FINAL SPRINT BEFORE SKA OBSERVATORY LAUNCH

LET’S TALK ABOUT... THE ORIGINS OF LIFE

DELIVERING A ‘SOFTWARE TELESCOPE’
Dear Friends and Colleagues,

2020 – what a year! If you cast your mind back, the big news at the beginning of the year was the Australian bushfires; we all felt for family, friends and colleagues in Australia and didn’t think things could get much worse. Well, it looks different now! In January the WHO announced that a deadly coronavirus had been detected; I don’t think any of us (except the epidemiologists and pandemic experts) understood what that meant – we do now. We’re living with the global impact of COVID-19 and will be for some time to come, although it is wonderful to see the rapid development and roll out of vaccines; let us hope 2021 sees a return to a normal world.

The world of politics in 2020 has been fascinating and worrying, with a hugely visible presidential election in the USA – and significant threats to democracy, although it is good to see the checks and balances working. For those of us in the UK, and our European neighbours, Brexit has been a show that has been painful to watch. The world woke up, yet again, to the need to fight endemic racism with the explosion of the Black Lives Matter movement; and saw sexism and misogyny tackled but not yet beaten on various fronts.

On a more parochial and much more positive note, after an extremely good year for the SKA, we end it the best possible way with a Note Verbaire from the Foreign, Commonwealth and Development Office informing us that the SKA Observatory Convention will officially enter into force on 15 January 2021, marking the start of a new era in the SKA history.

Previous editions of Contact, and our various news items and press releases have covered the various milestones this year, but it is worth gathering them all in one place, because it is an impressive story:

• December 2019 – March 2020: successful SKA1 critical design review;
• March 2020: successful operations review;
• April 2020: successful, external, cost audit;
• June 2020: South Africa ratifies;
• July 2020: successful business-enabling review;
• September 2020: Australia ratifies the Convention;
• September 2020: the SKA Board of Directors endorses the SKA1 Construction Proposal (CP), and the Observatory Establishment and Delivery Plan (OEDP);
• December 2020: Italy, Portugal and the UK ratify the Convention;
• December 2020: the Council Preparatory Task Force completes its 19th and final meeting and passes its final report and numerous policies to the SKAO Council for approval.

Achieving all of these milestones is testament to the highly professional team at SKA Organisation and across our partner institutes; it is an enormous body of work and I congratulate all staff and colleagues, all of whom contributed to this achievement.

2021 will see an equally auspicious year for the SKA, with the birth of the SKAO in January, to be celebrated at its first Council meeting. This will be followed soon thereafter by the formal transition from the SKA Organisation to SKAO and then, hopefully, Council approval to begin SKA construction. I also hope to see more countries join the Observatory as Members.

I wish good health and good cheer to all of you, the SKA family, as we end 2020, with a bright light in front of us for 2021.

Prof. Philip Diamond, SKA Director-General
IN MEMORY OF NICOLÒ D’AMICO
(1953 – 2020)

BY ANDREA POSSENTI (INAF)

The completely unexpected and sudden death of Prof. Nicolò D’Amico (Palermo – Solennino 2020), President of the Italian National Institute for Astrophysics (INAF), has been an irreparable loss for the Italian astrophysics community and beyond, and left a huge void in all the many people who, like me, had the privilege to work with him. During the years of his Presidency, Prof. D’Amico fully exploited his natural aptitude to synthesise all the received suggestions into a precise vision for the development of astrophysics: to maximise the quality of the research, and to make the best of the growth of the field, while paying special attention to education, outreach activities and science communication. He was the voting member for Italy in the SKA Board of Directors, and thanks to his remarkable managerial capabilities, coupled with an always crystal-clear and sound approach to the world of the institutions, he was the main actor securing the long-term Italian funding for the project and in promoting SKA.

Graduating in Physics in 1977, only four years later Prof. D’Amico focussed on “Nichi”, was already “permanent” at the University of Palermo. After beginning with gamma-ray astronomy, a visit to CSIRO in Australia re-oriented his studies towards radio pulsars, the apex of which was reached with his key role in the Parkes Multibeam surveys (1984-2004), which doubled the number of known pulsars and led to the discovery of the still-unique double pulsar PSR J0337–3039. That made him one of the recipients of the prestigious “Descartes Prize” for outstanding European scientific collaborations in 2005, among other prizes. Prof. D’Amico meanwhile obtained a full professorship at the University of Cagliari and became director of the local Astronomical Observatory and, later, director of the project for the construction of the Sardinia Radio Telescope. In autumn 2015, he was nominated President of INAF, and he was confirmed for a second term in December 2019, the first president to be reconfirmed in the history of this prestigious Italian institution.

Above: Prof. Nichi D’Amico during the second SKA IGO Negotiations meeting in January 2016 at the Accademia dei Lincei in Rome.

TEAMS READY FOR SKA SCIENCE DATA CHALLENGE 2

BY SKAO

Registration is complete for the SKA Science Data Challenge 2, with around 30 teams taking part from more than 60 institutions all over the world.

The challenge will see teams analyse a 1 terabyte (TB) simulated SKA HI data cube, using their own software tools to identify the distributional properties of galaxies across a distance of four billion light years.

An international network of high-performance computing centres are a crucial element to the challenge, providing access, processing and storage for the data. This is similar to how the SKA Observatory will disseminate the telescopes’ data via SKA Regional Centres (SRCs) in the future.

Eight facilities are involved, including two prototype SRCs: IRS UK (part of the UK Science and Technology Facilities Council), SKA France, Shanghai proto-SRC, Australia proto-SRC, Italy’s National Institute for Astrophysics - Information and Communication Technologies (ICT), Institute for Astrophysics of Andalucía (IAA) in Spain, ENGAGE-SKA in Portugal, and the Swiss National Supercomputing Centre (CSCS).

“[...] “The external SRC network will be how the SKA Observatory interacts with our user community, so beginning to put this idea into practice via the Data Challenge is an important step in demonstrating how this will work effectively as a system,” says SKA Science Director Dr Robert Braun. “It has also strengthened links between these facilities. We’ve had their representatives together in a virtual room discussing provision and access, which is something we have never had before now.”

Through December teams will each be given access to one of the computing facilities, ready for the challenge to formally kick off on 15 January. The results are due to be announced in July 2021.

Feedback from participants and the computing centres will be used to further inform work on the SRC model. SKAO is also encouraging best practice by working with the UK-based Software Sustainability Institute to give awards to teams that demonstrate reproducibility (using methods that can be replicated by others to achieve the same results).

The exercise relies at the heart of the SKA’s Open Science approach to its future operations. Making software transparent and open in this way means they can also be built on for other, different purposes in the future.

Above: Map of high-performance computing centres involved in SDC2. Eight facilities are involved, including two prototype SRCs.

IN BRIEF

BIRTHPLACES OF PLANETS WITH THE SKA

BY HILARY KAY (THE UNIVERSITY OF MANCHESTER – UK SKA)

Advancing our understanding of how habitable planets form is one of the key science drivers of the SKA telescopes. A team of astronomers, led by Dr. John Ilee at the University of Leeds in the UK, has performed the first investigation into the capability of the SKA-Mid telescope to observe the structure of protoplanetary discs, the birthplace of planets.

As planets form from the collision and coalescence of dust particles, they create structure in the disk, carving out concentric gaps at their location. Analysis of this structure can provide crucial information on the composition of the disk and the properties of the planets themselves. Dr. Ilee’s team has created a model of a protoplanetary disk similar to the famous HL Tau star-disk system, which they have used to simulate the observations that will be obtained by the SKA-Mid telescope when it is fully operational.

The team has confirmed that SKA-Mid will be able to detect emission from centimetre-sized pebbles, allowing them to analyse the structure created in the disk as planets form, shedding light on a crucial step in the formation of planets. As a result of its large field of view, SKA-Mid will be able to observe dozens of protoplanetary disks simultaneously, providing robust tests of planet formation. “Understanding how the raw material for planet formation behaves is essential if we are to understand how planetary systems, like our own Solar System, come into existence. SKA-Mid will allow us to observe this clearly for the first time,” Dr Ilee says.

BY DOMINGOS BARBOSA AND SONIA ANTÓN (INSTITUTO DE TELECOMUNICAÇÕES)

TOWARDS SKA REGIONAL CENTRES – THE PORTUGUESE CASE

BY SKAO

Registration is complete for the SKA Science Data Challenge 2, with around 30 teams taking part from more than 60 institutions all over the world.

The challenge will see teams analyse a 1 terabyte (TB) simulated SKA HI data cube, using their own software tools to identify the distributional properties of galaxies across a distance of four billion light years.

An international network of high-performance computing centres are a crucial element to the challenge, providing access, processing and storage for the data. This is similar to how the SKA Observatory will disseminate the telescopes’ data via SKA Regional Centres (SRCs) in the future.

Eight facilities are involved, including two prototype SRCs: IRS UK (part of the UK Science and Technology Facilities Council), SKA France, Shanghai proto-SRC, Australia proto-SRC, Italy’s National Institute for Astrophysics - Information and Communication Technologies (ICT), Institute for Astrophysics of Andalucía (IAA) in Spain, ENGAGE-SKA in Portugal, and the Swiss National Supercomputing Centre (CSCS).

“The external SRC network will be how the SKA Observatory interacts with our user community, so beginning to put this idea into practice via the Data Challenge is an important step in demonstrating how this will work effectively as a system,” says SKA Science Director Dr Robert Braun. “It has also strengthened links between these facilities. We’ve had their representatives together in a virtual room discussing provision and access, which is something we have never had before now.”

Through December teams will each be given access to one of the computing facilities, ready for the challenge to formally kick off on 15 January. The results are due to be announced in July 2021.

Feedback from participants and the computing centres will be used to further inform work on the SRC model. SKAO is also encouraging best practice by working with the UK-based Software Sustainability Institute to give awards to teams that demonstrate reproducibility (using methods that can be replicated by others to achieve the same results).

The exercise relies at the heart of the SKA’s Open Science approach to its future operations. Making software transparent and open in this way means they can also be built on for other, different purposes in the future.

Above: Map of high-performance computing centres involved in SDC2. Eight facilities are involved, including two prototype SRCs.

IN BRIEF

BIRTHPLACES OF PLANETS WITH THE SKA

BY HILARY KAY (THE UNIVERSITY OF MANCHESTER – UK SKA)

Advancing our understanding of how habitable planets form is one of the key science drivers of the SKA telescopes. A team of astronomers, led by Dr. John Ilee at the University of Leeds in the UK, has performed the first investigation into the capability of the SKA-Mid telescope to observe the structure of protoplanetary discs, the birthplace of planets.

As planets form from the collision and coalescence of dust particles, they create structure in the disk, carving out concentric gaps at their location. Analysis of this structure can provide crucial information on the composition of the disk and the properties of the planets themselves. Dr. Ilee’s team has created a model of a protoplanetary disk similar to the famous HL Tau star-disk system, which they have used to simulate the observations that will be obtained by the SKA-Mid telescope when it is fully operational.

The team has confirmed that SKA-Mid will be able to detect emission from centimetre-sized pebbles, allowing them to analyse the structure created in the disk as planets form, shedding light on a crucial step in the formation of planets. As a result of its large field of view, SKA-Mid will be able to observe dozens of protoplanetary disks simultaneously, providing robust tests of planet formation. “Understanding how the raw material for planet formation behaves is essential if we are to understand how planetary systems, like our own Solar System, come into existence. SKA-Mid will allow us to observe this clearly for the first time,” Dr Ilee says.

BY DOMINGOS BARBOSA AND SONIA ANTÓN (INSTITUTO DE TELECOMUNICAÇÕES)

TOWARDS SKA REGIONAL CENTRES – THE PORTUGUESE CASE

SKA software development and prototyping work on the SKA Regional Centres will be bolstered by a new Centre of Competence in Advanced Computing

Currently under commissioning, the centre is installed at the University of Aveiro (UA) in Portugal. The new centre is the result of a cooperation protocol signed on 9 November between UA and the Foundation for Science and Technology (FCT) as part of the national strategy INCODE 2030, and was inaugurated in the presence of Manuel Heitor, Portugal’s Minister of Science, Technology and Higher Education. The centre will strengthen national scientific production in areas involving advanced digital skills, such as artificial intelligence and Big Data.

The Centre of Competence is part of the National Advanced Computing Network and acts as a gateway to its supercomputing centres, with the high storage capacity and state-of-the-art software and visualisation hardware for Big Data analysis. These capacities will be key ingredients to the prototype Portugal-SKA Regional Centre that is currently being developed by ENGAGE SKA researchers at UA. In the near future, the centre will receive a strong boost from the European Commission. The inauguration was followed by a presentation at Instituto de Telecomunicações (IT) focusing on 5G, SKA and the local Software Bridging Teams and space science projects. “Aveiro has internationally recognised expertise in highly relevant areas, ranging from communications and security to Big Data and artificial intelligence,” said João Paulo Barraca, from IT and DETI-UA. “This centre opens new avenues to pursue first class science, and joint industry and academia innovation actions, as well as a stronger training environment to its alumns.”
CSIRO’s Iconic Parkes Radio Telescope Given Indigenous Name

By Dr Stacy Mader (CSIRO)

To mark Australia’s NAIDOC (National Aborigines and Islanders Day Observance Committee) week, where the culture and achievements of Aboriginal and Torres Strait Island peoples are celebrated, CSIRO’s famous Parkes radio telescope was given a traditional name by local Wiradjuri Elders.

The 64-metre telescope, an SKA pathfinder, is located on Wiradjuri country in New South Wales, about 380km west of Sydney.

During a naming ceremony it received the name Murriyang, which represents the ‘Skyworld’ where a prominent creator spirit of the Wiradjuri Dreaming, Biyaami (Blaaarme), lives. Two smaller telescopes at the Parkes Observatory also received Wiradjuri names.

Wiradjuri Elder Dr Stan Grant AM revealed the names. "This is a very proud day for our people and something that has been coming for a long time," said Dr Grant. "The naming of the telescope is one of the biggest things to happen to our people," referring to when as a young boy, it was illegal for the Wiradjuri to speak their language in public.

Over two years, CSIRO’s local Parkes staff worked in collaboration with Wiradjuri Elders, the NSW Aboriginal Education Consultative Group and the North West Wiradjuri Language and Culture NEST on the telescope naming project.

"Science is the search for truth, often we think we are the first to discover it, but much of the knowledge we seek was discovered long before us," said CSIRO Chief Executive Dr Larry Marshall. "We’re honoured that the Wiradjuri Elders have given traditional names to our telescopes at Parkes, to connect them with the oldest scientific tradition in the world.”

The Parkes telescopes join CSIRO’s Australian SKA Pathfinder (ASKAP) in Western Australia in being given traditional names.

Dr Leah Morabito, an Assistant Professor at Durham University in the UK, has been awarded a prestigious UK Research and Innovation (UKRI) Future Leaders Fellowship to continue her research into galaxy evolution, one of the science drivers for the SKA.

Dr Leah Morabito, a native of the Narragansett tribe from Rhode Island, USA, is currently a Hintze Fellow at the Department of Physics and Astronomy at the University of Oxford in the UK. She will subsequently become a Fellow at Leiden University in the Netherlands to complete her PhD and subsequently becoming a Hintze Fellow at the University of Oxford in the UK. She is a member of the UK SKA Science Committee, which acts as a liaison between the SKA Organisation and the wider UK science community, through the Science and Technology Facilities Council (STFC).

During her career, Dr Morabito has developed specialised data processing techniques for the Low Frequency Array (LOFAR) to achieve the highest resolution images at low frequencies, which are crucial in investigating active supermassive black holes in distant galaxies. Dr Morabito’s Future Leaders Fellowship secures an immediate leadership role for her in fully enabling and exploiting SKA pathfinder LOFAR’s transformational imaging resolution in grand-scale low-frequency sky surveys, that will remain unexplored for the foreseeable future.

"I’m really excited because this fellowship will allow me to build a diverse team to unlock the secrets of supermassive black holes and how important they are in galaxy evolution. We’ll use an SKA pathfinder to develop techniques and talent for the future,” Dr Morabito says.

MONITORING WILDFIRES IN PORTUGAL WITH SKA-RELATED TECHNOLOGY

By Domingos Barbosa and Miguel Bergano (Engage-SKA, Instituto de Telecomunicações)

One of the major hazards in Portugal is wild forest fires. Fires have great economic impact and pose a serious life threat to communities.

The improvement of real-time fire monitoring and fire mapping has become a top national priority following the extreme incidents and loss of life of the last few years. To tackle fire prevention, a new project called Eye in the Sky is using a combination of information technologies developed for the SKA (such as cloud computing technologies and communication technologies for infrastructure management and device control) by the ENGAGE-SKA team at Instituto de Telecomunicações (IT), with high altitude balloons (HAB) equipped with observation and communications payloads and unmanned aerial vehicles (UAV) responsible for the payload’s precise positioning above fire fronts.

It aims to improve the reliability of information for ground-based firefighting crews and provides real-time geotagged imagery to decision-making centres that coordinate the fighting resources.

According to Alexandra Moutinho, Principal investigator of the Eye in the Sky project, “our aim is to develop a platform for Earth observation that fills the gap between the large but time-constrained coverage provided by satellites, and the on-demand local coverage provided by drones. The autonomy and long range of our solution makes it an interesting one for environmental monitoring missions like wildfire detection or oceanic observation.”

As IT Auxiliary Researcher Miguel Bergano adds: “Information technologies developed for fundamental research projects like the SKA also enable applications with wider socio-economic benefits. Here, technologies developed for the SKA’s control systems combined with modern radio technologies enable reliable and real-time secure communication of critical forest fire data.”

Eye in the Sky is a collaboration between the Mechanical Engineering Institute at IST Lisbon, the Association for the Development of Industrial Aerodynamics (ADAI) at University of Coimbra and IT. It is funded by Portuguese national funds through FCT, the Foundation for Science and Technology.

UK FELLOWSHIP AWARDED TO EXPAND LOFAR RESEARCH

By Hilary Kay (The University of Manchester – UK SKA)

Dr Leah Morabito, Durham University

Credit: Leah Morabito, Durham University

By SKAO

After years of international negotiations and 18 months of ratifications, the SKA Observatory (SKAO) can now officially be established. The positive conclusion to 2020 follows a flurry of activity which saw Australia, Portugal and the United Kingdom ratify within weeks of each other.

The UK’s confirmation of their ratification on 16 December meant the SKAO Observatory can now officially be established. This kicked off a 30-day notification period after which the SKA Observatory will formally come into being and the first Council of the SKA Observatory, governing body representing the Member States, can meet. The first Council is now expected to take place in early 2021.

As we bow out of 2020, almost all the founding member countries are now in place: Australia, Italy, the Netherlands, Portugal, South Africa and the UK. The seventh country has been added: the SKA treaty, China, is expected to ratify early next year, as well as Sweden and India, who took part in the negotiations but did not sign at the time. Other current members of the SKA Organisation are also following their own pathways to accession to SKAO and it is expected they will join the Observatory by the end of the course of next year.

“To end this difficult year on such a positive note, with all the necessary steps completed for the SKA Observatory Convention to enter into force, is a testament to the determination of those across the SKA to keep things moving no matter the obstacles,” says SKA Director-General Prof. Philip Diamond (Read more on Prof. Diamond’s vision for the SKA Observatory on the following pages.)

Australia, future home of the SKA-Low telescope, announced its ratification at the end of September, with Minister for Industry, Science and Technology and Higher Education Minister Karen Andrews MP describing the SKA project as “an excellent example of how science and technology can drive industry forward, to grow our economy and create the jobs of tomorrow”. Australia has a long history of leading in radio astronomy. As well as ASKAP and MWA, it is also home to the iconic Parkes telescope, an SKA pathfinder instrument and the second largest steerable radio telescope in the southern hemisphere.

Portugal’s ratification was announced on 11 December, at a virtual event attended by Minister of Science, Technology and Higher Education Manuel Heitor. “Portugal’s participation in the SKA programme marks the fact that Portugal is a founding member of the SKA Observatory opens new opportunities for young people, researchers, astronomy professionals and amateurs in Portugal to be involved in one of the most revolutionary scientific cooperation initiatives at a global level,” said Manuel Heitor, Portuguese Minister of Science, Technology and Education.

Portuguese involvement in SKA will be managed by the Portuguese Space Agency, Portugal Space, while ENGAGE SKA, a national radio astronomy research infrastructure bringing together universities and industry, has contributed with several key computing infrastructures to support the wider Portuguese scientific community.

A large share of their compute time will be open to society for studies as diverse as fire monitoring, precision agriculture, and the COVID-19 pandemic, a prime example of radio astronomy’s wider impact in society.

Finally, on Wednesday 16 December, came the announcement that the United Kingdom had ratified the Convention. Jodrell Bank, Home to SKA Global Headquarters, was recognised as a UNESCO World Heritage Site in 2019 for its contributions to radio astronomy. It is the central hub of the UK’s e-MERLIN national facility. This network of seven radio telescopes spread across the UK (including the iconic 76m Lovell Telescope) together form an SKA pathfinder instrument.

UK institutions supported by the Science and Technology Facilities Council (STFC) led the SKA’s Science Data Processor and Signal and Data Transport engineering design consortia.

The ambition of the Square Kilometre Array is to build and operate cutting-edge radio telescopes to answer fundamental questions about our Universe.

To deliver on this mission, SKAO, with its distributed workforce, must operate as a single, integrated facility. This can be summarised by the mantra under which we have developed our joint thinking over the last two years: “The SKA will be one Observatory, with two telescopes, on three continents, all working as an integrated whole”.

We have committed to build a sustainable Observatory, this must be at the heart of any 21st century scientific facility. To do this we must be seen as a leader and act as an exemplar in all our actions. As such, we will ensure that our actions always consider sustainability, we did not choose to construct these sophisticated telescopes that will enable our scientists to explore the universe in ever more detail than ever before – potentially expanding our knowledge of astronomy.

What will be the philosophy and ethos of SKAO? We have an opportunity to build a 21st century observatory and inter-governmental organisation from the ground up, to establish a culture that will last for decades.

First, we should establish the mission of SKAO. For me, that can be captured in the following brief paragraph.

The SKA Observatory’s mission, is through a global collaboration, to build and operate cutting-edge radio telescopes to answer fundamental questions about our Universe.

To deliver on this mission, SKAO, with its distributed workforce, must operate as a single, integrated facility. This can be summarised by the mantra under which we have developed our joint thinking over the last two years: “The SKA will be one Observatory, with two telescopes, on three continents, all working as an integrated whole”.

We have committed to build a sustainable Observatory, this must be at the heart of any 21st century scientific facility. To do this we must be seen as a leader and act as an exemplar in all our actions. As such, we will ensure that our actions always consider sustainability, we did not choose to construct these sophisticated telescopes that will enable our scientists to explore the universe in ever more detail than ever before – potentially expanding our knowledge of astronomy.

We are very conscious that we require the support and goodwill of the taxpayers in our member countries and so we must ensure that we and our partners do all we can to inform the public of the importance of fundamental science and technology, to educate the next generation, to help strengthen STEM skills and to ensure we maintain a strong user community.

We must also work with our partners to ensure that technologies and other innovations developed for the SKA deliver impact and benefit society. If 2020 has shown us anything, it is that the world needs science and technology more than ever, and we in radio astronomy must do our part.

We also have a responsibility to our user community to ensure that they can produce transformational science using the SKA. To that end, we must do all we can to build the first phase of the SKA on schedule and within budget. This is always a challenge for such high-tech, world-first facilities, but we believe we have a well-crafted CP with appropriate budgetary and time contingencies. We must also ensure, with our members, that the tools and SKA Regional Centres infrastructure is delivered to maximise the impact of SKA science.

I am also committed to working with the members to deliver a well-funded Observatory Development Programme, which will drive continual development of technology, techniques, data processing and analysis so that SKA remains at the forefront of world astronomy and science.

It is my ambition to establish SKAO as the world-leader in radio astronomy.

We will be the world’s largest observatory, we will have a truly global membership, we will focus on equality, diversity and inclusion, we will be embedded within the DNA of the Observatory and its staff: we do and will ‘walk the talk’. We will continue to foster a culture of creativity, innovation and professional excellence, allowing ideas to thrive to deliver value to our staff and community. We will continue to work with our global partners and local stakeholders in a spirit of collaboration and mutual respect, recognising their roles as key participants in the project.

Finally, and vitally, we will continue with the establishment of strong cultural relationships with the Indigenous communities around the telescope sites, building on the initiatives our partner organisations in Australia and South Africa have initiated and using these as an inspiration to make sure our journey benefits them as well; we will acknowledge and understand their cultures and history, we will provide opportunities for development and be seen as a world-class custodian of local heritage.

With these elements of an SKAO culture we can build an Observatory for the 21st century.
In astronomy, observing how other worlds form and how life may emerge on them is part of ‘Cradle of Life’ studies, a field that spans many specialisms. Our brief expedition into this broad topic focuses on two aspects: planet formation and the search for the building blocks of life. Let’s start with those building blocks.

“Carl Sagan once said: ‘We are all made of stardust.’ And he was right,” says Dr Izaskun Jimenez-Serra of Spain’s Centre for Astrobiology, an expert in astrochemistry and former chair of the SKA’s Cradle of Life Science Working Group. “Not only do the atoms that form our body come from old stars; we currently believe that some organic compounds key for the metabolism and biochemical processes in living organisms could also have come from outer space, because the processes which may have led to life. Among them are the molecular precursors to RNA, a similar molecule to the well-known organism. In fact, here on Earth some viruses, including precursors to RNA, a similar molecule to the well-known organism. In fact, here on Earth some viruses, including

One theory which emerged in the 1960s (and is still being debated) sees RNA as the driving force behind the beginnings of life on Earth millions of years ago. It’s thought these prebiotic molecules could have become incorporated into comets and meteorites which intensively struck the Earth around four billion years ago, Izaskun says. Of course, molecules are tiny, and most of the regions where we study them are thousands of light years away. Luckily, the natural emission from COMs in the cold reaches of outer space is of low energy, placing them in the radio band of the electromagnetic spectrum, making radio telescopes uniquely able to detect them.

“Amy has its own unique fingerprint, made up of a collection of signals at different wavelengths - this is caused by molecules being excited into different energy levels, and in cold regions influenced by the molecules rotating,” Izaskun explains. Radio telescopes can search all these wavelengths, a bit like an old analogue radio searching for different channels. If all the wavelengths from a given molecule can be found, then the molecule is definitely present in space," Izaskun explains. Because they are made of more atoms, COMs are larger than simple molecules, so they rotate slower, resulting in centimetre wavelengths, which lie within the frequency ranges covered by the SKA.

“The SKA also has the potential to become a great COM detector because of its capability. Centimetre wavelengths are much ‘cleaner’ than millimetre wavelengths, which tend to be crowded with these simpler, smaller molecules. This, together with the high sensitivity of the SKA, will help us to identify new prebiotic molecules in space - molecules which have never been detected before Earth.”

Finding the molecules is one thing, but for life to eventually form requires a habitable home. That’s why understanding planet formation is crucial to Cradle of Life studies.

And before a planet, must come a star. As a star forms, a collection of dust and gas debris is left swirling around it, creating a protoplanetary disk. There’s still a lot that we don’t know about the process, but it’s believed that these microscopic dust particles stick together, a bit like how snowballs become larger and larger, except in this case over the course of a few million years.

Radio telescopes can watch the process unfold by detecting the signals emitted by these dust grains; smaller grains emit shorter wavelengths, and larger grains emit longer wavelengths. This makes for a great example of using the interferometry on Earth and the complementarity of different wavelengths.

Radio telescopes can watch the process unfold by detecting the signals emitted by these dust grains; smaller grains emit shorter wavelengths, and larger grains emit longer wavelengths. This makes for a great example of using the interferometry on Earth and the complementarity of different wavelengths.

The Atacama Large Millimetre/submillimetre Array (ALMA) in Chile has made huge advances in this field in recent years by observing millimetre-size dust grains as they begin to cool down. ALMA has been able to pinpoint for the first time the location where a young planet is being born, provided high resolution images of disks to identify commonalities and differences, between; in 2014 released a stunning image of the disk around a young star which turned existing thinking on its head.

The detailed image of the disk around HL Tauri, a million-year-old star (a relative baby in star terms), suggested the early stages of planet formation were already under way. Until then, it was thought the process was much slower, so wouldn’t be visible in such young star systems.

While ALMA deals with millimetre wavelengths, the SKA will step in to fill the current gap in our knowledge of the next step in the process, observing larger pebbles in the disk. A recent paper, co-authored by members of the SKA Cradle of Life Science Working Group, showed that it will also make a cleaner picture of the smallest particles of all, the centimetre scales to metres, and with sufficient resolution to watch the growth of planets in the habitable zone around their parent stars,” says Dr Tyler Bourke, SKA Project Scientist and a co-author on the paper.

“With the SKA we’ll be uniquely possible to witness this phase of planet assembly by observing at exactly those radio wavelengths that match the size of coalescing particles, from centimetre scales to metres, and with sufficient resolution to watch the growth of planets in the habitable zone around their parent stars,” says Dr Tyler Bourke, SKA Project Scientist and a co-author on the paper.

“ALMA has revealed amazing structure in disks but is not sensitive to objects bigger than dust, the longer wavelengths observed by SKA are needed to detect pebbles, which will reveal the birth-sites of exoplanets. This will also give us more clues about how our own Solar System formed.”

Since the discovery of the first exoplanet orbiting a Sun-like star in 1995 (for which Prof. Michel Mayor and Prof. Didier Queloz were awarded the 2019 Nobel Prize for Physics), studies have focused on their potential habitability, based on whether a planet lies in a zone where water can exist in liquid form. Part of the surprise surrounding the Venus phosphine announcement was that, on Earth, phosphine is associated with biological processes, but Venus is considered inhospitable in the extreme: intensely hot, smothered by an atmosphere of mainly carbon dioxide and clouds of sulphuric acid thrown in for good measure. If life were to be found there, it would radically change our definition of hospitable, and of where life can emerge, but further studies will be required to test and understand the results before making that jump. The team behind the results have themselves downplayed them since, due to questions over the data processing methods used. Irrespective of what’s happening on Venus, the Universe holds many more secrets on the origins of life, and the SKA is ideally placed to reveal them.

“The formation of planets and the viability of complex, preciotic molecules, during their formation are two exciting areas where observations at centimetre wavelengths with the SKA will be crucial for significant advances in our understanding,” Tyler adds. “Locating the formation sites of future planets, and understanding the evolution of complex molecules in these environments, are key to understanding how Earth formed, and the likelihood of life arising on other planets.”

The complex organic molecule hydroxylamine (NH2OH, in the image) and urea (NH2CONH2) were amongst those recently detected in the interstellar medium. These prebiotic molecules could have been part of the process that led to life on Earth within theories of a primordial RNA world. Credit: Nasa Spitzer Space Telescope, camera (IRAC) @ micron / Ben Mills / PrintCrapart.com / Victor M. Rivilla

“Not only do the atoms that form our body come from old stars; we currently believe that some organic compounds key for the metabolism and biochemical processes in living organisms could also have come from outer space, because the processes which may have led to life. Among them are the molecular precursors to RNA, a similar molecule to the well-known organism. In fact, here on Earth some viruses, including precursors to RNA, a similar molecule to the well-known organism. In fact, here on Earth some viruses, including
GOODBYE TO ARECIBO

For more than 50 years, Arecibo explored the cosmos from Puerto Rico, making countless discoveries and inspiring great affection from the astronomical community. Sadly, 2020 marked the end of the road for this giant of radio astronomy.

First came the breakage of two of the cables supporting Arecibo’s 900 tonne instrument platform, which housed the telescope’s receivers above that iconic 305m dish. The damage was extensive enough for the US National Science Foundation, which operated Arecibo, to announce that the telescope would be decommissioned, as it was deemed too dangerous to attempt repairs. Less than two weeks later, on 1 December, the instrument platform came crashing down too, completely destroying the telescope.

It was a sad end for a facility with such an impressive scientific legacy. Among its list of achievements, Arecibo was used to discover the first binary pulsar system, a major breakthrough supporting Einstein’s theory on the existence of gravitational waves, which went on to be awarded the Nobel Prize for Physics in 1993. The telescope is also credited with the first discovery of an exoplanet orbiting a millisecond pulsar in 1992, and the first detection of a repeating fast radio burst in 2016. These are all areas of science that the SKA will probe further, so as a pathfinder Arecibo really did pave the way for the next generation of facilities.

In-between all the science, Arecibo also made appearances on the silver screen, featuring in the James Bond film GoldenEye, and the sci-fi movie Contact (a particular favourite of many radio astronomers). It also helped to inspire many young scientists, as became clear when news of its planned decommissioning sparked a flood of reactions on Twitter under the hashtag #WhatAreciboMeansToMe.

“A giant has fallen,” says SKA Director-General Prof. Philip Diamond. “It is very sad to see a superb facility bow out in this way. This will be a difficult time for the Arecibo staff, our thoughts are with them.”

All images credited to Arecibo Observatory and NAIC.
**HQ CORNER**

**2 MINUTES WITH... DR SHEILA KANANI OUTREACH & DIVERSITY OFFICER, ROYAL ASTRONOMICAL SOCIETY (RAS)**

Dr Sheila Kanani recently gave a Speaker Series talk to SKAO HQ staff on equality, diversity and inclusion (EDI) issues. The event was organised by SKAO’s newly revamped EDI Working Group on the back of Black History Month, marked each October in the UK.

Tell us about your role as Diversity Officer.

Each day is different – one day I might be writing a report based on some survey findings, the next I might be delivering a careers session to 12-year-old Black, Asian and Minority Ethnic (BAME) girls in an area with high socio-economic deprivation! Together with my colleagues I also run surveys and analyse data to work out what we need to focus on, and our diverse themes change each year.

Why is it important for societies like the RAS and indeed research institutions to talk about EDI?

Learned societies have a really positive part to play in EDI. Other organisations look to us for advice and we would also hope to provide a voice for the minorities who might not ‘fit’ elsewhere. For changes to happen in EDI we need a ‘top down’ approach with buy-in from heads of departments and leaders in the field, rather than the orus being on the individual.

Where do global research projects like the SKA fit into this conversation?

I think global projects are really exciting with regards to EDI. We can get stuck in our bubbles, including in EDI, and forget what’s actually out there! The issues and challenges in EDI in the UK might be completely different to those in other countries. By sharing what we’ve learned and what we’ve done, we can all help each other improve.

What would you say to someone reading this who might be thinking “what can I do?”

If you’re an individual, look for “quick wins” as it doesn’t feel too overwhelming. Things like including your pronouns in your email signature, joining a diversity committee, becoming a diversity champion at work, or taking courses like ‘mental health first aider’ training. If you organise events, be mindful of who you invite to speak – no more ‘manels’ please! If you are on an awards committee make sure the application process is open for people from all walks of life, and think about who you celebrate and use role models for your field. And don’t forget about accessibility. This year, because of the pandemic, we’ve taken a lot of our work online, but that brings its own accessibility challenges, and we’ve also tried not to forget those who don’t have access to the internet or a laptop.

Why is it important for societies like the RAS and indeed research institutions to talk about EDI?

Equality, diversity & inclusion (EDI) is one of SKAO’s core values. With international staff from 20+ countries at the SKA HQ it’s essential that everyone feels welcome, valued, and that we fully represent and celebrate the diversity of people behind this global project.

During Black History Month (BHM), which takes place every October in the UK, SKAO took the opportunity to highlight Black voices in radio astronomy, and talked to members of Team SKA about the importance of EDI efforts and training within the workplace. With its global partnership and sites in South Africa and outback Western Australia, the SKA is a unique position among large-scale astronomy projects to focus on stories that have traditionally been under-represented in our field. As well as hearing personal experiences in a feature on the SKA website, SKAO’s EDI Working Group arranged a talk for SKA staff by Dr Sheila Kanani (see opposite), Diversity Officer at the Royal Astronomical Society, outlining recent progress in this area and discussing the challenges ahead, and shared Dr Samuel Okoye’s remarkable story (see summary on the right).

Marking BHM is part of a broader effort by the SKA Organisation’s EDI Working Group to ensure that our values of equality and diversity are promoted, respected, and backed by meaningful action at every opportunity. As SKA Director-General Prof. Philip Diamond said in a statement on racism and discrimination in June: “Just writing these principles down is not enough, meaningful action is required, by me, by our team leaders and by all of SKAO’s staff.”

**MARKING BLACK HISTORY MONTH**

**NIGERIA’S FIRST RADIO ASTRONOMER**

Samuel Ejikeme Okoye (1939–2009) was the first Black African astronomer to achieve a PhD in radio astronomy. He did so at the University of Cambridge in 1965, at the time when radio astronomy was beginning to reveal the high-energy universe. He went on to play a major role in establishing astronomy in Nigeria as both a discipline in itself and to drive development.

But when Okoye started his career, politicians and officials in his native Nigeria believed that astronomy was an esoteric topic of little practical use (Okoye 1990). His sustained efforts to bring astronomy to Nigeria throughout his career were repeatedly frustrated by lack of funding and practical support, but eventually, his employer the University of Nigeria Nsukka (UNN) started teaching astronomy and space as part of its undergraduate physics course, masters and doctoral students followed. Nigeria developed a small space programme, launching its first satellite in 1996. The Space Research Centre at UNN which he founded was the forerunner of today’s Centre for Basic Space Research (CBSR) which opened in 2001, part of the National Space and Development Agency set up by the Nigerian government in 1999.

Sam Okoye may have been the first Nigerian radio astronomer, but he was certainly not the last. His vision for astronomy as an end in itself and as a tool for development – in Nigeria and elsewhere – is finally being realised. Radio astronomy is taking root across the continent, not least in South Africa, home to the SKA’s dishes. The UK-led Development in Africa through Radio Astronomy (DARA; dara-project.org) is aiming to produce a technologically savvy workforce through radio astronomy. And now Nsukka is the home of the West African regional centre of the IAU’s Office of Astronomy for Development, setting the seal on this remarkable turnaround in attitudes to astronomy.

Read Dr Okoye’s full profile here.
SKA PROCUREMENT PREPARATIONS RAMPING UP

BY ANDREA CASSON AND MAURIZIO MCCOLIS (SKAO)

One of the main activities for the project next year, based on our expected timeline of SKA construction starting on 1 July 2021, will be preparing, awarding and kicking-off the first half of the over 50 contracts needed to build the SKA.

This activity is being led by the Programmes team, but involves practically every business unit within SKAO and of course all Members who have been allocated contract work by the Council Preparatory Task Force (CPTF). Our draft procurement schedule, covering preparation and review of the contract document packs and running the Invitation to Tender (ITT) processes and associated governance, has been shared with Member Industrial Liaison Officers (ILOs) – our network of professionals acting as the interface between in-country industry and SKAO – to support their preparation and is actively being updated by the project management team.

A lot of preparatory work has already happened this year with the writing of more than 20 Outline Procurement Plans each dealing with different parts of the telescopes. The selection of NEC4 as the contract form meant that all the project managers (who will run the construction contracts) and most of the engineers in the Programmes team participated in training alongside (well, at least on Zoom) delegates from the Mission Assurance, Procurement, Legal and Operations teams.

We’ve also been getting to grips with the Contract Event Management and Reporting (CEMAR) tool that will be used to administer the contracts.

Next year will start with a Progress Review, planned for the first half of January. This will allow us to check the construction progress and to refine the schedule. Two preparations are at the right stage in relation to the construction schedule.

THE PROCUREMENT PROCESS

Step 1: An internal Contract Readiness Review (CRR) is carried out by a cross-functional team, giving a go/no go on a contract’s readiness for procurement.

Step 2: A contract that is going to competition enters procurement at the market survey stage in the allocated Member country.

Step 3: Pre-qualification and invitation to tender (PI) stage of contracts.

Step 4: The Technical Evaluation Panel drafts an award recommendation for the Finance Committee ( Tender sub-committee) who reviews and formally recommends approval to the SKA Director-General.

Step 5: Following Director-General approval, the contract can be awarded.

PLACING OVER €800 MILLION OF CONSTRUCTION CONTRACTS OVER THE NEXT FEW YEARS IS BOTH EXTREMELY CHALLENGING AND HUGELY EXCITING. WE HAVE BEEN GEARING UP FOR THIS MOMENT FOR MANY YEARS AND, HAVING RECENTLY TRAINED MORE STAFF IN NEC4 CONTRACTS AND RECRUITING EXPERIENCED PEOPLE IN THIS AREA, WE ARE IN A STRONG POSITION. I’M SO LOOKING FORWARD TO 2021!

Andrea Casson, Head of Project Management Group

TWO YEARS OF AGILE SOFTWARE DEVELOPMENT AT SKA

BY DR JUANDE SANTANDER-VELA (SKAO)

It is already two years since we started our software development journey with the Scaled Agile Framework (SAFe®) with our first Program Increment (PI) planning, PI7.

In software development, agile practices approach discovering requirements and developing solutions through the collaborative effort of self-organising and cross-functional teams and their customer/end user.

In that first PI planning we had 55 people distributed across five agile teams plus the SKAO software management and engineering teams, which were able to develop 15 features (that’s what we call the chunks of work and functionality that we can develop in three months).

In early December we held PI9, which hosted 167 people across 17 agile teams from across the SKA partnership, now divided across two main parallel delivery tracks (what we call Agile Release Trains in SAFe parlance), plus one shared services group that provides engineering and computing support to teams across the two. This partitioning is required so that we can actually make sense of the planning!

The event was again a success: we planned the work for the execution of more than 129 Features! Before that, the work planned for PI8 was completed to our strict definition of “Done”, and resulted in the release of 95% of the expected value - that is, we accomplished 95% of our objectives. Note that we have been over 80% of value release since PI7, which is unheard of in non-agile software development for research infrastructures! This is a good demonstration of how increased interaction between developers and users facilitated by the Agile methodology improves success and helps make a better final product.

One staple of our software development is our three weeks devoted to Innovation & Planning (IP). While the PI9 Planning meeting was undoubtedly part of the IP, the Innovation is time set aside for people to work on unplanned things that might make a difference. For PI9 we added something new: participation in the AstroPy hackathon. Jointly organised by SKAO and the AstroPy collaboration (a community developing Python software for use by astronomers), this hackathon allowed people to devote two days to look at bugs in the AstroPy codebase and fix them, collaborating with them using their mature processes.

We are incredibly happy for — and somewhat incredulous of — the level of success that these two years of software development for the SKA have brought, which has allowed us to progress work at pace by co-opting resources and expertise where they are in the SKA community without recruiting hundreds of software developers! And this is thanks to our amazing teams and all the people that make everything work like clockwork. We sure hope to be ready for PI10, which is when SKA construction will begin in earnest!

Some of the 167 people working on SKA software at PI9: Observations, Management & Controls train on the top, Data Processing on the bottom.
by the observer, and finally, onto the massive data processing needed to make sense of those observations.

During this phase, it was critical to ensure a smooth and continuous interaction between all engineering consortia as well to understand interfaces between hardware—and its associated cooling, power, etc.— and software. Overall, more than a hundred experts from more than a dozen countries were involved in laying the foundations of the SKA without whose efforts this gargantuan effort required input from three separate engineering consortia:

- the Telescope Manager (TM) in charge of the telescopes’ control systems, led by India’s National Centre for Radio Astrophysics;
- the Central Signal Processor (CSP), also called the central processing brain of the telescope, led by Canada’s Natural Resources Council;
- the Science Data Processor (SDP), focusing on the design of the computing hardware platforms, software and algorithms needed to process raw science data and turn them into science data products, led by the UK’s Cambridge University.

“Though software is finally lines of code, getting it to do what it is meant to do (and do it well), requires significant thought and planning,” explains Prof. Yashwant Gupta, Director of NCRA and then TM Consortium Lead. “Many diverse requirements and varied scenarios needed to be catered for to feed, in TM, in addition to ensuring features like very high uptime, scalability to latest elements, etc.”

“Developing software for CSP has required working on two distinct kinds of software because of different computing platforms, so it represents a significant proportion of the overall development work,” explains Grant Hampson, Research Engineer at CSIRO and member of the TM Consortium. “CSP faces many software challenges, a key one being adaptability to implement a multitude of configurations. The software’s best test is the user and therefore the interfaces for which CSP has pioneered the development of dedicated facilities to enable integration testing.”

These years of work were validated in 2019 when TM, SDP and CSP respectively passed their Critical Design Reviews (CDRs) — the final step in the design of an engineering system. In order to probe the architectures of the systems, the TM and SDP teams used a process called Architecture Tradeoff Analysis Method (ATAM) both at the element CDR stage and also at the final systems.

Seven years of design

Where does the SKA Organisation and the pre-construction phase fit into this story? You’d be forgiven for thinking SOF must have already built all this software in the last seven years. Actually, on the software side of things, rather than writing lines of code, the focus of the detailed design phase from phase 1 to phase 2 is to provide “architectural blueprints.” These blueprints govern how to control the telescopes and their subsystems, but also how to handle observation requirements without discarding the infrastructure until the final building blocks of observations conducted...
system CDR to test them in an integrated way. “ATAM is a risk-mitigation process” explains Marco Bartolini, SKAO Lead Software Architect. “It helps choose a suitable architecture for a discovery tool by discovering trade-offs, and sensitivity points and works best when used early, when the cost of changing is low.”

These CDRs involved independent panels of external experts, as was the case for all SKA design consortia. “That was quite important, as that evaluation gave us confidence that we were on the right track with those architectural designs,” continues Marco.

**Bringing the gap between design and construction**

As they are meant to do, the reviews highlighted some risks. None of these were new, but it was important for the software team that they be recorded and prioritised. Since 2019, SKAO has been in a “bridging phase” ahead of construction. In terms of software, that provides an opportunity for the team to go through the most important risks and either plan or implement mitigations.

But there are also many other invisible activities going on behind the scenes to keep the whole software development process well oiled. “Under the hood, we’re looking at the development environments for our programmers, we’re looking at testing, especially testing the whole system end-to-end before deployment,” explains Juande. “All of this helps reduce the risk of things not working when we deploy them.”

**What happens next?**

In the short term, SKAO is making sure its software, which is working in simulated hardware for now, is deployed at Prototype System Integration (PSI) facilities. These facilities, like the Low PSI in Sydney (read our feature in Contact 93), bring real SKA hardware together in a controlled environment before deployment on site, and the Integration Test Facilities will also fulfil a similar purpose.

Grant Hampson leads the team that built the Low PSI. In a previous interview, he explained “We’re going into this next phase of bringing to try and de-risk some of those interfaces and some of the test infrastructure needed to do that.”

“It allows us to mask anything when we install our software!” summarises Juande.

In the longer term, SKAO’s software team, in consultation with each telescope’s Delivery Team, is developing a roadmap for software deployment on site. “The initial plan—and the software is selected so that they can support the right mixture of functionality which will be the focus of AIV for each AA,” explains Marco.

It’s an ambitious roadmap with a number of challenges, starting with a compressed schedule. “For software, we’ve got about 18 months from the start of construction activities to deploy software to a fully-functional telescope system,” says Juande. “We have to provide our telescope operators, and those checking the Array Integration and Verification (AV) tasks, the right software well before the actual start of the integration and verification of AIV-0.5.”

The second challenge the software team faces is that data rates (number of bytes per second) and data processing rates (number of computing operations per second) become very challenging by AA 1.0 and beyond. Low stations in Australia and 133 dishes in South Africa. “We’ll need to check that our software is efficient, and can cope with those data rates early on, so that we can revise how to achieve the required performance and adapt our architecture as needed if necessary,” explains Marco.

The third challenge is that the software is being written to exploit the confidentiality needs between both telescopes, so that the exact same software runs on both of them, but is configured to understand its environment and adapt itself. “But if there’s any delays or hiccups with the deployment of one of the telescopes, that could throw us off track,” adds Marco. To avoid that, the software is being built with configurability and modularity in mind.

**From software to science**

The goal of all of this effort is, of course, to enable the SKA science goals: the ultimate customers of this software will be the Principal Investigators and Co-Investigators that will use telescope time and archived data to do amazing science.

“The SKA project is just so inspiring,” beams Juande. “We want to probe into the history of the Universe, we want to see what galaxies were like when they were very young, we want to essentially find all the pulsars in our own galaxy—and even use them to indirectly see some gravitational waves... we want to learn about the formation of life-enabling molecules... Everyone is thrilled to work for a project like this.”

Speaking about SKAO’s software development process, Nick Rees, SKAO’s head of computing and software concludes: “We’ve developed a distributed, egalitarian, inclusive global culture, with clear messages so that everyone is where every opinion is heard, and people have autonomy to fix things. What is not to like about that?”

The Broader Impact of Software

Developing software for the SKA might seem very niche, but it isn’t just one way that will benefit the community of astrophysicists. Many SKA countries have been keen to get involved because they see the potential for knowledge industry in an increasingly competitive landscape, in terms of upskilling, developing new IP, diversifying their activities and opening new market opportunities.

“SDP technologies will eventually, probably via the SKA Regional Centres, find their way into the broader scientific community for analysing very-large volume, large-velocity data problems,” explains Paul Alexander. “Many of the most challenging data problems in society are in the medical and healthcare areas and already some of the SKA technologies may benefit there. It won’t be highly visible to the public, but there is real potential for the SKA to have a long term societal impact because we worked out how to tackle a really large big-data problem.”

“Given the scale at which things have to be done to deliver the SKA, industry participation has been essential,” adds Yashwant Gupta. “This is why we brought in some of the best talent available in the Indian software industry. As a result, not only did a large workforce get trained, but some of those individuals have now become experts in this area of work. It’s a great win-win for the SKA, for us at NCRA, and for Indian industry partners keen to play a significant role in SKA and in similar highly-competitive highly-skilled environments.”

Trouble in the Skies?

Satellite “mega-constellations” have been making headlines for the past year with widespread concern in the scientific community about their potential impact on astronomy. A couple of months ago, SKAO released its own preliminary analysis of the potential impact of current satellite mega-constellations on its telescopes. We sat down with our Radio Frequency Interference (RFI) Domain Specialist Federico Di Vruuto for a deep dive into the issues for the SKA telescopes and what we’re doing about it.

Tell us about this analysis and about the work we’ve been doing on this issue.

We’ve spent a good part of the last 18 months producing a study of the potential impact of these constellations on the SKA dishes in South Africa, which cover a very wide frequency range, including the frequency bands that the satellite constellations will use. We developed a complex model, with a simulation based on many variables, namely the characteristics of the satellites’ orbits (altitude, speed, trajectory, etc.) based on publicly available information and some proprietary data provided by the operators, the number of satellites (6,400 of them in the first instance), the number of SKA dishes and where they’re likely to be pointing to at any given moment.

So what will the impact be?

The satellites will transmit within the frequency range covered by our Band 5b receivers (8 - 15 GHz) on the SKA dishes, so without mitigation, there is likely to be an impact on all observations in that band, and in particular a loss of sensitivity in the frequency range used by these satellites to communicate with the ground – that’s 10.7 to 12.7 GHz. That would lead to observations in that range taking about 70% longer, which in the end means fewer observations and an impact on science. Just think of it like suddenly seeing bright lights at night, they reduce your ability to see what’s around you and you need more time to adjust, that is if you can adjust at all. That’s the case with a constellation of a few thousand satellites, but there are plans for up to 100,000 satellites in orbit. If that were the case, we’d lose the band completely.

There have been satellites in orbit for many years, why is this a problem now?

This isn’t new and existing satellites also use that frequency range which is standard for telecommunications. But we’re now talking about a much larger number of satellites in orbit since the beginning of the space age in just a few years. With increasing numbers of satellites...

Did You Know?

Under international regulations established by the International Telecommunications Union (ITU) the UN agency tasked with regulating the radio frequency spectrum and satellite orbits – the 10.7 to 12.7 GHz frequency band is prioritised for satellite communication. A number of narrow frequency bands were assigned to radio astronomy many years ago, but science has moved on since then. To detect the extremely faint radio signals and to take advantage of modern systems, radio telescopes need to go beyond the bands historically allocated to radio astronomy. In the case of the SKA-Mid telescope, observations will observe from 350 MHz up to over 15 GHz. This is possible thanks to the establishment of National Radio Quiet Zones (RQZs) in the two SKA telescope host countries protecting the sites from ground-based interference but not from aerial and space-based ones...

Above: A simulation shows how a 4,425 satellite constellation could be deployed for SpaceX’s Starlink satellite internet service. (Mark Handley / University College London)
Tell us more about that science impact.

I'm not an expert in this but our science team has been involved in assessing what that means in terms of science and it's particularly problematic for studies of complex organic molecules in our galaxy whose radio signature happens to fall in that frequency range (read our Let’s talk about article on page 10). These molecules are the building blocks of life as we know it, so if we cannot study them properly, it’ll make identifying the origins of life beyond Earth that much harder.

Could the satellites affect the rest of the receiver’s band too?

Possibly. This will depend on what we call the RFI-to-Signal ratio. The best thing that can happen is the power received from all the visible satellites in that range (the RFI) is low enough that it’s almost negligible even compared to the overall power we receive in the band 5b receiver (our intended signal). That would certainly be the case with “in the wrong direction at the wrong time” could swamp that effect.

However, the cumulative effect of many satellites pointing elsewhere, the power level can be a million times lower. The area of the sky a dish will observe is just 0.2 degrees on page 10). These molecules are the building blocks of life which is a relief! Back to eyesight, direct coupling is the equivalent of staring at the sun without protection which would burn your retina and result in permanent damage to your “instrument”, the eye… But that’s as far as the analogy goes, and it won’t happen in our case.

So are there any mitigation solutions possible?

Yes, there are options and we are actively looking at them with satellite operators. One option is to avoid directing the satellite beams at the telescope site. Steerable beam satellites can do that. It’s worth noting that the commercial incentive for operators to point their satellite beams towards the South African SKA site is already significantly limited, with the Radio Quiet Zone legislation regulating the licensing and roll out of the necessary ground-based infrastructure for satellite operators to service users in the area around the site. Additionally, satellite operators already use this technique to comply with international regulations when their satellites cross the path between geostationary satellites in higher orbit and their receiving ground stations, for example to avoid affecting telecommunications and TV transmissions, so it is technically possible.

What would be the effect of this mitigation?

We expect it would reduce the impact on the SKA by a factor of 10, so instead of observations in that range taking 70% more time, they would only “take” 7% more time. All loss of sensitivity in the frequency range is unfortunate but we understand this is a scarce resource that has to be shared among many applications.

You mentioned we’re focusing on the dishes. What about the impact on low frequencies?

Right now we’re focusing on higher frequencies because these would be the most directly impacted, where the signal is stronger because that’s the one satellites emit in. But it’s been demonstrated that radio signals emitted from the ground can bounce off airplanes so in theory they could also bounce off satellites and impact SKAT-Low in Australia. Then again, because of their size and altitude, it’s a much smaller surface area in the sky than a passing plane for signals to bounce off on, so the risk is low.

Another thing to bear in mind is that all electrical equipment emits electric noise, including satellites, which can be a concern for very sensitive radio telescopes, especially if we are talking about thousands of satellites.

On November 18, 2019, a constellation of Starlink satellites passed through the observing range of the Dark Energy Camera aboard the 4m telescope at Cerro Tololo Inter-American Observatory in Chile. Any technique used to detect these would hinder the ability to detect potentially hazardous asteroids or measure variable objects. CLIFF JOHNSON / CTIO / DECAM

United States radio spectrum frequency allocations chart as of January 2016 from 0 kHz to 300 GHz.

The narrow yellow bands are allocated to radio astronomy. Credit: US Department of Commerce

So, what’s your take-away message?

Let’s not panic. Yes, satellite mega-constellations are a concern but they affect a limited portion of the frequency range we’ll be observing. Also, from preliminary results, it looks like we will not be “blinded” for a large fraction of the time, which means that only a fraction of the band 5b will be impacted in principle and there is scope for mitigations from the operators, if they agree to implement them. Of course, this only holds if the number of satellites remains reasonable; if there are 100,000 or more satellites in the sky operating without further corrective measures, then the situation becomes much more difficult for radio astronomy.

There’s also more awareness and coordination at the international level. We are speaking with other organisations like the US National Radio Astronomy Observatory, the European Southern Observatory, the European Space Agency, the European Astronomical Society, the Committee on Radio Astronomy Frequencies of the European Science Foundation, the International Astronomical Union and others. There are also discussions within the United Nations framework, with a recent workshop organised by the UN Office for Outer Space Affairs (UNOOSA) that we were invited to take part in. The workshop led to the production of a 300-page document describing the impact that light and radio pollution has not only on optical and radio astronomy but also on wildlife and sky heritage. This report will be submitted to the upcoming meeting of the UN’s CCWSS (Committee of Peaceful Uses of Outer Space) in May, which could eventually lead to a resolution at the United Nations General Assembly.

But the reality is those discussions are difficult and take a lot of time. Those satellites are going up right now, and they’re not coming down. So collectively, we need to engage constructively with operators to educate them about our concerns and have mature conversations about possible mitigation, and we’ve been doing that quite successfully over the last 18 months or so.

We need to recognise that these constellations will operate within their ITU allocations, even if that means an impact on our operations. Unfortunately, the radio spectrum is finite and with increasing levels of technology in our everyday lives, there is fierce competition from all sectors of the economy to squeeze every bit of it. The SKA has taken a decision to engage directly with industry to find possible mitigation techniques, and so far that’s proven constructive.

We’ll continue those conversations and hope to come to a compromise that protects our interests and theirs.
The close proximity of a high energy pulse detected by CHIME, an SKA pathfinder facility located in Canada, suggests magnets may be the source of some fast radio bursts.

New data from a Canadian-led team of astronomers strongly suggest that magnets - a type of neutron star believed to have an extremely powerful magnetic field - could be the source of some fast radio bursts (FRBs). Though much research has been done to explain the mysterious phenomenon, their source has thus far remained elusive and the subject of some debate within the astrophysics community.

On 28 April 2020, a team of approximately 50 students, postdocs and professors from the Canadian Hydrogen Intensity Mapping Experiment (CHIME) Fast Radio Burst Collaboration detected an unusually intense radio burst emanating from a nearby magnetar located in the Milky Way. In a study published recently in Nature, they show that the intensity of the burst was three thousand times greater than that of any magnetar measured thus far, lending weight to the theory that magnetars are at the origin of at least some FRBs.

“We calculated that such an intense burst coming from another galaxy would be indistinguishable from some fast radio bursts (FRBs). Though this really gives weight to the theory suggesting that magnetars could be behind at least some FRBs,” said Pragya Chawla, one of the co-authors on the study and a senior PhD student in McGill’s Physics Department and one of the co-authors of the new study. “Moreover, the magnetar theory was not supported by observations of magnetars in our own galaxy as they were found to be far less intense than the energy released by extragalactic FRBs until now.”

Smoking-gun proof of a magnetar origin for some FRBs would come from the simultaneous detection of an extragalactic radio burst and an X-ray burst. However, this will likely only be possible for nearby FRBs. Fortunately, CHIME/FRB is discovering these in good numbers which should help identify the source eventually.

The discovery of the object dubbed Elegast, opens up a new path that uses radio telescopes to discover faint objects that are close-cousins of Jupiter-like exoplanets.

Brown dwarfs are objects between the mass of giant planets and small stars. They are sometimes called ‘failed stars’ because they don’t have enough mass to sustain the fusion required to become a star.

Radio waves emitted by brown dwarfs carry information about their magnetic field strength. Until now radio observations could only measure strong magnetic fields. LOFAR’s low frequencies of observation make it sensitive to magnetic fields comparable to that of a fridge magnet, which is within the range postulated to exist on the coldest brown dwarfs and large exoplanets.

“Magnetic fields control the atmospheric properties and radiation environment around exoplanets and radio observations are our best hope of measuring them. With this discovery, we have taken an important step towards realising the promise of radio astronomy to exoplanet science,” said Dr Harish Vedantham, ASTRON staff scientist and lead author of the study, which has been published in the Astrophysical Journal Letters.

“We could not have picked out Elegast in our standard radio images from among the crowd of millions of galaxies, but it immediately stood out when we made circularly polarised images,” said Dr Tim Shimwell, ASTRON staff and project scientist of the LOFAR survey that led to the discovery. Polarised radiation twists in the form of a helix as it travels. Astronomers made the images with a polarisation filter similar to the one used in anti-glare sunglasses, but implemented in software. The group then used infrared follow-up observations from the Gemini telescope and NASA’s Infrared Telescope Facility to confirm that Elegast was indeed a cold brown dwarf.

Elegast is the first object of its kind that has been directly identified in radio images. The group is now busy acquiring follow-up observations to measure its magnetic field and compare the results with theory. They are also sifting through LOFAR data to identify more objects like Elegast. The published journal article can be found here.

An open-access pre-print of the paper can be found here.

Above: Artist’s impression of Elegast. The blue loops depict the magnetic field lines. Charged particles moving along these lines emit radio waves that LOFAR detected. Some particles eventually reach the poles and generate aurorae similar to the northern lights on Earth. (Image credit: ASTRON / Danielle Futselaar)
ASKAP creates ‘Google Map’ of the universe

By Annabelle Young (CSIRO)

The Australian Square Kilometre Array Pathfinder (ASKAP) has conducted its first survey of the entire southern sky in record speed and detail, creating a new atlas of the Universe.

ASKAP, operated by CSIRO, Australia’s national science agency, at the Murchison Radio-astronomy Observatory (MRO) in outback Western Australia, mapped approximately three million galaxies in just 300 hours. The Rapid ASKAP Continuum Survey (RACS) is like a Google map of the Universe, where most of the millions of star-like points on the map are distant galaxies.

The telescope’s key feature is its wide field of view, generated by new CSIRO-designed receivers, that enable ASKAP to take panoramic pictures of the sky in exquisite detail. The RACS survey team observed 83 per cent of the entire sky. The initial results have been published in the Publications of the Astronomical Society of Australia.

This record-breaking result proves that an all-sky survey can be done in weeks rather than years, opening new opportunities for discovery. The new data will enable astronomers to undertake statistical analyses of large populations of galaxies, the same way social researchers use information from a national census.

“For the first time ASKAP has flexed its full muscles, building a map of the Universe in greater detail than ever before, and at record speed. We expect to find tens of millions of new galaxies in future surveys,” Dr McConnell said.

The 13.5 exabytes (or 13.5 billion gigabytes) of raw data generated by ASKAP were processed using hardware and software custom-built by CSIRO. The Pawsey Supercomputing Centre’s ‘Galaxy’ supercomputer converted the data into 2D radio images containing a total of 70 billion pixels. The final 903 images and supporting information amount to 26 terabytes of data-equivalent to the storage capacity of more than 50 average laptops.

The images and catalogues from the survey are publicly available through the CSIRO Data Access Portal and hosted at Pawsey.

CSIRO acknowledges the Wajarri Yamatji as the traditional owners of the MRO site.

This is the earliest epoch in the Universe for which there is such a measurement, giving new insights into how galaxies evolve. The research has been published in the journal Nature.

Atomic hydrogen gas is the primary fuel for star formation. Astronomers have long known that galaxies formed stars at a higher rate when the Universe was young than they do today, peaking about 8-10 billion years ago and declining steadily over time. The cause of this decline is unknown, mostly because – until now – there was no way to measure the amount of atomic hydrogen in galaxies in these early times. This new measurement has helped to fill that crucial gap.

“Given the intense star formation in these early galaxies, their atomic gas would be consumed by star formation in just one or two billion years. And, if the galaxies could not acquire more gas, their star formation activity would decline, and finally cease,” says Aditya Chowdhury, a PhD student at NCRA-TIFR and the study’s lead author. “The observed decline in star formation activity can thus be explained by the exhaustion of the atomic hydrogen.”

Unlike stars which emit light strongly at optical wavelengths, the atomic hydrogen signal, with a wavelength of 21cm, can only be detected with radio telescopes. However, the signal is extremely weak and difficult to detect from distant individual galaxies even with powerful telescopes like the upgraded GMRT. To overcome this, the team used a technique called “stacking” to combine the 21cm signals of nearly 8,000 galaxies that had earlier been identified with optical telescopes. This method measures the average gas content of these galaxies.

This study was made possible by GMRT’s new wideband receivers and electronics, which provided a boost in sensitivity enabling the telescope to use 10 times more galaxies in the stacking analysis than a previous similar study.

“This is the kind of science that the upgraded GMRT promised, and I am really pleased that we are now beginning to deliver,” says Prof. Vishwajit Gupta, Director of NCRA, who is also on the SKA Board of Directors. “This kind of science is also one of the main drivers of the SKA. So, true to its role as a SKA pathfinder facility, the upgraded GMRT is making discoveries that will prepare us for even more exciting science with the SKA!”

Above left: An image of the stacked 21cm signal detected with the upgraded GMRT, arising from atomic hydrogen gas in galaxies 22 billion light years away. The width of the signal gives an indication of the average rotation of galaxies eight billion years ago.

Above right: The spectrum of the stacked 21cm signal detected with the upgraded GMRT, arising from atomic hydrogen gas in galaxies 22 billion light years away.

by NCRA

Astronomers from India’s National Centre for Radio Astrophysics (NCRA-TIFR) in Pune, and the Raman Research Institute (RRI) in Bangalore, have used the upgraded Giant Metrewave Radio Telescope (GMRT), an SKA-pathfinder facility, to measure for the first time the atomic hydrogen content of galaxies seen as they were eight billion years ago.

This record-setting result proves that an all-sky survey can be done in weeks rather than years, opening new opportunities for discovery. The new data will enable astronomers to undertake statistical analyses of large populations of galaxies, the same way social researchers use information from a national census.

“For the first time ASKAP has flexed its full muscles, building a map of the Universe in greater detail than ever before, and at record speed. We expect to find tens of millions of new galaxies in future surveys,” Dr McConnell said.

The 13.5 exabytes (or 13.5 billion gigabytes) of raw data generated by ASKAP were processed using hardware and software custom-built by CSIRO. The Pawsey Supercomputing Centre’s ‘Galaxy’ supercomputer converted the data into 2D radio images containing a total of 70 billion pixels. The final 903 images and supporting information amount to 26 terabytes of data-equivalent to the storage capacity of more than 50 average laptops.

The images and catalogues from the survey are publicly available through the CSIRO Data Access Portal and hosted at Pawsey.

CSIRO acknowledges the Wajarri Yamatji as the traditional owners of the MRO site.

This is the earliest epoch in the Universe for which there is such a measurement, giving new insights into how galaxies evolve. The research has been published in the journal Nature.

Atomic hydrogen gas is the primary fuel for star formation. Astronomers have long known that galaxies formed stars at a higher rate when the Universe was young than they do today, peaking about 8-10 billion years ago and declining steadily over time. The cause of this decline is unknown, mostly because – until now – there was no way to measure the amount of atomic hydrogen in galaxies in these early times. This new measurement has helped to fill that crucial gap.

“Given the intense star formation in these early galaxies, their atomic gas would be consumed by star formation in just one or two billion years. And, if the galaxies could not acquire more gas, their star formation activity would decline, and finally cease,” says Aditya Chowdhury, a PhD student at NCRA-TIFR and the study’s lead author. “The observed decline in star formation activity can thus be explained by the exhaustion of the atomic hydrogen.”

Unlike stars which emit light strongly at optical wavelengths, the atomic hydrogen signal, with a wavelength of 21cm, can only be detected with radio telescopes. However, the signal is extremely weak and difficult to detect from distant individual galaxies even with powerful telescopes like the upgraded GMRT. To overcome this, the team used a technique called “stacking” to combine the 21cm signals of nearly 8,000 galaxies that had earlier been identified with optical telescopes. This method measures the average gas content of these galaxies.

This study was made possible by GMRT’s new wideband receivers and electronics, which provided a boost in sensitivity enabling the telescope to use 10 times more galaxies in the stacking analysis than a previous similar study.

“This is the kind of science that the upgraded GMRT promised, and I am really pleased that we are now beginning to deliver,” says Prof. Vishwajit Gupta, Director of NCRA, who is also on the SKA Board of Directors. “This kind of science is also one of the main drivers of the SKA. So, true to its role as a SKA pathfinder facility, the upgraded GMRT is making discoveries that will prepare us for even more exciting science with the SKA!”

Above left: An image of the stacked 21cm signal detected with the upgraded GMRT, arising from atomic hydrogen gas in galaxies 22 billion light years away. The width of the signal gives an indication of the average rotation of galaxies eight billion years ago.

Above right: The spectrum of the stacked 21cm signal detected with the upgraded GMRT, arising from atomic hydrogen gas in galaxies 22 billion light years away.
Telescope, LAMOST) is named after Guo Shoujing. He lived more than 900 years ago, and made important contributions to many fields of science, including astronomy. The largest optical telescope in China (the Large Sky Area Multi-Object Fibre Spectroscopic Telescope, LAMOST) is named after him. There is a memorial to Guo Shoujing in my hometown which I visited many times as a child, but I had only a vague idea that he was a famous scientist.

What made you want to be an astronaut?

The sky overhead is mysterious and fascinating to every child. On summer nights, lying outside to cool off offers a great view of the twinkling stars in the night sky. It is sad that with time, new activities come into our lives, and we lose interest in the night sky. It is fascinating to every child. On summer nights, lying outside to cool off offers a great view of the twinkling stars in the night sky. It is sad that with time, new activities come into our lives, and we lose interest in the night sky. It is an amazing and change day by day is like watching the prototype of SKA – to reveal a more complete picture of an event or object.

You’re now involved in many aspects of the project – tell us about those different roles.

Yes! I play a variety of roles, sometimes as a scientist, sometimes as a project manager, and sometimes as a government representative. This is very tough, as each role has different goals and challenges. SKA is the largest international astronomical research project in which China is deeply involved, so I feel a great deal of responsibility.

Among those roles, I’ve been heavily involved in work on the SKA Regional Centres (SRCs) (the global network of computing facilities which will process, store and give astronomers access to SKA data). I participate in the SRC Steering Committee as a Chinese representative, worked on the overall design of the global SRC network, and was responsible for the construction of the Chinese SRC prototype. We are proud that our team successfully built the world’s first SRC prototype with the help of the SKA Organisation and colleagues from partner institutes, and with great support from industry, particularly Huawei. I have fond memories of unveiling the prototype to the community at the 2019 SKA Engineering Meeting held in Shanghai in November. Seeing the prototype change day by day is like watching a child grow up; it’s an amazing and unforgettable feeling.

You’re also an astrophysicist of course! What’s your research focus?

I am mainly engaged in high-resolution interferometry (VLBI) technique. My research is on – to reveal a more complete picture of an event or object.

You’ve been working in radio astronomy since my PhD in Astrophysics, and a logical path for me was joining the SKA. My first contact with the SKA was when I visited ASTRON in the Netherlands for one year as a visiting researcher, through the China Scholarship Council, in 2011; it is one of the birthplaces of the SKA concept and has very active scientists involved in the SKA. During this period, I visited the Westerbork Synthesis Radio Telescope (WSRT) and Low-Frequency Array (LOFAR), both SKA pathfinders, and learned much scientific and technical knowledge about the SKA. After the SKA site decision was made in 2012, the Chinese government started the preparation work for participation in the project and the construction of prototypes. That’s when I joined these efforts and became a member of the SKA family.

So let’s begin at the beginning, Tao – were you always keen on science as a child?

I was born in an ordinary small town in northern China. I did not have much access to science as a child, but I was not a stranger to astronomy. The largest optical telescope in China (the Large Sky Area Multi-Object Fibre Spectroscopic Telescope, LAMOST) is named after him. There is a memorial to Guo Shoujing in my hometown which I visited many times as a child, but I had only a vague idea that he was a famous scientist.

As co-chair of the SKA-VLBI Science Working Group, I coordinate a team of over 100 astronomers. VLBI is a highly collaborative international scientific programme that demands a high degree of cooperation from each individual researcher. This is similar to the future SKA science teams. I am delighted to work with excellent colleagues from the VLBI family. Engaging in research is what we are all about.

What do you find so interesting about VLBI?

The ultimate goal of building and operating the SKA is to explore the mysteries of the Universe and to achieve major breakthroughs in natural science. In the era of multi-messenger, multi-wavelength, multi-frequency, VLBI provides essential complementary information for the high-resolution study of transient sources, helping us to build a more complete picture. It’s an incredibly powerful technique. In the future, I see the SKA as the core of the global VLBI network; it will be able to probe deeper into space, significantly broadening our understanding of the Universe. SKA’s powerful capabilities will undoubtedly live up to expectations.

“Big Data” is one of the most exciting aspects of the SKA. How did you get into the supercomputing side of astronomy?

Before I became involved with the SKA, I worked on supercomputing (differing kinds of light) and other research projects at my University, including gravitational waves and cosmic rays. Multi-wavelength astronomy combines observations made by different types of telescopes – radio, optical, infrared and so on – to reveal a more complete picture of an event or object.

You have been involved in testing SKA data processing on some of the fastest computers in the world – tell us about that.

That’s right, as part of some of the SKA’s Data Processor work packages my team and I tested how software workflows can be scaled up to meet the SKA’s data processing demands. This included carrying out testing in 2016 using Tianhe-2 in China, then the world’s fastest supercomputer, and more recently on SUMMIT, the current fastest supercomputer at Oak Ridge National Laboratory in the United States.
THE SKA IS NOT ONLY A TELESCOPE, BUT ALSO AN INTERNATIONAL COLLABORATIVE RESEARCH PLATFORM. NOTHING IS MORE WONDERFUL THAN THE SHARING AND PROPAGATION OF KNOWLEDGE UNDER THE SAME SKY.

Prof. Tao An – Head of SKA group of Shanghai Astronomical Observatory

After months of hard work, our (ICRAR/ Australia, ORNL/USA, SHAO/China) collaborative team finally completed the full-scale SKA1 workflow test in 2019, and presented the results at the 2019 SKA Engineering Meeting in Shanghai. The experiment simulated SKA1-Low observations from the cosmic reionisation era, performed a calibration and imaging pipeline, and finally generated spectral line cubes. This generated 2.5 petabytes of simulated data (if you have a 500 gigabyte laptop, you would need 5,000 of them to store this data!), and the processing consumed 99% of SUMMIT’s compute resource in its peak operation. The data was written to disk, just like your laptop does, except in this case it needed a tremendous amount of disk space in SUMMIT, and happened at 926 gigabytes/s, 1.5 times the SKA1-Low design capacity! Writing data at such speeds is extremely complex, and required us to make major technical advances.

This is the largest workflow ever generated in astronomy and fully demonstrates the big data challenges of the SKA. This success demonstrates the SKA community has the right tools, sufficient resources and expertise to handle the large SKA data flow, and the innovative techniques we developed are applicable to other data-intensive areas of scientific computing too. As a result of our efforts, this work was selected as a finalist for the 2020 Gordon Bell Prize.

What’s the best thing about being part of Team SKA?

Astronomy is a highly open discipline. The SKA is not only a telescope, but also an international collaborative research platform. Nothing is more wonderful than the sharing and propagation of knowledge under the same sky. SKA is also a huge project that spans the frontiers of science and technology in many fields such as astronomy, mechanical engineering, computers, communications, electronics and many others. That’s very exciting.

What is it like working with so many different nationalities as part of the SKA?

It’s certainly a pleasure to be a member of the SKA family. Participating in academic activities and engineering projects with colleagues from different academic backgrounds, countries, cultures, and ages, we not only exchange scientific results, but we also make many friends and share knowledge. This is a priceless asset and a very enriching experience! There are some challenges of course, like different time zones. Also, because English is not my first language, I have to adapt my hearing to many different accents!

Do you have time for hobbies outside the office?

When I was younger I enjoyed playing football, basketball and computer games, but now I am mostly busy with research or other business. On weekends or holidays I try to relax with my family watching movies or playing chess and cards with my son. Maybe after retirement I will have enough time to pick up some hobbies again!

What does it take to be a great scientist, in your opinion?

Scientific research is creative work and imagination is the source of innovative results. A good scientist must be able to think independently. New ideas, new methods, and scientific breakthroughs are often produced through questioning and debates. Winners in any field are not born, they are made. Excellent scientists must have

Credits: All images courtesy of Tao An.

Team SKA

In each issue of Contact, we’ll get to know one of the many talented people contributing to the SKA, hearing about their work, how they got here and their advice for the next generation.
**HERITAGE, HISTORY AND INDIGENOUS ASTRONOMY**

**BY SARAO COMMUNICATIONS**

SARAO recently hosted a virtual conversation focusing on Indigenous Astronomy as part of Heritage month in South Africa.

The event brought together important international stakeholders in an effort to acknowledge and reflect on the heritage of Indigenous peoples in partner countries, drawing on commonalities in the context of the SKA. It focused on the importance of Indigenous knowledge systems and their role in current and future scientific research.

The land on which the SKA telescopes will be constructed in both host countries has strong ties to Indigenous heritage. In South Africa, the Karoo region was inhabited by the early ancestors of the San people, who are considered to be some of the most ancient people on Earth, having been around for the past 22,000 years. There are still significant amounts of cultural heritage found on the land to date. In Australia, the Murchison Radio-astronomy Observatory, which was established in 2009, while being one of the world’s newest observatories, is built on ancient land where geologists have identified some of the oldest rocks on Earth. There is evidence that Aboriginal communities lived on this land for tens of thousands of years before it was settled in the 1800’s by pastoralists.

Throughout the conversation, common themes around the use of astronomy in the everyday lives of Indigenous peoples came to the fore; stories on how the moon and stars were used to determine weather patterns, agricultural cycles and the telling of mythological tales across generations. This was the first conversation of its kind and opens more opportunities for knowledge sharing on the social context that the SKA project exists within.

**TACKLING RESEARCH ACCESSIBILITY**

**BY DR SHARI BREEN AND MATHIEU ISIDRO (SKAO EDI WORKING GROUP)**

Earlier this year, SKAO was invited to join the organisation of a joint ESA/ESO/IAU/SKAO workshop on space and astronomy research accessibility, bringing together the three intergovernmental organisations in the field together with the professional body for astronomers worldwide.

The workshop took place at the beginning of December, and SKAO was represented by members of its Equality, Diversity & Inclusion Working Group. Twenty four speakers (at least a third of whom have conditions that impact their accessibility needs) took part in the event from the USA, Europe, South Africa, Australia and Asia in what is thought to be the first meeting on accessibility, disability and neurodiversity for the space and astronomy professional community.

Discussions centred around the needs of researchers who are blind or visually impaired, deaf or hearing-impaired, have a physical disability or are neurodiverse. Clear tips and recommendations were provided on how to organise more inclusive events and meetings - both virtual and in-person -, on the use of accessible research software, on inclusive behaviour and on accessible policy-making at an organisational level.

It is the hope of the organisers that these can be brought together into a joint document setting out recommendations for our own organisations and for the field, so keep an eye out for summaries of the discussions and good practice to be published in due time.

---

**THE SKA OBSERVATORY | VIRTUAL CONFERENCE**

**A PRECURSOR VIEW OF THE SKA SKY**

**15–19 MARCH 2021**

We are very pleased to announce that abstract submission for the 2021 SKA science meeting, entitled “A precursor view of the SKA sky”, is now open through the OnAir page.

In the year that marks the establishment of the SKA Observatory, as well as the start of SKA construction activities, we want to bring the focus to science, with the new and exciting results that are being produced by the SKA precursors and pathfinders and their implication for SKA.

The Conference will be a fully virtual event, to be held on 15-19 March 2021. It will include plenary sessions organised by the SOC, as well as splinter sessions organised independently by the Science Working Groups. The format will allow participation across all time zones.

The registration fee is £40 per person (£20 for students), to cover the cost of the online platform. We look forward to seeing many of you there!

The Scientific Organising Committee
NEWS FROM AROUND THE WEB

ABC NEWS

THE AUSTRALIAN
The big picture emerges in WA – Behind the scenes of a science-mets art documentary centered on the SKA and Indigenous astronomy, currently in production at the future SKA-Low site.

HPC WIRE
Four Teams Using ORNL’s Summit Supercomputer Named Finalists in 2020 Gordon Bell Prize – The finalists for the prestigious supercomputing prize included an international team working on data pipelines for the SKA.

CARTOON CORNER

PHYSICS
Physics in South Africa – How radio astronomy and involvement in the SKA is contributing to a boom in South Africa’s physics sectors.

SCIENCE
Starlink already threatens optical astronomy. Now, radio astronomers are worried – Science magazine explores the effect of satellite constellations on the SKA and other observatories, and efforts to mitigate the impact.

SCIENTIFIC COMPUTING WORLD
Harvesting data from large radio telescope arrays – Mark Stikells, executive director of Australia’s Pawsey Supercomputing Centre, discusses the centre’s vital role in processing astronomical data, and how the centre has contributed to the fight against the COVID-19 pandemic.

THE NAKED SCIENTISTS
The largest telescope ever made – The popular science podcast speaks to SKA Director-General Prof. Philip Diamond about the exciting science the SKA will make possible.

REFLETS DE LA PHYSIQUE
Le Square Kilomètre Array, un radiotélescope géant – Chiara Ferrari, Mission SKA-France Director, provides an overview of the SKA, and the science it will tackle in the French Physics Society’s magazine.

GITLAB
How SKA uses Gitlab to help construct the world’s largest radio telescope. SKA is leading the design of the globally distributed radio telescope SKA, using GitLab SCM and CI for scientific collaboration, development efficiency, and transparency.

PARTNER PUBLICATIONS
READ THE LATEST SKA-RELATED NEWS FROM SOME OF OUR INTERNATIONAL PARTNERS

SKA-FRANCE – BULLETIN – NOVEMBER 2020

MEDIA INAF LATEST SKA NEWS

ASTRON NEWSLETTER – NOVEMBER 2020

RADIONET- RADIONET NEWSLETTER – NOVEMBER 2020

DON’T MISS! SKA AT UN75 GA
On the occasion of the United Nations 75th General Assembly, SKAO was invited to deliver a series of presentations to discuss the role of the SKA in answering the UN’s Sustainable Development Goals. The talks, delivered by a number of SKAO staff and key partners from around the SKA’s family, presented the inspirational range of outcomes already being delivered across the SKA project, from human capital development, innovation and technology development, to education and culture. Speakers showed the prospects for the future, demonstrating how the alignment with the UN’s SDGs, and the footprint of the SKA across developed and developing countries, present a unique opportunity for the world.

As we ramp up towards start of construction in the next few months, we will be recruiting UK HQ based staff in Procurement, Finance, Communications, IT, Health & Safety and Engineering roles. We are also starting to recruit for some roles to be based in Australia and South Africa. Some of those roles will be employed through our partners CSIRO and SARAO. Make sure to register on our recruitment website to receive alerts.

SYSTEM ENGINEER
This role will report to the Senior Systems Engineer for the Observatory and will be part of team of six system engineers. This particular role will take on responsibility for complex system engineering tasks. This will require an expert in problem solving and system thinking.
Deadline: 25/01/2021
Apply here

SENIOR CONTRACTS SPECIALIST (construction and engineering categories)
The SKA seeks to recruit a Senior Contracts Specialist with a demonstrable track record of delivering against a challenging timeline whilst being a champion of commercial excellence and proactively drawing on their own extensive professional experience to enable the effective and efficient procurement of complex international contracts and agreements.
Deadline: 22/02/2021
Apply here

PROCUREMENT SPECIALIST (SOFTWARE AND ICT)
The SKA seeks to recruit a Procurement Specialist with a demonstrable track record of delivering to an agreed plan whilst being a champion of commercial excellence, proactively drawing on their own extensive professional experience to enable the effective and efficient procurement of software and ICT products and services.
Deadline: 11/01/2021
Apply here

TECHNICAL WRITER
This role is to support the production of technical documentation for use by the SKA team and the wider community. This will include product specification, data sheets, technical notes, and other documentation.
Deadline: 22/02/2021
Apply here

TREASURY MANAGER
Reporting to the CFO, the Treasury Manager will be responsible for the day to day centralised treasury function of the SKA Observatory and providing treasury support to Finance Managers located in the three host countries.
Deadline: 11/01/2021
Apply here

SKA REGIONAL CENTRE ARCHITECT
The SKA is seeking a new Regional Centre Architect to head up the architecture department at the Regional Centre in South Africa. The role will be a key strategic client-facing role ensuring that the Regional Centre is delivering the expected outcomes.
Deadline: 08/02/2021
Apply here

PARTNER INSTITUTE JOBS
POSTDOC POSITIONS AT EPFL
Two postdoctoral researcher positions (one in astrophysics and one in data science) are available at the Laboratory of Astrophysics (LASTRO) of the Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland, to work on developing astrophysics expertise in the context of the new large radio-interferometry projects.
Deadline: 03/01/2021
Astro - Apply here
Data science - Apply here

CAREERS AT SARAO
Are you ready to be part of building one of the world’s largest research infrastructure projects? After the successful completion of the MeerKAT radio telescope, SARAO is about to start the construction phase of the MeerKAT Extension project. Follow this link to find out more details and how to apply.

Apply here
Contact – The SKA magazine
Published by the SKAO Communications team.

Editor: William Garnier
W.Garnier@skatelescope.org
Editorial team: Mathieu Isidro, Cassandra Cavallaro
skao-outreach@skatelescope.org
Design: Joe Diamond, based on an original design by Carbon Creative

We welcome your contributions to Contact!
Find out how to submit ideas here.

All images in Contact are courtesy of SKAO unless otherwise indicated.

About the SKA
The Square Kilometre Array (SKA) Organisation leads an international effort to build the world’s largest radio telescope. The SKA will be constructed in Australia and South Africa with a later expansion in both countries and into other African countries. Its global headquarters is located at Jodrell Bank in the UK.

The SKA will conduct transformational science and help to address fundamental gaps in our understanding of the Universe including the formation and evolution of galaxies, fundamental physics in extreme environments and the origins of life in the Universe.

Front cover: A certified copy of the SKA Observatory Convention, which is held at SKA Global Headquarters, bearing the official seal of the UK Foreign and Commonwealth Office (now the UK Foreign, Commonwealth and Development Office). The necessary ratifications for SKAO to enter into force were reached in December 2020.

For printed versions
Hyperlinks: Contact is produced primarily as a digital magazine. If you are reading a print copy, use the QR code to read this and other issues of Contact online and access the hyperlinks.