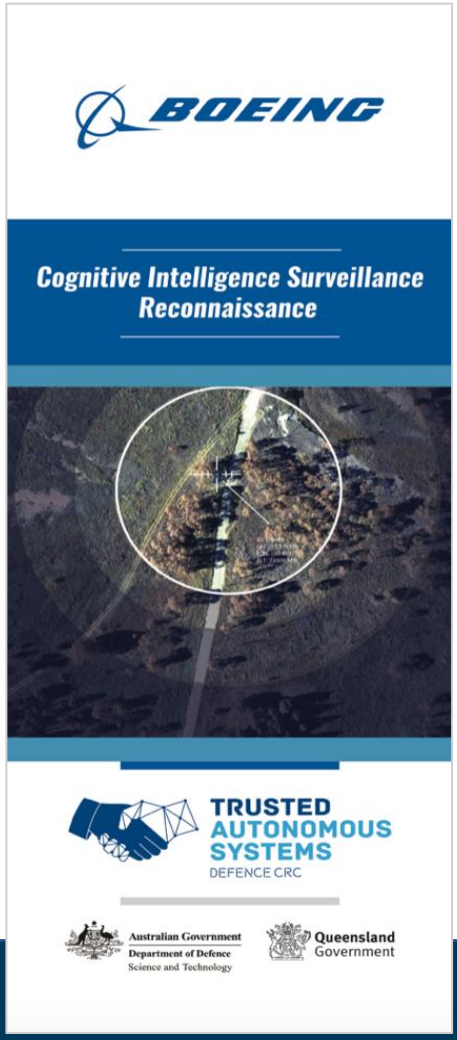
Led by Skyborne Technologies and Cyborg Dynamics Engineering with the University of Queensland (UQ) and Defence Science and Technology (DST) Group. Approved by the board in February 2019. The project aims to research and develop autonomous live reconnaissance effects assessment using AI and machine vision 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.

Field demonstrations of the Athena AI technology were provided to defence stakeholders and a high integrity Machine Learning (ML) image database pipeline developed by Skyborne and Cyborg continues to improve upon the ML algorithms. The company is engaging broadly on commercialisation opportunities.

Cognitive Intelligence Surveillance Reconnaissance

Led by Boeing Australia and approved by the TAS Board in March 2019, this project examined the embedding of machine learning techniques onboard multiple uninhabited aerial systems to better understand and react to the threat environment. The project designed and tested cognitive artificial intelligence algorithms to enable sensing under anti-access conditions and to navigate and conduct enhanced tactics in denied environments.

This project was completed in September 2020 with a live demonstration of four autonomous UAVs, coordinated to undertake find, fix, track, target and assess tasks. The system dynamically responded to loss of GPS and changing performance metrics. TAS has engaged with Defence stakeholders to advance to a higher TRL through the Defence Innovation Hub with support of Defence.



Trusted Autonomous Ground Vehicles for Electronic Warfare

BAE Systems, working with researchers at the Universities of Melbourne and Adelaide, are exploiting advanced AI techniques to deliver a prototype demonstration of a next-level trusted autonomous platform capable of robust and persistent operation in complex, contested land environments. A series of M113 vehicles have been fitted with robotics to enable optionally crewed operation as a pathway for this project.

Research has continued with planned demonstrations in the 2021-2022 financial year. To date the project has produced research with profound implications for advancing online-verifiable autonomy, providing a world-leading technique for assuring plans of autonomous systems against formal expressions of a mission.

Mine Counter-Measures in a Day

Thales is partnering with DST, INENI Realtime, Mission Systems, the University of Sydney, Western Sydney University, Flinders University and the University of Technology Sydney to develop new autonomous technologies that will revolutionise mine clearance capability in littoral operations.

The project will demonstrate a prototype system capable of Rapid Environmental Assessment, mine-like object detection and localisation, mine target recognition and simulated neutralisation, enabling zone preparation and clearance in a significantly shorter period of time – 'MCM in a day'.

Currently, the project has developed a detailed multi-physics simulation environment and used this to evaluate and develop reasoning and planning algorithms, and to explore human interfaces to support operational command of the system.

Swarming Gannet Glider

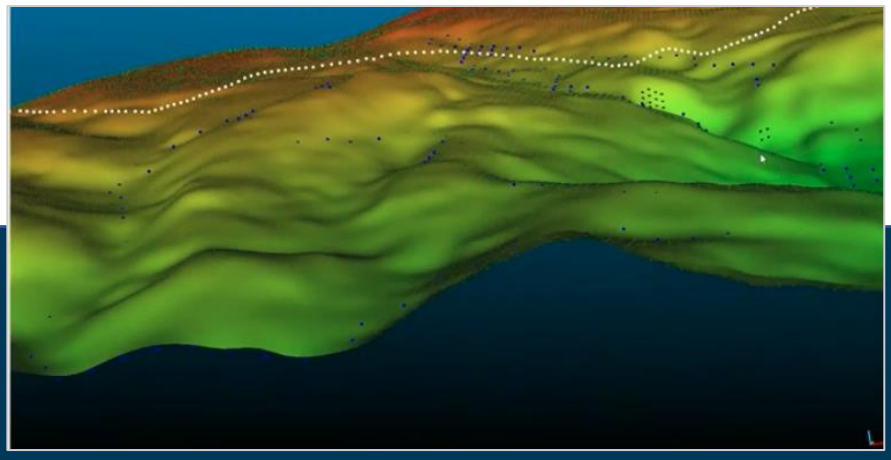
Skyborne Technologies are working with DSTG to develop a tube-launched glider that can be carried by the Cerberus UAV in a rotating launcher to provide long-range effects for lightly equipped soldiers. The Gannet Glider uses independently sweeping wings to provide stable, accurate glide control to a target location after command for release is received by the UAS operator. Skyborne Technologies recently posted material on their website to promote the Gannet Glider commercially.

The Glider is in the final stages of testing, with a full trials program developed by DSTG in support of the project and planning underway to conduct the trials at Queensland's Cloncurry test facility.

Right: Gannet Glider

Human Machine Teaming (HUM-T) Geospatial AI Decision Support

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 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. Athena AI have established a website where they are promoting the system commercially. Following the recent Land Forces Conference in June 2021 a series of cooperative ventures have been announced with other Defence industry platforms.



Top left: A visual depiction of terrain mapping as shown in demonstration video.

Bottom left: Elements of the Athena AI system.

Firefly Pathfinder

The Firefly Pathfinder contract was executed in August 2020. The project is developing a high-altitude balloon constellation for supporting surveillance, communications and payload delivery, with the Pathfinder undertaking important research and development work to prove the ability to maintain constellation formation and station-keeping.

Three industry partners are engaged – Lux Aerospace, Elson Space, and Danfield. COVID restrictions impacted the delivery of a final demonstration planned for the 2020-21 FY [delivered in September 2021 and detailed further in the FY21/22 annual report]. Areas for further research have been identified and incorporated into the HAPS Challenge (more below).

Enabling Agile Drones in Queensland

(Formally Agile-AI)

This project will advance tools for supporting the regulatory assessment of AI-enabled systems to accelerate operational development and deployment. The Enabling Agile Assurance of Drones contract was executed in July 2020.

The four milestones delivered provide a good overview of the maritime regulatory framework, issues related to remotely operated and autonomous vessels from an objective perspective and an operator's perspective, together with detailed regulatory process maps approved by the Australian Maritime Safety Authority (AMSA), and consideration of sandbox approaches for regulatory development.

The project has undergone an evaluation, and as a result TAS are working with the current lead to close out the Project Agreement and transfer the IP, before moving to source a new lead. The intended outcomes of this project remain unchanged.

HAPS Challenge

An Industry challenge to develop and demonstrate prototype high-altitude pseudo satellite capable of persistent manoeuvre.

The Project involves numerous partners including RMIT University Sir Lawrence Wackett Defence & Aerospace Centre, TAS, SmartSat CRC, RAAF (AWC), assistance from the Bureau of Meteorology and industry participants.

There was an assessment of six submissions for Phase 1 (Concept) with one successful team in Stream 1 (Automated or Autonomous HAPS Platform Station-Keeping & Constellation Maintenance) progressing to Phase 2 (Engineering). Two successful entrants for Stream 2 (Automated or Autonomous Attitude Determination & Correction of Payload Support Structure) have progressed to Phase 2. Phase 2 will last four-months, with the entrants undertaking an engineering design study, mostly document based, in preparation for further development, testing and trials in Phase 3- Prototype Development and Demonstration. Details on the challenge available on the RMIT website.

Activity 1

Ethics and Law of Trusted Autonomous Systems

Led by University of New South Wales (UNSW) and the University of Queensland (UQ), with DST. Approved by the board in November 2018. Activity 1 (A1) aims to develop ethical and legal assurance for projects and the benefit of participants, through advice and policy development at National and International levels. TASDCRC are represented as a non-government organisation at the United Nations (UN) Group of Governmental Experts (GGE) on Lethal Autonomous Weapon Systems (LAWS) to ensure the development of autonomous systems accord with ethical principles and the laws of armed conflict (LOAC). TAS is represented in the TTCP AI Strategic Challenge Ethics & Law Working Group, NATO Meaningful Human Control Working Group as well as contributing to ASPI, UNIDIR, SIPRI and ICRC activities and publications. The activity has demonstrated a high-level influence in the development of law, policy, and doctrine to ensure that Australia's reliance on TAS satisfies both humanitarian imperatives and national security interests and is consistent with Australia's commitment to upholding international law.

Ethics

The UNSW ethics contract was terminated by mutual agreement during the reporting period. A variation request will be submitted to the Department of Industry to update and amend the relevant ethics milestones under the Funding Agreement. The UQ Legal component continues unchanged.

As a result of the UNSW contract termination, the TAS Ethics Uplift Program (EUP) was launched, offering ongoing assistance to TAS participants (including DSTG, ADF, and Defence) through consultation, training, advice, and policy development, supported by case analysis, research, education and enculturation. The program provides Australian Defence and Defence industries access to the best of Australian theoretical and pragmatic expertise via universities and consultancies grounded in Defence-suitable methodologies and frameworks. The investment by TAS with Defence and other participants is accelerating and fostering a sustainable capability for ethical and legal sovereign RAS-AI in Australia. Consultancies engaged include: International Weapons Review (with a series of workshops conducted on Article 36 reviews) and researchers from UNSW@ADFA and ANU

There have been numerous publications, (available on the TAS Website, Resources) and notably the Australian Department of Defence publicly released *A Method for Ethical AI in Defence* DSTG-TR-3786 (MEAID) co-authored by TAS, RAAF Plan Jericho and Defence Science & Technology Group (DSTG). The report provides a practical methodology that could support AI project managers and teams to manage ethical risks. This methodology includes three tools:

1. an Ethical AI for Defence Checklist,
2. Ethical AI Risk Matrix and a Legal and
3. Legal & Ethical Assurance Program Plan (LEAPP)

These tools:

- facilitate communication between software engineers, integrators and operators during the development and operation of Artificial Intelligence (AI) projects in Defence
- provide resources for Defence, ADF and DSTG for education, training, and doctrine development
- provide a framework for Defence review of AI technology research, development, test and evaluation

Left: Image from Brochure in support of the Method for Ethical AI in Defence.

The method has been evaluated in:

1. Gaetjens, D., Devitt, S.K. & Shanahan, C. (2021). Ethical AI in Defence Case Study: Allied Impact. DST Technical Report. *Defence Science & Technology Group*
2. (Post-reporting period) Lockman, Z. (2021). Responsible and Ethical Military AI Allies and Allied Perspectives: CSET Issue Brief. Centre for Security and Emerging Technology, Georgetown University's Walsh School of Foreign Service. https://cset.georgetown.edu/wp-content/uploads/CSET-Responsible-and-Ethical-Military-AI.pdf
3. (Post-reporting period) Copeland, D., & Sanders, L. (2021, 8 October). Engaging with the industry: integrating IHL into new technologies in urban warfare. Humanitarian Law and Policy. https://blogs.icrc.org/law-and-policy/2021/10/07/industry-ihl-new-technologies/

Lockman (2021) notes that while not a formally adopted view of the Australian government, the Method is the clearest articulation of ethical AI for defence among the Indo-Pacific allies as well one of the most concrete practices that U.S. allies have thus far developed for AI ethics implementation in defence.

TAS has produced a series of robotics, autonomous systems and artificial intelligence ethics professional education videos for the Centre for Defence Leadership and Ethics, Australian Defence College. Four videos were made 2020-2021 with an additional ten videos contracted 2021-2022.

Law

The University of Queensland Law and the Future of War Research Group leads research to develop and promote a better understanding of international law that governs the use of trusted autonomous systems by the Australian Defence Organisation. It further aims to contribute to the development of law, policy, and doctrine to ensure that Australia's reliance on trusted autonomous systems satisfies both humanitarian imperatives and national security interests and is consistent with Australia's commitment to upholding international law.

The research group has contributed significant number of Academic publications, listed on the TAS Resources webpage, twenty four episodes of the Law and the Future of War Podcast and held trusted consultations and workshops with Defence including Defence Legal, ADF, and the Attorney General's Department and Defence Industries. Short 1-2 page briefing papers have been produced and are available via this link (listed above).

Briefing papers from UQ Law and the Future of War Research Group:

1. The potential benefits of autonomous functions in weapon systems
2. Legal frameworks for deploying autonomous aerial vehicles
3. The concept of autonomy applies to software and cyber-physical systems
4. Legal challenges of optimising spectrum use for military operations given both military and civilian users.
5. How autonomous military aircraft are impacted by international laws that aim to protect civilians and civil aviation.
6. How the legal obligation on States to carry out weapons review links with the high threshold that has been set for individual criminal responsibility for crimes triable before the International Criminal Court
7. Whether two of the basic classifications of the law, 'ship' or 'warship', affects the categorisation and operation of remotely controlled and autonomous systems.
8. How the United Nations Convention on the Law of the Sea (UNCLOS) regulates surveillance by UMVs in the Exclusive Economic Zone (EEZ) of foreign states, and if and how this law will constrain UMV design

Activity 2.

Assurance of Autonomy

Led by the Centre and funded by the Queensland Government. Approved by the board in February 2019. The aims are to create a trusted environment for test, risk analysis and regulatory certification support of autonomous systems and establish an independent world-class assurance service to global industry based in Queensland. Funding for both a National Accreditation Support Facility Pathfinder (NASF-P) and the Enabling Agile Assurance of Drones in Queensland project, intended to create a digital regulatory tool, were approved by the Queensland Government in May 2020.

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 industry and regulators. The Centre team, drawn from the Australian Maritime Safety Authority and Civil Aviation Safety Authority have deep regulatory and technical expertise in autonomous systems, and bring a wealth of practical experience and strong stakeholder relationships. The Assurance of Autonomy team collaborates with domestic and international industry, academia, Government, and regulators including the Assuring Autonomy International Programme (AAIP) at the University of York to better equip Australian industry and regulators to accelerate innovation in a way that meets a clear and coherent regulatory framework and enhances safety and efficiency.

Enabling Agile Assurance of Drones in Queensland

The Queensland government funded, TAS-led project 'Enabling Agile Assurance of Drones in Queensland' commenced on 20 July 2020 and will continue through to December 2022. The project will deliver smart digital regulatory tools to assist operators, regulators, and other stakeholders navigate the assurance and accreditation framework for autonomous and remotely operated vessels, thereby increasing efficiency, reducing resource burden, and facilitating innovation in industry.

The original technical industry lead, Biarri, together with Queensland University of Technology (QUT), supported by subject matter expertise from TAS, and significant stakeholder engagement, delivered a set of reports which provided a good overview of the maritime regulatory framework from a legislative perspective, process perspective, and a practical operator perspective, together with a Sandbox Design Report, and a Software Requirements Specifications Report. These reports will be used as the foundation for the first digital regulatory tool.

A new technical lead for the project is being identified to deliver the remaining project deliverables in partnership with TAS and Queensland University of Technology.

National Accreditation Support Facility Pathfinder Project (NASF-P)

The Queensland government funded, TAS-led project 'National Accreditation Support Facility Pathfinder' commenced in May 2020 and will continue through to mid-2023, with all deliverables due to be completed by December 2022.

The NASF-P will improve the assurance and accreditation framework for autonomous systems across the air, maritime and land domains, by:

1. Preparing a Body of Knowledge on the assurance and accreditation of autonomous systems,
2. Conducting an Air Domain Case Study and a Maritime Domain Case Study to demonstrate the practical application of NASF-P's work, resulting in a live technology demonstration at a Queensland test range, and
3. Preparing a business case for a new independent entity, the National Accreditation Support Facility (NASF), which will connect operators and regulators to speed up the assurance and accreditation process, drive innovation, stimulate job growth, and bring business to Queensland test ranges.

In addition to core deliverables, the NASF-P team have prepared a draft Australian Code of Practice for the Design, Construction, Survey and Operation of Autonomous and Remotely Operated Vessels in order to provide a tailored Australian voluntary standard. This project has been supported by AMSA and all stakeholders, noting the efficiency, certainty, and resource benefits that a tailored standard will provide.

The NASF-P team are conducting significant stakeholder engagement and consultation within industry, Government and Defence, and have had strong interest in, and contribution to, their work to date.

Publications

- Dickie, R. & Horne, R. (2021, 11 Aug). Enabling COLREGs Compliance for Autonomous & Remotely Operated Vessels. TAS Blog https://tasdcrc.com.au/enabling-colregs-compliance-for-autonomous-remotely-operated-vessels/
- Vanderkooi, M. & Horne, R. (2021, 8 Jul). Outcomes of successful webinar on TAS's project to develop an Australian Code of Practice for the Design, Construction, Survey and Operation of Autonomous and Remotely Operated Vessels in 2021. TAS Blog. https://tasdcrc.com.au/outcomes-of-successful-webinar-on-tass-project-to-develop-an-australian-code-of-practice-for-the-design-construction-survey-and-operation-of-autonomous-and-remotely-operated-vessels-in-2021/
- Putland, T. (2021, 5 Jul). New TAS project to develop a Detect and Avoid (DAA) Design, Test and Evaluation (DT&E) standard for low-risk, uncontrolled airspace outside the airport environment. TAS Blog. https://tasdcrc.com.au/new-tas-project-to-develop-a-detect-and-avoid-daa-design-test-and-evaluation-dte-standard-for-low-risk-uncontrolled-airspace-outside-the-airport-environment/
- Horne, R. (2021, 17 May). New TAS project to develop an Australian Code of Practice for the Design, Construction, Survey and Operation of Autonomous and Remotely Operated Vessels. TAS Blog https://tasdcrc.com.au/new-tas-project-to-develop-an-australian-code-of-practice-for-the-design-construction-survey-and-operation-of-autonomous-and-remotely-operated-vessels-in-2021/

Governance and Key Staff

Defence CRC TAS Limited (Company) manages the centre and is an unlisted public company limited by guarantee, incorporated, and domiciled in Australia. Its national office is located in Brisbane, Queensland.

Membership of the board, including key skills are detailed below. The board conducts activities of the Trusted Autonomous Systems Defence CRC through the Chief Executive Officer (CEO) and delegates specific powers and responsibilities to the CEO.

The Board's role is to govern the Defence CRC by:

- providing appropriate leadership
- contributing to and approving the Defence CRC's strategic plan
- approving operational plans and budgets to ensure consistency with the goals and objectives
- monitoring performance of the Defence CRC and its 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.

Advisory Committees

The following Board Committees were formed and in operation from 2 July 2020:

1) Audit and Risk Advisory Committee;
2) Remuneration Committee; and
3) Nomination and Selection Committee.

There is considerable continuity between the staffing of 2019-2020 and this financial year and minor changes have been undertaken to ensure role clarity and to meet the intent of the February Defence initiated Review. The Centre continues to offer itself as a workplace for key Brisbane-based DST interlocutors on Centre Activities as a more appropriate location than other local DST facilities. Some staff work flexibly from locations other than Brisbane.

Research Fellows

Four Centre Research Fellows were appointed last financial year as part of the Queensland Government funded Advanced Queensland TAS Defence CRC Fellowships program.

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

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.

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

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 $120 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, the services and from our DST, academic and industry Participants.

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 40 individual students and post-doctoral positions created. 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 30 June 2021 for Centre wide investment	KPI	Notes (excludes data for projects executed after 30 June 2021)
# Projects	18	Includes common good activities A1 and A2
Total Value of Program	$171.4M	Cash and In-kind from all sources
Cash Funding to Industry	$36.4M	Direct cash funds to Industry from NGTF, Qld Government or Defence (excludes Cash contributions from Industry and academia)
Cash Funding to Academia	$19.1M	Direct cash funds to Academia from NGTF, Qld Government or Defence (excludes Cash contributions from Academia)
Full Time Equivalent Employment Created	243	Total FTE created as a result of the Centre's investments over the life of the Projects and Activities (includes Centre staff and Fellows)
STEAM Impact	40	Number of PhD students, post-docs, senior fellows, Centre Fellows and undergrads engaged (included in total Job created above)
# Industry Participants	16	
# Academic Participants	12	
Leveraged Funds	$121.2M	Funds (cash and in-kind) attracted by leveraging the NGTF investment
Events hosted by TAS: 10 x Webinars 5 x Qld Research Fellows presentations Symposium in Townsville	 240 Registrations 341 Registrations 193 Attendees (156 Physical & 37 Virtual)	

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.

The Centre's third-party Participants provide support to the projects and activities with cash and in-kind commitments. These commitments over the life of the Centre are up to $51M of cash and in-kind from The Queensland State Government and an in-kind commitment of circa $17M representing approximately 50 FTE from Defence Science & Technology Group (DST).

Collaboration, Engagement & Education

Largely the functions of TAS Projects and Activity 1 contribute towards Defence Industry and Research Collaboration. A specific example of this outcome and engagement with Defence and SMEs was our Symposium in Townville in April 2021.

Symposium - Townsville

The TAS Symposium, Accelerating Trusted Autonomous Systems was conducted between 20 and 22 April in Townsville. The program included each ADF service on Robotics, Autonomy and AI, the Australian Strategic Policy Institute, Queensland's Chief Entrepreneur, an optional tour to the Australian Institute of Marine Science (AIMS) Reef Works facility and a display by the Army Combat Training Centre (CTC) who are exploring the integration of robotics and autonomous technologies in Defence, including with TAS Participants. Participants were also briefed on the Cloncurry UAV Test Facility by operators QinetiQ. Small businesses supported to attend by the Queensland Government were also provided an opportunity to provide a short pitch on an open mic during a Networking Event.

Above: The Townsville Symposium

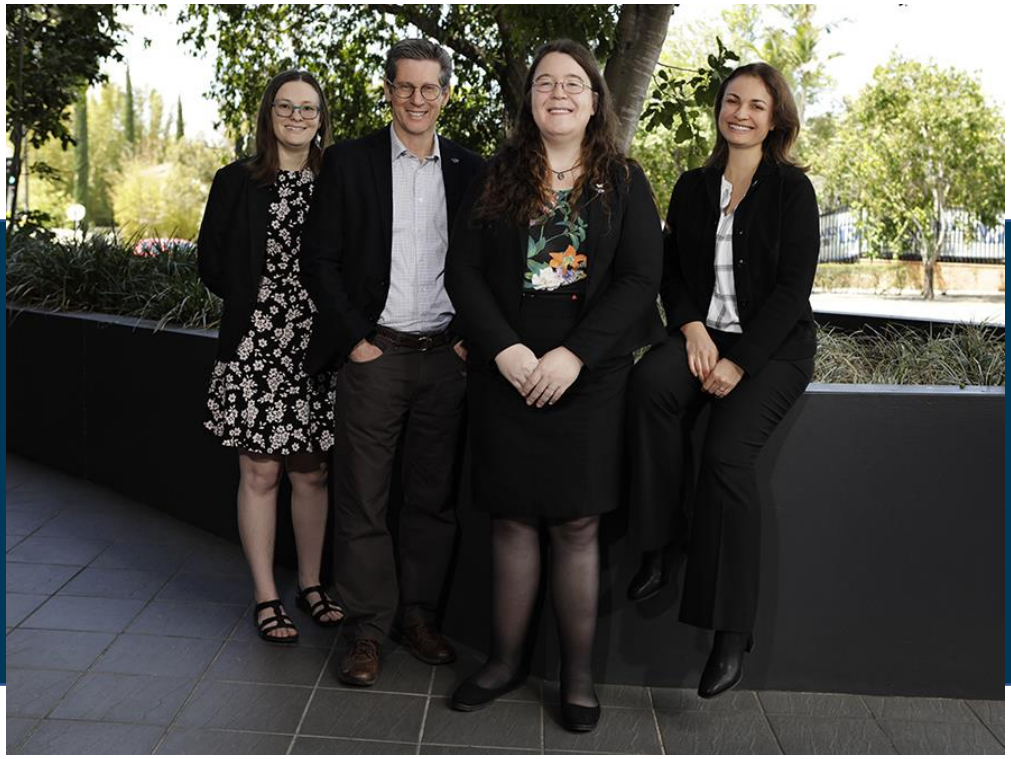
TAS Research and Education Activity

The STEAM impact across all Projects and Activities is the creation and maintenance of 40 positions, including PhD students, post-docs, senior fellows, undergrads, and Centre Fellows.

Four Centre Fellows were appointed in the last reporting period 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. The Fellows have presented Webinars on their research individually and collectively and these are made available for public good through the TAS YouTube channel. More information on the Fellows and their research is available on the TAS website.

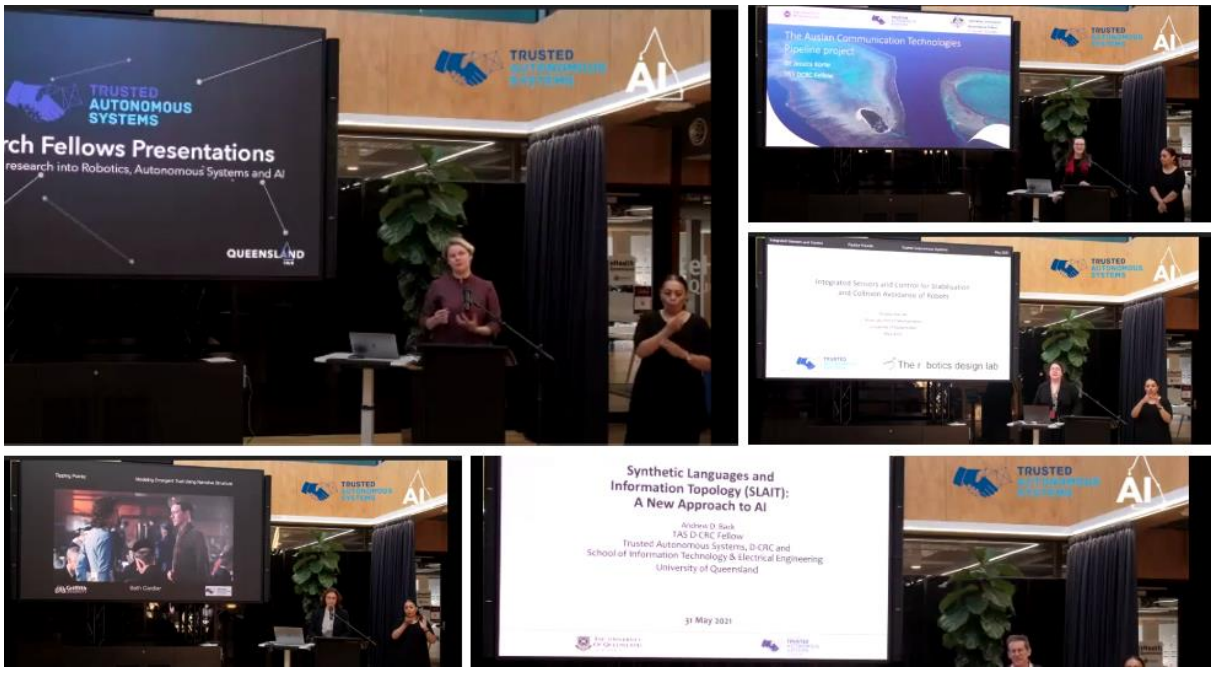
TAS while not having a STEM stream provides significant training & education outcomes. Additionally, TAS has provided funding for the supply of a BIA5 ground robotic to the University of New South Wales (ADFA Campus) to enable Officer Cadets to build their experience interacting with these emerging technologies. UNSW Canberra Professor Hussein Abbass said the exercise was designed to integrate real-world scenarios into the curriculum, "taking the classroom to the wild". By supporting parallel engagement with the technical and ethical aspects of using this technology, the program aligns with the University's cross-disciplinary approach to artificial intelligence. President of UNSW Canberra's Future of War (FoW) Vocational Extra-Curriculum Club (VECC), Australian Army Trainee Officer and Bachelor of Science student, John Le, described Exercise Enigma as an eye-opening experience that allows you to build technological capabilities around the UGV and apply them in a military exercise.

Right: BIA5 ground robot based at UNSW/ADFA.



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

As part of the education and training activities the Centre has hosted and participated in a number of additional webinars and workshops to increase the outreach of the Centre and these are also loaded to the TAS YouTube where they are made for a public audience. This included an invitational briefing at the Queensland AI Hub by each of the Research Fellows in May 2021.



Right: TAS Research Fellow presentations, Queensland AI Hub in May 2021

Publications

Numerous items have been published in the reporting period and these are linked to the TAS Website Resources along with other contributions including the UQ Law and the Future of War podcast series. Engagement has continued with defence, industry, and research institutions via a number of forums, including direct contact, project-based meetings and collaborative workshops to develop project proposals and activities. Work in the establishment years of TAS are now flowing through with numerous publications in the reporting period.

2021

- Galliott, J., MacIntosh, D. & Jens, D.O. (eds.) (2021). *Lethal Autonomous Weapons: Re-Examining the Law & Ethics of Robotic Warfare*. Oxford University Press.
- McKenzie, S. (2021). *Autonomous Technology and Dynamic Obligations: Uncrewed Maritime Vehicles and the Regulation of Maritime Military Surveillance in the Exclusive Economic Zone*. Asian Journal of International Law.
- 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).
- Selvaratnam, D, Cantoni, M, Davoren, J,M, Shames, I (2021), *Sampling Polynomial Trajectories for LTL Verification,* ArXiv (under review Theoretical Computer Science).

2020

- KaiLiao, Chwen, Manzie, Chris, Chapman, Airlie, (2020*), A distributed algorithm for UAV-based communication networks using constrained extremum seeking*, IFAC Papers Online.
- Korte, Jessica, Bender, Axel, Gallasch, Guy, Wiles, Janet, and Back, Andrew (2020*). A plan for developing an Auslan communication technologies pipeline.* ECCV 2020: Computer Vision – ECCV 2020 Workshops, Glasgow, Scotland, 23–28 August 2020. Cham, Switzerland: Springer International Publishing.
- Liivoja, R., Massingham, E., MacFarlane, T., and McKenzie, S., (2020). *Are autonomous weapons systems prohibited?,* TAS Game-Changer Blog and UQ Law School.
- McFarland, T. (2020*). Is an Autonomous Weapon System Just a Machine?*, Fifteeneightyfour, the blog of Cambridge University Press, Law & Government.
- McKenzie, S. (2020*). When is a Ship a Ship? Use by State Armed Forces of Un-crewed Maritime Vehicles and the United Nations Convention on the Law of the Sea*. Forthcoming Melbourne Journal of International Law
- Massingham, E. (2020). *Navigating to autonomy: legal questions in the use of autonomous aerial vehicles by the Australian military*. ANZSIL International Peace and Security Interest Group Seminar Series 2020, Online, 24 July 2020.
- Massingham, E. (2020). *Radio Silence: Autonomous Military Aircraft and the Importance of Communication for their Use in Peace Time and in Times of Armed Conflict under International Law*, University of Queensland Law School (This paper appeared in (2020) 1(1) Asia-Pacific Journal of International Humanitarian Law 184–208)
- Scholz, J.B. and Galliott, J. (2020). *The Case for Ethical AI in the Military*. Oxford Handbook of the Ethics of AI, Cases and Applications: Military. Chapter 36.
- Scholz, J.B, Lambert, D.A, Bolia, R.S, and Galliott, J. (2020). *Ethical Weapons: A Case for AI in Weapons*. In Moral Responsibility in Twenty-First-Century Warfare. SUNY Series in Just War Theory and the Ethical Challenges of Autonomous Weapons Systems, Steven C. Roach and Amy E. Eckert Editors, SUNY Press. September.

Commercialisation

Despite the TAS Projects and Activities still being principally in the early stages, progress has already been made in translation to commercialisation, as follows:

- DefendTex has made additional overseas sales connected with TAS projects.
- BAE Systems successfully demonstrated the ability to convert the M113 armoured personnel carriers for remote operation. This led to an order from the Australian Army to convert further vehicles for operational use and provides a pathway for the transition of Project-developed autonomous functionality into operations.

Uptake by Industry of research outputs is ensured by early engagement with Defence to better match outputs with needs. There are also fallback provisions whereby if the IP is not taken up ownership reverts to Defence.

Intellectual Property Management

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. In this reporting period there have not been any patents held or new patents filed.

Communications

TAS produces targeted updates to ADF stakeholders on projects and activities progress as a limited distribution to protect Participants intellectual property several times per year. Achievements are reported to the ADF client quarterly through DSTG, being Defence's corporate representative.

TAS continues to create and distribute to over 100 participants on an opt-in mailing summary of Autonomy and Robotic articles of interest to research, industry and defence on a weekly basis.

The TAS Blog Game-Changer along with social media on Twitter, LinkedIn, and YouTube provide additional Centre outreach.

Financial Management

TAS is in a sound financial position at 30 June 2021. TAS has implemented robust financial process to ensure prudent financial management and oversight on milestone and progress reporting to third-party Participants. BDO were appointed auditors for FY 2020-21.

TRUSTED AUTONOMOUS SYSTEMS

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