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Final report on recommendations regarding coordination of large infrastructure projects

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1 Introduction

The ASTRONET Infrastructure Roadmap (2008, update 2014) represents a community-based, comprehensive plan that aims to maintain and strengthen Europe's role in astronomy internationally over the next 10-20 years. It identifies the flagship projects that are currently in the preparatory and design phase, and that are needed to address the key scientific questions in astronomy for the next decade. The present role of ASTRONET is to coordinate European efforts in order to allow Europe to take up a performance determining role in the design phase, and leadership in the construction and operation phases of these large international astronomical infrastructure projects.

In order to realise the high priority large infrastructure projects on the Infrastructure Roadmap, one of the ASTRONET goals is to identify if specific coordination is needed, and if this is the case, to provide specific recommendations for the project implementation. This objective is addressed in the mid-term and final reports on *recommendations regarding coordination of large infrastructure projects*. The mid-term report provides (1) a status update of the large infrastructure projects on the ASTRONET Infrastructure Roadmap and recommendations for the role of ASTRONET in terms of European coordination with respect to each of these projects, and (2) a report on the first forum meeting, organised in the framework of this task, addressing the pan-European positioning of European Radio Astronomy for SKA. The current report addresses additional coordination actions undertaken by ASTRONET, and focuses on challenges of common interest to all facilities (Chapter 3), and the continuation of the discussion on the organisation of Radio Astronomy in Europe for the SKA (Chapter 4).

2 Ground and space-based projects on the Infrastructure Roadmap

In the ASTRONET Infrastructure Roadmap, a number of ground- and space-based projects emerged as clear future priorities. The European Extremely Large Telescope (E-ELT) and the Square Kilometre Array (SKA) are considered the two flagships for ground-based astronomy. These two projects emerged as clear and equal top priorities, with the E-ELT being more mature in its governance and technological readiness, and planned to be realised before the SKA. Three high priority projects have been identified in the medium scale category: the Cherenkov Telescope Array (CTA), the European Solar Telescope (EST), and the Cubic Kilometre Neutrino Telescope (KM3NeT). The ASTRONET Roadmap also lists several large space missions as high-priority projects. The Advanced Telescope for High ENergy Astrophysics (ATHENA+, formerly known as XEUS/IXO) and the New Gravitational wave Observatory (eLISA, formerly called NGO and LISA) were both ranked as the top priorities. Next in priority were two missions to the giant planets: JUPiter ICy Moon Explorer (JUICE, formerly known as LAPLACE) and the Titan Saturn System Mission (TSSM, formerly known as TandEM). Finally the ExoMars mission was ranked just below JUICE/TSSM.

Since the publication of the ASTRONET infrastructure Roadmap in 2008, the large infrastructure projects have been progressing significantly:

- The **E-ELT** project has been approved by the ESO council and has entered the construction phase. With the ratification of the Brazilian membership of ESO in the Brazilian senate and parliament, funding for the construction will be fully secured.
- The location for the **SKA** sites (SKA will be built at two sites, in South Africa and Australia) and the SKA Headquarters (Manchester) have been selected. An organisation structure for the pre-construction phase has been established. The project is now in its pre-construction phase.

- The final design review for **CTA** was completed. The candidate sites have been reviewed and the two sites (northern and southern hemisphere) will be selected in July 2015. A temporary legal entity has been created and plans for the establishment of a permanent organisation structure are in progress.
- The **EST** has gone through the design phase, the scientific community is well organised and preparing for scientific operations. The project is currently experiencing a serious delay because the funding for the preparatory and construction phases has not been secured yet. The EST project is not yet included on the ESFRI list and is trying to get a position on the ESFRI Roadmap.
- A large part of the funding for Phase-I of the **KM3NeT** project has been secured and Phase-I is now in the construction phase and will be operational in 2016. The funding for the full KM3NeT has not been fully secured yet.
- ESA has made a selection of the future large **space-based** projects. Four out of five of the high priority missions on the Infrastructure Roadmap have been selected by ESA: a mission focusing on *the hot and energetic Universe*, a mission focusing on *the gravitational Universe*, the JUperiter ICy Moon Explorer (JUICE), and the ExoMars mission. The fifth one, the Titan Saturn System Mission (TSSM) has not been selected.

Potential ASTRONET coordination actions

With the implementation of the large infrastructure projects advancing steadily, there is a role for ASTRONET to address issues that require coordination at the level of the European funding agencies. ASTRONET can facilitate forum discussions both to address specific needs of the individual infrastructure projects, and generic topics that are of interest to all projects. In the mid-term report the following potential actions have been defined:

- A forum meeting involving all large ground- and space-based projects focusing on Laboratory Astrophysics, the Virtual Observatory and the Astrophysical Software Laboratory, building on the recommendations formulated in other ASTRONET Tasks.
- SKA: there is a role for ASTRONET in the follow-up of the ERTRC recommendations concerning the pan-European organisation of Radio Astronomy in the SKA-era. A first forum discussion involving the key stakeholders has taken place and has been presented in the mid-term report.
- CTA, EST, KM3NeT: monitoring progress and keep exploring a possible role for ASTRONET.


No action is needed for:

- E-ELT: the project is well on track and governance is in the hands of ESO.
- Space-based projects: most high priority projects have been secured through selection by ESA, there is a clear implementation plan and ESA is in the lead. There is no specific role for ASTRONET in terms of European coordination.

The next two chapters describe the actions undertaken since the publication of the mid-term report, i.e. (1) actions aimed at issues that are of common interest to all facilities, and (2) continuation of the discussion on the organisation of Radio Astronomy in Europe for the SKA.

3 ASTERICS: addressing key challenges of common interest

The large projects on the Infrastructure Roadmap sharply focus on their own organisational structure and design requirements. ASTRONET can address issues that require coordination at the level of the European funding agencies, and has a role in stimulating and initiating interaction on topics that are of interest to multiple or all projects, e.g. through facilitating forum discussions. The recently started *ASTERICS* project, will address a number of these cross-cutting challenges and will aim at the implementation of common services and solutions. Jointly, ASTRONET and ASTERICS



will deliver a key contribution to European coordination by facilitating interaction and implementing common actions.

The ASTERICS project

ASTERICS, the Astronomy ESFRI & Research Infrastructure Cluster, has been funded through the Horizon 2020 INFRADEV-4-2014/2015 Call 'Implementation and operation of cross-cutting services and solutions for clusters of ESFRI and other relevant research infrastructure initiatives'. ASTERICS brings together the astronomy, astrophysics and astroparticle physics facilities encompassed within the ESFRI roadmap, including the SKA, the CTA, KM3-Net and the E-ELT. ASTERICS aims at identifying, addressing and solving key challenges of common interest, and at adopting cross-cutting solutions with mutual and wide-ranging benefit to all concerned.

Within the project, there is strong emphasis on Big Data: the general management, curation, interchange and scientific exploitation of data has rapidly emerged as a major challenge that is common to all the astronomy related ESFRI telescope facilities. Specifically, ASTERICS will aim at software re-use and technology co-development for huge data streams, investigate and demonstrate data integration, and adapt the Virtual Observatory framework and tools. In addition, ASTERICS looks towards enabling interoperability between the facilities, minimising fragmentation, encouraging cross-fertilisation and developing joint multi-wavelength/multi-messenger capabilities. ASTERICS will thus deliver an important contribution to the implementation of the ASTRONET Roadmap. ASTERICS will also establish a high level policy forum, and develop outreach and education activities.

Interaction with ASTRONET

ASTRONET has been closely involved in the development of the ASTERICS proposal. The preliminary ideas for the ASTERICS project have been presented to the ASTRONET Board in March 2014, and ASTRONET has actively participated in the ASTERICS preparatory meetings. There are clear links between the ASTERICS objectives and ASTRONET activities.

ASTRONET has presented its activities and discussed the recommendations put forward by the different ASTRONET review committees and working groups. Related to Big Data issues, the ASTRONET recommendations regarding the Virtual Observatory and the Astrophysical Software Laboratory have been very relevant. Big Data issues are key in the ASTERICS activities, and in particular for the Virtual Observatory, ASTERICS will set a major step towards the implementation of the Virtual Observatory for the ESFRI facilities.

There is also a specific role for ASTRONET in the ASTERICS project, i.e. in contributing to the policy forum. This role fits with the ambitions and positioning of ASTRONET in the European Astronomy landscape, and has at the same time a strong networking component for both ASTRONET and ASTERICS.

The ASTERICS Policy Forum

A high level Policy Forum, involving the ESFRI projects and other large astronomy research infrastructures, will be established in order to coordinate and agree new models for joint time allocation, observing and data access/sharing, in addition to other more general policy matters of common interest. ASTRONET and APPEC, the sister organisation of ASTRONET for astroparticle physics, will both play a key role in the organisation of these fora. This provides an opportunity to flag new developments that need to be addressed by the funding agencies in the future. At the same time, the fora will provide a means to involve other relevant research infrastructures. This role will be one of the means for ASTRONET to provide the coordination that is needed to ensure that the European research community can optimally benefit from the infrastructures.

4 Follow-up discussion on the Square Kilometre Array (SKA)

One of the first coordination actions that ASTRONET identified, was to address the organisation of Radio Astronomy Europe for the SKA. Together with RadioNet and GO-SKA, ASTRONET organised a round table meeting that brought together the key stakeholders. The outcomes of this first meeting have been extensively described in the mid-term report.

Further follow-up actions were also triggered by the conclusions and recommendations of the European Radio Telescope Review Committee (ERTRC), that has been established by ASTRONET in coordination with RadioNet. ERTRC presented draft conclusions mid-2013, and after extensive consultation with the community at large, published its final report in June 2015. The ERTRC takes a broader look, from the viewpoint of all of astronomy, at the present situation of radio astronomy in Europe. It also addresses the ongoing efforts to prepare the Square Kilometre Array (SKA) project, and the global collaboration of the radio astronomical community required to realize a project of this size. In parallel, RadioNet has initiated complementary activities in their *Que Sera* workpackage that addresses at the future organisation of European Radio Astronomy.

The ASTRONET activities have brought an external and independent view into the discussion, and have contributed to the common understanding that there is a need for European coordination in order to strengthen the positioning of European Radio Astronomy for the SKA. ASTRONET will continue its initiating and stimulating role in further discussions, and is happy with the recent bottom-up initiative for European SKA Regional Science Centres that is aiming at implementing the European coordination that is needed for the SKA. A first meeting was organised by the European Radio Astronomy research institutes at Schiphol airport in May 2015, and was attended by ASTRONET representatives. More meetings and actions will follow.

5 Conclusions

The coordination action aimed at future large astronomical infrastructures has provided (1) a status update of the large infrastructure projects on the ASTRONET Infrastructure Roadmap, (2) direction regarding the role of ASTRONET in terms of European coordination with respect to these projects, and (3) actions addressing the pan-European positioning of Radio Astronomy for SKA, (4) a role for ASTRONET in the ASTERICS project aiming at cross-cutting issues.

In the coming years ASTRONET will continue to focus on the astronomical flagship projects for the future. The following actions will be undertaken:

- Monitoring the progress of both the ground-based and space-based projects, and identifying potential actions that require coordination at the level of the funding agencies.
- Follow-up on the ERTRC recommendations concerning the pan-European organisation of Radio Astronomy in the SKA-era.
- Active participation in the *European SKA Regional Science Centres* discussions.
- Co-organizing the ASTERICS policy forum to discuss issues of common interest to all the large facilities.

Annex 1: List of Acronyms

ASTRONET	ERA-net aimed at strategic planning of European Astronomy
ASTERICS	The Astronomy ESFRI & Research Infrastructure Cluster
ATHENA+	Advanced Telescope for High Energy Astrophysics
CTA	Cherenkov Telescope Array
E-ELT	European Extremely Large Telescope
ERTRC	European Radio Telescope Review Committee
ESFRI	European Strategy Forum on Research Infrastructures
ESA	European Space Agency
ESO	European Southern Observatory
EST	European Solar Telescope
GO-SKA	Coordinating & supporting policy development of the global organisation of the Square Kilometre Array
JUICE	JUpter Icy Moon Explorer
KM3NeT	Cubic Kilometre Neutrino Telescope
RadioNET	Advanced Radio Astronomy in Europe
TSSM	Titan Saturn System Mission