Integrating and strengthening the European Research Area

ERA-NET

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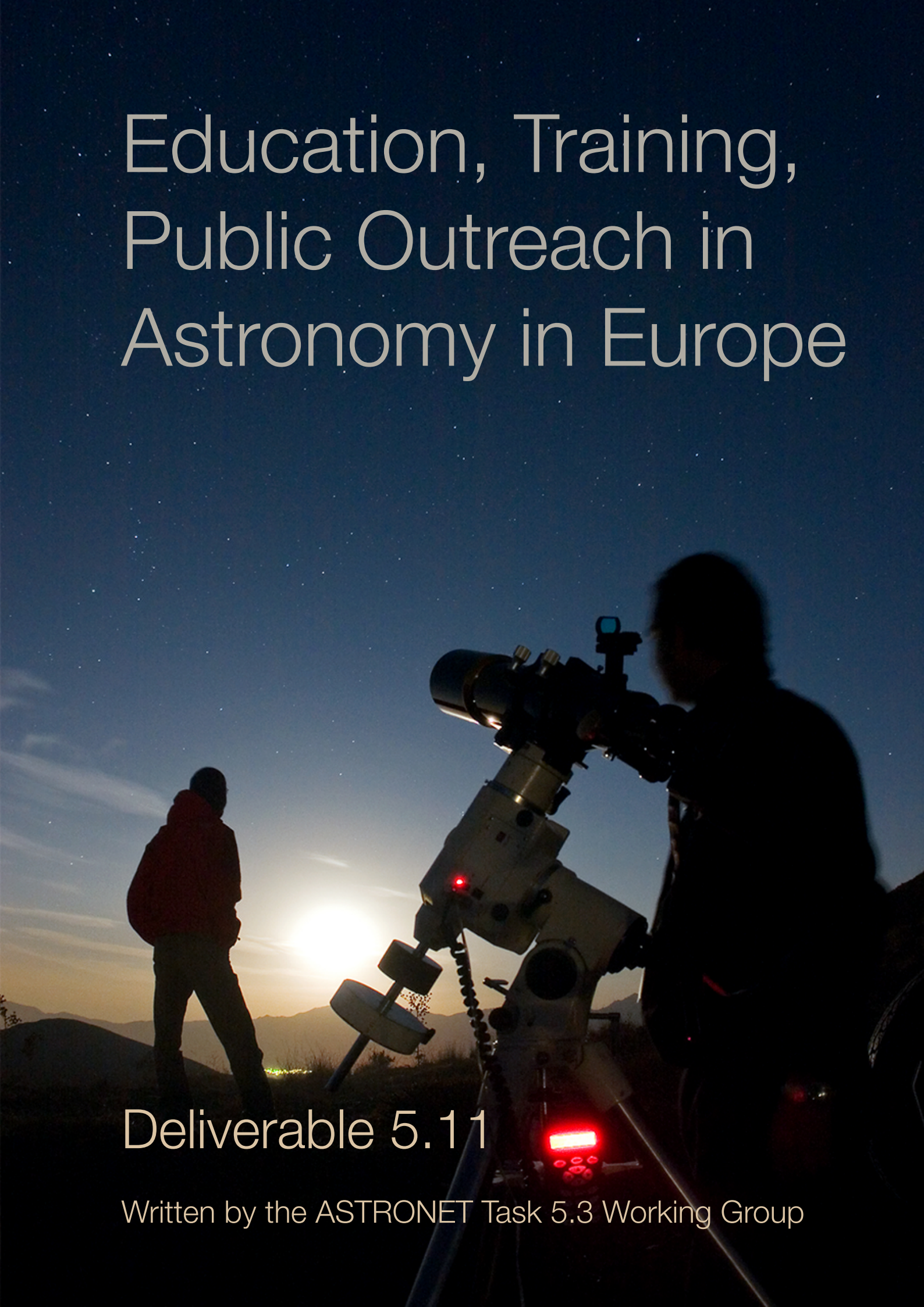
Education, Training, Public Outreach in Astronomy in Europe



Deliverable 5.11

Written by the ASTRONET Task 5.3 Working Group

Colophon

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People involved in Education and Public Outreach (EPO) engage the public and students in astronomy. Credit: ESO.

Foreword

This report is the Deliverable 5.11 presented by the ASTRONET Task 5.3 Working Group (WG) (for the WG composition please see Appendix 1). The WG went to considerable lengths (see Appendix 2) to investigate the landscape of Education and Public Outreach (EPO), Technology Transfer (TT) and Training in Europe. Two successful Workshops were held in 2013 and 2014 (see Appendices 3 and 4). These were respectively led by Markus Pössel (Haus der Astronomie), and Enikő Patkós (ESO), and we are very thankful for their major contributions. We are also grateful for the inputs and inspiration from the community and several individuals. A special thanks goes to Oana Sandu and Chris Marshall (both ESO) in this respect.

A star party. Credit: A. Dyer/IYA2009.

Introduction

ASTRONET was created by a group of European funding agencies in order to establish a permanent mechanism for strategic planning and coordination in European astronomy. It covers the whole astronomical domain, from the Sun and Solar System to the limits of the observable Universe, and from radio astronomy to gamma-rays and particles, on the ground as well as in space. In addition, theory and computing are important topics, as well as education, recruitment and training, public outreach, and industrial links. The latter five topics are the ones covered by ASTRONET Work Package 5.3, and are the topics of this report.

Since the original ASTRONET Roadmap was published in 2008, the area of education and public outreach has changed dramatically. This was also reflected in the 2014 revision of the Roadmap. As predicted, the International Year of Astronomy 2009 (IYA2009) provided enormous opportunities for the community. IYA2009 involved 148 countries and reached more than 800 million people. Star parties, public talks, exhibits, school programmes, books, citizen-scientist programmes, science-arts events, astronomy documentaries and parades honouring astronomy. Its achievements made IYA2009 arguably the largest science event in human history. IYA2009 positively changed astronomy education and public outreach in Europe. The community became more organised and more connected, enabling pan-European collaborations and projects. The collaborative spirit laid out in the Panel E Chapter of the original ASTRONET Roadmap was one of many important inspirations for the IYA2009 project. In a sense the same problems we are facing in the astronomy EPO area in Europe, had to be

solved on a global scale in IYA2009: collaborating on solving similar problems regardless of nationality, culture of language.

Since 2008 the media landscape has also changed dramatically, mainly in the form of a broadening of the available communication vehicles. Social media networks like Facebook, Twitter, Google plus, Instagram and their likes are proliferating (and in fact change so rapidly that any attempt of documenting them outdates almost as fast as the words are written). There has also been a notable shift in the profile of the information gatekeepers: from a select group of scientists, authors, journalists and editors to the new curators of knowledge: the crowd. Social media tools have grown from obscurity to near ubiquity with incredible rapidity, and the social media are the favoured knowledge-sharing tools among these new information gatekeepers.

In terms of technology in the new communication landscape, there has been a shift both upwards — to high-bandwidth video channels — and downwards — to lower bandwidth mobile devices like smartphones and tablets (with rapidly increasing bandwidth for mobile applications, as well).

As mentioned, every area of outreach — from teacher training to citizen science, content development for science centres and museums, and online resources — often work *locally* on solving the similar problems: how to communicate complex topics, how to visualise abstract concepts and how to demonstrate the usefulness of seemingly distant and irrelevant science. And often the answer to those issues have been worked out be people in different countries, speaking a different language. In other words, the EPO activities are mostly fragmented, and although many different initiatives exist at a local level, which have the benefit of addressing language issues and cultural boundaries, they are limited when considered for wider dissemination.

Astronomy, as a science, transcends boundaries, but in all too many cases, activities and best practices for astronomy EPO, currently do not. The IYA2009 and subsequent development have shown us not only the great potential of collaboration in astronomy EPO, but also that *the difficulty of fragmentation need to be overcome if we are to realise our full potential.*

The first challenge, all too familiar in a European context, is that of different languages. Where scientists — and also astronomy communicators amongst themselves — have long grown accustomed to communicating in English, education and outreach activities have lost a significant portion of their impact unless they take place in the target audience's own language. Europe's transnational astronomy-related institutions have addressed this problem in different ways — examples include the ESA Country Desks, the ESA European Space Education Resource Office network (ESERO), or the ESO Science Outreach Network (ESON); the latter translates material such as press releases into the majority of languages spoken in the EU Member States. It is, however, worth noting that each solution is meant to address the needs of a given agency only, not the larger, Europe-wide problem.

If one could get an overview of the many European astronomy EPO resources available, one would reach a staggering number. Unfortunately, it is very hard to get the overview of the

existing resources, although a start is presented on p.23 in the section *The landscape of astronomy outreach in Europe*. Also, most of these resources are not available in different languages or cultural adaptations. Some efforts have been made to bridge this gap. The ESO Science Outreach Network translates and adapts news items, documents, brochures, educational material and presentations, specifically to promote and disseminate astronomy. ESA and Universe Awareness (UNAWE) are using their own networks to translate their own resources. ESO, ESA and UNAWE are setting an example to follow in the future.

In the education sector, there is another challenge in the form of different curricula at a national — and, in the case of federal states, even at a sub-national — level. For certain resources (e.g. exercises tailored to a specific curriculum), this requires further adaptation before anything even approaching EU-wide utilization is possible.

There are different levels at which to meet these challenges. Obviously there is a need to continue the “classical” EPO work, but in order to meet the European challenges, more ambitious thinking is needed. One strategy is the creation of Europe-wide “light house” projects, to provide a framework for both content and activity development based on a common standard, and to address adaptation and dissemination needs, for one particular subset of astronomy EPO. The arguably most successful Europe-led initiative in this regard is the UNAWE educational programme, which uses the beauty and grandeur of the Universe to inspire young children aged 4–10 years old and to encourage them to develop an interest in science and technology. Built on the success of IYA2009, UNAWE received a large grant under the EU Framework Programme 7 which enabled the project to support the implementation of some of the Panel E recommendations (1, 2 and 4).

Another even more innovative strategy would be to lift the work out of the domain of individual projects and create “expert service structures”. These would support the numerous individual projects taking place on a local level, with translation, adaptation, audiovisual productions and dissemination, enabling such local projects to have a Europe-wide impact. Examples of programmes that fit part of the profile for these services include Scientix, the Open Discovery Space, and the R&D STEM Learning Exchange Resource Repository.

Educators creating mnemonics for their students. Credit: UNAWE.

Both in the case of light house projects and service structures, long-term funding is vital. UNAWE and its successor EU Universe Awareness (EU-UNAWE), for instance, has now had to close down a hugely successful operation, delivering a blow to already operational and well-functioning projects (cf. workshop 1 recommendation in Appendix 3). Service projects — particularly repositories — need long-term support to gain the long-term acceptance in the target community needed to achieve the desired wide reach.

Other changes have taken place. The demographics of the target groups have — for natural reasons — changed over time. The so-called millennials (or generation Y) are now an important target. They are accustomed to demanding co-ownership of the communication and the process. And they want to be involved on their terms and be able to co-create during the communication process.

Examples include the hugely successful citizen science projects that involve the target audience in the scientific process, and allow them to partake in the discovery process. Analogous to this are the equally successful crowdfunding initiatives.

Recent initiatives from the European Commission (EC) have been pushing for an open and flexible learning experience through the use of Information and Communications Technology (ICT) to improve education and training systems (EU Open Education Initiative), aligning them with the current digital world. In parallel, the EC has (justifiably) been demanding a more open

publication process for research (Open Access) and for the production of educational resources (Open Educational Resources). This will have an impact on future astronomy education initiatives. These initiatives will need to provide easy and open access to resources and training, like Massive Open Online Courses (MOOCs).

Abstract concepts like the seasons are best learned with models. Credit: UNAWE.

Executive Summary

Broadly speaking, the remit of ASTRONET Task 5.3 is to try to answer: How can Europe overcome the fragmentation in astronomy EPO, TT and Training and make a significant step towards the coordination and integration of European resources in these fields.

It seems clear that the need for a Europe-wide coordination and consolidation of efforts in education and public outreach is stronger than ever before. It is urgently needed to create opportunities, and find sufficient funding, for:

1. Creation of an integrated approach to astronomy education in Europe, with joint high-level literacy goals;
2. Creation of a European-wide Teacher Training agency with the wherewithal to coordinate Teacher Training initiatives, providing a framework as well as resources, expertise, and an evaluation methodology for existing programmes. This should include "training the trainers", documentation of best practices, and translation resources;
3. Liaising with current initiatives promoting the connection with nature and wildness in children and young people to encourage them to include sky-observing experiences;
4. Creation of a European training programme for Nature Tour Guides to include sky-observing experiences in nature tours and field trips.
5. Taking steps towards consolidating experiences, lessons and best practices for astronomy education across Europe;
6. Making a study on best practices for astronomy education across Europe. This should also identify anchor points to introduce astronomy in non-science-related subjects like literature, history or arts;
7. Creation of standards for a "Top-50" list to define the astronomy literacy standards for the most important astronomical topics/concepts/phenomena that students need to be

acquainted with at some point during their studies (e.g. seasons, lunar phases, tides, gravity etc.);

8. Creation of a European-wide translations agency that can serve as a service to agencies and national entities for the translation of English-language content;
9. Adoption of a European-wide educational material repository, such as AstroEdu;
10. Creation of Europe-wide standardised open access educational resources: kits that can be mass-produced and localised, images, videos, educational activities, presentations and planetarium content;
11. Ensuring access to professional communication departments, which are staffed with the necessary functions to carry out modern science communication and have professional science communicators, working alongside active scientists;
12. Ensuring that 2% of the budget for funding research is devoted to education and communication to the public;
13. Ensuring that publishing continuously in science-2-science or science-2-laypeople blogs are regarded as important scientific contributions in the recruitment process of junior researchers;
14. Extending the one-dimensional measure of publication impact in citations to a second dimension for the measurement of outreach activities in the recruitment process. Depending on the needs of the hiring institute, the weight of the “public engagement dimension” should be adjusted for the different job offerings;
15. Continuing and strengthening training programmes on small-class telescopes (1 to 2 metres) in regional observatories for graduate and PhD students;
16. Continuing and strengthening summer schools organised by EC networks and science programmes to complement regular training sessions from university programmes;
17. Using actual visits and use of cutting-edge telescopes and robotic telescopes for recruitment purposes;
18. Following the trend of increased service mode observing for the type of training that is required to distil a scientific question into an observational programme that lends itself to a queue-based and remote-user peer review application system.

Universe in a Box teacher training. Credit: UNAWE.

1. Education

1.1 Teacher Training (Roadmap Recommendation 1)

Teacher training plays a vital role in EPO: teachers are among the most important multipliers for astronomy EPO content, making them an interesting target group for any strategy aimed at sustainable and wide-reaching dissemination of EPO content. From the perspective of education, astronomy, with its widespread fascination for people of all ages, is an asset for the teaching of physics and, more generally, science, in a way that reliably awakens and sustains pupils' interest. Studies such as *The Relevance of Science Education* (ROSE) (with more than 40 countries participating) have shown that astronomical topics have a particularly high appeal to pupils, and in particular also manage to capture the interest of more girls than other topics from the physical sciences. The question that generated the most interest from boys and girls was "Is there life elsewhere in the universe?".

In astronomy, there are numerous local teacher training activities — typically by astronomical research institutes providing training workshops for their local or regional population of teachers — but also nation-wide training events and even teacher training programmes at the European or global level.

Local events are hard to keep track of, and no comprehensive listings exist. A few scattered examples of national training events are: training events at the National STEM Centre in the UK, the yearly German-wide astronomy teacher training at the University of Jena (organised by Karl-Heinz Lotze), or the more recent W.-E.-Heraeus Teacher Training in Astronomy at Haus der Astronomie in Heidelberg, Germany.

A list of transnational organisations that provide teacher training in astronomy can be found in Table 1 below. At the Primary education level, EU-UNAWE has developed and implemented a comprehensive teacher training programme in 5 European countries (Italy, Germany, the Netherlands, Spain and the United Kingdom) and South Africa. In total 1800 primary school teachers was trained by EU-UNAWE from 2011–2013. At the secondary level, the IAU programmes Galileo Teacher Training Program (GTTP) has been training hundreds of teachers in Europe.

Table 1: Transeuropean Teacher Training, or so-called Continuing Professional Development (CPD), providers in Astronomy.

	Universe Awareness	Galileo Teacher Training Program	ESA (including ESERO)
Reach (National, European or Global)	Global	Global	European
Organisation	Coordinated by Leiden University	Coordinated by NUCLIO – Núcleo Interativo de Astronomia	Coordinated by ESEROs and ESA
Target Level (Primary or Secondary)	Primary	All grade levels	Primary and secondary
Average number of teachers training / year	2000	At least 50 (estimated)	100s (estimated)
Pre-service / In-Service?	Both. Focus on in-service	Mostly in service	Both
Follow-up	Communication through mailing lists and other network activities	Communication through network activities	ESA workshops - teachers expected to disseminate
Accreditation	No	Country dependent	No
Costs for teachers (support to teachers, replacements, etc)	Free	Training is for free or a small charge to support local expenses.	Free
School hours / Weekends / holiday?	Afterschool	Most countries tend to host training out of regular school hours	Variable
Logistics	Co-organised with local schools or with teaching training centres	Usually the venue is for free and the requirements are simply a space to hold presentations and hands-on activities equipped with a data projector	
Type of Training (Practical, Theoretical (lectures by scientists, teaching methodology, resource-based, etc…, percentage, balance between them)	Lectures by astronomers, followed by hands-on activities with UNAWE resources	It varies according the partner promoting it. In general there is the participation of scientists. The training involves theoretical parts, sharing of new teaching methodology like Inquiry Based Science Education (IBSE) for instance. The training is required to promote sky observing sessions (naked eye, telescope, remote telescope) and the introduction of ICT resources.	Theoretical lectures by scientists and practical sessions

An additional European activity of relevance is the Erasmus+ programme, run by the European Commission from 2014–2020, which provides funding to support teacher mobility and transnational partnerships across Europe for education, training and youth institutions. In addition, the programme aims to modernise education, training and youth systems. The programme is open to organisations (public, private or non-profit) and supports three main actions: mobility of individuals; cooperation, innovation, and exchange of good practises; and support for policy reform.

From the perspective of Europe's astronomical community, the main challenge of the current situation is, once more, fragmentation. While it is vital for local current efforts — often initiated by individual motivated scientists or educators — to prosper, the likelihood of these initiatives disseminating materials and best practices Europe-wide is very small. This is where consolidation and support of these teacher training efforts across Europe can make a considerable difference, helping to maximise both reach and impact.

The recommended support measures depend on the scope of the training event. For local events, organised by individual scientists/educators or institutes, the focus should be on disseminating best practices information in both directions — both as a toolkit for individual astronomers trying to learn the basics of teacher training (including evaluation information, and standards for a useful and effective training event) and for disseminating excellent individual best practice examples throughout the community. For a series of events organised by larger institutions on a regular basis, certification would be a way to implement common standards (e.g. through an ISO certification, possibly supplemented with astronomy-specific criteria).

A comprehensive solution would be the establishment of a European-wide agency with the wherewithal to coordinate these initiatives, providing a framework as well as resources, expertise, and an evaluation methodology for existing programmes. Specifically, it is recommended that this include "training the trainers", documentation of best practices, and translation resources. In addition, European funding for existing Europe-wide "light house" projects would help with establishing standards, and disseminating best practice information, by example.

Nothing replaces real sky-observing experiences. Credit: IAU/IYA2009/L. Pullen.

1.2 Sky-observing Experiences (Roadmap Recommendation 2)

One of the main goals of IYA2009 was to promote widespread access to the universal knowledge of fundamental science through the excitement of sky-observing experiences. Five years later this goal is even more pressing. The convenience of modern life and the "parallel universes" offered by the omnipresent TVs, tablets and smartphones, disconnect us from nature as never before. Several countries have initiated programmes such as Project Wild Thing to reconnect children and teenagers with nature, while initiatives like Dark Sky Parks or the IYA2009 Galileoscope project are promoting a widespread access to sky-observing experiences for students and the general public. The EU-UNAWE programme created several Playground Human Orreries in schools in Northern Ireland (UK) and Celestial Sphere Playground Models in Spanish primary schools. It would be of great value to liaise with current initiatives promoting the connection with nature and wildness in children and young people to encourage them to include sky-observing experiences.

The use of robotic telescopes in the classroom is now easy and accessible to most European schools. Some examples are Las Cumbres Observatory Global Network (LCOGT), the Open University's PIRATE and the Astronomical Observatory of Trieste's Le Stelle Vanno A Scuola (SVAS) being unified into a national network with a common interface and booking system. LCOGT has recently launched the new On Sky interface, that allows straightforward access to professional telescopes to many schools in Europe. Support in other languages is, however, necessary for these initiatives to really reach the wider Europe. The need for coordination and collaboration in the area of robotic observing is not just an issue of avoiding to "reinvent the

wheel", but a practical necessity. A network of telescopes in many different timezones would enable any school to connect with at least one telescope in a location where it is night during school hours, and also clear weather.

Some emerging "do-it-yourself" initiatives, like the Ultrascope from Open Space Agency, are also good examples of how to engage the public with sky-observing experiences through co-creation.

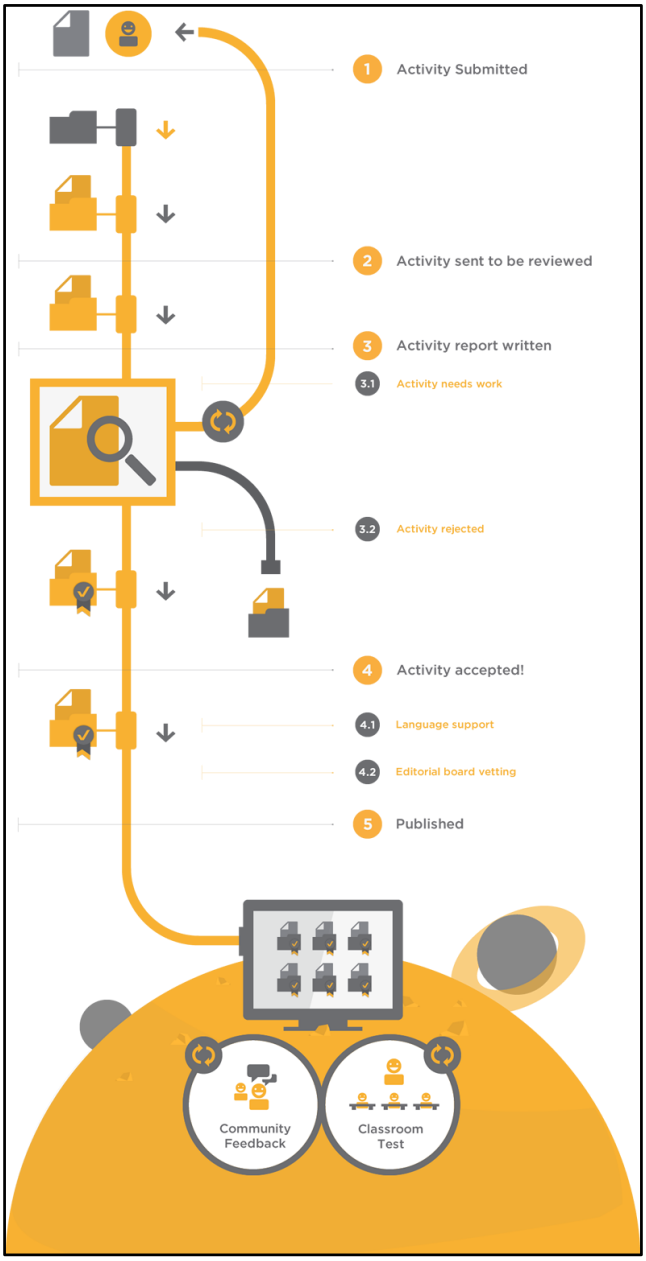
Sky-observing experiences are also becoming part of the activity portfolios of nature reserves. In the UK several Nature Parks have established Dark Skies Reserves to promote appreciation for the night sky, including night sky tours and workshops. Other countries like Germany, Hungary and Poland are following the same trend. Training for nature tour guides is however necessary, so that they can enhance the experience of the visitors. This could be achieved in collaboration with the local nature and field tour guides associations. A European training programme should be created for Nature Tour Guides to include sky-observing experiences in nature tours and field trips.

Best Practice: In Iceland the amateur astronomer association collaborates with the national tour guides training programme to provide training about northern lights (auroras) to the nature guides.

For the little ones, the awareness and interest in astronomy is best awakened with fun activities. Credit: ESO/B. Tafreshi.

1.3 Consolidation of Astronomy Education in Europe (Roadmap Recommendation 3)

Since 2008 little progress has been made in consolidating experiences, lessons and best practices for astronomy education across Europe. A big opportunity would be lost if steps are not made towards this goal. A study on best practices for astronomy education across Europe should also be made. This study should also identify anchor points to introduce astronomy in non-science-related subjects like literature, history or arts. Defining literacy standards in astronomy is also essential to create a common framework to develop educational programmes, resources, curriculum and evaluation strategies. Partly triggered by ASTRONET a project called “50 Concepts” was started in 2014 by some of the Task 5.3 WG members (Haus der Astronomie and ESO) to define the astronomy literacy standards for the most important astronomical topics/concepts/phenomena that students need to be acquainted with at some point during their studies. Topics like the seasons, lunar phases, tides, gravity etc. have been gathered in a “Top-50” list, and the concepts will until 2020 be explained in text, images, and animations for classroom, documentaries and planetariums. The deliverables will be released under Creative Commons and be available to everyone for free. Similar initiatives have been implemented by other scientific fields like Earth Sciences.

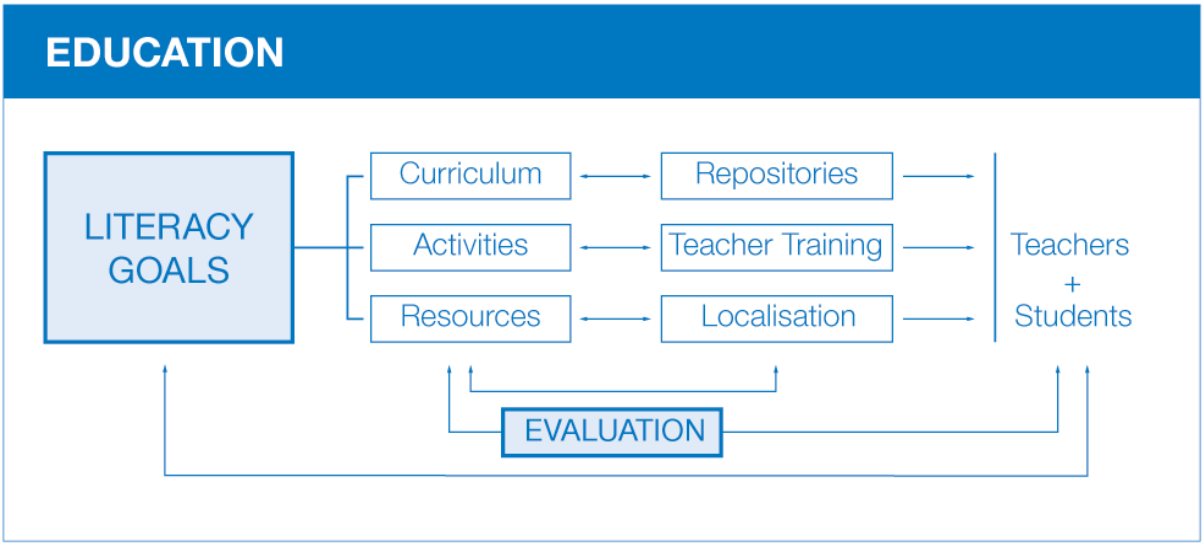


The astroEDU evaluation process. Credit: IAU/astroEDU.

1.4 A (Web-based) Distribution System for Educational Material (Roadmap Recommendation 4)

Considerable progress has been made on this point. Inspired in part by the ASTRONET Roadmap, the IAU recently launched an open-access platform for peer-reviewed astronomy education activities: astroEDU. astroEDU is an open-source platform that allows educators to discover, review, distribute, improve and remix astronomy education activities, and offers a free peer-review service by professionals in education and science. Educational activities are made available in many different formats: PDF, DOC, HTML, and epub, including the source files for future translations and adaptations. One of the main goals of the astroEDU is to promote the use of excellent astronomy activities worldwide. For that, astroEDU links its educational content with existing European educational repositories like TES Connect (think, educate, share), Scientix and global ones like OER Commons (Open Educational Resources). All the astroEDU

activities are licensed with a Creative Commons Attribution 3.0 Unported license. In addition, all astroEDU activities are labelled with a Digital Object Identifier (DOI), to provide a form of persistent identification for future reference and an easy way for educators to reference their activities just like in scholarly paper. In late 2014, astroEDU received the Scientix Award for Best Resources in Science, Technology, Mathematics and Engineering. At the moment the platform is only available in English (Italian and Dutch versions are expected in 2015). It will be necessary to provide structural and long-term support for astroEDU to make the best educational resources available to educators in Europe, and to allocate financial resources to expand the platform to other European languages and to create the necessary momentum in the community. For the translation alone, the costs are estimated at around 0.25 FTE per language, so a total of 6 FTE would be needed to cover the 24 official EU languages.



Astronomy education is an intricate process involving many stakeholders and services. In Europe, educators use the national curriculum as well as available educational resources and activities to teach astronomy to students in formal and informal settings. Teacher training, localisation of resources and effective distribution through repositories are essential for an effective use of astronomy content. A continuous evaluation (through peer-review and classroom test) is essential to improve the quality of resources and services involved. Top-level literacy goals for astronomy education also need to be regularly updated to meet the current modern astronomy knowledge. Credit: P. Russo.

In general it is extremely important to provide access to localised educational resources for teachers and significant additional efforts are needed to meet this well identified need. ESO, ESA, Universe Awareness and others are paving the way by establishing translation initiatives (see Table 2). However a more consolidated approach is necessary to maximise the impact of the EPO efforts across Europe. One possible approach could be the establishment of a European-wide “translations agency” that could serve agencies and national entities with a consolidated multilingual support for astronomy EPO material.

Table 2: Astronomy translation/localisation Initiatives in Europe.

	ESO Science Outreach Network	Universe Awareness	Scientix	ESA Country Desks	Science in School
Type of Documents	Press Releases Announcements Brochures	Space Scoops; some educational material	Educational material from all fields of science	Press releases, web pages	Magazine articles, teaching material, book reviews; all fields of science
Translators' Profile	Press Information Officers (PIOs)	Volunteers (from university students to primary school teachers)	Qualified volunteers	Contractor journalist or communication specialist	Qualified volunteers
Workload	1000 words/week	400 word/week		Variable	
Number of Languages	19 languages (+ English)	Maximum 23	(official EU languages)	15	Maximum 31
Number of Countries	31			20 countries)	
Budget	Average 0.1 EUR/word. Total 100,000 EUR/year. Funded by ESO	In-kind (educational material, travel grants)	Funded by FP7 Scientix	Funded by ESA	200,000 EUR/year Funded by EIROForum (incl. the English source material)

Journey to a billion Suns*, a planetarium show from ESA takes the audience on a journey through the Milky Way. Credit: ESA/Stargarten.*

2. Public Communication and Outreach

2.1 The landscape of astronomy outreach in Europe

The number of European astronomy outreach activities available is considerable but it is hard for any one individual to get an overview. A multitude of local, regional, national and European EPO resources exist, and they often occupy the same niche, but have small (but significant) differences such as language.

A need to create a pan-European “map” of the astronomy local, regional, national and European EPO activities was identified by the Task 5.3 WG. A beginning was made by the WG, but since this only reflects the WG members’ limited knowledge and geographical spread, we decided to open the map to the community as a crowdsourcing initiative. The list is now an open editable page in Wikipedia, which with time can be updated dynamically with astronomy ESO resources by members of the community.

Best Practice: The landscape of astronomy outreach in Europe
https://en.wikipedia.org/wiki/List_of_Astronomy_Outreach_Resources_in_Europe

We hope this list will contribute to the collaboration and potential coordination of activities between the European EPO projects.

2.2 Science Museums and planetariums (Roadmap Recommendation 5)

One of the ways that research institutes engage in outreach initiatives is through external organisations, such as science centres and planetariums. In astronomy, planetariums especially play an important role as external infrastructures to engage the public with astronomy research (cf. Javier Armentia's talk at the first ASTRONET Workshop in Heidelberg, p.37).

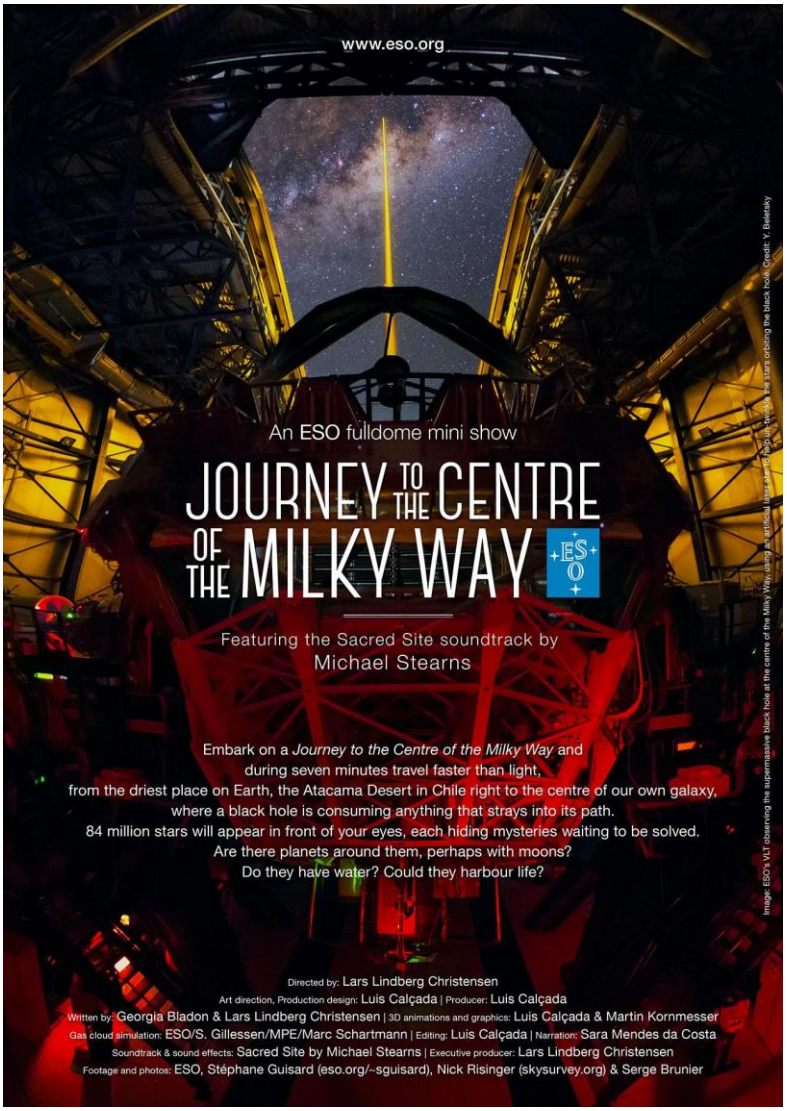
Since 2008 there has been significant progress in this area: ESA and ESO have in total published a bit more than a handful of planetarium shows. It is worth noting that most of these were done in collaboration with commercial partners, as there were insufficient funding inside ESA and ESO to cover all productions expenses. Hence it was not possible to clear most of the resources for free use.

Recently ESO and ESA/Hubble has started to provide some materials for free use in planetariums and is ramping up to develop a system for innovative distribution that would allow other planetariums to use open access content from agencies and observatories. This is one of the foundations in the philosophy of the planned ESO Supernova Planetarium and Visitor Centre in Garching (scheduled to open in mid-2017). The ultimate end-goal would be to provide a “menu” that every morning allows the planetarium presenter to select interesting news and dataset previews downloaded overnight — planetary maps, images of sky objects, tabular data, event data etc. — and mark the full datasets and metadata (descriptions, web URLs, licensing etc.) up for download and for possible inclusion in show segments during the day. The analogy would be to think of this as an “astronomical weather man”.

Examples of planetarium shows co-produced by ESO and ESA are as follows:

1. *Touching the Edge of the Universe* (ESA/Media Faculty of the Kiel University of Applied Sciences/Planetariums)
   Touching the Edge of the Universe tells the story of astronomy from the time of Galileo and his simple optical telescope to today’s sophisticated space astronomy missions, such as the Herschel infrared space observatory and Planck satellite. Premiered during the IYA2009, the show was developed by ESA in partnership with more than 30 German-language planetariums across Germany, Austria and Switzerland with digital production expertise from the creative team at the Media Faculty of the Kiel University of Applied Sciences, Kiel, Germany.
2. *Journey to a Billion Suns* (ESA/Stargarten/Planetariums)
   Journey to a Billion Suns looks back to the astronomers whose quest it was to seek out the distance to the stars. From the star maps of our forefathers to the third dimension soon to be revealed by the Gaia mission, *Journey to a Billion Suns* takes the audience on a journey through the Milky Way to explore the many questions that have been asked about the origin and evolution of our home galaxy. *Journey to a Billion Suns* was produced by Stargarten in cooperation with ESA and planetariums across Europe.

3. *Water: A Cosmic Adventure* (APLF/Hamburg Planetarium/ESO)
   Water: A Cosmic Adventure is a 30-minute planetarium show exploring how water formed, its relationship with the cosmos, and how we search for it on distant exoplanets. The Association des Planétariums de Langue Française (APLF) in collaboration with Hamburg Planetarium and ESO invite viewers to join astrophysicist Eva Luna as she explores the turbulent origins of hydrogen and oxygen in the Universe and discover how they combined to form one of the most essential molecules on Earth, H_2O. The backbone of life as we know it.
4. *In search of our Cosmic Origins* (ESO/APLF)
   In search of our Cosmic Origins is a planetarium show about ALMA, the Atacama Large Millimeter/submillimeter Array, a revolutionary radio telescope in the Chilean Atacama Desert. The show was produced by ESO and APLF, in collaboration with the Planetarium of Augsburg in Germany.
5. *Mysteries of the Southern Sky* (ESO/APLF)
   On the occasion of ESO's 40th anniversary APLF produced, in collaboration with ESO, a classical planetarium show about astronomical research and discoveries with ESO telescopes. Entitled *Mysteries of the Southern Sky* the show is available in French, German, English, Dutch and Spanish.
6. *Journey to the Centre of the Milky Way* (ESO)
   For twenty years, ESO's Very Large Telescope and the Keck telescopes have observed the centre of our galaxy, looking at the motion of more than a hundred stars and identifying the position of an otherwise invisible object — the supermassive black hole at the centre of our galaxy. *Journey to the Centre of the Milky Way* is the first fulldome planetarium mini-show produced in-house by ESO for its Planetarium and Visitor Centre, the ESO Supernova, due to open in 2017. Available for free in 4k resolution, the mini-show can be downloaded and used by any planetarium in the world.



Journey to the Centre of the Milky Way*, a European mini-show in 4k resolution can be downloaded and used for free by any planetarium in the world. Credit: ESO.*

In 2012 the European Network of Science Centres and Museums (Ecsite) created a thematic group dedicated to the topic of space. ESA and Ecsite Space Group have defined a partnership project aimed at promoting European space activities. This project will be based on the networking capacity of both ESA and Ecsite, and on the communications resources of ESA and the European space sector. The Ecsite Space group includes ESA working together with more than 30 science centres and museums with the aim of joining forces and resources (content, networks and capacities) to enable a larger audience to be reached. In 2013 the group selected science centres to collaborate with ESA to develop events, an exhibition, and an education programme based on the topic of ESA's Rosetta mission for implementation in 2014.

On the 12 November 2014 more than 20 science centres and museums across Europe organised special events to follow the landing of the Rosetta mission's Philae lander on the surface of a comet.

In the future, data from the ESA Gaia mission could potentially create a small revolution for the

data catalogues used in digital planetariums, such as the Digital Universe from American Museum of Natural History's Hayden Planetarium.

2.3 Funding for Public Communication and Outreach (Roadmap Recommendation 6)

Despite the recession, the level of EPO funding in astronomy has only decreased marginally. There is however a significant and urgent need to provide strategic long-term support for public communication and education in Europe, especially operational funding for existing and new projects, and not only seed-funding (as in the case of UNAWE described above). An often quoted number for the total amount of sustainable funding for EPO activities is 1-2% of the total budget for a given scientific organisation. This breaks down to the minimum size of an institute of ~50 people to allow for a full-time communication officer. Often, science communication in smaller institutes is carried out by scientists as a small part of their normal duties or in their spare-time. There continues to be a need to ensure access to professional communication departments, which are staffed with the necessary functions to carry out modern science communication and have professional science communicators, working alongside active scientists.

All national funding agencies should be encouraged to ensure the same 2%-benchmark expenditure on public outreach activities accompanying research activities. The expansion of outreach activities can occur in two ways: The first is to provide supplementary outreach funding, for example by an agency funding a research project and also by funding outreach directly related to the project (the German DFG is an example of a funding agency where such supplementary outreach funding is possible). In addition to such project-dependant funding, the second option is to have funding available for independent outreach activities based only on the proposed activity's excellence, feasibility and impact, not on its connection to a specific research project.

2.4 Recognition for scientists involved in education and public outreach (Roadmap Recommendation 7)

Not much has formally happened to ensure clear career-relevant recognition for scientists who become involved in public communication or to offer media training courses for researchers. The IAU Commission 55 Washington Charter covers the former but not much has been done to promulgate it in Europe and thereby gain recognition for the field of outreach in general. One of the problems is the need to provide evaluation processes and criteria to assist career development, peer esteem and measurement of "impact" in the field. PLOS Article-Level Metrics (ALMs) is providing a mechanism to measure the impact of published research articles, including social media impact, but there is a need to develop similar metrics for EPO initiatives.

One form of recognition for researchers and also astronomy teachers could be a form of certification. Another form would be to encourage the publication of articles in the Communication of Astronomy to the Public Journal (CAPjournal) as a method to generate (and measure) career-relevant publications on EPO activities.

Some organisations like ESO provide media training when resources allow, but in general this area should be strengthened. Since the media landscape has changed since 2008, social media training should also be provided. Funding agencies should include mandatory training in public outreach and media contacts as a requirement in the funding scheme for junior researchers (e.g. Marie Skłodowska-Curie Innovative Training Networks and other funding schemes in Horizon 2020).

Over the last few years, a new way for S2S (science to science) and S2L (science to laypeople) communication has developed in the form of blogs. On platforms like scienceblogs.com and many private blogs, researchers communicate and comment on new research findings. Typically the blogs have a number of "fans" who steadily comment on blog posts. The scientific level of communication in the blog comments varies a lot between lowest level explanations up to high-level dissection of single scientific papers. Publishing continuously in such blogs should be regarded as important scientific contributions in the recruitment process of junior researchers.

In general, for the recruitment process, the one-dimensional measure of publication impact in citations should be extended to a second dimension for the measurement of outreach activities. Depending on the needs of the hiring institute, the weight of the "public engagement dimension" should be adjusted for the different job offerings.

2.5 Creation of a standardised European science communication portal for media, educators, interested laypeople (Roadmap Recommendation 8)

There has been significant progress in this area. The Portal to the Universe (PTTU) was created in mid-2009 to address this exact recommendation, but has not yet managed to attract the necessary funding to gain the desirable visibility and momentum. This is mainly due to the lack of funding for promotion and marketing —and due to the fact that operational funding is very difficult to obtain (as discussed above)[1].

The PTTU enables real-time access to content by aggregating (pulling) from providers of dynamic content like blogs, images, news, etc., and distributing (pushing) to users, as well as indexing and archiving, and collecting and maintaining a central repository of useful information. State-of-the-art technology such as RSS feeds and standardised metadata make it possible to tie all the suppliers of astronomy information together with a single, semi-automatically updating portal. The result is a technologically advanced site that brings together strands of astronomy content from across the Internet and enables anyone with a web connection to stay up-to-date with cutting-edge astronomy and space science breakthroughs. However, PTTU is currently only available in English and Slovenian.

[1] This is exacerbated into a downward spiral if also no resources for fundraising are available.

Members of the public interacting with scientists and engineers explaining technologies used in modern astronomy. Credit: ESO.

3. Relationships with Industry

The construction of any major facility or instrument relies heavily on industry. This may not always involve cutting-edge technology, but in the area of control and instrumentation, it absolutely will. In this latter area there is a clear dependence on a close link and working relationship between cutting-edge (beyond the state-of-the-art) research, mainly carried out in university and government laboratories, and the high-tech industries that will often be required to take these low-value Technology Readiness Levels (TRLs) to a production capability. The ability to forge a good working relationship with industry is therefore vital for these new facilities.

There is another area in which industry has an important part to play, and that is the strategic value of certain components, so that Europe is not beholden to a foreign party that can dictate the availability and price of components. Infrared detectors for space-based, and to some extent ground-based, telescopes are a clear example where currently Europe is dependent on the US, who can then leverage scientific influence (e.g. EUCLID) and also set the price and availability for the provision of components. While this has not been a real problem so far, being self-sufficient in this area is something that Europe has been striving towards through various EU initiatives. It is important that this concept is seen through to a successful conclusion.

3.1 Creation of a Technology Transfer network (Roadmap Recommendation 9)

The ASTRONET recommendation 9 asks for the creation of a network of experts in Technology Transfer (TT). In our second workshop we found that (a) there already exists broader informal European networks of TT which are used by the TT professionals from large scientific institutes such as CERN and ESA; (b) there are very few (if any) real TT professionals in astronomy.

Based on the presentations at the second Task 5.3 workshop it can be concluded that, depending on the mission of the respective organisation, the role and structure of the technology transfer units, as well as the applied innovation tools, varies considerably. Funding agency-type organisations seems to rely on a broad range of external services and networks, while more research-oriented organisations tend to build up many functions in-house and outsource to a more limited set of activities networks.

It is important to emphasize that technology and knowledge transfer in Astronomy cannot have the aim of creating a large financial return from licenses or spin-offs. Instead, astronomical knowledge transfer should provide the public with inventions that could in return result in innovations (which are typically implemented by commercial companies).

It is undeniably a very pertinent and important task to showcase the benefits of astronomy for the society by raising awareness of also the short-term gains found in technology transfer, for instance by publishing “TT success stories”. However, to enable this it is necessary to:

1. Solve the problem that the size of most ASTRONET partner organisations are below the critical mass for carrying out professional TT activities.
2. Take a significant step towards the coordination and integration of European resources in the field of technology transfer by urging the ASTRONET partner organisations to consider appointing contact persons for this area.
3. By setting up a light and informal networking structure where all or most ASTRONET partner organisation are represented with their appointed contact person for technology transfer activities.
4. To collect technology transfer success stories from areas where complementary expertise of the partner organisations exist, in order to allow a focused collaboration that has the potential to provide added value.

Post-docs and students at ALMA. Credit: ESO/M. West.

4. Recruitment and Training

Also the ASTRONET 2 Deliverable 5.3 agrees that the training of next generation of users for future facilities is apriority issue. As stated in this report, this includes training and provision of access to telescope time preferentially for Master students. This measure would support an education of the next generation of European astronomers, making them familiar with the new technologies and the most recent observing techniques.

The 2008 ASTRONET Roadmap recommended that “fast-track” funding mechanisms be implemented to support the scientific exploitation of the large European facilities, enabling young astronomers to be more internationally competitive in large collaborations. Little progress has been seen on this score, as this is a structural issue that requires inter-agency (e.g. ESO, ESA, national agencies) agreements to be overcome. Clearly a balance needs to be struck between individual peer-assessed programmes and major programmes that are potentially world-beating but need access to a wide variety of facilities to create the maximum impact. ASTRONET remains the appropriate body to promote this important recommendation and make it happen.

It has long been recognised that small-class telescopes (1 to 2 metres) in regional observatories have considerable value for the training of graduate and PhD students. The 2008 ASTRONET Report by the European Telescope Strategic Review Committee (ETSRC) recommended that formal graduate schools be maintained, in addition to resorting to graduate and PhD students for carrying out the observations in places where there are no telescope operators. End-to-end projects, from instrument development or characterisation, observation and calibration to data analysis allow students to gain valuable hands-on professional experience.

Summer schools (usually 1-week long) organised by EC networks and science programmes can complement regular training sessions from university programmes. Continued access to these programmes should be maintained and encouraged by the agencies, enabling the training of hundreds of students every year.

The past few years have seen the development of university nanosatellite programmes for the training of students in high technology projects. These projects require expertise in a broad range of domains, from project management to orbitography, electronics, mechanics, thermal control, etc. Student projects can be easily developed at moderate costs in specialised labs, and can, in addition, provide valuable research opportunities, e.g. to raise the technology readiness level of specific components. Indeed, Europe is lagging behind the US in this domain, and astronomy institutes with instrument development capabilities could play an important role in promoting and developing such projects.

Although the potential of using “old” telescopes and facilities as educational devices is considerable, the use of visits to active facilities is naturally better. However as these are often quite remote, time and cost become obvious barriers to experiencing what a cutting-edge observatory can do (in this context radio telescopes have an obvious advantage also being located in mainland Europe). There are a number of initiatives and competitions that allow a very small group of undergraduate students and even high-school students to visit a front-line observatory, but these remain a minority.

The use of actual visits, secondments and use of telescopes remains one of the key themes in recruitment, both to undergraduate courses and also to some extent in the postgraduate career. It has long been recognised that the “excitement” of working at a real observatory and undertaking real-time observations gives a real “buzz”, and studies have shown that this is an effective tool in recruitment. The use of robotic telescopes, often aimed at secondary schools, gives that early edge to propel students into science at university, perhaps even astronomy degrees. However, robotic telescopes also have a cutting-edge place in observational astronomy, being able to undertake a number of projects, usually of a long-term or monitoring nature, that are very hard to gain time for on mainstream, staffed and scheduled facilities.

Following on from this theme, an interesting concept to note is that more large-scale facilities (space- and ground-based) are now scheduling observing on an essentially queue-based process, scientifically ranked but executed according to availability or specific conditions (e.g. seeing or water vapour content for ground-based facilities). The observer then need not be present for these “service mode” observations, a position long held for many space-based observations. This has an impact on the staffing of the observatories and also on the training of students. As the drive to make facilities as productive as possible continues, this “service mode” trend is unlikely to diminish and this changes the need for the type of training that is required. The ability to distil a scientific question into an observational programme through a queue-based and remote-user peer review application system is something that pedagogy may need to consider, rather than the long-distance travelling and the luck of the prevailing weather at the telescope (although this is one of the most exciting and rewarding aspects of ground-based observational astronomy).

All of the original recruitment and training recommendations still stand; however, it is clear that progress on implementing them has been less than ideal for reasons expressed earlier. While progress in the overall field has been huge, the pan-European aspect has made little progress, with brilliant beacons from individual nations, organisations or agencies shining out from an otherwise bland landscape. It is clear that without "champions" to take these ideas forward along with supporting funding, they will remain just that: ideas.

4.1 Provide funding for data analysis at a competitive level (Roadmap Recommendation 10)

The 2008 Roadmap put forward a strong recommendation to use the observatory time allocation reviewing process as a proxy to *also* allocate "fast-track" funding for the data analysis and publication afterwards. With the extra funding, scientists would be able to better exploit the typically one-year period where the data are proprietary, and thereby better enable them to be internationally competitive.

More and more the big science projects are pan-European and pan-continental in nature, and are likely to use multiple facilities, often from both ground- and space-based facilities. Hence they need a large degree of coordination of the efforts needed for data analysis and further steps should be taken to coordinate in this area.

During the reporting period, there were no new pan-European or EU institutions established to try to solve the problem of the missing resources for data analysis, however important steps to coordinate the time allocation itself have been taken:

1. The largest European astronomical research infrastructure — the European Southern Observatory — has opened a new chapter for European astronomy, with dedicated Public Survey projects and mechanisms for managing them, to ensure their legacy and their usefulness for the astronomical community at large.
2. The EC-funded OPTICON project established a common observing time allocation Process for several observatories and telescopes, to better ensuring that astronomers are able to carry out state of the art research on state of the art facilities.

Appendix 1: ASTRONET Task 5.3 Working Group membership

- Lars Lindberg Christensen (ESO, chair) <lars@eso.org>
- Pedro Russo (EU-UNAWE/Leiden Observatory) <russo@strw.leidenuniv.nl>
- Francisco Colomer (OAN-IGN, Madrid) <f.colomer@oan.es>
- Jens Kube (PT-DESY) <jens.kube@desy.de>
- Markus Pössel (Haus der Astronomie) <poessel@mpia.de>
- Rebecca Barnes (HE Space Operations for ESA) <rebecca.barnes@esa.int>
- Massimo Ramella (INAF–OATs) <ramella@oats.inaf.it>
- Maria Teresa Fulco (INAF–Naples Observatory) <mtfulco@oacn.inaf.it>
- Gražina Tautvaišienė (Vilnius University) <grazina.tautvaisiene@tfai.vu.lt>
- Penny Woodman (STFC) <Penny.Woodman@stfc.ac.uk>
- Anthony Teston (CNRS-INSU) <Anthony.TESTON@cnrs-dir.fr>

Appendix 2: Activities of ASTRONET 2 Task 5.3

1. 15 July 2012: Establishing a work programme for Working Group, face to face meetings, teleconferences
2. 12 Sept 2012: Telecon 1
3. 12 Dec. 2012: Telecon 2
4. 1 February 2013: Face-to-face meeting at ESO
5. 5 March 2013: Telecon 3
6. 17-18 June 2013 Workshop 1 and second face-to-face meeting: Astronomy Education & Public Outreach: 34 participants (internal planning doc). Website.
7. 9 July 2013 Telecon 4
8. 29 October 2013 implementation plan
9. 12 February 2014 ASTRONET Panel E Roadmap Update (for ASTRONET 1 Panel E, delivered to Ian Robson)
10. 22 September 2014 Telecon 5
11. 7 Oct. 2014 Telecon 6
12. 21 Oct. 2014 Telecon 7
13. 24 November 2014 Workshop 2 on TT
14. 25 November Third face-to-face meeting
15. End of 2014: Final report (D5.11) and end of ASTRONET 2

Appendix 3: ASTRONET 2 Task 5.3 Workshop 1

Haus der Astronomie, Heidelberg
17 & 18 June 2013

http://www.eso.org/public/events/special-evt/astronet2013.html

Haus der Astronomie where ASTRONET 2 Task 5.3 Workshop 1 was held. Credit: Haus der Astronomie.

The mission of ASTRONET-Coordinating strategic planning for European Astronomy, a network supported by the European Commission, is to establish a strategic planning mechanism for all of European astronomy for the next 5–25 years. An important part of ASTRONET is Education, Public Outreach and Training, coordinated by the Task 5.3 Working Group.

This workshop included Working Group members as well as international experts on astronomy education and outreach, and had the purpose of gathering information and evaluations on the European perspective on astronomy EPO, to enable the definition of European priorities concerning future astronomy EPO infrastructure. Some of the questions we addressed were:

- Which EPO activities need support at the European level?
- How can the EU help to leverage national EPO resources
- How can we best share best practice examples, as well as EPO material?

Workshop Venue

The venue of the workshop was the Haus der Astronomie (literally “House of Astronomy”), a Centre for Astronomy Education and Outreach operated by the Max Planck Society on the Königstuhl mountain in Heidelberg, Germany.

Organisers & Partners

The organiser of this Workshop was the ASTRONET Task 5.3 Working Group (chaired by the European Southern Observatory, ESO) and the host was Haus der Astronomie (Center for Astronomy Education and Outreach, Heidelberg; HdA).

Schedule

Monday, 17 June, 2013
13:30 – Bus leaves to workshop venue

14:00 – Closed meeting of the ASTRONET Task 5.3 Working Group in preparation of the workshop.

15:00 – *Opening remarks* – Lars Lindberg Christensen (ESO) and Markus Pössel (Haus der Astronomie)

Session 1: Supranational aspects of EPO (chair: Jens Kube)

15:15 – *UNAWE and EUNAWE – A Europe-wide and global effort to bring astronomy to children* – Pedro Russo (UNAWE) 20 + 5 min.

15:40 – *The Office of Astronomy for Development: Why Astronomy must go global* – Cecilia Scorza (Haus der Astronomie, TBC) 20 + 5 min.

16:05 – *EPO at ESA in multinational context* – Markus Bauer (ESA) 15 + 5 min.

16:25 – Coffee break

16:45 – *Science in School – Highlighting the best in science teaching and research* – Marlene Rau (EMBL) 15 + 5 min.

17:05 – *Outreach via Planetaria, radio, etc.* – Javier Armentia (Planetario de Pamplona) 15 + 5 min.

17:25 – *A Network of Visitor Centers at European Radio Astronomy Observatories* – Francisco Colomer (Instituto Geográfico Nacional) 15 + 5 min.

17:45 – *In classroom with the Virtual Observatory: a new tool for students and teachers* – Massimo Ramella (INAF-OATs) 15 + 5 min.

18:05 – End of first day

Tour of Haus der Astronomie

18:35 – Bus leaves to Hotel Central

~19:30 – Dinner at Restaurant TATI

Tuesday, 18 June, 2013

Session 2: Sharing knowledge on a multilingual continent (Chair: Massimo Ramella)

08:30 – Bus leaves to workshop venue

09:00 – *Translating to 20 languages on a deadline — about ESO's Science Outreach Network* – Olivier Hainaut (ESO) 15 + 5 min.

09:20 – *Scientix – building a community for science education in Europe* – Agueda Gras-Velazquez (European Schoolnet, TBC) 15 + 5 min.

09:40 – *Using the right channels to reach the right target groups with the right products* – Lars Lindberg Christensen (ESO) 15 + 5 min.

10:00 – Panel discussion (with questions from the audience): *Efficient sharing of educational and outreach material across languages and cultures – how can it work?*

Speakers + Pedro Russo

10:30 – Coffee break

Session 3: Outreach and the career scientist (Chair: Francisco Colomer)

11:00 – *Outreach performed by "Units of Scientific Culture" in astronomical research centers* – Natalia Ruiz Zelmanovitch (AstroMadrid) 15 +5 min.

11:20 – *Researchers and public outreach: examples from an exoplanet scientist* – Lisa Kaltenegger (MPIA, CfA) 15+5 min.

11:40 – Panel discussion
Speakers + Grazina Tautvaisiene

12:10 – Lunch

Session 4: Astronomy in the context of science education (Chair: Loïc Bommersbach)

13:30 – *The use of Z-flux to show astronomy-related content in 3D* – An Van der Eecken

(UGent-Volkssterrenwacht, TBC) 15 + 5 min.

13:50 – *EduCosmos: Participative science for high school students with 1m telescopes* – Olga Suarez (Observatoire de la Cote d'Azur) 15 min.

14:05 – *A network of telescopes for classrooms* – Anne-Laure Melchior (European Hands On Universe) 15 min.

14:20 – *Citizen science projects* – Rob Simpson (Zooniverse) 15 +5 min.

14:40 – *Deep Space – Enquiry based learning for the classroom* – Tania Johnston (Royal Observatory Edinburgh Visitor Centre and STFC) 15+5 min.

15:00 – *The Galileo Teacher Training Program (GTTP) and the creation a network of Galileo Schools* – Rosa Doran (GTTP) 15 + 5 min.

15:20 – Coffee break

15:40 – Panel discussion: *Astronomy education and outreach – what should be done on a European level?*

16:10 – Closing words

16:20 – End of workshop

Participants

WG members **in bold** + invited speakers *in italics*:

1. **Lars Lindberg Christensen, ESO**
2. **Loïc Bommersbach, CNRS/OdP**
3. **Gražina Tautvaišienė, TFAI**
4. **Francisco Colomer, OAN-IGN, Spain**
5. **Jens Kube, PT-DESY**
6. **Markus Pössel, HdA**
7. **Massimo Ramella, INAF-OATs**
8. **Pedro Russo, EUNAWE**
9. *Agueda Gras-Velazquez, European Schoolnet*
10. *Olivier Hainaut, ESO*
11. *Natalia Ruiz Zelmanovitch, AstroMadrid*
12. *Javier Armentia, Planetario de Pamplona*
13. *Rosa Doran, GTTP*
14. *Anne-Laure Melchior, LERMA-Observatoire de Paris/EU-HOU*
15. *Cecilia Scorza (Haus der Astronomie)*
16. *Markus Bauer (ESA)*
17. Sadie Jones, University of Southampton
18. Manfred Gaida, DLR
19. Laura Ventura (ESO Chile)
20. Hanna Sathiapal, University of Applied Sciences and Arts Northwestern Switzerland

21. Peter Habison, Austrian Planetarium Society
22. Philippe Mollet, MIRA Public Observatory
23. Pawel Ziemnicki, Copernicus Science Centre
24. Francoise Genova, CNRS - Observatoire Astronomique de Strasbourg
25. Olga Suarez, Observatoire de la Cote d'Azur
26. Monica Orienti, Istituto di Radioastronomia Bologna
27. Tania Johnston, STFC
28. An Van der Eecken, VSRUG vzw
29. Carolin Liefke, Haus der Astronomie
30. João Retrê, Observatório Astronómico de Lisboa
31. Tracey Dickens, University of Leicester
32. Lisa Kaltenegger, MPIA-CfA Harvard
33. Rob Simpson, Zooniverse-University of Oxford (through teleconf.)

Results/Outcome

The contributions were organized in 4 sessions, followed by 3 panel discussions.

The first session, **"Supranational aspects of EPO"**, featured impressive examples for EPO efforts that have been/are being developed in Europe, including global efforts with major European participation. With *UNAWE and EU-UNAWE*, Pedro Russo presented a highly successful Europe-wide and global effort to bring astronomy to children — using the power of the fascination of astronomy to introduce children to science, and also to make them understand their place in a wider universe. The same potential in an international context, using astronomy to activate education and research in countries that are currently underrepresented in the international scientific community, is utilized by the *Office of Astronomy for Development*, as presented by Cecilia Scorza. As an example of Europe-wide outreach by a specific organisation, Markus Bauer presented the *European Space Agency*'s outreach activities in an international context. The talk by Javier Armentia stressed the importance of existing frameworks, notably planetariums as natural outreach allies. Francisco Colomer, more specifically, talked about radio astronomy visitor centres, while Massimo Ramella talked about a more general subject, namely the Virtual Observatory as an outreach tool.

The second session, "**Sharing knowledge on a multilingual continent",** focused on a particular challenge for supranational communication, namely the need to present a given message in various languages to guarantee accessibility to general audiences in different countries. Oliver Hainaut presented the European Southern Observatory's (ESO) solution to this challenge, namely ESO's Science Outreach Network of translators and outreach scientists helping to translate the organization's releases and messages into the languages of a total of 27 states, including ESO's member states. Agueda Gras-Velazquez presented another translator model, namely Scientix as a portal for, among other things, presenting translations of material developed in the context of EU-funded projects. Lars Lindberg Christensen wrapped up the talks in this session with an analysis of how to reach various target groups in suitable ways.

The third session, "**Outreach and the career scientist"**, tackled the issue of the role active

researchers play in outreach - and the synergies with, but also possible adverse effects their work as scientists. First, Natalia Ruiz Zelmanovitch talked about efforts to systematically involve researchers in outreach activities in Spain. Then, Lisa Kaltenegger talked about her experiences as an exoplanet researcher active in public outreach - including some negative feedback by colleagues indicating an attitude that sees extensive outreach activities as incompatible with work as a serious researcher.

In the fourth session, **"Astronomy in the context of science education"**, we explored the interplay between (formal and informal) science education and astronomy outreach, ranging from visualization issues (Van der Eecken) to remote observing/participative science (Olga Suarez, Anne-Laure Melchior) to inquiry-based space-related projects (Tania Johnston). Via video link, Rob Simpson gave a presentation about citizen science projects, while Rosa Doran talked about the systematic GTTP training programs for teachers.

Summing up both the talks and the discussion rounds, a number of general (and in a number of cases not astronomy-specific) issues with relevance to the ASTRONET recommendations were identified by the workshop participants:

- All participants noted the large number of high-quality Education and Public Outreach (EPO) activities that have been / are being developed in Europe — an invaluable resource both in the form of best practices and in the form of experienced EPO practitioners.
- Funding for EPO remains a general problems — many EPO activities are developed in the context of a "project" which then runs for a limited number (typically 3-4) years; this runs counter to the need for stable, reliable long-term outreach initiatives. Most project financing is meant to kick-start projects that then find alternative long-term funding; in reality, long-term funding is extremely difficult to get, and it is not rare for good and promising projects to be abandoned as their time-limited funding runs out — to be replaced by the next, slightly different, but also time-limited project. The strong recommendation of workshop participants to national and EU funding agencies: **Make long-term funding available to the best EPO projects (e.g. EU UNAWE and GHoU).** Good projects must have a perspective for sustainability!
- In the context of EU funding, it was noted by a number of participants that those tend to address very specific issues - and not necessarily those seen as most pressing by the outreach communities "on the ground". Both more general calls (allowing for funding for the best EPO projects, regardless of specific aims) and soliciting input from the outreach communities were suggested as a solution.
- For EPO to be effective, it must be embedded in the overall activities of the developers (institutes, schools, etc.).
- Networks (such as ESON or the IPS) play a crucial role in dissemination of materials, and in the optimization of efforts. While EPO will always need to act locally, the exchange of best-practice information, and services such as translation, are best located on an international level.
- Both to reach general audiences (which, unlike scientists, do not communicate predominantly in English) and to make effective use of available resources, excellent EPO material should be available in many languages. This poses a challenge on several

levels. Translation takes a sizeable effort, and translation-on-demand by volunteers (as for “Scientix”) or a coordinated network (such as ESON) call for a significant amount of coordination. Whenever volunteers are involved, content checking is essential - which demands additional resources. Since Europe-wide translation and dissemination of materials is an essential step towards a unified European outreach community, funding for translation services or, ideally, a coordinated outreach service, was seen as a key possible contribution by the EU to science outreach in general.

- Dissemination, even of excellent material, remains a challenge — even trying to get an overview of activities with a view towards identifying best practices is difficult due to the fragmentation of local-level activities. A Europe-wide network with the resources to actively collect and curate best-practice activities in EPO was identified as essential for an effective European outreach community.
- The participation by research scientists is a key factor for authentic, effective science outreach. In order to foster and support research scientists’ contributions, actions on different levels are necessary: First of all, scientists should have the opportunities to receive training in outreach, building the necessary skills e.g. in dealing with the media, or in an informal education setting. Most importantly, EPO performed by scientists needs to be recognized (by their Directors, in CV, if possible as a secondary qualification in hiring decisions). Scientists need to become aware of the importance of their own outreach, and become more involved.
- Workshop participants agreed in the special role played by astronomy as a low-threshold gateway science, ideal for getting students interested in physics, but also in science in general.
- Astronomy has a number of specific allies and tools that everyone who is active in astronomy EPO should consider. Natural allies include planetariums, but also amateur astronomers (aim to include them, e.g. via amateur astronomer associations, in your local EPO activities!). Specific tools include the means to create inquiry-based experiences using both real observations (e.g. via remote observations) and via the Virtual Observatory (VO) as a great tool to guide students through and towards real science.

Appendix 4: ASTRONET 2 Task 5.3 Workshop 2

Tools, best practices and methodologies for Technology Transfer — An ASTRONET Workshop

ESO Headquarters
24 November 2014

http://www.eso.org/public/events/special-evt/astronet2014/

The group photo from ASTRONET 2 Task 5.3 Workshop 2: Tools, best practices and methodologies for Technology Transfer. Credit: ASTRONET.

Rationale

There has always been a close coupling between frontier scientific research and cutting-edge industrial development. The ASTRONET Roadmap found that many countries and organisations however lacks a mechanism within their astronomical community to efficiently identify industrial relevance/transfer to other interlocutors or communities as an integral component of their R&D. ASTRONET is now arranging a workshop for new and experienced individuals working with technology and knowledge transfer activities in European astronomy, primarily in the ASTRONET partner organisations, as well as in the EIROforum organisations. Digital tools, best practices and methodologies are used by many technology and knowledge

transfer networks and offices nationally and internationally. This ASTRONET workshop is intended to introduce some of these digital tools and networking possibilities used by existing Technology and Knowledge Transfer Offices for the benefit of the ASTRONET Partners and Associates.

Participants

WG members **in bold** + invited speakers *in italics*:

1. **CHRISTENSEN, Lars L.**	ESO
2. PATKóS, Enikő	ESO (SOC Chair)
3. **KUBE, Jens**	PT-DESY
4. **COLOMER, Francisco**	OAN-IGN
5. **PÖSSEL, Markus**	Haus der Astronomie
6. **Tautvaišienė, Gražina**	TFAI
7. *CHESTA, Enrico*	CERN
8. *SALZGEBER, Frank*	ESA
9. *DIAZ , Lluc*	ESA
10. *MAZUR, David*	CERN
11. *MITCHELL, Edward*	ESRF
12. *BONUCCI, Antonio*	XFEL
13. *ROTH, Martin M*.	AIP, innoFSPEC
14. SKARDA, Vlad	STFC
15. PERNA, Corrado	INAF
16. BONEV, Tanju	BAS
17. WILSON, Sandi	STFC
18. HUGOT, Emmanuel	LAM
19. BERNAGOZZI, Andrea Ettore	OAVdA, INAF
20. WANG, Qiming	SKA

Programme

09:00 *Welcome* by Lars Lindberg Christensen, ESO Head of Outreach and ASTRONET Task 5.3 Chair

09:05 *Welcome* by Enikő Patkós, ESO Risk and IP Manager

09:10 *Introduction to the EIROforum IMKTT activities,* Enrico Chesta, Head CERN TT and IP Management Section, chair of the EIROforum TWG-IMKTT

09:20 *ESA TT lines of innovation*, Frank Salzgeber Head ESA TT Programme Office

09:40 *ESA and the broker network,* Luc Diaz, ESA TT Programme Office

10:00 Q&A

11:00 *Overview of CERN TT activities and networks*, Enrico Chesta, Head CERN TT and IP

Management Section

11:20 *TT tools for active patent portfolio management*, David Mazur, CERN TT Office

11:40 *CERN IP Management and Collaboration Tools*, Nick Ziogas, CERN Software Technology Transfer Officer

12:00 Q&A

14:00 *TT tools & networks and ESRF*, Edward Mitchell, Head ESRF Business Development

14:20 *Innovation tools*, Antonio Bonucci, In-Kind Contributions Supply Chain Manager IKC, XFEL

14:40 *Best practises of KTT in Astrophysics: innoFSPEC Potsdam, a Case Study*, Martin M. Roth, innoFSPEC Potsdam, AIP

15:20 Q&A

16:00 Round table discussion

17:00 Conclusions

17:10 END

Summary

After the introductory presentations ESA gave a very detailed account of the strategy and rationale behind its technology transfer (TT) and knowledge transfer activities (KTT), including explanations on why and how they use many different innovation networks. The second ESA talk allowed the Workshop participants to have an insight into the broker network that ESA built up to support its activities in many ESA Member States.

CERN, similarly to ESA, built up a robust technology transfer unit within its organisational structure. In the very detailed presentation CERN explained why they put a special emphasis on providing in-house expertise to CERN staff to identify transferable intellectual property and know-how. Besides the available in-house technology transfer support, CERN also relays on a set of carefully chosen networks with specific innovation activities. True to its traditions, CERN is proactive in developing tools (e.g. software) to support innovation processes.

Based on the ESA and CERN presentations, it can be concluded that depending on the mission of the respective organisation, the role and structure of the technology transfer units, as well as the applied innovation tools varies a lot. Funding agency-type organisations seems to rely on a broad range of external services and networks, while more research-oriented organisations tend to build up many functions in-house and outsource to networks a more limited set of activities.

ESRF, although the actual manpower dedicated to technology transfer in terms of full-time equivalent is limited compared to ESA and CERN, the account of innovation activities is broad and varied. Technology transfer is a core activity for ESRF. The fairly business-oriented approach that forms the innovation activities of ESRF ensure that the organisation remains successful in the niche market it operates.

The XFEL presentation introduced the concept of innovation malls to the Workshop participants. XFEL, in the process of setting up its own technology transfer unit's structure keeps an eye on many possible ways of making its technology known and available for the benefit of society and its member states. Innovation malls represent a fairly new, but nevertheless already popular way of pushing innovation.

The presentation of innoFSPEC Potsdam gave a perfect example of technology transfer success story in the field of astronomy. The presentation also shed light on the need to set realistic expectations with regard to the time and effort needed to establish an effective innovation procedure.

Conclusions

The last part of the Workshop was dedicated to a Roundtable discussion that allowed the participants to reflect on the respective ASTRONET recommendation in the light of the lessons learned from the speakers.

In broad consensus the workshop participants supported the idea of joint efforts by the ASTRONET members to showcase the benefit of astronomy for the society by publishing technology transfer success stories. However, to enable the joint effort, the following concerns were raised:

1. The size of most ASTRONET partner organisations are below the critical mass for carrying out professional TT activities, as demonstrated by the world-leading speakers in the workshop.
2. Most ASTRONET partner organisations do not even have a contact person for technology transfer activities. To make a significant new step towards the coordination and integration of European resources in the field of technology transfer, ASTRONET partner organisations ought to consider appointing contact persons for this area.
3. Should the above contact persons be appointed, a light and informal networking structure where all or most ASTRONET partner organisation are represented, could be set up.
4. In order to allow a more focused collaboration that has a potential to provide added value, the technology transfer success stories should be collected from areas where complementary expertise of the partner organisations exist.