

DATA TO DECISIONS CRC ANNUAL REPORT 2016/17

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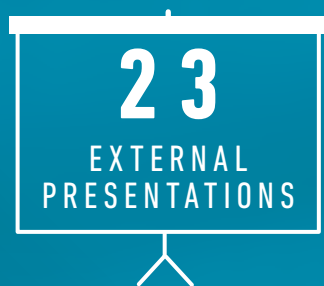
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5 HONOURS
SCHOLARSHIPS
PROVIDED

23 PHDs
COMMENCED

11 PROJECTS COMMENCED



HOSTED
INTERNS

8



325 DATA
SCIENTISTS
TRAINED



85.16

FTE



ABOUT THE D2D CRC

The Data to Decisions Cooperative Research Centre (D2D CRC) was established in July 2014 with a grant of \$25 million from the Australian Government and is part of the Cooperative Research Centres Programme. D2D CRC brings researchers and industry together to be a leading provider of capability resulting in a safer and more secure nation and a sustainable big data workforce for Australia.

VISION

The D2D CRC's vision is to be a leading provider of capability resulting in a safer and more secure nation and a sustainable Big Data workforce for Australia.

MISSION

Its mission is to undertake research, development, education and training that delivers outcomes to national security and other data intensive sectors.

CHAIRMAN'S REVIEW

Following a year of “visible achievement” where we demonstrated our capabilities, the D2D CRC has quickly moved to trialling them with government agencies, resulting in close engagement with front line analysts. Our three major technology programs, *Apostle™*, *Beat the News™* and *Integrated Law Enforcement*, have been successfully trialled by several national security agencies, with very positive feedback received to date. Such successful engagement has also opened up our work to more agencies, such as the Department of Immigration and Border Protection.

The last year also saw the completion of several projects:

- The *Large-scale Image Classification and Exploiting Contextual Cues in Large-scale Machine Learning* projects conducted by University of Adelaide developed world class capability for object identification in images and video and the automation of image captioning, respectively. Both projects ranked highly in international competitions, with the object identification capability finishing first in the CityScapes competition, second in the ImageNet Scene Parsing competition and fourth in the ImageNet Detection competition. Some of this capability will be used in new projects with Defence.
- The *Guiding principles in the design, regulation, implementation, governance and oversight of data-based decision-support technologies for law enforcement and national security* project conducted by the *Law and Policy* team deepened the analysis and focused the application of the first program project *Comparative International Perspectives on Strategy, Policy and Law in Australia, the United Kingdom, the United States, New Zealand and Canada*.
- A study on *A Governance Framework for the National Criminal Intelligence System (NCIS)* was delivered to the Australian Criminal Intelligence Commission (ACIC).

- The *Identity Assurance, ‘Pattern of Life’ and Big Data Analytics* project was completed for the Attorney-General’s Department (AGD). The project focused on pattern of life usage for identity proofing.
- The *Information sharing and the National Criminal Intelligence System* project was completed for the ACIC. The study considered legal and policy aspects relating to information sharing as well as data drawn from interviews and focus groups.

The *Education and Training Program* has produced a Data Science Competency Framework (DSCF), an Australian first. The framework defines a series of competencies specifically focused on describing the abilities, knowledge and experience required by data scientists, data engineers and data analysts. This framework is also the basis for our Data Science Development Planning Tool (DPT), which is an online self-assessment system that enables people to identify gaps in their competencies. In turn, the tool provides development options for data scientists, data engineers and data analysts of any level. Both the framework and tool have been piloted by a small group of end user agencies and it will become more widely available later in the year.

More broadly in our *Education and Training Program*, we welcomed another 23 PhD students in 2016/17, bringing our total cohort to 46 PhD students at the end of the year. We have also hosted eight interns and supported five Honours students through various programs and trained 325 data scientists in the D2D seminar series.

And to top off these achievements, we hosted yet another very successful annual conference which attracted over 160 people.

Our collaboration in other sectors is also progressing very well. We established the *Health Analytics Program* transferring knowledge and expertise developed in big

data research and development (R&D) for national security to the health industry. This covers four projects: linking mental health data, pandemic outbreak modelling, reducing complications in cardiac procedures and emergency waiting times application. Our work with the Sheep CRC concluded with the launch of the ASKBILL application, a web-based system that predicts risks to livestock. Still in agriculture, we joined the Precision to Decision Agriculture Project, which is funded by the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit Program. D2D's role has been to lead the development of an Agriculture Data System Architecture which will provide a common framework and guidance around the use of big data collection, storage and analysis in agriculture.

On the Board of Directors, we said farewell to Professor Hugh Durrant-Whyte who took up the position of Chief Scientific Advisor to the UK Ministry of Defence. Following Hugh's resignation, we welcomed Andrew Stead as a new director, bringing with him significant expertise that will help us progress our commercialisation efforts.

Our management team, led by Chief Executive Officer (CEO) Sanjay Mazumdar, our Chief Technology Officer (CTO) Brenton Cooper and Chief Operations Officer (COO) Niall Fay, continues to do a sterling job and has grown with the addition of a commercialisation manager.

Given our passion for data analytics and our belief that they will play an increasingly important role in Australia's national security decisions, we were ideally placed to contribute to the 2017 Independent Review of the Australian Intelligence Community (AIC). Our submission focused on the need among the AIC and law enforcement agencies for:

- effective sharing and coordination of data analytics capabilities;

- the development of common capabilities across the Community;
- a coordinated approach to legislative and policy changes to support agencies' functions; and
- a coordinated approach to assess and address current and emerging technology and workforce gaps.

As we move into our fourth year, we are seeing increasingly productive collaboration with our government partners, particularly as we engage with analysts at the 'coal face' of national security analytics. The in-agency trials are introducing analysts to the power of the D2D capabilities and, in turn, their expertise is helping us build world class tools to help them make decisions faster and more accurately. In the coming year, we hope to engage more deeply with analysts in agencies who are on the front line of Australia's national security challenge.



Tim Scully, Chairman

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The third year of operation of the D2D CRC was focused on delivering capability to the national security end users. The team performed exceptionally well in this regard with several successful trials of the *Apostle™*, *Beat the News™* and *Integrated Law Enforcement* capabilities undertaken over the year. In addition, the *Law and Policy* team delivered several significant reports and papers during the 2016-17 financial year (FY). The team's focus on delivering value to the end user was reaffirmed when a senior executive in one of the national security agencies contacted me about a new project after being referred to us by another agency who was extremely satisfied with a project we had delivered to them – there can be no better accolade than one of your end users singing your praises!

With very positive feedback from trials, the D2D CRC also increased its focus on commercialisation activities, with the appointment of a Commercialisation Manager, creation of our first spin-out company (Fivecast™) and execution of several licensing deals.

In his Chairman's report, Tim has outlined specific achievements of the CRC in FY 2016-17, but I would like to elaborate on two of these.

Investigation Management System (IMS) – the IMS development is a leading example of co-creation between the CRC researchers and engineers and the law enforcement community. This has resulted in a capability which delivers against unique needs of counter-terrorism investigations and ultimately positions the IMS as one of the preferred investigation management capabilities for Australian law enforcement. It is a shining example of the type of collaboration that can be achieved in a CRC.

Data Science Competency Framework – the DSCF was developed in response to the fact there is no formal competency framework for Data Scientists, Data Analysts and Data Engineers. To support the framework, we have also created a web-based DPT which enables individuals and organisations to assess their staff against the competencies. This provides a useful tool to plan personal development, organisational learning and development activities or recruitment. The DSCF and DPT has been developed in conjunction with industry, academia and several Australian Public Service (APS) departments and they have been trialled by several national security agencies, with a view towards a broader APS and industry roll-out.

With 60% of the life of the CRC now complete, it a good time to reflect on the performance of the CRC and how we are tracking towards our final goals. The table below reaffirms the outstanding performance of the CRC team

OUTPUT	3 YEAR GOAL	3 YEAR ACTUALS	5 YEAR GOAL
User trials	3	11	12
Patent/Innovation disclosures	11	14	23
Publications	152	226	351
Data Scientist trained	500	693	1000
PhD students commenced	23	48	48

Despite all these significant achievements, the CRC still faces some challenges. The most significant revolves around ensuring that we can transition the capabilities into the national security agencies in the most effective manner. This challenge is a combination of getting appropriate access to people, data and systems to undertake our activities, given the agencies are subject to extremely high operational tempo, and ensuring that the CRC implements the right commercialisation strategy to service the agencies' long-term needs. This is a topic we regularly discuss in our Defence and National Security Advisory Committee.

On a final note, I'd like to offer my thanks to CRC staff, researchers, Board and advisory committee members for their efforts over the past year. The D2D CRC is focused on areas of national importance and this is reflected in the commitment and contribution of everyone involved.



Sanjay Mazumdar, CEO

ACHIEVEMENTS

RESEARCH

The following key research achievements have been made:

- The *Integrated Law Enforcement Program* has undertaken further research and development of the IMS – a system to revolutionise investigations management practice for law enforcement practitioners. As a result of extensive user engagement and workshops, the system will deliver a base platform to address the immediate needs of counter terrorism investigators across Australia and enable the integration of leading-edge capabilities derived from the research activities of the D2D CRC – including data curation, and narrative visualisation.
- Several provisional patent applications have either been filed or under development as part of the IMS project.
- The *Apostle™ Program* has delivered non-operational trials to several law enforcement and national security agencies. The Program will incorporate leading-edge collection and analysis capabilities using automated techniques to extract meaning from unstructured data. The platform delivers a solution to an immediate capability need from users – but also enables integration of the research outputs from a range of D2D CRC research projects into text, image and video understanding to be incorporated.
- World leading capabilities were delivered from the research streams including new approaches to face recognition, logo detection, semantic indexing of videos, object recognition, image clustering, visual question answering and interactive knowledge extraction.
- Completion of the Large-scale Image Classification and Exploiting Contextual Cues in Large-scale Machine Learning projects conducted by the University of Adelaide.
- The *Beat the News™ Program* has matured several approaches to event prediction from publicly available information. These techniques have identified the need to increasingly focus on the analytic tasks undertaken by intelligence analysts – and the project is now adapting the approaches developed so far to address these emerging needs.
- The *Law and Policy Program* initiated several targeted projects that focus on the business needs of end users. These include projects to evaluate the issues related to use of advanced data analytics for identity verification, information sharing and governance processes within the national criminal intelligence system.

COLLABORATION

All projects at the D2D CRC must demonstrate collaboration between researchers and end users (government and/or industry). Specific collaboration of note included:

- co-creation of the Investigation Management System between the ANZCTC, the D2D CRC and several of its research participants. The Investigation Management System is now undergoing extensive trialling and workshops to ensure it meets user's expectations;
- co-creation of the *Apostle™* system with various national security agencies – the system incorporates leading edge research outcomes with the processes and tools required for effective use by agencies;
- completion of several *Law and Policy* projects which were a direct result of business needs identified by the Attorney-General's Department (AGD) and the ACIC;
- partnered with 15 RDCs on the *Accelerating precision agriculture to decision agriculture* project run by the *Rural R&D for Profit Programme*;
- collaborated with the Sheep CRC to create ASKBILL, a web-based app which predicts risks to livestock;
- conducted *Health Analytics* projects with SA Health, Flinders University, University of Adelaide and Queen Elizabeth Hospital;
- working with several Commonwealth departments to develop, pilot and evaluate the Data Science Competency Framework project; and
- developing and delivering data science training with national security agencies.

COMMERCIALISATION & UTILISATION

The D2D CRC has undertaken a variety of actions to ensure that there will be effective and appropriate utilisation and/or commercialisation of the CRC's outputs. The specific milestones for FY2017 include:

- appointment of a Commercialisation Manager and new board director with significant experience in commercialisation;
- producing and executing on commercialisation plans for all of the research projects;
- engagement of several agencies in trial and evaluation of the *Beat the News™*, *Apostle™* and *Integrated Law Enforcement* software;
- launching the CRC's first spin off company, Fivecast™, to commercialise the *Beat the News™* and *Apostle™* technology;
- licensing two new visualisation methods to Esri Australia to further develop the technology for the Department of Defence;
- completion of a United States customer development mission;
- development of the ASKBILL app in collaboration with the Sheep CRC;
- filing a provisional patent application for visualisation methods developed by the University of South Australia (UniSA); and
- recording nine innovation disclosures and drafting several patents for filing later in 2017.

EDUCATION & TRAINING

Over the last year, the *Education and Training Program* has focused on building a sustainable data workforce for Australia. The achievements include:

- expanded the community of PhD students with 23 students commencing in 2016/17, reaching the Commonwealth milestone of 48 PhD Scholarship students;
- hosted eight interns through a variety of programs and in liaison with multiple universities;
- supported five Honours students through a variety of programs;
- the seminars and short courses have increased the knowledge of 325 data scientists;
- the Data Science Competency Framework was launched and made available to the Public Sector; and
- built the Data Science Planning Tool, an online self-assessment for data scientists, engineers and analysts.

RISKS AND IMPEDIMENTS

The D2D CRC employs an active risk and opportunity management process which involves regular assessment of risks and opportunities by the management team, the Audit and Risk Committee and the Board.

In last year's annual report, the two high impact risks identified related to in-kind contributions and ensuring the CRC is generating a return on investment for its participants. With a strong focus on trials in FY 2016-17, the CRC has been able to mitigate both potential risks. Conduct of the trials has resulted in agency staff being involved in CRC activities which has addressed the shortfall in in-kind contributions. Moreover, these trials have demonstrated that the CRC is delivering capability that will meet national security needs which is helping to address any concerns about return on investment.

The key risk for the CRC going forward revolves around ensuring that the D2D CRC can transition the capabilities into the national security agencies in the most effective manner. This challenge is a combination of getting appropriate access to people, data and systems to undertake the CRC's activities given the agencies are subject to extremely high operational tempo, but also ensuring that the CRC implements the right commercialisation strategy to service the agencies' long-term needs. It is something that is being focused on closely by the CRC's executive, Commercialisation Manager and Board and discussed regularly with senior national security executives.

IMPACTS

The D2D CRC remains on track to meet these impacts and, as outlined in the Executive Summary, has exceeded some of these already. A significant achievement in FY2016-17 (ahead of the Commonwealth milestone) was the establishment of the first commercial spin-out from the CRC, Fivecast™. This spin-out will take the Beat the News™ and Apostle™ IP to market.

The projected impacts of the D2D CRC are:

- improved security for Australians and their interests;
- reduced acquisition risk for national security project;
- reduction in national security operating costs;
- royalties from the exploitation of D2D CRC intellectual property (IP);
- growth of small to medium enterprises (SMEs);
- economic benefits in other sectors;
- commercial spin outs leveraging D2D CRC IP;
- approximately 20 innovation disclosures, 350 publications, 48 PhD graduates and 1000 trained data scientists;
- improved balance between privacy laws and national security; and
- an overall benefit: cost ratio of 3.31.

RESEARCH

COMPLETED SIX
RESEARCH PROJECTS

PERFORMANCE AGAINST THE ACTIVITIES

APPLICATION RESEARCH PROGRAM: SECURITY ANALYTICS FOR COUNTER TERRORISM AND POLICING

The program's key activities are to research, develop, integrate and evaluate concept demonstrators that address the data analysis and exploitation needs of users in the law enforcement and intelligence community. Specifically, the program focus is:

- prediction of events such as social disruption, disease outbreak and election outcomes from analysis of open data sources (*Beat the News*TM); and
- integrated access, linking and analysis of distributed law enforcement data (*Integrated Law Enforcement*).

Key research achievements and evidence of research quality is demonstrated by the following:

BEAT THE NEWSTM

- Delivering upon a multi-year, multi-stream research and development project to forecast social disruption events from analysis of publicly available data.
- A large-scale data analytics platform has been prototyped and deployed. The analytics platform is able to process millions of records per day, can execute a variety of predictive algorithms and is used by multiple research teams.
- A variety of predictive models have been developed that forecast socially disruptive events from a variety of data sources. A subset of the predictive models has been integrated into a live system, operating on real data and producing live forecasts of events.
- A revised architecture has been developed that enables quick addition and ingestion of new data sources.
- New use cases have been developed that focus on analyst's having the ability to generate insights from data by easily creating signals from the data feeds.
- Several provisional patent applications are currently in drafting.

INTEGRATED LAW ENFORCEMENTTM

- Delivering a multi-year, multi-stream research and development project to provide integrated access, linking and analysis of law enforcement data.
- The Australian New Zealand Counter Terrorism Committee (ANZCTC) IMS working group has identified that the D2D CRC IMS is the preferred candidate for use as a national investigations management tool.
- Successful pilots and trials of the D2D CRC IMS have been undertaken with several law enforcement agencies.

The following specific impediments are acknowledged and will be addressed:

- Development of tools and techniques for integrated information access and analysis within the law enforcement community will necessarily require access to real data sets, but access to these data sets is challenging within the end user community for the D2D CRC. Close engagement with several agencies is underway to provide a pathway for data access and system evaluation.

Extensive end user involvement provides evidence that research is meeting their needs, in particular:

- A process of co-creation involving extensive engagement with the ANZCTC and Australian Federal Police (AFP) has been undertaken to ensure that the D2D CRC will deliver a national investigation management system that is fit for need, and incorporates the latest research innovations.
- The *Beat the News*TM event forecasting system has been delivered as a non-operational concept demonstrator to several law enforcement agencies. The resultant feedback has been in-depth and used to better shape the future research and development direction of the D2D CRC.
- Project steering committees composed of representatives from a range of end user agencies have been established.
- End user participants have been extensively consulted throughout the product research and design activities for the *Integrated Law Enforcement* system.

No changes to future research directions are envisaged for this program.

APPLICATION RESEARCH PROGRAM: DEFENCE INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE

The program's key activities are to research, develop, integrate and evaluate concept demonstrators that address the data analysis and exploitation needs of users in the defence community. Specifically, the program focus is:

- automated techniques to extract meaning from unstructured data (images, video, text) (*Apostle*TM); and
- guidance to architects, designers and managers to be used when building big data systems (Reference Architecture).

The following list provides key research achievements and evidence of its quality:

FUTURE ARCHITECTURE FOR THE DEPARTMENT OF IMMIGRATION AND BORDER PROTECTION

- Developed a proposed solution architecture for Department of Immigration and Border Protection's (DIBP) future operational analytics capability

APOSTLETM

- Delivering upon a multi-year, multi-stream research and development project to provide effective search, interrogation and understanding of open source multi-media (text, image and video) data.
- Extensive engagement with end users to develop a series of detailed use case scenarios for the *Apostle Program*.
- Developed and successfully demonstrated automated techniques to extract meaning from unstructured data (images, video, text) to a range of law enforcement agencies.

While not a specific impediment, it is acknowledged that there is a need for continuing engagement and input from end users to guide research and development activities, in particular to develop effective tools and techniques for users and analysts in the national security community.

Extensive end user involvement provides evidence that research is meeting their needs, in particular:

- The *Apostle*TM system, has been deployed as a non-operational concept demonstrator, to four law enforcement or intelligence agencies.
- A project steering committee composed of representatives from a range of end user agencies have been established.
- End user participants have been extensively consulted throughout the problem scoping and architectural design activities for the *Apostle*TM Program. The resultant feedback has been in-depth and used to better shape the future research and development direction of the D2D CRC.

No changes to future research directions are envisaged for this program.

FOUNDATION RESEARCH PROGRAM 1: DATA STORAGE AND MANAGEMENT

The program's key research areas are:

- information architectures for access and analysis of diverse, distributed data;
- scalable graph processing and query architectures; and
- sharing, query and mining of distributed data.

The following list provides key research achievements and evidence of its quality:

DATA CURATION FOUNDRY

- Proposed Case Walls which is an innovative, analyst-friendly, collaborative, and assistive platform.
- Designed and implemented the Case Walls for Investigation prototype, which enables the Investigators to collect information, trace investigation actions, manage tasks, share notes and make decisions. The Case Walls prototype has been successfully demonstrated to multiple law enforcement agencies.
- Designed entity-mention based techniques to index and search investigation records. An application programming interface (API) was developed to support these techniques as well user interfaces to illustrate the usage of such techniques in investigation Case Walls.

- Developed an API that allows programmers to create and update data curation and tagging rules.
- Developed a novel method to evaluate and automatically enrich and update data curation rules at both design and run time. The new method combines entity extraction, summarisation, and re-enforcement learning to allocate rewards to features used in a curation rule.
- Developed APIs to enable data scientists to easily add features – such as extracting keywords; identifying and linking extracted entities to external knowledge bases; classifying, sorting and categorising data, and indexing structured and unstructured data into their data applications.

FEDERATED DATA PLATFORM

- Designed API for federated data and search access. Implemented on law enforcement test data.
- Implemented an analytics pipeline combining federation capability with the D2D CRC reference architecture pipeline; demonstrated search functionality on law enforcement test data.
- Developed draft interoperability anchor data model, based on law enforcement data, National Information Exchange Model standard, and other sources.

ENTITY LINKING AND RESOLUTION

- Implemented the designed graph model for the linked entity store. This model allows provenance data and repetitive attributes to be stored. The model enables information from relational database and extractions from text to be integrated and stored.
- Implemented ingesting processes to ingest entity profiles and relationships from representative law enforcement databases. The ingesting process supports initial linking of entities so that entity profiles are stored with links to other entities.
- Implemented matching processes to enable ID, keywords, and structured query searches using exact, approximate, synonym, and phonetic matching. With the matching process, all profiles in the linked entity store form a graph and is ready to traversal and visualise.

- Implemented entity profile update, linking, and delinking functions. The update enables the change to an entity profile to be propagated into the entity store. The linking function supports the merge of two entity profiles and the delinking function enables a previously merged entity profile to be split apart to correct linking errors.
- Implemented web service APIs for the search functions and update functions to be called from the internet.
- Implemented user interfaces with term highlighting to showcase how end users can be supported to use the above search and update functions.

DISTRIBUTED EVENT MINING

- Completed construction of an extensive ontology of event types, actors, targets and locations for monitoring a foreign conflict, with input from social scientists.
- Automated the software pipeline for ingestion of data sources, classification of events using the ontology, and storage of events in a searchable database.
- Created and validated three gold standard datasets: (1) events for a foreign conflict extracted from news media, (2) events for a foreign conflict extracted from Twitter, (3) 2016 Australian federal election tweets labelled for target, topic and sentiment.
- Evaluated an interface to allow human annotators to define rules for event extraction for use with the event extraction pipeline.
- Conducted machine-based experiments to determine where human input could best be used in the event extraction process.
- Evaluated the use of general and domain-specific neural network models to improve event classification for small classes and rare words.
- Implemented a multi-stream event extraction evaluation framework to allow experiments on different stream event extraction methods.
- Implemented a basic multi-stream mining method to efficiently perform event extraction.
- Identified issue motivated groups of interest for the second phase of the project.

- Constructed an initial dataset of issue motivated groups.
- Developed and evaluated basic models for target entity identification, topic detection, and sentiment classification on the Australian federal election tweets.
- Contributed modules to open source software projects (Snacktory and Deeplearning4j).

KNOWLEDGE GRAPH CONSTRUCTION, CURATION, MANAGEMENT AND QUERY

- Constructed a processing pipeline to disambiguate and link mentions in the text to entities in the Knowledge Graph.
- Constructed a processing pipeline to perform semi-automatic concept graph construction from document collections.
- Constructed a processing pipeline to perform interactive relation extraction.
- Devised new methods to perform Named Entity Recognition with a special emphasis on domain-independence.
- Constructed a prototype system to perform relatedness queries in knowledge graphs, including ability for navigation and concise summarisation.

While not a specific impediment, it is acknowledged that there is a need for continuing engagement and input from end users to guide research and development activities, in particular, to develop effective tools and techniques for users and analysts in the national security community.

Extensive end user involvement provides evidence that research is meeting their needs. In particular, this foundation research program will deliver outputs to the *Beat the News™*, *Apostle™* and *Integrated Law Enforcement* concept demonstrator projects. Each of these projects undertakes regular demonstrations to representatives selected from the end user community. Each concept demonstrator project is also governed by a project steering committee consisting of senior executives from the end users, whose role is to ensure that the projects are meeting end user needs.

No changes to future research directions are envisaged for this program.

FOUNDATION RESEARCH PROGRAM 2: ANALYTICS AND DECISION SUPPORT

The program's key research areas are:

- information extraction techniques;
- search and retrieval of data;
- risk profiling and prediction; and
- visualisation techniques.

The following list provides key research achievements and evidence of its quality:

NARRATIVE VISUALISATION

- Held workshops with the AFP, former state and federal public prosecutors to gain an understanding of the issues and needs of the organisations.
- Three new visualisations have been developed to support AFP agents and the Commonwealth Director of Public Prosecutions prosecutors in gaining a deeper understanding of cases in shorter time period.
- These visualisations have been validated by agents from the AFP along with former prosecutors.
- Working concept demonstrator showing dynamic case data in each of the three visualisations.
- Held workshops with UNSW and Defence Science Technology Group (DST Group) to further develop the technology enabling the visualisations.
- A number of peer-reviewed conference publications on the use of narrative visualisations published.

IMMERSIVE INTELLIGENCE POD

- The research resulted in two new visualisations (Parallel Schedule Plot and Braille Plot) developed working with Defence and other agencies.
- After being used internally by Defence, they requested that it commercialised for use by the organisation in a production capability.
- ESRI is currently commercialising the research into their portfolio of products for AGO to use, with the research now titled "Meeting Mapper" for commercial purposes.
- The CRC has patented the visualisation given their IP value.
- A number of peer-reviewed conference publications from the project.

BUILDING CLASSIFICATION AND PREDICTION SYSTEM FOR CIVIL UNREST

- A variety of predictive models have been developed that forecast socially disruptive events from open source data.
- Volume-based model has been integrated into the CARBON system, primarily operating on producing live forecasts of events.
- Time Series model 2.0 has been implemented to make predictions based on approximate matching between evolutionary patterns and recent trends of historical events.
- A model of early bursty event detection has been developed to detect burstiness of social disruption related events from open source data.
- Text has been labelled based on the characterisation of gold standard record texts for the sake of building an improved volume-based model.

TOPIC MINING AND TREND MONITORING IN TEMPORAL TEXT SOURCES

- Project successfully completed as planned.
- Completed integration of topic mining and trend detection research outputs into the CaseGenix platform.

CIVIL UNREST AND ELECTION PREDICTION

- Implemented keyword volume-based daily prediction model for Australian and Indonesian cities.
- Testing a new Bayesian model for recursive event prediction from online posts.
- Research on large-scale feature extraction techniques from unstructured text.

DISEASE PREDICTION

- Characterisation of seasonal influenza in Australia using state-of-the-art model selection and Bayesian estimation techniques to estimate underlying epidemiological quantities.
- Methodology and prototype full-season forecasting system using fusion of extant disease surveillance systems with advanced mathematical models.

SEMANTIC INDEXING OF VIDEO

- Developed a fast and efficient video concept detection toolkit.
- Proposed a new hierarchical video representation method and achieved state of the art performance in video captioning – most of the top performers in the ActivityNet-16 competition used the team's video representation.
- D2D CRC researchers had five papers accepted to the International Conference on Computer Vision and Pattern Recognition in July, which is the foremost conference in the area.
- Achieved first place in the TREC Video Retrieval Evaluation Localisation competition organised by National Institute of Standard and Technology.
- Developed a fast and accurate face detection and recognition system for videos.

PICTURING EVERYDAY KNOWLEDGE

- Developed and delivered a representative image ranking web app for D2D CRC.
- Developed a novel probabilistic knowledge completion method with active learning, and published at the CIKM 2016 conference.
- Continue to develop new technologies for stylistic image description. Proposed a new sentence simplification method to incorporate attention-based word copying.
- Developed a large-scale system for multimedia content collection system, that monitors news articles, social media posts, and images on 12 ongoing news topics. The technology includes large-scale crawling, information extraction on both text and images, as well as indexing and front-end clustering and explorative browsing.

EXPLOITING CONTEXT IN MACHINE LEARNING

- Developed the world's best image captioning technology and were leading on the synthetic scenes benchmark, and the much larger Visual Genome dataset in 2016
- Developed an attribute-based method for vision and language problems, with world-leading results on COCO (Common Objects in Common) and visual question answering on COCO-QA.
- Developed a Visual Question Answering (VQA) method capable of exploiting a Knowledge Base (KB), as required by the technology roadmap, and motivated by discussions with Defence. World's first, and still the only technology capable of using known facts from a KB in answering visual questions
- Created a dataset to train and evaluate the method, as none of the existing datasets are applicable.
- Developed Zero Shot VQA, to answer questions about objects in images that the method hasn't seen before

LARGE SCALE IMAGE CLASSIFICATION

- Developed the world's best Convolutional Neural Network architecture. This is evidenced by the following recent results in computer vision challenges: 2nd place in ImageNet Scene Parsing in 2016 and 1st place in CityScapes, the new semantic segmentation benchmark.
- Developed world-leading fine-grained classification technologies.

Extensive end user involvement provides evidence that research is meeting their needs. In particular, this foundation research program will deliver outputs to the *Beat the News*[™], *Apostle*[™] and *Integrated Law Enforcement* concept demonstrator projects. Each of these projects undertakes regular demonstrations to representatives selected from the end user community. Each concept demonstrator project is also governed by a project steering committee consisting of senior executives from the end users, whose role is to ensure that the projects are meeting end user needs.

No changes to future research directions are envisaged for this program.

RESEARCH PROGRAM 3: POLICY FOR BIG DATA ANALYTICS

The major achievement of this program was the completion of three projects and the commencement and substantial completion of a fourth. Three of these projects were undertaken for specific government end users, responding to specific business cases prepared by them.

- *Guiding principles in the design, regulation, implementation, governance and oversight of data-based decision-support technologies for law enforcement and national security* (completed in October 2016), deepened the analysis and focused the application of the first program project (*Comparative International Perspectives on Strategy, Policy and Law in Australia, the United Kingdom, the United States, New Zealand and Canada*).
- *Identity Assurance, 'Pattern of Life' and Big Data Analytics* (completed in June 2017), a project on pattern of life usage for identity proofing, was undertaken for the Attorney-General's Department.
- *A Governance Framework for the National Criminal Intelligence System (NCIS)* (Completed in June 2017) identified key principles for appropriate governance of the NCIS. This project was undertaken for the ACIC.
- *Information sharing and the National Criminal Intelligence System* (Completed in June 2017) was undertaken for the ACIC. The project investigated enabling information-sharing rules and practices in relation to the NCIS.

While not a specific impediment, it is acknowledged that academic research expertise on law and policy in this field is limited in Australia. It is therefore encouraging that participation in the program broadened during 2017. La Trobe Law School joined Deakin Law School and UNSW Law in the program and further capacity and expertise was added by productive collaborative relationships with the Office of the Victorian Commissioner for Privacy and Data Protection and the Institute of Law and Technology of the Autonomous University of Barcelona. While it has proved challenging to attract PhD students with the law, policy and technology academic profile required in this program, four PhD candidates were working in the program by June 2017.

The level of end user support for research projects is indicative of the relevance and impact of the research program. The AGD is a key representative of the Australian government as an end user. AGD officials have facilitated extensive user engagement for the CRC across the National Security Community. AGD officials supported the first research project of the Program to ensure that the project outcomes meet end user needs. During the reporting period the AGD requested the *Identity Assurance* project and facilitated access to various government officials. The ACIC was also a very active and supportive end user. It provided the business cases for two of the projects that were undertaken during the reporting period. It facilitated access to information and relevant officials and also commented on draft reports. The Program team also interacted with various government departments and agencies about key questions that should be pursued in the next reporting period. Two projects have already been identified and project proposals are being prepared.

No changes to future research directions are envisaged for this program.

INNOVATION EXCHANGE

The major accomplishments of the program are:

HEALTH

- A data platform that links Medicare records with hospital data has been developed. This provides a visual representation of a patient's medical history. Currently, alert algorithms are being worked on to flag potential problems with medication adherence or medical appointments. Early detection of these aspects of patient care will reduce hospital admissions further down the track.
- Several papers and presentations have been developed based on analysis of cardiac data across Australia and New Zealand. This study is the first of its kind to be conducted in Australia with very interesting results emerging in risk adjusted mortality and readmission rates for various cardiac procedures.
- An emergency waiting time application was created, coupling hospital waiting time data with Google maps and the user's current location to recommend the fastest possible method of treatment. Several possible extensions are being considered after discussion with key stakeholders, including recommending medical clinics

to reduce emergency department burden and integration with the health direct application.

- A project on disease outbreak prediction has been conducted with a focus on Influenza like illness. The early detection of disease outbreak, including predictions of peak timing and magnitude, can aid in various aspects of health care, including vaccination production/distribution, hospital bed occupancy, etc.

MANUFACTURING

- Successful implementation of a big data decision support tool for SEAPA Pty Ltd (a South Australian manufacturer of oyster equipment). The project was undertaken as part of the Department of State Development's Big Data Connect Program and utilised both public and private data sources such as climate and customer information to provide the SEAPA sales team with insightful CRM and sales support. SEAPA are now exploring how to develop the platform further to extend their competitive edge.
- Successful implementation of a big data system with predictive analytics for Pacific Marine Batteries Defense Pty Ltd (PMB). The success of this project has allowed PMB Defense to gain valuable insights into their products and leverage the advantages of predictive maintenance. As a leader in defence manufacturing in South Australia, it is hoped that this will encourage other defence sector manufacturers towards big data adoption and predictive analytics.
- Following the success of the previous projects the Department of State Development are funding a further five big data projects in partnership with the D2D CRC. This will see the creation of two investigatory projects and three development projects focused on furthering big data adoption by the South Australian manufacturing sector.
- D2D CRC undertook a number of successful extension and education exercises in partnership with the Department of State Development to promote the benefits of big data and data science within the South Australian Manufacturing Industries.

AGRICULTURE

- The Sheep CRC Wellbeing Data Platform has been successfully completed and transferred to the Sheep CRC for further development under their commercial ASKBILL platform. The platform makes available historic weather data for the whole of Australia back to 1981, and provides live weather observation and seven day forecast data to a number of biophysical models covering pasture availability and susceptibility risks such as Flystrike, Temperature extremes and Worm loa. The platform has been designed to support a "bring your own model" approach and is easily extensible to cover other biophysical risk models based on climate data.
- As part of the work undertaken with the Sheep CRC, D2D CRC also helped the Bureau of Meteorology test their new Access-S product in a production system.
- A suite of machine learning models for predicting live weight, body condition score, and disease susceptibility for individual sheep were successfully developed and provided promising initial results.
- Successful implementation of an automated condition score analytics tool. A tool for evaluating the condition score of an animal was developed in collaboration with the Sheep CRC and Primary Industries and Regions South Australia. The initial result of the work was promising and address a specific pain point and valuable measure within the industry. An academic paper is being produced on the work and it is hoped that the project will receive further future funding.
- The initial draft of a Big Data Reference Architecture focused on the Australian agricultural industries has been successfully completed and well received by initial stakeholders. The project, funded through the Department of Agriculture and Water Resources Rural R&D for Profit Program is examining the requirements for the fifteen Industry Research Development Corporations (RDCs) as to how they can successfully leverage big data analytics to provide decision support within their Industries. The first phase of the project will be completed in February 2018 and it is hoped that there will be further future initiatives to continue to forward the use of big data in Australian agriculture.

EDUCATION AND TRAINING

LAUNCHED AN AUSTRALIAN
FIRST DATA SCIENCE
COMPETENCY FRAMEWORK

The Education and Training activities focus on the D2D CRC's objective of increasing the sustainability of the data science workforce. A large component of this involves engaging with and developing the workforce of the future through PhD Scholarships, Honours Scholarships and internships.

This year the D2D CRC reached the Commonwealth milestone of 48 PhD Scholarships. The students represent a diverse range of backgrounds and experiences, with 18 Australian Citizens/ Permanent Residents and 30 International students. In addition to funding scholarships, the D2D CRC supports the development of critical career skills, for example, providing workshops on creativity, innovation and communication, attendance at the Annual Conference and an induction for new students. Students are also encouraged to create a network through these events, not just with each other, but with industry partners and the team at the D2D CRC. The past year has also seen the launch of the Applied Research Program, which provides an additional grant to PhD students to undertake activities that will enhance their research, professional development and career. Three students were successful in receiving a grant, with all three travelling overseas to participate in conferences, meet with other research groups and exchange knowledge.

2016/17 was also a busy year for the Honours students and internships community. The D2D CRC offered Honours Scholarships to two students at various universities and was also successful in engaging with the Defence Science Technology Engineering and Mathematics (STEM) Scholarship Program to work with three additional Honours students. As well as offering support through mentoring, access to data, and feedback on their research project, the D2D CRC encourages Honours students to spend time in the office to gain workplace experience, with a number taking up that offer on a regular basis. Similarly, the D2D CRC welcomed six interns, again from various universities and with diverse backgrounds to work on national security and health analytics projects.

To help ensure a two-way sharing of knowledge, each student is invited to present on their work or research project at the end of their scholarship or internship, often leading to new ideas and perspectives on the work of the D2D CRC.

Over the past year the D2D CRC has expanded its training to offer greater depth and engage different audiences. The seminar series continued strongly, with five seminars being facilitated across various states and on topics ranging from data science in agriculture to reference architecture. Towards the end of last year, the D2D CRC also worked closely with Deakin University to deliver an introductory course on data analytics. The need for this course, plus an intermediate data science course, has been highlighted by a number of agencies. Work on delivering both courses continues as greater understanding of development needs is gained through liaison with industry partners. Finally, 2017 also saw the launch of the Big Data Leaders Series, a series of more intensive sessions aimed at covering the intersection of strategic and technical information. Overall, the D2D CRC trained 325 data scientists over 2016/17, bringing the total number to over 600.

In addition to the ongoing training and development activities of the D2D CRC, this year the CRC also contributed to data science workforce sustainability through the completion and dissemination of the Data Science Competency Framework. Identifying and describing 20 data science/ analytics competencies across five maturity levels, the Data Science Competency Framework aims to support workforce development, enabling organisations to provide role clarity, identify individual and team development needs, support recruitment and contribute to workforce planning. So far, the Data Science Competency Framework has been shared with the Australian Public Sector, including agencies both within and external to the defence and intelligence sector, receiving very positive feedback. Further, an online tool that enables individuals to self-assess their proficiency against the competencies is also under development, with options for commercialisation to be explored.



PhD Students at Induction Day



Design Thinking Workshop



RESULTS

LAUNCHED FIRST
SPIN OFF COMPANY,
FIVECAST™

SME ENGAGEMENT

Through the *Innovation Exchange*, the D2D CRC has engaged with several SMEs. The D2D CRC has successfully completed two projects with manufacturing SMEs (PMB and SEAPA Pty Ltd) under the *Big Data Connect Program*. These projects have enabled the CRC to transition its expertise in big data to enable the aforementioned SMEs to realise business benefit from the application of data analytics.

Through projects with the Sheep CRC and Rural R&D Corporations, the CRC has also engaged closely with several other SMEs to help transition big data analytics know-how from national security to the agriculture sector.

The CRC is also engaging with SMEs in the health sector as part of the health analytics projects being undertaken in the *Innovation Exchange*. It is envisaged that one of these SMEs may become a commercialisation partner for the health program IP.

The D2D CRC continues to have two very active SMEs in its participant group, namely Semantic Sciences and Genix Ventures. Semantic Sciences continues to participate in the *Multi-source Information Analysis Platform* project, while Genix Ventures and La Trobe University completed the *Topic Mining and Temporal Trend Monitoring* project and are now commencing a new project titled *Cognitive analytics for autonomous predictions in CT policing*.

COMMERCIALISATION

The D2D CRC has undertaken a variety of actions to ensure that there will be effective and appropriate utilisation and/or commercialisation of the CRC's outputs. The specific milestones for FY 2016-17 include:

- appointment of a Commercialisation Manager to develop and execute commercialisation plans for each of the research projects;
- appointment of a new director, Mr Andrew Stead, who has worked extensively with start-up founders and early stage investors, through private and public incubators, accelerators and venture funds;
- engagement of several agencies in trial and evaluation of the Beat the News™, Apostle™ and Integrated Law Enforcement software, to ensure that functionality is aligned to priority capability needs;
- launch of the CRC's first spin off company, Fivecast™, to commercialise the Beat the News™ and Apostle™ technologies. The company aims to build an automatic forecasting capacity for law enforcement and national security agencies;
- licensing two new visualisation methods to Esri Australia, the nation's leading Geographic Information Systems technology and services provider, to further develop it for the Department of Defence;
- completion of a United States mission to develop connections with potential international customers in the US national security community;
- development of the ASKBILL app, which is used to predict the requirements of livestock, in collaboration with Sheep CRC, the Bureau of Meteorology and the University of New England; and
- conducting market research to identify potential technology applications outside the defence and national security sectors.

INTELLECTUAL PROPERTY MANAGEMENT

The D2D CRC has the essential mechanisms in place to ensure adherence to the National Principles of IP Management. Provisions within the Commonwealth and Participants' Agreements provide the key elements for IP management. In addition to the Agreements, the D2D CRC has implemented appropriate policies, procedures and systems, including those for:

- *mandatory IP awareness training;*
- *identification and disclosure of IP;*
- *assessment of existing IP;*
- *protection of IP; and*
- *record keeping via an IP register.*

The D2D CRC has established an IP strategy process and has developed commercialisation plans for all of the research projects. All programs have an established IP strategy and review the strategy on a regular basis. Regular patent scrubs are conducted with the development teams and intellectual property architectures for each of the software products have been created.

In 2017, D2D CRC filed its first patent application which was developed under the *Immersive Intelligence Pod Project*, run by Professor Bruce Thomas from University of South Australia. The project created two new visualisations that can understand the relationship between moving entities. D2D CRC has licensed the technology to Esri Australia to further develop it for the Department of Defence.

Nine new innovation disclosures were recorded during the year and many of these are currently under review by patent attorneys. Several new patents are currently being drafted with the intention to file in the second half of 2017.

Patent filing: *New Australian Provisional Patent Application: A SYSTEM FOR COOPERATIVE VISUAL ANALYSIS OF TEMPORAL GEOSPATIAL DATA Filed 19 April 2017*

COMMUNICATION

The D2D CRC's communication program is intended to:

- increase awareness of the D2D CRC;
- increase awareness of the Australian Government's CRC Programme;
- ensure research outcomes, impacts and company news are communicated beyond D2D CRC's partners through the D2D CRC's eNews, a quarterly electronic newsletter;
- publicise D2D CRC's contribution to developing a sustainable data science workforce;
- promote and support women in STEM;
- build the understanding of the D2D CRC's programs and projects through the Project Booklet, Datacast magazine and animations;
- promote the CRC's achievements via the company website, media releases and social media channels; and
- continuously increase social media following:
 - » Twitter @D2DCRC;
 - » LinkedIn [linkedin.com/company/data-to-decisions-crc/](https://www.linkedin.com/company/data-to-decisions-crc/);
 - » Facebook – [facebook.com/d2dcrc/](https://www.facebook.com/d2dcrc/); and
 - » YouTube – Data to Decisions CRC.

During the reporting period, the D2D CRC:

- made 23 external presentations to end user focused audiences in Adelaide, Canberra, Melbourne, Sydney and Hobart;
- was reported 28 times in the media;
- launched the Big Data Round Tables;
- began sponsorship of R Ladies Adelaide;
- launched a company blog;
- redesigned the company website;
- developed three project animations;
- published 12 articles in scholarly refereed journals and 11 full written conference paper (refereed proceedings); and
- held regular meetings and presentations to participant organisations.



Annual Conference Dinner



R Ladies Adelaide Launch

MEDIA TABLE

PUBLISHED	NAME	PUBLICATION	MEDIUM
06/09/16	Data unlocking hidden potential for businesses	The Advertiser	Online
06/09/16	Big data at the cutting edge	The Advertiser	Print
07/09/16	CRC project showed potential usefulness of analytics: Seeley	Manufacturers Monthly	Online
26/10/16	Data Analytics Advances for SA Health Sector	CRC Association Newsletter	Online
17/11/16	Engineering and Computer Science – Create and Capture	Careers with STEM	Online
24/11/16	Data to Decisions Annual Conference	CRC Association Newsletter	Online
27/11/16	Disrupting terrorism and crime	Science Meets Business	Online
01/02/17	IoT in agriculture	Farm Institute Insights	Online
06/02/17	New laws should give Australian farmers more control over data	Medianet	Online
28/02/17	Lessons learnt from big data use in America could cut costs for Australian Farmers	Medianet	Online
03/03/17	SA Node for Australian Cyber Security Network	Defence Business	Print
14/03/17	New data visualisation tools for the Department of Defence completed	Defence Connect	Online
21/03/17	New Data Visualisation tools for the Department of Defence	CRC Association Newsletter	Online
21/03/17	D2D CRC Board Director becomes Chief Scientific Advisor to the UK Ministry of Defence	CRC Association Newsletter	Online
28/04/17	Research centre appoints new board director	Defence Connect	Online
04/05/17	Cutting through the telco jargon to drive profit through 'big data'	Medianet	Online
04/05/17	Tracking trends from our digital footprints	CRC Know How	Print
04/05/17	The Disruptors – Using Big Data on the farm	CRC Know How	Print
05/05/17	Data to Decisions CRC appoints Andrew Stead as new board director	CRC Association Newsletter	Online
16/05/17	To see your livestock's future, just ASKBILL – new app live from Monday	Sheep CRC website	Online
22/05/17	The power of prediction now in sheep producers' hands – just ASKBILL	Sheep CRC website	Online
23/05/17	ASKBILL phone app gives farmers power to prevent	The Standard	Online
24/05/17	Beat the News with digital footprints	Science Meets Business	Online
30/05/17	The Disruptors – Using Big Data on the farm	Science Meets Business	Online
31/05/17	New app provides predictive sheep management	Farming Ahead	Online
31/05/17	DIBP joins D2D CRC	Government Technology Review	Online
02/06/17	Immigration signs up for data crunching	Public Service News Network	Online
29/06/17	A blueprint for decision-making that delivers profit	Medianet	Online

RESOURCES

THE DEPARTMENT OF IMMIGRATION
AND BORDER PROTECTION JOINED
THE D2D CRC

GOVERNANCE – BOARD, COMMITTEES AND KEY STAFF

The D2D CRC continued to be a tax exempt, not-for-profit body that operated to the fiduciary and governance standards required of an incorporated body under Australian Law.

At the 2016 Annual General Meeting, in accordance with clause 24 of the D2D CRC Constitution, three directors retired from the Board: Ms. Cath Ingram, Mr. Tim Scully and Ms. Fatima Beattie. All three retiring directors nominated for re-election.

Additional nominations of suitable independent and skilled individuals were sought from the CRC's Essential Participants; however, none was received. As a result, all three directors were re-appointed to the D2D CRC Board for a term of two years.

On 18 April 2017, the D2D CRC held a Special General Meeting to replace Professor Hugh Durrant-Whyte who retired from the Board on 31 March 2017. After seeking nominations of suitable independent and skilled individuals to fill this vacancy, Mr. Andrew Stead was appointed for a term of two years.

The D2D CRC Board is supported by one sub-committee and two advisory committees:

- The Audit and Risk Committee (ARC)
– sub-committee
- The Research Advisory Committee (RAC)
– advisory committee
- The Defence and National Security Advisory Committee (DNSAC) – advisory committee

The Commercialisation and IP Advisory Committee, a Board advisory committee active since the start of the D2D CRC, was disbanded by the Board on 31 October 2016 without having met in 2016/2017. Its responsibilities are being undertaken jointly by the Commercialisation Manager, D2D CRC executive and the D2D CRC Board.

BOARD MEMBERSHIP

The following members served on the Board during the year ended 30 June 2016

NAME	ORGANISATION	CRC POSITION/ROLE	KEY SKILLS
Tim Scully	Independent	Director and Chairman	<ul style="list-style-type: none"> - Public Service Administration - Strategy Development and Planning - Management Public Sector - Defence Intelligence Surveillance and Reconnaissance (ISR) - National Security and Intelligence
Fatima Beattie	Independent	Director	<ul style="list-style-type: none"> - Public Service Administration - Corporate Governance - Strategy Development and Planning - Intellectual Property - Management – Public Sector
Cath Ingram	Independent	Director	<ul style="list-style-type: none"> - Finance - Risk, audit, insurance - Public Service Administration - Corporate Governance - Director Public and Private Sector - Management Private Sector - Strategy Development and Planning
Kathryn Adams	Independent	Director	<ul style="list-style-type: none"> - Public Service - Corporate Governance - Strategy Development and Planning - Intellectual Property - Research and Development - Director Public Sector - Management Public Sector - CRC - Research Provider – Industry Interface
Stephen Merchant	Independent	Director	<ul style="list-style-type: none"> - Defence ISR - National Security and Intelligence - Public Service - Management Public Sector
Andrew Stead	Independent	Director	<ul style="list-style-type: none"> - Information Technology - Strategy Development and Planning - Research and Development - Research within University Sector - Research Provider – Industry Interface - Intellectual Property - IP Commercialisation
Sanjay Mazumdar	D2D CRC	Director and D2D CRC CEO	<ul style="list-style-type: none"> - Information Technology - Management – Private Sector - Research Provider – Industry Interface - Defence ISR - Strategy Development and Planning - Research and Development
Hugh Durrant-Whyte (retired)	Independent	Director	<ul style="list-style-type: none"> - Information Technology - Defence ISR - National Security and Intelligence - Strategy Development and Planning - Research and Development - Research within University Sector - Research Provider – Industry Interface

KEY SKILLS OF BOARD MEMBERS

TIM SCULLY

Tim Scully is a senior leader with over 30 years of experience building and leading operational capabilities in government and industry. He has played lead roles in developing operational responses to national and international intelligence and security challenges. Tim's leadership roles include Director, Stoneleigh Consulting; CEO Stratsec and Head of Cyber Security at BAE Systems Australia; inaugural Head of Defence's Cyber Security Operations Centre; Head of the Defence Security Authority; Director General Support to Military Operations; and Assistant Secretary Intelligence Analysis and Production.

FATIMA BEATTIE

Fatima Beattie is currently the Deputy Director General of IP Australia. She joined IP Australia in 2003 as the Commissioner of Patents, in 2007 she was appointed Deputy Director General having responsibility for all the registered intellectual property rights in Australia including the roles of Commissioner of Patents, Registrar of Trade Marks, Designs and Plant Breeder's Rights.

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Fatima Beattie is currently the Deputy Director General of IP Australia. She joined IP Australia in 2003 as the Commissioner of Patents, in 2007 she was appointed Deputy Director General having responsibility for all the registered intellectual property rights in Australia including the roles of Commissioner of Patents, Registrar of Trade Marks, Designs and Plant Breeder's Rights.

CATH INGRAM

Cath Ingram is the KPMG Chairman of Partners for the Canberra Office which is the centre of excellence for government. As the Lead Partner responsible for Federal Government, Cath has over 27 years' experience in the delivery of professional services to the Public Sector. Through these engagements she has a strong appreciation for the Australian Government accountability framework, policy drivers, inter-agency relations and the importance of collaboration.

KATHRYN ADAMS

Kathryn Adams is a microbiologist and lawyer and specialises in intellectual property management, commercial application of R&D and corporate governance. She has had extensive experience in R&D investment from the perspective of a researcher, research institute leader and as an investor. She is currently on the Boards of a number of CRCs as well as Agriculture Victoria Services Pty Ltd and PBIP Ltd.

STEPHEN MERCHANT

Stephen Merchant, currently conducts his own consultancy business, having completed almost 40 years of service with the Australian Government. During the latter part of his career, he held a variety of senior appointments in the Australian Intelligence Community and acted as Secretary of the Department of Defence on numerous occasions. Stephen holds a Bachelor of Arts (Honours) from the University of Sydney.

ANDREW STEAD

Andrew Stead has worked extensively with startup founders and early stage investors, through private and public incubators, accelerators and venture funds. As a founder, advisor and board member, he specialises in the commercialisation of technology products, creation of new businesses, capital raising, and mergers and acquisitions. He is currently responsible for product incubation at insurer IAG, a committee member of early stage investment group Sydney Angels and a director of Hivery. Andrew has a background in technology strategy and operations within the telecommunication industry including the British Army. He holds a BSc(Hons) (USYD) and MBA (MGSM), is a graduate of RMA Sandhurst and a Churchill Fellow.

SANJAY MAZUMDAR

Sanjay Mazumdar is the CEO of the D2D CRC. Sanjay is a proven and experienced senior leader who has worked across the defence, ICT, government and academic sectors. Sanjay has had senior roles in engineering management, general management, business development and project management. His former roles include the CEO of the Defence Systems Innovation Centre, Head of Engineering for BAE Systems Australia, Operations Manager at Motorola Australia and Research Scientist at the DSTO (now DST Group).

HUGH DURRANT-WHYTE (RETIRED)

Hugh Durrant-Whyte is a successful academic, engineer and entrepreneur with a proven track for successfully engaging and achieving research outcomes with industry. From December 2010 to December 2014, he was the CEO of National ICT Australia (NICTA) and while working as an academic, Professor Durrant-Whyte pioneered the field of statistical data fusion, in particular its application in autonomous robotics and in large-scale intelligent systems. Hugh holds a PhD and MSE from the University of Pennsylvania and a Bachelor of Science (Engineering) from the University of London.

BOARD MEETINGS AND ATTENDANCE

The attendance of the Board members at Board meetings is outlined in the table below.

MEETING DATE AND LOCATION	25/8/16 (ADELAIDE)	16/11/16 (CANBERRA)	28/2/17 (SYDNEY)	2/6/17 (MELBOURNE)	TOTAL	ELIGIBLE TO ATTEND
Board Member						
Tim Scully	Yes	Yes	Yes	Yes	4	4
Sanjay Mazumdar	Yes	Yes	Yes	Yes	4	4
Cath Ingram	Yes	Yes	Yes	No	3	4
Fatima Beattie	Yes	Yes	Yes	Yes	4	4
Kathryn Adams	Yes	Yes	Yes	Yes	4	4
Stephen Merchant	Yes	Yes	Yes	Yes	4	4
Andrew Stead	N/A	N/A	N/A	Yes	1	1
Hugh Durrant-Whyte (retired)	Yes	Yes	Yes	N/A	3	3
Total	7	7	7	6	27	28

COMMITTEES

AUDIT AND RISK COMMITTEE

The Audit and Risk Committee is a sub-committee of the Board. It provides assurance and advice to the Board on the D2D CRC's risk, control and compliance framework as well as overseeing the audit process for the D2D CRC financial statements.

MEMBERSHIP

MEMBER	ORGANISATION	ROLE	KEY SKILLS
Cath Ingram	D2D CRC Director	Chairman/Director	<ul style="list-style-type: none"> Finance Risk, Audit and Insurance Public Service Administration Corporate Governance Director Public and Private Sector Management – Private Sector
Kathryn Adams	D2D CRC Director	Director/Member	<ul style="list-style-type: none"> Public Service Corporate Governance Strategy Development and Planning Intellectual Property Research and Development Director Public Sector Management Public Sector CRC Research Provider – Industry Interface
Niall Fay (advisor only)	D2D CRC	D2D CRC advisor to Committee	<ul style="list-style-type: none"> Defence, National Security and Finance

MEETING ATTENDANCE

MEMBER	5/8/16	20/1/17	9/6/17	TOTAL	ELIGIBLE TO ATTEND
Cath Ingram	Yes	Yes	Yes	3	3
Kathryn Adams	Yes	Yes	Yes	3	3
Niall Fay (advisor only)	Yes	Yes	Yes	3	3

RESEARCH ADVISORY COMMITTEE

The Research Advisory Committee provides advice to the Board on the quality, scope, effectiveness and relevance of the D2D CRC research program. The Committee also provides advice and recommendations to the Board on proposed new projects with a specific focus on their alignment with the D2D CRC's Strategic Plan, Capability Roadmap, Technology Roadmap and linkage to the D2D CRC's impacts, outputs and utilisation milestones from the D2D CRC impact tool and Commonwealth Agreement.

MEMBERSHIP

MEMBER	ORGANISATION	ROLE	KEY SKILLS
Dale Lambert (from Oct 2016)	DST Group	Chairman	<ul style="list-style-type: none"> Defence ISR National Security and Intelligence Management and delivery of end user focused research programs
Kathryn Adams	D2D CRC	Board Representative	<ul style="list-style-type: none"> Management and delivery of end user focused research programs Commercialisation and utilisation strategies
Paul Compton	UNSW	Member	<ul style="list-style-type: none"> Data storage and management Management and delivery of end user focused research programs Commercialisation and utilisation strategies
Greg Wood	SAS	Member	<ul style="list-style-type: none"> Data storage and management Commercialisation and utilisation strategies
Brenton Cooper	D2D CRC	D2D CRC Representative	<ul style="list-style-type: none"> Defence ISR National Security and Intelligence Data storage and management Data analytics, decision support and data visualisation Management and delivery of end user focused research programs Commercialisation and utilisation strategies
Anna Harmer	AGD	Member	<ul style="list-style-type: none"> National Security and Intelligence Data analytics, decision support and data visualisation Management and delivery of end user focused research programs
Tony Lindsay (retired)	DST Group	Chairman	<ul style="list-style-type: none"> Defence ISR National Security and Intelligence Management and delivery of end user focused research programs

MEETING ATTENDANCE

No meetings of the RAC occurred in FY 2016/2017.

DEFENCE AND NATIONAL SECURITY ADVISORY COMMITTEE

The Defence and National Security Advisory Committee provides advice to the Board regarding its strategic and business plan's relevance to the National Security Community. In addition, it provides guidance on how to best ensure the transfer of outputs from the D2D CRC into the national security community. Deputy Commissioner Ramzi Jabbour (Australian Federal Police) replaced Deputy Commissioner Michael Phelan as Chairman of the Committee in March 2016.

MEMBERSHIP

MEMBER	ORGANISATION	ROLE	KEY SKILLS
Ramzi Jabbour	Australian Federal Police	Chairman	<ul style="list-style-type: none"> National Security Public Service Management Public Sector
Chris Keane	BAE Systems	Member	<ul style="list-style-type: none"> Defence ISR Transition of capability from industry to end users
John Percival (retired)	DST Group	Member	<ul style="list-style-type: none"> Defence ISR National Security
Scott Tilyard	Tasmania Police	Member	<ul style="list-style-type: none"> National Security
Steve Godinho	Genix Ventures	Member	<ul style="list-style-type: none"> Transition of capability from industry to end users
Dirk Klein	SAS Institute	Member	<ul style="list-style-type: none"> Transition of capability from industry to end users
Stephen Merchant	D2D CRC	Board Representative	<ul style="list-style-type: none"> Defence ISR National Security and Intelligence Public Service Management Public Sector
Dara Williams	Office of National Assessments	Member	<ul style="list-style-type: none"> National Security and Intelligence Public Service Management Public Sector
Brett Greenshields	Department of Foreign Affairs and Trade	Member	<ul style="list-style-type: none"> National Security and Intelligence Public Service Management Public Sector
Jane V	Attorney-General's Department	Member	<ul style="list-style-type: none"> National Security and Intelligence Public Service Management Public Sector
Maria Fernandez	Department of Immigration and Border Protection	Member	<ul style="list-style-type: none"> National Security and Intelligence Public Service Management Public Sector
Sanjay Mazumdar	D2D CRC	D2D CRC and Board Representative	<ul style="list-style-type: none"> Defence ISR Transition of capability from industry to end users
Tim Pattison (March 2017)	DST Group	Member	<ul style="list-style-type: none"> Defence ISR National Security and Intelligence Management and delivery of end user focused research programs

MEMBER	ORGANISATION	ROLE	KEY SKILLS
Sheridan Kearnan (March 2017)	Department of Defence	Member	<ul style="list-style-type: none"> National Security and Intelligence Public Service Management Public Sector
Warren Karle (retired)	Department of Defence	Member	<ul style="list-style-type: none"> National Security and Intelligence Public Service Management Public Sector
Michael Phelan (retired)	Australian Federal Police	Chairman	<ul style="list-style-type: none"> National Security

MEETING ATTENDANCE

MEMBER	13/9/16	24/3/17	TOTAL	ELIGIBLE TO ATTEND
Ramzi Jabbour	Yes	Yes	2	2
Chris Keane	No	Yes	1	2
Scott Tilyard	Yes	Yes	2	2
Steve Godinho	Yes	Yes	2	2
Dirk Klein	Yes	Yes	2	2
Stephen Merchant	Yes	Yes	2	2
Sanjay Mazumdar	Yes	Yes	2	2
Dara Williams	Yes	Yes	2	2
Brett Greenshields	Yes	No	1	2
Jane V	Yes	Yes	2	2
Maria Fernandez	Yes	Yes	1 (1)	2
Tim Pattison	N/A	Yes	1	1
Sheridan Kearnan	N/A	No	(1)	1
Warren Karle (retired)	Yes	N/A	1	1
John Percival (retired)	Yes	N/A	1	1

* note () indicates a delegate attended

KEY STAFF

This table shows key staff as at 30 June 2017

NAME	ORGANISATION	CRC POSITION	TIME COMMITMENT
Sanjay Mazumdar	D2D CRC	Chief Executive Officer	100%
Brenton Cooper	D2D CRC	Chief Technology Officer	100%
Niall Fay	D2D CRC	Chief Operations Officer	100%
Duane Rivett	D2D CRC	Commercialisation Manager	100%
Megan Prideaux	D2D CRC	Education and Training Manager	100%
Voula Dimitrakopoulos	D2D CRC	Marketing and Communication Officer	100%
Prof Markus Stumptner	University of South Australia	Research Program 1 Leader (Data Storage and Management)	54%
Prof Anton van den Hengel	University of Adelaide	Research Program 2 Leader (Analytics and Decision Support)	40%
Prof Louis de Koker	Deakin University	Research Program 3 Leader (Policy and Law)	61%

PARTICIPANTS

Details of the Essential Participants involved in the D2D CRC during the reporting period are provided in this table.

ESSENTIAL PARTICIPANT	ABN	ORGANISATION TYPE
Attorney General's Department	92 661 124 436	Australian Government
Australian Federal Police	17 864 931 143	Australian Government
BAE Systems Australia	29 008 423 005	Industry
Deakin University	56 721 584 203	University
Defence SA	42 912 246 233	State Government
Department of Defence	68 706 814 312	Australian Government
eResearch SA	61 249 878 937	Research
Genix Ventures	84 117 733 696	Industry
Leidos	12 001 071 239	Industry
Pivotal	97 162 413 274	Industry
SAS Institute Australia	13 002 287 247	Industry
Semantic Sciences Research	80 132 254 089	Industry
The University of Adelaide	61 249 878 937	University
University of New South Wales	57 195 873 179	University
University of South Australia	37 191 313 308	University

Details of the Other Participants involved in the D2D CRC during the reporting period are provided in this table.

OTHER PARTICIPANTS	ABN	ORGANISATION TYPE
Australian National University	52 234 063 906	University
Basis Technology	N/A	Industry
Carnegie Mellon University Australia	97 116 769 423	University
Department of Immigration and Border Protection	33 380 054 835	Australian Government
La Trobe University	64 804 735 113	University
Office of National Assessments	87 904 367 991	Australian Government
Palantir Technologies Australia	48 144 948 309	Industry
Teradata Australia	77 125 071 374	Industry
The Boston Consulting Group	70 007 347 131	Industry
Unisys Australia	31 105 642 902	Industry
University of Technology Sydney	77 257 686 961	University

The Department of Immigration and Border Protection joined the CRC during FY 2016-17. The Boston Consulting Group withdrew from the CRC during FY 2016-17.

COLLABORATION

D2D CRC has built strong collaboration in all aspects of its research program, from proposal development through to advisory panel assessment, research development and evaluation of the programs.

The *Integrated Law Enforcement Program* exemplifies the collaboration established by the D2D CRC. The program enables and leverages collaboration between all the participants of the Australian New Zealand Counter Terrorism Committee (which represents all law enforcement agencies involved in counter terrorism – including the Australian Federal Police and all State Police forces), and research and development teams from the D2D CRC, University of South Australia, University of New South Wales, and Deakin University. The team has collaborated extensively and are co-creating solutions to the needs of counter terrorism investigators across the country.

The *Apostle™ Program* has engaged extensively across the end user participants in the D2D CRC with trials currently underway in four national security agencies. The *Apostle™ Program* leverages the outputs from the research and development teams at the D2D CRC, University of Adelaide, University of New South Wales, University of Technology Sydney and the Australian National University. Similarly, the *Beat the News™ Program* has brought together researcher and development from across several universities and undertaken trial activities with several end user participants in the D2D CRC.

In each of the technology programs mentioned above, the collaboration has resulted in innovations that are closely matched to the industry needs. The D2D CRC is considering commercialisation pathways for the outputs.

The *Law and Policy Program* has exemplified collaboration with end users and between research participants. This program involves researchers from La Trobe University, Deakin University and the University of New South Wales who have very effectively collaborated with their end user sponsors including the Australian Criminal Intelligence Commission and the Attorney-General's Department to deliver well received research outputs.

Further collaboration, outside the national security domain, has been achieved through the *Innovation Exchange Program*. The D2D CRC has collaborated with the Sheep CRC on the development of data analytics platforms for monitoring sheep well-being. The establishment of the Big Data Connect Program with the South Australian Government, a data analytics capability improvement program for manufacturing SMEs, has also been a project of further collaboration. The D2D CRC has also engaged with many rural development corporations to identify opportunities for data analytics in agriculture. In addition, D2D CRC has collaborated with SA Health, Queen Elizabeth Hospital and two South Australian universities on the Health Analytics program.

ADDITIONAL REQUIREMENTS

CRC FUTURE PLANS AND TRANSITION ARRANGEMENTS

In the D2D CRC Transition Plan v2.0, June 2016, four possible future states were identified:

1. a CRC, focused on new big data challenges in the national security sector or big data challenges facing other sectors (e.g. health, mining, agriculture etc.);
2. the continuation as a non-CRC funded big data R&D organisation for national security and/or other sectors;
3. the establishment of a spin-off company or companies that will deliver big data analytics products, consulting services or training services across multiple sectors; or
4. winding up the D2D CRC.

The D2D CRC is continuing to explore the first three future states. Specifically, the CRC executive is consulting with national security end users about a new CRC focused on new national security challenges, as well as a directly funded R&D innovation centre. It is expected that the plans on these two strategies will mature over FY 17-18. In parallel, the CRC is already progressing its plans around establishing spin-out companies, with the first of these (Fivecast™) being established to take the *Beat the News*™ and *Apostle*™ IP to market.

PERFORMANCE REVIEW

On 8 December 2015, the Chairman and CEO of the D2D CRC met with the CRC Advisory Committee to undertake a review of its first-year activities. The D2D CRC was commended by the Advisory Committee for its “excellent progress against the achievement of its outcomes” and it was also acknowledged that the D2D CRC has a “strong, effective and independent governance structure; is generating IP of significant commercial value and working with its participants to identify commercialisation opportunities”.

No specific recommendations were made by the CRC Advisory Committee that required D2D CRC actions or responses.

No other performance reviews have been undertaken since this time.

OTHER ACTIVITIES

As described earlier, the D2D CRC has undertaken work in the agriculture, manufacturing and health sectors under the Innovation Exchange program. While additional funding has been obtained to undertake these activities without impacting the original Commonwealth grant, they still align to the Activities specified in the Commonwealth Agreement.

There were no activities undertaken by the CRC outside the activities specified in the Commonwealth Funding Agreement for this financial year.

The CRC is discussing with the Australian Cyber Security Growth Network the establishment of a memorandum of understanding to cover the application of big data analytics to cyber security.

FINANCIAL MANAGEMENT

Financials available on request

APPENDIX

LIST OF PUBLICATIONS TABLE

PROGRAM TITLE	PUBLICATION TITLE	STREAM TITLE	PUBLICATION TYPE	PUBLISHED
Apostle	Probabilistic Knowledge Graph Construction: Compositional and Incremental Approaches	Picturing Knowledge	Conference Publication	Yes
Apostle	A Framework of Online Learning with Imbalanced Streaming Data	Semantic Indexing	Conference Publication	Yes
Apostle	Unlabelled Samples Generated by GAN Improve the Person Re-identification Baseline in vitro	Semantic Indexing	Conference Publication	Yes
Apostle	Visual Question Answering: A Survey of Methods and Datasets	Exploiting contextual cues in large-scale machine learning	Conference Publication	Yes
Apostle	Wider or Deeper: Revisiting the ResNet Model for Visual Recognition	Exploiting contextual cues in large-scale machine learning	Conference Publication	Yes
Integrated Law Enforcement	On Automating Basic Data Curation Tasks	Data Curation Foundry	Conference Publication	Yes
Integrated Law Enforcement	Temporal-Geospatial Cooperative Visual Analysis	Immersive Information Pod	Conference Publication	Yes
Integrated Law Enforcement	Ontology Matching Algorithms for Data Model Alignment in Big Data	Federated Data Platform	Conference Publication	Yes
Integrated Law Enforcement	Capturing Cinematic Shots of Virtual Reality Scenes in Unity	Narrative Visualisation	Book Chapter	Yes
Integrated Law Enforcement	Towards a Linked Information Architecture for Integrated Law Enforcement	Federated Data Platform	Conference Publication	Yes
Integrated Law Enforcement	Temporal-Geospatial Cooperative Visual Analysis	Narrative Visualisation	Conference Publication	Yes
Law and Policy	Making Sense of Big Data for Security	Comparative International Perspectives on Strategy, Policy and Law	Journal Article	Yes
Law and Policy	Algorithmic Prediction in Policing: Assumptions, Evaluation, and Accountability	Comparative International Perspectives on Strategy, Policy and Law	Journal Article	Yes
Law and Policy	The retention and disclosure of location information and location identifiers	Comparative International Perspectives on Strategy, Policy and Law	Journal Article	Yes
Law and Policy	A Linked Democracy Approach to Regulate Public Health Data	Project B0	Journal Article	Yes

PROGRAM TITLE	PUBLICATION TITLE	STREAM TITLE	PUBLICATION TYPE	PUBLISHED
Law and Policy	Regulation of Big Data: Perspectives on Strategy, Policy, Law and Privacy	Project B0	Journal Article	Yes
Apostle	An Adaptive Semi-Supervised Feature Analysis for Video Semantic Recognition	Semantic Indexing	Journal Article	Yes
Apostle	Image Classification by Cross-Media Active Learning with Privileged Information	Semantic Indexing	Journal Article	Yes
Apostle	The Many Shades of Negativity	Semantic Indexing	Journal Article	Yes
Law and Policy	Open Secrets: Balancing Operational Secrecy and Transparency in the Collection and Use of Data for National Security and Law Enforcement Agencies	Comparative International Perspectives on Strategy, Policy and Law	Journal Article	Preliminary Approval
Law and Policy	Tests of proportionality to control access and usage of personal data for national security purposes: A comparative analysis of the UK and Australian law	Comparative International Perspectives on Strategy, Policy and Law	Journal Article	Preliminary Approval
Law and Policy	Big Data For National Security Purposes: Perspectives on Independent Oversight In Australia and The United Kingdom	Comparative International Perspectives on Strategy, Policy and Law	Journal Article	Preliminary Approval
Law and Policy	No Worries: Privacy Activism and Privacy Rights in Australia	Law and Policy – Project B2	Journal Article	Preliminary Approval
Integrated Law Enforcement	ICSOC 2016: Propagation of Event Content Modification in Business Processes	Integrated Policing – Federated Data Platform	Conference Publication	Preliminary Approval

EDUCATION AND TRAINING TABLE

PHD STUDENT	COMMENCEMENT DATE	RESEARCH PROGRAM	PROJECT TITLE	RESEARCH ORGANISATION	COUNTRY	EXPECTED COMPLETION DATE
Adrian Johnston	February 2015	Apostle	Large Scale Geospatial Image Understanding and Visualisation	University of Adelaide	Australia	February 2018
Alasdair Tran	July 2017	Apostle	Active Learning with Multimedia Knowledge Graphs	Australian National University	Australia	July 2020
Alex Mathews	January 2017	Apostle	Automatic sentence re-writing/generation and building visual knowledge graphs	Australian National University	Australia	June 2017
Alexander Long	March 2017	Apostle	Adaptive Querying for Knowledge Graph construction via deep reinforcement Learning	UNSW Australia	Australia	March 2020
Alireza Tabordbar	July 2016	Integrated Law Enforcement	End-user big data analytics – integrating analyst curation tasks into case management	UNSW Australia	Iran	July 2019
Ang Yang	August 2014	Beat the News	An information Quality Model for Big Data	University of South Australia	China	August 2017
Asif Ali (Muhammad)	August 2016	Apostle	Personal Profiling via Interlinked Spatiotemporal Networks--Crime Prevention and Control	UNSW Australia	Pakistan	August 2019
Caitlin Gray	March 2017	Beat the News	Modelling information cascades: creating predictive models on temporal networks	University of Adelaide	Australia	March 2020
Carolyn Riechherzer	December 2016	Integrated Law Enforcement	Briefing Tool for Law Enforcement with Narrative Visualisation	University of South Australia	Germany	December 2019
Christopher Targett	March 2015	Apostle	Utilising context for unsupervised learning of features and their relationships	University of Adelaide	Australia	June 2018
Craig Jones	March 2015	Apostle	Image geolocation: Using Big Data, Deep Learning and Visual Computing for photographic location prediction	University of Adelaide	Australia	March 2019
Daniel Cater	March 2015	Law and Policy	Mass Data Analysis; National and International implications for data with limited protection	UNSW Australia	Australia	March 2018
Dinithi Jayaratne	February 2016	Beat the News	Advanced predictions in social media by incorporating user generated content	La Trobe University	Australia	February 2019
Edwin Tongoi	January 2016	Law and Policy	Mobile financial services: Regulatory responses in Australia, Kenya and South Africa	La Trobe University	Kenya	January 2019

PHD STUDENT	COMMENCEMENT DATE	RESEARCH PROGRAM	PROJECT TITLE	RESEARCH ORGANISATION	COUNTRY	EXPECTED COMPLETION DATE
George Stamatescu	June 2014	Apostle	Modelling intelligent behaviours with stochastic processes	University of Adelaide	Australia	December 2017
Hayden Faulkner	March 2015	Apostle	Scene Interpretation from Video	University of Adelaide	Australia	March 2018
Jeff Ansah	April 2016	Beat the News	Discovery and use of Twitter network structural features for civil unrest prediction	University of South Australia	Ghana	April 2019
John Steven Calvo Martinez	March 2015	Apostle	Distributed stream mining	UNSW Australia	Brazil	March 2018
John Wondoh	February 2014	Integrated Law Enforcement	Bi-temporal event driven process interoperability	University of South Australia	Ghana	November 2017
Linchao Zhu	March 2016	Apostle	Semantic indexing of large scale video	University of Technology Sydney	China	March 2019
Li Sun	June 2017	Integrated Law Enforcement	Linking Entities by Connection Inferences	University of South Australia	China	June 2020
Madhura Jayaratne	January 2016	Beat the News	Scalable big data analytics techniques for the integration of structured and unstructured information	La Trobe University	Australia	January 2019
Manqing Dong	September 2016	Integrated Law Enforcement	Algorithmic Data Curation for Spam Detection	UNSW Australia	China	September 2019
Matthew Heather	February 2016	Affiliate	Ethics of big data and artificial intelligence for law enforcement and national security	Charles Sturt Uni	Australia	February 2019
Max Glonek	March 2016	Beat the News	A census of social media users: statistical techniques for quantifying and correcting biases in big open data sources	University of Adelaide	Australia	March 2019
Miah Hammond-Errey	February 2017	Law and Policy	Improving strategic direction and implementation of big data (technologies and analytics) in Australian national security agencies: A new framework to inform decision makers.	Deakin University	Australia	February 2020
Peter Mathews	January 2015	Beat the News	Trend detection from social media using probabilistic graphical models	University of Adelaide	Australia	April 2018
Pingbo Pan	August 2016	Apostle	Efficient and effective logo detection in large scale images and videos	University of Technology Sydney	China	August 2019
Ruochen Cao	March 2017	Integrated Law Enforcement	A semi-automatic tool for the creation of a Data Video	University of South Australia	China	March 2020
Ruth Frimpong	February 2016	Integrated Law Enforcement	Ontology Matching Algorithms for data model alignment in Big Data	University of South Australia	Ghana	February 2019

PHD STUDENT	COMMENCEMENT DATE	RESEARCH PROGRAM	PROJECT TITLE	RESEARCH ORGANISATION	COUNTRY	EXPECTED COMPLETION DATE
Sandeepa Kannangara	March 2015	Apostle	Opinion polarity classification using unstructured texts	UNSW Australia	Sri Lanka	March 2018
Seung Youb Ssin	February 2015	Integrated Law Enforcement	Assistance of Natural User Interface, Sensor Tracking in real time for Robot teleoperation (or) "Real-time Spatial programming for Robot teleoperation	University of South Australia	Korea	February 2018
Shayan ZamaniRad	February 2016	Integrated Law Enforcement	Query Answering and Predictive Techniques for Analyst Tasks in End-User Big Data Analytics	UNSW Australia	Iran	February 2019
Shifeng Liu	August 2016	Apostle	Fine grained named entity recognition in social networks	UNSW Australia	China	August 2019
Stanley Shanapinda	July 2014	Law and Policy	The dynamic relationship between national security intelligence and law enforcement powers, communication technologies and oversight in Australia	UNSW Australia	Namibia	March 2018
Tharindu Bandaragoda	June 2015	Beat the News	Real-time Cognitive Analysis for Capturing Suspicious Behaviours	La Trobe University	Sri Lanka	June 2018
Umanga Bista	February 2017	Apostle	Learning Knowledge Graph on Massive Data Streams	Australian National University	Nepal	February 2020
Usama Salama	February 2016	Affiliate	End user analytics	UNSW Australia	Australia	February 2019
Xiaodong Ning	September 2016	Integrated Law Enforcement	Algorithmic Data Curation for Offensive Content Detection	UNSW Australia	China	September 2019
Xuanyi Dong	March 2017	Apostle	Logo detection	University of Technology Sydney	China	March 2020
Xuying (Ada) Yao	July 2016	Beat the News	Precursor pattern analysis and interpretable classification	University of South Australia	Australia	July 2019
Yujie Wang	April 2015	Beat the News	New multi-dimensional knowledge base to capture and store patterns in evolving text streams	La Trobe University	Australia	Apr 2018
Yukai (Kevin) Miao	January 2017	Apostle	Open Relation Extraction and Refinement	UNSW Australia	International	January 2020
Yufei Wang	July 2017	Apostle	Improving information extraction using linguistic and knowledge base information	UNSW Australia	China	July 2020

PHD STUDENT	COMMENCEMENT DATE	RESEARCH PROGRAM	PROJECT TITLE	RESEARCH ORGANISATION	COUNTRY	EXPECTED COMPLETION DATE
Yanbin Liu	March 2017	Apostle	Efficient object detection and vision-language joint modelling	University of Technology Sydney	China	March 2020
Zahidul Islam	July 2016	Beat the News	Civil Unrest Events Detection from Multiple Credible Sources	University of South Australia	Bangladesh	July 2019
Zhedong Zheng	January 2017	Apostle	Face detection and recognition	University of Technology Sydney	China	January 2020
Zishou Ding	August 2016	Apostle	Semantic Search with Knowledge Graphs	UNSW Australia	China	August 2019

WITHDRAWALS

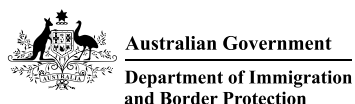
PHD STUDENT	COMMENCEMENT DATE	RESEARCH PROGRAM	PROJECT TITLE	RESEARCH ORGANISATION	COUNTRY	DATE OF WITHDRAWAL
Collins Oppong-Kwakye	November 2016	Integrated Law Enforcement	Identity resolution in text data	University of South Australia	Ghana	April 2017
Hossein Mobasser	February 2016	Integrated Law Enforcement	Uncertainty in Bidirectional Data Model Transformations	University of South Australia	Australia	September 2016
Marianne Rieckmann	February 2016	Integrated Law Enforcement	Ontology of graph-structured meta-data for uniform interoperable data access to distributed heterogeneous data sources ¹	University of South Australia	Australia	March 2017

GLOSSARY OF TERMS

ACIC	Australian Criminal Intelligence Commission
AFP	Australian Federal Police
AGD	Attorney-General's Department
AIC	Australian Intelligence Community
ANZCTC	Australia-New Zealand Counter-Terrorism Committee
API	Application Programming Interface
APS	Australian Public Service
ARC	Audit and Risk Committee
Big Data	A term for any collection of data sets so large and complex that it becomes difficult to store, process and analyse using current technologies. Big Data comes from many sources (e.g. text, image, audio, social media etc.) at an alarming velocity, volume and variety.
Big Data Analytics	The process of examining large data sets containing a variety of data types -- i.e., big data -- to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful business information.
CEO	Chief Executive Officer
COO	Chief Operations Officer
CTO	Chief Technology Officer
CRC	Cooperative Research Centre
D2D CRC	Data to Decisions Cooperative Research Centre
DIBP	Department of Immigration and Border Protection
DNSAC	Defence and National Security Advisory Committee
DPT	Development Planning Tool
DSTG	Defence Science and Technology Group
DSCF	Data Science Competency Framework
FY	Financial Year
IoT	Internet of Things
IMS	Investigation Management System
IP	Intellectual Property
ISR	Intelligence surveillance and reconnaissance
KB	Knowledge Base
Machine Learning	A subfield of computer science that evolved from the study of pattern recognition and computational learning theory in artificial intelligence. Machine learning explores the construction and study of algorithms that can learn from and make predictions on data.
NICTA	National ICT Australia is Australia's Information Communications Technology Research Centre of Excellence
PMB	Pacific Marine Batteries Defense Pty Ltd
R&D	Research and Development

RAC	Research Advisory Committee
RDCs	Research Development Corporations
SEAPA	A South Australian manufacturer of oyster equipment
SMEs	Small to Medium Enterprises
STEM	Science Technology Engineering and Mathematics
UniSA	University of South Australia
UNSW	University of New South Wales
VQA	Visual Question Answering

GOVERNMENT

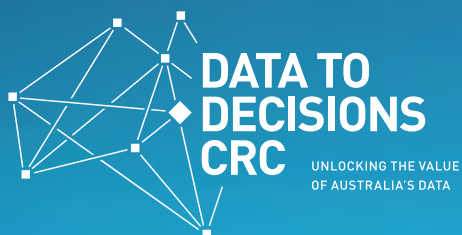


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