RadioNet

SEVENTH FRAMEWORK PROGRAMME

SEVENTH FRAMEWORK PROGRAMME
Capacities Specific Programme
Research Infrastructures

Grant agreement for:

Integrating Activity - Combination of Collaborative Project and Coordination and Support Action

Annex I - "Description of Work"

Project acronym: *RadioNet-FP7*
Project full title: Advanced Radio Astronomy in Europe
Grant agreement no.: 227290

Date of preparation of Annex I (latest version): 9 March 2009
Date of approval of Annex I by Commission: 26 March 2009

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Part A

A.1 Project summary form.

A2 List of beneficiaries

Beneficiary Number	Beneficiary name	Beneficiary short name	Country	Date enter project	Date exit project
1(coordinator)	Netherlands Institute for Radio Astronomy	ASTRON	NL	1	36
2	Institut de Radioastronomie Millimetrique	IRAM	FR	1	36
3	Istituto Nazionale di Astrofisica	INAF	IT	1	36
4	Joint Institute for VLBI Europe	JIVE	NL	1	36
5	Max-Planck-Gesellschaft zur Foerderung der Wissenschaften	MPG	DE	1	36
6	The University of Manchester	UMAN	UK	1	36
7	Chalmers University of Technology	OSO	SE	1	36
8	Torun Centre for Astronomy	UMK	PL	1	36
9	Science and Technology Facilities Council	STFC	UK	1	36
10	Netherlands Institute for Space Research	SRON	NL	1	36
11	Observatoire de Paris	OBSPAR	FR	1	36
12	Universität zu Köln	KOSMA	DE	1	36
13	Fundacion General de la Universidad de Alcala	FG	ES	1	36
14	Technical University of Delft	TUD	NL	1	36
15	European Southern Observatory	ESO	INO (DE)	1	36
16	Korean Astronomy & Space Science Institute	KASI	KR	1	36
17	University of Roma Tor Vergata	UROM	IT	1	36
18	University of Cambridge	UCAM	UK	1	36
19	University of Oxford	UOXF	UK	1	36
20	Bordeaux University 1	BORD	FR	1	36
21	Ventspils University College	VENT	LV	1	36
22	Helsinki University of Technology	TKK	FI	1	36
23	National Radio Astronomy Observatory	NRAO	US	1	36
24	University of Orléans	UORL	FR	1	36
25	Fraunhofer Institut für Angewandte Festkörperphysik	IAF	DE	1	36
26	National Research Foundation	HARTRAO	ZA	1	36

A.3 Overall Budget breakdown for the project

Project Number 1	227290	Project Acronym 2	RadioNet-FP7

One Form per Project

Participant number in this project 3	Participant short name	Estimated eligible costs (whole duration of the project)						Total receipts	Requested EC contribution
		RTD (A)	Coordination (B)	Support (C)	Management (D)	Other (E)	Total A+B+C+D+E		
1	ASTRON	797,375.00	0.00	611,438.00	767,141.00	0.00	2,175,954.00	0.00	1,631,340.00
2	IRAM	437,939.20	0.00	437,826.00	9,375.00	0.00	885,140.20	0.00	614,862.00
3	INAF	773,240.00	448,632.00	153,354.80	15,000.00	0.00	1,390,226.80	0.00	904,655.00
4	JIVE	885,972.80	0.00	1,127,746.80	83,300.00	0.00	2,097,019.60	0.00	1,582,922.00
5	MPG	653,350.00	168,125.00	594,178.00	15,000.00	0.00	1,430,653.00	0.00	1,228,928.00
6	UMAN	1,033,622.40	198,667.20	596,360.20	18,750.00	0.00	1,847,399.80	0.00	1,259,427.00
7	OSO	232,889.60	0.00	312,531.00	5,625.00	0.00	551,045.60	0.00	464,997.00
8	UMK	179,520.00	0.00	29,251.00	0.00	0.00	208,771.00	0.00	118,891.00
9	STFC	169,671.00	0.00	419,205.00	5,625.00	0.00	594,501.00	0.00	526,832.00
10	SRON	227,268.80	0.00	0.00	0.00	0.00	227,268.80	0.00	146,736.00
11	OBSPAR	110,960.00	0.00	0.00	0.00	0.00	110,960.00	0.00	66,576.00
12	KOSMA	71,048.00	0.00	0.00	0.00	0.00	71,048.00	0.00	53,286.00
13	FG	361,544.00	0.00	73,121.00	0.00	0.00	434,665.00	0.00	269,535.00
14	TUD	244,564.00	0.00	0.00	0.00	0.00	244,564.00	0.00	146,738.40
15	ESO	159,000.00	0.00	0.00	0.00	0.00	159,000.00	0.00	99,000.00
16	KASI	240,000.00	0.00	0.00	0.00	0.00	240,000.00	0.00	0.00
17	UROM	53,600.00	53,182.40	0.00	0.00	0.00	106,782.40	0.00	75,765.73
18	UCAM	153,787.20	0.00	0.00	0.00	0.00	153,787.20	0.00	65,640.00

Participant number in this project *	Participant short name	Estimated eligible costs (whole duration of the project)						Total receipts	Requested EC contribution
		RTD (A)	Coordination (B)	Support (C)	Management (D)	Other (E)	Total A+B+C+D+E		
19	UOXF	217,732.80	0.00	0.00	0.00	0.00	217,732.80	0.00	95,100.00
20	BORD	250,600.00	0.00	0.00	0.00	0.00	250,600.00	0.00	132,950.00
21	VENT	0.00	0.00	29,214.00	0.00	0.00	29,214.00	0.00	29,214.00
22	TKK	0.00	0.00	29,248.00	0.00	0.00	29,248.00	0.00	29,248.00
23	NRAO	146,040.00	0.00	146,256.00	0.00	0.00	292,296.00	0.00	213,216.00
24	UORL	82,000.00	0.00	0.00	0.00	0.00	82,000.00	0.00	51,500.00
25	IAF	218,091.00	0.00	0.00	0.00	0.00	218,091.00	0.00	163,567.00
26	NRF	0.00	0.00	29,251.00	0.00	0.00	29,251.00	0.00	29,251.00
TOTAL		7,699,815.80	865,606.60	4,585,960.80	919,816.00	0.00	14,077,219.20	0.00	9,999,997.13

PART B

B1. Concept and objectives, progress beyond state of the art, S/T methodology and work plan

B 1.1 Concept and project objective(s)

The radio astronomy window is uniquely broad, spanning 5 decades of frequency and wavelength. A huge variety of different phenomena can be studied through metre, centimetre, millimetre and sub-millimetre observations. These range from the imprint of the last scattering surface on measurements of the cosmic microwave background emission, to the complex astro-chemistry observed in comets. A wide variety of radio telescopes and observing techniques are required in order to cover the entire radio spectrum. The technology used to address this huge range of wavelength, is as diverse, as it is advanced. Radio astronomy stands on the brink of a new golden era – in particular, several large facilities are either coming on-line, are under construction or in an advanced preparatory phase e.g. APEX, LOFAR, Yebes-40m, SRT, ALMA and SKA (FP7 PrepSKA). In addition, many of the existing radio telescopes in Europe and elsewhere, have undergone, or are in the process of undergoing, significant upgrades. Examples include SCUBA-2 for the JCMT, the IRAM telescopes, e-MERLIN, EVLA and the Effelsberg 100-m telescope. In Australia and South Africa, the respective SKA pathfinders – ASKAP and MeerKAT - have each received funding of about 75 M€. All these instruments are set to transform radio astronomy in its broadest context, and the community is expected to grow significantly over the course of the following years, embracing the full extent of the wider global astronomical community.

RadioNet FP7 will build on the highly successful FP6 Integrated Infrastructure Initiative also called RadioNet. RadioNet FP6 has transformed radio astronomy in Europe. It is now natural for most, if not all, radio astronomers to think in terms of European collaboration as the way to proceed; this situation did not exist across the broad subject five years ago.

The general objective of RadioNet, as an Integrating Activity, is to optimise the use and development of European radio astronomy infrastructure. A primary goal will be to ensure that European researchers have access to the radio astronomical facilities they need to undertake the science they wish to pursue. Another major goal is to ensure that key technical developments in Radio Astronomy are supported on a European-wide basis, pooling the broad range of skills, resources and expertise that exists in Europe. This will provide a critical mass that will ensure that progress is not made slowly in isolation but quickly and efficiently, via a broad-based, yet well-focused, scientific and engineering collaboration.

Many of the activities (in particular the Joint Research Activities) are inter-dependent. As a collective body, RadioNet can provide the coordination and overview that is essential to ensure that these are properly matched, and that the end user, the astronomer, plays a major part in shaping the final overall product. The telescope facilities recognised of paramount interest to the astronomical community in terms of trans-national access, are also those that will benefit most directly from the JRAs. At the same time, building on the highly positive experience of RadioNet FP6, sufficient Management & Networking mechanisms are in place to provide the level of coherent feedback and response that is absolutely vital in ensuring that the project delivers a fully integrated Radio Astronomy development programme.

The principal and specific objectives of RadioNet, supported by the defined milestones, are:

- To provide an integrated radio astronomy network which will ensure that European scientists have access to world-class facilities;

- To provide an integrated research and development programme which will support and enhance European radio astronomy facilities;
- To develop a programme of networking activities which will ensure close European collaboration in engineering and science, sharing their knowledge and expertise, expanding the use community,
- To foster the development of the next generation of astronomers in the use of the current state-of-the-art and future radio astronomy facilities;
- To foster the development of the next generation of engineers who will lead the design and construction of the instruments of the future;
- To prepare for the next generation of world-class radio astronomy facilities through a wide discussion of their scientific motivation, through integrated research and development initiatives, and through the planning of the future structure of European radio astronomy;
- To promote public knowledge of radio astronomy and public understanding of science.

These objectives will serve to strengthen the European astronomical community; to enhance the scientific output of its members, both in quality and quantity; and to ensure that it is well placed to take full advantage of the new generation of facilities under construction or being planned.

Even more important is the vital role that the RadioNet facilities must play in facilitating the emergence of the next generation of radio-astronomers. Clearly, without state-of-the art facilities in the next decade, European astronomers will not be ready to successfully compete for observing time or play a leading role in the early science opportunities presented by large global telescope projects, such as ALMA and the SKA.

B 1.2 Progress beyond the state of the art

The state-of-the-art in radio astronomy facilities and technology has advanced tremendously over recent years, especially since the start of the FP6 RadioNet I3. These past few years have seen the widespread introduction of fibre networks and digital transmission of data for distributed arrays, and the development of multi-pixel cameras and focal-plane arrays. There has also been a transformation in the bandwidth, low noise capabilities and overall performance of mm/sub-mm hardware. The techniques of data handling, and the implementation of new algorithms for interferometry have also advanced significantly. Many of these new and exciting developments are associated or have been directly supported by the previous RadioNet FP6 project.

RadioNet FP7 will continue to support state-of-the-art developments in radio astronomy via a programme of Networking Activities, Transnational access, and Joint Research Activities.

Networking activities

The RadioNet FP7 Networking Activities will comprise the following key WPs.

- *WP2 (Science Working Group)* will organize a series of workshops focusing on the science goals of the facilities, but having a wide coverage of different techniques (e.g. radio, IR, optical, X-ray etc.). WP2 will also have strong connections with WP4 (Training for Radio Astronomers), and WP5 (Spectrum Management). It will also provide input to the work of the various JRAs, guiding the specification and capabilities of the instrumentation R&D.
- WP3 (Engineering Forum) will focus on enhancing the communication, training and scientific interactions amongst engineers. It will have strong links with all RadioNet facilities and JRAs, ensuring information exchange on a wide variety of subjects. As for WP2, it will also ensure that links exist with WP4 and WP5, both essential activities for engineers as well as scientists.

- WP4 (Training) is an essential NA whose work will underpin much of the activities undertaken by the TNA facilities, by WP2 and WP3. It will also educate astronomers in the latest techniques and instrumentation.
- WP5 (Spectrum Management): radio facilities operate in an increasingly commercialised RFI environment and this NA will continue the excellent work done to provide a European voice within the regulatory bodies to protect the radio astronomy bands. It will, of necessity, work closely with the RIs, WP2 and WP3.

Transnational Access activities – coherence and quality

Observations at cm, mm and sub-mm wavelengths offer a powerful and unique view of the cosmos. The RadioNet FP7 TNA programme presents a range of world-leading radio telescopes offering unique capability over an unprecedented range of wavelengths – from the largely uncharted territory of the decametric emission to be observed by LOFAR, to the sub-mm emission measured by the JCMT, IRAM and now APEX. In total 21 state-of-the-art radio telescope facilities are included in the RadioNet FP7 TNA programme. These facilities are all hosted by research organisations, universities or national observatories, in which world-class research is being carried out. TNA-supported astronomers receive support at each stage of the observing process, have the opportunity to interact with scientists and engineers at these institutes, and very often develop long-term collaborations with staff at working at the facilities.

JRA programme

The RadioNet FP7 JRA activities largely build on the successful activities within FP6 RadioNet or earlier FP5/6 programmes. They form a coherent project plan aimed at providing innovative developments to support the scientific programmes on the RadioNet telescopes and keep the facilities state-of-the-art.

A common element to all the JRAs is that they directly address the effectiveness with which the existing radio-telescopes can be deployed in the next decade. For example, the deployment of multi-pixel detectors will revolutionise single-dish astronomy by enhancing the large scale imaging speed by many orders of magnitude. The development of multi-pixel arrays is a theme common to two of the JRAs: **AMSTAR+** (WP7) for mm/sub-mm telescopes and **APRICOT** (WP8) for cm/mm telescopes. Although the goals of the two JRAs are similar, i.e. to provide major enhancements to the field-of-view and, thereby survey capabilities of single-dish telescopes, the techniques and technologies involved are very different in the two wavelength regimes.

The volume of data which will be produced by multi-pixel cameras on single-dishes will be similar to that generated by the new generation of interferometers. They will require flexible, powerful, digital backends which can be used for a variety of different applications. The JRA **UniBoard** (WP9) will develop a generic digital processing board that will enhance the signal processing capabilities of the existing telescopes for spectroscopy, pulsar searches and high-resolution interferometry. Similarly, the software JRA **ALBiUS** (WP6) will provide the software tools needed to fully exploit the emergence of new and upgraded telescopes, such as e-MERLIN and LOFAR. Moreover, the AMSTAR+ and APRICOT projects have a strategic role in securing the supply of Monolithic Microwave Integrated Circuits (MMICs) in Europe.

Performance indicators

Each of the RadioNet NA and JRA work packages has clearly defined tasks or sub-work packages with clear objectives, milestones and deliverables. These, together with the associated timeline, can be used to measure and verify the projects performance. Many RadioNet deliverables are reports, and their timely delivery will be a clear indicator that the project is progressing as expected. Other deliverables involve the construction of prototype hardware and software; again on-time delivery will be a measure of the projects progress. In the area of TNA, the number of hours observed by each facility can be compared with the original planning. In addition, the number of papers arising from the provision of data can also be counted. The impact of these publications (number of citations) can also be determined per facility, and for the project as a whole.

B 1.3 S/T Methodology and associated work plan

B 1.3.1 Overall strategy and general description

RadioNet FP7 involves 26 partners contributing effort to 18 different work packages (5 NAs, 4 JRAs and 9 TNAs). Technically there is very little direct dependency between one work package and another. This is a deliberate decision on the part of the RadioNet consortium – it serves to minimise the possible growth of inter-related risks, and makes the project management simple and transparent. Each WP will run in a largely independent way – usually a failure in one WP has no immediate consequence for another.

At the same time, the work programme as a whole is very much an integrated endeavour. The overall aim is to support the radio astronomy community in general, and to improve the capabilities of, and enhance access to, the major radio astronomy facilities in Europe and beyond. At the core of the project sits the Transnational Access programme. Each TNA largely runs independently but there is significant overlap in the kind of science each facility addresses. For the astronomer, a common proposal tool, known as "NorthStar" (originally developed in RadioNet FP6), provides a common entry interface to many of the RadioNet TNA facilities. The Networking Activities support the broad radio astronomy community (scientists, operators and engineers) in disseminating results, initiating new collaborations, maintaining and enhancing expertise, spreading best practice and supporting the essential job of protecting the radio spectrum from non-passive users. The Joint Research Activities (WPs 7, 8 and 9) are pushing the state-of-the-art in astronomical instrumentation forward, in order to meet the future demands and growing expectations of the community. At the base of this overall strategy, lies an experienced project management.

Significant risks associated with the JRAs

The work of the Joint Research Activities naturally carries some level of risks, as they are research and development activities.

WP6 ALBiUS: this JRA takes two distinct approaches to solving some of the software problems currently facing radio astronomy. The first approach is to improve the accessibility of existing implementations of important algorithms via interoperability and the development of standardised interfaces. This carries little risk, requiring good communication between partners and sufficient manpower to implement the necessary software infrastructure. The second, and more challenging, part is to develop new algorithms to solve known problems in radio astronomy. Most of these are new algorithms where the main uncertainty is whether these methods can provide the computational efficiency required for use with the huge datasets provided by cutting edge radio astronomy facilities. Successful implementation of some of these methods may also impact on the data and calibration models used by the data analysis packages, which could potentially limit their applicability or require very large infrastructure changes. However, in most cases even this small risk is mitigated by the investigation of alternative methods, the best of which will be chosen for the final implementation.

WP7 AMSTAR+: the risk level on several developments considered here is relatively high. Components like integrated planar mixers, balanced SIS mixers at high frequencies and high energy gap junctions have so far not been or been only superficially studied. This is the reason why most of the deliverables are limited to prototypes of components. In fact, in the most critical cases, there is parallel work on backup, lower risk, solutions. Overall the risk is mitigated by the demonstrated experience of the participating investigators (already working together in the RadioNet FP6 JRA AMSTAR) and the step-wise approach that is adopted.

WP8 APRICOT: in this JRA two possible risks can be identified. The first is the possible failure to make major improvements on current system architectures and passive component sub-systems. This risk is very low, as the partnership consists of highly experienced European radio astronomy and radio engineering groups, which have collaborated before on the FP5 FARADAY and/or FP6 RadioNet PHAROS programmes.

This second risk is associated with the objective of finding a European supply chain for world-competitive MMICs for cryogenic operation. This is addressed by obtaining devices from the UMAN InP facility, the IAF Freiburg GaAs facility and a commercial GaAs foundry OMMIC, each of which offers different advantages.

WP9 UniBoard: a risk for the UniBoard project lies in its dependence on the future availability of suitable ADCs. However, interleaved ADCs could offer a solution using, for example, commercial products which should become available soon (e.g. broad-band input, multi-bit ADCs clocked at 8 GHz). Another risk is that the complexity of this board will prove too much to handle; the extensive expertise in the development of FPGA boards currently available at ASTRON, built up throughout the LOFAR project, should be a sufficient safeguard. Finally, the correlator work could show that a software-based approach is more suitable, but as this is only one of several independent applications, this does not constitute a major risk. Although this collaboration is newly established, it has acquired a lot of expertise in developing e-VLBI and ALMA/LOFAR components.

Risks associated with the TNAs

RadioNet FP7 also offers several new facilities or significantly upgraded facilities that are still under construction or undergoing significant upgrade *e.g* the Sardinia Radio Telescope (SRT), LOFAR and to a lesser extent e-MERLIN.

During contract preparation news was received from HARTRAO that the 26m telescope has experienced a major failure of a polar shaft bearing. It will be unavailable for observations with immediate effect.

Investigations into the possible replacement of the bearing have commenced, but the likely success of such an undertaking is unclear at this point. This makes the availability of HARTRAO for EVN in RadioNet FP7 unlikely in the first year, and uncertain in the remaining period.

TNA WP14 Sardinia Radio Telescope (SRT): The major risk here is a possible delay in the availability of the telescope (currently under construction) or the complete suite of receivers. In order to mitigate this risk, the SRT TNA programme begins in a phased fashion around Month 12 of the project (2010).

TNA WP15 LOFAR: The major risk is a possible delay in the availability of the telescope (currently under construction). A major advantage of LOFAR is that scientifically productive operations can begin once a small subset of the full array has been deployed. To further mitigate possible risks, the LOFAR TNA programme also has a phased implementation.

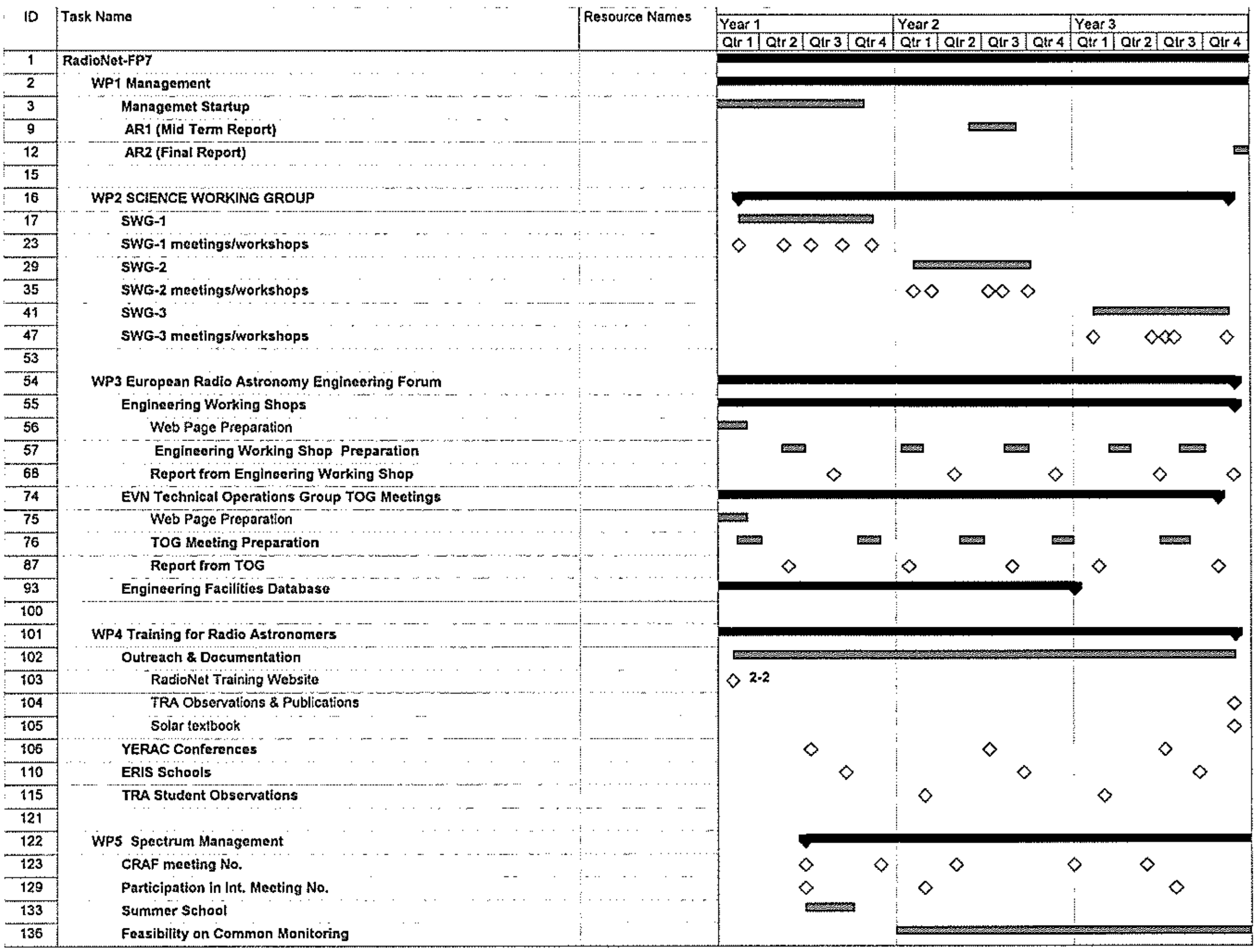
TNA WP12 e-MERLIN: e-MERLIN is a major upgrade to a well-established radio imaging array. The new receivers are in operation, the optical links have been installed, the new telescope electronics and the main boards for the correlator have been prototyped. The remaining risk is the production and integration of the full 8-station correlator. To mitigate this risk, a prototype correlator is due for delivery in 2008, so that commissioning can begin then. The full correlator will follow within approximately 9 months. The basic operation of e-MERLIN will not be radically different to MERLIN. The TNA funding has a phased implementation.

Risks associated with the NAs:

There are few major risks associated with the various RadioNet networking activities. WP2, 3, 4 and 5 sponsor events (meetings, workshops etc.) and, in particular, the associated travel of the participants. There has been great interest in these activities in RadioNet FP6 – the problem has been satisfying demand, rather than worry about lack of participation. Experienced scientists and engineers are involved in the organisation of these workshops and meetings, and all the WPs have been set up so that they are naturally open to spontaneous initiatives. The astronomical community is well aware of the existence of these opportunities and the people leading the activities are well known. Experience with FP6 has shown that many "last minute" requests for funding are often received - flexibility is required, as are frequent revisions of the budget and its distribution.

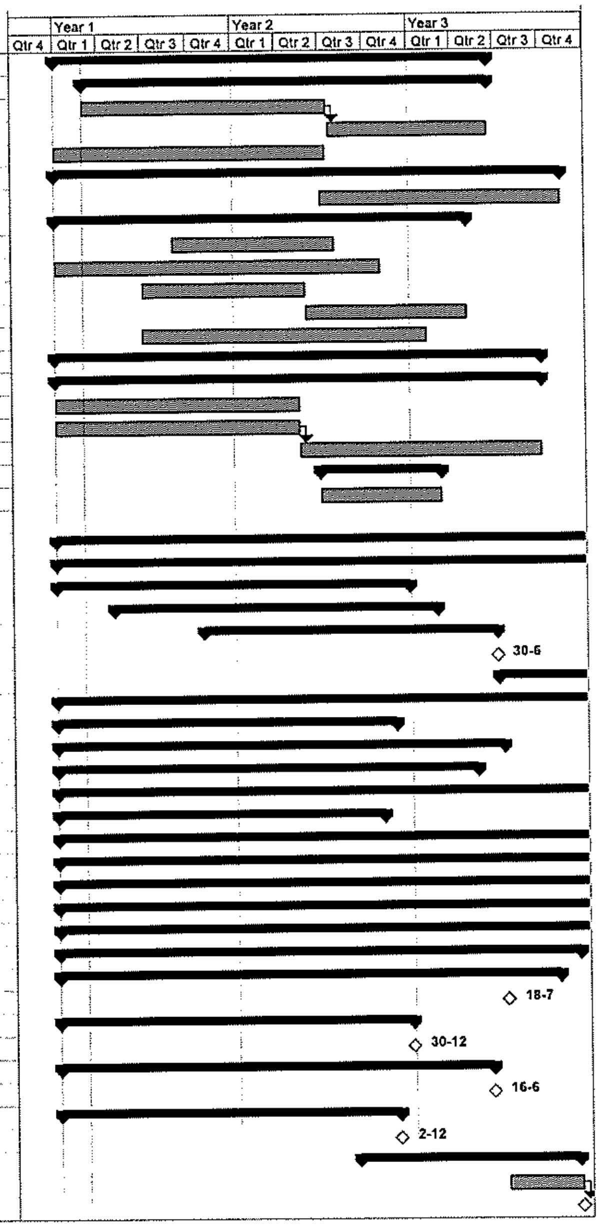
B 1.3.2 Timing of work packages and their components

Networking Activities



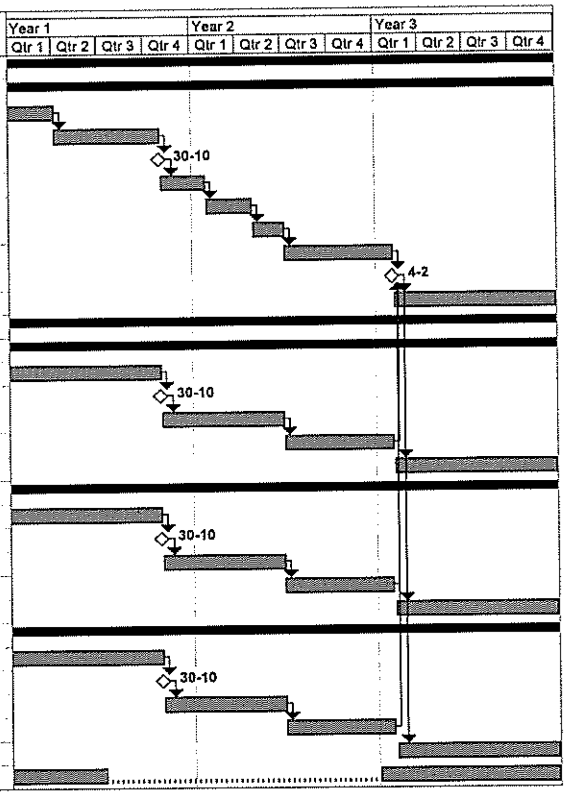
Joint Research Activities:

ID	Task Name	Resource Names
141	Task 1 - Interoperability	
142	1.1 Portable Algorithms	
143	1.1.1 Interoperable framework (JIVE, ESO)	
144	1.1.2 Data formats (ESO)	
145	1.2 Distributed ParselTongue (JIVE, UMAN)	
146	Task 2 - Calibration Algorithms	
147	2.1 Global Fringe Fitting (JIVE, NRAO, UMAN)	
148	2.2 Image Plane Calibration	
149	2.2.1 Ionospheric, tropospheric corrections (UMAN)	
150	2.2.2 Primary Beam and Mosaicing (ESO, NRAO, UMAN)	
151	2.2.3 Polarization corrections (UCAM)	
152	2.2.4 Distributed Processing (ASTRON and UOXF)	
153	2.3 Calibration of Astrometric Source Positions (BORD, JIVE, UMAN	
154	Task 3 - Tools for Large Datasets	
155	3.1 Automated Data Quality Control	
156	3.1.1 RFI mitigation (MPI)	
157	3.1.2 Data inspection (UOXF and ASTRON)	
158	3.1.3 Data Excision (UCAM)	
159	3.2 Source Parameterization	
160	3.2.1 Source parameterization (ASTRON)	
161		
162	WP7 AMSTAR+	
163	Task 1: 3-mm array module using metamorphic HEMT techno	
164	Cryogenic HEMT Modeling + MMIC design	
168	Manufacturing runs of MMICs	
171	Design iteration of heterodyne modules	
174	Design of dual polarization W-band pixel module finalized	
175	Integration and tests of single pixel module	
178	Task 2: Integrated pixel and photonic LO for large mm FPAs	
179	SIS-LNA direct coupling study	
184	2SB on-chip	
189	LNA design	
193	Integrated pixel	
197	Photonic LO	
201	Task 3: Sub-mm wave FPAs	
202	Optical and LO coupling study	
205	Mixer development for Focal Plane Arrays	
210	FPA infrastructure scalability and IF system	
217	Mixer technology development	
226	Task 4: Heterrodyne mixers for FPAs at 1-2 THz	
227	Hig gap, high Jc SIS development	
233	THz SIS Test devices for waveguides	
234	HEB development	
239	HEB device on membrane	
240	Waveguide mixer development	
245	SIS THz test mixer block ready	
246	Quasi Optic mixer development	
251	QO test mixers ready	
252	RF testing& FPA assessment	
256	Study THz FPA capabilities based on mixer measurement results	
257	Final Report on THz FPAs	



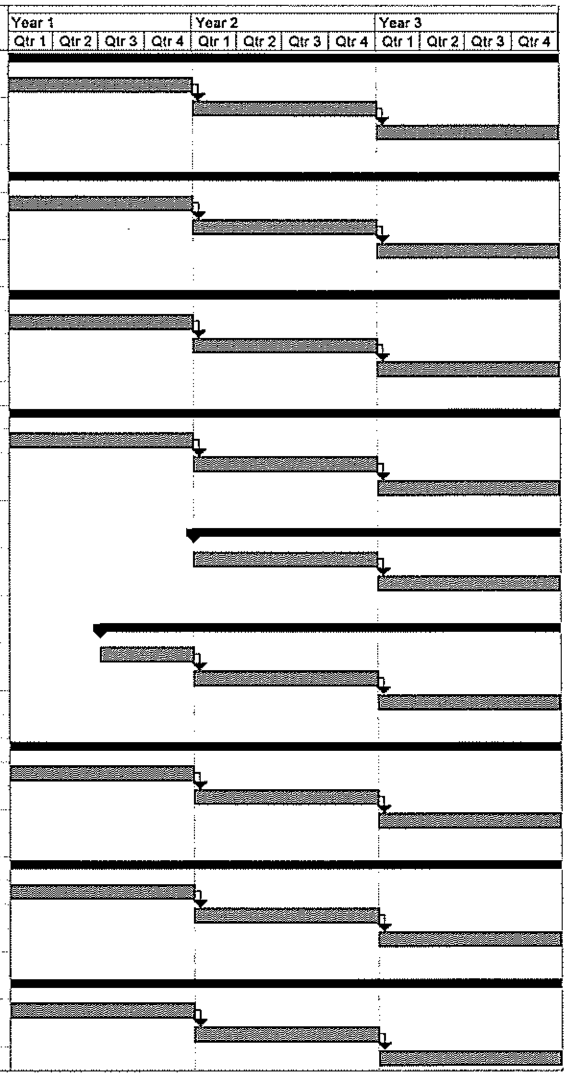
ID	Task Name	Resource Names	Milestone
261	WP8 APRICOT		
262	**Task 1- Receiver architecture: specification and test**		
263	Study of receiver architectures and definition of preferred concept		
264	Report on receiver architectures		1-7
265	Definition of interfaces and functions for the building blocks		
266	Definition paper of functions and interfaces for the building blocks		5-7
267	Model new technology chain from measured performance of compor		
268	Comparison of passive chain performamce against classical designs		27-5
269	**Task 2 - Passive components design and manufacture**		
270	Preliminary design of new technology passive chain		
271	Complete design of new technology passive chain		
272	Report on new technology passive chain		12-7
273	Manufacture of passive components for new technology receiver ch		
274	Report on tests of passive component performance		4-7
275	Develop very low loss passive on low low substrates components		
276	Report on very low loss components on low loss substrates		
277	**Task 3 - MMIC design and procurement**		
278	Procure Euro MICs first devices to establish noise performance		
279	Deliver Euro MICs first devices to establish noise performance		28-12
280	Procure Euro MMICs amplifiers and other circuits for RF & IF applic		
281	Deliver Euro MMICs amplifiers and other circuits for RF & IF applic		12-7
282	Procure Euro MICs, advanced technology devices aimed at improve		
283	Deliver Euro MICs advanced technology devices aimed at improved		4-1
284	Procure Euro MMICs with improved noise performance		
285	Deliver Euro MMICs with improved noise performance		29-9
286	**Task 4 - Testing of low noise amplifiers**		
287	Test noise & 1/f performance of first Euro MIC devices		
288	Report performance of first Euro MIC devices		18-6
289	Test noise & 1/f Euro MICs with improved noise performance		
290	Report on Euro MICs with improved noise performance		1-1
291	Test noise & i/f performance of Euro MMICs aplifiers and other circu		
292	Report on Euro MMICs, amplifiers and other circuits for for RF & IF		18-6
293	Test noise & 1/f performance of Euro MMIC LNAs with improved noi		
294	Report on Euro MMIC LNAs with improved noise performance		27-2
295	Establish transfer amplifier standard		
296	Report on transfer amplifier standard		3-1
297	**Task 5 - optimisation of receiver usage**		
298	Develop atmospheric model		
299	Report on atmospheric model		20-7
300	Develop techniques of atmospheric subtraction		
301	Report on feasibility of atmospheric subtraction; implications for rece		5-1
302	Develop calibration procedures and queue scheduling strategies		
303	Report on calibration procedures and queue scheduling strategies		31-5

ID	Task Name	Resource Names
305	WP9 UniBoard	
306	Hardware	
307	System design	
308	Board design	
309	Completed board design	
310	Board implementation	
311	Production run	
312	Basic hardware test	
313	Test & Integration	
314	Completed test	
315	Preparation for 2nd phase	
316	Software	
317	Correlator	
318	VHDL design	
319	Completed VHDL design	
320	VHDL implementation	
321	Test & Integration	
322	VHDL implementation 2nd phase	
323	Pulsar Binning Machine	
324	VHDL design	
325	Completed VHDL design	
326	VHDL implementation	
327	Test & Integration	
328	VHDL implementation 2nd phase	
329	Digital Receiver	
330	VHDL design	
331	Completed VHDL design	
332	VHDL implementation	
333	Test & Integration	
334	VHDL implementation 2nd phase	
335	Generic control software	



Transnational Access

ID	Task Name	Resource Names
337	**WP10 EVN**	
338	TNA-year-1	
339	TNA-year-2	
340	TNA-year-3	
341		
342	**WP11 JCMT**	
343	TNA-year-1	
344	TNA-year-2	
345	TNA-year-3	
346		
347	**WP12 E-Merlin**	
348	TNA-year-1	
349	TNA-year-2	
350	TNA-year-3	
351		
352	**WP13 Effelsberg-100 m**	
353	TNA-year-1	
354	TNA-year-2	
355	TNA-year-3	
356		
357	**WP14 SRT**	
358	TNA-year-2	
359	TNA-year-3	
360		
361	**WP15 LOFAR**	
362	TNA-year-1	
363	TNA-year-2	
364	TNA-year-3	
365		
366	**WP16 WSRT**	
367	TNA-year-1	
368	TNA-year-2	
369	TNA-year-3	
370		
371	**WP17 APEX**	
372	TNA-year-1	
373	TNA-year-2	
374	TNA-year-3	
375		
376	**WP18 IRAM**	
377	TNA-year-1	
378	TNA-year-2	
379	TNA-year-3	



B 1.3.3 Work package list / overview:

Work package No	Work package title	Type of activity	Lead beneficiary No	Person-months	Start month	End month
WP1	Management	MGT	1	65	1	36
WP2	Science Working Group	COORD	3	2 (+ 16)	1	36
WP3	Engineering Forum	COORD	5	7	1	36
WP4	Training for Radio Astronomers	COORD	6	2 (+ 8)	1	36
WP5	Spectrum Management	COORD	3	0 (+ 48)	1	36
WP6	ALBiUS	RTD	4	218	1	36
WP7	AMSTAR+	RTD	2	184,4	1	36
WP8	APRICOT	RTD	3	212	1	35
WP9	UniBoard	RTD	4	234	1	36
WP10	EVN TNA	SUPP	4	0	1	36
WP11	JCMT TNA	SUPP	9	0	1	36
WP12	e-Merlin TNA	SUPP	6	0	1	36
WP13	Effelsberg TNA	SUPP	5	0	1	36
WP14	SRT TNA	SUPP	3	0	1	36
WP15	LOFAR TNA	SUPP	1	0	1	36
WP16	WSRT TNA	SUPP	1	0	1	36
WP17	APEX TNA	SUPP	7	0	1	36
WP18	IRAM TNA	SUPP	2	0	1	36
	TOTAL			924,40 (+ 72)		

B 1.3.4 Deliverables list

Del. No.	Deliverable name	WP no.	Lead beneficiary	*Estimated indicative person-months*	Nature	Dissemination level	Delivery date (proj.month)
1.01	First RadioNet Report	WP1	1	4	R	PU	19
1.02	Final RadioNet Report	WP1	1	6	R	PU	36
1.03	First Promotional Materials	WP1	1	3	P	PU	11
1.04	Second Promotional Materials	WP1	1	3	P	PU	23
2.14	Conf. Proceed 1	WP2	3	0.5	R	PU	9
2.15	Conf. Proceed 2	WP2	3	0.5	R	PU	23
2.16	Conf. Proceed 3	WP2	3	0.5	R	PU	35
3.06	Rep. EVN TOG 1	WP3	5	0.5	R	PU	5
3.07	Rep. EVN TOG 2	WP3	5	0.5	R	PU	13
3.08	Rep. EVN TOG 3	WP3	5	0.5	R	PU	20
3.09	Rep. EVN TOG 4	WP3	5	0.5	R	PU	26
3.10	Rep. EVN TOG 5	WP3	5	0.5	R	PU	34
3.11	Datab. Rel 1	WP3	17	1	P	PU	12
3.12	Datab. Rel 2	WP3	17	1	P	PU	24
4.01	Website online	WP4	6	1	P	PU	2
4.02	List TRA Propos 1	WP4	6	1	R	PU	12
4.03	List TRA Propos 2	WP4	11	1	R	PU	24
4.04	List TRA Propos 3	WP4	2	1	R	PU	36
4.05	Sol. Phys School Book	WP4	11	1	B	PU	36
4.06	Final TRA List	WP4	6	1	R	PU	36
4.07	Final Rep.	WP4	2	1	R	PU	36
4.08	YERAC proceeding 1	WP4	6	1	R	PU	12
4.09	YERAC proceeding 2	WP4	6	1	R	PU	24
4.10	YERAC proceeding 3	WP4	6	1	R	PU	36
5.10	Spect. Man. School	WP5	3	4	P	PU	10
5.11	ITU WRC Rep.	WP5	3	4	R	CO	24
5.12	Feas. Stud. Comm. Monitoring Scheme	WP5	3	4	R	PU	36
6.1.1	Final report on	WP6	4	33	R	PU	16

	calibration of pilot experiment using interoperability framework						
6.1.2	Release of distributed ParselTongue	WP6	4	23	D	PU	21
6.2.1	New implementation of Global Fringe Fitting algorithm	WP6	23	24	D	PU	36
6.2.2	Direction dependent ionospheric, tropospheric, calibration to test data set	WP6	6	12	R	PU	21
6.2.3	Software for mosaic imaging including primary beam correction	WP6	15	24	D	PU	25
6.2.4	Report on image plane polarization calibration effects	WP6	18	12	R	PU	19
6.2.5	Final report on the implementation of algorithms for image plane calibration in a distributed environment	WP6	1	17	R	PU	30
6.2.6	Final report on new algorithms and observing strategies for astrometry	WP6	20	27	R	PU	28
6.3.1	RFI mitigation software	WP6	5	6	D	PU	18
6.3.2	Final report on Data Quality algorithms and excision methods	WP6	19	31	R	PU	36
6.3.3	Final report on models for extended sources	WP6	1	9	R	PU	28
7.01	AMSTAR+ progress report	WP7	2	1	R	PP	7
7.02	AMSTAR+ progress report	WP7	2	1	R	PU	13
7.03	Design report for photonic LO for mm SIS of spectroscopic	WP7	9	8	R	PU	17

	quality						
7.04	Design report on final cryogenic W-band HEMT model	WP7	5	8	R	PP	18
7.06	Design report for 2SB mm-wave SIS mixer-on-a-chip	WP7	2	12	R	PP	20
7.07	Design study report on sub-THz mixer and IF amplifier integration	WP7	10	8	R	PP	21
7.08a	Batches of AlOx and AlN barrier junctions for sub-THz SIS mixer (I)	WP7	14	8	P	PP	21
7.08b	Batches of AlOx and AlN barrier junctions for sub-THz SIS mixer(II)	WP7	14	8	P	PP	36
7.09	Test report of photonic LO with SIS mixer, photomixer at cryogenic temperature	WP7	9	6	R,D	PU	23
7.10	Design report on optimal coupling of mm SIS mixer to input stage of LNA	WP7	2	8	R	PP	24
7.11	Design study report on balanced sub THz mixer	WP7	10	8	R	PU	24
7.12	Report on Quasi Optical THz test mixer	WP7	11	8	R	PU	24
7.14	Report on THz waveguide test mixer and devices	WP7	2	10	R	PU	30
7.16	Prototype of W-band module suitable for array integration	WP7	2	12	D	RE	36
7.17	Study report on High Gap SIS junctions	WP7	10	10	R	PU	36
7.18	Test report of W-band prototype module	WP7	5	10	R	PU	36
7.19	Design and Test report of integrated 2SB mm mixer and LNA pixel	WP7	2	10	R,D	PU	36
7.20	Sub-THz prototype mixer demonstration	WP7	10	10	D	PP	36
7.21	Design study report on sub-THz Array infrastructure	WP7	10	10	R	PU	36
7.24	Final Report THz FPAs	WP7	12	4	R	PU	36

8B

7.25	Final Report on AMSTAR+	WP7	2	4	R	PU	36
8.01	Study of receiver architectures and definition of the preferred concept (Task 1)	WP8	6	12	R	PU	6
8.03	Comparison of passive chain performance against classical designs (Task 1)	WP8	6	8	R	PU	35
8.04	Report on design of passive chain using new technology for low replication costs, low weight and suitable performance (Task 2)	WP8	6	12	R	PU	24
8.06	Designs for very low loss passive components, on low loss substrates (Task 2)	WP8	6	12	P,R	PU	35
8.08	Euro MMICs: Amplifiers and other circuits for RF&IF applications (Task 3)	WP8	6	12	P	PU	18
8.09	Euro MICs: advanced technology devices aimed at improved noise performance (Task 3)	WP8	6	6	P	PU	24
8.10	Euro MMICs with improved noise performance (Task 3)	WP8	6	4	P	PU	33
8.12	Establishment of Transfer Amplifier Standard (Task 4)	WP8	6	12	D,R	PU	24
8.14	Atmospheric model (Task 5)	WP8	6	12	R	PU	6
8.15	Report on feasibility of atmospheric subtraction without spatial switching; implications for receiver architecture (Task 5)	WP8	6	12	R	PU	24
8.16	Report on calibration procedures and queue scheduling strategies	WP8	6	12	R	PU	29
9.1	Hardware design	WP9	1	20	R	PU	11

	document						
9.2	Firmware design document: correlator	WP9	4	20	R	PU	11
9.3	Firmware design document: pulsar binning machine	WP9	6	20	R	PU	11
9.4	Firmware design document: digital receiver	WP9	3	20	R	PU	11
9.5	First generation board	WP9	1	16	P	PU	17
9.6	Hardware design document version 2	WP9	1	24	R	PU	36
9.7	Firmware design document version 2: correlator	WP9	4	34	R	PU	36
9.8	Firmware design document version 2: pulsar binning machine	WP9	6	34	R	PU	36
9.9	Firmware design document version 2: digital receiver	WP9	3	34	R	PU	36
9.10-9.12	Functional control code	WP9	4	12	O	PU	36
			TOTAL	770			

Access costs

The TNA programmes also make provision for travel of users (and in some cases e.g. the EVN, travel of the programme committee) to the facility. This is summarised below:

TNA Travel Budget

TNA travel	
JCMT	46000
e-Merlin	21600
Effelsberg	40000
EVN	136000
SRT	18600
IRAM-30	
IRAM-PdBI	36000
LOFAR/WSRT	25000
APEX	0
Total	323200

(travel including 7 % overhead)

Most facilities participating to the RADIONET FP7 TNA programme offer access in two different ways: either as facilities operated independently from each other ("*standalone*" operation) or as part of a distributed infrastructure, the European VLBI Network (EVN), the control centre of which is located at the site of the correlator, JIVE (participant No 4). Consequently, two different tables for access costs are reported:

TNA programme – "standalone" operation

Participant Number	Organisation short name	Short name of infrastructure	Installation		Operator Country Code	Unit of access	Unit Cost (€)	Min. quantity of access provided	Total Access Cost	Total Estimated Access Eligible	Estimated Number of Users	Estimated Number of Projects
			Number	Short Name								
4	JIVE	EVN			NL	hour	4908,86	336	1.651.218	62.665.183	210	112
9	STFC	JCMT			UJ	hour	955,00	391	373.205	10.086.755	165,00	34
6	UMAN	e-MERLIN			UK	hour	805,00	610	490.943	8.703.976	112	37
5	MPG	Effelsberg			DE	hour	478,00	1006	481.050	7.166.893	75	27
3	INAF	SRT			IT	hour	413,00	67	27.552	5.478.507	18	6
1	ASTRON	LOFAR			NL	hour	925,00	388	358.750	14.599.739	90	22
1	ASTRON	WSRT			NL	hour	322,00	480	154.560	3.864.232	75	24
7	OSO	APEX			SE	hour	798,00	300	239.400	1.736.555	60	12
2	IRAM	PdBI			FR	hour	1.319,00	166	218.920	10.180.390	112	60
2	IRAM	PV			FR	hour	463,00	357	165.074	7.900.215	150	52
Total									4.160.673	132.382.444		

TNA Programme: WP10 access to the European VLBI Network

Participant Number	Organisation short name	Short name of infrastructure	Installation		Operator Country Code	Unit of access	Unit Cost (€)	Min. quantity of access provided	Total Access Cost	Total Estimated Access Eligible	Estimated Number of Users	Estimated Number of Projects
			Number	Short Name								
4	JIVE	EVN	1	EVN	NL	hour	2748,07	336	924.382	5.664.466	210	112
1	ASTRON (WSRT)	EVN	2	WSRT	NL	hour	217,4	336	73.128	3.864.232	210	112
3	INAF	EVN	3	SRT	IT	hour	65,21	336	21.935	5.478.507	210	112
3	INAF	EVN	4	Noto	IT	hour	113,05	336	38.027	4.416.462	210	112
3	INAF	EVN	5	Mc	IT	hour	113,05	336	38.027	4.849.957	210	112
5	MPG	EVN	6	Effelsberg	DE	hour	217,4	336	73.128	7.166.893	210	112
6	UMAN	EVN	7	JBO	UK	hour	217,37	336	73.118	1.758.529	210	112
7	OSO	EVN	8	Onsala	SE	hour	217,41	336	73.131	4.588.255	210	112
8	UMK	EVN	9	UMK	PL	hour	86,96	336	29.251	2.234.160	210	112
13	FG	EVN	10	Yebes	ES	hour	217,38	336	73.121	4.179.420	210	112
21	VENT	EVN	11	Vent	LT	hour	86,85	336	29.214	655.953	210	112
22	TKK	EVN	12	Metsahovi	FI	hour	86,95	336	29.248	3.269.531	210	112
23	NRAO	EVN	13	VLBA	US	hour	434,8	336	146.256	11.061.204	210	112
26	HARTRAO	EVN	14	HARTRAO	SA	hour	86,96	336	29.251	3.477.615	210	112
Total									1.651.218	62.665.183		

B.1.3.5 Work package description.

In all Work Packages description tables the available effort is recorded as follows:

(i) Person-months in bold are those funded through EC funds,

(ii) Person-months in normal type are provided as in-kind, auditable contributions,

(iii) Person-months in parenthesis are in-kind contributions that are part of the radio astronomy programme in Europe not audible

Work package number	WP1		**Start date or starting event:**								month 1
Work package title	RadioNet FP7 Management										
Activity Type	MGT										
Participant id	1	4									Total
Person-months per beneficiary:	**49**+4	**12**+0									**61**+4

Objectives
The main objective of this activity is to set up a governance and management structure that will ensure that RadioNet is a well-managed, efficient and financially transparent project. Associated objectives include the promotion of RadioNet FP7 within the astronomical community and beyond.

Description of work (possibly broken down into tasks)

- Prepare and introduce a transparent governance and appropriate management structure
- Distribute EC financing throughout the duration of the project, in a timely manner, including the central administration (ASTRON/JIVE) of travel funds associated with various WPs (Work Packages),
- Implement appropriate mechanisms for monitoring progress within WPs, including milestones and relevant deadlines,
- Establish and coordinate a reporting procedure and schedule for all stake-holders (Consortium board, European Commission, User Community etc.),
- Develop a close-knit network of intra-project communication channels between all WPs and the central project management and consortium board,
- Provide project support and expertise in issues related to contractual obligations, financial declarations and audit compliance,
- Ensure the full and broad engagement and participation of the astronomical community in all RadioNet activities and related opportunities,
- Maintain and continuously update an Intellectual Property (IP) register
- Promote the activities of RadioNet within the astronomical community and beyond by a dedicated outreach program, by establishing a website and producing promotional materials
- Nurture a close liaison with other associated (EC) projects e.g. PrepSKA FP7 (Square Km

Array Preparatory Study), SKADS FP6 (Square Km Array Design Study).

Deliverables (brief description) Deliverables 1. Generation of Annual report, Mid-term evaluation data and Final report. 2. Production of phase 1 and phase 2 RadioNet promotional materials.

Work package number	WP2	**Start date or starting event:**				month 1						
Work package title	Science Working Group											
Activity Type	COORD											
Participant id	3	19	2	7	6	18	4	5	1	21	8	Total
Person-months per beneficiary:	2+(1)	0+ (1,5)	0+ (1,5)	0+ (1,5)	0+ (1,5)	0+ (1,5)	0+ (1,5)	0+ (1,5)	0+ (1,5)	0+ (1,5)	0+ (1,5)	2+ (16)

Objectives

The main aims of this activity are to further develop strong connections between RadioNet and the wider astronomical community, and to ensure that the results of RadioNet activities (in particular those associated with access to the TNA radio telescope facilities) are presented to the widest possible audience. This will be achieved by holding topic orientated meetings throughout the duration of the contract. The objective of WP2 is to sponsor such meetings and to partially support the attendance of European participants. Meetings will scale the full range of possibilities – from small, well-focused workshops, to large international conferences. In addition, the WP will encourage (and in some cases support) the publication of papers associated with these meetings in conference proceedings or via the RadioNet web pages.

Description of work (possibly broken down into tasks)

As in FP6 the activity will be chaired by Dr. Tiziana Venturi (INAF) with support from co-chairs Prof. Steve Rawlings (UOXF) and Dr. F. Gueth (IRAM). An advisory group composed of representatives from other RadioNet partners will also provide input (usually via e-mail) with suggestions for meeting topics; they will also act as a contact point for other colleagues with meeting ideas that will mostly arise outside of this group. The names of the group will appear prominently in the RadioNet web pages. To make sure that each European radio astronomical Institute is equally involved, the geographical coverage of the activities will also be considered.

Members of the advisory group include: Raffaella Morganti (ASTRON-NL), Magdalena Kunert-Bajraszewska (TRAO-PL), Ivar Shmeld (VENT-LV), Suzanne Alto (OSO), Rob Beswick (UMAN), Keith Grainge (UCAM), Leonid Gurvits (JIVE), Andrei Lobanov (MPG), Andrea Possenti (INAF), Ben Stappers (UMAN) with additional representatives from outside of the formal RadioNet consortium Benedetta Ciardi (MPA), Marc Ribo (University of Barcelona) Sandor Frey (SGO-FOMI, Hungary) and Vlahakis (University of Athens). The group covers a wide-range of different interests and expertise.

As in FP6, the SWG will be open to support meetings that emerge via independent, bottom-up processes. As such, the programme must remain extremely flexible – in FP6, meetings were chosen in response to emerging scientific priorities that could not have been fully specified in advance. The necessity to keep an open attitude, encourage and support the birth of spontaneous meetings and initiatives is critical. The SWG coordinates activities with the Training Working Group (WP5), so as to complement the efforts and integrate science and training, especially for the new generation of scientists.

A general description of the list of activities includes provision for:

(1) Well-focused topic-oriented workshops (1 or 2 each year; ~ 50-70 people; duration 2-3 days), thought of and organised within this networking activity. The scientific topics will be chosen among the members of the Advisory Board, based on astrophysical issues and questions that are related to RadioNet and radio astronomy more generally. The objectives of such events are to promote discussion of ongoing developments, nurture collaborations and consider new scientific and related instrumental projects;

(2) Small meetings (1 or 2 per year, a dozen participants, duration 2 days) to discuss specific scientific and/or instrumental (e.g. calibration) developments and problems (1 or 2 each year);

(3) Large conferences (on average 1 every year, > 100 participants, duration 4-5 days), where astronomers from different areas of expertise and background (across the entire electromagnetic spectrum) meet to address broad issues of the day.

One of the main goals of the WP is to ensure a wide scientific coverage, and to tighten the link among different astronomical communities (radio, IR, optical, X- and gamma-ray, and in particular theoretical studies). Potential areas of interest are expected to be: observational cosmology, deep wide field surveys, physics of AGN, birth and evolution of radio galaxies, dust in galaxies, collapsed objects, pulsar-timing, stellar evolution. Scientific meetings driven by the new opportunities associated with the upcoming new or upgraded generation of radio telescopes and instruments will also be considered. Young or inexperienced researchers, including those from less-favoured regions will be given priority for travel support.

Deliverables (brief description)

Given the need for flexibility, a detailed programme is given only for the first year and a more general scenario for the subsequent years. The exact topics will be decided during the implementation of the project. It is expected to be able to support, and in some cases organise, on average of 5-7 meetings/workshops every year with various levels of support. The Chair of the SWG will regularly present a detailed implementation plan to the Project Coordinator and to the Board.

Meeting organisers will make material presented at RadioNet supported events easily accessible in the form of reports (in the case of small meetings), and conference proceedings/on-line presentations for larger meetings.

Deliverables list:

1. Topic Orientated Workshop (Topic TBD) reports – Months 3, 8, 12, 15, 20, 27, 32, 36
2. Small Meeting reports (Topic TBD) – Months 6, 16, 21, 31, 33
3. (Large) Conference proceedings (Topic TBD)– Months 9, 23, 35

Work package number	WP3		**Start date or starting event:**									month 1	
Work package title	European Radio Astronomy Engineering Forum												
Activity Type	COORD												
Participant id	5	17										Total	
Person-months per beneficiary:	5+0	2+0										7+0	

Objectives

The communication, training and scientific interaction among engineers involved in the development and operation of Radio Astronomy instruments represent a key issue in keeping these facilities at a world-leading technical level. While several opportunities for dissemination and training are possible for radio astronomy scientists and guaranteed by the scientific community, radio astronomy engineers are *de facto* limited to minor interactions. Building on the RadioNet FP6 Engineering Forum, and the VLBI operations (EVN Technical Operation Group), the Engineering Forum will address this problem. The major objectives of this network activity is to further strengthen the collaboration between those groups active in the development and operation of Radio Astronomy instruments at the European level, providing a solid and formal ground for mutual growth, collaboration and support. With local manpower and range of expertise limited at most observatories, close cooperation among engineers is essential. Collaborations and mutual support structures on a European scale will be enhanced so that duplication of effort can be avoided, and it permits expertise to be shared freely, across the RadioNet institutes. This Networking Activity is heavily focused on improving the data quality of current radio telescopes in Europe, in particular the Transnational Access facilities.

More specifically, the objectives, related to the larger radio astronomical community, including not only radio astronomy institutes but also academic groups and industrial collaborators operating in the development of high-performance hardware for radio astronomy, are to:

- Identify the technical expertise and competence areas of the larger European Radio astronomy community thus providing a database of design, characterisation and manufacturing facilities,
- Facilitate and assess the best practice of high performance systems and design methodologies,
- Train the next generation of radio astronomy engineers by means of short courses and lectures given by experts in the specific field,
- Identify key technical issues and directions, in order to provide appropriate solutions or to propose collaborative projects in particular areas of technological development,
- Strengthen and ease the interaction with industrial (and other academic) entities, with the two-fold objective of commercially capitalising the remarkable technical know-how and to have affordable and reliable partners for the development of future large-scale instrumentation in the era of SKA.

Description of work

The main activity of the RadioNet FP7 Engineering Forum will be to organise and support meetings and workshops of European radio astronomy engineers and other partners in related academic and industrial environments. The training of young engineers will also form a crucial part of the work programme. The forum will maintain and update a series of web pages in the appropriate section of the RadioNet FP7 web/wiki sites. These pages will be the central reference location for calls for technical material, meeting registration and event announcements. This work package will be lead by engineers from the MPG (Reinhard Keller and Walter Alef) and UROM (Ernesto Limiti).

European Radio Astronomy Engineering Special Sessions
In order to bring the results and expertise of the European radio astronomy engineers to the notice of the broader engineering community, special sessions will be organised within the framework of large international conferences (e.g. IEEE conferences, European Microwave Week etc.). The objective will be to exchange ideas and new directions, and to attract the interest of researchers in related fields to collaborate in the development of Radio Astronomy applications. Particularly in the field of new digital back-ends, and enormous growth of technology for more and more bandwidth is underway. Industry can already deliver of-the-shelf components meeting the requirements of the current facilities, but the detailed implementation still requires significant effort within institutes. One special session per year will be organised. The session organiser will provide a brief report detailing a summary of the presented contributions, the number of participants and major points raised. The management of this WP will be lead from MPG and partially funded by the EC.

Topic related engineering Workshops.
Forum participants will meet at least once per year for at least one day. The meetings (workshops) will be topical ones, and the themes will be selected and planned on a yearly basis. An appropriate call for contribution will be published on the Forum pages and the perspective contributors will upload presentation material to be accessible in advance to every meeting participant. In any case, each meeting will be configured to provide enough time both for formal presentation of high-level achievements and informal discussions on details of the work or further planning. The meetings will be preferably hosted by one of the participating WP3 institutions that, in conjunction with the event, may describe its own technical facilities and achievements. The meeting Chair will be responsible for providing, for each meeting, a report containing a series of information amongst which:

- Meeting Agenda;
- Material from the formal presentations;
- List of participants;
- Summary of the meeting.

EVN Technical Operation Group (TOG).
The European VLBI Network (EVN), Technical & Operations Group (TOG) meetings have a long and colourful history that extends back over more than 3 decades. TOG meetings represent the main basis on which other engineering collaborations have been built (e.g. SKADS), and they form a solid foundation of the success of WP3. Due to the nature of VLBI operations, standardised data recording and handling is required at each station. These meetings will take place 5 times in the duration of RadioNet FP7 and will provide an element of training and development, targeting topical subjects of direct relevance to VLBI operations and thus the quality of the data received by EVN and Global VLBI users.

The activities will include:

- Meeting Agenda, List of participants,
- A programme of bi-annual lectures and practical demonstrations by the EVN TOG,
- Progress reports from EVN stations, correlators and other VLBI related institutions,
- Minutes of the meetings and material from the formal presentations,
- Action item list, to be pursued between meetings.

Engineering Facilities Database
To maximise the technical interaction among the participating institutes, the knowledge of the

capabilities, expertise and methodologies adopted by the various partners is an essential starting point. To further this goal, one of the activities of the engineering forum in the first 24 months, will be to build-up a database of relevant technical facilities and engineering capabilities. Such a database or register will be regularly updated during the project duration, and will form a fundamental WP deliverable. The database will be populated either utilising the description generated by each participating partner or, in the case of facilities of particular importance to the community, by a direct visit to the facilities. In the latter case, the description of the facility and the methodologies adopted for characterisation and testing will be addressed, eventually utilising a common test vehicle, to be agreed among the participants. The database will therefore include not only the hardware facilities, but also the methodologies and processing of the participating institution. This activity will be lead by UROM.

Participants

Members of the European Radio Astronomy Engineering Forum will include both engineers from RadioNet FP7 partners, academic institutions engaged in the development of radio astronomy hardware and representatives from selected industrial entities: Massachusetts Institute of Technology Haystack Observatory ((MIT, USA); National Radio Astronomy Observatory (NRAO, USA); Arecibo- Cornell University (USA); Jet Propulsion Laboratory (JPL, USA); NASA Goddard Space Flight Center (NASA/GSFC, USA); Bundesamt für Kartographie und Geodäsie (BKG, Germany); University of Bonn (Germany); Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia); Berkeley University of California (USA), National Space Agency of Ukraine (NSAU, Ukraine), Ventspils International Radio Astronomy Center (VIRAC, Latvia), Crimea Astrophysical Observatory (CrAO, Ukraine).

Deliverables (month of delivery)

1. Reports from Engineering Workshops 1-5 – months: 8, 16, 23, 30, 35
2. Reports from the EVN TOG meetings 1-5 – months: 5, 13, 20, 26, 34
3. Database of technical facilities, engineering expertise – months: 12, 24

Work package number	WP4		**Start date or starting event:**								month 1
Work package title	Training for Radio Astronomers (TRA)										
Activity Type	COORD										
Participant id	6	11	2								Total
Person-months per beneficiary:	2+(2)	0+(3)	0+(3)								2+(8)

Objectives

The objective of Training for Radio Astronomers (TRA) is to improve the scientific exploitation of Radio Astronomical data with an emphasis on the products of observatories within the RadioNet consortium. Europe is a leading player in developing new and enhanced radio observatories and of specific instruments for solar physics. Training in areas such as how to prepare experimental proposals, data reduction and interpretation and opportunities for enhanced collaboration will be provided, especially for early-career radio astronomers. The programme will also address the needs of researchers from other wavelength domains and also theorists wishing to use the suite of new and upgraded radio telescopes currently being deployed (e.g. LOFAR and ALMA).

Description of work (possibly broken down into tasks)

A series of courses, workshops and schools with a significant "hands-on" approach will be organised, led by radio astronomy experts. They will benefit not only early-career astronomers but also more advanced researchers needing to exploit the new techniques being developed for the next generation of ultra-sensitive instruments. Such events provide "added-value" via the interaction between trainees and experienced RadioNet staff, initiating and strengthening a Europe-wide approach to research and collaboration. As forums for young researchers to discuss ideas with experts, the TRA activities will lead to the development of new techniques and promote awareness of advances throughout the community. A website (linked to the main RadioNet FP7 website) will be developed and regularly updated to archive all the teaching material generated by TRA e.g. lecture notes, data reduction tutorials and feedback.

Three annual events will be held in each of the three series, accompanied by related on-line material. Each of the three main participants (UMAN, OBSPAR & IRAM) will lead one event in each of the 3 years, according to their expertise.

The event leaders will be:

- Anita Richards (UMAN) has experience in cm-wave interferometry and Virtual Observatories through her employment as an AstroGrid astronomer and MERLIN archivist,
- Karl-Ludwig Klein (OBSPAR) President of the Community of European Solar Radio Astronomers and
- Pierre Cox, Director of the Institut de Radioastronomie Millimétrique (IRAM).

Each of the event leaders will be responsible for organising a suitable venue for the activity (and arranging local support) and will also set up a Scientific Organising Committee (SOC) of international experts. SOC membership will be chosen with regard to the domain of each School, Workshop etc. and SOC members will be responsible for inviting lecturers/tutors and providing guidance on maintaining a high quality of teaching material. They will also manage the related web pages, ensure that applications for supplementary funding/sponsorship are arranged (as required), and collect feedback from trainees after each event is complete. This feedback will be used to evaluate the event. The overall TRA leader (Richards) will ensure overall coordination and monitoring of milestones, including the impact of the activity as measured by the use of European telescopes by new trainees, and the associated publication rate.

The three series of events are:

1) European Radio Interferometry Schools (ERIS)

The annual ERIS will continue, alternating each year between schools focusing on cm and longer or mm and shorter wavelengths. The former will be led by UMAN (Richards), and the latter by IRAM (Cox). Expert lecturers will provide an overview of the scientific potential and techniques of radio interferometry, and the capabilities of current and future facilities, complemented by hands-on data reduction sessions led by experienced tutors. These will include the use of common data reduction packages to process raw data through to final images or other products, plus the associated analysis of these products in order to tackle real astrophysical problems. Participants will be introduced to the 'life cycle' of an experiment, from proposal-writing and planning observations, through to making their results accessible and retrievable via data archives. These schools will provide an opportunity for every interested European graduate student or newcomer to radio interferometry to gain direct experience. An on-line library of course materials, references and recipes for ongoing consultation and wide dissemination will be set up and made available.

2) Focussed Training

Single Dish Experience: IRAM (Cox) will lead the organisation of two schools on single-dish (sub-mm) astronomy, in Granada (Spain) near the IRAM 30-meter telescope. The lectures and tutorials will concentrate on the techniques of single dish sub/mm-astronomy and their applications to different areas of astrophysics. Students will conduct their own scientific projects, observing at the 30-meter telescope, reducing, analysing and interpreting their data under the supervision of the lecturers. This activity will provide a unique environment of hands-on experience with one the current leading millimetre single-dish telescope, essential training if European astronomers are to take advantage of future opportunities associated with JCMT-SCUBA-2 and APEX. Synergies with other major facilities will also be emphasised e.g. the Herschel sub-millimetre satellite and forthcoming ESO instruments, in particular ALMA.

Solar Physics: OBSPAR (Karl-Ludwig) will lead the organisation of a school on the Radio Physics of the Sun and the Interplanetary Medium, at a European venue with good internet connectivity (e.g. .DPG Physik Zentrum, Bad Honnef near Bonn). The course will give an overview of the Solar atmosphere and processes of incoherent and coherent radio emission, specific observational techniques and data processing, the physics of plasma-magnetic field interaction and of particle acceleration. Solar radio astronomy provides essential diagnostics of the plasma of the solar corona, of propagating disturbances such as shock waves, and of high-energy electrons, their energisation and propagation in the corona and interplanetary space. European solar radio astronomers operate several small telescopes dedicated to monitoring solar activity and the only solar-dedicated metre-wave aperture synthesis array in the world, located at Nançay. LOFAR is also expected to make a significant impact in this area and long-baselines between E-LOFAR stations (including those being built in France, Germany, Sweden and the UK) will provide an entirely new tool for solar studies.

3) Young European Radio Astronomers Conference (YERAC)

The first YERAC meeting was held in Paris in 1968, during the height of student and workers protests and unrest. With this auspicious start, the meetings have been held almost every year thereafter, and they form part of the fabric that binds the European radio astronomy community together. The goals and format of the meetings have not changed much over 40 years – YERAC remains a forum mainly for European (including Eastern-Europe and in particular Russia) graduate students, and occasionally early-career postdoctoral staff. The conferences represent an ideal opportunity for students to form close friendships and collaborations with their own peers, and to learn the basic skills of presenting and explaining their own research work in an informal and supportive environment. TRA will continue this tradition and make the educational content of YERAC more secure in several ways: ample time for discussion in each session will be ensured, with chairs trained to guide it; introduce a "surgery" for presentation techniques and add a final assimilation session in which trainees are split into groups, guided by local experts on the most popular topics. Feedback from the students will help form the course content for subsequent years.

Deliverables (brief description)

1. Website - announcements and organisation of the forthcoming events (month 2). Workshop/school/conference materials updated on-line continuously.
2. List of TRA student proposals (months 12, 24, 36)
3. Lectures on Solar Physics school compiled into a (draft) text book (month 36)
4. Final list of TRA student proposals and publications (month 36)
5. Final report analysing student feedback and lessons learnt (month 36)
6. YERAC contributions/proceedings available online (months 12, 24, 36).

Work package number	WP5		**Start date or starting event:**					month 1			
Work package title	Spectrum Management										
Activity Type	COORD										
Participant id	3	1	5	6	11	2	7	18	13		Total
Person-months per beneficiary:	0+(16)	0+(4)	0+(4)	0+(4)	0+(4)	0+(4)	0+(4)	0+(4)	0+(4)		0+(48)

Objectives

The objective of this WP is to keep the radio astronomy frequency bands free of man-made interference in order to safe-guard this environment for fundamental astronomical research. The broad aims of the activity centre on coordinating activities designed to protect the electro-magnetic spectrum for passive radio astronomy observations. The radio astronomy community is at a significant disadvantage in pursuing this objective because it brings it into conflict with commercial and governmental and EC interests.

WP5 will have the following specific objectives:

- Supporting the activities of the Committee on Radio Astronomy Frequencies (CRAF) an Expert Committee of the European Science Foundation, ensuring that the radio astronomy community remains organised, alert and active in the pursuit of keeping the frequency bands used by radio astronomers free from man-made interference.
- Present the case for radio astronomy as a valuable passive service via discussions with the major public and private telecommunications agencies and the international bodies that allocate frequencies and manage standards (including the EC).
- Form a coherent European voice acting in concert with other groups of radio astronomers around the world (e.g. CORF – the Committee on Radio Frequencies representing the interests of US scientists)
- Continue to educate the European scientific community via a summer school that offers a comprehensive view of both regulatory and technical issues related to radio astronomers' use of the spectrum, as well as how these issues are considered by other both active and passive radio services.

Description of work (possibly broken down into tasks)

WP5 will support the efforts of the radio astronomy community in protecting the spectrum for passive use via the following activities:

Support of CRAF

Since 1987 CRAF is mandated by all the European radio observatories to coordinate their spectrum management activities at the local, national and international level. The radio observatories finance CRAF, in particular they support the appointment of a dedicated Spectrum Management Officer, Laurentiu Alexe (hosted and formally employed by ASTRON). The current CRAF chairperson is Roberto Ambrosini, who will lead the WP5 in RadioNet FP7. CRAF meets twice per year and WP5 will partially support the travel of members to these meetings.

Engaging agencies and international bodies that allocate frequencies and manage standards

It is essential that CRAF remains vocal and visible at both the national and international level. CRAF members actively lobby their own National Telecommunication Administration in order to raise enough votes to place issues and concerns of the radio-astronomy community on the agenda of the appropriate international fora (such as meetings of the Conférence Européenne des Postes et des Télécommunications, CEPT, and the World Radio Conference of the International Telecommunication Union). WP5 will partially support the travel of CRAF members to 1-2 meetings per year, in order to protect radio astronomy interests in the context of the regulatory rules and conditions, now determined by various international bodies, including the European Commission Radio Spectrum Policy Unit.

The changing environment in the Radio Spectrum results in a new activity for CRAF: starting a dialogue with the EC and at European political level about the importance of the Radio Astronomy windows for science purposes. The widespread use of a large number of wireless applications has given the Radio Spectrum a significant commercial value. In order to maintain and preserve a window in the radio spectrum that allows passive use like radio astronomy science, a dialogue with Brussels is required. The goal is to discuss current and future applications that severely threaten radio astronomy and to preserve the current radio astronomy allocations. Assistance and cooperation with DG Research and DG Information Society can be of great use in finding the right platforms to argue the case of radio astronomy.

Education and Global Collaboration

The need to have new scientists and engineers entering the community of spectrum management and protection is a priority. For newcomers the learning curve will be long and steep, due to the intrinsic difficulty of combining many different areas of expertise: a background in radio astronomy, a thorough understanding of the relevant technologies, good negotiation skills and a deep knowledge of the regulatory procedures on how the spectrum is managed at international and European levels. The CRAF education programme (supported via WP5) aims to nurture the next generation of astronomers and engineers that will be capable successors to the current generation of CRAF members and ensure its future continuity.

"Spectrum Management Seminars" alongside the twice-yearly plenary CRAF meetings will continue and partial travel support for seminar participants will be provided. WP5 will also make a modest contribution to the local organising costs.

Support for the larger and more formal "Summer Schools for Spectrum Management in Radio Astronomy" will also continue.

An important (implicit) aspect of these activities is the strong element of global cooperation that is involved. Within RadioNet FP7 and WP5, the aim is to achieve a better integration of efforts with colleagues worldwide: with CORF in the US, RAFCAP in the Asia-Pacific region and with IUCAF as the overall coordinator of global Spectrum Management activities for radio astronomy.

Common monitoring schemes

The idea of developing a common radio frequency interference (RFI) monitoring scheme for all the European radio observatories has been discussed within CRAF. The purpose would be to harmonise monitoring measurements and to coordinate common procedures in reporting interference to the National Administrations. A common monitoring format would also help in realising a central European repository of out of band emissions. The benefit of such a standardised implementation can be summarised by the sentence "no proof of interference, then no damage done". It should be noted that the right to claim protection from out of band interference can only be requested when a certain level of data loss is exceeded; a network of standardised RFI monitors will help to produce such evidence.

WP5 will conduct a preliminary feasibility study for a common monitoring scheme (hardware and data format) for all CRAF sites.

Deliverables (brief description)

N.B. unlike most other RadioNet FP7 Network Activities, the deliverables generated by WP5 are largely restricted in terms of their distribution. This reflects the environment in which CRAF and WP5 must operate – experience shows that the need for caution (especially when dealing with commercial, regulatory and licensing entities) should not be ignored.

The main deliverables of WP5 are:

1. CRAF meeting reports – Months: 6, 12,17, 25, 30
2. International Regulatory reports (and similar international meetings) - Months: 7, 15, 26, 32
3. Spectrum Management Summer School – Month: 10.
4. ITU WRC report 2010 – Month 24.
5. Feasibility Study for Common monitoring scheme – Month 36.

Work package number	WP6	**Start date or starting event:**					month 1			
Work package title	Advanced Long Baseline interoperable User Software									
Activity Type	RTD									
Participant id	4	1	18	15	5	23	19	6	20	Total
Person-months per beneficiary:	**26**+18	**13**+13	**12**+10	**18**+12	**6**+0	**12**+9	**12**+9	**15**+12	**12**+9	**126**+92

Objectives

The objectives of ALBiUS (Advanced Long Baseline interoperable User Software) are to develop key algorithms required for the successful exploitation of the upgraded and new generation of RadioNet telescope facilities (e-MERLIN, LOFAR, APERTIF, ALMA etc). These new telescopes will result in an explosion of data rates, and an expansion in the continuum spectral window of one to two orders of magnitude. ALBiUS will produce new software systems and algorithms that are designed to meet these challenges. The focus will lie in the production of new algorithms that address issues of calibration (both in the uv and image plane) and sky modelling. The need for identifying bad data and the issue of data quality control in general, will also be addressed. In addition, ALBiUS aims to make good use of existing software packages - the goal is to make these algorithms available in a modern, distributed computing environment, and to provide transparent interoperability between the different software suites. The latter will encourage a more unified approach to software development in radio astronomy across Europe and beyond.

Description of work

Task 1 Interoperability

Portable Algorithms

A pilot project is carried out to transparently process a dataset using software from multiple packages. There is scope to exploit the commonality in the Python user interface of AIPS, Casa, MIRIAD and GILDAS to implement this. The major issue is the variation in the data formats and calibration models used by the different packages. A simple approach is to convert between the different data formats using an intermediate data format, which is already accessible to all the packages, such as UV FITS. An alternative approach would be to adopt HDF5 as the basis of an interoperable data format. The interoperable packages would then either have to be made HDF5-aware, or else be provided with a conversion routine from HDF5 to their native format. Using HDF5 has the added benefit of giving access to additional HDF5 tools not found in the main interferometry packages, in particular for 3-D data visualisation. This work will be carried out at JIVE and ESO.

Distributed ParselTongue

ParselTongue was developed by the ALBUS project as a Python interface to classic AIPS. This is the main vehicle for making the algorithms developed in ALBUS available to the user community. It has also proved an extremely effective tool for pipeline data processing, and has been incorporated into the production environment of the EVN and MERLIN arrays. In addition, it is used by an increasing number of astronomers for processing datasets which are either large in size or consist of repeated observations, each requiring similar processing. The current ParselTongue functionality will be developed in the context of interoperability with other packages. Given the continuing dependence on AIPS of a large part of the radio astronomy community, even in this era of ever increasing data volumes, there is a necessity for enhancing ParselTongue to allow better exploitation of AIPS on a distributed computing environment. Some initial progress has already been made within ALBUS on creating an infrastructure that allows data distribution for parallel processing, but there are many issues which require more atomic procedures than currently available in the AIPS suite - these problems need to be addressed. This work will be carried out at JIVE.

Task 2 - Calibration algorithms

Global Fringe Fitting

Global fringe fitting is a crucial calibration step for EVN and e-MERLIN, the extended (European) LOFAR baselines and the highest ALMA frequencies, where the residuals to the correlator model of the station-based delays must be determined. The algorithm for this is currently only implemented in AIPS, but will have to be incorporated into the new software packages for these arrays. In addition, the current algorithm produces results which are difficult to interpret in an automated way due to peculiarities of the weighting scheme and resulting anomalies in the reported signal to noise ratio. The procedure is complex and there are many pitfalls for both the user and the potential developer. Alternative methods to the non-linear least squares fit (Levenberg-Marquardt algorithm) used in AIPS are also likely to produce more robust results, less susceptible to converging on local minima. The current fringe-fitting algorithm will be evaluated and based on this evaluation an improved version will be provided. This work will be carried out at NRAO, Manchester and JIVE.

Image Plane Calibration

In ALBUS, methods were developed for calibrating the effects of ionospheric and tropospheric fluctuations on long baseline interferometry data. These methods have been implemented in AIPS with some success. A limitation, however, is that the AIPS calibration model assumes that a single calibration factor is applicable across the instantaneous field of view of the interferometer. This assumption does not hold for the large fields of view and/or large fractions of the primary beam which will be observed by LOFAR, ALMA and APERTIF and which are becoming available for the EVN, e-MERLIN and EVLA as the correlator capabilities of those instruments are enhanced. Polarisation imaging over wide fields of view presents additional challenges for all these instruments. In particular, the polarisation response of the dipole arrays used by LOFAR will have strong direction dependence.

These image plane effects can be corrected using some of the more modern calibration packages, which are currently being developed, but the algorithms will require enhancements to the calibration model to incorporate the required direction dependence. At the same time, some related calibration issues will be addressed, such as correcting for station primary beams, and using mosaicing techniques to produce images covering areas of the sky much larger than is achievable with a single pointing, the latter being particularly important for ALMA with its relatively small instantaneous field of view.

High spectral and temporal resolution is required to achieve large fields of view as well as to allow high quality spectroscopy, and the study of transient phenomena (both astronomical sources and contaminants such as RFI). This implies very large data sets: 100's of GBytes for EVN and several TBytes for LOFAR. Efficient processing of such large data sets requires access to a distributed computing environment and therefore existing algorithms to enable this need to be modified. This will also require investigating the support for distributed computing in the chosen calibration packages. Solving this issue will be important for LOFAR and ALMA, but suitable test datasets from GMRT, Westerbork and the EVN already exist. This work will be carried out at ASTRON and Oxford, Manchester, Cambridge, NRAO and ESO.

Calibration of Astrometric Source Positions
Having highly accurate source positions is essential for almost any astronomy application, and certainly for high-resolution interferometric imaging of weak targets. At present, astrometric measurements are carried out with two different techniques: wide-angle astrometry based on the total interferometric phase response (for major calibrator sources distributed on a 5° grid on the sky) and narrow-angle astrometry based on relative phase measurements (for sources located between the major calibrators). There are ways to develop innovative algorithms and observing techniques that will combine the two approaches to produce an improved, denser, and unified celestial reference frame comprising all sources (whether observed with wide- or narrow-angle astrometry). Ultimately, these new methods should serve as a basis for conducting deep astrometric surveys with instruments such as the EVN, e-MERLIN (or the geodetic IVS2010 network). Algorithms such as those used in traditional geodesy to adjust positions of second-order geodetic markers into a first-order grid of markers may be adapted to realise such a global adjustment. The multi-beam capabilities of future instruments such as the SKA will be taken advantage off. The work will include studies of potential algorithms, simulations to test these algorithms, and analysis of test data acquired with the EVN and e-MERLIN to validate observing strategies. This work will be carried out at Bordeaux in collaboration with JIVE and Manchester.

Task 3 - Tools for Large Datasets

Automated Data Quality Control
The new generation of interferometers currently coming on line (LOFAR, eEVN, e-MERLIN, EVLA, ALMA) will have vastly increased output data rates compared with current instruments. Traditional methods for data inspection will become impractical for these new instruments. It is therefore necessary to develop new techniques, such as subspace decomposition, to allow automated identification (and either correction or excision) of artefacts resulting from poor calibration, poor atmospheric or ionospheric conditions, man-made interference or other (instrumentation) problems. Some methods to mitigate RFI are known to be very effective, but are not yet implemented at many radio observatories. The usefulness of existing algorithms will be investigated and to make them available in interferometry, where appropriate. The most useful algorithms would then be implemented in one (or more) of the mainstream interferometry analysis packages. This work will be carried out at MPG, ASTRON, Cambridge and Oxford.

Source Parameterisation
One of the primary scientific deliverables of LOFAR (and other SKA pathfinders like APERTIF) will be huge catalogues of all the detected sources. This so-called Global Sky Model will also provide the basis for the calibration, as a good sky model will be required to make tractable the complex calibration needs of these instruments. Most sources will be unresolved, so simple point-source models can be used, but a significant fraction will be extended. The vast size of the Global Sky Model means that new and innovative methods must be developed to:

1. automatically extract from the data an accurate description of the sources in a computationally efficient way,
2. store the source descriptions in a form which is compact and yet retains sufficient information to allow an accurate reconstruction of the objects described in it.

Traditional methods for doing this have involved describing sources in terms of collections of point sources (CLEAN components) or as collections of elliptical Gaussians. However, these methods are neither very compact, nor can they be easily extended to incorporate a complex time or frequency dependence. They do not provide sufficient dynamic range for instruments such as LOFAR or APERTIF. A possible solution is to use techniques based on shapelets or pixons. Such techniques can describe extended sources with relatively few parameters to high accuracy and, given their continuous nature, do not suffer from the problems caused by the discreteness of CLEAN-component models and will be able to achieve much higher dynamic range. An optimal means of producing a Global Sky Model based on these techniques will be produced. This work will be carried out at ASTRON.

Deliverables (brief description)

6.1.1 Final report on calibration of pilot experiment using interoperability framework – Month 21

6.1.2 Release of distributed ParselTongue - Month 21

6.2.1 New implementation of Global Fringe Fitting algorithm – Month 36

6.2.2 Direction dependent ionospheric, tropospheric calibration to test data set – Month 21

6.2.3 Software for mosaic imaging including primary beam correction – Month 25

6.2.4 Report on image plane polarization calibration effects – Month 19

6.2.5 Final report on the implementation of algorithms for image plane calibration in a distributed environment – Month 30

6.2.6 Final report on new algorithms and observing strategies for astrometry – Month 28

6.3.1 RFI mitigation software – Month 19

6.3.2 Final report on data quality algorithms and excision methods – Month 36

6.3.3 Final report on models for extended sources – Month 28

Work package number	WP7				**Start date or starting event:**					month 1		
Work package title	Focal plane Arrays at Millimetre/Sub-millimetre wavelengths and THz frequencies for Astronomical Research (AMSTAR+)											
Activity Type	RTD											
Participant id	2	5	7	9	10	11	12	13		14	25	
Person-months per beneficiary:	**33,8 +0**	**0+0**	**17+0**	**9,6+0**	**24,7 +0**	**10,8 +0**	**6+0**	FG **24+0**	IGN **9+9**	**23+0**	**14,6 +0**	
Participant id	3	19	Total									
Person-months per beneficiary:	**0+0**	**2,9+0**	**175,4+9**									

Objectives

The objective of AMSTAR+ is to develop the technology required for the construction of large format (two dimensional) focal plane heterodyne arrays (FPAs) operating from 80 GHz (3.8 mm) to 2 THz (0.15 mm). The aims of the project include the:

1. development of a prototype W-band heterodyne array module using metamorphic HEMT technology,
2. exploration of practical solutions for the construction of large 2-D heterodyne FPAs,
3. investigation of integrated pixel and photonic LO solutions for a large mm-wave FPA,
4. extension of low noise heterodyne FPA technology into the 1-2 THz frequency band.

The 3-year programme will target the technical developments needed for the construction of large format (two dimensional) focal plane heterodyne arrays (FPAs) operating at up to 2 THz. The focus will lie in the development of heterodyne detection devices. Prototype array modules will demonstrate the adequacy of these devices for the construction of large FPAs for single-dish telescopes, as well as interferometers. Optimization of local oscillator (LO) distribution and integration of components will lead to more effective arrays.

Description of work (possibly broken down into tasks)

The technical requirements for FPAs, especially for two dimensional arrays with ~100 pixels, or more, are considerable: in addition to low noise and wide frequency bandwidth, they demand high compactness, high reliability, low fabrication cost and high reproducibility of the detector elements. Moreover, stringent constrains exist on LO power generation and distribution, IF amplification and matching, and cryogenic cooling. Novel solutions for these demanding requirements will be developed. The progress realised through the FP6 JRA AMSTAR. Detecting devices will be based on SIS mixers, on solid-state MMICs amplifiers or, for THz operation, on HEB mixers and/or SIS mixers with advanced superconductive materials. Innovations, such as integrated planar structures, will be developed to reduce drastically the mixer footprints and decrease the fabrication costs. Other solutions must be explored to resolve the critical question of LO distribution, a topic that has been addressed in a preliminary manner during AMSTAR.

Four tasks will explore the solutions best suited for the 4 frequency intervals 80-120 GHz, 120-400 GHz, 400 GHz-1.2 THz and 1-2 THz, which are all equally important from the astronomical point of view and are each accessible by existing large RadioNet telescopes.

Task 1: Prototype W-band heterodyne array module using metamorphic HEMT technology

At frequencies up to the mm-wavelength range, the current state of the art in low-noise front ends is the InP-based HEMT technology developed by JPL/NGST. The devices operate at 15K using rugged closed-cycle cryocoolers. The main goal is to explore the potential of the metamorphic HEMT process on GaAs, developed by the Fraunhofer Institute for Applied Solid State Devices, Freiburg (IAF), in order to deliver a noise performance at mm-wave-length that is competitive to the current InP-based technology. Indeed a similar performance is expected from theoretical considerations. IAF's expertise in large scale integration of solid state circuits offers the capability within Europe to build large, highly integrated mm-wavelength FPAs using MMIC's. In comparison to the InP based technology, IAF's process could offer lower cost, especially for large area MMIC's, integrating many building blocks on a single chip. The active participation of IAF researchers in developing cooled W-band HEMT amplifiers and incorporating these into MMICs will be the key factor for achieving the best noise figures and for reaching the upper edge of the 3-mm atmospheric window. This level of integration will be made possible for cryogenic designs as well. The devices developed within this project shall be demonstrated by laboratory characterisation of a prototype module. A dedicated prototype test at the IRAM 30-m telescope is planned outside the scope of this project.

Subtask 1.1: Cryogenic modelling of single HEMT devices and design of cryogenic MMICs. In order to develop circuits for low-noise amplifiers a thorough characterisation of the single HEMT device that results in a cryogenic transistor model including noise is needed. In parallel to this effort the design of LNA's will start, allowing feedback to the model from their measured performance. (participants: MPG, IAF, FG-IGN)

Subtask 1.2: Manufacturing runs of MMICs. There will be a minimum of 2 runs in 2009 and 2010, using space on IAF standard wafers which are fabricated using the current process for room temperature devices. There will be a minimum of 1 run beginning of 2011 to use a new process optimised for cryogenic devices that will be established by the results of this task (IAF).

Subtask 1.3: Design iteration of heterodyne modules (pixels). Heterodyne modules that constitute a single pixel of an array receiver will be designed that contain 2 linearly polarised RF-channels per module. A compact, full band waveguide orthomode transducer will be designed for this purpose. The level of integration will be pushed as far as possible, although a full integration on GaAs seems beyond the scope of the current project (MPG, IRAM, INAF-OA)

Subtask 1.4: Module tests. The IRAM design for an array test cryostat will be single-pixel dual-polarisation with full band coverage including of course the CO line at 115 GHz. The design and construction of the test cryostat and its supporting hardware is not part of RadioNetFP7. (IRAM, MPIfR)

Task 2 – Integrated pixel and photonic LO for large mm-wave focal plane array

The objective of this task is to design, build, and demonstrate a compact pixel, meeting the following conditions: a) small footprint, suitable for 2D stacking in a focal plane; b) sideband separating and wide IF band for maximum scientific throughput; c) completely integrated signal processing from RF input to pre-amplified IF output.

In addition, a photonic local oscillator (LO) for the near-millimetre range, meeting the following conditions: a) scalable to large (~100 pixels or more) focal plane arrays; b) spectral purity suitable for all single dish application (and if possible, also for interferometry).

Subtask 2.1: DSB mixer with LNA. Design and co-optimize an SIS mixer for 200-270 GHz and a LNA with direct coupling (no isolator), wide IF band and low noise. Perform an experimental proof of concept (participants FG-IGN+IRAM).

Subtask 2.2: 2SB mixer. Design and test an SIS sideband separating (2SB) mixer for 200-270 GHz, with RF quadrature hybrid and LO splitter integrated on the same substrate as the SIS junctions (IRAM).

Subtask 2.3 Compact version. Design and test a small footprint version of the LNA developed in (2.1) above (FG-IGN).

Subtask 2.4: Test. Joint test of LNA (2.3 above) and SIS mixer (2.2 above)

Subtask 2.5: Photonic LO. Design, build, and demonstrate a photonic local oscillator for 130-170 GHz or 200-270 GHz, having an accuracy, and line width of 1kHz or less; minimum frequency step possibly 100kHz. Joint test of photonic oscillator with SIS mixer (RAL/SFTC+IRAM)

Task 3: Sub-millimetre Wave Heterodyne Focal Plane Array

This task will explore practical solutions for the construction of large 2D heterodyne FPAs, based on SIS junction mixers, in the sub-THz/sub-mm range. The short wavelengths raise specific problems for large arrays: a) The LO power generation and injection becomes critical; solutions such as on-chip LO integration, quasi-optical injection and photonic LO will be considered. b) The atmospheric noise is large at these wavelengths; solutions such as sideband-separating mixers and balanced mixers will be explored to reduce this noise and the required LO power. c) The short wavelengths make the mixer and horn fabrication delicate and expensive; new manufacturing technologies will be exercised and new solutions for IF signal filtering, amplification and matching will be sought. The work is organised in four sub-tasks:

Sub-task 3.1: Optical and LO coupling study. Issues connected with the signal and LO coupling to sub-mm FPAs will be studied to investigate the optimum solution. Important study topics include: waveguide vs. quasi-optical coupling, efficient focal plane sampling and packaging strategy, as well as LO configuration and integration. Several options for LO power insertion will be considered. (SRON, TUD, OSO)

Sub-task 3.2: Mixer development for Focal Plane Arrays. Mixers for FPAs need to be specifically designed, as they have to be modular and very compact. Advanced mixer layouts (compact single-ended, sideband-separating, balanced) will be developed and different mixer micromachining fabrication techniques will be investigated (SRON, TUD, OSO, FG-IGN])

Sub-task 3.3: FPA infrastructure scalability and IF system. As the FPA layout requires the densest possible focal plane sampling, the physical size of components such as IF amplifiers become crucial. The optimum solutions for IF coupling schemes and the IF subsystem design, as well as the receiver infrastructure will be developed. (DC bias, magnetic field, wiring and multiplexing) (SRON, TUD, OSO, FG-IGN).

Sub-task 3.4: Mixer technology development. For sub-mm frequencies, novel SIS junction technology and materials needs to be investigated. This includes NbTiN/SiO2/Al, all metal tuning structures, epitaxial metal, and higher Tc materials (e.g. NbN, NbTiN, Nb3Al). Also new junction barriers will be explored for these higher frequencies. Junctions fabricated will be used in sub-task 3.2. (SRON, TUD, OSO)

Task 4: Low noise heterodyne mixers for focal plane arrays in the 1-2 THz frequency band.

This task will extend the heterodyne FPA technology into the Terahertz windows. For this frequency range, the first priority is the development of new detecting devices. By the application of new materials for HEB mixer devices an attempt is made to increase the IF bandwidth and improve the device manufacturing reproducibility. In addition, as an alternate solution, the development of novel SIS junctions, with a high gap voltage and a high current density barrier in order to extend the use of SIS mixers above the present limit of 1.2 THz. The latter solution, which makes use of high critical temperature superconducting materials, is particularly challenging, but it potentially yields a lower noise and a larger bandwidth. The other priority of Task 4 is the investigation of both waveguide and quasi optic THz mixer technologies adapted to FPA implementation; indeed mixer technology determines for a significant part the ultimate sensitivity of SIS and HEB THz mixers.

Sub-task 4.1: High gap voltage, high current density Superconductor Insulator Super- conductor (SIS) device development. Because of their superior IF bandwidth and stability compared to SHEB devices, SIS junctions are the most promising mixer device for the 1-2 THz range. The superconductive junction electrode materials with a sufficiently high gap frequency for the THz range that can be combined with a high current density barrier material will be explored. (TUD, KOSMA).

Sub-task 4.2: Superconductive Hot Electron Bolometer (SHEB) device optimisation. SHEB devices are presently the most sensitive mixers for THz frequency detection. However, uniformity and reproducibility of the SHEB devices need to be improved. Moreover, an increased IF bandwidth is needed before these devices are suitable for array applications, which is also much desired for extragalactic astronomy observations (SRON, OBSPAR & TuD).

Subtask 4.3: Waveguide mixer design and development. For use in FPAs, waveguide mixers have advantages compared to mixers using planar antennas (Subtask 4.4 QO mixers), because the mixer beam is determined by the waveguide horn and alignment of waveguide mixers for arrays is generally more straightforward than for the present QO mixers. The fabrication of waveguide mixers is more challenging, however. Waveguide mixer devices must be on membranes for THz frequencies, and mounting the devices in the waveguides is a critical step. This task further develops the THz waveguide fabrication towards a reliable series fabrication. The work will consist in the design, construction and test of a waveguide mixer. The deliverable will be a test report. (OSO, KOSMA).

Subtask 4.4: Planar antenna mixer (QO mixer) design and development. QO mixers have been indispensable in the development of mixers at THz frequencies. They can be fabricated on bulk substrates, as well as on membrane substrates. For array applications it is important that the fabrication process of QO mixers leads to uniform noise performance and local oscillator power consumption, as well as to a high yield (> 90 %). The fabrication process on bulk substrates (e.g. NbN on Si) is reasonably well developed. The present QO bulk substrate mixer design needs to be adapted to make it suitable for FPAs. A QO SHEB mixer using a membrane substrate for HEB and an antenna combined with a metallic mirror will be investigated as an alternative, more promising, solution (OBSPAR, SRON)

Subtask 4.5: Assessment of the most promising THz FPA configurations. Measurement results and design evaluation of the mixers and devices developed in Sub-tasks1-4 will be used as input for a discussion about the possible configurations of future medium and large scale FPAs for 1-2 THz (KOSMA, SRON, TUD, OSO, OBSPAR).

Deliverables (brief description)

1. AMSTAR+ progress report, month 7

2. AMSTAR+ progress report, month 13
3. Design report for photonic LO for mm SIS of spectroscopic quality, month 17
4. Design report on final cryogenic W-band HEMT model, month 18
5. Progress report, month 19
6. Design report for 2SB mm-wave SIS mixer-on-a-chip, month 20
7. Design study report on sub-THz mixer and IF amplifier integration, month 21
8. Batches of AlOx and AlN barrier junctions for sub-THz SIS mixer, month 21, 36
9. Test report of photonic LO with SIS mixer, photomixer at cryogenic temperature, month 23
10. Design report on optimal coupling of mm SIS mixer to input stage of LNA, month 24
11. Design study report on balanced sub THz mixer, month 24
12. Report on Quasi Optical THz test mixer, month 24
13. Progress report, month 25
14. Report on THz waveguide test mixer and devices, month 30
15. Progress report, month 31
16. Prototype of W-band module suitable for array integration, month 36
17. Study report on High Gap SIS junctions, month 36
18. Test report of W-band prototype module, month 36
19. Design and Test report of integrated 2SB mm mixer and LNA pixel, month 36
20. Sub-THz prototype mixer demonstration, month 36
21. Design study report on sub-THz Array infrastructure, month 36
22. Batches of AlOx and AlN barrier junctions for sub-THz SIS mixer, month 36
23. High Gap SIS junctions, month 36
24. Final Report THz FPAs, month 36
25. Final Report on AMSTAR+, month 36

Work package number	WP8		Start date or starting event:				month 1
Work package title	APRICOT: All Purpose Radio Imaging Cameras on Telescopes						
Activity Type	RTD						
Participant id	3	5	6	8	13		17	Total
Person-months per beneficiary:	**35**+17	**35**+0	**35**+18	**29**+15	FG **12**+0	IGN **0**+6	**10**+0	**156**+56

Objectives:

The objective of APRICOT (All Purpose Radio Imaging Cameras on Telescopes) is to develop the capability to construct, and to maximise the impact of, large-format focal plane "radio cameras" for astronomical observations in the scientifically rich frequency range of 30-50 GHz. This region of the radio spectrum is poorly-explored, and is in the gap between the frequencies which will be covered by the Square Kilometre Array (SKA) and ALMA. Single-telescope results can, however, be followed-up at higher resolution with current and upgraded interferometric arrays (e.g. the EVLA and mm-wave VLBI). The main technical objectives are to:

1) develop the design and the sub-system technology for an all-purpose large-format (~100 pixels) focal-plane "radio cameras" for astronomical observations at 30-50 GHz. The partners have established the current state-of-the-art, and are ideally placed to develop very highly integrated systems with an order-of-magnitude more pixels. Europe is fortunate in having a suite of large radio telescopes that can exploit such cameras: the Effelsberg 100-m; the Sardinia Radio Telescope 64-m and the Yebes 40-m. Other telescopes, around the world, will also benefit enormously from the European technology base established in APRICOT. Integrated radio cameras, able to provide both polarisation-sensitive continuum and spectroscopic observations at the flick of a switch, will greatly increase the operational efficiency of the host telescope, and enable users to carry out hitherto impossibly large sky surveys.

2) secure the availability of state-of-the-art Monolithic Microwave Integrated Circuits (MMIC) devices from within Europe. Radio cameras will require many complex RF integrated circuits but a long-standing problem for European radio-astronomy is that the supply of low-noise MMICs is currently dominated by US companies, and hence subject to ITAR regulations. Establishing a European source of state-of-the-art, multi-function, MMICs is crucial for the future health of European radio astronomy, and has obvious spin-off potential into other arenas (e.g. space). The APRICOT team has the MMIC experience to develop this capability.

Once the technology base has been established within APRICOT, national will be requested for camera systems for specific telescopes .

Description of work and role of participants:

The overall goals are to develop an innovative architecture and suitable components to make available *all* the scientific observables across a large fractional bandwidth (30%) for a large number of pixels simultaneously. This is beyond the current state-of-the art and will necessitate a complex, highly integrated system design and the development of novel compact, low-cost, yet high performance sub-systems. To obtain the maximum continuum sensitivity, the entire RF band (10-15 GHz wide) will be sent directly to detectors after splitting into a few sub-bands to provide atmospheric and spectral discrimination. It may not yet be feasible to process the entire band in spectroscopic mode, but a broad-band IF output (≥2 GHz wide), selected from anywhere within the overall band, can be sent to high-speed digital Fourier Transform Spectrometers. This output could be sent directly to the generic back-end being developed by UniBoard (WP9).

To a great extent, the present partners have established the state-of-the-art in multi-pixel receivers in this wavelength range. Technological challenges of increasing the levels of active and passive RF component integration to new levels while, at the same time, achieving the lowest possible noise and the lowest possible unit cost per pixel (hence Task 1, Task 2). A possible risk is the problems of securing the supply of state-of-the art MMIC components from USA, as opposed to European, suppliers (hence Task3, Task4). Task 5 will develop techniques that maximise the scientific return from integrated cameras.

There is some commonality of goals with Task 1 of WP7 AMSTAR+ and some common partners. Although WP7 involves operation at different (shorter) wavelengths than APRICOT this work package intends to work closely with WP7 in single-pixel design and MMIC design.

Starting from an established base and the APRICOT receiver concept is considerably more complex and requires a much higher level of integration than that which can currently be envisaged in WP7. Although both work packages share the same objectives there will be no overlap in deliverables.

Task 1: Receiver Architecture: specification and test (MPG with UMAN, INAF, FG-IGN, UMK)

To build a receiver combining high performance, high reliability and a large number of pixels operating at cryogenic temperatures, a sophisticated mechanical and electrical receiver architecture will be developed. This task will define the functions and interfaces appropriate for integrating the components into a working system and will prepare a careful design for the generation and distribution of signals such as local oscillator, calibration and control signals, IF outputs and detected outputs. The work will be carried out in close cooperation with the work on passive (Task 2) and active (Task 3) component design. To verify the concepts and interfaces defined in this Task the predicted performance of an integrated single-pixel receiver chain based on component measurements will be compared with measurements of classical receiver designs. The results will be assessed for making recommendations on the final design of a large-format multi-purpose camera. The goals of this task are:

1. To develop appropriate architectures for highly integrated multi-pixel receivers
2. To define interfaces and functions for all components suited for optimal integration and maintenance.
3. To develop an appropriate model to predict the performance of the integrated pixel receiver chain based on the measurements of the components developed and realized in this JRA.

Task 2: Passive components: design & manufacture (INAF with UMAN, MPG):

The development of broad-band low-cost and low-weight passive components (horns, transitions, polarisers, OMTs, hybrid couplers, transmission lines) which can be integrated into a dense multi-feed system and operated in a cryogenic environment is vital for the final camera design. All or part of the feed horns must be cryogenically cooled; these may be made individually using standard techniques, alternatively the platelet construction technique may be employed. Passive components between the feeds and the first gain stages must have very low loss to avoid the introduction of significant noise, but such components are not available commercially. They must also be small and an appropriate technology will reduce their dimensions so that they can fit within an ideal cylinder whose circular base is defined by each horn aperture. Planar technology is a good starting point for the development of these parts. The components of a single pixel chain will be built to compare the performance of different approaches with the "reference" provided by a standard waveguide solution. The outputs of this task are:

1. Identification of construction technologies able to provide a complete passive chain with replication costs as lowest as possible combined with low weight and suitable performance.
2. Design of avery low loss components for specific applications where loss is critical
3. Manufacture novel passive components intended for an integrated receiver chain and to test their performance against those of "reference" components

Task 3: MMIC Design and Procurement (UMAN with MPG, INAF, FG-IGN):
Large format multi-purpose cameras will require many LNAs (operating at cryogenic temperatures); phase switches; mixers; hybrids; power amplifiers. The MMIC challenges are, therefore: minimum noise, excellent reproducibility and high levels of integration.

The US based company NGST is the main supplier of these devices but this situation is not preferred since cost, USA ITAR regulations and inflexibility in respect of materials and purposes Devices will therefore be obtained from three European sources, each of which offers different advantages. At the completion of this JRA, and in collaboration with WP7 Task 1, RadioNet partners will have established a clear picture of European MMIC capabilities. The facilities are:

The *UMAN M&N Facility* from the Microelectronics and NanoStructures group in the School of Electrical and Electronic Engineering offers the ability to explore new materials and to fabricate new discrete component (MIC) and MMIC designs quickly at no incremental cost. The group leader, Prof. M. Missous leads the LNA Design Task for the FP6 "SKADS" programme. The UMAN programme will be based on InP substrates and will employ conventional (100-nm) e-beam lithography but will introduce new semiconductor materials and new device architectures, including highly-strained channel materials (e.g. InAs) to reduce the ionised impurity scattering. These new materials and architectures will be tested first as discrete components. The principal goal is improved noise performance.

The *Fraunhofer Institute for Applied Solid State Devices, Freiburg (IAF)* has established a 50-100nm mHEMT (metamorphic-HEMT) process using GaAs substrates which may be competitive with InP-based devices. IAF also have great experience in producing multi-function MMICs for other applications IAF's existing GaAs technology will be fully explored and careful test device performance at 30-50 GHz will be carried out.

The *OMMIC company* has established a 70nm mHEMT process using GaAs substrates. MIC and MMIC experience has been gained with this company and experimental LNAs have been procured at 43 and 90 GHz with promising results. The existing technology will be used and careful test device performance at 30-50 GHz will be carried out. The goals of the task are:

1. To develop and secure European supply of HEMT and MMIC devices whose noise performance and reproducibility is competitive with that from the leading US supplier.
2. To seek improved noise performance, closer to the quantum limit, via the UMAN partner.
3. To seek increased levels of integration and multi-function capability within a MMIC circuit.

Task 4: Establishing accurate performance of LNAs (FG-IGN with MPG, INAF, UMAN):
Making accurate noise measurements in cryogenic environments is a complex problem and results obtained by different laboratories can differ significantly, highlighting the lack of established absolute standards for calibration and measurement techniques in this area. Overall testing homogeneity will be established, by sending samples of devices and LNAs to an experienced central site IGN (Third party to FG). Discrete devices (MICs) will be included in each MMIC run, and these will be inserted in the first stage of dedicated test amplifiers at IGN. Representative MMIC LNAs measured by the procuring partners will also be assessed independently in IGN, and some devices circulated between partners as "transfer standards" for noise calibration. Adopting a similar strategy to the noise measurements, the measurement of gain fluctuations (using a combination of Allen variance and temporal spectra) will also be coordinated through IGN. The

goals of this task are:

1. To make a reliable assessment of MMIC cryogenic noise temperature performance,
2. To make an assessment of MMIC gain fluctuations.

Task 5: Optimisation of Receiver Usage (UMK with MPG, INAF, UMAN).
Careful consideration of operational issues is a vital component of this JRA in order to optimise the architectural design and optimally exploit the receiver/telescope combination. APRICOT cameras allow surveys of the sky in continuum and spectroscopy modes at the same time. This maximises the use of observing time and also, in principle, allows homogeneous calibration of the continuum/spectral lines outputs, which is required for high fidelity imaging of large areas of sky.

A very large-format camera can only deliver its full potential, if it is possible simultaneously to solve for the calibration problems. The development of simulation software and algorithms will make full use of the multi-spatial, multi-spectral information provided by APRICOT cameras to tackle these problems. Fluctuations in atmospheric transmission due to water vapour are a particular challenge to continuum imaging at sea-level sites. The standard solution, spatial beam-switching of one form or another differentiates the sky brightness and hence limits the ability to make large-area images containing all the accessible Fourier components. The data from many spatially-distinct pixels with broad-band (30% fractional bandwidth) spectra and dual-polarisation from each can provide a new approach to solve this problem. Starting from simulation work associated with the FARADAY programme, the extensive programme of water vapour radiometry at MPG and data from the current generation of receivers, numerical models of the turbulent atmosphere and of the camera system will be used to develop new algorithms for atmospheric subtraction without spatial beam switching.

Since spectroscopy is not impervious to atmospheric fluctuations the simulations will also provide figures of merit appropriate for queue-scheduling of continuum and spectroscopic observations based on measurements at the telescope. This has never been done before. Within FARADAY the UMK group developed the data analysis package for a multi-beam single-polarisation, single frequency channel continuum receiver and also a new image visualisation system for spectroscopic mapping within the CSIRO LiveData software system. The goals are:

1. To develop and test algorithms using the full range of multi-pixel and multi-spectral data for the subtraction of atmospheric water vapour without spatial switching,
2. To develop and test figures-of-merit to support queue-scheduling of the receiver in both continuum and spectroscopic modes.

Deliverables

1. Study of receiver architectures and definition of the preferred concept (Task 1), month 6
2. Definition of interfaces and functions for the building blocks (Task 1), month 18
3. Comparison of passive chain performance against classical designs (Task 1), month 35
4. Report on design of passive chain using new technology for low replication costs, low weight and suitable performance (Task 2), month 24
5. Manufacture of passive components for one receiver chain using new technologies (Task 2), month 30.
6. Designs for very low loss passive components, on low loss substrates (Task 2), month 35
7. Euro MICs: first devices to establish noise performance (Task 3), month 12
8. Euro MMICs: Amplifiers and other circuits for RF&IF applications (Task 3), month 18
9. Euro MICs: advanced technology devices: aimed at improved noise performance (Task 3), month 24
10. Euro MMICs with improved noise performance: (Task 3), month 33
11. Tests of noise & 1/f performance of Euro MIC devices (Task 4), month 18, month 30

12. Establishment of Transfer Amplifier Standard (Task 4) , month 24
13. Tests of noise and 1/f performance of Euro MMICS (Task 4) month 24, month 35
14. Atmospheric model (Task 5), month 6
15. Report on feasibility of atmospheric subtraction without spatial switching; implications for receiver architecture (Task 5), month 24
16. Report on calibration procedures and queue scheduling strategies (Task 5) month 29

Workpackage number	WP9		**Start date or starting event:**					month 1			
Work package title	The UniBoard, a multi-purpose scalable computing platform for Radio Astronomy										
Activity Type	RTD										
Participant id	4	1	6	3	20	24	16				Total
Person-months per beneficiary:	**28**+23	**23**+25	**23**+13	**19**+5	**13**+2	**10**+2	**0**+48				**116**+118

Objectives

To date, much of the "back-end" hardware used in radio astronomy, such as formatters, receivers, samplers and correlators, has been custom designed and built. It is clear that future developments will increasingly make use of commercial off-the-shelf (COTS) components. For example, the massive computing power required for LOFAR, albeit with limited bandwidth per telescope, is provided by standard computer chips in an overwhelmingly large (Blue-Gene) supercomputer architecture. While purely software-based correlators are increasingly being deployed, it is far from clear whether the increase in computing power predicted by Moore's law will be sufficient for future radio-astronomical instruments, such as the SKA. Power consumption and cooling issues (costs) are becoming increasingly important, and may to a high degree determine the direction of future developments, especially for very large arrays.

In this work-package a generic digital board (UniBoard) will be developed. This board will provide as much computing power as will fit on a reasonably sized PCB, in the form of a large number of state-of-the-art FPGAs, yielding up to 4 Tops (Tera-operations per second). The board will communicate with the external world using a large number of high-speed links. FPGAs are extensively used nowadays (e.g. for ALMA, EVLA, Korean VLBI Network correlators), but the attractive, and unique, aspect of the UniBoard is that it will intrinsically be a multi-purpose instrument, re-programmable for a wide variety of radio-astronomical applications, as well as be usable as a building block for larger systems. Combining unprecedented computing power and I/O capacity, it will enable new capabilities for a next generation of instrumentation, crucial for the future of the RadioNet facilities, as well as serve as a Peta-operations test bench for SKA development.

Description of work (possibly broken down into tasks)

Task 1 Common functionality development (ASTRON, BORD, KASI, JIVE)

The UniBoard approach is based on a common hardware and firmware environment. Hardware development will take place exclusively at ASTRON, with some external testing provided by Bordeaux and Korea. These partners will also contribute critically to the design evaluation. The development of common control software will be located at JIVE.

Task 2 Correlator development (JIVE, KASI)

This task creates the UniBoard correlator function. The architecture of the UniBoard is such that each board of a UniBoard correlator will receive frequency chunks from all stations and will effectively be a single-board all-baseline correlator. This will make it possible to trade bandwidth versus number of stations, making it a scalable solution. To achieve this, the signal at each station will have to be split, packed-up and sent via Ethernet to the correlator boards. Note that these boards do not need to be at the same physical location but could be located at the telescope sites or be distributed over a Grid-like architecture. The performance of the UniBoard correlator function will be validated and benchmarked against comparable efforts.

The group at KASI is developing a different, but comparable correlator based on FPGA processors. Their expertise is of great value for this part of the project

Task 3 Pulsar Processing Machine (UMAN + UORL)

This taks concerns the UniBoard as a pulsar binning machine. Its function will be to remove the effects of dispersion of Pulsar signals caused by the distortion on the way to Earth, by applying two methods:

1. Known dispersion: implementing an inverse phase filter
2. Unknown dispersion: splitting the signal into small frequency channels and looking for the frequency drift off-line using an incoherent de-dispersion technique.

The Pulsar Processing on UniBoard will bring uniformity to the pulsar backend processing and provide a standard data product for use in projects like the European Pulsar Timing Array (EPTA). The high throughput and computational power combined with its configurability will make the UniBoard concept particularly suited for future multi-beam telescopes such as APERTIF, LOFAR and SKA.

Task 4 Digital receiver (INAF, BORD)

In this task the digital receiver functionality of the UniBoard will be implemented. In this mode, the UniBoard will be used as a Digital Base Band Convertor, converting a very wide input bandwidth into a number of data streams of manageable bandwidth. Each individual stream can then be processed in a VLBI correlator slot, a high-resolution spectrometer or a pulsar processor.

Deliverables (brief description)

1. Hardware design document, month 11
2. VHDL firmware design document: correlator, month 11
3. VHDL firmware design document: pulsar binning machine, month 11
4. VHDL firmware design document: digital receiver, month 11
5. First generation board, month 17
6. Revised hardware design document, month 27
7. Revised firmware design document: correlator, month 27
8. Revised firmware design document: pulsar binning machine, month 27
9. Revised firmware design document: digital receiver, month 27
10. 2nd generation VHDL code: correlator, month 36
11. 2nd generation VHDL code: pulsar binning machine, month 36
12. 2nd generation VHDL code: digital receiver, month 36

Work package number	WP10	**Start date or starting event:**				Month 1
Work package title	EVN Transnational Access					
Activity Type	SUPP					
Participant number	4	5	6	1	7	3	13
Participant short name	JIVE	MPG	UMA N	ASTRO N	OSO	INA F	FG-IGN
Person-months per participant:	0	0	0	0	0	0	0
Participant number	8	22	21	23			
Participant short name	UMK	TKK	VENT	NRAO			
Person-months per participant:	0	0	0	0			

Description of the infrastructure

Name of the infrastructure: European VLBI Network

Location (town, country): The EVN is a distributed network of radio telescopes located across the European continent and beyond. EVN telescopes located within the EU and associated states include: Effelsberg (DE), Jodrell Bank and Cambridge (UK), Westerbork (NL), Onsala (SE), Medicina, Noto, and San Basilio (IT), Yebes (ES), Torun (PL), and Irbene (LV). When conducting EVN observations, the participating telescopes operate as a single entity. Signals from each telescope are combined together at a central processing facility at JIVE (Dwingeloo, NL) for correlation. There are additional EVN telescopes located in China (4), South Africa, and Puerto Rico. Joint observations with telescopes operated by NRAO (U.S.) are made on a regular basis.

Web site address: www.evlbi.org

Legal name of organisation operating the infrastructure: Joint Institute for VLBI in Europe

Location of organisation (town, country): Dwingeloo, the Netherlands

Annual operating costs (excl. investment costs) of the infrastructure (€): 20,888,394

Description of the infrastructure:

The European VLBI Network (EVN) is a cooperative effort among institutes in nine EU countries, plus China, South Africa, and Puerto Rico. The EVN also often observes in conjunction with the U.S. Very Long Baseline Array (operated by NRAO), forming a global VLBI network (GVN). From its formation in 1980 as a consortium of 5 European observatories, the EVN has been in the vanguard of bringing about effective inter-operation among the European radio astronomy institutes. The stations in China and South Africa permit EVN baselines > ~ 8000 km, providing milliarcsecond (mas) resolution at cm wavelengths. GVN observations have significantly more baselines in the range of 6000-11000 km. EVN observations conducted in conjunction with the U.K. MERLIN array, introduce baselines as short as about 10 km, providing sensitivity to more extended emission on the order of arcseconds.

The correlator facility for the EVN, located at the Joint Institute for VLBI in Europe (JIVE), can correlate up to 16 telescopes, each recording data at up to 1 Gbps, and can compute a quarter-million complex lags. Flexibility in distributing correlator resources can satisfy various observational goals – from large-array, high-sensitivity, full-Stokes continuum mapping, to high spectral-resolution kinematic studies of astronomical maser emission. Velocity resolutions can exceed 0.1 km/s for OH-, methanol-, and water-maser emission lines. The current minimum integration time is 0.25s for a fully-loaded correlator. The combination of high spectral resolution and short integrations permits mapping over a wide field of view. A single correlator pass of an array comprising the European stations can often map fields the size of the primary beam of each participating telescope. Real-time e-VLBI is a new and still experimental development in which the data from the telescopes are sent to JIVE over high-speed fibre-optic links and stream directly into the correlator. The PI can have access to the correlated data within hours of the observation, a turn-around time typically several weeks shorter than in traditional VLBI experiments. Rapid progress in real-time e-VLBI over the past year-and-a-half, permits VLBI to be used as a dynamic instrument with which transient and flaring sources may be meaningfully studied at a resolution of a few milliarcseconds (mas).

Description of work

Modality of access under RadioNet FP7:

The process by which external users gain access to the EVN begins with the thrice-annual Call for Proposals, promulgated via e-mail distribution lists and web-pages that reach the main body of radio astronomers in Europe and beyond. The possibility of TNA support is discussed in the call, with links to more information on the JIVE and EVN web pages. There are typically three EVN observing sessions per year, each of about three weeks long, plus around 10-15 days of e-VLBI. Following the review of proposals by the EVN Program Committee (PC), the EVN Scheduler places observations into the EVN block schedule at the next available opportunity, consistent with the proposal's consensus grade from the PC review and technical requirements. Urgent target of opportunity experiments have their own expedited proposal procedures to request observing time outside the standard scheduled sessions. When granted observing time, the PI creates a schedule file to specify how each station should conduct the observations, using standard VLBI scheduling software. The observations themselves, involving many widely dispersed stations, most naturally proceed in absentia. The individual telescopes use the PI's schedule to create a set of locally appropriate telescope commands, and observe independently. The stations forward their data to JIVE for correlation, which also proceeds in absentia (both steps occur in real-time for e-VLBI observations). With the correlated data in hand, most PIs will use standard radio-astronomy software packages that many will have available at their home institutes, but visits to JIVE or other EVN institutes are encouraged.

Support offered under RadioNet FP7:

All steps in the process of using the EVN, from proposing to data analysis, are discussed in separate entries in the EVN Users' Guide on the EVN web page. Assistance in each step is available from the support scientists in JIVE's Science Operations and Support Group. New or inexperienced users are encouraged to request help from JIVE in the course of writing their proposals. When the EVN block schedule appears, JIVE sends an e-mail to the PI of each experiment pointing out how to obtain assistance in scheduling and, if applicable, the benefits and responsibilities of TNA eligibility. JIVE support scientists check each submitted schedule; this can lead to further liaison with the PI to ensure that the schedule will maximise the scientific return of the observations, prior to their taking place. Prior to correlation, JIVE confirms the correlation tactics with the PI. Following correlation, JIVE support scientists review the correlated data to ensure the highest possible quality, and place the resulting data on the EVN Archive from where the PI can download them via a web tool (data can also be distributed on DAT, DVD, or other physical media, if requested). Support scientists also run the EVN pipeline, archiving these results as well. The pipeline produces calibration tables that the PI can apply to the data, as well as making preliminary source images and other diagnostic plots. The entire correlated data and the pipeline results associated with sources selected by the PI remain proprietary for one year on the EVN Archive. The PI receives a one-month notification of the expiry of this proprietary period, and can request an extension from the PC chairman..

When the correlated data are made available, JIVE discusses the advantages of data analysis visits, especially for new or inexperienced users, again reviewing the benefits and responsibilities of TNA eligibility as applicable. One person from each TNA-eligible project can have their travel expenses reimbursed for such visits to JIVE or to another EVN institute.

The EVN strives to provide the same high-level support to all users, but without the backing of the TNA program, it would not be able to maintain support to external users at this level. In particular, the assignment of dedicated JIVE support scientists to external users to provide the services discussed in this section might not be possible. In short, the EVN would lose much of its open, user-friendly nature for external astronomers.

Outreach to new users:

The distribution of the thrice-annual Call for Proposals reaches the body of radio astronomers in Europe and beyond, through the VLBI and EVN e-mail distribution lists and inclusion in the EVN and NRAO newsletters. The EVN sponsors biennial symposia and Interferometry schools. The former brings users together to discuss their science, and allows them to learn about recent enhancements in the EVN. An associated EVN Users' meeting focuses on more operational issues, and provides a forum for lively feedback. In the schools, new and inexperienced users can benefit from presentations by seasoned EVN astronomers covering all the aspects that contribute to conducting successful VLBI experiments. EVN astronomers also maintain an active, visible presence at topical scientific meetings; in such forums they can engage potential new users outside of the traditional radio-astronomy community and discuss how VLBI may make a unique contribution to their research. The advent of e-VLBI is the clearest case in which the EVN becomes attractive to a new community of astronomers – those studying transient objects for which rapid-response mas-scale images can be crucial. The access opportunities in European radio astronomy have been advertised more generally to the broader astronomical community through FP6 RadioNet presentations at large international congresses (a booth in the most recent IAU general assembly, an invited talk at the most recent JENAM)

Review procedure under RadioNet FP7:

The EVN Programme Committee (PC) meets typically 4-6 weeks after each proposal deadline. The PC comprises twelve experienced European astronomers representing a broad spectrum of scientific and technical expertise. Four members are not affiliated with any of the EVN institutes. Each member serves a renewable 3-year term. The PC can also receive technical input from non-EVN institutes whose resources are also requested in a proposal. Proposals for global VLBI observations are reviewed in parallel by the NRAO (VLBA) programme committee.

The PC evaluates proposals based solely on their scientific merit and technical feasibility. Each member reviews all proposals, and each proposal is discussed at length until the PC reaches a consensus judgement. This review results in a numerical grade, a recommended time allocation, and perhaps a set of conditions (*e.g.*, an intermediate report on the success of initial epoch(s) might be requested to authorize additional epochs). The PI receives as feedback the consensus result, plus the collection of comments from the individual PC members. These are helpful in cases where the PI is requested to resubmit the proposal after addressing specific points of attention.

Implementation plan

Short name of installation	Unit of access (See Notes on page 5)	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
EVN	Hour	2748.07	336	210	150	112
WSRT	Hour	217.40	336	210	150	112
SRT	Hour	65.21	336	210	150	112
Noto	Hour	113.05	336	210	150	112
Mc	Hour	113.05	336	210	150	112
Effelsberg	Hour	217.40	336	210	150	112
JBO	Hour	217.37	336	210	150	112
Onsala	Hour	217.41	336	210	150	112
UMK	Hour	86.96	336	210	150	112
Yebes	Hour	217.38	336	210	150	112
Vent	Hour	86.85	336	210	150	112
Metsahovi	Hour	86.95	336	210	150	112
VLBA	Hour	434.80	336	210	150	112
HARTRAO	Hour	86.96	336	210	150	112

Notes: The Unit of Access is an "hour" – one hour of observation in which the participating telescopes observe the same schedule. Included in this access is the subsequent correlation, which may take considerably longer than the observations depending on the correlation set-up desired by the PI (e.g., different spectral lines correlated in separate passes, each using the maximum spectral resolution available from the full correlator). Also included is all support prior to the observations and following correlation, as discussed in the **Description of Work** section.

RadioNet FP7 WP13: TNA JCMT

Work package number	WP11	**Start date or starting event:**				Month 1	
Work package title	JCMT Transnational Access						
Activity Type	SUPP						
Participant number	9						
Participant short name	STFC						
Person-months per participant:	0						

Description of the infrastructure
Name of the infrastructure: James Clerk Maxwell Telescope (JCMT)
Location (town, country): Mauna Kea, Hawaii, USA
Web site address: http://www.jach.hawaii.edu/JCMT
Legal name of organisation operating the infrastructure: UK Science and Technology Facilities Council (STFC)
Location of organisation (town, country): Swindon, UK
Annual operating costs (excl. investment costs) of the infrastructure (€): 3,362,252 (FY 2008/09)

Description of the infrastructure:

The James Clerk Maxwell Telescope (JCMT) is the world's premier ground-based facility for astronomical observations at sub-millimetre wavelengths. This status is afforded by three essential ingredients: the size and quality of the telescope, its location, and its aggressive programme of instrumentation.

The JCMT is the largest single-dish telescope in the world designed specifically to operate in the sub-millimetre region of the spectrum (wavelength range 450µm – 1mm). The primary reflector of the JCMT has a diameter of 15 metres and its figure is maintained at an accuracy of just 22µm rms through a programme of periodic holography and panel adjustment. The facility is situated at the summit of Mauna Kea, on the island of Hawaii, at an altitude of 4092m. This is one of the best sites in the world for sub-millimetre astronomy, and certainly the very best in the northern hemisphere.

Two categories of instrument are provided for users of the facility. (a) Heterodyne receivers are available in a number of atmospheric transmission windows to measure line emission from specific molecules, revealing physical information about the source being observed (composition, temperature, and velocity). One of these receivers, HARP, was commissioned in 2007 and is the world's first array (4x4) receiver operating in the 345-GHz band, providing the JCMT community with a sub-millimetre spectral imaging capability for the first time. (b) A new continuum camera called SCUBA-2 will be commissioned during 2008 and will offer simultaneous high-fidelity imaging at 450µm and 850µm.

Survey covering a wide range of astrophysical topics has been approved and will take up 55% of the telescope time. The remainder has been set aside for conventional PI-led proposals. It is from this remaining 45% that transnational access will be offered under RadioNet.

The JCMT is a joint project of the United Kingdom, Canada and the Netherlands. The managing agency is the UK Science and Technology Facilities Council (STFC). The Director JCMT is responsible for the operation and development of the telescope. Oversight is provided by the JCMT Board, a governing body which is defined by the tripartite agreement between the agencies. The administrative base for the facility is the Joint Astronomy Centre (JAC), a STFC establishment located at sea level in Hilo, Hawaii.

As a non-European country, Canada has declined to participate in the RadioNet project. Transnational access will be offered from UK and Netherlands telescope time only.

Description of work

Modality of access under RadioNet FP7:

The JCMT operates a novel flexible-scheduling system which was designed to enhance the completion of the highest-ranked projects within the constraint posed by the variable observing conditions on Mauna Kea. All projects are placed into a queue, ordered by scientific priority as assigned by the ITAC (see below), and the observational details are entered remotely into a database by PIs. The observations can then, in principle, be carried out by any observer. Approved projects are carried out in one of two modes:

- 'observer mode': A member of the user group visits the telescope for an observing run. The duration of the run typically exceeds the time allocated to the user's project. The observer is given limited privilege to override the queue priorities in order to observe his/her own project, providing that the weather conditions are appropriate for the project, that the source is at an observable local elevation, etc.; if these conditions are not met, then the observer carries out observations from the queue. Observers are usually invited from the highest-ranked projects.
- 'service mode': The user group does not send an observer to the telescope, but the data are obtained by other observers over the course of the semester. Data are made available for download within 24 hours of the observations taking place.

Support offered under RadioNet FP7:

One of the JCMT scientific staff is assigned to each project as the 'Friend of Project', and provides support and advice for all aspects of the observing process: designing the observations, confirming the accuracy of the programme entered into the database, checking data quality as observations proceed, and advising on the data reduction.

Projects carried out in observer mode are also assigned a Support Astronomer. The role of the Support Astronomer, who may or may not be the Friend of Project, is to support the actual observing process. This includes training in the JCMT's observing system, safety briefing, review of the observing strategy, and resolution of any open issues.

In addition, a Telescope Systems Specialist (TSS) is assigned to each observing night. It is the TSSs who actually carry out the telescope and instrument operations on behalf of the observer. The TSSs are also fully responsible for the safety of the facility and the personnel during the observing.

All of the above support is provided to all projects regardless of origin. No distinction is made, at the operational level, between internal and external projects and users.

Outreach to new users:

Throughout FP6, the availability of RadioNet support has been prominently noted in JCMT Calls for Proposals. The front page of the JCMT website also indicates the observatory's membership in the RadioNet consortium. More generally, outreach to potential new users of the facility has been managed centrally by the RadioNet office, and it is anticipated that this will continue through FP7. In 2007, a PI from Poland was awarded time on the JCMT – the first user group from eastern Europe. The EU support for transnational access provides many external users with resources to travel to the telescope under observer mode (by far the preferred mode for new users of the telescope) which would otherwise not be available to users from outside the JCMT partner countries.

Review procedure under RadioNet FP7:

The JCMT issues Calls for Proposals twice per year. Proposals are assessed by three national Time Allocation Groups (TAGs), which then make recommendations to the International Time Allocation Committee (ITAC). The ITAC resolves any conflicts between the three national TAGs (e.g., overlapping proposals), assesses any international proposals, and formally allocates the time. The members of the TAGs and the ITAC are selected by the three partner agencies from amongst the submillimetre user communities in the three countries; the ITAC itself is composed of the chairs of the three national TAGs and one additional member of the UK TAG (to reflect the UK's 55% share in the facility). The observatory provides the ITAC's technical secretary.

Implementation plan

Short name of installation	Unit of access (See Notes)	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
JCMT	telescope time in hours	955	391	165	93	34

Notes: Unit of Access: Time is allocated on the telescope in units of hours and this is the adopted unit of access. As in FP6, it is proposed to calculate the quantity of delivered access differently for the two modes of operation:

- For projects undertaken in service mode: the delivered access is the number of hours spent observing the project.
- For projects undertaken in observer mode: the delivered access is the number of hours allocated to the project.

This scheme recognises that the observatory staff will provide the full range of support to visiting observers regardless of which projects are actually observed during the observer's run. All of the support functions described above (logistical support, observing training, scientific support before and after the observations) are included in the unit cost.

Work package number	WP12	Start date or starting event:			Month 1	
Work package title	e-MERLIN Transnational Access					
Activity Type	SUPP					
Participant number	6					
Participant short name	UMAN					
Person-months per participant:	0					

Description of the infrastructure
Name of the infrastructure: e-MERLIN
Location (town, country): Macclesfield (Operations centre) and Manchester (Visitor Support), UK
Web site address: www.merlin.ac.uk
Legal name of organisation operating the infrastructure: University of Manchester on behalf of the Science and Technology Facilities Council
Location of organisation (town, country): Oxford Road, Manchester, M13 9PL, United Kingdom
Annual operating costs (excl. investment costs) of the infrastructure (€): 2,901,325
Description of the infrastructure: MERLIN is a unique astronomical facility which provides radio imaging, spectroscopy and polarimetry with 10-150 milliarcsecond resolution and sub-mJy sensitivity at centimetre wavelengths. With a maximum baseline of 217 km, it provides significantly higher (x 7) angular resolution than the VLA at a given observing frequency, while providing a natural short-baseline complement to the European VLBI Network. Joint MERLIN and EVN observations are regularly scheduled for radio imaging across a wide range of angular scales., MERLIN has been operated as a national facility by the University of Manchester on behalf of the UK research councils (PPARC/STFC) since 1991. The e-MERLIN project represents a major upgrade: the fundamental infrastructure of six large radio telescopes distributed across England has been enhanced by new receivers (with improved sensitivity, wide frequency coverage, and greater flexibility) and a 210 Gb/s optical fibre network has been installed to connect each telescope to a powerful new correlator at Jodrell Bank Observatory, which will be commissioned in 2008-2009.

Description of work
Modality of access under RadioNet FP7: Application for observing time with MERLIN/e-MERLIN is made via Northstar, a Web-based application tool with associated scientific justification. Observing applications are received for two proposal deadlines in each calendar year (15 March and 15 September). MERLIN is operated under a policy of open access to all research users and user groups both within the United Kingdom and internationally. Technical and engineering support for MERLIN is based at Jodrell Bank Observatory (JBO), whilst science support is provided by National Facility (NF) personnel located in the Jodrell Bank Centre for Astrophysics (JBCA) on the campus of the University of Manchester. Support offered under RadioNet FP7: Users and user groups wishing to use MERLIN/e-MERLIN are provided with substantial assistance at every stage from proposal preparation through scheduling, calibration, and final imaging. JBO and JBCA are centres of excellence in astronomical imaging and have been involved in external MERLIN user support for over 10 years. On-line help is available for proposal preparation and data

processing, and the web-based proposal tool is linked to this site. Additional individual help is available by email contact with user-support personnel. JBCA is a rich scientific environment, with leading research groups investigating a wide range of astronomical subjects from pulsars to star-formation, and AGN jets to gravitational lensing. Visitors to the Support Unit will benefit from contact with the institute staff and other visiting scientists. Visitors are invited to present talks outlining their areas of research; providing ideal opportunities to work with collaborators and develop new projects.

Outreach to new users:
Calls for proposals are issued twice per year before each proposal deadline. These are available on the MERLIN web page, are contained in the MERLIN Newsletter which is published in March and September, and specifically distributed to identified user groups and institutes worldwide. The calls indicate that travel and subsistence funding is available to EU user groups for such visits through RadioNet. Latest scientific results are presented in conferences and workshops where access to MERLIN is advertised. National Facility support personnel routinely give presentations on aspects of imaging at radio interferometry schools within Europe – for example in 2007, the Bologna MCCT-SKADS school and the ERIS school at Bonn where NF personnel gave five presentations.

Review procedure under RadioNet FP7:
Following the proposal deadline, applications are circulated to external referees for peer review, where typically around 50% are from outside the UK, drawn mostly from Europe. Formal reports are returned and all applications are vetted by a Time Allocation Group (TAG) appointed by STFC under the auspices of the Panel for the Allocation of Telescope Time (PATT). The TAG consists of four external members and one University of Manchester representative. The external members are drawn primarily from UK user groups and contain one European representative from outside the UK. Membership is rotated on a staggered timescale of two to three years. Detailed feedback is prepared by TAG members for both successful and unsuccessful proposals. The detailed time allocation is included and for rejected applicants, a description of why the proposal was unsuccessful together with advice on re-submission. This feedback is then circulated to proposal PIs by STFC

Implementation plan

Short name of installation	Unit of access (See Notes)	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
e-MERLIN	hrs	805	610	112	90	37

Work package number	WP13	**Start date or starting event:**				Month 1	
Work package title	100-m Radio Telescope Effelsberg Transnational Access						
Activity Type	SUPP						
Participant number	5						
Participant short name	MPG						
Person-months per participant:	0						

Description of the infrastructure
Name of the infrastructure: Radio Observatory Effelsberg
Location (town, country): Max-Planck-Strasse 28, 53902 Bad Münstereifel, Germany
Web site address: http://www.mpifr.de/english/radiotelescope/informationAstronomers/index.html
Legal name of organisation operating the infrastructure: Max-Planck-Gesellschaft zur Förderung der Wissenschaften
Location of organisation (town, country): Hofgartenstrasse 8, 80539 München, Germany
Annual operating costs (excl. investment costs) of the infrastructure (€): 2,388,964

Description of the infrastructure:

The 100-m radio telescope of the Max-Planck-Institut für Radioastronomie (MPIfR) is situated in a protected valley near Bad Münstereifel-Effelsberg. It is one of the two largest fully steerable single-dish radio telescopes in the world and is a unique high frequency radio telescope in Europe.

The telescope can be used to observe radio emission from celestial objects in a wavelength range from 73 cm (corresponding to a frequency of 408 MHz) down to 3.5 mm (86 GHz). Observations at short cm- and mm-wavelengths have become increasingly important for all kinds of observing programmes during the last years. The combination of the high surface accuracy of the reflector (the mean deviation from the ideal parabolic form is $\leq$ 0.5 mm rms) and the construction principle of "homologous distortion" (i.e., the reflector in any tilted position has a parabolic shape with a well-defined, but shifted, focal point) enables very sensitive observations at unprecedented high frequencies for such a large telescope.

With the advent of the new subreflector in 2006, observations from the secondary (Gregorian) focus gained significantly in efficiency (more than 50 % at the high frequencies) due to the very high accuracy of the new mirror (~0.06 mm) and its active surface which is able to compensate small-scale deviations of the main dish due to imperfect homology. The new system is equipped with a hexapod focus driving system, allowing a fast and accurate positioning (better than 0.1 mm) of the receiver in the focal point. A new mechanism allows automatic receiver exchanges between the nine systems located in the secondary focus and the receiver box located in the prime focus. Thus, the telescope has strongly improved its frequency agility. Additionally, new prime focus receiver boxes were developed which contain up to four receiving systems (in contrast with the former situation where only one receiver per box was possible). The first multi-frequency receiver box (with the 18/21, 1.9, and 1.0 cm systems) was tested in summer 2007 and will be fully functional in spring 2008. The construction of more multi-receiver boxes is foreseen for 2008 and 2009.

Description of work

Modality of access under RadioNet FP7:

Observer's access to the Effelsberg Radio Observatory with its 100-m telescope is awarded on the basis of a successful observing proposal, subject to a peer review procedure (see below). The proposal preparation will be done using the web-based proposal tool "Northstar" .The proposers are informed about the success of their application soon after the meeting of the programme committee. Proposals selected for observation are scheduled as soon as possible (normally within a year). The Primary Investigator is responsible for the preparation, execution and analysis of the proposed observations. Usually, it is expected that at least one of the investigators is present at the observatory for the scheduled observing time, although absentee and remote observations are possible and became more common recently (and are normal for VLBI observations).

In one year, the total observing time available is about 5000 hours (excluding test observations and reserved time for international obligations like VLBI). About 10 user groups (supported under RadioNetFP7) per year can be hosted with an average observing time per proposal being about three nights (~45 hours). Normally, one or two observers are present at the telescope for the observations, hence, the estimated number of users over a four-year course is 60; about 180 person-days are expected to be spent at the observatory.

Support offered under RadioNet FP7:

External users are supported by the experienced staff of the radio observatory: The scientific support includes the preparation of the proposal and the observations as well as help during the observing run and through the data reduction process. In addition, the technical staff at the radio observatory (receiver engineers, telescope operators, etc.) offer all help necessary for successful observations.

Users who gain access to the telescope under the provision of RadioNetFP7 can, in addition, count on the help of scientists ("friends of observers") from the institute's headquarters in Bonn who are experienced in the corresponding observing modes (spectroscopy, continuum, pulsars, and VLBI). Furthermore, the MPIfR provides these users with transportation from Bonn to the telescope site (approx. 40 km distance), accommodation at the observatory (for up to two observers per project), a well-equipped library, office space, and computer access. (Outside the TNA programme, visitors have to pay for their own travel expenses and the costs of local accommodation). A collection of all information necessary for observers can be found on the web pages of the observatory: http://www.mpifr.de/english/radiotelescope/informationAstronomers/index.html.

Outreach of new users:
Regularly (i.e. three times per year; about a month prior to the proposal deadline), the community is informed by a "Call for Proposals" providing detailed information regarding the submission of an observing proposal. This "Call" is posted to the research institutes in the fields of radio astronomy and astrophysics, and distributed by electronic mail to a wide group of astronomers and astronomical institutes in Europe. The Institute also provides (and continuously improves the existing) information regarding the access to the infrastructure in its web pages (see address above).

Review procedure under RadioNet FP7:
Observer's access to the Effelsberg 100-m radio telescope is awarded on the basis of successful observing proposals, subject to a peer review procedure (by the "Programme Committee Effelsberg"). These proposals must include a scientific justification and a target list, and also address the required instrumentation. The Programme Committee currently consists of three members from the scientific staff of the Institute, and five members from outside the MPIfR. Currently the non-MPIfR members come from the Universities of Bonn and Cologne, from Jodrell Bank Observatory (UK), from the Istituto di Radioastronomia (Italy), and from the Torun Centre for Astronomy (Poland).

The PC has three face-to-face meetings per year. In these meetings the referees judge the scientific merit and technical feasibility of each proposal. They assign a certain grade to the proposal, make suggestions to the Project Investigators and – if necessary – recommend a reduction of the observing time granted or a full rejection of the proposal. Time requests connected with PhD projects are usually considered favourably. Large proposals (with more than 100 hours time requested) are usually discussed more thoroughly by the PC and are presented to MPIfR's board of directors for further consideration.

The time allocation – by the telescope scheduler – follows the ranking of the proposals, but also logistical constraints (ie., receiver availability and international observing obligations like VLBI), as well as scientific needs. With the higher flexibility gained by the installation of the new subreflector and its receiver exchange mechanism, the waiting time of successful proposals is expected to decrease further. In case of "rapid science" needs, MPIfR accepts "Target-of-opportunity" proposals which are distributed to the PC members immediately. In such cases, decisions are normally made within one or two days only.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
100-m Radio telescope	Hours	478	1006	75	135	27

Work package number	WP14	**Start date or starting event:**			Month 1		
Work package title	SRT Transnational Access						
Activity Type	SUPP						
Participant number	3						
Participant short name	INAF						
Person-months per participant:	0						

Description of the infrastructure

Name of the infrastructure: Sardinia Radio Telescope

Location (town, country): c/o Istituto di Radioastronomia – INAF, Bologna, Italy

Web site address: http://srtproject.ca.astro.it

Legal name of organisation operating the infrastructure: Istituto Nazionale di Astrofisica

Location of organisation (town, country): Rome, Italy

Annual operating costs (excl. investment costs) of the infrastructure (€): 1,826,169

Description of the infrastructure:
The IRA in collaboration with the observatories of Cagliari and Florence is currently constructing the Sardinia Radio Telescope (SRT) in the location of San Basilio (about 35 km north of Cagliari, Sardinia). Start of operation will be in 2009, i.e. during the course of FP7.

The SRT will be a parabolic dish of 64-m diameter with the following characteristics:

- Actively shaped surfaces (primary and secondary):
- Continuous frequency coverage between 300 MHz and 100 GHz with (multi-beam) state-of-the art receivers:
- Multiple focus positions and frequency agility:
- Fibre optics link:

The SRT will be among the largest five fully steerable single-dish radio telescopes in Europe and the largest one with an active primary surface (world-wide second only to the NRAO 110-m GBT). Because of the excellent precision of its primary mirror, the SRT will show its true strengths at high-frequencies (above 20 GHz). Consequently, one of the first-light instruments will be a new 7-feed array for observations between 18 and 26 GHz, unique at this frequency in Europe.

The global concept of single-dish observing with the Italian radio telescopes foresees the long-term monitoring, the large-scale surveying or the rapidly scheduled observations with the smaller 32-m telescopes, while the new 64-m SRT would mainly be used for dedicated follow-up work, in particular at high frequencies at which it will be at its most impressive.

Description of work

Modality of access under RadioNetFP7:
Being part of the Italian radio-astronomical infrastructure, the SRT access policy will be the same as currently applied for the two existing 32-m dishes. In principle, the IRA telescopes are used for single-dish observations for 200 days per year. For the SRT a typical duration of few 10 hours per project can be assumed.

Support offered under RadioNetFP7:
The IRA observatories are staffed with small teams of engineers and astronomers. In general,

observers are encouraged to come to the telescopes to carry out their observations themselves. They are lodged on the sites, and assisted by staff members over the duration of their project.

Outreach of new users:
Calls for observing proposals are issued twice a year and published on the institute's web site (http://www.ira.inaf.it/proposal) and the INAF Newsletter. They are also advertised via various email exploders currently reaching basically the entire Italian astronomical community and the Principal Investigators of previous projects. Observing proposals for the periods from May 1 to October 31 and from November 1 to April 30 can be submitted electronically before the deadlines at the beginning of April and October using the web-based proposal submission engine. Target of Opportunity proposals can be submitted at any time.

In order to attract more users, especially from outside Italy, the calls for proposals will be distributed more widely to the international astronomical community. More than two thirds of the observing proposals are typically submitted from research groups outside the IRA. Judging from the informal requests from non-Italian institutions, one can be confident that the SRT will meet a wide interest of the European astronomical community. Considering the huge leap forward in terms of sensitivity, frequency coverage and general observing conditions provided by the SRT, an even stronger interest can safely be assumed during RadioNet FP7.

Review procedure under RadioNetFP7:
All users follow the same procedure in requesting access to the IRA telescopes. Observing proposals are evaluated by the Time Allocation Committee (IRA-TAC). The five members of the IRA-TAC are appointed by the IRA director. Currently, three of them are affiliated with research institutes at Padova, Torino and the University of Bologna while two are affiliated with the IRA (representing Medicina and Noto). With the SRT in operation a representative of this observatory as well as a foreign member will be added. Observing proposals are ranked according to their scientific merit and technical feasibility, taking into account technical advice provided by the telescope schedulers. The results (including the overall rating of the proposal as well as individual comments) are communicated to the proposers by email. If the proposal was accepted for observations, it will be scheduled for observations within the following semester, taking into account a series of constraints (observers' preference, technical feasibility, general scheduling).

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
SRT	Hour	413	67	18	93	6

Work package number	WP15	**Start date or starting event:**				Month 1		
Work package title	LOFAR Transnational Access							
Activity Type	SUPP							
Participant number	1							
Participant short name	ASTRON							
Person-months per participant:	0							

Description of the infrastructure
Name of the infrastructure: LOFAR
Location (town, country): Distributed array of Antennas centred on Exloo, The Netherlands; Operational and Scientific User Support Centre at ASTRON, Dwingeloo, The Netherlands.
Web site address: www.lofar.nl
Legal name of organisation operating the infrastructure: ASTRON
Location of organisation (town, country): Dwingeloo, The Netherlands
Annual operating costs (excl. investment costs) of the infrastructure (€): 4,866,580
Description of the infrastructure: LOFAR is a brand-new, uniquely powerful telescope for highly flexible observations at low radio frequencies, 10—240 MHz, where it offers a sensitivity orders of magnitude better than that of previous telescopes: around 50 microJy at 150 MHz (1 mJy at 75 MHz) in just 1 hour of integration time. LOFAR is the first generation of so-called "software telescopes" – its high sensitivity, huge (multiple) field-of-view capability and data "playback" facilities, promise to make it nothing less than a transformational instrument for radio astronomy. ASTRON leads a consortium of national and international partners that have developed and are now constructing LOFAR. With 20 LOFAR stations on the ground by early 2009, and full operations (40 stations) a year later, it is highly important to begin offering access and appropriate support levels to these users from across Europe as soon as FP7-RadioNet TNA funding starts, and then to ramp it up in future years. Support is proposed here for 50, 125 and 225 hours in 2009, 2010 and 2011.

Description of work

Modality of access under RadioNetFP7:
Well ahead of scheduled observing time, the users will refine the basic design of projects, described in their proposals, into detailed instrumental setups. Documentation and specification tools are available online. ASTRON specialists can advise by e-mail or telephone, and users are welcome to visit the observatory in Dwingeloo during any stage of the process, including proposal preparation. The most intensive personal interaction may follow immediately after observations. The tremendous initial volume of the raw data necessitates initial reduction within a week. The analysis of interferometric data, using purpose-built software, is likely to proceed stepwise, allowing progressively longer storage, and therefore more interaction and iteration in further calibration and processing steps. Users may also need to make decisions concerning follow-up observing. There will be a proprietary period for data products in the archive, after which they become publicly available.

Support offered under RadioNetFP7:
ASTRON is currently in the process of building up a group of Support Scientists. The group resides within the Radio Observatory division, and will support both LOFAR and WSRT users. It will consist of 8 scientific staff led by a Senior Support Scientist. In addition, ASTRON's recently created Astronomy Group will also be available to provide expert advice.

The support scientists group will provide comprehensive support for users at all stages of their projects, from proposal preparation, through observing specification, to data analysis. A substantial part of these interactions will happen via the internet but it is envisaged that astronomers will also visit ASTRON. The mixture of astronomical and technical disciplines represented in Dwingeloo, with WSRT, JIVE, and now also LOFAR users, is considered by all to be highly stimulating.

Outreach of new users:
Calls for LOFAR proposals will be sent to a list of more than 500 addresses of institutes and individuals internationally. The calls will describe the most recent capabilities of LOFAR, and refer to the website for much more extensive information.

User meetings and workshops are planned at least twice in the first few years, to be a forum for interaction and feedback, where users can learn about the latest scientific results and the latest technical capabilities of LOFAR.

Review procedure under RadioNetFP7:
LOFAR proposals will be submitted from anywhere in the world via the web-based tool NorthStar. The independent time allocation committee, which will meet for the peer-review of all proposals for LOFAR and the WSRT, will have an international composition, with scientists selected first and foremost for their astronomical and technical expertise. The amount of open-time is expected to begin at around 30% in 2009, but will grow steadily over the following years. Allocation of observing time also takes into account the fit into an overall well-filled telescope and data processor schedule. The basic unit of access is therefore the Telescope-Processor hour.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
LOFAR	Telescope Processor Hour	925	388	90	105	22

Work package number	WP16	**Start date or starting event:**		Month 1			
Work package title	WSRT Transnational Access						
Activity Type	SUPP						
Participant number	1						
Participant short name	ASTRON						
Person-months per participant:	0						

Description of the infrastructure

Name of the infrastructure: Westerbork Synthesis Radio Telescope (WSRT)

Location (town, country): Dwingeloo/Westerbork, The Netherlands

Web site address: www.astron.nl

Legal name of organisation operating the infrastructure: ASTRON

Location of organisation (town, country): Dwingeloo, The Netherlands

Annual operating costs (excl. investment costs) of the infrastructure (€): 1,288,078

Description of the infrastructure:
The WSRT is a radio interferometer with 14 telescopes each 25-m in diameter, giving a total collecting area equivalent to a 93-m single dish. It is amongst the most sensitive radio telescopes in the world and well-established as the premier instrument for neutral hydrogen studies of nearby galaxies. The telescope baseline lengths range between 36 metres and 2.8 km, giving a resolution of 14" at 1.4 GHz.
The WSRT has recently been augmented with 115-180 MHz receivers (called LFFEs), and with a separately mountable receiver for 6 GHz (5 cm) spectroscopy. Thus, there is now full frequency agility within a suite of nine dual polarisation wideband decimetre and centimetre receivers, spanning the range from 115 to 8700 MHz. The instantaneous tuneable bandwidth of up to 160 MHz is processed by a highly flexible half-million channel correlator. Re-circulation provides exquisite spectral resolution – finer than 100 Hz across the entire band.

Description of work

Modality of access under RadioNetFP7:
Most WSRT observations are 12-hour synthesis runs, carried out by expert operators, who calibrate and tune the instrument before hand, and monitor the state of the system from the integrated LOFAR & WSRT Control Room, located in Dwingeloo. Direct intervention of users, and/or their presence at the WSRT, is possible upon request.

Immediately upon completion of an observation, the data may be retrieved over the internet (depending on the speed of the user's connection; the WSRT archive is connected at 10 Gbit/s), or a copy on DVD can be ordered. The data can also be analysed during a visit to Dwingeloo (see below). The data are stored in the archive but remain available for the private use of the investigators for twelve months after completion of the observations, after which they become publicly available.

Observatory experts inspect the data quality soon after observation, and provide feedback for the user as well as for the engineering staff involved in maintenance. An automated data reduction pipeline produces first-look results that are available to the users and the observatory staff alike.

Support offered under RadioNetFP7:
The support scientists group will provide comprehensive support for users at all stages of their projects, from proposal preparation, through observing specification, to data analysis. A substantial part of these interactions will happen via the internet but it is envisaged that astronomers will also visit ASTRON.

Outreach of new users:
Calls for WSRT proposals are sent to a list of more than 500 addresses of institutes and individuals internationally. The calls describe recent developments and new capabilities of the WSRT, and refer to the website for much more extensive information. User meetings, at which astronomers can learn more about the facilities of the WSRT, are planned every year, as a forum for interaction and feedback with the user community.

Review procedure under RadioNetFP7:
The WSRT has an independent peer-review panel for the assessment of all proposals; there are two submission deadlines each year. The panel will assess WSRT as well as LOFAR proposals from 2009 onwards, and is therefore being broadened: members will be drawn from the full radio-astronomical community in Europe, and there will be a wide range of astrophysical and technical expertise represented.

WSRT proposals can be submitted from anywhere in the world via the web-based tool NorthStar, which is also used to facilitate the peer-review process. Observing time on the WSRT will, as always, be fully allocated according to an Open Skies policy, strictly based on scientific and technical merit, with no regard for affiliation of the proposers. The assessment panel holds a face-to-face meeting after each deadline. On the basis of pre-ratings given by all members, and an introductory assessment prepared by two persons, the merits of the proposals are carefully discussed before ranking them. Allocation of observing time also takes into account the fit into an overall well-filled telescope schedule.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
WSRT	Telescope Observing Hour	322	480	75	60	24

Work package number	WP17	**Start date or starting event:**				Month 1		
Work package title	APEX Transnational Access							
Activity Type	SUPP							
Participant number	7							
Participant short name	OSO							
Person-months per participant:	0							

Description of the infrastructure

Name of the infrastructure: APEX (Atacama Pathfinder Experiment)

Location (town, country): Llano Chajnantor, Chile (at 5100 m altitude in the Atacama Desert; the base camp is located in Sequitor, close to the town San Pedro de Atacama)

Web site address: www.chalmers.se/rss/oso-en/observations/apex

Legal name of organisation operating the infrastructure: Chalmers tekniska högskola AB

Location of organisation (town, country): Göteborg, Sweden

Annual operating costs (excl. investment costs) of the infrastructure (€): 578,852(OSO share)

Description of the infrastructure:

APEX is a 12-m sub-mm radio telescope located at 5100 m altitude on Llano Chajnantor, Chile (see http://www.apex-telescope.org/). Observations are carried out from early April to late December (excluding the Bolivian winter). OSO is one of three partners that operate APEX, and its share of the costs is 23%. This is also the Swedish share of the observing time, but, as the host country, Chile gets 10% of the Swedish time. Consequently, OSO distributes 21% of the observing time to the community. The partners have signed a contract to operate APEX at least until the end of 2012.

Description of work

Modality of access under RadioNetFP7:
Access to APEX is through a proposal and peer review process (see below). The observations at APEX are complicated by the high altitude of the telescope, 5100 m, which prevents the use of a regular visiting-astronomers scheme. APEX observations are therefore made in semi-service mode through a scheme where the APEX staff and (selected) visiting astronomers carry out the observations. The observations are scheduled in roughly five 11-day blocks spread over the year. For each block OSO coordinates the selection of (at least) two visiting astronomers that will help to execute all observations scheduled in the block. These observers must pass a high-altitude physical test. The help of visiting astronomers increases the amount of usable observing time by about 50%, and thus is absolutely essential for an effective use of the investment. Users must fill in a web-based "Project submission form". The observed data is validated by the APEX staff, distributed to PIs on CDs, and archived in the ESO archive.

Support offered under RadioNetFP7:
The observations are carried out in semi-service mode as described above. TNA-eligible users may, if they wish and pass the physical test, act as visiting astronomers at the expense of OSO. OSO offers help, both during the proposal phase and the data reduction phase, to those unfamiliar with radio astronomy methods and techniques.

Outreach of new users:

Calls for proposals are issued twice per year, and they are available at the OSO web site (http://www.chalmers.se/rss/oso-en/observations/proposals). Information about the Calls is also sent by email to more than one hundred previous users of OSO telescopes and other potentially interested astronomers. By providing clear guidelines and on-line tools for estimating observing time, the proposal process is as simple as possible for new users. The proposal tool NorthStar is currently being implemented to handle proposals for Swedish time on APEX.

Review procedure under RadioNetFP7:
Observing proposals for Swedish time on APEX are accepted twice per year, on April 15 and October 15, and are evaluated by a programme committee (PC) with five members. The grading of a proposal is done solely on scientific merit, and takes into account whether the stated goals are likely to be reached with the observing time requested and how well the methods to reach the goals are expressed in the proposal. The principal investigator of each proposal (accepted as well as rejected) is informed about the outcome of the review procedure. The actual observing time scheduled on the telescope is determined by the APEX staff based on the recommendations by the PC (the scheduled time can differ slightly from the recommended time, due to, e.g., weather conditions and the availability of the requested local sidereal time interval).

The programme committee currently consists of

- Prof. René Liseau (Onsala Space Observatory, Sweden, chairman)
- Prof. Melvyn B. Davies (Lund Observatory, Sweden)
- Ass. prof. Bengt Edvardsson (Uppsala Astronomical Observatory, Sweden)
- Dr. Magnus Thomasson (Onsala Space Observatory, Sweden, secreatry)
- Docent Merja Tornikoski (Metsähovi Radio Observatory, Finland)

Up to a maximum of 30% of the observing time distributed by the programme committee can be allocated to Large Programmes. The definition of a Large Programme is similar to that used by ESO (e.g., a minimum of 100 hours telescope time, a potential to lead to a major advance in the field of study, and a strong scientific justification).

Implementation plan

Short name of installation	Unit of access (see Notes)	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
APEX	hour	798	300	60	32	12

Notes: Unit of Access: The unit of access is hours of observing time (including possible time for calibrations, etc.)

Work package number	WP18	**Start date or starting event:**				Month 1	
Work package title	IRAM Transnational Access						
Activity Type	SUPP						
Participant number	2						
Participant short name	IRAM						
Person-months per participant:	0						

Description of the infrastructure

Names of the infrastructure: Plateau de Bure Interferometer & 30-metre Telescope

Location (town, country): Plateau de Bure Interferometer: Bure (Hautes-Alpes), France
30-metre Telescope : Pico Veleta, Granada, Spain

Web site address: www.iram.fr

Legal name of organisation operating the infrastructure: Institut de Radioastronomie Millimétrique (IRAM)

Location of organisation (town, country): Saint-Martin d'Hères, France.

Annual operating costs (excl. investment costs) of the infrastructure (€): 6,026,868

Description of the infrastructure:

The *30-metre telescope* located at an altitude of nearly 3000 metres on Pico Veleta in the Spanish Sierra Nevada. The 30-metre telescope has a surface accuracy and a pointing capability, which allow exploiting the atmospheric windows at 3, 2, 1 and, during the best weather conditions, 0.8 mm. It offers unique observing capabilities through simultaneous availability of a series of low-noise heterodyne receivers, an 18-channel multi-beam heterodyne array and a 119-channel bolometer array. A variety of back-ends enable spectroscopic studies at various spectral resolutions. As of 2008, a new generation set of state-of-the-art dual polarisation receivers (from 3 to 0.8mm) with 4 GHz bandwidths will be installed at the 30-metre, which will result in significant improvements in sensitivity.

The *Plateau de Bure Interferometer* is located at 2550 metres in the French Alps, near Gap. The array consists of six 15-metre antennas equipped with a new generation of low-noise dual polarization heterodyne receivers for the 3, 2 and 1 mm atmospheric windows. At the end of 2008, all the antennas will also be equipped with 0.8 mm receivers. The recent doubling of the baselines enables to obtain sub-arcsecond angular resolution (0.2-0.3 arcsecond) at the highest frequencies, comparable to the largest optical telescopes. The signals from the 6 antennas are processed in an IRAM developed digital correlator, which allows for a large variety of observing modes. All 6 antennas can be phased up for VLBI experiments and successful experiments have been conducted over the years in the global mm-VLBI network.

Description of work

Modality of access under RadioNetFP7:
The IRAM telescopes of the Plateau de Bure Interferometer and the 30-metre telescope are operated by specialist (operators) who have a technical background and have received special training for each facility. 'Astronomers on duty' support these specialists. At the 30-metre telescope, guest observers carry out a large fraction of the observations. They are lodged on site and are assisted in their observations by the operators and the astronomer on duty. Alternative modes are so-called "pool observations" (similar to queue observations) and remote observations for shorter projects or routine measurements.

Support offered under RadioNetFP7:
IRAM provides all the necessary logistics and the best possible environment for users to ensure that their projects are successful, both during the acquisition of the data itself and during their analysis. Be it at the telescope or during visits at the Headquarters in Grenoble (where most of the technical staff and the astronomers are based), users are therefore exposed to high quality support and will be able to meet with some of the world-experts in millimetre radioastronomy.

Outreach of new users:
Under the TNA scheme, calls for observing proposals would explicitly mention the guaranteed access to both the Plateau de Bure interferometer and the 30-metre telescope on the basis of the scientific merit (up to the proposed access quota). The calls will explicitly encourage astrophysicists who are not radio astronomers to obtain data at millimetre wavelengths that complement their data, e.g. in the optical or near-infrared.

Review procedure under RadioNetFP7:
The fundamental principle for allocating time at the IRAM Observatories is the scientific merit of the proposals received. IRAM issues twice per year (mid-March and mid-September) a call for proposals for both instruments corresponding to the summer and winter semesters. A Program Committee (comprising 12 members – the current members of the Programme Committee are: F. Walter, A. Baker, E. Sturm, G. Lagache, A. Fuente, M. Hogerheijde, P. Planesas, A. Weiss, F.-X. Désert, J.-M. Girart and B. Lefloch) who advise the IRAM Director and review the proposals on the basis of their scientific merit and technical feasibility. The successful proposals are A-rated (leading to a direct allocation of time) or B-rated (scheduled at the telescope with a lower priority, i.e. no guarantee of observing time, which allows for scheduling flexibility and overall balance). Typically, 30% of the observing time goes to observers that are not from one of the IRAM partner countries. For proposals received under the TNA scheme, the same procedure is applied, with the same peer review process in place. All A-rated projects would be scheduled, independent of the fraction of time that this will take. IRAM will organise a scheme to include large (>100 hours) programmes and/or key science projects.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
PdBI	Hours	1319	166	112	120	60
PV	Hours	463	357	150	300	52

B 1.3.6 Efforts for the full duration of the project:

Project Effort Form 1 - Indicative efforts per beneficiary per WP

Template: Project Effort Form 1 - Indicative efforts per beneficiary per WP

Project number (acronym) :227290

Workpackage	WP1 Management	WP2 Science Working Group	WP3 Engineering Forum	WP4 Training for Radio Astronomers	WP5 Spectrum Management	WP6 ALBiUS	WP7 AMSTAR+	WP8 APRICOT	WP9 UniBoard	TOTAL per Beneficiary
ASTRON	53,00					26,00			48,00	127,00
IRAM							33,80			33,80
INAF		2,00						52,00	24,00	78,00
JIVE	12,00					44,00			51,00	107,00
MPG			5,00			6,00		35,00		46,00
UMAN				2,00		27,00		53,00	36,00	118,00
OSO							17,00			17,00
UMK								44,00		44,00
STFC							9,60			9,60
SRON							24,70			24,70
OBSPAR							10,80			10,80
KOSMA							6,00			6,00
FG							24,00	12,00		36,00
IGN							18,00	6,00		24,00
TUD							23,00			23,00
ESO						30,00				30,00
KASI									48,00	48,00
UROM			2,00					10,00		12,00
UCAM						22,00				22,00
UOXF						21,00	2,90			23,90
BORD						21,00			15,00	36,00
VENT										0,00
TKK										0,00
NRAO						21,00				21,00
UORL									12,00	12,00
IAF							14,60			14,60
HARTRAO										0,00
TOTAL	65,00	2,00	7,00	2,00	0,00	218,00	184,40	212,00	234,00	924,40

Please indicate in the table the number of person months over the whole duration for the planned work , for each work package by each beneficiary

Project Effort Form 2 - indicative efforts per activity type per beneficiary

	Activity Type	ASTRON	IRAM	INAF	JIVE	MPG	UMAN	OSO	UMK	STFC	SRON	OBSPAR	KOSMA	FG	IGN	TUD	ESO	KASI	UROM	UCAM	UOXF	BORD	VENT	TKK	NRAO	UORL	IAF	HARTAO	Total 'RTD'
	RTD																												
WP 6	ALBiUS	26,00			44,00	6,00	27,00										30,00			22,00	21,00	21,00			21,00				218,00
WP 7	AMSTAR+		33,80					17,00		9,60	24,70	10,80	6,00	24,00	18,00	23,00					2,90						14,60		184,40
WP 8	APRICOT			52,00		35,00	53,00		44,00					12,00	6,00				10,00										212,00
WP 9	UniBoard	48,00		24,00	51,00		36,00											48,00				15,00				12,00			234,00
	Total 'RTD'	**74,00**	**33,80**	**76,00**	**95,00**	**41,00**	**116,00**	**17,00**	**44,00**	**9,60**	**24,70**	**10,80**	**6,00**	**36,00**	**24,00**	**23,00**	**30,00**	**48,00**	**10,00**	**22,00**	**23,90**	**36,00**			**21,00**	**12,00**	**14,60**		**848,40**
	COORD																												**Total 'COOR'**
WP 2	Science Working Group			2,00																									2,00
WP 3	Engineering Forum					5,00													2,00										7,00
WP 4	Training for Radio Astronomers						2,00																						2,00
WP 5	Spectrum Management																												0,00
	Total 'COOR'			**2,00**		**5,00**	**2,00**												**2,00**										**11,00**
	Consortium Management activities: MGT																												**Total Management MGT'**
WP 1	Management	53,0			12,0																								65,00
	Total 'management MGT'	**53,0**			**12,0**																								**65,00**

	SUPP																												Total SUPP
	EVN TNA																												0
	JCMT TNA																												0
	e-Merlin TNA																												0
	Effelsberg TNA																												0
	SRT TNA																												0
	LOFAR TNA																												0
	WSRT TNA																												0
	APEX TNA																												0
	IRAM TNA																												0
	Total 'SUPP'																												0
	TOTAL BENEFICIARIES	**127,00**	**33,80**	**78,00**	**107,00**	**46,00**	**118,00**	**17,00**	**44,00**	**9,60**	**24,70**	**10,80**	**6,00**	**36,00**	**24,00**	**23,00**	**30,00**	**48,00**	**12,00**	**22,00**	**23,90**	**36,00**	**0,00**	**0,00**	**21,0**	**12,00**	**14,60**	**0,0**	**924,40**

B 1.3.7 List of milestones and planning of reviews:

Tentative schedule of project review			
Review no.	**Tentative timing, i.e. after month X = end of a reporting period**	***planned venue of review***	***Comments , if any***
RV1	**Month 18**	**Dwingeloo**	**Activity Report 1 (AR1) & Mid-term review**
RV2	**Month 36**	**Dwingeloo**	**Activity Report 2 (AR2)/Final review**

List and schedule of milestones					
Milestone no.	**Milestone name**	**WPs no's.**	**Lead beneficiary**	**Delivery month from Annex I**	***Comments***
6.1.1	Calibration of pilot experiment using interoperability framework	WP6	4	16	
6.1.2	Release of ParselTongue for distributed processing	WP6	4	21	
6.2.1	New implementation of Global Fringe Fitting algorithm	WP6	23	36	
6.2.2	Direction dependent ionospheric, tropospheric, calibration data set test	WP6	6	21	
6.2.3	Primary beam correction and mosaic imaging exercised	WP6	15	25	
6.2.4	Inclusion of polarization calibration in image plane calibration	WP6	18	19	

6.2.5	Evaluate algorithms for image plane calibration in a distributed environment	WP6	1	30	
6.2.6	New algorithms and observing strategies for astrometry	WP6	20	30	
6.3.1	RFI mitigation software	WP6	5	18	
6.3.2	Evaluation of data quality characterization algorithms and excision	WP6	19	36	
6.3.3	Present models for extended sources	WP6	1	28	
7.1	Standalone, bench top test of photonic LO with spectroscopic quality	WP7	9	17	Test report
7.2	Establish final cryogenic HEMT model for MMIC design	WP7	5	18	Report
7.3	Test of 2SB mm SIS mixer integrated on-a-chip with isolator on IF path	WP7	2	20	Prototype and Test report
7.4	Completion of sub-THz mixer design	WP7	10	21	Mixer design report describing a complete mixer
7.5.1	Batches of AlOx and AlN barrier junctions produced (1)	WP7	14	21	Batches of AlN and/or AlOx junctions are produced and evaluated
7.5.2	Batches of AlOx and AlN barrier junctions produced(2)	WP7	14	36	Batches of AlN and/or AlOx junctions are produced and evaluated

7.6	Test of photonic LO with SIS mixer, photomixer at cryogenic temperature	WP7	10	22	Test report
7.7	Test of LNA designed for direct coupling, with standard DSB SIS mixer	WP7	8	23	Prototype and Test report
7.8	Balanced sub THz mixer designs finished	WP7	8	24	Design of balanced mixer
7.9	Quasi Optical test THz mixer	WP7	8	24	Report
7.10	HEB devices on membranes	WP7		24	Report
7.11	Design of dual polarization W-band module suitable for array integration	WP7	12	30	Report
7.12	THz waveguide test mixer block	WP7		30	Report
7.13	Test of 2SB mm mixer and LNA, both designed for direct coupling	WP7	10	31	Prototype and Test report
7.14	THz waveguide test devices	WP7		31	Report
7.15	Fabrication and test of module	WP7		36	Prototype and Test report
7.16	High-gap SIS junctions study completed	WP7	10	36	Higher gap materials studied and suitable ones are proposed
7.17	Demonstration of integrated pixel, small footprint, 2SB, direct coupling	WP7		36	Prototype and Test report
7.18	Completion of optics configuration study for sub-THz mixer	WP7	10	36	Design report for array configuration and optics,
7.19	Sub-THz prototype mixer demonstration	WP7	10	36	Prototype mixer hardware demonstrated

7.20	Sub THz Array infrastructure design report	WP7	10	36	Solutions for array elements proposed
7.21	High Gap SIS junctions are produced	WP7	10	36	New technology SIS junctions produced and their DC characteristics are evaluated
7.22	Final Report THz FPAs	WP7	4	36	Report
8.01	Report on receiver architectures (Task1)	WP8	6	6	Post on web-site
8.02	Report on atmospheric model	WP8	6	6	Post on web-site
8.03	Deliver Euro MICs: first devices to establish noise performance (Task 3)	WP8	6	12	UMAN results on web-site
8.04	Definition paper of functions and interfaces for building blocks (Task 1)	WP8	6	18	Post on web-site
8.05	Deliver Euro MMICs amplifiers and other circuits for RF&IF applications (Task 3)	WP8	6	18	UMAN results on web-site. Receipt of devices from companies
8.06	Report on performance of first Euro MIC devices (Task 4)	WP8	6	18	Post on web-site
8.07	Report on new technology passive chain (Task 2)	WP8	6	24	Post on web-site
8.08	Deliver Euro MICs with advanced technology aimed at improving noise performance (Task 3)	WP8	6	24	UMAN tests with results on web-site

8.09	Report on Euro MMICs, amplifiers and other circuits for RF & IF applications (Task 4)	WP8	6	24	Post on web-site
8.10	Report on transfer amplifier standard (Task 4)	WP8	6	24	Post on web-site
8.11	Report on feasibility of atmospheric subtraction and implications for receiver architecture (Task 5)	WP8	6	24	Post on web-site
8.12	Report on calibration procedutes and queue scheduling strategies	WP8	6	29	Post on web-site
8.13	Report on tests of passive component performance	WP8	6	30	Post on web-site
8.14	Report on performance of Euro MICs with advanced technology (Task 4)	WP8	6	30	Post on web-site
8.15	Deliver Euro MMICs with improved noise performance (Task 3)	WP8	6	33	UMAN results on web-site
8.16	Report on very low-loss components on low-loss substrates (Task 2)	WP8	6	35	Post on web-site
8.17	Report on Euro MMICs with improved noise performance (Task 4)	WP8	6	35	Post on web-site

8.18	Report on comparison of passive chain performance against classical designs (Task 1)	WP8	6	35	Post on web-site
9.1	Completed board design	WP9	1	11	Design document
9.2	Completed VHDL design (correlator)	WP9	4	11	Design document
9.3	Completed VHDL design (pulsar binning machine)	WP9	6	11	Design document
9.4	Completed VHDL design (digital receiver)	WP9	3	11	Design document
9.5	Conclusion system test	WP9	4	27	Functioning hard-, and firmware

B2. Implementation

B 2.1 Management structure and procedures

The management of RadioNet FP7 will be largely based on the successful structure and procedures already employed by RadioNet FP6.

RadioNet FP7 Consortium Board

The main governing body will be the RadioNet FP7 Consortium Board of Directors (hereafter "the Board"). Each of the formal participating institutes will nominate one representative to the board. The board will nominate a chairperson who will serve for a period of 3 years. The board will meet at least once per year, and will hold additional teleconference meetings as required. The Board will make decisions based on consensus. If consensus cannot be achieved, a decision will be passed by majority vote of a quorum. A quorum will exist if 2/3 of the Board members are present. Work Package leaders will normally be invited to attend Board meetings, at the discretion of the chairman of the Board.

The principle responsibilities of the RadioNet FP7 Consortium Board will be as follows:

- Oversee all RadioNet activities as defined in the work programme,
- Develop annually an 18-month plan for the strategic direction of the RadioNet programme and the distribution of resources therein.
- Receive and review regular reports from the RadioNet Management Team (RMT) on all RadioNet activities,
- Confirm the appointments of the leaders of the various Work Packages,
- Ensure compliance with the regulations laid down in the contract with the EC and the RadioNet Consortium Agreement,
- Approve the allocation and distribution of resources,
- Maintain control of the project contingency funding, and allocate such funds in support of new RadioNet FP7 activities, as and when appropriate.
- Maintain contact with the European SKA Consortium, the Board will appoint the RadioNet FP7 representative in ESKAC.

RadioNet Coordinator

The coordinator of RadioNet FP7 will be Prof. Michael A. Garrett. The coordinator will report to the Board, but will not be a member of the Board. The Coordinator will be the primary contact person with the European Commission. He will be responsible for administering the distribution of the EC financial contribution, according to decisions taken by the RadioNet Board regarding its allocation to participants and activities. The position will not be funded by RadioNet but by the Coordinator's institute; it will require ~25% of the Coordinator's time.

The principal responsibilities of the Co-ordinator are to:

- monitor all activities and ensure that each is following the plan laid down by the WP leaders as approved by the Board,
- ensure that WP leaders provide all reports and documentation on a timely basis to the Board and to the EC as appropriate,
- be responsible for and monitor all financial matters pertaining to the project;
- ensure that the project web-site is kept up to date and that all documents emerging from project activities are available under version control,
- report any and all activities to the Board,
- act as an ambassador for the RadioNet consortium.

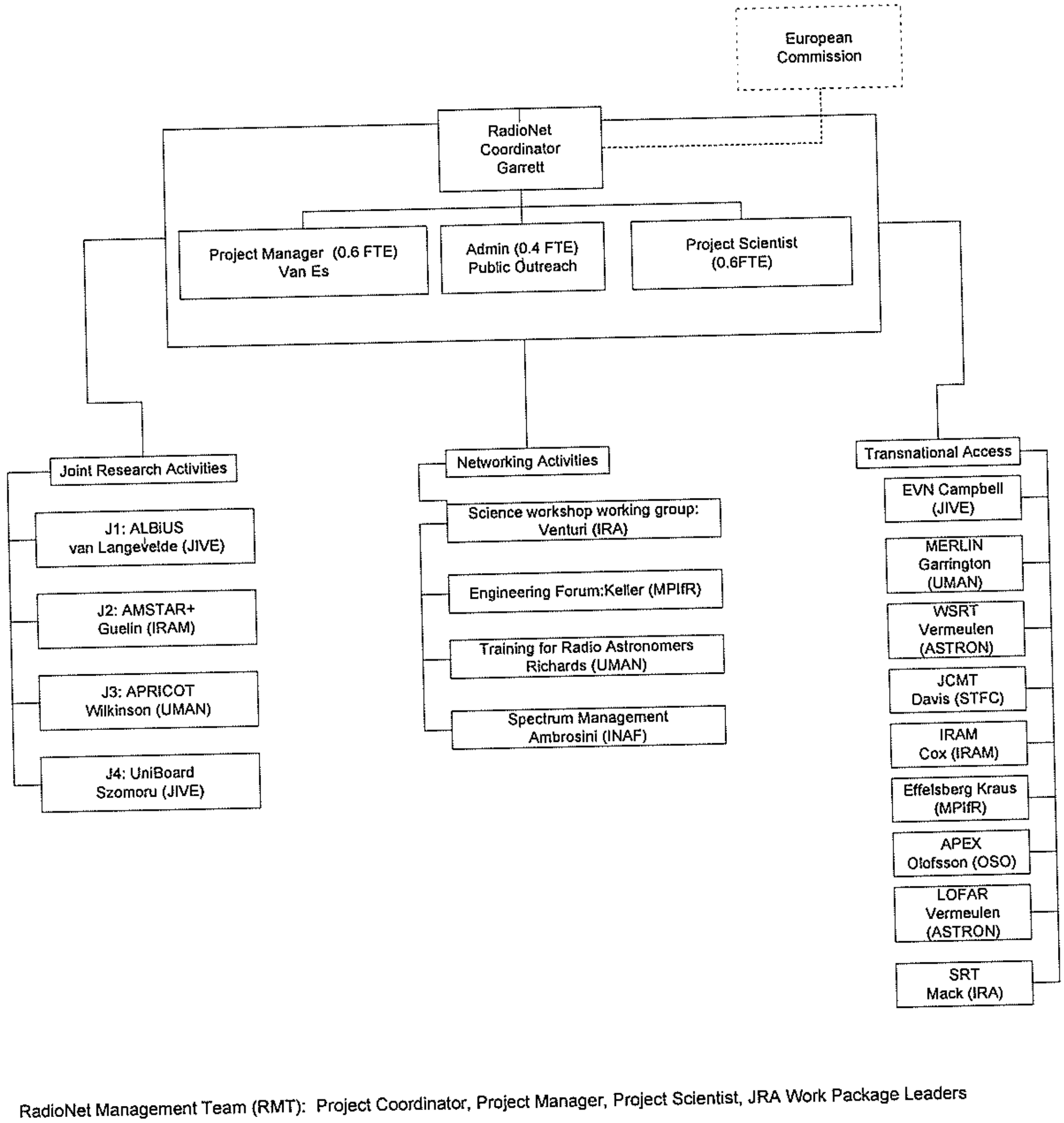


Figure 2.1.1: *RadioNet FP7 Structure*

RadioNet Management Team (RMT)

The coordinator will chair the RadioNet Management Team (RMT). Staff of the RMT will be partially funded by RadioNet and will include:

- Project Manager (0.6 FTE)
- Project Scientist (0.6 FTE)
- Administrative staff (0.4 FTE)

In addition, the RMT will include leaders of the Joint Research Activities. Experience in FP6 shows that the Project Scientist can represent the interests and present issues associated with the Networking Activities and Transnational Access programme. The RMT will meet via monthly telecoms organised by the Project Manager.

The Project Manager will:

- be responsible for the day-to-day operation of RadioNet and the RMT;
- be responsible for the detailed management of all financial aspects of RadioNet;
- receive financial and progress reports for all RadioNet activities;
- be responsible for coordinating the generation of reports, both technical and financial,
- organise board meetings and telecoms
- be the primary contact person for technical details regarding contractual issues.

The Project Scientist will:

keep track of all RadioNet activities, especially NA and TNAs reporting to the coordinator and board,

- monitor timely generation of deliverables from the project,
- represent RadioNet (in the absence of the coordinator) at scientific meetings and events,
- ensure that the many and varied opportunities and possibilities RadioNet offers (especially in terms of networking activities and facility access) is well communicated to the wider community,

Consortium Agreement
The governance of RadioNet FP 7, the relation between contract parties, the organisation of the work between the parties and the rights and obligations will be laid down in detail in the consortium agreement.

B 2.2 Beneficiaries

Participant No. 1: ASTRON (NL)
ASTRON is the Netherlands Institute for Radio Astronomy, and is part of the Netherlands Organisation for Scientific Research (NWO). It provides front-line observing capabilities (e.g. WSRT and LOFAR) for Dutch and international astronomers across a broad range of frequencies and techniques. It has a strong technology development programme, encompassing both innovative instrumentation for existing telescopes and the new technologies needed for future facilities. ASTRON also conducts a vigorous programme of fundamental astronomical research. ASTRON will provide overall coordination and management of RadioNet and contribute to most of the Networking Activities. ASTRON will also provide access to the WSRT and LOFAR telescopes and will contribute as a participant in the ALBiUS and UniBoard JRAs.

Role in RadioNet FP7: *Prof. Dr. Michael A. Garrett* is the general director of ASTRON and Professor in radio techniques in astronomy at University of Leiden. He has extensive experience of EC contract management (extending back to FP4) and is the coordinator of RadioNet FP7. *André van Es* will be responsible for RadioNet FP7 Project Management. He is currently project manager for FP6 SKADS. *Dr. René Vermeulen* is the director of the ASTRON Radio Observatory that operates both LOFAR and the WSRT telescopes. *André Gunst*, system engineering manager of LOFAR and expert in the field of digital signal processing and correlators and specialized in A/D conversion. He will be involved in the UniBoard JRA.

Participant No. 2: IRAM (EU)
IRAM is an international institute funded by the CNRS (France), the MPG (Germany) and the IGN (Spain), operating two observatories .The first facility is the 30-metre telescope located on Pico Veleta (Spain) at an altitude of 3000 metres. The second facility is an interferometer consisting of 6 x 15-m antennas located at 2550 metre in the French Alps operating at 3, 2 and 1 mm. The technological research, development and construction of equipment (including software), is done at the IRAM headquarters in Grenoble. The technical expertise of IRAM mainly concerns the

development and making of mm and sub-mm mixers with waveguide technology, the manufacturing of SiS junctions and Hot Electron Bolometers, and the development of analogue and digital backends. IRAM has been organising for the past 10 years, regular schools on millimetre wave astronomy and interferometry.

Role within RadioNet FP7: IRAM is involved in all the various networking activities, in particular WP5 (Training). The 30-metre telescope located on Pico Veleta will be made available and the IRAM Plateau de Bure interferometer via the RadioNet Transnational Access programme. It leads the AMSTAR+ Joint Research Activity (WP7), building on the success of AMSTAR in RadioNet FP6 (also led by IRAM). Key staff involved in RadioNet FP7 include: *Dr. Pierre Cox,* IRAM Director. Scientific interests mostly in the fields of interstellar dust and molecules, circumstellar environments and high redshift galaxies; *Dr. Karl Schuster,* IRAM Deputy Director. Scientific interests mostly in the fields of circumstellar disks, interstellar medium and receiver front ends. *Dr. Michel Guelin,* PI of WP7 (AMSTAR+). Former Deputy Director of IRAM and PI of the FP6 JRA AMSTAR. Scientific interests mostly in the fields of molecular spectroscopy, astro-chemistry, interstellar medium in galaxies; *Pr. Bernard Lazareff,* Head of IRAM receiver group, PI of Task 2 of WP7. *Dr. Doris Maier.* Research Engineer. Head of the mixer development group; *Dr. Frederic Gueth,* Responsible of the IRAM interferometry schools (IMISS).

Participant No. 3: INAF (IT)

The vast majority of the radioastronomical activities of the Italian Istituto Nazionale di Astrofisica (INAF) are centralized in the Istituto di Radioastronomia (IRA) supported by the INAF Osservatorio di Cagliari (OAC) and Osservatorio Astrofisica di Arcetri (Florence).IRA operates the major national infrastructures (the Medicina and Noto observatories) and is responsible for the design, construction and operation of the Sardinia Radio Telescope, a parabolic antenna of 64 m diameter. IRA is member of the European VLBI Network (EVN) and the International VLBI Service for Astrometry and Geodesy (IVS). It is involved in major international ground-based projects such as ALMA, LOFAR and SKA. On behalf of INAF, IRA hosts the Italian ALMA Regional Centre. On the technological side, IRA has expertise in the development of state-of-the-art components for mm/sub-mm receivers, including MMICs and also has long-term experience with cryogenically cooled low-noise amplifier systems.

Role within RadioNet FP7: IRA will provide Trans National Access to the SRT and through the EVN and will strongly be involved in the JRAs ALBiUS, APRICOT and UniBoard. IRA personnel will collaborate in several NAs and coordinate the NAs Science Working Group, Spectral Management and VC-Net. Key staff include *Roberto Ambrosini*: Physicist, expert in frequency protection, Chair of the Committee on Radio Astronomy Frequencies (CRAF), an Expert Committee of the European Science Foundation, Chair of the NA on Spectral Management and member of the Board in RadioNet FP6, Chair of the NA Spectral Management. *Luigina Feretti*: Physicist, Director of the Istituto di Radioastronomia. *Karl-Heinz Mack*: Physicist, Scientific expertise in extragalactic radio astronomy, User Support Coordinator for the IRA telescopes, partner in FP6 NA Synergy, responsible for the implementation of the TNA at the SRT. *Franco Mantovani*: Physicist, Scientific expertise in extragalactic radio astronomy, Board member in several EC funded projects (currently EXPReS). *Alessandro Orfei*: Engineer with expertise in antenna and receiver design, telescope manager of the Medicina 32-m antenna, partner in FP6 JRA PHAROS, responsible for the INAF contribution to JRA APRICOT. *Stefania Varano*: Astronomer, Master in Science Communication at S.I.S.S.A. (Trieste), Master in Teaching of Maths and Physics at High School, Public Outreach Officer. *Tiziana Venturi*: Astronomer, Scientific expertise in extragalactic radio astronomy, Chairman of the EVN Programme Committee, responsible for the NA Science Working Group in RadioNet FP6, Chair of the NA Science Working Group.

Participant No. 4: JIVE (NL, EU)

The Joint Institute for VLBI in Europe (JIVE) is funded by several major Research Councils and Radio Astronomy national facilities in Europe. It operates the MkIV VLBI Data Processor of the European VLBI Network (EVN). In its capacity as the central institute of the EVN JIVE, provides both end-user support, as well as support to the telescopes in the array. JIVE scientists conduct forefront astronomical research, using VLBI in a wide range of applications including astrometry. JIVE staff is developing state-of-the-art VLBI (Very Long Baseline Interferometry) techniques and technology, including real-time VLBI, so called e-VLBI. JIVE is the coordinator of the EXPReS FP6 project. JIVE also hosts the central data archive of the EVN and facilitates the access of users to the data by providing several software interfaces and web services. There is extensive expertise in software development with an emphasis on data processing and calibration tools. JIVE participates in many SKA projects with a focus on simulations and correlator architectures. This is motivated by the ambition to construct a new correlator to accommodate the enhanced bandwidth that e-VLBI will make available.

Role in RadioNet FP7: As the central institute of the EVN, JIVE will provide the user services and access to outside users of the EVN through its TNA program. Building on the experience in previous framework programs, JIVE will work closely with ASTRON on the central management of RadioNet, in particular by carrying out the administration of the TNA & NA travel budget. JIVE will house the PI's of the UniBoard and ALBiUS JRAs, again building on the success in previous RadioNet and EXPReS FP6 projects. Key staff involved in RadioNet FP7 include: *Huib Jan van Langevelde,* the current JIVE director, expert in mm interferometry and the study of masers around AGB stars. Formerly ALBUS FP6 PI, he will continue to play an important role in ALBiUS; *Dr. Bob Campbell:* Head of operations at JIVE and responsible for the implementation of the EVN TNA. World expert on interferometer techniques and astrometry; *Dr. Arpad Szomoru:* Head of JIVE's R&D division and a leading figure in the development of e-VLBI. PI of the UniBoard JRA and in particular the correlator application that will eventually be deployed for e-VLBI; Drs *Aukelien van den Poll:* project assistant responsible for carrying out the central services for TNA travel that have been implemented at JIVE.

Participant No. 5: MPG (DE)

The Max-Planck-Institut für Radioastronomie (MPIfR) is one of 80 independent research institutes of the Max Planck Society (Max-Planck-Gesellschaft - MPG). The institute is primarily active in the areas of radio astronomy and infrared astronomy. The institute operates the 100-m radio telescope in Effelsberg at centimetre and millimetre wavelengths, one of the world's most important facilities in radio astronomy. The MPIfR also leads the operations and further development of the Atacama Pathfinder Experiment (APEX), a 12-m telescope in the Chilean Atacam Desert built in 2005. The institute completed in 2007 the first international LOFAR station DE-1 in Effelsberg. MPIfR staff has been involved in very-long-baseline interferometry (VLBI) since the mid-1970s and has been operating five generations of VLBI correlators. Currently, MPIfR operates a new-generation correlator – a software correlator based on an international cooperation with the USA, Australia and Finland. MPIfR operates several technical labs that develop technical equipment for mm-cm, mm-sub-mm, infrared, and optical telescopes.

Role in RadioNet FP7: MPIfR will contribute as a participant in three JRAs: AMSTAR+, ALBiUS and APRICOT. MPIfR will coordinate the Engineering Forum (WP3). It makes the 100-m Effelsberg telescope available to the community via the TNA programme. Key staff involved in RadioNet FP7 include: *Prof. Dr. A. Zensus*, Director, overall responsibility for MPIfRs participation in RadioNet. He is current Chairman of the RadioNet Board and will be a member of the new Board; *Dr. Alex Kraus* (head of the Effelsberg Observatory since 2006, leader of the Effelsberg TNA programme in RadioNet FP6 and will lead it again in FP7 subject to funding; *Dr. Reinhard Keller* (head of the electronic division, chairperson of Engineering Forum in RadioNet FP6 and FP7 (WP3); *Dr. Walter Alef* (chairman of the EVN TOG), heavily involved in WP3; *Dr. Alan Roy* participant in ALBUS in FP6, experienced in the interferometry techniques, and the application of water-vapour radiometer and GPS receiver data), will lead MPIfR's contribution to ALBiUS (WP6).

Participant No. 6: UMAN (UK)

UMAN is the largest single-campus university in the UK, with 27,000 undergraduate and 10,000 postgraduate students. It spends ~ £300M annually on research. The Jodrell Bank Centre for Astrophysics (JBCA), which is an integral part of UMAN's School of Physics and Astronomy, is, with 180 staff and students, the largest astronomy and astrophysics group in the UK. JBCA runs Jodrell Bank Observatory, home of the 76-m Lovell Telescope, and the e-MERLIN/VLBI National Facility. It has a broad ranging research programme, from studies of solar plasmas to the origins if the Universe, and most astrophysical phenomena that lie therein. JBCA also has a strong technology programme, with groups working on instrumentation R&D for multi-pixel cameras for studies of the Cosmic Microwave Background; for a wide range of technologies for the SKA, for broadband data transmission, for improved receiver systems and for algorithmic development. JBCA is also the host organisation for the SKA Programme Development Office.

Role in RadioNet FP7: UMAN is leading the APRICOT (WP8) JRA and is also involved in ALBiUS and UniBoard. It will make the e-MERLIN facility available via the RadioNet FP7 TNA programme. Key staff involved in RadioNet FP7 will include: *Prof. Philip Diamond*, Director of JBCA, currently the co-ordinator of FP6 RadioNet, and will be coordinating the SKA Preparatory Phase Study, PrepSKA. His scientific interests lie in the fields of star formation and stellar evolution, VLBI, interferometry technical development and in algorithmic research/implementation; *Prof. Peter Wilkinson* is a senior academic within JBCA, PI of the current UK SKADS programme, led the FP5 FARADAY project and is PI for APRICOT (WP8), main scientific interests lie in cosmology, gravitational lenses and studies of galaxies and AGN. *Prof. Simon Garrington* is the Director of the e-MERLIN/VLBI National Facility and the Head of Operations at JBO. His research interests are wide, and he has published papers in fields as diverse as VLBI studies of stars in Orion to deep-field observations of the most distant parts of the Universe. He is the leader of the e-MERLIN upgrade project, which expects to see first light in summer 2008. Dr. Anita Richards is coordinator of the Training Workpackage; she is employed by the UK ALMA Regional Centre and AstroGrid and her scientificinterests include stellar evolution, astrophysical masers, the starburst-AGN connection and interferometric techniques.

Participant No. 7: OSO (SE)

Onsala Space Observatory (OSO) is the Swedish National Facility for Radio Astronomy. It is operated by Chalmers University of Technology. The Swedish Research Council evaluates and provides funding for its operation. OSO operates two telescopes at Onsala, a 25-m cm-wave telescope and a 20-m mm-wave telescope. It is one of three partners in the APEX Project, a 12-m sub-mm telescope at 5100 m altitude in Chile. OSO also has a strong receiver development programme for mm and sub-mm wavelengths. OSO's main purpose is to provide Swedish, and international, astronomers with the possibility to pursue astronomical research in frequency bands in the radio range from about 0.8 GHz up to 1.5 THz. In addition, OSO provides the channel through which Sweden is involved in large international radio astronomy projects, such as the EVN, JIVE, LOFAR, SKA, and ALMA.

Role in RadioNet FP7: OSO provides Transnational Access to APEX and participates in the Joint Research Activity AMSTAR+. Key staff involved in RadioNet FP7 include: *Prof. Victor Belitsky*, an expert on superconducting electronics, mm-, sub-mm, and THz-mixer technology, and quasi-optical systems, head of the Group for Advanced Receiver Development at Onsala Space Observatory, Chalmers Univ. of Technology, more than 110 publications, patents, etc; *Prof. Hans Olofsson,* director of Onsala Space Observatory (OSO), Chalmers Univ. of Technology, responsible for the TNA programme at OSO that includes APEX, has published more than a hundred papers on the circumstellar properties of highly evolved solar-type stars.

Participant No. 8: UMK (PL)
The Torun Centre for Astronomy (TCfA) at the Nicolaus Copernicus University consists of two Departments (Astronomy and Astrophysics and Radio Astronomy). It is an institute of the Faculty of Physics, Astronomy and Computer Sciences. The Faculty is one of 15 at the Copernicus University. The University has about 40 000 students and 4000 staff. Currently TCfA teaches about 100 students (undergraduates, graduates and Ph.D.). Recent evaluation of astronomical institutes on (6) Polish Universities, has located Torun as the number one. TCfA has been officially awarded the status of "excellence". The evaluation is valid for the next 10 years and was made by the National Commission for Education, an independent body operating at ministerial level.

Role in RadioNet FP7: UMK makes the 32-m radio telescope in Torun available to the EVN TNA programme, and is involved in various networking activities and the APRICOT JRA (WP8). Key staff involved in RadioNet FP7 include: *Andrzej Kus*, Professor of Radio Astronomy, Director of TCfA, his expertise is in instrumentation - receivers and back-ends, interferometry, interest in cosmic masers and extragalactic radio astronomy; *Anna Bajraszewska*, scientific interest and expertise in VLBI; Dr. *Jerzy Usowicz*, RFI monitoring and mitigation, CRAF member representing TcfA; *Eugeniusz Pazderski*, head of Instrumental Group, R&D for VLBI and single dish instrumentation, low-noise receivers, antennas, digital backends, software development; *Roman Feiler*, partially works for TCfA, software engineer, astronomer, develops software for multi-beam systems (phased and horns arrays).

Participant No. 9: STFC (UK)
The Science and Technology Facilities Council (STFC) is one of Europe's largest multidisciplinary research organisations supporting scientists and engineers world-wide. It is a non-departmental government public body, and was formed in 2007 through a merger of the Particle Physics and Astronomy Research Council (PPARC) and the Council for the Central Laboratory of the Research Councils (CCLRC). STFC has a wide remit which includes: administering research grants in astronomy, particle physics, space science and nuclear physics; operating world-class UK research facilities; and providing UK access to a range of research facilities overseas. STFC owns and operates the James Clerk Maxwell Telescope (JCMT), the world's premier facility for sub-millimetre astronomy, and the Rutherford Appleton Laboratory (RAL), the UK's leading physics-based research institute.

Role in RadioNet FP7: STFC will make the JCMT available for transnational access, and will also participate in the AMSTAR+ JRA. Key staff involved in RadioNet FP7 will include: *Prof. Gary Davis*, Director of the JCMT and a member of the RadioNet Board under FP6; *Prof. Brian Ellison*, Senior Principal Scientist at RAL, UK Project Manager for the Atacama Large Millimetre Array (ALMA), with many years experience in millimetre/sub-millimetre wave (terahertz) technology, and also a member of the RadioNet Board under FP6; and *Dr Peter Huggard*, a Principal Scientist at RAL, a specialist in photomixer sources of THz radiation and high-performance filtering for heterodyne radiometry. The STFC participation in AMSTAR+ will be carried out wholly within the Millimetre Technology Group in the Earth Observation & Atmospheric Science Division of RAL's Space Science and Technology Department.

Participant No. 10: SRON (NL)
SRON is the Netherlands Institute for Space Research and is funded by NWO, the Netherlands science foundation. Its main mission is the development and use of innovative instrumentation for cutting-edge space research. SRON has laboratories in Groningen and Utrecht. SRON-Utrecht concentrates on research for x-ray astronomy and Earth oriented science, while SRON-Groningen is

the expertise centre for (far-) infrared and sub-millimetre technology and instruments. SRON-Groningen has many years of experience in the development of advanced optical, infrared and sub-millimetre instrumentation for astronomical applications.

Role in RadioNet FP7: SRON is heavily involved in AMSTAR+ (WP7). Key staff involved include: *Prof. F.Helmich*, instrumentation expert, astronomer, member of the Radionet Board, group leader, management and oversight; *Dr. A. Baryshev, s*enior instrument scientist, mixer and receiver research, leader of Task 3 of AMSTAR+; *R. v.d der Schuur, f*ine mechanic, machining and prototype fabrication.

Participant No. 11 OBSPAR (FR)
Paris Observatory (www.obspm.fr) is the largest astronomy centres in France, and one of the most important in the world. It has the status of an independent University. It represents itself one third of astronomy in France. It covers almost all the fields of Astronomy/Astrophysics. Among its 7 different laboratories, the whole Nançay Radio Astronomy Station personnel, and part of GEPI, LESIA and LERMA researchers and engineers, work in the field of radio astronomy.

Role in RadioNet FP7: OBSPAR is a partner in AMSTAR+ (WP7) and contributes to various networking activities: Training for Radio Astronomers (WP5), and Spectrum Management (WP7). Key staff involved in RadioNet include: *Ludwig Klein*, astronomer, LESIA, theoretical interpretation of solar radio data, chairman of CESRA, Community of European Solar Radio Astronomers, co-I of the Training for Radio Astronomers NA (WP5); *Jean-Michel Krieg*, LERMA, technical manager for the OBSPAR participation in JRA AMSTAR+, responsible for various R&D projects for CNES and space missions in the mm/sub-mm domain; *Guy Kenfack*, participation, in cooperation with UORL, to JRA UNIBOARD, engineer expert in hardware implementation (e.g. FPGA) of RFI algorithms; *G. Theureau*, Nançay/GEPI, astronomer working on NRT data, galaxies, pulsars (Member of EPTA European Pulsar timing Array), specialist of public outreach, and with UNIBOARD (WP9) for pulsar expertise; *Michel Tagger*, astronomer, associated with Nançay, co-chairman of the French LOFAR consortium; *Wim van Driel*, astronomer, GEPI, expertise in particular on spectrum management, member and former chairman of IUCAF and CRAF, member of IAU commission 50, participates in NA Spectrum Management (WP7).

Participant No. 12: KOSMA (DE)
KOSMA is a part of the Physikalisches Institut of the University of Cologne. Its astronomical research focuses on the submm and THz frequency range. It has a strong instrument development group that has provided (multipixel) receivers for KOSMA's own telescope at Gornergrat, and receivers or parts of receivers for various other observatories throughout the world. It has recently provided the mixers for Band 2 of HIFI on the Herschel Satellite (launch End 2008) and for GREAT 1.4/1.9 THz on SOFIA. Currently KOSMA is involved in building state of the art receivers for the SOFIA airplane observatory and for the NANTEN2 observatory in the Atacama in Chili. All receiver development and fabrication is done in house. KOSMA has its own nanostructure facility, state of the art high frequency design/measurement tools, and an excellent mechanical workshop.

Role in RadioNet FP7: Participant and sub work-package leader in JRA AMSTAR+ (WP7) for the development of 1-2 THz mixers and mixer devices. Key staff involved in RadioNet include: *Dr.K. Jacobs*: head of the nanostructure facility, 20 years of experience in submm/THz detector development; *Dr. C. Honingh*: mixer development, 15 years of experience in submm/THz detector development; *Dipl. Ing. S. Wulff*: head clean room engineer; *Mr. S. Schultz*: mechanical design & mixer assembly.

Participant No. 13 FG (ES)
FG (Fundacion General de la Universidad de Alcala) coordinates and manages administrative issues related to Third Parties, the EC and other bodies on behalf of the University of Alcala. The IGN

(Instituto Geografico Nacional) operates national facilities at Yebes including two millimeter-wave radio telescopes. IGN is particularly involved in RF-technology development including quasi-optics, in its laboratories at Centro Astronomico de Yebes (CAY-OAN). IGN is a third party to FG.

Role in RadioNet FP7: major participant in JRAs (AMSTAR+ and APRICOT. It makes available the Yebes 40-m antenna as part of the EVN TNA programme (WP10). Key staff involved in RadioNet include: *Rafael Bachiller* (Director of OAN-IGN): general coordination; *Francisco Colomer* (OAN-IGN): project manager for FG-IGN in RadioNet FP7, leader for FG-IGN in VC-Net and EVN TNA, *Juan Daniel Gallego* (OAN-IGN), leader for FG-IGN in APRICOT and AMSTAR+; *Alberto Barcia* (OAN-IGN), *Isaac Lopez* (OAN -IGN), *Carmen Diez* (OAN–IGN) engineers involved in AMSTAR+ & APRICOT (WP7 & 10); *Pablo de Vicente*, astronomer, VLBI technical friend, involved in EVN TNA programme (WP10).

Participant No. 14: TUD (NL)
Delft University of Technology (TUD) is the oldest and largest engineering school in The Netherlands. It was founded in 1842, and received the right to grant PhD degrees in 1905. Education at TUD covers the major fields of engineering and it has a particularly strong research profile in the nanosciences. The Department of Nanoscience has become the Kavli Institute of Nanoscience to acknowledge its leading position in many areas of nanoscience such a molecular biophysics, quantum information processing, nanoelectronics for space research, physics of nano-electronics and theoretical physics. It has a commonly run nanofacility equipped for various general processes and for specific research groups. Research is funded through a variety of national, European and US research organisations.

Role in RadioNet FP7: TUD participates in AMSTAR+ (WP7). Key staff involved in RadioNet FP7 include: P*rof. Teun M. Klapwijk* has collaborated with astronomers on instruments to detect THz radiation with contributions to the Jamer Clerk Maxwell telescope, the Herschel Space Telescope, as well as the Atacama Large Millimetre Array. His current interest is in nano-electronics for space research, including quantum cascade lasers and mesoscopic superconductivity; *Jianrong Gao*, senior scientist at SRON and at Delft University, specializing in hot electron bolometers and quantum cascade lasers, contributions to TELIS and to Herschel. Currently involved in kinetic inductance detectors and possible contributions to SPICA; *Tony Zijlstra*, senior technician in nanotechnology, years of experience in reactive ion etching and anisotropic etching processes, has contributed to Band 3 and band 4 of HIFI in Herschel, in particular the integration of NbtIN materials with Nb SIS tunnel junctions. TUD has developed a new plasma process for tunnel barriers using AlN materials.

Participant No. 15: ESO (INO-DE)
ESO (the European Organization for Astronomical Research in the Southern Hemisphere) operates the La Silla-Paranal Observatory in Chile. This observatory includes the Very Large Telescope, one of the most successful ground based observatories in the world. ESO is one of the three partners (the other two being North America and East Asia) constructing the Atacama Large Millimetre Array (ALMA) in Chile. ALMA is the world's largest ground based astronomy project. The construction is planned to finish in 2012. In 2010, Early Science with ALMA is planned to begin. The interface between the European user community and the ALMA observatory will be the ALMA Regional Centre (ARC) in Garching. The ARC consists of the central office and six to seven partners or ARC Nodes which will help ALMA users obtain the best science from this instrument.

Role in RadioNet FP7: Active participant in Scientific Working Group networking activity (WP2). Key staff involved in RadioNet FP7 include: *P. Andreani* (ARC Manager at ESO); *L. Testi* (European Project Scientist for ALMA at ESO); *R. Laing* (Instrument Scientist for ALMA at ESO); L. Testi (project scientist for ALMA at ESO)).

Participant No. 16: KASI (KR)

The Korea Astronomy and Space Science Institute (KASI) is the national astronomy research institute of Korea established in 1974. KASI has played a major role in establishing a modern programme of astronomical research in S. Korea. KASI established the Sobaeksan Optical Observatory & Bohyunsan Optical Observatory, expanded the observational wavelength range to the radio via the establishment of the Taeduk Radio Observatory, and is responsible for the construction of the Korean VLBI Network (KVN). The KVN project started in 2001 – it is a dedicated mm-VLBI array that employs a unique simultaneous multi-frequency observation system. KASI is developing the Korean-Japanese Joint VLBI correlator (KJJVC). The KJJVC will be locate at the KVN headquarters and be responsible for VLBI data processing of the KVN, the East-Asian-VLBI & VSOP-2.

Role in RadioNet FP7: KASI will contribute as a participant in the UniBoard JRA (WP9). Key staff involved in RadioNet FP7 include: *Dr. Bong Won Sohn*, senior researcher & associate professor, overall responsible for KASI's participation in RadioNet FP7. *Yong Woo Kang* - senior engineering staff and responsible for the FPGA test board design. *Jae Hwan Yeom* is part of engineering staff and responsible for the FPGA test board manufacturing.

Participant No. 17: UROM (IT)

The activities of the Electronic Engineering Department of the University of Roma Tor Vergata date back to 1982, and since then the department has been growing both in research interests and international reputation. With over 60 staff researchers (comprising professors, researchers and research graduated technicians), its research activities span from optoelectronics to molecular electronics, from telecommunications networks to space communications, from sensor networks to electrical engineering, from digital to analogue high frequency electronics. In the latter field, i.e. microwave and millimetre wave electronics, the expertise ranges from design capabilities in linear and nonlinear circuits to characterisation and modelling of active devices, both linear, non linear and noisy: this is the team joining the RadioNet FP7 project.

Role in RadioNet FP7: UROM will participate both in the 'Engineering Forum' Networking activity (WP3), building up a database of existing and future facilities for technological development of instrumentation for radioastronomy, and to the APRICOT JRA, with the aim to support MMIC design and characterisation. Key staff involved in RadioNet FP7 include: *Ernesto Limiti*, professor of microwave instrumentation and measurements at the University of Roma Tor Vergata, Engineering Faculty, his research activities are in the field of microwave and millimetre wave active device characterisation and modelling, together with advanced design methodologies for a series of microwave subsystems (low noise, power, control). Ernesto Limiti will be directly involved in the activities related to the Engineering Forum NA, and will be the supervisor of the team involved in the APRICOT JRA. In the latter activities, two senior researchers will participate, namely *Dr. Antonio Serino* and *Dr. Lucio Scucchia*, with the main objective to carry out MMICdesign and characterisation activities. The team will be completed by PhD and Post-doc researchers, the latter specifically enrolled to carry out the JRA research work.

Participant No. 18: UCAM (UK)

The Cavendish Astrophysics group manages the Mullard Radio Astronomy Observatory and has a long history of work in radio astronomy. Currently research covers instrument development and data analysis, together with observational and theoretical astrophysics. Currently, it focuses on: CMB astronomy; the SKA; mm-instrumentation; data reduction techniques; and optical interferometry. Current project and commitments include: a new telescope, AMI, for CMB astronomy which is nearing completion at the observatory; running the level-3 Planck analysis centre; running DS3 within the SKADS FP6 programme; leading the design of the Magdalene Ridge Observatory; designing the water vapour radiometers for ALMA.

Role in RadioNet FP7: UCAM will contribute to many of the networking activities and is a participant within ALBIUS+. Key staff involved in RadioNet FP7 include: *Dr. Paul Alexander*, head of the group with interests in galaxy evolution, telescope design and data processing. He is the leader of DS3 in FP6 SKADS, and will lead the data management work package in PrepSKA FP7; *Dr. Michael Hobson* is an expert in data analysis techniques, most recently applied to problems in CMB cosmology. He is closely involved in Planck data reduction. His current research interests are data analysis, observational and theoretical CMB cosmology.

Participant No. 19: UOXF (UK)
The University of Oxford is over 700 years old. The RadioNet FP7 activity will take place largely within Astrophysics, which is one of the six sub-departments that together make up the Department of Physics, although there are linked activities in the Oxford e-Research Centre and the Department of Engineering.

Role in RadioNet FP7: Oxford will be major contributor the NA SWG (WP2) and to two JRAs, ALBiUS (WP6) and AMSTAR+ (WP7). Key staff involved in RadioNet FP7 include: *Prof. Steve Rawlings* is the Head of Astrophysics at Oxford, a co-organiser of the SWG, building on his experience as International Project Scientist for the SKA. As Deputy Chair of the European SKA Science Consortium (ESKAC), and deputy leader of LOFAR-UK, Rawlings is also heavily involved in E-LOFAR. Oxford's work as part of AMSTAR+ will be led by *Ghassan Yassin* (an expert on electromagnetics and high-frequency detectors, mixers and devices) and *Mike Jones* (an expert on analogue and digital signal processing and other aspects of radio astronomy). They will extend their group's work in (i) finline SIS chip technology, (ii) `smooth-wall horns' and (iii) novel photonic local oscillators for SIS mixer pumping. Oxford's work as part of ALBiUS will include further development of novel algorithms for image plane calibration, building on an existing collaboration between Stefano Salvini (OeRC) and ASTRON. PDRAs involved in the work will include *Paul Grimes* and *Jamie Leech* -- key contributors to the preparatory work that have allowed Oxford to join AMSTAR+ -- and *Hans-Rainer Kloeckner* and *Francois Levrier* who have been developing novel software solutions for calibration and imaging with long interferometric baselines (preparatory work allowing Oxford to join ALBiUS).

Participant No. 20: BORD (FR)
Bordeaux Observatory is a research institute funded by the University of Bordeaux and the CNRS. The major topics of research are focused on the study of reference systems, galaxy evolution, the interstellar medium, star and planet formation, planetary surfaces and atmospheres, and astrobiology. In addition, Bordeaux plays a prominent role in two major technology programs for radioastronomy, ALMA and Herschel-HIFI. This includes innovative developments in digital filtering, fast digitisers, and IF/RF analogue signal conditioning for ALMA and the organisation of the corresponding industrial production as well as the delivery of the correlator system aboard Herschel-HIFI. Bordeaux cooperates with ESO and various European institutes or local industry partners on these technology programs.

Role in RadioNet FP7: Bordeaux will participate in two JRAs, UniBoard (WP9) and ALBiUS (WP6). Bordeaux will contribute to the firmware implementation and the selection of the wideband digitiser required for the multi-purpose applications of the digital filter. Bordeaux will contribute to ALBiUS by developing innovative algorithms and observing techniques for calibration of astrometric source positions and for conducting deep astrometric surveys with present and future radio-interferometers such as the EVN, the IVS2010 network and in the longer term SKA. Key staff involved in RadioNet FP7 include: *Alain Baudry* has led many radio astronomy observation projects with the IRAM telescopes, is currently leading the ALMA European correlator team, and is a Herschel-HIFI co-investigator; *Philippe Cais* is in charge of the Electronics Laboratory, is involved in the construction of the digital filtering sub-system of the ALMA correlator and has co-led the Herschel-HIFI correlator team; *Pascal Camino* and *Benjamin Quertier* are experts in the mathematical tools required for digital signal processing and in digital electronics at large. *Patrick Charlot* is leading the astrometry group and is currently involved in several international astrometry projects, among which the construction of the successor of the IAU International Celestial Reference Frame (ICRF), its extension to higher VLBI frequencies and a survey to link the ICRF to the future GAIA optical frame; *Arnaud Collioud* is an expert in VLBI imaging and is currently developing simulations to evaluate the imaging capabilities of the IVS2010 network.

Participant No. 21: VENT (LV)

Ventspils University College (VUC) is one of the leading higher education establishments in Latvia. VUC offers both academic and professional studies in various specialties, particularly Electronics and Information Technologies. During the academic year 2007/2008 there were about 800 students studying at VUC. Three institutes have been founded at VUC and one of them – Ventspils International Radioastronomy Center (VIRAC) will be involved in RadioNet FP7. The primary tool for radio astronomical observations is the 32-m diameter radio telescope (RT-32) situated 30 km from the city Ventspils on the premises of VIRAC. This radio telescope, left by Soviet Army after its withdrawal from Latvia, is now being equipped with the necessary equipment to take part in VLBI observations with the aim to become a full member of the EVN consortium.

Role in RadioNet FP7: VIRAC will make available the facilities of the 32-m radio telescope via the EVN transnational access programme. Key staff involved in RadioNet FP7 include: *Asoc.prof. Juris Zagars,* director of VIRAC, coordinator of VIRAC development projects, Latvian delegate in FP7 "Space" and "Security" program committees. His scientific interests lie in the fields of space navigation, reference frames, SLR and geodetic VLBI theory and applications; *Dr. Ivars Smelds* is the leader of VLBI group of VIRAC and is responsible for developing VLBI technologies and the implementation on Irbene Radio telescope.

Participant No. 22: TKK (FR)

Metsähovi Radio Observatory of Helsinki University of Technology TKK is a long time partner in the EVN and has been participating in VLBI measurements since 1991. Metsähovi is a specialist in mm-VLBI, and in technology development. At high frequencies, Metsähovi strengthens the coverage of the EVN array of telescopes, making the EVN more attractive to astronomers specialising in high-frequency VLBI. Since the early 1990's, Metsähovi Radio Observatory has been one of the few institutes in the world where VLBI data acquisition systems have been actively constructed and developed. After delivering sets of Mark4 read/write electronics to all major EVN observatories and the NASA Deep Space Network (DSN) tracking stations, Metsähovi has focused on maximizing the applicability of Commercially Available Off-the-Shelf (COTS) technology for VLBI data acquisition appications. Metsähovi is at the moment developing a next-generation (multi-Gbps) network-connected data acquisition system (DAS) within the FP6 EXPReS project.

Role within RadioNet FP7: Metsähovi makes available the facilities of it mm-VLBI radio telescopes as part of the EVN TNA programme (WP10). Key staff involved in RadioNet FP7 include: *Ari Mujunen*, software engineer at Metsähovi Radio Observatory. At MRO, he has written software and created electronic designs for the in-house telescope control and single-dish data acquisition system. *Jouko Ritakari* is a hardware engineer at Metsähovi Radio Observatory. At MRO, he has developed hardware and firmware for high-speed data acquisition systems and led the project where MRO manufactured its own VLBI "VLBA DAS" rack in 1991. He has also experience in designing data communication networks - he has designed several of the largest private networks in Finland.

Participant No. 23: NRAO (USA)

The National Radio Astronomy Observatory (NRAO), under Associated Universities, Inc. (AUI), is the primary institution developing and operating federal radio astronomy observatories in the United States. It provides front-line observing capabilities on an open-skies basis to astronomers throughout the world, ranging across several orders of magnitude in frequency and resolution. NRAO operates the Very Long Baseline Array (VLBA), consisting of 10 identical remotely located 25-meter antennas, which is a primary participant in global VLBI sessions. As the only full-time imaging VLBI array in the world, the VLBA also provides thousands of hours of additional observing time to European and other international astronomers. NRAO's strong technology development program keeps the Expanded Very Large Array (EVLA) and Green Bank Telescope at the forefront of modern astronomy, and has enabled NRAO to be the primary North American partner in construction of the Atacama Large Millimetre Array.

Role within RadioNet FP7: NRAO will provide access to the VLBA via the Global VLBI TNA programme (WP10). It will also participate within ALBiUS (WP6). Key staff involved in RadioNet FP7 include: *Dr. Robert Dickman* the EVLA/VLBA site director, leads the TNA effort together with *Dr. James Ulvestad*; the head of the NRAO New Initiatives Office. Both are internationally known astronomers with substantial research and management experience.

Participant No. 24: UORL (FR)

The University of Orleans (UORL) founded in the 14th Century has over ~ 15000 students and employs 882 lecturers in 4 Faculties, 1 School of Engineering and Technology and 4 Institutes of Technology. 34 research laboratories are coordinated by the Research Department and are divided into 6 centres of excellence including "Mathematics, informatics and electronics". UORL is also a participant in the EC FP6 SKADS programme and is involved in other FP6 and FP7 programmes.

Role in RadioNet FP7: participates in the UniBoard JRA. UORL activity will include implementation of pulsar detection algorithms in the UniBoard board. Key staff involved in RadioNet FP7 include: *Rodolphe Weber,* scientific coordinator of the Radio Frequency Interferences mitigation group at the Nançay radio Observatory. His interests are in digital backends and signal processing algorithms for radio astronomy. *Ismael Cognard* is a scientist working on timing millisecond pulsars.

Participant No. 25: IAF (DE)

The Fraunhofer Institute for Applied Solid-State Physics, IAF, is a leading research and technology centre for compound semiconductors and their application in microelectronics and optoelectronics. Fraunhofer IAF is a gateway between state-of-the-art research and industrial implementation of novel micro- and nanoelectronic circuits, as well as optoelectronic devices. The IAF focuses on III-V compound semiconductors and their heterostructures for advanced transistors and optoelectronic devices. Epitaxial growth in atomic dimensions and device structures of less than 50 nm are the daily essentials of IAF technology. For military and commercial applications, the IAF develops a broad variety of microwave and millimetre-wave monolithic integrated circuits (MMICs) based on III-V compound semiconductors using advanced HEMT technology. Operating between 1 GHz and 0.5 THz, these integrated circuits combine high functionality with small chip size and cost-effective production. The IAF offers epitaxial and technology services, design, prototyping and small volume production for packaging and module fabrication and covers the complete MMIC technology chain. In presently ongoing projects the metamorphic HEMT technology is extended to cryogenic temperatures and related ultra-low noise applications.

Role in RadioNet FP7: essential partner in AMSTAR+ (WP 9). Key staff involved in RadioNet include: *Matthias Seelmann-Eggebert,* Senior Scientist, Technical Officer and local Project Coordinator for RadioNet activities. Expertise in modeling of semiconductor devices, ca. 20

authored and co-authored publications on MMICS in the last 3 years. *Sébastien Chartier*, Designer of front end MMICs, i.e. LNAs,VCOs, Mixers, frequency dividers etc. for mm-wave applications, ca. 13 publications in the last 5 years on SiGe based mm-wave circuits.

Participant No. 26: HARTRAO (SA)
Hartebeesthoek Radio Astronomy Observatory (HartRAO) is located west of Johannesburg, South Africa. It operates as a National Research Facility under the auspices of the National Research Foundation (NRF). HARTRAO is a long time partner in the EVN and has been participating in VLBI measurements since the1990s. HartRAO, the only fiducial geodetic site in Africa, participates in VLBI, GPS and SLR global networks. At cm-wavelengths, the 26-m radio telescope greatly improves the coverage of the EVN array of telescopes, especially for sources located at southerly declinations.

Role within RadioNet FP7: HARTRAO will make available the facilities of the 26-m telescope, as part of the EVN TNA programme (WP10). Key staff involved in RadioNet FP7 include: *Roy Booth* (Director of HRAO) and *Jonathan Quick* (hardware/software engineer for the astronomy programme).

B 2.3 Consortium as a whole

The participants of RadioNet FP7 bring together a wide range of relevant expertise in the field of radio astronomy. The consortium includes 26 organisations, including all of the major radio observatories in Europe. In addition, institutes with state-of-the-art knowledge in advanced electronics are also valued partners in the programme. Large international organisations and associations such as ESO and NRAO also play a fundamental role. The competence of the participants spans the areas of (i) fundamental astrophysical research, (ii) operations of large-scale radio telescope facilities, (iii) scientific support, (iv) innovative technology development for astronomical instrumentation and (v) public outreach, teaching and higher education. This distributed knowledge base reflects the diverse set of activities within RadioNetFP7.

The consortium has significant experience in managing large projects, including large EC projects. The consortium is based on the previous RadioNet FP6 partnership: the long standing collaboration and trust that exists between the participants, leads naturally to good communication and an easy exchange of information. Each of the work packages is led by a particular institute and individual, chosen by the consortium on the basis of their expertise and knowledge. Some of the activities build on initiatives funded under FP6, in particular the Transnational Access programme. In this area, the experience of the consortium in operating and making available high quality data products to the international astronomical community is considerable. The consortium operates the largest and the best radio telescopes on the planet – collaboration between telescopes is especially close in the area of European and Global VLBI. The consortium also boasts significant expertise in the area of fundamental research and education. Partners include some of the largest Universities and research institutes in Europe. They address problems in fundamental astrophysics and enjoy an international reputation in the development of advanced and innovative technology (for radio astronomy). The members of this consortium account for a large fraction of all publications (both scientific and technical) associated with the field of radio astronomy.

In summary, the RadioNet FP7 consortium is constituted by internationally leading institutes with complimentary and overlapping expertise. This broad expertise is spread both within and across the partners. The consortium is mature and reliable, but also flexible in terms of embracing new partners and ideas. The result is that this consortium can fully deliver on the entire range of different activities and associated deliverables.

The objectives of the Joint Research Activities (JRA) are mostly to produce prototypes of highly specialised equipment (or software) for forefront astronomical research. Although there is no direct role for industrial partners within RadioNet, many of the participants are closely connected to industrial partners (e.g. TU Delft) or have commercial business units (e.g. The Fraunhofer Institute for Applied Solid-State Physics). Industrial interest in the R&D research associated with the JRAs is likely to be high. APRICOT (see WP8) will purchase MMICS from the fully commercial OMMIC Company in France, and the non-profit Fraunhofer Institute. The aim is to conduct a thorough evaluation of low-noise multifunction MMIC capability available within Europe. This should have immediate spin-offs in the specialised European communications sector *e.g.* ground-space communications. It is expected that all the JRA partners will also make use of local SMEs for the manufacture of specialised passive components. The UniBoard project also presents the possibility of collaboration with commercial parties – the board's general application makes it at an attractive system for non-science application domains. ASTRON already has experience in this area, making the LOFAR processor boards available to local commercial entities. To make the UniBoard more accessible for the commercial domain, a product leaflet will be published. Care will be taken to ensure that "popular" connectors and interfaces are available – a problem encountered with earlier initiatives in this area. The potential for industrial involvement via production manufacturing is high, provided the JRAs lead to successful prototypes. ALMA is a good example of where this approach can work well (e.g. production of water radiometers etc). Industrial interest in next generation telescopes such as the SKA is assured, partly due to the large number of receptors in the array, and the challenges associated with power consumption, data transport and processing.

Sub-contracting

OMMIC

A requirement of the RadioNet FP7 project, JRA APRICOT, is specialized Monolithic Microwave Integrated Circuits (MMICs) with exceptionally low-noise characteristics. OMMIC is a leading supplier of advanced semiconductor technologies and is the only commercial semiconductor foundry in Europe offering a 70-nm metamorphic-HEMT process based on GaAS substrates. This MMIC technology has the potential for meeting the performance specifications required for future European radio astronomy requirements. OMMIC can make this process available for the research performed in the APRICOT JRA. For this purpose OMMIC will act as a subcontractor to INAF.

Third parties (other than subcontractors)

The Fundacion General de la Universidad de Alcala (FG). FG is a non-profit public foundation which gives administrative services to the University of Alcala and associated institutes. The Foundation engages in contracts on behalf of the university and its departments, contracting staff and purchasing equipment for the projects. The *National Astronomical Observatory*, a department of the National Geographical Institute- IGN), is specialised in the development of state-of-the-art instrumentation for radio astronomy with its laboratories at Yebes (Guadalajara, Spain). The Fundacion General, not having access to such specialised equipment, wishes to delegate part of the technical work associated with RadioNet to the IGN, that will act as a third party. An agreement already exists between the two institutes to facilitate this process. In the same way, the *National Astronomical Observatory also participates in FP6 SKADS and FP7 PrepSKA.*

IGN operates national facilities at Yebes including the 40m radio telescope involved in the EVN. The research department of IGN is particularly involved in RF technology and quasi optics. IGN is third party to RadioNet FP7 acting as a department for the University.

Funding for beneficiaries from "third" countries

While RadioNet is based on a strong tradition of European cooperation, radio astronomy itself is a global pursuit. In order to attain the objectives of the RadioNet project it is essential that several non-European countries are included as full participants in the project.

NRAO (USA): In particular, it is of vital importance for the success of RadioNet, that the National Radio Astronomy Observatory (NRAO) of the US becomes a full member of this programme. They enter the project in two areas; the EVN TNA programme (WP13) and the JRA ALBiUS (WP6). The future of the EVN requires a much closer collaboration between the US and Europe in the field of VLBI. For more than three decades, a close collaboration has flourished in this field, and the user community of the US VLBA Network and the EVN, is largely the same. A very high fraction of VLBA usage is associated with European scientists. Both the EVN and VLBA telescopes have adopted similar scheduling and operating policies, and they use similar equipment and processing software. The two networks co-operate regularly in so-called Global VLBI experiments, increasing the array's baseline length and collecting area – thus providing higher resolution, better sensitivity and much improved imaging capabilities. Global VLBI accounts for about 50% of the EVN observing programme and many of the very best projects demand this facility. For the future it is important that this collaboration in global VLBI is formalised, and that the networks start to present themselves as a single facility to the user community. In the same way that the EVN created a basis on which to build a broad radio astronomy collaboration in Europe, global VLBI has achieved much the same results in the international arena. It is therefore natural to include NRAO within the RadioNet FP7 EVN TNA programme – the contribution the VLBA makes to the combined array is a significant one – the enhanced sensitivity and imaging capabilities will provide a complementary facility to LOFAR, as well as the EVLA and e-MERLIN. Even closer collaboration between the EVN and NRAO is now warranted, in order to make sure both networks react to the new technological options in such a way that compatibility is guaranteed. An important facet of the need for a much closer cooperation also lies in the area of data processing software, as outlined in the ALBiUS project (WP6). As NRAO is also a major partner in ALMA, and responsible for the user software, bringing this expertise into ALBiUS is absolutely essential to close the circle, and to ensure that European users are able to fully capitalise on the opportunities that will become available during the ALMA "early science" phase. A large fraction of the aips++ and essentially all of the AIPS software originated at NRAO. Without a full partnership with NRAO, this programme would be crippled.

KASI (South Korea): The Korean Astronomy and Space Science Institute (KASI) joins the RadioNet FP7 project as a self-funding partner. The current agreement is that local national funding will be made available by the South Korean government to support KASI's contribution to the RadioNet FP7 programme (~ 3 FTEs). KASI participates in the Uniboard JRA (WP7) and makes a significant contribution to the project. It also brings considerable expertise – KASI is developing a new correlator for the Korean VLBI Network and for VSOP-2 (the next generation, Japanese Space VLBI project – due to launch in 2012).

HARTRAO (South Africa): Operates the 26m telescope for VLBI. The location of this telescope in the southern hemisphere greatly improves the imaging capability of the EVN for low declination (e.g. galactic) sources. The inclusion of HARTAO within the EVN greatly improves the scientific capabilities of the array.

Additional beneficiaries / Competitive calls

At present there are no unidentified beneficiaries in RadioNet FP7 and competitive calls for additional beneficiaries are not foreseen.

B 2.4 Resources to be committed

The table presented in this section (Table B2.4) provides a management level description of resources and budget that are needed to carry out the project (including personnel, indirect costs, equipment etc).

Table B2.4: Management level description of resources

Beneficiary	Personnel costs	Consulting	Equipment	Direct costs	Indirect costs	Total	EC contribution
WP1 Management							
ASTRON	358.854		9.200	192.387	206.700	767.141	724.458
IRAM				9.375		9.375	9.375
INAF				15.000		15.000	15.000
JIVE	38.000			22.500	22.800	83.300	83.300
MPG				15.000		15.000	15.000
UMAN				18.750		18.750	18.750
OSO				5.625		5.625	5.625
STFC				5.625		5.625	5.625
WP2 Science working group							
INAF	10.333			189.000	119.600	318.933	213.287
WP3 Engineering forum							
MPG	31.250			90.000	46.875	168.125	129.738
UROM	15.239			18.000	19.943	53.182	35.566
WP4 Training for Radio Astronomers							
UMAN	11.667			112.500	74.500	198.667	132.859
WP5 Spectrum management							
INAF				81.062	48.637	129.699	86.736
WP6 ALBiUS							
JIVE	183.333			12.000	117.200	312.533	144.400
ASTRON	193.700			7.500	115.700	316.900	121.650
MPG	37.500			6.000	56.500	100.000	75.000
UMAN	111.375			5.500	70.125	187.000	80.860
ESO	125.000			7.500	26.500	159.000	99.000
UCAM	91.117			5.000	57.670	153.787	65.640
UOXF	108.500			5.000	68.100	181.600	80.400
BORD	87.500			5.000	55.500	148.000	66.000
NRAO	82.775			8.500	54.765	146.040	66.960
WP7 AMSTAR+							
IRAM	177.374			96.338	164.227	437.939	185.513
INAF				17.400	10.440	27.840	10.440
MPG				30.350		30.350	22.763
OSO	86.816			58.740	87.334	232.890	146.844
STFC	55.254			56.400	58.017	169.671	101.802
SRON	103.143			38.900	85.226	227.269	146.736
OBSPAR	53.550			15.800	41.610	110.960	66.576
KOSMA	30.005			14.400	26.643	71.048	53.286
FG	171.500			87.952	9.800	269.252	141.039
TUD	116.349			8.000	120.215	244.564	146.738
UOXF	9.583			13.000	13.550	36.133	14.700
IAF	76.345			70.746	71.000	218.091	163.567
WP8 APRICOT							
INAF	260.000			153.000	187.800	600.800	348.600
MPG	175.000			85.500	262.500	523.000	392.250
UMAN	299.764			61.500	216.758	578.022	311.347
UMK	110.000			2.200	67.320	179.520	89.640
FG	73.500			13.892	4.900	92.292	55.375
UROM	30.000			3.500	20.100	53.600	40.200
WP9 UniBoard							
JIVE	249.900			108.500	215.040	573.440	294.840
ASTRON	285.600			2.875	192.000	480.475	173.794
INAF	88.000			2.375	54.225	144.600	86.450
UMAN	165.000			2.875	100.725	268.600	129.950
KASI	200.000				40.000	240.000	0
BORD	62.500			1.625	38.475	102.600	66.950
UORL	50.000			1.250	30.750	82.000	51.500
Totals	4.415.326	0	9.200	1.783.942	3.279.770	9.488.238	5.516.128

Beneficiary	Personnel costs	Consulting	Equipment	Direct costs	Indirect costs	Total	EC contribution
WP10 EVN TNA				1.854.582		1.854.582	1.787.217
WP11 JCMT TNA				419.205		419.205	419.205
WP12 e-Merling TNA				523.242		523.242	512.543
WP13 Effelsberg TNA				521.050		521.050	521.050
WP14 SRT TNA				55.365		55.365	46.152
WP15 LOFAR TNA				383.750		383.750	383.750
WP16 WSRT TNA				154.560		154.560	154.560
WP17 APEX TNA				239.400		239.400	239.397
WP18 IRAM TNA				437.826		437.826	419.994
Totals	0	0	0	4.588.981	0	4.588.981	4.483.869
Total General	4.415.326	0	9.200	6.372.923	3.279.770	14.077.219	9.999.997

Note that travel funds for WP2, WP3, WP5 and WP7 will be administered by JIVE centrally, after approval by the leading participants (chairpersons) of the various WPs. This continues the very successful practice of RadioNet FP6.. Note also that the sponsorship of meetings falls under "Other" in Table 2.4.1. There is a very limited request for manpower in order to coordinate WP2, 3 & 5 (less than 1 FTE in total). WP1 (Management) includes part of the fee associated with RadioNet's membership of ESKAC. WP1 (Management) clearly requires significant man-power support, some PC equipment for staff (~ 20kEuro) and incurs significant costs associated with institute audit certificates (~ 152.5 kEuro). The latter is presented (for convenience) under "sub-contracting". The total management costs are 6 % of the total request (excluding audit costs).

B3. Potential Impact

B 3.1 Strategic impact

An Integrating Activity should have a structuring effect on the European Research Area and on the way research infrastructures operate, evolve and interact with similar infrastructures and with their users. RadioNet is designed in such a way as to maximise the structuring effect. It builds on the highly successful FP6 RadioNet I3 to provide significantly greater integration of European radio astronomical facilities, of networking activities and of the JRAs. The radio astronomical community has learnt from earlier FP4, FP5 and FP6 projects, and from the EVN experience, and now routinely functions in a coherent and integrated fashion.

Expected impact of the TNA programme

The portfolio of European radio astronomy research infrastructures provides unique, world-leading capabilities over a wide range of wavelengths and with the ability to carry out high resolution imaging, all-sky surveys, spectroscopy, astrometry and polarimetry. All these facilities operate on a principle of "open skies" access, so that at least a portion of their observing time is available to all astronomers, purely on the basis of scientific merit. The principal impact expected from the TNA programme is as follows:

- the removal of technical, financial and logistical barriers which prevent European astronomers from taking full advantage of these world leading facilities,
- positive encouragement of external European use of the full range of nationally funded radio astronomy facilities via various outreach activities,
- a contribution towards the provision of a high level of professional support given to external European users of nationally funded facilities covering all aspects of their use, from proposal preparation, through scheduling and execution of observations, to data analysis and interpretation,
- the opportunity for external European users to visit world-leading radio astronomy facilities, participate in the observing process, and interact with other expert engineers and scientists at these institutes.

To the user, these facilities offer an increasingly uniform proposal user interface. The proposal tool Northstar will be the primary portal to the majority of RadioNet facilities. Its use should be extended to all facilities over the next few years. The objective is to use the TNA funds to continue to finance Northstar's development and adoption within the community. For instance the IA OPTICON also uses Northstar for some of its telescopes.

The anticipated outcome from this broader European use of radio astronomy facilities is an increase in the scientific output of European research groups, by providing them with access to a wide range of observational capabilities, and an injection of novel observational programmes for European radio astronomy facilities, which will, in turn, stimulate their technical development. Since these facilities are unique and spread across Europe, it is clear that this can best be achieved on a European rather than national level. The FP7 TNA programme, together with the open skies approach of radio astronomy generally, seeks to put the world's best radio astronomy facilities at the finger tips of Europe's most talented astronomers.

Expected impact of the Networking Activities (NAs)

The NAs are designed as an integrated work programme, the principal aim being the support of all other RadioNet activities. The expected impact from the NAs is considerable:

- a significant increase in the number of astronomers familiar with, and using RadioNet facilities;
- a broadening of the scientific topics to be addressed by users of RadioNet facilities;

- an expansion of the exchange of best practice between operational engineers at RadioNet facilities;
- the preparation of the European astronomical community for the scientific exploitation of ALMA;
- a plan for the future structure of European radio astronomy in the era of ALMA and SKA;
- the fostering and training of students and new users in the techniques of radio astronomy;
- increasing public knowledge and understanding of radio astronomy and the science achieved with RadioNet facilities.

There is another, somewhat intangible impact expected from the NAs that is a significant increase in contacts between astronomers and engineers across Europe. This will translate to an increased level of collaboration and cooperation.

Expected impact of the Joint Research Activities
WP6 ALBiUS will have the most visible (short-term) impact of the JRAs because it focuses on developments which will be accessed directly by users. ALBiUS will develop key algorithms required for the successful exploitation of the upgraded and new generation of RadioNet telescope facilities (e-MERLIN, LOFAR, APERTIF, ALMA etc). In addition, ALBiUS aims to make good use of existing software packages, making the new and existing algorithms available in a modern, distributed computing environment. It also aims to provide transparent interoperability between the different software suites. The latter will encourage a more unified approach to software development in radio astronomy across Europe and beyond. The major impact will be the ability of users to exploit the transformational capabilities of the facilities that will be available to European astronomers in the next few years.

ALMA will be one of the major facilities of the coming decade delivering very high sensitivity and angular resolving power, but only over a very narrow field of view. A complementary approach demands a considerable improvement of existing mm/sub-mm telescopes, in particular in their mapping speed for both continuum and spectroscopic observations. WP7 AMSTAR+ will focus on developing the technology required for the construction of large format (two dimensional) focal plane heterodyne arrays (FPAs) operating from 80 GHz (3.8 mm) to 2 THz (0.15 mm). The expected impact from such developments will be to provide a huge leap forward in the surveying capability of mm/sub-mm single-dishes; such advances are essential not only for the stand-alone science that they will do, but also as facilities which will find the sources for ALMA to observe.

In a similar manner, but using different technology, WP8 APRICOT will develop the design and sub-system technology for large-format focal plane "radio cameras" for astronomical observations in the scientifically rich frequency range of 30-50 GHz. This region of the radio spectrum is poorly explored, and is in the gap between the frequencies which will be covered by the Square Kilometre Array (SKA) and ALMA. A major impact will therefore be the ability to greatly increase the operational efficiency of the host telescope (e.g. SRT 64-m, Effelsberg 100-m and Yebes 40-m) and enable users to carry out hitherto impossibly large sky surveys. Another major expected impact is technological: the APRICOT team expect to secure the availability of state-of-the-art Monolithic Microwave Integrated Circuits (MMIC) devices from within Europe. Establishing a European source of state-of-the-art, multi-function, MMICs is crucial for the future health of European radio astronomy, and has obvious spin-off potential into other fields (e.g. space).

WP9 UniBoard will develop a generic digital board that combines unprecedented computing power and I/O capacity. This board will intrinsically be a multi-purpose instrument, re-programmable for a wide variety of different radio-astronomical applications, as well as being useable as a building block for larger systems. Its impact is expected to be considerable in several areas of immense interest to the RadioNet community:

- the board will form the basis of the DSP for the next generation EVN correlator
- it will lie at the heart of the next generation of pulsar processing hardware
- it will be an essential component of a new development, a high-bandwidth, high-throughput digital receiver, which will have many different applications.

B 3.2 Plan for the use and dissemination of foreground

RadioNet activities will result in the generation of new knowledge or "foreground". One of the aims of the consortium will be to disseminate such knowledge as widely as possible. Most of the results generated by RadioNet are expected to be public. These will be made available via the RadioNet web pages. In addition, all RadioNet partners will be actively encouraged to participate in international conferences and workshops and to present RadioNet results as oral papers and posters at such meetings. The Networking Activities (in particular WPs 1, 2 & 3) have an important role in nurturing and supporting these activities. The results attained by RadioNet and the associated opportunities of the work programme, will be presented at large international astronomy meetings that engage the whole community e.g. General meetings of the International Astronomical Union (IAU), and JENAM (the Joint European and National Astronomy Meeting). RadioNet will endeavour where possible to support and sponsor European meetings such as JENAM. RadioNet activities and will be advertised via the publication of popular articles in the Newsletter of the European Astronomical Society. Astronomers benefiting from Transnational Access will be expected and actively encouraged by WP leaders, to publish their results in refereed journals. Technical results arising from JRAs will also be published in appropriate engineering and/or scientific journals. It will be a regular requirement that RadioNet and the associated EC-funding be clearly acknowledged in all publications.

Another important tool in widely disseminating RadioNet results will be the RadioNet web-site. This site will be mastered and maintained by the project scientists together with the various WP leaders. It will present information on all of RadioNet's activities; the public minutes of RadioNet meetings; the electronic proceedings of workshops arising from the networking activities; and lists of, and links to, preprints and publications arising from RadioNet activities. The RadioNet Project Scientist will also play an important role in ensuring the RadioNet project is clearly visible – not only within the community but also to the wider public.

RadioNet FP7 will allow free and open access to its scientific results and ideas, and to the technologies it develops, within the limits of possible IPR. Given the academic status of most of the RadioNet participants, an "open" model of innovation will be adopted, in which there is free exchange of ideas between the partners. At the same time, the management of knowledge capital (and indeed its protection) is an increasingly important issue, especially as state-of-the-art technology development in radio astronomy, has now many applications outside of the classical academic environments in which they are typically developed. A balanced and flexible approach to IP rights will therefore be established. This will build on the experienced gained in RadioNet FP6 and SKADS. In particular, the RMT will develop and maintain an Intellectual Property (IP) register. This will be updated on a regular basis by the Project Manager (with assistance from the Project Scientist and WP leaders), with the stated goal of continuous identification and registration of knowledge as it is produced within the project. It will be a fundamental database of the project and will enable IP tools (such as patents) to be invoked as required. Decisions on ownership of IP are covered in detail within the RadioNet FP7 Consortium Agreement. In particular, the agreement provides adequate and effective protection of knowledge that is capable of industrial or commercial application. This is clearly required for the Joint Research Activities and IP will be a standing agenda item at the Board meetings. It will be a requirement of the project that RadioNet and the related EC FP7 funding source be acknowledged in all relevant publications.

Contribution to policy developments

Radio astronomy is going through a period of rapid change. At mm-wavelengths ALMA is under construction. At cm-wavelengths, European radio astronomers wish to play a major role in the construction of the SKA. Both ALMA and the SKA will provide unprecedented sensitivity and offer other new capabilities that go far beyond what is possible with existing facilities. These new facilities will also call on the appropriation of significant resources, not only during the construction phase but also for operations and scientific exploitation. A road map detailing the future evolution of existing facilities and the institutes that operate and exploit them is part of the remit of RadioNet FP6. In FP7 it will be necessary to extend this process still further, and to begin to understand the impact these new facilities will have in shaping the radio astronomy programme in Europe. Areas and issues to be addressed include: (i) a critical examination of the future of existing large-scale radio astronomy facilities, including those currently under construction, (ii) a continued (and evolving) role of the major radio astronomy institutes in the era of ALMA and SKA; (iii) actions required to maintain a vibrant and engaged radio astronomy community in Europe; (iv) steps required to facilitate easy access of European PIs to both SKA and ALMA, (v) Europe's contribution to the structure and organisation of scientific support for SKA, data archiving/mining and possible remote array operations. This activity will take place within WP1, Management, but will make use of the resources that are also available in WP2 and WP3. The FP6 RadioNet roadmap will be updated in this process. In the case of SKA (still under construction), the findings of the roadmap will feed into the PrepSKA FP7 programme (in particular Work Package 6 – Funding models).

Risk assessment and related communication strategy:

There are no potential risks (real or perceived) for society/citizens associated with the RadioNet FP7 project.

B4. Ethical issues

There are no ethical issues associated with the RadioNet FP7 project.

B5. Gender aspects *(optional)*

In general, women represent about 50% of the total student population in European universities but later attain only 10% of the senior positions. Females are particularly under-represented in the physical sciences and engineering. It is self-evident that Astronomy generally (and Radio Astronomy in particular) is no exception. The result is that women are poorly represented in decision-making bodies concerned with institute management, and strategic decisions.

The RadioNet community is aware of these problems, and is actively taking steps to encourage female recruitment and participation. All institutes involved in RadioNet FP7 have a policy of promoting and developing their staff equally, regardless of gender or race. The RadioNet board will adopt a policy of equality in the treatment of associated personnel, regardless of sex, ethnic origin, physical handicap, sexual orientation or religion. The board and participating institutes will endeavour to provide a working environment that is free of discrimination or harassment, that addresses the day-to-day needs of all genders, religions and race, and that enables all personnel to work in an atmosphere of safety, dignity and mutual respect. Where appropriate, flexible working hours (including possible part-time appointments) and the ability to work at home will be encouraged.

The process of recruitment and promotion within RadioNet will be fair and transparent – all appointments will be made on the basis of merit alone and the selection panel will (whenever possible) include a female staff member. She will not only participate in the interview process, but will also be involved in drawing-up the associated selection criteria. All staff involved in any

RadioNet recruitment process, will be made aware of their obligation to enforce equal opportunity regulations.

With these policies and actions in place, RadioNet FP7 can positively promote gender equality issues without the need for a specific work package or task within a work package.