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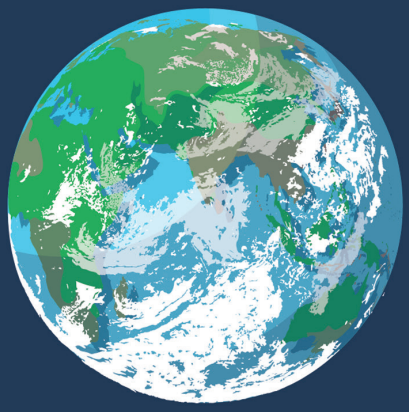

100 Years Under One Sky

Lessons learnt and challenges of planning and coordinating the IAU 100th anniversary celebrations

Above and Beyond Exhibition

Creating a travelling exhibition portraying the last 100 years of astronomy

NameExoWorlds

Implementing the largest international naming campaign of exoplanets and its hosting stars

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News

The IAU100 initiative exceeded initial expectations with over 5000 registered activities in 143 countries, and facilitated the direct involvement of an estimated 5 to 10 million people along with an estimated further reach of 100 million people through communication activities. The IAU 100th Anniversary Celebrations Final Report showcases the implemented activities, event highlights, finances, communications, impact numbers and IAU100 legacy. Credit: IAU / IAU100 / Aneta Magraf-Druc

Guest Editorial

We are delighted to present the IAU100 special edition of the Communication Astronomy with the Public Journal. For this issue, the IAU100 Secretariat collaborated with the CAP journal to explore the best practices and lessons learnt behind the IAU100 initiative.

The celebration of the International Astronomical Union's 100th anniversary in 2019 engaged millions of people in 143 countries who celebrated the astronomical breakthroughs that have shaped science, technology and culture over the last century as well as the importance of astronomy as a tool for education, development and diplomacy.

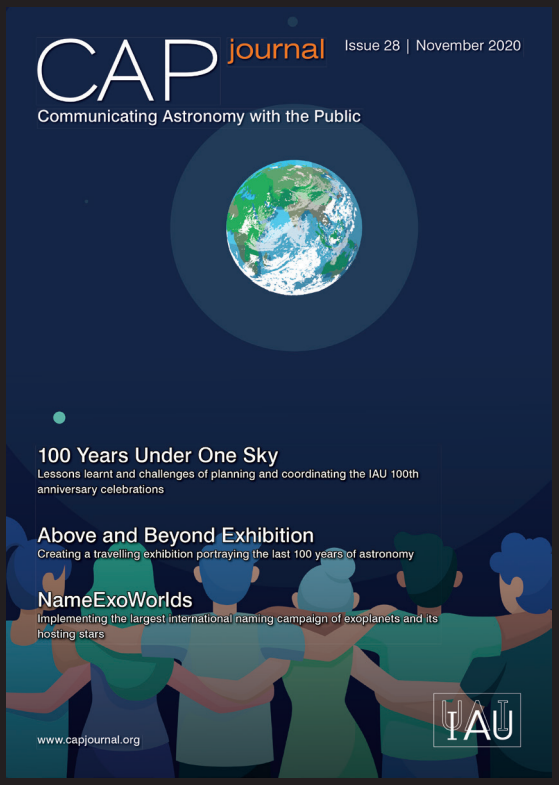
While the IAU100 Final Report gives the reader an overview of the bigger picture of the IAU100 initiative, for the IAU100 special issue of the CAP journal our goal was to explore in detail best practices from the IAU100 projects.

From a detailed analysis of the approach and methodology used for the overall coordination of the IAU100 initiative, in this issue, you can also discover the behind the scenes of successful IAU100 Global Projects such as the IAU100 NameExoWorlds and the IAU Above and Beyond exhibition; lessons learnt from the Eddington@Sundy project commemorating the centenary of the 1919 Eddington Eclipse; and reflections from regional/ local actions such as the LightSound project that helped communities of visually impaired people in Chile and Argentina to experience a solar eclipse, the Amanar project that shared astronomy with Sahrawi refugees, a workshop for inclusion in Thailand within the framework of the IAU Inspiring Stars project, and dark skies awareness actions around Ireland and Iran.

Despite the IAU100 official ending just eight months ago, due to the current COVID-19 Pandemic around the world, we are in a complete new scenario worldwide for the organisation of large-scale public engagement activities such as IAU100. While we wait to find out what will be the "new normality" in the coming years, we can be sure that networks such as the IAU network of Outreach Coordinators, the coordinators of the IAU100 Global and Special projects and the thousands of organisers of IAU100 grassroots activities around the world, which were fundamental for the success of IAU100, will continue working hard to adapt to the new times and keep engaging their communities with the wonders of astronomy.

The IAU100 Secretariat
Invited Guest Editors for CAPjournal #28

Cover: Pale Blue Dot was the last of IAU100 Global Programs and signalled the end of the IAU100 Celebrations by highlighting the importance of protecting our Earth through tolerance, peace and international cooperation. Credit: IAU / IAU100 / Aneta Magraf-Druc



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Explained in 60 Seconds: The IAU National Outreach Coordinators (NOCs) Network

Lina Canas
IAU Office for Astronomy Outreach
lina.canas@nao.ac.jp

Sze-Leung Cheung
National Astronomical Research Institute of Thailand (NARIT)
cheungszeleung@narit.or.th

The IAU National Outreach Coordinators (NOCs) are a network composed of astronomy outreach-related professionals active in national and local public engagement. With communication and accessibility at the core of the IAU Office for Astronomy Outreach (OAO)[1], this network is actively committed to bringing astronomy to everyone through the IAU-led outreach actions.

The NOC is the principal outreach national representative appointed under the IAU outreach structure, coordinated by the IAU Office for Astronomy Outreach (OAO). The primary role of the NOC is to encourage astronomy outreach activities in their country. The three key tasks of the NOCs are to (1) implement the IAU outreach initiatives at the national level, (2) disseminate information nationally and (3) bridge the IAU with local/national outreach communities (e.g. amateur astronomers, science centres, etc.).

In 2019, the IAU celebrated one hundred years, and with it, the world united "under one sky" in a truly global celebration of astronomy. With the IAU OAO network in place, and with a focus on representativeness and localisation to increase impact at local and regional levels, the NOCs and their National Committees composed by professional and amateur astronomers, outreach professionals and formal educators to increase reach and impact, were a focal point for the high visibility and impact of this IAU milestone.

In the next decade, the role of the NOC will continue to be paramount in implementing the IAU strategic vision[2] for astronomy communication and outreach, engaging with the amateur astronomy groups within each country, helping to spread the word about the dark and quiet sky initiatives and to promote citizen science projects in their communities. The IAU envisions the IAU National Outreach Coordinators as bridge-builders, facilitating access to astronomical information across communities, from professional astronomers to the general public, and continuing the IAU pursuit of taking astronomy to all in years to come.

Notes

[1] The IAU Office for Astronomy Outreach (OAO) is a joint venture between the International Astronomical Union (IAU) and the National Astronomical Observatory of Japan (NAOJ) and is primarily responsible for coordinating the IAU's communication and outreach initiatives and to manage the international network of IAU Outreach National Coordinators in more than 130 countries.

[2] IAU Strategic Plan 2020-2030: https://www.iau.org/static/administration/about/strategic_plan/strategicplan-2020-2030.pdf

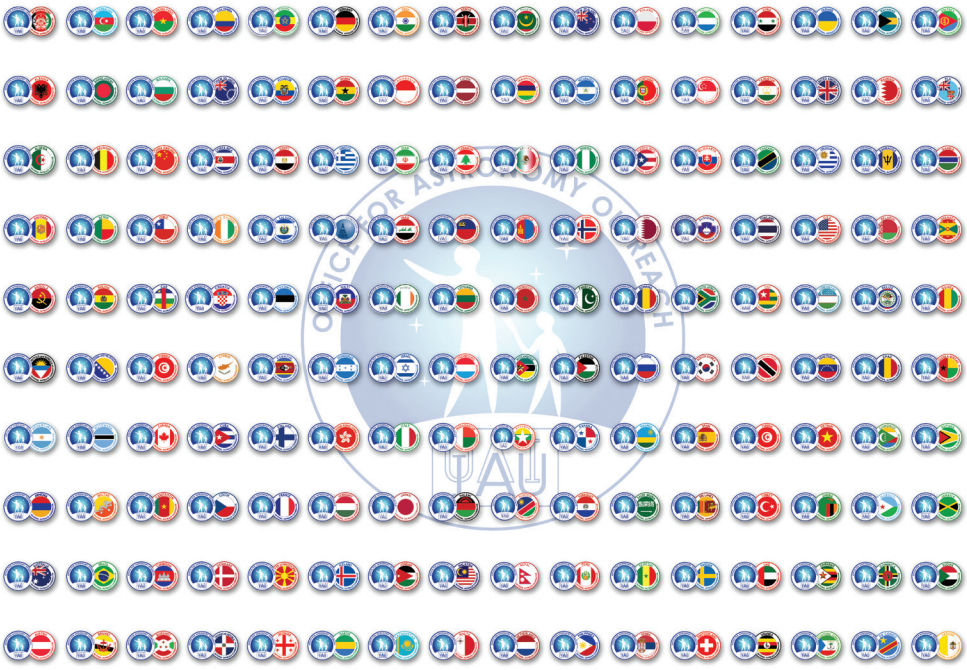

Figure 1. *Mosaic of all NOC logos, with the OAO logo at its centre. Credit: IAU OAO*

Above and Beyond: Creating a Travelling Exhibition to Portray the Last 100 Years of Astronomy

Claudia Mignone
National Institute for Astrophysics (INAF)
claudia.mignone@inaf.it

Łukasz Alwast
Science Now
lukasz.alwast@sciencenow.studio

Jan Pomierny
Science Now
jan.pomierny@sciencenow.studio

Milena Ratajczak
Science Now
milena.ratajczak@sciencenow.studio

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"Above and Beyond — Making Sense of the Universe for 100 Years" is an exhibition created as part of the International Astronomical Union centenary, providing a journey through a century of astronomical research and its broader impact on technology and culture. After the opening in Vienna, Austria in 2018, it was on display across Europe throughout 2019, reaching an audience of many tens of thousands, with scaled-down versions displayed in 75 countries around the world. This article presents the development, from concept to implementation, and a preliminary analysis of the project, along with lessons learnt of potential interest to organisers of similar science outreach projects with global reach.

Introduction

One of the flagship initiatives to mark the 100th anniversary of the International Astronomical Union (IAU100) in 2019 *(Gonzales et al., 2018)* entailed the production of a travelling exhibition to showcase major achievements in astronomy in the last century, along with selected IAU milestones. Aimed at reaching a diverse audience – from the global astronomical community to national scientific societies, policy-makers, and the general public — the exhibition was replicated worldwide in various formats, also thanks to open-source materials, in combination with other IAU100 activities.

Eventually described as *"a humble attempt at navigating through some of the most important and spectacular achievements in modern astronomy"*[1], the project had an ambitious goal: to condense a century of scientific and technological advancements — and not just any century, but one in which astronomers moved from having hardly any clue about the size of the cosmos *(Trimble, 1995; Kragh & Smith, 2003)* or the energy source that powers stars *(Kragh, 2016)* to a comprehensive understanding of the Universe, which naturally opened new fundamental questions. The exhibition strived to convey the science breakthroughs along with their relevance to culture and society — how they fuel one another — to trigger a feeling of awe and wonder for astronomical discovery.

The production timeline was extremely challenging: with the IAU100 flagship programmes defined in late 2017 and the exhibition concept in early 2018, the show was to premiere at the XXX IAU General Assembly in Vienna, Austria in August 2018 *(Downer et al. 2018)*, ahead of many replications throughout 2019, the year of the IAU centennial.

In March 2018, a team of astronomers and science communicators brainstormed on the content and format, to be later approved by the IAU Executive Committee on IAU100. In April, the production team was defined, with quotes provided by two different companies and the contract awarded to the multidisciplinary science and strategic design studio Science Now[2]. After inspection of the available space at the Austria Center Vienna (ACV), the IAU General Assembly venue, development started with two workshops in May, design work in June, text production in July, manufacture and set-up in August. The inaugural exhibition was on display 20–31 August 2018 (Figure 1).

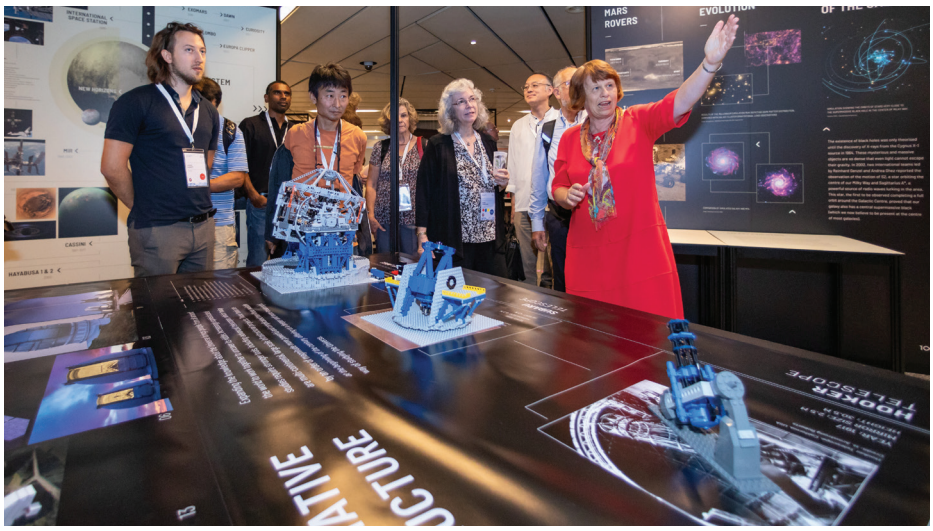

Figure 1. *Ewine van Dishoeck, then-IAU President-elect, presenting the exhibition during the opening in Vienna. In the foreground, telescope scale models built out of Legos. Credit: IAU/M. Zamani*

Figure 2. *The exhibition poster, highlighting the distinctive visual language and the three key questions guiding viewers throughout the show. Credit: IAU*

The full-scale show[3] would later travel to nine cities across Europe, which were selected from proposals by IAU members and IAU100 national organising committees; have a nine-month exhibition at the Leiden Old Observatory in the Netherlands, and be displayed in small-scale versions around the globe.

Distilling 100 Years of Astronomy

The initial definition indicated that, while celebrating major science achievements — including key milestones of the IAU's first century — the exhibition should present the interdisciplinary character of contemporary astronomy and its international scope. The content should portray science as a process, not a series of individual discoveries. This could be achieved by guiding viewers through multiple fruition paths via major questions about the Universe that the audience could also relate to, and by featuring the people behind the research — their stories and possibly also their voices. The use of objects was also recommended — historical artefacts and modern technology — to emphasise the relevance to everyday life. The target audience should include the general public, young children and families, but also science enthusiasts and professional astronomers; the format should be reusable, scalable, and localisable to achieve a global reach.

A request for input to all IAU Divisions, Commissions and Working Groups resulted in over 200 proposed highlights, organised over the ten decades between 1919 and 2019. A board, consisting of five IAU members with expertise in different areas of astronomy, received the full list, cast votes and down-selected the proposed highlights to 75 for the creative team to further focus on. A few additional highlights were added to cover themes such as space science and public outreach. There was no reporting back to Divisions, Commissions and Working Groups on the final selection, but no complaints were received.

To convey such a rich history to a broad audience, the team chose three fundamental questions in the history of modern astronomy to help navigate through the exhibition content (Figure 2 and 7):

1. What is the size and structure of the Universe?
2. How do stars form and shine?
3. Is there life elsewhere in the Universe?

The questions were selected to focus on broad topics that would lend themselves to different layers of storytelling, and also resonate most with the public interest. The story arch of the show was then built around the questions, which work as a leitmotif through the evolution of astronomy over the decades, enabling viewers to experience the exhibition either in a chronological or in a thematic fashion.

Even if the target audience included different publics, the text for the panels was developed with a non-expert public of non-native English speakers in mind, keeping written content minimal, plain language, and a strong emphasis on visual elements. The visual language included astronomical images, whose striking beauty is an established tool to engage with wide audiences *(Arcand & Watzke, 2009)*, alongside specially created infographics[4] on specific concepts, for example, the history of exoplanet discoveries (Figure 3, 6 and 11) or the development and growth of space exploration.

Design and Production

After an initial evaluation, it was decided to base the exhibition on analogue rather than multimedia experiences. This was partly due to budget constraints. The exhibition would not be staffed, so with visitors discovering the content on their own: this posed another constraint. Therefore, the visual language and visual storytelling had to play a significant role in the fruition of the show[5].

Given the originally allotted space for the inaugural exhibition in Vienna — a rectangle of 6.9m x 19.8m — the team

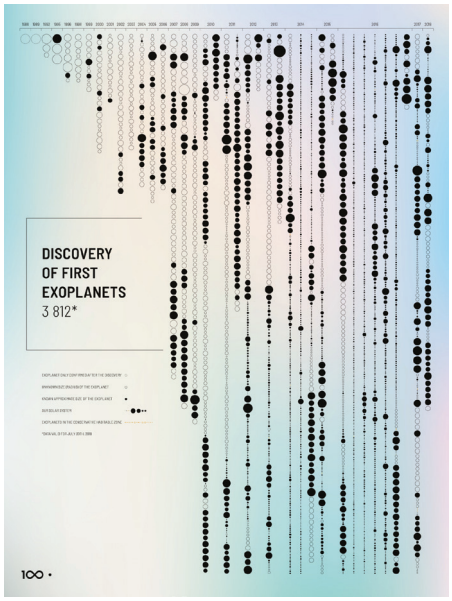

Figure 3. *An infographic summarising the discoveries of exoplanets, planets beyond the Solar System, as of July 2018. Credit: IAU*

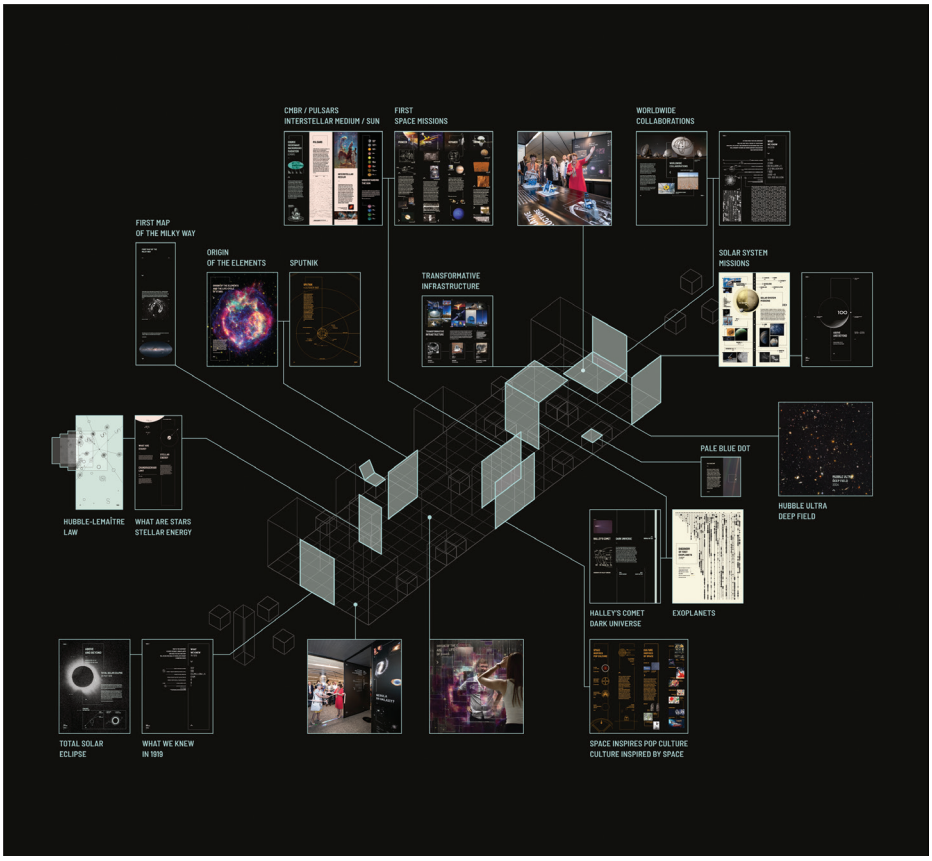

Figure 4. *The grid structure and story framework translated into the ensuing construction solution. Credit: Science Now*

developed the narrative arch starting at one end of the structure and leading to the opposite end in chronological, linear order (Figure 4).

The 75 highlights gave rise to over 200 individual content interactions[6], complemented by three "key experiences" — distinctive installations on crucial achievements: the origin of elements, the Moon landing, and the Hubble Ultra Deep Field (Figure 5 and 6). Two sets of "cubicles" were located at the beginning and at the end, to first set the scene in the early 20th century, and then reflect on how the key questions have changed over the intervening 100 years.
The spatial structure, using a modular grid concept, and the visual language were developed to enable three simultaneous layers of storytelling[7]. Viewers can thus experience the exhibition in a chronological fashion (as the paths progresses linearly), via the three questions (each highlighted in a different colour; see e.g. Figure 7), or via the contributions to science, technology and culture (each presented along a different trajectory: left, centre, and right).

Only a couple of weeks before the opening, the team was informed that the available space at the venue was not the previously agreed rectangle, but instead a triangle[8]. This posed a substantial and unforeseen challenge, calling for a rethink of the exhibition layout at very short notice, with all materials and content already produced for a different spatial logic. Eventually, a satisfactory solution was found by distributing the content along a V-shaped trajectory, displaying the chronological order from corner to corner to make the best use of the triangular space. While there were no complaints about the triangular format, it is the opinion of the team that the exhibition content was quite cramped in the opening show in Vienna, and that subsequent versions (for example, the one in Brussels) where the content was arranged according to the original design provided a more spacious and comfortable experience, based on casual observations of the audience and analysis of photographs.

Travelling Exhibition and Scaled-down Versions

After the inaugural show in Vienna, primarily visited by astronomers attending the IAU General Assembly, the same version of the exhibition was on display in science centres and other venues across Europe (see Table 1). The shows were organised by IAU100 partner institutions and were supplemented by additional content and/or public events featuring local astronomers. Meanwhile, an extended exhibition[9] was produced in Leiden, the Netherlands by Science Now (design studio) in collaboration with Stellar Fireworks (production company). It included extra content to showcase the local history of astronomy, in Dutch and English, with archival images, display objects, backlit panels, and a brand new section dedicated to astronomical futures portrayed by a number of design fiction posters (Figures 8–11).

In the open science spirit, all content and designs are available under an open-source license for adaptation and reuse. The designs allow anyone to reproduce the full-scale show, with the original modular design, and a scaled-down, low-cost version, with content adapted into 100 posters (a mix of A3 and B1 sizes) for easy replication in any printing facility worldwide and flexible space display (all materials are available via *Russo et al., 2018*). Sharing the source design files allows for local adaptation and translation.

Exhibitions based on these materials (often translated) were replicated through the IAU network of National Outreach Coordinators and national astronomical societies, bringing the show to Algeria, Aruba, Bulgaria, Canada, India (Figure 12), Japan[10], Spain, Tunisia, Uruguay[11].

The text and visual content were further condensed to create a set of twelve A0 posters (in English) featuring the exhibition's highlights, producing a budget version for display at meetings, universities and schools (posters are available via: *Russo et al., 2019*). Three hundred sets of posters, printed by the IAU100 secretariat, were distributed to 75 countries[12].

Location	Period	Number of visitors (type of audience)
Vienna, Austria (A)	August 2018	3000 (astronomers)
Bratislava, Slovakia (A)	Oct 2018—Feb 2019	13 000 (general public)
Brno, Czech Republic (A)	Feb—Mar 2019	4500 (general public)
Brussels, Belgium (A; B)	April 2019	500 (astronomers, policymakers)
Armagh, Northern Ireland, UK and Birr, Dublin, Cork, and Galway, Ireland (A)	Jul—Oct 2019	8000 (general public)
Matera, Italy (A)	Dec 2019—Feb 2020	3000 (general public)
Leiden, the Netherlands (C)	Apr 2019—Jan 2020	13 000 (general public)
Uruguay: Montevideo and several cities across the country (D)	Jul—Oct 2019	2000 (general public)
Sofia, Bulgaria (D)	May—June 2019	1500 (general public)
Bulgaria: 20 cities across the country (D)	Jan 2019—Jan 2020	1000 (general public)
Temse, Belgium (E)	October 2019	300 (general public)

Table 1. *Number of visitors to the travelling exhibition and selected local exhibitions.*
(A) Travelling exhibition
(B) On the occasion of the IAU100 Flagship Ceremony
(C) Permanent exhibition
(D) Local exhibitions (scaled-down version)
(E) Local exhibition (12-poster version)

While the open-source content remains available online for any venue who wishes to replicate the exhibition locally in the future, the IAU100 organisers have also been considering possible ways to keep the travelling exhibition alive in order to maximise the resources invested in its development. Plans to display the show in new locations throughout 2020 were halted due to the onset of the COVID-19 pandemic, and are being re-evaluated at the time of this writing. One of the possible courses of action could be to organise an open call for science institutions or visitor centres who wish to display the exhibition for six months or longer; this, however, would call for additional costs in terms of storage and partial replacement of any damaged exhibits. Discussions are also ongoing regarding a possible publication to preserve a permanent record of the panel texts.

Audience Engagement

The exhibition, in its different formats, was on display on four continents, reaching many tens of thousands of visitors (see Table 1 for information from several of the hosting venues.) The permanent version in Leiden received a formal, very positive review by the Dutch national newspaper NRC, which described the exhibition as *"small and beautifully designed"* and rated it with four out of five stars[13].

Due to several factors, including the short production timeline, a lack of dedicated personnel, and limited resources, there was no formal evaluation of the exhibition's outcomes and its impact on visitors performed. A very preliminary analysis of public engagement was conducted using input collected as part of the overall evaluation of IAU100 activities. To this aim, all event organisers were invited to assess and report on some aspects, including: event duration; estimated number of participants; local budget and sponsors (if any); brief description of the event; aims of the event and IAU100 Goals covered; target audience; level of audience participation in the event; audience breakdown;

Figure 5. *XXX IAU General Assembly participants exploring the "Origin of Elements" installation at the inaugural exhibition in Vienna. Credit: IAU/Science Now/A. Majewska*

Figure 6. *The Hubble Ultra Deep Field "key experience" at the Vienna exhibition; on the right, the exoplanet timeline infographic. Credit: IAU/M. Zamani*

Box 1. Comments from local organisers

"A well prepared travelling exhibition, including all important material for installation and graphics package. It was just missing some interactive exhibits [...] All exhibition texts were in English, so not all visitors could understand them."

Barbora Procházková (Vida Science Center, Brno, Czech Republic)

"It was a very hard work due to lack of resources. On the one hand I had to get and learn to use a program to edit the original AI files to translate the texts into Spanish, and on the other to get the financial resources to print them [...] In most of the centers that hosted the exhibition, there was no adequate infrastructure or suitable personnel to unpack, assemble, care and pack the exhibition. However, the great effort and time invested was compensated by the interest it had on the public, especially educators, students and educated or expert public."

Andrea Sosa Oyarzabal (Centro Universitario Regional del Este, Universidad de la República, Uruguay)

"This was an awesome event. The AW Mercator team was present in the exhibition room to give some extra explanation to the public about the posters and we got very good reactions. So thanks again for providing the posters !!"

Kris Schoeters (VVS AW Mercator, Temse, Belgium)

"The exhibit [...] has been a real success in terms of impact on society, with regards to both the public and the excellent framework of institutional collaborations. For the Italian edition [...] we created a guided path with a yellow circle in every (suggested) step of the exhibition (both thematic and chronological steps) and a special map. Furthermore, we distributed a free booklet [...] where all the astronomical discoveries described in the English panels were explained in a very friendly and funny way [...] In the framework of the exhibit, daily interactive activities and science laboratories addressed to a specific age target were organised."

Rossella Spiga (INAF, IAU Deputy National Outreach Coordinator, Italy)

considerations on audience diversity, inclusion and accessibility; and lessons learnt. Several, though not all, partners who hosted the travelling exhibition or set up a scaled-down version using the open-source materials responded to this call for feedback. No partner reported on the presence of systems to gather feedback from visitors.

Figure 7. *Structural and visual elements – such as the key questions highlighted in different colours – at the Brussels exhibition. Credit: I. Ma – CC BY-NC 2.0*

In their feedback, partners listed informative and educational objectives among their aims, to generate curiosity and interest in astronomy and science by showcasing the beauty of the Universe and a broad range of scientific achievements. All partners targeted a mixed audience of adults and young people, experts and non-experts. One of the travelling exhibition hosts (Brno, Czech Republic) reported a detailed breakdown of the audience: 56.3% female, 43.8% male; level of education: 12.5% preschool, 34.4% elementary school, 35.5% high school, 30.2% university. Most partners reported a 'passive' level of engagement, with audience viewing panels and reading the texts; one of the partners explicitly flagged the lack of interactive exhibits; another partner noted some level of interactivity (e.g. audience asking questions to experts).

Partners praised the content quality and the straightforward design and installation. Some hosts of the travelling exhibition flagged the fact that all text was in English, and so it was not accessible to all visitors in non-English speaking countries; one of the hosts (Matera, Italy) reported supplementing the exhibition by distributing additional material in Italian. Several partners who set up scaled-down exhibitions using the open-source content translated the text to local languages (e.g. Bulgarian, Japanese, Kannada, Spanish); this did, however, entail a large deal of extra work by local partners. Outstanding comments from local organisers are reported in Box 1.

Lessons Learned

Several aspects discussed in the project definition were not eventually implemented, mainly due to budget and/or production timescale constraints.

Multimedia Exhibits

The team considered audiovisual material, e.g. interviews to IAU astronomers reflecting on the past, present and future of the discipline and the organisation. This could have served different purposes: 1) to provide a positive emotional experience for visitors by adding personal science stories and voices *(Burns, O'Connor, & Stocklmayer, 2003);* 2) to reflect the diverse community of IAU members in terms of

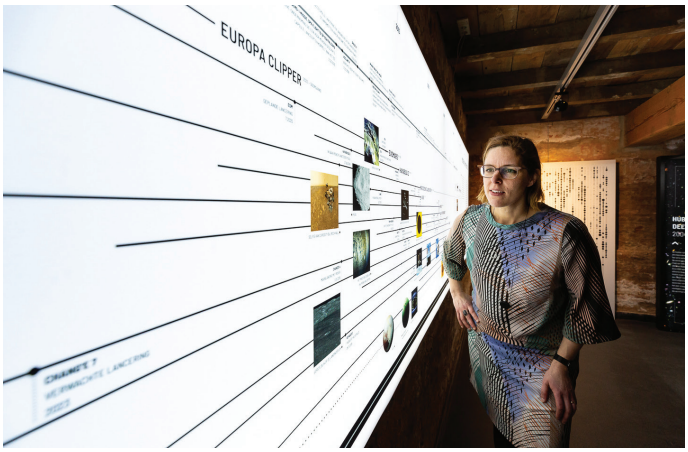

Figure 8. *Backlit panel featuring the timeline of space science missions at the Leiden exhibition. Credit: M. Shaw/Leiden University*

Figure 9. *A prototype of the Heterodyne Instrument for the Far-Infrared (HIFI) which flew on the European Space Agency's Herschel Space Observatory, on display at the Leiden exhibition. Credit: M. Shaw/Leiden University*

age, nationality, ethnicity, gender, sexuality, disability (fostering inclusiveness in the advancement of astronomy, in line with Priority IV of the IAU Strategic Plan 2020–2030[14]); 3) to produce multilingual content, leveraging on the many languages spoken by IAU members worldwide. However, it would have required content production, hardware support and maintenance well beyond the project budget, and could have been problematic to replicate for the smaller-scale versions, so it was decided early on to focus on an equally rewarding, analogue experience. In future projects, the hardware issue could be overcome by harnessing the storytelling opportunities for science museums offered by social media *(Jarreau, Dahmen, & Jones, 2019)*, though still requiring substantial effort to produce and maintain the digital content.

Objects and Interactive Exhibits

The original brief discussed the use of objects: historical images and artefacts, cutting-edge technology examples, and 3D-printed models of astronomical objects (Comet 67P/Churyumov–Gerasimenko, for example), along with interactive elements, for instance small telescopes or lenses. It was recommended that each host venue procure locally relevant objects; this was pursued, for example, in the Leiden exhibition, featuring an early 20th-century calculator and the prototype of a space observatory instrument (Figure 9). In the end, the travelling exhibition included, as 3D objects, three scale models of telescopes built with Lego bricks, to illustrate the size growth of astronomical instrumentation over time (Figure 1). Elements of interactivity are included in the three "key experiences" – where viewers are invited to be part of the elements created in a supernova explosion, walk on the Moon on the footsteps of Apollo astronauts, or look up at the immensity of the cosmos in the Hubble Ultra Deep Field (Figures 5, 6 and 10). In hindsight, the addition of 3D printed objects *(Arcand et al., 2017)* or other tactile exhibits *(Krauss, 2016)* could enable an extra layer of interactivity, while also providing content accessible to visually impaired visitors.

Diversity and Inclusion

One of the most challenging tasks in the content production was to steer clear of the mainstream Eurocentric narration while navigating through the proposed pool of highlights, which featured a disproportionate majority of white, male scientists from Europe and North America. On one hand, the team decided to include as many highlights as possible featuring astronomers from traditionally underrepresented groups and contributions to science, technology and culture from non-western/non-anglophone countries. This was not meant as a tokenism exercise but rather as an attempt to imagine an audience more diverse than the largely white, largely male scientific community of today, providing a broader variety of historical models to foster cross-cultural learning opportunities *(Dawson, 2014)*. On the other hand, the team acknowledged past (and present) issues of unequal representation in astronomy, highlighting gradual improvements over time where present, as a self-reflection exercise for the community itself. With this awareness, extra care went into crafting the text to avoid instances of misrepresentation that could be perceived as a form of cultural imperialism *(Dawson, 2018)*. This is a very first step, and future projects would have to prioritise diversity at concept level to develop more inclusive content and further engage with marginalised groups.

Accessibility and Language

As mentioned above, the exhibition included no dedicated content for visually impaired visitors, nor for other special needs audiences *(Ortiz-Gil et al., 2011)*. This highlights the importance to prioritise accessibility for disabled visitors at project definition, as explored by Inspiring Stars, another travelling exhibition developed for IAU100 to disseminate initiatives addressing inclusion in professional astronomy *(D'Antonio, et al., 2019)*. Another barrier that might have prevented a more widespread access is language *(Márquez & Porras, 2020)*. The content was originally produced in English and all source files shared for re-use and adaptation, meaning that local hosts could translate and adapt the content, which happened in many places around the world (Figure 12). This, however, relied on individual local initiative, requiring extra effort in terms of translation and layout. Besides, the travelling exhibition and the budget set

Figure 10. *The "Origin of Elements" installation at the Leiden exhibition. Credit: K. Mai/Leiden University*

Figure 11. *The exoplanet timeline infographic at the Leiden exhibition. Credit: K. Mai/Leiden University*

of 12 posters were only provided in English. In retrospect, this raises again the question of priorities, and whether a smaller pool of content, translated centrally and provided to all global partners in their local language(s), could have had a broader impact. Regarding the barrier posed by the financial cost to visitors, the exhibition was free to access in most venues, and in a few cases entrance was included as part of the ticket to visit the hosting science centre.

Production Timeline and Interdisciplinary Team

The very tight production timeline – only five months to create the entire exhibition from scratch – posed several challenges, so the breadth of skills and expertise of the creative team was key to ensure the success of the project. The team included: producers, supervising the holistic content, design and production process; architects, envisioning spatial solutions for imagined content experiences; content interpreters/researchers, seeking engaging forms of presenting science, technology and culture-based content; graphics designers, responsible for design nuance, consistency and special infographics; concept artists, responsible for artistic interpretations of specific phenomena; set designers and builders, making sure the exhibition is executed in a reliable and safe format. It was this combination of competencies that, paired with the input of the IAU100 Organising Committee and IAU global nodes, allowed for a high-quality, inclusive and engaging project. Budgeting in a substantially longer time scale for planning and production is one of the major lessons learnt from all IAU100 activities *(Gonzalez et al., 2020)*. In retrospect, the project would have benefitted from a dedicated part-time coordinator/project manager with experience in the exhibition sector to look for the best venues across Europe 1—2 years before the inaugural show in mid-2018, to open a discussion with local organisers with substantial notice, secure high-visibility venues in advance, and start fundraising to cover the non-negligible costs for transportation early on.

Evaluation

A project manager dedicated to the exhibition would have also enabled a proper evaluation of its outcomes and impact, which unfortunately could not be conducted on this project due to lack of resources. Such a project manager could have defined early on key performance indicators to assess whether the exhibition objectives were reached, both globally and locally, along with identifying relevant evaluation methods and outlining guidelines for local organisers to collect visitor feedback; later on, they could have followed up with all hosts, collecting and analysing the locally gathered feedback (or liaising with external experts on the analysis) to produce a thorough evaluation report. The team agrees that gathering and analysing quantitative and qualitative data, including a survey of at least a small fraction of the visitors before and after the experience, would have provided valuable input to inform future projects, and that an "evidence-based" approach *(Jensen & Gerber, 2020)* would have to be prioritised at concept – and budget – level since inception for similar science communication activities in the future.

Conclusions

Our preliminary analysis shows the exhibition was successful in its goal of reaching a wide audience of experts and non-experts in many parts of the world, showcasing major achievements in astronomy and selected IAU milestones while portraying science not as something static but as a human endeavour that is *"still in the making or still being debated" (Hine & Medvecky, 2015)*. Could it have reached and/or engaged more people? Probably. As discussed in the "Lessons Learned" section, and reported to the relevant IAU Officers to improve similar processes in the future, several issues encountered along the way point to the need to prioritise certain aspects at definition rather than implementation. Finally, on the basis of private conversations with IAU members and other astronomers who collaborated to produce, hosted or simply visited the exhibition, we argue that the project served not only as a public outreach activity but also as a beneficial exercise for the organisation and the overall astronomical community to reflect on their identity, image and reputation *(Davies et al., 2019)*,

Figure 12. *A poster-based exhibition in Bengaluru, India, with translated text in Kannada next to the original English, during a public event as part of the IAU100 "100 Hours of Astronomy" project in January 2019. Credit: Dr M.Y. Anand – CC BY 2.0*

providing valuable insight to approach the challenges facing astronomy in future decades.

Notes

[1] Above and Beyond exhibition website: https://100exhibit.iau.org

[2] Science Now website: https://sciencenow.studio

[3] The costs (around 50k Euro for concept and production, and 5-7k Euro for transport and poster production) were part of the IAU100 budget; additional transport and on-site installation costs for the travelling exhibition were covered by local hosts.

[4] Data visualisations and graphics: https://www.behance.net/gallery/78642081/IAU100-exhibition-data-visualization-and-graphics

[5] Branding and visual design: https://www.behance.net/gallery/78641137/IAU100-exhibition-branding-and-visual-design

[6] The full-scale exhibition is intended for display in an area of 120–140 square metres. It includes 23 small scale objects with printed panels on one or more faces (width: 68 cm; depth: 68 cm; height: 75 cm) and 50 large panels of various dimensions (maximum height: 260 cm), plus the Moon landing "cubicle" (width: 190 cm; depth: 190 cm; height: 240 cm). Further details in the exhibition manual (included in *Russo et al., 2018*).

[7] Travelling exhibition concept: https://www.behance.net/gallery/78641695/IAU100-travelling-exhibition-concept

[8] Floor plan for the Vienna exhibition: https://astronomy2018.univie.ac.at/typo3temp/pics/ca9f00fdd4.png

[9] Exhibition at the Leiden Old Observatory: https://www.universiteitleiden.nl/en/news/2019/04/experience-one-hundred-years-of-astronomy-at-the-old-observatory

[10] The exhibition in Tokyo, Japan: https://www.iau-100.org/aboveandbeyond-tokyo

[11] The exhibition in Montevideo, Uruguay: http://www.iau-100.edu.uy/galeria-de-la-exposicion-itinerante-iau100-mas-arriba-y-mas-alla/

[12] IAU100 Final Report: https://www.iau.org/static/archives/announcements/pdf/iau100-final-report-ann20019.pdf

[13] "Na een eeuw is het helaal veel groter," NRC article, 19 April 2019 (in Dutch): https://www.nrc.nl/nieuws/2019/04/19/na-een-eeuw-is-het-heelal-veel-groter-a3957561

[14] IAU Strategic Plan 2020–2030: https://www.iau.org/administration/about/strategic_plan/

[15] Full credits: https://100exhibit.iau.org/#stripe11

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Biographies

Claudia Mignone, PhD, is an astrophysicist, science writer and communicator. After ten years working in public outreach for the European Space Agency, she has recently joined the National Institute for Astrophysics in Italy. She was part of the team that defined the IAU Above and Beyond exhibition content and format, collaborated to the panel texts, and curated the highlights for the poster sets.

Jan Pomierny is the founder and Chief Executive Officer at Science Now and Fellow of the Royal Astronomical Society. Jan was the Producer of the Ambition and Ambition: Epilogue short films and branded content campaign for ESA's Rosetta mission, and Executive Producer of the IAU Above and Beyond exhibition.

Łukasz Alwast is the Chief Development Officer at Science Now and Honorary Research Associate at the Institute for Innovation and Public Purpose (IIPP), University College London. He was the Creative Producer of the IAU Above and Beyond exhibition.

Milena Ratajczak, PhD, is Head of Education at Science Now and a postdoctoral fellow at the Astronomical Observatory of the University of Warsaw. She is a board member of the Polish Astronomical Society, New Space Foundation and Multiświat Foundation, actively involved in the organisation of numerous STEM-related workshops, and holds the role of the content consultant and editor of space-themed books, educational games and exhibitions.

Lessons Learnt and Challenges of Planning and Coordinating the IAU 100th Anniversary Celebrations

Jorge Rivero González
Leiden University/IAU100 Secretariat
rivero@strw.leidenuniv.nl

Bethany Downer
Leiden University/IAU100 Secretariat
downer@strw.leidenuniv.nl

Lina Canas
IAU Office for Astronomy Outreach
lina.canas@nao.ac.jp

Pedro Russo
Leiden University/IAU100 Secretariat
russo@strw.leidenuniv.nl

Ewine van Dishoeck
Leiden University/IAU100 Secretariat
ewine@strw.leidenuniv.nl

Keywords
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The International Astronomical Union centenary (IAU100) comprised a year-long worldwide public engagement initiative that celebrated the fascinating past century of astronomical discoveries as well as the importance of astronomy for education, development, diplomacy and outreach. Through the coordination of the IAU100 Secretariat and the IAU Office for Astronomy Outreach (OAO), a combined worldwide effort from the IAU National Outreach Coordinators (NOCs) network, IAU bodies, astronomical organisations and astronomy communicators outside academia such as amateur astronomers, teachers, science centres and planetariums implemented the IAU100 ambitious goals. The approach and methodology used favoured the wide participation of grassroots organisations, which overwhelmingly responded by organising around 66% of the over 5000 registered activities in 143 countries. Moreover, the IAU 100th anniversary celebrations also benefited the IAU NOC network, both by the increase in the number of countries involved and the increased levels of engagement. An exploratory study about the impact on the network helps us better understand the impact and stress on the national representatives, highlighting the type of activities and numbers of them that could be sustainable in the future. These findings have helped the IAU OAO to plan sustainable future actions for the NOC network to keep celebrating astronomy Under One Sky.

Introduction

The IAU 100th Anniversary Celebrations (IAU100) in 2019 (Rivero, 2020) exceeded initial expectations with over 5000 registered activities in 143 countries. This facilitated the direct involvement of an estimated 5 to 10 million people, along with an estimated further reach of 100 million people through communication activities.

In this article, the IAU100 Secretariat members present some of the key factors considered behind the planning and implementation of the initiative (a full consideration will exceed the word limit for articles in the CAPjournal). Lessons learnt and challenges will be discussed.

Approach

One of the most important challenges faced in planning a transnational public engagement initiative is the development and implementation of an approach that allows for reach throughout a global audience while maximising the efficiency of your assets (i.e. expertise, networks, etc.). Due to our previous experience of coordinating actions with large scopes — the UN International Year of Astronomy 2009 (IYA2009) *(Russo & Christensen, 2010)* and the International Year of Light 2015 (IYL2015) *(Dudley, 2016)* — the IAU100 Secretariat decided to have a mixed approach of actions that included a strong central coordination, with an extensive programme of central Flagship initiatives implemented by the IAU National Outreach Coordinators (NOCs), while providing high visibility to grassroots actions. In the following we discuss the most important aspects:

Flagship Initiatives

A key lesson learnt from IYA2009 *(Russo & Christensen, 2010)* was the importance of having an exciting programme of global actions: a broad and attractive portfolio of activities that can engage the participating communities. In that sense, we had the successful experience from the IYA2009 Cornerstone Projects, global programmes of activities centred on specific themes to accomplish the IYA2009 Goals.

Initially, the NOCs and several stakeholders in the astronomical community provided various suggestions and ideas for projects that were subsequently narrowed down by the IAU100 Secretariat and Steering Committee to a programme of 11 IAU100 Global Projects (see Figure 1 for an overview of the IAU100 Global Projects) that covered the main IAU100 Goals[1]. These Global Projects were designed to be mainly implemented by the NOCs and/or to use their networks to reach out to people in their countries to get involved in organising activities.

Strong National Nodes Network

Another important focus was to ensure a strong central coordination of a network of national nodes with a collaboration between the IAU100 Secretariat and the IAU Office for Astronomy Outreach (OAO) *(Cheung, 2015)*. This central point aimed to act as a catalyst and facilitator, providing clear project framework standards, procedures and information on the results. This is important to effectively coordinate the network and to avoid engagement problems in this type of communities of practice[2] *(Russo, 2015)*.

The primary IAU asset for initial implementation of a project of this scale was the NOC network coordinated by the IAU OAO. Based on the success of the established network that implemented IYA2009 worldwide, the IAU OAO was set up in 2012 to implement the Beyond IYA2009 *(Russo, 2015)* plan and to maintain a network of national nodes. The NOCs are responsible for the implementation of national outreach activities as well as maintaining a constant exchange with the local amateur astronomer communities. They were the base to form the IAU100 National Committees to implement and encourage participation in their respective regions.

Participation of Grassroots Communities

Unlike international observances supported by United Nations and its agency UNESCO (e.g. IYA2009/IYL2015), which benefit greatly from institutional/political support and funding, IAU100 did not have that kind of benefit in terms of visibility and support at the higher levels. Therefore, it was very important to optimise the IAU100 initiative for grassroots communities participation.

Since astronomy is a science with immense popular appeal *(Graham, 2009)*, there are numerous professional astronomers that try to bring it closer to the general public, driven by different combinations of factors *(Entradas & Bauer, 2019)*, but mostly relying on their love for astronomy. This unites them with a large part of the communicators of astronomy from outside academia *(Gibbs & Berendsen, 2007)*, including amateur astronomers, teachers, students, museum workers, science communicators, etc.

For IAU100 it was essential to engage grassroots communities outside of the IAU membership to maximise our reach. We, therefore, established the following measures:

- We moved the focus away from the IAU's centenary to a broader and more inclusive main goal (the celebration of the past century of astronomical discoveries) to include grassroots participants in the initiative;
- All Global Projects encouraged everyone to take an active role in the organisation of the programmes and events;
- Anyone could integrate their astronomy outreach activities (outside of the scope of the Global Projects) to our worldwide programme of activities, as long as these activities were aligned with the IAU100 Goals. It was, therefore, important to establish and maintain the IAU100 Event Calendar[3], where event organisers could feature their activity and event information;
- The establishment of a call for funding of grassroots actions[4] at national/local level to support the mobilisation and engagement of different communities.

Planning and Implementation

Planning a project of this scale requires a considerable amount of time to develop a solid framework and effective engagement with various stakeholders. Projects of comparable scales — at least from an organisational point-of-view such as the IYA2009 or IYL2015 — were initiated five years in advance. These initiatives also demonstrated more solid actions from their respective secretariats of at least two years prior to the main project implementation.

The IAU100 time frame was shorter, as initial considerations began two-and-a-half years in advance and the IAU100 Secretariat was established around one year prior to the project's main implementation in January 2019. This was considerably challenging, as the lack of appropriate time for developing the different phases of the projects added high amounts of stress to the coordination efforts, as we felt as though we were running while we were tying our shoes. However, we were confident about the process due to the previous experience of the IAU100 Secretariat members on organising transnational public engagement projects of similar scale and the strong NOC network that was already in place in many countries.

Two phases are highlighted that briefly discuss the main lessons learnt and challenges that arose:

Planning Phase (October 2017 - December 2018)

The first months were focused on establishing the Global Projects and finding the right persons to coordinate them. For some, it was a natural choice, as individuals who suggested the various projects had previous experience with similar IYA2009 actions and had acted as volunteers. For others, such as IAU100 NameExoWorlds (see article in this issue), the 100 Hours of Astronomy, and the Moon Landing 50 global projects, these initiatives required full-time coordination. We, therefore, established fellowships for project managers to oversee their coordination. This period was also used to strengthen the node networks and to increase the number of countries involved.

The Communicating Astronomy with the Public Conference in March 2018, with the participation of over 400 astronomy communication practitioners (including most NOCs), served as a valuable opportunity to present the initiative, to engage our core community, and to organise co-creation sessions to gather feedback. The reaction to IAU100 was positive, however, it was important to lower the expectations, as the IYA2009's shadow is still very wide in the community. IAU100 was always an ambitious project, but also sought to be realistic, as we could never reach the level of engagement of a UN International Year. IAU100 was always therefore regarded as a spin-off, rather than a sequel, to IYA2009 — it was important to establish a singular identity. The co-creation sessions were helpful as many generated suggestions were included in our actions. However, the lack of time prevented our initial plans to follow-up with the people who participated in the sessions to gather feedback during the rest of the year.

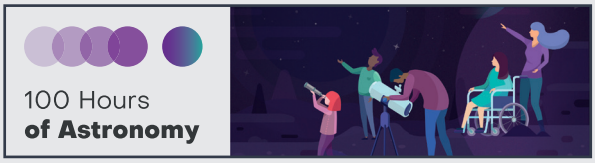
From April to August 2018, we focused on establishing the main communication platforms, such as the IAU100 website[5], and building a communication plan.

IAU100
Global Projects

IAU100 100 Hours of Astronomy

Coordinated by Bethany Downer (IAU100 Secretariat)

1,200 astronomy activities took place on 10-13 January 2019 across **86 countries** and regions, with the direct involvement of roughly **500,000 people**.



https://www.100hoursofastronomy.org/

IAU100 Open Astronomy Schools

Coordinated by Rosa Doran and Gustavo Rojas (NUCLIO, Portugal)

830 teachers participated in **20 teacher training sessions** in **20 countries**. The project also distributed **250 educational telescopes** for the organisation of **26 teacher training** in **22 countries**.

https://open-astronomy-schools.org/

IAU100 Women and Girls in Astronomy Events

Coordinated by Hannah Harris (IAU100 Secretariat)

Over **300 events** organized in **70 countries** to discuss gender equity, the role of women in science, the importance of role models and encourage the participation of girls in STEM careers.

https://www.inclusiveastronomy.org/

IAU100 Moon Landing 50

Coordinated by Bethany Downer (IAU100 Secretariat)

The IAU100 Moon Landing 50 project was the largest coordinated action in the world celebrating the Moon Landing 50th anniversary with more than **1 million people** actively participating in over **1,000 events** in **128 countries and regions**.

https://www.moonlanding50.org/

IAU100 Astronomy Day in Schools

Conceived by Paulo S. Bretones (Universidade Federal de São Carlos, Brazil) and coordinated by Bethany Downer (IAU100 Secretariat)

Over **500 events** and activities were organized in **70 countries** around the world for this education--focused global project in November 2019.

https://www.iau-100.org/astro-day-schools

Figure 1. *Overview of IAU100 Global Projects. Credit: Aneta Magraf-Druc (original design)*

IAU100 Pale Blue Dot

Coordinated by Bethany Downer (IAU100 Secretariat)

This project celebrated the 30th anniversary of the iconic Pale Blue Dot image with **over 500 activities** conducted in **51 countries** worldwide on 13-20 February 2020.

https://www.iau-100.org/pale-blue-dot

IAU100 NameExoWorlds

Coordinated by Eric Mamajek (JPL-Caltech, USA), Alain Lecavalier des Etangs (Institut d'Astrophysique de Paris, France) and Eduardo Penteado (IAU100 Secretariat)

More than **780,000 people** participated in **113 national campaigns** to select names of **113 sets of exoplanets and host stars**.

http://www.nameexoworlds.iau.org/

IAU100 Dark Skies

Coordinated by Sze-leung Cheung (NARIT, Thailand) and Constance Walker (NSF's National Optical-Infrared Astronomy Research Laboratory, USA)

A network of **123 ambassadors** organised **197 activities** in **30 countries** throughout 2019 to raise awareness about light pollution. In addition, **54 educational kits** were distributed in **41 countries**.

https://darkskies4all.org/

IAU100 Einstein Schools

Coordinated by Stephen Pompea (NSF's National Optical-Infrared Astronomy Research Laboratory, USA)

Around **200 schools** in **45 countries** learned and communicated about gravity throughout 2019

https://www.einsteinschools.org/

Inspiring Stars

Coordinated by Lina Canas (IAU OAO, Japan), Wanda S. Diaz Merced (IAU OAD) and Rosaria D'Antonio (IAU Secretariat, France)

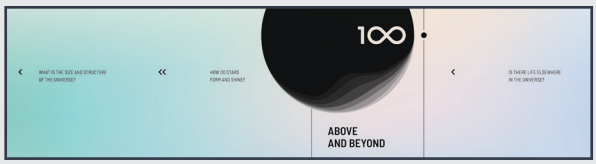
Itinerant international exhibition to highlight world initiatives that address the concept of inclusion that organised **17 activities** in **10 countries**, reaching over **5,000 people**.

https://sites.google.com/oao.iau.org/inspiringstars

IAU Above and Beyond Exhibition

Developed by the IAU & ScienceNow Studio

Open-source exhibition showcasing the fascinating past century of astronomy that was present in **75 countries**.



http://100exhibit.iau.org/

This plan used the established IAU dissemination channels and could then be replicated by the dissemination channels of all national committees. Following the experiences from IYA2009 and IYL2015, at this stage the involvement of the National Committees was vital. They translated the primary IAU100 messages and updates to their respective languages to optimise the reach of the central actions while preparing relevant target audiences in their countries to actively participate in IAU100 actions.

The second important milestone was the IAU General Assembly in Vienna, Austria in August 2018. This event marked the launch of full promotion of IAU100 with the official opening of these centenary celebrations, the opening of the IAU Above and Beyond exhibition (see article in this issue), and the release of the IAU100 website. This event gave us the opportunity to engage in person once more with many of the NOCs and to engage with the larger community of astronomers.

For the last three months of 2018, the main focus was to engage as much as possible with different audiences to participate in the first actions of the year. During this time we also established a simple framework of evaluation for individual organisers to report feedback on their events.

Implementation Phase (January 2019 - February 2020)

The implementation phase was quite hectic, as we planned to have actions every month, i.e. Global Projects, the release of a publication/resource for the community, or the organisation of a specific event. On one hand, this was helpful to maintain the momentum of the grassroots communities participating over the course of the whole year and to attract new participants and supporters along the way. On the other hand, it caused continuous stress to the central coordination as well as the network of national nodes. This also resulted in challenges for engagement, especially at the end of the year.

As an example, two Global Projects that relied heavily on grassroots participation are discussed with regards to their specific implementation:

100 Hours of Astronomy

For the first Global Project of the year, we decided to repeat a successful activity organised during IYA2009: the 100 Hours of Astronomy *(Simmons, 2008)*. For three days, the project encouraged people around the world, especially amateur astronomers, to organise activities around astronomy. Our motivation to start with this project was (i) to use this event as a test for a prospective template with regards to the organisation and coordination of an outreach astronomy project on a global scale and (ii) to engage communities such as amateur astronomers, teachers and other astronomy communicators to be an active part of IAU100 activities throughout the year. For the latter, we opted to have an approach that was as open as possible, as any astronomy-related activity was eligible to be included in the global events list.

Another goal of the project was to support and establish a framework for inclusive actions[6]. For this purpose, we encouraged organisers to follow guidelines developed for the organisation of inclusive events. This included tips for sky observation activities and outreach, and detailed suggestions for how event organisers should consider the matters of inclusion, diversity and equity in their organised activities. Furthermore, a list of outreach and educational resources were developed to support event organisers to conduct their activities. These resources, in particular, sought to support those who do not have accessible means to expensive astronomy-related infrastructure or equipment to conduct their outreach. This included low-budget activities, online resources and various activities that are specially designed for participants with various impairments or disabilities. A variety of visual resources were also developed and disseminated, such as the translations of the IAU100 and 100 Hours of Astronomy logos, and the development of a key visual. This not only supported the development of an accessible brand and visual for the event but provided event organisers with means of adapting these visuals for their own events. Many event organisers used these translated tools to create and adapt their own event visuals and posters.

A key lesson learnt was that in order to attract the engagement of grassroots actions, the organisation of competitions (including relevant prizes such as telescopes) and the dissemination of outreach and educational resources is critical. In that respect, we were able to encourage the organisation of inclusive actions, identify best practices, obtain reports of the activities, and provide materials to communities that typically do not have access to astronomical equipment.

Figure 2. *Participants of the IAU100 Co-creation Sessions at the Communicating Astronomy with the Public Conference 2018. Credit: Thilina Heentigala.*

Figure 3. *Children look through the telescope during 100 Hours of Astronomy activities in Ethiopia. Credit: Mekbeb Tamrat.*

Overall, it was a successful IAU100 start, with over 1200 activities conducted across 86 countries and regions. This resulted in the direct participation of roughly 500 000 people, and additional reach due to global media coverage.

IAU100 Moon Landing 50

The 50th-anniversary celebrations of the Moon landing in July 2019 was one of our main events of the year, with more than one million people participating in over 1000 events in 128 countries/regions. This was the IAU100 action with the largest direct participation in terms of geographic coverage. It was clear from the outcomes of the 100 Hours of Astronomy that we could accomplish our goals to reach at least 100 participating countries. The initial engagement was easier, as this was a well-known global milestone. However, it also highlighted the challenge of IAU100 being diluted into other actions organised by bigger stakeholders (such as NASA). Therefore, we focused our message and outreach for this event on topics to which our networks could bring added value with respect to other stakeholders (such as the organisations of star parties to observe the Moon landing site and the promotion of lunar science).

To increase the engagement of this event, we collaborated with organisations such as the Astronomical Society of the Pacific, the International Planetarium Society, the Space Generation Advisory Council, and NASA's Observe the Moon Night to help us with cross-promotion. However, reaching the milestone of 100 participating countries was only possible due to the dedicated efforts made in the months prior to the event in identifying astronomical organisations or amateur astronomy groups in countries who had not yet engaged with IAU100 activities. This was very demanding in terms of the coordination of the activity, however, it was deemed valuable. Not only were we able to exceed our goal of participating countries registered, but this effort also served to establish strong relations with organisations in new countries that eventually joined the IAU NOC network, ensuring the long-term sustainability of the IAU100 actions.

Response from Grassroots Communities

For the IAU100 Secretariat, it was fundamental to reach beyond IAU networks and members to engage the communities of amateur astronomers, teachers, planetariums, science centres and individuals that overwhelmingly supported IYA2009 to participate in organising IAU100 activities. We were confident in our potential for success, as the IAU had maintained and nurtured the connections with these communities since IYA2009 through the IAU OAO and the NOC network. Moreover, as discussed in "Approach", the IAU100 approach was optimised for their active participation.

From the total of 5240 IAU100 activities registered, 2697 (51%) were organised by astronomy clubs, schools, teachers and individuals. This indeed illustrates the large grassroots response and the strength of the IAU100 actions to engage them. If we also consider the activities organised by museums, planetariums and science centres (792, 15%), we could conclude that two out of every three activities were organised by individuals/organisations without official links to the IAU. We also identified 866 activities (17%) that were organised by persons/organisations linked directly with IAU (mainly from NOCs, but also includes the IAU Commissions and Divisions, IAU Offices, and IAU members). We could also extend this relation to IAU to the activities organised by astronomical institutes and universities, of which the proportion of registered events for this demographic was the same, where the

professional astronomers are mainly based (885, 17%).

These findings validate the IAU100 approach, planning, and implementation, while also strengthening the links with grassroots communities (particularly with amateur astronomers and teachers). This will be followed-up with IAU100 legacy actions implemented by the OAO in the coming years, such as the IAU OAO Global Outreach Events[7] and the establishment of a central platform[8] for event organisers around the world to showcase their astronomy activities, serving as an inspiration to other event organisers.

Impact on the NOC Network and Lessons Learnt

It is clear that the success of the IAU100 initiative relied heavily on the efforts of the extensive network of IAU NOCs around the world. However, IAU100 also benefited the network. This is illustrated by the increase in the number of countries involved (from 80 countries in the spring of 2018 to 127 countries by February 2020) and the increased levels of engagement (from 80 active members at the end of 2018 to 120 active members by February 2020).

On the other hand, IAU100 also brought high stress to this network, as it demanded large amounts of work throughout the year. This was a clear increase in the engagement and participation needed from previous years. Therefore, it is important to understand its impact on the network and lessons learnt for its long-term sustainability.

Below we present preliminary results of an exploratory study to understand this impact that was performed in the summer of 2019 during the middle of IAU100's implementation[9]. We disseminated a survey to the IAU NOCs participating in IAU100 (n=122) with questions regarding their participation in the program at the time. We received replies from 47 NOCs (39%). Here we shared an overview of the most important outcomes:

- Not surprisingly, the majority of the feedback pertaining to workload and engagement in the network show that the respondents are more invested than usual in IAU100;
- 80% of respondents feel large-scale public engagement projects like IAU100 have a positive impact on engaging people in their regions;
- 87% states stated that it is important to have a strong central coordination that also facilitates the collaboration within the NOC network;
- 89% feel that the IAU100 Secretariat provided the necessary support to NOCs and that the communications from the IAU100 Secretariat to the NOCs were relevant;
- 72% of respondents indicated above-average engagement in their local activities due to IAU100 actions;
- NOCs identified that the most successful actions in their countries were the IAU100 NameExoworlds, Moon Landing 50 and 100 Hours of Astronomy Global Projects;
- Two-thirds of all respondents indicated that up to three global initiatives was a sustainable number for subsequent yearly flagship actions.

These findings support the value of the establishment of strong coordination and reiterated the clear benefit of a central coordination in terms of exchanging ideas and getting inspiration and support for the organisation of events. The preliminary study also identified the number of sustainable yearly global activities for the network and the importance to provide a framework to showcase the activities. This has helped the IAU OAO to identify follow-up legacy actions.

Conclusions

The successful implementation of a large-scale public engagement initiative such as IAU100 required the strong central coordination of an extensive network of national nodes as well as establishing the procedures to engage the large community of astronomy communicators outside academia. The IAU was in the perfect position to organise this kind of project in a relatively short time frame, due to the strong structures and networks developed after IYA2009, namely the IAU OAO and the NOCs network.

However, from a coordinating point-of-view, more time to develop the project would have helped to engage more efficiently with the community in important aspects such as the inclusive dimension of all activities and on the assessment of the actions. On the latter aspect, future work will involve the analysis of the specific activities implemented by the NOCs and the evaluation reports received from individual activities registered on the IAU100 Event Calendar.

Notes

[1] The major goals of the IAU100 celebrations were: (1) Increase awareness of progress and excitement in astronomy over the past century, in particular: (a) The importance of collaborative enterprise of astronomy as a whole, (b) The importance of technology development for astronomical progress, (c) The coordinating role of the IAU fostering communication and exchange of ideas for the global astronomical community. (2)Promote widespread access to astronomy knowledge and observing experiences. (3) Support and improve the use of astronomy as a tool for education, development and diplomacy. (4) Support and improve an inclusive, egalitarian and diverse astronomy community. (5) Facilitate the preservation and protection of the world's cultural and natural heritage of dark and quiet skies. (6) Raise awareness and discuss prospective new exciting developments in the next 100 years of astronomy.

[2] A community of practice (CoP) is a group of people that share the same passion or interest and exchange ideas and knowledge learning from each other (Wenger et al, 1998, 2002, 2010). And even though the concept has evolved over time (Li et al, 2009), the three main characteristics that define a CoP remain as specified by Wenger (1998): mutual engagement in a specific domain, a community, and a practice, meaning that members of a CoP are actively involved rather than just having a strong interest only, so through their interactions they learn together and form a shared repertoire.

[3] IAU100 Events webpage: https://www.iau-100.org/events

[4] IAU100 Special Projects webpage: https://www.iau-100.org/special-projects

[5] IAU100 website: https://www.iau-100.org

[6] This was conducted under the Inclusive Astronomy IAU100 theme, which was a yearlong, worldwide initiative to celebrate and promote inclusivity, equity, and diversity in astronomy in 2019. For more information see https://www.inclusiveastronomy.org.

[7] IAU OAO Global Outreach Events: https://www.iau.org/public/oao/oao_global_events/

[8] IAU OAO Global Outreach Events Calendar: https://www.iau.org/oao-events/

[9] This exploratory study was aimed to be expanded during the first half of 2020 to gather results from a larger number of NOCs after IAU100 was closed through a stay of the IAU100 Global Coordinator at the IAU OAO in Japan through the OAO Visitors Programme. However, the COVID-19 pandemic situation has prevented this action and will hopefully be accomplished as soon as possible.

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Biographies

Jorge Rivero González is an astronomer and science communicator who served as IAU100 Global Coordinator. For the past three years, he was a member of the Astronomy & Society Group at Leiden Observatory. Previously, he worked for the European Physics Society, where he participated in the global organisation of the UN's International Year of Light and Technologies based on Light 2015 and UNESCO's International Day of Light. Since 2009 he has been a member of the science outreach programme GalileoMobile.

Bethany Downer served on the IAU100 Secretariat and organised four IAU100 Global Projects. She works in the domain of science communication and outreach for various organisations, including the Hubble Space Telescope for the European Space Agency, the International Day of Light, the Space Generation Advisory Council. Bethany also coordinates the Space Scoop project.

Lina Canas is the International Outreach Coordinator for the IAU Office for Astronomy Outreach (OAO), based at the National Astronomical Observatory of Japan (NAOJ). With a degree in Astronomy and a Masters in Geophysics, Lina Canas has worked for the past thirteen years in astronomy outreach and education.

Pedro Russo is Assistant Professor in Astronomy & Society at Leiden University, the Netherlands. He was the global coordinator for the International Year of Astronomy 2009. Pedro is involved with several international organisations, like the European Astronomical Society and the International Astronautical Federation. His work has received several awards, including the Most Innovative Educational Activities in 2017 and 2018 by HundrED and 2018 Leiden University's K.J. Cath Prize.

Ewine F. van Dishoeck is professor of molecular astrophysics at Leiden University, the Netherlands. She has received many awards, including the 2000 Dutch Spinoza award, the 2015 Albert Einstein World Award of Science, and the 2018 Kavli Prize for Astrophysics. She is a Member or Foreign Associate of several academies, including that of the Netherlands, USA, Germany and Norway. As of 2018, Ewine serves as the IAU president.

Best Practice

Public Naming of Exoplanets and Their Stars: Implementation and Outcomes of the IAU100 NameExoWorlds Global Project

Eric Mamajek
Jet Propulsion Laboratory, California Institute of Technology
mamajek@jpl.nasa.gov

Lars Lindberg Christensen
NSF's NOIRLab
lchristensen@aura-astronomy.org

Hitoshi Yamaoka
National Astronomical Observatory of Japan (NAOJ)
hitoshi.yamaoka@nao.ac.jp

Debra Meloy Elmegreen
Vassar College
elmegreen@vassar.edu

Eduardo Monfardini Penteado
monfpent@gmail.com

Gareth Williams
gwilliams@cfa.harvard.edu

Guillem Anglada-Escudé
Institute for Space Science (ICE/CSIC), Queen Mary University of London
anglada@ice.csic.es

Alain Lecavelier des Etangs
Institut d'Astrophysique de Paris
lecaveli@iap.fr

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The IAU100 NameExoWorlds public naming campaign was a core project during the International Astronomical Union's 100th anniversary (IAU100) in 2019, giving the opportunity to everyone, everywhere, to propose official names for exoplanets and their host stars. With IAU100 NameExoWorlds the IAU encouraged all peoples of Earth to consider themselves as "Citizens of the Universe", united "under one sky". The 113 national campaigns involved hundreds of thousands of people in a global effort to bring the public closer to science by allowing them to participate in the process of naming stars and planets, and learning more about astronomy in the process. The campaign resulted in nearly 425 000 votes, and 113 new IAU-recognised proper names for exoplanets and 113 new names for their stars. The IAU now officially recognises the chosen proper names in addition to their previous scientific designations, and they appear in popular databases.

Introduction

Over the past three decades, astronomers have discovered thousands of planets orbiting other stars, which are known as exoplanets. The results from the NASA Kepler mission[1] suggest that most stars must have exoplanets. The ubiquity of planets orbiting other stars, and the commonality of chemical species which are the building blocks of life, suggest that extraterrestrial life may be likely. These discoveries open an enormous perspective of humanity's place in the cosmos.

Within the NameExoWorlds programme, the IAU encourages all peoples of Earth to consider themselves as "citizens of the Universe", and set aside borders, wars, and religious and cultural differences for a universal, peaceful view of humanity as one.

While celebrating its first 100 years (IAU100) of fostering international collaboration, the International Astronomical Union (IAU) wished to contribute to the fraternity of all people with a significant token of global identity.

As part of the IAU's mission to promote and safeguard the science of astronomy through international cooperation, the IAU is the authority responsible for assigning official names to celestial bodies. With the IAU100 NameExoWorlds Global Project, the IAU aimed to offer all countries and as many people as possible the opportunity

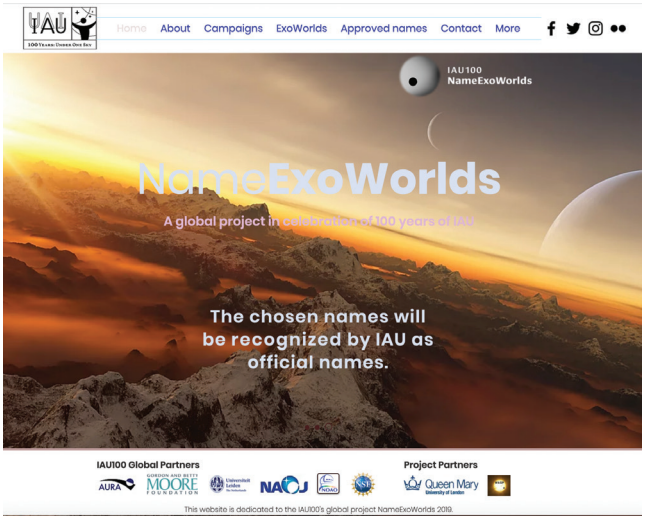

Figure 1. *IAU100 NameExoWorlds website. Credit: IAU*

to participate in the official naming process of exoplanets and their stars.

The IAU Office for Astronomy Outreach (OAO) invited all IAU National Outreach Coordinators (NOCs) and countries without a NOC to compose a National Committee in their country responsible for holding the national contest.

The project was officially launched on 6 June 2019[2] (Figure 1) and came to an end on 17 December 2019 when the results from 112 national campaigns were publicised. Results from an additional campaign in Mongolia took several weeks of additional deliberation and were decided in early 2020.

The national campaigns involved hundreds of thousands of people as a global effort to bring the public closer to science — learning more about astronomy and other planets — and by allowing them to participate in the process of naming stars and planets *(Penteado et al., 2019)*. The names for the planets and stars in these 113 systems reflect the rich culture of human practices and natural wonders, all now immortalised in the sky (Figure 2).

Early Planning

In 2019, the IAU completed 100 years since its foundation. As decided in the XXXth General Assembly in Vienna, Austria in 2018, a year-long celebration was organised to promote and support outreach and educational events taking place worldwide, as an effort to foster astronomy as a tool for development and diplomacy. One of the global projects proposed in the framework of IAU100 was the NameExoWorlds programme as a suitable way to pursue the central theme of IAU100, "Under One Sky".

The 2019 edition of NameExoWorlds built upon the experience acquired in the previous edition of 2015, but now offered the opportunity for all countries and territories of the world to run their own national contests to choose names of an assigned exoplanet and its host star. This new format proposed by Piero Benvenuti, IAU General Secretary from 2015 to 2018, aimed at directly involving the population within each country. The experience of NameExoWorlds in 2015 had indeed shown that all over the world the population is truly involved in the process, especially when local people interested in astronomy organise outreach activities related to the contest. Moreover, the involvement is further increased when the population is given the opportunity to draw a link between the names given to the extrasolar systems and its own culture.

IAU100 NameExoWorlds Steering Committee

To coordinate the IAU100 NameExoWorlds project, the IAU100 Secretariat set up a Steering Committee with members from all around the globe. The Steering Committee selected and assigned planetary systems to each participating country, and developed naming guidelines to be followed by the National Committees. The IAU president Ewine van Dischoeck invited Eric Mamajek and Alain Lecavelier des Etangs to co-chair the IAU100 NameExoWorlds Steering Committee and Eduardo Monfardini Penteado to be the project manager. Additional Steering Committee members included IAU President-Elect Debra Elmegreen, former IAU General Secretary Piero Benvenuti, IAU OAO

Figure 2. *Example graphic for the Trinidad & Tobago IAU100 NameExoWorlds campaign, showing the winning selections for the exoplanet HD 96063b/Ramajay and its star HD 96063/Dingolay. Credit: IAU100 / Aneta Magraf-Druc*

International Outreach Coordinator (IOC) Lina Canas, former OAO IOC Sze-leung Cheung, IAU Press Officer Lars Lindberg Christensen, IAU100 Coordinator Jorge Rivero González, and researchers Guillem Anglada-Escudé, Gareth Williams, Hitoshi Yamaoka, and John Brown Paul Strachan.

Exoplanetary Systems: Vetting and Assignment

Mamajek, Lecavelier des Etangs, and Anglada-Escudé vetted exoplanetary systems in early 2019, producing a list of systems for naming. The vetting process involved searching the Washington Double Star Catalogue[3], the Gaia Data Release 2 Catalogue[4] and published journal papers. To level the naming opportunities among the national campaigns, each campaign would yield a pair of names (an exoplanet and host star) for a system currently thought to have a single exoplanet and no other known stellar or substellar companions.

The selected exoplanets are mostly thought to be giant planets with masses between 0.1 and 5 Jupiter masses and mostly discovered before 2013. All had been detected via either the radial velocity or ground-based transit method. The host stars are all fainter than the naked eye with magnitudes between 6 and 13. The selected range was chosen for educational and practical purposes. Stars in this range require binoculars or small telescopes for observation, which encourages their use. Additionally, there were too few naked-eye host stars for all the countries, and the committee wanted to avoid any controversy over whether or not a given country had a star visible to the naked eye or create a hierarchy among countries with the brightest naked-eye star. An initial attempt was made to sort the candidates by declination and assign them to countries based on the latitude of the country's capital. However, in several instances stars were assigned where there was an obvious connection between the exoplanet and the nationality of the discoverers or the location of the observatories used to discover the planet. For example, HD 109246 (dec +74°) was assigned to the northernmost country (Iceland, lat. +64°) and HD 137388 (dec -80°) was assigned to the southernmost (New Zealand, lat. -41°). All the systems assigned have declinations within 52° of the latitude of the capital of the country that conducted the naming campaign, and hence are locally visible at least partially during the year. In many instances the stars are circumpolar.

The Steering Committee gave the National Committees the opportunity to request changes to their assigned systems as long as a reasonable reason was provided and the requested planetary system followed the rules of assignment, such as the star magnitude and planet mass constraints. Reassignment requests taking into consideration the nationality of a member of the discovery team, thus increasing local engagement and publicity for the campaign, were considered reasonable[5].

Establishment of the National Committees

The 2019 NameExoWorlds campaign intended to broaden the participation of the public, which was possible through individual national campaigns. This was the first time that such a project was proposed to the IAU National Outreach Coordinators (NOCs) networks, and for most, this was also the first opportunity to lead an international project at a national level. The participation of NOCs was crucial for the success of this latest edition. The Steering Committee also accepted proposals to run campaigns from autonomous territories (e.g Aruba) and other regions (e.g China Nanjing, China Taipei) in which the local community displayed a high level of excitement and engagement with astronomy.

Most of the national campaigns had committees chaired by the corresponding NOC. In the cases where the NOCs could not take the lead, another person was appointed by them. NOCs were responsible for appointing other members to join the National Committees, which was recommended to be diverse in terms of backgrounds and experience, and taking gender balance into account. In total, nearly one thousand people supported the 113 National Committees.

In the absence of a NOC to lead the national campaigns, a form was made available through the official NameExoWorlds website[6] for people and organisations interested in running the contest in their national communities as an effort to offer the opportunity to include and represent as many peoples as possible in the campaign. As a result, a total of eight countries or territories joined the project following the acceptance by the Steering Committee: China Taipei, the Cook Islands, Costa Rica, Madagascar, the Pitcairn Islands, Singapore, Paraguay, and Haiti. In some of these geographical areas, the proposer later became a NOC.

A total of 113 national campaigns successfully carried out public naming campaigns from the initial proposal to the acceptance of selected names (Figure 3). Three countries were unable to complete their contests. The main reasons were a lack of resources to promote the project on a national scale, which resulted in no direct participation of the public, and difficulties recruiting members to form a National Committee. Social and political disturbances, and security and safety concerns also played an important role in deterring the successful conclusion of the contest, in at least one case.

Naming Guidelines

The first IAU NameExoWorlds campaign in 2015 kept very general naming guidelines based on those used for minor planets *(Montmerle et al., 2016)*. For the 2019 campaign, additional guidelines (Box 1) to improve the quality and diversity of the winning entries, to create long-standing value to the IAU and the rest of the astronomical community, and to inform future naming guidelines[7]. The NameExoWorlds campaign was seen as a celebration of world culture and people's connection to the sky.

One of the challenges was to inform the public of which names the IAU already recognised as "official". In 2015 several top vote-getters duplicated existing minor planet names, and the committee spent large amounts of time identifying and handling these duplicates. Therefore, as a lesson learnt from the 2015 campaign, a single IAU database of such names was created for the 2019 edition making it easier to avoid conflicts with the roughly 22 600 IAU-recognised names for exoplanets, solar system planets, planetary satellites, minor planets, constellations, and stars. An electronic version of the file is being prepared for long term curation and future use on the IAU website.

The Steering Committee allowed additional direct queries by all National Committees regarding guidelines and naming rules, and in an effort to answer any further questions from the public a Frequently Asked Questions was made available online[8].

National Campaigns

The NameExoWorlds National Committees had approximately six months to run their campaigns, with an additional three months of earlier preparation.

The exact time a country could join the project was quite flexible, as it depended on their availability. Most countries started their national contests on the official launch date, while others joined later on.

Most national campaigns were composed of three main steps: (1) advertising the contest, (2) collecting and down-selecting name proposals, and (3) voting on the finalists. National Committees were in charge of the whole process, and free to develop a timeline that best suited their local needs, as long as all results were delivered on the date established by the Steering Committee.

Advertising the Contest

The first step was performed in a very broad manner. Social media, altogether with a visually appealing artwork and design (including an official NameExoWorlds logo) was the most used method to advertise the project, while other traditional media, such as TV and radio, were also used on a smaller scale. Many countries created websites to advertise their campaigns. One of the most critical characteristics of NameExoWorlds was involving the general public as much as possible in the naming process. Therefore, it was mandatory that all names were proposed exclusively by the public.

Selection and Voting

For the voting phase, in case the National Committee lacked the time or resources to organise a secured vote open to the public, guidelines allowed a voting system where the final decision was made solely by the National Committee or by a hybrid system with input from the public and the National Committee.

Results and Global Announcement

The voting results submitted by each National Committee were composed of the highest-ranked name of the country's exoplanet and star, plus two backup names for each.

The Steering Committee then performed a validation process. When the highest-ranked names followed the naming rules, they were recognised as the official names of the respective "exoworlds"; otherwise, backups were identified and chosen.

After the vetting process was concluded and the Steering Committee had reached

Box 1. Additional Naming Guidelines

- The proposed names should be of things, people, or places of long-standing cultural, historical, or geographical significance, worthy of being assigned to a celestial object.
- Although not necessary, the names may be drawn from themes related to the sky and astronomy, or related in some way to the constellation or a cultural asterism in which the exoplanetary system lies.
- In recognition of the UN 2019 International Year of Indigenous Languages (IYIL2019)[21], speakers of Indigenous languages are encouraged to propose names drawn from those languages.
- Two (2) names should be proposed — one (1) for the exoplanet and one (1) for the star it orbits.
- The two names should follow a common naming theme. The naming theme describing how the names are related in some logical way should be summarised in a sentence or two, and be broad enough that additional names could be drawn from the literature to name additional objects in that exoplanetary system in the future (e.g. additional planets which might be discovered, additional stellar companions). Example: Rivers of country XYZ. Fictional lands in 19th-century stories from country XYZ, etc.
- Proposed names, after translation, should be:
  - Between 4 and 16 characters in length in Latin alphabet (including spaces or punctuation),
  - Preferably one word,
  - Pronounceable (in some language),
  - Non-offensive,
  - Not identical to, or too similar to, an existing name of an astronomical object. Names already assigned to astronomical objects can be checked using these links.
    - IAU names for minor planets in the Minor Planet Centre (MPC) database[22],
    - Names of galactic and extragalactic objects in the Sesame name resolver[23],
    - IAU names for planets, dwarf planets, and satellites[24],
    - IAU names for stars[25],
    - IAU names for exoplanets[26].
  - In addition, proposed names may not be:
    - Names of a purely or principally commercial nature,
    - Names of individuals, places or events principally known for political, military or religious activities,
    - Names of individuals that died less than a century ago (1919),
    - Names of living individuals,
    - Names of organisations related to the selection,
    - Names of pet animals,
    - Contrived names (i.e. new, invented),
    - Acronyms,
    - Names that include numbers or punctuation marks (diacritics are acceptable),
    - Names that are principally known as trademarks or protected by intellectual property claims.

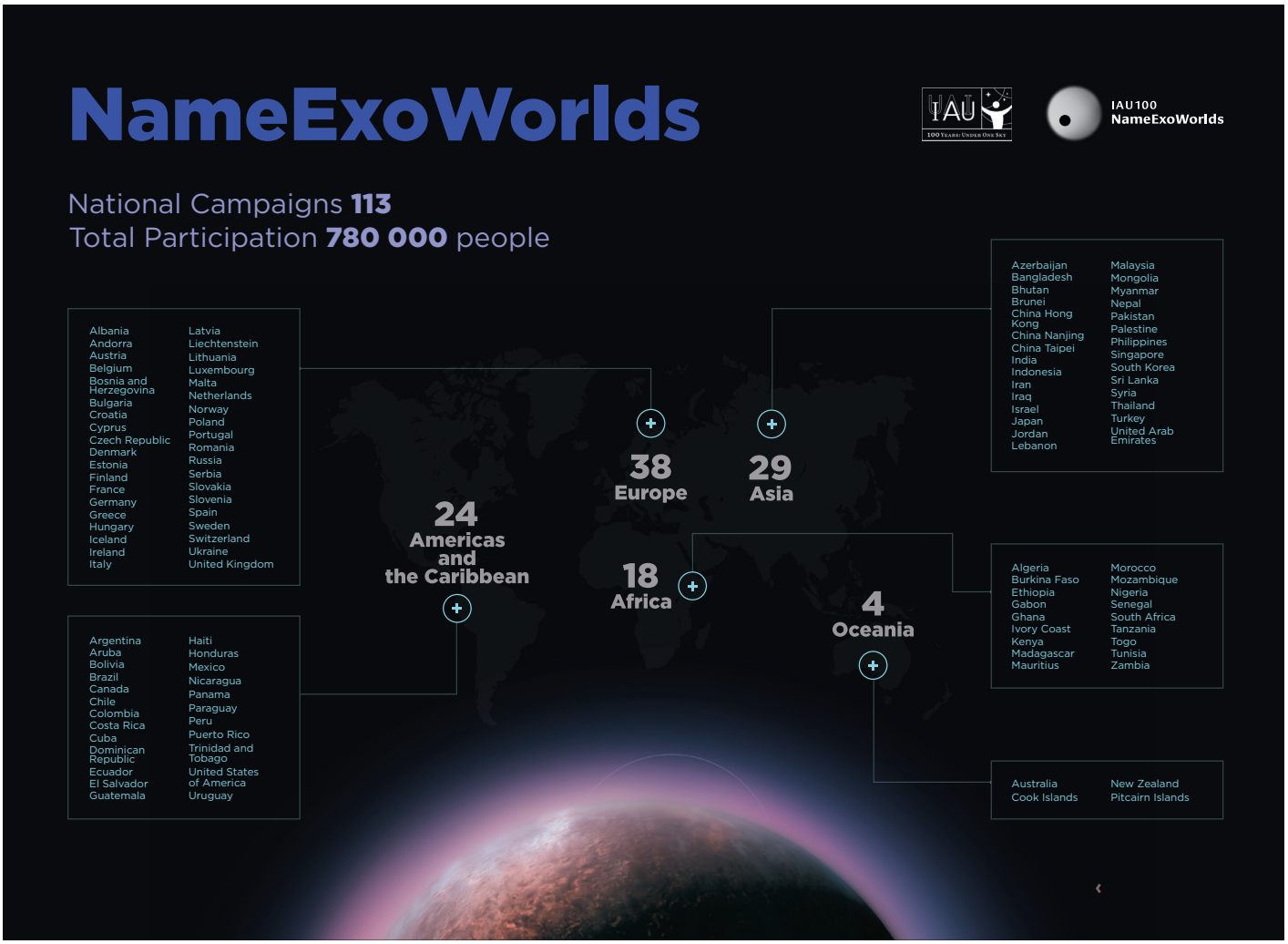

Figure 3. *Worldwide distribution of the IAU100 NameExoWorlds campaigns. Credit: IAU100 / Aneta Magraf-Druc*

a final decision, the first draft of the names and themes descriptions were sent to each National Committee, giving them the opportunity to address any questions or concerns. Nearly 355 000 proposals were received (79.2% in Africa, 2.4% in Americas, 10.5% in Asia, 7.7% in Europe, and 0.2% in Oceania). For the total number of votes, which was nearly 425 000, 3.6% were in Africa, 9.3% in Americas, 34.6% in Asia, 51.5% in Europe, and 1.0% in Oceania.

The results show an enormous diversity of meanings, ranging from names associated with indigenous culture to wonders of nature, mythology, literature, history and more[9]. This is expected due to the broad public participation and reflecting the fact that the NameExoWorlds project was truly a global event with the direct participation of hundreds of thousands of people who played a key role in proposing and voting for their preferred choices of names that represent their countries in the sky.

The IAU now officially recognises the chosen proper names in addition to their previous scientific designations, and they appear in popular databases like SIMBAD[10] and the NASA Exoplanet Archive[11], and night sky programs like Stellarium[12].

The official press release was shared with the National Committees beforehand for national translation and tailored dissemination in each country.

The project was advertised in widely viewed channels, such as the New York Times[13] in the US and Le Parisien[14] in France. Results were also covered worldwide by different media, such as a podcast in Argentina[15], a TV show in Dominican Republic[16], a report by CNN[17], and a video on Twitter of the moment when schoolchildren learnt their name proposal was chosen by the UK campaign[18]. The Wide Angle Search for Planets (WASP) project also advertised NameExoWorlds and posted the final results on their website[19] for the assigned WASP planets.

Lessons Learnt to Inform Future Campaigns

Considerations on "Contrived" Names

Future public naming campaigns should consider relaxing the guidelines with respect to "contrived" names. The exact meaning of "contrived" was sometimes

misunderstood or contentious. It was decided to encourage names "of things, people, or places of long-standing cultural, historical, or geographical significance" — and discourage new, invented names (e.g. names based on acronyms, portmanteaus, or completely new words with no etymology). However, what could be considered as "contrived" in a given culture may not be in another. For instance, it was decided that names which were pure invention were considered "contrived"; this rule led to rejecting some names built by composition of existing names that might have been acceptable with more relaxed guidelines. For future campaigns, the issue of acceptable names, with a good balance between quality and originality, will need to be reassessed.

Considerations on "Names of organisations related to the selection"

The guideline prohibiting "Names of organisations related to the selection" needed to be more specific, modifying it to "Names of organisations, institutions and countries related to the selection". For "non-commercial" and "non-political" names, the guidelines must be clearer, for example by giving some examples illustrating the rule. The proposed names which required the most deliberation and follow-up research bordered on the commercial, political, and military - future naming campaigns will benefit from further clarification on these guidelines for the proposers.

Clarification of "proper names" and "alphanumeric designations"

Members of the public and press were also sometimes confused assuming that the new IAU proper names "replace" the alphanumeric designations, which is not the case. Alphanumeric designations continue to be officially regarded, and exoplanets often have multiple designations — a fact of life for astronomers that may catalogue the same object multiple times over the years for different reasons.

Time Allocation for the Vetting Process

Future public campaigns should incorporate more time allocation for the vetting processes, since it proved to be a difficult, time consuming task, requiring long hours of focus and attention. Vetting proposals before they are submitted to public voting may also help to ease the process, but then more human resources are necessary to manage such a high workload.

Final Remarks

The IAU100 NameExoWorlds Global Project, organised in the framework of the celebrations of the 100th anniversary of the IAU, was carried out from June to December 2019. It was designed to offer the opportunity to all countries and territories of the world to name an exoplanet and its host star, to raise awareness of the vastness of the Universe and recognising Earth as just one planet amongst many others. Ultimately, NameExoWorlds invites people to consider themselves as "citizens of the Universe", sharing a fragile planet that must be preserved.

The project was developed in collaboration with the NOCs, as nominated by the OAO, who created National Committees to carry out the project at a national level. The participation of the NOC network proved to be essential for the success of the project. As a direct result of NameExoWorlds, some committee members proceeded to become part of the NOCs network following their successful participation and wish to continue to be actively engaged with the IAU outreach initiatives and global network. The NameExoWorlds project contributed to increasing even more this community, bringing together different science outreach groups worldwide, strengthening their actions and experiences.

The campaign was considered the "project with the greatest worldwide impact" in the IAU100 Final Report[20], and was successful in engaging people across the globe to help contribute diverse names to exoplanetary systems. The results now appear in a popular planetarium software, which can be used as one of a vast range of other possibilities for outreach and educational purposes enhancing the results to a wider audience, increasing awareness about the culture behind each chosen name now immortalised in the sky. It is hoped that the international astronomical community will continue to encourage future public naming campaigns that build off of the success of IAU100 NameExoWorlds.

Notes

[1] NASA Kepler Mission: https://www.nasa.gov/mission_pages/kepler/overview/index.html

[2] Name an Exoplanet Press Release: https://www.iau.org/news/pressreleases/detail/iau1908/

[3] Washington Double Star Catalogue: http://www.astro.gsu.edu/wds/

[4] Gaia Data Release 2 Catalogue: https://www.cosmos.esa.int/web/gaia/dr2 and Gaia Archive: https://gea.esac.esa.int/archive/

[5] The exception was WASP-161, whose discovery paper was in 2019. The Morocco National Committee requested WASP-161 as it was the first exoplanet whose discovery paper was led by authors from Morocco (Barkaoui et al. 2019). Assessment of the published paper led to the conclusion that the planet is firmly detected.

[6] Official NameExoWorlds Website: http://www.nameexoworlds.iau.org

[7] Naming rules for exo-systems: http://www.nameexoworlds.iau.org/naming-rules

[8] NameExoWorlds FAQs: http://www.nameexoworlds.iau.org/faqs

[9] IAU100 NameExoWorlds Results Press Release: https://www.iau.org/news/pressreleases/detail/iau1912/

[10] SIMBAD Astronomical Database: http://simbad.u-strasbg.fr/simbad/

[11] NASA Exoplanet Archive: https://exoplanetarchive.ipac.caltech.edu/

[12] Stellarium Astronomy Software: http://stellarium.org/

[13] "So Long, Exoplanet HD 17156b. Hello Sauron…?" by Dennis Overbye: https://www.nytimes.com/2019/06/14/science/exoplanets-astronomy-space.html

[14] "Les Français sont invités à trouver un petit nom à l'exoplanète HD 8574 b" by Vincent Gautier: http://www.leparisien.fr/sciences/les-francais-sont-invites-a-trouver-un-petit-nom-a-l-exoplanete-hd-8574-b-08-06-2019-8089272.php

[15] Malos Días programme on FM UTN Mendoza 94.5: https://radiocut.fm/radiostation/utnmendoza/listen/2019/12/19/10/48/53/?created_cut_id=927957

[16] "Hoy conocemos el resultado del concurso busca nombre para un exoplaneta" from Esta Noche Mariasela: https://www.youtube.com/watch?v=5wQQR-Auwbw&feature=youtu.be

[17] "Nachtwacht? Mulchatna? 112 exoplanets and stars get new names from countries around the Earth" by Katie Hunt: https://edition.cnn.com/2019/12/17/world/exoplanets-new-names-scn/index.html

[18] Video of the students celebrating on Twitter (via user Claire C Smith): https://twitter.com/ClaireCSmith/status/1207379385646551040

[19] WASP Planets press release: https://wasp-planets.net/2020/01/05/the-iau-announces-names-for-wasp-exoplanets/

[20] IAU 100th Anniversary Celebrations: Final Report: https://www.iau.org/static/archives/announcements/pdf/iau100-final-report-ann20019.pdf

[21] International Year of Indigenous Languages: https://en.iyil2019.org/

[22] Minor Planet Center (MPC) database: https://www.minorplanetcenter.net/iau/lists/MPNames.html

[23] Sesame name resolver: http://cds.u-strasbg.fr/cgi-bin/Sesame

[24] Gazetteer of Planetary Nomenclature: https://planetarynames.wr.usgs.gov/Page/Planets

[25] IAU "Naming Stars" theme: https://www.iau.org/public/themes/naming_stars/

[26] IAU "Naming Exoplanets" theme: https://www.iau.org/public/themes/naming_exoplanets/

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Biographies

Eric Mamajek was co-chair of IAU100 NameExoWorlds and is chair of IAU Division C WG Star Names. He is Deputy Program Chief Scientist of the NASA Exoplanet Exploration Program and his research is on the formation and evolution of stars and exoplanetary systems.

Lars Lindberg Christensen is an astronomer and science communicator. He has authored a dozen popular science books translated into more than ten languages, and has directed more than 10 documentaries and planetarium movies that have received critical acclaim around the world. He is responsible for the communication, education and community engagement for NOIRLab consisting of Cerro Tololo, CSDC, Gemini, Kitt Peak and Rubin Observatory operations.

Hitoshi Yamaoka is an astronomer and press and information officer. He is working as the IAU National Outreach Coordinator of Japan and is a committee member of IAU WG Star Names.

Debra Meloy Elmegreen is President-elect of the IAU and Professor of Astronomy on the Maria Mitchell Chair at Vassar College. Her research is on the structure and evolution of galaxies through multiwavelength observations.

Eduardo Monfardini Penteado is an astronomer and specialist in science communication and outreach. He was project manager of IAU100 NameExoWorlds and is currently working as IAU National Outreach Coordinator of Brazil.

Gareth Williams worked at the IAU Minor Planet Centre for thirty years, before semi-retiring in early 2020. He still serves on the IAU Working Group on Small Body Nomenclature and the IAU Working Group on Planetary System Nomenclature.

Guillem Anglada-Escudé is an exoplanet researcher specialised in searches for nearby possibly terrestrial planets. His interest is also in communicating space sciences with the public, and led the Pale Red Dot campaign & Red Dots follow-up programmes (scientific and outreach) that reported the discovery of Proxima b, the nearest exoplanet to the Solar System.

Alain Lecavelier des Etangs was co-chair of IAU100 NameExoWorlds and chair of IAU Commission n°53 "extrasolar planets" (2012-2015) and Commission F2 "Exoplanets and the Solar system" (2015-2018). His research activity is on atmospheres of exoplanets and exocomets.

Eddington at Sundy: From History to Legacy

Column

Joana Latas
University of Coimbra, IIIUC &
NUCLIO – Núcleo Interativo de Astronomia
joana.latas@mat.uc.pt

Rosa Doran
NUCLIO – Núcleo Interativo de Astronomia &
University of Coimbra, CITEUC
rosa.doran@nuclio.pt

Maria José dos Prazeres
Regional Government of Príncipe Island,
Secretary of Environment and Sustainable Development
cunyprazeres_rap@hotmail.com

João Fernandes
University of Coimbra, CITEUC, Department of Mathematics, Geophysical and Astronomical Observatory
jmfernan@mat.uc.pt

Keywords
solar eclipse, Príncipe Island

Eddington at Sundy: 100 Years Later celebrated the centenary of the observations of the 1919 solar eclipse, a landmark event that resulted in the first experimental confirmation of Einstein's General Theory of Relativity. This celebration was recognized by the International Astronomical Union (IAU) as a milestone event for their centenary celebration. More than 50 institutions contributed to nearly 100 initiatives developed in different formats, climaxing in an intense programme experienced by hundreds of people at the Roça Sundy landmark on Príncipe Island at the end of May 2019. Like the 1919 expeditions, three continents were directly involved in these celebrations, showing that international collaboration can result in a sum greater than its parts, leaving a legacy that will prevail for many years to come.

Introduction

On 6 November 1919, in a session of the Royal Astronomical Society, three renowned British astronomers presented the report of two expeditions, one to Sobral, Brazil, and one to the island of Príncipe, a then-colony of Portugal. The goal of the expeditions was to observe the total solar eclipse of 29 May 1919 and test one of the predictions of the then- recent general theory of relativity: that light would deflect due to mass. In their conclusions, the astronomers, Sir Frank Watson Dyson, Arthur Stanley Eddington and Charles Rundle Davidson, were emphatic: 'Thus the results of the expeditions to Sobral and Príncipe can leave little doubt that deflection of light takes place in the neighbourhood of the Sun and that it is of the amount demanded by Einstein's generalized theory of relativity, as attributed to the Sun's gravitational field' *(Dyson, Eddington & Davidson, 1920)*.

Einstein's General Theory of Relativity has been acclaimed as one of the most fruitful theories in science. The applications of the theory have ranged from the orbital movement of Mercury around the Sun to the structure of black holes to the shape of the universe to gravitational waves, both recognized with Nobel Prizes. However, its impact can also be seen in our daily life. Relativistic effects play a crucial role in determining precise locations and exact timing via global navigation satellite systems such as the American Global Positional System (GPS) and European Galileo.

The discovery itself is also a story of resilience. The observation occurred just after World War I. However, the preparation that started two years before was held back by the lack of specialized manpower, old instrumentation that was ill-adapted to this monumental experiment, and continental division. However, the collaborative pursuit of scientific overcame these restrictions.
The transcontinental effort across London (Europe), Príncipe (Africa), and Sobral (South America), and its magnificent history and results inspired Eddington at Sundy: 100 Years Later (E@S). Despite the difficulties a layperson has in understanding General Relativity and the full scientific topics encompassed, the dozens of collaborators and institutions involved in the celebration prepared and implemented activities with care and enthusiasm to produce a rewarding and successful experience. Now, the legacy – Espaço Ciência Sundy (Sundy Science Space)– will guarantee that the celebration will materialize into a long-lasting vision to change and enrich the community.

Strategy and Implementation

E@S brought together people from diverse backgrounds to celebrate the centenary of the 1919 solar eclipse under a unified vision[1] challenged by an organizational team including the Regional Government of [the Island of] Principe, Santomean and Portuguese universities, and educational and science outreach institutions. This was accomplished through international communication channels among various public groups and the cultural impact of the 1919 solar eclipse in São Tomé and Príncipe.

The E@S programme took place between 14 April, 2018 and 30 November, 2019, with nearly 100 events about science, history of science, science education, and science communication.

From May 24 to 29, 2019, the island of Príncipe hosted the culmination of the E@S celebrations, with 35 events in ten different locations around the island.

The six-day programme balanced public interests, expectations, and cultural inputs from residents and visitors with the available resources across the island. Before this 'main event in Príncipe' – as we will call it – a pre-event in January 2019 allowed us to listen to the local community,

gather their views and expectations, and establish important collaborations.

Resilience and trust built between the international organising committee and the local commission in Príncipe proved fundamental to the management of available resources in an environment that rarely holds international events like E@S. For example, about a month before the main event, a deadly shipwreck in the crossing between São Tomé and Príncipe, and a fire in another boat in the São Tomé harbour caused concern about the timely arrival of goods and fuel for the event.

Communication and coordination were key to the success of E@S. In fact, the interlinking between concepts, activities, institutions, people, and places was crucial to ensure the global coherence of the celebrations.

Communication was used to strategically promote an interest in science using a two-way dialogue between society and science, which recognized mutual benefits for different audiences *(Trench, 2008)*. Consistent with this model of science communication, we highlight four principles that were present in the development of E@S actions: i) co-creation, ii) interactions, iii) network, and iv) glocal.

Co-creation

The Global Science Opera (GSO)[2] is a collaborative project that brings scientific and artistic inquiry into schools through a process of virtual interaction between students from different countries. The 2019 GSO Gravity honoured the 1919 expeditions.

The main story of Gravity resulted from a five-month online collaboration between students and teachers from schools of both islands of São Tomé and Príncipe, Campos, and Sobral in Brazil, and Porto in Portugal, with support from artists, musicians, scientists, computer programmers, and other specialists from different fields. This format allowed participants to actively discuss and negotiate during production. The diverse array of participants enriched the production's storyline with diverse interpretations of 'gravity', from Einstein's General Theory of Relativity to today's advanced knowledge of gravitational waves.

The performance was broadcasted on 29 May 2019 during the main E@S event in Príncipe (Figure 1). The world premiere took place in November 2019 with the participation of more than 20 countries.

Interactions

The interactions between scientific knowledge and society were also established through the Trilho da Ciência (Science Trail), a nature walk that explores the universe through 'stations' which explain the science of the surrounding environment (Figure 2). The trail concept was inspired by the 1919 eclipse observations and the designation of Príncipe as a UNESCO World Biosphere Reserve[3] and bridged implicit and explicit representations of scientific knowledge in an environment familiar to local community members. Each station engaged participants through touch, cognition, and emotion ('hands-on, minds-on, hearts-on') creating a fully interactive knowledge-sharing experience for both audiences and specialists. In this Trilho da Ciência, scientists and teachers from the Príncipe High School iteratively worked together to design some stations of the trail.

The Trilho da Ciência was also used in teacher training organized by the Portuguese Language Office of Astronomy for Development (PLOAD)[4] with representatives from five Portuguese-speaking countries and members of the PLOAD and science teachers from Príncipe.
In addition, the concept of the Trilho da Ciência was presented in the exhibition 3E - Três Eclipses (3E - Three Eclipses)[5] an exhibition of the 1914, 1919, and 2013 total solar eclipses produced by the Science Museum of University of Coimbra, Portugal.

Network

The growing credibility of the E@S project was reflected in the participation by the international scientific community. The network of astronomers and other science specialists who, individually or institutionally, supported the celebration and participated in the main event on Príncipe, and enriched the celebration

Figure 1. *Performances of the 2019 Global Science Opera Gravity by students of Príncipe High School and Portuguese School of São Tomé and Príncipe on 29 May 2019 at the Roça Sundy landmark on Príncipe Island. Credit: Marina Balbina*

Figure 2. *Trilho da Ciência (Science Trail) station 'Why do eclipses occur?' taught by Joyn Tioló, teacher at Principe High School. Credit: Marina Balbina*

Figure 3. *In a manifestation of culture, actors perform an excerpt from the Príncipean play Auto de Floripes near the entrance of Espaço Ciência Sundy (Science Space Sundy). Credit: Valente Cuambe*

Figure 4. *Videoconference Príncipe e Sobral 100 Years Later. On the Príncipe side, seated left to right are the Jorge Bom Jesus, Prime Minister of São Tomé and Príncipe; José Cassandra, President of the Regional Government of Príncipe; Aires Bruzaca, Dean of the Public University of São Tomé and Príncipe; IAU President Ewine van Dishoeck; and José Sande Lemos, President of the Center for Astrophysics and Gravitation (CENTRA). Each delivered a speech during the videoconference. Credit: Maique Madeira*

with their networking and knowledge sharing. Interactions between individuals in different arenas consolidated the E@S network and brought different perspectives to the E@S actions.

E@S was recognized by the International Astronomical Union (IAU) as a Milestone project in their own centenary celebration, IAU100. IAU President Ewine van Dishoeck and IAU General Secretary Teresa Lago attended the main event in Príncipe to show support from the IAU100.

The international conference From Einstein and Eddington to LIGO: 100 Years of Gravitational Light Deflection[6], held in Príncipe between 26-28 May 2019 promoted a face-to-face collaboration between fifteen prestigious experts. They were invited to discuss, share, and reflect on scientific development in Relativity-related topics over the last century *(Lemos et al., 2019)*.

Relationships were also established between members of the scientific community and the media, resulting in a number of productions, namely the documentary À Espera das Estrelas (Waiting for the Stars)[7] produced by RTP Africa.

Glocal

In the same place that Eddington and Cottingham chose to observe the eclipse on 29 May 1919, the Roça Sundy received more than five hundred visitors exactly a hundred years later. About a hundred were scientists, educators, science communicators, along with other official guests and representatives of partner institutions.

Community members, local students and teachers, visiting researchers, and guests connected through activities throughout the landmark's campus. Traversing between the global and local dimensions created a place for cultural moments, such as the honouring of literary and musical contributions by the Príncipe diaspora, and discussions of gravitational waves between high-level specialists in culture and science (Figure 3).

Through videoconference, public authorities and scientists in Príncipe and Sobral talked, which strengthened their ties (Figure 4). A British historian of science spoke with the people of Príncipe next to the telescope used during the 1919 expedition to Sobral. From Príncipe to the world, impressions and interpretations about science, history, and culture were shared.

Moreover, the inauguration of the Espaço Ciência Sundy (Sundy Science Space) marked the political commitment of São Tomé and Príncipe to global science and the historical location (Figure 5).

E@S achieved its goal of a global celebration for one of the most important discoveries of the 20th century, and in turn built links among people across the globe and placed the foundation stone of a new era of science and education for the island.

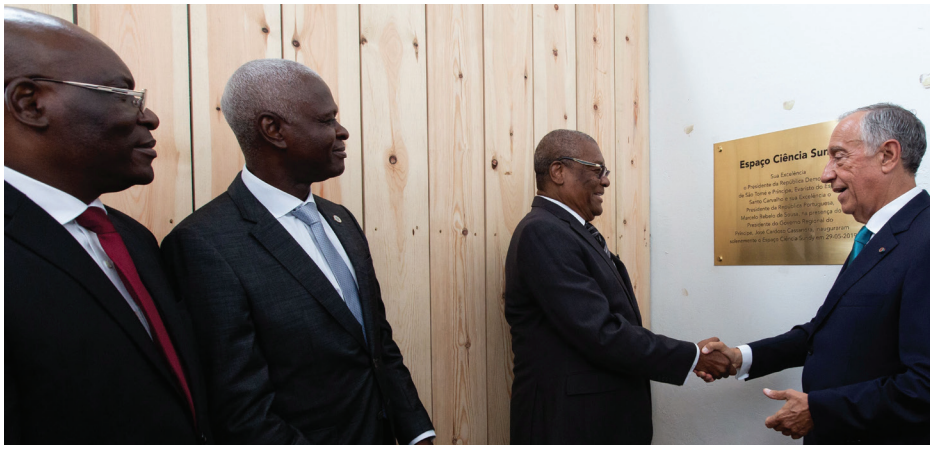

Figure 5. *Unveiling of the inaugural plaque of Espaço Ciência Sundy (Science Space Sundy) by the presidents of São Tomé and Príncipe and Portugal in the presence of the President the Autonomous Region of Príncipe and the Minister of Foreign Affairs of Equatorial Guinea. Credit: Maique Madeira*

Legacy

The E@S legacy has been materialized through Espaço Ciência Sundy. This non-formal educational setting was developed by an interdisciplinary team and aims to embody the link between history and science, safeguarding the legacy of a major scientific event. This space broadens the range of science education options on Príncipe beyond what is currently supported in the school infrastructure. The space will also stimulate initiatives in training and innovation in responsible tourism, in line with the development plan of Príncipe[8] with the aim of improving the residents' quality of life *(Latas, 2019)*. To bolster local development, a planetarium was constructed in this space at the end of March 2020. Although there is no public opening date due to the COVID-19 pandemic, this planetarium will be the first in the country and one of the few on the west coast of Africa.

Additionally, the media of E@S have won awards in the months following E@S. RTP Africa received the international Harambee Communicate Africa prize for the Terra Príncipe episode 'Jewels of Príncipe'[9] and the comic Einstein, Eddington, and Eclipse – Travel Impressions *(Simões & Sousa, 2019)* received a Portuguese 2019 Comics Award prize.[10]

In addition to these awards, but no less important, the organizational division into independent, remote teams has established new collaborations beyond the E@S context. These initiatives are still ongoing.

Final Remarks

Eddington at Sundy: 100 Years Later united hundreds through one eclipse one hundred years after a landmark experiment. The unique celebration brought together scientists, artists, politicians, educators, students, families, and community members to commemorate the interactions of science, history, diversity, society, and culture across borders. The event is a testimony of the importance of the observations, and its legacy will continue on the island of Príncipe.

Notes

[1] Vision for Eddington at Sundy webpage: https://esundy.org/index.php/en/about-es/vision/

[2] Global Science Opera website: https://globalscienceopera.com/.

[3] UNESCO webpage of the UNESCO World Biosphere Reserve on Príncipe: https://en.unesco.org/biosphere/africa/island-of-principe

[4] Portuguese Language Office of Astronomy for Development (PLOAD) website: http://pload.org/

[5] The 3E - Três Eclipses exhibition and other E@S activities are further explained on the E@S website: https://esundy.org/index.php/en/homepage/.

[6] From Einstein and Eddington to LIGO: 100 Years of Gravitational Light Deflection Conference website: https://science.esundy.tecnico.ulisboa.pt/en/

[7] The documentary, in Portuguese, is available at https://www.rtp.pt/play/p5865/espera-das-estrelas. The collection of resources produced by RTP Africa within the scope of Eddington @ Sundy are available at https://esundy.org/index.php/es-na-imprensa/.

[8] Príncipe 2030 official website: https://www.principe2030.com/

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Biographies

Joana Latas is currently a PhD researcher in the History of Science and Scientific Education at the University of Coimbra. She is also active in international networks in the areas of mathematics education and astronomy for development. Recently, she coordinated Eddington at Sundy: 100 Years Later project (esundy.org).

Maria José dos Prazeres is currently the Director of Environment and Nature Conservation on Príncipe Island. She graduated from the University of Lisboa and since 2013 she has taught mathematics at Príncipe High School. Maria José coordinated the Local Organizing Committee for the Eddington at Sundy: 100 Years Later project on Príncipe Island.

Rosa Doran is a science educator devoted to the integration of modern trends for innovation in the classroom, with a special emphasis on the use of astronomy for STEAM learning. She received a PhD in Science Education from the University of Coimbra in 2020 and holds leadership positions in a number of international astronomy research and outreach organizations.

João Fernandes is an astronomer and Assistant Professor in the Mathematics Department at the University of Coimbra. He received a PhD in Astrophysics from the University of Paris in 1996 and habilitation in Physics/Astrophysics from the University of Coimbra, in 2014. He was the Portuguese SPOC for the International Year of Astronomy 2009.

A Refuge in the Stars: Outcomes from the Amanar Project

Column

Sandra Benitez Herrera
IAC - Instituto de Astrofísica de Canarias
sandra.benitez.herrera@gmail.com

Felipe Carrelli
UFRJ - Universidade Federal do Rio de Janeiro
felipecarrelli@gmail.com

Eduardo Monfardini Penteado
National Outreach Coordinator for Brazil (OAO - NOC Brazil)
monfpent@gmail.com

Andrea Rodríguez-Antón
Institute of Heritage Sciences (Incipit)-CSIC
rodriguezantonandrea@gmail.com

Nayra Rodríguez Eugenio
IAC - Instituto de Astrofísica de Canarias
nayrare@gmail.com

On behalf of GalileoMobile and the Amanar Task Force

Keywords
astronomy for peace, Western Sahara, Sahrawi refugees, Amanar project

Amanar: 'Under the Same Sky', is a project that aims to use cultural aspects of astronomy to encourage common understanding and bridge two communities from the Canary Islands and Western Sahara. The Sahrawi people fled their country due to armed conflict more than four decades ago and continue to face harsh living conditions in refugee camps near Tindouf, Algeria. This project sought to empower and inspire these people, especially the youth. Amanar was selected as a special project for the centenary celebrations of the International Astronomical Union. The project was organised by GalileoMobile in collaboration with the Canarian Association of Friendship with the Sahrawi people and the Instituto de Astrofísica de Canarias as well as other astronomical institutions and volunteer associations. The success of this collaboration shows how both the scientific community and civil society can mobilise to promote the United Nations Sustainable Development Goals.

Introduction

Forty-four years after a failed process of decolonisation from Spain, the invasion of their country by Morocco, and the establishment of a peace plan by the United Nations, half of the Sahrawi population continue to be refugees *(Bárbulo, 2011)*, despite the promise of a self-determination referendum that never happened. According to the United Nations High Commissioner for Refugees1, 173 600 Sahrawis reside in the refugee camps, in territory provided by Algeria, in a situation that is both provisional and permanent. The five camps are named after the main Sahrawi cities under Moroccan occupation: Ayoun, Smara, Bojador, Auserd, and Dajla (see the map in Figure 1), and their management is administered by the Sahrawis themselves.

Fresh food, water, medical, and hygiene supplies are limited, and the Sahrawi families depend on international humanitarian aid to survive. In education, the Sahrawi schools face various challenges, such as the quality of teaching,

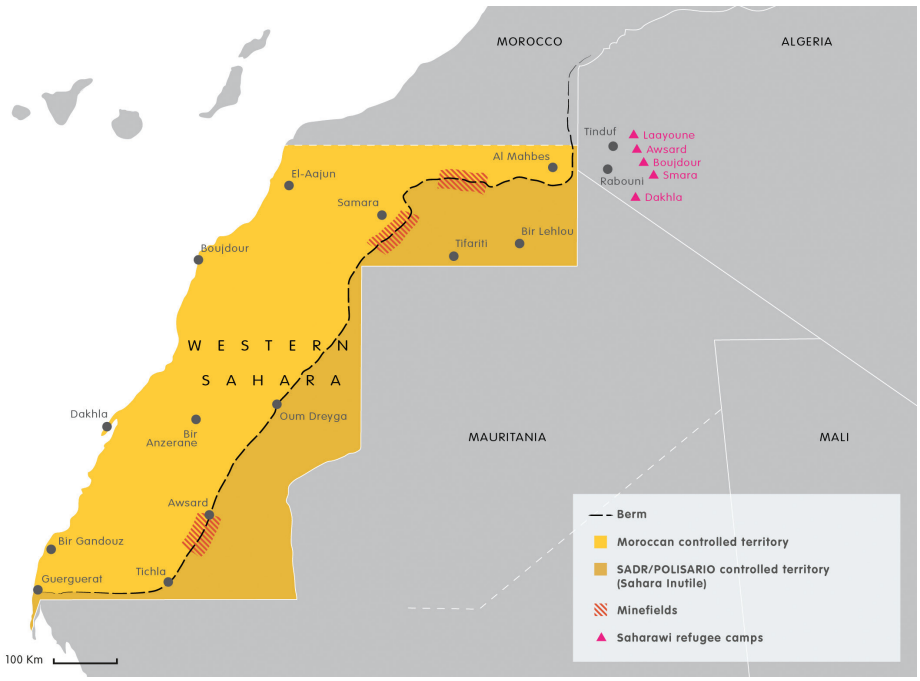

Figure 1. *Map of the Western Sahara region. Two-thirds of the country is currently under the occupation of Morocco and is divided from the Sahrawi-controlled area by a 2700 km wall. Credit: European Council of Foreign Relations.*

a shortage of educational materials, equipment, and infrastructure, and few training opportunities or incentives to retain skilled educators. Another worrying issue is the lack of motivation among the youth, who experience limited prospects and high levels of frustration resulting in high class absenteeism and unemployment rates.

The Amanar Project: Hope through Astronomy

Amanar is an outreach project that aims to empower and inspire the Sahrawi refugee community through astronomy and promote peace, guided by the Sustainable Development Goals defined by the United Nations2.

Special attention was given to children and young people through the project to awaken their interest in science, stimulate their imagination and critical thinking skills, and contribute to strengthening their resilience. This was done by organizing fun and memorable hands-on activities where the children learned about aspects of our universe. Of particular importance was the collaboration of participants in groups to find answers, with their teachers involved in the process. Outside group activities were also performed to familiarize the students with the Amanar team.

A fundamental aspect of the project was to support the teachers of the camps in their pedagogical practise by offering continuous training (face-to-face during the annual planned visits to the camps and, in 2020, online via WhatsApp) and donating telescopes and other necessary educational resources.

The project was divided into two stages, both carried out during 2019. The first part took place in July and August and consisted of astronomical outreach activities and observations with Sahrawi children, who visited the Canary Islands through the 'Holidays in Peace' programme *(Crivello et al., 2005)*.

Activities took place at the professional Teide and Roque de los Muchachos observatories in Tenerife and La Palma of the Canary Islands, Spain, and included visits to some of the largest telescopes in the world. At nightfall, the group gazed at one of the clearest skies in the northern hemisphere using amateur telescopes. In Gran Canaria, activities were carried out at the primary school in Arucas involving both Sahrawi and local children and their families to encourage solidarity between the two communities as they learned about the cosmos together (Figure 2).

Figure 2. *Sahrawi children and their Spanish host families visiting the Gran Telescopio de Canarias and the Large-Sized Telescope at the Roque de los Muchachos Observatory, La Palma. Credit: Antonio Gonzalez (Cielos de La Palma).*

In October, the Amanar team travelled to the camps near Tindouf, Algeria, for two weeks to work with local students and teachers and donate kits of educational materials. At the schools, the team presented astronomy-related talks and workshops, particularly focused on the Sun-Earth-Moon, Solar System, the constellations, and space missions. Previous experience in the Canary Islands helped with selecting activities to develop for the camps. 'The 'Voyager Mission'3 activity was particularly successful. Here, students built their own 'Golden Record' including aspects of the Sahrawi culture (e.g. their music, poetry or typical cuisine) and of their daily life in the camps (e.g. the appearance of their houses and animals)4 (Figure 3).

Figure 3. *A group of students during the Voyager-inspired 'Golden Record' activity. Credit: GalileoMobile.*

The team also performed inquiry-based learning workshops with the teachers, in which the teachers became acquainted with the GalileoMobile 'Handbook of Activities' and with donated materials such as telescopes and interferometers (Figure 4). Specific meetings with the teachers allowed for discussion about modern and traditional Sahrawi astronomy as well as their training needs.

The team also delivered a talk at a vocational training centre for women, and debated with students about the participation of women in STEM, particularly in astronomy.

The total audience reached during the different stages of the project in 2019 is presented in Table 1.

Figure 4. *A teacher learns how to use a donated telescope. Credit: GalileoMobile.*

Under the Same Sky

In addition to educational activities, the project had two further aims: to collect and record the oral tradition of ancestral astronomical knowledge of the Sahrawi people, and to preserve this knowledge for future generations.

Through the Sahrawi Oral History Department, the team interviewed four experts, three men and one woman (Figure 5), with knowledge about an ancestral astro-meteorological system called Anwas, which uses the visible rising and setting of specific stars and asterisms to predict rain or the hottest season. Within this system, dating back hundreds of years, specific stars are also used for orientation in the desert and for religious practises.

The interviews and recordings were not considered a mere case of study, but as living knowledge and a valuable worldview to be used to strengthen the Sahrawi collective memory and cultural identity, engaging the youth in the process.

In the beautiful words of the star expert interviewee, Alhaizza AlDih AlNah:
Science must expand to all of humanity and not be monopolised by a person or a group [...] I learned astronomy from my father[...] My father had a very good memory. When I heard something, I quickly memorised it [...] I'm trying to take care of that knowledge. When someone comes to ask, I try to teach what I know [...] My children know and are learning. 5

Throughout, it was evident that, for the Sahrawis, the scientific subject could not be disconnected from political issues. As one of the most protracted refugee situations worldwide, many aspects of their nomadic culture and lifestyle are lost or seriously threatened. Quoting Salec Mohamed Omar, a Sahrawi sage, and another interviewee,
Surely, we all see this sky, but we have different perceptions, different interpretations of it. Everything that leads to finding us, bringing us closer is important. And the best tool for that is science. [...] It is a difficult topic to deal with in a situation like ours in a refugee camp, where people have in mind other things, which they consider to be of primary need. But there is no doubt that there are people who are very interested.6

The results of all interviews and data collection will be presented at the annual meeting of the European Society for Astronomy in Culture in 2021. In addition, we are applying for two grants to further

Audience	Nº of participants
Schools	6 high schools, 1 vocational training centre for women, 1 teacher training centre
Students at the camps	550
Teachers at the camps	66
General public at the camps	60
Sahrawi children in the Canary Islands	45
Spanish public in the Canary Islands (host families, monitors, volunteers, etc...)	103
TOTAL	824

Table 1. *The audience reached during the Amanar project activities in 2019.*

Figure 5. *Amanar team members learn from one of the Sahrawi sages about their knowledge of the sky. Credit: GalileoMobile.*

support the research and allow the Sahrawi to become the real agents of it.
In preparation for the project, the Amanar team trained with experts in immigration and refugee phenomena and in ethnoastronomy. A literature review was also conducted, in which the sociologist Abdelmalek Sayad *(Sayad, 1998)* was the main reference. In addition, a search for previous experience of science engagement with refugees was carried out, and team members were updated on the subject of worldwide forced migration by following the most recent statistics[7].

This training enabled the team to develop a methodology for working in the camps based on empathy, participant observation and listening, and critical hope *(Martin, 2018)*. The training will continue as new actions are developed under the Amanar framework.

Audiovisual Products

As highlighted by Omah Ahmed, director of the Abidin Kaid Saleh Audiovisual School of the Sahrawi Arab Democratic Republic, 'In the Sahara, all forms of artistic expression have been transformed, evolving and enriching the cultural identity of the Sahrawi people' *(Real Bollero, 2011)*.

Cinema has been one of these expressions, consolidated through the establishment of the Sahara International Film Festival (FiSahara)[8], which is the only film festival in the world held in a refugee camp. The Amanar team had the opportunity to attend the festival and meet some of the organisers and local artists, an experience that enhanced the project's audiovisual products.
These products include a linear feature film, an interactive documentary (i-doc) and a virtual reality piece (Figure 6). The audiovisual products aim to denounce the long-standing conditions of the Sahrawi people through the dissemination of their culture and worldview, approaching their own scientific knowledge from a decolonial perspective *(Castro-Gomez & Grosfoguel, 2007)*. We hope to present these films at FiSahara, 2021.
Moreover, based on the principles of co-creation *(Cizek et al., 2009)* and research-creation *(Owen & Sawchuk, 2012)*, the ethnographic recordings and interviews will be returned to the Sahrawi community so that this material can be used, reinterpreted, and adapted for cultural and educational purposes.

Conclusions

Amanar is essentially an attempt to bring hope to a sometimes forgotten place and people by stimulating their imagination and critical thinking skills through science. Built on experience acquired from previous GalileoMobile projects, it moves a step further by empowering and providing the Sahrawi people living in refugee camps an opportunity to wonder about the universe and share their traditional knowledge of the sky.

A key element was the study of their cultural practises, with the aim of preserving them and facilitating their dissemination through the recording of audiovisual materials. This encouraged the direct participation of local people in the production process so that they are the real protagonists in their story of hope through astronomy.

Figure 6. *A child looks through a VR device. One of the audiovisual products will be a virtual reality piece about the Sahrawi astronomical tradition. Credit: GalileoMobile.*

The project is committed to continuing the summer activities in the Canary Islands and expanding them to other regions in Spain and Italy next year as well as continuing teacher training online and in-person, and visits to the camps in the following years.

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Notes:

[1] Download of 'Humanitarian Needs of Sahrawi Refugees in Algeria 2018-2019' by the United Nations: https://bit.ly/2Xbpxep

[2] United Nations Sustainable Development Goals: https://sustainabledevelopment.un.org/?menu=1300

[3] GalileoMobile, 2019, 'Handbook of activities', version 1.42. https://docs.google.com/presentation/d/14WR0n-e85y2eJoefgepMad-SWbVmAFiYBKexVfGBvxo/edit?usp=sharing

[4] Golden Record activity video: https://youtu.be/LGray070AHI

[5] Amanar Task Force, 2019, 'Interview to Alhaizza AlDih Alnah' Translation: Hamdi Ahmed Aomar. Ausserd Wilaya.

[6] Amanar Task Force, 2019, 'Interview to Salec Mohamed Omar'. Rabouni Protocolo Centre

[7] United Nations High Commissioner for Refugees. 2017, 'Global Trends: Forced displacement 2018' https://www.unhcr.org/statistics/unhcrstats/5d08d7ee7/unhcr-global-trends-2018.html

[8] FiSahara website: https://fisahara.es

Acknowledgements:

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Biographies

Sandra Benítez Herrera is an astrophysicist and specialist in science communication and outreach. She currently works at the IAC's Press and Outreach Department, where she coordinates several educational and teacher training projects. She has been a member of the GalileoMobile programme since 2011 and has organised astronomy outreach projects in Bolivia, Brazil, Chile, Ecuador, India, and Uganda. She is the coordinator of Amanar.

Felipe Carrelli is a master' s student in creative media at the Universidade Federal do Rio de Janeiro and co-coordinator of GalileoMobile. He graduated in Image and Sound from the Federal University of São Carlos and specialises in science communication and outreach. He has experience in audiovisual, with an emphasis on documentary.

Eduardo Monfardini Penteado is an astronomer and specialist in science communication and outreach. He was a project manager at IAU100 NameExoWorlds and is currently working as the IAU National Outreach Coordinator in Brazil. He has also been a member of GalileoMobile since 2012.

Andrea Rodríguez-Antón is an archaeo-astronomer and ethnoastronomer currently working at Instituto de Ciencias del Patrimonio (Incipit)-CSIC. Her main research topic is the role of astronomy in Roman urbanism and landscape, but she studies other ancient cultures in the Mediterranean. She is a member of the Amanar team and is developing a study of Sahrawi folk astronomy.

Nayra Rodríguez Eugenio is an astrophysicist and science communicator. She works at the IAC's Press and Outreach Department, coordinating the Educational Project with Robotic Telescopes (PETeR) and other outreach and teacher training initiatives, including the international course, 'Astronomy Adventure in the Canary Islands' She is a member of the Amanar team.

LightSound: The Sound of An Eclipse

Allyson Bieryla
Center for Astrophysics, Harvard & Smithsonian
abieryla@cfa.harvard.edu

Sóley Hyman
Center for Astrophysics, Harvard & Smithsonian, University of Arizona
soleyhyman@email.arizona.edu

Beatriz Garcia
El Instituto de Tecnologías en Detección y Astropartículas (CNEA, CONICET, UNSAM)
beatrizgarciautn@gmail.com

Wanda Diaz-Merced
Center for Astrophysics, Harvard & Smithsonian, University of Colorado at Boulder
wanda.diaz.merced@gmail.com

Paulina Troncoso Iribarren
Universidad Central de Chile
paulina.troncoso@ucentral.cl

Erika Labbe
Universidad Diego Portales
elabbew@gmail.com

Daniel Davis,
Harvard Natural Sciences Lecture Demonstrations
ddavis@fas.harvard.edu

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solar eclipse, inclusion, accessibility, sonification

LightSound was originally developed as a tool for the blind and visually impaired (BVI) community to experience events, like solar eclipses, live. LightSound is a handheld device, built with Arduino components, that converts light into sound via a light sensor and MIDI board. It has an audio jack to output sound and can connect to a computer to record data via Python scripts. The software and instructions for assembly and use are open source and available online in English and Spanish. Through an IAU100 Special Project Grant, 21 LightSounds were distributed to schools, research centres and museums across Argentina and Chile that hosted events for the July 2019 solar eclipse. These events, which reached tens of thousands of people, were accessible to BVI observers with the help of the LightSound. The devices will also be used for the December 2020 South American eclipse. We discuss the highlights of the project and our future plans.

Introduction

A solar eclipse is one of the most visually striking astronomical phenomena. Astronomy is generally thought of as a visual science and because of this, resources for the sensorially-biased community, such as the BVI community, are often limited. For populations with some of their senses reduced, access to knowledge is hindered, complicated and sometimes impossible. The access to all aspects of astronomical phenomena should be, from the point of view of human rights, one of the objectives of astronomers dedicated to all natural aspects of the field.

LightSound is a sonification device that was designed as a tool for the blind and visually impaired (BVI) community for use during a solar eclipse (Figure 1). It was originally designed for the Great American Solar Eclipse in 2017. The idea came to be from a conversation between Allyson Bieryla and Wanda Diaz-Merced. Diaz-Merced was teaching in South Africa at the time and wanted her BVI students to have the opportunity to experience the much-hyped North American eclipse. Bieryla brought the idea to a prototype designer at Harvard University, Daniel Davis, and the work began to design the device. Three of the original prototype LightSound devices were set up at outreach events along the path of totality as a proof of concept. Bieryla took one to Jackson Hole, Wyoming and the two others were sent to schools in Kentucky. The devices in Kentucky were used to collect data and Bieryla used the device in Wyoming to stream sound on the internet for the students in South Africa and people all over the world to listen.

In 2019, Sóley Hyman, then a Harvard University undergraduate, joined the team. Repurposing Adafruit's PianoGlove project[1], Davis adapted the LightSound device to have a more robust chassis and include a MIDI synthesizer, enabling Hyman to develop a better sound profile to prepare for the 2019 South American solar eclipse. The redesigned LightSound project was awarded an International Astronomical Union (IAU) Special Project Grant to fund the distribution of 21 devices across Argentina and Chile. Bieryla and Hyman built the devices that were sent to Chile and Paulina Troncoso Iribarren and Erika Labbe distributed them across Chile. In Argentina, Beatriz Garcia and her team

Figure 1. *LightSound device on a portable tripod with headphones attached. Credit: Allyson Bieryla*

built and distributed the devices to the Argentinean sites.

The LightSound Device

Designed to be both low-cost and easy to assemble, LightSound uses Arduino technology[2] to sonify changing ambient light levels in real-time. The device consists of three main components, all of which are produced by Adafruit Industries[3]: the Flora v3 microcontroller board, the TSL2591 light sensor and the VS1053 Codec (MIDI synthesizer) board. The other components for the device are generic — a toggle switch for power, audio jack, 5-volt voltage regulator and a 9-volt battery. Although any type of box or casing can be used to house the completed LightSound circuit, we designed a custom chassis with Hammond Manufacturing[4] that has pre-cut holes for the power switch, audio jack and micro-USB port (located on the Flora microcontroller board). Excluding the costs of standard electrical and soldering equipment (e.g. soldering iron, wire strippers, hookup wire, etc.), the LightSound components total to around $70 USD.

Assembly of the device requires only basic soldering skills and can be completed in a few hours. Even those who have little to no experience soldering have been able to successfully build their own devices. Safe, inclusive-tested soldering methods for the BVI community have been developed by Dr Leonard Garcia and Diaz-Merced and are available upon request[5]. After assembly of the device circuit is complete, the LightSound code is uploaded to the Flora board via the micro-USB port. This port is also used to connect the device to a computer, where the LightSound can run off computer power and record the light intensity during observations. Figure 2 shows a side-by-side comparison of the original and re-designed LightSound with the components labelled.

Available Resources

We have gone to great lengths to make all documents and software open source. Detailed instructions to assemble a LightSound device are available online[6]. We also provide instructions to use the software, written in Python, which allows users to collect and plot data for future analysis, regardless of programming experience. All documentation is currently available in English and Spanish, and we hope to expand to other languages soon.

Part of the broader impact of the LightSound is the lesson plans. The LightSound device, while designed for use during a solar eclipse, can also be used as an educational tool in classrooms or outreach events for BVI students. Lesson plans on orbits and eclipses[7], which can be used for various age students, have also been developed and more lesson plans are currently under development.

In an attempt to reach more people, we developed a workshop which we debuted at the American Astronomical Meeting in Honolulu, Hawai'i in January 2020[6]. The two-day workshop aimed to guide participants through the process of building a LightSound device and learning how to use and edit the software. Each participant was able to go back to their home institution with the LightSound they built and the tools that they learned, in hopes that they would transfer their new knowledge to their community. Our goal is to hold more workshops in the coming years in preparation for the next North American solar eclipse in 2024.

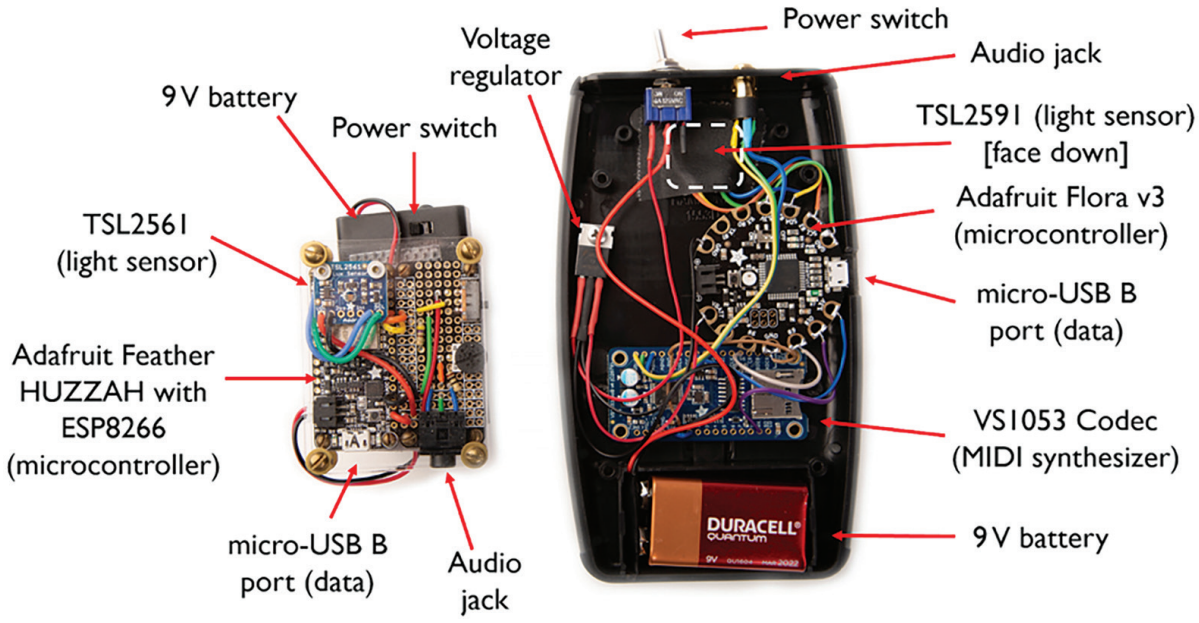

Figure 2. *Comparison of LightSound 1.0 (left, designed for 2017 eclipse) and LightSound 2.0 (right, designed for 2019 eclipse) with components labeled. Credit: Sóley Hyman*

2019 South American Solar Eclipse

Through an IAU100 Special Project Grant, we built and distributed 21 LightSound devices throughout Argentina and Chile in preparation for the July 2019 solar eclipse (see Table 1 and Figure 3). Over 10 000 people attended these events across Argentina and Chile. Figure 4 shows an event held in La Serena, Chile where people gathered at a local stadium. The LightSound devices were used during the solar eclipse to sonify the diminishing light of the Sun as it was being eclipsed by the Moon. This made the event accessible to a larger group of individuals including those with different perceptual styles.

The 2019 solar eclipse was the news highlight of the year for many countries in South America. Hundreds of interviews, newspaper articles, blogs and social media posts were geared toward these events highlighting the LightSound. Hyman gathered the data from the sites where the LightSound recorded the eclipse data and made a video sonification map[8]. The video plays the sonified data from four locations in South America, synchronised with a NASA animation of the eclipse.

Argentina	Chile
Colegio Provincial de Santa Lucía, Santa Lucía, San Juan	AstroBVI/U. Antofagasta — Municipalidad de Antofagasta, Antofagasta
Municialidad de Calingasta y CASLEO, Calingasta, San Juan	ALMA — Atacama
Club de Astronomía Villa Mercedes, San Luis	NPF/IFA/MAS — Atacama
Escuela Especial Vicenta Castro Cambon, Río IV, Córdoba	GEMINI/CTIO — Coquimbo
Escuela Especial Luciernagas, Río IV, Córdoba	IFA — Valparaíso
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Instituto Helen Keller, Córdoba Capital	MIM — Santiago
Municipal camping of Villa Cañas, Santa Fe	U Autónoma — Planetario Chile — Santiago
Escuela Helen Keller, Godoy Cruz, Mendoza	Dedoscopio — Penco, Biobío, Chile
Fac. de Cs. Astronómicas y Geofísicas y Fac. De Arquitectura, La Plata, BsAs	Patricio Antiman — Plaza de Armas de Aysén, Aysén
Centro de Recursos Educativos para Personas con Discapacidad, Córdoba Capital	

Table 1. *Location of LightSound devices during the 2019 South American Eclipse.*

Figure 3. *Map of the LightSound locations during the solar eclipse on 2 July 2019. Credit: Google Maps.*

Conclusion and Future Plans

We are continually trying to build the community of LightSound users[9]. LightSound is a low-cost, high-impact project. Each LightSound can potentially impact hundreds to thousands of people. We intend to explore the use of haptics (vibration) and the use of a memory card for data storage. This would extend access to more platforms. Our hope is that we can spread knowledge and resources through continued workshops and online open-source documents. But this is not enough. We want and need to be able to reach all communities, including those communities with very limited resources and funds. To tackle this problem, we rely on grants from organisations to fund endeavours for communities most in need. LightSound can be used with and without a computer and can provide an entire school or community access. It can give all participants a needed tool to aid in the immersion of astronomy, science and phenomena that was previously a more abstract concept.

Building on the success of the LightSound, we developed a second device called Orchestar[10]. Orchestar works using the same technology with the major difference being that the light sensor is now multi-wavelength. The sound is output based on the colour of the light with longer wavelength light having a lower pitch sound as compared to higher wavelength light. Orchestar has a great potential impact. One focus of this project has been to develop Orchestar as an observing tool on a telescope. Orchestar has been highlighted in the IAU Inspiring Stars[11] travelling exhibit that focuses on inclusive and accessible astronomy resources and tools. It was also used to listen to Atacama Large Millimeter/submillimeter

Figure 4. *Thousands of people gather at Estadio La Portada in La Serena, Chile to witness the solar eclipse on 2 July 2019. LightSound is shown on the table connected to speakers for BVI individuals to hear the sound of the solar eclipse. Credit: Katherine Marchant, Estadio La Portada.*

Box 1. Selected testimonials from the July 2019 solar eclipse events

"The activity went really well, beautiful experience. All impressed by such beauty. We had a great expectation. The students enjoyed it immensely. At the time of the totality that lasted 30 seconds, all of the people were amazed. Total euphoria! Thank you all very much, especially for the possibility of providing the opportunity for blind people to perceive the eclipse."

Ana Belén de Alias - Primary Teacher, San Juan, Argentina

"Today, July 2, was a very exciting day, beautiful and unforgettable, enjoying a wonderful event such as a solar eclipse in the stadium 'La Portada', and best of all, there was a machine that transformed the solar light into sound ... And when the Sun was completely covered by the Moon, the machine began to sound lower until there was a small moment of silence. (...) this made the eclipse more inclusive and blind people could enjoy this wonderful event just like everyone else."

Katherine Marchant, La Serena, Chile

Array (ALMA) maps and Hubble Space Telescope (HST) images at the First Stars IV conference (Figure 5)[12].

The LightSound devices that were used during the 2019 solar eclipse will also be used during the upcoming South American solar eclipse in December 2020. In Chile, funded by the Gemini Observatory and the European Southern Observatory (ESO), Troncoso Iribarren and her team are building more than 200 LightSound and Orchestar devices for distribution to outreach centres and some rural schools for the 2020 eclipse.

Notes:

[1] Adafruit's PianoGlove project: https://learn.adafruit.com/pianoglove/what-youll-need

[2] Arduino website: https://www.arduino.cc

[3] Adafruit Industries website: https://adafruit.com/

[4] Hammond Manufacturing website: https://www.hammfg.com

[5] Information about the development of the soldering techniques can be found in this article: https://www.nasa.gov/audience/foreducators/k-4/features/F_Tuning_in_Sounds_of_Space.html. Please contact abieryla@cfa.harvard.edu if you are interested in learning more about the soldering techniques.

[6] LightSound IAU100 Project website in English: http://astrolab.fas.harvard.edu/LightSound-IAU100.html. LightSound IAU100 Project website in Spanish: http://astrolab.fas.harvard.edu/LightSound-IAU100-sp.html

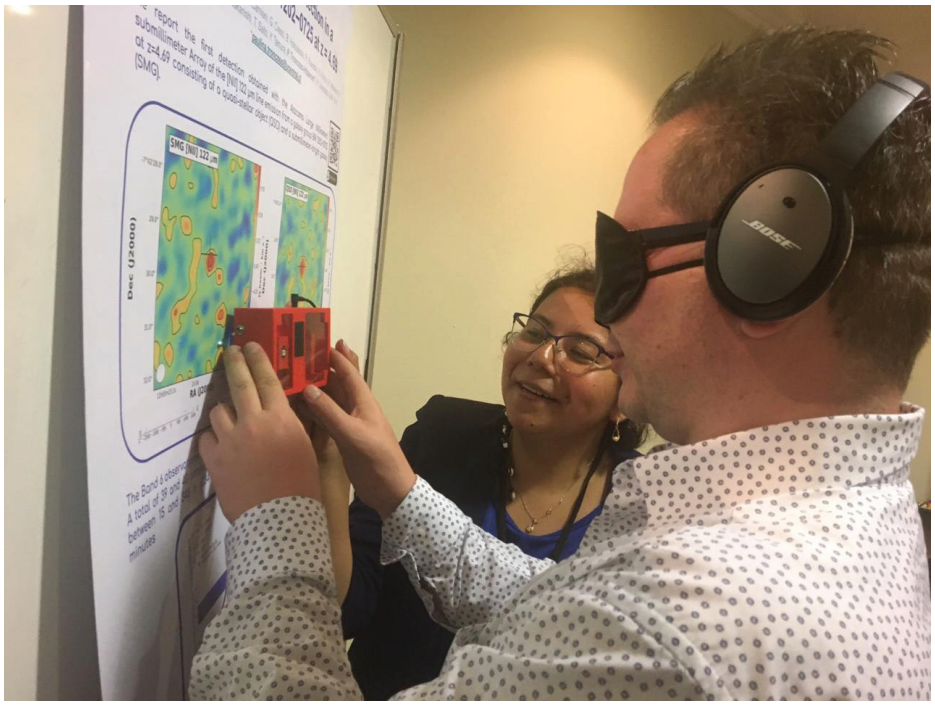

Figure 5. *Orchestar being used to listen to ALMA maps and Hubble Space Telescope images during the First Stars IV conference. Credit: Paulina Troncoso Iribarren*

[7] AAS 235 Workshop and Events website: https://aas.org/meetings/aas235/workshops-events

[8] Video sonification map: https://www.youtube.com/watch?v=RraNpZkSxNY

[9] We are always interested in feedback and collaboration! Please do so by contacting abieryla@cfa.harvard.edu.

[10] Harvard Astronomy lab accessibility website with information about the Orchestar: http://astrolab.fas.harvard.edu/accessibility.html Spanish documentation available (still under development): https://drive.google.com/drive/folders/18kJ-43SJCuozmF4ysBqpPCVQ0T_C3Bfr

[11] Inspiring Stars website: https://sites.google.com/oao.iau.org/inspiringstars

[12] First Stars IV conference: http://www.astro.udec.cl/FirstStarsVI/Program.pdf

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Biographies

Allyson Bieryla is an astronomer at the Center for Astrophysics | Harvard & Smithsonian. She is involved in exoplanet research and manages the astronomy lab and telescopes for undergraduate courses at Harvard University.

Sóley Hyman is a graduate student at the University of Arizona's Department of Astronomy and studies the orbit of the star S2 around our galaxy's supermassive black hole. She also became involved in multiwavelength AGN research while at the Harvard-Smithsonian Center for Astrophysics.

Beatriz García is an astronomer at the Instituto de Tecnologías en Detección y Astropartículas, a subsidiary of CNEA, CONICET and UNSAM. She works on topics related to Ultra High Energy Cosmic Rays and CMB and conducts research on inclusive astronomy.

Wanda Diaz-Merced is an astronomer from Puerto Rico. She has worked on various topics in high-energy astrophysics and uses sonification techniques in her research.

Paulina Troncoso Iribarren is an extragalactic astronomer, focusing on the birth and evolution of galaxies using the synergy of simulations and observations. She is the director of the astronomy major at the Universidad Central de Chile, where she is teaching about inclusive technology in the formal education of future teachers and astronomers.

Erika Labbé Waghorn is an astronomer and Outreach Coordinator for the Astronomy Nucleus of Diego Portales University. She has taught general formation courses in astronomy and scientific communication in several universities. In 2015 she started the astronomy outreach project for the UDP Astronomy Nucleus, which quickly extended to areas such as art and inclusion.

Daniel Davis is an applied physicist, educator, and Director of Harvard Natural Sciences Lecture Demonstrations, whose work is to reveal the wonder and utility of phenomena to enhance their perception, enjoyment, and implementation.

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Inspiring Stars: Implementing a Workshop on Astronomy for Inclusion for Thai Outreach Practitioners and Science Teachers

Column

Pisit Nitiyanant
National Astronomical Research Institute of Thailand (NARIT)
pisit@narit.or.th

Suwanit Wutsang
National Astronomical Research Institute of Thailand (NARIT)
suwanit@narit.or.th

Suparerk Karuehanon
National Astronomical Research Institute of Thailand (NARIT)
suparerk@narit.or.th

Wichan Insiri
National Astronomical Research Institute of Thailand (NARIT)
wichan@narit.or.th

Keywords
inclusion, Inspiring Stars, Thailand

The 'NARIT-IAU100 Inspiring Stars Workshop 2019' was a workshop designed with the goal of exchanging knowledge and best practices on inclusive astronomy outreach resources and activities between the international community and Thailand. The workshop was developed and implemented by the National Astronomical Research Institute of Thailand (NARIT), in collaboration with the IAU Office for Astronomy Outreach (OAO) and the National Astronomical Observatory of Japan (NAOJ). This workshop was held in Chachoengsao in Thailand in late June 2019 with a group of thirty Thai science communicators, astronomical outreach practitioners, and science teachers from Thai schools for students with disabilities. This workshop helped participants discover various astronomical learning media and activities used internationally and inspire the development and dissemination of inclusive astronomical outreach materials in Thailand. As a legacy of the workshop, NARIT continues its national astronomical outreach for inclusion programmes and is preparing related projects, such as a catalogue of astronomical vocabulary in Thai Sign Language.

Introduction

The beauty of stars and the universe can be a powerful motivator to attract people into astronomy and inspire the new generation to pursue careers in science and technology. Therefore, it is paramount that opportunities to engage with astronomy are accessible to all.

The 'Report on the Situation of People with Disabilities in Thailand' (in Thai language) by Thai Ministry of Social Development and Human Security[1] states that the total number of people with disabilities in Thailand is 1 995 767, representing 3.01% of the Thai population, with the three largest groups being:

- People with mobility impairments: 986 583 people (49.43%)
- People with hearing impairments: 372 189 people (18.65%)
- People with visual impairments: 196 081 people (9.82%)

Astronomical outreach and teaching methodologies should be inclusive of people with hearing, visual, or mobility impairments (and those who are neurodiverse) and not only be limited to certain 'mainstream represented' groups alone. Science educators and outreach professionals must diversify their astronomy teaching and outreach skills in order to reach and accommodate the broader spectrum of universal needs of their students and audiences.

The National Astronomical Research Institute of Thailand (NARIT) is the main national astronomical organization in Thailand, offering a wide range of outreach and educational activities and resources in astronomy to provide nationwide support to astronomy outreach practitioners and formal educators.

As the IAU National Member and close partner in many international programmes, our NARIT outreach team has identified the need to become more inclusive in our practices in order to reach and accommodate a more diverse group of audiences. In the past few years, NARIT has taken its first actions to create inclusive outreach facilities for visiting school groups. Additionally, in Thailand many educators and outreach practitioners lack experience in teaching astronomy for these particular groups. For these reasons, NARIT has identified the need to establish a workshop in inclusive astronomy outreach in 2019. In collaboration with the International Astronomical Union (IAU) Office for Astronomy Outreach (OAO) and the National Astronomical Observatory of Japan (NAOJ), NARIT held the 'NARIT-IAU100 Inspiring Stars Workshop 2019'[2] in Thailand on 25-28 June 2019. The workshop aimed to introduce and inspire different groups of Thai people, especially those interested in inclusion, to apply astronomy to their work and, at the same time, support the outreach expansion of NARIT.

The Format of the Workshop

Inspiring Stars is an itinerant international exhibition of international inclusive resources in Astronomy, gathered by the IAU to promote inclusive astronomy[3]. The content of the Inspiring Stars exhibition

was used as a starting point to draft the content of the workshop and inform the sessions and topics presented.
The NARIT astronomy outreach centre considered the largest groups of people with disabilities[1] in Thailand and adapted premade international content from the Inspiring Stars exhibition for these groups in the Thai adaptation of the workshop.
The planning was also based on the target group of participants, 40 science communicators, astronomy outreach practitioners, and science teachers in specialized schools for students with disabilities across the country (in Thailand, the education school system currently assigns, in its vast majority, students with disabilities to attend specialized education schools).

The workshop was composed of five sessions:

Overview Session on Best Practices

The NARIT astronomy outreach centre selected the topic 'An Overview of Worldwide Best-practices in Astronomy for Inclusion for People with Visual and Hearing Impairments' as the first session of the workshop so the participants could have a general view of the best practices on astronomy for inclusion and how inclusive activities in astronomy are implemented and carried around the world.
The topics addressed included (1) characterising different types of impairments and the differences between them; (2) challenges and obstacles faced by each group in learning astronomy and (3) the importance of astronomy dissemination and outreach for inclusion.

Astronomy for People with Visual Impairments

People with visual impairments are one of the largest groups of people with disabilities in Thai society; thus, astronomical media and activities for this group are of great importance. This session introduced astronomical learning media, related software and hardware, and tactile learning media for people with visual impairments.

The activities presented included measuring solar energy by one's face and learning through tactile models of constellations. This session was presented by Beatriz Garcia (IAU National Outreach Coordinator (NOC) for Argentina) and the NARIT outreach staff:

1. Photometers and photometry in astronomy: determination of the sun's power for inclusion[4]
2. 'SonoUno': The sonification software for scientific data[5]
3. 'LightSound': the sonification device for eclipses[6]
4. Moon and Mars tactile models, from Spanish project 'A Touch of the Universe'[7]
5. The Subaru Telescope and ALMA radio telescope tactile models, from NAOJ[8]
6. DIY constellation tactile models using clay (by Suwanit Wutsang (NARIT)).

Astronomy for People with Hearing Impairments

The session consisted of educational activities for people with hearing impairments, introducing concepts of stellar magnitude and temperature by using LEDs of different colours (analogous to the colour of the stars and their surface temperatures) and sizes (larger LEDs representing brighter stars).
This session also included an introduction to astronomy vocabulary in various sign languages and designing astronomical words in Thai Sign Language (TSL), using the 'Hands in the Stars: The First International Comparative List of Astronomical Words in Sign Languages'[9]. Inspired by a lack of astronomical words in TSL and using a close collaboration between teachers of hearing-impaired students knowledgeable of Thai Sign Language, science communicators, and astronomy outreach practitioners who could verify the accuracy of the words created.

Astronomy Activity for Neurodiverse People

The activity in this session was focused on making planet keychains as an example of an astronomy activity for neurodiverse individuals. With the purpose of increasing the concentration span, during one to two hours participants coloured spherical wood models representing the planets using an image of the planet as a reference. This

***Figure 1. a**) A participant of the workshops makes a tactile constellation model using clay as a medium. **b)** A participant of the workshop paints a planet to be used on a keychain. **c)** A participant of the workshop during a session about designing astronomy-related words in Thai Sign Language (TSL). Credit: NARIT*

activity was designed by NARIT outreach staff member Suwanit Wutsang.

The Planetarium Show and Stargazing

This session was planned with the intent of supporting and improving NARIT's efforts to expand our planetarium programming to people with disabilities. The content of the session focused on identifying the necessary steps to adapt existing NARIT outreach programmes for students with disabilities to experience an accessible visit to the public NARIT facilities.
The NARIT outreach team first presented our regular outreach programmes (planetarium shows and stargazing activities) and NARIT's facilities for visitors to the workshop participants.
The participants, who included specialized education professionals, were encouraged to directly engage with planetarium and observatory staff and discuss how to adapt the outreach programmes to be more accessible and inclusive. As a result of this dialogue, for the planetarium show, although NARIT will not provide a sign language interpreter, NARIT will facilitate the incorporation of sign language interpretation for visiting groups of schools for hearing impairments and their interpreters and use tactile models for people with visual impairments. Stargazing activities may also include sign language interpretation, but inclusive stargazing sessions have proved to be technically impossible with the current technical capabilities.

Feedback and Lessons Learned

Hosting the 'NARIT-IAU100 Inspiring Stars Workshop 2019' brought helpful insights to the NARIT outreach staff on the path forward into becoming more inclusive in our outreach practices and resource production.

Challenges in Identifying Participants

Many members of the science communicators and astronomy outreach practitioners group were part of the NARIT staff or the staff from Thai science museums who were already part of the NARIT collaborative networks.
It was a difficult task for us, the organizers, to find specialized education professionals as NARIT did not have many contacts with specialized education schools or groups. Developing long-term relationships with specialized education schools (e.g., through visits by professional astronomers or astronomy outreach practitioners to the specialized education schools or school trips to NARIT public facilities) is essential in building relations with the community and from which to find more participants and encourage more educators to join these initiatives.

Establishing such networks is also paramount to receive direct feedback on the content production of inclusive resources and activities and have specialized education professionals to take part in the process of content creation.

Figure 2. *A demonstration of the LightSound device, an instrument that transforms light into sound for people with visual impairments can experience an eclipse. Credit: NARIT*

The Challenges in Adopting Complex International Resources to a Thai Audience

A large percentage of Thai specialized education teachers, science communicators, and astronomy outreach practitioners were of the opinion that there are difficulties in implementing Lightsound device and SonoUno software for (1) the lack of availability of the materials, and (2) its operational complexity of the sonification media by both visually impaired individuals and educators.

As a first experience in delving into astronomy inclusive resources, participants preferred learning media and activities that could be created by themselves (e.g. tactile models, tactile planispheres, and astronomy vocabulary in TSL).

The Challenge in Presenting Information to the Diverse Participants in the Workshop

There were two main participating groups: teachers from specialized education schools, who are versed in the media and learning of individuals with disabilities, and science communicators and astronomy outreach practitioners, who are skilled with the accuracy of astronomy information.
Some activities were straightforward and easy for both groups to understand (e.g., using and exploring tactile models or making planet keychains).

Notably, each group could 'fill the gap' with each other's skills when designing astronomical words in TSL. The specialized education teachers helped with the grammar and facilitated the understanding of people with hearing impairments. Science communicators and astronomy outreach practitioners checked the accuracy of the sign and the written definition. Each group was also able to correct misconceptions related to their respective specialities as well.

Figure 3. *School visits at the Princess Sirindhorn AstroPark in February 2020. a) NARIT planetarium show for hearing-impaired students with the collaboration of Thai Sign Language (TSL) interpreters from the school for hearing-impaired. b) Students with visual impairments visit the astronomical exhibition. Credit: NARIT*

Including Feedback from Specialized Education Professionals

By carrying out the workshop, research institutions with a strong component on outreach and education such as NARIT can learn directly from experts, such as specialized education teachers, on how to meet the necessary requirements to create inclusive programmes for differently abled students.

The exchange of ideas originated by the workshop can improve the future direction of the inclusive astronomy-related work of the NARIT outreach team, planetariums, observatories, educational tours, collaboration between astronomical institutes/organizations with schools/organizations for people with disabilities, etc.

The Legacy of the Workshop

Suggestions from teachers of visually impaired and hearing-impaired students have led to NARIT's next steps in inclusive outreach actions: the development of a planetarium show for visually impaired individuals and a standardized astronomical vocabulary in TSL.

Astronomy learning media in TSL has been created by many specialized education schools, but there are differences in astronomical words between schools due to a lack of a 'standardized scientific vocabulary'. Specialized education professionals suggested that as the leading national authority in astronomy, NARIT should determine the standard astronomy vocabulary in TSL.

The participating teachers brought their students to the Princess Sirindhorn AstroPark exhibition and planetarium a few months after the workshop. Because of these visits, NARIT plans to continue developing inclusive astronomical outreach activities, particularly for people who are vision and hearing impaired in 2021.

Notes

[1] 'The report on the situation of people with disabilities in Thailand, 1st April 2020' (in Thai language) by Thai Ministry of Social Development and Human Security (Page 1-2)

[2] First Inclusive Astronomy Workshop Held in Thailand News articles on the IAU100 website https://www.iau-100.org/inclusive-astronomy-workshop

[3] Inspiring Star Website https://sites.google.com/oao.iau.org/inspiringstars

[4] Photometers and photometry in astronomy: determination of the sun 's power for inclusion http://sac.csic.es/astrosecundaria/en/proyectos_con_unesco/la_potencia_del_sol_y_como_medirla/la_potencia_del_sol_y_como_medirla_en.pdf

[5] SonoUno http://sion.frm.utn.edu.ar/sonoUno/

[6] LightSound http://astrolab.fas.harvard.edu/LightSound-IAU100.html

[7] Touch of the universe (Moon and Mars tactile models) https://www.uv.es/astrokit/

[8] NAOJ Subaru Telescope Tactile Model https://prc.nao.ac.jp/3d/index_e.html

[9] The first international comparative list of astronomical words in sign languages https://www.iau.org/news/pressreleases/detail/iau1706/

Biographies

Pisit Nitiyanant is an experienced astronomical outreach officer in the centre of the astronomy outreach of NARIT in Chiang Mai, Northern Thailand since 2013. His main fields of interest are planetary geology, Far East cultural astronomy, and astronomy for inclusion.

Suparerk Karuehanon is the head of the astronomical public outreach, the centre of astronomy outreach of NARIT in Chiang Mai, Northern Thailand and working in NARIT since 2007. His main fields of interest are the interactive astronomical exhibitions and planetarium control system development for NARIT facilities for the public.

Suwanit Wutsang is an experienced astronomical outreach officer in the Regional Observatory for the Public, Chachoengsao of NARIT in central Thailand, raising awareness and research on astronomy in NARIT since 2007. His main fields of interest are astronomy, astrophysics, cosmology, telescope development, and astronomy for inclusion.

Wichan Insiri is working at NARIT as a Director of Foreign Affairs. He specializes in international collaborations under different frameworks. His main duties include OAD and OAO coordination, where he serves as a national representative. He is also involved with NARIT's International Training Centre in Astronomy under the auspices of UNESCO (ITCA) as an oversight committee member.

Communicating Dark Sky in Iran: Heritage of the Sky Project Achievements and Challenges

Column

Saeed Jafari
Department of Science Communication, Saros Science Popularization Team
sjafari@saros.ir

Amirreza Kamkar
Digikala Mag, Science Section
akamkar@skyheritage.com

Mehrsa Latani
Saros Science Popularization Team
mlatani@saros.ir

Atabak Akson
Faculty of Entrepreneurship, University of Tehran
aakson@saros.ir

Mahdi Abdollahi
Saros Science Popularization Team
abdollahi.m94@gmail.com

Hamed Parsaeyan
Saros Astronomical E-Magazine
h.parsaeyan@astronomyonline.ir

S.M. Hossein Khalili
Under Iran Sky Project
hkhalili@astro4edu.ir

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The IAU100 Special Project "Heritage of the Sky" sought to link night sky conservation and national heritage by inviting professional and amateur photographers to submit their astrophotos capturing natural, cultural and historical heritage. The contest provided a notable graphic collection of resources of the natural, historical and intangible heritage and allowed nightscape photography with official permission in all Iranian heritage sites. People in different locations, from different gender and cultural backgrounds submitted over 200 photos with informative storytelling from relevant sites. The award ceremony brought together astrophotographers, amateur astronomers and the tourism community to discuss how to empower the public with the tools and resources to help bring back the night sky.

Introduction

"Heritage of the Sky" is a project to raise public awareness of the beauty of dark skies, the impact of light pollution and make historical and natural heritage accessible through social media campaigns, citizen science and education and outreach projects. Our mission is to promote and safeguard natural, cultural, and historical astronomy and national heritage sites, including education, outreach and development through international cooperation in an online portal.

The sky is our common and universal heritage, and is an integral part of the surrounding environment perceived by humankind. This heritage is important for the recognition and safeguarding of cultural properties and of cultural or natural landscapes that transcribe the relationship between people and the sky[1].

"Over the Plateau of Iran" Photo Contest (Figure 1) was a highlight of the "Heritage of the Sky" project within the framework of the IAU100[2]. The contest was open to anyone of any age, from any natural, cultural, and historical astronomy heritage locations in Iran, and to both professional and amateur photographers anywhere in the world. Participants were required to take photos of astronomical and historical monuments or nightscape photography from dark sky national parks and to provide a detailed explanation — storytelling of the site — alongside each photo[3].

"Over the Plateau of Iran" is a biennial contest and aims to identify, protect and preserve historical, natural and cultural resources and to represent the importance of the dark sky.

Under Iran Dark Sky: the Potential for Astrotourism Development

With its vast and pristine natural attractions, Iran has a great potential for the development of astronomical tourism in the Middle East, with a significant number of natural and historical heritage located at the heart of these landscapes.
Currently, the majority of Iran's population lives in metropolitan areas, and the uncontrolled expansion of urban areas has led to the unrestricted growth of housing

Figure 1. *The official poster of the Over the Plateau of Iran Night Sky Photo Contest. Credit: Saros Team/ Mahdi Abdollahi*

and commercial development areas. Furthermore, this has led to an increase in light pollution in some metropolises and its suburbs.

Meanwhile, Iran has a variety of national parks and protected areas which many of them are located in dark skies places.
Some of the Iranian national parks, like Khar Turan, are great potential places for the country's first international dark-sky park. It can be a wonderful attraction for astro-tourists who can also enjoy wildlife safari at the national park, explore the culture and life of the local people in the villages and see desert landscapes.

The existence of Lut desert and Dasht-e Kavir at the central and south-eastern parts of Iran have made it the perfect and darkest place for observing the dark sky. Nevertheless, non-standard lights around these areas and cities are threatening the clear skies of these unspoiled nature regions.

"Over the Plateau of Iran" Photo Contest: Design and Implementation

The contest aimed to raise awareness about the night sky as the reflection of our distant past and a brief look at our forebears' heritage. Saros Team, the project organisers[4,5], writes: *"The moment you look at the night sky, remember that you are looking at the past. The concept of 'past' has become the subject to cling to for the rest of our study; We knew that a society which is a stranger to its past was forced to repeat it. We realized that a nation without a past did not have the data to analyse its future. Therefore, we have woven the subject of sky into the threads that have been inherited for us from the past. We are responsible for the past; in regards to knowing it, to make it known to others, and to keep it for future generations."*

Concept Design

The idea behind the logo of "Heritage of the Sky" (Figure 2) was taken from three concepts: "Identity", "Nature" (the Damavand Peak in particular) and "Star Trails in the Night Sky". These three concepts contain the core message of the "Heritage of the Sky" project: our identity, drawn from the legacy of our ancestors' life on Earth and that still remains, to this day, from a long distant past; our surroundings and the distant night sky lights, which are also a way to look back in time at our very origins.

Implementation

The "Over the Plateau of Iran" photo contest was designed and implemented around three main categories: "Night Sky and Natural Heritage", "Night Sky and Historical Heritage", and "Night Sky and Intangible Heritage", with a sub-category on "Photo Narrative". Additionally, all submissions should include, in addition to the night sky, a national historical and natural heritage in the photographed image.

Due to restrictions related to the protection of historical and natural sites, night sky photographers, both men and women, but especially young women, find it difficult to access these sites for nightscape photography. We collaborated with the Research Institute of Cultural Heritage and Tourism to acquire permission for nighttime access for photographers to all world heritage sites in Iran[6]. This allowed men and, in particular, women and young women (18 to 35 years old) to be able to stay on heritage sites after dark.

"Over the Plateau of Iran" photo contest received a total of 177 qualified works, with 95 photos under "Night Sky and Historical Heritage" category, 71 photos under "Night Sky and Natural Heritage" category and 11 photos under "Night Sky and Intangible Heritage".
Most of the images were from diverse geographical areas (Figure 3), where some of the photographers spent days planning their trips. The presented works included sites that date back to ancient Iranian civilisation and that are symbols of its history and culture.

Figure 2. *Mount Damavand, the tallest mountain in Iran, was used as a symbol of Iran's natural heritage in the logo, official poster and the general visual identity of the Heritage in the Sky contest. Credit: Saros Team/Mahdi Abdollahi*

Panel of Jurors

The submitted works were judged in three categories according to the theme of the contest: natural, cultural and historical heritage. The panel of jurors consisted of twelve national and international experts in the field of photography, astrophotography and literature. The literary experts, some of the most well-known Iranian writers in the fields of tourism, fiction and literature, assessed the photo-narratives, providing considerations on the connection between the national heritage and the night sky captured in the photo.

Dissemination and Reach

A total of 84 images were posted on Instagram, with an average reach of 820 people and an average of 520 individuals visiting each post from different locations. Over a four-month social media campaign, more than 700 followers followed the project's Instagram[7] page. With a demographics of 66% male and 34% female and with 56% between 25 to 34 years of age.

The final announcement and report of the project was announced and presented on Channel Four of the Iranian state television and published in national popular science and tourism magazines and well-known national newspapers. One of the awarded photos featured the cover image of the IAU 100th Anniversary Celebrations Final Report[8].

The final statistics drawn from public impressions and engagement in different media and from contest reports in the media identified a reach of more than 90 000[9,10].

Collaborating with science writers, journalists, and graphic designers, we shared a series of supplementary content

Figure 3. *a) Award winners' photos were taken from different locations by people of different genders and cultures. b) All winning and highly commended photographs were displayed at the Heritage of the Sky exhibition, which in 2019 took place at the National Museum of Iran. Credit: Heritage of the Sky Project*

from the National Heritage Sites of Iran with photographers and the public. The online availability of content and the large feedback received from various media outlets has been remarkable. Producing multimedia content about the dark sky and the effects of light pollution, and disseminating it consistently through online educational campaigns over a long period of time had a crucial impact in informing the public about the importance of preserving the night sky.

Awards Ceremony and "Heritage of the Sky" Exhibition

The award ceremony took place in Tehran[11], gathering over 250 participants and was composed of some internationally renowned Iranian night sky photographers, internationally acclaimed by their work in astrophotography.

The winners of the 1st, 2nd and 3rd place, were awarded with monetary prizes and statues depicting the actual topography of Damavand Summit and the surrounding area. The statues were designed by Iranian graphist Mahdi Abdollahi.

The awarded and highly commended photos were also invited to participate in a week-long exhibition (Figure 3) showcased during the award ceremony hosted in Tehran, at the Islamic Era Museum of Iran. The images were also published in well known printed and online media.

Challenges of the Night Sky Awareness and Equality in Iran

About 60% of Iran's amateur astronomers are female on average *(Tafreshi, 2011)*, but they play a small role in promoting astronomy due to the prevailing social conditions in Iran. The traditional attitudes about the status and role of women are among the many obstacles that stand in the way of women and girls fully exercising their right to participate in, complete and benefit from education[12]. Due to these difficult conditions for girls to visit natural and historical sites, most of which are dark, out of town and difficult to reach, they cannot easily photograph such places at night[13]. Subsequently, in this contest, girls submitted the fewest number of photos.

Future Plans

Given the feedback received during the contest and discussions with amateur astronomers and night sky photographers, as well as specialists and activists in the field of tourism and the environment, we are designing and implementing future programmes that take existing challenges and opportunities into account.

The long-term plans for the project include a comprehensive online portal with an interactive map of the dark sky and Iran's national heritage; and multimedia educational resources on dark sky preservation and national heritage value for students, teachers, night sky event organisers and the general public[14]. In addition, and with the collaboration of enthusiastic photographers from diverse provinces of Iran, the next edition of the contest will also run training workshops for night sky photography alongside a photo exhibition with photos from previous editions, under the theme of light pollution, dark skies and astronomical heritage.
This approach helps make quality astronomy education inclusive and equitable and peaceful interaction with nature awareness accessible to those interested, especially young girls.

Conclusion: Challenges Are Still Ahead

We are trying to expand the "Heritage of the Sky" into a "project without borders". When we talk about Humanity's common past, and try to raise awareness to both the UNESCO's world heritage sites and the night sky, we are, in fact, taking steps towards connecting to our ancestors and learning of our common celestial origins[15].

We strive to create diverse and targeted programmes in line with the sustainable development goals, including holding a

series of exhibitions on national heritage and night sky to showcase the rich and significant aspects of culture and heritage of the Earth.

Moreover, a newer and larger version of night sky photography contest will be presented and also world-class online media education campaigns will be offered. In these programmes, we will use the support of the IAU Office for Astronomy Outreach, the International Dark-Sky Association, and UNESCO's Astronomy and World Heritage Initiative to engage the majority of people from different geographies and cultures.

The most important challenge is creating a project that uses the dark sky to unify various astronomical organisations and amateur astronomy associations across the country, and use the meaning of this natural resource to promote collaboration between these groups of diverse geographic and cultural heritages. A network that can carry out more effective activities to preserve national heritage conservation and light pollution control with the capacity and expertise it possesses[15].

Notes

[1] More information on Astronomy and World Heritage Thematic Initiative: http://whc.unesco.org/en/astronomy/#portal

[2] Webpage of the project on the IAU100 website: https://www.iau-100.org/heritage-sky

[3] You can see this initiative on http://skyheritage.com/ and see the photos of the event on Flickr: https://www.flickr.com/photos/186589181@N02/albums

[4] Saros Science Popularization Team social media: @SarosTeam

[5] Saros Science Popularization Team has entered its eighth year of science communication and astronomy for education and outreach in Iran. During this period, Saros has been working to increase the quality of education through organising science communication projects and actions throughout the country, and has been combining astronomy with communication and art to bring the scientific message to different publics.

[6] List of World Heritage Sites in Iran: https://en.wikipedia.org/wiki/List_of_World_Heritage_Sites_in_Iran

[7] Heritage of the Sky Project Instagram: https://www.instagram.com/skyheritageproject/

[8] IAU 100th Anniversary Celebrations Final Report: https://iau.org/news/announcements/detail/ann20019/

[9] Heritage of the Sky Project Facebook: https://www.facebook.com/SkyHeritageProject/

[10] Heritage of the Sky Project Twitter: https://twitter.com/SkyHeritage

[11] All videos of the speakers in the award ceremony event are available on YouTube: https://www.youtube.com/channel/UCFQnmLKQ2ZpFWQYKpusiH0g

[12] UNESCO webpage on education and gender equality: https://en.unesco.org/themes/education-and-gender-equality

[13] Sepideh documentary is about a girl who dreams of being an astronaut, but at her age the nightly stargazing excursions into the desert are a dangerous thorn in the side of family and traditions.

[14] The website is in Farsi and we have been working on the English version. It will be available to the public with a complete listing of national astronomical monuments and dark skies sites of which there is no current enough information or resources available.

[15] Online UNESCO–IAU Portal to the Heritage of Astronomy website: https://www3.astronomicalheritage.net/

[16] All our attempts are to preserve the knowledge and experience of our ancestors, which are being forgotten, as intangible heritage and as a kind of collection and revival for future generations.

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Tafreshi, 2011. "Popularising astronomy in Iran", Proceedings of the International Astronomical Union, pp. 754-757

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Biographies

Saeed Jafari is a science communicator and a science journalist. He has completed his studies in linguistics at the University of Kurdistan. He serves as Director of Intl. and Science Communication in the Saros Science Popularization Team. For more than nine years, Saeed has led astronomy communication, outreach and education for many organisations and institutions, and currently researches public understanding of science in media, technology and society.

Amirreza Kamkar is a freelance night sky photographer and science journalist. His nightscape images have been published in some of the most well-known and respected popular science magazines, such as Discover, Sky & Telescope, Astronomy, Astronomy Now and Sky at Night.

Mehrsa Latani is keen on trying different things. She works as an electronic technician. While at university she was a volunteer teacher at a charity and an editorial board member of a university magazine. She leads advertising and public relations for the Saros Science Popularization Team.

Atabak Akson is the Managing Director of the Saros Science Popularization Team, where he is responsible for event management and coordinating education and outreach projects. He received a master's degree in entrepreneurship from the University of Tehran and currently is a community builder at the Zavie Coworking Space in Tehran.

Mahdi Abdollahi is Head of Graphic Design in the Saros Science Popularization Team and has designed the visual identity and fantastic posters for many projects and events. He has been working as a 3D animator.

Hamed Parsaeyan is a materials engineer and an amateur astronomer. He completed a master's degree in materials engineering from Tarbiat Modares University and is currently the social media manager of the Heritage of the Sky project. He was also a member of the Saros E-Magazine editorial board.

Hossein Khalili is an astronomy communicator and a science journalist. He graduated in physics and nuclear engineering. Hossein is a co-founder of the Under Iran Sky project, an open online astronomy education platform in Iran, and also the developer of several innovative projects that aim to involve the general public in active astronomy communication.

Dark Skies For All Project in Ireland

Column

Rob O' Sullivan
CIT Blackrock Castle Observatory
rob.osullivan@bco.ie

Niall Smith
CIT Blackrock Castle Observatory
niall.smith@cit.ie

Clair McSweeney
CIT Blackrock Castle Observatory
clair.mcsweeney@bco.ie

Keywords
dark skies, light pollution, Ireland

Dark Skies for All was a flagship programme of the IAU100 to raise awareness of dark skies as a vital element of cultural and natural heritage. Furthermore, it advocated the preservation of dark skies by demonstrating the alignment between this goal and those of decision-makers focused on energy conservation and environmental protection. These goals were achieved through strategic meetings with stakeholders and policymakers, as well as campaigns advocating a transition to eco-friendly lighting. Some of the key successes included two major symposia, such as "The European Symposium for the Protection of the Night Sky"; successful lobbying of the Road Management Office to remove high temp LEDs from nationwide plans; and the facilitation of an application for International Dark-Sky Association recognition from an island community. In addition, outreach activities also measurably improved public awareness. It is clear the approach of aligning Dark Sky objectives with those of environmental protection and energy conservation is effective.

Introduction

Ireland hosts some of the most pristine dark skies in the Northern Hemisphere. The relative lack of heavy urban development on the west coast and midlands, coupled with the Atlantic Ocean to the west means that sizable portions of the island are subject to relatively low levels of light pollution.

Ireland is home to two internationally recognised dark sky locales: Kerry International Dark Sky Reserve and Mayo Dark Sky Park. Both have been awarded a gold tier for the quality of their night skies, which are free from light pollution and important assets of natural night sky heritage (Figure 1).

However, despite this natural resource, due to heavy concentrations of population in urban areas such as Dublin, nearly 50% of Irish people live in areas where they cannot see the glow of the Milky Way, and only 5% of Irish skies can be classed as pristine[1].

The night skies are an asset to Ireland, both as a natural and cultural resource for citizens, but also as a potential source of revenue through astrotourism.

The Dark Skies For All project was undertaken with the mission of advancing awareness of this asset, to protect it, and to improve access to it for people throughout the island of Ireland.

Dark Sky Ireland

In October 2018, Dark Sky Ireland (DSI)[2] was formed as a national and cross-border partnership of stakeholders, a group consisting of academics, park representatives, astronomy clubs, and special interest groups, from across the island of Ireland. Their common goal is to raise awareness of light pollution in Ireland and promote the use of responsible lighting through education and development of a national policy and strategy in the absence of appropriate legislation (Figure 2).

Figure 1. *Aurora over Ballycroy National Park in Ireland. Credit: Stephen Hanley.*

Figure 2. *Beacons of light over Valentia Island in Kerry International Dark Sky Reserve in Ireland. Credit: Ian Carruthers Photography.*

The Programme

Spearheaded by CIT Blackrock Castle Observatory (BCO)[3] in 2019, The Dark Skies For All project was funded under an IAU100 celebrations special call (Figure 3). The DSI network continues to deliver its programme into 2020 and beyond. The programme is multifaceted, with policy development, education and public outreach elements.

For maximum impact, DSI partners organised a number of high impact events while also training and facilitating others to deliver events of their own to expand reach.

The DSI website continues to serve as a central hub for resources on light pollution in an Irish context, including documents pertaining to policy and best practices[4].

Key Events in Ireland

Earth Hour

While dark sky activities were undertaken throughout the year, Earth Hour[5] served as an excellent promotional tool from which to launch a six-week programme of dark sky events which incorporated Dark Sky Week. Launched by the Lord Mayor of Cork at CIT BCO, the event received media attention and helped bolster conversations with policymakers about environmentally-conscious initiatives that would tangentially lead to dark sky gains.

EcCoWell Symposium

Held at Cork County Hall, the EcCoWell symposium "Bright Planning For The Urban Environment – The Dark Side Of Illumination"[6] was a very significant event for the 2019 activities. It brought together key stakeholders from across the community, from architects, policymakers, and special interest groups, to concerned and informed citizens, within Ireland (Figure 4).

Expert speakers from a number of disciplines, including ecology, environment and astronomy, were invited to speak before breakout groups were formed to discuss innovative approaches to issues pertaining to light pollution including environmental, economic, education, social, health, and art and culture.

14th European Symposium for the Protection of the Night Sky

This symposium about dark skies protection across Europe was held in Mulranny, County Mayo, from 3-5 November 2019. It featured speakers[7] from over a dozen countries, and had over 100 attendees, half of whom were overseas visitors. A wide array of subjects were covered, including ecology, astrotourism, cultural heritage and policy.

Evaluation of the experience overwhelmingly reported a field trip to the Mayo Dark Sky Park as the highlight of the symposium for visiting attendees. Speaking further on evaluation and feedback from the symposium, Georgia MacMillan of Mayo Dark Sky Park reports, *"The biggest outcome for legacy is to keep the event going and to highlight environmental issues more in policy documents".*

The symposium directly followed the annual Dark Sky Festival celebrating Mayo's Dark Sky park. The festival saw record numbers in 2019, bringing over 400 people to the rural community.

Cape Clear Island, Ireland

DSI supported an island community in their bid to become internationally recognised by the International Dark Sky Association by assisting them in operating their first dark sky event in late May 2019. The remote island is already benefiting from its pristine conditions through ecotourism centred around whale watching and bird watching, and as such the local community has already seen that treating an unspoiled landscape as a natural resource can benefit the community if carefully managed and maintained.

Road Management Office

A vital victory during a busy year was the successful lobbying of the national Road Management Office, to amend plans to install high temperature LEDs on roads across nationwide. Professor Brian Espey of Trinity College Dublin was particularly instrumental in this victory, as his scientific expertise in the area of light pollution and

Dark Sky Ireland

IAU 100 Years: Under One Sky

BLACKROCK CASTLE OBSERVATORY The Space For Science

Figure 3. *Dark Sky Ireland, IAU100 and Blackrock Castle Observatory logos.*

Figure 4. *Dark Sky Ireland partners and special guests at the EcCoWell symposium on light pollution. Credit: Rob O' Sullivan.*

his written guidelines led to government departments contacting the Road Management Office in 2019 to enable DSI's increased access to steer consultation for best lighting practices[8].

The Road Management Office removed high temperature LEDs from all specifications (bar some necessary exceptions). Efforts continue to identify and engage with stakeholders in positions to affect large-scale changes in Ireland's light pollution footprint (Figure 5).

Education Initiatives

CIT BCO has an education remit, reaching thousands of students and teachers every year. Throughout 2019 a special emphasis was given to the development and delivery of educational workshops that explore light pollution and potential solutions to it. The light pollution workshops continue to be one of the BCO Education Team's most popular offerings.

To build capacity, teachers and Continuous Professional Development Facilitators throughout the country were trained on how to deliver these workshops in their own classroom. External evaluation of these sessions by Eric Jensen of the Institute for Methods Innovation was overwhelmingly positive, and it was particularly encouraging that many participants had a strong working knowledge of light pollution prior to the training.

Outreach Initiatives

Artistic projects played a key role in public outreach efforts. One such project, Starman, was borne out of an artistic collaboration between CIT BCO, renowned Irish musician Jack Lukeman and a number of students from around the country. The project culminated in a cover version of David Bowie's "Starman" including a high production video featuring footage from dark sky locations throughout Ireland. This STEAM initiative served as an excellent showcase for these unspoiled landscapes, and as a sort of informal "anthem" for dark sky advocacy throughout the year, including at high-reach events such as the Dublin Bowie Festival.

Another artistic exhibit of note was the visiting *Chasseur de Nuit* which was shown at venues throughout the country[9]. *Chasseur de Nuit* is a series of tactile demonstrations of constellations that allow people with blindness and vision impairments to grasp the night sky without the need to see it.

Conclusions

Evaluations and feedback across events saw a number of recurring themes. Most prominently, while appreciation for dark

Figure 5. *The Milky Way as seen from Mayo Dark Sky Park. Credit: Stephen Hanley.*

skies is generally easy to garner, the sentiment towards mitigation measures can be less enthusiastic when considered purely for their own sake. For instance, perceived safety as a result of more illumination can understandably be weighted more heavily than the ability to appreciate the night sky. However, conversations around tangential goals were easier to broach and, in many cases, proved more convincing. Mitigating light pollution to improve safety for drivers, to conserve electricity and to potentially help human health was an incredibly effective means of communicating the collective goal.

It was also found that participants were generally receptive to evidence-based challenges to their preconceived notions. Again, looking at the perception that increased illumination improves visibility of potential threats at night, participants were often convinced that the reality is more complex when you consider issues such as glare, intensifi cation of shadows and reduced night vision due to pupil constriction.

It is fortunate that the goals of Dark Skies For All supports the objectives of the Irish Government's Project Ireland 2040 plan[10] which has, as a key pillar, the support of rural populations and their natural and cultural heritage. Such serendipitous alignment of goals makes the task of garnering support considerably easier. We would encourage those pursuing avenues to promote and conserve dark skies to identify, and work with, special interest groups with closely aligned objectives as darker skies can be achieved as a side effect of those efforts rather than being an explicit goal in and of itself.

Notes

[1] Irish Times. "Only 5 per cent of Ireland's night skies are free from artifi cial light, says expert": https://bit.ly/2B13EFW

[2] Dark Sky Ireland website: https://www.darksky.ie/

[3] CIT Blackrock Castle Observatory website: https://www.bco.ie/

[4] Dark Sky Ireland Policy Documents: https://www.darksky.ie/policy/

[5] Earth Hour website: https://www.earthhour.org/

[6] Symposium event listing and schedule of speakers: https://www.darksky.ie/bright-planning-for-the-urban-environment-the-dark-side-of-illumination/

[7] 14th European Symposium for the Protection of the Night Sky programme: https://www.mayodarkskyfestival.ie/symposium-programme

[8] Espey, Brian. "Public Lighting Recommendations." (2020). http://www.tara.tcd.ie/bitstream/handle/2262/91582/Lighting_guidelines_13Feb2020.pdf?sequence=1

[9] *Chasseurs de Nuit* website: https://www.chasseursdenuits.eu/

[10] Project Ireland 2040 plan website: http://npf.ie/

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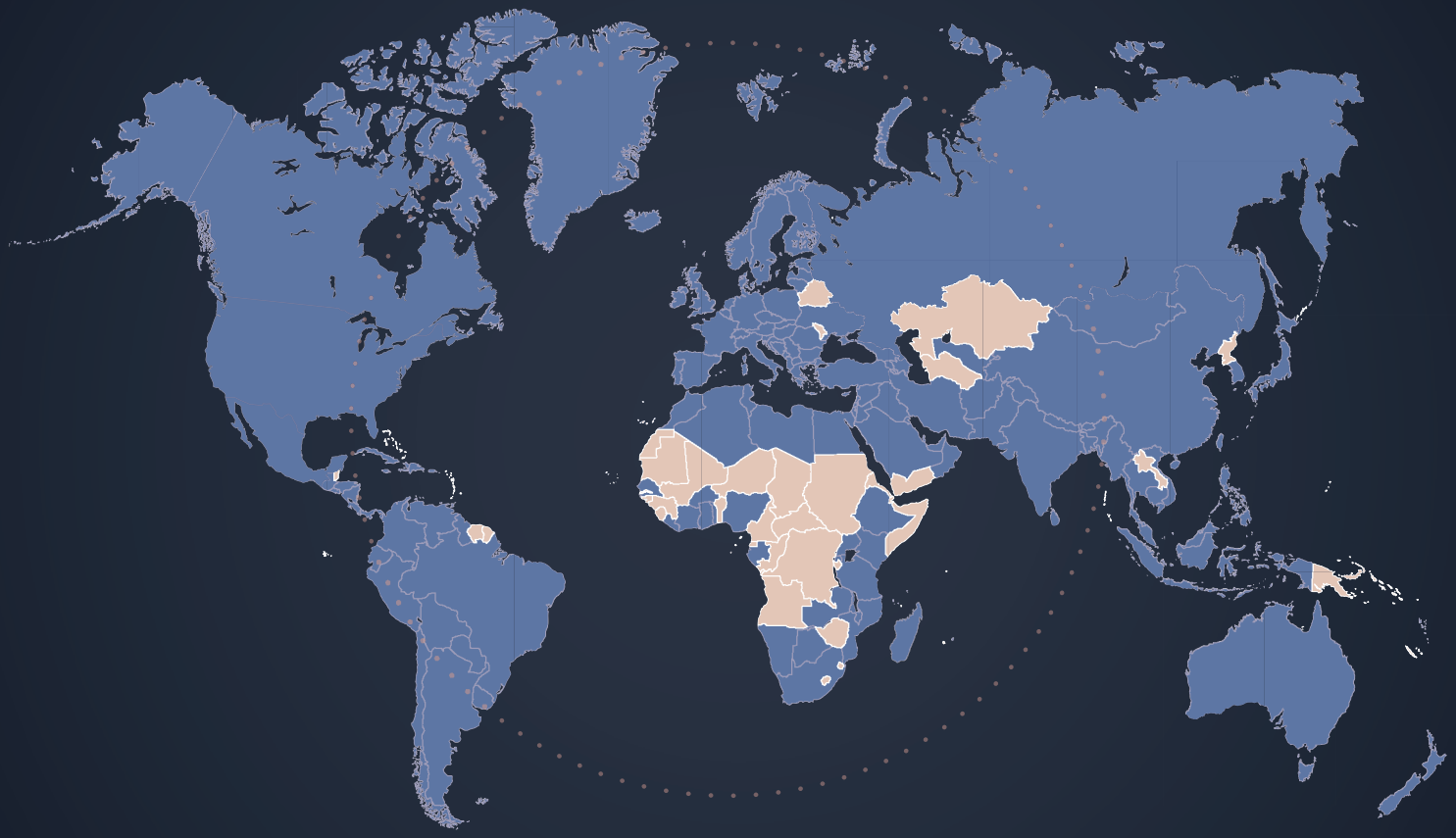
Biographies

Rob O' Sullivan is the Communications Officer at CIT Blackrock Castle Observatory and Science Centre (BCO). He brings a background in science communication to dark sky advocacy on behalf of the observatory team.

Clair McSweeney is the Centre Manager at CIT Blackrock Castle Observatory and Science Centre (BCO). She has extensive experience in advocating for dark skies in Ireland and further abroad.

Niall Smith is the Head of The Observatory at CIT Blackrock Castle Observatory and Science Centre (BCO). He is part of a dedicated team at BCO and helps them realise their vision to use astronomy and space for societal and economic benefit.

Activities registered in



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countries/regions

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