

Highlights from 2020

SMART
INFRASTRUCTURE
FACILITY

smart
infrastructure facility



UNIVERSITY
OF WOLLONGONG
AUSTRALIA

smart

A message from our leaders



It was a year of disruption that has seen rise in technical innovation exemplified at SMART by IoT projects, such as: SMART's award winning research that identified the economic and social impacts of COVID-19; Research to aid women's safety on public transport with world-first artificial intelligence identifying violence; and SWIRL – assessing the economic impacts of better connecting the Illawarra to Greater Sydney and the Western Sydney Aerotropolis.

Despite all the disruptions and uncertainty, our researchers' commitment to helping governments and businesses better plan for the future is unwavering and it is this passion that drives SMART. Guided by our values and strategic plan, we continue to deliver projects that ensure our research culture is focused on excellence and over the past 12 months we had success across a range of grants, commissioned research projects, award nominations and 29 peer reviewed publications.

SMART was proud to sponsor the Women in IOT Award at the IoT Alliance Australia Industry Awards, demonstrating our commitment to boosting and celebrating the number of women who specialise in the tech industry's fastest-growing sector. It is universally understood that diversity greatly improves outcomes, because by bringing together a diverse workforce, you bring more creativity to the fore, which is incredibly important in addressing the problems our cities and regions are facing in the coming years.

SMART's Director was nominated by IOT Alliance Australia to become a member of Standard Australia's technical committee IT-268. The committee will be charged with creating standards for sustainable cities and communities and contribute to its international counterpart entity, TC-268, set up by the International Organization for Standardization (ISO). SMART Director was also invited to chair the Technical Advisory Committee of the NCRIS-funded Australian Urban Research Infrastructure Network (AURIN).

SMART's COO played a key role in presenting SMART's views and contributions to the Illawarra-Shoalhaven City Deal submission. SMART COO also coordinated SMART's contribution to the Gateway Cities report and seminar series, alongside colleagues from the University of Newcastle, Deakin University, Geelong, Newcastle and Wollongong City Councils.

As we say goodbye to an extra-ordinary year, we thank our industry partners and affiliated research partners for their ongoing commitment to delivering IoT projects that will shape a better future. And finally, our dedicated team who continue to steer and support SMART into the future.

**Director, Senior Professor
Pascal Perez**

**Chief Operating Officer
Ms Tania Brown**

WHO ARE WE...

One of the largest research institutions in the world dedicated to helping governments and businesses better plan for the future, SMART brings together experts from fields such as rail, infrastructure systems, transport, water, energy, economics and modelling and simulation, providing 30 state-of-the-art laboratories to facilitate this important research.

Smart's award winning research identifies the economic and social impacts of COVID-19



Senior Research Fellow Dr Rohan Wickramasuriya analysed data to understand pedestrian movement during COVID-19 lockdown

CITIES ARE USING PEDESTRIAN COUNTING DATA TO PLAN THEIR ROAD TO RECOVERY

A new award-winning study finds some cities had a decline of up to 60 percent foot traffic since the COVID-19 restrictions began in March.

Researchers from the University of Wollongong's SMART Infrastructure Facility partnered with Meshed IoT to examine the impact of the global pandemic on local economies and community vitality, across 24 Australian cities and regions, with the project recently winning the Social Good Award at the IoT Alliance Australia Industry Awards.

The COVID-19 Pedestrian Index Research was based on real time data collected from nearly 100 locations, sourced from counting devices that recognise mobile Wi-Fi signals. Researchers used baseline data from a pre-COVID time to compare how pedestrian activity had changed after mandatory social distancing and quarantining policies were imposed across the country.

The study found a 36 percent drop in the median value of pedestrian activity after the initial lockdowns occurred, with some locations experiencing as much as a 60 percent decline.

SMART Infrastructure Facility Director, Senior Professor Pascal Perez, said using technology to gather data helps make cities smarter.

"Pedestrian activity is the pulse of a city, so when that is

taken away, you start to experience a downturn in both the economy and social health of an area," he said.

"Pedestrian data can also underpin investment decisions, which contribute to vibrant and safe places, creating community vitality."

Senior Professor Pascal Perez hopes businesses can use the research to plan for their recovery back to full operation.

"The research showed a significant drop of 50 percent in pedestrian traffic on peak days, normally Thursdays, and a 44 per cent decline on Sundays, which is the lowest traffic count day of the week," he said.

"Businesses can use this information to plan their return to operating to full capacity, perhaps using the data sets to map out business hours and staff numbers for particular days."

The data also showed a 17 percent drop in average dwell times during the crisis, with people unable to socialise in public spaces or make unnecessary trips.

"This pattern coincides with significant job losses in the food, entertainment, retail and services sectors, which heavily rely on passing trade for business," Meshed IoT Co-Founder and Director Catherine Caruana-McManus said.

"With this data, the local authority can automatically see the areas that are most affected by the crisis in order to assist in recovery and targeted stimulus."

This project was also Highly Commended in the Impact Award category, at the Smart Cities Council Awards.

SWIRL – ASSESSING THE ECONOMIC IMPACTS OF BETTER CONNECTING THE ILLAWARRA TO GREATER SYDNEY AND THE WESTERN SYDNEY AEROTROPOLIS

Urgent call for new rail line as commuter traffic soars

A new report recommends calls for urgent action to address the doubling of commuter traffic and a massive increase of freight movements between the Illawarra and Sydney by 2041.

The report, undertaken by the University of Wollongong's SMART Infrastructure Facility, and commissioned by the Illawarra Business Chamber and consortium partners Wollongong City Council and Wollondilly Shire Council, calls for a new rail link between the Illawarra and St Marys in Western Sydney.

It is the most ambitious of three options canvassed as the South West Illawarra Rail Link (SWIRL) linking the Illawarra, Wollondilly and Western Sydney.

The \$3.2billion dual freight and passenger line would be a 48-kilometre extension of the partially built Maldon-Dombarton line, and would connect the region with Western Sydney Airport at Badgerys Creek, and a planned Western Sydney Freight Terminal at St Marys.

Project leader Senior Professor Pascal Perez said work on the first stage of the line was urgently needed before the existing rail link between Illawarra and Sydney, the South Coast Line, reaches capacity in 2036.

He said the benefits of building a second dual-purpose, electrified rail link linking the Illawarra, Wollondilly and Sydney were too significant to be ignored.

"There is an urgent need for work to start now on this link in order to increase local employment in the region, reduce commuting times and increase regional freight capacity to unlock the potential of Port Kembla," he said.

"We calculate that these improved rail and road connections would contribute to the creation of 17,500 extra jobs in our regions by 2041."

The report notes that the planned container terminal at Port Kembla would generate an extra 1.6 million road trip per year, and 9300 train paths by 2041.

This would be in addition to a near doubling of daily commuter trip from 26,000 to 46,000.

"We are calling for the immediate start of planning for the first stage, from Maldon near Dapto to Dombarton near Picton, including a train station at Wilton and connection to the main rail line," he said.

"Considering the population growth and increasing freight demand, we recommend that planning and design work start immediately so the line is operational by 2036, when the South Coast Line is predicted to reach capacity."

The 2020 report builds on a study completed in 2017, which estimated that SWIRL would cost \$1.6 billion compared to the \$2 billion for an intense upgrade to the South Coast line.

It was the first report to recommend a dual freight and passenger line along the corridor.



SAFETY AFTER DARK FOR WOMEN ON PUBLIC TRANSPORT

Researchers from the SMART Infrastructure Facility at the University of Wollongong, have developed software that will allow existing closed circuit television cameras to automatically identify and report suspicious or violent incidents.

The project was one of four winners of Transport for NSW's Safety After Dark challenge.

"Research into women's safety revealed that girls and women do not always feel safe participating in our city at night," the brief stated.

"While many factors contribute to this, transportation was identified as an area where improvement could be made."

A team led by Dr Johan Barthelemy will develop artificial intelligence (AI) software that will automatically analyse real-time camera feeds and alert an operator when it detects a suspicious incident or an unsafe environment.

"The AI will be trained to detect incidents such as people fighting, a group of agitated persons, people following someone else, and arguments or other abnormal behaviour," Dr Barthelemy said.

"It can also identify an unsafe environment, such as where there is a lack of lighting.

"The system will then alert a human operator who can quickly react if there is an issue."

The data and reports automatically generated by the software can then be used to help prevent the abuse and violence committed towards women after dark in public transportation.

Helping him on the project is PhD student Yan Qian, who is looking at using computer vision across multiple cameras to understand traffic and pedestrian flow.

"We are using open source code that tries to estimate the poses of a human being and predict if there's a fight," she said.

"The incident will then be reviewed by a human controller who will accept or reject the suggestion made by the artificial intelligence.

"In this way, the program will become smarter, learning in a similar way to a human being.

"As far as we know, nothing like this has been attempted globally. We are pushing the limits of the technology."

A third solution, designed following COVID, will monitor social distancing at the corner of South Street and Memorial Drive. The data collected will assist with understanding behaviour changes in response to the provision of visual public domain (on-ground) guidance for social distancing.

Smart sensors to secure Antarctica's future

Sensors developed by SMART researchers will collect data from the harsh climate of Antarctica to measure the impact of climate change and bio-diversity.

The University of Wollongong has secured a slice of \$36 million in Federal Government funding to take part in a program called Securing Antarctica's Environmental Future (SAEF).

The program will deliver world-leading research that will forecast environmental change across the Antarctic, deploy effective environmental stewardship strategies, and secure Antarctica as a natural reserve devoted to peace and science.

Dr Johan Barthelemy said he was thrilled to be a part of the project that will offer significant technical challenges.

He said his team would develop multiple embedded sensors capable of transmitting data using long-range technologies.

They would also develop a new terrestrial smart remote sensing platform, able to run for an extended period of time.

"Our sensors and sensing platform will have to work in the Antarctic environment," he said.

"We will have to learn about how to make sensor life longer, we need to understand the challenges of power supply and installation."

He said current data from the ground relied on the presence of researchers, which meant that none had been gathered during the long winter.



"Even at the best of times, the researchers are only there for two or three months a year during the summer," Dr Barthelemy said.

"The rest of the time there is no-one to deploy, so we don't know what is going on."

THE LIMITS ON RESEARCH WERE INCREASED DURING THE COVID-19 PANDEMIC, WHEN NO AUSTRALIAN RESEARCHER WAS ALLOWED ON THE CONTINENT.

The project is expected to last more than five years, and will require the development of a laboratory at SMART that can simulate the Antarctic environment to test equipment before deployment.

"The sensors will need to be able to withstand the cold but also last as long as possible – we need it to work for months," he said.

"So we will be looking at the same type of battery that you would use in space."

The sensors will measure the effects of climate change, collecting data about temperature and humidity of both soil and air.

But they will also record the growth and health of mosses, because they are a good indicator of climate change.

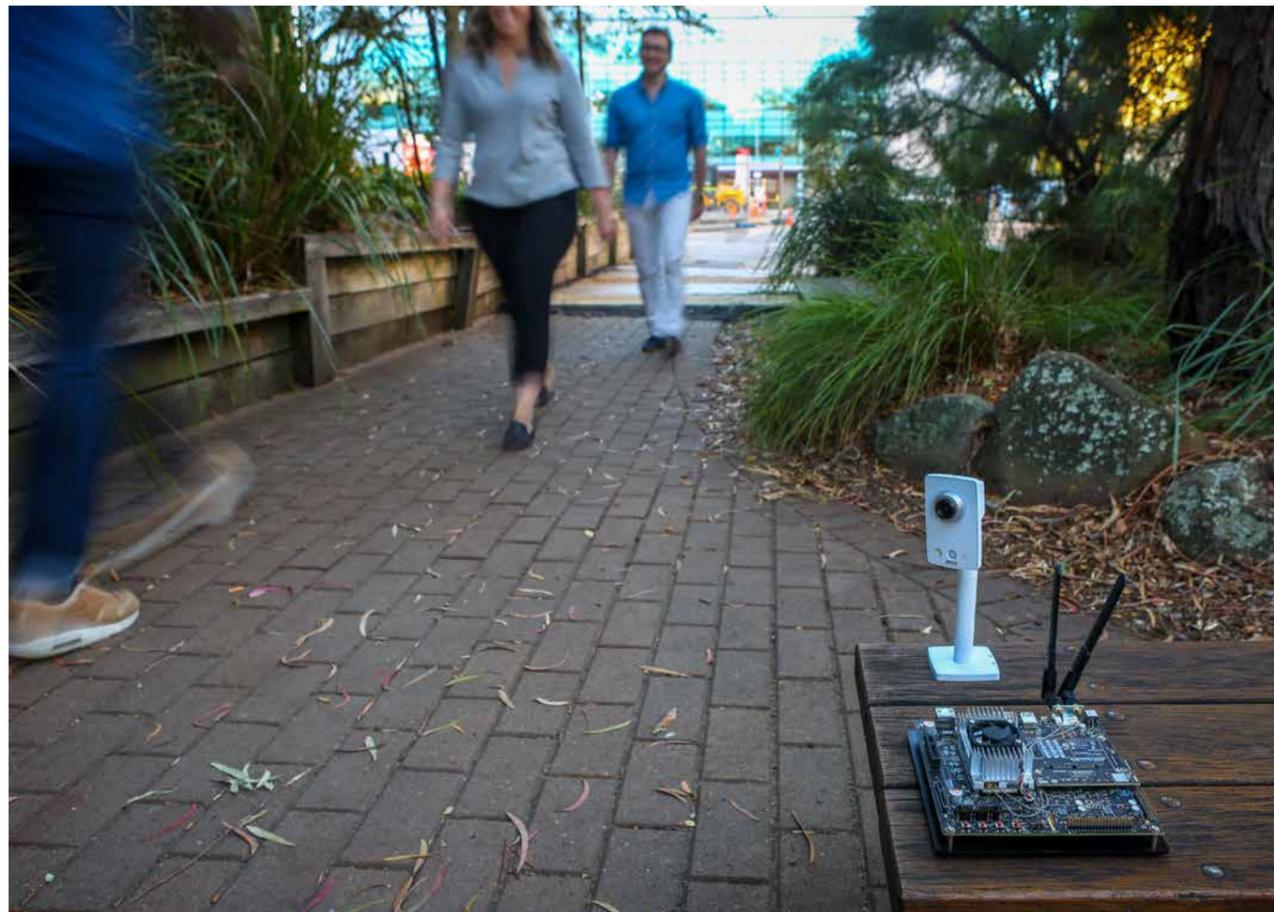
"When the moss becomes stressed because there is not enough water or too much heat it turns red,"

Dr Barthelemy said.

SAEF is led by Monash University and brings together researchers from UOW, the Queensland University of Technology, University of New South Wales, James Cook University, University of Adelaide, the Western Australian Museum, and the South Australian Museum.

It will also involve peak industry bodies and Antarctic programs from five nations.

Education Minister Dan Tehan announced the project in April and work is expected to start at SMART towards the end of this year, or start of 2021.



GRANVILLE SMART PRECINCT

More liveable and more productive – one city at a time

The latest SMART Cities Project will use solar-powered smart poles to enable sensors to be placed almost anywhere.

The Granville Smart Precinct Pilot project is expected to start collecting data by the end of the year, and builds on a portfolio of similar projects.

Lead researcher Dr Johan Barthelemy said the project would focus on three separate outcomes.

“The city wants to know how long it takes you to travel through the city,” he said.

“So we are using techniques similar to the work we have already completed in Liverpool.

“We are deploying smart cameras to detect cars and their anonymized licence plate. Once it is spotted exiting the CBD we can look at how long they spent in the CBD.

“At no point do we transmit video or licence plates – it’s all privacy compliant.

Another use case will utilise cameras to detect pedestrian mobility patterns across the open space located in front of the Granville Swimming Pool’s main entrance. Apart from pedestrian counts and trajectories, the system

will help with assessing social distancing as part of Cumberland City Council’s strategy against COVID-19.

SMART is partnering with Valen Energy to embed the sensors in solar-powered poles, so they can be placed at almost any location, without any significant trenching or permanent foundations

The project is the latest in a series undertaken by the SMART Infrastructure Facility on behalf of local government authorities in NSW.

All are customized according to the client’s needs.

“There is no formal definition in what a smart city is,” Dr Barthelemy said.

“The main idea is to use technology and data to solve an issue first identified by a community. It is about using existing data or collecting data to solve an existing problem. “That can be about making the city more liveable or more productive.”

SMART has also worked with Liverpool City Council to deliver an understanding of the nature of the public spaces in Liverpool that are used and enjoyed the most.

In the South Australian city of Holdfast Bay, the council wanted to know the interaction between pedestrians and cyclists on a new coastal path. Along with project partner Datacom, the sensors also capture the speed of cyclists on the path in a solution that is privacy compliant solution.

How twitter helps and hinders bushfire recovery



Work has started on a project to study how social media is affecting the recovery of South Coast communities following recent bushfires.

Led by SMART researcher Dr Robert Ogie, the project *#RecoverSouthCoast: Understanding Social Media Use in Bushfire Recovery* has already collected more than 200,000 Tweets for analysis.

The Global Challenges project employs researchers with expertise in data analytics and machine learning, psychology and mental health, primary health care, social science and linguistics.

“There is so much research looking at social media and how it is used to respond to bushfires as they impact communities,” Dr Ogie said.

“But there is not nearly so much work on how it is used for recovery.”

The first task is to collect relevant Tweets that were posted over 12 months following the 2019-2020 bushfires on the South Coast, from the Shoalhaven to the Victorian border.

The second task is to sift out the ‘noise’ – Tweets that contain irrelevant or trivial content – before the analysis can begin.

The team is using a number of methods to ensure that the data is relevant.

Since only about 1 per cent of Tweets are geo-located, they will be looking for hashtags using South Coast locations such as #Cobargo, #Shoalhaven or #Bega.

In addition, they will conduct keyword analysis for the relevant content so that – for example – if tourism and bushfires are used together in single Tweet, that data will be captured.

Once collated, researchers will look at the sentiment of the data as well as looking for six emotions – anger, disgust, fear, surprise, happiness and sadness.

“We want to see how those change and fluctuate over time,” Dr Ogie said.

“One of the really interesting things is to see how social media can actually complicate recovery.

“To this end, we are developing an algorithm that might detect messages which tend to be troubling for people.

“In the future, we would like to develop ways of responding to these Tweets in real time.”

The origins of the Tweets will be sorted into four different categories – government agencies (such as the NSW Rural Fire Brigade), NGOs (such as the Salvation Army or the Red Cross), citizens and politicians.

“We will see which of these categories contribute positively or negatively to the recovery process,” Dr Ogie said.

“We are aiming to go to the next phase of the research which will create a real time system to detect and respond to troubling messages.”

He said social media platforms were used in the recovery processes by keeping communities connected, helping them share experiences, and helping to access information and resources for rebuilding communities.

“This includes mobilising donations of goods and money, encouraging tourism, expressing feelings, seeking assistance, and showing empathy or solidarity for those requiring emotional support,” he said.

“That is why it is important to understand how bushfire-affected communities engage with social media content and how this engagement supports community recovery.”

The first stage of the project will run for 12 months with team members: social scientist Dr Joshua Whittaker; linguist Dr Alison Moore; SMART researcher Dr Mehrdad Amirghasemi; primary nursing care specialist Dr Sharon James; and psychologist Professor Mitch Byrne.

UGPN Coalition for greener and cleaner cities



Researchers from the University of Wollongong and University of Surrey have secured funding from the University Global Partnerships Network (UGPN) to develop research on urban green screens and walls in order to assess their effective use against air pollution.

The research team will include experts in smart cities, an atmospheric chemist, an ecologist, and specialists in air quality and health.

UOW's SMART Infrastructure Facility Director and one of the project leaders, Senior Professor Pascal Perez, says the funding is just the beginning of a long-term partnership that he hopes will include researchers from institutions spanning the globe.

"Whether it's designing green walls, screens or bus stops with native plants and climbers, we need to get smart about the way we think of our cities," Professor Perez said.

"Street canyons are the most polluted city environments, due to high traffic volumes and limited ventilation.

"Green infrastructure has many benefits, including combatting air pollution and making our cities more livable and cooler."

The partnership aims to support decision-makers but developing a new framework for street-scale greening that can have widespread use that fights pollution, that is evidence-based and that is practical.

SMART will work with Liverpool City Council to measure

air quality and traffic flows around its CBD to facilitate better planning.

Researchers at SMART have designed both sensors and the relevant software to analyse air quality, and intend to use this experience to measure the effectiveness of so-called 'green screens'.

These are essentially walls of vegetation – whether in pots or using climbers – that can be quickly placed around cities in ways that are simply impossible for permanent tree cover.

"We are trying to solve the air pollution but we are also ticking other boxes," Professor Perez said.

"These green screens are essentially a separation wall or bus stop and you hope it will attract and keep the particulates from traffic pollution.

"We want to research how effective they are, and especially in an Australian context."

One of the team members, Dr Clare Murphy, was able to collaborate with academics from around the globe earlier this year, to measure the 'biogenics' or gases and particles emitted by vegetation at Cataract Scout Camp, near Wollongong.

Her aim is to discover which native species will be the most efficient at trapping particulate matter from traffic pollution, and which may actually make the situation worse.

There is a reasonable amount of data concerning trees that are endemic in North America and Europe, but very little Australian data.

Another team member is Dr Kris French from UOW's Centre for Sustainable Environmental Solutions, and is regarded a leader in the area of ecology in Australia.

She believes that it's important for birds and insect life to plant Australian, and preferably, endemic species in urban settings.

This is borne out by the SMART project in Liverpool, where the expansion of the south-western Sydney fringe is building over a threatened ecosystem.

This, believes Dr French, can be offset if you use these disappearing plants for the city's streetscapes, parks and other public open spaces.

Also leading the project is Dr Hugh Forehead (pictured), a researcher at SMART, who says the benefits of using Australian native species for street plantation is already becoming apparent.

"Urban heat islands are formed because a bitumen and concrete surface absorbs heat better than trees, and therefore cities become hot in summer," he said.

"Dr French has done studies to show that the native trees with their open canopies can lead to better air circulation than exotic trees with closed canopies.

"Many exotic species can actually trap some of the heat close the ground whereas the more open eucalypts allow air circulation."

The project – Street-scale Greening for Cooling and Clean Air in Cities – just announced, will support a PhD student from the University of Surrey to study at the University of Wollongong.

Mamatha Tomson's work aims to support decision-makers to develop a new framework for street-scale greening that is generic, inclusive of pollution-cooling trade-offs, evidence-based, and practicable.

"We will use experimental and modelling approaches, undertake trial demonstrations, and integrate results to create a collaborative platform," Dr Forehead said.

The University Global Partnerships Network (UGPN) aims to develop sustainable world-class research, education and knowledge transfer through an active international network of selected universities collaborating in research, learning and teaching to benefit global society.

The program will develop a range of jointly enabled innovative solutions to world problems based on shared research expertise and a mobility strategy for increasing the number of faculty, staff and students with international experience.

The UGPN annual conference will be held in Wollongong in 2021.



SMART WATERWAYS PROJECT

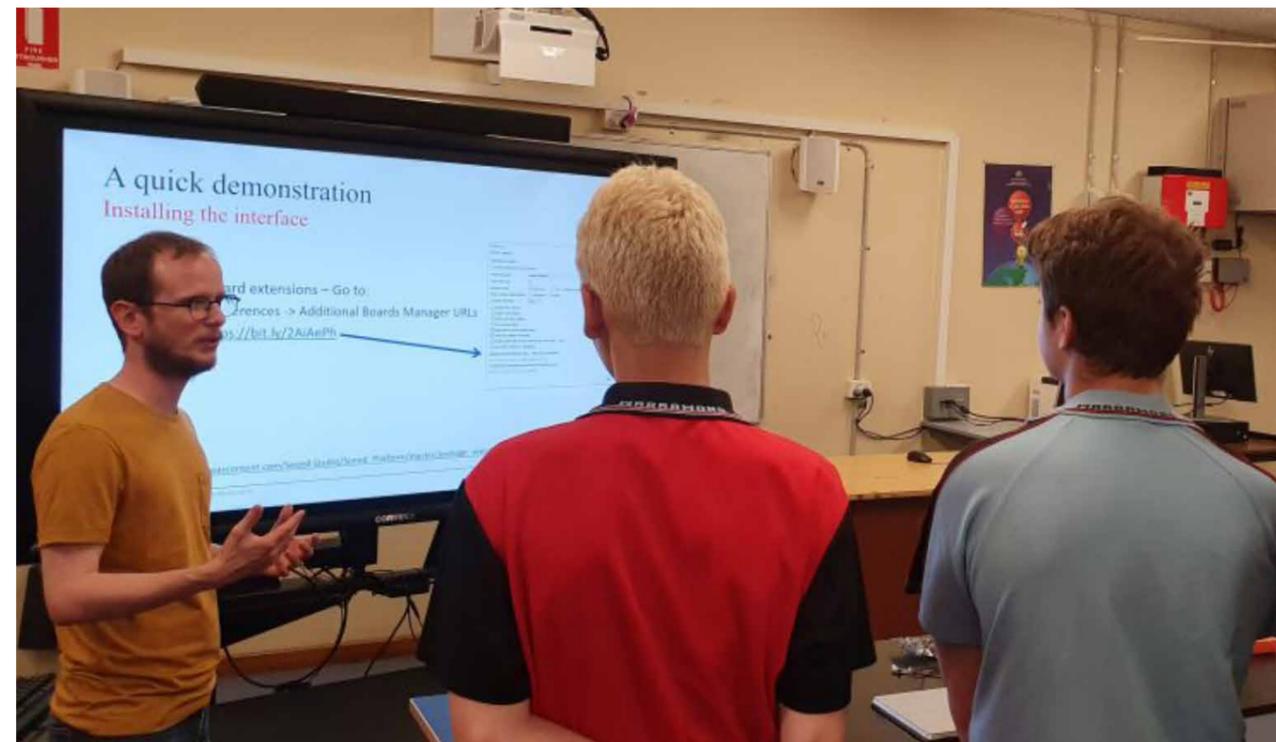
Over the past 50 years the Illawarra Shoalhaven had more than 30 serious floods and three extreme floods, resulting in a fatality.

Floods have devastating consequences and affect the economy, environment and local people. To help combat the issue the Federal Government awarded \$478,449 to the region for the Smart Waterways project.

Illawarra councils, under the banner of the Illawarra Shoalhaven Joint Organisation, partnered with the SMART Infrastructure Facility and Lendlease Calderwood

Valley Communities, to use smart technologies to better understand the region's waterways and reduce the impact of severe weather events.

Smarter Schools for a Smarter Planet is one component of the project and is aimed at enabling regional high school students studying science, technology, engineering and mathematics, to gain skills in the construction and use of smart technologies to monitor water issues relevant to their school environment.



“For our students it can be difficult to get excited about what is taught in the classroom if they don’t understand how it is relevant and applies in the real world.”

SMARTER SCHOOLS FOR A SMARTER PLANET

Students studying STEM (science, technology, engineering and mathematics) were provided with a real-life, hands-on chance to apply smart technology.

As part of the Smarter Schools for a Smarter Planet project, SMART Infrastructure Facility collaborated with more than ten high schools throughout the region, to introduce how smart technology can help manage the risk that flash flooding provides to residents and help users to understand water quality, how our rivers interact with our beaches and oceans, and how to manage our stormwater more effectively.

SMART researchers Dr Johan Barthelemy (pictured), Bilal Arshad and IOT Engineer Nethra Nandagudi Venugopal visited Warrawong High School to teach the students to build sensors.

“It is a chance for students to ‘break away from the norm’ and embrace authentic learning... learning by doing,” Warrawong High School Science Teacher Marc Gunner said.

“For our students it can be difficult to get excited about what is taught in the classroom if they don’t understand how it is relevant and applies in the real world.

This project is a great opportunity for our students to use smart technology and understand how it can help us improve how we look after our environment. It provides an opportunity to solve real-life issues.”

The next generation of scientists also spent a day at the SMART Infrastructure Facility to learn the power of the Internet of Things, for gathering data and providing information about the region’s waterways.

“We hope they will learn how to use sensor technology – with the hardware supplied by SMART – to monitor water or air quality from an environmental point of view,” Dr Barthelemy said.

“They will then share what they discover with other schools and with the community.”

Dr Barthelemy said he wanted to share the message that STEM does not have to be complicated or hard, and that the Internet of Things can be used by everyone.

The Smart Waterways project is a collaboration between Wollongong City Council, Shellharbour City Council, Kiama Municipal Council, Shoalhaven City Council, Lendlease Calderwood Valley Communities and SMART Infrastructure Facility, University of Wollongong.

The Smart Waterways Project was a finalist in The Future of Place Award at the Smart Cities Council Awards.



Universities from **around the globe** have announced a collaboration to reduce plastic waste in the environment



Dr Bo Du is the team leader of the ADAPT project

The funding from the University Global Partnerships Network (UGPN) will enable researchers from the University of Wollongong to join colleagues from the University of Surrey and the University of Sao Paulo. The project is called 'Rethinking Plastics Pollution post-Pandemic: no virus, no waste?'

They will work with the Governing Plastics Network and discuss further opportunities for research and education.

The team consists of researchers from many disciplines: law, chemistry, engineering, and business. The network is also gender and career level diverse, including PhD students, ECR and senior professors.

Dr Marcella Bernardo Papini (pictured), an expert in plastic waste from the SMART Infrastructure Facility, said people were finally starting to understand the damage that plastic waste is causing our planet.

"We need to develop tools to help turn that understanding into local action in communities

worldwide. There will have to be a range of strategies to ensure that plastics do not continue to degrade the environment, hurting wildlife and polluting the oceans," she said.

"The COVID-19 pandemic has had an impact on the generation of plastic waste. Due to many factors and measures such as lockdown, the consumption of single-use plastic products in society and healthcare has risen tremendously.

"The project is all about understanding how plastic waste has impacted the environment and our health prior and post COVID-19, and how a sustainable plastic waste management can be achieved post COVID-19."

The core of the collaboration project is two joint studies, strengthened by various collaborative activities, such as workshops, short-course, podcast series, and forum, which will create knowledge for educating and shaping the field of plastic waste in the post-COVID-19 context.

The University of Wollongong will host a two-day conference next year – virtual if necessary – and a short course to provide postgraduate students with knowledge of selective waste collection systems that have been adopted worldwide.

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The program will develop a range of jointly enabled innovative solutions to world problems based on shared research expertise and a mobility strategy for increasing the number of faculty, staff and students with international experience.

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CONTACT US

uow.edu.au/smart

(02) 4221 5031

smart-facility@uow.edu.au

smart
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