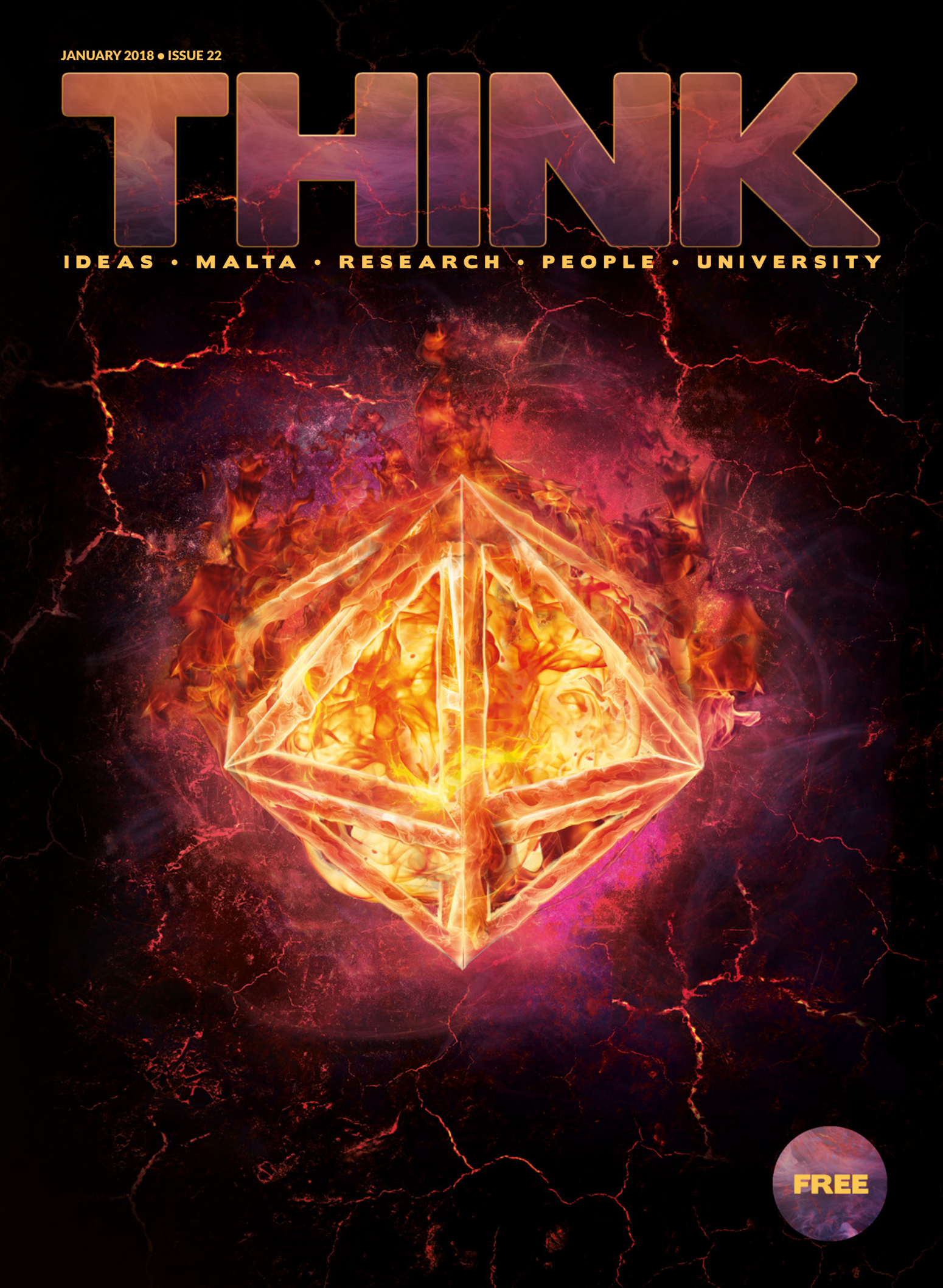
JANUARY 2018 • ISSUE 22

THINK

IDEAS • MALTA • RESEARCH • PEOPLE • UNIVERSITY



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EDITORIAL

FIRE

Humans discovered their ability to control fire over a million years ago. Since then fire has been central to human progress; from extracting metals and minerals from their ores, to forging tools and weapons, to energy generation and enabling the internal combustion engine. Our focus pays homage to this stupendous discovery with an inferno of research.

A common theme shining throughout this edition is harnessing the power of the sun. Prof. Ing Luciano Mulè Stagno transformed a derelict building in Marsaxlokk into the cutting-edge Solar Research Lab at the heart of the Institute for Sustainable Energy (University of Malta, [UM]; pg. 4 & 20). Their main aim is to advance solar energy panel technologies and enhance their efficiency.

Another team on campus has gone one step further. Instead of trying to capture the sun's energy, they are working to ignite a miniature sun right here on Earth. Dr Ing. Nicholas Sammut and his colleagues are part of the International Thermonuclear Experimental Reactor (ITER), trying to harness nuclear fusion and create a reactor that could power whole countries with practically no pollution (pg. 28).

The journey towards sustainability comes with challenges. The legal issues involved in writing legislation that addresses climate change are vast (pg. 32). Encouraging renewable energy encounters another major problem—how does one store excess energy on a sunny or windy day? The FLASC project has devised a clever way to do so (pg. 48).

As well as fire, the issue covers health research on dementia (pg. 62), ALS (a life-threatening neuromuscular disorder; pg. 44), and how patients can co-produce knowledge with researchers through dynamic consent (pg. 13). Artists are also helping patients cope with their ailments in different ways (pg. 64), while students are building a Maltese Thesaurus (pg. 15), and understanding the universe (pg. 14)—this research is truly on fire.

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Are you a student, staff, or researcher at the University of Malta? Would you like to contribute to **THINK** magazine? If interested, please get in touch to discuss your article on **think@um.edu.mt** or call **+356 2340 3451**

COVER STORY

FIRE

Issue 22's cover is on fire. Literally. Designed by illustrator Roberta Scerri, she used a variety of textures and warm tones to bring this last edition within **THINK**'s elements theme to life.

FIRE FOCUS

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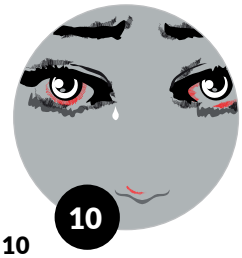

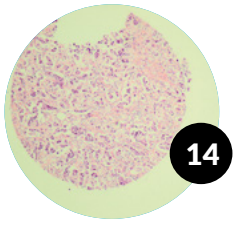

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THINK is a quarterly research magazine published by the Marketing, Communications & Alumni Office at the University of Malta
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JANUARY 2018 - ISSUE 22

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RIDT

TOOLKIT

In search of perfect silicon

Silicon is the go-to material for solar devices like photovoltaic panels despite its relatively low energy conversion rate of 15-22%. Researchers all over the world are analysing materials and creating new ones to find a better solution. A lucky handful are armed with a laser scattering tomograph (LST), the best instrument for the task.

An LST illuminates the sample material with an infrared laser beam, which scatters wherever it finds a defect. If there is a defect in a material's structure, even one just a few nanometers wide, the very sensitive CCD camera at the other end of the machine will pick it up, allowing researchers to learn and adapt. It also boasts a robotic system that allows it to automatically load multiple samples at once.

This enables the UM to conduct cutting-edge research in a field that is practically nascent, putting it at the forefront.

The LST is very rare, but fortunately, one has found a home at the University of Malta's (UM) Institute for Sustainable Energy (ISE), a brand new, state-of-the-art facility aimed towards finding efficient solutions for harnessing solar power to its fullest extent. 'There are probably 10 to 12 of these worldwide,' confirms Prof. Luciano Mule' Stagno, Director of the Lab at the ISE. 'Ours is one of the few in the world to be found in a university, almost certainly the only one in a university in Europe. Most of these machines are in industry settings,' he says.

This enables the UM to conduct cutting-edge research in a field that is practically nascent, putting it at the forefront. With the LST, material engineers could unlock the secrets behind the perfect variation of defect-reduced silicon. This rise in efficiency could have a substantial impact on the worldwide sustainable energy market.

Photos by James Moffett

Above: Laser scattering tomograph (LST)
On left page: Weather station.

WITHOUT BORDERS

Go&Learn+ Network

Closing the skills gap

At a time when new discoveries and developments are daily occurrences, the worlds of academia and business should be best buddies. For businesses looking to stay on top, it makes sense to tap into fresh insights from tomorrow's professionals. For students, what better way is there to prepare for their future than to shape their ideas with first-hand knowledge in their preferred areas of employment?

The process of bringing those worlds together continues to pose challenges. Start-ups and small businesses, the backbone of the Maltese economy, do not have the HR departments and resources necessary to organise such exchanges. The gap between these companies and students is difficult to overcome. However, steps are being taken to change the situation.

Go&Learn+ is providing a bridge between education and industry through an online platform that catalogues training seminars and company visits for students and educators in a multitude of sectors. The initiative has garnered a slew of supporters. 17 agencies in Europe and beyond are listed on the site, opening their doors to others. Among those are the Maltese companies, Thought3D, ZAAR, and The Galley, to name but a few.

Locally, the Malta University Holding Company and the Malta Business Bureau, the teams behind Go&Learn+, have worked together to create two new circuits involving groups of seminars, visits and programmes. One is dedicated to ICT for business, leisure and commodity, seeing students visit and learn from the people at Altaro, Scope Solutions, MightyBox, Trilith Entertainment, and Flat Number. The second circuit is related to food, involving companies such as Elty Food, Benna, Fifth Flavour, Da Vinci Pasticceria, and Contribute Water. Students reported that the visits were insightful, helping them to gain a better understanding of the sector and its nuances. In the case of the food circuit, it even proved popular with students from Italy who organised a trip to Malta to visit the companies involved.

The reality is that learning cannot be separated from work. The lack of communication between these endeavours has unfortunately contributed to a skills gap that threatens economic growth and employment. Programmes like Go&Learn+ are working towards remedying that situation. Continued support is essential.

Go&Learn+ is a project co-funded by the Erasmus+ Programme of the European Union. For further information on the project, visit www.goandlearn.eu or kindly contact Alexia Pace Kiomall on alexia.pacekiomall@muhc.com.mt and Marija Elena Borg on mborg@mbb.org.mt

DESIGN

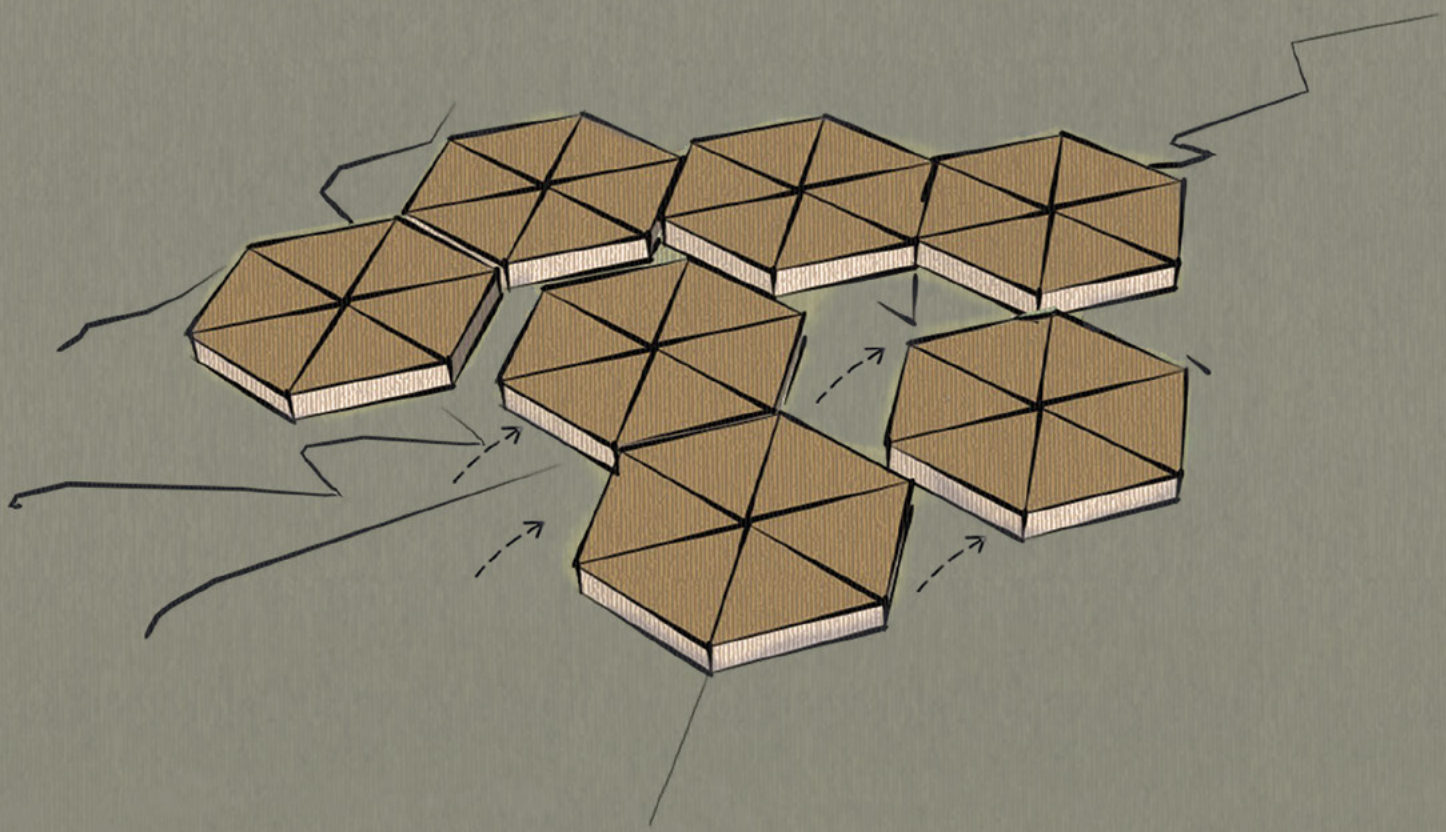
The floating lantern

In Japan, candle-lit lanterns are released into rivers in *Toro nagashi* to guide the spirits of ancestors back to the other world. The lanterns exude beautiful, orange light as they float downstream. At times they group together, creating what look like small, glowing platforms. This very image was what inspired the floating platform Dr Rebecca Dalli Gonzi is building, together with her colleagues Dr Joseph Falzon, Prof. Tonio Sant, and NAS Limited. The project is being consulted with Prof. Claire DeMarco and ALTERN Limited.

By bringing together the sea, the arts, architecture, and engineering, they are giving rise to a lightweight platform that sits on the water's surface, providing a unique space for artistic performances, installations, and exhibitions. The lanterns' rectangular shapes are being replaced with hexagons—a more efficient fit. Holding everything together are mounts or magnetic currents, depending on research results. The modular approach allows adjustability in shape and size, potentially seeing the platform expand beyond its current three meters, while making it easy to disassemble, respecting the environment it inhabits.

The team hopes that the platform, or lantern as it is affectionately referred to, will provide artists and practitioners with a new approach to their art that will bring joy, while also inspiring creative thinking in the construction industry.

Concept Sketch
FLOATING PLATFORM



CONCEPT SKETCH
Platforms moving into formation before connection
Area: 3.96sqm each platform

Domestic violence is no longer a private matter

Prof. Andrew Azzopardi

Domestic violence is a social issue scarring our communities. It is also on the rise. According to the *CrimeMalta Annual Crime Review for 2016*, there were 'only' 450 reports in 2008 compared to the 1272 instances in 2016, marking a jump of 183%.

Paradoxically, increasing reports of domestic violence are a good sign. They clearly indicate that people are more aware of domestic violence, that they recognise it, and find it unacceptable. Another positive is that the media is highlighting these cases. Domestic violence against women also has a lasting impact on children. Once exposed to intimate partner violence, the ramifications ripple through their lives both in the short term and when they become adults (Sammut Scerri, 2015).

According to the European Union Agency for Fundamental Rights, one in three European women experience physical and/or sexual violence by a partner. In Malta 15% of women over the age of 15 have experienced physical and/or sexual violence at the hands of a partner. Looking at the National Prevalence Study conducted in 2011 by the Commission for Domestic Violence, 26.5% of women have experienced one or more acts of violence by a partner, which include, physical, emotional, or sexual violence. Probably one of the most worrying facts, according to the same study, is that 54% of women who have experienced violence did not seek assistance. Domestic violence significantly impacts female survivors who are low income, unemployed, or inactive.

Malta has to act, and the Faculty for Social Wellbeing (University of Malta) has already recommended a number of action points. First on the list is a one-stop-shop with a multidisciplinary response team, specially trained to address the situation holistically. This team involves police working with legal, social work, health, and psychological support. We also suggested a well–resourced National Action Plan, in-line with the Istanbul Convention, that is comprehensive and evidence-based. This would work hand in hand with a national programme on relationship education, targeting different age groups and genders, addressing gender stereotypes and issues around power and control. We also believe that court sentencing needs to be significantly harsher to reflect the seriousness of the crimes. Similarly, protection orders and treatment orders need to lead to significant punishments if broken. Finally, we must also work to alleviate the financial burden of domestic violence victims. Social assistance cheques have to be issued promptly, social housing must be made available, and child support contributions cannot be interrupted.

Domestic violence is no longer a private matter, but a community responsibility. For the good of everyone, it is an issue that needs to be addressed by academia, civil society, and the state in a coherent and well thought-out manner.

Further reading:
Sammut Scerri, C., Living with contradictions of love and violence: A grounded theory study of women's understanding of their childhood experiences of domestic violence, Doctoral dissertation, University of Surrey, 2015.
http://crimemalta.com/documents/CrimeMalta_Annual_Report_SF_2016.pdf

The circular economy and Malta

Dr Jonathan Spiteri

Our globalised economy has generated wealth and prosperity for millions of people around the world. Living standards have been raised to unprecedented levels. But this comes at a cost. The environment has suffered greatly, not only in terms of constant extraction of natural resources, but also at the hands of polluting processes and end-of-pipe waste.

Recognising that economies, and indeed our planet, have finite resources, the circular economy has become a popular concept among policymakers and stakeholders in recent years. The current linear 'take, make, use, and throw away' model of production entails substantial value losses and negative effects along the material chain. Because of this, we should ideally be designing and manufacturing products for continuous reuse and recycling, maximising resource efficiency, and minimising leakages and waste.

The appeal of the circular economy lies in its various environmental and economic benefits. Using secondhand materials and waste within business could cut costs, while their sale adds a potential revenue stream. The circular economy also offers new and vast business opportunities in areas such as product eco-design and product/material regeneration, all of which help create high-skilled jobs and investment in new technology.

The idea of the circular economy is particularly relevant to Malta, given its geographical circumstances, high import dependency, and lack of natural resources. Embracing the principles embodied within the circular economy concept would have an immediate positive impact on the environment while benefitting Malta's long-term economic prospects. However, we are still at the doorstep of circularity. Malta's natural resource productivity fell by 7.6% between 2000 and 2015, with increased domestic material consumption outpacing economic growth. Waste management in key sectors like construction remains a major issue.

To encourage the shift from concept to the creation of circular economy business models, the University of Malta is part of the R2Pi Horizon 2020 project. Among other goals, it hopes to identify both market and policy failures that hinder the uptake of such models by business entities across Europe.

R2Pi Horizon 2020: www.r2piproject.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730378.

Hailing a new era for ocean literacy

Prof. Alan Deidun

The Maltese Islands, despite their miniscule terrestrial extent, have always managed to punch way above their weight when it comes to aquatic matters. Hosting the International Ocean Institute, the Islands also have a pivotal role in the formulation of the Law of the Sea through the Maltese representative to the United Nations, Arvid Pardo. The 'father of the law of the sea', as he is affectionately known, delivered a prophetic speech to the UN General Assembly on November 1st, 1967. He described the sea as 'the common heritage of mankind', a phrase which still resonates to this very day, and which is enshrined within Article 136 of the United Nations Convention on the Law of the Sea.

Europe's seas are currently being assessed more than ever for their potential, as Blue Growth (the long term strategy to support sustainable growth in the marine and maritime sectors as a whole) gains greater traction throughout the continent. We are plumbing our seas to greater depths in the search for elusive minerals, cures, genetic resources, energy sources, and a plethora of other untapped assets. In the race to unlock more of the ocean's secrets, ocean literacy assumes a compelling role—to revise the paradigm of human impacts on our ocean so far. In fact, in the history of human exploitation of the ocean, we first exerted deleterious impacts on the ocean environment, only to become aware of those impacts and resort to ocean literacy to generate further awareness, control, and change.

The challenge now is to anticipate developments. A precautionary approach is needed to soften impacts when venturing into unchartered grounds. Some might label this utopic, I prefer to call it 'foresight.' For us to reach this stage, governments and institutions must invest heavily in ocean literacy to ensure more responsible use and treatment of that 70% of our planet. It is imperative for potential investors to have a grounding in ocean literacy principles, with the aim of paralleling the considerable success being had introducing ocean literacy concepts within school curricula and initiatives across Europe. We are gearing up towards the International Decade of Ocean Science for Sustainable Development. Proposed by UNESCO last June at the Ocean Conference in New York, it will span from 2021 until 2030. The considerable number of abstracts submitted for the European Marine Scientists Educators Association (EMSEA) Malta conference, now approaching the 70 mark, is testimony to the profile that EMSEA has managed to achieve since its establishment a decade ago. It also confirms the status that ocean literacy now holds across the European continent and beyond. Let's keep the momentum going!

He described the sea as 'the common heritage of mankind'

Read more here:
http://www.emsea.eu/

Shifting power dynamics in genomic research

Dr Gillian M. Martin

Donation of human tissues has been at the core of medical research in Europe since religious restraints were relaxed towards the end of the Middle Ages, making this altruistic act socially and morally acceptable. Altruism is the key word—the individual donates their tissues for the greater good: for the advancement of science, the extension of boundaries of medical knowledge, and for the potential to deliver better medical care. The individual donating their tissues or blood does so with no expectation of return or personal gain, and hands over sample ownership to the scientific community in confidence that ethical use will be made of it.

Many would assume this is still the case… but is it? Genomic research has opened up new and exciting avenues for medical research that have the potential to dramatically transform the way medical practitioners strategically select treatment regimes. Personalised medicine is no longer a pipe dream, it is clearly in the cards—the pack has been dealt, and the game is well underway.

The game-changer here is the genome. The established practice of donors passively handing over their samples of blood or tissues for research is impacted by the fact that DNA is in focus here. Their DNA.

Should this make any difference? Some argue that the fundamental process of donating for the greater good, with no consequent active involvement, is still the cornerstone of the process. There are, however, important shifts in the current social and cultural context that impact the researcher-donor dynamic. Two of these are of particular relevance here. The first is knowledge: the accessibility (via the web) of information about the research process, its impacts and applications, have led to the burgeoning new field of citizen engagement in research. Genomic research, in particular, attracts participants who are personally motivated in the process, with research into genetically linked diseases offering hope for their relatives and future generations. The second shift is that of rights over personal data. Individuals' rights to the control of their personal data are to be entrenched in the General Data Protection Regulation in May 2018. This EU regulation will sanction a process that is already clear in practice: the trend for individuals to demand control over the ways their personal data are used and stored.

This is where the detached and passive sample 'donor' exits stage left, and the research participant takes the limelight. Cynics might claim that nothing much has changed. Samples are collected with consent and research continues, but there is an exciting difference in the dynamics involved. The participant now has the potential to remain engaged by using a process of web-based consent. The various versions of this eConsent or 'dynamic consent' that are now available offer the participant and researcher a real-time channel of communication which enables optimum use and reuse of the sample and the accompanying personal data that make it so valuable. The biomedical samples now come with persons digitally attached: individuals who actively engage in the research process by offering flexible consent via web-based tools. When pooled and stored within biobanks, these samples offer a viable source of DNA with real potential for wide use in research.

Within this scenario, ethicality is enhanced as banked anonymised samples can be used to their full potential and shared, with consent, within the research community. In this way doing justice to the individual participant's key motivation: to advance scientific knowledge for the benefit of future generations.

STUDENTS

Borderline

Maria Victoria Vella, Josephine Vella, and Karen Muscat

At the European Organization for Nuclear Research (CERN), an army of researchers from around the world are studying the very structure of our universe, starting from the very basic constituents of matter: the fundamental particles.

CERN has some of the largest laboratories in the world, boasting cutting-edge purpose-built instruments like particle accelerators and detectors. It therefore comes as no surprise that, when lecturers from the G. F. Abela Junior College's Physics Department announced they were organising a visit, all the positions available were quickly snapped up.

There was a recurring theme present throughout our CERN experience: 'borders'. During our stay, we crossed the Franco-Swiss border several times from our lodgings in France to CERN in Switzerland. Coming from a small island state, where any inter-country travel requires a plane or boat ticket, it was a little surreal being able to put our passports away and walk to Switzerland.

The visit helped us reflect on the boundaries we create when trying to study how nature works. We compartmentalise topics into physics, chemistry, or biology, when really these topics are all one large subject seen from different viewpoints. This was most evident in the permanent exhibitions at CERN that touched on topics including atomic structure, PET scans, and the development of computer technology at CERN. There were no borders between the different subjects we studied in different departments back at Junior College.

During this amazing week, we experienced tours of the facility using CERN's own transport. Many of the researchers use bicycles, taking advantage of all the green areas. We saw dedicated individuals working together for the good of the world, no matter their colour or creed. They overcame yet another border: a cultural one. Their mission is simply to produce outstanding work that will help us understand the universe around us.

The trip opened our eyes in many ways. As a group, we learnt together and supported one another when needed. We shared ideas. Discussed. We were our own mini-unit. With an understanding of this dynamic and all the fields involved, some of us have even been inspired to add a new goal to our list: join the team at CERN.

This visit was made possible thanks to our sponsors: Liquigas Malta Ltd, Mizzi Motors, and Buzzer Stationers & Publishers. We wish to thank our lecturers for organising the experience, namely Ms. M. Soler, Ms. A. Vella, Mr. C. Busuttil, Ms. L. Bonello, and Ms. E. Bugeja.

Compiling the first Maltese-to-Maltese Thematic Thesaurus

Dwayne Ellul

Think of a chubby guy you know. It's been awhile since I read J.K. Rowling's books but the image of Harry Potter's Uncle, Vernon Dursley, just popped into my mind. OK. Now how would you describe him in Maltese? Would you use *imbaċċaċ* or *qawwi*? Would you choose *kbir*, *tqil*, *goff* or *matnazz*? Or maybe you're given to more flowery language and would instead go for *qisu l-vara l-kbira*, *donnu katuba* or *qisu ħanżir imsemmen*? If these nine expressions all happen to have a place in your vocabulary, then you're on the right track. Before I started my research, I didn't know there were at least 37 alternatives you could consider before reverting to the default *oħxon!*

The main aim of my work over the last three years—*Il-Kompilazzjoni ta' teżawru tematiku Malti dwar in-natura tal-bniedem u r-relazzjonijiet soċjali tiegħu*, supervised by Prof. Manwel Mifsud—has been to compile a Maltese-to-Maltese thematic thesaurus. This would not only help users find alternatives to the words and phrases they already know, but also to act as a 'word prompter' that would enable people to better express themselves when a specific word eludes them.

To help people speak or write better in Maltese, this thesaurus is not structured alphabetically, but rather has a thematic macrostructure. The six themes it covers are: *1. Il-familja u l-ħbieb* (family and friends); *2. Il-ġisem u l-kura tiegħu* (the body and its care); *3. Id-deskrizzjoni fiżika* (physical description); *4. Id-deskrizzjoni tal-karattru* (character description); *5. Is-sentimenti u l-emozzjonijiet* (sentiments and emotions); and *6. Il-fażijiet tal-ħajja* (life's phases). Each theme is further organised into sub-themes, allowing users to drill down to the headword they need, a sentence that illustrates its use, and a group of synonyms, tagged whenever necessary to indicate archaic words or idioms among other examples.

Even if the advantages of using a thematic thesaurus outweigh those of using an alphabetically organised one, I kept renowned lexicographer Sidney I. Landau's position in mind: 'Alphabet is the only sure way of arranging words.' Consequently, I gave the user a back entry to this thematic thesaurus through an exhaustive alphabetic index that includes around 12,000 entries.

The thesaurus will be published by Merlin Publishers, and we also want to make it available online to encourage widespread use.

This research was carried out as part of M.A. in Maltese, Faculty of Arts, University of Malta.

Researchers' panel

Young Scientist Awards

Earlier this year the Malta Council for Science and Technology organised the Malta Young Scientists Awards to bring island's brightest to the fore. The winners went on a visit to the Joint Research Centre in Ispra Italy, to share their projects and findings. Here is what they are working on.

1 Sephora Sammut

Our study was the first of its kind. It focused on sediment behaviour and transport in Maltese pocket beaches, which were analysed using wave modelling in different areas and times. The published paper shows how wave exposure, geological background, and coastal configuration contribute to the behaviour of beach sediment, and hence the shaping of our coast. The study has highlighted the importance of coastal landforms, and contributed to awareness regarding beach management and erosion threats. Now, more investigations need to be made to fully understand the ramifications of changes to our coastline and how to protect beaches through policy.

2 James Ciarlo

Projections of future climates typically make vast assumptions in order to simplify the task of climate models when simulating the complex atmosphere. Organic chemicals, for example, go through several changes throughout their lifetime; they interact with incoming solar radiation and influence weather and climate in many ways. As a result of their complicated nature, they are often eliminated from these models. My work focused on the development of a chemistry module for a state-of-the-art Regional Climate Model. It addressed the issue of over-simplification by introducing these chemical processes into the model, as well as the physical properties that cause these particles to affect our climate.

3 Vanessa Petroni Magri

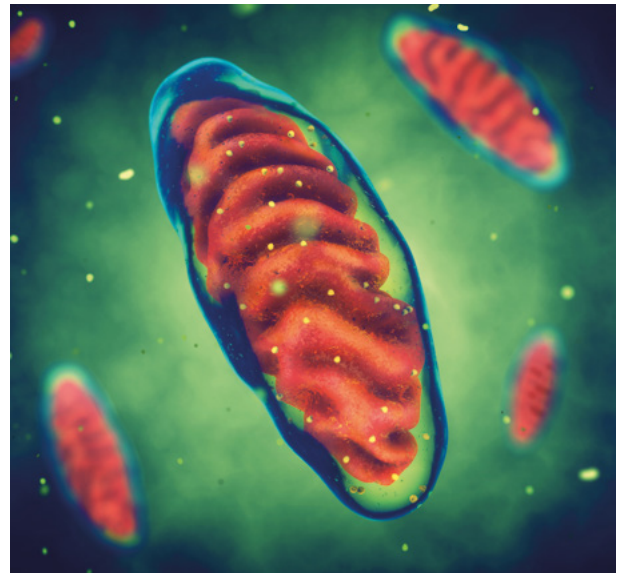
Our research aimed to discover novel therapeutic approaches of drug combinations which would be effective in breast cancer cells and potentially safer than individual therapy. We found that combining separate treatments at lower concentrations achieved the same response as using those individual treatments at their original higher concentrations. This is a positive step, as lower doses cause fewer side effects than current therapies. Cells from different types of breast cancer also underwent profiling in order to identify which genetic responses are influenced by our treatment. Results from this work can also be used to genetically identify the breast cancer cell types that respond best to our treatment, bringing therapies closer towards patient-centred individualised treatment.

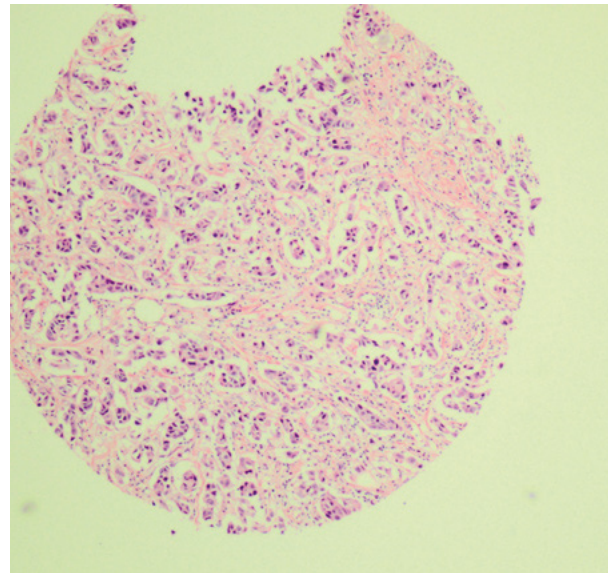
4 Joanna Vella

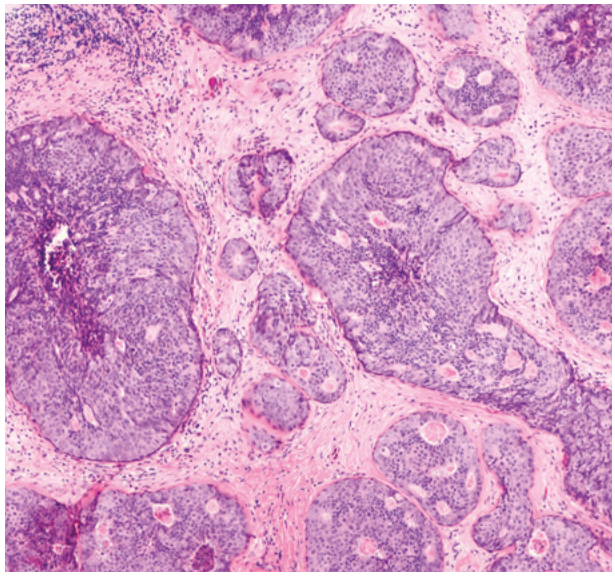
One of the Malta BioBank's rare disease projects is focused on understanding the genetic causes of mitochondrial disorders and sudden cardiac deaths (SCD) in young adults. A total of 50 whole exomes (protein coding genes) were sequenced from patients with genetically undiagnosed mitochondrial disorders from the Malta BioBank (BBMRI.mt) and Hacettepe University, Turkey as part of a EuroBioBank, RD-Connect and BBMRI-LPC collaborative project. A retrospective study shows that 42% of all sudden deaths in Malta under the age of 40 were related to the cardiovascular system. Joanna will analyse a panel of mitochondrial and nuclear genes implicated in SCD to unravel the genetic causes.

5 Shawn Baldacchino

Our research explores the potential application of a cutting-edge technology to test and identify different types of breast cancer using newly developed biomarkers. Biomarkers are measurable indicators that can identify particular cancer types, and are needed to develop personalised treatment plans for patients. So far, we have effectively identified biomarkers which select a novel type of breast cancer that is potentially treatable with a new targeted therapy. Identification of new specific biomarkers is particularly important for currently difficult to treat cancer types, such as the triple-negative strain of breast cancer.







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FIRE

Fire lies at the heart of the human journey. It kept us alive in the colds of winter. It changed our diets and enabled our brains to develop. It played a crucial role in our ingenuity and technological advancements.

From the forging of basic tools, to nuclear fusion; our species would not be in its current position without fire. Below is a cross-section of the University of Malta's researchers' contributions linked to this powerful element.

HARNESSING THE POWER OF THE SUN

Malta is not a resource rich country, but in the shift towards renewable energies, our sunshine is now coveted for more than just tanning. ***Hans-Joachim Sonntag*** *talks to* ***Prof. Luciano Mulè Stagno*** *about his experience in improving solar panel materials and building a research facility from scratch.*

Prof. Luciano Mulè Stagno

Visiting the University of Malta's (UM) new Solar Research Lab in Marsaxlokk, it is hard to believe that just a few years ago the site was in a dire state of disrepair. '[It] was overgrown with grass, and the walls were falling apart,' says Prof. Luciano Mulè Stagno, director of the lab at the Institute for Sustainable Energy (ISE). Now it is an oasis of calm, with newly-planted olive trees, fully restored buildings, and, fittingly, a solar tracking system—with plans to make the site completely carbon neutral.

Due to its climate, the conditions for solar power generation in Malta are among the best across European countries. By the end of 2020, photovoltaic installations are expected to double and reach 180 megawatts: roughly the same as the Electrogas plant across the bay from the solar lab. While this potential was always clear, Malta was not conducting a lot of research that aimed to harness solar power to its fullest extent. Now, things have changed, and we can start looking up and aiming higher.

BUILDING A RESEARCH FACILITY

The ISE has been around for a while. It was set up in the late 1980s when the government signed an agreement for a project with an Austrian research institute. But when the project ended, the ISE was left behind with no resources and little manpower. Three decades later renewable energy research began garnering worldwide attention; this caused then UM Rector Juanito Camilleri to breathe new life into the Institute. 'It was in a forgotten state,' Mulè Stagno recalls, 'existing staff were running research with no budget. When I started, I had absolutely nothing, not even a solar panel to perform a measurement.'

The first step for Mulè Stagno was to pursue funding. He applied for money through the European Regional Development Fund (ERDF) in 2012, but his project did not win approval. Nevertheless, he remained persistent, tried again, and eventually in 2014 won a large grant to the tune of €4.2 million. The UM also invested in the project, giving the ISE a total budget of almost €5 million to spend on site refurbishment and cutting edge equipment. The catch? The nature of the funding required the project to be completed in 18 months, otherwise the money would be lost.

A mad rush to set everything up followed. The task of building the Solar Research Lab took over the vast majority of Mulè Stagno's life for nearly two years. While the site in Marsaxlokk was undergoing reconstruction, the team were working in a trailer when visiting, and a whole warehouse in Qormi was steadily filling up with all the required equipment.

Due to its climate, the conditions for solar power generation in Malta are among the best across European countries

Photos by James Moffett

Top: Solar lab at ISE during pre-construction phase (left), and after construction was complete (right)
Bottom: Solar lab at ISE during pre-construction phase (left), and after construction was complete (right)

In the end the process was smoother than expected, and over 40 pieces of state of the art equipment made it to Marsaxlokk. Among them was a laser scattering tomograph, able to detect the tiniest defects in materials being tested at the lab. Explained simply, it works by shining light on the sample, section by section, and measuring the response. If there is a defect in a material's structure, even one just a few nanometers wide, the machine's infrared camera will pick it up. Approximately ten of these devices are used worldwide, and the UM now boasts one of them (pg. 4).

Once the lab was outfitted, academic Dr Maurizio Fenech and engineers Ryan Bugeja and Jessica Attard were hired, together with lab officer Mark Anthony Callus. With staff and equipment in place, research could now begin.

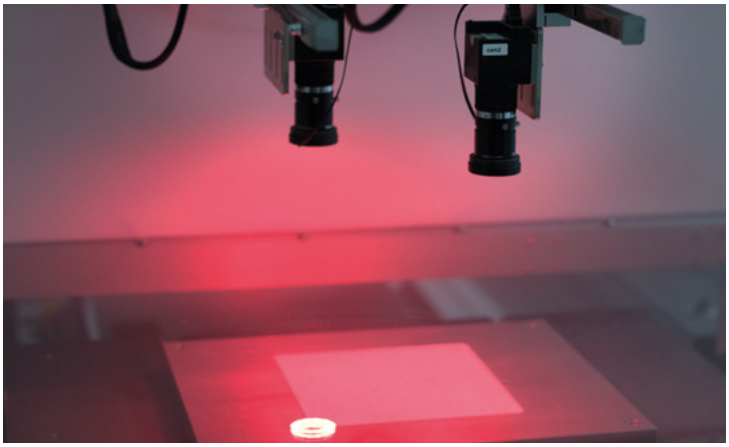
But what does the Solar Research Lab hope to achieve?

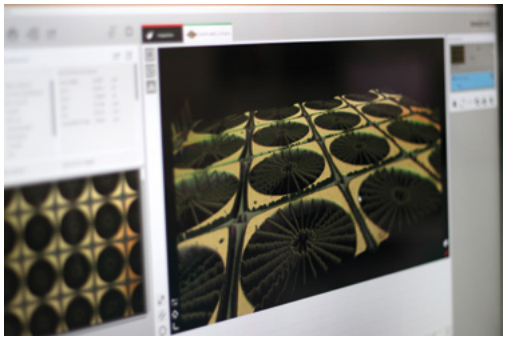
A VISION OF CHEAP, EFFICIENT SOLAR PANELS

The basic principle of the photovoltaics (which convert light into electricity) that form the basis of solar cells is the photoelectric effect: when light falls onto a surface, it can transfer its energy to negatively charged particles called electrons, which use this energy to move inside the object. In solar cells, the electrons instead stay inside a semiconducting material such as silicon, where separating the electrical charges creates electrical energy.

However, not all the energy coming from sunlight is converted into electricity: an outcome dictated by the properties of the material. Mulè Stagno's career has revolved around silicon, and this metalloid element is still a strong contender in the long quest to find the perfect material for photovoltaics. 'With silicon, photovoltaic efficiency ranges from 15% to 21%,' explains Mulè Stagno. While 21% looks like a low number, bulk silicon accounts for about 90% of solar capacity installed worldwide. Improving the efficiency of solar cells is a Solar Lab priority. Any small increase achieved by studying the small-scale defects would have a huge impact worldwide.

In Marsaxlokk, they are also investigating other relevant materials. Once a promising option to replace silicon entirely, thin-film solar cells made from exotic-sounding materials such as cadmium telluride are cheaper to produce because the photovoltaic layer need only be a few micrometres thick. Unfortunately, they have proven to be less efficient than silicon, meaning more panels are needed to provide the same electricity output. Silicon's popularity is also cemented by the fact that it has fallen dramatically in price over





Photos by James Moffett

Top: Photoluminescence tool (left), Moving clocksie - screen printing tool (right)
Bottom: Non-contact profiler image of concentrator solar cells (left), interior of Lab 2 at ISE (right)

the past decade. Nonetheless, thin-film solar cells make up the remainder of the market, and advances in this technology are equally likely to make a difference in global solar power output.

'None of the other materials we have studied so far have lived up to expectations,' Mulè Stagno revealed. However, this will not stop the Solar Research Lab from pursuing fresh lines of thinking. Newly emerging materials are in their line of sight as well. A third generation of solar cells might well be based on perovskites. These are materials with a particular crystal structure resembling a cube, and in the laboratories, they have already achieved efficiencies around the 21% mark. However, perovskites tend to degrade in moisture and even air, so more research is needed to make these commercially viable. 'If we can overcome the stability issues that plague perovskites, they could truly revolutionise the solar industry by making the cost of energy production much cheaper,' concludes Mulè Stagno. The team in Marsaxlokk is ready to join the frontiers of this research as well, with rudimentary perovskites already being produced in the lab.

FOCUSING ON THE ROAD AHEAD

Having overcome the trials and tribulations of setting up the Solar Research Lab, and with a clear plan in mind to characterise bulk silicon, investigate widely used thin-film materials, and build new materials of their own, Mulè Stagno and his colleagues are now able to kick start their research, while setting up collaborations with other universities and industry partners from all over the world. The brand new, cutting-edge lab puts them on a level playing field with global leaders; all the planning and hard work is already paying off.

What is more, the ISE is now hosting students from several other fields, ranging from chemistry to microelectronics. The study of materials pervades all these disciplines, meaning the plethora of surface characterisation tools available at the Solar Research Lab are a valuable resource for the university as a whole.

The ultimate vision of the Solar Research Lab is to be able to completely produce and characterise solar cells, gaining an insight into the entire process and how it can be improved. Seeing how much has been achieved on the site in Marsaxlokk in a few years, one can imagine that the next revolution in solar cell efficiency might start right here in Malta. T

EXTREME HEAT FOR GEARS

Cars, motorcycles, machinery—gears are at the heart of them all. ***Dr Ing. Ann Zammit*** *writes about challenges in producing and improving gears to make everything safer.*

***Issus coleopatrus* bug**

Gears are often considered a symbol of human ingenuity: a product of humankind's efforts to use physical and mechanical principles to its advantage. In their basic form, they are toothed wheels that mesh together to make things turn, transferring power from one moving gear to another. Many of history's great minds have dedicated time to these mechanisms. The earliest mention of gears likely came from Aristotle, who observed how 'rotation is reversed when one gear wheel drives another gear wheel'. Later, in the 15th century, Leonardo da Vinci gave us the Madrid Codices, two manuscripts chock full of inspired designs for gears and gadgets that would revolutionise our thinking.

However, a discovery in 2013 has shown that the original invention of gear mechanisms should be merited to none other than Mother Nature. The Issus bug has evolved curved, cog-like strips of teeth on its hind legs that interlock and rotate like a mechanical gear, enabling the creature to hop from plant to plant. Interestingly, this feature is only present in the young insect, and scientists have speculated that loss of the Issus' intricate gear system occurs alongside the loss of its self-repair abilities. The baby bug can replace a tooth on the gear, but the adult cannot, so it would be too risky for the adult to rely on the mechanism.

In an attempt to surpass nature, researchers at the Department of Metallurgy and Materials Engineering at the University of Malta (UM) are designing materials that would extend the lifespan of gears and make them more resistant to cracks and general wear. Mechanical gears have so many applications, ranging from the movement of a watch's hands, to the power transmission systems of industrial machines, so having a combination of desirable properties, both in terms of strength and longevity, would provide massive benefits to industry and society as a whole.

In 2006 Prof. Ing. Maurice Grech and I teamed up to investigate a material called Austempered Ductile Iron (ADI) for use in automotive gears.

CHANGING MATERIAL STRUCTURE FOR IMPROVED TOUGHNESS

ADI is widely used for vehicle components by companies worldwide: General Motors, BMW, and Renault, to name a few. The material itself is a type of cast iron that has an impressive combination of properties, including high strength, high toughness, and a great

The Issus bug has evolved curved cog-like strips of teeth on its hind legs that interlock and rotate like a mechanical gear, enabling the creature to hop from plant to plant.

A heat treatment process called 'austempering' improves these properties, and a big part of the research is dedicated to optimising this.

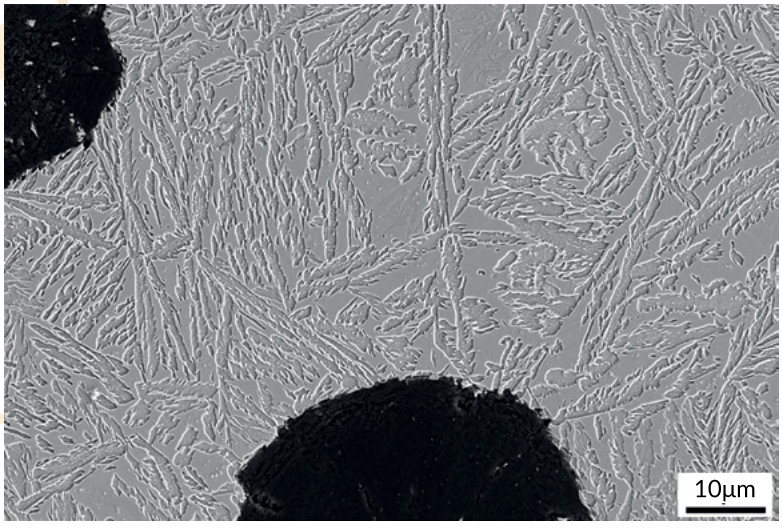
damping capacity that can reduce vibrations in the moving parts.

A heat treatment process called 'austempering' improves these properties, and a big part of the research is dedicated to optimising this.

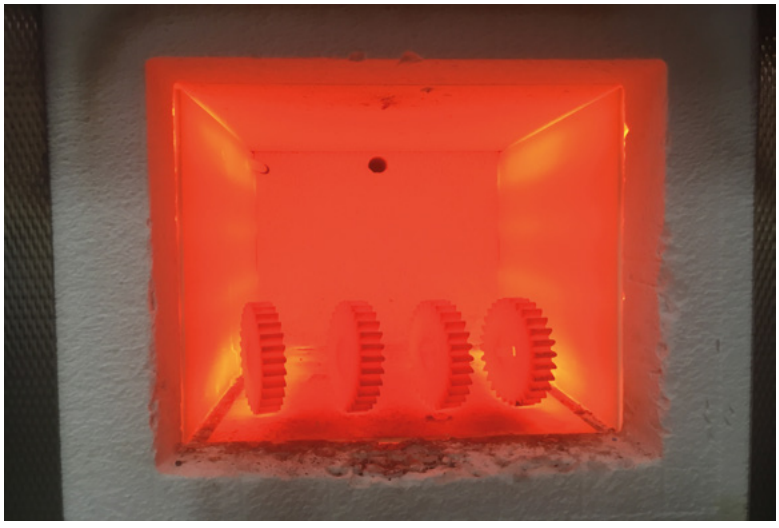
As a first step, the base material is heated in an electric box furnace, reaching scorching temperatures between 850°C and 1000°C. The material is then quenched in a bath of liquid salt maintained between 250°C and 450°C. The gears are left there for enough time to transform their underlying crystal structure, before being cooled to room temperature. By applying this thermal cycle to the material and changing its microstructure, its properties can be improved.

A key point is to choose the exact temperature; this critical step will greatly affect the final outcome.

Generally speaking, when good wear resistance is desired, low austempering temperatures, somewhere between 230°C and 330°C, are chosen. If the final product needs high toughness and resistance to bending, austempering is carried out at higher temperatures—around 350°C to 400°C.



ADI microstructure



Base material is heated in an electric box furnace, reaching scorching temperatures between 850°C and 1000°C

Dr Ing. Ann Zammit

Automotive Gearbox

In an ideal world, we would have a combination of high toughness and good wear resistance, but the perfect mix has proven elusive. A potential solution would be to use a two-step approach, whereby the high toughness required in the core of a gear is achieved by austempering in the higher temperature range of 350°C to 400°C. Subsequently, the material is further processed using surface modification techniques to improve its wear resistance.

DURABILITY AND THE SURFACE OF GEARS

After optimising the heat treatment to strengthen the core of our gears, further decisions need to be made to achieve the best possible longevity. A common method we are using to improve the surface is called shot peening. Bombarding the surface with round metallic, glass, or ceramic particles under controlled conditions leads to compression of the material, causing it to relieve tensile stresses and harden. Different intensities and shot materials can provide different results, adding to the long list of parameters that need to be considered.

For example, an important finding of the experiments carried out by our group is that repeating the process of peening significantly improved results. A first round of larger shots creates deep hardened layers, and a second round of smaller diameter shots improves the surface finish, removing areas of roughness that are likely to cause problems. Another smooth-finishing process being studied uses a high-power laser beam to harden the surface with minimal distortion.

Having all these possible methods to choose from makes testing long and arduous.

SOLVING A COMPLEX PUZZLE

Finding the optimal combination of parameters to use, both in the heat treatment and surface engineering processes, is a huge challenge. There are so many potential variable combinations that the complex task is akin to solving a Rubik's cube. A single turn can make the colours line up on one side whilst messing up another side completely, moving us further away from the final solution. Ultimately these engineering choices need to be driven by a lot of testing and data collection, to help make sense of this complex puzzle.

After improving the process on test coupons (small example pieces of the material), the research team is now beginning to test on actual gear systems. Dr Ing. Glenn Cassar has joined the effort and we are also seeking out industrial collaborators. This is an essential step in bringing the manufacturing and mechanical insights gained over the previous years onto the road as part of the gear systems of cars. Our ultimate goal is to perfect the systems that are already taken for granted, and improve lives, one gear at a time.

IGNITING A SUN ON EARTH

The Sun is the most important source of energy for life on Earth. Powerful as it is, what would happen if humankind could create a miniature sun in a lab and harness its energy? This is the mission of ***Dr Ing. Nicholas Sammut****,* ***Dr Ing. Andrew Sammut*** *and* ***Karl Buhagiar.***

The sun's diameter is 109 times that of Earth, and its mass is 330,000 times larger. Its sheer magnitude, along with its 'benevolent' effect of making life on Earth possible, meant it was regarded as a deity in ancient cultures. Now, things have changed. We understand the Sun and its processes in a lot more detail, but our respect for this turbulent ball of hydrogen and helium still remains.

When gravity pulled matter together to the point of igniting it through nuclear fusion, a process began that would create an energy source humankind would be inspired to harness. Today, a massive network of scientists and researchers from all over the globe have united in an attempt to do just that and provide a clean alternative to the planet's energy woes.

The International Thermonuclear Experimental Reactor (ITER—Latin for 'The Way'), is one of the most ambitious energy research projects in the world today. It has brought together the European Union, the United States, Russia, China, India, Japan, and South Korea. Their aim? To prove that energy released during nuclear fusion can be harnessed by combining several cutting-edge technologies, including avant-garde controls and diagnostics, cryogenics, remote maintenance, and safety mechanisms. Together, they will work to produce 10 times the energy input of the system. Currently, fusion reactors have barely produced double.

The €20 billion nuclear fusion reactor in this set up—the Tokamak—is being built in the Cadarache facility in Saint-Paul-lès-Durance, France. It uses very strong magnetic fields to confine plasma within a donut-shaped (toroid, to be fancy) volume of 840m^3 and ignite it through a sustained fusion reaction.

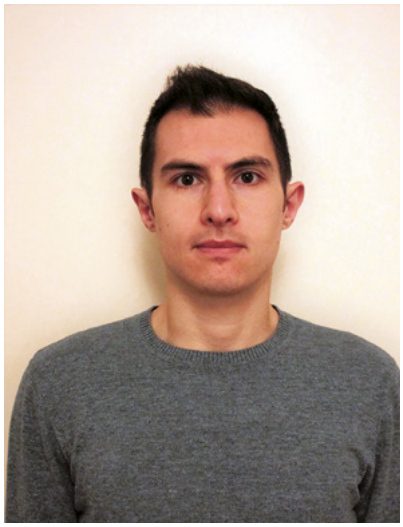
Plasma is one of the four fundamental states of matter. It can simply be thought of as a gaseous mixture of negatively charged electrons and highly charged positive ions. Lightning, for example, makes plasma.

When sufficiently dense plasma is heated at scorching temperatures of 150 million°C and confined magnetically for enough time, a controlled fusion reaction occurs, releasing energy. Controlling this plasma is a key problem for fusion reactors. By using deuterium-tritium plasma (heavier hydrogen isotopes) in which the reaction is sustained through internal heating, not only will the machine produce much more fusion energy than previous designs, but it will also remain stable for longer.

The goal of the Tokamak is to prove the feasibility of nuclear fusion as a large-scale, carbon-free source of energy, based on the same principle that powers the Sun.

Through a collaboration set up with the Paul Scherrer Institute (PSI) in Villigen, Switzerland, Karl Buhagiar, Dr Ing. Nicholas Sammut (Faculty of ICT), and Dr Ing. Andrew Sammut (Faculty of Engineering) from the University of Malta (UM) worked on the measurement and characterisation of the ITER Toroidal Field (TF) coils which are core elements of the machine.

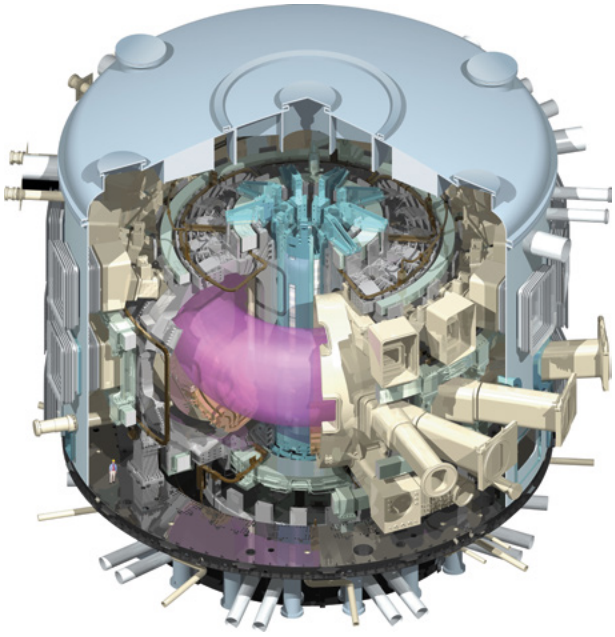
The UM team, together with the team at PSI, worked specifically on ITER's superconducting D-shaped TF coils. These 18 coils each measure 13m by 8m and are cooled to 268°C in cryogenic operating conditions.That is really cold. For reference, the coldest village Siberia only makes it to a 'mere' -90°C!



Karl Buhagiar

Dr Ing. Nicholas Sammut

Dr Ing. Andrew Sammut



Fusion Reactions power the Sun; our most important energy source.

Nuclear fusion reactors can release three times as much energy as current fission reactors, and also produce 100 times less radioactive waste.

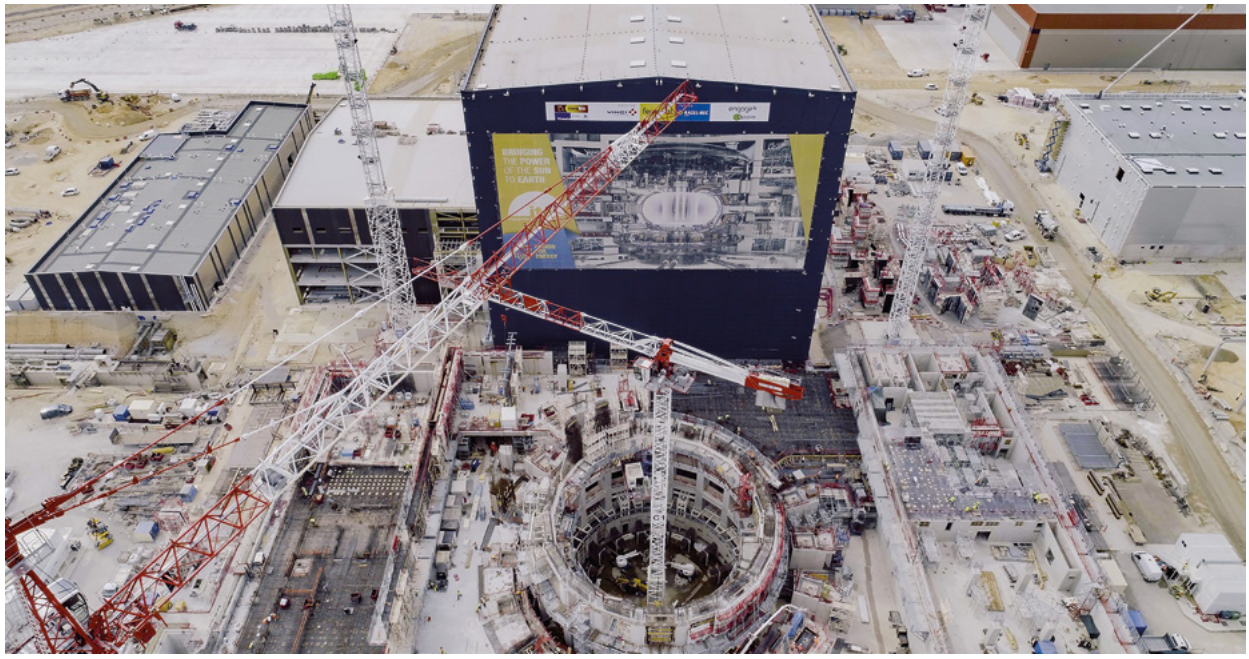
These super high-tech magnets have a design current of 68,000A: approximately 2,000 times that found in a household wire. These currents generate a peak magnetic field of 11.8T, which is required to confine the plasma and control its shape and direction of movement inside the reactor chamber.

'The scale of the project is truly massive,' exclaimed Andrew Sammut, 'reading about the project is one thing, but being part of it is really something else. It is a real privilege to form part of such a venture.'

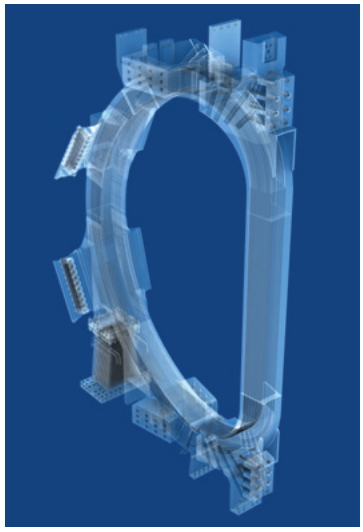
'When you are working on ITER, despite the technological and financial challenges you face, you know that you are part of something so much larger than yourself: an energy source that is practically free with virtually no pollution. That's a really noble way of contributing to the well-being of the planet and to mankind's sustainable future,' says Nicholas Sammut, who was previously on the ITER European Governing Board.

'For me, meeting top-notch scientists and being part of the team was a truly enriching experience,' says Masters student Karl Buhagiar. 'Such international projects put you in contact with a whole different scientific and technological world.' The ITER consortium is indeed a very large global venture, consisting of the world's best specialists from 35 countries and representing half the global population and 85% of its GDP.

The research team's goal so far has been to develop a critical magnetic measurement system for the determination of the TF coil current



The ITER Construction Site in Cadarache, France



D-Shaped Toroidal Field Coils; Eighteen of these toroidal field coils will surround the vacuum vessel and produce a magnetic field to confine the plasma particles. Each coil is 14m high, 9m wide and weighs 360 tonnes.

centre line (CCL). The determination of the CCL makes it possible to ascertain the TF coil's magnetic field and hence how well the plasma can be confined. Without this kind of characterisation, it will be impossible for the machine to control the nuclear fusion reaction. If the plasma is not controlled to very high precision, it could touch the walls of the chamber and destroy the entire machine.

Nuclear fusion reactions are very challenging to confine sustainably due to the extremely high plasma temperatures involved. However, they can release three times as much energy as current fission reactors. They also produce 100 times less radioactive waste, which is not long-lived. The closing highlight of the Tokamak's design is that it will contain a very limited amount of fuel (less than four grams) at any given moment. Since the fusion reaction relies on a continuous input of fuel, if there is a perturbation in this process the reaction ceases immediately. This will make large-scale runaway chain reactions, as seen in the Fukushima accident, impossible.

If this technology is harnessed, fusion reactors will be able to produce reliable electricity with virtually zero pollution. This could be the answer to all our energy prayers, allowing us to meet skyrocketing demand while doing so sustainably, and with little environmental impact. We can hardly ask for more.

FURTHER READING

- P. Lerch, K. Buhagiar, D. Wassemer, A. Gabard, A. Barutti, M. Buzio, N. Sammut, S. Sanfilippo, A. Foussat, 'Magnetic Determination of the Current Center Line for the Superconducting ITER TF Coils'
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PLAYING WITH FIRE

Climate change is a real threat. The scientific evidence is irrefutable. The problem is that countless talks and rallies calling for action have only pushed things forward at a snail's pace. ***Prof. Simone Borg*** *explains why.*

Back in the mid-1970s the scientific community was already sounding the alarm that emissions from human activities were unbalancing the composition of greenhouse gases in the atmosphere, leading to an unprecedented increase in global temperatures.

A decade later, on 21st September 1988, Malta raised the issue at the largest and arguably the most influential global political forum—the United Nations General Assembly. Malta appealed, to all nations present, to initiate action at the political and legal level in response to these increasingly alarming scientific reports.

Following Malta's initiative at the UN, things began to move quickly. The Intergovernmental Panel on Climate Change (IPCC) was set up: a remarkable step in the right direction. For the first time, science was taking centre stage, becoming the guiding light that would spur governments into taking evidence-based national and global action. Malta's initiative, in

For those of us who have braved the negotiations through thick and thin, we consider the Paris Agreement as a legal instrument that has the potential to finally bridge the chasm between climate science and climate action required at the political and legal level.

fact, aimed to persuade other nations to respond urgently to concerns raised by the scientific community and determine a global legal agreement to address anthropogenic (human-induced) climate change.

Greater impetus came in 1990 when UN states were given a two-year timeframe within which to negotiate a climate treaty. For a short while, the usual lack of coordination between scientists and politicians appeared to be a thing of the past. States were eager to embark on partnerships to address human-induced climate change.

Sadly, things became complicated and negotiations turned acrimonious. The IPCC churned out scientific reports by the dozen, all demonstrating the high risks involved in maintaining a 'business as usual' attitude towards fossil fuel consumption. Politicians echoed this concern and climate change became a staple item on the agenda at all major global meetings. It was, and remains, by far one of most discussed topics in these last three decades. However, the wheels of change stalled, and the set of robust legal commitments which would encourage states to 'walk the walk' continued to prove elusive.

To explain this stagnation, it is necessary to understand why negotiators take so long to agree on something that seems 'obvious' and requires urgent action.

A CLIMATE CHASM

The relationship between science and law has been compared to oil and water, in that they differ primarily in the methodology they use to achieve 'results'. Scientific conclusions are based on evidence acquired via a specific, predetermined methodology. Laws, serving to regulate human behaviour and ensure order, develop over time and are formulated in a way that accommodates priorities, whilst protecting the balance of interests among the different stakeholders involved.

At international climate negotiations, priorities are set by governments. In democracies, government priorities are meant to be determined by the will and needs of the electorate. In other forms of government, priorities are set by whoever is in authority. Climate negotiators are envoys of their governments, meaning they have a set mandate from which they cannot depart, whatever their personal sentiments about climate action may be.

Climate negotiators representing different states may wholeheartedly agree that the planet needs climate action, but because their agenda is dictated by national interests and red lines they cannot cross, they will disagree on the type of measures that need to be adopted. For example, while states would give climate action due priority, they may still find difficulty in phasing out coal or imposing carbon taxes on fossil fuels.

Admittedly, such concerns are sometimes rooted in politicians' desire for re-election, but not always. Governments may acknowledge the effectiveness of certain climate action measures, but due to socioeconomic repercussions would refuse the legal binding required to carry them out on a national level. Some states may simply be unable to afford the heavy investment required for action. Governments may also need to postpone implementation because of more pressing needs, such as the eradication of poverty. Other times, solutions depend upon changing consumption patterns, a social awareness that would take years, if not decades, to instil, or upon alternatives which are not yet widely accessible due to their exorbitant price points—think electric vehicles and, to a certain extent, solar and wind energy.

Other difficulties have played a significant part in the procrastination of international negotiations about climate change legislation. The interplay between science and law is arduous in all environmental agreements. In the cases of pollution or ozone depletion, identifying and tracing the origin and cause, the pollutant and pollutor, are relatively straightforward. This means specific action can be taken. However, many greenhouse gases are emitted naturally by a range of human activities, and all contribute to the negative effects. This means that while the concentration of greenhouse gases is scientifically proven to lead to warming of the atmosphere, it cannot be scientifically proven that, for example, an individual Category 5 Hurricane is the direct result of a specific amount of gases emitted by one or more states. The result is an absence of any causal link between an action and the resultant damage: essential proof in legal proceedings. This explains why sceptical politicians constantly harp on about the absence of absolute scientific proof and that climate change is a natural phenomenon.

Prof. Simone Borg

The negotiation history highlights this complex landscape faced by negotiators. The first treaty, the United Nations Framework Convention on Climate Change (UNFCCC), was concluded in 1992. It had a fairly mild, albeit useful, legal mandate, serving as a good point of departure. However, as its name implies, it was but a framework and would need other legal instruments to be effective. Its parties were to inventory their greenhouse gas emissions and to submit a report on

how they aim to deal with climate change, by mitigating it at the national level. Industrialised nations were singled out in a list called Annex I, a move which later haunted them, with an additional legal obligation to stabilise their emissions at 1990 levels by the year 2000. Over time, this distinction between Annex I and non-Annex Parties was referred to as the 'firewall' because it contrasted those states that had to reduce emissions with all the others that had no such obligation. Some of the countries in Annex I, those with high income status and advanced industry, were also included in a separate Annex II, which legally required them to provide green technology to developing countries. The aim was to enable developing states to adopt cleaner energy generation processes.

HALF-BAKED DEALS

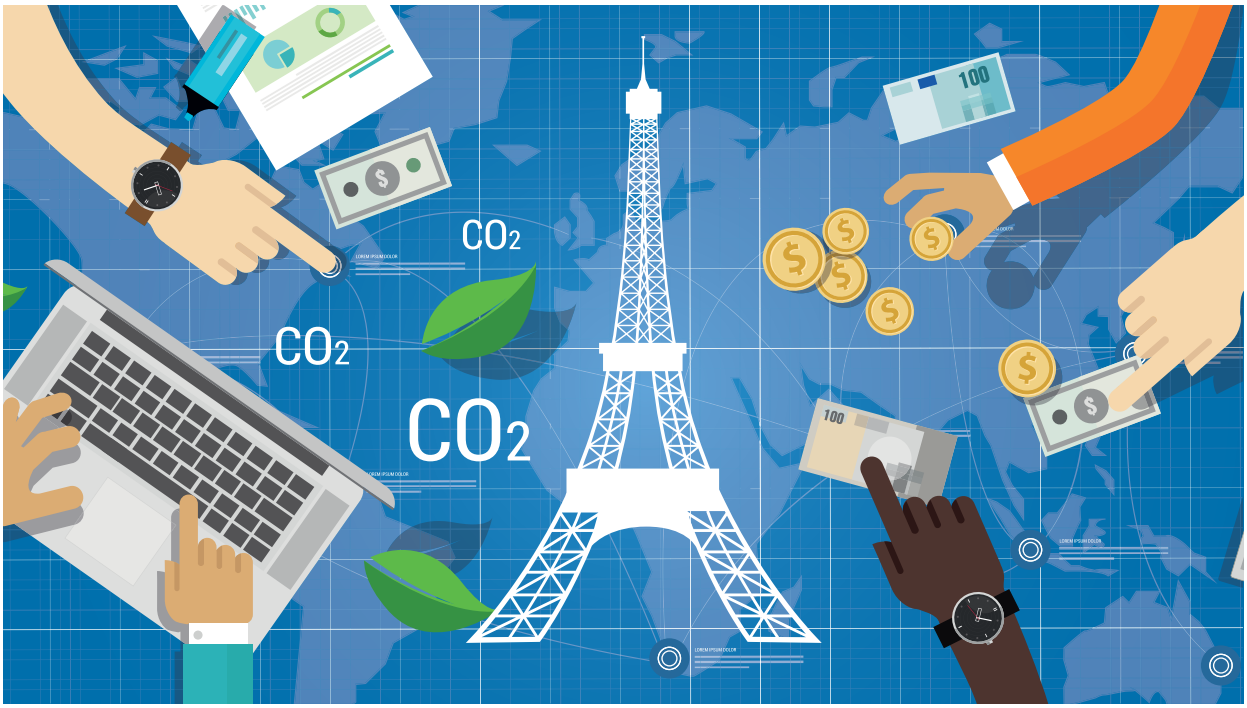
The UNFCCC treaty was considered too weak because it did not provide specific reduction targets. It merely aimed to reduce emissions by requiring only Annex I Parties to limit theirs. Efforts to introduce stricter obligations led to the Kyoto Protocol in 1997, as an additional legally binding instrument to the Treaty. The Protocol still imposed emission reduction targets only upon Annex I Parties, but included a number of 'sweeteners'. There were 'market friendly' measures such as granting Annex I Parties credits to meet their emission reduction targets if they provided developing countries with cleaner technologies. Annex I Parties also had the potential to engage in a greenhouse gas emission trading scheme, where they could buy or sell surplus emissions to meet their targets. This meant they could make profits if they generated less emissions, by selling their surplus to others who had exceeded their targets. The latter would therefore incur expenses, which they could have avoided had they generated less greenhouse gases.

To the IPCC scientific reports however, the Protocol remained a half-baked response. The US, the world's greatest emitter at the time, refused to become a party to the Protocol, objecting to the so-called 'firewall', branding it as discriminatory and harmful to its competitiveness. On the other hand, developing countries saw Annex I Parties as being historically responsible for human-induced climate change and expected compensation for present and future damages they were suffering. Annex I Parties ratified the Protocol, but refused to negotiate any form of compensation. Instead, they established funding mechanisms to assist developing countries in adapting to climate change to reduce risks and losses.

The UNFCCC and the Kyoto Protocol were a far cry from the IPCC's evidence-based recommendations. Even though greenhouse gas emissions were nowhere near decreasing, the process stalled for the next twenty years, as a complex game of political tug of war ensued each time the Conference of the Parties (COP) met once a year.

High expectations were raised in 2009 when the COP met in Copenhagen. Although the expected new legal deal to set specific targets was disappointingly absent, two important milestones were reached. These would later pave the way to the Paris Agreement. It was agreed that the ultimate aim of an effective global agreement should be to halt the global temperature increase, keeping it below 2°C, and that 100 billion US dollars per year would be provided to developing states to enable them to take both mitigation and adaptation measures towards climate change. This kind of financial support was hypothesised to bridge the gap between developed and developing countries

Governments may also need to postpone implementation because of more pressing needs, such as the eradication of poverty.



and indirectly provide financial assistance in lieu of compensation which cannot be legally upheld.

Two years later in Durban, South Africa, the Parties finally agreed that a new legally binding agreement with no firewall would happen by December 2015. But, while negotiators were later relieved at what was achieved in Durban, the outside world appeared to have lost faith. Climate conferences became the butt of countless political jokes.

LIGHT AT THE END OF THE TUNNEL

In 2015 the Paris Agreement brought hope after nearly 50 years since researchers highlighted the climate change problem. It was perceived as the long-awaited deal that would ultimately regulate state behaviour, making them take the right steps towards truly addressing climate change. Non-governmental organisations also adopted a more positive attitude. However, jubilation came mostly from politicians and the thousands of negotiators representing the various states, legal advisers, and technocrats. Scientists remained sceptical, describing the agreement with the (in)famous quip, 'too little too late'.

For those who braved the negotiations through thick and thin, the Paris Agreement is the legal instrument that has the potential to finally bridge the chasm between climate science and the climate action required at the political and legal level.

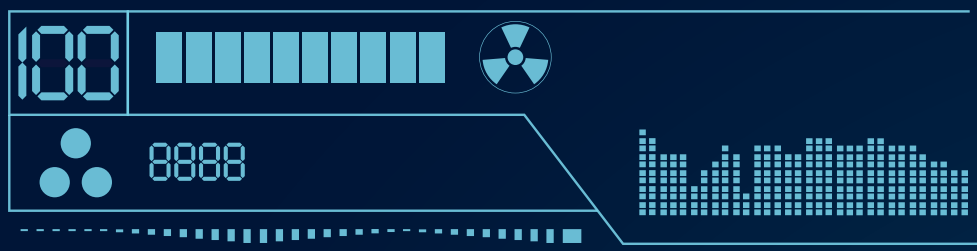
Finalised through consensus, the Paris Agreement is a huge achievement that saw a shift away from the previous top down approach. This was accomplished thanks largely to the global leadership demonstrated by key personalities, such as Pope Francis with his encyclical letter Laudato Si, referring to the urgent need to address unsustainable consumption, and Ban Ki Moon, who, throughout his tenure as secretary general of the United Nations, championed the need for a meaningful multilateral agreement to combat climate change. Endorsements like these added trust into the equation and did away with the firewall, seeing states commit themselves to climate action irrespective of whether they are

Greater impetus came in 1990 when UN states were given a two year timeframe within which to negotiate a climate treaty.

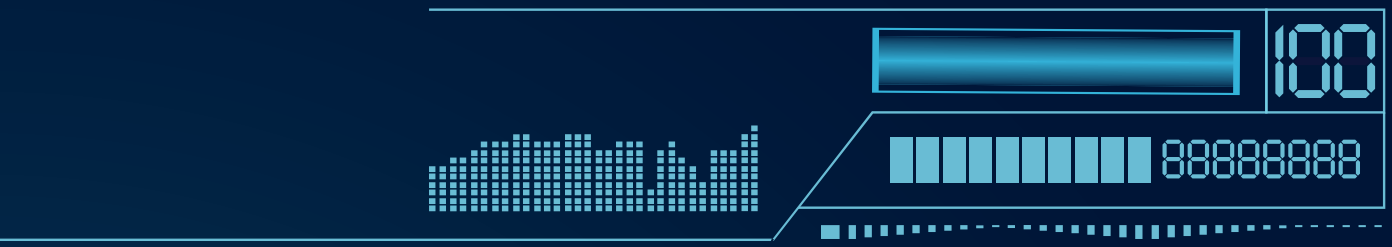
developing or developed countries. Each state set out specific plans and policies, the so-called 'nationally determined contributions' (NDCs), that will be verified and reviewed to carry out what the vast majority of scientific reports had been clamouring about for decades. This methodology allows for greater flexibility, enabling each state to focus on reducing emissions in the most favourable way according to its national circumstances. The NDCs can be revised periodically, but stakes can only be raised, not lowered. The Paris Agreement also establishes a mechanism that will introduce transparent accounting rules and verify the mitigation measures adopted by states. If correctly adhered to, by the end of the century the plan should lead to a carbon-neutral planet, ensuring that temperatures will not rise beyond 2°C.

The 100 billion US dollars pledged in Copenhagen as aid for developing states is to be provided by a variety of funding mechanisms. Accessibility will be linked to performance based on the implementation of the NDCs. The Paris Agreement also achieved another unique milestone by giving both the private and civilian sectors a role as the drivers of change. The private sector will be key in achieving this paradigm shift to a carbon-neutral planet. Its vested interest in expanding research, job creation, and innovation will serve the world well.

Fifty years is way too long to justify procrastination on a course of action that would benefit the globe, but the Paris Agreement shows that a multilateral response is the only way to curb a global ailment. Time is necessary to achieve momentum behind all the moving parts involved in concerted global action, the formulation of international norms, and the acceptance of their legally-binding nature. A pro-climate action government can be replaced by a skeptical one almost overnight. A single state can make or break international law. By involving communities, governments will no longer dominate such dialogues. When it comes to climate change, science and the law can once more work hand in hand to overcome this unprecedented, multi-generational threat. It will all depend on human goodwill. T



Mission display HUD.



Artificial Intelligence is being trained to make weapons and predict the outcome of battles. But fear not—there is no nefarious purpose behind this work at The Institute of Digital Games; the research intends to make games more balanced and enjoyable.

The fear of a robot uprising is real. Terrible fictional creations like the Terminator and HAL are clear proof. But when Artificial Intelligence (AI) is taking a day off from becoming self-aware and attempting to destroy the world, it also plays an important role in contemporary video game design.

AI is not as mysterious as a lot of sci-fi makes it out to be. 'AI' is an umbrella term that refers to any device which perceives its environment and takes actions to maximise its chance of success at some goal. At the Institute of Digital Games (IDG, University of Malta), researchers are developing programmes that will build weapons and predict the outcome of battles. Not to help them on their path to world domination, but to find perfect game balance.

Game balance is at the core of 'good' game design. A football pitch is perfectly symmetrical with goals of equal size on each side. Increasing the size of one goal post, or narrowing one part of the field, would upset the game's balance and make it a lot less fun to play. In video games, playing fields involve different weapons, special abilities, and even multiple floors. This increased complexity causes game balance to become a bit more tricky.

While game balance is often in the hands of human designers, at the IDG, we are trying to automate some of the process with AI's help.

LEARNING BALANCE

Level-designing humans rely on gut feeling, experience, and countless hours of play-testing to produce a balanced level, and could surely use a little help from their machine friends. One method of assistance would be to use neural networks—a specific form of machine learning that progressively improves performance of its task. It is these neural networks that Daniel Karavolos, a Ph.D. student at the IDG, is currently teaching to predict the outcomes of multiplayer first person shooter (FPS) games.

Why is it cool?

Game designers tweak the playing field for game balance, but it is more challenging in the FPS genre because having a perfectly symmetrical open field is not an option. A gunfight on an open field would be about as exciting as drawing straws. The predictive deep learning model that Karavolos is developing could help designers see how changes in the level impact the balance of the match in real time. This would save countless hours of

The ANNs predicted the matches that would result in a balanced kill ratio with 75% accuracy, while the CNNs predicted the advantage of a team with 74% accuracy.

playtesting, while also saving the company from the usual barrage complaints about unbalanced levels. Ultimately, using AI to predict game balance will reduce costs in game development and cut down sales losses. Tragically, however, it will also leave countless chronic complainers on the Internet with nothing to do.

How does it work?

Not all AI is created equal. Researchers like Karavolos have to find the most effective AI for their purpose. Generating enough data for a machine to detect a pattern accurately takes time, so choosing the right machine learning algorithm is key. Karavolos tested a large number of different networks, but the most effective networks were the convolutional neural network (CNN) and the fully connected artificial neural network (ANN). These neural networks were 'trained' with over 50,000 3v3 deathmatches across a diverse set of levels created by 39 generators. The levels were spawned with 50 obstacles and weapons like a shotgun, a rifle, a submachine gun, a sniper rifle, and a rocket launcher. Each level varied object size and object placement. These levels were input as 100x100 pixel images with three colours, allowing the network to distinguish between large objects blocking line of sight, small objects providing cover, and no objects. The neural networks then analysed the parameters of the levels and the weapons, before predicting the outcomes of the games. Since playing a level 50,000 times is a tall order, even for the most hard-core gamer, AI agents were used to simulate the gameplay and train the neural network. Each agent had unlimited lives, but once 20 kills were achieved, the match ended. The balance was then calculated by the ratio of kills of each team. A match is balanced when the kills of each team are equal, or only have a marginal difference. After the networks' training montages were complete, it was time to pit them against each other.

The ANNs predicted the matches that would result in a balanced kill ratio with 75% accuracy, while the CNNs predicted the advantage of a team with 74% accuracy. Both also had a very low probability of identifying the wrong team to win, meaning that once trained the neural networks are able to predict game balance with about 75% accuracy overall.

SURPRISING WEAPONS

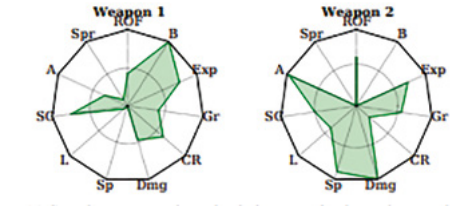
Procedurally generated content is created by an algorithm rather than game designers and graphic artists. *No Man's Sky*'s procedurally generated worlds generated a lot of buzz, but also distinctly highlighted the gameplay challenges that come with algorithm-generated content—a lack of overarching story or structure that often resulted in aimless wandering and repetitive actions. To overcome this problem, Ph.D. student Daniele Gravina is looking into procedurally generating balanced weapons with surprising characteristics. These will be used in *Unreal Tournament III*: an arena FPS focusing on head-to-head deathmatches.

Why is it cool?

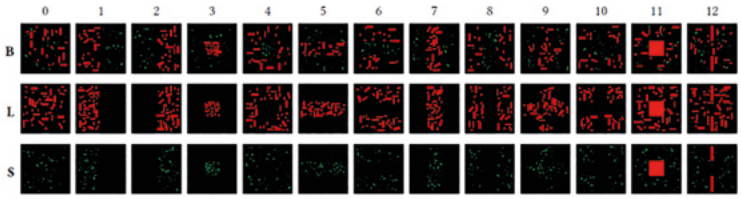
Gravina's algorithm will generate a pair of weapons with unusual and unexpected properties. This should encourage unconventional gameplay but still manage to keep a sense of balance. If the standard weapons favour one player, the duel will be frustrating and boring for their opponent as they struggle uselessly. Using this new algorithm, the weapons can vary greatly, surprising players and encouraging them to adapt their strategy to the specific strengths of the weapon while still maintaining the duel's balance.

How does it work?

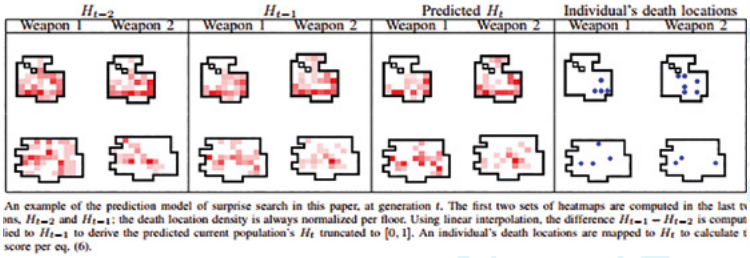
The weapons are generated through a genetic algorithm which uses



Daniele Gravina: Weapon Pair



Daniel Karavolos: Sizes and formation of object placement map AI



An example of the prediction model of surprise search in this paper, at generation t. The first two sets of heatmaps are computed in the last tv ons, H_{t-2} and H_{t-1}; the death location density is always normalized per floor. Using linear interpolation, the difference $H_{t-1} - H_{t-2}$ is comput lied to H_{t-1} to derive the predicted current population's H_t truncated to $[0, 1]$. An individual's death locations are mapped to H_t to calculate t score per eq. (6).

Daniele Gravina: Heatmap

Daniel Karavolos

Daniele Gravina

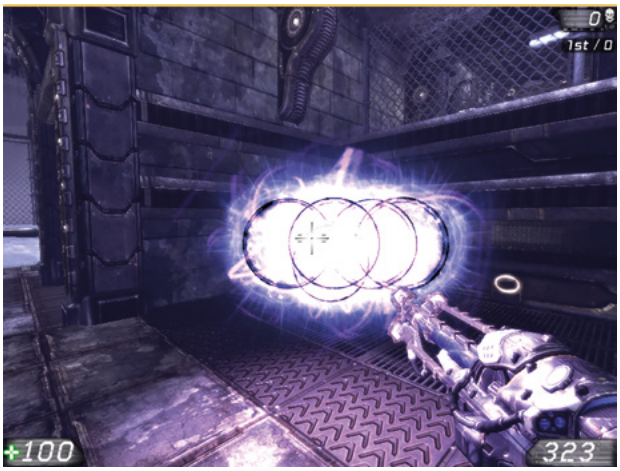
WHAT ARE NEURAL NETWORKS?

ANN

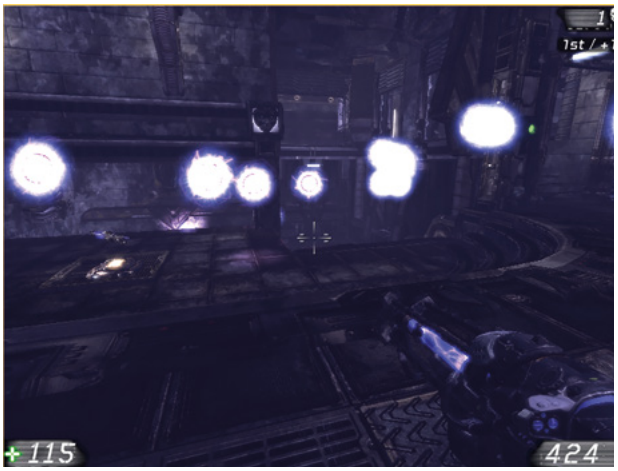
An Artificial Neural Network is a computing system inspired by modes of biological information processing in the brain and nervous system. Instead of having task-specific programming, the system improves progressively thanks to a large bank of similar scenarios that it can reference. For example, an ANN could learn to identify images of cats by analysing a large quantity of images tagged as 'cat' or 'not cat'.

CNN

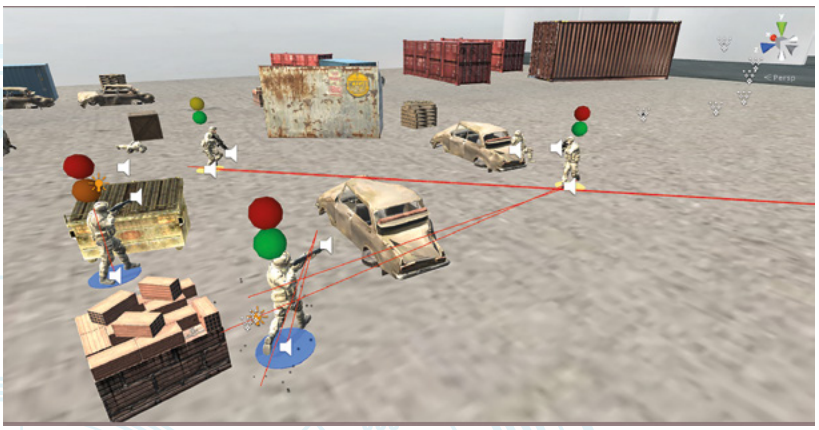
Convolutional Neural Networks are artificial networks which often contain layers to detect various parts of a more complex object. In facial recognition, for example, it might detect pupils, then feed to the next layer that detects the eye, then the next for mouth, and so on, until finally the complex object of the face is recognised. As opposed to conventional neural networks, this architecture makes it explicit that the input is an image. This allows encoding of certain properties in the architecture, making the forward function from one layer to the next more efficient and drastically reducing the parameters in the network.

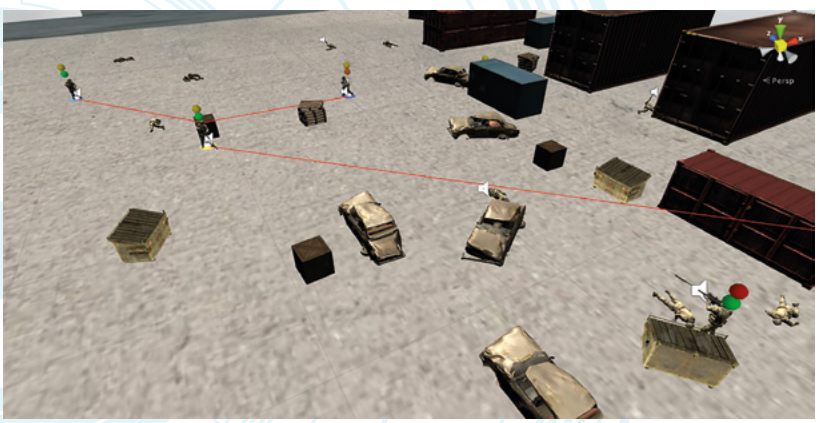


Daniele Gravina: Surprise first weapon



Daniele Gravina: Third weapon





1

2

Daniel Karavolos:
1. Close combat
2. Long versus short range

The extreme diversity of the actions reinforces the illusion that the player is immersed in a different reality.

characteristics of the original weapons to develop new ones. Parent weapons have 11 parameters such as the rate of fire, spread, speed, damage, and number of bullets per shot. When paired, they make little weapon babies that are an evolutionary product of their parents.
When generating the new baby weapons, the algorithm will pick varied values based on the parent weapons' parameters. When selecting the values, the probability distribution is skewed away from the middle values, to avoid the weapon babies merely becoming the average of their parents and devoid of any real novelty.

Simultaneously, certain thresholds are also put in place to determine balance, effectiveness, and safety, to ensure playability. After all, you cannot bring a nuke to a gunfight. Now, evolution would not be fun without a few mutations, which is where the 'heatmaps of death' come in. Feasible weapons were tested by AI Agents on the Biohazard level of *Unreal Tournament III*, and the kills were mapped. These heatmaps showed the most common areas where the AI Agents died. To add a dash of surprise to the balanced weapons, the AI searched the heatmap and tried to find ways to deviate from the generated heatmaps of death. Given that weapons with certain characteristics have advantages on specific parts of the map—that perfect sniper spot, or that corridor where we can go to town with the grenade launcher—the AI will use that information to adjust the weapon and cause deaths in unexpected locations. Tweaking the weapon so that the kill heatmap is not the same makes the level more dynamic and exciting.

YIN AND YANG

Without bodily balance, you will fall. Without level balance, a game will fail. Games are often based on a set series of actions within a framework. The extreme diversity of the actions reinforces the illusion that the player is immersed in a different reality. Having designers work extensively on each level and each weapon to ensure this balance limits the player's options. Even when designers do take the time to do this, mistakes happen and unbalanced weapons find their way into games. Combining procedural content generation with AI balancing tools is the way of the future. It can lead to games where every level is different; where weapons and level structure force you to think up new strategies each time you play.

The time has come for the machines to rock the world of game design by helping it stay balanced. Maybe someday they will take over, but for now they are content making games more awesome, expansive, and cheaper to produce. Step by step, the gaming world is on the cusp of change. Are you game?

FURTHER READING

- Daniel Karavolos: **https://dl.acm.org/citation.cfm?id=3110568**
- Daniele Gravina: **http://ieeexplore.ieee.org/document/7860408/?reload=true**

A story of flies and ice:

Unravelling the mysteries of ALS

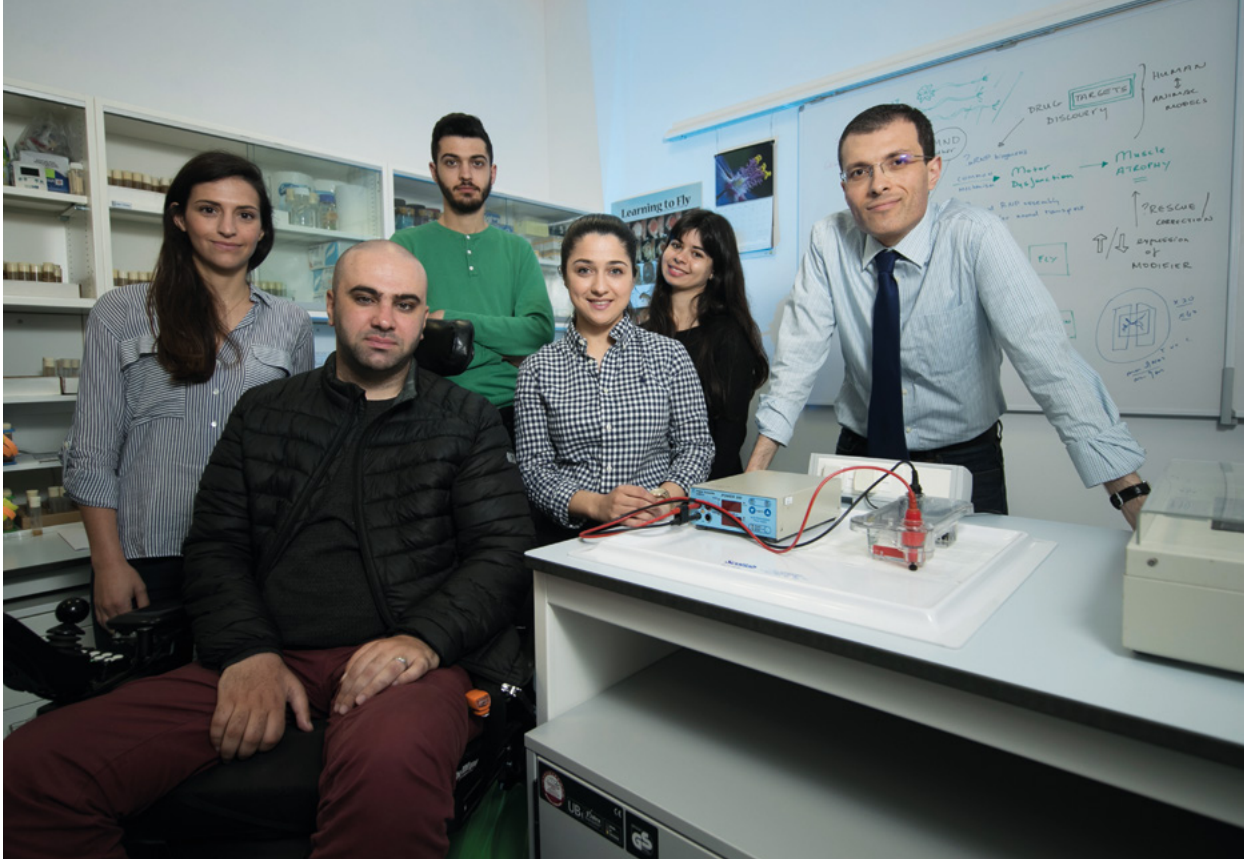
The Ice Bucket Challenge shot motor neuron diseases into the limelight in 2014. But how much did the ice cold water really represent ALS, and what legacy has it left for research into these diseases? ***Becky Catrin Jones*** *speaks to* ***Dr Ruben Cauchi*** *and* ***Maia Lanfranco*** *to find out more.*

The summer of 2014 was memorable for a number of reasons: Germany crushed hosts Brazil at their own FIFA World Cup, the new supposedly-bendy iPhone 6 plus was revealed to an expectant audience, and celebrities and civilians alike (including Malta's prime minister) joined in with the latest viral craze: dumping buckets of ice-cold water over their heads. Why? The reasoning behind subjecting themselves to the shock of freezing water was to raise awareness of a devastating neuromuscular disease, ALS. That frozen moment of paralysis as the water hits is somewhat similar to the patients' daily experiences: leaving them with a lack of bodily control or inability to move.

Many dismissed the viral challenge as just another pseudo-charity stunt attracting the 'slacktivists' who want to be seen as involved, but with minimum effort. However, the Ice Bucket Challenge was incredibly successful in single-handedly raising the profile of a previously obscure disease, practically overnight. More than 2.4 million videos of the stunt were published on Facebook, and at its peak the Ice Bucket Challenge was the subject of over 70,000 tweets a day. Motor neuron disease (MND), most specifically Amyotrophic Lateral Sclerosis (ALS) was suddenly on everyone's mind. Here in Malta, the conversation also focused on the research of the ALS/MND Lab headed by Dr Ruben Cauchi. Their pioneering work into motor neuron diseases such as ALS and Spinal Muscular Atrophy (SMA) in children began attracting new attention, investment, and researchers.

THE BIOLOGY OF MOTOR NEURON DISEASE

Motor neurons make up the nerves that control movement in the body, from lifting a pen or kicking a ball, to basic functions like breathing, blinking, and swallowing. An electrical charge from the brain activates these nerves, exciting the neuron, which in turn tells the muscle to move. During the progression of motor neuron disease, neurons are kept in an active, excited state, which eventually



The Malta ALS Research Group together with ALS Malta founder Bjorn Formosa

exhausts them. When they wither and die, controlled movement of muscles is lost. This process can eventually lead to difficulties with speaking, swallowing, and breathing, which result in the patient's premature death.

Diseases that affect motor neurons are usually caused by a mutation in the genes that regulate their action. This typically happens during cell division, when the cell replicates itself by copying its genetic code. When a mistake occurs during this copying phase, the resulting protein will be mutated and it will affect the whole cell's ability to survive. Zooming in to look at the genetic scale can therefore reveal clues to curing these diseases.

Much of Cauchi's career, beginning with his days as a Ph.D. student at the University of Oxford, has been focused on researching these diseases. 'As motor neuron diseases are relatively uncommon, the work I was doing was considered as researching something 'exotic,' Cauchi remembers. During his doctoral project, some of his work revealed that SMA was an entirely genetic disease, brought about by mutations in one single gene. This gene was named the Survival Motor Neuron (SMN) gene and is involved in the cell's ability to successfully translate genetic information in the form of RNA into the respective protein. This discovery was groundbreaking and is paving the way to develop therapeutics.

ALS, however, is a far more complex disease. Unlike SMA, ALS is not entirely genetic. Environmental factors such as diet, excessive exercise, or alcohol and tobacco use are responsible for 90% of its incidence. Also, mutations in ALS can occur in a number of different genes responsible for encoding a variety of different proteins. As a polygenetic disorder, the combinations of different gene mutations seem never-ending, and it is very likely that these mutations are linked. So, how do you even begin to start studying such a disease?

LOOK TO THE FLIES

Luckily, Cauchi and his lab have a very useful tool up their sleeves. 'Most people think it strange at first that we use flies to study a human disease,' he explains. However, the fruit fly (*Drosophila*) is a smart choice, as it has a well-defined genome which can be easily manipulated. Their rapid breeding rate also means that the results of any mutations can be seen very quickly, making fruit flies perfect for studying genetic disease.

When it comes to researching ALS, the genes that encode parts of the fruit fly's motor neuron system are very similar to those found in humans; so much so that some drugs seen to work in a fly model of ALS can progress straight to trials on human patients.

These models have already produced some success stories. The identification of the SMN gene would not have been possible without the ability to modify and document genetic changes in *Drosophila*, and some work has also led to the development of a specific treatment for SMA, named Spinraza. This treatment uses a small region of genetic code, antisense oligonucleotide, to bind the faulty gene and change the way it is expressed. This exciting discovery was approved by the FDA in December 2016 and has since shown much success in clinics across the world.

THE SEARCH FOR A TREATMENT

Could such a success story be seen with ALS, considering the complexity of the disease? 'I don't think that it would be such a ridiculous idea to suggest that a similar treatment could work for ALS,' comments Cauchi. Though more difficult to map back to the genetic level, the final changes seen in both diseases are very similar. By employing the same tactics, but targeting a network of genes rather than one singular gene, scientists may be able to adapt this technology. The problem is identifying which mutations to target. Many potential combinations have probably already been studied, but if these do not produce successful results, it is unlikely that anyone will hear of them. 'The pressure to produce positive results means that negative ones don't get published, and so other groups will continue to try the same failing methods rather than progressing as a field.' Another huge problem is the cost of producing and developing these drugs. 'It can cost €6 billion to bring an ALS drug to market,' Cauchi explains. The lack of funding combined with the relatively low incidence of the disease often means that large pharmaceutical companies are reluctant to invest time and money into such drugs.

One way to circumvent the cost of developing new drugs is to use those which already exist. The drug edaravone, originally developed as a stroke treatment, has been found to yield benefits in patients with ALS. However, since completing its clinical trials in Japan, edaravone has faced criticism due to its lack of sufficiently solid data. More studies into its long-term side effects are required, and as a result, it has so far only received conditional FDA approval. More worryingly, the mechanism by which the drug is effective in ALS is not well understood. A systematic approach to understanding the genetic causes will be needed to develop a better treatment.

MAKING IT PERSONAL

The term 'personalised medicine' is used throughout medical biology today, as we begin to understand how treatment outcomes are affected by variation between different people. This is particularly important while studying genetic diseases, and ALS is no exception. 'I really think personalised medicine will be the revolution in the treatment of motor neuron diseases,' Cauchi states. To begin, we must gather as much information as possible from patients currently suffering from ALS or other motor neuron diseases, in order to increase our understanding of the causal pathways.

To this end, Cauchi, along with others, has established the Malta ALS/MND BioBank. The aim of this project is to work with patients in Malta, understanding their experiences, symptoms, and progression, as well as collecting blood samples and carrying out other tests when necessary. The genomes of these patients and their family members are being sequenced to piece together the genetic puzzle of the disease. This communication with patients has already benefitted the researchers; once new, unknown mutations are found in patients, they can be translated back into the fly model for further research.

Dr Ruben Cauchi discussing the next experimental step with Maia Lanfranco

Dr Ruben Cauchi discussing the research endeavours of the Malta ALS/MND Lab with ALS Malta Founder Bjorn Formosa

COMPETING FOR THE LIMELIGHT

The incidence of ALS and other motor neuron diseases is relatively low, and so the funding available from government is very restricted, with favour going to other better-recognised diseases. Funding for ALS research in Malta is therefore heavily reliant on charities, NGOs, and citizens. But even among these sections of society, how do you compete for funding against big diseases such as cancer and blood disorders that are highly prevalent in Malta, while motor neuron diseases are still fairly unknown?

'Science communication is increasingly important, and creative methods bring the most impact,' says Cauchi. ALS awareness surged thanks to the Ice Bucket Challenge, which initially had an unbelievable effect on the numbers of people who had even heard of the disease. The release of *The Theory of Everything*, a film documenting the life of Professor Stephen Hawking and the impact of motor neuron disease on his career, again did wonders for the awareness of ALS and brought it to the attention of millions globally. Malta has its own champion in the shape of Bjorn Formosa, who has turned his experience with the disease towards positive ends by dedicating his life to raising funding and awareness. Cauchi speaks very highly of him and the relationship they have, as he does with other patients. 'I would love to have more time for public engagement, however there are so many pressures that come with academia that communication can sometimes be left behind.'

Another positive result of all the ALS publicity and funding is that it is attracting students and enabling them to continue the research of the lab. Maia Lanfranco is a Masters Biochemistry student and was keen to join Cauchi's lab for deeply personal reasons. 'It was the immense suffering and eventually death of one of my relatives from this terrible condition which spurred me on to begin researching ALS,' Lanfranco recalls. 'What I enjoy about the research is finding creative methods of unravelling the mysterious ways in which ALS works.' Communicating the research is also just as important for students as it is for later-stage researchers, and it's a particular passion of Lanfranco's, who recently coordinated the lab's contribution at the national festival, Science in the City.

'The message is always that ALS is curable, but underfunded,' concludes Cauchi. And so the reliance on public funding is ever important, with one-off events such as the Ice Bucket Challenge being incredibly useful, but unreliable. With more consistent investment into both researching these diseases and keeping up a constant communication channel with citizens as well as patients, it is possible to envision a cure for motor neuron diseases, led by work being done right here in Malta.

Research at the Malta ALS/MND Lab is supported by the ALS Malta Foundation, facilitated by the Research Trust (RIDT) of the University of Malta.

Maia Lanfranco is supported by an Endeavour Scholarship (Malta), part-financed by the EU – European Social Fund under Operational Programme II – Cohesion Policy 2014–2020, "Investing in human capital to create more opportunities and promote the wellbeing of society".

Reliable renewables need storage

Renewable resources cannot be implemented if the energy they generate cannot be stored. ***Daniel Buhagiar*** *explains the solution they're cooking up at the University of Malta.*

Try and imagine living without a wallet or a bank account. As soon you get your paycheck, you have to spend it immediately; anything you can't spend is wasted. Can you imagine how inefficient this would be? How it would limit your growth?

Renewable energy sources face a similar problem, especially large offshore systems. They generate large quantities of energy that have to be used immediately, and since most of the time supply and demand do not match, lots of clean energy is wasted. The greater the use of renewables, the larger the problem stunting the clean energy market.

The solution? Store energy where it is generated, and use it when needed. Use of renewables would then parallel the energy demand, breaking the cycle of wasted resources, and delivering a bevy of benefits to industry, governments, consumers, and ultimately the planet. Producers would be able to sell more energy at lower prices, making it beneficial for them and accessible to consumers. With widespread adoption, governments could meet their green energy targets and consumers and communities would reap the rewards of a cleaner environment.

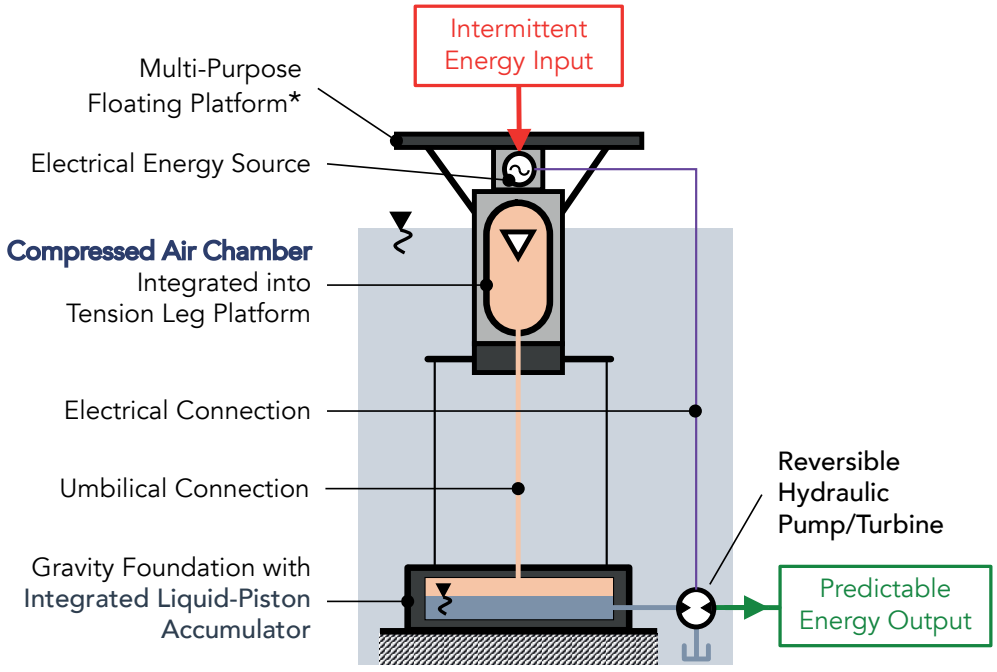
THE TROUBLE WITH BATTERIES

Batteries have transformed our lives. Consider mobile phones. Yet, while batteries are useful in a million different ways, especially when it comes to smaller applications, the same cannot be said for large-scale multi-megawatt storage. Moreover, current battery technologies often rely on harmful chemicals, lithium-ion in particular, that are notoriously difficult to recycle.

Back in 2014 this problem was at the centre of my postgraduate research. Together with my supervisor, Prof. Tonio Sant, and fellow researcher, Dr Robert Farrugia, we set out to find a storage solution. Cue fluid-based energy storage and compressed air systems.

In normal compressed air storage, the pressure of the system changes all the time, depending on how much charge there is. Think of this as a battery where the voltage is changing all the time. It is not a good idea. So the key challenge with compressed air energy storage systems is keeping the operating pressure stable.

The most notable concepts in the scientific field of energy generation and store were those being developed by MIT, the University of Nottingham, and the Fraunhoffer Institute in Germany. These systems were all designed for the offshore environment and suitable for large-scale storage, but they had one common drawback. The systems utilise hydrostatic pressure at the seabed, meaning the amount of energy stored is dependant on water depth. This limited



Schematic diagram of the FLASC technology

***Floating Wind, PV, Tidal & Wave Energy, Oil & Gas Applications, Artificial Island**

their use to areas with very deep water.

After weeks of intensive discussions, and mountains of rolled-up balls of paper, the 'aha!' moment arrived, and the Floating Liquid-piston Accumulator using Seawater under Compression (FLASC) was born.

TRYING SOMETHING NEW

FLASC uses two interconnected chambers, one at the seabed and one at the surface. Initially, both chambers contain a fixed volume of compressed air. To charge the system, electricity is used to pump seawater into the seabed chamber where it displaces the air, some which moves to the surface chamber and is further compressed, basically acting like a spring. To discharge, the pressurised water is released, passing it through a hydraulic turbine to recover the electricity. A stable pressure can be maintained by selecting the right ratio between the volumes of the two chambers, and limiting the volume of water being pumped to the bottom chamber. This configuration becomes particularly interesting when we consider how easily it can be integrated into existing floating platform designs (like offshore wind turbines). The surface chamber is added to the floating platform, contributing stabilising upthrust to keep the platform steady. This way, the seabed chamber can be easily anchored to the seabed or to existing gravity anchor designs.

The concept needed to be proven. The next step was to develop detailed thermodynamic models that would determine FLASC's potential performance and determine whether it could really be used to store energy. For this, we needed money.

Luckily, this venture coincided with the first ever Take-Off Seed Fund Award (TOSFA) launched by the University of Malta's (UM) Knowledge Transfer Office (KTO).

TOSFA is a fund for academics and entrepreneurs who want to either test their concepts or start commercialising existing work. I was sceptical, thinking the project was still too young, but Sant believed we could push the project forward through TOSFA. My doubts were exacerbated when I suffered a bumper-to-bumper accident on my way to the first information meeting! However, we persevered, and the application was eventually submitted. The plan was simple: build a small experimental setup.

A few weeks later we received news that things did not go as planned. We did not get money for the equipment we wanted, but it was not a sad day for the team. We actually got something better. After listening to Prof. Sant's pitch, the panel vetting our application decided that it was better to use the money requested to submit a patent and protect the intellectual property (IP). For a team who had not yet realised that

we had something worth protecting, this was amazing news! It also brought us into contact with Andras Havasi, a Knowledge Transfer Executive, who would go on to become a close advisor on aspects of IP and commercialisation.

Work began on the patent, but when the Malta Chamber of Science and Technology (MCST) launched their Fusion Grant, our ambition to build a working system prevailed. We jumped at the opportunity and progressed through many commercialisation stages. Our major snag was in finding the right people to build and deploy FLASC at sea.

After speaking to our colleagues at the KTO, they helped us engage with Medserv plc, a market leader in offshore logistics for the oil and gas industry. With the KTO's input, we prepared a pitch and presented it to Medserv chairman Anthony Diacono.

Diacono took a keen interest in the project and told us that the board would consider it. We anxiously awaited a response, and it arrived a few weeks later—Medserv were in!

WHEN IT ALL COMES TOGETHER

The collaboration was successfully funded by MCST to the tune of €200,000, money that would see my Ph.D. work transform from thesis into a real product. At this point, I was engaged as a postdoc at the Department of Mechanical Engineering to design the prototype itself, and the UM started working closely with Medserv engineers Thomas Gauci and Jean Marc Pace who were just as enthusiastic about the project as we were. With all this in place, the first FLASC prototype started taking shape.

The process was not without its hiccups. The system required highly specialised equipment, some of which needed to operate underwater. As a team, we pooled all our experience and contacts to source everything. Some additional funding through the UM's research trust (RIDT) was quickly put to use in developing a system for monitoring the surface temperature of FLASC pressure vessels.

Following this was a modular testing phase at the Institute for Sustainable Energy, graciously hosted by Prof. Luciano Mule' Stagno. Students Luke Aquilina (MGSS-funded MSc by research) and Daniel Farrugia, contributed greatly to this effort. In the meantime, under Gauci's direction, Medserv's highly skilled welders constructed the main sections of the prototype and assembled everything at their facilities.

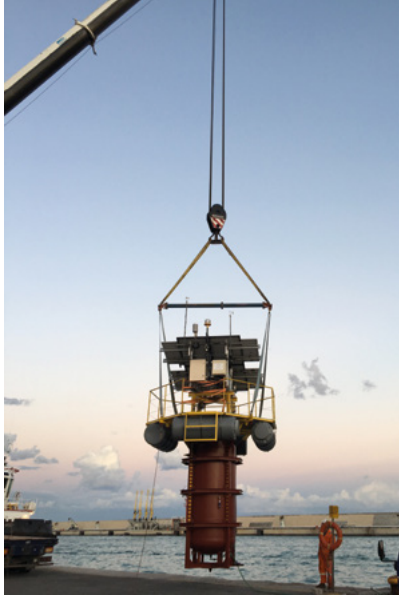
The prototype has now been deployed at the Dock 1 in Bormla (with the support of Transport Malta, the American University of Malta,

After weeks of intensive discussions, and mountains of rolled-up balls of paper, the "aha!" moment arrived.

1 2 3 4
5 6 7

1. Tonio Sant
2. Daniel Buhagiar
3. Robert N. Farrugia
4. Thomas Gauci
5. Daniel Farrugia
6. Luke Aquilina
7. Federica Maria Strati

Daniel Buhagiar checking that the FLASC pressure vessel is properly secured to the cement platform



FLASC floater being lowered into the water for buoyancy tests at the Medserv quayside

Medserv construction crane lifting the FLASC pressure vessel

Daniel Buhagiar and Tonio Sant overseeing the deployment of FLASC at sea

FLASC pressure vessel is successfully lowered into the sea

and the Bormla local council). The system will be charged using solar photovoltaic panels as opposed to a wind turbine due to the relatively small scale of the set-up. On-board sensors will monitor the temperatures and pressures of the compressed air chambers, along with meteorological data and other system parameters. This data will be fundamental to expanding the current understanding of the system and validating existing computational models. A key aspect of FLASC technology is how it exchanges heat with its surroundings as it charges and discharges, since this affects the efficiency of the system. This will be closely monitored throughout the 18-month testing window. Experimental data will also enable us to explore the application of the FLASC technology to desalination and to the liquefaction of natural gas. Thanks to funding through the Maritime Seed Fund, this work is being undertaken by Dr Federica Maria Strati, the newest member of the FLASC team.

This prototype has built our team's confidence and credibility to push the project towards a commercial product. Our ambition is to license the technology to offshore systems manufacturers and have them integrate FLASC into their designs. We have already filed patents in the United States, Europe, China, and Japan, so momentum is growing, and we are actively seeking investors and funding opportunities to continue on this journey.

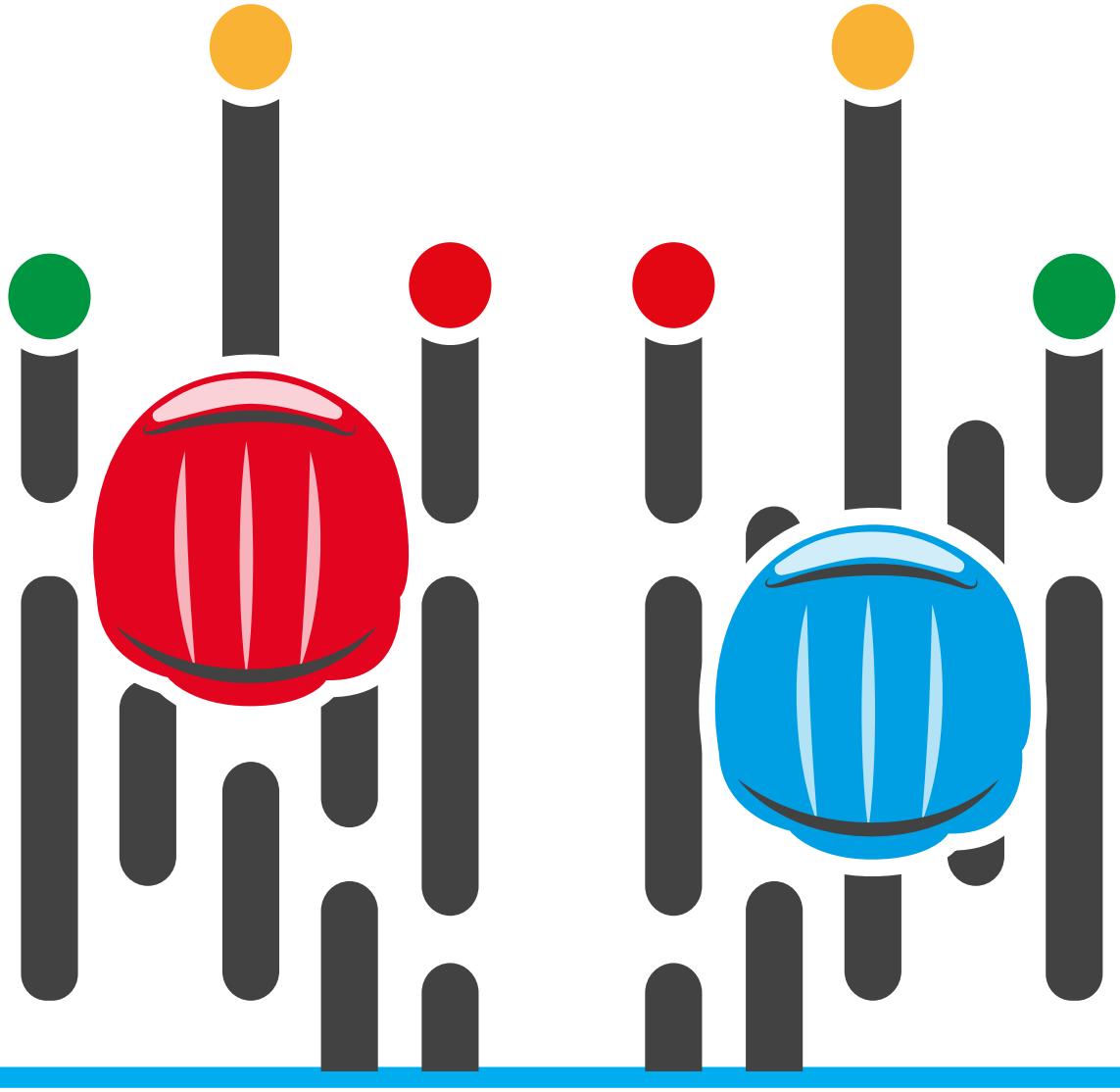
This effort has recently brought us to the PowerUp! regional final in Greece (the biggest regional competition for energy startups in central and eastern Europe) where Sant and myself undertook intensive training in pitching and commercialisation. We went up against seven Greek teams and won, passing through to the European Grand Final, where we will compete to become one of the top energy startups in Europe.

We hope to see our technology applied within the next few years. Our goal is to give offshore renewables a means to store extra energy and allow these systems to better meet demand. Unlocking the problem of storage is key to increasing renewables on the grid, towards a cooler and brighter future for generations to come.

More information on FLASC can be found at: www.offshoreenergystorage.com

START UP

EasyPeasyCoding:
Giving kids a head start



In today's plugged-in world, kids need to think critically and learn basic coding. ***Cassi Camilleri*** *speaks to Headstart founder* ***Klaus Conrad*** *about his mission to give children the leg up they need to learn these key skills.*

For most, education is one of life's primary objectives. Be it centered around academia, the relationships we cherish, or even ourselves, knowledge is a coveted boon. Childhood is shaped by learning and the teachers who make it possible. But while many educators have the best of intentions to instill children with a healthy curiosity about the world, wide gaps in curricula continue to afflict their efforts.

With three young boys of his own, Klaus Conrad sees these holes as 'troublesome'. And he's not the only one. The skills gap growing in science, technology, engineering, and math (STEM) is often described by experts as a bane to Malta and the world's economies. 'I have often complained that schools don't do enough when it comes to teaching kids essential skills like critical thinking. For the first 16 years of their life, they're expected to sit and listen instead of participate.'

Conrad started his career as a teacher and has first-hand knowledge of the difficulty met when trying to change teaching approaches. 'There is a rigidity inherent in the system,' he says. 'That is why there is such a high turnover of teachers in the sector. It's stifling.'

Conrad himself moved on to the private sector, working as a software specialist with a Canadian company in corporate performance management. 'I loved it,' he says, 'but I realised that for many years decisions were out of my hands. Bad choices were made and progress stalled. I wanted to start making the decisions, taking the responsibility, but also reaping the benefits.'

Knowing that he needed a change in his life, Conrad started mulling over the skills gap question again. He was riddled with questions: how could he address the skills gap issue and help both children and schools? Where should he start?

Conrad considered doing an MBA but quickly dismissed the idea, as it would have 'trained [him] to work in an established structure.' He also thought about enrolling at the renowned Edward de Bono Institute to read for a course in creative thinking, 'but it involved a residency in Sweden at the time. That was not going to be possible for me with a family and kids, so it was immediately ruled out,' he says. Finally, he settled on a Masters in Entrepreneurship at the University of Malta's Centre for Entrepreneurship and Business Incubation (CEBI).

Talking about his experience in the course, Conrad does not hold back. 'It was life changing,' he states. 'It gave me the knowledge I needed and asked the right questions.' A formative

'Learning coding and programming is much like learning an instrument. You need practice.'

point was when Prof. Russell Smith asked the class to think about what would make them happy.

'I always loved teaching but the last thing I wanted to do was move into something that is familiar, and regretting it,' says Conrad. That is when Headstart Ltd. found its feet: an educational technology (edtech) company set up to identify problems within education and find practical solutions for them.

MIND THE GAP

With the rise of technology, coding is becoming a required skill. Writing in the language of computers is the backbone of nearly everything related to technology. Your browser, your phone, the apps on it, social media, and every other website in existence, all of them are built with code. This said, in Europe, according to various EU studies, there will be around 750,000 unoccupied jobs by 2020. With this gap in mind, Conrad started looking into local after-school activities, and found another. While some short summer courses existed, he found no long-term, structured activities related to technology and programing.

'Learning coding and programming is much like learning an instrument. You need practice. You need to do it over and over again. The fact that there is nothing along the same lines is just nonsensical,' says Conrad. Alarmed by the lack of outcry at children missing this opportunity, he took an analytical approach and looked into the thinking behind it. 'I soon understood why this was happening. The people who realise coding is important are normally from IT, so they teach their own kids. The ones who don't know coding don't seek it out.'

And so, Headstart began developing a series of after-school coding lessons, starting with EasyPeasyCoding.

EasyPeasyCoding is for kids between the ages of five and ten. 'They come to the lessons, have fun, play with robots, and develop computational thinking skills. It's that simple,' Conrad says. Another 'simple' but genius idea he had was to also encourage parents to attend. 'When you have five year olds, what is the most important thing in their lives? Their parents. Engage the parents and you have the kids. They learn together and start using the same language. The whole thing becomes a nourishing family activity,' Conrad smiles.

To make sure kids continue on their educational journey, they then created the tech club *TeenTronik* with sessions aimed at 11 to 16-year-olds. 'In Malta, we have a problem with attracting young people to education. We have a problem with keeping them within the educational system,' Conrad says. Looking at the country's rate of early school leaving, he is not wrong. In a previous THINK article, we spoke to Prof. Carmel Borg, who shed light on the situation. His studies showed that two out of 10 students in Malta were early school leavers, meaning that a fifth of our

local student population is neither in school, nor in training, and with less than five SEC exams under their belt.

'Our approach is to bring them back by offering education that is fun, engaging, and practical. We learn how to build a circuit, not just about the theory of electricity,' says Conrad. 'It's about giving kids the skills to turn their ideas into actual tangible things from the word go. We foster the entrepreneurs of tomorrow by giving them the skills they need to produce the products they will be making.'

ALL ABOARD! PARTNERSHIPS AND CONNECTIONS

One of the biggest leaps for the venture came about by shifting thinking. When developing the courses, Conrad kept reminding the team that they did not have to reinvent the wheel. He notes how other companies in the edtech sector not only invest in crafting their version of the perfect course but they also build their own line of products to go with it from scratch and roll everything out.

'What I discovered is that if you provide a service, you don't have to provide every single product yourself. You can identify what works and bring the different elements together. In our case, we built a curriculum and became curators of various products that acted as resources for kids to work with. One of Headstart's first partners were Evollve Inc., a tech company whose focus is on introducing new ways to combine social interaction with digital apps. Their star product has been the famous line-sensing robot, Ozobot.

Conrad says, 'I was looking for a product that has zero barriers for users. I couldn't find anything simpler than paper and a marker and asking people to draw. Parents and children could use the Ozobot so easily and learn how to give commands while doing it. As we started using Ozobot in classroom settings, we also realised that we could differentiate the product from others by directly showing parents how useful and educational it was. This in turn meant that we established a direct distribution channel to parents, bypassing retailers. We were adding real value for the manufacturer.'

When I ask how Conrad establishes these partnerships, he gave a simple answer: 'We reach out to companies on the phone. We call them up and say we like their work and would like to use it within our courses. When you have another person at the end of the line, the dynamic is more conducive to success than an email.'

Now that the course has grown, companies themselves are approaching Headstart to introduce their products. After a successful Kickstarter campaign, Scottish robotics company Robotical launched Marty, a new generation, 3D-printed, customisable walking robot. Having met at a local robotics fair, Robotical sent Headstart the very first production of Marty worldwide to be used in the programme.

'When people see that you believe in what you're doing, that goes a long long way. Even if you don't have the financial clout. A lot of business boils down to personal relationships,' Conrad asserts.

GETTING THERE

But the journey to success hasn't been without its challenges. We now live in a world that is becoming increasingly obsessed with work. The more hours we spend at our desks, slaving

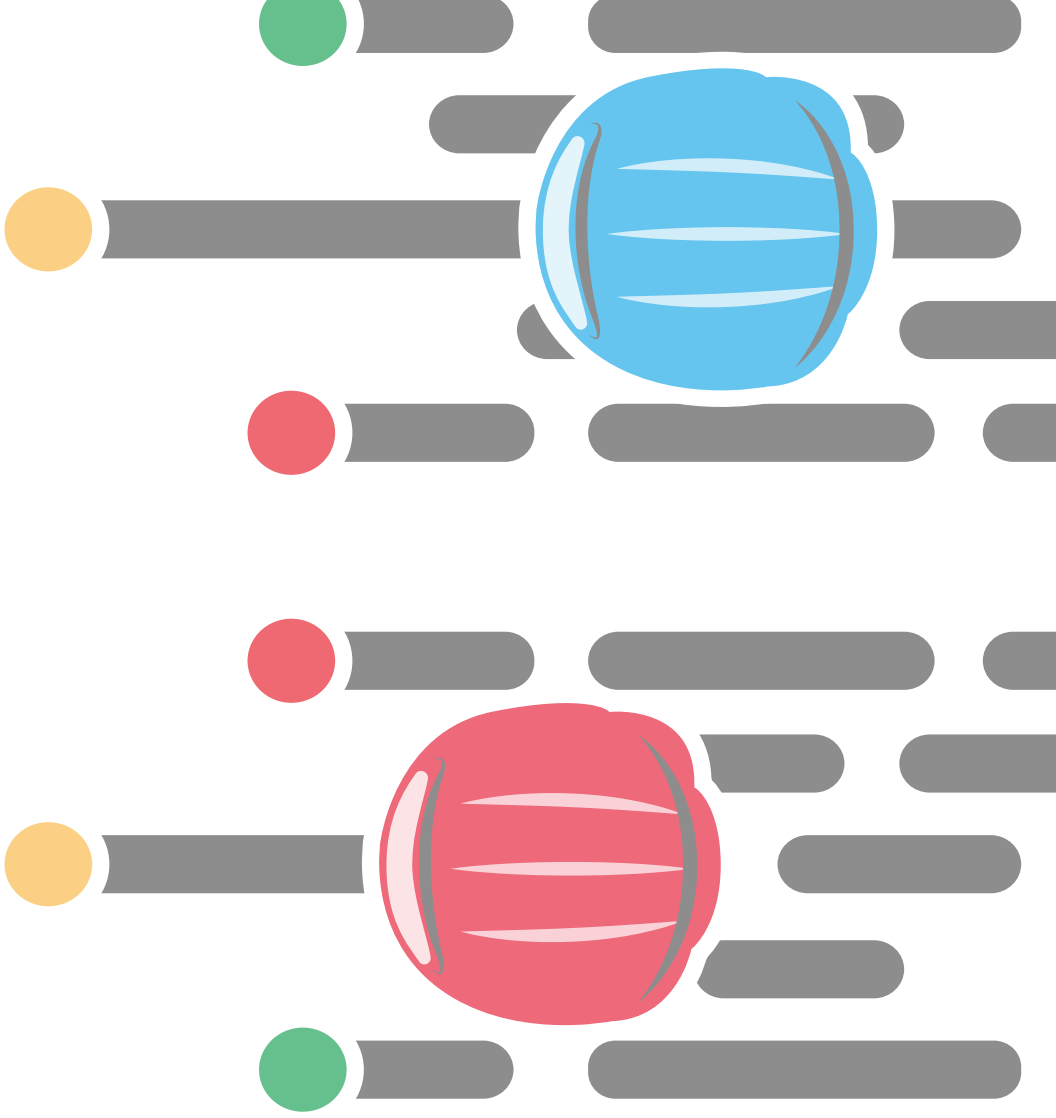
'We foster the entrepreneurs of tomorrow by giving them the skills they need to produce the products they will be making.'

away, the better we are, apparently. 'When it comes to entrepreneurship, there's this 'all or nothing' mentality that just doesn't work. I reject the notion completely.' When Headstart was in its infancy, Conrad had a specific plan in mind for how it would work. Having a family, he wanted to make sure that the business would not put them at risk in any way.

'A lot of these ideas one hears: that you have to leap, you have to fly, you have to give it 100%. It's damaging. Everyone has their own circumstances and responsibilities. What really makes an entrepreneur is somebody able to define which movement they need to make to achieve what they want to do. If I can't fly because I have children tying me down, then I need to find a way to get to point B in a way that works for me.'

Conrad encourages budding entrepreneurs to carve their own path.

Klaus Conrad during the Ideas from Europe conference



'You don't have to stick with any particular motto of how things should be. You need to find your own. This romanticised idea of being a pauper while you build a business, pay off your investors and move to something else is damaging. No. You need to find a way to make it sustainable from the get-go to have it grow.'

This approach has paid off for Headstart. After being founded in October 2015 and launched officially in January 2016, they began giving classes in three schools. Now, they are in seven with demands and requests chasing them wherever they go. Due to the retention rate of students, currently standing at 90%, Headstart is consistently looking for new teachers, and this has been a tough process.

'Finding the right people is absolutely the biggest challenge,' says Conrad, pointing out his belief that teachers have the biggest responsibility in the world—to instill the next generation with curiosity, knowledge, and values. However, Conrad remarks how he has experienced an unwillingness to learn and adopt new approaches among some teachers that he has met. 'But for me, growing fast is not a priority. I want us to grow at a rate that maintains quality, because that is the most important part. This is how we remain sustainable,' he says.

FRUITFUL THOUGHTS

For Conrad and Headstart, the future looks bountiful. Recently, the company launched its first set of classes in France, Dubai, Abu Dhabi, and Belgium, and will soon launch in Chile, Egypt, Lebanon, and Jordan. The one thing Conrad says he will continue to do throughout this journey is to listen to the kids that attend their classes. 'Kids are smart and we need to listen to them. We will continue to do so and build on the work we have done, offering them more fun and more diversity,' he says.

At the moment, Headstart is working with kids. Conrad says they are shaping 'little entrepreneurs' by bringing subjects together and crossing disciplinary divides to create a teaching structure that is more holistic. He hoped that Headstart's approach will have ripples into the future, not only in growing the volume of technical professionals, but by connecting them. 'Us 'nerds' grow up alone. With Headstart, we're bringing them together in a space that celebrates and encourages them.' T

LAB TO LIFE

SMART SEARCH FOR MALTESE LEGAL PROFESSIONALS

***Cassi Camilleri** talks to **Dr Albert Gatt** and **Prof. Gordon J. Pace** about their efforts to make life easier for legal professionals across the island by digitising Maltese law through an app called Assiduity.*

You would be forgiven for thinking that information technology and the legal world do not mix. In ways, the two disciplines are diametrically opposed: one being as 'old skool' as they come, the other still-nascent by comparison. If they were people, they would definitely not get along. The technological revolution sent lawmakers into an unrelenting frenzy, trying to keep up with an endless stream of new *modus operandi*, all the while creating effective regulations to keep all stakeholders safe.

That said, technology is now being incorporated into the legal process, and not just by using computers and word processing to draft out contracts and agreements. Researchers from the University of Malta (UM) are collaborating with legal professionals to create an app called Assiduity that is set to revolutionise Maltese lawyers' workflow.

WHERE DOES THE MONEY GO?

To receive legal advice, you need two things: time and money. This notion is so pervasive that a large portion of people willingly give up on a legal issue, even before they start pursuing it through the proper channels. Why? Because they want to avoid the stress that comes with even trying to pursue legal action. Upon reflection, one might pause for a moment to question this status quo, asking where the money actually goes? A one word answer follows: research.

Research is where the bulk of the money, and time is spent in the legal arena. This is due to the meticulous nature of legal work, requiring lawyers to trawl serially through mountains of legislation and policy documents, referencing and cross referencing, to build up a case. It was this issue brought together UM researchers Dr Albert Gatt (Institute of Linguistics and Language Technology) and Prof. Gordon J. Pace (Department of Computer Science).

'For quite a while we've been interested in this problem of interpreting texts and getting to their underlying meaning,' says Gatt. Being a computational linguist, Gatt builds models of how human language is understood, in the hope of making artificial intelligence models smarter and more intuitive. As a computer scientist, Pace had already started to experiment with law and text: 'At one stage I started working on logical

By the end of 2018 Gatt and Pace want to have a prototype of the app ready and in the hands of law students.

techniques to analyse law. But this was from a purely mathematical perspective. So, the next step was to push it forward and work with natural language text.'

Gatt sees 'meaning' as something that underlies language. 'It is the logic in a piece of law that describes who has to do what in a given situation, and when.' Problems arise when the English the law is written in gets in the way of the underlying meaning itself. 'So as I focus on techniques to analyse language, Gordon develops his formulas to represent meaning.' And a great partnership was born.

GOING DEEPER

Assiduity's beginnings are found in a different project. Gatt and Pace were initially collaborating on a contract drafting tool. The software was intended to have various functions such as highlighting clauses relevant to the lessee in the case of a rental agreement. It would allow lawyers to leave notes for each other on a contract. It could also be used for tracking changes in law. 'The idea was to have lawyers' brains dedicated to reasoning and build a case, instead of being occupied with the tedious double-checking and sifting through masses of documents to ensure there are no inconsistencies,' says Gatt.

Pace and Gatt built a prototype of the tool, but the need for a more structured and searchable representation of legal data began to feel like a requirement in its own right, a potentially valuable standalone application for practitioners in the field. 'Before you can start doing intelligent stuff with an article of law, first you have to break it up into chunks and find the links between the different documents,' Gatt says. And this is how Assiduity came to the fore.

'With Assiduity we want to create an app that enables law students and professionals to search through the body of Maltese laws intelligently. We are applying techniques of artificial intelligence to find structure in the documents and represent all that information in a database, which the app will then query,' says Pace.

To work on this project and provide an end user's perspective, Pace and Gatt partnered up with Wayne Pisani from legal firm Grant Thornton. Asked how the app would impact the work they do, he said that 'Assiduity will help our legal team, and me, exhaust all Maltese legislative references for any job at hand in a timely and efficient manner.' This would allow professionals to focus their time on 'more demanding core legal advisory aspects, enabling the efficient application of available resources.' Pisani added, 'Employing human resources to navigate pieces of legislation when such talent can be better employed towards applied legal knowledge is certainly counterproductive.'

ONE STEP AT A TIME

The second step involves squeezing out the information from that text. Law is essentially a set of rules and regulations divided across categories. 'It's a bit like playing a game of Nomic,' says Gatt, a game created in 1982 by philosopher Peter Suber, in which the rules of the game include

Dr Albert Gatt

Prof. Gordon J. Pace

mechanisms for the players to change those rules. In Nomic, the game ends when you put a contradiction in the rules. 'In real life, we need to make sure laws don't contradict either,' says Gatt. 'This is the nightmare that the UK is facing while they're going through the Brexit process.'

'By annotating the text digitally, the data will become self-describing. Imagine a new layer of information on top of the words themselves that a machine would be able to read, making the links between laws explicit. This way, all laws that talk about the same things can be grouped together. If you have lots of clauses here and there that deal with theft, you should be able to access those together,' says Pace. 'We want to create a web of connections, not just one document to another, but across parts of the same document, all of the links ranked by importance to best help the user,' says Gatt.

This process will also help highlight inconsistencies in the legal framework. 'Something our work has shown us is the problematic discrepancies between Maltese and English legal jargon. In some cases, comparing the Maltese and English versions of a law can shed light on ambiguities or inconsistencies that creep in during the translation process,' says Gatt. Maltese Law is increasingly being built upon foreign legislation; however, Maltese Courts themselves give priority to the Maltese translation, creating potential issues. 'Maltese Law can be likened to a game of telephone: a translation of a translation. The true

messages can easily get lost along the way, wreaking havoc,' says Pace.

The next step will be to package the extracted information into a database. 'What is challenging here is designing user experience,' notes Gatt. 'You need to make it easy, but you need to make sure that you will provide control. You have a legal browser, you read the chapter, and you see these annotations. This search and browse needs to be combined in an intuitive way.'

PLANS APLENTY

Assiduity may be in its early stages, but there is much promise and drive behind it. By the end of 2018 Gatt and Pace want to have a prototype of the app ready and in the hands of law students. 'We want to get the students to start using the app, receive their feedback, and then roll it out, after tweaks and amendments.' The pair are also considering conducting a market research campaign to get more information about how it will be used and if they are on the right path. 'This way we find out how it will be used in the real world,' says Pace.

As Pisani rightly said, when it comes to Assiduity, 'Whatever the application, be it within a law firm, an in-house legal department, a non-profit legal aid organization, a firm of architects, a law academy, or an individual's basic interest in a legal matter, the intuitive timely availability of knowledge is essential; efficiency is key.' T

WANDERING FREE

A new study is trying to help people with dementia become more independent, via devices that use complex algorithms to recognise human activities. Simultaneously, their carers will receive unique insights into the condition. Here, ***Iggy Fenech*** *chats to* ***Dr Conrad Attard*** *to understand how pervasive electronic monitoring works and what impact it is having.*

You don't even have to be paying attention to notice that your body is constantly reminding you to do things. If you do not eat, you get hunger pangs. If you are parched, your mouth dries up. If you hear a loud noise, your reflexes kick in. In its own amazing way, your body keeps you alive, nourished, and safe. But what happens when cognitive functions deteriorate, taking with them that link between body and brain?

Dementia is a condition that affects everything from memory to orientation, language to judgement, and afflicts tens of millions of people around the globe. It also impacts those nearest and dearest to the sufferers, as the more advanced the condition becomes, the more monitoring a patient requires.

It was with this in mind that Dr Conrad Attard, a Computer Information Systems lecturer (Faculty of ICT, University of Malta [UM]), set out to conduct a study to improve the use of wearable healthcare devices with pervasive electronic monitoring (PEM) capabilities.

'One of the most unfortunate side-effects of dementia is that sufferers are often stopped from walking about because of the risk of injury and fatality,' explains Attard. 'Although 'wandering', as we call it, can be a positive thing, helping patients remain active, it requires someone to be with them constantly. But through a PEM system, which uses sensor-based monitoring, we could give a leap in the quality of life patients with dementia have.'

Currently in its early stages, researchers want to create a framework through which a wearable or implanted device can function.

'We want to make it easier for carers to keep an eye on dementia patients without actually being physically present with them all the time. This can be done by creating datasets simulating complex human activity recognition, that would send updates to caregivers in real-time through a tablet application. The implications are huge.'

Dr Conrad Attard

The real challenge here, however, is not to just track and let carers know when a person with dementia is at risk, but rather to anticipate danger. Therefore the device needs to be able to pre-empt dangerous scenarios, which can be anything from ingesting soap to walking out of hospital, and then give carers enough time to get to the patient before they potentially hurt themselves.

The proposed wearable devices would pick up on patterns of wandering, such as zigzagging, or walking backwards and forwards, and be able to differentiate between when a patient is walking aimlessly and when they are walking with purpose. Then, it would also need to find the probability of danger for the patient in their surroundings. Additionally, the device could serve as a way of collecting data that helps researchers and doctors understand dementia.

'In order to turn this concept into reality, we need to improve our technologies and ensure that they are trusted by caregivers and comfortable for patients,' continues Attard, whose background is in enterprise solutions, particularly aviation. 'At this point in time we are testing the best solution through our recently established lab. Here, volunteers can simulate potential scenarios related to dementia and wandering, so that future devices would have the information needed to recognise potentially dangerous situations.

'Of course the data required for such a project is vast, as collecting sensory data from devices wouldn't only need to work remotely, but its software would also need to be able to detect changes in the environment that could stop it from properly performing. It is for this reason that doctors, nurses, physiotherapists, occupational therapists, and management from St Vincent de Paul Residence (SVPR)—the people who work directly with dementia patients—are being consulted at every stage.'

Working together with Joseph Bonello (Department of Computer Information Systems, UM) and Dr Ronald Fiorientino (SVPR), Attard does not have all the funding for the project, but he and his team are adamant to keep at it.

'According to Eurodrem 2013, an estimated 5,301 people have been diagnosed with dementia in Malta. That's 1.26% of the population! Such a device could revolutionise the way we care for patients,' Attard concludes.

The application of this technology is not limited to dementia cases. A new thesis by Attard and his team argues that the data being collected for the hypothetical device has the potential to be used to monitor many other chronic illnesses, and lead to the evolution of other technologies. In fact, they are looking to make all the collected data available to other researchers so as to facilitate the process for further technological development.

The project, which only commenced a year ago, is expected to take years to complete, but the potential impact it could have on thousands of people's quality of life is what continues to drive Attard and his team.

This research is part of a project supported by Information Systems Limited (ISL) through the Research, Innovation and Development Trust (RIDT) in collaboration with SVPR and the UM.

Photo by Anna Runefelt, edited by Pamela Baldacchino

Living between two worlds

Valletta 2018 Foundation

Cesar A. Cruz famously said that 'art should comfort the disturbed and disturb the comfortable.' People have placed plenty of emphasis on the second half of that sentence—art is often used to provoke and make the viewer rethink their perception of the world. But what about the first half of that famous maxim? Can art serve as a comfort to those enduring difficult times? Pamela Baldacchino, the artist who founded the *Deep Shelter* project, certainly believes so.

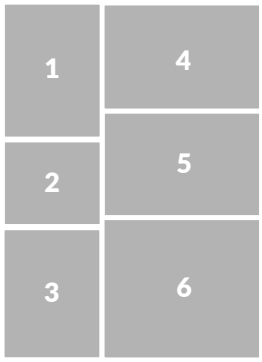
Baldacchino has experience with serious illness. Not only is she a qualified nurse, but she also suffered from fibromyalgia for 14 years, a chronic condition characterised by constant pain, fatigue, and trouble sleeping.

While reading for her Master's degree in Fine Arts, Baldacchino created an audiovisual work purposely designed for a hospital environment. The work expressed empathy with patients by erasing the distinction between the sufferer and the audience, visually and symbolically showing states that merge into one another; the flesh of the artist's hand becomes one with the 'flesh of the sea', for example. In another piece, the boundaries between sky, earth, and tree blur. She wanted to explore the concept further, to take her ideas beyond her degree and see them implemented in a practical manner within a clinical environment. With this goal in mind, she successfully acquired funding from the TAKEOFF Business Incubation Centre (University of Malta) as well as Arts Council Malta. Deep Shelter also forms part of the Valletta 2018 Cultural Programme and was presented during the *Living Cities, Liveable Spaces* conference held in November.

Others embraced Baldacchino's approach to use art in helping those suffering from illness. A mutual friend introduced her to Dr Benna Chase, a psychologist within the Oncology Department (Mater Dei Hospital), who started using Baldacchino's work during therapy with her patients. They then met clinical aromatherapist Marika Fleri, and the trio was complete. 'We realised how much in sync we were. Through completely different mediums, we came together with instant understanding,' Chase says.

As the Deep Shelter project, they have organised two series of sensory workshops, consisting of six sessions each, as well as artist workshops for the creation and donation of artworks to clinical hospital spaces. Some of these workshops were aimed at people in palliative care, many of whom are aware that they are nearing the end of their lives. The workshops aimed to help them recognise, create, and make use of the 'language' that art provides when words are not enough.

'In one of the workshops, author Leanne Ellul started reading from *Tereża*, a book she translated about



1. Photo by Eliza Von Brockdorff
2. Photo by Sara Pace
3. Photo by Pamela Baldacchino
4. Photo by Pamela Baldacchino
***5.* Dr Benna Chase, Marika Fleri & Pamela Baldacchino.**
Photo by Tim Lewis
6. Photo by Pamela Baldacchino

Do you think art can be used as a tool to process the experience of a serious illness?

Most certainly. I believe that art is a very powerful tool, which if carried out by professionals in their various fields, serves to stimulate not only the will to overcome a serious illness, but it also helps the individual concerned to reach out for help. More important still it leads the individual towards accepting help, learning that seeking help is not a weakness but, to the contrary,

It is difficult for patients whose lives are punctuated by clinical sights, sounds, and smells to feel in tune with nature.

a girl during the Second World War. Several of the patients had lived that experience and it took them back to their own childhoods. Then, we asked composer and percussionist musician Luke Baldacchino to pick up on the feelings conveyed in the writing, compose a piece of music, and play. We realised that something was happening within them,' Baldacchino says. The most marvelous transformation was in an elderly woman who usually sat perfectly still and was almost totally unresponsive to the outside world. 'While we were using spoken language, we couldn't manage to get through, but then a piece of music brought a rare smile to her face. Through this alternate sensory experience, we were allowing processing to happen; it's a form of therapy as well.'

Nature has always been central to the context of the Deep Shelter project; it becomes 'a metaphor of the self, where both fluidity and tension are captured.' But it is difficult for patients whose lives are punctuated by clinical sights, sounds, and smells to feel in tune with nature. With the help of her aromatherapy oils, Fleri brings in an element of nature and tactility to the patients. 'The kind of experiences we are trying to create are aimed at making the patient feel contained and held,' Baldacchino explains. 'We want to provide something that supports their gritty journey towards acceptance. Even if it does not fit into what we traditionally think of as contemporary art, it fulfils the scope.' She expresses her frustration with the art in spaces where people are undergoing medical treatment that is merely 'decorative' or 'clever', and does not provide any sustenance to the patient's emotional well being. There has to be a story woven behind the artwork that leads one to feel understood when they are going through a time of change, upheaval, or trauma.'

Baldacchino, Chase, and Fleri have received both support and contempt about the project's goal to derive value from art for the process of healing. However, the patients that the Deep Shelter project has treated are unequivocal about its benefits.

One patient says she believes the workshops serve to 'release' emotions, while supporting them throughout their different journeys. When she felt that she had nothing to lose, the artistic outlet Deep Shelter provided gave her a way to release the emotions of anger, fear, and regret she had been holding within for so long. 'The health system needs to be more open to other therapies to be able to provide a truly holistic healing modality, incorporating mind and body and not seeing the person as 'parts''.

Humans are the only species on the planet with the ability to tell stories about their life through art and sensual expression. But during the cancer journey, it is harder to find yourself and your experiences reflected in a meaningful way. The Deep Shelter project seizes art's potential as a means to process illness, pain, and trauma and puts that power into the hands of the people who need it most. **T**

Encounters with the unseen

Dr Maria Felice *works in a little-known but highly sought-after field of engineering that keeps our trains, planes, and roller coasters running safely. She tells* ***Veronica Stivala*** *how her passion for mathematics and physics, coupled with the desire to do a meaningful job, led her to where she is today.*

Non-Destructive Testing (NDT) is a field of engineering few know about. It uses ultrasound, X-rays, and other techniques to check for defects in everything from bridges and airplanes to roller coasters. Engineer Dr Maria Felice applies all the above to aerospace engines where miniscule, millimetre-sized cracks can have catastrophic consequences.

Since primary school, Felice has harboured a love for the sciences and maths. She says she found immense satisfaction in how 'logical and neat' everything looked from a mathematical perspective when problems are solved. This inclination continued into her university years, seeing her reading for an undergraduate degree in Mechanical Engineering at the University of Malta. She also wanted to contribute to society. 'I think nearly all science and engineering jobs are beneficial to society. But I wanted to delve into engineering because I thought the benefits would be more tangible.'

Looking back on this time, Felice praises the course, pointing out computer programming as one of the strong points. 'It was great that we were taught computer programming since this is so important for engineering, yet not always part of engineering degrees,' she notes. 'Most devices nowadays have a computer inside them, and the physical world and digital world overlap so much that engineers rarely deal with just the physical aspects of a system. Also, computer simulations are extremely widespread. So even if an engineer is working on something very physical, like testing the strength of a material, it is likely that they will perform computer simulations to understand this,' Felice says.

She celebrated wrapping up her undergrad by diving straight into an Engineering Doctorate (EngD) in Bristol with a strong link to industry. Felice worked with Rolls-Royce's aerospace arm. The opportunity was 'very coincidental' according to Felice.

While working as a student research assistant at Strathclyde University, Felice was reading up about different EngD programmes online. It was there that she discovered one in Non-Destructive Testing. 'One of the EngD's managers was based at Strathclyde, so I set up a meeting with him.' Everything

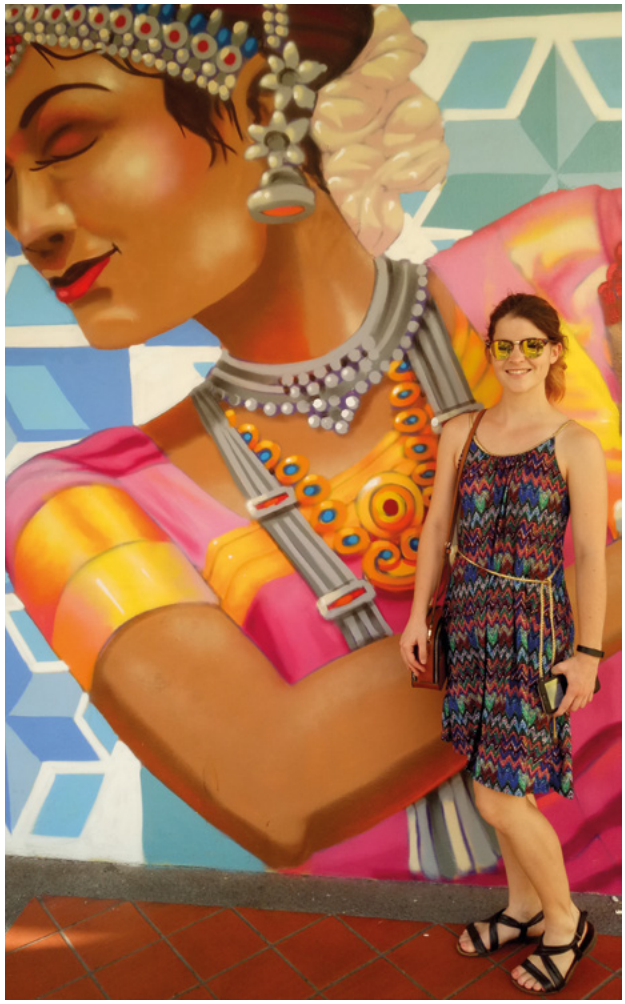
For her project, she developed a method of obtaining real stress corrosion crack shapes from X-ray Computed Tomography (CT) images.

else, including her sponsorship from Rolls-Royce, followed from there.

Throughout Felice's EngD, she focused on stress corrosion cracks in aerospace engines, complex-shaped cracks that can develop in components as they are being used. They can grow quickly and are challenging to detect, making them very dangerous. Explaining further, she notes, 'there was motivation to develop an inspection for such cracks. Computer simulations can be extremely useful for optimising an inspection; however, such simulations are often slow and unrealistic.' For her project, she developed a method of obtaining real stress corrosion crack shapes from X-ray Computed Tomography (CT) images. 'I inputted these into an efficient ultrasonic computer model developed at the University of Bristol, thereby achieving more realistic results than when cracks are assumed to have simple shapes. This approach could then be used to optimise the inspection by modelling different inspection designs,' she says. Interestingly, towards the end of her EngD she worked on a smaller project that measured sub-millimetre cracks accurately, which ended up being more easily transferrable to industry. It gained more recognition than her main project. She wrote a paper on this topic that has been downloaded and cited many times. The topic is now being pursued further by researchers.

Felice is indeed a very successful, dedicated scientist, but as with anything worth achieving, there were many difficult moments. She recalls all the exams and associated stress during her undergraduate years. 'I hated the fact that months, or even years, of work all boiled down to a few hours of exams,' she notes, though the exam meant that a big chunk of work was over. With the EngD, she did not have exams but instead several months of work could lead to little reward. 'In terms of overcoming these difficulties, experience taught me that stressing out did not improve my performance. So I tried to calm down and put things into perspective. Those nearest to me were always very supportive,' she says.

But all's well that ends well. During her EngD journey she learnt about the Manufacturing Technology Centre (MTC) in Coventry. The MTC is one of seven High Value Manufacturing Catapult centres the British government set up to increase the uptake of new technology by UK companies. Felice's talent and hard work saw her landing



Top: Maria in Chinatown in central Singapore.
Bottom left: Maria in Little India in Singapore.
Bottom Right: Steel plate being inspected for internal defects using ultrasonic testing.
Opposite Page: Maria descending from the summit of Mount Rinjani in Indonesia.

the position of Research Engineer in Metrology and NDT at MTC.

Here, she worked on a range of inspection projects for industrial partners. While a lot of the information is confidential, Felice explains how additive manufacturing (3D printing) is the new kid on the block now, changing the engineering landscape. Felice tells us how additive manufactured metal parts are now coming into play, creating difficulties for inspection processes. 'Manufacturing companies benefit greatly from the work we did there because we could try out different techniques to test their components, most of which were typically very expensive, as in the case of aerospace engine parts. They also benefitted from the human resource at MTC. While any one company might have one or two in-house NDT specialists, at MTC there were about eight of us,' she explains.

'The job was a great mix of technical work, customer liaison, and project management,' Felice says. In fact, while there, she gained the necessary experience to become a Chartered Engineer with the Institution of Mechanical Engineers in 2016.

Fast forward to a year later and Felice is now working as an NDT academic at Nanyang Technological University in Singapore. Felice reveals this move was inspired by her wish to experience life outside Europe. 'Singapore offered a lot, especially in terms of diverse culture, quality of life, and the value given to engineering,' she says. 'And while the job is more technical and academic than the one at the MTC, I still work on applied projects which are very relevant to industry.'

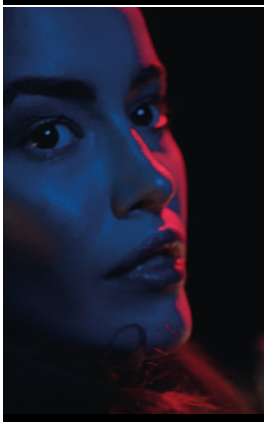
Looking to the future, Felice has her eyes set on moving to another country. She is grateful that her career in research enables her to travel, having visited China, South Africa, the USA, and multiple locations in Europe so far. A sporty person and adventure-seeker, she loves combining sport and travel and trekked up Mount Rinjani in Indonesia last August.

For those considering a career along the lines of Felice's, she advises maintaining a balance between both technical subjects and the arts. 'I always enjoyed writing English essays at school and this has turned out useful because of the many reports I write for work. I did not put much effort into art, which I regret because it is very useful to be able to sketch out 3D drawings to explain a concept,' she says.

Felice also encourages those looking for a postgraduate course to turn to the Internet to see what is available in Malta and beyond. 'But more importantly,' she stresses, 'talk to as many people as possible and learn about what they do, whether in engineering or outside it. And do not be daunted if you want to enter a field you currently know little about. Engineering is so vast, it is impossible to know everything straight after MCAST or the University of Malta. Good engineers aren't the ones who know it all but are the ones who are curious and able to teach themselves new things.'

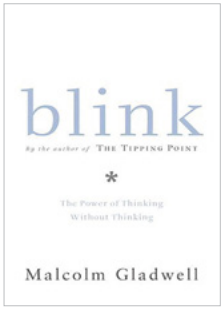
TO-DO LIST

MUSIC



Lauv — ***The Other***
It's really pretty.

BOOK



Blink: The Power of Thinking Without Thinking by Malcolm Gladwell takes research on the adaptive unconscious (from psychology and behavioral economics) and presents it in a popular science format.

YOUTUBE CHANNEL

Sadia is a Canadian nutritionist living in the Netherlands. Her focus is simple: 'live a vibrant and uncomplicated life fueled by plant-based foods.' Her channel, ***Pick Up Limes***, offers a healthy dose of easy-to-make, delicious vegan recipes.

PODCAST

Emma Gannon's interviews focus on tech and creative women. Her guests have included the likes of Mara Wilson and Lena Dunham, discussing topics such as work and feminism.

MOVIE

In portraying the financial crisis of 2007 and the people who knew it was coming, ***The Big Short*** takes on complicated financial rhetoric and lays it out for the audience, all the while maintaining its energy and making us laugh in the process. This movie is special.

TV

Inspired by the stories of legendary Norse hero Ragnar Lothbrok, ***Vikings*** provides earthy respite from that high-flying, haughty fantasy show you've been watching. Bonus points for a healthy degree of historical accuracy thanks to its collaboration with the History Channel.

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