Report of the Review Committee for the Joint Institute for VLBI in Europe (JIVE)

27 March 2012

Contents

Executive Summary

JIVE is the Joint Institute for VLBI in Europe, formally established in 1993 by members of the European VLBI Network (EVN) Consortium. It is an internationally funded Institute hosted by ASTRON, the Netherlands Institute for Radio Astronomy located at Dwingeloo. The primary mission of JIVE is to operate and further develop the data processor, often referred to as the correlator, and the initial data processing for the EVN, to support EVN operations and the scientists that use EVN facilities. The Institute also carries out a broad range of Research and Development activities in VLBI related fields.

The Review Committee was very impressed indeed by the effectiveness of JIVE and its achievements. The support provided by the JIVE team is quite outstanding. We cannot imagine the job being done more effectively. In our view, JIVE has a major role to play in the future development of precision astronomy and astrometry.

The Committee strongly recommends the continuation of the present programme with all the planned enhancements of the facilities. Equally, the development initiatives should be supported very strongly. We stress that JIVE provides essential infrastructure for the EVN/VLBI network. We cannot imagine the European-global VLBI being achievable without JIVE support.

The EVN and JIVE teams should grasp the opportunities for innovative science which will be of great interest outside the traditional VLBI community. There is great potential for expanding the scope of VLBI observations to much wider areas of astrophysics than in the past and this should be proactively supported by the staff of EVN/JIVE. JIVE staff and EVN users need to give talks at international topical meetings which are not specialised VLBI meetings to make known the new capabilities of VLBI for many different types of astronomy.

The profile of the EVN is lower in Europe than it should be. Increased awareness throughout the European community should be strongly fostered, leading to enhanced involvement. We recommend that champions be identified in each of the partner countries who will promote the importance of the science for astronomy as well as enhancing outreach activities in all EVN member states.

An improved and effective means of keeping exact track of publications which use data obtained with the EVN and correlated at JIVE should be developed. JIVE should formulate a clear policy that the acknowledgement sections of published papers should contain words which recognise the contributions of the EVN and JIVE.

The research and development activities, specifically on digital technology, connectivity, space science applications and astronomical software are very impressive in all aspects . The development of the UniBoard processor is of very considerable importance for the future since it may be the processor of choice for the SKA .

The capabilities for precise solar system astrometry are of considerable interest for the European Space Agency (ESA). We strongly recommend discussion and negotiation with ESA to investigate what

near-field VLBI and e-VLBI can contribute to solar system missions, including a study of the comparative accuracy of VLBI and clock timings for accurate distance measurements.

The science output of the staff is very good. The number of publications in refereed journals per year amounts to 19 for an average FTE staff of 4.5.

The funding of the JIVE operation is of some concern. Senior management has made proposals for stabilising the level of funding. The requests for future funding are entirely reasonable and necessary. We encourage the JIVE board to make strenuous effort to develop a fair and stable funding formula for JIVE since present funding rules are not very satisfactory. The budget will benefit significantly from the introduction of new members, including Poland, Finland, Russia and South Africa. All EVN members should be involved in the JIVE activity and provide support for it.

We welcome the initiative for JIVE to become an ERIC pan-European project if it results in a more secure basis for funding of JIVE. JIVE must remain an inclusive facility for all those partners who wish to use its functions and facilities.

1. Introduction

JIVE is the Joint Institute for VLBI in Europe, formally established in 1993 by members of the European VLBI Network (EVN) Consortium. It is an internationally funded Institute hosted by ASTRON, the Netherlands Institute for Radio Astronomy located at Dwingeloo in the north-east of the Netherlands. JIVE is governed by the JIVE Board which is nominated by the participating national research councils and research institutes which form a sub-group of the EVN Consortium.

The primary mission of JIVE is to operate and further develop the data processor, often referred to as the correlator, and the initial data processing for the EVN, to support EVN operations and the scientists that use EVN facilities. The Institute also carries out a broad range of Research and Development activities in VLBI related fields. A comprehensive description of the Institute and its activities can be found at www.jive.nl.

The JIVE Board has asked the Physical Sciences division of the Netherlands Organisation for Scientific Research (NWO) to coordinate this review of JIVE. The review is intended to consider and assess developments and operations at JIVE since the last review which was carried out in 2006 under the auspices of the European Science Foundation. It also addresses the possible development of JIVE over the next five year period and beyond, particularly in relation to its support and involvement in the Square Kilometre Array (SKA) project. The formal terms of reference provided by the JIVE Board and accepted by the JIVE Review Committee are given in Annex 1.

The membership of the Committee is given in Annex 2. The composition of the Committee consists of an internationally diverse group of expert scientists, some of whom are experts in VLBI, but others are from cognate fields which have the potential to be strongly impacted by the developing capabilities of VLBI. The secretary of the Panel was Saskia Matheussen, Senior Policy Officer at the NWO, who ensured that all aspects of the Terms of Reference of the Panel were discussed and provided guidance on NWO's requirements as appropriate.

The full Committee met on 5, 6 and 7 March 2012 and followed the Agenda in Annex 3. This agenda was developed in consultation with the Chair and members of the Review Committee.

The Committee is most grateful to Dr. van Langevelde and his colleagues for the comprehensive material prepared for the review, for their excellent help throughout the conduct of the Review and for the splendid hospitality enjoyed by Panel members. Special thanks are due to Yvonne Kool who looked after all the detailed arrangements for the meeting and helped it run flawlessly.

2. Overall impressions

The technique of Very Long Baseline Interferometry (VLBI) provides the highest angular resolution obtained in any astronomical waveband. Connecting radio telescopes across continents typically results in angular resolutions of a milliarcsecond or better. In the 1970s and 1980s, these techniques resulted in the discovery of superluminal motions of radio components in active galactic nuclei and

through the following decades the techniques advanced to produce higher and higher fidelity maps of high surface brightness objects, including, for example, supernova remnants and maser sources.

These important astronomical developments resulted in the formation of the European VLBI Network (EVN) in 1980 and in the construction of the Very Long Baseline Array (VLBA) in the USA in 1993. While the latter was a dedicated array of large telescopes, the EVN consisted of a number of large radio telescopes within Europe and then extended to include radio telescopes in Russia, Asia and South Africa. On occasion, telescopes in the Americas join the network for global VLBI observations. Currently, the maximum number of telescopes which have been deployed in any one observation is 22. The agreement between the partners in the EVN network ensures that there are three 3-weeks sessions per year as well as ten 1-day e-VLBI days. By e-VLBI, we mean the operation of the EVN with real-time correlation of the signals from each element of the array (see below). To these 73 days, typically a few days per year are allocated for Targets-of-Opportunity so that the total number of days per year is about 75. In practice, neither the VLBA nor the EVN is 100% efficient in aligning the observing blocks, so that the net hours for the EVN are close to 900 hours per year, compared with 4,000 hours/year for the VLBA. Thus, the time available for VLBI under the EVN agreement amounts to only about one-fourth of that of the VLBA. The EVN has the advantage of a very large collecting area and large numbers of telescopes.

In the early days of VLBI, the observations and data analysis were confined to a relatively small community of radio astronomers. The data analysis required a good understanding of the techniques of radio astronomy and the astronomical topics were largely confined to the traditional interests of radio astronomers. That perspective has changed dramatically over the last 20 years, thanks to the efforts of organisations such as JIVE, which started in 1993, and which have made the techniques and data analysis much more accessible to the user community, also providing effective support in reducing the observational data.

Equally important is the fact that, as the sensitivity, quality and wide field capabilities of the observations have improved, the range of science accessible by VLBI techniques has increased dramatically. In fact, nowadays there is almost no area of astronomy which does not benefit from VLBI observations. In our view, this remarkable advance has not yet been fully appreciated by the community at large. VLBI should no longer be regarded as a niche specialism accessible only by 'black-belt' radio astronomers. Rather, it should be a normal part of the arsenal of observational techniques available to astronomers at large. It is helpful to give some examples of the types of programmes which have already been successfully accomplished by the EVN community supported by JIVE and which are outside classical VLBI topics such as active galactic nuclei, blazars and radio-galaxies. We regard these new areas as of central importance for other astronomical disciplines.

- **Supernovae**
  The milliarcsec resolution available by the VLBI technique enables young supernovae and supernova remnants to be detected in nearby galaxies and their early evolution observed as the shell of the remnant begins to form. In addition, since the detection of radio supernovae is not affected by interstellar extinction, supernova events can be observed in the dustiest star-forming galaxies, events which would not be observed in optical supernova searches. The

development of wide-field imaging using the VLBI technique means that, in galaxies such as M82, the radio supernovae can be monitored, both for their discovery and their evolution.

- **Circumstellar rings and high mass star formation**
  The observation of intense methanol and water vapour maser sources in star forming regions has enabled unique information to be obtained about the kinematics of the rings which form about newly-formed stars. In one striking case, it has been clearly demonstrated that the rings are infalling onto the young star. The wide-field capabilities of the EVN enable the location of the proto-stars in the centres of high mass star-formation regions to be determined, again free from the effects of dust.

- **Distant star-forming galaxies**
  Impressive images have been taken of the central regions of nearby and very distant star-forming systems. The VLBI observations allow the nature of distant ultra-luminous galaxies to be revealed, namely whether they are powered by star formation or by active galactic nuclei. The observations can provide direct measures of the cosmological star formation history, unaffected by the effects of interstellar extinction. Potentially, these observations can extend well into the re-ionisation epoch which will be difficult to access by optical and near-infrared observations.

- **Spacecraft tracking**
  A remarkable application of VLBI has been its application in extremely precise determination of the state vectors of planetary probes. Positions have been measured to a few tens to hundreds of metres precision at a distance of several AU and these have enabled a number of new types of science to be undertaken. Examples include Titan atmospheric dynamics and the mass distribution of Phobos.

- **Astrometry**
  VLBI has provided the most precise astrometry yet achieved in any waveband. The use of methanol masers in star-forming regions has enabled remarkably precise distance measurements to be made. As an example, a parallax with an accuracy of 34 micro-arcseconds has been obtained from 12 epochs of observation over three years for the methanol masers in the Cygnus X complex. The resulting distance of about 1.5 kpc is the most accurate yet measured. It is expected that with the planned enhancement of the facilities, just as for the VLBA, proper motions will be measured beyond the Milky Way, and parallaxes and proper motions obtained throughout the Milky Way itself. The remark was made that, at the VLBA in the USA, the mantra is ‘astrometry, astrometry, astrometry”, indicating the importance of these types of observations for the long-term involvement of the community in the VLBA. In addition, these types of observation will be crucial in relating the astronomical fundamental reference frame determined by GAIA to the radio frame established with even higher precision from the VLBI extragalactic reference frame established by observations of quasars.

These are just a few examples of the outstanding science being carried out by the techniques of VLBI which are of the greatest interests to astronomers whose specialisms lie outside the traditional fields

of the VLBI community. We foresee many opportunities for the wider astronomical community to use the EVN facilities, becoming involved in these types of study, particularly through the efforts of JIVE.

3. The effectiveness of the organisation and its achievements

The Review Committee was very impressed indeed by the effectiveness of JIVE and its achievements. We address each of the questions to which we were asked to respond below. Besides the outstanding support provided by the JIVE team, we highlight three very considerable achievements:

- The wide-field capability of the EVN network supported by JIVE is very impressive. VLBI with many telescopes is no longer just the production of maps of `blobs'. The images produced over wide areas enable large and important new areas of astrophysics to be addressed. We stress the importance of the new JIVE software correlator in obtaining these results.
- Real-time observing using e-VLBI is a remarkable and unique achievement. This development means that the signals from widely separated telescopes can be correlated in real time, resulting in the rapid turn-round of observations to the observer. This development is particularly important for the observation of transient sources such as gamma-ray bursts and rapid X-ray variables. It is also psychologically important since the perception that VLBI consists of much data taking followed by a lengthy period of calibration and image reconstruction is no longer the case.
- More generally, the development efforts in software correlators and the new generation of hardware correlators, such as the UniBoard processor, are striking achievements

We provide the following evaluations of the aspects of the JIVE project which we were asked to address. We use the normal scale of 5 to mean excellent and 1 unsatisfactory.

a*. All aspects of EVN support, specifically correlation, user services, support of the network*

The support provided by the JIVE team is quite outstanding. The evidence provided by the responses to the questionnaire showed a very high degree of satisfaction by the users, with whom the team maintains excellent dialogue. Given the staffing level and resources, we cannot imagine the job being done more effectively. The activities go well beyond simply supporting the users in correlating, collecting and analysing the data. There are many innovative developments led by the JIVE team in the areas of network communications, soft/hardware correlators and analysis software development. We were strongly impressed by the enthusiasm of the staff. We met most of the staff during the session with them and it was clear that it is a happy and strongly motivated organisation. **Score: 5/5**.

b. ***The science output of the EVN***

The EVN, thanks also to the support by JIVE, is clearly producing excellent science. It must be strongly emphasised that JIVE is now responsible for almost all the data correlation required by EVN observations and first data processing. Moreover JIVE provides expert support to non-expert users in data calibration and reduction. Without this support, the activity would fall upon the individual users in the partner countries and it would be very difficult to attain the data quality in such a model.

We are of the strong opinion that the profile of the EVN is lower in Europe than it should be. There is still a perception that VLBI is a 'black-belt' science, but this is no longer true with the services and expertise provided by the team at JIVE. The system is now user-friendly and any astronomer should be able to obtain and reduce their data with the help and guidance of the JIVE staff. At the moment, 440 astronomers are registered in the JIVE database but we believe many more scientists would wish to become involved. Increased awareness throughout the European community should be strongly fostered, leading to enhanced involvement. Stewardship of the science should be diffused. We encourage EVN and JIVE management to identify champions in each of the partner countries who will promote the importance of the science for astronomy. It has to be continually emphasised that the role of JIVE is essential and that the staff participate in the science and support the community in constructive and positive ways.

To support the case for the role of the EVN and JIVE in producing the science, an improved and effective means of keeping exact track of publications which use data obtained with the EVN and correlated at JIVE needs to be established. Recognition of the use of EVN facilities and of JIVE support should appear in the acknowledgements of all papers which use the facilities. A form of words to be used in the acknowledgement sections of published papers should be recommended by the Boards of the EVN and JIVE**. Score: 5/5**.

c. ***The research and development activities, specifically on digital technology, connectivity, space science applications and astronomical software.***

This is very impressive in all aspects. The JIVE team is not just maintaining the system, but is constantly improving and enhancing the capabilities of VLBI. It is also being innovative in, for example, the development of the software correlators which have been built by the experts on-site. As already stated, making eVLBI a reality is a very considerable technical achievement. A measure of that achievement is the very high percentage of time during which the eVLBI real-time correlation procedures have run with 100% success. We note that these developments have been facilitated by the access to wide bandwidth communication at very favourable rates on average. The software correlator has been used as a test-bed for future UniBoard processor and for specialised programmes. The development of the UniBoard processor is of very considerable importance for the future – there will be and are already many potential customers for it and, although challenging, this must be the way ahead. We note that the UniBoard correlator could be of vital importance for the SKA. **Score: 5/5.**

d. ***JIVE's activities as a research infrastructure and its ability to implement EC programmes in the interest of the EVN and its user community.***

We stress that JIVE provides essential infrastructure for the EVN/VLBI network. We cannot imagine the European-global VLBI being achievable without JIVE support. The future programme of JIVE is well aligned with the various European roadmaps with which we are familiar. The JIVE team has demonstrated the ability to coordinate European programmes, examples including the Express, and Nexpress programmes as well as their early involvement in the SKA. In addition, we are strongly impressed and supportive of JIVE involvement in global collaborations, notably with Africa, Russia and China. It is an inspiring model for international collaborations. Through membership of EVN and facilitating correlation and data processing for all participating countries, JIVE has been able to

incorporate countries into scientific collaborations where the development of high technology is of great societal value. We consider in this context the involvement of telescopes in remote parts of China and the various African countries such as Ghana where redundant communications antennae can be fruitfully used for VLBI at modest cost**. Score: 5/5**

e*. In-house scientific research and educational activities.*

Given the size of the staff and the large service load, the science output of the staff is excellent. The number of publications in refereed journals per year amounts to 19 for an average FTE staff of 4.5. It is impressive that the in-house scientists are leading some of the efforts in real-time observations of outburst sources.

JIVE is a service operation for the EVN community and so students associated with it have to be registered at a University. Typically, at any one time, about 3 PhD students are directly involved in the observing programme. The Committee was impressed by the quality of the students whom it met.

The Interferometry schools and annual EVN symposium, in which JIVE participates, are important initiatives, as are the efforts of the summer students who work at JIVE.

Outreach activities are significant but tend to be a subset of those of the host organisation ASTRON.

We strongly recommend enhanced interaction with all member states of the EVN to increase outreach activities. A particular recommendation is that the JIVE staff and EVN users need to give talks at international topical meetings which are not specialised VLBI meetings. We re-emphasise our conviction that VLBI is for the whole astronomical community and that the EVN and JIVE will benefit from the broadening of user community. We like very much the ASTRON-JIVE daily images which can be used to increase awareness. Score: 4/5

Summary:

Taking the five above scores in Section 3**, Overall score = 4.8/5.00 = Excellent**

4. Reflections and Recommendations on Past, Present and Future Activities

The Committee was asked to reflect upon the following topics (see Terms of Reference). We have already covered a number of these topics in Sect. 3.

a. *The satisfaction of the partners in JIVE and their wishes for the development of JIVE services.*

In the view of the Committee, the clear response to this topic is 'Excellent, outstanding, exemplary'. As described above, there is clear evidence that JIVE is satisfying the needs of users in an exemplary manner. They are also being proactive in leading development of EVN on behalf of the community, which attests to the excellence of the team and the confidence that inspires in the community.

b*. The financial implications foreseen on the basis of these wishes.*

The funding of JIVE has been flat for a number of years. As a result, there has been the need to dig into reserves to maintain the appropriate staffing levels. Senior management has made proposals for stabilising the level of funding. We have studied the requests for future funding and find them to be entirely reasonable and necessary. We encourage the JIVE board to make strenuous effort to develop a fair and stable funding formula for JIVE since present funding rules do not appear reasonable and could be a problem in involving all EVN members in JIVE activity. As has been emphasised, JIVE is essential for the correlation and distribution of EVN data. All EVN countries should therefore contribute to the funding of the JIVE operations. Appropriate inflation corrections should be included in the JIVE subscriptions. The budget would benefit significantly from the introduction of new members, including Poland, Finland, Russia and South Africa. It is important for JIVE/EVN to make efforts to increase the user base in all member countries, especially the new ones and China. In the view of the Committee, investment in JIVE represents very good value for money, increasing EVN activity and supporting frontier science with remarkably modest investment.

c*. Options for future technical and operational development at JIVE towards its mission.*

We were strongly impressed by how well the team was on top of all the key elements for the future development of the EVN and JIVE. The path to the future is clear for the whole JIVE team in supporting its mission objectives and enhancing the capabilities through future developments. Among them we include as top priorities:

- the development of the new UniBoard correlator which could be of vital importance for the SKA,
- to continue the excellent support to EVN operations and to EVN users,
- to give attention to the high frequency VLBI including ALMA,
- maintain a strong connection and commitment to the SKA project.

d*. The scientific achievements of JIVE staff obtained in the past years.*

We have discussed this aspect of the operation in Section 3. Given the limited amount of manpower which can be devoted to pure research, the achievements are very good. The support team often become co-authors on some of the very best papers to come out of the EVN consortium.

e*. The science case for the future, in a world-wide context.*

The Committee's view is that the continuation of the present programme with all the planned enhancements of the facilities and development initiatives is to be strongly supported. In addition, we strongly recommend that the EVN and JIVE teams grasp the opportunities for innovative science which will be of strong interest outside the traditional VLBI community. Here are a few examples of what we have in mind.

- The incorporation of e-MERLIN into the EVN will result in much enhanced fidelity and sensitivity for all classes of VLBI observation. The enhancements of capability should be made known widely in the community.
- The full EVN collecting area already amounts of about 10% of that of the SKA.
- Real-time eVLBI observations enhance the attractiveness of the community for all classes variable or burst phenomena and can lead to significant discoveries.
- Using the real-time facility increases the synergies with other telescopes across the electromagnetic spectrum. We would expect strong interest in the study of, for example, LOFAR and optical transients.
- The success of the near-field VLBI observations of space vehicles involved in planetary missions such as Huygens, Mars Express and others planetary missions indicate the possibilities for significant contributions to planetary science. The science includes the study of planetary atmosphere, the surface and sub-surface properties of planets and their satellites and their mass profiles. These possibilities come about because of the great precision with which positions can be measured, accuracies of the order of a few tens to hundreds of metres having already been achieved.
- These capabilities for precise solar system astrometry are of considerable interest for the European Space Agency (ESA). We strongly recommend discussion and negotiation with ESA to investigate what near-field VLBI and eVLBI can contribute to solar system missions, potentially leading to a contribution to JIVE operations. EU involvement in these endeavours should also be explored.
- We noted that there is great potential for expanding the scope of VLBI observations to much wider areas of astrophysics than the traditional disciplines. With the increasing bandwidth, sensitivity and speed to observation, we expect there to be significantly greater interest in the astronomical capability of VLBI observations. Some of the obvious areas were mentioned above, for example supernova and star formation rates in galaxies, but we believe a thorough review would reveal many more important areas. We repeat that making these capabilities known to the non-expert community is an important challenge.
- We note the importance of some of the capabilities for fundamental physics, for example, in precise satellite tracking. The comparative accuracy of VLBI and clock timings for accurate positioning of, say, GPS or Galileo satellites, should be investigated, ideally in collaboration with ESA.
- The importance of relating the GAIA reference system with the quasar-defined absolute fundamental reference system is an important area for fundamental astrometry.
- The development of high frequency VLBI which should include ALMA as a phased array will open a new window in high frequency - high resolution observations.

f. *Governance issues for JIVE and European radio astronomy.*

We were informed of the potential benefits to JIVE of participating in the EU's European Research Infrastructure Consortium (ERIC) programme. Following a detailed study, the JIVE board has made the decision to go ahead with the ERIC. Probably not all the partners can join the ERIC programme, but we were informed that there are ways in which this issue can be overcome. This is seen as a means of providing greater security for the future of the EVN and JIVE. We welcome this development if it

results in a more secure basis for funding of JIVE, on the understanding that JIVE remains an inclusive facility for all those partners who wish to use its functions and facilities. We believe that all EVN members should be involved in the JIVE activity and support.

5. Summary and Conclusions

The Review Committee was very impressed indeed by the effectiveness of JIVE and its achievements. The support provided by the JIVE team is quite outstanding. Given the staffing level and resources, we cannot imagine the job being done more effectively. Our score 4.8/5 = excellent gives some reflection of our judgement of the quality of the operation (Sect 3a). We believe JIVE has a major role to play in the future development of precision astronomy and astrometry. Our specific conclusions and recommendations are as follows:

1. The Committee's view is that the continuation of the present programme with all the planned enhancements of the facilities and development initiatives should be supported very strongly. We stress that JIVE provides essential infrastructure for the EVN/VLBI network. We cannot imagine the European-global VLBI being achievable without JIVE support. (Sect. 3d)

2. We strongly recommend that the EVN and JIVE teams grasp the opportunities for innovative science which will be of great interest outside the traditional VLBI community. We repeatedly noted that there is great potential for expanding the scope of VLBI observations to much wider areas of astrophysics than in the past and this should be proactively supported by the staff of EVN/JIVE (Sect. 4e). A specific recommendation is that JIVE staff and EVN users need to give talks at international topical meetings which are not specialised VLBI meetings to make known the new capabilities of VLBI for many different types of astronomy (Sect 3).

3. The profile of the EVN is lower in Europe than it should be. Increased awareness throughout the European community should be strongly fostered, leading to enhanced involvement. We recommend that champions be identified in each of the partner countries who will promote the importance of the science for astronomy. We strongly recommend enhanced interaction with all member states of the EVN to increase outreach activities. (Sect. 3b)

4. An improved and effective means of keeping exact track of publications which use data obtained with the EVN and correlated at JIVE should be developed. JIVE should formulate a clear policy that the acknowledgement sections of published papers should contain words which recognise the contributions of the EVN and JIVE. The forms of words should be determined by the Boards of the EVN and JIVE. (Sect. 3b)

5. The research and development activities, specifically on digital technology, connectivity, space science applications and astronomical software are very impressive in all aspects (Sect 3c). The development of the UniBoard processor is of very considerable importance for the future since it may be the processor of choice for the SKA (Sect 3c).

6. The capabilities for precise solar system astrometry are of considerable interest for the European Space Agency (ESA). We strongly recommend discussion and negotiation with ESA to investigate what near-field VLBI and e-VLBI can contribute to solar system missions. The comparative accuracy of VLBI and clock timings for accurate positioning of, say, GPS or Galileo satellites, should be investigated, ideally in collaboration with ESA. (Sect. 4e)

7. Given the size of the staff and the large service load, the science output of the staff is very good. The number of publications in refereed journals per year amounts to 19 for an average FTE staff of 4.5 (Sect 3e).

8. The funding of the JIVE operation is of some concern. The project may have to dig into reserves to maintain the appropriate staffing levels. Senior management has made proposals for stabilising the level of funding. We find the requests for future funding to be entirely reasonable and necessary. We encourage the JIVE board to make strenuous effort to develop a fair and stable funding formula for JIVE since present funding rules are not very satisfactory (Sect 4b). The budget will benefit significantly from the introduction of new members, including Poland, Finland, Russia and South Africa. It is important that JIVE/EVN to make efforts to increase the user base in all member countries, especially in new partner countries and China (Sect 4b).

9. We welcome the initiative for JIVE to become an ERIC pan-European project if it results in a more secure basis for funding of JIVE. JIVE must remain an inclusive facility for all those partners who wish to use its functions and facilities. We believe that all EVN members should be involved in the JIVE activity and in providing support for it (Sect. 4f).

Annex 1.

Terms of Reference for the review of the Joint Institute for VLBI in Europe (JIVE) on behalf of JIVE foundation partners under coordination of NWO-Physical Sciences

August 2011

The review will consider and assess developments and operations at JIVE since the time of the ESF-coordinated review of JIVE, published in February 2006. It will address the possible development of JIVE over the next funding period 2012-2017 and a longer-term perspective, particularly in view of the development of the SKA, as well as consider the development of its mission.

In making its reasoned judgment on the mission, strategy, and performance of JIVE, the review panel will consider both JIVE's mandated role to support the operations of the European VLBI Network (EVN) and its in-house programme, both for astronomy as well as technical research and development.

In making the review it will consider:

- The satisfaction of the partners in JIVE and their wishes for the development of JIVE services,
- The financial implications foreseen on the basis of these wishes,
- Options for future technical and operational development at JIVE towards its mission,
- The scientific achievements of JIVE staff obtained in the past years,
- The science case for the future, in a world-wide context,
- Governance issues for JIVE and European radio astronomy.

In the review, the panel will distinguish a number of aspects of JIVE. The panel is asked to provide a rating for all of these aspects separately, as well as an overall rating. The specific elements for consideration are:

1. All aspects of EVN support, specifically correlation, user services, support of the network,
2. The science output of the EVN,
3. The research and development activities, specifically on digital technology, connectivity, space science applications and astronomical software,
4. JIVE's activities as a research infrastructure and its ability to implement EC programmes in the interest of the EVN and its user community,
5. In-house scientific research and educational activities.

The review panel is expected to base its review and evaluation on:

- Documents provided by JIVE: bi-annual reports and additional specific documentation,
- Self-assessment document by the JIVE management,
- The responses on a questionnaire sent by e-mail to JIVE users,
- Statements by the JIVE partners,
- A site visit to JIVE and meetings with its staff.

The JIVE board shall establish the review panel. Financial support for the panel is provided directly from JIVE's general funds. The report of the Review shall be issued as a public document by the JIVE board.

Annex 2.

Membership of the JIVE Review Panel

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Annex 3.

JIVE Review 5-6-7 March 2012, Dwingeloo

Agenda

Monday 5 March 2012			
Hooghoudt/Muller/Colloquium Room, ASTRON/JIVE, Dwingeloo			
13:00 – 13:30	**Pick-up at hotel or direct transport to JIVE**		
	Lunch with JMT		
time	item	speaker/responsible	session open to
13:30 1	**Welcome and introduction**		**JIVE board, JIVE MT**
1.1	Agenda	M. Longair	
1.2	Term of Reference	S. Matheussen	
14:00	Introduction of JIVE	H.J. van Langevelde	
	Progress report 2011	H.J. van Langevelde	
15:30 - 16:00	**Tea break**		
16:00	**Tour of facility**	**MT members**	**All staff**
17:00	**JIVE structure**	**H.J. van Langevelde**	**JIVE board, JIVE MT**
	Personnel, Finances, Governance	H.J. van Langevelde	
	Correlator operations	B. Campbell	
18:15	Return to hotel		
18:30	**Closed dinner**		

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Agenda

Tuesday 6 March 2012			
Hooghoudt/Muller/Colloquium Room, ASTRON/JIVE, Dwingeloo			
8:00	Taxi transport from hotel to ASTRON/JIVE		
8.20	**Current activities**	**JIVE MT**	**JIVE MT, JIVE board**
8:20	e-VLBI	A. Szomoru	
8:45	Correlator progress	A. Szomoru	
9:10	Space Science	L. Gurvits	
9.45	Science by JIVE	Z. Paragi	
9.45 – 10.10	**Coffee break**		
10:10	**EVN science**	**T. Muxlow**	**EVN reps**
10:40	**Science talk 1**: Unveiling the dust heating mechanism in the central regions of (U)LIRGs	Miguel Angel Perez Torres,(IAA),Granada, Spain: research scientist	
11:10	**Science talk 2**: From the edge of the Universe to our own Galaxy	Sandor Frey FOMI Satellite Geodetic Observatory, Penc, Hungary.Deputy Head	
11:40	**Science talk 3**: Methanol maser parallax measurements in the Cygnus X giant star forming region.	Kazi Rygl, Istituto di fisica dello Spazio Interplanetario (IFSI), Rome, Italy. postdoc,	
13:00 – 13:30	**Lunch at ASTRON/JIVE**		
13:30	**Closed session**	**M. Longair**	**Closed**
14:30	Strategy and future	H.J. van Langevelde	otherwise closed
15:15 - 15:45	**Tea break and Meeting with Staff members**		
15:45	Meet with EVN representatives	T. Muxlow S. Garrington	otherwise closed
16:30	Meet with JIVE Board	H. Olofsson S. Garrington	otherwise closed

18:30	**Dinner with JIVE board representatives**		
			T. Muxlow S. Garrington R. Stark 3 users

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Agenda

Wednesday 7 March 2012			
Hotel			
8:30	Session to be held at hotel		
9:00	**Closed session**	**M. Longair**	**Closed**
10:45	Director available for questions	H.J. van Langevelde	Closed
10.50	Preliminary feedback to director	H.J. van Langevelde	R. Stark
12:00	Adjourn		
12:15 – 13:30	**Lunch at ASTRON/JIVE**		