

# Report of the Radio Astronomy Visiting Committee of INAF

31 January 2015

## Executive Summary

A Radio Astronomy Visiting Committee was appointed by INAF in 2014 to advise on possible actions aimed at improving the impact of Italian radio-astronomical research. Committee members are Profs. P.J. Diamond (SKAO), A. Ferrara (SNS PISA), M.A. Garrett (ASTRON), and J.A. Zensus (MPIfR). The panel conducted a series of meetings with the INAF President and his team at the Headquarters in Rome, with the leadership and staff at the Institute of Radio Astronomy in Bologna and at Medicina, at the Astronomical Observatory in Cagliari. Staff at Florence, Catania and Noto were also interviewed.

The RVC recommends that the two major structures, IRA (incl. Medicina and Noto) and OAC (incl. SRT), should be merged and organized into one united INAF Level-2 structure, under a single General Director. The General Director should implement an optimised management structure, especially addressing a coordinated assignment of resources and management for the national facilities such as the SRT and for the national projects such as VLBI, ALMA and SKA. INAF personnel working in radio astronomy in Arcetri and Catania should be invited to join the new structure.

The institutional head office of the new structure, at least initially, should not be co-located with one of the existing structures. A logical choice could be to install this within the INAF headquarters in Rome. The General Director should be present frequently at the sites and should maintain local offices there. This will help to minimise the friction generated by the reorganisation. A standing visiting committee should be formed to advise INAF and the General Director. The two top priorities for the General Director should be to complete the SRT and to bring it into full international VLBI and single-dish operation as soon as possible, and to ensure that Italy is fully engaged in the SKA project.

## Rationale

Radio-astronomical research in Italy and Europe is on the verge of an epochal revolution driven by the advent of new national telescopes like the *Sardinia Radio Telescope (SRT)* and of large international facilities like the *Square Kilometre Array (SKA)*, *Very Long Baseline Interferometry (VLBI)* and the *Atacama Large Millimeter Array (ALMA)*.

In recent history, radio astronomy has always represented one of the most important assets of Italian research in the field of astrophysics. The continued relevance of radio astronomy does not need to be stressed. In addition to complementing optical/IR and high-energy observations in the study of many fundamental astrophysical processes, radio astronomy represents an optimal tool for studies of the early Universe and its constituents. This field of research also plays an important role in driving cutting-edge technological developments. Examples with a significant impact on industrial applications include new digital signal processing approaches, the development of the most accurate clocks, geodesy, Earth remote sensing, weather satellite technology, WiFi, space security, imaging techniques and much more.

INAF has recognized that Italian radio astronomy must be reorganized in order to maintain and to expand its pivotal national role and strong position in the international context, and to prepare for the challenges it will face in the next decades. This reorganization will be informed by an external review of the current structures and activities.

A *Radio Astronomy Visiting Committee (RVC)* was appointed by the INAF Board on 23 May 2014. The members are Prof. Philip J. Diamond (Director General of the Square Kilometre Array Organization), Prof. Andrea Ferrara (Scuola Normale Superiore, Pisa and INAF Board Member), Prof. Michael A. Garrett (General Director of the Netherlands Institute for Radio Astronomy ASTRON) and Prof. J. Anton Zensus (Director at the Max-Planck-Institute for Radio Astronomy). They were invited to act as individual experts and not as representatives of any organization. Prof. Ferrara was appointed by INAF as the Committee President and the Committee elected Prof. Zensus as Chair.

The key objective of the RVC is to advise the INAF Board on possible actions aimed at improving the impact of Italian radio-astronomical research. The RVC was asked to prepare a report within six months and to consider the following in its deliberations:

- Quality and impact of Italian radio astronomy research
- Impact of current national facilities on scientific production
- Present organization and use of human resources and infrastructures
- Projected international impact of national radio-astronomical facilities in the mid- and long-term periods
- Other scientific or technical issues as appropriate.

The report should contain a prioritized list of recommendations for future restructuring, development and engagement of the national radio-astronomical community in the next 20 years.

### **The Activities of the Committee**

The RVC conducted its deliberations in meetings at INAF Headquarters in Rome, by visiting Bologna and Cagliari, and by teleconference. The inaugural meeting was held on 22 September 2014 at INAF Headquarters in Rome. The RVC met for an introduction and initial overview with INAF's President Prof. Giovanni F. Bignami, the Director of Science Dr. Giampaolo Vettolani, the General Director Dr. Umberto Sacerdote and the Head of Ground Based Structures, Dr. Filippo M. Zerbi.

The committee agreed to conduct site visits to Bologna, Medicina and Cagliari, including participation (partly by video conference) from Florence, Catania and Noto. Furthermore, the following specific documentation was requested:

- Self-evaluation documents by 24 October 2014 from the directors of the Institute of Radio Astronomy (IRA), and of Cagliari Observatory (OAC), and from the radio astronomy leaders in Catania and in Florence. These should include:
  - 2 pages of description and self-evaluation of performance in the last 5 years with particular emphasis on strengths and weaknesses;
  - Answers (max 1 page each) were requested to the following questions:
    - Provide information on the total budget including the level of external funds (possibly in form of a pie chart)
    - Describe engagement of the node with industrial projects/development/collaborations
    - Future scientific and technological vision: short-term vs. long-term
    - Describe your local organization node and human resources structure; indicate any problems you may have
    - Directors are invited to ask for questions of unclear aspects. Questions can be directed to the RVC via INAF Administration.
- The committee also requested the following documentation for from INAF administration:
  - Contact list and duty of relevant INAF persons

- Report from Visiting Committee 2007
- Tables from INAF: refereed papers, citation analysis (H-index), PI and participants of approved PRIN/EU projects, engineering papers, outreach
- Papers using Italian facilities
- Global costs of various nodes including personnel
- Demographic information on the staff
- INAF Mission and Strategic plan (in English).

On 3/4 October 2014, the RVC visited the IRA in Bologna and the telescope in Medicina, the following discussions occurred:

- Private meeting and presentation from the director
- Private meetings with IRA staff members
- Private meeting with Florence group leader and staff
- Teleconference with Noto staff
- Executive session
- Medicina site visit to telescope and laboratories

On 17/18 October 2014 the RVC visited Cagliari Observatory, and conducted a series of interviews:

- Private meeting and presentation from the OAC director
- Private meetings with OAC staff members
- Private meeting with Catania group leader and video conference with staff
- Executive session at the SRT site and laboratories

The final face-to-face meeting of the RVC was held on 13 January 2015 at INAF headquarters and included:

- Discussions with the president and the director of science
- Internal discussion of the report and recommendations

The RVC held a further meeting by video-conference on 27 January 2015, to finalise its report and recommendations.

## **The strengths of Italian radio astronomy**

### ***Science***

It was not within the purview of the INAF RVC to comment extensively on the quality of science undertaken by Italian radio astronomers, nor on their productivity. The overall portfolio of research in radio astronomy in Italy is comprehensive and much high quality work is conducted in many areas in all the INAF groups. The committee recognizes two science areas in particular in which Italian radio astronomy has an internationally strong reputation:

1. The study of pulsars is the primary research topic at the Cagliari observatory, the group there is highly productive and engaged in world-class research. Through collaboration, it is fully involved with the key international pulsar projects pursuing the detection of gravitational waves and developing a deep understanding of gravitational and other physics. With the commissioning of the SRT the Italian community will have a powerful tool to provide to the global arsenal of instruments for this research.
2. Extragalactic radio sources and their evolution: the group at IRA has focused on the physics of extragalactic radios sources for many years, using a suite of instruments across the electromagnetic spectrum and a variety of techniques. In particular, their

expertise in the use of polarization techniques to understand the magnetic structure of jets, galactic structures and galaxy clusters, is world-class.

In addition, there is strong and growing expertise in areas primarily related to galactic radio astronomy, namely, astro-chemistry at OAC, stellar evolution at OACT and the study of the interstellar medium and star-formation at IRA; all these areas will benefit greatly as ALMA observations become more routine. Finally, the small geodetic research group at IRA is clearly excellent.

### ***Technology***

INAF is well served by an excellent, world-class radio astronomy engineering team. The team has, necessarily, focused on the development and support of technologies for the SRT, Medicina and Noto dishes. The skills within the team are broad, covering everything from the design and construction of state-of-the art receiver systems, digital signal processing hardware, telescope mechanics, especially in the area of active surface control, digital data transmission, VLBI techniques, antenna control software and more. The staff at IRA (Medicina and Noto) has decades of cumulative experience in many areas; those at OAC are younger, gaining in experience but with superbly equipped laboratories.

The group at OAA is also world-class as evidenced by their involvement in and delivery of key hardware and techniques across a variety of projects. The smaller team at OACT is contributing significantly to SKA design efforts; in particular, the group jointly leads (with Chinese colleagues) the development of the local monitor and control systems for SKA dishes.

INAF has efficiently organized its engagement with the SKA design activities, with engineering resources from across all four groups engaged in four SKA design consortia: Dish, Low Frequency Aperture Array, Telescope Manager, and Central Signal Processing.

### ***Observing Facilities***

After many years of planning and construction effort the SRT is finally approaching full scientific use. As a large, single-dish it will become a major component of the arsenal of such facilities supporting, especially, pulsar timing. When equipped with the planned suite of receiver systems and backends it will also be a useful facility for spectral line astronomy, especially if the atmospheric transparency at the site allows good, high-frequency performance. It must also become an integral part of the European and global VLBI networks. With its relatively southern location and large aperture it will become a cornerstone of the EVN.

The 32-m antennas at Medicina and Noto have been valuable, indeed critical, facilities within the EVN for many years. Their flexibility and reliability, especially when supported by the strong engineering and science teams at IRA, have benefited European and world radio astronomy. Their continued use as well-coordinated Italian members of the EVN is essential.

These INAF radio telescopes taken together present a significant national observing resource that must benefit from well-coordinated and integrated development and operations.

### ***Challenges***

There have been many impressive scientific and engineering developments in INAF's portfolio of radio astronomy activities as the field has evolved from previous local observatory-style operations to national facilities such as VLBI with multiple elements, the SRT as a versatile world-

class instrument and now ALMA and SKA as global megaprojects with Italian R&D stakeholder interests. Unfortunately, INAF's current distributed organization model for radio astronomy is no longer suitable to address the challenges posed by these activities. Overall, there is a lack of efficient coordination and coherence in the management of the large project activities and especially in the allocation of human and financial resources. The individual leadership at all sites is empowered with little autonomy and at the same time a steadily growing friction among the decision makers has reduced to a painfully slow pace the progress in solving even seemingly small problems that involve coordination of resources across INAF radio astronomy structures. The coordination by committee, despite considerable financial support to the projects by INAF, has not been successful in compensating these deficiencies. This is most evident in the commissioning effort for the SRT.

Radio telescopes represent the major investment in astronomical instrumentation residing in Italy and taken together are a major national facility. However, there exists a noticeable gap in INAF's radio astronomy in terms of effective coherent strategic planning and leadership development viewed from a common perspective. Correcting this is essential if INAF wishes to address the challenges of timely and optimal execution of major development projects, but especially of maintaining a competitive international position for the Italian radio astronomy community.

The Italian radio telescopes have their own scientific observing programmes, in addition to a commitment to VLBI, and in particular the EVN. It appears however that the (non-VLBI) single-dish programmes of the 32-metre telescopes is currently generating a very limited science output - the number of publications produced per year and the external demand for access are both low. The justification for continuing to resource the 32-metre single-dish capability is thus unclear. Maintaining the telescopes for VLBI operations is however strongly justified. The SRT is a significant astronomical instrument in its own right but additional resources (in particular additional personnel) are required to make it fully operational. In addition to the pulsar science now planned with the telescope, the SRT represents a major enhancement to the EVN. It is essential that national resources are deployed effectively in order for the telescope to meet its full potential, and international commitments. Overall, in terms of operational facilities, the focus of Italian radio astronomy should lie with the VLBI and single dish capabilities of the SRT, and with the VLBI capabilities of Medicina and Noto.

The IRA in Bologna is widely recognized as the leading and central force of Italian radio astronomy for over 50 years and this is reflected in the institute's broad engagement in radio astronomy development and research. Important developments were initiated there, including the design and construction of the SRT, in the engagement in ALMA and in the leadership towards a participation in the SKA. Many successful Italian radio astronomy engineers and scientists began their careers in Medicina or Bologna before moving on to the other Italian or to international institutions. In recent years there has been a transfer of staff, especially younger people, to Cagliari, Catania, or Florence. This exodus of talented scientists combined with ageing staff demographics has limited IRA's effectiveness in recent years. An increase in scientific staff appointed via an internationally open and competitive process and with diverse research topics is necessary to rejuvenate the development of the scientific staff, to overcome scientific isolation and to better align the IRA with the new science topics that will be enabled via ALMA and the SKA (including the various pathfinders/precursors).

Cagliari Observatory has undergone a very positive transformation towards a second INAF radio astronomy centre. A vibrant research portfolio has developed, primarily based on modern pulsar research. At the same time, the staffs and postdocs have been contributing increasingly in the construction and commissioning efforts for the SRT. Even though the SRT must be viewed and managed as an Italian national observatory, the dedication and enthusiasm of the local staff is key to the efficient and effective exploitation of the new research opportunities. Regional funding to the new national facility, a uniquely Sardinian opportunity not readily available to the same extent elsewhere in Italy, has contributed to this positive development, clearly going beyond the original SRT funding agreement between INAF, the Italian Space Agency and the region. Full

operation of the SRT will require a review of necessary operational staff resources and clear assignment of responsibility, while enabling the observatory staff to conduct and maintain a competitive research programme. This is especially relevant for VLBI coordinated within the EVN and among the Italian telescopes.

Italy is preparing to make a major investment in the SKA and participation in this project increasingly requires strong national coordination. Currently, Italy makes a significant contribution to the SKA design phase but it is not leading any of the consortia work packages. The effort of engaging with the various national scientific, technical and industrial stakeholders is already good but it must be expanded in order to ensure that Italy reaps the full benefit of its investment.

## **Recommendations of the RVC**

The Italian radio astronomy effort is currently distributed across various institutes and facilities. This is a strength, but it has also led to some inefficiency and to considerable friction, especially in terms of the coherence and coordination of the overall programme. While a good collaborative partnership is observed between staff at the various institutes (especially in the area of joint technical developments), the same level of cooperation does not appear to be present at management level. This reduces the impact of Italian radio astronomy in general, and it has, to a degree, led to institutes pursuing primarily their own specific interests. The need for integrated management and control of INAF resources at the various sites is key. In particular, central control of resources and expertise is required in order to rapidly and efficiently bring the SRT into full and reliable operation for VLBI and for single dish observing modes. Only such an integrated approach will result in full scientific exploitation of the SRT by the user community. Therefore, the fusion of the two major institutes (IRA and OAC) under the leadership of a single director is a key recommendation of the panel. The new unified radio astronomy institute under a strong leadership will be well positioned to address these challenges and to implement an effective organizational coordination while maintaining and building on the existing strong local radio astronomy activities at the existing structures.

The RVC recommends the following:

1. The two major structures, IRA (incl. Medicina and Noto) and OAC (incl. SRT), should be merged and organized into one united INAF Level-2 structure, under a single General Director.
2. The General Director should implement an optimised management structure incorporating the existing structures, especially addressing a coordinated assignment of resources and management for the national facilities such as the SRT and for the national projects such as VLBI, ALMA and SKA. One model that the General Director might consider is the appointment of a Head of Operations and a Head of R&D.
3. INAF personnel working in radio astronomy in Arcetri and Catania should be invited to join the new structure.
4. The mission of the united structure should include
  - a. to develop and to execute a comprehensive programme for facilities, research, development, and training in radio astronomy;
  - b. to provide access to top-grade national and international radio astronomical facilities for Italy;

- c. to formulate, lead and manage a coordinated technical R&D programme in radio astronomy and to foster interaction with relevant industries;
  - d. to coordinate radio telescope facility operations and development within a coherent operational programme for all Italian radio astronomy facilities;
  - e. to ensure coherent and efficient Italian participation in international projects, in particular VLBI, ALMA the SKA.
5. The institutional or formal head office of the new structure, at least initially, should not be co-located with one of the existing structures, in order to minimise the friction generated by the reorganisation. A logical choice could be to install this within the INAF headquarters in Rome. The General Director, however, should be expected to maintain continuous contact with the radio astronomers, to be present frequently at the sites, and to maintain local offices there.
6. A standing visiting committee should be formed to advise INAF and the General Director.
7. SRT is a major facility investment. It must remain a top priority to complete the instrument and to bring it into full international VLBI and single-dish operation as soon as possible.
8. INAF participation in the SKA should be considered a top national priority as a future radio astronomical facility for Italian astronomers and should be forcefully pursued.

30 January 2015



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