Second Annual Report

Contract N°	**HPRI-CT-1999-40003**
Start date of contract	01 March 2000
End date of contract	29 February 2004
Network Title	**Infrastructure Cooperation Network in Radio Astronomy (RadioNET)**
Website address	www.jive.nl/jive/jive/european/radionet.htm
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Partnership Summary

Participant number (Coordinating partner as participant N°1	Name of Participating Organisation	Name of responsible person	Role in network*
1.	Joint Institute for VLBI in Europe (JIVE)	R.T.Schilizzi	LSF-IHP
2.	National Research Council of Italy (CNR.IRA)	F.Mantovani	LSF-IHP
3.	Max-Planck-Gesellschaft zur Förderung der Wissenschaften (MPG.IRASTR)	K.Menten, J.A.Zensus	LSF-IHP
4.	Helsinki University of Technology (UHELS.MRRS)	S.Urpo	LSF-IHP
5.	Centro Nacional de Informacion Geografica (CNIGE.OAN)	J.Gómez-González	LSF-IHP
6.	Netherlands Foundation for Research in Astronomy (NFRA)	H.R.Butcher	LSF-IHP
7.	The Victoria University of Manchester (UMNC.NRAL)	P.J.Diamond	LSF-IHP
8.	Chalmers University of Technology (CUT.OSO)	R.S.Booth	LSF-IHP
9.	Nicholas Copernicus University (UNICO.DRA)	A.J.Kus	LSF-IHP
10.	Université de Bordeaux 1 (UBOD1.OSU)	A.Baudry	OTHER
11.	Institut de Radioastonomie Millimetrique (IRAM)	M.Grewing	LSF-OTH

* LSF-IHP: a research infrastructure funded for access under the IHP programme
LSF-TMR: a research infrastructure funded for access under the TMR programme
LSF-OTH: a research infrastructure outside the IHP or TMR programmes
USER: a research organization representative of users of the facilities covered by the Round-Table;
SOC: European scientific societies
IND: an industrial or commercial enterprise
OTHER: other types of participant

1. Executive Summary

The Infrastructure and Cooperation Network in Radio Astronomy (RadioNET) coordinates new initiatives in the field of radio astronomy. These include enhancing the quality of operations and making more effective use of the existing European VLBI Network of radio telescopes (EVN), and building up the necessary scientific, technical and organizational consensus for the two major future radio astronomy facilities, the Atacama Large Millimetre Array (ALMA) and the Square Kilometre Array (SKA).

During the second year, RadioNET supported coordination activities at nine EVN institutes aimed at improved quality and interoperability of the network and improving the access to the research infrastructure. A special workshop was held at the Effelsberg Observatory (MPG.IRASTR, Bonn, Germany) to exchange best practices of VLBI operations. The newly established EVN Reliability Index (ERI) was used as a measure of the quality of operations. RadioNET participated in sponsorship of an EVN Summer School (San Pietro, Italy, September 2001) and publication of its proceedings. The Network is also involved in the preparation for the EVN Symposium 2002 (Bonn, Germany, June 2002).

RadioNET supported in part three ALMA working meetings for European astronomers on the ALMA project development (Grenoble, February 2001; Cambridge, June 2001; Paris, February 2002). This resulted, in particular, in achieving progress in such the issues as ALMA configuration design and calibration strategy.

Finally, RadioNET supported participation of the European radio astronomical community in the world-wide effort of designing the Square Kilometre Array. This activity was coordinated through the European Square Kilometre Array Consortium established under aegis of RadioNET in 2000.

2. General Meetings

The contractors met at the Jodrell Bank Observatory (Macclesfield, UK), on 23 November 2001 to review progress and to hear comments from users of the EVN, the European Astronomical Society, OPTICON, and DG Research. The summary of the meeting is attached as Annex 1.

The agenda for the meeting, chaired by R.T.Schilizzi, ICN RadioNET coordinator, was as follows:

1. Welcome, introduction — P.J. Diamond, R.T. Schilizzi
2. Minutes of the previous meeting in Madrid, December 2000
3. RadioNET coordination activity report:
    - 3.1. EVN
        - 3.1.1. Status of EVN — P.J. Diamond
        - 3.1.2 EVN reliability — M.A. Garrett
        - Comments — EVN contractors
        - Comments from EVN users: A.Tarchi (MPIfR, Bonn, Germany)
          M.Marcha (Lisbon University, Portugal)
        - 3.1.3. EVN-2010 — R.T. Schilizzi
        - 3.1.4. EVN School 2001 — F. Mantovani
        - 3.1.5. Future EVN users meetings, symposia and schools — J.A. Zensus
    - 3.2. ALMA — R.S. Booth, A. Baudry
        - 3.2.1. Status of the ALMA project in Europe
        - 3.2.2. RADIONET/ALMA activities
    - 3.3. SKA — H.R.Butcher
        - 3.3.1. Status of the SKA project in Europe
        - 3.3.2. RadioNET/SKA activities
        - 3.3.3. SKA activities in Australia
4. Reports on other EC contracts
    - 4.1. Access to Major Research Infrastructure — M.A.Garrett
    - 4.2 RTD - Enhancing the EVN — L.I.Gurvits
    - 4.3 RTD – Faraday — P.N.Wilkinson
    - 4.4 RTD – AVO — P.J.Diamond
5. Sixth Framework Program — P.Moschopoulos
6. Report on the meeting with OPTICON and joint activities — R.T.Schilizzi, G.Gilmore
7. Comments from the EAS — H.RButcher
8. RadioNET Annual reports, brochure on Radio Astronomy and other administrative matters — R.T.Schilizzi, LIGurvits
9. AOB
10. Date and venue of the next General Meeting

3. Work Progress of the Joint Scientific/Technological Activities or Studies

The Infrastructure Cooperation Network in Radio Astronomy (RADIONET) was established to provide a forum for the exchange of information on good practice amongst infrastructures forming the European VLBI Network (EVN) and between the EVN and its user community, as well as to monitor and stimulate progress in initiatives leading to future large-scale facilities in radio astronomy, the Atacama Large Millimetre Array (ALMA) and the Square Kilometre Array (SKA).

Specific goals of the Network are to

1) enhance the quality and quantity of the access provided to users of the EVN;

2) coordinate input on the scientific imperatives and technical requirements for the ALMA project from the wider astronomical community in Europe as part of the ongoing design and development phase of this project;

3) map out collaborations leading to a formal proposal for the construction of the Square Kilometer Array.

The first annual “Round Table” meeting on astronomy involving RadioNET and OPTICON (the Infrastructure Cooperation Network in optical and infra-red astronomy) took place at the annual meeting of the European Astronomical Society (JENAM 2001, Munich, Germany) on 11 September 2001.

Progress has been made on each of these specific goals during the second year of the contract. Details are given in the following sections of the report.

3.1 Enhancing EVN operations

The goal of this theme of RadioNET is to coordinate the achievement of sustained reliable operation of the EVN as a whole. The work involves

1) organising workshops on VLBI-specific operational practices, optimum maintenance, and on automated systems:
2) coordination and synchronisation of the implementation of new practices and technical improvements at the radio telescopes, participating in VLBI observations;
3) coordination of observations with the EVN, testing the reliability achieved.

The deliverables at the end of the contract period are:

1) improved inter-operability of the radio telescopes in the EVN measured in terms of sustained reliable operation, with the percentage of data lost due to equipment and operational failures being less than 10%;
2) frequency agile operation;
3) automated calibration and flagging of data.

3.1.1 Specific objectives in year 2

The specific objectives for the second year of the contract were to

1) continue implementation of the measures aimed at achieving sustained reliable operation as agreed in the previous contract year, and
2) work out criteria and algorithms for calculating the performance of the array (deliverable no 1). The measures to be implemented are long term in nature and, as planned, will be pursued through the entire duration of the contract.
3) continue a study of new generation data transport methods for the EVN.

3.1.2 Progress made

3.1.2.1 Specific objective 1 – achieving sustained reliable operations

At the start of this ICN contract a detailed investigation was conducted into what factors limit EVN reliability. At this point the main problem was identified with recorder maintenance and check-out. The special-purpose recorders used by the EVN (and other VLBI networks) are now at the end of their development path. It is becoming increasingly difficult to maintain the systems as they become older and in recent years they have been pushed by various development programmes to the very limit of what the technology can deliver. The maintenance and checkout of these systems thus formed the basis of the second RadioNET workshop held in Bonn (see below). Since the workshop took place, there appears to have been a dramatic improvement in the playback performance of the tapes now recorded by the EVN. Although problems with tape recording performance are probably still the dominant area with respect to reliability issues the situation is much better than before. Other problems are beginning to rival recording issues, in particular faults in the data acquisition electronics.

In addition to the RadioNet workshop several other initiatives involving the RadioNet partners have been made in order to improve network reliability and performance. These initiatives have been conducted locally at the EVN institutes. A common theme at many sites is the introduction of a more planned approach to local VLBI activities. In some cases these have taken the form of regular meetings of all staff involved in various aspects of VLBI activities. These so-called "VLBI Target Teams" are designed to ensure that possible problem areas are identified well in advance of VLBI observing sessions. Since VLBI operations usually interact with many other local activities these meetings are essential in order to avoid local conflicts (w.r.t. resources, telescope time, personnel etc). Target Team meetings are also held after the results of the session are known- these ensure some form of critical self-assessment w.r.t. local VLBI operations.

Various other local initiatives have also been taken to improve reliability. More details of these activities are listed below. In many cases, these areas of development are common at several EVN telescopes. It has therefore been important to coordinate all of these activities in order to avoid duplication, ensure compatibility and in particular, continue to encourage knowledge sharing across the EVN.

Typical areas of development that fall into this category include: reducing the complexity and time required to switch from one mode of telescope operation (e.g. local synthesis observations) to VLBI observing, RFI robust receiver development, frequency switching, phase-cal switching, semi-automatic schedule checking, enhanced alarm monitoring via the Field System (FS), improved FS reliability, improved reliability of "remotely" operated telescopes.

A workshop sponsored by the ICN RadioNET was held at the Effelsberg Radio Observatory (Germany) on 24 June 2001. The workshop was attended by twenty engineers and scientists from the EVN institutes. Lectures were given by A.Krauss (MPIfR, Germny), G. Tuccari (IRA, Italy), D. Smythe (Haystack Observatory, USA) and E. Himwich (GSFC/NVI, USA). The participation of both Smythe and Himwich was directly supported by RadioNET under a special authorization from the Commission (e-mail from D.Pasini of 27.04.2001). The travel of many workshop participants was also charged against the ICN RadioNET contract.

The workshop included lectures and practical demonstrations on the following topics: the data acquisition and telescope control system, recorder check-out, second head test procedures, antenna calibration, and a description of the new MkV system.

Each of the elements discussed is crucial to achieving sustained reliable EVN operations. The workshop was considered to be a resounding success. Plans are now being made to repeat the exercise in September 2002.

3.1.2.2 Individual contractor's reports

3.1.2.2.1 Joint Institute for VLBI in Europe (JIVE)

Overall coordination of the improvement in EVN reliability has been the responsibility of the Chairman of the EVN Technical and Operations Group (TOG), Dr Michael Garrett. This has involved setting out the goals of the project, and monitoring progress at the different institutes – ICN RadioNET partners. It is his responsibility to make an evaluation of the performance of the EVN in regard to the first deliverable; a start has been made in terms of the EVN Reliability Indicator (see section 3.1.2.3). He is assisted by the network coordinator, Dr. Z.Paragi who began his term in February 2002 (and by Dr. A.Biggs in the period November 2001 – January 2002). The network performance is being assessed in terms of the EVN Reliability Indicator (ERI). The goal set by the RadioNET work programme is to achieve value of ERI=0.9 (or higher). In close collaboration with the RadioNET partner, HUT.MRRS (see below) JIVE personnel is also actively involved in the development of the next generation VLBI data acquisition systems, based on the disc technology and real-time fibre-optics links between VLBI telescopes and the data processor.

3.1.2.2.2 Institute of Radio Astronomy (CNR.IRA), Italy

The activities at the Medicina and Noto Stations during the second year of the contract were mainly aimed at improving the data acquisition quality. Most of the upgrading work was done in the electronic hardware and to improve the efficiency of the 32-m dish. Great care was also taken to increase the reliability of the station during the VLBI sessions. The tasks have been coordinated by the scientists and engineer supported by RadioNET funding. An engineer was hired to work on the tasks of the Infrastructure Cooperation Programme RadioNET. The main duties for this engineer are:
1) check the observing schedules for VLBI projects and the requested data acquisition set-up;
2) coordinate the completion of the 'frequency agile' system for the antenna;
3) improve the station calibration information.

A new version of the Linux operating system has been installed on the computers which drive the antennas and the data acquisition systems. The computers hardware has also been upgraded. The updated version of the FS (9.5.1) has been installed.

The GPS-Formatter (Station Clock) difference is now continuously acquired in the log file of each VLBI observing project. Two-heads recording is now available. Two new heads (triple cap) have been mounted. Local playback tests showed that recording is of good quality at 80 and 135 ips.

The pointing model of the Medicina dish has been improved by implementing two more parameters. The pointing rms accuracy achieved is +/- 10 arcsecond. A further correction of non-systematic pointing errors is under investigation by an electronic tiltmeter system.

A final design for the new Vertex Room is ready for the Medicina telescope. The replacement has been postponed because of the upgrading of the Noto dish and urgent work on the Azimuth track of the Medicina telescope. The goal of the project is to achieve full frequency agility at both Medicina and Noto 32-m telescopes. The Vertex room will host 8 receivers which will cover the frequency band 4.3-48 GHz. A wide-band receiver working in the

frequency range 4.3-5.8 GHz is under tests. The feed system (horn/directional coupler/polarimeter/omt) is under construction by CSELT.

The active reflecting surface system developed by the Medicina and Noto teams for the Noto dish has been installed. The surface accuracy is now better than 200 microns. The calibration phase in under way. New gain curves for the telescope will be made available. A 50% efficiency is expected at 43 GHz.

Engineers and scientists took part in two meetings mainly devoted to present and future stations reliable operations. The first one was in Bonn (see 3.1.2.1). The second one was at CERN (Geneva) where problems related to the connection of the EVN stations to wide band data transfer links on optical fibre were discussed.

3.1.2.2.3 Max-Planck-Institute for Radio Astronomy (MPG.IRASTR, Germany)

Under the ICN RadioNET contract, MPIfR is enhancing the accuracy of the amplitude calibration data from the Effelsberg radio telescope and is improving the phase-referencing performance of Effelsberg through remote sensing of the atmosphere above the telescope. Future work will involve reduction of downtime due to wind and hardware setup errors. Dr Alan Roy was hired on 01.12.2001 and is carrying out this work.

Effelsberg amplitude calibration is already maintained well by Dr Alex Kraus, so additional efforts are being directed towards measuring and correcting the atmospheric opacity. This will be done using water-vapour radiometry during high-frequency EVN experiments. Construction of a 22 GHz radiometer is nearing completion and testing will begin soon. The radiometer was conceived for phase correction of 86 GHz VLBI experiments, but the RadioNET effort is focused on the extraction of the atmospheric opacity and on the incorporation of these values into the amplitude calibration data for distribution to EVN users.

Added value achieved: This item reduces the workload on PIs, who presently spend significant amounts of time recovering from poor amplitude calibration. Improved calibration will improve users' productivity.

Phase referencing observations often have poor dynamic range, most likely because the actual atmospheric delay is different from that assumed in the correlator model. Under the RadioNET programme, Dr Alan Roy is trialling the use of GPS data to derive the zenith tropospheric delays from measurements made by dual-frequency GPS receivers co-located with the EVN stations. The GPS data reduction package BERNESE is being used in collaboration with the Geodetic Institute at the University of Bonn. A dual-frequency GPS receiver is presently being installed at Effelsberg for atmospheric measurements and for tying the VLBI reference point into the local geodetic network.

Added value achieved: This item reduces the dominant source of error in the correlator model and will lead to the detection of fainter sources with greater reliability, and will consequently reduce the observing time required to achieve a given sensitivity and will reduce the number of re-observations due to failed phase-referencing experiments.

Downtime at Effelsberg has been mostly due to wind. A future study of site weather statistics at the EVN stations could allow optimisation of the session dates to reduce the time lost due to wind. Downtime at Effelsberg has more rarely been due to swapped polarizations or incorrect filter selection. Both could be detected during the setup for EVN sessions if a test signal of known polarization and frequency could be radiated briefly into the front end. Such a project will be considered.

Added value achieved: This item improves the likelihood of Effelsberg participating in EVN sessions as scheduled, by reducing the most common causes of failure.

3.1.2.2.4 Centro Nacional de Informacion Geografica / Observatorio Astronomico Nacional of Spain (CNIGE.OAN)

The "Centro Nacional de Informacion Geografica" (CNIG) has contracted a company (TTI Norte SL) to coordinate achieving sustained reliable operations of the 14 meter radiotelescope at the National Astronomical Observatory (OAN) at Yebes (Guadalajara, Spain) in the VLBI observational campaigns for the European VLBI Network (EVN).

The ICN RadioNET project is coordinating the implementation of the following changes at the 14-m Yebes radio telescope and VLBI data acquisition system:

The MKIV formatter has been upgraded with new firmware on the Data Acquisition Rack (DAR). A new decoder has been installed in the VLBA4 DAR. Several modules of the VLBA4 recorder have been upgraded, including installation of a new headstack, improvement of thin tape transport, and modifications to the Analog Sensor Module.

The replacement for the telescope control computer is progressing well. Several new features have been implemented, in particular, the automatic pointing correction using data from inclinometers.

OAN is also building at Yebes a new 40-meter radio telescope that will operate in the 2-115 GHz band from 2004. Reliability of the new instrument will be a key issue. The expertise being acquired during the ICN RadioNETcontract is being used to better identify the needed specifications of the 40-m for VLBI.

The ICN RadioNET project outcome has been very positive in solving long-standing technical and logistical problems at the 14-m Yebes radio telescope, with the goal of achieving more reliable operations. In particular, the following issues have been addressed:

1) In order to ensure a smooth transition between regular single-dish observations and VLBI experiments with the radio telescope, several aspects of the operations has been upgraded and/or brought under automatic computer control. In particular:

2) An upgraded method for optimal change of the sub-reflector (needed to switch frequencies during the observations) that provides minimum time and maximum security for people and materials has been developed. The phase calibration unit (needed to change between continuum and spectral line experiments) is now under computer control. An automatic computer script to check that the correct software setups, observing schedules, observing modes and procedures, are used, is being developed. A system to monitor the control variables of the S/X receiver has been developed.

3.1.2.2.5 Netherlands Foundation for Research in Astronomy (NFRA, The Netherlands)

During the second year of the RadioNET contract, the primary priority of the Westerbork Radio Telescope (WSRT) has again been to make the telescope robust and reliable and to make it produce quality data. A number of issues have been addressed, coordinated by the RadioNET-supported staff members, Dr. A.R.Foley and Mr. H.-J.Stiepel.

Observing procedures – Work has progressed significantly during the second year with regard to the Telescope Management System (TMS) that manages and controls all WSRT

operations. The VLBI Field System communicates with the TMS in order to execute the VLBI observation patterns. The reliability of TMS control has improved dramatically because of installing new computer hardware and improving the communication handling procedures.

Technical Improvements – The EVN Field System has been upgraded and also a new decoder was installed and the formatter was upgraded in the Mk 4 VLBI station. In addition, the phase-cal injection hardware and software were improved to ensure reliable operation and calibration.

System reliability – It was noted during the first report that the reliability of the whole operation has been approached using modern process control techniques. This effort has continued and has been applied on certain parts of the equipment such as the Multi-Frequency Front Ends at each of the telescopes. The gained experience is now being applied to other parts of the system. In particular, the logging of system parameters has been improved in order to allow tracing errors in the system and to monitor system performance parameters.

Interference monitoring – The WSRT continues an intense program of RFI monitoring in order to identify and analyse sources of RFI. A long-term hardware program has been initiated to install hardware in the system in the data stream at each telescope before the VLBI adding gets done. While this *digital signal processing* hardware is designed to remove the effects of the strongest RFI sources before the process of correlation happens in the WSRT data stream, this hardware will also directly benefit the (tied-array) added signals that results from EVN observations. The results of this pilot program will be known towards the end of the current calendar year.

3.1.2.2.6 The Victoria University of Manchester, Jodrell Bank Observatory (UMNC.NRAL, UK)

The EVN-related work in Year 2 of the ICN RadioNET contract has concentrated on the completion of the VLBI reliability project, coordinated by the ICN-supported VLBI engineer Mr. P. Burgess;
Mr. P. Burgess has overseen the completion of the VLBI reliability programme. This has been an intensive programme aimed at enabling routine switching between the various single-dish and interferometric observing modes at JBO. In the past, this was a labour-intensive process that often resulted in some form of error and the resultant loss of valuable observing time. This year has seen the completion of the mode-selection switch; the writing of software to enable local oscillator signals from a single synthesizer to be propagated to all telescopes and through all observing modes thus removing the need to change synthesizers; and a major effort on improving the reliability of signal transmission and calibration information from the remote Cambridge antenna.

Since the start of this ICN-funded programme we have seen a significant improvement in reliability in JBO's VLBI operation. In the past 9 months we have not lost any data due to a switch between observing modes, whereas in the previous 9-12 month period several observing periods were affected.

3.1.2.2.7 Chalmers University of Technology, Onsala Space Observatory (CUT.OSO, Sweden)

Development of hard- and software to improve reliability and performance of the Onsala VLBI telescopes continued. J.Conway initiated, supervised and/or developed these

improvements whilst being funded by the ICN RadioNET programme. Specific tasks accomplished are described below.

A new local oscillator (LO) system was designed and implemented at the Onsala 25-m telescope in time for the November 2001 EVN session. This allows the LO to be tuned anywhere in the range 600 – 7000 MHz increasing flexibility. This is particularly important in allowing almost instantaneous changes between observing wavelengths of 18 and 21 cm. Previously this required manual intervention at the focus box, which in some cases would be impossible due to high winds. This change was important for the EVN since now all the network telescopes can have rapid changes between 18 and 21 cm improving the efficiency of the session block schedule.

Another important advance was the final design and start of manufacture of a lens-feed system to allow 6cm operations on the 20-m telescope. By moving most 6 cm operations from the 25-m to 20-m telescope, reliability will increase because the latter telescope is enclosed in a radome so that observing time will not be lost due to high winds - a significant problem at present. In addition despite its smaller collecting area the 20-m telescope is expected to be equally or more sensitive because of its more accurate surface. It is expected that the lens-feed and polariser system will be tested in June 2002, possibly including test VLBI observations to check the polarisation purity.

In addition new ultra-broad-band 5 GHz receivers have been obtained from the Chalmers receiver lab (where they were developed for the FIRST satellite IF system, under a separate contract). These receivers can cover the range 4.7 - 7GHz with 5 K noise temperature.

Design work has been finalised on an optical arrangement at the focus box to allow rapid frequency switching on the 20 m telescope. It is hoped to start implementing this later this year.

There have been advances in using the VLBI field system computer to control the telescope parameters automatically, another important aspect of reliability and frequency agility. In the next few months these should allow the phase-cal and LO frequency to be automatically set under the control of the VLBI schedule, removing another source of errors which has limited reliability in the past.

In addition to the work above ,J.Conway at Onsala has been active in promoting improved amplitude calibration across the network. Before the February 2002 EVN session, software was disseminated to allow a standard format for reporting calibration data into the station logs. Software was also made and distributed to all the EVN station friends to calculate flux densities of standard calibrators and antenna beam modifications. Finally local software was produced to analyse station cal data. J.Conway continues to liase with Field System programmers in the US to design improvements in the Field System software to help improve calibration.

3.1.2.2.8 Nicholas Copernicus University (UNICl.DRA, Poland)

The critical areas of the 32-m radio telescope operations as a mmber of EVN affecting the reliability of VLBI data acquisition remained in the center of attention by the management group composed of Prof. A. Kus (Director Torun Centre for Astrophysics-TCfA), Dr. Kazimierz Borkowski (friend of VLBI – coordinator of EVN observations), Mr. Eugeniusz Pazderski (chief engineer, coordinator of all instrumental work at Torun), Mr. Andrzej Kepa (coordinator of telescope mechanical maintenance), and Mr. Grzegorz Hrynek (chief of the software group). In the reported year (March 2001-February 2002), the telescope was fully used and the resulting astronomical observing time covered 84% of the total time. The

accounted loss was due to 11.3% service and test observations, and 1.0% due to technical failures. The total EVN observing time for Torun 32m antenna in reported period 2001/2002 was about 582 hours. The significant improvements of observation quality, compared to 2000/2001, has been achieved by continuing organisational changes and tough operational rules resulting in better coordination of all activities related to the EVN programs.

Technical improvements

The climatic conditions in the front-end of the 32-m radio telescope were improved substantially by several technical measures (an automatic system to blow dry air into the dewar input window and into the feed horns, a better insulation and special plastic covers for L- and C-band feeds).

An old faulty cooling compressor and other parts of the cooling system were replaced. This development is particularly important for the 6.7 GHz receiver, which enables EVN to observe the celestial methanol – an operational feature unavailable at any VLBI network but EVN.

Most of this work related to the front-end and colling system improvements was coordinated by Mr. Kepa and Mr. Pazderski.

Further improvements of the receiver's performance and the reliability of amplitude calibration are the EVN's prime targets. In the reported period the RadioNET-supported staff in Torun supervised and coordinated the following work on the receiver systems of the 32-m telescope:

- Laboratory tests on amplitude calibration for continuous T_{sys} measurements via noise adding radiometer;
- Design and implementation of phase-cal unit for all receivers with allow control via *Field System (FS)* computer;
- Improvements of sensitivity of the 6.7 GHz (5 cm) system;
- Automated operation of all receivers in the vertex room, including frequency selection via *FS* on a minute time scale;
- Redesign of the IF-distribution unit aimed at better isolation between channels.

A newly purchased GPS receiver was installed and put in service. The GPS 1pps versus VLBI formatter clock and H-maser clock are being monitored and recorded. A new HP 53131A counter provides the required high accuracy and reliable time measurements of the Torun's atomic clock.

A systematic service and upgrade of the VLBI data acquisition terminal continued at the 32-m telescope. One of the several important items was to mount the second headstack and a new positioning unit. This was done in 2001 as the major improvement of the terminal characteristics. A new version of the *Field System* with the special modifications for Torun has been successfully installed. The two-headstack operation is now possible. The coordination work done by Mr. Hrynek and his team led to significant improvements of the terminal operation.

The IRDAM weather station WST7000 was fully installed and the required software written. The access to weather data via session's log was enabled. The current weather conditions at the station are provided in real time on our web pages. It can give the PI's an additional, sometimes very important information regarding the quality of data due to local meteorological conditions.

3.1.2.3 Specific objective 2

The reliability of the EVN has been improved by scheduling fringe test (verification) experiments before each major EVN session. The idea is to get basic feedback to the telescopes before user observations are made. In addition, the reliability of the EVN has been monitored through the year via special Network Monitoring Experiments (NME). These are scheduled within each major frequency session. Rapid feedback from the EVN MkIV correlator at JIVE to the telescopes also characterises these experiments, but in addition each experiment is carefully analysed via an automated data analysis pipeline. This produces enough diagnostic information for a very accurate assessment of the network performance to be made. The EVN Reliability Indicator (ERI) was thus introduced during the period of this report - this indicator measures the ratio of good data measurements to the total data measurements originally expected. In the past evaluation the amount of good data was difficult, with the pipeline in place this is simply the amount of data that effectively contributes to the final image/spectral line cube. The average ERI values per year for NMEs scheduled during the past 4 years are shown in Figure 1.

Several other tests coordinated by RAdioNET were made during the first two years in order to improve EVN reliability and performance. These include:

- 2-head test effectively doubling the sustained data rate of the EVN available to EVN users;
- Tests of the upgraded formatter - providing new modes for EVN users;
- Determination of the apparent clock offsets as a function of tape speed and filter width;
- Deep imaging test designed to investigate limits on the thermal noise achievable by the EVN.

These activities were supported by RadioNET, in particular with respect to coordination and management effort. Significant fraction of this effort was contributed by JIVE staff members (M.A.Garrett, R.T.Schilizzi, L.I.Gurvits) as well as the two support scientists – network coordinators, A.D.Biggs (November 2001 – January 2002) and Z.Paragi (from February 2002).

Figure 1. The plot shows an upward trend towards the goal of 0.9 (10% of data lost). Triangles show the ERI values based on the preliminary analysis of NME data before an in-depth analysis has been carried out (usually ending with the production of a radio image). In 2001, a 'pipeline' processing software was introduced to enable a fully automated analysis of NME data. The ERI values for the years 2001 and 2002 are presented as preliminary (triangles) and full pipeline (squares) evaluations. The values for 1997 and 1998, before RadioNET was established, reflect the initial poor performance of several new telescopes in the EVN during the commissioning phase of their equipment.

3.1.2.4 Specific objective 3

A small working group has been set up to investigate options for the future development of raw VLBI data transport in the EVN from the telescopes to the data processor. Particular attention is being paid to new generation commercial off-the-shelf (COTS) tape recorders and portable hard disk drives, as well as possibilities of making use of the pan-European research and education network fibre infrastructure provided by the National Research and Education Networks and GÉANT. The main scientific thrust of this activity is to achieve far greater sensitivity to faint radio sources by transporting data at higher bit rate than has been possible so far. The working group is composed by the scientists and engineers of the Joint Institute for VLBI in Europe and Metsähovi Radio Observatory (Helsinki University of Technology).

Technical Progress
The Metsähovi group built the first prototype of the new VSI-H standard compatible data acquisition board in May-June 2001. At the same time the Haystack group in the USA had built a prototype of the Mark 5 disk-based VLBI recorder and the JIVE group had done some preliminary design work on an alternative disk recorder.

A special meeting to discuss new hard-disk based VLBI data recording systems was held in August 2001 at Schiphol. The relative merits of US-developed Mark 5 prototypes and PC-EVN development work progressing at JIVE and Metsähovi were compared. This coordination meeting discovered that PC-EVN plan would offer significant cost savings and expandability in the future when compared to Mark 5. Thus the meeting recommended continuing the PC-EVN development work. A collaboration network between Metsähovi and JIVE development teams was set up. The coordination has been accomplished mainly with email and teleconferences, but additionally several coordination meetings have been arranged (Metsähovi Radio Observatory, November 2001; JIVE, December 2001).

After successful tests, the Metsähovi group has designed the second prototype and a test interface board for connecting the new data acquisition system to existing VLBI equipment. Compatibility issues with Mark 4 and VLBA systems, the Japanese gigabit VSI sampling system, and data format compatibility issues with Mark 5 disk-based system have been evaluated and taken into consideration in the system design.

The Metsähovi group has written three progress reports:

- "The Sustained Disk Streaming Performance of COTS Linux PCs" by Ari Mujunen describes the results of data storage part of the system.
- "True Off-the-Shelf Mark 5" describes the Metsähovi system architecture.
- "A VSI-H Compatible Recording System for VLBI and e-VLBI" is Jouko Ritakari's paper for the IVS 2002 conference.

The reports have been published on the web and are available at http://kurp.hut.fi/vlbi/instr/'.

Planned/Accomplished Activities
In the original workplan an evaluation of COTS magnetic tape drives was suggested. The recent developments at MIT Haystack Observatory demonstrating the use of magnetic disks have shown that disks will outperform tapes very quickly and at lower cost.

The development groups at Metsahovi and JIVE are building and testing the prototype of the next-generation VLBI data acquisition system that is able to use standard computers and data networks in VLBI.

Standard commercial Gigabit Ethernet switch performance has been briefly evaluated as the basic building block of next-generation VLBI data interconnect/crosspoint switch. Multi-Gbps performance can be achieved using off-the-shelf switches and properly configured Linux computers with both UDP/IP and TCP/IP protocols.

Planned Activities for the Next Period

Coordinating development activities for the next period will include evaluating different methods of extracting sampled VLBI data with standard COTS computers and data communications equipment. A software autocorrelator will be used to verify the validity of data. A simple scalability analysis of COTS hardware/software is performed to check the feasibility of the scalable architecture suggested in design goal documents.

The interoperability between US Mark 5 system and PC-EVN system will be discussed at the Haystack e-VLBI meeting in April 2002. Representatives of Metsahovi and JIVE will attend the meeting under RadioNET sponsorship. .

Exploitation

The three documents created have been published on the EVN Technical email exploder which effectively reaches not only European but also most of the international technical VLBI experts in the world. The documents created important discussion of the feasibility of the ideas presented and they have apparently left a permanent mark in the area.

3.2. EVN Summer Schools and Symposia

3.2.1 EVN Summer School 2001

The NATO Advanced Study Institute Summer School 'The Role of VLBI in Astrophysics, Astrometry and Geodesy' was held in Castel San Pietro Terme (Bologna, Italy) September 17-28, 2001. The school has been co-sponsored by RadioNET, NATO, Italian Consiglio Nazionale delle Ricerche, Istituto di Radioastronomia and attended by 77 participants. The RadioNET funding administrated by JIVE was used to support 11 participants (listed in the JIVE Cost Statement – Details by category appended to this report) from the Member or Associated states. The proceedings of the School are to be published in 2002.

3.2.2 Planned activity: EVN Symposium 2002

Max Planck Institute for Radio Astronomy (MPIfR, Bonn, Germany), an ICN RadioNET contractor, is leading the effort to organise the EVN Symposium 2002 which will be held at the Gustav-Stresemann-Institut (Bonn, Germany) 25–28 June 2002. The Symposium will be followed by the EVN Users Meeting. Procedings of the meeting will be published in 2002 with partial funding from the ICN RadioNET grant. The RadioNET funding will be also used for travel support for selected participants based on the scientific value of their suggested

contribution. The selection will be conducted by the Symposium SOC and the RadioNET coordinator. Information on the Symposium is available at http://www.mpifr-bonn.mpg.de/index_e.html.

3.3. ALMA

RadioNET funds are being used for the coordination of scientific and technical input to the design and development phase of the Atacama Large Millimetre Array (ALMA). In particular, the aim is to establish European scientific and technical priorities for ALMA by organising workshops, writing reports on the outcomes for the ALMA project management, and presenting the outcomes of international scientific and technical meetings.

3.3.1 Specific objectives in year 2

The RadioNET-sponsored ALMA developments in Europe were coordinated via a series specialized scientific and technological meetings In particular, the following major workshops were held during the second year of the RadioNET project

ALMA configuration, IRAM, Grenoble, France, 26 February – 1 March 2001,
ALMA calibration strategy, Cambridge, UK, 21 – 22 June 2001 (Annex 2)
ALMA European Science Advisory Committee, Pars, France, 3 – 5 February 2002

3.3.2 Progress made

ICN RadioNET-sponsored experts continued to be active in the ALMA configuration design process. An ALMA memo (J.Conway, OSO, ALMA Memo series No.348, http://www.eso.org.8082/memos/) was produced in February 2001 describing a self-similar reconfigurable design which fitted into the Chajnantor site.

Work funded by ICN RadioNET was also used to start to develop new linear image processing algorithms which will be valuable in reducing data from the new generation of radio instruments such as ALMA and SKA. Finally funding was used by J.Conway in preparing for the January 2002 ALMA Configuration Critical Design Review in Socorro, USA. At this meeting the main principles of the zoom array concept were formally adopted by the project and the interaction with optimisation methods proposed by others clarified. The European ALMA project will from March 2002 formally employ J.Conway as a consultant on a contract charged with finalising the ALMA configuration design. J. Conway has been involved in meetings with other RadioNET-funded personnel on how the experience gained in ALMA array design can be transferred to the design of SKA configurations.

RadioNET funds were used to support a meeting in Paris in February 2002 to discuss the operation of ALMA. Specifically, the meeting was organised to discuss European coordination of a Regional Support Centre (RSC) i.e. a centre to assist users of ALMA in the generation of their proposals, the reduction of the data and to provide access to the ALMA archive. The meeting was spirited, with various viewpoints being expressed but the conclusion was that an RSC was required to enable full European exploitation of ALMA. A call for proposals for hosting an RSC will be issued in mid-2002.

3.4.3 Planned vs accomplished activities

Three workshops were planned and organised in the second year of the project. The themes of the workshops reflected those topics, which had become crucial in the course of ALMA development. As it was stated in the first RadioNET annual report, a prolongation of the

RadioNET-sponsored ALMA activities into the third and fourth years is highly desirable. A letter requesting such the prolongation will be submitted to the Commission in the second quarter of 2002

3.4.4 Planned activities in year 3

A Workshop on cosmological applications of ALMA originally planned for the second year of the contract will be held in Bordeaux (France) in May 2002. A proposal to organise in mid 2003 a joint scientific workshop on the major large-scale astronomical projects (ALMA, SKA, NGST, OWL) is under consideration

3.5. Mapping studies for the Square Kilometre Array (SKA)

The Square Kilometre Array (SKA) is in an early phase of development as a global project. The main goal of RadioNET activity in this area is to assist in mapping out the collaborations leading to a formal proposal for the telescope. The deliverable will be a document which outlines the scientific case for the SKA, the technical concepts to be employed, plans for prototyping critical elements, a proposal for managing the project including the division of responsibility amongst the partners, and a strategy for seeking funding for the project.

3.5.1 Specific objectives in year 2

The main objectives were

1) to continue coordination efforts in Europe through the consortium of the institutes interested in contributing to the development of SKA,
2) to play a leading role in the global coordination of the project, and
3) to hold workshops on specific technical issues as part of the process of evaluating competing technologies.

3.5.2 Progress

As reported previously the European SKA Consortium has been formed to carry out the activities under this contract and to coordinate with international partners elsewhere in the world. The following activities took place during the second year of the contract.

Contract change

Late in the period, largely as a result of discussions beginning at the December workshop in Bonn, it was decided that an additional activity crucial to deciding the location of the SKA will be a careful study to optimise the array configuration. Funding for this activity could not readily be found, and it has been decided to request a contract change, such that the funding for part-time secretarial support would be reprogrammed to help finance a postdoc to do the needed study. A formal request to this end will follow shortly.

Outreach

A web site to make known as widely as possible the activities of the European SKA Consortium has been constructed. Its address is www.EUSKA.org.
As an aid in promoting discussion of the science to be made possible by SKA, Prof. P.N.Wilkinson at Jodrell Bank has developed generic SKA presentation material that is accessible over the internet. Version 1.0 is now complete and is available at via anonymous ftp at: ftp.jb.man.ac.uk, directory /pub/pnw (one PowerPoint file and 6 movies) or via the web at: http://www.jb.man.ac.uk/~pnw/files.html . Refinement and extension of the material will continue.

Europe-wide Future Planning
In response to a request for comment on proposed guidelines for the Research Infrastructures line of the EU's Sixth Framework Programme (2004-2007), a proposal for an integrated initiative was submitted involving (i) coupling the EVN telescopes to JIVE in Dwingeloo with high capacity fibres, (ii) participation in ALMA, (iii) developing plans for SKA in a global context, and (iv) evolving the initiative into a Council for Radio Astronomy in Europe to provide some of the functions that ESO provides in optical astronomy.

Coordinating a diversity of technical R&D
R&D activities related to SKA are currently concentrated at NFRA in Dwingeloo, Jodrell Bank (JBO) in Manchester, IRA in Bologna, and TCfA in Torun. Very briefly, the main lines of work relating to the SKA project are given below. Coordination of these activities has been made possible by the current ICN RadioNET contract.

Financing under contract HPRI-CT-2001-50031 has been received jointly by these four groups for a coordinated development effort called FARADAY. A main goal is to carry out R&D for producing phased array antenna systems for use at the foci of parabolic dish antennas. At the heart of the project is system integration using complex monolithic microwave integrated circuits (MMICs). The applications planned include cryogenic receivers in the 20-40 GHz band (InP technology) and phased arrays in the 2-5 GHz band (GaAs and SiGe technologies). In addition to the European partners, the ATNF in Australia is participating in the effort, which is planned to yield prototype arrays and feasibility studies for large production arrays.

Added value to the ICN and RTD contracts has been achieved by the addition of grants from other sources. A summary of the main efforts:

The Jodrell Bank group is currently installing COBRA (Coherent Online Baseband Receiver for Astronomy). COBRA consists of a 182-node Beowulf PC cluster designed to handle, in the first instance, a dual polarisation 100 MHz signal from the Lovell Telescope. Its primary role will be to act as a sophisticated pulsar signal processing machine through coherently de-dispersing pulsar data. It can also operate in a spectroscopic mode and can be configured to find and remove RFI. It is hoped that COBRA is a prototype for future radio astronomy software receivers such as those that will be used for SKA.

In collaboration with the University of Birmingham, JBO was recently awarded a grant for the development of High Temperature Super-Conducting (HTSC) filters. These filters are being developed, in the first instance, for use in the L-band and UHF receivers on JBO and MERLIN telescopes with the aim of improving their survivability in the presence of strong RFI.

JBO staff have continued their development of prototype receiver/transmitter systems for the ALMA fibre-optics systems. This is an offshoot of the generic fibre-optics development in which JBO is involved, primarily for the e-MERLIN project. It is envisaged that both ALMA and e-MERLIN will use similar systems based on wavelength-division-multiplexing. The current design for e-MERLIN will result in 30 Gbps/telescope being transmitted to JBO over a few hundred kilometres; ALMA will require data transmission rates of 120 Gbps/telescope but over much smaller distances. Fibre-optics will naturally play a major role in the data transmission system of any conceivable SKA system, as well as in the EVN.

As reported in previous annual report, the group at NFRA has a long-term program to develop the technologies required for the wide-band phased array concept for SKA. In recent months this effort has focussed on completing the Thousand Element Array, THEA. THEA consists of 1024 receiving antenna elements and will be used as an outdoor phased-array system to detect (known) radio sources in the frequency band ranging from 600 to 1700 MHz

in the presence of several strong RF Interfering (RFI) signals. The THEA phased-array system has various new features compared with conventional radio telescope designs: multi-beam operation, adaptive nulling, interference monitoring and reconfigurability of the sub-array units. THEA will also serve as a test-bed for new and advanced technologies that should lead to a higher level of integration and cost reduction. Examples are the use of a high-speed optical link (32 Gb/s) and a new multi-beam analogue beamformer with a high level of integration including the antenna elements.

ICN RadioNET funds were used to organize a meeting on the high-resolution options for the SKA at the MPIfR in Bonn, Germany in December 2001. The talks from this meeting have been published on the web and are being used as a significant constraint on the design of the SKA.

3.5.3 Planned vs accomplished activities

The planned activities were largely accomplished. As explained above, it is expected that the appointment of a post-doctoral scientist to carry out SKA configuration study will be made in mid 2002.

3.5.4 Planned activities in year 2

- Appointment of post-doctoral scientist responsible for SKA configuration studies.
- SKA 2002 Conference (Groningen, the Netherlands, August 2002).
- Participation in International SKA Steering Committee meetings.
- Preparation for the joint meeting on SKA, ALMA, OWL and NGST projects (second quarter 2003).

3.5.5 Meetings and workshops

Three workshops and coordination meetings directly and solely related to the SKA project were held during the report year:

(i) "SKA: Defining the Future" was held on 9 – 12 July 2001, in Berkeley, California. The meeting served to coordinate European activities with colleagues from around the world. Detailed information concerning the program, attendees and results of the meeting are available atwww.skatelescope.org/skaberkeley/ .

(ii) "High-resolution (including VLBI) imaging with SKA" was held on 10 and 11 Dec in Bonn at the Max-Planck-Institut für Radioastronomie. A detailed report on this workshop is available at www.EUSKA.org (Annex 3)

(iii) "New Frontiers in Astrophysics: the Square Kilometer Array" was held on 14 and 15 January, 2002, in Bologna, Italy. A one-day meeting on 16 January presented the project to the wider Italian community. Detailed workshop information (scientific program and list of attendees) is available at www.ira.bo.cnr.it/~skawork/

4. Deliverables

4.1 Enhancing EVN operations

The deliverables at the end of the contract period are:

i) improved inter-operability of the radio telescopes in the EVN measured in terms of sustained reliable operation, with the percentage of data lost due to equipment and operational failures being less than 10%.

ii) frequency agile operation

iii) automated calibration and flagging of corrupted data.

At this mid-point in the contract, we can say that the EVN Reliability Indicator shows that the percentage of data lost is close to the 10% goal for the observing sessions as a whole, but the improvement in performance is showing the desired trend as the measures taken to improve inter-operability become operational practice at the individual EVN telescopes (see sections 3.1.2.2 – 3.1.2.3). Two workshops a year were foreseen in the original work programme, but early on in the contract it was decided that a frequency of once per year for the four years of the contract would allow time to implement the changes arising from the workshop and carry out the test observations. The second workshop was organised in Bonn/Effelsberg in June 2001.

Measures required to implement frequency agile operation differ in both cost and duration from telescope to telescope. Work on this is ongoing at Onsala (Sweden), Noto (Italy), and Jodrell Bank (UK), and is expected to be completed by the end of the contract.

Standard procedures for the provision of calibration data have been agreed by the EVN telescopes and implemented across the network. Concatenated calibration files are produced by JIVE Support Scientists for the users. Work on automated flagging of corrupted data is ongoing and will be completed in the third year of the contract.

4.2 EVN Symposia and Schools

EVN School 2001 was organised as planned in Annex 1 to the contract. The School fulfilled its goal of propagating knowledge of radio interferometry and VLBI widely throughout the astronomical community in Europe. The School Proceedings are in preparation.

4.3 ALMA Workshops

By mid-term in the contract, six ALMA workshops should have taken place instead of the four that were organised. The project as a whole has suffered delays in funding that have had an impact on the priorities for workshop topics. The remaining two workshops are planned to be held in the third and fourth years of the contract. A major deliverable was the document “Science with ALMA”; additional memos have been produced defining the European perspective on the issues covered by the other workshops. This has enabled European astronomers and engineers to be directly involved in defining the scientific and technical profile of ALMA.

4.4 Mapping studies for the SKA

Two meetings a year were foreseen in the original work programme. One technical and two scientific meetings have been organised by the European Consortium to date to focus attention on the desired instrumental specifications, and to establish Europe as a leading partner in this global project. RadioNET partners in the European SKA Consortium also played an active role in an additional technical meeting held in the USA in the second year of the contract.

5. Exploitation and dissemination of results

The results of the workshops on good practice in the EVN are exploited by the individual RadioNET partners, and information on new capabilities for the EVN as a whole are advertised to the wide astronomical community via an action in the Access contract.

The results of the ALMA and SKA workshops directly influence the development of these two projects both from the scientific and technical points of view. The science cases are disseminated to the astronomical community via reports and talks at conferences. Results of a technical nature are generally disseminated as memos, and form part of presentations on the projects at national and international meetings.

A draft brochure on radio astronomy developments in Europe was prepared in December 2001 (in press at the time of this report preparation).

The following list includes major publications on all three themes of the RadioNET contract:

Enhancing the European VLBI Network:

- Proceedings of the 5th European VLBI Network Symposium, ed. J.E.Conway et al. Onsala Space Observatory, June 2000 (67 presentations);
- The Role of VLBI in Astrophysics, Astrometry and Geodesy, NATO ASI Proceedings, ed. F.Mantovani, 2002 (in preparation)
- A.Mujunen, The Sustained Disk Streaming Performance of COTS Linux PCs, MRRS.HUT, Helsinki, 2001, progress report (http://kurp.hut.fi/vlbi/instr/)
- A.Mujunen, J.Ritakari, True Off-the-Shelf Mark 5, MRRS.HUT, Helsinki, 2001, progress report (http://kurp.hut.fi/vlbi/instr/)
- J.Ritakari, A VSI-H Compatible Recording System for VLBI and e-VLBI, MRRS.HUT, 2002, progress report (http://kurp.hut.fi/vlbi/instr/)

ALMA project

- Science with LMA, 2001, http://www.eso.org/projects/alma/science/.
- ALMA Memo Series, No. 300, 303, 310, 348, 360, 363, 371, 386, 394, 395, 396, 398, 410 (http://www.eso.org.8082/memos/).

SKA project:

- High Resolution Options for SKA, ed. R.W.Porcas and M.A.Garrett, 21 presentations, Bonn, Germany, Dec 2001, www.EUSKA.org
- Presentations by R.W.Porcas, M.A.Garrett, P.N.Wilkinson, G.Tofani, M.Perez-Torres, A.Lobanov at the symposium 'New Frontiers in Astrophysics: the Square Kilometer Array', Bologna, Italy, 14-16.12.2002 (www.ira.bo.cnr.it/~skawork/).

6. Management and coordination

RadioNET is managed by the directors of the partner institutes. Coordination of activities takes place via face-to-face meetings at the time of the RadioNET annual general meeting (Jodrell Bank, UK, 23 November 2001), the twice-yearly meetings of the European VLBI Consortium (Torun, Poland, May 2001, and Jodrell Bank, UK, November 2001), ALMA management meetings, and meetings of the International and European SKA Steering Committees. Communication at other times occurs via email and telephone. A website has been established for RadioNET atwww.jive.nl/jive/jive/european/radionet.htm. This includes pointers to the EVN, ALMA and SKA homepages.

The RadioNET Secretariat is headed by Dr Leonid Gurvits at JIVE. His duties have involved organisation of meetings, administering the travel support provided to participants in EVN School 2001 as well as to participants in the ALMA and SKA meetings, and writing reports.

The partnerships with institutes in Australia and Canada have not yet yielded RadioNET-related collaborations because no matching travel funds have yet been made available in those countries. There is hope that this situation will improve in the near future, at least in Australia.

Table 1 summarizes the actual budget profile during the second year f the contract against the original plan.

The RadioNET and OPTICON coordinators and many of the partners plan to meet on a regular basis once a year at the JENAM (Joint European-National Astronomical Meeting) and on other suitable occasions. These Round Tables provide a forum for discussion of the separate and joint activities in the two networks, as well as for the discussion of the

timescales and priorities for future large projects in European astronomy. The first such meeting took place at the JENAM in Munich (Germany) in September 2001.

Table 1: Budget profile in the year 2 of the contract

Partner	Personnel cost (kEuro)		Travel costs (kEuro)		Other specific costs (publications) (kEuro)		Overhead (kEuro)	
	plan	actual	plan	actual	plan	actual	plan	actual
JIVE	31	41.214	7.75	15.899[a]	0	0	0	0
CNR.IRA	30	23.238	2.10	4.473	0	0	0.4	0
MPG.IRASTR	30	8.035	7.10	3.680	4.0	0	0.4	1.018
UHELS.MRRS	30	40.374	0	2.425[b]	0	0	0	0
CNIGE.OAN	30	27.136	0	0	0	0	0	0
NFRA	41.25	49.566	12.10	9.488[c]	0	0	2.4	0
UMNC.NRAL	20	16.579	2.1	6.73[d]	0	0	4.417	4.662
CUT.OSO	30	34.619	12.1	1.275[e]	0	0	2.4	0
UNICO.DRA	30	19.268	2.1	0	0	0	0.4	0.4
UBOD1.OSU	0	0	10	0[f]	0	0	2.0	0
IRAM	0	0	0	10.395[g]	0	0	0	2.078[g]

[a] Travel expenses include those of D.Smyth and W.E.Himwich (both USA), authorized by the Commission (e-mail from D.Pasini of 27 Apil 2001) and M.Garrett (for R.Schilizzi) to the SKA meeting in Berkeley (USA), authorized by the Commission (e-mail from P.Moschopoulos of June 2001).

[b] Travel by J.Ritakari to the Second IVS meeting (Japan) authorized by the Commission (e-mail from P.Moschopoulos of 24 Jan 2002).

[c] Travel expenses include those of H.Butcher and A. van Ardenne to the SKA meeting in Berkeley (USA), authorized by the Commission (e-mail from P.Moschopoulos of June 2001).

[d] This include:

- subsistence expenses of P.Wilkinson (SKA meeting, Boston, USA, January 2001); corresponding transportation expenses appeared in the first annual report cost statement. The trip authorized by the Commission (D.Pasini) in December 2000;
- travel expenses of P.Diamond to the SKA meeting in Berkeley (USA), authorized by the Commission (e-mail from P.Moschopoulos of June 2001).

[e] Major ALMA-related travel expenses are reallocated from the Year 2 to the Year 3 of the contract.

[f] Major ALMA-related travel expenses are reallocated from the Year 2 to the Year 3 of the contract.

[g] All expenses related to ALMA meetings; funds re-allocated from the Year 1 of the contract.

Annex 1:

Summary of the second Annual General Meeting of the Infrastructure Cooperation Network in Radio Astronomy

Jodrell Bank, UK, 23 Nov 2001

1). EVN reliability. A summary of the co-ordinated activity across the EVN was given by the chairman of the EVN Technical and Operations Group. A very useful Workshop on tape recorder maintenance and check-out procedures had been held in July 2001. The concept of the EVN Reliability Index (ERI) was introduced for the first time; it provides a quantitative measure of the fraction of usable data going to the astronomer compared to the ideal situation. Comments on this report were made by the partners and again by two users supported by the Access contract. Both users showed exciting results obtained with the EVN.

2). *EVN-2010.* Progress in developing concepts for next generation data transport systems for the EVN were reported. This included a short term solution based on PC hard-disks to directly replace the tape recorders and, on the longer term, the transport of radio astronomy data along the national and European optical fibre networks from the telescopes directly to the data processor in the Netherlands. This holds the exciting prospect of creating an online telescope as large as Europe.

3). *EVN School 2001*. A report was given on the successful EVN School held in September in Italy and co-sponsored by the NATO Summer School programme. Thirty-seven students and 15 lecturers spent 10 days examining the scientific and technical aspects of high angular resolution observations for astronomy and geodesy.

4). *ALMA activities.* Reports were given on the Grenoble workshop on array configuration design. The European concept from one of the RadioNET partners, Onsala Space Observatory, has been adopted.

5). *SKA activities*. A brief summary of the SKA science meeting in Berkeley (July 2001)was given and preparations for the High Resolution SKA workshop (Bonn, December 2001) and the SKA science symposium in Bologna (January 2002) discussed.

6). *Relations with Opticon*. The first “Round Table” meeting held during the JENAM conference in Munich in September was judged to have been very useful in informing the wider astronomical community of the activities in both ICNs, and in particular the status and timescales of the major new instruments planned in the Radio and Optical/IR communities. It was decided to make these Round Tables an annual event.

7). *RadioNET brochure.* Details of the requirements for the brochure on RadioNET commissioned by the EC were discussed and responsibilities assigned.

8). *Status of related EC contracts, and information on the FP6 programme.* Progress reports were given on the FP5 Access and FP5 RTD (Faraday) contracts, as well as a final report on the FP4 RTD. Illuminating information on the FP6 programmes was also given by the EC representative.

Annex 2:

Report of Calibration Strategy Review Committee on ALMA Calibration Strategy
Preliminary Design Review
Cambridge, England, 21-22 June 2001

Committee Members:
ALMA Division Heads/IPT Leaders
Jaap Baars (jbaars@eso.org), Bob Brown (rbrown@nrao.edu), Darrel Emerson (demerson@nrao.edu), Stephane Guilloteau (guillote@iram.fr), Tetsuo Hasegawa (tetsuo.hasegawa@nao.ac.jp), Kohno Kotaro (kotaro@nro.nao.ac.jp), Morita Koh-Ichiro morita@nro.nao.ac.jp), John Payne (jpayne@nrao.edu), Simon Radford (sradford@nrao.edu), Gie Han Tan (ghtan@eso.org), Wolfgang Wild (wild@astro.rug.nl), Al Wootten (awootten@NRAO.EDU)
External Reviewers:
Mel Wright (wright@astro.berkeley.edu), Anne Dutrey (Anne.Dutrey@obs.ujf-grenoble.fr), Bob Sault (Bob.Sault@atnf.csiro.au), Peter Schilke (schilke@mpifr-bonn.mpg.de).
The Committee believes that although a start has been made, there is a substantial amount of work remaining before we can be sure that ALMA may be calibrated to the desired accuracy.
General comments
1) Getting an end-to-end description of the calibration system (whether this be stability requirements on the hardware or calibration observations or calibration technique) needs to be pursued vigorously.
Moreno and Guilloteau's work on the times required to calibrate the instrument is also obviously an important adjunct to this.
2) It is attention to detail in much of this work that is required in the long run, and it is too easy for approaches which involve sophisticated modelling to fail to note or solve the real problems. It is important to prototype as much as possible of the calibration system, and preferably in an environment which is as similar to Atacama as possible.
3) The lack of coherent direction in the present design and development stage of ALMA clearly reflects on work in the calibration area. A coordinated Calibration Group is needed to direct and assess efforts.
At the present meeting, representatives of the system, receiver and science groups were in attendance; this seems a sensible core for this group.
4) Although the SSR group actively pursues examination of the observing modes for ALMA they should do so in close collaboration with the Calibration Group.
5) The ASAC has recommended a goal: "The ALMA calibration specification of 1% for absolute intensity is adequate scientifically perhaps even a bit aggressive." This may be achievable in the millimeter region but will be difficult in the submillimeter. The committee recommends that the specification for acceptance be achievable, for instance 1% * (nu/100 GHz). At 3mm standing waves may compromise achieving this; work should be directed at understanding this aspect of calibration.
Specific details:

Absolute calibration.
Welch described a system under study at BIMA incorporating a standard gain horn used to observe a standard object. The calibration is then transferred to the antenna by comparison with the antenna receiver, thence to the array. Study should continue at BIMA and migrate to the
ALMA project book for incorporation into the array.
Receiver calibration In conjunction with points 1 and 2 above, it is important for the project to devote resources to implementing the semi-transparent vane calibration system, on an existing antenna or on one of the prototype antennas. This will test basics of the design but

the final complex design can only be tested with an ALMA dewar and prototype receiver system.
Proposals include the semi-transparent vane system, and the dual load calibration system described in the project book. For the former, materials need to be tested to identify one whose scattering properties are acceptable. Engineering is apparently soluble though complex and should be carried out on a prototype antenna. The dual load system provides continuous monitoring of the atmosphere and an engineering model exists. However, questions about standing waves, frequency dependence and access/reliability cause some concern; further investigation should be pursued.

Phase calibration

The phase calibration system employs novel elements water vapor radiometry and fast switching. The radiometry remains in a boutique stage employed by some few observers for demonstrations. It needs to be developed so that observers use it in the course of executing normal scientific experiments. Extension to 183 Ghz is urgent as nothing will highlight the problems implementing this on ALMA more than a prototype system will. Simulations should be performed to help guide the hapless observer toward employing the system which will do his science the most good. Simulation of calibration at one frequency and transfer to another should be considered. WVRs will be totally useless for dry fluctuations. There are other instrumental phases that will still need to be solved for, such as incorrect baselines. Scaling astronomical phase measured at 3mm to other frequencies ignores some residual instrumental phase errors that may not scale with wavelength The IRMA device has sensitivity but details of its implementation remain unclear--how does it respond to particulate water. Some discussion was devoted to an IRMA sweeping a cone on the radio axis as a seeing monitor (see below).

Photonic calibration

The photonic calibration system is promising but needs to be demonstrated in the field. Point 2 is particularly relevant here how does the system interact with other systems on the telescope (particularly the antenna/receiver system).

Bandpass calibration

Bandpass calibration will be complicated by weak available sources, standing waves and other problems. For single antennas in total power mode sideband gain ratio calibration is to be performed in interferometric mode.

Single antenna

Single antenna calibration was notably lacking in discussion although originally on the agenda. Calibration of single antennas differs from calibration of interferometers in critical ways. More attention should be paid the standing wave patterns in the antenna owing to possible problems with the dual-load calibration system and the antenna of the photonic calibration. This requires collaboration between Antenna, Science, System and Receiver groups, at least. What is an acceptable level?

Atmosphere

Modeling of the atmosphere has progressed very well. The effects of ice particles and liquid water in the higher frequency windows cannot be accounted for well by the WVR alone. A standalone FTS at array center could provide a diagnosis for this. When particles are present it is unclear the WVR will be useful. A temperature sounder operating at 60 GHz was described; this off the shelf item should be operated in conjunction with the array weather station.

Pointing

Pointing calibration seems well in hand. Wave front tip/tilt problems could conceivably cause 20-50% amplitude errors at the highest frequencies but need further investigation. This was identified as a possible implementation of IRMA. The scanning IRMA system sounds very promising, but is totally unproven and no more than a concept. Demonstrating this would seem to be a priority. Using a guide star for pointing sounds a good technique if calibration of the offset in the optical and radio axes, which is likely to be frequency and elevation dependent, can be accomplished. This technique needs to bedemonstrated at the the 0.5 arcsec level.

Polarization

Discussion of polarization calibration was deferred to a subsequent meeting. The photonic system needs further investigation to know whether it will be sufficient.

Actions Needed

1) Receiver calibration needs engineering realization. Materials need to be identified for vane calibration and incorporated into a working version for testing. Testing of the dual load calibration system should continue.

2) The final calibration design will result from iteration between the groups constituting the Calibration Group. In particular, the receiver group should supply a reaction to Memo No. 372 how stable will the receivers be and how often will these various calibration steps need to be performed? What level of saturation will be encountered? How stable will sideband gain ratios be in a tunerless receiver? Although this is critical for development of a working system, prototype receivers probably need to be built to push the calibration system toward final design.

We suggest that when the third prototype antenna arrives at the VLA site, the evaluation receiver from one of the earlier antennas be transferred to it and the prototype receiver from which they were taken be outfitted with prototype receivers and calibration system. This is an urgent necessity.

3) Characterization of the standing wave patterns on the prototype antennas should be performed and assessed.

4) The WVR and fast switching schemes need further work. The former does not yet work in a production fashion at 22 GHz. The combination of the two and formulation on which to employ under what conditions needs to be understood. Simulations are needed.

1) Effects of refraction on the site need to be investigated. The ASTE antenna may help considerably in this.

1)
Annex 3:

Report from the SKA Workshop
"HIGH RESOLUTION OPTIONS FOR THE SKA"

MPIfR Bonn, 10-11 December2001

R.W.Porcas (MPIfR) and M.A.Garrett (JIVE)

The Square Kilometer Array (SKA) will be an enormous advance for cm-wave radio astronomy, both in sensitivity and observing efficiency. Although it was originally christened as the "Hydrogen array" for sensitive mapping of low surface brightness radio emission, there is a growing realisation that SKA's scientific potential can be greatly increased by considering arrays of higher resolution than initially conceived. In particular, the opinion has been expressed many times that the SKA should be designed, from the outset, as an instrument with resolutions comparable with present global VLBI networks. The Bonn workshop "High resolution options for the SKA" was therefore planned as a 2-day, "round-table" forum where participants were invited to
give presentations on a wide range of astronomical topics; these were chosen to be those where one could expect significant new results with an SKA with stations separated by many thousands of kilometers.

Following an initial announcement at the Berkeley SKA Meeting, active participation in the workshop was solicited, mainly from the present VLBI community. The final attendance was 24, from a total of 10 different institutes. Although the workshop was originally set up under the auspices of the European SKA Consortium, it was highly gratifying that participants from both Australia and North America attended. High-resolution options also make SKA attractive to new groups, and both the astrometry and geodesy communities were represented in the meeting. A key feature of the workshop was its moderate size, which encouraged true interaction amongst the participants. Financial support for some of the organisation was provided by the ICN "RADIONET" which is supported by the European Commission.

A major aim of the workshop was to stimulate thought in the radio astronomy community on the potential for high-resolution, high sensitivity observations. From the point of view of SKA design and operation, fundamental issues must be considered. In the past it has been noted that the dense, central area of the "reference design" SKA could be used as a single, phased-array element (referred to as "SKApa") together with any pre-existing VLBI array. However, major gains in sensitivity can be achieved by having a significant fraction of the SKA collecting area spread over much longer baselines. In the reference design there are extensions to 500 km; in the high resolution workshop we considered the science that could be done by increasing this by at least a factor of 10 to continental or even inter-continental size - termed "SKA++". Throughout we assumed that any high-resolution SKA is a "connected element" array with real-time correlation - something which the present VLBI community is considering very seriously at present and which we may well presume will be realisable by the time SKA is built. Finally, any long-baseline SKA must have stations whose elements have a wide hour-angle coverage - an important constraint for choice of element design.

We chose not to try to get presenters to produce write-ups of their contributions for a bound "proceedings" volume but, rather, encouraged deposition of contributions, either as power-point or scanned view-graphs. This has been 100 percent successful - there are 21 presentations available at the workshop www site:

http://www.euska.org/workshops/hr_ws_MPIfR_Bonn.html

In addition, some presenters were persuaded to write short abstracts on their chosen topics, including two for presentations not actually given; these are also available at the web site. And, of course, there is a workshop photograph to prove who was there

In the final session of the workshop there was a general discussion of some of the key-points which had arisen: these include the need to convince the community, both radio astronomical and others, of the desirability of a high-resolution SKA. Many of the topics of the presentations clearly fall in the remit of the scientific working groups already defined; others could lead to the formation of additional groups. All the participants were urged to actively pursue their interests at future SKA meetings. In the near future we plan to circulate a more detailed review of the discussions that took place and the final conclusions that were drawn.

Presentations given at the Workshop

Welcoming Remarks	A. ZENSUS (MPIfR)
Introduction to SKA	P. DIAMOND (JBO)
The need for a high resolution SKA	M. GARRETT (JIVE)
Plan for the Workshop	R. PORCAS (MPIfR)
X-ray Binaries	R. SPENCER (JBO)
Stellar emission	S. DOUGHERTY (U. Calgary)
Stars & protoplanetary disks	S. GARRINGTON (JBO)
Radio star astrometry	E. ROS (MPIfR)
Low-lum. black holes in nearby gals.	H. FALCKE (MPIfR)
Young Supernovae and SNRs	M. PEREZ-TORRES (IRA, Bologna)
AGN at high redshift with SKA	I. SNELLEN (IfA, Edinburgh)
High-z starburst systems	T. MUXLOW (JBO)
HI abs. in NGC2146 and starburst gals	A. TARCHI (MPIfR)
Neutral Hydrogen and Radio Galaxies (abstract only)	R. MORGANTI (Astron)
Molecular emission in Galaxies	W. BAAN (Astron)
H2O Megamasers	Y. HAGIWARA (MPIfR)
Space-VLBI	L. GURVITS (JIVE)
High dynamic range imaging	A. LOBANOV (MPIfR)
The SKA and intra-day variability (abstract only)	S. TINGAY (ATNF)
Astrometry with the SKA	P. CHARLOT (Bordeaux Obs)
Geodesy with SKA	A. NOTHNAGEL (Geod. Inst, U.Bonn)
Optical fibre transmission	R. SPENCER (JBO)
Workshop Summary	R. SCHILIZZI (JIVE)