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1 Introduction

The Strategy & Policy forum (SPOOR) is a task that falls under the auspices of the RadioNet “Sustainability” Work Package (WP4). The goal of the activity is to address high-level strategic and policy matters that are relevant to the coordination, development and funding of radio astronomy in Europe. A good summary of the scope of the activity is included in the previous 18 and 36-month progress reports (D4.1 & D4.4).

In the course of 2018, it became clear that RadioNet was unlikely to be funded by the European Commission (EC) in its current form. At that point, the main focus of the SPOOR core Group was to consider the various options that would permit us to continue to coordinate Radio Astronomy in Europe, including the organisation of key joint networking and research activities previously supported by RadioNet. Towards the end of RadioNet, activities of the Group were also conducted against the backdrop of the development of the recently submitted OPTICON RadioNet Pilot (ORP) proposal. The deliberations and findings of the SPOOR Core Group have been regularly presented to the full RadioNet Board at their face-to-face and teleconference meetings.

In 2020, the SPOOR Core Group was able to reach a consensus regarding the way forward. This draft report summarises the activities over the course of the last 4 years and presents the Group’s main recommendations to the RadioNet Board meeting of 5 October 2020.

2 SPOOR meetings

During the course of the current RadioNet project, several face-to-face meetings occurred, in addition to various remote telecon/video sessions. Details of meetings conducted during the first 36 months of the project are presented in previous progress reports (D4.1 & D4.4). Since then, the SPOOR Core Group met remotely on the 27th of May 2020¹ - outputs from these meetings are recorded via the RadioNet events page. In addition, the SPOOR chair reported to the RadioNet Board on the Core Group’s discussions at its meeting a few days later on the 29th of May 2020. A special RadioNet Board meeting was held on the 5th of October to discuss a draft of the SPOOR Final report (including its recommendations) and the next steps to be taken in maintaining the European Radio Astronomy Collaboration beyond the end of the current RadioNet contract was also discussed.

3 Radio Astronomy in Europe

The discussions of the SPOOR Core Group have taken place against a backdrop of significant change in the field of radio astronomy. In this section, we attempt to “set the scene”, presenting some of the main features of the European radio astronomy landscape, analysing the historical aspects of this very special collaboration and looking forward to the continued coordination of European radio observatories and institutes in the absence of EC funding for RadioNet.

3.1 Setting the scene

The various national radio observatories operate state-of-the-art telescopes that operate over almost the entire radio domain (from metre to millimetre wavelengths). They offer users unique

¹ <https://events.mpifr-bonn.mpg.de/indico/event/153/>

capabilities and are being continuously upgraded and improved. In the last 10 years, several new radio instruments have appeared such as the International LOFAR Telescope (ILT), NenuFAR, WSRT-APERTIF, the Sardinia Radio Telescope (SRT), the Northern Extended Millimeter Array (NOEMA), and of course ALMA. As a result, the size of the radio astronomy community has expanded greatly, and new research groups have appeared all over Europe, often residing within new or expanding university departments. Several observatories are also engaged in related activities, for example, acting as fundamental stations of the geodetic network or participating in global astronomical projects such as the EHT (Event Horizon Telescope).

Many of the European radio telescope facilities are providing the astronomical user community with a level of support that often culminates in the receipt of science-ready data products. The trend for interferometer arrays to include many more antennas (or many more receiver elements), has greatly increased the size and complexity of data astronomers must handle. As the field of view of these instruments has improved, facilities are undertaking systematic large-area sky surveys. In order to deal with this “data deluge”, large scientific collaborations have become more common, often encompassing hundreds of individual scientists. These large multi-national collaborations are familiar with processing extremely large data sets on remote computer servers, often located in other countries. At the same time, individual astronomers or astronomers working in relatively small groups continue to play an important role in the discovery process by focusing on observations of individual objects or specialised topics. Often these small groups are also benefiting from multi-wavelength large-area sky surveys that place their data rapidly in the publicly domain.

3.2 European Radio Astronomy Collaboration

There is a long history of close collaboration between the European radio astronomy observatories that can be traced back to the formation of the EVN (European VLBI Network) and IRAM (Institute de Radioastronomie Millimétrique) in the mid to late 1970's, and the establishment of JIVE (Joint Institute for VLBI in Europe) in the early 1990's. By the mid-1990's, JIVE was beginning to receive significant support from the European Commission (EC), via an EVN programme of Transnational Access (TNA). This eventually led to the first RadioNet project (FP5: 2000-2004) which quickly expanded to encompass not only Networking Activities (NA) but also Joint Research Activities (JRA) and TNA (FP6: 2004-2008, FP7: 2009-2011 & 2012-2015 and H2020: 2017-2020). In the slipstream of these research infrastructure contracts, various activities associated with the development of e-VLBI and the SKA were also supported – EXPReS and NEXPReS (FP6: 2006-2009 and 2010-2013), and SKADS (FP6: 2005-2009), PrepSKA (FP7: 2008-2012), ASTERICS, AENAES & ESCAPE (H2020: 2015-2019, 2017-2019 & 2019-2022). This very strong connection with the EC made it natural for JIVE to adopt the ERIC (European Research Infrastructure Consortium) legal form in 2014 (JIV-ERIC) with associated funding via Jumping JIVE (H2020: 2016-2021). Currently, the ILT is also poised to adopt this legal form in 2021. With the JIV-ERIC now in place, a closer relation now exists between the EVN and the JIV-ERIC, with the latter taking on more responsibility for tasks that are best performed centrally.

RadioNet has undoubtedly proved itself to be a highly successful vehicle for European collaboration in radio astronomy, increasing the diversity of participating institutes beyond the main radio observatories, and addressing issues that scaled the full breadth of the radio astronomy wavelength domain. In particular, RadioNet nurtured several major instrumentation and software R&D programmes, provided direct and unfettered access to national facilities for all European astronomers, and supported a dynamic and inclusive user community. As noted earlier, it also created a staging point for many other EC projects. Over the last 15 years, RadioNet also provided a platform through which important strategic issues could be discussed (e.g. QueSERA and SPOOR), and it assumed responsibility for organising many key community networking activities/events.

As it became clear that the EC would not fund RadioNet in its current form beyond 2020, an important focus of the SPOOR Core Group has been to consider how the overall scientific and technical collaboration of the partners and the associated user community can be maintained.

While the ORP proposal maintains a strong provision for TNA, most of the current RadioNet NAs and JRAs will need to find a home elsewhere. In addition, a major aim of the ORP proposal is to create a new funding model for Transnational Access (now referred to as TA) involving the national funding agencies.

3.3 OPTICON RadioNet Pilot (ORP)

The ORP proposal was submitted to the EC in May 2020, and brings the OPTICON and RadioNet communities together for the first time. The main aims of the proposal are to: (i) provide astronomers with direct access to optical/IR and radio telescope facilities including virtual archives, (ii) harmonise standards and user services across these facilities, also providing specialised training for users, and encouraging joint activities between the various user communities, and (iii) continue to improve and enhance the capabilities of the telescopes and the data products they produce.

The ORP proposal also includes specific Joint Activities (JA) in strategic areas such as long-term funding models for TA, equal opportunities, diversity, and preservation of the sky. The project is also charged with developing a strategic vision with respect to the relation between astronomical research infrastructures and the EC.

Since the ORP attempts to bring two mature but until now largely independent communities together, the consortium is by necessity large – 37 partners in total. In addition, while OPTICON has had a tradition of involving the major funding agencies in the consortium and its Board, RadioNet adopted a more “bottom-up” approach, with the Board populated by observatory or institute directors. Since the ORP proposal has a strong focus on TA, only about half of the current RadioNet partners (13 out of 28) are involved in the ORP. This means that the ORP consortium cannot act as a substitute for the strategic and policy platform European radio astronomy really needs.

In November, the ORP consortium was informed that the proposal had been positively evaluated by the EC. Contract negotiations were underway as this document was in the process of being finalised.

3.4 Impact of the Square Kilometre Array (SKA)

The Square Kilometre Array (SKA) is a 2B€ global project with the SKA1-low and SKA1-mid telescopes sited in Western Australia and the Karoo in South Africa. Initial funding for the telescope is expected to be approved in 2021, with science operations targeted towards the end of this decade. In many different ways, the impact of the SKA on European radio astronomy is likely to be profound. The *SKA Organisation* with its headquarters located at Jodrell Bank is in the process of transitioning to the *SKA Observatory*, the latter being governed by an intergovernmental agreement that is in the process of being ratified by the member countries.

Historically, the European radio observatories have been the major driving force behind the SKA project, largely defining the original concept and helping to establish it as a mega-science project of huge potential and wide European interest. Many of the European radio observatories have very close ties with the current project, actively developing the science case and Key Science Programs (KSPs), and making key contributions to the telescopes’ technical design, including substantial elements of the science data processing system. A similar relation exists between some of the European radio observatories and ALMA. Telescopes such as the ILT, NenuFAR, APERTIF, e-MERLIN, EVN and the Effelsberg 100-m telescope are formally recognised as SKA pathfinders.

While the design of the SKA telescope is now “fixed in stone”, the European radio observatories will remain at the very forefront of the field by continuing to take advantage of the latest technologies that will continue to materialise over the course of the next 10 years. The aim of the European observatories is to provide unique capabilities that both complement the SKA but also realise a highly synergetic relationship with the new telescope, similar to the highly successful relation millimetre/sub-millimetre facilities (e.g. NOEMA) currently enjoy with ALMA.

The SKA intends to devolve the full scientific exploitation of telescope data to SKA Regional Centres – the generation of advanced data products is not in scope of the core project as currently envisaged. Europe will establish a major SKA Regional Centre (SRC) that is likely to be highly distributed, using compute resources spread across the continent. Several European radio observatories have strong ambitions to play a leading role in this activity, especially in terms of providing the expertise amassed via the successful exploitation of the current SKA pathfinder telescopes.

3.5 Future ambitions

The European radio astronomy community has been spectacularly successful over the last two decades, maintaining national facilities at the state-of-the-art, and championing the creation of international facilities on a global scale e.g. EVN, ILT, ALMA, EHT and the SKA. The ambition to preserve an exceptionally strong European radio astronomy capability in the Northern hemisphere is self-evident, and the drive to continue to expand and train an expert user community that is capable of exploiting these facilities directly, including ALMA and the SKA in the South, plus the SKA pathfinders and precursors around the world is indisputable.

Future priorities associated with the RadioNet consortium over the next 10 years include:

- Developing and adopting the latest new technologies, in order to ensure the unique radio astronomy facilities in Europe remain competitive with comparable facilities around the world, and complementary with ALMA and the SKA,
- Growing a vibrant European Radio Astronomy science community capable of fully exploiting, national and international facilities, and providing them with a high-level of uniform services across all facilities,
- Playing a leading role (together with other organisations such as ESKAF – the European SKA Forum) in the establishment and operations of a distributed European SKA Regional Centre, capitalising on current Pathfinder expertise, including scientific exploitation of extremely large data sets,
- Retention of the impressive radio astronomy engineering expertise that has been built up over many decades, and has greatly profited from transnational collaboration in a wide range of different technical projects,
- Protection of the radio spectrum for European and other international radio astronomy facilities, in the face of significant challenges, such as broadband mobile networks and large satellite constellations,
- Expanding Long Baseline Interferometry networks at metre, cm and mm wavelengths, creating global networks augmented by ALMA, the SKA and its pathfinders/precursors.

4 SPOOR Core Group deliberations

Over the course of the last four years, the SPOOR Core Group has participated in a very frank and honest discourse. The discussion was “accelerated” by the news that RadioNet would not be funded beyond 2020. It was also widely appreciated, that a successor to RadioNet would also need to be acceptable to existing organisations that have interests that span the full breadth of the radio astronomy spectrum, i.e. m/cm/mm/sub-mm wavelengths. After some preliminary exchanges, members of the Core Group were prepared to make some personal statements about their own visions for European radio astronomy and how we might best retain and further develop this special collaboration.

4.1 Common objectives

Some common positions emerged from these discussions with shared objectives that need to continue beyond the term of the current RadioNet contract identified. These included the need to:

- Retain within RadioNet an inclusive membership that encompasses all aspects of the entire radio astronomy discipline in Europe,
- Guide and inform the RadioNet contribution to the ORP project.
- Conduct an internal road-mapping exercise for European radio astronomy that covers the full radio spectrum, and couples with major facilities such as ALMA, FAST, ngVLA, ngEHT and the SKA (including its precursors and pathfinders),
- Prepare for European radio astronomy to play a leading role in establishing, operating and exploiting SKA Science Regional Centre activities,
- Connect more closely with the European funding agencies – also via the ORP and ERIC councils,
- Further develop our close connections with radio astronomy partners outside of Europe and engage with broader user communities e.g. Optical/IR (via ORP), X-ray, Gravitational Waves etc.,
- Ensure RadioNet maintains a positive influence on large global projects involving strong European participation e.g. SKA, ALMA etc.
- Identify common technical challenges and scientific interests that all or a subset of the RadioNet partners share, and develop these jointly as part of a multi-partner collaboration,
- Seek and exploit possible sources of new funding (e.g. via future EC R&D programmes) that could potentially support new technical initiatives that are not accommodated within the ORP,
- Continue to share best practice, common procedures, lobbying strategies and information exchange between the RadioNet partners,
- Harmonise so far as possible the user environment, interfaces, proposal systems and analysis software across the RadioNet facilities – also via the ORP,
- Maintain the networking activities that are considered to be core RadioNet responsibilities and that are not covered by the ORP e.g. hosting the CRAF frequency manager, YERAC meetings, etc.

4.2 Concepts & Ideas

Some of the ideas discussed by the Core Group have their roots in the QueSERA Study Group and indeed earlier RadioNet programmes extending back to at least FP6 – e.g. the establishment of a European Radio Observatory (ERO) with a small central office that would act as an umbrella organisation for the myriad of radio astronomy projects that currently operate in relative isolation from each other, despite there being significant overlap in the actors and stakeholders involved. SPOOR discussed a more recent variant of this scenario - developing the JIV-ERIC as this ERO umbrella organisation while pursuing various unions and fusions between boards, projects, organisations etc. Using an existing ERIC as the ERO host is an interesting option since it immediately provides an appropriate legal entity for any scientific infrastructure operating on a European scale, and it also offers significant fiscal benefits on capital expenditures. However, it was also clear that it is difficult for an existing organisation with a record of achievement in a particular area to gain easy acceptance from all RadioNet partners, especially for an expanded role that would cover all of radio astronomy.

Another concept proposed within RadioNet3 QueSERA was the “RadioNet-work” initiative – an entity based on a low-barrier MoU that would be persistent between funding opportunities and have a responsibility to maintain a minimum level of key activities between (or in the absence of) EC funding cycles. This construct was presented in the QueSERA white paper [1] during a period of some uncertainty regarding RadioNet’s future but was never implemented once RadioNet received the news of EC funding in 2016.

This MoU concept was further expanded within SPOOR, also taking into account how other fields organise themselves – a particular example being APPEC (Astroparticle Physics European Consortium). While there are aspects of APPEC that are probably not immediately desirable for RadioNet as it currently is envisaged, it was agreed that adding elements of strategy, policy development, road-mapping and lobbying to the range of core activities did make sense. The need for RadioNet to have awareness of upcoming EC funding opportunities was also considered to be an important activity.

The Core Group therefore discussed two main routes to continue the RadioNet collaboration and the coordination of its key activities:

- (i) Expand the role of the JIV-ERIC to accommodate RadioNet,
- (ii) Establish a new European Radio Astronomy Consortium based on a low-barrier, light-weight Memorandum of Understanding (MoU) agreement.

The first option was not one that all the partners were prepared to develop or endorse. However, a consensus emerged within the Group that pursuing the second option was one way forward that all of the partners could subscribe to. It was also accepted, that institutes such as the JIV-ERIC may be well placed to absorb some of the activities RadioNet has previously organised (subject to funding limitations).

The SPOOR Group also agreed that retaining the name “RadioNet” was important for all options under discussion. The RadioNet brand has significant traction within the community and is highly visible and well recognised at EC and funding agency levels. By retaining the RadioNet brand, the new collaboration can build upon a successful track record built up over 20 years.

5 SPOOR Core Group recommendations

The Core Group recommends that the second option discussed in section 4 should be adopted as the way in which the RadioNet collaboration and its activities can best be continued beyond 2020.

The RadioNet partners should therefore establish a new European Radio Astronomy Consortium also called “RadioNet”, based on a low-barrier, light-weight Memorandum of Understanding (MoU) agreement.

6 Implementation

The goal is to re-establish RadioNet via a low-barrier, light-weight MoU in 2021.

A first goal is for a related Letter of Intent to be signed by as many of the current RadioNet partners as possible, presenting this at the Board meeting scheduled for the 26th of November 2020. This will be the first step in establishing the new MoU organisation.

A sub-group of the RadioNet partners was established to draft the LoI and to further develop the MoU concept. A draft of the LoI text was circulated to the current RadioNet consortium on the 10th of November 2020. The sub-group will also discuss whether the Consortium should include a membership fee. This topic will also be explored at the November Board meeting.

Once the LoI has been signed by a significant number of the current RadioNet partners, the intention is for the new RadioNet consortium to be quickly established in 2021, with all partners signing up to the MoU during the course of that year.

7 Impact of SPOOR

It is clear that SPOOR has addressed some of the key issues facing European radio astronomy on both short and longer timescales. The discussions that have taken place within the Core Group have been candid and frank. There have been difficult moments but the process by which leading observatory and institute directors have expressed their visions for the future has been an extremely healthy and fruitful one. Matters that were not always openly discussed or fully explored have now received significant attention. Input has also been received from the RadioNet Board which has been regularly informed of the Core Group’s progress at all stages. The European radio astronomy landscape has evolved rapidly, even over the last few years, and it is important that leaders in the field consider how best to cooperate in this rapidly changing environment. Ensuring the retention of some key RadioNet activities and attributes beyond 2020 will be the distributed responsibility of the proposed RadioNet MoU-based consortium.

8 RadioNet financial support

RadioNet has supported the organisational cost and the travel expenses of some members of the SPOOR Core Group to the face-to-face meetings. RadioNet funding has been also used to support the participation of the SPOOR WP leader to the IAU General Assembly in Vienna in 2018.

9 Acronyms

ALMA	Atacama Large Millimetre/sub-millimetre Array
APERTIF	Aperture Tile in Focus
APPEC	Astroparticle Physics European Consortium
e-MERLIN	UK radio interferometry array
CRAF	Committee Radio Astronomy Frequencies
EC	European Commission
EHT	Event Horizon Telescope
ERIC	European Research Infrastructure Consortium
ERO	European Radio Observatory
ESKAF	European SKA Forum
ESO	European Southern Observatory
EVN	European VLBI Network
FAST	Five-hundred meter Aperture Spherical Telescope
IAU	Int. Astronomical Union
ILT	Int. LOFAR Telescope
IRAM	Inst. de Radio Astronomie Millimetrique
JIV-ERIC	Joint Institute for VLBI ERIC
LOFAR	Low Frequency Array
nenuFAR	New Extension in Nancay upgrading LOFAR
ngEHT	Next Generation EHT
ngVLA	Next Generation VLA
NOEMA	Northern Extended Millimeter Array
OPTICON	Optical Infrared Coordination Network for Astronomy
QueSERA	Work Package under RadioNet3
RadioNet3	EC funded project under FP7, grant Agreement 283393
RadioNet	EC funded project under H2020, grant Agreement 730562
SKA	Square Kilometre Array
SPOOR	Strategic & Policy Forum, activity under RadioNet
SRC	SKA Regional Centre
SRT	Sardinia Radio Telescope
ORP	OPTICON RadioNet Pilot
VLBI	Very Long Baseline Interferometry
YERAC	Young European Radio Astronomy Club
WP	Work Package
WSRT	Westerbork Synthesis Radio Telescope

References

[1] Garrett, M.A., Charlot, P., Garrington, S.T., Klockner, H-R., van Langevelde, H.J, Mantovani, F., Russel, A., Schuster, K., Zensus, A. 2016, RadioNet3 Study Group White Paper on: The Future Organisation and Coordination of Radio Astronomy in Europe [arXiv:1602.04216](https://arxiv.org/abs/1602.04216)

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