SIXTH FRAMEWORK PROGRAMME
Research Infrastructures
Communication network Development

Contract for:

INTEGRATED INFRASTRUCTURE INITIATIVE

Annex I - "Description of Work"

Project acronym: EXPR*e*S
Project full title: A Production Astronomy *e*-VLBI Infrastructure
Proposal/Contract no.: 026642 EXPReS

Date of preparation of Annex I: 19 September 2005

Start date of contract*:* 1/03/2006

1. Project Summary

1.1 Abstract

We wish to create using high-speed communication networks, a distributed, large-scale astronomical instrument of continental and inter-continental dimensions, a Very Long Baseline Interferometer (VLBI) operating in real-time, and connecting together some of the largest and most sensitive radio telescopes on the planet. The overall objective of the proposed I3, EXPReS, is to create a production-level "electronic" VLBI (e-VLBI) service, in which the radio telescopes are reliably connected to the central supercomputer at JIVE in the Netherlands, via a high-speed optical-fibre communication network, including the pan-European research network, GÉANT. With an aggregate data flow of up to 16 Gbps into JIVE, we aim to create a unique e-VLBI infrastructure that is open to the international scientific community, one in which access is based solely on scientific merit. The e-VLBI infrastructure will be a unique facility in the world, generating high-resolution images of cosmic radio sources in real-time, providing astronomers with a reliable and rapid-result service, well matched to the study of transient phenomena such as active stars, supernovae and Gamma-Ray bursts. The rapid results service is also expected to be of practical interest to the geodetic VLBI and precision spacecraft navigation communities. Fundamental to the proposed EXPReS I3, is the need to modify and upgrade the VLBI data processor at JIVE, in order for it to reliably and robustly process VLBI data streams in a real-time environment. A second goal is to expand the number of telescopes that are "on-line", connecting together telescopes located throughout Europe, Asia, South America, South Africa and the USA. EXPReS also seeks to design and prototype elements of the hardware, software and data transport services required to support future e-VLBI facilities in which the net VLBI data flows will be hundreds of Gbps, with a central data processing environment possibly based on Grid-based computing resources

1.2. Table 1 - List of participants

Participant number (co-ordinator as participant N°1)	**Participant name (Organisation, city, country)**	**Participant Short Name**	**Date enter project****	**Date exit project****	**Short description (i.e. fields of excellence) and specific roles in the consortium**
1	Joint Institute for VLBI in Europe, Dwingeloo, The Netherlands	JIVE	1/3/2006	28/2/2009	JIVE is funded by the major Research Councils and Radio Astronomy national facilities in Europe. Its role is to develop and operate the EVN MkIV VLBI Data Processor and provide both end-user and network support to the EVN (European VLBI Network – a recognised large-scale, distributed radio astronomy facility). JIVE staff conduct forefront astronomical research and are developing state-of-the-art VLBI (Very Long Baseline Interferometry) techniques and technology, including real-time VLBI, so called *e-VLBI.* Member of the EVN. JIVE is the Coordinator of the proposed EXPReS I3, and is involved in all activities addressed by the proposal (NA1-NA4, SA1-SA2 & JRA1).
2	AARNET Pgy Ltd., Canberra, Australia	AARNET	1/3/2006	28/2/2009	AARNET is Australia's National Research and Education Network. It provides high-capacity leading-edge Internet services for the tertiary education and research sector communities and their research partners, as well as a range of advanced communications services. Participant in SA2, NA1 & NA2. AARNET comes from a non-associated third country; they provide essential connectivity between radio astronomers in Europe and radio facilities in Australia (see CSIRO). This connectivity is essential in order to meet some key goals of SA2.
3	Delivery of Advanced Network Technology to Europe Limited, Oxford, UK	DANTE	1/3/2006	28/2/2009	Builds, plans and manages pan-continental academic data communication networks, providing essential infrastructure for researchers across Europe and globally, on behalf of Europe's National Research and Education Networks. Broadly involved in supporting the EXPReS project via GEANT2; active participant in NA2 & NA1.

4	Instytut Chemii Bioorganicznej Pan (Poznan Supercomputing and Networking Center), Poznan, Poland	PSNC	1/3/2006	28/2/2009	Operator of the Polish national optical network PIONIER, operator of the Polish link to the GEANT2 network, HPC centre. Partner in several European projects in FP5 and FP6 in Grid technologies and networking. Experience will be vital in addressing networking issues & using Grid technology for VLBI data processing (correlation). Two years ago, PSNC started a project allowing access to remote labour equipment. Participant in NA1, NA2, JRA1.
5	SURFnet B.V., Utrecht, The Netherlands	SURFnet	1/3/2006	28/2/2009	Operates and innovates the Dutch national research network, which connects over 150 institutions in higher education and research in The Netherlands. Responsible for the realization of GigaPort Next Generation Network, a project of the Dutch government, trade and industry, educational institutions and research institutes to strengthen the national knowledge infrastructure. Research on optical and IP networking and Grids is a prominent part of the EXPReS project. Participant in NA1 & NA2
6	Netherlands Foundation for Research in Astronomy, Dwingeloo, The Netherlands	ASTRON	1/3/2006	28/2/2009	Operates the Westerbork Radio Telescope, currently constructing the LOFAR facility. Broad expertise in radio astronomy; interferometry; astronomical VLBI, optical/mm/sub-mm technology development; development of low frequency multi-beaming technology; software development; industrialisation of radio astronomy. Founding member of the EVN. Participant in NA1, NA2, NA3, SA2, JRA1.
7	Centro Nacional de Informacion Geografica - Instituto Geografico Nacional, Madrid, Spain	CNIG-IGN	1/3/2006	28/2/2009	Commissioning the 40-m radio telescope at Yebes, operator of a 14-m radio telescope. Expertise in astronomical and geodetic VLBI; technology development for cm – mm/wave techniques. Member of the EVN. Participant in NA1, NA2, NA3, SA2.
8	CSIRO Australia Telescope National Facility, Epping, Australia	CSIRO	1/3/2006	28/2/2009	Operates the ATCA, Parkes and Mopra. Expertise in all aspects of radio astronomy instrumentation from cm-wave to mm-wave; digital techniques; software and correlators. Participant in NA1, NA2, NA3, SA2. CSIRO comes from a non-associated third country; they provide remote radio astronomy facilities that can (in principle) be accessed by European astronomers. Access to these facilities is essential in order to meet some key goals of SA2.

9	Hartebeesthoek Radio Astronomy Obervatory, Krugersdorp, South Africa	HARTRAO	1/3/2006	28/2/2009	Operates a 26-metre radio telescope, constructing a large radio telescope array – a technological pathfinder to the Square Km Array. Expertise in radio astronomy; astronomical and geodetic VLBI, digital signal processing of radio astronomy signals. Member of the EVN.Participant in NA1, NA2, NA3, SA2.
10	Istituto Nazionale di Astrofisica, Istituto di Radioastronomia, Roma, Italy	INAF	1/3/2006	28/2/2009	Operates the 32-m telescopes at Noto and Medicina. Constructing the 64-m radio telescope in Sardinia. Expertise in radio astronomy; astronomical and geodetic VLBI; antenna technology; RF and digital technology development. Construction of 64-m Sardinia Radio Telescope. Founding member of the EVN. Participation in NA1, NA2, NA3, SA2.
11	Max-Planck-Institut für Radioastronomie, Bonn, Germany	MPIfR	1/3/2006	28/2/2009	Operates the largest radio telescope in Europe, the100-m radio telescope at Effelsberg. Expertise in Cm/mm/sub-mm wave astronomy; VLBI; operation of MkIV correlator; development of radio astronomy technology and software. Founding member of the EVN. Participant in NA1, NA2, NA3, SA2, JRA1
12	Teknillinen Korkeakoulu, Metsähovi Radio Observatory, Espoo, Finland	MRO	1/3/2006	28/2/2009	Operates 14-m mm radio telescope. Develops VLBI instrumentation and software. Expertise in digital and FPGA design. Member of the EVN. Participant in NA1, NA2, NA3, SA2, JRA1
13	National Astronomy and Ionosphere Center, Arecibo Observatory, Arecibo, USA	NAIC	1/3/2006	28/2/2009	Operates the largest radio telescope in the world, the Arecibo 305-m antenna. National research center operated by Cornell University under a cooperative agreement with the U.S. National Science Foundation. Expertise in radio astronomy, VLBI & ionospheric research. Member of the EVN. Participant in NA1, NA2, NA3, SA2.
14	Nicolaus Copernicus University, Torun Radio Observatory, Torun, Poland	NCU	1/3/2006	28/2/2009	Operates the 32-m telescope in Torun. Expertise in radio astronomy; astronomical VLBI; cm-wave technology development. Member of the EVN. Participant in NA1, NA2, NA3, SA2

15	Chalmers University of Technology, Onsala Space Observatory, Onsala, Sweden	OSO	1/3/2006	28/2/2009	Operates the 20 and 25-m telescope in Onsala. Expertise in Mm/sub-mm single-dish and interferometry (both astronomy and geodetic VLBI). Develops technology for cm – sub-mm astronomy. Provides data centre and scientific coordination for the Odin satellite. Founding member of the EVN. Participant in NA1, NA2, NA3, SA2, JRA1.
16	Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai, China	ShAO	1/3/2006	28/2/2009	In charge and responsible for VLBI in China (operational facilities at Seshan & Urumqi; Miyun and Kunming – under construction). Operates and maintains the Seshan 20-m radio telescope. Expertise in astronomical and geodetic VLBI, develops VLBI technologies: receivers, digital techniques (DBBC), software correlator. Participant in NA1, NA2, NA3, SA2. ShAO comes from a non-associated third country; they are members of the EVN and essential partners in realising a global e-VLBI infrastructure.
17	Observatorio Geodesico TIGO, Universidad de Concepcion, Concepcion, Chile	TIGO	1/3/2006	28/2/2009	Operates a transportable S/X-band 6-m offset radio telescope, optical 50cm telescope for satellite laser ranging, GPS/Glonass permanent station, super conducting gravity meter, seismometer, water vapour radiometer, meteorological sensors, atomic clock ensemble, realizes UTC time scale in Chile, develops e-VLBI protocols. Expertise in Geodetic VLBI. Participant in NA1, NA2, NA3, SA2. TIGO comes from a non-associated third country, Chile; they provide extremely long baselines between Europe and China and present an interesting test case; located in an area that is of strategic importance to astronomy generally.
18	The University of Manchester, Jodrell Bank Observatory, Manchester, UK	UniMan	1/3/2006	28/2/2009	Operates the MERLIN radio telescope array in the UK, including the 76-m Lovell, 32-m Cambridge and 25-m Mk2 VLBI radio telescopes. Expertise in radio astronomy; interferometry; astronomy VLBI; development of RF and digital technology and software; algorithmic development; data transfer via fibres. Participant in NA1, NA2, NA3, NA4, SA1, SA2, JRA1.
19	Ventspils International Radio Astronomy Center, Riga, Latvia	VIRAC	1/3/2006	28/2/2009	Operates the 32-m telescope at Ventspils. Expertise in the development of RF technology. Aspiring towards membership of the EVN. Participant in NA1, NA2, NA3, SA2.

** Normally insert "month 1 (start of project)" and "month n (end of project)"

1.3. Table 2 - List of activities

Activity Number	Descriptive Title	Short description and specific objectives of the activity
Networking activities		
NA1	Management of *I3*	Provides resources to effectively manage the EXPReS I3 project. The objective is to efficiently manage EXPRES and monitor the overall progress of the project goals, in particular the realisation of a production-level e-VLBI infrastructure. Responsible for the overall financial management of the project and the generation of annual and final reports via input from the chairs of the NA, SA and JRAs.
NA2	EVN-NREN Forum	Partially supports a forum in which representatives of the networking and radio astronomy technical community will meet and interact with each other, including day-to-day communication via the on-line EVN-NREN email forum. The objective is to ensure that both communities are effectively engaged and that together they agree and move forward on the solutions, objectives and development priorities within EXPReS.
NA3	e-VLBI Science Forum	Partially support the activities of the e-VLBI Science Advisory Group (eVSAG). The objectives of this activity will be to ensure that e-VLBI end-users are well informed and organised about EXPReS developments and can provide critical review of the project's evolution. This group will also help promote & develop the full potential of the e-VLBI technique as an astronomical application.
NA4	e-VLBI Outreach, Dissemination & Communications	Partially supports outreach and communication aspects of the EXPReS I3.Objectives include: creation of the EXPReS web-site (addressing public outreach, project management and end-user communication requirements), general promotion of EXPReS to the broad scientific and networking communities via a programme of PR activities.
Specific Service activities		
SA1	Production e-VLBI Service	A programme of integration and development that will provide astronomers (and other end-users) with a production level e-VLBI infrastructure service, capable of servicing and robustly processing e-VLBI data streams of up to 16 Gbps (net) at the EVN data processor at JIVE. The objectives will be to realise a distributed scientific instrument with unique capabilities - an e-VLBI infrastructure operating in real-time - a service that will be expandable to include input from up to 16 telescopes located across the planet (including individual telescopes of the UK e-MERLIN array).
SA2	Network Provision for a Global e-VLBI Array	A programme of network communication provision that will permit radio telescopes across Europe and the rest of the world to obtain last mile connections to high-speed communication networks that can be

		connected to national research networks and international communication networks, in particular GÉANT.
Research activities		
JRA1	Future Arrays of Broadband Radio Telescopes on Internet Computing	A research project that looks towards the future hardware and software requirements that will enable the development of an e-VLBI facility in which data flows of ~ 10-30 Gbps *per telescope* can be reliably sustained and processed. The main objectives are to design and prototype an e-VLBI data acquisition platform (based on COTS hardware), investigate transport mechanisms and identify protocols that are optimal for e-VLBI, develop a software correlator (e-VLBI data processor) that can run on standard workstations and take advantage of distributed Grid computing resources.

Table 3 – Summary table of expected budget and of the Community contribution requested

		Participant number															
	Activity	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**	
	Amounts (euro)	exp. budget	req. contrib.	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib.	exp. budget	req. contrib.
Networking activities	NA1	331500	212100	3900	3100	6300	4700	3900	3100	3900	3100	3900	3100	3900	3100	3900	3100
	NA2	38200	28300	5500	4000	10900	10100	3400	2600	3400	2600	2400	1600	2400	1600	4500	3000
	NA3	30600	18400									3400	2400	3400	2400	5500	4000
	NA4	193750	160900														
	Sub-total Networking	594050	419700	9400	7100	17200	14800	7300	5700	7300	5700	9700	7100	9700	7100	13900	10100
Specific service Activities	SA1	1084000	1084000														
	SA2	180000	40000	50000	10000							45000	10000	530000	100000	50000	10000
	Sub-total Specific Service	1264000	1124000	50000	10000							45000	10000	530000	100000	50000	10000
Research activities	JRA1	924000	474000					298000	158000			154000	77000				
	Sub-total Research	924000	474000					298000	158000			154000	77000				
	Total exp. budget (€)	2782050		59400		17200		305300		7300		208700		539700		63900	
	Max Comm. Contrib.. req.		2017700		17100		14800		163700		5700		94100		107100		20100

Table 3 – Summary table of expected budget and of the Community contribution requested (cont.)

		Participant number															
	Activity	**9**		**10**		**11**		**12**		**13**		**14**		**15**		**16**	
	Amounts (euro)	exp. budget	req. contrib.	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib.	exp. budget	req. contrib.
Networking activities	NA1	3900	3100	3900	3100	3900	3100	3900	3100	3900	3100	3900	3100	6300	4700	3900	3100
	NA2	4500	3000	2400	1600	2400	1600	2400	1600	4500	3000	2400	1600	2400	1600	4500	3000
	NA3	5500	4000	3400	2400	3400	2400	3400	2400	5500	4000	3400	2400	11400	10400	5500	4000
	NA4																
	Sub-total Networking	13900	10100	9700	7100	9700	7100	97	7100	13900	10100	9700	7100	20100	16700	13900	10100
Specific service activities	SA1																
	SA2	55000	10000	2855000	110000	2250000	210000	330000	38000	396000	50000	60000	25000	115000	30000	650000	75000
	Sub-total Specific Service	55000	10000	2855000	110000	2250000	210000	330000	38000	396000	50000	60000	25000	115000	30000	650000	75000
Research activities	JRA1					154000	79000	338000	188000					164000	89000		
	Sub-total Research					154000	79000	338000	188000					164000	89000		
	Total exp. budget (€)	68900		2864700		2413700		677700		409900		69700		299100		663900	
	Max Comm. Contrib.. req.		20100		117100		296100		233100		60100		32100		135700		85100

Table 3 – Summary table of expected budget and of the Community contribution requested (cont.)

		Participant number																	
	Activity	**17**		**18**		**19**												**Total expected budget (€)**	**Max. Community contribution requested (€)**
	Amounts (euro)	exp. budget	req. contrib.	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib.	exp. budget	req. contrib.		
Networking activities	NA1	3900	3100	3900	3100	3900	3100											406600	271100
	NA2	4500	3000	2400	1600	2400	1600											105500	77100
	NA3	5500	4000	3400	2400	3400	2400											96700	68000
	NA4			37500	37500													231250	198400
	Sub-total Networking	13900	10100	57300	44600	9700	7100											839950	614500
Specific service activities	SA1			253500	148500													1337500	1232500
	SA2	70000	30000	120000	12000	151000	40000											7907000	800000
	Sub-total Specific Service	70000	30000	373500	160500	151000	40000											9244500	2032500
Research activities	JRA1			338000	188000													2370000	1253000
	Sub-total Research			338000	188000													2370000	1253000
	Total exp. budget (€)	83900		768800		160700												12454450	
	Max Comm. Contrib.. req.		40100		393100		47100												3900000

Table 3 – Summary table of expected budget and of the Community contribution requested to 18 mths

		Participant number															
	Activity	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**	
	Amounts (euro)	exp. budget	req. contrib.	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib.	exp. budget	req. contrib.
Networking activities	NA1	110000	70000	1300	1000	2000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
	NA2	12000	9000	1600	1200	2000	2000	1000	800	1000	800	800	500	800	500	1000	1000
	NA3	10000	6000									1000	800	1000	800	1500	1000
	NA4	60000	40000														
	Sub-total Networking	192000	125000	2900	2200	4000	3000	2000	1800	2000	1800	2800	2300	2800	2300	3500	3000
Specific service Activities	SA1	300000	300000														
	SA2	40000	10000	10000	2000							10000	3000	150000	30000	10000	5000
	Sub-total Specific Service	340000	310000	10000	2000							10000	3000	150000	30000	10000	5000
Research activities	JRA1	300000	150000					90000	50000			50000	25000				
	Sub-total Research	300000	150000					90000	50000			50000	25000				
	Total exp. budget (€)	832000		12900		4000		92000		2000		62800		152800		13500	
	Max Comm. Contrib.. req.		585000		4200		3000		51800		1800		30300		32300		8000

Table 3 – Summary table of expected budget and of the Community contribution requested to 18 months (cont.)

		Participant number															
	Activity	**9**		**10**		**11**		**12**		**13**		**14**		**15**		**16**	
	Amounts (euro)	exp. budget	req. contrib.	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib.	exp. budget	req. contrib.
Networking activities	NA1	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	2000	1500	1000	1000
	NA2	1500	1000	800	500	800	500	800	500	1500	1000	800	500	800	500	1000	1000
	NA3	1500	1000	1000	800	1000	800	1000	800	1500	1000	1000	800	1000	800	1500	1000
	NA4																
	Sub-total Networking	4000	3000	2800	2300	2800	2300	2800	2300	4000	3000	2800	2300	3800	2300	3500	3000
Specific service activities	SA1																
	SA2	5000	2000	1000000	50000	500000	100000	150000	30000	100000	20000	20000	5000	30000	10000	100000	25000
	Sub-total Specific Service	5000	2000	1000000	50000	500000	100000	150000	30000	100000	20000	20000	5000	30000	10000	100000	25000
Research activities	JRA1					25000	0	100000	60000					30000	20000		
	Sub-total Research					25000	0	100000	60000					30000	20000		
	Total exp. budget (€)	9000		1002800		527800		252800		104000		22800		63800		103500	
	Max Comm. Contrib.. req.		5000		52300		102300		92300		23000		7300		32800		28000

Table 3 – Summary table of expected budget and of the Community contribution requested to 18 months (cont.)

	Activity	Participant number: 17		18		19												Total expected budget (€)	Max. Community contribution requested (€)
	Amounts (euro)	exp. budget	req. contrib.	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib	exp. budget	req. contrib.	exp. budget	req. contrib.		
Networking activities	NA1	1000	800	1000	800	1000	800											130300	87900
	NA2	1000	800	800	500	800	500											30800	23100
	NA3	1500	1000	1000	800	1000	800											26500	18200
	NA4			10000	10000													70000	50000
	Sub-total Networking	3500	2600	12800	12100	2800	2100											387900	179200
Specific service activities	SA1			70000	40000													370000	3400000
	SA2	20000	10000	30000	5000	30000	10000											2205000	317000
	Sub-total Specific Service	20000	10000	100000	45000	30000	10000											2575000	657000
Research activities	JRA1			100000	60000													695000	365000
	Sub-total Research			100000	60000													695000	365000
	Total exp. budget (€)	23500		212800		32800												3657900	
	Max Comm. Contrib.. req.		12600		117100		12100												1201200

1.4. DELIVERABLES

Deliverable No[1]	Activity No.	Deliverable title	Lead Participant	Delivery date[2]	Nature[3]	Dissemination Level[4]
D1	NA4	Creation of Public EXPReS web-site	JIVE	2	O	PU
D2	JRA1	Data acquisition requirements document	MRO	2	R	PU
D3	JRA1	Protocols strategic document	JBO	2	R	PU
D4	NA2	EVN-NREN meeting No. 1 (under auspices of EXPReS)	DANTE	3	R	PP
D5	SA1	Central data link control	JIVE	3	D	PU
D6	NA3	First meeting of eVSAG under auspices of EXPReS	OSO	4	R	PP
D7	NA4	Creation of EXPReS web-based management tools	JIVE	4	O	PP
D8	JRA1	Visualization software	JIVE	4	P	PU
D9	JRA1	Correlator design specification	JIVE	5	R	PU
D10	NA4	Generation of PR material (phase 1)		6	O	PU
D11	SA1	Job preparation utilities	JIVE	6	D	PU
D12	SA1	Fast/adaptive scheduling tools	JIVE	6	D	PU
D13	SA2	Feasibility study of the last-mile connection to the nearest GÉANT node for participant CNIG-IGN	CNIG-IGN	6	R	PU
D14	SA2	Feasibility study of the last-mile connection to the nearest GÉANT node for participant MPIfR	MPIfR	6	R	PU
D15	SA2	Equipment of the last-mile infrastructure for participant INAF (telescope in Medicina)	INAF	6	O	PU
D16	SA2	Feasibility study of the last-mile connections to the nearest GÉANT node for participant CAS (Shanghai, Urumqi, Miyun, Yunnan)	CAS	6	R	PU
D17	SA2	Feasibility study of the last-mile connection to the nearest GÉANT node for participant VIRAC	VIRAC	6	R	PU
D18	SA2	Feasibility study of the last-mile connection to the nearest GÉANT node for participant HRAO	HRAO	6	R	PU

[1] Deliverable numbers in order of delivery dates: D1 – Dn
[2] Indicate the month of delivery. This should be relative to the start date of the *I3*, month 1 marking the first month of the project.
[3] Please indicate the nature of the deliverable using one of the following codes:
- **R** = Report
- **P** = Prototype
- **D** = Demonstrator
- **O** = Other

[4] Please indicate the dissemination level using one of the following codes:
- **PU** = Public
- **PP** = Restricted to other programme participants (including the Commission Services).
- **RE** = Restricted to a group specified by the consortium (including the Commission Services).
- **CO** = Confidential, only for members of the consortium (including the Commission Services).

D19	SA2	Feasibility study of the last-mile connection to the nearest GÉANT node for participant NAIC (Arecibo)	NAIC	6	R	PU
D20	SA2	Feasibility study of the last-mile connection to the nearest GÉANT node for participant TIGO	TIGO	6	R	PU
D21	SA2	Feasibility study of the last-mile connection to AARNET for participant CSIRO	AARNET	6	R	PU
D22	JRA1	Overall design document	ALL	6	R	PU
D23	JRA1	eVLBI-Grid design document	PSNC	6	R	PU
D24	JRA1	eVLBI fringes PC-EVN	OSO	7	D	PU
D25	JRA1	LOFAR connection strategic document	ASTRON	7	R	PU
D26	JRA1	Data acquisition design document	MRO	8	R	PU
D27	SA1	eMERLIN VSI interfaces design	UniMan	9	P	PU
D28	SA1	Selective data processor controls	JIVE	9	D	PU
D29	SA2	e-VLBI test observations, Medicina	INAF	10	R	PU
D30	JRA1	eVLBI-Grid interface document	OSNC	10	R	PU
D31	NA2	NA2 annual report No. 2 (as part of EXPReS Ann. Rep No. 2)	JIVE	24	R	PP
D32	NA1	Annual report (incl. Financial information) to EC	JIVE	12	R	PP
D33	NA2	NA2 annual report No. 1 (as part of EXPReS Ann. Rep No. 1)	JIVE	12	R	PP
D34	NA4	e-VLBI Demonstration and attendance at Network events.	JIVE	12	O	PU
D35	SA1	Network protocol decision	JIVE	12	D	PU
D36	SA1	Monitored information handling modules	JIVE	12	D	PU
D37	SA2	Equipment of the last-mile infrastructure for participant MRO	MRO	12	O	PU
D38	SA2	Construction and equipment of the last-mile infrastructure for participant CNIG-IGN	CNIG-IGN	12	O	PU
D39	SA2	Construction and equipment of the last-mile infrastructure for participant MPIfR	MPIfR	12	O	PU
D40	SA1	Monitoring processes	JIVE	12	D	PU
D41	JRA1	Protocols performance report	JBO	13	R	PU
D42	JRA1	Software correlator core	JIVE	14	P	PU
D43	JRA1	Software data product	JIVE	15	P	PU
D44	SA1	Real-time data processor control software	JIVE	15	P	PU
D45	SA1	Tests using local Jodrell Bank home e-MERLIN telescope	UniMan	15	D	PU
D46	NA3	eVSAG meeting No. 2	OSO	16	R	PP
D47	SA1	Real-time Pipeline	JIVE	16	D	PU
D48	NA2	EVN-NREN meeting No. 2	JIVE	18	R	PP
D49	NA4	Generation of new PR material (phase 2)	DANTE	18	O	PU
D50	SA1	Visibility monitor	JIVE	18	D	PU
D51	SA1	Tested software for operational improvements	JIVE	18	D	PU
D52	SA1	Test using remote e-MERLIN telescope	UniMan	18	D	PU
D53	SA1	VSI support software	JIVE	18	D	PU

D54	SA1	VSI Interfaces	JIVE	12	D	PU
D55	SA2	10 Gbps link upgrade between MERLIN and JIVE	MERLIN JIVE	18	O	PU
D56	SA2	e-VLBI test observations, Metsahovi	MRO	18	R	PU
D57	SA2	Construction and equipment of the last-mile infrastructure for participant Shanghai	CAS	18	O	PU
D58	SA2	Construction and equipment of the last-mile infrastructure in AARNET to allow connection of participant CSIRO	AARNET CSIRO	18	O	PU
D59	SA2	Construction and equipment of the last-mile infrastructure for participant Urumqi	CAS	18	O	PU
D60	SA2	Construction and equipment of the last-mile infrastructure for participant Miyun	CAS	18	O	PU
D61	SA2	Construction and equipment of the last-mile infrastructure for participant Kunming	CAS	18	O	PU
D62	SA2	Construction and equipment of the last-mile infrastructure for participant VIRAC	VIRAC	18	O	PU
D63	SA2	Equipment of the last-mile infrastructure for participant NAIC	NAIC	18	O	PU
D64	SA2	Construction and equipment of the last-mile infrastructure for participant TIGO	TIGO	18	O	PU
D65	SA2	AARNET connectivity enhancements	AARNET	18	O	PU
D66	JRA1	Data acquisition interface document	MPI	18	R	PU
D67	JRA1	LOFAR station interface report	ASTRON	18	R	PU
D68	JRA1	Software for workflow management	PSNC	18	P	PU
D69	SA2	Feasibility study of the last-mile connection to the nearest GÉANT node for participant INAF (Sardinia)	INAF	20	R	PU
D70	SA2	10 Gbps link between UniMan and OSO for ultra-VLBI tests	UniMan OSO	20	O	PU
D71	SA1	Flexible local GE network	JIVE	21	D	PU
D72	SA2	e-VLBI test observations, Effelsberg	MPIfR	21	R	PU
D73	SA2	e-VLBI test observations, Metsahovi	ATNF	22	R	PU
D74	SA2	e-VLBI test observations, Yebes	OAN	22	R	PU
D75	JRA1	Software for correlation on cluster	JIVE	23	P	PU
D76	JRA1	Data acquisition test report	MPI	23	R	PU
D77	JRA1	Data acquisition prototype at telescope	OSO	23	P	PU
D78	JRA1	Overall broadband demonstration	JIVE	23	D	PU
D79	JRA1	Software cluster correlation	JIVE	23	P	PU
D80	JRA1	First fringes software correlator	JIVE	23	D	PU
D81	NA1	Annual report (incl. Financial information) to EC	JIVE	24	R	PP
D82	NA2	NA2 annual report No. 2 (as part of EXPReS Ann. Rep No. 2)	JIVE	24	R	PP
D83	NA4	e-VLBI Demonstration and attendance at Network events.		24	O	PU
D84	SA1	Network monitoring tools	JIVE	24	D	PU
D85	SA1	Multiple e-MERLIN telescope tests	UniMan	24	D	PU
D86	SA2	Construction and equipment of the last-mile infrastructure for participant HartRAO	HRAO	24	O	PU
D87	JRA1	Software to collect distributed output	JIVE	24	P	PU

D88	NA2	EVN-NREN meeting No. 3	DANTE	26	R	PP
D89	NA2	EVN-NREN representatives present EXPReS networking results at the e-VLBI Science & Technology Workshop	DANTE	26	R	PU
D90	NA2	EVN-NREN meeting	DANTE			
D91	NA3	eVSAG meeting No. 3	OSO	26	R	PP
D92	JRA1	Software to create data product from distributed correlation	JIVE	27	P	PU
D93	JRA1	Software routing	PSNC	29	P	PU
D94	NA3	e-VLBI Workshop held in Onsala		30	O	PU
D95	SA1	Improved network applications	JIVE	30	D	PU
D96	SA1	Monitoring user interfaces	JIVE	30	D	PU
D97	SA2	e-VLBI test observations, Urunqi	CAS	30	R	PU
D98	SA2	e-VLBI test observations, Mijun	CAS	30	R	PU
D99	SA2	e-VLBI test observations, Kunming	CAS	30	R	PU
D100	SA2	e-VLBI test observations, VIRAC	VIRAC	30	R	PU
D101	SA2	e-VLBI test observations, HRAO	HRAO	30	R	PU
D102	SA2	e-VLBI test observations, NAIC, Arecibo	NAIC	30	R	PU
D103	SA2	e-VLBI test observations, TIGO	TIGO	30	R	PU
D104	SA2	Construction and equipment of the last-mile infrastructure for participant INAF (Sardinia)	INAF	30	O	PU
D105	JRA1	eMERLIN interface available	JBO	30	P	PU
D106	JRA1	Fringes with new routing	JIVE	31	D	PU
D107	NA3	Publication of e-VLBI Workshop proceedings	OSO	32	R	PU
D108	JRA1	Software distributed correlation	JIVE	33	P	PU
D109	JRA1	First fringes Grid correlator	JIVE	34	D	PU
D110	JRA1	First fringes on FABRIC	JIVE	35	D	PU
D111	NA1	Annual report (incl. Financial information) to EC	JIVE	36	R	PP
D112	NA1	Final Report to Board and EC	JIVE	36	R	PP
D113	NA1	Final Plan for using and disseminating knowledge	JIVE	36	R	PP
D114	NA1	Implementation of the Gender Action Plan	JIVE	36	R	PP
D115	NA1	Raising public participation and awareness	JIVE	36	R	PU
D116	NA2	NA2 annual & Final reports	JIVE	36	R	PP
D117	NA4	e-VLBI Demonstration and attendance at network events.	JIVE	36	O	PU
D118	JRA1	Final report	JIVE	36	R	PU

2. Objectives of the I3

2.1 EXPReS Project objectives

Over the last decade, enormous progress has been made in the area of Information & Communication Technologies (ICT). Like many other research communities, radio astronomy have greatly benefited from the ready availability of cheap, large-capacity storage media; affordable high-performance desktop computers and local multi-processor PC clusters. Radio astronomers have also proven themselves to be adept at taking advantage of the emergence of high-speed, optical-fibre based communication networks. Such networks are of prime interest to radio astronomers as the sensitivity of a radio telescope array is roughly proportional to the square-root of the radio telescope data output rate (i.e. the digitally sampled observing bandwidth). Motivated by this fact, and the possibility of creating a distributed real-time Very Long Baseline Interferometer (VLBI) radio telescope array, an international consortium that includes the leading radio astronomy institutes in Europe, together with DANTE (operators of the pan-European Research Network, GÉANT), and the major National Research Networks (NRENs) in Europe, have come together over the last two years and successfully demonstrated the feasibility of conducting real-time, VLBI observations, now known as electronic VLBI or e-VLBI.

VLBI is a technique invented by astronomers, in which physically independent and widely separated radio telescopes observe the same region of sky simultaneously in order to generate very high-resolution continuum and spectral line images of cosmic radio sources. The technique also has practical applications in geodesy (measuring secular and periodic motions of the Earth's surface and variations in the Earth's rotation rate) and in precision spacecraft navigation. Since VLBI telescopes are usually separated by many thousands of kilometres, data from each telescope are digitally sampled and stored locally, using high-capacity magnetic tape systems (or more recently magnetic disk-array systems). These tapes and disks are physically transported to a central data processor (a purpose-built supercomputer) where the data from each telescope are decoded, accurately aligned, and then correlated together in an exhaustive pair-wise fashion for every possible telescope combination. The total flow of data into the central processor is approximately 10-100 Terabytes per observation, after processing this is reduced to 10-100 Gbytes. The output from the data processor may be pipelined - a process in which the data are automatically calibrated and preliminary images are made. These data (including the raw processed data) are presented to the astronomer for further detailed and careful analysis.

In Europe, VLBI observations are organised and conducted by the European VLBI Network (EVN). The central EVN data processor was developed (and is now operated) by JIVE - the Joint Institute for VLBI in Europe, located in Dwingeloo, the Netherlands.

The overall objective of EXPReS, is to create a production-level "electronic" VLBI (e-VLBI) service, in which the radio telescopes are reliably connected to the central data processor at JIVE via a high-speed optical-fibre communication network. With an aggregate data flow of up to 16 Gbps into the central processor, we aim to create a robust and distributed e-VLBI infrastructure of continental and indeed trans-continental dimensions, capable of generating high-resolution images of cosmic radio sources in real-time. EXPReS also seeks to design and prototype elements of the hardware, software and data transport services required to support future e-VLBI facilities in which the net VLBI data flows will be hundreds of Gbps, with a central data processing environment possibly based on distributed (Grid-based) computing resources.

Explicitly, the principal objectives of EXPReS are:

· To develop an operational, production-grade e-VLBI network that is capable of simultaneously transferring data at aggregate data rates of up to 16 Gbps, from telescopes located across the globe, through to the central data processor at JIVE via public networks operated by the NRENs & DANTE (GÉANT2),
· To expand the number of e-VLBI capable telescopes in Europe by either supporting the provision of additional last-mile (local-loop) connections or upgrading existing fibre connections to Gigabit Ethernet standard. In total, at least 12 European telescopes will be part of the e-VLBI network offered to astronomers,
· To transparently include the UK e-MERLIN telescope array within the e-VLBI facility.
· To support the connection of radio telescopes located outside of Europe, recognising that VLBI is very much a global pursuit, requiring network provision to telescopes in the US, Asia, South Africa, Australia & South America. By including telescopes across the globe, we aim to offer a 16 telescope e-VLBI array to astronomers,
· To reliably service and robustly process in real time, e-VLBI data streams of up to 16 Gbps (net) at the EVN data processor at JIVE.
· To ensure that this state-of-the-art, real-time e-VLBI network is able to conduct "Target of Opportunity" and "Rapid Response" science, reacting reliably and flexibly to unexpected astronomical events, such as supernovae explosions, giant magnetar & x-ray binary flare stars, (orphan) radio gamma-ray bursts and other transient phenomena,
· To assess the suitability of advanced networking and computing technology to support the creation of a next-generation e-VLBI network in which the aggregate data flows will be many hundred of Gbps with a data processing environment possibly based on distributed Grid-based computing resources,
· To investigate how the new radio astronomy facilities now under development (e.g. e-MERLIN in the UK, and LOFAR in the Netherlands, Germany and Sweden), can further expand using e-VLBI as a model for their own use of public communication networks,
· To promote and demonstrate the way in which communication research networks can be used to create enhanced, large-scale distributed scientific facilities and strengthen the links between radio astronomers, engineers, network operators and Grid computing experts via a comprehensive programme of networking activities.

2.2 Relevant to the objectives of Communication Network

The integrated nature of the proposed programme is strong:

Specific Support Activities: EXPReS contains 2 interdependent Specific Service Activities (SA) and these form the core of the overall proposal. SA1 aims to realise a production-level e-VLBI service in which data can be transparently transferred to the data processor at JIVE, generating net data flows of up to 16 Gbps. An important part of the overall effort will be to ensure that when the data arrives at JIVE, it can be processed in real-time in a robust manner, with a level of reliability that closely approaches that achieved via traditional (non-realtime) VLBI data processing. A corner stone of the project is to ensure that the telescopes of the MERLIN National Facility (operated by Jodrell Bank Observatory in the UK), will also participate transparently within this e-VLBI network. SA2 aims at expanding the number of radio telescopes that have direct access to the GÉANT network, and thus the EVN data processor at JIVE. In particular, we wish to stimulate and partially finance "last mile" connections to some of the largest and most sensitive radio telescopes in the world. In some cases we wish to improve and enhance existing communication services to these telescopes. The vast majority of the radio astronomy partners within EXPReS already participate in VLBI observations, and are operated by institutes that are members of the EVN. SA2 aims to create links to telescopes and radio telescope facilities in Europe, Asia, Australia, South Africa, South America and the USA. Critical review of the progress made by SA1 and SA2 (and their management) will be partially provided by the Network Activities, NA1, NA2 & NA3.

Joint Research Activities: EXPReS also has a strong research component - addressing various issues including the possibility of replacing the current data processing system at JIVE with a distributed Grid-based e-VLBI processing system, a system that would naturally increase in performance and capability as the Grid itself evolves and expands. Another component of the EXPReS research programme is to test the potential of new communication technologies, data acquisition platforms and emerging network techniques (such as lambda-switched networks) to investigate the practicality of supporting aggregate telescope data rates of several hundred Gbps across next generation public networks - potential successors to GÉANT2. There is expected to be considerable synergy between SA1 and JRA1, particularly in the area of network performance and adopted transport protocols. It is expected that some of the results associated with JRA1 may feed back into SA1 on a time scale shorter than the overall EXPReS programme duration.

Networking activities: The networking activities supported by EXPReS form the bonds that will tie together the other active elements of the EXPReS programme. The NA2 "EVN-NREN Forum" will support project-wide (face-to-face) technical meetings and provide the day-to-day coordination and communication instrument (the existing EVN-NREN e-mail forum) that will address all the participants involved in the major elements of EXPReS (SA1, SA2 and JRA1). This form of alliance and engagement between technical experts from the network and radio astronomy community has been crucial in the success of the current e-VLBI Proof-of-Concept project, and we seek to continue this under the auspices of NA2. The migration of e-VLBI from a technical development into an astronomical instrument also requires input from professional astronomers and other end-users. NA3 "e-VLBI Science Forum" will ensure a forum for contact between developers of the EXPReS e-VLBI infrastructure and astronomical users of the instrument. There will be significant overlap in the membership of the bodies associated with NA2 & NA3. Both NA2 & NA3 will report directly to NA1 (responsible for the overall management of EXPReS) and will also support the dissemination of e-VLBI scientific and technical results at major networking and astronomical conferences. NA4 "e-VLBI Outreach" will support public outreach activities associated with EXPReS. It will be pivotal in presenting the technical and scientific successes of EXPReS to the broader community, especially during networking and other scientific events. As discussed in NA1, "Management of EXPReS", the EXPReS programme will have a strong and efficient management structure. This will include provision for a project manager who will be responsible for the overall management and coordination of the different elements of EXPReS, and will critically monitor the overall progress of the I3, taking into account input from the NA2 and NA3 chairs, and the leaders of the JRA and SAs.

2.3 Long term sustainability and structuring effect

EXPReS brings together (on a truly global scale) scientists and engineers from the radio astronomy community, working together with experts in operational, high-speed communication networks, and developers of high-performance network software and hardware platforms. By the nature of their activities, both the VLBI and networking communities are at the forefront of international collaboration. Both know the benefits (and possible pitfalls) of close cooperation with international partners, and over the last few years both communities have moved closer together as they became familiar with the roles, motivation, activities and cultural characteristics of the other. In short, the EXPReS partners have already demonstrated that they can work together as a very effective team; there is an opportunity now to further strengthen this unique collaboration and get on with the job of developing e-VLBI as a powerful, real-time astronomical instrument, a distributed facility in which the network itself is performing the same focusing function as the curved parabolic dish of a single giant radio telescope of continental and intercontinental dimensions. EXPReS includes the leading radio astronomy institutes in Europe, united in a common vision that recognises e-VLBI as the leading radio astronomy project on a truly European and Global dimension. The realisation of the EXPReS objectives will serve to strengthen the European VLBI community; providing researchers with access to a unique e-infrastructure: a state-of-the-art, real-time e-VLBI instrument, based on advanced, public network technology and capable of transforming the reliability and operational flexibility of VLBI. Such an instrument will engage the interest of the entire astronomical community, especially with respect to its capability to conduct "rapid-response" follow-up observations of unexpected (transient) events. Building on the e-VLBI Proof-of-Concept project, EXPReS will also be a vehicle that considers how future networks can accommodate the increasing demands of the radio astronomy community, both in terms of an expanded and higher performance e-VLBI network, and European access to remote instruments sited in other areas of the world (e.g. Chile, South Africa and Australia).

3. Potential Impact

EXPReS will realise the first operational e-VLBI network dedicated to astronomy. This will be a unique facility in Europe and will be competitive with similar projects now being planned in Australia and Japan. The creation of a real-time e-VLBI network will represent an important step forward for European astronomy and will be a technological pathfinder for future, next generation instruments, such as the Square Kilometre Array (SKA). The SKA is included in the ESFRI "list of opportunities" – as one of the large global projects that might be developed within FP7. In particular, the technology (both software and hardware) developed for EXPReS will address various issues that are relevant to SKA, including distributed data processing (both data correlation and data analysis) and station-to-station communication over distances of up to 4000 km. Elements of EXPReS may have a much wider impact. e-VLBI data transfers are already exercising high-speed networks such as GEANT2, and discovering new and more efficient ways of transferring data using new or modified communication protocols. Specifically, EXPReS will also pioneer the use of lambda switching with the first e-VLBI tests between the UK and Dwingeloo already underway. These innovations should have widespread application, not only in the research community but also the wider-society – improving everyday Internet connectivity (in particular high bandwidth video and high fidelity audio applications). Scientific and related engineering results from EXPReS will appear in refereed journals and conference proceedings. All astronomy related results will also appear on the *astro-ph* preprint server. For results that are of public interest, we will generate and distribute special press-releases to national and international press agencies. This will be part of the activities supported by Networking Activity NA4 "Public Outreach, Dissemination & Communication". Other activities of NA4 will include the production of brochures, promotional folders and a transportable EXPReS display board – all these will be aimed at informing the layman of the activities supported by

EXPReS. These materials will be used by the radio astronomy partners (and possibly the NRENs) during PR events such as annual open days.

VLBI is by its very nature an international pursuit. Collaboration on a European and indeed global scale is unavoidable, and has been successful over a period that spans almost 4 decades, beginning in 1968 with the first transatlantic VLBI fringes between Onsala (SE), Haystack and Greenbank (USA). Clearly working at a European level is essential for a project such as EXPReS with many of the telescopes located in various EU countries, as well as farther a field (China, USA, South Africa & Chile). The European and global dimension of a distributed e-VLBI network fits easily into the international reach of today's high-speed networks, in particular GÉANT. On a national level there are several projects that compliment EXPReS. In the UK the ESLEA project (Exploitation of Switched Lightpaths for E-Science Applications) will study how switched optical networks (UKLight) can benefit two of the most network-intensive application areas, High Energy Physics (HEP) and VLBI. ESLEA is led by Peter Clarke (NeSC) and includes HEP and VLBI researchers at the University of Manchester. UCL is also involved. The specific e-VLBI related goal of ESLEA is to use light paths to connect radio telescopes in the UK to the correlator at JIVE. The results arising from this work will benefit EXPReS directly and will hopefully be applicable to other telescopes located in other (European) countries. In the Netherlands a consortium led by JIVE (and including SARA, the Computing and Networking Services Organisation, the Universities of Amsterdam & Leiden have recently submitted a proposal to the NWO-STARE programme – this project is intended to enhance cooperation between astronomers and networking experts and will hopefully provide additional matching for EXPReS (JRA1- FABRIC).

3.1 Contributions to standards

As the use of e-VLBI becomes more and more prevalent, so the importance of a standard framework for the transport of VLBI data across wide area networks and between various data acquisition and data processing systems increases. To address this problem a VLBI Standard Interface – Electronic (VSI-E) standard has been defined – currently in draft form. This is going through the standard process of review within the VLBI community and is expected to be adopted by the international VLBI community within the next 12 months. The main objectives of VSI-E are (i) interoperability, (ii) Internet friendliness, (iii) ease of implementation and (iv) transport flexibility – permitting users to choose the transport mechanism and protocols that best suit their networking environment. EXPReS is expected to adopt the VSI-E standard and Work Package 5 (SA1) includes a task to absorb the new standard and develop the new hardware and software interfaces that will be required in order to take full advantage of VSI-E.

3.2 Contribution to policy developments

EXPReS brings together the major radio observatories in Europe and beyond, together with various NRENs – some directly, others indirectly (via NA2). The goal of realising a reliable and robust real-time e-VLBI network will be a significant achievement that will influence the way in which major global scientific projects evolve – in particular the SKA. In addition, it will demonstrate to other research communities the transformational nature of high speed networks and will bring to the attention of regional, national and European funding agencies, the relevance of investing in research networks and the need for future investment in this area. Given that many of the EXPReS partners are also members of RadioNet, the success of EXPReS will be relevant to the development of radio astronomy within RadioNet's mandate to coordinate the radio astronomy community within Europe, with particular reference to the construction of next generation (global) radio instruments.

3.3. Risk Assessment

There are no potential risks for citizens or society associated with the EXPReS I3 – at least in matters of ethics, safety and security. If the EXPReS project were to fail in its basic aim (to deliver a real-time e-VLBI network to the global community of astronomers), then the major effect would be a reduction in Europe's scientific output. An opportunity will have been lost for Europe to take the lead in this area and the reputation and perception of the European radio astronomy community would be very much diminished.

We believe the risks of failure in EXPReS are small but not insignificant. We discuss some areas of concern and assess their impact on the overall project.

The main technical risk is that a large fraction of the telescopes that we aim to connect to JIVE cannot be connected, or at least, cannot be connected at reasonable cost (the main risk in EXPReS is thus largely associated with SA2). There are also 3 telescopes within SA2 that are currently under construction (Sardinia – IT, Miyun & Kunming – both CN) and one that is in the process of acquiring VLBI capability (VIRAC). We see these telescopes as having the largest risk in this regard. There is also a risk that the substantial levels of non-EC co-financing that is required to realise these high-speed telescope connections may not be realised, at least in some cases. It is difficult to estimate the risk in some cases.

An additional concern for telescopes located outside of Europe (in particular the Chinese, South African & South American telescopes), is the availability of a high-speed (at least 2-3 Gbps) inter-continental network between GEANT and other associated international networks. We are encouraged by the success of the ORIENT proposal that aims to link China and Europe at several Gbps, but the case of South Africa, for example, appears to be less positive. It is implicit that the EXPReS project relies on free access to the GEANT2 network but we understand GN2 is funded beyond the duration of EXPReS. The levels of useage planned by EXPReS are also within the application boundaries accepted as reasonable use by DANTE.

In terms of the timeliness of deliverables and milestones, it is likely that SA2 by its uncertain nature, will show the largest deviations from the 18 month plan presented in this document.

However in all these matters it is important to realise that the current e-VLBI array is already quite large and via EXPReS we are confident of further enlargement with the addition of the Medicina (IT), Yebes (ES), Metsahovi (FI) and Effelsberg (DE) telescopes being very likely. The addition of the giant 100-m Effelsberg telescope deserves special comment in this section – it will be crucial in the success of EXPReS providing a critical mass that will make the e-VLBI EXPReS network very attractive to the broad astronomical community. Currently 8 different telescopes are connected to JIVE and the addition of these other 4 telescopes (via SA2) will ensure that SA1 can provide a robust and reliable e-VLBI service to the community.

Compared to SA2 the risk associated with SA1 is small. One small point of concern within SA1 is the upgrade of the data processor at JIVE – the full upgrade depends on the availability of a new (VSI-E compatible) PC playback system (the Mk5B) that is currently under development at the MIT Haystack Observatory in the USA and will then be manufactured by a commercial company (also in the US). Currently the timescales associated with these developments in the US and the associated requirements of EXPReS are well matched and we do not expect this to change.

Naturally there is some risk associated with JRA1 – otherwise it would not be a research programme. It's important to realise that the success or failure of JRA1 has only a minor bearing on the success of SA1 and SA2 i.e. the major goal of EXPReS – providing a real-time e-VLBI service. JRA1 is very much future oriented – the success (or otherwise) of JRA1 will thus have a profound impact on future developments in e-VLBI with failure risking further support in this area at both national and European funding levels.

4. Outline implementation plan for the full duration of the I3

EXPReS includes 4 Networking Activities (NA1-4); 2 Support Service Activities (SA1 & SA2) and 1 Joint Research Activity (JRA1). These various components of EXPReS are described below.

4. A Activities

4.1 Networking Activities

NA1 – Management of the EXPReS I3

NA1 focuses on the management of all aspects the EXPReS I3. The EXPReS I3 will be run by a governing board (hereafter termed the Board) whose members will comprise the Directors or representatives of all the institutes involved in the I3. The overall coordinator of EXPReS is Dr. M.A. Garrett (Director JIVE). He will be the contact person for the European Commission and will be aided by the appointment of an EXPReS Programme Manager and an Administrative Assistant. The coordinator, project manager, administrative assistant and the leaders of SA1, SA2 and JRA1 will form the EXPReS Management Team (EMT). The EMT will implement decisions made by the Board. The Project Manager (together with other members of the EMT) will be responsible for the day-to-day management of EXPReS and will continuously monitor the status of all project activities, including the generation of deliverables, meetings, financial & technical reports and the completion of milestones. Members of the EMT will be located at JIVE, except Dr. F. Colomer (leader of SA2) who will be based at OAN.

NA2 – EVN-NREN Forum

The chairman of the NA2 EVN-NREN forum will be Dr. John Chevers (DANTE). The EVN-NREN forum will bring together a broad range of expertise from all parts of the EXPReS consortium, both the networking and radio astronomy partners. Face-to-face meetings of this group will take place once per year and the maintenance of an EVN-NREN email forum will facilitate continuous dialogue through the rest of the year. NA2 will address the resolution of various technical problems that arise, provide input into project planning, define evolving programme objectives, and critically assess/review the results arising from SA1, SA2 & JRA1.

NA3 – e-VLBI Science Forum

The chairman of NA3 e-VLBI Science Forum is Dr. John Conway (Onsala Space Observatory). This activity will partially support the existing e-VLBI Science Advisory Group (eVSAG, also chaired by Dr. Conway). NA3 activities will be to ensure that potential users of the EXPReS e-VLBI facility are well informed of the instrument's scientific capabilities and are able to generate and submit technically sound observing proposals. An online e-VLBI Science discussion group will be set up so that e-VLBI users can provide direct feedback to the eVSAG. The eVSAG is also charged with identifying the potentially new and transformational capabilities e-VLBI can deliver to the astronomical community. The group will also play a crucial role in ensuring that developments within the EXPReS project are closely coupled to the scientific demands and requirements of the community. In addition to organising face-to-face meetings once per year, the eVSAG will also organise an international e-VLBI Science and Technical Workshop during the course of the EXPReS project. The EXPReS coordinator is also a member of the eVSAG.

NA4 – e-VLBI Outreach, Dissemination & Communication.

NA4 will address the needs of EXPReS in terms of internal project communication, dissemination of project results to the broader networking and scientific research community and public outreach. An EXPReS Outreach Officer will be appointed (a half-time position) and NA4 activities will benefit from close coordination with the RadioNet Outreach Office at Jodrell Bank. The outreach officer will be responsible for setting up the EXPReS web pages, including wiki-based project management and communication tools. He/She will help organise EXPReS related PR and outreach events, promote EXPReS at key networking and astronomy meetings, produce a range of high quality publicity material (including a transportable EXPReS display stand, brochures, merchandise), create and manage a database of all EXPReS presentations, generate Press Releases, create and distribute information about the EXPReS e-VLBI service that is relevant to end users from the astronomical community. NA4 has interaction with every component of EXPReS and it is a key element in the success of the project, especially from an external perspective. The outreach officer will be based at JIVE and will be aided by local administrative staff.

4.2 Specific Support Activities

SA1: Production e-VLBI Service

The goal of SA1 is to realise a production level, real-time e-VLBI service and make the unique features of the distributed infrastructure available to the astronomical community at large. Various work packages in SA1 aim to upgrade the existing VLBI data processor at JIVE so that it can robustly and reliably process e-VLBI data in real-time, correlating data from as many as 16 telescopes each delivering data at rates of up to 1 Gigabit per second (Gbps). As well as accepting data from standard VLBI telescopes, the data processor will also transparently correlate data from the UK's e-MERLIN network of telescopes. SA1 will be led by Dr. Arpad Szomoru (JIVE) and the work will be carried out at JIVE and the University of Manchester, Jodrell Bank Observatory (operators of e-MERLIN). Dr. Simon Garrington will be responsible for the e-MERLIN aspects of SA1. Three new appointments will be made: a software engineer and network engineer, specialist software/hardware engineer, a support scientist (all to be located at JIVE), and a senior digital engineer (to be located at Jodrell Bank). In addition to the upgrade of the data processor SA1 activities will include (i) software development in order to ensure satisfactory high-speed data transport across GEANT22, (ii) development of online scheduling, monitoring and pipeline data analysis tools required in order to return feedback to the telescopes and scientific data rapidly to the user as soon as possible, (iii) introduction of new hardware and software devices that comply with emerging e-VLBI standards (e.g. VSI-E), including explicit provision for transparent connectivity of the e-MERLIN telescopes. SA1 is very much at the heart of the EXPReS, it will enable robust e-VLBI observations to be made with the telescopes that are already connected to JIVE via GEANT22, success in procuring further telescope network connections via SA2 will extend the array further and significantly enhance its scientific capabilities.

SA2: Network Provision for a global e-VLBI array

SA2 aims to connect various radio telescopes located in Europe, China, South Africa, Chile and the USA to the EVN correlator at JIVE via the GEANT2 (and other international and national) research networks. SA2 will provide partial funding for network provisioning, but the majority of costs will be covered by the local authorities, regional & national governments and the radio observatories themselves. SA2 will be led by Dr. F. Colomer (OAN). The first activity will be to define the extent of the last-mile problem at each radio telescope location and consider what is the optimum and most cost-effective solution. A dynamic status report will be created that will be updated through the duration of the EXPReS contract. Each of the radio telescope institutes will be responsible for raising funds for network provisioning and negotiating their own network connection. They will lobby relevant NRENs and local network providers and sources of possible funding. DANTE may also play an important role in cultivating this process. When network connections have been achieved the link will be tested and real-time e-VLBI capability verified. SA1 will be able to test additional telescope links, as they become available – experience has already shown that once the link is in place real-time operations can begin almost immediately. Connection of the Chinese telescopes relies on the successful implementation of the ORIENT research network, linking China and Europe at 3 Gbps.

4.3 Joint research activities

JRA1: FABRIC - Future Arrays of Broadband Radio Telescopes on Internet Computing

FABRIC is the research oriented component of EXPReS that looks towards the future development e-VLBI. In the next decade it is hoped that individual telescope data transfer rates across public research networks will increase to at least several tens of Gbps, similar to the type of connectivity currently enjoyed by private networks (e.g. e-MERLIN & LOFAR). The processing of multiple 30 Gbps data streams will require a significant upgrade of the existing data formatting and transport mechanisms/protocols, as well as a much larger data processor capacity. JRA1 will address all of these aspects and will be led by Dr. H.J. van Langevelde (JIVE). Other key players are PNSC, MRO, MPIfR, JBO, OSO & ASTRON. A key objective of the research programme is to demonstrate scalable connectivity (at up to 10 Gbps) and to develop a prototype e-VLBI software correlator utilising local PC clusters and finally (multiple) distributed Grid-based computing nodes. The aim is to establish e-VLBI data processing as a possible future Grid application. Much of this work will also be applicable to next generation radio telescopes such as the SKA.

4. B Plans

4.4 Plan for using and disseminating knowledge.

EXPReS activities will result in the generation of new knowledge. One of the aims of the consortium will be to disseminate such knowledge as widely as possible. EXPReS will have an Office for Public Outreach and a public website ran by the EXPReS Outreach Officer. The web-site will contain information on all of EXPReS's activities; the public minutes of EXPReS meetings; the electronic proceedings of workshops arising from the networking activities; and lists of, and links to, preprints and publications arising from all EXPReS activities.

All EXPReS partners will be actively encouraged to participate in international conferences and workshops (both in the astronomy and networking domains) and to give papers and posters at such meetings. The astronomers benefiting from the e-VLBI service will be encouraged to publish their scientific results in refereed astronomical journals (such as Astronomy & Astrophysics). Technical results arising from SA1, SA2 & JRA1 will also be published in appropriate engineering and/or scientific journals.

The EXPReS Management Team (EMT) will develop and maintain an Intellectual Property (IP) register. This will be updated on a regular basis. IP will be a standing agenda item at the Board meetings.

It will be a requirement that EXPReS and the EC-funding be acknowledged in all publications. All reasonable attempts will be made to ensure that a significant level of public outreach is maintained. This might be through public lectures at EXPReS facilities; the maintenance of the EXPReS website and interaction with amateur astronomical associations.

4.5 Gender Action Plan

It is self-evident that astronomy as a whole is dominated by males. There appears to be a similar (but less prevalent) trend in the Research Network community. This is not a deliberate policy on behalf of the governing institutions of science or research but appears to be a consequence of social pressures. Similar gender statistics are seen in most other physical sciences. In some countries, e.g. France and Italy it is common to find females occupying senior posts within institutes; in other (mostly Northern European) countries that is less common. What is noticeable over recent years is that there are an increasing number of young female astronomers and engineers entering the profession. It is our hope that this will develop into a more equitable distribution of the genders in the future.

All institutes involved in EXPReS have a policy of promoting and developing their staff equally, regardless of gender or race. JIVE, the coordinating institute of EXPReS, has created (together with ASTRON) a "Diversity Committee" in order to ensure any issues of gender and race are brought to the attention of all management levels. The EXPReS Board will ensure that appointments to positions of responsibility within the project will be made entirely on merit. The EXPReS consortium will promote equality in the treatment of members of its personnel regardless of sex, ethnic origin, physical handicap, sexual orientation or religion. The process of recruitment and promotion within EXPReS 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 that is involved in drawing-up the selection criteria and participates in the interview process. The EXPReS partners are resolved to promote policies and practices that encourage equality of opportunity in all respects. They 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 within EXPReS.

A female participant within the EXPReS project will be charged with considering and monitoring all gender aspects of the EXPReS project through the duration of the work programme. She will also solicit input from other staff involved in EXPReS and will report any concerns to the coordinator and (as necessary) the EXPReS Board. The publicity materials prepared within NA4 (Public Outreach, Dissemination & Communication) will include the use of language and pictures that are inclusive of women and support a positive image of their role in research projects.

4.6 Raising public participation and awareness

EXPReS is strongly committed to engaging both the broader research community and the general public in terms of the exciting developments (both ain terms of astronomy and research networking) that will be associated with the development of a distributed, real-time e-VLBI telescope of global dimensions. The actions described in NA4 (XXXX) will enable the project as a whole to develop a coherent and visible outreach programme. In particular, the outreach materials (brochure, leaflets, posters, press releases, magazine articles and transportable display boards) generated via NA4 will be used in the successful outreach programmes that the individual EXPReS radio observatories and other partners currently operate. For example, several of the radio observatories host significant visitors centres (Effelsberg, Medicina, Jodrell Bank, Parkes, Haartebeesthoek and Arecibo) that will be able to make good use of NA4 publicity materials. Other EXPReS partners hold annual open days for the general public (e.g. ASTRON and JIVE), and many are actively involved in developing and supporting the role of scientific research in local education establishments (both primary and secondary schools). Almost all the radio astronomy institutes are associated with University departments where staff teach courses in Physics & Astronomy and supervise PhD students and postdocs. Some technical institutes such as ASTRON are also involved in jointly developing engineering courses with local colleges.

The materials generated by NA4 will be useful in profiling EXPReS to the general public internationally. JIVE recently hosted a major EC PR Event on the Future of Research Infrastructures in Astronomy in which e-VLBI (and EXPReS) appeared prominently. The event was attended by the Commissioner for Science and Research (Janez Potocnik), the Dutch Minister for Education (Maria v.d. Hoeven) and over 70 international journalists. The results of EXPReS (and in particular their distillation within NA4) will feed back into future events such as this, and will also positively impact the existing outreach programmes of the individual EXPReS institutes. EXPReS will also produce results that will be useful in maintaining strong links between the observatories and with local amateur astronomy associations.

4. C Milestones

The EXPReS project will deliver several major milestones over the duration of the three year contract.

4.7 Major milestones over the full project duration

The formal start date of the EXPReS contract is 1 March 2006. We have chosen this start date so that we may hit the road the running – in particular it is our intention for almost all the addition FTEs associated with EXPReS to begin working on the project from day 1, month 1, year 1. These appointments will include key personnel, including the Project Manager and Administrative Assistant. Early appointments of this type will be important in order to establish good progress in what is a very tight project plan. While formally these are not milestones within the contract duration, success in this area will ensure EXPReS gets off to a flying start.

It is important that the EXPReS project offers users a e-VLBI service from the very start of the project. In this regard a major milestone will be the publication of an e-VLBI Call for Proposals – in order to have full penetration into the astronomical community the text of this Call will be included within the general EVN and Global VLBI Call for Proposals. It is expected that this Call will appear about 2 months before EXPReS formally starts. We can expect to start observing our first experiments in month 3 or 4 of the EXPReS contract. The service offered will clearly be limited at this early stage of the EXPReS programme but we expect that some competitive science projects will be scheduled, perhaps including some sort of Target of Opportunity observing programme. The Call for proposals will be repeated throughout the duration of the EXPReS project – each Call will have a deadline 1, February, 1 June and 1 October.

At this early stage of attracting new e-VLBI users, it will also be important to ensure that the EXPReS Web Pages are up and running – both in terms of external and internal communications. Clearly, it will be important to have a meeting of the Consortium Board as soon as the project kicks-off – these milestones are scheduled to occur within the first 2 months of the contract start date. Similar kick-off meetings are planned for the eVSAG (NA3) and the EVN-NREN forum (NA2). Further meetings of these bodies will also represent major milestones throughout the duration of EXPReS. In particular, the e-VLBI Science and Technical workshop to be held at Onsala Space Observatory will be a major highlight of the EXPReS project. We hope to demonstrate several key science results, along side the technical developments supported by EXPReS. This will be an international meeting, attracting e-VLBI experts from around the world.

We expect to make significant progress in SA2 (telescope connectivity) over the first 12 months. Almost all telescopes are required to provide a feasibility study of the last-mile connection status in month 6 of the project. We are cautiously optimistic that several telescopes that are currently not connected to GEANT2 will be well advanced in obtaining high-speed connections to GEANT within 12 months of the project start date. This advance guard" is likely to include in its numbers Medicina, Metsahovi and possibly Effelsberg. A significant milestone will be the detection of real-time e-VLBI fringes to Medicina (currently planned for month 10).

The first 12 months of EXPReS promise to be busy ones for SA1 – Production e-VLBI Service. This is perhaps the most important and fundamental of the activities within EXPReS and there is an ambitious time-line that requires substantial progress to be made within the first 12 months. The success of EXPReS is firmly embedded within the project planning of SA1. The major milestone within the first 12 months will be to significantly improve the robustness and reliability of real-time e-VLBI correlation at JIVE and to be able to control the data sources (at the telescopes) centrally. At the same point a choice will be made with respect to the choice of transport protocols – very likely this will a switchable option allowing us to choose the optimal solution depending on network conditions. In addition, the nature of the VLBI astronomy observations might also important in choosing between protocols – in some cases a high data rate with relatively large losses may be optimal – at least in terms of the scientific goals (often governed by limited atmospheric coherence times).

At the end of the first reporting period we also hope to provide some sort of limited Target-of-Opportunity adaptive scheduling capability. Within SA1 another key milestone is the transparent incorporation of e-MERLIN telescopes with the e-VLBI network. The first tests are scheduled for month 15 using local MERLIN telescopes at Jodrell, and by month 18 we should also receive the first data from remote e-MERLIN telescopes located outside of JBO.

During the second half of the EXPReS programme, efforts within SA2 will focus on the connection of the telescopes in China and South Africa. Milestones will again be the detection in real-time of e-VLBI fringes to these telescopes. A real-time e-VLBI pipeline should also be made available at the correlator and sophisticated monitoring tools will also be in place. These will be useful for staff located at both JIVE and the remote telescope sites.

The first major milestone of the FABRIC project will be the correlation of at least one baseline at a data rate of up to 4 Gbps. One option for this is to use the prototype e-MERLIN correlator, sited at Jodrell Bank Observatory in the UK and currently scheduled for delivery in 2006/7. The target will be to connect one EVN telescope from outside the UK using a link with multi-Gb/s capacity and demonstrate that this can be achieved using the prototype data acquisition system. The projected date for this milestone is month 23. For the second major milestone up to 5 telescopes will observe and deploy distributed correlation, resulting in a scientific product of comparable size and improved quality over existing observations. The bandwidth of such an experiment would be limited (< 256 Mbps), but the whole scheme will be easily scalable to higher data rates. This milestone may be reached in month 35. FABRIC paves the way for a much more ambitious e-VLBI programme under FP7.

5. DETAILED IMPLEMENTATION PLAN (FOR FIRST REPORTING PERIOD PLUS 6 MONTHS)

5. A EXPReS NETWORKING ACTIVITIES

5. A.1. ACTIVITY NA1 – MANAGEMENT OF THE EXPRES I3

5. A.1.1. Quality of the Management of EXPRES

The EXPReS I3 will be managed and run by a Consortium Board of Directors. The Board will comprise the Directors (or their representatives) of all institutes involved in EXPReS. Members of the Board will have authority to make decisions on behalf of their institutes. The Coordinator of EXPReS will be a member of the Board of Directors, but not its Chairman. The Board will elect a Chairman who will serve for a period of three years (the full duration of the proposed contract). The coordinators of the complimentary I3s – GN2 and RadioNet, will also be members of the EXPReS board. Most of the partners of this proposal are members of RadioNet – if successfully funded the EXPReS consortium agreement will use this as an advanced starting model.

The board will make decisions based on consensus. If consensus cannot be achieved, then a decision will be passed by majority vote of a quorum. A quorum will be achieved if 2/3 of the Board members are present. The Board will be able to take decisions by meeting face-to-face (see JIVE MoU). New applicants to EXPReS will be accepted only by a unanimous decision of the Board.

The EXPReS Coordinator will be the contact person with the European Commission. He will be the person through whom the EC contribution is paid and will be ultimately responsible for administering the distribution of the financial contribution according to decisions taken by the EXPReS Board regarding its allocation to participants and activities. The position will not be funded by EXPReS but by the Coordinator's institute; it will require ~ 25% of the Coordinator's time. The proposed EXPReS coordinator is Dr. Michael A. Garrett, Director of the Joint Institute for VLBI in Europe, Dwingeloo, The Netherlands.

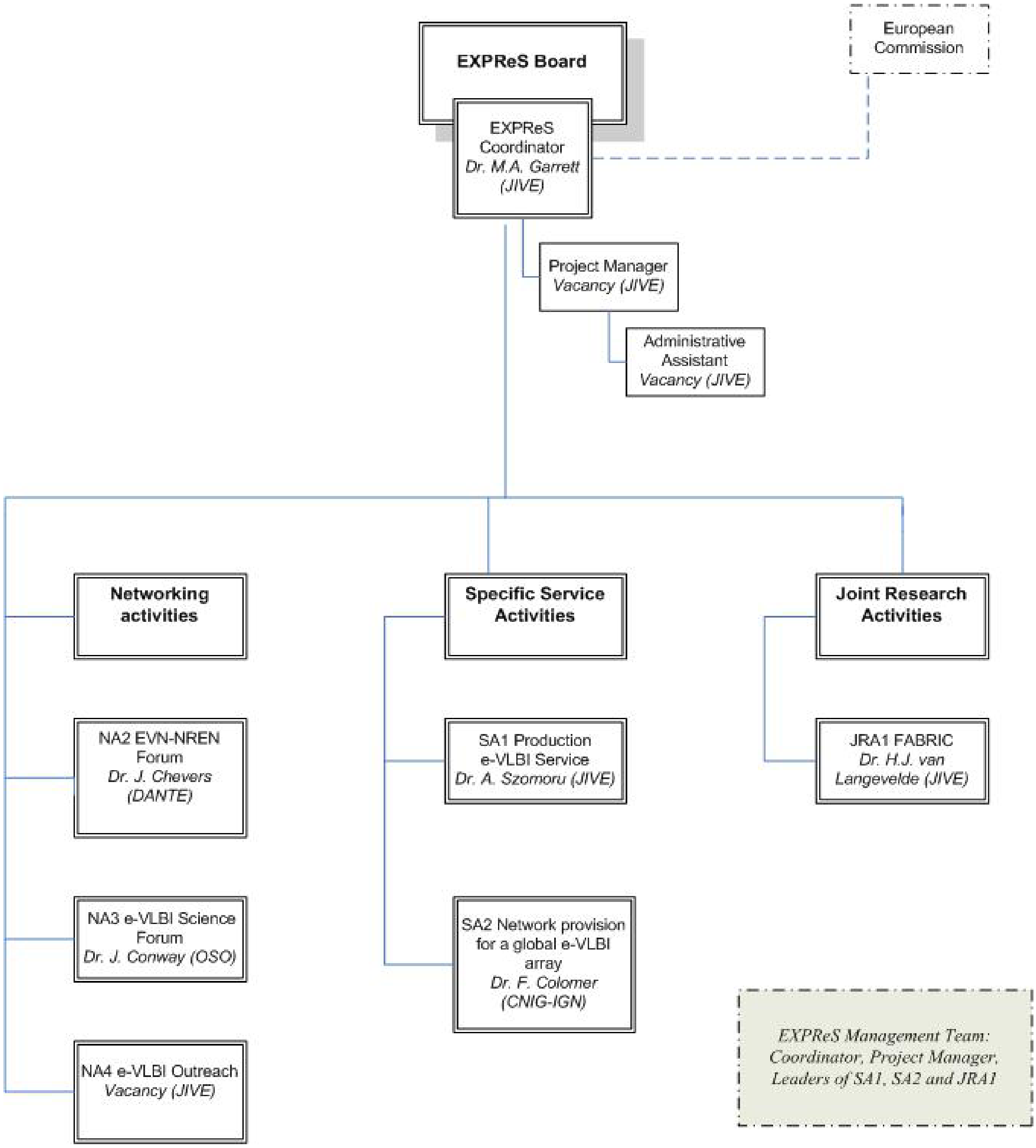


Figure N1.1: A schematic diagram of the management structure of EXPReS

Funds for the I3 will be received by the Coordinator and will be distributed as agreed by the EXPReS Board in accordance with the plan agreed with the EC. Financial dealings will be in accordance with an institute's own financial policies and procedures. Each institute will be required to conduct an annual audit of costs following their usual policies. 10% of all EXPReS funds will be held in a central contingency account. These may be used at the discretion of the Board but, under normal circumstances, can be expected to be distributed to the activities for which they were originally intended. This will add much needed flexibility to the management of EXPReS as the project evolves.

Each Networking Activity, Specific Service Activity and Joint Research Activity will have an identified team leader. This individual will be responsible for producing the main deliverables of that particular activity. In particular, each NA, SA and JRA will be required to generate provide input into the Monthly Highlight Reports, Quarterly Management Reports (QMR) and Annual Reports (including financial reports) to the project management (NA1) and the Board of Directors. These annual reports will form part of the material required for the EC year 1, 2, 3 & Final Reports. Each activity will be largely responsible for its own internal management. The team-leader will also be responsible for planning all activities of the JRA, NAs & SAs, monitoring and managing the overall effort of the activity, and reporting on progress to the Board and to the EXPReS coordinator. These team leaders are already identified and are senior members of staff at the EXPReS partner institutes, with a wealth of experience in managing distributed projects involving many international partners.

The day-to-day management of EXPReS and its various activities will be led by the EXPReS Coordinator, supported by the EXPReS Management Team (EMT). The membership of the EMT will include the team leaders of the major elements of the project, in particular SA1, SA2 and JRA1. In addition, the EMT will require additional staff effort. This will be funded by EXPReS and will include:

- A Project Manager (PM) 1.0 FTE
- Financial & Administrative Assistant (0.5 FTE)

The Project Manager (PM) will be responsible for the day-to-day operation of EXPReS and the EMT. He or she will have a strong engineering or scientific background and will be the “eyes and ears” of the coordinator; he or she will be responsible for the general oversight of all EXPReS activities. The PM will be expected to attend meetings associated with the various project activities, reporting back to the coordinator, and ultimately the EXPReS Board. He or she will be responsible for coordinating the generation of all reports associated with EXPReS including the monthly, quarterly and annual reports to the EC. The project manager will be responsible for monitoring the quality of reports and the timely production of deliverables. The leaders of the various EXPReS activities will be allocated an annual budget by the PM, as approved by the Board. The Project manager (aided by the financial and administrative assistant) will be responsible for all financial aspects of EXPReS, including the generation of mid-year and annual reports. He or she will also be the primary contact person for technical details regarding EC contractual issues. The production of the minutes of the EXPReS board meetings will also be the responsibility of the Financial and Administrative Assistant. The administrative assistant will also play a leading role in organising EXPReS events e.g. meetings of the board, workshops etc.

Table N1.1: Management Costs of EXPReS (JIVE)

Activity	Costs per annum.	EC contribution	Total EC request	Grand Total
EMT Staff Personnel	€81000 x 3 yrs (incl. 20% overhead)	83%	€202500	€243000

Coordinator	25% of 100000 (incl. 20% overhead)	0%	€0	€75000
Travel budget	€20000 (25 board members, 1 meeting per year @ 800 Euro)	100%	€40000	€60000
Admin. costs	Audit certificates 19 partners @ €1500 over 3 years	100%	€28600	€28600
Annual Total	€135500			
Totals			€271100	€406600

The overall management structure and communication flow within the consortium is presented in Figure N1.1. Note that for efficiency, the Project Manager and the Financial & Administrative support will be located at the same institute as the Coordinator, *viz.* JIVE. The community financing for the Management of EXPReS includes a travel budget that will support travel to EXPReS Board meetings and will also be used to support the travel of NA1 staff to meetings associated with EXPReS activities.

Table N1.2 ACTIVITY DESCRIPTION (REPORTING PERIOD PLUS 6 MONTHS)

Activity number :	NA1	**Start date: Month 1, Year 1**				
Participant (Short name):	JIVE	AARNET	DANTE	PSNC	SURFnet	
Expected Budget per Participant:	110000	1300	2000	1000	1000	
Requested Contribution per Participant:	70000	1000	1000	1000	1000	

Activity number :	**Start date: Month 1, Year 1**				
Participant (Short name):	ASTRON	CNIG-IGN	CSIRO	HARTRAO	INAF
Expected Budget per Participant:	1000	1000	1000	1000	1000
Requested Contribution per Participant:	1000	1000	1000	1000	1000

Activity number :	NA1	**Start date: Month 1, Year 1**				
Participant (Short name):	MPIfR	MRO	NAIC	NCU	OSO	ShAO	TIGO
Expected Budget per Participant:	1000	1000	1000	1000	2000	1000	1000
Requested Contribution per Participant:	1000	1000	1000	1000	1500	1000	800

Activity number :	NA1	**Start date or starting event:**					
Participant (Short name):	UniMAN	VIRAC					

Expected Budget per Participant:	1000	1000					
Requested Contribution per Participant:	800	800					

Objectives:
The objectives of NA1 are to provide EXPReS with an effective project management structure. The project management will be responsible for concluding a consortium agreement between the partners before the project commences; be ultimately responsible for the overall coordination of the project; ensure meetings of the EXPReS Consortium Board of directors are conducted in an organised and prepared fashion; be the central point of contact for all partners concerning contractual issues; be a single point of contact within EXPReS for the EC; ensure that financial prudence and accountability is observed throughout the programme; efficiently interact with the EXPReS partners gathering relevant management information from the participants; generate an distribute annual and final reports to the EXPReS Board and the EC.

Description of work

The first order of business will be to appoint new staff – the Project Manager and Administrative Assistant. The project management will interact with the team leaders of SA1, SA2 & JRA1. Together with the coordinator they will form the EXPReS management team. They will also have direct contact with the Outreach Officer (NA4) and the chairmen of the NA forums – NA2 & NA3. The project management office will monitor progress in all these areas and will be able to help the NA, SA and JRA leaders with respect to all contractual and reporting issues. The EXPReS management team (EMT) will be proactive in all aspects of the project and the project manager will organise monthly face-to-face meetings of the EMT (the coordinator, project staff and team leaders of SA1 & JRA1 are all co-located – the team leader of SA2 will attend via videoconferencing facilities). The Project Manager (PM) will be responsible for the day-to-day operation of EXPReS and the EMT. The PM will be expected to attend meetings associated with the various project activities, reporting back to the coordinator, and ultimately the EXPReS Board. He or she will be responsible for coordinating the generation of technical reports associated with the mid-year and annual reports. The financial and administrative assistant will be responsible for all financial aspects of EXPReS, including the generation of mid-year and annual reports. The administrative assistant will also play a leading role in organising EXPReS events, *e.g.* meetings of the board, workshops *etc.*

The risks associated with this activity are not insignificant – the usual problem in EC projects is communication between the project management and remote team leaders. We have tried to minimise this problem by ensuring that the team leaders of the JRA and SA are either local or have both an excellent track records in providing feedback to the project and all-round management skills. With the team we have assembled we are confident the project management can operate effectively.

Deliverable No[5]	Deliverable title	Delivery date[6]	Nature[7]	Dissemination Level[8]
DNA1.01	Annual report (incl. Financial information) to EC	12	R	PP
DNA1.02	Annual report (incl. Financial information) to EC	24	R	PP
DNA1.03	Annual report (incl. Financial information) to EC	36	R	PP
DNA1.04	Final Report to Board and EC	36	R	PP
DNA1.05	Final Plan for using and disseminating knowledge	36	R	PP
DNA1.06	Implementation of the Gender Action Plan	36	R	PP
DNA1.07	Raising public participation and awareness	36	R	PU

Milestones[9] and expected result:

The first and necessary milestone is the appointment of the PM staff, in particular the aim is to make these appointments as soon as the project begins. The reports detailed in the list of deliverables are also milestones in themselves – in particular the approval from the board and the EC at the end of each reporting year. Other project milestones include:

MN1.1 Conclusion of the Cons. Agreement (month –3)

MN1.2 Appointment of the project manager (month 0)

MN1.3 Appointment of the administrative assistant (month 0)

Justification of financing requested:

The overall costs are mainly associated with the manpower required to employ the EXPReS Project Management team, in particular the Project Manager and Financial & Administrative Assistant. Both these (part-time) positions are essential for the effective management of a very distributed project such as EXPReS. The coordinators position is self-financing. Travel funds for the EXPReS board are also requested.

---

[5] Deliverable numbers in order of delivery dates: D1 – Dn

[6] Indicate the month of delivery. This should be relative to the start date of the *I3*, month 1 marking the first month of the project.

[7] Please indicate the nature of the deliverable using one of the following codes:

- **R** = Report
- **P** = Prototype
- **D** = Demonstrator
- **O** = Other

[8] Please indicate the dissemination level using one of the following codes:

- **PU** = Public
- **PP** = Restricted to other programme participants (including the Commission Services).
- **RE** = Restricted to a group specified by the consortium (including the Commission Services).
- **CO** = Confidential, only for members of the consortium (including the Commission Services).

[9] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Community financing is not requested to purchase durable equipment. Community financing is not being used to conclude subcontracts.

5. A.1.2. Quality of the plan for using and disseminating knowledge

EXPReS activities will result in the generation of new knowledge and new scientific results. One of the aims of the consortium will be to disseminate such knowledge as widely as possible. EXPReS will have a website run by NA4 "Outreach, Dissemination & Communication". This wiki-based system will contain information on all EXPReS activities; minutes of board meetings; electronic proceedings of workshops arising from the networking activities; and lists of, and links to, preprints and publications arising from EXPReS activities. It will be the place where the activity team leaders deposit reports through the course of the project. PR materials will also be available to download.

All EXPReS partners will be actively encouraged to participate in international conferences and workshops and to give papers and posters at such meetings. The astronomers that use the e-VLBI network will be encouraged to publish their scientific and results in refereed journals. Technical results arising from the JRA will also be published in appropriate engineering and/or scientific journals.

It will be a requirement that EXPReS and the EC-funding be acknowledged in all publications.

5. A.2 Description of the other networking activities

5.A.2.1 ACTIVITY NA2 – EVN-NREN Forum

Objectives and expected outcome of the activity

The EVN-NREN forum has become an essential part of the proof-of-concept stage of the e-VLBI project, allowing networking engineers and managers from the national research networks and GÉANT to meet with the technical teams from the various radio astronomy observatories and the EVN data processor at JIVE. It has been used routinely to disseminate results, evaluate progress, resolve technical issues and plan future activities. It has brought together experts from a wide range of disciplines into a cohesive working group with the aim of applying the concept of a high-speed research network infrastructure to the distribution of VLBI data across Europe and beyond. The EVN-NREN forum has been the everyday working foundation on which the success of the e-VLBI proof-of-concept has been built.
The objectives of NA2 are as follows:

- To provide and promote project-wide meetings of stakeholders from the radio-astronomy and networking communities, for planning purposes and to agree on common objectives,
- To provide a forum for discussion and resolution of networking and other technical issues arising from the project on a day-to-day basis (via the EVN-NREN email forum),
- To discuss, critically review and develop results and ideas arising from SA1, SA2 & JRA1,
- Provide input to the EXPReS Outreach Team (NA4) with respect to the promotion of the networking aspects of the EXPReS programme.

The EVN-NREN meetings will take place at least once per year, at a location convenient to all the participants. In some cases, meetings will take place along side other scheduled events (*e.g.* the e-VLBI Science & Technical workshop). It is suggested that the format of the meetings should be split into two parts; the first dealing with network-related issues, the other relating to more general technical issues.

The co-ordination and scheduling of the meetings will be conducted under the auspices of the EVN-NREN forum e-mail list. This list also provides a means for ongoing discussion of technical and organisational issues relating to the project as a whole. At present the forum is hosted by NORDUnet.

A conscious effort will be made to liaise between the NA2 group and the parallel NA3 *e-VLBI Science Forum* activity, to ensure that the expectations of a production e-VLBI network are adequately understood. Indeed, there will be considerable overlap between the membership of the EVN-NREN Forum and the e-VLBI Science Advisory Group (supported via NA3). In particular the team leaders of SA1, SA2 and JRA1 (and the EXPReS Coordinator) are members of both the EVN-NREN and eVSAG. User requirements and aspirations will be captured within NA3 and thus feed into the day-to-day activities of the EVN-NREN forum and the EXPReS project more generally.

Tangible deliverables at the end of the contract period will be:

- **Report of the EVN-NREN Forum meetings:** A set of six reports, each detailing the presentations and discussions at the semi-annual *Forum* meetings.
- **Annual Overview Report:** Detailing the activities of the EVN-NREN discussion group, the resulting technical and scientific achievements thus providing input into JRA1, SA1, SA2, NA1, NA3 and NA4.
- **Attendance and presentation of networking participants at appropriate conferences:** this should highlight the relationship developed between the radio astronomy and networking communities, and the technical & networking achievements of the project.
- **Maintenance and further development of the EVN-NREN e-mail forum.**

Benefits to the community from NA2 will include:

- The continuation of the excellent collaboration and communication between networking experts and the radio astronomy community (as realised within the e-VLBI PoC project),
- Critical review of the EXPReS development programme, thus ensuring that a capable e-VLBI infrastructure is delivered to the end-user community,
- Project monitoring – ensuring that progress is being made in the right direction and on the expected timescales,
- The opportunity for the networking experts to work in close collaboration with the scientific community, obtaining a better understanding of their needs, requirements and approach.

5A.2.2. Participants

Participants in this activity will include DANTE - the leading participant in this Networking activity and the operator of the pan-European research network, GÉANT. DANTE representatives will bring expertise in the networking field to the forum, co-ordinate the meetings and the submission of deliverables. Other partners are the representatives of the radio astronomy institutes – they will bring specialist technical expertise relating to the VLBI technique and an understanding of the requirements of the Radio-Astronomy community. Finally, the National Research and Education Networks (NRENs) associated with each of the participating national observatories will be invited to take part in the Forum meetings, bringing valuable networking knowledge and insight into the activity. Dr. John Chevers (Project Planning and User Support, DANTE) will chair the EVN-NREN forum.

Table N2.1 List of the current members of the EVN-NREN Forum

Name	e-mail address	Organisation/Institution
Walter Alef	alef@mpifr-bonn.mpg.de	Max-Planck-Institute
Paul Burgess	pb@jb.man.ac.uk	Manchester University
Simon Casey	scasey@jb.man.ac.uk	Jodrell Bank Observatory
John Chevers	john.chevers@dante.org.uk	DANTE
Michael Enrico	michael.enrico@dante.org.uk	DANTE
Tony Foley	foley@astron.nl	ASTRON
Mike Garrett	garrett@jive.nl	JIVE
Marcin Garstka	marcinga@man.poznan.pl	PSNC
Hanno Holties	holties@astron.nl	ASTRON

Richard Hughes-Jones	r.hughes-jones@manchester.ac.uk	Manchester University
Giuseppe Maccaferri	g.maccaferri@ira.cnr.it	INAF-IRA
Marco Marletta	marco.marletta@garr.it	GARR
Ari Mujunen	amujunen@cc.hut.fi	Metsahovi Observatory
Per Nihlen	per@nordu.net	NorduNET/SUNET
Michael Olberg	olberg@oso.chalmers.se	Onsala Space Observatory
Niels den Otter	otter@surfnet.nl	SURFnet
Eugeniusz Pazderski	ep@astro.uni.torun.pl	Torun
Sergei Pogrebenko	pogrebenko@jive.nl	JIVE
Duncan Rogerson	duncan@nosc.ja.net	UKERNA
Jouko Ritakari	jr@kurp.hut.fi	Metsahovi Observatory
Toby Rodwell	toby.rodwell@dante.org.uk	DANTE
Ralph Spencer	res@jb.man.ac.uk	Jodrell Bank
Arpad Szomoru	szomoru@jive.nl	JIVE
Martin Wilhelm	wilhelm@dfn.de	DFN

5. A.2.3. Justification of the finance requested

The justification of the costs associated with NA2 are detailed in Table N2.2. The chairman of NA2 (Dr. John Chevers, DANTE) will be responsible for chairing meetings of the EVN-NREN forum and monitoring the activity.

Table N2.2. Budget request

Activity	*Participants/Quantity*	*Total Cost (Euro)*	*Requested EC Contribution (Euro)*
EVN-NREN face-to-face meetings	Support for 22 participants @ €800 plus 8 (non-EU) participants @ €1500 per meeting, 3 face-to-face meetings over the contract period.	88800	60000
Forum venue	3 meetings @ €2500	7500	7500
Attendance of NREN representatives at eVLBI Science Workshop & other conferences	10 NREN participants @ €1000 Euro	10000	10000
Total Network Cost		105500	77000

The requested contribution from the EC only covers part of the total Networking activity costs. In particular the travel of participants to the various face-to-face meetings will be partially (or in some cases fully) supported by the participants' local institutes. The manpower associated with organising the EVN-NREN forum, the associated meetings and reports, and providing input to e-VLBI press releases (see NA4) will be spread across the NA2 participants.

Several non-associated third countries will be required to attend the EVN-NREN forum meetings. These include representatives of the radio telescopes (and in some cases NRENs) in China, South Africa, USA, Australia and South America. EXPReS seeks to realise a telescope that is distributed on a global scale – it will be essential for the overall coherence of the project (especially in its international dimension) for the main technical players in EXPReS to be present at the EVN-NREN forum meetings.

5A.2.4 Summary

Table N2.1 ACTIVITY DESCRIPTION (REPORTING PERIOD PLUS 6 MONTHS)

Activity number :	NA2	**Start date: Month 1, Year 1**				
Participant (Short name)**:**	DANTE	AARNET	PSNC	SURFNET		
Expected Budget per Participant:	2000	1600	1000	1000		
Requested Contribution per Participant:	2000	1200	800	800		

Activity number :	NA2	**Start date: Month 1, Year 1**				
Participant (Short name)**:**	JIVE	ASTRON	CNIG-IGN	CSIRO	HARTRAO	INAF
Expected Budget per Participant:	12000	800	800	1000	1500	800
Requested Contribution per Participant:	9000	500	500	1000	1000	500

Activity number :	NA2	**Start date: Month 1, Year 1**					
Participant (Short name)**:**	MPIfR	MRO	NAIC	NCU	OSO	ShAO	TIGO
Expected Budget per Participant:	800	800	1500	800	800	1000	1000
Requested Contribution per Participant:	500	500	1000	500	500	1000	800

Activity number :	NA2	**Start date or starting event:**					
Participant (Short name)**:**	UniMAN	VIRAC					
Expected Budget per Participant:	800	800					
Requested Contribution per Participant:	500	500					

Objectives
To bring together the main technical elements of EXPReS (the network and radio astronomy

technical communities) in order to discuss the progress of EXPReS. Maintain and further develop the EVN-NREN forum (the day-to-day instrument for EXPReS technical coordination and communication) and organise project-wide face-to-face meetings of stakeholders from the radio astronomy and networking communities for planning purposes and to agree on common objectives. The forum also provides input to the EXPReS Outreach Team (NA4) with respect to the promotion of the networking aspects of the EXPReS programme.

Description of work

The EVN-NREN forum will critically assess and review developments in SA1, SA2 & JRA1. The forum will identify solutions to unexpected problems that may arise during the course of EXPReS. Most day-to-day exchanges between members of the forum will take place via the existing EVN-NREN email forum. The EVN-NREN forum will also be responsible for organising face-to-face meetings that bring together the main technical players in EXPReS. In addition to considering input from the SA and JRA1, it will also seek input from the e-VLBI Science Advisory Group (as supported by NA3). Like NA3, this activity will also be required to provide guidance to the EXPReS Consortium (in particular the development team and project management). NA2 will support the presentation of e-VLBI Networking results at international networking events. The group will be active in identifying interesting networking results achieved by the EXPReS project, and feeding NA4 (Outreach) with text and information required for the generation of PR material. The only real risk to this activity is that the e-VLBI infrastructure does not produce interesting networking results – we believe that this is very unlikely, and that the risk of failure is thus low.

Deliverable No[1]	**Deliverable title**	**Delivery date**[2]	**Nature**[3]	**Dissemination Level**[4]
DNA2.01	EVN-NREN meeting No. 1 (under auspices of EXPReS)	3	R	PP
DNA2.02	NA2 annual report No. 1 (as part of EXPReS Ann. Rep No. 1)	12	R	PP
DNA2.03	EVN-NREN meeting No. 2	18	R	PP
DNA2.04	NA2 annual report No. 2 (as part of EXPReS Ann. Rep No. 2)	24	R	PP
DNA2.05	EVN-NREN meeting No. 3	26	R	PP
DNA2.06	EVN-NREN representatives present EXPReS networking results at the e-VLBI Science & Technology Workshop	26	R	PU
DNA2.07	NA2 annual & Final reports	36	R	PP

Milestones[1] and expected result:

[1] Deliverable numbers in order of delivery dates: D1 – Dn
[2] Indicate the month of delivery. This should be relative to the start date of the *I3*, month 1 marking the first month of the project.
[3] Please indicate the nature of the deliverable using one of the following codes:
- **R** = Report
- **P** = Prototype
- **D** = Demonstrator
- **O** = Other

[4] Please indicate the dissemination level using one of the following codes:
- **PU** = Public
- **PP** = Restricted to other programme participants (including the Commission Services).
- **RE** = Restricted to a group specified by the consortium (including the Commission Services).
- **CO** = Confidential, only for members of the consortium (including the Commission Services).

The major milestones will be the organisation of the EVN-NREN meetings, generation of the various reports, maintenance and development of the EVN-NREN e-mail forum, and generating a number of network related PR announcements. It is expected that the NA2 activity will act as the forum in which problems associated with EXPReS are identified, discussed and solved. It will play an important role in ensuring the overall success of the project.

EVN-NREN chair attends EXPReS Board Meeting No. 1 – month 2

EVN-NREN chair attends EXPReS Consortium Board Meeting No. 2 – month 14

EVN-NREN chair attends EXPReS Board Meeting No. 3 – month 26

Justification of financing requested:

The overall costs of NA2 concern the costs associated with EVN-NREN meetings. While the EVN-NREN forum has an important role to play within EXPReS, face-to-face meetings are essential in cementing the collaboration between the various groups. Only partial support is requested – the additional costs will be met by local funds at the participating institutes The requested funding from the EC is €77000, but the total cost of the activity as a whole is €105500 (not including the man-power associated with organising the activity. Community financing is not requested to purchase durable equipment. Community financing is not being used to conclude subcontracts.

[1] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

ACTIVITY NA3 – E-VLBI SCIENCE FORUM

5. A.3.1. Objectives and expected outcome of the activity

The overall EXPReS project must ensure a close connection between the infrastructure, its technical development and the end-users of the e-VLBI system. This will be realised via Networking Activity NA3 – the e-VLBI Science Forum. This activity will partially support the activities of the e-VLBI Science Advisory Group (eVSAG). This group was set up by the EVN Consortium Board of Directors in November 2004, and under the EXPReS NA3 activity its membership and role will be further expanded.

The job of eVSAG will be to ensure that potential users of the e-VLBI facility will be informed of the current technical capabilities of the e-VLBI infrastructure, so that exciting astronomical proposals can be generated. Likewise, those developing the technology and defining the instrument itself must also be aware of how e-VLBI developments can be best directed in order to ensure the user community is well served. It will be the role of the eVSAG to ensure that the scientific needs of the wider community are directly communicated to the EXPReS Management Team, the EVN Board of Directors and the EXPReS Consortium as a whole.

As is the case with the current EVN facility, we expect the astronomers located at the e-VLBI observatories to be fully active in all facets of the EXPReS programme, including technical developments associated with the e-VLBI array. This will ensure that the EXPReS project is closely coupled to the requirements of the e-VLBI end-users. This networking activity, NA3, will create and organise an e-VLBI Science Forum (eVSF) – an on-line discussion group that will be open to *all* potential users of the e-VLBI infrastructure, and will be similar in operation to the current EVN-NREN e-mail forum (see NA2). It will permit e-VLBI users to submit their opinions (including user feedback associated with the use of the array). This feedback will be channelled via the e-VLBI Science Advisory Group (eVSAG) directly to the EXPReS project management and other major elements of the e-VLBI infrastructure, including the EXPReS and EVN Board of Directors. This process of user feedback will also be facilitated via existing EVN mechanisms, in particular the performance of the EXPReS e-VLBI facility will be included as a standing agenda item at EVN User, EVN Programme Committee and the EVN Consortium Board meetings. The chairman of the eSVAG will attend (by invitation) meetings of the EXPReS Board of Directors. A significant subset of eSVAG is also represented within the EVN-NREN group (NA2). The eVSAG group will also include members that can represent the geodetic and spacecraft navigation communities – these groups also have an interest in e-VLBI.

The eVSAG will also consider the ways in which the full potential of e-VLBI can be developed scientifically – it's likely that some elements of the "cultural change" we expect to encounter with e-VLBI will only be recognised when we begin to use e-VLBI as a production-level astronomical tool. The eVSAG is thus charged to play a central role in identifying the potentially new and transformational capabilities e-VLBI might deliver.

During the course of the EXPReS contract, the eVSAG will organise an International e-VLBI Science and Technical workshop. There have been three technical e-VLBI workshops to date (one in the US, one in Europe and one in Japan). We would like to bring this series of meetings back to Europe, but to shift the emphasis towards the scientific potential of the production e-VLBI infrastructure realised via EXPReS.

Tangible deliverables at the end of the contract period will be:

- The generation of e-VLBI Memos and scientific reports that discuss the potential of e-VLBI on specific topics. Reports of eVSAG meetings will be made available to the whole community via the EXPReS web pages.
- Proceedings of the e-VLBI workshop to be organised by eVSAG as editors of the publication
- Active and direct representation of eVSAG within the EXPReS project, via participation in NA1, NA2, SA1, SA2 & JRA1 and the overall EXPReS Consortium and Project management team meetings.
- The eVSAG chair will communicate to potential users via various sources, including contributions to the EVN Newsletter,
- The eVSAG team will highlight the capability of the new e-VLBI infrastructure by giving oral and poster presentations at conferences, workshops and symposia.
- The eVSAG team will provide input to the EXPReS Outreach Team (N4) with respect to promoting new science results via press releases.

Benefits to the community via NA3 will include:

- Enhanced collaboration and communication between different potential e-VLBI end-user groups and the technical developers of EXPReS
- Stimulation of the use of new, high-speed research networks, and the direct engagement of the wider scientific community in realising the potential of utilising these systems for day-to-day research.

Table N3.1. Current membership of the eVSAG Committee

Name	***Institution***	***Position/Field of research***
Dr. J. Conway (Chair)	Onsala Space Obs, SE	Weak AGN, masers, starbursts
Dr. P.Charlot	Bordeaux Observatory, FR	EVN PC Chair
Dr. R.Porcas	MPIfR, Bonn, DE	EVN Scheduler, Gravitational lenses
Dr. S.Garrington	Jodrell Bank Observatory, UK	eMERLIN manager, AGNs
Dr. M. Bondi	INAF-IRA, Bologna, IT	Young AGN, starbursts
Dr. R. Strom	ASTRON, Dwingeloo, NL	Pulsars, galactic sources
Dr. A. Szomoru	JIVE, Dwingeloo, NL	HI galaxies, e-VLBI s/w
Dr. T. Ghosh	NAIC, Arecibo Puerto Rico, USA	Megamasers
Dr. H.J. Van Langevelde	JIVE, Dwingeloo, NL	Interstellar and circumstellar matter, masers
Prof. A. Kus	Torun observatory, PL	Extragalactic sources
Dr. M.A. Garrett (EXPReS Coordinator)	JIVE, Dwingeloo, NL	Deep Field Studies, Wide-field Imaging & Calibration, Galactic Transients.

5. A.3.2. Participants

The e-VLBI Science Advisory Group (eVSAG) membership is currently restricted to those radio telescopes involved in the e-VLBI Proof-of-Concept project. The current membership is provided in Table N3.1. The coordinator of EXPReS is a member of eVSAG, as is the team leaders of SA1. We expect the leaders of SA2 & JRA1 to join this group in the event that EXPReS proposal is successful. It is proposed to expand the eVSAG membership base within EXPReS, so that all the major radio observatories involved in the e-VLBI infrastructure are represented. We expect about 20 participants in total – all of whom will be leading European scientists, active in conducting a broad programme of astronomical research. The chairman of eVSAG, Dr. J. Conway, is a leading European astronomer who is based at Onsala Space Observatory and is a staff member of Chalmers University in Gottenborg, Sweden.

5. A.3.3 Justification of the finance requested

The justification of the costs associated with NA3 are detailed in Table N3.2. The chairman of NA3 (also the eVSAG chair) will be responsible for monitoring and allocating part of the travel budget associated with NA3. Some of the travel budget associated with NA3 includes the costs of representatives of those e-VLBI end-users not formally participating in EXPReS. These funds will be held by JIVE.

Table N3.2. Budget request

Activity	*Participants/Quantity*	*Total Cost (Euro)*	*Requested EC Contribution (Euro)*
eVSAG face-to-face meetings	Support for 13 participants @ €800 plus 5 (non-EU) participants @ €1500 per meeting, 3 face-to-face meetings over the contract period.	53700	40000
eVLBIScience Workshop	30 participants @ €1000 Euro Conference Organisation at Onsala Space Observatory	30000 4000	20000 4000
Publication of Workshop proceedings by Onsala Space Observatory	100 copies for distribution. @ 40 Euro/copy	4000	4000
Presentation of e-VLBI Science results by eVSAG members	5 meetings at €1000 per trip	5000	0

Activity	*Participants/Quantity*	*Total Cost (Euro)*	*Requested EC Contribution (Euro)*
Total Network Cost		96700	68000

The requested contribution from the EC only covers part of the total Networking activity costs. In particular the travel of participants to the various face-to-face meetings will be partially (or fully) supported by the participants local institute. The manpower associated with organising the eVSAG and the associated meetings, writing-up memos, editing the workshop proceedings, providing input to e-VLBI press releases (see NA4) and publishing scientific report and papers on e-VLBI is spread across the members of the eVSAG and will be funded by the EXPReS radio astronomy partners. Travel of the eVSAG chair to EVN PC + EVN user meetings will be covered by the RadioNet I3 EVN Transational Access programme.

Several non-associated third countries will be required to be represented at eVSAG meetings. These include representatives of the radio telescopes in China, South Africa, USA, Australia and South America. EXPReS seeks to create a telescope that is distributed on a global scale - it will be essential for the overall coherence of the project (especially in its international dimension) for the astronomers of *all* the e-VLBI radio telescopes to be present at eVSAG meetings.

5. A.3.4. Summary

Table N3.3 ACTIVITY DESCRIPTION (REPORTING PERIOD PLUS 6 MONTHS)

Activity number :	NA3	**Start date: Month 1, Year 1**				
Participant (Short name)**:**	JIVE	ASTRON	CNIG-IGN	CSIRO	HARTRAO	INAF
Expected Budget per Participant:	10000	1000	1000	1500	1500	1000
Requested Contribution per Participant:	6000	800	800	1000	1000	800

Activity number :	NA3	**Start date or starting event:**					
Participant (Short name)**:**	MPIfR	MRO	NAIC	NCU	OSO	ShAO	TIGO
Expected Budget per Participant:	1000	1000	1500	1000	1000	1500	1500
Requested Contribution per Participant:	800	800	1000	800	800	1000	1000

Activity number :	NA3	**Start date or starting event:**					
Participant (Short name)**:**	UniMAN	VIRAC					
Expected Budget per Participant:	1000	1000					
Requested Contribution per Participant:	800	800					

Objectives

The objective is to organise the end-user e-VLBI community, in such a way that it continues to have direct input into the EXPReS development project beyond the generation of this proposal. The success of the activity can be measured by the number of face-to-face meetings & reports, together with the overall operational and scientific success of the e-VLBI infrastructure, as reported via the e-VLBI Science Forum and as presented in the proceedings of the e-VLBI Science & Technology Workshop.

Description of work

The objectives will be realised by bringing the e-VLBI end-user community together to further develop the potential use of e-VLBI, provide expert guidance and feedback to the EXPReS Consortium (in particular the SA, JRA development teams and project management) and deliver direct feedback on the performance of the e-VLBI infrastructure. NA3 will also support the presentation of e-VLBI science results at international astronomy conferences. The activity will result in various presentations and reports being made at EXPReS and EVN-related meetings; plus the production of scientific e-VLBI reports and memos. eVSAG will act as editors of the proceedings of the e-VLBI workshop proceedings and will be responsible for its publication.

The main risk for the activities detailed in NA3 are that the e-VLBI infrastructure supported via SA1 and SA2 does not perform as expected, or does not provide new scientific results. With adequate funding, we believe that this is very unlikely and the risk of failure is low.

Deliverable No[1]	Deliverable title	Delivery date[2]	Nature[3]	Dissemination Level[4]
DNA3.1	First meeting of eVSAG under auspices of EXPReS	4	R	PP
DNA3.2	eVSAG meeting No. 2	16	R	PP
DNA3.3	eVSAG meeting No. 3	26	R	PP
DNA3.4	e-VLBI Workshop held in Onsala	30	O	PU
DNA3.5	Publication of e-VLBI Workshop proceedings	32	R	PU

[1] Deliverable numbers in order of delivery dates: D1 – Dn

[2] Indicate the month of delivery. This should be relative to the start date of the *I3*, month 1 marking the first month of the project.

[3] Please indicate the nature of the deliverable using one of the following codes:

R = Report
P = Prototype
D = Demonstrator
O = Other

[4] Please indicate the dissemination level using one of the following codes:

PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).

Milestones[1] and expected result:

The major milestone will be the successful organisation of the proposed e-VLBI workshop. The proceedings will represent and encompass much of the basic aims of this activity and will publicly present many of the first astronomical results from the e-VLBI array, together with description of the EXPReS technical development project, along-side other international e-VLBI efforts.

We also expect to make a major Press Release during the e-VLBI workshop.

Other milestones include:

EVSAG chair attends EXPReS Consortium Board Meeting – month 2

EVSAG chair attends EXPReS Consortium Board Meeting – month 14

EVSAG chair attends EXPReS Consortium Board Meeting – month 26

Justification of financing requested:

The overall costs are justified in detail in the text of NA3. These are mainly travel costs associated with face-to-face meetings of the expanded eVSAG (€ 40k), travel support for the e-VLBI workshop and the production of proceedings. In many cases this is partial support *e.g.* the attendance of the eVSAG chair at key meetings, the presentation of e-VLBI science results at international conferences will be met by local funds at the participating radio astronomy institutes. The requested funding from the EC is €68k, but the total cost of the activity as a whole is at least €97k. The EC funding has been distributed evenly over the individual participants, except for Onsala Space Observatory which will organise the e-VLBI workshop, including the production of the proceedings. Some of the funds allocated to JIVE will cover the costs of e-VLBI users that may not be affiliated to an EXPReS partner. The total costs claimed here do not include a substantial contribution in terms of man-power associated with the eVSAG activities. Community financing is not requested to purchase durable equipment. Community financing is not being used to conclude subcontracts.

[1] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

ACTIVITY N4 – e-VLBI OUTREACH, DISSEMINATION & COMMUNICATION

5. A.4.1. Objectives and Expected outcome of the activity

Public interest in astronomy is huge: astronomy is deeply-rooted in most cultures; it plays a role in philosophical studies but also includes many crucial practical applications; it has aesthetic and emotional dimensions, as well as scientific ones; it is an enjoyable and inexpensive hobby for hundreds of thousands of European citizens. The benefits of astronomy are cultural and educational, as well as scientific. Astronomy engages and attracts the attention of the brightest young students in primary, secondary and university education. This is of great importance at a time when interest in university studies in some areas of natural science is declining rapidly. The general public and the scientific community alike have a high level of interest in new astronomical discoveries and the development of new astronomical instruments and techniques. The success of the e-VLBI Proof-of-Concept (PoC) project has demonstrated this, and it has been a very important vehicle for highlighting the way in which new technologies (such as research networking) can play a major role in realising new distributed instruments with unique scientific capabilities.

Outreach activities directed towards the international astronomy community are also important in ensuring that the e-VLBI infrastructure is readily and transparently accessible. Project communication within the EXPReS I3 is also an essential ingredient in the successful management of the overall project. NA4 will also address these issues of end-user and internal project communication.

The objectives of the Networking Activity, NA4, *e-VLBI Outreach, Dissemination & Communication* are:

- Set-up and manage the EXPReS e-VLBI website, including wiki-based project management tools (directly adopting the type of wiki-based system used by RadioNet I3),
- Help organise (together with the Programme Management Office) EXPReS related events that are relevant to PR and outreach,
- Promote and publicise EXPReS at key networking and astronomy events,
- Produce a range of high quality publicity material that can be easily transported to different venues and is suitable for all EXPReS partners to use to publicise e-VLBI,
- Create and manage a database of all EXPReS presentations,
- Ensure (together with the eVSAG), that prospective e-VLBI users have easy access to the information they require in order to submit technically sound e-VLBI proposals,
- Create Press Releases highlighting new e-VLBI astronomical and network related results.

Tangible deliverables from NA4 "e-VLBI Outreach, Dissemination & Communication" include:

- The creation of an EXPReS e-VLBI website – a portal for both public outreach and project management activities,
- The inclusion on the web site of wiki-based project management tools,

- Produce a range of high quality (and transportable) publicity material suitable for all EXPReS partners,
- The EXPReS Outreach office will organise EXPReS related events, such as project meetings and conferences,
- Create and manage a database of all EXPReS PPT presentations that will be available to all partners,
- Create a web portal for e-VLBI end-users, capturing the key information they require to effectively use the e-VLBI infrastructure,
- The generation of Press Releases, highlighting new astronomical and network related results that arise from the e-VLBI infrastructure and EXPReS.

Benefits to the community via NA4 will include:

- Raising awareness of the role research networks have to play in creating large-scale, distributed scientific instruments with unique capabilities,
- Enhancing the general public and scientific communities' perception of the benefits research networks can provide,
- Informing astronomers and other potential users of the capabilities of the new e-VLBI infrastructure,
- Addressing the need to ensure that international researchers enjoy easy and transparent access to the e-VLBI infrastructure.

5. A.4.2. Participants

All the EXPReS partners will benefit from the N4 Outreach activity. The principle contributors to the project will be JIVE and Jodrell Bank Observatory (UNIMAN). DANTE (on a self-financing basis) will also be involved in ensuring the Research Network PR aspects of this activity are well served; they will use results derived from NA4 for part of their own well-established PR programme. In a similar way, the EXPReS outreach programme will coordinate and cooperate with the Jodrell Bank and RadioNet Outreach office led by Dr. Alastair Gunn.

JIVE, Jodrell Bank and DANTE have worked together to produce several successful press releases, highlighting the success of the e-VLBI Proof-of-Concept project. The most recent success was the PR announcement of the successful detection and tracking of the ESA Huygens probe led by JIVE and which also included an element of e-VLBI data transfer from telescopes in Australia. Network related e-VLBI achievements such as these have appeared on several occasions in the EC IST Newsletter. JIVE has contributed material and text to various publications organised by the European Commission, (including a multi-media presentation), and has actively publicised the growing role research networks can play in supporting scientific research infrastructures, during various events (*e.g.* EU Networking delegation to North America, E-Infrastructure meeting in Dublin, China-Europe Bridges meeting in Shanghai, Terrena). With the support of DANTE, JIVE has been active in presenting live demonstrations of e-VLBI at key networking events, such as iGRID 2002 & IST 2004. The activities of JIVE in this area have, until now, been entirely self-supporting, relying on limited local travel funds.

In June 2005 JIVE hosted a large EC PR event, where all the astronomy activities funded by the EC FP6 (RadioNet, OPTICON, EUROPLANET, ILIAS, ELT DS, SKADS, VO) presented their work to the European Commissioner for Science & Research, and selected members of the European press. The highlight of the day was an e-VLBI demonstrations experiment that nicely illustrated the key role of research networks play in creating distributed scientific instruments.

5. A.4.3. Justification of the finance requested

The justification of the costs associated with NA4 are detailed in Table NA4.1. Partial support for the manpower required to create an EXPReS outreach office (in particular the web-based aspects of this activity) are requested, together with the material costs associated with good quality PR products. We also request support for manpower at the Jodrell Bank Outreach office – their experience and pre-existng "know-how" will be important in the EXPReS project office, realising a critical mass.

Table N4.1. Budget request

Activity	*Participants/Quantity*	*Total Cost (Euro)*	*Requested EC Contribution (Euro)*
Man-power to create organise web-based interface and tools and generate all aspects of PR	JIVE: 1.5 FTEs over 3 years	112500	112500
Man-power to organize administrative aspects of Outreach office	JIVE: 0.75 FTE over 3 years	56250	0
Manpower at UniMan Outreach Office	UniMan: 0.5 FTEs over 3 yr	37500	37500
Materials required for high quality PR products	JIVE: Display Board and Prints €3000; 1000 Brochures €2500; 1000 Promotional Folders €1500; Merchandise €2000	9000	9000
Attendance of EXPReS Outreach officer at Networking events & Consortiun Board Meetings	JIVE: 2 staff at 8 Events @ 1000 Euro	16000	16000
Total Network Cost		231250	175000

The requested contribution from the EC only covers part of the total Networking activity costs. In particular, the manpower to organize administrative aspects of the Outreach office will be provided by JIVE.

5A.4.4. Summary

Table N4.2 ACTIVITY DESCRIPTION (REPORTING PERIOD PLUS 6 MONTHS)

Activity number :	NA4	**Start date: Month 1, Year 1**				
Participant (Short name)**:**	JIVE	UniMAN				
Expected Budget per Participant:	60000	10000				
Requested Contribution per Participant:	40000	10000				

Objectives

The objective is to promote the EXPReS project and the e-VLBI infrastructure to potential end-users, the broader scientific community and the general public. In particular, we wish to emphasise through this activity the role research networks can play in realising distributed research infrastructures capable of conducting unique scientific research. We also wish to ensure that end-users of the e-VLBI infrastructure are well served with information and direct access to the e-VLBI facility. The EXPReS Outreach activity will be closely coupled to the EXPReS Project Management Office and will help ensure that the profile of EXPReS is high at relevant meetings and events. The creation and maintenance of an EXPReS web-site (including Wiki-based project tools – à la RadioNet) will be used as a public (and an end-user) portal to EXPReS and will also fulfil a project management function. NA4 will support the presentation, display and demonstration of the e-VLBI technique at Networking and Scientific events. The success of the activity can be measured by the quality of the PR products, their impact in the media and at networking events.

Description of work

An EXPReS Outreach officer will be appointed (a half-time position) and will be located at JIVE. He/She will be responsible for creating and maintaining the EXPReS web site and the associated management tools and user facilities required to ensure the NA4 objectives are met. He/She will be an active astronomer and will be able to write the text of PR releases and generate all promotional material. The outreach officer will work closely with the EXPReS management team and will be supported by or interact with Outreach administrative staff at JIVE, Jodrell Bank Observatory and DANTE. e-VLBI demonstrations will be organised at networking events and the concept of a distributed research infrastructure will also be promoted at scientific conferences. These events will be attended by EXPReS staff, and EXPReS PR material will be widely distributed. The risks associated with this activity are small; the largest problem is to find an appropriate candidate for the Outreach Officer position. Given the breadth of the EXPReS consortium, we believe an appropriately qualified individual can be identified.

Deliverable No[1]	Deliverable title	Delivery date[2]	Nature[1]	Dissemination Level[2]

[1] Deliverable numbers in order of delivery dates: D1 – Dn

[2] Indicate the month of delivery. This should be relative to the start date of the *I3*, month 1 marking the first month of the project.

DNA4.01	Creation of Public EXPReS web-site	2	O	PU
DNA4.02	Creation of EXPReS web-based management tools	4	O	PP
DNA4.03	Generation of PR material (phase 1)	6	O	PU
DNA4.04	e-VLBI Demonstration and attendance at Network events.	12	O	PU
DNA4.05	Generation of new PR material (phase 2)	18	O	PU
DNA4.06	e-VLBI Demonstration and attendance at Network events.	24	O	PU
DNA4.07	e-VLBI Demonstration and attendance at network events.	36	O	PU

Milestones[3] and expected result:

Major milestones include: (i) The EXPReS web-site goes public and on-line; (ii) Management tools are added to the web-site and used effectively for Project management; (iii) the first PR material is produced and presented at the first iGRID networking event; (iv) EXPReS participates in annual public open-days at JIVE and the other partner institutes involved in such outreach activities; (v) Press release announcing the EXPReS e-VLBI facility as an open, production-level facility open to all astronomers. Other milestones include: the appointment of the EXPReS Outreach Officer.

Justification of financing requested:

The overall costs are mainly associated with the manpower required to employ the EXPReS Outreach staff, in particular the EXPress Outreach officer (€112k) – these costs are spread between JIVE and Jodrell Bank (UniMAN). The financing requested from the EC covers only part of the total cost (€231k). Travel support required to ensure EXPReS is well represented at networking events is also requested, as is material costs for PR products that will also be made available at these events. Community financing is not requested to purchase durable equipment. Community financing is not being used to conclude subcontracts.

5. A.5 Overall Implementation and Co-ordination of the networking activities

A multi-annual execution plan for the EXPReS networking activities is shown below. This includes a detailed execution plan for the first 18 months of the project.

We propose four networking activities in the EXPReS I3, these include NA1 "Management", NA2 "EVN-NREN Forum", NA3 "e-VLBI Science Forum" and NA4 "Outreach,

[1] Please indicate the nature of the deliverable using one of the following codes:
- **R** = Report
- **P** = Prototype
- **D** = Demonstrator
- **O** = Other

[2] Please indicate the dissemination level using one of the following codes:
- **PU** = Public
- **PP** = Restricted to other programme participants (including the Commission Services).
- **RE** = Restricted to a group specified by the consortium (including the Commission Services).
- **CO** = Confidential, only for members of the consortium (including the Commission Services).

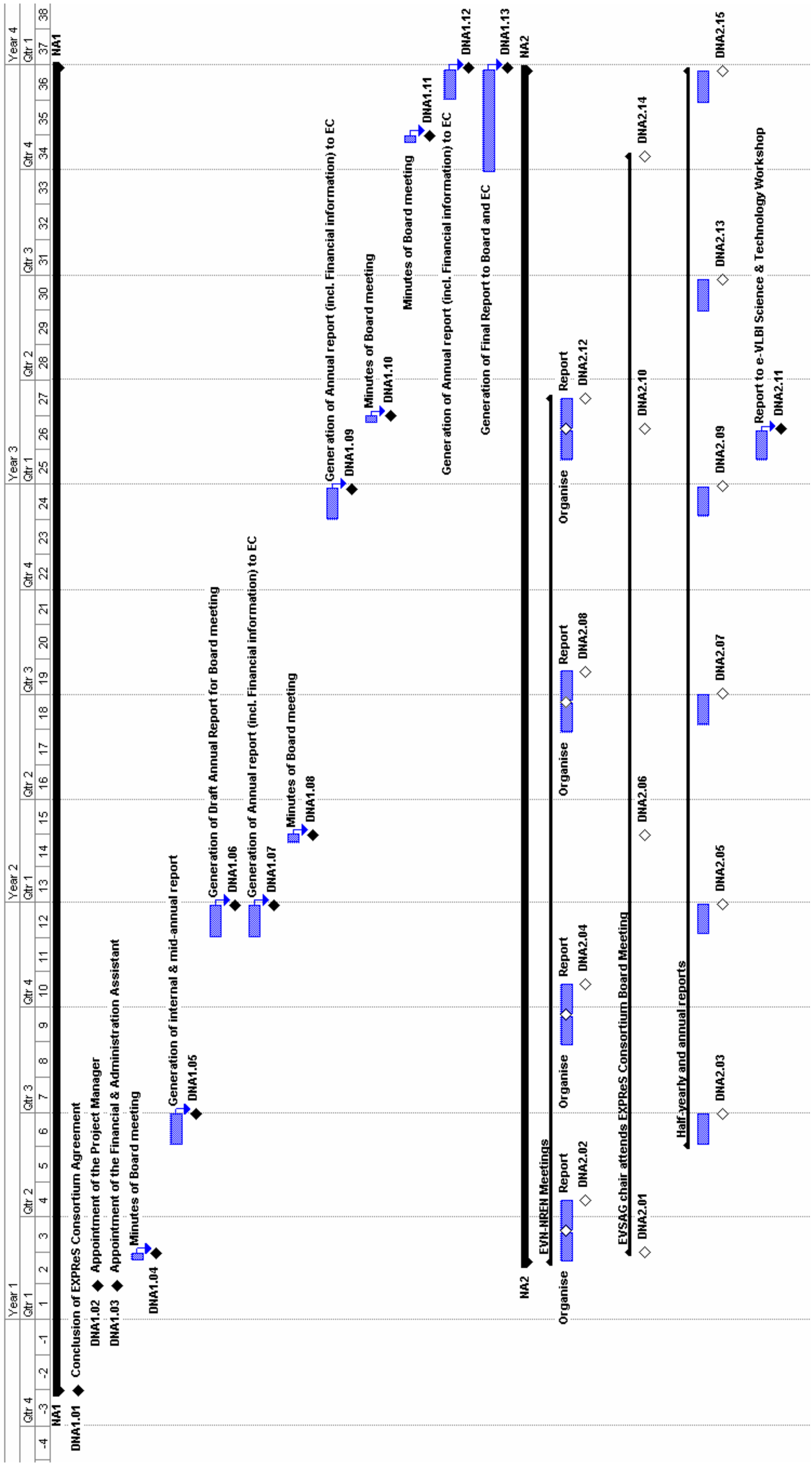
[3] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Dissemination & Communication". Two of these are already in operation (NA2 & NA3), and EXPReS will broaden the scope of these activities and formalize them. NA2 and NA3 have arisen naturally from the EVN-NREN e-VLBI Proof of Concept (PoC) project and they have both been remarkably successful. The EVN-NREN Forum (and the e-VLBI PoC generally) has led to an interesting, but more importantly, an effective collaboration between networking experts, astronomers and radio astronomy engineers. It will be essential to keep this group closely coupled to the EXPReS project, especially the activities that are planned within the service and research activities. There is considerable overlap between membership of the EVN-NREN forum and the e-VLBI Science Forum (NA3). It is part of the culture of the EVN that the end-user community (mostly astronomers) are intimately involved in the specification, design, development and evolution of the instrument, exactly the same culture will be fostered within EXPReS – NA3 has important role to ensure that the wider community is engaged in this process too.

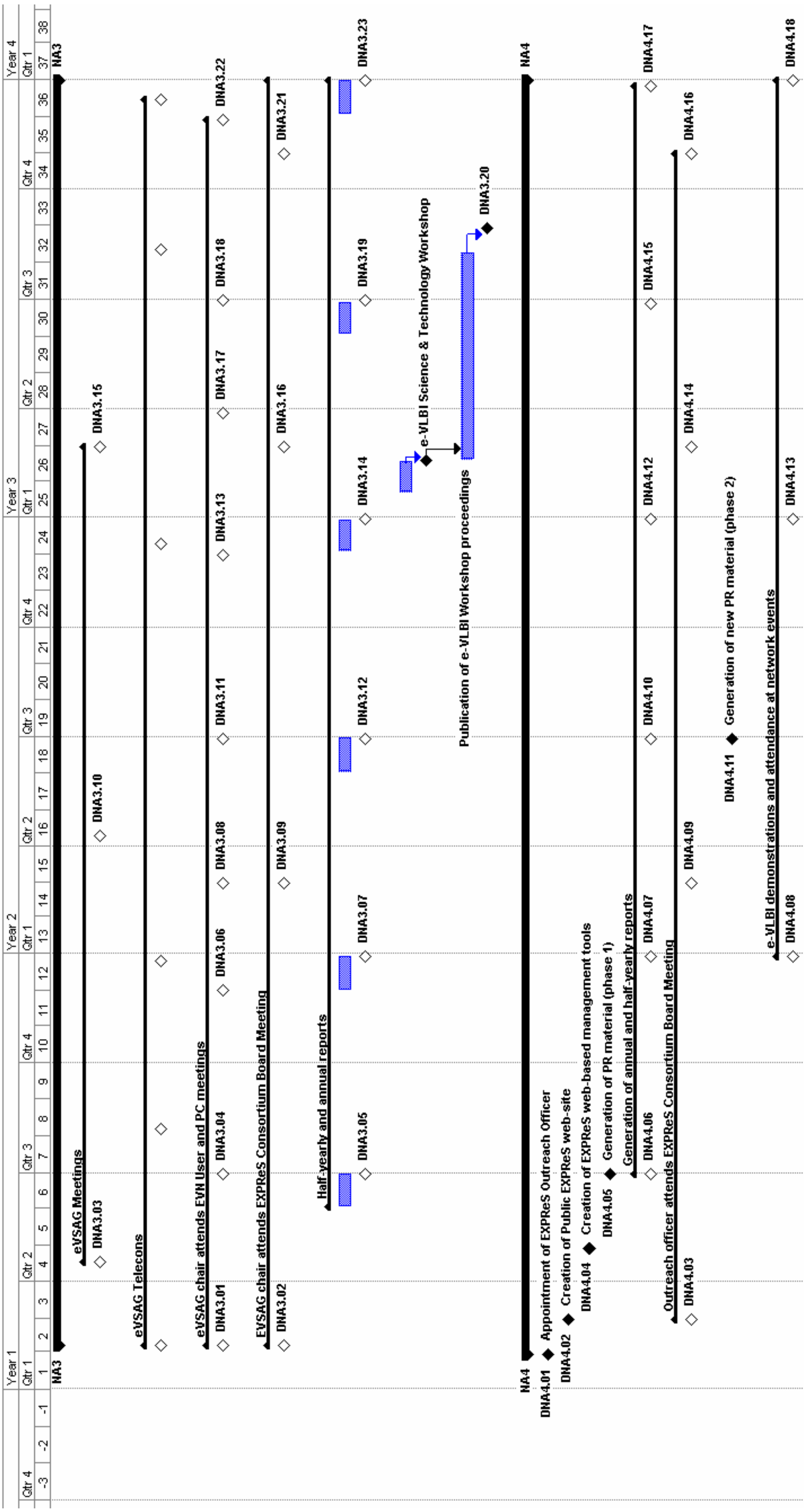
Within the first year of EXPReS we expect the e-VLBI facility to be openly accessible to the international astronomical community – NA3, and in particular the e-VLBI Science Advisory Group, will have an important role in deciding when that should happen and how the facility can best be presented to the community. We expect that by the end of EXPReS, the majority of VLBI observations within Europe will use the e-VLBI technique. This will lead to a sustained use of GÉANT on a scale that has not been seen before – at least with respect to a single application. e-VLBI will access GÉANT over time scales of several months per year, and in addition, there will likely be frequent Target of Opportunity observations, scattered randomly through the calendar year. GÉANT are happy that they have enough spare capacity to easily accommodate this sustained use of the network via the e-VLBI application. The EVN-NREN and Science for will form an alliance that provides crucial support to the EXPReS project and the end-users that stand to benefit from this new e-VLBI facility.

The Outreach, Dissemination and Communication networking activity (NA4) will also have an important role to inform the scientific community and broader general public of the opportunities the EXPReS e-VLBI facility provides, and the exciting science it can generate. It will also play an important part in demonstrating the key role research networks can play in the creation of a distributed infrastructure where the whole is greater than the sum of the parts (*i.e.* the individual radio telescopes and the data processor at JIVE). NA2 and NA3 will act as a source of information for the EXPReS Outreach Office and both sides will be pro-active in identifying results that will be of broad interest beyond the narrow confines of the EXPReS project itself. It will be important to ensure that there is good communication between the EXPReS outreach officer and Dale Robertson (DANTE's Public Relations Manager). There has already been excellent collaboration between JIVE and DANTE, regarding the PR that has arisen via the e-VLBI PoC project, and within EXPReS we aim to maintain and indeed enhance that collaboration still further. In general, all the networking activities have a responsibility to look outwards and beyond the confines of the EXPReS project, seeking synergies with other groups and other leading scientific fields. This is especially true with respect to Grid computing where we aim to increase our connection with groups such as EGEE; in particular the EXPReS JRA1 "FABRIC" aims to thoroughly investigate how the the undeniable potential of Grid computing can be applied to e-VLBI processing (correlation) but the Grid may also be relevant to the calibration and imaging of extremely large wide-field e-VLBI data sets too.

At the same time, the e-VLBI community has its own expertise – we are probably one of the more advanced scientific groups in terms of our ability to take advantage of the GÉANT network – the EXPReS project and the networking activities associated with it, will be an important vehicle to raise awareness within the scientific and academic research community of the possiblilties high-speed research networks can bring. The expertise developed within the e-VLBI community (for example with respect to achieving high data rate transfers usimg advanced public domain protocols) can benefit other groups with similar requirements – we have learned things the hard way, but there is no reason why other groups need repeat this process. All the networking activities of EXPReS are very much motivated towards achieving these goals.



Year 1
Year 2
Year 3
Year 4
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Qtr 1
-4
-3
-2
-1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
NA1
DNA1.01
Conclusion of EXPReS Consortium Agreement
DNA1.02
Appointment of the Project Manager
DNA1.03
Appointment of the Financial & Administration Assistant
Minutes of Board meeting
DNA1.04
Generation of internal & mid-annual report
DNA1.05
Generation of Draft Annual Report for Board meeting
DNA1.06
Generation of Annual report (incl. Financial information) to EC
DNA1.07
Minutes of Board meeting
DNA1.08
Generation of Annual report (incl. Financial information) to EC
DNA1.09
Minutes of Board meeting
DNA1.10
Minutes of Board meeting
DNA1.11
Generation of Annual report (incl. Financial information) to EC
DNA1.12
Generation of Final Report to Board and EC
DNA1.13
NA1
NA2
EVN-NREN Meetings
Organise
Report
DNA2.02
Organise
Report
DNA2.04
Organise
Report
DNA2.08
Organise
Report
DNA2.12
EVSAG chair attends EXPReS Consortium Board Meeting
DNA2.01
DNA2.06
DNA2.10
DNA2.14
Half-yearly and annual reports
DNA2.03
DNA2.05
DNA2.07
DNA2.09
DNA2.13
DNA2.15
Report to e-VLBI Science & Technology Workshop
DNA2.11
NA2


Year 1
Year 2
Year 3
Year 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
NA3
eVSAG Meetings
DNA3.03
DNA3.10
DNA3.15
eVSAG Telecons
eVSAG chair attends EVN User and PC meetings
DNA3.01
DNA3.04
DNA3.06
DNA3.08
DNA3.11
DNA3.13
DNA3.17
DNA3.18
DNA3.22
EVSAG chair attends EXPReS Consortium Board Meeting
DNA3.02
DNA3.09
DNA3.16
DNA3.21
Half-yearly and annual reports
DNA3.05
DNA3.07
DNA3.12
DNA3.14
DNA3.19
DNA3.23
e-VLBI Science & Technology Workshop
Publication of e-VLBI Workshop proceedings
DNA3.20
NA4
DNA4.01 Appointment of EXPReS Outreach Officer
DNA4.02 Creation of Public EXPReS web-site
DNA4.04 Creation of EXPReS web-based management tools
DNA4.05 Generation of PR material (phase 1)
Generation of annual and half-yearly reports
DNA4.06
DNA4.07
DNA4.10
DNA4.12
DNA4.15
DNA4.17
Outreach officer attends EXPReS Consortium Board Meeting
DNA4.03
DNA4.09
DNA4.14
DNA4.16
DNA4.11 Generation of new PR material (phase 2)
e-VLBI demonstrations and attendance at network events
DNA4.08
DNA4.13
DNA4.18

5.B. SPECIFIC SERVICE ACTIVITIES
DESCRIPTION OF THE INFRASTRUCTURE AND SERVICES

5. B.1. SCIENTIFIC & TECHNOLOGICAL EXCELLENCE

5. B.1.1. Quality of the e-VLBI Infrastructure

The European VLBI Network (EVN) is an existing radio telescope array that conducts Very Long Baseline Interferometry (VLBI) of cosmic radio sources at centimetre wavelengths. The EVN is a part-time array, operating in fixed blocks of time through the year. These observing sessions are pre-determined many months in advance. There are at least 16 telescopes that regularly participate in EVN astronomical observations. About a dozen of these are located in EU member states. Each of the EVN telescopes is equipped with state-of-the-art, low-noise radio receivers, connected to data acquisition systems that sample and digitise the radio signal. During VLBI sessions, the EVN telescopes observe the same cosmic radio sources simultaneously. The VLBI data from each telescope are processed by a purpose-built supercomputer (data processor) that was developed and is now operated by the Joint Institute for VLBI in Europe (JIVE), located in Dwingeloo, the Netherlands. Together, the EVN and JIVE form a major research infrastructure – a distributed but coordinated, continent-wide radio telescope. VLBI achieves the highest angular resolution of all astronomical instruments and is crucial to our understanding of the most energetic phenomena in the universe.

By implementing the Specific Service Activities presented in this proposal, we aim to realise a distributed, real-time e-VLBI Network (based on the EVN), in which the data from each of the participating radio telescopes are transferred to the central data processor at JIVE via the European NRENs, GÉANT and other international multi-Gigabit communications research networks.

There are two Specific Service Activities that are required to achieve this goal. The first, SA1, seeks to provide astronomers with a production e-VLBI service. This activity will ensure robust correlation of VLBI data in real-time, realising data flows of up to 1 Gbps per participating telescope. Up to 16 telescopes can be processed simultaneously, realising net data flows of up to 16 Gbps streaming into the EVN Data Processor at JIVE. Currently 5 telescopes in Europe have high-speed network connections to GEANT2. The goal of SA2 will be to extend the number of telescopes than can participate in the e-VLBI array. The goal is for a total of 12 European telescopes to be added to the network. In addition, SA2 has an international dimension, extending the e-VLBI array to Asia, South Africa, South America & USA.

This grid-empowered e-VLBI infrastructure would be unique in the world (and certainly in Europe) and would include some of the largest radio telescopes on the planet (see Figure S1), including the 300-m Arecibo telescope (USA), the 100-m Effelsberg telescope (DE), the 76-m Lovell telescope (UK) and the 93-m WSRT array (NL). This e-infrastructure would offer several important new capabilities that would be of prime interest to the international community and the European astronomical community in particular.

Figure S1: The e-VLBI infrastrucure will connect together the largest telescopes in the world - Arecibo 300-m (top left) and Effelsberg 100-m (top right); the upgraded Lovell Telescope (bottom left) in the UK (as inaugurated by HRH Prince of Wales) and the recently constructed Yebes 40-m telescope (bottom right), near Madrid, Spain.

The advantages of a real-time e-VLBI network include:

- *Very High Sensitivity* – the ability to conduct *sustained* high data observations (up to 1 Gbps per telescope) by a globally distributed 16-telescope array, that is not dependent on expensive and limited capacity magnetic media,
- *Improved Array Reliability* – e-VLBI results in VLBI data being processed in real-tine at the data processor; feedback on the performance of the participating telescopes can be immediately provided by staff at JIVE to the astronomers and engineers located at the telescopes as the observations progress,
- *"Target-of-Opportunity" Science Capability*– e-VLBI produces immediate results, reliably (see point ii). The e-VLBI array that we envisage can rapidly follow-up unexpected transient events (*e.g.* supernova explosions, gamma-ray bursts etc.), without worrying about the logistical aspects of magnetic media, and can automatically generate results on the same time-scale as other real-time instruments. Since transients are usually evolving events (the source is often expanding rapidly and/or fading in brightness) – such

rapid verification of previous e-VLBI observations can be useful in establishing the optimal observing strategy for the next set of observations (*e.g.* choice of telescope array, observing frequency, choice of calibration sources etc.). The rapid delivery of processed VLBI data to the astronomer also means that results relevant to the overall interpretation of a transient event can be published on time-scales that are competitive with other instruments,

- *Rapid Result Service* – In addition to Target-of-Opportunity (ToO) observations, there are several other VLBI applications that would benefit from a more rapid e-VLBI service, these include: (a) geodetic VLBI (and in particular the generation of standard geodetic VLBI products such as Earth-orientation and Earth-rotation parameters) rotation and (b) precision spacecraft navigation. In the latter case, it is crucial to minimise the delay between observing the spacecraft and determining its position. Astronomers would also benefit quite generally in a reduction in the observe/results turn-around time, especially so for observing programmes associated with PhD students/projects. The e-VLBI array we propose would reduce the typical turn-around time between an astronomer observing and obtaining the results from many months to a few days (or even shorter in the case of ToO events),
- *Combined e-VLBI and e-MERLIN observations* – a cornerstone of this proposal is to ensure that the fibre-based e-MERLIN array of radio telescopes in the UK can transparently be connected to the rest of the e-VLBI network and to JIVE. This will enable astronomers to produce high fidelity images of complex radio sources over a large range of angular scales, corresponding to the (inverse) range of telescope separations, from the closest MERLIN telescope separation (a few kilometres) to the most distributed e-VLBI telescope separation (many thousands of kilometres).
- *Flexible & Expanded e-VLBI Operations* – the use of fibre communication networks to transfer VLBI data to JIVE will substantially reduce the labour intensive nature of having to constantly change magnetic media during the course of VLBI observations. Maintaining and tracking the provision and location of media throughout the telescope array, as well as the continuous burden of having to ship the magnetic media to and from the telescopes and the data processor will also disappear. Without these logistical headaches, e-VLBI can permit a much more flexible mode of operation. This raises the possibility of expanding VLBI observations through the year (perhaps using a subset of the full telescope array), while retaining the traditional block-sessions where all telescopes participate.

With these advantages in place, this e-VLBI array would conduct unique research in several different and diverse areas of astronomy. These include: (a) the quiescent and eruptive states of radio stars and exotic x-ray binary systems that exhibit superluminal motions in our own galaxy; (b) the evolution and expansion of supernova remnants and their interaction with the interstellar medium; (c) probing the immediate environment surrounding active nuclei in nearby galaxies from spectral line absorption and maser emission studies, (d) detailed individual studies of nearby star forming and starburst galaxies; (e) distinguishing between starburst and AGN activity in optically faint and distant, high-redshift dust obscured galaxies via deep, wide-field surveys; (f) determining the nature of dark matter, its distribution and the expansion rate of the universe through high resolution observations of gravitational lenses; (g) the classification and determination of the morphology and evolution of compact radio sources and the detailed study of relativistic radio jet physics; (h) 6.7 GHz observations (a frequency unique to the EVN) of methanol maser emission around proto-stars, (high precision astrometry, including the search for planetary companions around the nearest radio stars; (i) precision spacecraft navigation using VLBI techniques as recently highlighted during the ESA-Huygens mission.

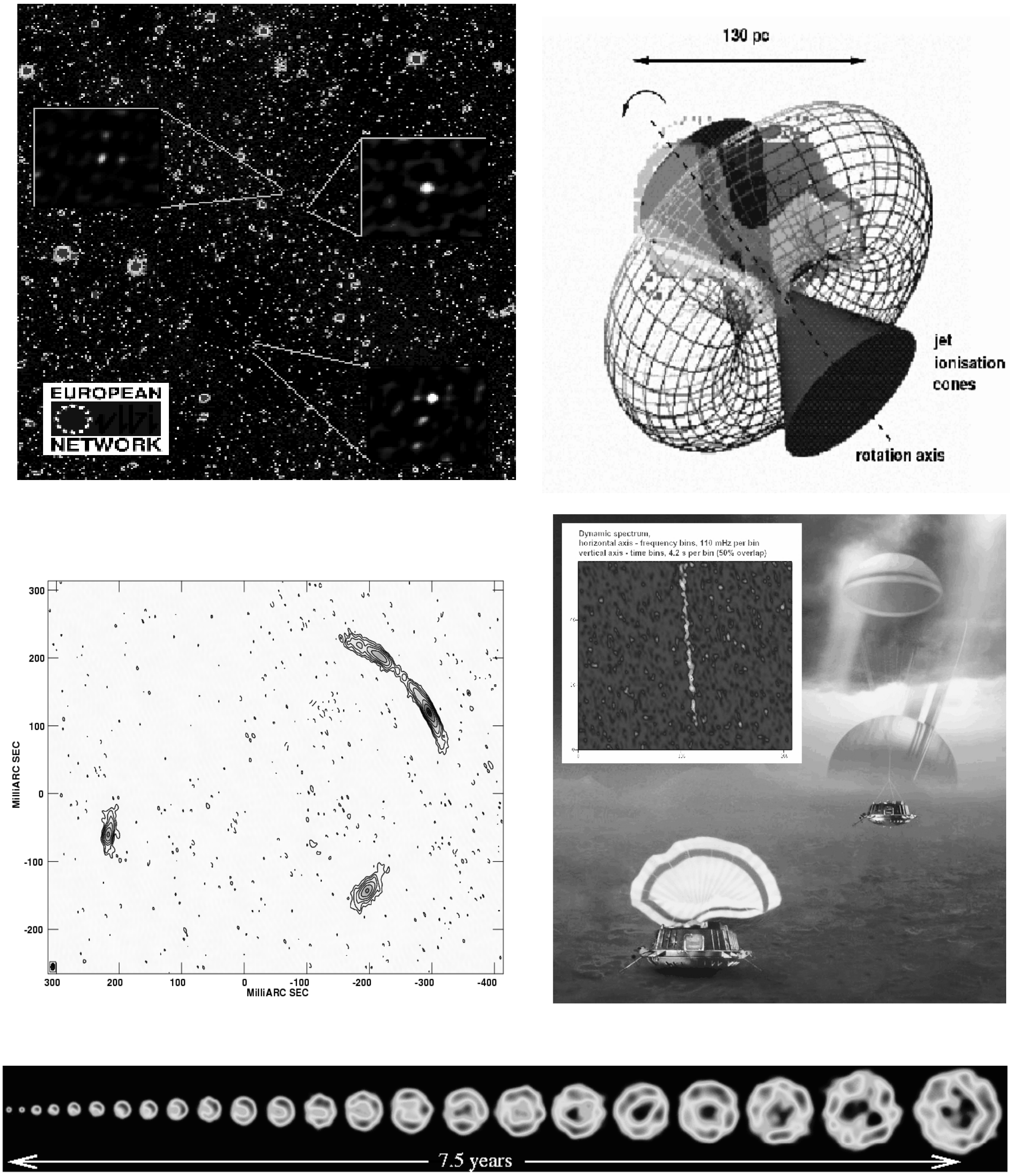


Figure S2: Recent scientific highlights of the EVN - the detection of faint radio source in the Hubble Deep Field (top left), the velocity field of OH emission revealing a torus of gas surrounding the central regions of a nearby star-forming galaxy (top right), High-fidelity mapping of a multiply imaged gravitational lens system (bottom left), Precision tracking of the Huygens probe during its descent on to the surface of Titan (bottom right) and the evolution of a Supernova explosion in a nearby galaxy (bottom).

The e-VLBI Grid-empowered infrastructure is composed of distributed ensemble of radio telescope facilities. These will be integrated together by connecting each of the telescopes to a high-speed National Research Networks (NRENs) and thereafter to the data processor at JIVE in the Netherlands, via GÉANT and SURFnet. The telescopes are mainly located within Europe but VLBI is a global pursuit and we aim to incorporate telescopes in Asia, South Africa, South America and the USA into the e-VLBI network. GÉANT has established (or is in the process of establishing) direct connections with many of the associated NRENs. Each of the telescopes is (or will be) equipped with a standard MkIV VLBI data acquisition system that samples and digitises the telescope signal. The digitised data will be recorded on a Mk5 VLBI recorder system, developed by Haystack, and already widely deployed around this telescope network. The Mk5 will not record data on disk, but will instead stream the data directly onto the network. This has been demonstrated during the Proof-of-Concept tests but at very modest data rates. The data will stream directly from the telescopes to JIVE, each data stream being associated with identical Mk5 units at the data processor. The data will be processed in real-time at JIVE and the output stored on disk. These output data will be calibrated and preliminary radio source images will be generated via an automatic pipeline system. Control of the telescopes, data acquisition systems and the correlator will be conducted via an electronic schedule that runs on identical control computers. This situation largely mirrors the way in which VLBI currently operates, with the exception that the delivery of data to JIVE (and the subsequent processing and pipeline process) is made in real-time. Due to safety regulations, telescope control resides locally, but command of telescope data-flow channels and network connections will be made centrally at JIVE. As with normal VLBI data processing, the original and pipelined VLBI data (including preliminary images) will be made available to astronomers via the EVN archive – a secure, web-based data repository.

A general description of the constituent parts of the e-VLBI network is presented in Table S1.

The constituent components of the e-VLBI infrastructure are essentially identical to the current European VLBI Network facility, with the addition of various network resources, including high-speed (local-loop) connections to the radio telescopes and use of the European NRENs and GÉANT. SURFnet, AARNET and naturally GÉANT are named specifically as constituent parts of the e-infrastructure, as either their participation is essential to the success of the project or their contribution is at a level above and beyond the normal network service provisions that can be expected. The other European NRENs are also involved in the project via Networking Activity NA2. The e-VLBI Proof-of-Concept project already brings together the main constituents listed in Table S1. Members of the EVN and JIVE have a long and successful track record with respect to international collaboration, and a very similar situation exists between the individual European NRENs and GÉANT. The relationship between the EVN and the research networking community is strong and the collaboration is evolving quickly. The construction of a Grid-enabled e-VLBI facility will strengthen these links further – the current collaboration may be seen as a model for engaging other scientific communities, those that are only now emerging as potential network applications.

Table S1 - General description of the constituent parts of the Grid-empowered infrastructure

Name of the constituent parts	
Location (town, country)	**Dwingeloo, The Netherlands**
Web site address	www.jive.nl
Organisation legal name and address	Joint Institute for VLBI in Europe (JIVE) Oude Hoogeveensedijk 4, 7991 PD Dwingeloo, The Netherlands

Facilities made available to the Grid-empowered infrastructure	VLBI Data Processor (Supercomputer), Pipeline data processing, Telescope & User Support, High-speed network connections to GÉANT.
Location (town, country)	Canberra, Australia
Web site address	www.aarnet.edu.au
Org. Legal Name, address	AARNET, GPO Box 1559, Canberra ACT 2601, Australia
Facilities made available	High-speed light-paths from Australian radio telescopes facilities to Europe (JIVE)
Location (town, country)	Oxford, United Kingdom
Web site address	www.dante.net
Org. Legal Name, address	Delivery of Advanced Network Technology to Europe Ltd., City House, 126-130 Hills Road, Cambridge CB2 1PQ, United Kingdom
Facilities made available	GÉANT – the pan-European Research Network which interconnects the radio telescopes to the VLBI Data Processor at JIVE.
Location (town, country)	Poznan, Poland
Web site address	www.man.poznan.pl
Org. Legal Name, address	Instytut Chemii Bioorganicznej Pan, Noskowskiego 12/14, 61-704 Poznan, Poland
Facilities made available	NREN connection from Torun Radio Telescope to GÉANT; access to super-computing GRID facilities.
Location (town, country)	Utrecht, The Netherlands
Web site address	www.surfnet.nl
Org. Legal Name, address	SURFnet B.V., P.O. Box 19035, 3511 CK Utrecht, The Netherlands
Facilities made available	The SURFnet network in the Netherlands - managing the High-speed connection that links JIVE to *all* the other e-VLBI capable radio telescopes; Lamda Networking Technology.
Location (town, country)	Dwingeloo, The Netherlands
Web site address	www.astron.nl
Org. Legal Name, address	Netherlands Foundation for Research in Astronomy, Oude Hoogeveensedijk 4, 7991 PD Dwingeloo, The Netherlands
Facilities made available	The WSRT radio telescope, VLBI data acquisition systems and high-speed network connection.
Location (town, country)	Alcala de Henares, Spain
Web site address	www.cnig.es
Org. Legal Name, address	CNIG-IGN, Observatorio Astronomico Nacional, Campus Universitario, Carretera N-II, km 33,600. E-28871 Alcala de Henares, Spain

Facilities made available	The 40-m radio telescope at Yebes, VLBI data acquisition systems and (via SA2) high-speed network connection
Location (town, country)	Epping, Australia
Web site address	www.atnf.csiro.au
Org. Legal Name, address	CSIRO Australia Telescope National Facility, P.O. Box 76, Epping NSW 1710, Australia
Facilities made available	The radio telescope facilities in Australia, VLBI data acquisition systems and high-speed network connection.
Location (town, country)	Krugersdorp, South Africa
Web site address	www.hartrao.ac.za
Org. Legal Name, address	Hartebeesthoek Radio Astronomy Observatory, P.O. Box 443, Krugersdorp 1740, South Africa
Facilities made available	The 26-m radio telescope, VLBI data acquisition systems and (via SA2) high-speed network connection.
Location (town, country)	Bologna, Italy
Web site address	www.inaf.it
Org. Legal Name, address	Istituto Nazionale di Astrofisica, Istituto di Radioastronomia, Via Gobetti 101, 40129 Bologna, Italy
Facilities made available	The radio telescope at Medicina, VLBI data acquisition systems and high-speed network connection via SA2. The radio telescope at Sardinia (also via SA2) & high-speed network connections
Location (town, country)	Bonn, Germany
Web site address	www.mpifr-bonn.mpge.de
Org. Legal Name, address	Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
Facilities made available	The 100-m radio telescope at Effelsberg, VLBI data acquisition systems and (via SA2) high-speed network connection.
Location (town, country)	Kylmälä, Finland
Web site address	http://kurp-www.hut.fi
Org. Legal Name, address	Helsinki University of Technology, Metsähovi Radio Observatory, Metsähovintie 114, 02540 Kylmälä, Finland
Facilities made available	The 14-m radio telescope, VLBI data acquisition systems and (via SA2) high-speed network connection.
Location (town, country)	Arecibo, USA
Web site address	www.naic.edu
Org. Legal Name, address	National Astronomy and Ionosphere Center, Arecibo Observatory, HC3 Box 53995, Arecibo, Puerto Rico

	00612, USA
Facilities made available	The 300-m Arecibo radio telescope, VLBI data acquisition systems and high-speed network connection.
Location (town, country)	Torun, Poland
Web site address	www.umk.pl
Org. Legal Name, address	Nicolaus Copernicus University, Torun Centre for Astronomy, Dept. of Radio Astronomy, ul. Gagarina 11, 87-100 Torun, Poland
Facilities made available	The 32-m radio telescope, VLBI data acquisition systems and high-speed network connection.
Location (town, country)	Onsala, Sweden
Web site address	www.oso.chalmers.se
Org. Legal Name, address	Chalmers University of Technology, Onsala Space Observatory, SE-43992 Onsala, Sweden
Facilities made available	The 20 and 26-m radio telescope, VLBI data acquisition systems and high-speed network connection.
Location (town, country)	Shanghai, China
Web site address	www.shao.ac.cn
Org. Legal Name, address	Shanghai Astronomical Obervatory, Chinese Academy of Sciences, 80 Nandan Road, 200030 Shanghai, China
Facilities made available	The VLBI capable radio telescopes in China, including VLBI data acquisition systems. High-speed network connections to Shanghai (via SA2).
Location (town, country)	Concepcion, Chile
Web site address	www.tigo.cl
Org. Legal Name, address	Observatorio Geodesico TIGO, Universidad de Concepcion, Camino Einstein Km 2,5. Casilla 4036, Correo 3, Concepcion, Chile
Facilities made available	The radio telescope, VLBI data acquisition systems and (via SA2) a moderate-speed network connection.
Location (town, country)	Jodrell Bank, United Kingdom
Web site address	www.jb.man.ac.uk
Org. Legal Name, address	The University of Manchester, Jodrell Bank Observatory, Macclesfield, Cheshire SK11 9DL, UK
Facilities made available	e-MERLIN and Lovell 76-m radio telescopes, VLBI data acquisition systems and high-speed network connections.
Location (town, country)	Riga, Latvia
Web site address	www.virac.lv

Org. Legal Name, address	Ventspils International Radio Astronomy Center, Ventspils University College, Akademijas laukums 1-1503, LV-1050 Riga, Latvia
Facilities made available	The 32-m radio telescope, VLBI data acquisition systems (to be procured via local funds) and (via SA2) high-speed network connection.

The use of high-speed communication links as proposed here, permits the radio telescopes and the data processor at JIVE (see Figure S3) to connect together to form an interferometric network - the equivalent of a single, integrated radio telescope of continental dimensions, capable of producing high quality radio images of astronomical sources with unprecedented angular resolution. The added value of creating this distributed telescope is enormous – the resolution (level of detail) that can be attained by the e-VLBI array of radio telescopes is 100000 times better than that of a single, unconnected radio telescope, operating in isolation.

Figure S3: The heart of the EVN data processor at JIVE - a purpose-built super-computer developed to process VLBI data.

The facilities offered by the e-VLBI array are considerable. The services discussed in this proposal are specifically related to the radio astronomy community and the international astronomical community more generally. However, many of the EXPReS partners (e.g. OSO, ShAO, TIGO, HARTRAO, INAF, MRO) are also involved in geodetic VLBI where there is significant interest in e-VLBI's capability to provide fast results. We also expect that the e-VLBI infrastructure will be of interest to the spacecraft navigation community. JIVE recently demonstrated the benefits of VLBI, and indeed e-VLBI, as they relate to precision spacecraft tracking in support of space science. We have close links with the ESA community as demonstrated by a letter of interest (see Figure S4).

The e-VLBI array offers real-time VLBI observations and processing, providing astronomers with pipelined data a few days after the observations have been made (or in the case of Target-of-Opportunity (ToO) observations, only hours after the observations are complete). The array will be available at all the standard EVN frequencies, ranging from 1.4 to 22 GHz. Both spectral-line and continuum-mode observations will be offered to astronomers. The e-VLBI infrastructure will also have a rapid science response capability, and will service requests from astronomers for ToO observations of unexpected transient phenomena.

esa

Scientific Projects Department

Dr. M.A. Garrett,
Director
Joint Institute for VLBI in Europe
P.O. Box 2
7990 AA Dwingeloo
The Netherlands

our reference SCI-P-7091-JL

14th March 2005

Dear Dr. Garrett,

On behalf of the European Space Agency, Science Projects Directorate, I am pleased to express our support to the proposal in response to the EC FP6 call for 'Structuring the European Research Area' aimed at developing the electronic VLBI (eVLBI) Infrastructure – EXPReS.

Over the recent years synergy between radio astronomy, space science and space exploration has been demonstrated on many occasions. The latest and most visible example of extremely valuable radio astronomy support to a space mission came from the VLBI Tracking Project of the Huygens Titan mission. This mission culminated on 14 January 2005 with a successful entry in the atmosphere, parachute gliding and touch-down on the surface of Titan. The radio signal from the Huygens Probe was tracked by a VLBI network of Earth-based radio telescopes enabling unprecedented accuracy of trajectory measurements achieved by the JIVE-led team of radio astronomers.

We realise that the Huygens mission defines the cutting-edge of the present day VLBI technology. We also realise that the way forward includes such developments as broadening the observing bandwidth, operating at even higher data rates and providing real-time capability to VLBI observations. In all these developments we clearly see a wealth of potentially beneficial applications for future ESA missions.

I therefore confirm that we maintain keen interest in the success of your proposal and look forward for fruitful collaboration in eVLBI applications for future ESA Space Science missions.

Yours sincerely,

Jacques Louet
Head of the Science Projects Department

Figure S4: A letter of support for EXPReS from the ESA Head of Science Projects Department, Jacques Louet.

The way in which these services will be offered to the community will be based on the same well-established procedures employed by the EVN. In brief, the e-VLBI array will be an open facility in which access is solely dependent on the scientific merit of the observing proposal. Access to the facility will be offered via the standard EVN Call for Proposals system, including the proposal evaluation and selection procedure. The EVN issues, and widely circulates, three Calls for Proposals per year (with 1 February, 1 June and 1 October deadlines). These are propagated via the VLBI e-mail exploder, the EVN home web page and the EVN Newsletter. The e-VLBI service will also be highlighted via the Newsletter of the European Astronomical Society. A major part of the activities of NA3 & NA4 will also involve publicising the scientific opportunities associated with the e-VLBI infrastructure. The Call for Proposals contains (or points to) sources of useful information that may be required to prepare and generate the proposal. In particular, research teams will complete a proposal form that contains a technical description of the e-VLBI (EVN) observations they wish to perform, and a scientific justification. The proposals may be submitted by normal mail (as paper copies) or electronically (via e-mail).

Table S2 - General description of the services provided by the Grid-empowered infrastructure.

	Objectives	User Community served
Specific Service # 1 (SA1)	Provide a production level e-VLBI service. The objectives are to make available to the user community a real-time e-VLBI infrastructure that is *open to all* and capable of conducting state-of-the-art scientific research. The facility will offer end-users unique capabilities, especially in terms of Target-of-Opportunity observations.	Radio astronomy, geodesy, spacecraft navigation.
Specific Service # 2 (SA2)	Network Provision for a global e-VLBI array. The objectives are to expand the network of e-VLBI capable telescopes, *i.e.* to increase the number of radio telescopes with high-speed network connections in order to realise an e-VLBI infrastructure than is distributed across Europe and beyond.	Radio astronomy, geodesy, spacecraft navigation.

5.B.1.2. QUALITY OF THE MANAGEMENT

Decision making structures, communication flow and rights & responsibility

The management of the e-VLBI infrastructure will be the prime responsibility of the European VLBI Network (EVN). The role of EXPReS itself will be to realise a distributed e-VLBI production facility, extending across Europe and beyond. The EXPReS consortium will manage the programme of Networking, Specific Service and Joint Research activities – all of which are required in order to realise that goal. The EVN will operate the e-VLBI facility, following the standard management structure and operational procedures that are already in place for the EVN. All the radio telescopes that will participate within the e-VLBI array are current members of the EVN with the exception of VIRAC (Latvia), which is in the process of being upgraded to EVN standards, and is an aspiring EVN member. The overall coordinator of EXPReS (Dr. M.A. Garrett) is a member of the EVN Consortium Board of Directors. He has eight years of experience as a project manager of several EC funded Transnational Access contracts, was coordinator of FP5 RadioNet and is a member of the RadioNet FP6 board of directors. He is also leading European astronomer, active in many different aspects of radio astronomy. Since the coordinator of EXPReS is also a member of the EVN Board, he will report to the board on progress being made in the context of the EC project. The EVN board will critically view progress being made in realising the e-VLBI infrastructure.
The EVN was formed in 1980 by a consortium of five of the major radio astronomy institutes in Europe (the European Consortium for VLBI). Since 1980, the EVN and the Consortium has grown to include 9 institutes with 11 telescopes in 8 EU states, as well as other member institutes with telescopes in China, South Africa and the USA. All these institutes are participants within EXPReS. The Grid-empowered e-VLBI facility will also be managed by the EVN Board of Directors. Members of the board are the Directors of the individual radio astronomy institutes (including JIVE), plus the BKG (operator of the Wettzell telescope in Germany, and the major geodetic VLBI institute in Europe). The Board of Directors meets every 6 months and receives reports from the EVN officers (the EVN Scheduler, Selection Panel chairperson & chairperson of the Technical Operations Group). The EVN Programme Committee (observing project selection panel) will evaluate e-VLBI proposals submitted by researchers in response to the published EVN & e-VLBI Call. It is composed of 12 distinguished astronomers with a mixture of both scientific and technical expertise. Four members of the panel (currently including the PC chair) are independent *i.e.* they are not affiliated to any of the EVN institutes. PC members are appointed by the EVN Consortium Board of Directors.

If an e-VLBI proposal has been favourably evaluated by the EVN Programme Committee, details of the proposed observations (duration, observing mode, time-critical aspects etc) are passed by the PC chair to the EVN scheduler. The scheduler will inform the leader of the e-VLBI research team when the observations will take place by distributing an electronic version of the e-VLBI observing session. The e-VLBI Support Scientist (see SA1) will be assigned to provide scientific support to the research team. Since the e-VLBI facility will be a distributed network of radio telescopes, the e-VLBI observations are necessarily performed in absentia; the astronomer will control the telescopes via the electronic schedule or "e-Schedule". It will be the responsibility of the research team to generate an observing schedule (the latter is self-contained and will control all the radio telescopes, plus associated e-VLBI equipment, e.g. Mk5 network units, observing frequency etc.). Comprehensive scheduling assistance will be provided by the e-VLBI Support Scientist. This "e-schedule" will be created by new, public domain e-VLBI scheduling software, based on existing VLBI software. It will be the responsibility of the EVN Consortium and the e-VLBI array to provide the astronomer with useful data. Observations that result in the failure of more than 1/3 of the data will be re-observed automatically. Some revision of these procedures may be necessary in order to properly support ToO observations, but existing arrangements will suffice initially and will naturally evolve in the long term.

Research teams that observe with the e-VLBI array will have a very high degree of independence from the network. The EVN's role is to provide the processed data requested and justified in the original proposal and scheduled by the EVN scheduler. Thereafter the execution of the research project itself is considered the responsibility of the research team itself, not the network. Research teams will choose the level of scientific and technical support they require. The interpretation of the processed data is always the *sole* responsibility of the research team.

Scientific, Technical & Logistical Support

e-VLBI astronomers will be invited to visit JIVE (the central VLBI data processor) at the time the e-VLBI observations are actually being made. In the past this was not a useful option, but with a real-time instrument with immediate feedback to both the individual telescope staff and the astronomers, we believe the simultaneous and active involvement of *all* participants will result in a crucial "cultural change" in the way VLBI is conducted. For the first time it will be possible to fully connect the astronomer with the instrument, able to make changes to the observing strategy as events unfold. Such changes might include modifications to not only the observing strategy but also the data processing (correlation) parameters. While this is a common scenario for most non-distributed, real-time, astronomical instruments, it is virtually unknown in the case of VLBI. It will of course also be possible for the astronomer to monitor events remotely.

As the data flows from the data processor, the visiting astronomer will be able to observe the automatic pipeline processing of the data. This process will be fully supported by the e-VLBI support scientist. He or she can provide expert advice and "hands-on" assistance in order to ensure good progress is made. The support scientist will also ensure that the visitor's logistical needs are met. Support Scientists are post-doctoral fellows conducting their own programmes of research and are often available outside normal working hours. The processed and pipelined data (images) will be available to the astronomers via the standard EVN archive (naturally this can also be accessed remotely via the same high-speed internet that was used to accommodate the original telescope data flows). The data generated by the e-VLBI array will be subject to the same proprietary rules as EVN data. Specifically, the data generated by the EVN data processor at JIVE will be the sole preserve of the lead astronomer and his or her research team – the group that submitted the original research proposal. After 12 months, the data will be freely accessible by all via the EVN archive – this follows the standard EVN data policy. The rights of access to the data then enter into the public domain.

Both the processing and analysis of e-VLBI data requires specialised computer software running on high-end Unix workstations and for large wide-field or spectral-line data sets, on computer (Grid-based) clusters. Often such software will not be available at an external users own institute, and its installation and maintenance is often non-trivial. We expect many e-VLBI astronomers from universities where these facilities (specifically the software environment) may not be readily available. We will invite all e-VLBI users to visit JIVE in order to optimally analyse their data with the direct support of a dedicated e-VLBI support scientist. The goal is for visitors to leave JIVE with a final e-VLBI image (or spectrum) of the astronomical object(s) proposed in the original proposal, only a few days after the observations were made. At this stage the research team should be in a position to begin to write-up the observations as a scientific research paper and present the results at astronomical meetings.

JIVE and its host institute, the Netherlands Foundation for Research in Astronomy (ASTRON), moved into a new building at the end of 1996. Modern, on-site visitor accommodation (including kitchen facilities) is available to visiting scientists. JIVE provides permanent office space for five visiting scientists. Six high performance computer workstations are dedicated to visitors who wish to analyse VLBI data, a 16-node Cluster Computer is also available. A library that stocks all the major astronomical journals is also freely available to visitors. Visitors to JIVE can therefore expect outstanding levels of scientific and logistical support. In addition, JIVE and ASTRON jointly organise weekly colloquia and less formal “Astro-Lunch” clubs. Speakers usually include internationally recognised researchers who are visiting one of the institutes. JIVE staff are familiar with the VLBI technique generally but several are experts in their own fields, including spectral-line VLBI, faint source detection, polarisation calibration, wide-field imaging, astrometry, space VLBI and precision spacecraft navigation techniques. Astronomers who visit the JIVE and EVN facilities are therefore exposed to a stimulating, international research environment, and are in a perfect position to forge important links with some of the main players in European astronomy.

5. B.1.3. EUROPEAN ADDED VALUE AND IMPACT

Interest in the e-VLBI infrastructure & Impact

The e-VLBI infrastructure that we plan to create has many advantages over the current EVN array. These have been presented in section 1. By the end of the 3-year EXPReS programme, we expect that a substantial fraction of EVN users will have taken advantage of the new capabilities e-VLBI will provide. Currently the total number of users given access to the EVN in a typical year is 300. Of these 300 about half are affiliated to the EVN institutes and the other half are external users. The latter are mainly located in Europe, USA, Australia, and Japan.

The EVN is widely recognised as one of Europe’s major research infrastructures. Access to the EVN for external, European astronomers, has been funded by the EC’s Transnational Access Programme since FP3 (1992). This programme of support has continued across FP4, FP5 and most recently FP6 – as part of the RadioNet I3 collaboration. We expect a significant increase in the astronomical community’s interest in using the European VLBI Network if it is able to provide a real-time capability. In particular, the ability of an e-VLBI array to conduct Target of Opportunity observations will be an important advantage in attracting additional users. The ability of the e-VLBI infrastructure to deliver immediate results will make it unique in VLBI, and we can expect significant interest in this new potential capability.

An additional factor in this area is that we also expect Target of Opportunity projects to become more frequent, especially with the recent and successful launch of the NASA SWIFT observatory. This is equipped with several instruments that make it an ideal observatory for the detection of a variety of transient astrophysical sources, and we can expect that some fraction of these will also result in the generation of prompt and compact radio emission.

We expect the results that are obtained via the proposed e-VLBI infrastructure will have most impact within the international astronomy community. As is the case for EVN results, new knowledge obtained form the e-VLBI array will be published in peer-review astronomical journals, including *Astronomy & Astrophysics, Astrophysical Journal, Monthly Notices of the Royal Astronomical Society* etc. Outstanding results (often associated with transient events) are likely to be published in journals such as *Nature* and *Science.*

We will also expect astronomers to present their results at various international meetings, conferences, symposia, *etc.* In particular, e-VLBI results will feature in the biennial EVN Symposia that are held at one of the EVN institutes. Inexperienced e-VLBI users will also attend radio interferometry schools (supported by RadioNet) where the e-VLBI technique will form part of the curriculum. We also hope to generate Press Releases (via Networking Activity NA4) that will present those results of EXPReS that will be of particular interest to scientists in other fields, the communication network community and the general public. Interest in astronomy is large in all walks of life – we expect results from the e-VLBI array to feature prominently in Press Releases associated with EXPReS.

Telecommunications connectivity services

We propose to use EC financing to upgrade the telecommunications connectivity of the radio facilities that are involved in EXPReS, particularly those that are elements of the e-VLBI infrastructure (see SA2). Commercial and contractual activity will be an important part of building and operating the e-VLBI infrastructure. In all cases, the EC's contribution to the network provisioning will always be very much less than 50% of the total costs. It should be noted that in order to connect some remote radio telescope sites, the total cost of network connectivity may run to several million Euro. It will be important in these cases (but indeed in all cases) that the radio observatories adhere to the appropriate standards of public procurement, in particular the tendering process, contract publication, award procedures/criteria, also taking into acount social policy and other measures that ensure that a competitive and fair bidding process takes place. In particular, the EXPReS Consortium members agree to comply with all aspects of the rules of public procurement, as they apply nationally and within the European Community itself.

The developers and operators of GÉANT, DANTE (and indeed the other EXPReS NRENs), have an enormous amount of experience in public procurement of network infrastructure. They will play an important role in guiding the e-VLBI radio telescopes with respect to this activity (SA2). In addition, several EVN observatories have already gone through the process of procuring or leasing network infrastructure, in particular Jodrell Bank Observatory recently negotiated the provision of 600 kilometres of dedicated dark-fibre for e-MERLIN, signing a multi-million Euro contract with Fujitsu and Global Crossing. In addition, 80 km of new fibre have been installed along minor roads in order to connect the e-MERLIN telescopes to the trunk fibre. The other observatories at Onsala Space Observatory (SE), Westerbork Array (NL), Torun Radio Observatory (PL) and JIVE (NL) have also successfully negotiated their own high-speed network connections (see Figure S4).

Figure S4: Fibre being installed at JBO (2004) and JIVE (2002).

The nature of EXPReS, and in particular the fundamental objective of creating a distributed real-time radio telescope of continental dimensions, offers network suppliers an attractive opportunity to be involved at the leading edge of large-scale scientific networking. We hope to establish some good but fair deals in an atmosphere of general cooperation. It is possible that a certain amount of re-tendering, in particular for connectivity, might take place as networking technologies continue to develop.

5. B. 2 SPECIFIC SERVICE ACTIVITY 1: PRODUCTION E-VLBI SERVICE

5. B.2.1. Scientific and Technological excellence

5. B.2.1.1 Objectives and originality of the service activity

A two-year, proof-of-concept investigation has confirmed that real-time, gigabit-scale e-VLBI is possible using existing radio telescope data acquisition technology and the capacity provided by the National Research Networks and the pan-Europe Research Network (GÉANT). The primary aim of Service Activity 1 (SA1) will be to integrate these resources into a production-level, e-VLBI service, and in particular ensure that the VLBI data processor at JIVE is able to reliably process (in real-time) net e-VLBI data streams of up to 16 Gbps.

Experimentally, real-time e-VLBI has been achieved by manual adjustment, quick-fixes and ad hoc coordination. For production grade real-time operation, these disjoint operations must be integrated into a coherent whole. This will require the re-engineering of software structures and the creation of new software services to merge functionality and manage end-to-end performance. In particular, we must achieve and reliably process data rates that are an order of magnitude greater than that demonstrated by the e-VLBI Proof of Concept (PoC). SA1 activities will be implemented in such away that expansion of the e-VLBI telescope array is supported. In particular, provision will be made to ensure that the UK MERLIN network (currently being upgraded to e-MERLIN, an interferometer array connected using dedicated fibre-optic networks) can participate as a component of the e-VLBI infrastructure. SA1 will include provision for the addition of this and other new data sources (e-VLBI capable telescopes –see SA2) as they become available. The implementation of the project is designed to be flexible to ensure that any potential for new modes of operation that enables new kinds of science, offered by real-time operation, can be fully realised. In particular, the ability to respond to Targets of Opportunity (ToO) will be cultivated. One of the important limitations of traditional VLBI is the long delay between observation and evaluation of data. Transitory events and processes that develop on short time scales require multiple observations, ideally with the ability to adjust and refine the observing parameters in a way that immediately maximises the scientific return. This is a mode of operation that most other astronomical instruments can achieve but VLBI is unable to complement. SA1 will include a work package that develops the ability to analyse data on-line and adaptively reschedule further observations.

The following work-packages describe the activities that are required in order to realise the goal of a production grade, distributed e-VLBI infrastructure service:

WP1 Operational Improvements for e-VLBI: Changes are needed in the various software modules used to control operations at telescopes and the data processor. Real-time operation, by definition, requires the automation of several processes. In addition, the fact that human operators are present for non-real time VLBI has, historically, lowered the priority for automation of many other functions. Interruptions and delays that represent a small proportion of the current operational overhead become significant in a real-time system and must be streamlined. A number of off-line utilities that convert the observer's requirements into detailed equipment configurations and actions, at telescopes and the data processor, must be revised. They must first be purged of all irrelevant functions concerned with magnetic media. The data entry path will also be changed. Data entry to these utilities is currently via a pre-prepared, strictly formatted text file. In a later work package an on-line data entry console will be created to facilitate rapid changes to the observation and data processor configuration. This will require a new data entry interface.

The technique of VLBI requires accurate positions of the telescopes and the target source. The Earth is not a stationary platform however, so a precise geometric model, synchronised to wall-clock time is used to dynamically track the positions of all components of the system. In normal VLBI the observe-time reference clock is re-created during correlation, but in a real-time system wall-clock time and observe-time are one and the same. Experimentally the alignment of these clocks has been achieved manually. This work package will automate this synchronisation and optimise the sequence of events for real-time operation.

WP2 Data transmission developments: All tasks associated with moving data from the telescopes to the data processor across the R&E networks are collected in WP2. A first step will be to centralise control of the data-link. This will require the creation of client code for the end systems and a controlling application, synchronised to other real-time processes and system configuration parameters. The first generation of network interface for e-VLBI transparently transports data (in existing formats) from telescope to data processor. However, these formats are restricted to a series of "octave" data rates that prevent efficient use of network bandwidth. New application layer code will be written to allow frequency channels to be mapped to individual IP streams. This will permit network demand to be matched to network capacity with finer resolution. VLBI has data transmission needs that are quite different from many other applications. The signal collected by the telescopes is broad-band Gaussian noise. Useful information is extracted by correlating data from two telescopes to locate and characterise the signal that is common to both. This is revealed after averaging over many millions of samples. Errors in the data from one antenna are thus eliminated in the process and error rates can be high by normal communication standards. Errors of 1 part in 10^5 bits or even occasionally 1 part in 10^4 are acceptable. To maintain a reliable continuous flow of data is of far greater importance however. A network protocol that suitably favours data flow in preference to data integrity must be identified and integrated into the applications used to implement the data link between telescope and data processor. The selected protocol must also have the technical and political support of the R&E network providers. Current experience has shown that the success of e-VLBI depends heavily on the status of the intervening network. If bottlenecks can be located precisely and quickly it is often possible to take corrective action. Where this is not possible there may be scope to adjust the parameters of the observation to make best use of the bandwidth available. Adequate network monitoring is therefore vitally important. Suitable monitoring clients will be identified and deployed across the networks and tools for integration and presentation of network status information will be prepared. Important network statistics will be compiled into a database and strategies for optimum network utilisation will be devised and implemented.

WP3 Target of Opportunity Support: The first task of this work package will be to provide a means of rapidly evaluating the radio astronomy source targets. The tool currently available during correlation is a single baseline fringe display. This gives a powerful end-to-end, diagnostic check of the technical performance of the system, but provides no information to the scientist about the nature of the observed source. In fact a recognisable fringe display is usually only possible when a strong calibration source is being observed. Instead the ability to display an evolving calibrated "visibility" plot of much fainter sources will be developed. Once an evaluation of the initial observation has been made the next step is to modify the parameters and/or subject of the experiment. In the current system this is a manual operation and a complete re-run of the observation and correlation job is required. Tools to enable selective adjustments to be made will be developed. To enable more comprehensive evaluation of an initial observation, a real-time pipeline will be created, generating results from available data as an observation progresses.

WP4 Real-time Monitoring Functions: A significant benefit of real-time operation is that telescope faults can be isolated, diagnosed and corrected during the observation. This can only be achieved if adequate feedback of the technical status of the array are available to telescope and data processor operators. This work package will provide these facilities. Currently, telescope operators can confirm that VLBI data are correctly formatted and are able to check error rates. When data are flowing directly into the data processor however, these functions are largely redundant. Data processor fringe checks confirm more comprehensively the accuracy, stability and coherence of the entire data path. Existing monitoring functions will be modified and enhanced to enable the outcome of these powerful checks to be monitored by everyone involved in the technical performance of the experiment. Additional data processing and presentation tools will be developed as necessary.

WP5 Data Processor Upgrades: The existing data processor input is designed to receive data from tape, which is naturally a continuous flow of parallel streams. New digital equipment for data acquisition will make use of disk and/or network technologies, where the natural data format is a "file." Plans are therefore already in place to remove many redundant features of the current system. The international VLBI community has agreed to a standard interface for future VLBI data transport systems called "VSI" (VLBI Standard Interface), which takes account of this trend. Work Package 5 includes a task to absorb these new standards when they become available – new interfaces will be required and some changes to embedded software modules will be necessary. As the e-VLBI array expands to include more telescopes, improved and expanded facilities to connect these to the data processor will be needed. The current network installation routes a separate Gigabit Ethernet line to each network interface unit. In an expanded array more lines will be needed. A more flexible network interface will also be beneficial, allowing data from multiple sources, at sub-gigabit rates, to be carried on individual Gigabit Ethernet lines.

WP6 Addition of MERLIN Telescopes: The upgrade to VSI included in WP5 will enable VSI equipped data sources to be incorporated into the e-VLBI array. One such candidate is e-MERLIN in the UK. It will be efficient to enhance e-MERLIN with suitable VSI outputs since the two projects will proceed in parallel. This work package supplies the additional effort needed at Jodrell Bank to achieve this and associated support at JIVE.

WP7 Tests and Demonstrations: Experience has shown real progress is only made with regular, live tests. Once every six weeks, available telescopes will join an e-VLBI test. Instrument and staff time at the telescopes and data processor, represent a large and self-financing contribution to the project.

Europe is currently leading the way in the exploitation of e-VLBI as a new scientific tool for astronomy. The current Proof-of-Concept (POC) tests have demonstrated the e-VLBI distributed array concept at data rates of up to 64 Mbps per telescope. The PoC generated the first e-VLBI image (from 3 telescopes) and the first e-VLBI science demo (from 5 telescopes). The success of the PoC has a lot to do with the excellent research network facilities within Europe (in particular GÉANT), and the strong scientific motivation and technical competence of the radio observatories and JIVE. The activities we propose in SA1 will lead to a production grade real-time e-VLBI infrastructure. It will be a unique international astronomical facility – not just in Europe but in the rest of the world. As the EXPReS work programme is implemented, the current (albeit limited) e-VLBI service will not be disrupted. On the contrary, our aim is to ensure that end-users will see a constant improvement in the capability and reliability of the e-VLBI service through the course of the contract. It is estimated that the end-user community will be able to take advantage of the EXPReS SA1 work programme within the first nine months of the project start date, and within 18 months a basic e-VLBI service will be available for regular use. The comprehensive support provided to astronomers that use the EVN (in particular the personal assignment of JIVE Support Scientists), will be transparently expanded to the e-VLBI service.

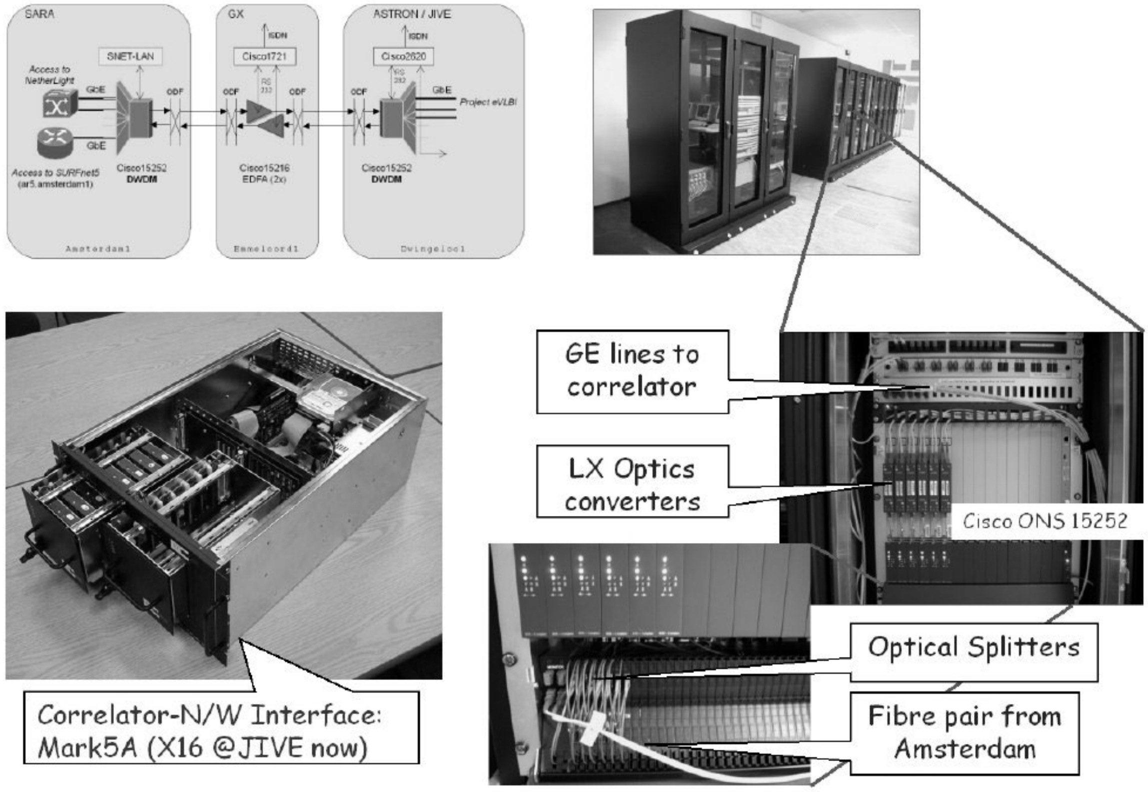


Figure SA1.1: Details of the advanced, DWDM fibre-optic link between JIVE and the Amsterdam Internet Exchange. Separate wavelengths in a single fibre-pair are seen as Gigabit Ethernet lines terminating in the ASTRON central computer/network facility. From there, internal optical fibres carry data to the correlator via Mark5 interface units. The six lines available now need to be expanded to sixteen, enabling the full capacity of the existing correlator to be exploited. The installed fibre trunk carries additional unused fibres that can be lit in the future to provide virtually unlimited capacity in and out of JIVE.

5. B.2.1.2 Execution-plan of the service activity

An indicative multi-annual execution plan is shown in Figure SA1.2. A summary of the various work packages is also provided here.

Table SA1.1: WORKPACKAGE SUMMARY				
Work package	**Objectives**	**Effort (FTE)**	**Resource**	**Deliverable**
WP1 Operational Improvements for eVLBI	Revise and augment observation/correlation software and associated utilities for real-time operation.			

1.1 Job preparation utilities	– Purge utilities of non-relevant actions – Optimise for real-time case.	0.5	SWE	Job preparation utilities
1.2 Data processor control with respect to wall-clock time	– Optimise data processor control software to run in real-time. – Minimise need for manual intervention. – Integrate data-link control.	0.7	SWE	Real-time data processor control software
1.3 Testing	– Testing support	0.5	SS	
WP2 Data transmission developments	Actions to improve the data rate and robustness of e-VLBI data transfers across the R&E networks			
2.1 Central data link control	Create integrated tool for setting up and controlling data-links from a single location	0.3	NWE	- End systems client code - Controlling application
2.2 Application layer improvements	Re-arrange mapping of data to IP streams to enable full use of available network bandwidth.	1.0	NWE	Improved network applications
2.3 Transport protocol evaluation and selection	Determine which of the available protocols is optimum for e-VLBI.	0.5	NWE	Protocol decision
2.4 Network monitoring	– Deploy monitoring clients across the networks. – Prepare tools for integration and presentation of network status information. – Devise and implement strategies for optimum network utilisation.	1.0	NWE	- Monitoring client - Tools and databases - Strategies
2.5 Testing	– Testing support	0.5 0.1	SS HWE	
WP3 Target of Opportunity Support	Facilitate and allow dynamic scheduling of the observation.			
3.1 Visibility Monitoring	Facilitate rapid evaluation of observational targets.	0.4	SHE	Visibility monitor
3.2 Fast/adaptive re-scheduling	Enable rapid and selective revision of observational objectives and parameters.	0.5	SSHE,	Fast/adaptive scheduling tools
3.3 Adaptive scheduling for data processor operation.	Corresponding selective control of data processor operational parameters.	0.5	SHE	Selective data processor controls
3.4 Real-time pipelining	Full pipeline for thorough evaluation enabling early follow-up observations	0.4	SHE	Software modules
3.5 Testing	– Testing support	0.5 0.1	SS HWE	

WP4 Real-time monitioring functions	Provide feedback to telescopes and data processor enabling operators to achieve optimal performance and to isolate and correct faults during the observation.			
4.1 Monitoring processes	Software modules to monitor VLBI system status and data quality.	0.5	SWE	Monitoring processes
4.2 Information handling	Collection, manipulation and storage of information.	0.5	SWE	Monitor information handling modules
4.3 User interfaces	Web interface, secure user log-in, user input, visualisation.	0.5	SWE	Monitoring user interfaces
4.4 Testing	– Testing support	0.5 0.1	SS SHE	
WP5 Data processor upgrades	Data processor hardware upgrades to remove redundant, tape-media specific elements and otherwise optimise infrastructure for eVLBI.			
5.1. VSI Hardware changes	Upgrade disk/network interface to VSI standard.	0.6	HWE	- Upgraded interface - Serial links
5.2. VSI Software changes	Adjust corrlelator control software to operate in VSI hardware environment.	0.3	SWE	VSI support software
5.3. Flexible local GE network	To allow flexible data processor/telescope mapping	0.2	NWE	Flexible local GE network
5.4 Testing	– Testing support	0.5	SS	
WP6 Addition of MERLIN telescopes	e-MERLIN enhancements enabling MERLIN telescopes to be added transparently to the e-VLBI array			
6.1. e-MERLIN VSI interfaces	Provide direct digital output from multiple e-MERLIN telescopes for transmission to JIVE using VSI protocol.	1	SDE	VSI interfaces
6.2 Testing	– Testing support	0.5	SS	
WP7 e-VLBI tests and Demonstrations	Live tests of e-VLBI approximately once every six weeks. Each test will consume 8 hours of VLBI network time. Normal telescope and data processor operational costs of €3.5k/hour will be absorbed by the EVN. For 26 tests over the life of the project this amounts to an equivalent contribution of €728k.			
Labour Totals: FTE		12.7		
k€ (@75k)		952.5		

Material Costs:

Work package.task	Item	Cost (k€)
5.1	Data processor network interface upgrade	100
5.1	New serial links	20
5.3	New network infrastructure	100
6.1	VSI conversion modules	30

Resources:

SWE:	Software Engineer	3.0 FTE	SHE:	Software/Hardware Engineer	2.7 FTE
NWE:	Networking Engineer/Specialist	3.0 FTE			
SDE:	Senior Digital Engineer	1.0 FTE	SS:	Support Scientists	3.0 FTE

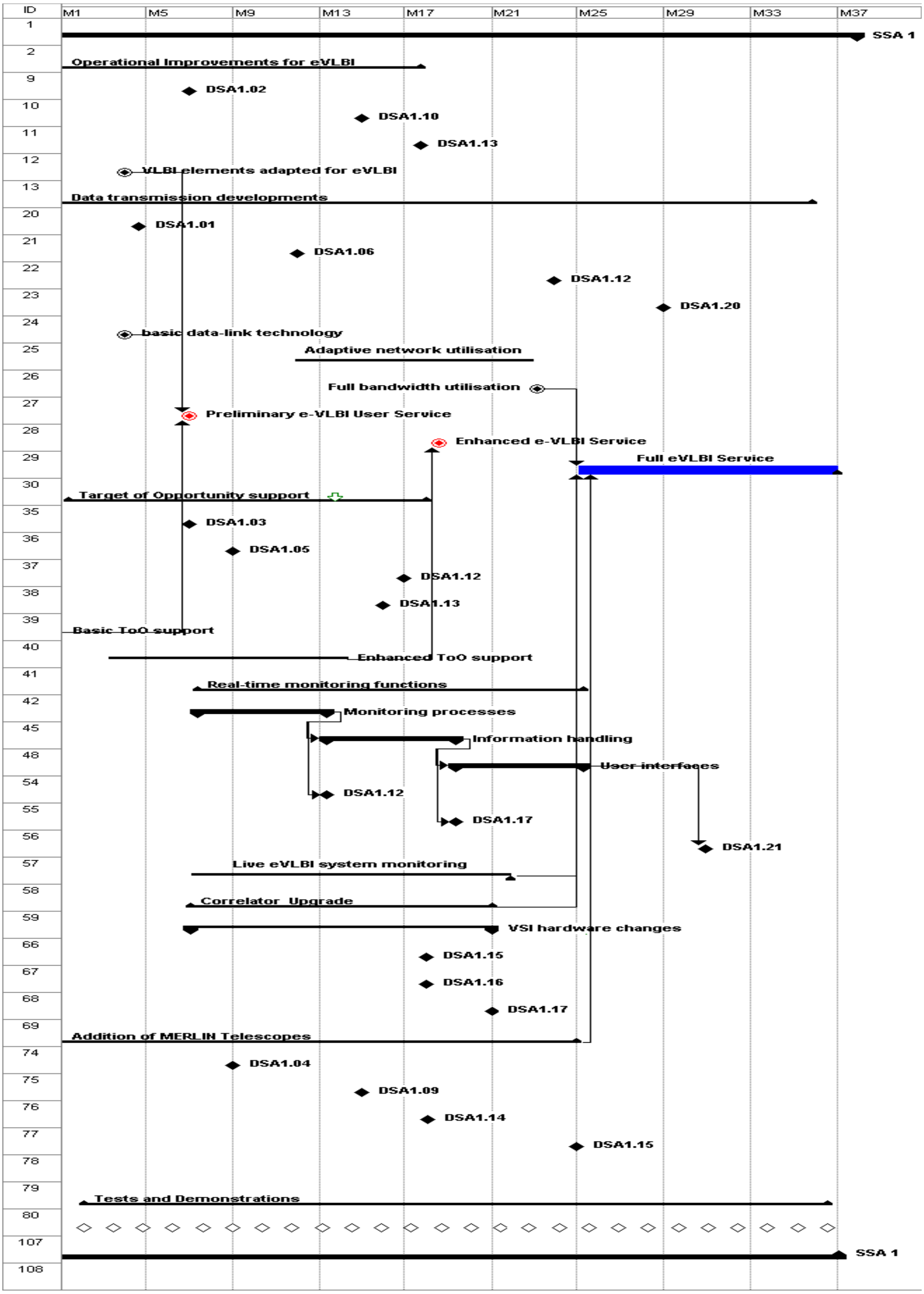


Figure SA1.2: Multi-annual execution plan

A detailed execution plan for the first 18 months of SA1 is presented in Figure SA1.3 and Table 5 (section 5.B.2.4).

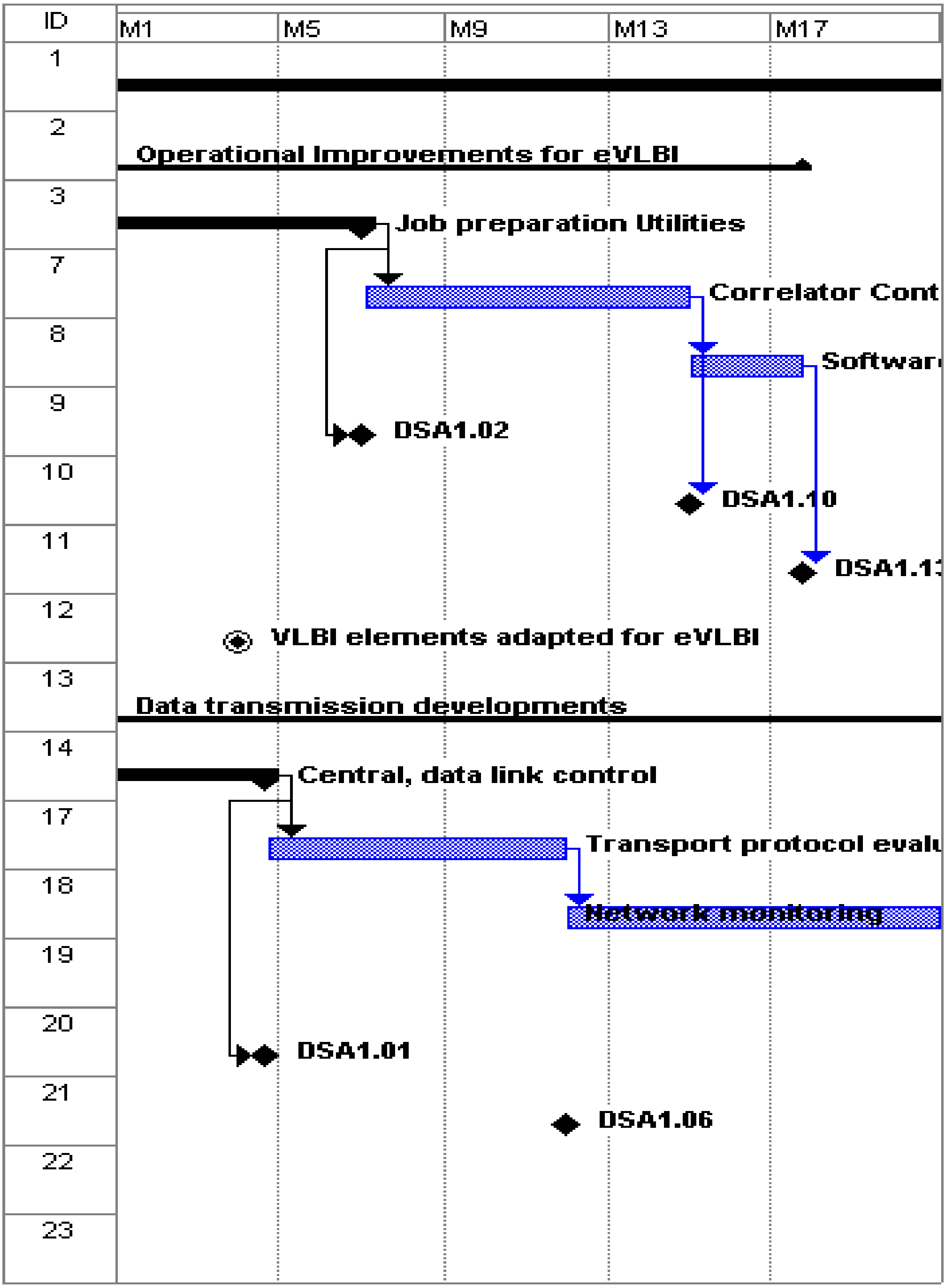


Figure SA1.3: Detailed execution plan for the first 18 months

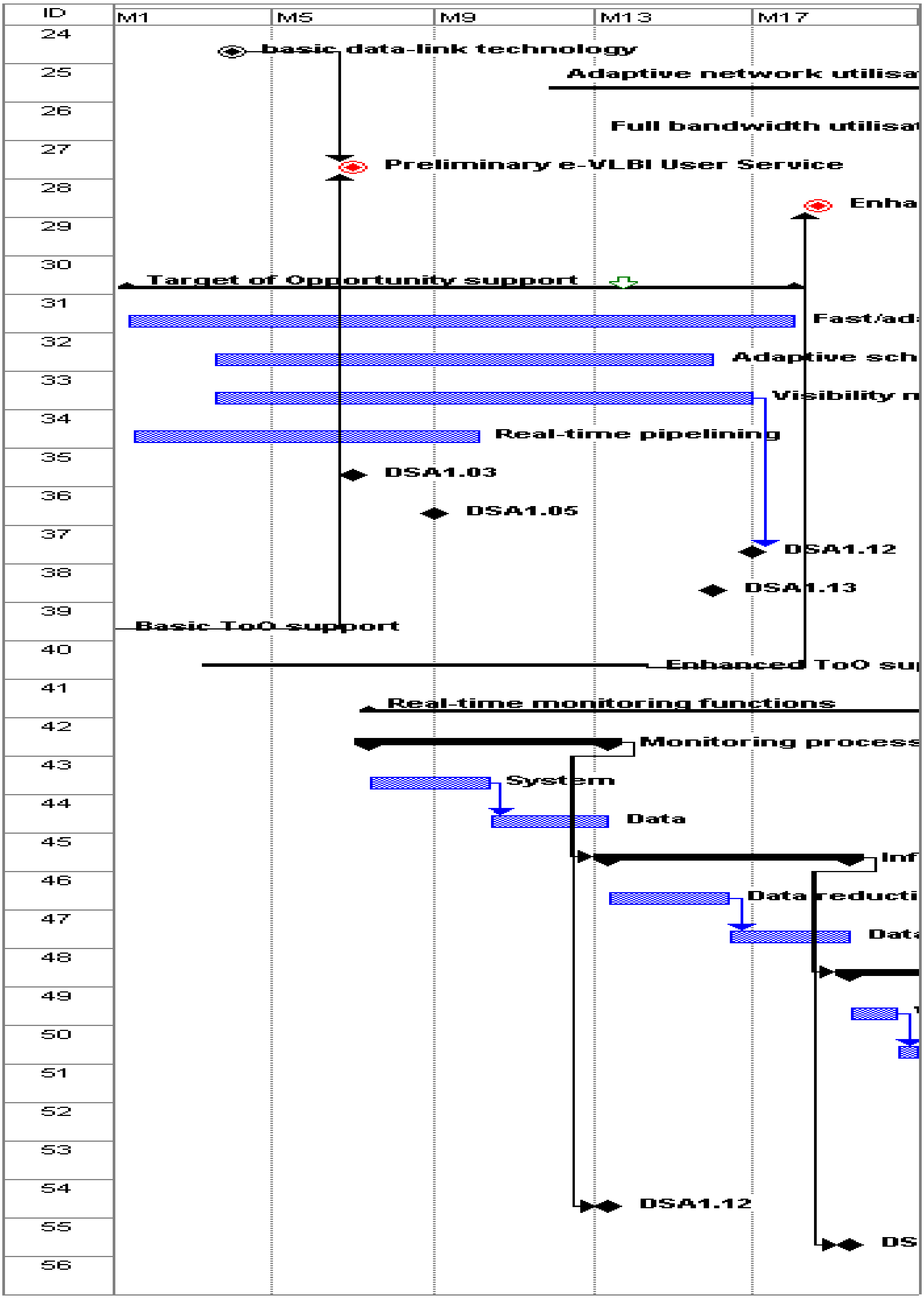


Figure SA1.3: Detailed execution plan for the first 18 months

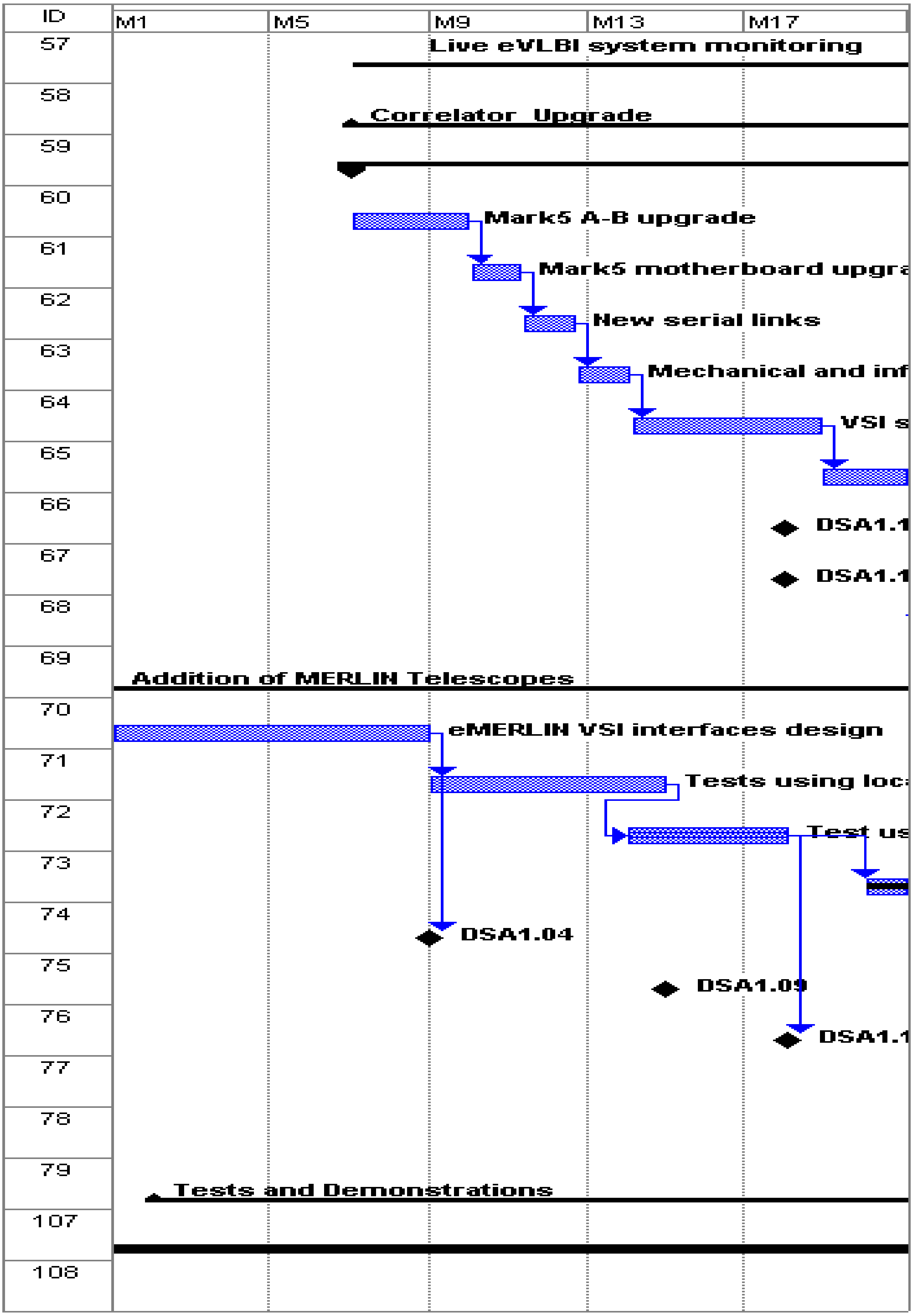


Figure SA1.3: Detailed execution plan for the first 18 months

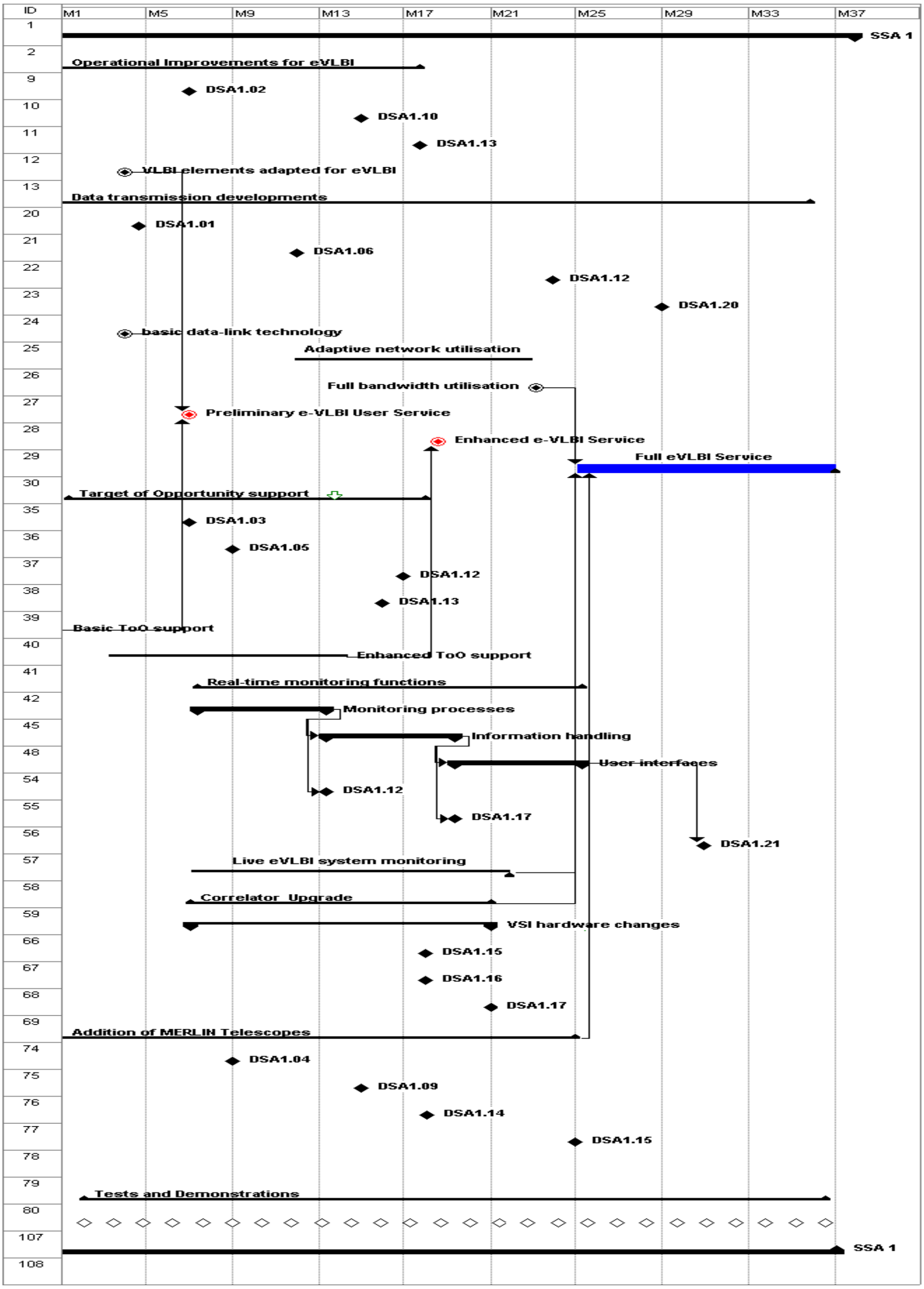


Figure SA1.4: Detailed execution plan for 36 months

5. B.2.2. Quality of the management

5. B.2.2.1 Management and competence of the participants

The overall SA1 manager will be Dr. Arpad Szomoru at JIVE (the Netherlands) who will act as the overall Team Leader or Principal Investigator (PI). He has led the team that successfully demonstrated the principle of e-VLBI within the EVN-NREN e-VLBI Proof-of-Concept (PoC) project. He has significant experience of managing complex development projects. Each work package will be lead by a manager. A plan of implementation and resource utilisation will be prepared for each task, and it will be the responsibility of mangers to maintain progress in their individual work packages. They will also ensure that any problem that affects the overall SA is reported to the PI in a timely manner. The PI will monitor dependencies and take corrective action to ensure that goals are being met, and that the SA is on time and on cost.

The major part of this service activity will take place at JIVE making coordination and management relatively straightforward. The only major off-site component, WP6, will be undertaken at Jodrell Bank in the UK. The most important tool for coordination of individual work packages is the early definition of interfaces. This is especially so in the case of Jodrell Bank. With a good definition of the interface requirements this work package can be undertaken as a semi-autonomous project. JIVE components fall within the scope of a three-week cycle of Technical Operations, Science Operations and Software Development meetings, already firmly established at JIVE. These projects will become a fixed item on the agenda of these meetings enabling any problems to be recognised immediately. The meetings supported by NA2 will provide an opportunity to review progress in a broader forum and the annual NA3 e-VLBI/Science meetings will ensure that SA1 is correctly targeted to meet the needs of the users.

Participating Institutes

Jodrell Bank Observatory, part of the School of Physics and Astronomy of the University of Manchester, owns and operates the 76-m Lovell Telescope (LT) and the 7-element MERLIN/VLBI National Facility. Both the LT and MERLIN are integral components of the EVN, indeed JBO was one of the founding members of the EVN. MERLIN is undergoing a ~ €12.5M upgrade. The telescopes of e-MERLIN, as the upgraded instrument will be known, will be connected with fibre-optic cables each transmitting up to 30 Gbps of data, new receivers, new digital transmission equipment and a new broadband data processor will enable observations a factor of 10-30 times more sensitive than the current array. e-MERLIN will be providing “early science” with its prototype data processor in 2007 and is planned to be fully operational in 2009. It will be, as the current array is, a central component of the EVN. The availability of joint MERLIN+EVN observations is an increasingly popular option for users and it is expected that enhancements using fibre-optic connections will make the joint EXPReS e-VLBI array one of the most powerful astronomical instruments in the world.

The **Joint Institute for VLBI in Europe** (JIVE) has played a central role in the development of e-VLBI to date and is the logical centre for this SA. JIVE co-developed, and now operates and maintains the EVN data processor, which is the subject of many of the developments of the project. The JIVE data processor is connected to the Amsterdam Internet exchange via an advanced, DWDM fibre-optic link. This facility places JIVE logically at the centre of an important hub of the global Internet and various international network development test beds.

Many of the key personnel are also located at JIVE. The institute employs extensive expertise in software and hardware development with an emphasis on real-time data processing using a hybrid of dedicated hardware and state-of-the-art microprocessor components. Exceptionally, JIVE personnel combine a thorough understanding of the science and theory of radio interferometry with a sound knowledge of relevant software and electrical science.

Collaborators

Beginning with the current membership of the EVN-NREN proof-of-concept project, SA1 will grow to call upon the support of most EVN member institutes and their corresponding NRENs. In the scope of the e-VLBI PoC current collaborators are:

DANTE	Pan-European Network
SURFnet	Dutch NREN
GARR	Italian NREN
UKERNA	UK NREN
PSNC, PIONIER	Polish NREN
DFN	German NREN
SUNET/NORDUnet	Nordic NREN
Manchester University	Network application software
JIVE	EVN Data processor
Westerbork telescope	Netherlands
Onsala Space Observatory	Sweden
Metsähovi Radio Observatory	Finland
MPIfR	Germany
Jodrell Bank Observatory	UK
Torun Centre for Astronomy	Poland
Istituto di Radio astronomia	Italy

These partners have established a close working relationship for e-VLBI development, centred around the series of successful tests that have been staged over the last few years. An e-mail discussion group is used to exchange ideas and expertise, and to negotiate instrument time for e-VLBI tests. Telephone conferencing is used for on-line coordination during e-VLBI observing tests. The group has met annually until now. More meetings will be supported by NA2.

Individual Participants

The principal participants in each task are identified in Table SA1.3 together with a specification of the effort contributed in professional man-months for the additional hires (Software Engineer –SWE, Network Engineer –NWE, Software/Hardware Engineer – SHE and Support Scientist –SS). Table SA1.2 specifies, for each individual participant, qualifications, experience and knowledge relevant to the project. In some cases the individual will be a new employee, hired for the project. In such cases the description acts as a requirement specification for the post.

Table SA1.2: Individual Participants

Resource	Individual	Inst.	Qualifications	Experience and knowledge
PI WP Man.	A. Szomoru	JIVE	PhD	Software engineer with Astronomical background. Architect of current e-VLBI Correlator software and protocol developments.
WP Man. HWE	S. V. Pogrebenko	JIVE	PhD	Hardware for astronomical applications
WP Man.	S. T. Garrington	UniMan	PhD	e-MERLIN project manager. Experienced in software for astronomical applications
SDE	New hire	UniMan		High speed digital hardware and interfaces. FPGAs
SWE	New hire	JIVE		C, C++, HTML, custom hardware drivers, databases
NEW	New hire	JIVE		Network: hardware, middleware, architectures, protocols, security, test & measurement techniques.
SSE	F. Olnon	JIVE	PhD	Software for astronomical applications
SSHE	New Hire	JIVE		C, C++ prog. Skills, scientific applications
SSS	C. Reynolds	JIVE	PhD	e-VLBI observations, data analysis, scheduling s/w. pipeline-processing
SS	New hire	JIVE	PhD	e-VLBI scientific/user support, testing, software development.

Publications

Diamond, P.J., Astronomische Gesellschaft Abstract Series, Vol 18, JENAM 2001.

Garrington et al, “e-MERLIN”, Proceedings of the SPIE, Vol 5489, pp 332-343 (2004).

Garrett, M; Muxlow, T., Garrington,S et al 'AGN and starbursts at high redshift: High resolution EVN radio observations of the Hubble Deep Field', 2001 A&A 366 L5

S.M. Parsley; "eVLBI Research in the European VLBI Network", IVS 2004 General Meeting Proceedings, edited by N. R. Vandenberg and K. D. Baver, NASA/CP-2004-212255. 2004

R. Hughes-Jones, S. M. Parsley and R. Spencer; "High data rate transmission in high resolution radio astronomy vlbiGRID", Journal of Future Generation Computer Systems (FGCS), Elsevier Science Press, Vol. 19, Issue 6, pp. 883-896, 2003.

S.M. Parsley, P. Burgess, R. Hughes-Jones, A. Mujunen, S. Pogrebenko, J. Ritakari, R. Spencer, A. Szomoru, H. Verkouter; "eEVN", ASP Conference Series, Volume CS-306, New Technologies in VLBI, p229, 2003

5. B.2.2.2 Justification of financing requested and value for money

A detailed justification for each item of expenditure and for each participant is given in Table SA1.3. Material costs quoted include only equipment comprising the final installation for the SA and consumables.

Collaborating EVN telescopes participate on a self-financing basis, funded from their normal budgets for non-VLBI operations. The table indicates the level of contributed funding represented by this support.

Table SA1.3: Justification of financing requested

Participant	Item	Justification	Requested Funds	
			FTE-yrs	k€
JIVE	Staff	– Core staff are a software engineer and a networking engineer/specialist to streamline VLBI for real time operation and to ensure satisfactory data transport across the European R&E networks: 6FTE – A specialist software engineer will modify various utilities used for preparation of VLBI observations: 1.8 FTE – A specialist hardware engineer will modify interfaces for real-time operation and support testing: 0.9 FTE – A support scientist will provide general assistance for all design and testing activities: 2.5 FTE	11.2	840
	Materials	– 16 network interface units will require new I/O boards and new motherboards: 16 X €6.25k = €100k – A new data path to the data processor requires 32 new, high speed serial links: 32 X €625 = €20k – New network infrastructure: €100k		220
	Travel	– International travel @ €1k: One trip per person per year = €12k – Domestic travel @ €0.5k: Two trips per person per year = €12k		24
JBO	Staff	– A senior digital engineer will design VSI conversion modules for the e-MERLIN data processor: 1.0 FTE (the same individual will contribute 1.0 FTE to JRA1) – A support scientist will provide general assistance for all design and testing activities: 0.5 FTE – e-VLBI post-doc: 1.0 FTE (contributed) – Management and other support: 0.4 FTE (contributed)	1.5	112.5
	Materials	VSI conversion modules for the eMERLIN data processor: 4 X €7.5k		30.0
	Travel	– International travel @ €1k: One trip per person per year = €3k – Domestic travel @ €0.5k: Two trips per person per year = €3k		6
EC Requested:		JIVE:	11.2 FTE	€1084k
		JBO:	1.5 FTE	€148.5k
		Totals requested:	12.7 FTE	€1232.5k

Contributed resources:	Labour JBO:	1.4 FTE	€105k
	EVN Operations time:		€728k
	Totals contributed:	1.4FTE	€833k

5.B.2.3. Exploitation of results

The outcome of this SSA is expected to be a fully functional service that can be used immediately by professional astronomers for scientific research. Access to this service will be provided using existing agreements between partner institutes within the EVN and other affiliated institutes. There will be no limitation in the subsequent exploitation of scientific results. e-VLBI somewhat liberalises access to telescope data, it will be essential that the rules now followed by the EVN are adopted by e-VLBI, in particular data will be owned by the end-user that submitted the original observing proposal and no one else. All data will enter into the public domain, 12 months after the user has received processed data from JIVE (barring a successful please to the EVN PC, for example in the case of PhD students).

The partnership policy established between the participants of the EVN-NREN Proof-of-Concept project will continue to apply to EXPReS and in particular SA1, *i.e.* the project will develop freely in a spirit of open scientific and technical collaboration. It is our intention that all documents depicting concepts, technological solutions and results should be made freely available to all EXPReS parties. The EVN works in collaboration with several other VLBI networks and technology developers worldwide. Standard VLBI only works if participants share compatible equipment and common data formats. There is therefore a long tradition of shared technology. The project will endeavour to absorb relevant and useful technological contributions from other groups, and to promote and propagate the results of EXPReS in support of this established culture. Many of the results that are achieved by SA1 will be relevant to the construction of next generation radio telescopes, such as the Square Kilometre Array (SKA). Most of the radio observatories associated with EXPReS are also partners of the FP6 SKA Design Study (SKADS).

There is also some degree of competition between the various VLBI Technology Centres located across the world (chiefly in Eurasia, USA & Japan). There is a small risk that another group will develop an incompatible solution to the problems addressed by SA1 that gain a dominant position before completion of the project. This risk is low for two reasons. First, the competition to define the standard interface unit for e-VLBI is, for all practical purposes, over between the US and Europe. These two groups now use a common data acquisition platform known as Mark 5, developed at MIT Haystack Observatory and manufactured by a commercial company. Secondly, other groups in the world that use different systems do not share any mutually visible sky, so compatibility is not normally an issue. Besides, end system processing power is advancing rapidly and on-the-fly format conversion will soon be entirely feasible, as recently demonstrated in the recent observations of the ESA-Huygens probe (as led by JIVE). In addition, the European model for R&E network infrastructure has proved to be much more amenable to e-VLBI than elsewhere in the world. European e-VLBI was the first to produce scientific output from a real-time international e-VLBI observation, and leads the way in terms of connectivity and available resources. A key motivator for SA1 is to extend this lead to create the world's first continental-scale real-time radio telescope.

The technical risk is also low. Most of the technology involved has been proven in the proof-of-concept project. One unknown is the level of competition for network capacity, but projected growth of network bandwidth is, at the moment, expected to accommodate e-VLBI and other known high demand applications, at least at the rates we will approach with EXPReS.

5. B.2.4. Summary

TABLE S1.4 ACTIVITY DESCRIPTION (REPORTING PERIOD PLUS 6 MONTHS)

Activity number:	**SA1**	**Start date or starting event: Year 1, month 1**					
Participant (Short name)**:**	JIVE	JBO					
Expected Budget per Participant:	€300000 [not incl/ EVN ops]	€70000					
Requested Contribution per Participant:	€300000	€40000					

Objectives

The primary activity aims to create a real-time e-VLBI network, transparently connecting together an array of up to 16 telescopes operating reliably, at data rates of up to 1Gb/s per telescope.

Success will be judged first against the established performance of standard VLBI. The real-time instrument must be capable of producing a deliverable data set, comparable in quality to the existing product. The observing capability of the e-VLBI array must approach those of the standard system in terms of baseline coverage, bandwidth and available observing modes. Having met these fundamental requirements the further aims of the SA will be achieved when data are delivered on a time scale of days and hours rather than weeks and months to the end-user.

The project will aim to prove and demonstrate potential new capabilities offered by e-VLBI. In particular, successful observations of transient events involving dynamic and adaptive re-scheduling of the experiment will provide comprehensive confirmation of all aspects of the development.

Description of work

Software will be developed to streamline VLBI for real time operation and to ensure satisfactory data transport across the European R&E networks. New software services will enable VLBI to match the quick turn around offered by other instruments for target of opportunity observations. A basic service, with some quick reaction capability, will be available after the first 18 months. Reliability will be enhanced by the development of on-line monitoring tools and further performance improvements will be realised by the introduction of new hardware data interfaces. Developments in the UK will enable e-MERLIN telescopes to transparently join the EXPReS e-VLBI infrastructure array.

There is a small risk that another group will develop an incompatible solution to the problems addressed by SA1 that gain a dominant position before completion of the project, but this risk is judged to be very low. The overall technical risk is also low. Most of the technology involved has been proven in the proof-of-concept project. One unknown is the level of competition for network capacity but projected growth of network bandwidth is, at the moment, expected to accommodate e-VLBI and other known high demand applications, at least in the short-term.

Deliverable No[1]	Deliverable title	Delivery date[2]	Nature[3]	Dissemination Level[4]
DSA1.1	Central data link control	3	D	PU
DSA1.2	Job preparation utilities	6	D	PU
DSA1.3	Fast/adaptive scheduling tools	6	D	PU
DSA1.4	eMERLIN VSI interfaces design	9	P	PU
DSA1.5	Selective data processor controls	9	D	PU
DSA1.5	Network Protocol decision	12	D	PU
DSA1.7	Monitored information handling modules	12	D	PU
DSA1.8	Monitoring processes	12	D	PU
DSA1.9	Tests using local Jodrell Bank home e-MERLIN telescope	15	D	PU
DSA1.10	Real-time data processor control software	15	P	PU
DSA1.11	Real-time Pipeline	16	D	PU
DSA1.12	Visibility monitor	18	D	PU
DSA1.13	Tested software for operational improvements	18	D	PU
DSA1.14	Test using remote e-MERLIN telescope	18	D	PU
DSA1.15	VSI Interfaces	18	D	PU
DSA1.16	VSI support software	18	D	PU
DSA1.17	Flexible local GE network	21	D	PU
DSA1.18	Network monitoring tools	24	D	PU
DSA1.19	Multiple e-MERLIN telescope tests	24	D	PU
DSA1.20	Improved network applications	30	D	PU
DSA1.21	Monitoring user interfaces	30	D	PU

Milestones and expected result		Month
MSA1.1	Call for Proposals for e-VLBI service	01
MSA1.2	Preliminary e-VLBI Service	04

[1] Deliverable numbers in order of delivery dates: D1 – Dn
[2] Indicate the month of delivery. This should be relative to the start date of the *I3*, month 1 marking the first month of the project.
[3] Please indicate the nature of the deliverable using one of the following codes:
R = Report
P = Prototype
D = Demonstrator
O = Other
[4] Please indicate the dissemination level using one of the following codes:
PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).

MSA1.3	Basic data-link technology	06
MSA1.4	Basic VLBI elements adapted for e-VLBI	06
MSA1.5	Enhanced ToO support	17
MSA1.6	Enhanced e-VLBI Service	18
MSA1.7	Enhanced ToO support	22
MSA1.8	Adaptive network utilization	22
MSA1.6	Full bandwidth utilization	24
MSA1.7	Live e-VLBI system monitoring	24
MSA1.8	Full e-VLBI Service	24

Justification of financing requested:

The transformation of the current VLBI operational network and the data processor at JIVE into a production grade e-VLBI facility requires significant effort, largely in terms of addition skilled labour – people with specialised knowledge in the area of software, hardware, networking and radio astronomy operations. The majority of this manpower is required in order to upgrade the current VLBI data processor – the hardware and software (imbedded, offline and online) were never designed to operate in a real-time environment. Most of the finance requested is thus directed towards creating a real-time e-VLBI data processing capability in Europe. This system would be the most powerful and capable real-time VLBI correlator in the world. In addition, there is a modest request for the hardware that is also required at both the site of the data processor but also at Jodrell Bank, home of the e-MERLIN facility. Manpower is also required to ensure that the e-MERLIN array can be easily incorporated into the EXPReS e-VLBI infrastructure. In comparison to SA2, most of the support required in order to realise the goals of the project are requested from the EC. However, a significant level of self-financing effort is also contributed by the partners and the EVN. In particular, the costs of operating the radio telescopes during e-VLBI test time is borne by local, institute sources of funding. Community financing is not being used to conclude subcontracts.

SPECIFIC SERVICE ACTIVITY 2: NETWORK PROVISION FOR A GLOBAL e-VLBI ARRAY

5. B.3.1 SCIENTIFIC AND TECHNOLOGICAL EXCELLENCE

5. B.3.1.1 Objectives and originality of the service activity:

The European VLBI Network (EVN) is a unique large-scale facility for Radio Astronomy, which performs coordinated observations of celestial radio sources to be processed at the EVN correlator at JIVE in the Netherlands. To date, the data are recorded on high-capacity disks and mailed to the correlator; processed data are made available to the scientists as much as several months after the original observations were made.

The objective of the EXPReS e-VLBI network is to allow real-time transmission of the data at 1 Gbps (and greater – see JRA1) from the EVN telescopes to the EVN data processor at JIVE. Currently 5 telescopes are connected to GEANT2 with 1 Gbps connectivity or better (see Figure SA2.1). The EVN-NREN Proof-of-Concept e-VLBI project has demonstrated the feasibility of the e-VLBI technique and its enormous potential. The advantages of e-VLBI have already been described but include: improved array reliability, very high sensitivity, "Target-of-Opportunity" science capability, rapid result service, flexible operations, etc. This can be achieved with an effort that, though significant, is small if compared to the actual capital cost of the EVN itself. It is estimated that the total capital investment cost of the EVN radio telescopes is more than €400 Million (2005).

While GÉANT can provide European-wide connectivity, a problem that remains to be solved for most radio telescopes that aspire to participate in e-VLBI observations is the well known "last-mile" or "local loop" problem. Most radio telescopes are located in remote areas far from centres of population; the nearest Point of Presence (POP) can often be several tens of km away.

This specific service activity aims to coordinate the various technical and logistical aspects that are required in order to achieve last-mile connections to the radio telescopes that will form the EXPReS e-VLBI infrastructure. It requests partial funding from the Commission – in most cases this is a small fraction of the total connection cost, but it is believed that support from the Commission (even at a fairly modest level) will act as a significant ***catalyst,*** *encouraging commercially fair, affordable and competitive quotations, and releasing substantial sources of local and national funding.*

The vast majority of the EVN institutes are in close contact with their local NRENs and have made significant progress in understanding the optimal solution to their last mile problem. Within EXPReS there is a significant level of knowledge on how to make progress in this area and one of the aims of SA2 is to ensure this knowledge and experience is shared between the partners.

The objectives of SA2 are listed below, in some cases there is already significant progress in some of these areas, in other cases progress is very modest. For completeness, all the objectives are listed:

- The first step is to define the extent of the last-mile problem at each radio telescope, this requires the establishment of good communication between aspiring e-VLBI radio telescopes and their appropriate NRENs, Network Service providers, telecom carriers, public utility providers *etc.*
- Identify the optimal route to access the (inter-)national gateway to GÉANT,
- Select the optimum way to access GÉANT, via the use of existing services or the construction of new fibre links,
- Identify and apply to appropriate sources of local and national funding (together with the support requested from the Commission in this activity) in order to procure last-mile telescope connections,
- Negotiate the initial (up-front) and recurring service costs of the network connection required for e-VLBI participation,
- Test the quality and performance of the connection and begin EXPReS production e-VLBI operations.

The above objectives will be realised in a number of work packages:

WP1 - Dynamic status report & EXPReS support of the last-mile telescope connections to the nearest (GÉANT) NREN node: This work package will run throughout the duration of the EXPReS contract until all telescopes are connected. The status of the last mile connections at each of the EXPReS telescopes will be continually updated (see Tables SA2.1, SA2.2 and Figure SA2.1 & SA2.2), including the most feasible and cost-effective solution (commercial fibre leasing, construction of private "local-loops" between the telescope and nearby PoP *etc).* Some institutions have access to academic "free" networks and need appropriate equipment to set the connection, while others are in very remote areas and need to build expensive private optical-fibre links. In some cases, commercial links are available but need to be contracted by public procurement procedures, in particular, public-tendering processes, contract publication, award procedures, *etc.* These (mostly local) activities will be monitored and coordinated by SA2, pooling together the knowledge and experience of the EXPReS partners.

WP2 - Construction and procurement of equipment for the last-mile infrastructure: Once the optimum process to access the GÉANT node is identified, the participants are to fulfill the necessary steps to lease or build the needed infrastructure: optical-fibre link between the telescope and the GÉANT node, and specific equipment needed to manage and operate the network. The EXPReS e-VLBI infrastructure aims to operate routinely at 1 Gbps, but scalability to higher data rates (2, 4, 8, 10 Gbps) is desirable – even in the short-term.

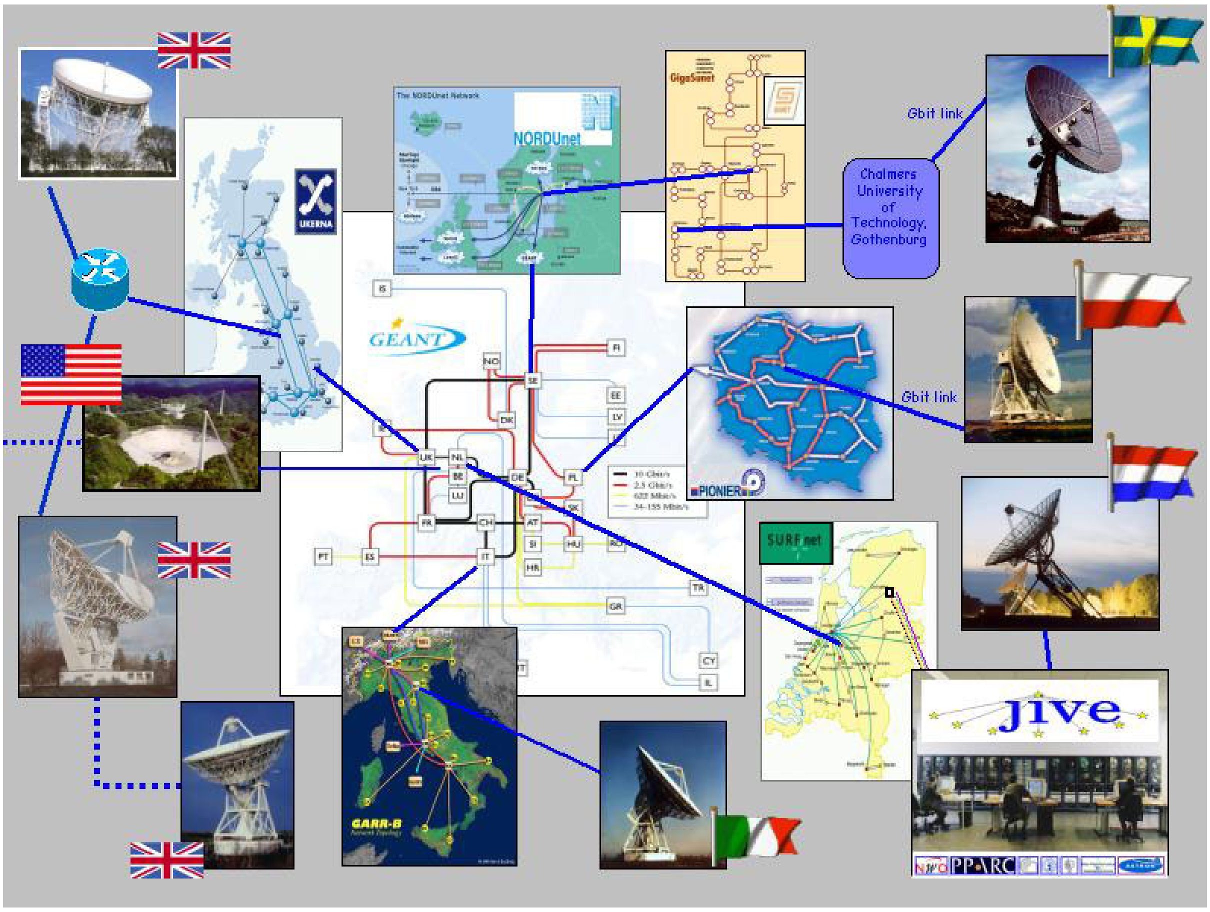


Figure SA2.1: Current status of the e-VLBI Proof-of-Concept Telescope Network connections. Five telescopes are connected to their NREN, GEANT2 & ultimately JIVE at 1 Gbps (Jodrell Bank & Cambridge – UK; Westerbork –NL; Torun – PL; Onsala – SE). Arecibo (USA) is connected at 155 Mbps.

WP3 –Testing of the link and verification of real-time e-VLBI capability: When the link is in place a programme of testing must begin, ultimately the radio telescope (together with the rest of the telescope network and JIVE) must demonstrate real-time e-VLBI operation. From the outset SA1 will be able to handle additional telescopes as they become available. In addition, the services of the scientific staff at JIVE will be available to report on the performance of the telescope as part of the EXPReS e-VLBI infrastructure. The monitoring utilities included in SA1 will also permit telescope staff to diagnose problems and to play with the system. Experience has shown that once the link is in place, real-time operation can begin almost immediately.

The coordination of these activities is essential, since real-time VLBI can only be performed if all the relevant radio telescopes have access to the correlator with an adequate fibre-optics connection. Any telescope not connected would be excluded from the e-EVN. In some cases (e.g. the links to South Africa and Chile) the data rates that will be achieved (at least initially) will not be suitable for broad-band continuum e-VLBI, but they will permit spectral-line e-VLBI to be conducted, and in addition, they will allow us to test the system and to stress and use these new network connections. There is also the expectation that via bandwidth greedy applications like e-VLBI, connectivity to these regions will improve – even on the time-scale of the duration of the EXPReS project.

This Service Activity aims to realise a *global* e-VLBI infrastructure, able to conduct unique radio astronomy observations of cosmic radio sources, a real-time array that will include the largest radio telescopes on the planet. The real-time capability, with its described advantages, can be achieved – especially with support from the European Commission acting as a significant catalyst in the process of establishing last –mile connections.

5. B.3.1.2 Execution plan of the service activity:

The main objective of this Specific Service Activity is to achieve in the majority of cases, and to progress significantly in others, the last-mile ("local-loop") connection of all EVN telescopes to the correlator at JIVE via GÉANT. Given the variety of institutes (15, operating 18 telescopes) and circumstances, it is not possible to give specific dates for each connection, as these depend not only on the availability of funds but also on the request to all institutes to adhere to the appropriate standards of public procurement for competitive and fair bidding processes. Therefore, within the first 6 months of the contract, we aim to understand in all cases the optimum way to solve the last-mile connection problem, and if possible, to start contracting the construction of the last-mile infrastructure and purchase the equipment needed to manage the network.

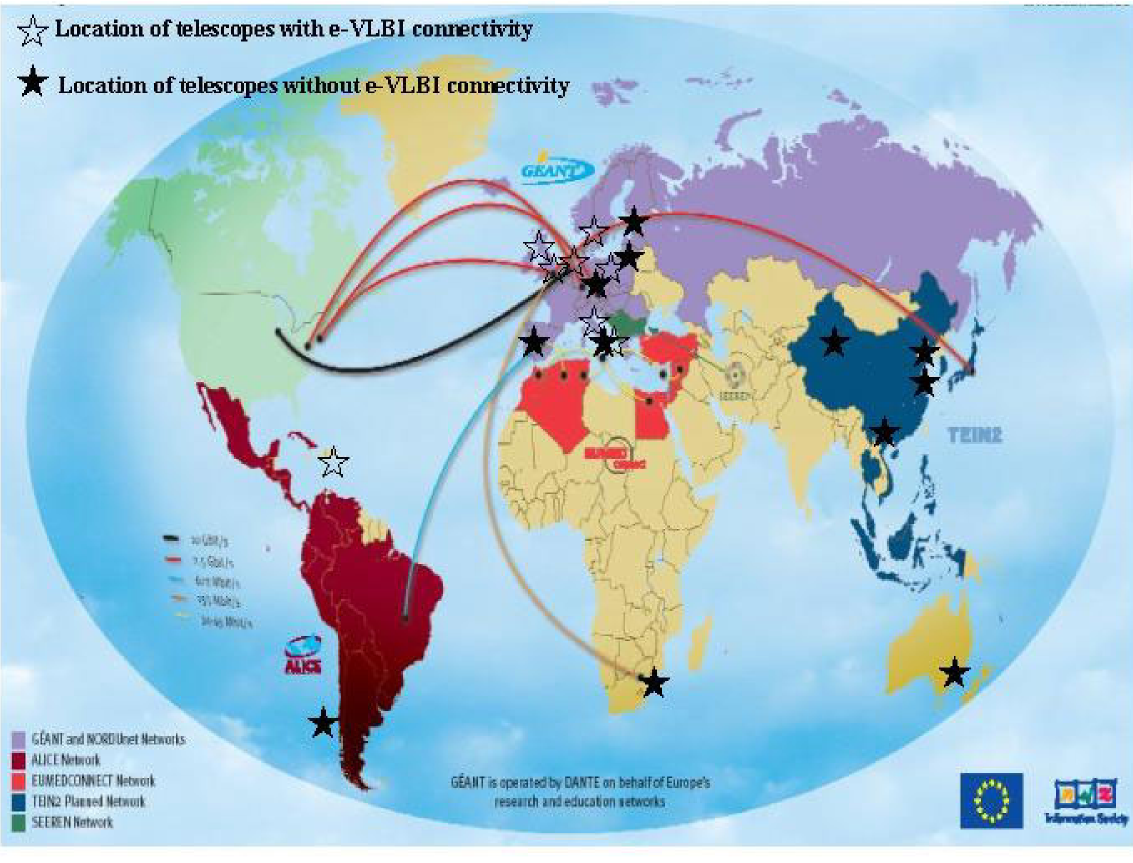


Figure SA2.2: The GEANT2 Global connectivity map – radio telescopes with e-VLBI capability are shown as open stars. The EXPReS SA2 activity aims to stimulate the connection of other telescope locations that are not yet connected by fibre – these are shown as filled stars. GÉANT has multiple high-capacity links to the USA, Canada and Japan. A connection to South Africa has also recently been implemented and the ORIENT network will soon enable a high-bandwidth link to China. With 4 VLBI telescopes located in China, e-VLBI is a potential large user of this link. The pan-continental networks connecting to and working with GÉANT include RedCLARA (which connects national networks across Latin America) and TEIN2 (currently under construction this will provide network connectivity between nations in the Asia-

Pacific region). The reach of all these networks together with GÉANT, provides the European radio astronomy community with an unparalleled opportunity to use the e-VLBI technique to maximum effect, delivering huge benefits for international research collaboration.

A preliminary e-VLBI service will be offered to users within 4 months of the start of EXPReS, using telescopes that are already connected to JIVE.

The major deliverables expected from this service activity, in the period 2005-2008, are:

- Dynamic overview of the last-mile problem across the EXPReS Network of radio telescopes,
- Connection of the radio telescopes to the central processor at JIVE, which will produce a pan-European, real-time scientific infrastructure, an e-VLBI facility that will be unique and will strengthen the European and international dimension of the facility,
- Inclusion of the (e-)MERLIN array as an element of the EXPReS e-VLBI facility, through the upgrade of the Jodrell Bank Observatory link to JIVE to 10 Gbps,
- Establishment of a 10 Gbps link between Jodrell Bank Observatory (UK) and Onsala Space Observatory (Sweden), a test-bed for prototyping ultra-high-data rate VLBI studies (4 and 8 Gbps),
- Connection of (EVN) radio telescopes located outside of Europe to JIVE, in particular telescopes that already have clear connectivity ambitions or are already in the process of establishing these – *e.g.* Arecibo in North America (Puerto Rico), Hartebeesthoek in South Africa, Shanghai Astronomical Observatory in China (Shanghai), Urumqi Astronomical Observatory (Nanshan, China) and TIGO in South America (Chile).
- Connection of Australian radio telescope facilities to JIVE, in order to conduct e-VLBI tests (including spacecraft navigation demonstrations) and to promote the remote access (and real-time, local on-line data processing) of radio telescope facilities in Australia from astronomers located in Europe. This latter activity has close synergy with the way in which European astronomers may interact with the SKA, assuming it is located in the Southern hemisphere.

To date, five EVN telescopes (Westerbork–NL, Onsala-SE, Torun-PL, Jodrell Bank-UK & Cambridge-UK) have direct fibre-link 1 Gbps connections to JIVE through GÉANT, and Medicina (IT) is expected to come on-line at 1 Gbps in June 2005. Several other EXPReS radio telescopes (see Table SA2.1) are in a fairly advanced stage of solving their last mile problem (at least technically, and also have a realistic chance of financing the links with partial support form the EC and EXPReS). Other telescopes are beginning the process of understanding how to achieve Gbps connectivity (see Table SA2.2).

A summary of the activity is provided in a GANTT chart (see Figure SA2.

Table SA2.1 local-loop in advanced stage of planning or complete

Radio Telescope Site	Last-mile Status & Ambitions
JIVE – Joint Institite for VLBI in Europe, NL.	Currently connected by SURFnet to GEANT2 at 6 x 1 Gbps. Requirement to increase connectivity to 16 x 1 Gbps.
UniMan - Jodrell Bank Observatory (JBO) and MERLIN, UK.	(i) 2.5 Gbps connectivity to JIVE – last mile funded via e-MERLIN project. (ii) Seeking to upgrade to a 10 Gbps link to JIVE (0.5 Gbps per MERLIN telescope). (iii) 7 x 30 Gbps links from the e-MERLIN telescopes to the correlator at Jodrell Bank under construction

NCU - Torun Radio Astronomical Observatory (TRAO), Poland.	Currently connected to JIVE through GÉANT at 1 Gbps – last mile was funded via local government.
OSO - Onsala Space Observatory, Sweden.	Currently connected to JIVE at 1 Gbps - last-mile funded from institute and private funds. Seeking to upgrade to 10 Gbps (partially via SA2, see also JRA1)
ASTRON - Westerbork Synthesis Radio Telescope (WSRT), the Netherlands.	Currently connected to JIVE at 1 Gbps – last-mile funded from regional Dutch funds.
INAF – IRA, Medicina, Bologna, Italy.	Connected to JIVE at 1 Gbps (2006) – last mile to be realised via dark fibre and funded via local government funds (Regione Emilia-Romagna). Partially funded via SA2.
NAIC – Arecibo, Puerto Rico, USA	Connected to JIVE at 155 Mbps. Seeking to upgrade to 1 Gbps (partially via SA2)
MRO – Metsähovi, Finland.	Realistic and advanced plans to connect to JIVE at 1 Gbps – connection to be achieved via the Finnish University Network and a new dark-fibre link in 2005. Funding now being sought.
HartRAO, South Africa.	Hartebessthoek Radio Astronomy Observatory has built a private optical-fibre link that will operate at 1 Gbps after October 2005. Connection to JIVE - bottleneck is likely to be connectivity between South Africa and Europe.

Table SA2.2 local-loop infrastructures under study

Radio Telescope	Plans for high-speed connection
CNIG/IGN - Observatorio Astronómico Nacional (OAN), Spain.	The construction of a new 40-m radio telescope at Yebes will be completed in 2005. The institute plans a call for tender for the service of 1 Gbps data transfer to the GÉANT NREN node in RedIRIS-Madrid, subject to funding via various sources (incl. SA2). Several options are available, mostly through commercial operators. The link is expected to start operations in 2006, together with the telescope first light.
Max-Planck Institute for Radio astronomy (MPIfR), Germany.	Operates the 100-m radio telescope at Effelsberg, the largest radio telescope in Europe and a major partner in the EVN. Located at a remote site, its connection to GÉANT is under study. Significant links between the radio telescope and potential service providers. A proposal to the MPG has been issued to finance most of the cost of the link, estimated at 2 M Euro. Partial funding via SA2 would provide important leverage in this ambition. The Effelsberg radio telescope is an essential element of the production e-VLBI infrastructure.
INAF – IRA, Sardinia, Italy	The new 64-m radio telescope under construction in Sardinia will be ready by 2007. Thanks to the high-speed networking and supercomputing project "CyberStar", a link to Pop-Garr in Cagliari is expected by 2008.

ShAO - Chinese Academy of Sciences	The CAS operates the radio telescopes in Shanghai, Urumqi, Miyun, and Kunming. Urumqi is already linked by fibre and needs equipment to run, Miyun and Kunming need a few km of new fibre to CSTNET, and Shanghai needs up to 25 km. The latter will be financed via SA2. The ORIENT project will be important in realising connectivity to the Chinese telescopes.
VIRAC, Latvia	VIRAC has been granted EC Structural Funds for scientific equipment and infrastructure development, including an optical fibre link from the observatory (Irbene) to Ventspils and to central Europe using GÉANT (via Stockholm). The link will be built with complementary Latvian government funds. Equipment will be needed.
CSIRO - Australia Telescope National Facility (ATNF).	CSIRO telescopes will be connected on the AARNET3 network in the second half of 2005. This will enable 1 Gbps connections immediately. Connectivity to Europe will be achieved via (on-demand) user-controlled light paths and will be initially limited to 1 Gbps.
TIGO, Concepción, Chile.	The TIGO radio telescope is located in a very strategic position and, combined with the EVN would provide very long baselines. The telescope is connected by optical-fibre, and aspires to upgrade the network equipment to be able to transmit at high data-rates for a very moderate cost (via SA2).

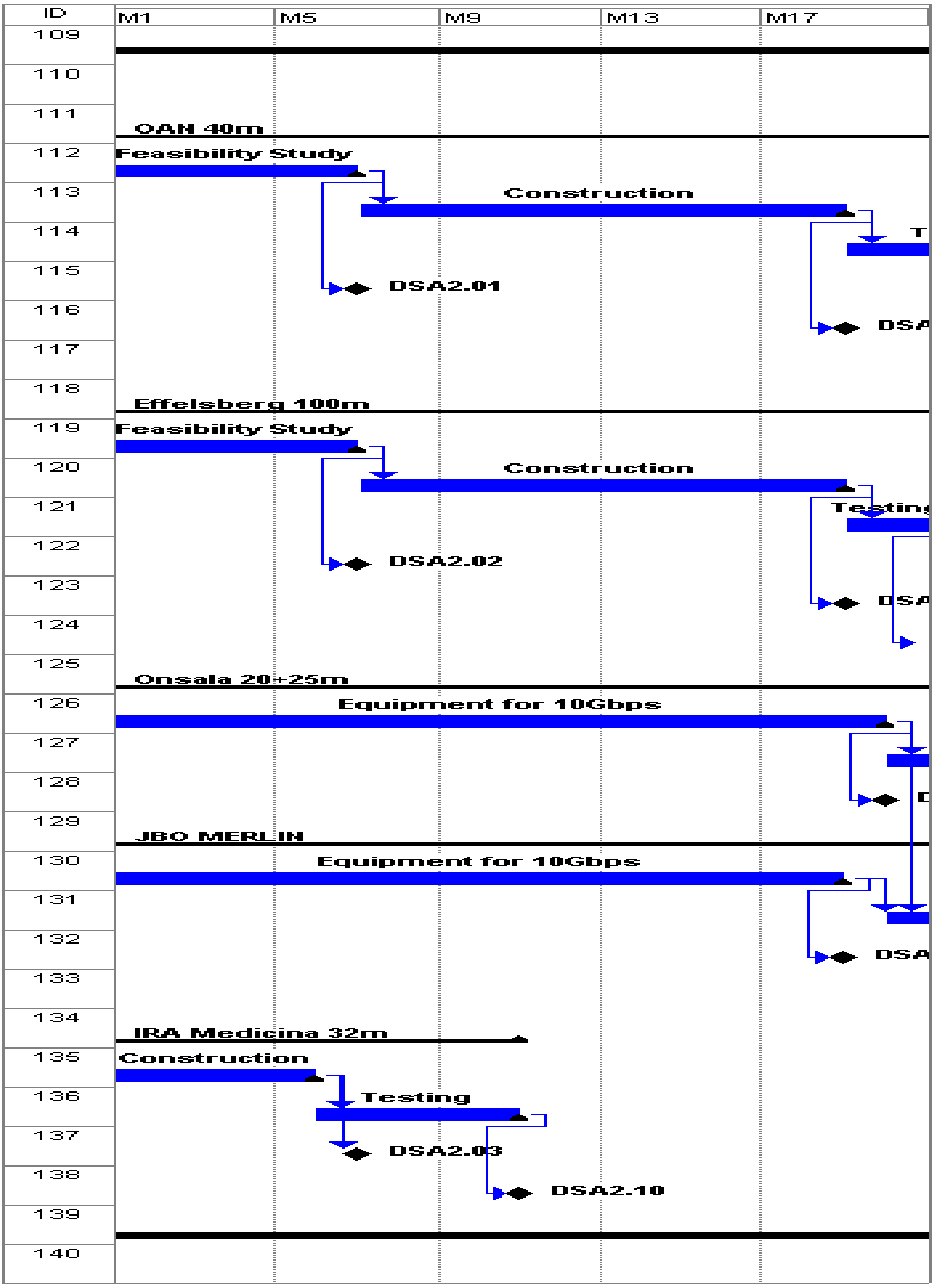


Figure SA2.3: Multi-annual execution plan for SA2, including detailed 18 month plan.

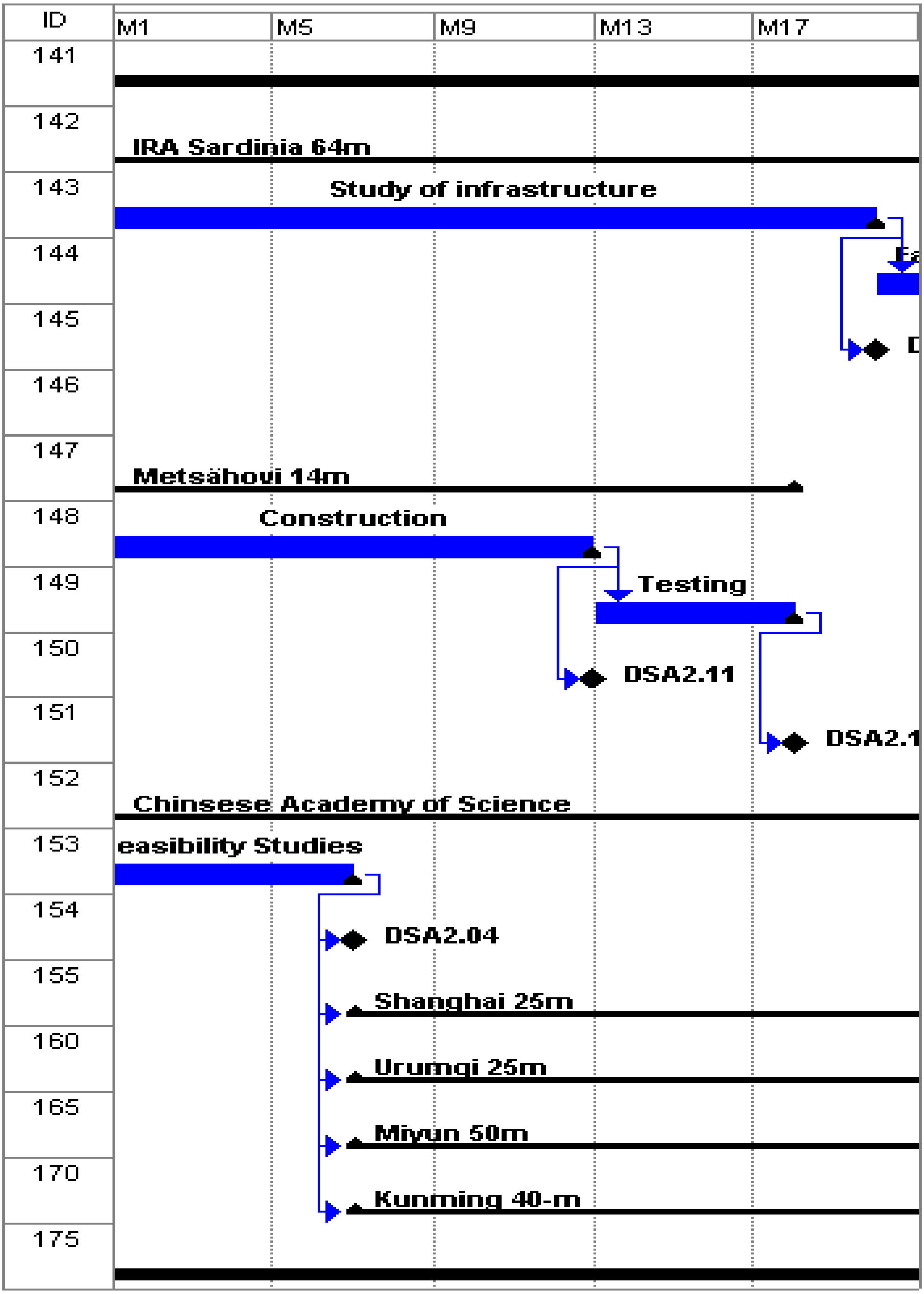


Figure SA2.3: Multi-annual execution plan for SA2, including detailed 18 month plan.

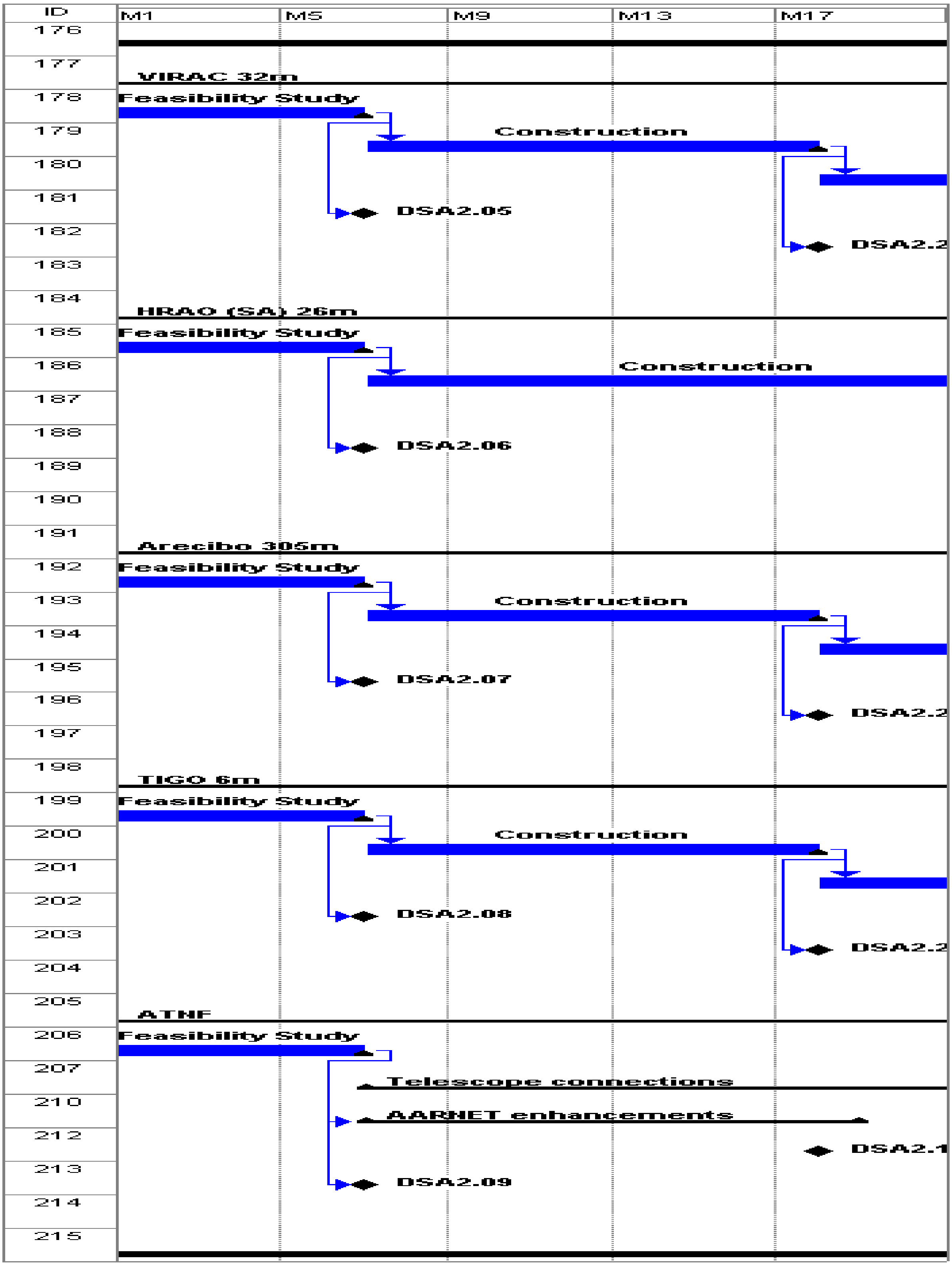


Figure SA2.3: Multi-annual execution plan for SA2, including detailed 18 month plan.

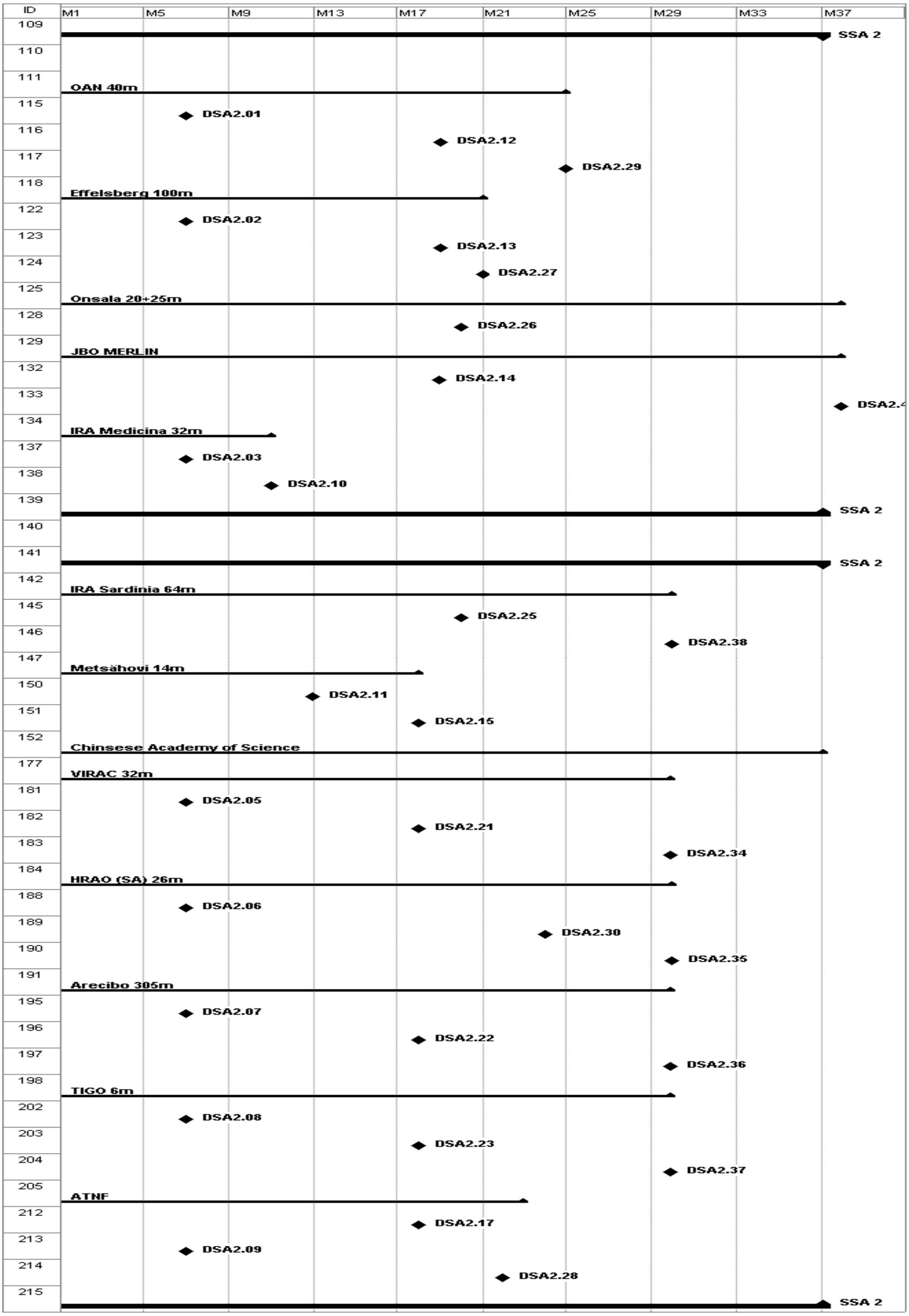


Figure SA2.4: detailed execution plan for 36 months

5. B.3.2. QUALITY OF THE MANAGEMENT

5. B.3.2.1 Management and competence of the participants

The majority of the radio telescope institutes are members of the EVN and have a long track record of cooperation. Individually the institutes are experienced in managing large capital projects such as the construction and upgrade of major radio telescope facilities. The EXPReS radio telescopes located in China, South Africa and the USA (Puerto Rico) are members of the EVN and play significant roles in the organisation. The EVN has demonstrated success as a unique large-scale scientific facility for radio astronomy, and is constantly being upgraded – major additions to the array include the construction of two new radio telescopes in Europe (the Yebes 40-m in Spain, and the IRA 64-m in Sardinia), and two new telescopes in China (the 50-m in Miyun and the 20-m in Kunming).

The overall coordination of SA2 will be the responsibility of Dr. Francisco Colomer (CNIG/IGN, Spain), currently involved in construction of a 40-m telescope in Yebes, near Madrid. This is a €15 Million project and the telescope is expected to be operational by the end of this year. He is very much involved in all aspects of this project and is also involved in negotiating a high-speed network connection for the antenna site.

As coordinator of SA2, Dr. Colomer will chair SA2 project telecoms that will be attended by representatives of the radio telescopes and relevant NRENs. Face-to-Face meetings will occur via NA2 where the issue of last mile connections is a standing agenda item. The coordinator will ensure that all the participating institutes have detailed and timely technical and logistical information on the progress of the EXPReS network connectivity activities, as well as for retrieving and distributing the specifications required for the telescope connections, equipment, and service performance standards. Progress will be monitored via minuted teleconferences and reports (these are in fact major deliverables for each telescope after the study of the optimum connection solution is finished, and prior to the construction of the last-mile infrastructure itself).

The specific support action will coordinate the different phases needed to build the individual last-mile connections, which are common tasks to all participants: study of the available options, issuing a competitive call for tender when applicable, construction of the fibre-optics link based on specifications, purchasing the needed equipment to run the link, and performing e-VLBI and general data transfer test to ensure appropriate performance. Many of these actions need to be developed in the specific country where the telescope is located, but the available experience from the existing infrastructures and Proof-of-Concept tests will be spread through the network via this support action.

5. B.3.2.2 Justification of financing requested and value for money

The requested EC contribution to SA2 (~ €1 Million) is required in order to partially finance the last-mile connection of the radio telescopes to GÉANT at data rates of at least 1 Gbps. The total cost of realising these connections (see Table SA2.3) is currently estimated to be ~ €10 million (total). It must be emphasised that although the EC contribution is only 10% of the total, this is considered by many of the radio astronomy institutes to be a very important catalyst to release significant funds from other regional and national sources. The effect of the

EC recognising the potential of EXPReS in terms of its network ambitions, cannot be underestimated. Of course it also represents very good value for money for the EC.

All participants in this support action need to connect their radio telescopes to the EVN correlator in JIVE via GÉANT. To do so, leasing or building of the last-mile optical-fibre connection is necessary, together with the appropriate specific durable equipment to manage the network. The detailed justification of expenditures is given below. The largest single expenditure is the connection of the giant 100-m radio telescope located at Effelsberg. This telescope is one of the most important large-scale scientific instruments in the world – with a collecting area of 30000 square meters, it is sixteen times more sensitive than a typical 25-m diameter telescope. The inclusion of Effelsberg within the EXPReS e-VLBI infrastructure would represent a huge boost to the scientific capability of the e-VLBI technique. Combining together Effelsberg with the other large EXPReS telescopes (including the 300-m Arecibo telescopes) will provide European astronomy with a world-beating, real-time astronomical facility.

Table SA2.3: Justification of financing requested for whole contract (36 months)

Participant	Justification	Total budget (€)	Requested funds (€)
JIVE	Cost of upgrade to 16 x 1 Gbps links • 60 kE / yr	180000	40000
AARNET	Provider of “on-demand” user controlled light-paths between Australia and Europe to facilitate e-VLBI tests and remote use of radio telescopes facilities in Australia (one of the possible SKA sites) by European astronomers. • Connectivity 25 kE	50000	10000
ASTRON	Cost of 1 Gbps line 15 kE/yr	45000	10000
CNIG-IGN	Contract of 1 Gbps data transfer to the GÉANT NREN node in RedIRIS-Madrid. • Fibre 175 kE • Service 132 kE/yr	530000	100000
CSIRO	Construction of high-speed connections between Australia and Europe to allow remote users in Australia to access the EVN. It will also serve as a proof-of-concept tool for Europeans to access one of the possible SKA sites. • equipment 50 kE	50000	10000
HARTRAO	Private optical-fibre link that will operate at 1 Gbps after October 2005.	55000	10000

	• Fiber 50 kE • Equipment 5 kE		
INAF	Medicina connection via dark fibre provided by local government; new equipment is needed to operate at rates up to 10 Gbps. • fibre 1400 kE • equipment 40 kE Setup of Sardinia thanks to the high-speed networking and supercomputing project CyberStar. • fibre 1300 kE • equipment 40 kE	2780000	110000
MPIfR	Connection of the 100-m radiotelescope at Effelsberg, the largest EVN instrument in Europe. • link 2 ME	2250000	210000
MRO	Connected to the Finnish University Network by new dark-fibre link, operated by a commercial company. New equipment is being purchased to run the link up to 1 Gbps. • link 90 kE/yr • equipment 60 kE	330000	38000
NAIC	Studies to increase the bandwidth from 155 Mbps to 1 Gbps. • service 132 kE/yr	396000	50000
NCU	Cost of 1 Gbps link: • service 20 kE/yr	60000	25000
OSO	Will equip the existing network with upgraded equipment to allow 4-10 Gbps operation and links through GÉANT to JBO e-MERLIN. • fibre 10 kE/yr • equipment 85 kE	115000	30000
ShAO	Connection of the EVN telescopes in China: Shanghai, Urumqi, Miyun, and Yunnan. Urumqi is already linked by fiber and needs equipment to run; Miyun and Yunnan need a few km of new fiber to CSTNET and Shanghai needs up to 25 km. • Shanghai 350 kE • Urumqi 100 kE • Miyun 100 kE • Yunnan 100 kE	650000	75000
TIGO	Upgrade of the network equipment to	70000	30000

	be able to transmit at high data-rates. • Service 45 kE/yr • Equipment 25 kE		
UniMan	MERLIN will build a 10 Gbps link to JIVE (0.5 Gbps per telescope) in order to operate together with the EVN.	120000	12000
VIRAC	Equipment for the new optical fibre network built with EC Structural Funds for scientific equipment and infrastructure development to Latvia. • fibre 145 kE • equipment 5 kE	151000	40000
Total budget:		7832000	
Total EC requested:			800000

5.B.3.3. Exploitation of results

This Support Action is expected to result in the connection of a substantial number of radio telescopes to GÉANT and the VLBI data processing facility at JIVE. The telescopes to be connected at data rates of 1 Gbps include some of the largest and most sensitive radio antennas in the world. Once connected to GÉANT, the newly telescopes will be able to take full advantage of the production grade e-VLBI service associated with SA1. It is our intention for telescopes to effectively contribute to the EXPReS e-VLBI infrastructure as soon as they come “on-line”.

Access to this extended global e-VLBI facility will be provided using existing agreements between partner institutes within the EVN and other affiliated institutes (See general SA introduction). There will be no limitation in the subsequent exploitation of scientific results. Processed e-VLBI data will be owned by the end-user who submitted the original observing proposal and those he or she authorises. However, all processed VLBI data will enter into the public domain 12 months after delivery of the processed data to the user. The e-VLBI infrastructure will be openly accessible to the international astronomical community. There is also likely to be interest in this technique from other VLBI users – in particular the geodetic and spacecraft navigation communities. However, the astronomical community will be the main beneficiary of the e-VLBI facility delivered by SA1 and SA2. Scientific results obtained by end-users will be published in refereed journals, following the standard process that applies to all such submissions. No limitations will be placed on the freedom of end-users to publish their data widely and to present their results at conferences and workshops.

The partnership policy established between the participants in the EVN-NREN Proof-of-Concept project will be the same as that described in SA1 – the SA2 project will develop freely in a spirit of open scientific and technical collaboration. We do not foresee any eventualities that will limit any subsequent exploitation of the technical (development) results that might arise via SA2.

The risks associated with SA2 are probably larger than in some of the other activities included in the EXPReS project. We can be very confident that the majority of telescopes listed in

SA2.3 will achieve 1 Gbps connectivity; several already have. The largest risk is associated with South Africa – not with respect to the local last mile connection but concerning the bandwidth that will be available between South Africa and GÉANT. Even if the bandwidth is restricted, it will be possible to test the link and also to conduct narrow-band (low data-rate) spectral-line e-VLBI. Such narrow-band science observations can be usefully made using data rates of 32 Mbps per telescope and the telescope in South Africa is equipped with radio receivers at the appropriate observing frequencies for such observations to be made (in particular 1.6 GHz, 6 GHz, 12 GHz & 22 GHz). The case for improving connectivity between Europe and South Africa is a good example of the way in which high-bandwidth applications such as e-VLBI can help to leverage better connectivity to many distant parts of the world.

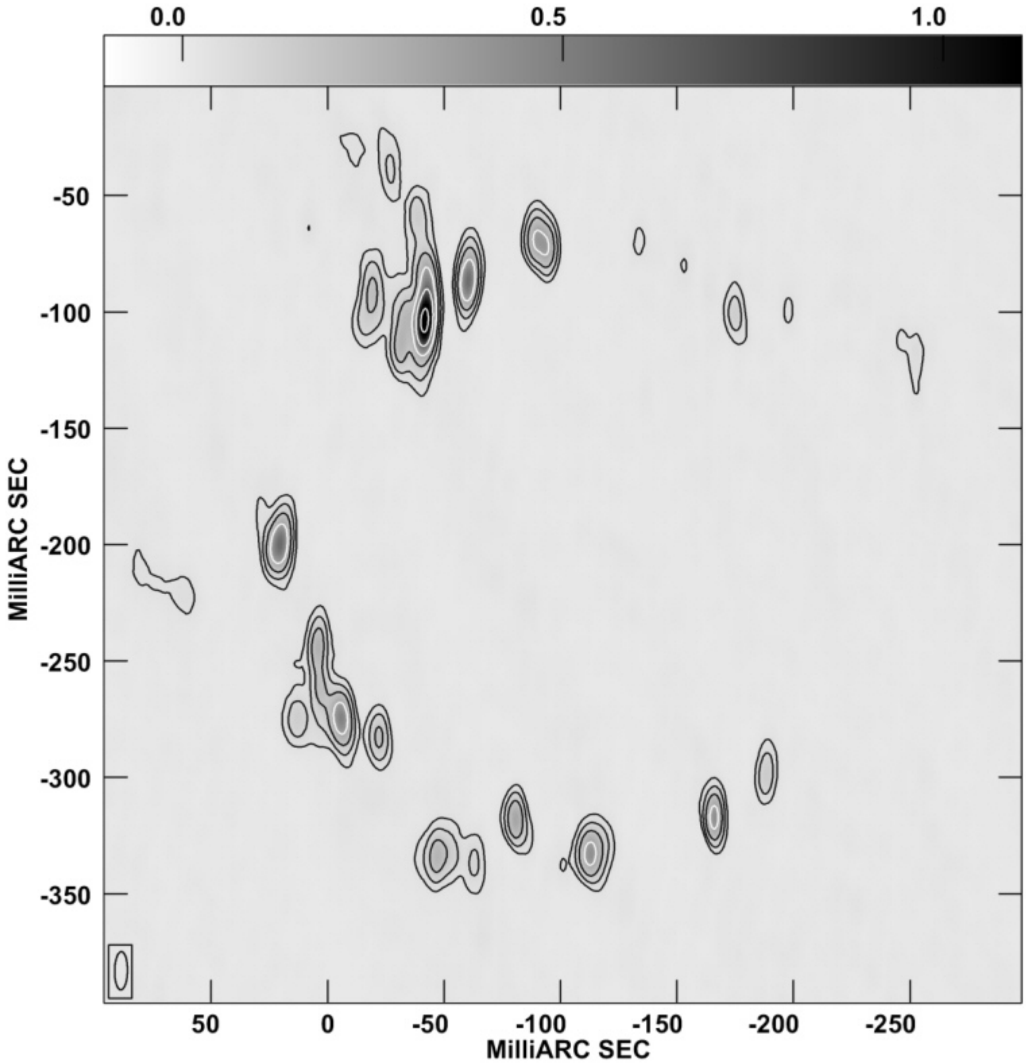


Figure SA2.4: A 6.7 GHz EVN image of the galactic radio source G23.657. The ring of emission seen here is due to methanol maser emission, probably arising in the shock initiated by a young, massive star at the centre of the ring. Since the maser spectral-line emission is very narrow-band, this kind of science can be conducted with very modest data rates (a few tens of Mbps). Such observations yield a new perspective on the problem of the origin of methanol masers and star formation.

The risks associated with the last-mile connections presented in table SA2.2 are somewhat higher than those associated with table SA2.1. However, the radio telescopes listed in table SA2.2 have indicated that EC funding at the level requested would be an important source of funding to them, and in addition, would be the kind of trigger that could release much larger local, regional and national support. We have only included in our request for funding those telescopes where we believe the chance of success realising 1 Gbps connections are reasonably good. For connectivity to China we are less worried about the last-mile connection and more worried about the general connectivity between Europe and China. As in the case of South Africa, a low-bandwidth link would still permit us to conduct spectral-line VLBI and useful tests (see Figure SA2.4). In addition, the Chinese antennas are involved in the Chinese Lunar Programme and both ShAO and JIVE are building up considerable expertise in this area – a precision spacecraft navigation e-VLBI demo would be possible using very modest data rates between Europe and China, since the spacecraft signals are very narrow-band, only a few kHz wide.

7.6 Table SA2.4 - Deliverables List

Deliverable No[1]	**Activity No**[2] **and title**	**Deliverable title**	**Lead participant**	**Delivery date**[3]	**Nature**[4]	**Dissemination level**[5]
DSA2.01	SA2	Feasibility study of the last-mile connection to the nearest NREN node for participant CNIG-IGN	CNIG-IGN	6	R	PU
DSA2.02	SA2	Feasibility study of the last-mile connection to the nearest NREN node for participant MPIfR	MPIfR	6	R	PU
DSA2.03	SA2	Equipment of the last-mile infrastructure for participant INAF (telescope in Medicina)	INAF	6	O	PU
DSA2.04	SA2	Feasibility study of the last-mile connections to the nearest GEANT NREN node for participant CAS (Shanghai, Urumqi, Miyun, Yunnan)	CAS	6	R	PU
DSA2.05	SA2	Feasibility study of the last-mile connection to the nearest NREN node for participant VIRAC	VIRAC	6	R	PU
DSA2.06	SA2	Feasibility study of the last-mile connection to the nearest NREN node for participant HRAO	HRAO	6	R	PU

[1] Deliverable numbers in order of delivery dates: D1 – Dn
[2] Activity that will produce this Deliverable
[3] Month in which the deliverables will be available. Month 0 marking the start of the project, and all delivery dates being relative to this start date.
[4] Please indicate the nature of the deliverable using one of the following codes:
- **R** = Report
- **P** = Prototype
- **D** = Demonstrator
- **O** = Other

[5] Please indicate the dissemination level using one of the following codes:
- **PU** = Public
- **PP** = Restricted to other programme participants (including the Commission Services).
- **RE** = Restricted to a group specified by the consortium (including the Commission Services).
- **CO** = Confidential, only for members of the consortium (including the Commission Services).

DSA2.07	SA2	Feasibility study of the last-mile connection to the nearest NREN node for participant NAIC (Arecibo)	NAIC	6	R	PU
DSA2.08	SA2	Feasibility study of the last-mile connection to the nearest NREN node for participant TIGO	TIGO	6	R	PU
DSA2.09	SA2	Feasibility study of the last-mile connection to AARNET for participant CSIRO	AARNET	6	R	PU
DSA2.10	SA2	e-VLBI test observations, Medicina	INAF	10	R	PU
DSA2.011	SA2	Equipment of the last-mile infrastructure for participant MRO	MRO	12	O	PU
DSA2.12	SA2	Construction and equipment of the last-mile infrastructure for participant CNIG-IGN	CNIG-IGN	12	O	PU
DSA2.13	SA2	Construction and equipment of the last-mile infrastructure for participant MPIfR	MPIfR	12	O	PU
DSA2.14	SA2	10 Gbps link upgrade between MERLIN and JIVE	MERLIN JIVE	18	O	PU
DSA2.15	SA2	e-VLBI test observations, Metsahovi	MRO	18	R	PU
DSA2.16	SA2	Construction and equipment of the last-mile infrastructure for participant Shanghai	CAS	18	O	PU
DSA2.17	SA2	Construction and equipment of the last-mile infrastructure in AARNET to allow connection of participant CSIRO	AARNET CSIRO	18	O	PU
DSA2.18	SA2	Construction and equipment of the last-mile infrastructure for participant Urumqi	CAS	18	O	PU
DSA2.19	SA2	Construction and equipment of the last-mile infrastructure for participant Miyun	CAS	18	O	PU
DSA2.20	SA2	Construction and equipment of the last-mile infrastructure for participant Kunming	CAS	18	O	PU
DSA2.21	SA2	Construction and equipment of the last-mile infrastructure for participant VIRAC	VIRAC	18	O	PU
DSA2.22	SA2	Equipment of the last-mile infrastructure for participant NAIC	NAIC	18	O	PU
DSA2.23	SA2	Construction and equipment of the last-mile infrastructure for participant TIGO	TIGO	18	O	PU

DSA2.24	SA2	AARNET connectivity enhancements	AARNET	18	O	PU
DSA2.25	SA2	Feasibility study of the last-mile connection to the nearest GÉANT node for participant INAF (Sardinia)	INAF	20	R	PU
DSA2.26	SA2	10 Gbps link between UniMan and OSO for ultra-VLBI tests	UniMan OSO	20	O	PU
DSA2.27	SA2	e-VLBI test observations, Effelsberg	MPIfR	21	R	PU
DSA2.28	SA2	e-VLBI test observations, Metsahovi	ATNF	22	R	PU
DSA2.29	SA2	e-VLBI test observations, Yebes	OAN	22	R	PU
DSA2.30	SA2	Construction and equipment of the last-mile infrastructure for participant HartRAO	HRAO	24	O	PU
DSA2.31	SA2	e-VLBI test observations, Urunqi	CAS	30	R	PU
DSA2.32	SA2	e-VLBI test observations, Mijun	CAS	30	R	PU
DSA2.33	SA2	e-VLBI test observations, Kunming	CAS	30	R	PU
DSA2.34	SA2	e-VLBI test observations, VIRAC	VIRAC	30	R	PU
DSA2.35	SA2	e-VLBI test observations, HRAO	HRAO	30	R	PU
DSA2.36	SA2	e-VLBI test observations, NAIC, Arecibo	NAIC	30	R	PU
DSA2.37	SA2	e-VLBI test observations, TIGO	TIGO	30	R	PU
DSA2.38	SA2	Construction and equipment of the last-mile infrastructure for participant INAF (Sardinia)	INAF	30	O	PU

Milestones[1] and expected result

The relevant milestones include:

M1: Feasibility study of the last-mile connection to the nearest GÉANT node. To + 6 months.

M2: Construction and equipment of the last-mile infrastructure. To + 18 months.

M3: e-VLBI Fringes (Detection). To +10 months.

The major milestone for each of the participants in SA2 will be the successful connection of the telescope to GÉANT and successful participation with the EXPReS e-VLBI facility (see SA1). This milestone will take place at different times at different telescopes – the aim is to have the majority of participants connected within 24 months of the project start date.

[1] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Justification of financing requested:
The total cost of connecting the EXPReS radio telescopes to GEANT2 and the correlator at JIVE is ~ €7 Million. The requested EC contribution is ~ €0.8 Million. This contribution from the EC (~10% of the total cost) is identified by all partners of SA2 as an important catalyst that will be essential in releasing other sources of funding, in particular at the local, regional, national (and in some cases) private level. The effect of the EC recognising the potential of EXPReS in terms of its network ambitions should not be underestimated. We also note that this division of funding also represents very good (added) value from the EC funding perspective. In most cases, the participants are requesting funds that are directed towards solving the telescopes' "last-mile" connection problem. Durable equipment is also required in some cases to light the fibre. The largest single expenditure is the connection of the giant 100-m radio telescope located at Effelsberg. This is one of the most flexible and sensitive radio telescopes in the world, and its inclusion within the proposed e-VLBI infrastructure would be a huge boost to the capabilities of the facility.

5. B.3.4. Summary

A summary of this activity is given in Table SA2.5.

Table SA2.5 - ACTIVITY DESCRIPTION (REPORTING PERIOD PLUS 6 MONTHS)

Activity number :	SSA2	**Start date or starting event:**			Year 1, month 1
Participant (Short name)**:**	JIVE	AARNET	ASTRON	CNIG-IGN	CSIRO	HartRAO
Expected Budget per Participant:	40000	10000	10000	150000	10000	5000
Requested Contribution per Participant:	10000	2000	3000	30000	5000	2000

Activity number :	SSA2	**Start date or starting event:**			Year 1, month 1
Participant (Short name)**:**	INAF	MPIfR	MRO	NAIC	NCU	OSO
Expected Budget per Participant:	1000000	500000	150000	100000	20000	30000
Requested Contribution per Participant:	50000	100000	30000	20000	5000	10000

Activity number :	SSA2	**Start date or starting event:**		Year 1, month 1
Participant (Short name)**:**	ShAO	TIGO	UniMan	VIRAC	SSA2 TOTAL
Expected Budget per Participant:	100000	20000	30000	30000	2205000
Requested Contribution per Participant:	25000	10000	5000	10000	317000

Objectives
The objective of this support action is the provision of high-speed optical-fibre connections to a

large number of VLBI capable telescopes, permitting them to deliver VLBI data to the EVN Data Processor at JIVE (the Netherlands). This connection is achieved by the construction of the needed infrastructures between the NREN nodes and the telescopes. The activity is a challenging one since the telescopes are often located in remote areas. The aim is to realise 1 Gbps connectivity per telescope and for special cases, realise 10 Gbps (*e.g.* in order to include the entire e-MERLIN array with the EXPReS e-VLBI infrastructure). Other high speed connections are required in order to test future aspects of e-VLBI, beyond the production network envisaged in SA1. The situation and solution of the last mile problem varies very much among the participants; some have access to academic networks while others need to purchase the service from commercial companies. This action will coordinate all efforts, providing a forum where the necessary technical and logistic information can be shared.

The overall objective is to provide the end-user community with access to a widely distributed state-of-the-art astronomical instrument. SA2's role is to maximise the participation of individual radio telescopes in the unique EXPReS e-VLBI infrastructure.

Description of work

The objectives will be realised in 2 work packages: WP1 (Dynamic status report & EXPReS support of the last-mile telescope connections to the nearest NREN node) WP2 – (Construction and procurement of equipment for the last-mile infrastructure) & WP3 – Testing and e-VLBI verification. For a few participants of SA2, the first priority will be to establish the extent of the last-mile problem. Although this has already been established for the vast majority of cases, conditions evolve rapidly and communication between the relevant parties needs to be a continuous activity of WP1. The expertise of the EXPReS participants will be important in identifying the optimal way to access GÉANT via the use of existing services or the construction of new fibre links. This expertise and experience will also be useful when contracts are being negotiated. When telescopes come on line the connections will be tested and when certified they can begin to interface to the EXPReS e-VLBI data processing facilities at JIVE.

The risks associated with SA2 are probably larger than in some of the other activities included in the EXPReS project. One significant problem may be the amount of bandwidth that is available between Europe, China and South Africa. The problem with China is being addressed in a complimentary project (ORIENT– led by DANTE). The case for South Africa is less clear but it is known that there is considerable support for better communications at high government level, especially as part of South Africa's bid to host the Square Km Array (SKA). In any case, even modest bandwidths to China and South Africa will permit useful testing to take place and interesting science to be conducted, in spectral-line astronomy and spacecraft navigation.

5. B.4 OVERALL IMPLEMENTATION AND CO-ORDINATION OF THE SPECIFIC SERVICE ACTIVITIES

The Specific Service Activities of EXPReS are split into two separate activities, SA1 & SA2. At the basis of the e-VLBI facility that EXPReS envisages, there is a fundamental requirement to be able to process VLBI data in a real-time environment. The objectives of SA1 are to realise this fundamental objective via the modification and upgrade of the (embedded/on-line/offline) software and hardware associated with the EVN data processor.

The SA1 project is in many ways a standalone activity – it will in itself result in a very useful e-VLBI facility for Europe, using the telescopes that are now on-line or about to come on line. In particular, it will offer end-users a real-time capability that will not only improve the reliability of the complex VLBI technique, but also make it well matched to the study of transient phenomena such as active stars, supernovae and gamma-ray bursts. The work programme associated with SA1 will thus realise a scientifically useful instrument in its own right. SA1 is also being implemented in such a way that if and when new telescopes come on-line, they can be transparently added to the infrastructure.

The goal of SA2 is to expand the e-VLBI facility taking advantage of the processing facilities provided via SA1, by expanding the number of telescopes that are online with Gbps connectivity. The number of telescope pairs (baselines) roughly scales as the square of the number of telescopes; currently there are 4 telescopes within Europe that are online, providing a total of 6 baselines. The addition of another telescope to the array (e.g. Medicina – as expected in June 2004) will expand the network to 5 telescopes and thus provide 10 baselines. The more telescopes in the array, the more baselines; the more baselines the better the aperture coverage of the distributed telescope. The result is that better (higher fidelity, higher dynamic-range) images are generated when more telescopes are included in the array, and then processed by the data processor at JIVE. A 16 telescope array generates 120 baselines – in these conditions it is possible to make excellent images of cosmic radio sources.

In addition, another important aspect of a VLBI array is the maximum separation between the telescopes. This is because the angular resolution of the array (the angular scale on which the instrument can clearly separate two features in an image) improves as the separation between the telescopes increases. Currently the maximum e-VLBI baseline within Europe is just 1400 km (the distance between Jodrell Bank, UK, and Torun, Poland). By including the Yebes 40-m telescope near Madrid, Spain, and the Seshan 20-m telescope near Shanghai, China, the longest baseline is extended to 9000 km, essentially quadrupling the resolution of the array. This permits the astronomer to see very fine details in the radio image, and can be very useful in the full astrophysical interpretation of the source properties.

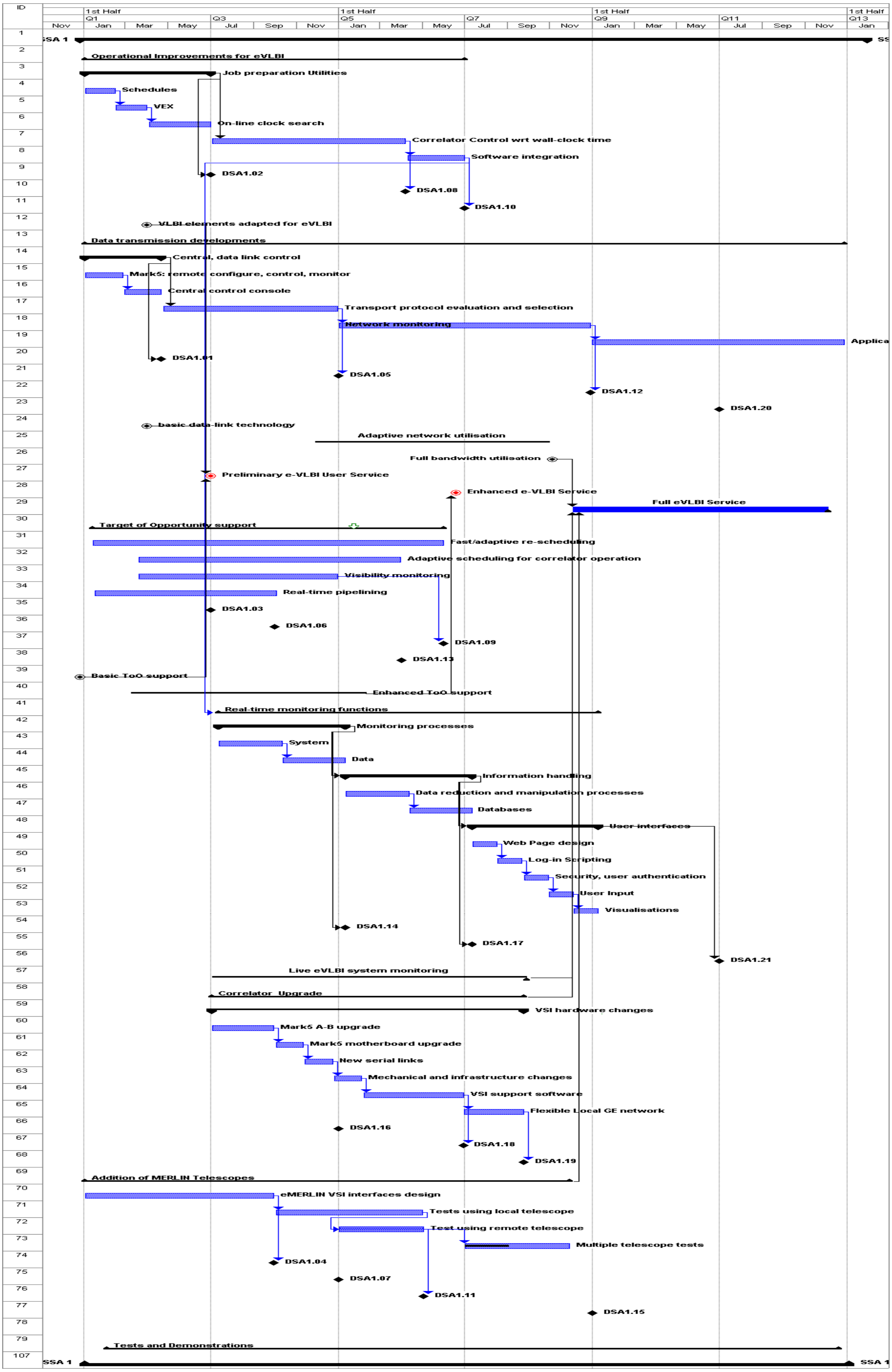
As presented, both SA1 and SA2 (in their own specific way), improve the service that can be provided to astronomers but also to other interested end-users, such as the geodetic and spacecraft navigation communities. The inclusion of these two service activities within EXPReS will undoubtedly improve the quality of the fully loaded e-VLBI service we wish to use and also deliver to the wider scientific community.

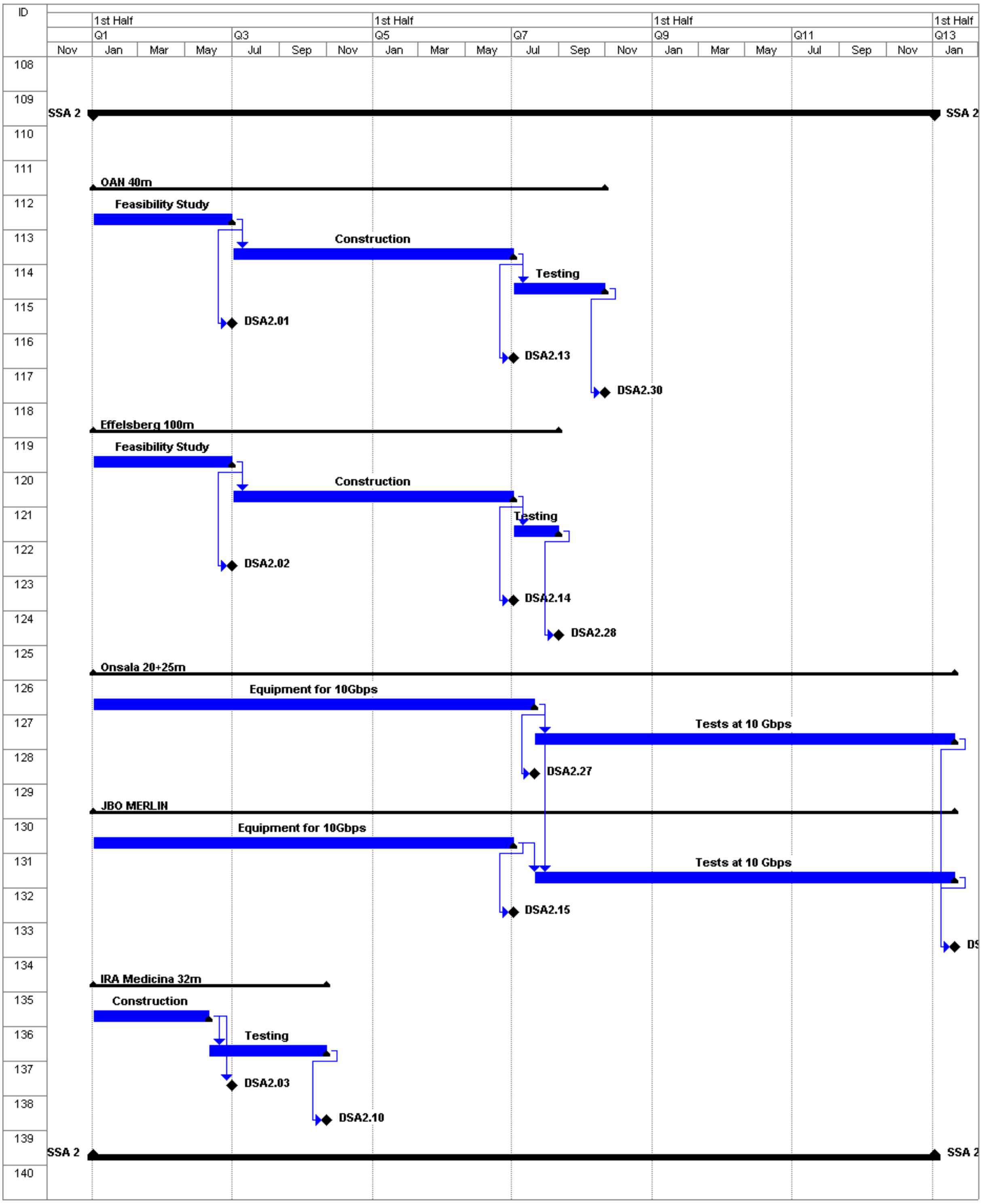
Both the SA1 and SA2 activities can develop in a fairly independent way – at least until the point at which a telescope in SA2 obtains connectivity. Before that point the mutual dependencies between the SA1 and SA2 activities are weak. However, at the stage a telescope comes on-line, it can immediately begin to participate in the e-VLBI test and verification programme of SA1. A functionally similar programme was set up as part of the e-VLBI Proof-of-Concept project with tests conducted on a 6-weekly cycle (this is in addition to and separate from science demonstration time – currently scheduled by the eVSAG chairman). This current arrangement has been successfully proven in the EVN-NREN e-VLBI Proof-of-Concept (PoC) project – the tests are organised in their entirety by the proposed team-leader of SA1, Dr. Arpad Szomoru. A cycle of 6 weeks also seems appropriate for EXPReS, at least with respect to the technical test and verification activities associated with both SA1 and SA2.

Our experience is that once a telescope is connected it will quickly move from the SA2 phase into SA1. The dynamic monitoring of the progress being made at each telescope (a deliverable of SA2) will be useful in gauging the progress being made, in order that the e-VLBI verification test programme can begin as soon as a telescope is capable of participating. This will be a on-going point of discussion at the EXPReS Management Team (EMT) meetings – mostly involving the combined and coordinated forces of the team leaders of SA1 and SA2.

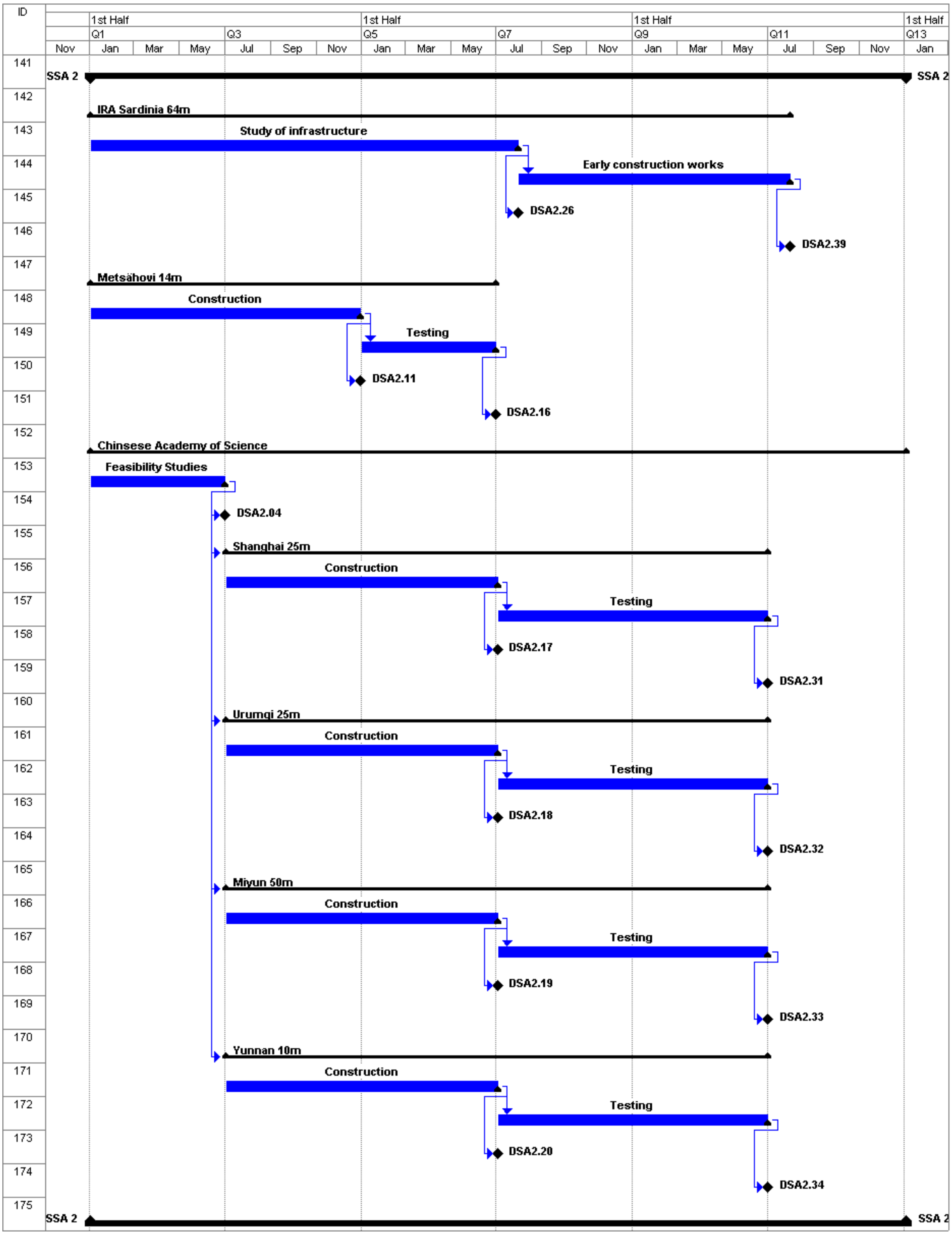
During this telescope “transfer” or “promotion” stage, it will also be important to involve directly the staff at the Data Processor (essentially SA1 manpower) and staff at the telescope. This already happens naturally within the PoC programme, and during tests continuous conference calls are set up in which the telescope and processor staff are in constant communication for many hours – the dialogue is an impressive demonstration of European and indeed international collaboration.

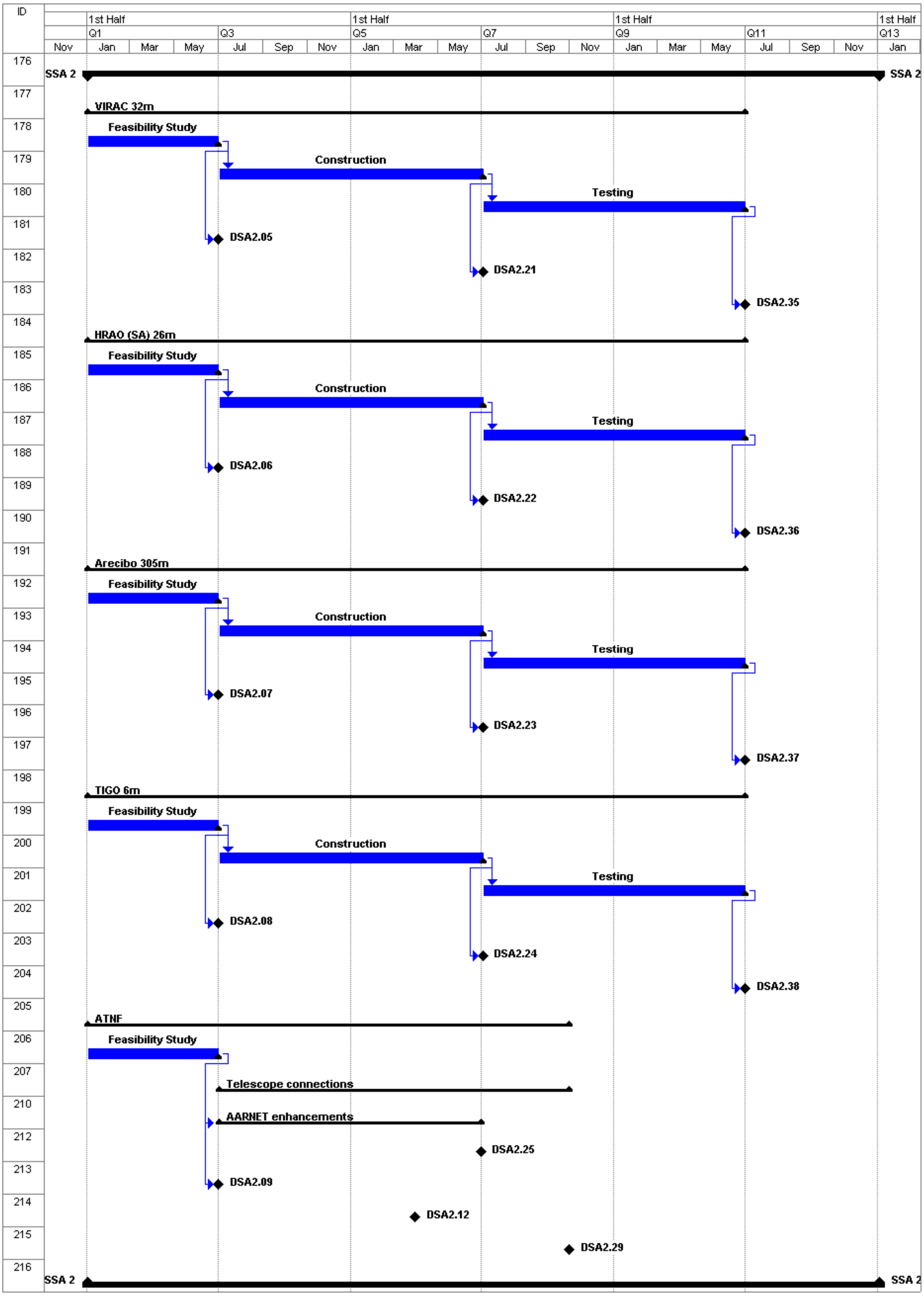
An indicative multi-annual execution plan for the service activities in EXPReS is presented below.


SSA 1
Operational Improvements for eVLBI
Job preparation Utilities
Schedules
VEX
On-line clock search
Correlator Control wrt wall-clock time
Software integration
DSA1.02
DSA1.08
DSA1.10
VLBI elements adapted for eVLBI
Data transmission developments
Central, data link control
Mark5: remote configure, control, monitor
Central control console
Transport protocol evaluation and selection
Network monitoring
DSA1.01
DSA1.05
DSA1.12
DSA1.20
basic data-link technology
Adaptive network utilisation
Full bandwidth utilisation
Preliminary e-VLBI User Service
Enhanced e-VLBI Service
Full eVLBI Service
Target of Opportunity support
Fast/adaptive re-scheduling
Adaptive scheduling for correlator operation
Visibility monitoring
Real-time pipelining
DSA1.03
DSA1.06
DSA1.09
DSA1.13
Basic ToO support
Enhanced ToO support
Real-time monitoring functions
Monitoring processes
System
Data
Information handling
Data reduction and manipulation processes
Databases
User interfaces
Web Page design
Log-in Scripting
Security, user authentication
User Input
Visualisations
DSA1.14
DSA1.17
DSA1.21
Live eVLBI system monitoring
Correlator Upgrade
VSI hardware changes
Mark5 A-B upgrade
Mark5 motherboard upgrade
New serial links
Mechanical and infrastructure changes
VSI support software
Flexible Local GE network
DSA1.16
DSA1.18
DSA1.19
Addition of MERLIN Telescopes
eMERLIN VSI interfaces design
Tests using local telescope
Test using remote telescope
Multiple telescope tests
DSA1.04
DSA1.07
DSA1.11
DSA1.15
Tests and Demonstrations



ID
1st Half
Q1
Q3
1st Half
Q5
Q7
1st Half
Q9
Q11
1st Half
Q13
Nov
Jan
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sep
Nov
Jan
108
109
SSA 2
SSA 2
110
111
OAN 40m
112
Feasibility Study
113
Construction
114
Testing
115
DSA2.01
116
DSA2.13
117
DSA2.30
118
Effelsberg 100m
119
Feasibility Study
120
Construction
121
Testing
122
DSA2.02
123
DSA2.14
124
DSA2.28
125
Onsala 20+25m
126
Equipment for 10Gbps
127
Tests at 10 Gbps
128
DSA2.27
129
JBO MERLIN
130
Equipment for 10Gbps
131
Tests at 10 Gbps
132
DSA2.15
133
134
IRA Medicina 32m
135
Construction
136
Testing
137
DSA2.03
138
DSA2.10
139
SSA 2
SSA 2
140


ID
1st Half
Q1
Q3
1st Half
Q5
Q7
1st Half
Q9
Q11
1st Half
Q13
Nov
Jan
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sep
Nov
Jan
141
SSA 2
SSA 2
142
IRA Sardinia 64m
143
Study of infrastructure
144
Early construction works
145
DSA2.26
146
DSA2.39
147
Metsähovi 14m
148
Construction
149
Testing
150
DSA2.11
151
DSA2.16
152
Chinsese Academy of Science
153
Feasibility Studies
154
DSA2.04
155
Shanghai 25m
156
Construction
157
Testing
158
DSA2.17
159
DSA2.31
160
Urumqi 25m
161
Construction
162
Testing
163
DSA2.18
164
DSA2.32
165
Miyun 50m
166
Construction
167
Testing
168
DSA2.19
169
DSA2.33
170
Yunnan 10m
171
Construction
172
Testing
173
DSA2.20
174
DSA2.34
175
SSA 2
SSA 2



ID
1st Half
Q1
Q3
1st Half
Q5
Q7
1st Half
Q9
Q11
1st Half
Q13
Nov
Jan
Mar
May
Jul
Sep
Nov
176
SSA 2
177
VIRAC 32m
178
Feasibility Study
179
Construction
180
Testing
181
DSA2.05
182
DSA2.21
183
DSA2.35
184
HRAO (SA) 26m
185
Feasibility Study
186
Construction
187
Testing
188
DSA2.06
189
DSA2.22
190
DSA2.36
191
Arecibo 305m
192
Feasibility Study
193
Construction
194
Testing
195
DSA2.07
196
DSA2.23
197
DSA2.37
198
TIGO 6m
199
Feasibility Study
200
Construction
201
Testing
202
DSA2.08
203
DSA2.24
204
DSA2.38
205
ATNF
206
Feasibility Study
207
Telescope connections
210
AARNET enhancements
212
DSA2.25
213
DSA2.09
214
DSA2.12
215
DSA2.29
216
SSA 2

5 C. JOINT RESEARCH ACTIVITIES

5. C.1. DESCRIPTION OF EACH RESEARCH ACTIVITY

JRA1, FABRIC: FUTURE ARRAYS OF BROADBAND RADIO-TELESCOPE ON INTERNET COMPUTING

5. C.1.1. Scientific and Technological excellence

5. C.1.1.1. Objectives and originality of the joint research activity

Networks of radio telescopes can be used to produce detailed radio images of stars and galaxies: the resolution of the images depends on the overall size of the network (the maximum separation between the telescopes) and the sensitivity depends on the total collecting area of all the telescopes involved and, crucially, the bandwidth of the connection between the telescopes. In this technique, called Very Long Baseline Interferometry (VLBI) the signals between all telescope pairs are combined in a data processor. Typically this processor needs to find the correlated response in 2-bit (4 level) signals on every baseline pair with high resolution, and must be able to cope with as large bandwidths as possible (currently 1 Gbps per telescope). Traditionally, this functionality has been implemented by constructing a massively parallel, purpose-built 'supercomputer' – usually referred to as a Data Processor or Correlator. As these machines only need to implement a very limited number of operations and are dealing with 2-bit signals, these have been implemented on commodity silicon. A decade ago, a 20000 node PC cluster would have been required to match the processing power of the EVN MkIV Data Processor at JIVE. However, this number is falling rapidly as processor technology continues to advance and develop.

The EVN data processor at JIVE will be the heart of the e-VLBI Network that is the main subject of the specific service activity (SA1) included in this proposal. However, beyond 2010 one may expect that telescopes and networks will be able to perform at data rates well beyond 1 Gbps, boosting the sensitivity of e-VLBI with the existing telescope resources (collecting area). A project has been initiated by the EVN to develop digital back-ends that will deliver up to 4 GHz of sampled bandwidth from each telescope. Plans call for a 30 Gbps telescope capability before the end of the decade. The processing of multiple 30 Gbps data streams will clearly require an upgrade of the existing data formatting and transport mechanisms, as well as much increased data processor capacity.

The current VLBI system started out with a longitudinal tape recording format (MkIV) and was upgraded with disk-based recording (Mk5). These systems have proven to be useful for the implementation of e-VLBI. However, it is clear that they are not optimised, nor scalable for future transportation bandwidths. It is desirable to develop equipment dedicated for this type of processing, based on commercial off-the-shelf (COTS) components. Similarly, data processors are nowadays constructed with more readily available components (e.g. FPGAs). The massive computing power required for LOFAR with 77 stations, albeit with limited bandwidth per telescope, will be implemented on standard computer chips in an overwhelmingly large (Blue-Gene) supercomputer architecture. These developments make it seem likely that the next generation e-VLBI data processor will be based on standard computing components.

However, it is not just the issue of sheer computing power that drives the design issues of radio astronomy data processors. The connectivity issues are just as demanding, and may in fact be the defining issue in the future. As high-speed data sampling becomes available at the telescope, it will be more and more challenging to bring all data to a single place. Moreover to form all the baseline pairs a matrix of compute nodes needs to be fed to calculate all data products, requiring massive switching capacity. An attractive idea for future data processors is to map this computational topology onto an international Grid of compute nodes (Figure J1.1). This will reduce the requirement to have all data converge to one central place; with a large fabric of reasonably fast, interconnected data processor nodes it will be possible to provide the necessary computer power for a wide band data processor, while the international wide band connections themselves provide the complex interconnect. In such a scheme, digital data must be packaged at the telescope and copied for distribution to several data processor nodes, arbitrarily distributed over Europe. The resulting data product must be archived as a single entity, presumably at a central node, as there are proprietary issues associated with its use for scientific research.

FABRIC Key Objective: Develop a prototype for high data rate e-VLBI using distributed correlation. The following components constitute the vital areas of development:

- **Data acquisition platform and formatting for future e-VLBI:** Develop optimal buffering between the digital output of the radio telescope and transport protocol. The new data acquisition platform should allow for local quality control, calibration operations and recording of hard copies. Establish (or identify) a transportation protocol that optimises transport characteristics, including copies for different routes (multicast). Push data transfer to rates well beyond 1Gbps, develop a hardware interface capable of sustaining these rates between public and dedicated networks in order to integrate existing facilities.

- **Software Data processor**: Develop code that will run on standard workstations using open source compilers, deployable on Grid nodes. Conduct a programme of research designed to improve data processor algorithms, allowing a variety of geometric models and enabling zooming functionality for spacecraft navigation and spectral line applications. Format output data such that it can be transparently merged into central archive, available for real-time access and automatic pipelining (calibration and imaging).

In order to achieve these goals we will address several elements in the data transport and correlation process. Current e-VLBI has adopted so-called Mk5 units for data transmission, which were primarily designed as disk recording systems and contain dedicated hardware for this task. Currently digital filters are being developed that will increase the available bandwidth (the so called DBBC project). In order to take advantage of this, a better platform needs to be developed that can interface between the net and the digital output directly, and that will serve as a command interface between the telescope and the user. This platform will exploit the latest PC technology in parallel architecture when necessary. Furthermore, current schemes implement the data transport via TCP/IP or UDP, protocols that are sub-optimal for our application. This is a wide-band application, in which the loss of a few percent of the data is not critical. Either special IP-based protocols that have low impact on other users or direct lambda connections seem more appropriate in the long run. Note that in this project we are also concerned with the connectivity to all data processor nodes and not just the telescopes.

With the start of an e-VLBI experiment that employs distributed correlation, a central routing scheme needs to be implemented. Each telescope needs to be instructed where to send data and computer resources must be allocated accordingly. There are different topologies possible for the implementation; we aim for scalable solutions that can work both with relatively few data processor nodes, as well as implementations in which there are more nodes than baselines between telescopes. To support data management and information flow for the entire e-VLBI experiment in an automated way, a workflow management system will be created. The workflow module is placed on top of the existing applications and steers them to control the measurement process in a Grid environment. The total process must be real-time in the sense that it keeps up with observing, but otherwise processing can be asynchronous. Future e-VLBI arrays may want 32 telescopes combined with 4 GHz bandwidth (generating at least 16 Gbps of sampled data per telescope), which requires two orders of magnitude more compute power than available in the current data processor. Conceptually, the processing of a single baseline product will be assigned to a cluster computer at some random Grid point. This requires a state-of-the-art implementation of a correlation code which is completely scalable and easily distributed. Recent research has shown that it is possible to take advantage of floating point processing to implement more accurate and sensitive algorithms, that also allow special functionality, such as unlimited spectral zoom. This unique machinery will allow spacecraft tracking with VLBI precision.

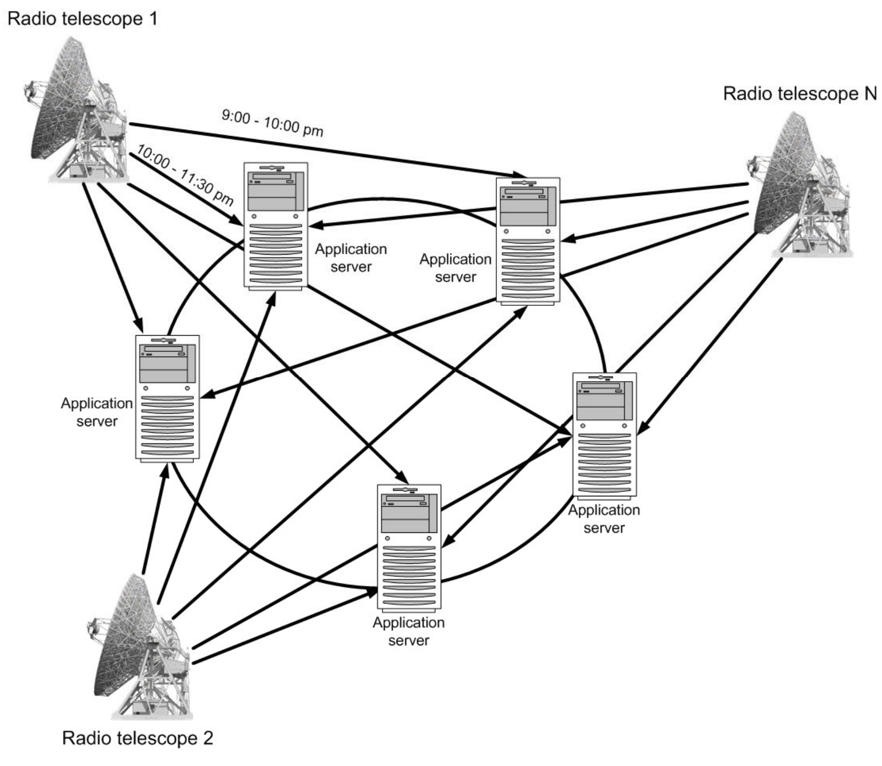


Figure J1.1. Possible topology for future distributed correlation. Note that the number of compute nodes would grow with the number of telescopes squared. In this naive sketch one node (which could be an entire Grid cluster computer) is assigned to one baseline, in reality the data may be sliced in time, frequency band or polarisation.

In European radio astronomy there are two state-of-the-art initiatives that employ high bandwidth connectivity on a similar time-scale as e-VLBI. The e-MERLIN array is complementary to the EVN in the sense that it has shorter baselines, providing sensitivity to extended objects. LOFAR will observe the sky at frequencies much below the EVN observing frequencies, yielding capabilities to study sources that have different physical characteristics. Both arrays rely on dedicated networks for their data transport. Interesting possibilities exist to combine some of the capabilities of these dedicated arrays with an EVN e-VLBI array in the future. In particular, LOFAR seeks to extend its baselines by co-locating LOFAR stations at EVN sites. Solutions for the data transport and correlation issues of the EVN should be implemented with compatibility considerations in mind. Both facilities offer interesting possibilities to test the R&D effort and explore new scientific applications.

We define two pilot projects which will focus the deliverables of this JRA and may give direct benefit to astronomers interested in intensive monitoring programs or wide band capabilities. The first target will be the correlation of at least one baseline at a data rate of up to 4 Gb/s. One option for this is to use the prototype e-MERLIN correlator, sited at Jodrell Bank Observatory in the UK and currently scheduled for delivery in 2006/7. This correlator will be capable of handling data rates of up to 24 Gb/s per telescope, but it has been designed to accept a proprietary format optimised for dedicated dark fibre connections. The target will be to connect one EVN telescope from outside the UK using a link with multi-Gb/s capacity and demonstrate that this can be achieved using the prototype data acquisition system. Remote LOFAR stations may exercise the same transport mechanism.

In the second pilot experiment up to 5 telescopes will observe and deploy distributed correlation, resulting in a scientific product of comparable size and improved quality over existing observations. The bandwidth of such an experiment would be limited (< 256 Mbps), but the whole scheme will be easily scalable to higher data rates. This experiment can serve as a prototype for a semi-permanent small VLBI network with low operations costs, as there are few consumables.

5. C.1.1.2. Execution plan of the joint research activity

These topics fit naturally into 2 work packages:

- **WP1 – Scalable connectivity,**
- **WP2 – Distributed correlation.**

Table J1.1 summarises the first and second level work breakdown structure and gives a summary of the effort required, as well as which partner has the primary responsibility. The overall timeline of the project is presented in Figure J1.1a & J1.1b. Table J1.2 gives a more detailed description of the tasks involved. Table J1,3 focuses on the deliverables that are planned to be reached in the first 18 months.

The timeline is not only dedicated by the available new and matching manpower. The data acquisition system depends on the availability of a DBBC prototype. The demonstration of wide-band correlation could be dependent on the successful commissioning of the eMERLIN correlator.

TABLE J1.1: WORK PACKAGE SUMMARY

Workpackage	Objectives	Effort [fte·yr]	Primary Respons.
Management		1	JIVE
WP0. System analysis			
0. System design	Do detailed system design, defining interfaces. Set overall goals and plan integration tests..		
WP1. Scalable connectivity			
WP1.1. Data acquisition	Develop a scalable framework of both hardware and software that takes digital output available at telescope and formats for electronic transport and/or recording. Must feature remote central control, data quality checks, and calibration.		
1.1.1. Data acquisition architecture	Design scalable data acquisition system based on COTS	1.4	MHO
1.1.2. Data acquisition prototype	Demonstrate design in prototype	2.6	MHO
1.1.3. Data acquisition control	Interface FieldSystem Tsys, stats etc	2.0	MPIfR
WP1.2. Broadband data path	Make strategic decision on transport mechanism that is optimal for future e-VLBI application: scalable to large bandwidth, relaxed fault tolerance, multicasting, Grid enabled.		
1.2.1. Broadband protocols	Investigate different IP protocols vs lambda switching	2.0	JBO
1.2.2. Broadband data processor interface	Develop interface to public network, e-MERLIN processor	2.0	JBO
1.2.3. Broadband integration and test	Test with 10Gb/s using Onsala station	2.0	OSO
1.2.4. Public to dedicated network interface	LOFAR transport, LO & timing issues	1.0	ASTRON
WP2 –Distributed Correlation			
WP2.1 – Grid Resource allocation	Selection, integration and adaptation of existing solutions for VLBI workflow management. Resource allocation must be based on knowledge		

	of connectivity and available computing.		
2.1.1. Grid - VLBI collaboration	Establish presence of VLBI on Grid	1.2	PNSC
2.1.2. Grid Workflow management	Tool to manage VLBI workflow	1.4	PNSC
2.1.3. Grid Routing	Commands for routing data flow	1.4	PNSC
WP2.2 – Software correlation	Develop a correlator engine that can run on standard workstations, deployable on cluster computers and grid nodes. Innovative features will be spectral filtering and high accuracy fringe tracking. Output product conform EVN standard.		
2.2.1. Correlator algorithm design	Design correlator algorithm	1.4	JIVE
2.2.2. Correlator computational core	Single node machine that works on Mk5	0.8	JIVE
2.2.3. Scaled up version for clusters	Distributed correlator in local environment	1.4	JIVE
2.2.4. Distributed version, middleware	Package deployment on Grid nodes	1.4	JIVE
2.2.5. Interactive visualization	Display correlator results on web	1	JIVE
2.2.6. Output definition	Output from individual correlator nodes ready to merge	2	JIVE
2.2.7. Output merge	Client that connects output data to archive	3	JIVE
TOTAL		30	

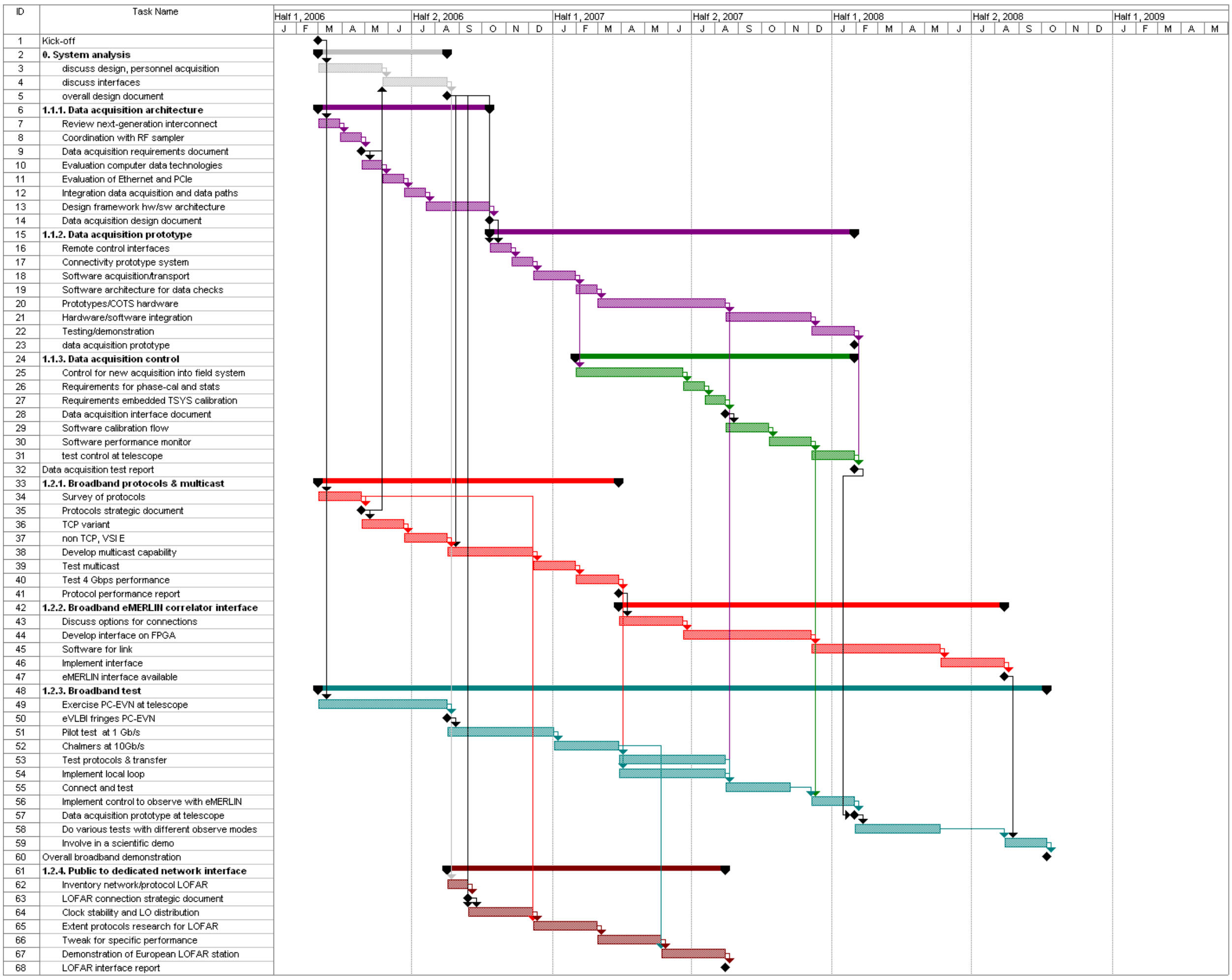


Figure J1.2a. Chart showing the timeline for the work in the first work package "Scalable connectivity" over the entire project.

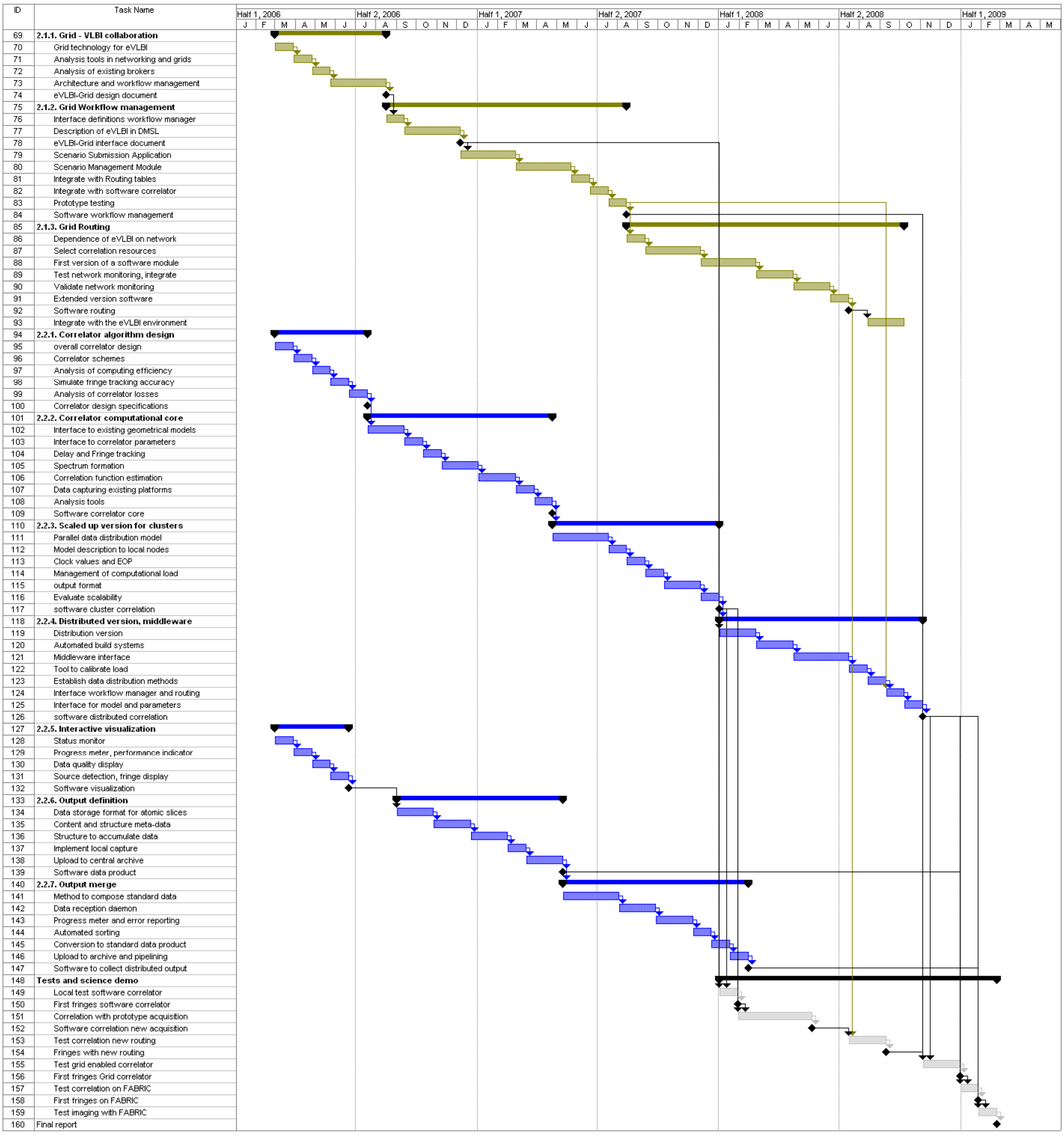


Figure J1.2b. Chart showing the timeline for the work in the first work package "Distributed correlation" over the first 18 months.

TABLE J1.2: TASK DETAILS	
Workpackage	Activities and deliverables. Deliverables shown in italic font
0. System analysis	discuss design, personnel acquisition discuss interfaces *overall design document*
1.1.1. Data acquisition architecture	Review next-generation interconnect Coordination with RF sampler *Data acquisition requirements document* Evaluation computer data technologies Evaluation of Ethernet and PCIe Integration data acquisition and data paths Design framework hw/sw architecture *Data acquisition design document*
1.1.2. Data acquisition prototype	Remote control interfaces Connectivity prototype system Software acquisition/transport Software architecture for data checks Prototypes/COTS hardware Hardware/software integration Testing/demonstration *data acquisition prototype*
1.1.3. Data acquisition control	Control for new acquisition into field system Requirements for phase-cal and stats Requirements embedded TSYS calibration *Data acquisition interface document* Software calibration flow Software performance monitor test control at telescope *Data acquisition test report*
1.2.1. Broadband protocols & multicast	Survey of protocols *Protocols strategic document* TCP variant non TCP, VSI E Develop multicast capability Test multicast Test 4 Gbps performance *Protocol performance report*
1.2.2. Broadband eMERLIN correlator interface	Discuss options for connections Develop interface on FPGA Software for link Implement interface *eMERLIN interface available*
1.2.3. Broadband test	Exercise PC-EVN at telescope *eVLBI fringes PC-EVN* Test at 1 Gb/s Establish 10Gb/s connection Chalmers Test protocols & transfer Implement local loops Connect and test at 10Gb/s

	Implement control to observe with eMERLIN *Data acquisition prototype at telescope* Do various tests with different observe modes Involve in a scientific demo *Overall broadband demonstration*
1.2.4. Public to dedicated network interface	Inventory network/protocol LOFAR *LOFAR connection strategic document* Clock stability and LO distribution Extent protocols research for LOFAR Tweak for specific performance Demonstration of European LOFAR station *LOFAR interface report*
2.1.1. Grid - VLBI collaboration	Grid technology for eVLBI Analysis tools in networking and grids Analysis of existing brokers Architecture and workflow management *eVLBI-Grid design document*
2.1.2. Grid Workflow management	Interface definitions workflow manager Description of eVLBI in DMSL *eVLBI-Grid interface document* Scenario Submission Application Scenario Management Module Integrate with Routing tables Integrate with software correlator Prototype testing *Software workflow management*
2.1.3. Grid Routing	Dependence of eVLBI on network Select correlation resources First version of a software module Test network monitoring, integrate Validate network monitoring Extended version software *Software routing* Integrate with the eVLBI environment
2.2.1. Correlator algorithm design	overall correlator design Correlator schemes Analysis of computing efficiency Simulate fringe tracking accuracy Analysis of correlator losses *Correlator design specifications*
2.2.2. Correlator computational core	Interface to existing geometrical models Interface to correlator parameters Delay and Fringe tracking Spectrum formation Correlation function estimation Data capturing existing platforms Analysis tools *Software correlator core*
2.2.3. Scaled up version for clusters	Parallel data distribution model Model description to local nodes Clock values and EOP Management of computational load output format Evaluate scalability

	software cluster correlation
2.2.4. Distributed version, middleware	Distribution version Automated build systems Middleware interface Tool to calibrate load Establish data distribution methods Interface workflow manager and routing Interface for model and parameters *software distributed correlation*
2.2.5. Interactive visualization	Status monitor Progress meter, performance indicator Data quality display Source detection, fringe display *Software visualization*
2.2.6. Output definition	Data storage format for atomic slices Content and structure meta-data Structure to accumulate data Implement local capture Upload to central archive *Software data product*
2.2.7. Output merge	Method to compose standard data Data reception daemon Progress meter and error reporting Automated sorting Conversion to standard data product Upload to archive and pipelining *Software to collect distributed output*
Tests and science demo	Local test software corretor *First fringes software correlator* Correlation with prototype acquisition *Software correlation new acquisition* Test correlation new routing *Fringes with new routing* Test grid enabled correlator *First fringes Grid correlator* Test correlation on FABRIC *First fringes on FABRIC* Test imaging with FABRIC *report*

TableJ1.3. activities and deliverable in the first 18 months			
workpackage	activity	deliverable/milestone	
0. System analysis	discuss design, personnel acquisition discuss interfaces	overall design document	6
1.1.1. Data acquisition architecture	Review next-generation interconnect Coordination with RF sampler Evaluation computer data technologies Evaluation of Ethernet and PCIe Integration data acquisition and data paths Design framework hw/sw architecture	Data acquisition requirements document Data acquisition design document	2 8
1.1.2. Data acquisition prototype	Remote control interfaces Connectivity prototype system Software acquisition/transport Software architecture for data checks Prototypes/COTS hardware Hardware/software integration		
1.1.3. Data acquisition control	Control for new acquisition into field system Requirements for phase-cal and stats Requirements embedded TSYS calibration Software calibration flow	Data acquisition interface document	18
1.2.1. Broadband protocols & multicast	Survey of protocols TCP variant non TCP, VSI E Develop multicast capability Test multicast Test 4 Gbps performance	Protocols strategic document Protocol performance report	2 13
1.2.2. Broadband eMERLIN correlator interface	Discuss options for connections Develop interface on FPGA		
1.2.3. Broadband test	Exercise PC-EVN at telescope Test at 1 Gb/s Establish 10Gb/s connection Chalmers Test protocols & transfer Implement local loops Connect and test at 10Gb/s	eVLBI fringes PC-EVN	7
1.2.4. Public to dedicated network interface	Inventory network/protocol LOFAR Clock stability and LO distribution Extent protocols research for LOFAR Tweak for specific performance Demonstration of European LOFAR station	LOFAR connection strategic document LOFAR interface report	7 18
2.1.1. Grid - VLBI collaboration	Grid technology for eVLBI Analysis tools in networking and grids Analysis of existing brokers Architecture and workflow management	eVLBI-Grid design document	6
2.1.2. Grid Workflow	Interface definitions workflow manager	eVLBI-Grid interface	10

management	Description of eVLBI in DMSL Scenario Submission Application Scenario Management Module Integrate with Routing tables Integrate with software correlator Prototype testing	document Software workflow management	18
2.1.3. Grid Routing	Dependence of eVLBI on network		
2.2.1. Correlator algorithm design	overall correlator design Correlator schemes Analysis of computing efficiency Simulate fringe tracking accuracy Analysis of correlator losses	Correlator design specifications	5
2.2.2. Correlator computational core	Interface to existing geometrical models Interface to correlator parameters Delay and Fringe tracking Spectrum formation Correlation function estimation Data capturing existing platforms Analysis tools	Software correlator core	14
2.2.3. Scaled up version for clusters	Parallel data distribution model Model description to local nodes Clock values and EOP		
2.2.4. Distributed version, middleware			
2.2.5. Interactive visualization	Status monitor Progress meter, performance indicator Data quality display Source detection, fringe display	Software visualization	4
2.2.6. Output definition	Data storage format for atomic slices Content and structure meta-data Structure to accumulate data Implement local capture Upload to central archive	Software data product	15
2.2.7. Output merge	Method to compose standard data Data reception daemon		

5. C.1.2 Quality of the management

5. C.1.2.1 Management and competence of the participants

This JRA will be led by JIVE (the Netherlands), where the project leader will be based. The tasks will be led by local managers at each participating institute, who will report to the central project leader. The participants have extensive experience in collaborating with each other and other partners on an international scale, which is the way the EVN has operated for decades. Recently we have had quite a lot of experience with the management of EC funded R&D projects (e.g. RTD FP4, RadioNet FP5 and FP6), which show that with well-defined work packages of reasonable size, good progress can be made.

In addition, it is crucial that a clear overall focus is maintained. A number of electronic means are available to share knowledge and ideas (e-mail exploders, wiki pages). Most importantly, it is anticipated that all participants meet twice a year. These meetings serve as a platform for reporting progress and exchanging ideas on implementation methods and coding platforms. In addition, there will be meetings with partners that share a common interface, which focus on defining work packages, dividing resources and interface definitions. Each work package will require a written plan of implementation and resource planning to the level of functional modules. Where appropriate results of the (scientific) research will be discussed in publications and presented at international meetings.

List of participants and relevant expertise

Metsähovi Radio Observatory (MRO)

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 further. After delivering sets of MkIV 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 applications. Metsähovi has pioneered the use of VSI (VLBI Standard Interface), the internationally-agreed interfacing standard for VLBI data acquisition. For the PCEVN project a Linux PC-based VSIB disk recorder design was completed in 2002. This is now in use at many VLBI observatories across the world, in particular Australia.

The principal responsibility of the Metsähovi group is to construct the prototype data acquisition system that, amongst other things, can channel broadband data from the telescope to the network.

Max Planck Institut für Radioastronomie

MPIfR operates the 100-m radio telescope in Effelsberg near Bonn, one of the key elements in the successful VLBI programme conducted by the EVN. MPIfR staff have been involved in VLBI both at the recording and correlating end of the business since the mid-seventies. Members of the group have always contributed to the online and offline software and hardware developments of the record terminals and the data processors. The group has been operating 4 generations of VLBI correlators. Presently members of the group are developing a so-called IF switch box to further automate the mode selection at the MkIV/Mk5 recording terminals. The required modifications to the control software 'Field System' will also be implemented in house. The present MkIV/Mk5 data processor is used for MPIfR-based astronomical observations, where the emphasis is on mm-wavelengths, astrometry and special VLBI experiments, and also serves the German geodetic community. In the last 20 years several new VLBI observing techniques have been developed at MPIfR. Its scientists are actively developing techniques for mm-VLBI, and several projects are underway using remote sensing of the atmosphere to improve the calibration and sensitivity of high-frequency VLBI observations.

It will be the responsibility of the MPI staff to oversee the adaptation of the new data acquisition system in the existing protocols for VLBI.

Jodrell Bank Observatory (JBO)

Jodrell Bank Observatory, part of the School of Physics and Astronomy of the University of Manchester owns and operates the 76-m Lovell Telescope (LT) and the 7-element MERLIN/VLBI National Facility. Both the LT and MERLIN are integral components of the EVN, indeed JBO was one of the founding members of the EVN. MERLIN is undergoing a ~ €12.5M upgrade. The telescopes of e-MERLIN, as the upgraded instrument will be known, will be connected with fibre-optic cables each transmitting up to 30 Gbps of data; new receivers, new digital transmission equipment and a new broadband correlator (data processor) will enable observations a factor of 10-30 times more sensitive than the current array. e-MERLIN will be operational in 2009. In addition, JBO recently commissioned a 2.5 Gbps fibre link to Manchester and from there onto the UK's research network; this link was recently used for e-VLBI tests, including the first e-VLBI Proof-of-Concept science demo. JBO staff has extensive experience in digital hardware, software and, more recently, data transmission standards and protocols.

The JBO expertise is required to make a strategic decision on the transport mechanism for FABRIC. This includes the multicast capability deemed essential for distributed correlation. In addition the JBO staff will establish an interface between data arriving on public networks and the eMERLIN correlator.

The Netherlands Foundation for Research in Astronomy (ASTRON)

The mission of ASTRON is to facilitate astronomical research through innovative and unique instrumentation and services. ASTRON operates one of the world's largest existing radio telescopes, the Westerbork Synthesis Radio Telescope, and maintains a well-equipped technical laboratory for the purpose of developing innovative instrumentation for scientific research. Since 1993, ASTRON has been working towards the next generation radio telescopes. The ultimate goal in this development is the Square Kilometre Array, which will give unprecedented sensitivity at GHz frequencies (with a square kilometre of effective collecting area). ASTRON identified several intermediate steps on the roadmap towards this instrument. The LOFAR telescope, which has recently been funded by the Dutch government, is one important stepping stone towards the SKA. E-VLBI is another. LOFAR will be the first operational facility that utilises massive phased array signal processing, using high-speed data networks, high performance streaming supercomputing and full Grid-based post-processing. ASTRON participates in VLBI through the Westerbork telescope and by hosting JIVE at its HQ in Dwingeloo.

ASTRON staff will exercise the protocols established in FABRIC for the transport of LOFAR data and clock signals to and from remote stations.

Onsala Space Observatory

Onsala Space Observatory, Sweden is a part of Chalmers Technical University. Onsala has been one of the leading observatories in Europe in implementing e-VLBI connectivity and has been heavily involved with the early e-VLBI Proof-of-Concept test observations. In addition, Onsala also gave the first transatlantic e-VLBI fringes to the MIT Haystack correlator in April 2004. In addition to its astronomy activities, Onsala is one of the main geodetic VLBI sites in Europe and is interested in partaking in geodetic e-VLBI for the near real-time measurement of Earth orientation parameters. An Onsala staff member, Dr. John Conway has been appointed by the directors of the EVN to lead a small group to study astronomical applications of e-VLBI. This e-VLBI Science Advisory Group (see also Networking Activity, NA3) is also charged with organising demonstration science experiments, the first of which, a spectral line experiment in September 2004, was highly successful. A second higher bit rate continuum experiment will be observed in mid-March 2005. As part of its educational outreach, the observatory has developed a small antenna and backend for student use, this antenna has integrated digital filters, samplers, and auto-correlators constructed via FPGA chips. This expertise can be used to build future samplers/digitizers and to demonstrate 1-10 Gbps e-VLBI. The observatory has extensive expertise in building near real-time software in LINUX. Finally, there is extensive support and enthusiasm for the e-VLBI project from the Chalmers University network group and the Swedish SUNET academic network provider.

At Onsala the infrastructure will be established to test the new data acquisition prototype and connect it at high data rate with the eMERLIN correlator initially.

Poznań Supercomputing and Networking Center (PSNC)

PSNC is the operator of the national optical network PIONIER, as well as the Polish link to the GÉANT network. The PSNC Supercomputing Department administers an HPC environment of 1.5 TFLOPS peak performance. It is a successful partner in several projects of the fifth and sixth framework programme on Grid technologies and networking, most noticeably GridLab, CrossGrid, CoreGRID, EGEE, HPC Europa, 6NET, Mupbed and ATRIUM. It has developed several relevant technologies that employ portals for workflow and information management. The current research activity of PSNC concerns the management and monitoring of computer networks, development of optical technologies and development of new network services. Most relevant is the Virtual Laboratory (VLab) project, which enables remote access to lab equipment.

The PSNC group brings Grid expertise to the project. Here the workflow management software to distribute the correlation over Grid computers will be established. The next level is to establish methods to route the data across Europe to the nodes where sufficient computational resources are available.

JIVE

The Joint Institute for VLBI in Europe co-developed and now operates the world's most technically advanced correlator for radio interferometry as part of the European VLBI Network. The software team that has developed and maintained the control of the EVN MkIV data processor is specialized in dealing with high capacity data-flow problems and has implemented the world's largest capacity correlator backend on parallel computers. A local cluster computer is part of NL-Grid. Amongst its staff there is unique expertise in correlation algorithms, as is demonstrated by the recent success in the Huygens project, for which space-craft navigation with narrow-band VLBI was developed. The JIVE team has taken the lead in demonstrating e-VLBI for astronomy in collaboration with GÉANT. It has successfully used up to 5 telescopes in real-time, using the existing data acquisition systems and the existing hardware correlator. It routinely employs so called 'ftp-VLBI' to monitor the integrity of the telescope network. JIVE has a long track-record of managing EC supported projects, both in user support (Transnational Access), as well as (software) development.

JIVE runs the overall management of FABRIC. In addition its staff will establish the algorithms for wideband software correlation. This will be ported to cluster computers and enabled for the Grid. In addition the user product has to be compiled and archived, even when its creation is widely distributed.

Other EXPReS participants

This JRA has been structured around 'critical-mass' teams at seven institutes. However, we still anticipate significant scientific and technical input from other EXPReS participants with expertise in several of the key areas of this proposal. The technical expertise in the EVN is organised through its Technical and Operations Group (chaired from MPIfR), and we expect that progress in this JRA will also be discussed there. An important interface constitutes the EVN project on digital base-band converters (DBBC), which is an EVN activity with a focus point at The Institute of Radio Astronomy (IRA), Italy. Similar expertise is required for scheduling observations and interfacing with the telescope control. All this expertise exists within the larger scope of EXPReS.

5. C.1.2.2 Justification of financing requested

A detailed justification of the requested finance is reported in Table J1.4. Community financing is not being used to conclude sub-contracts. Community financing is being used to purchase durable equipment to the extent of building prototypes only. The budget for this JRA is not aimed at providing new physical connections to any e-VLBI elements.

Table J1.4: Justification of financing requested

		Requested Funds		Matching Funds	
		FTE-yrs	K€	FTE-yrs	k€
OSO	Staff	1	75	1	75
	Travel		4		0
	Hardware		10		0
ASTRON	Staff	0.5	75	0.5	75
	Travel		2		2
MPIfR	Staff	1	75	1	75
	Travel		4		0
MRO	Staff	2	150	2	150
	Travel		8		0
	Hardware		30		0
JBO	Staff	2	150	2	150
	Travel		8		0
	Hardware		30		0
PSNC	Staff	2	140	2	140
	Travel		8		0
	Hardware		10		0
JIVE	Staff	6	450	6	450
	Travel		24		0
		14.5	1253	14.5	1117

Note: All use additional cost (AC) model, except ASTRON which follows full cost model (FC)

5. C.1.3. European added value

Interest for European research infrastructures and their users

Most of the tools that will be investigated and developed in this Joint Research Activity will eventually be of benefit to the users of the radio interferometers, in particular the EVN. As explained the work will prepare for the expansion of the EVN in bandwidth and number of stations, by research of the necessary components for high bandwidth capabilities and a very cost-effective distributed correlator. The EVN is a bottom-up organisation based on the international collaboration of many telescopes. The establishment of distributed correlation fits this organisation in a very natural way.

The EVN is currently the world's most sensitive VLBI array. Its ambition to maintain this leading position is demonstrated by the current construction of several new telescopes. The development of distributed correlation will allow it to expand its bandwidth capacity, which will provide the necessary improvement in sensitivity to stay in the lead. Besides the long term perspective there will be an opportunity to use the array defined for the pilot projects for specific projects. This can be done without putting more strain on the currently scarce resources in the EVN: recording media, correlator time and observing time on the few largest telescopes.

The proposal for *FABRIC* sketches a visionary picture of the way we think e-VLBI might look in the next decade. Such an implementation is in itself a step towards the Square Kilometre Array, currently under consideration by radio astronomers around the globe. The objective of this proposal is to start development of the components that entail the roadmap to the future VLBI network. There is no other comparable effort anywhere in the world, although, obviously, this project has a lot of synergy with the ongoing LOFAR and e-MERLIN projects. Moreover, it aims to create interfaces between these arrays and the EVN where they use public resources (Network and Grid). Thus a contribution is made to their future interoperability, which opens up interesting new capabilities for radio-astronomical research.

This research and development work builds on our successful project to employ the network provided by GÉANT to implement e-VLBI. Where wide-band data transport is already part of the ongoing effort, we now propose to also look into the possibility of distributed computing for VLBI. Essential components for this are therefore not only the network, but also Grid computational elements. This proposal does not cover the construction of such a Grid, but the necessary development of components that will allow VLBI to use such distributed computing. As is the case with data transport problems, we can imagine that distributed correlation for e-VLBI will push the envelope of Grid capabilities for data-intensive distributed processing.

The implementation of correlator functionality on standard computing platforms actually allows important advantages over current implementations. In the first place it will be possible to move beyond 2-bit data representations. Current data processors (correlators) make crude statistical approximations of the correlator function by using 2-bit representations. Although such a 2-bit representation (4-level sampling) will continue to be the most cost-effective for bandwidth limited transport, there will be opportunities to improve the correlation product and eventually accommodate 8-bit data representation. Secondly, spectral zoom functionality, required for spacecraft navigation, can be implemented (as is currently being demonstrated by JIVE scientists for the Huygens-Cassini mission to Titan). The correlator algorithms being considered will have more accurate fringe tracking and will be able to take advantage of improved calibration algorithms. This is only one of the facets where this proposal is technologically innovative.

Some of the partners in this project collaborate in the EC funded RadioNet consortium on several aspects of data processing in radio-astronomy. These are distinctly different from the e-VLBI specific applications we develop here. In some areas however they are complementary; robust pipeline processing of VLBI data is for example essential for fast dissemination of all VLBI results, the focal plane arrays under consideration in RadioNet will impose much more severe requirements on future data processors, by effectively multiplying the number of stations. Ongoing research and development for SKA and LOFAR, focuses on antenna design issues and models for data processing. In this respect our proposal is quite revolutionary, yet applicable on a relevant timescale.

Finally, a unique perspective is the possible application for spacecraft navigation, being pioneered currently at JIVE for the Huygens mission. At JIVE a special purpose software correlator has been developed to track the position of the Huygens probe during its recent successful descent to Titan. It implements the correlation of an extremely narrow band signal, which on current PC hardware is still much, much slower than real-time. This effort is an important exercise for testing correlation algorithms.

5. C.1.4 Exploitation of results

While the motivation for this JRA is the development of new techniques for future VLBI observations, the two pilot projects will deliver interesting new capabilities that can be exploited for direct scientific use.
The wide band capability and possible connection to e-MERLIN will allow fast detection experiments of very weak sources. Even more interesting capabilities arise when distributed correlation will provide permanent cheap (albeit limited bandwidth) VLBI capabilities, with very flexible spectral zooming. We describe two such applications below in detail.

1. *Application to Large Astronomical Surveys and Transients*

Current media based VLBI using specialised hardware correlators is limited to an operational model of a few multi-week sessions per year. While e-VLBI combined with the JIVE correlator will greatly increase the flexibility of the VLBI technique the scarce central correlator (data processing) resource must still be allocated, limiting its application. In contrast, software correlation combined with e-VLBI gives the prospect of completely automated observations, and the possibility to run, in addition to normal operations, small antenna arrays doing survey type science. For instance, a small number (2 to 4) of the medium sized antennas of the European network could, via software correlation, undertake observations lasting months at a time.

Particularly interesting as an initial application for such an array is 1) Observations of galactic masers, which emit only over a narrow bandwidth and hence can be observed without loss of information with very modest bit rates (8Mbps station; Fig J1.3). Intensive observations over the course of a year can be used to find the distances to these masers by parallax (their change in apparent position due to motion of Earth around the Sun). Such modest bandwidth observations can also be useful for time monitoring of bright continuum emitting objects.

Applications here include 2) Looking for time delays in the variability between the multiple images of gravitationally lensed objects. 3) Monitoring structural variability in bright quasar or stellar jets. After the initial proof of concept more computing resources can be applied allowing real time observations with higher bandwidth so that weaker sources could be observed. Applications here include 4) doing large finding surveys for compact black holes in the centres of galaxies. 5) Monitoring the positions of nearby stars to detect orbiting planets. Finally, such a sensitive continuously observing array could 6) Make quick response observations of newly detected or transient radio sources such as exotic stars or Gamma ray burst sources.

2. Application to phase referencing VLBI of deep space and planetary probe signals

The use of software correlator algorithms was successfully demonstrated by JIVE scientists during the analysis of the Huygens probe VLBI tracking project, as well as prior test observations involving the Cassini and Mars Express spacecraft.

The great flexibility of software correlators, including such features as practically unlimited resolution in both time and frequency zooming, makes them particularly useful for phase referencing experiments involving spacecraft and natural radio sources, where correlation of both broad-band and ultra-narrow-band signals is required. The synergy produced between VLBI and deep-space missions when one signal is used as a phase reference for study of the other, opens up new horizons for experiments in fundamental physics, astronomy and planetary sciences.

Policy issues

As is common in scientific development, the project results will be freely available for scientific and technical collaborations. Documents and software are generally put in the public domain. The EVN collaborates with radio-astronomy developers worldwide and VLBI only works if participants agree on standard data interfaces. There is therefore a long tradition of shared technology. The aim will be to promote the results of FABRIC to other VLBI networks, and where applicable to the Square Kilometre Array (SKA).

The exploitation of the results of this project in an international context depends on the ongoing international competition to establish the standards for VLBI observing. There is a risk that somewhere components will be developed that will be accepted for exploitation before the results of this project become available. However, it is clear that the proposed R&D would put the European partners ahead in this competition.

5. C.1.5. Summary

Table 5 - ACTIVITY DESCRIPTION (REPORTING PERIOD PLUS 6 MONTHS)

Activity number :	JRA1: FABRIC	**Start date or starting event:**				1/3/2006	
Participant (Short name)**:**	JIVE	PSNC	ASTRON	MPIfR	MRO	OSO	UniMAn /JBO
Expected Budget per Participant:	300000	90000	50000	25000	100000	30000	100000
Requested Contribution per Participant:	150000	50000	25000	0	60000	20000	60000

Objective: Develop methods for high data rate e-VLBI using distributed correlation.

Develop a scalable prototype for broadband data acquisition.

- Employing off-the-shelve components
- Using control interface that connects to existing steering software
- That incorporates the data streams for calibration
- And formats the data for future transport protocols

Establish a transportation protocol for broadband e-VLBI

- That optimizes transport characteristics for e-VLBI
- Includes making copies for different routes (multicast).
- Push data transfer to rates well beyond 1Gb/s

Interface e-VLBI public networks with LOFAR and e-MERLIN dedicated networks

- Interface remote LOFAR stations through GÉANT network
- Interface Onsala EVN antenna to e-MERLIN
- Demonstrate broadband e-VLBI with new data acquisition system

Setup data distribution over Grid

- Implement resource allocation methods for e-VLBI
- Do workflow management for distributed correlator
- Control the routing of data streams and control parameters

Develop a software correlator

- Establish correlator algorithms for processing on standard computing
- Develop correlator software for cluster computers
- Make the software Grid enabled
- Interface with workflow management and protocols
- Demonstrate software correlation in science demo

Expected results and their possible impact are:

Prototype for broadband data acquisition

- This prototype could be replicated for use in all EVN stations for e-VLBI
- The data acquisition system may also become the standard for disk based recording
- The system may become a cheap acquisition system for new stations
- The system may become a realistic alternative world-wide for data acquisition systems

Protocol for e-VLBI data transport

- May be applicable for e-VLBI without distributed computing
- May become world standard for astronomical VLBI

- May become world standard for geophysics VLBI, time and EOP services
- May become the standard for other radio-astronomy data transport like LOFAR and SKA
- May be applicable for other scientific data transport

Interface public dedicated network

- May facilitate co-observing EVN and e-MERLIN in both directions
- May facilitate co-observing with LOFAR and later SKA (prototypes)
- May allow integration of future radio-telescopes (e-VLA, ALMA)
- May be applicable in other data transport problems

Broadband science demo

- May lead to scientific observations with e-MERLIN and a few EVN antennas
- Gives unique wide-band, long baseline capabilities
- May lead to new astronomical observing facility
- Opportunity for new scientific discoveries

e-VLBI workflow and routing software

- Enables e-VLBI distributed correlation
- May be applicable to future radio astronomy projects (SKA)
- Could be generally applicable to data intensive, distributed computing
- Pushes the envelope of Grid capabilities

Correlator software for standard computing

- Will yield more precise results for VLBI and other long baseline interferometry
- May yield efficient algorithms for astronomical correlation
- May allow more ad-hoc quality control by individual stations
- Can be used by other VLBI networks around the world
- Will allow establishment of VLBI networks much more flexibly and cheaply
- May be used by future radio-astronomy projects
- May be used for spacecraft navigation

Demonstration of distributed correlation

- May establish semi-permanent e-VLBI network for monitoring and event follow up
- May be turned into future wide-band VLBI correlator
- Could lead to semi-permanent e-VLBI network for spacecraft tracking
- May be used by other geo- and astronomical VLBI arrays
- Could be applicable for future radio-astronomy projects

Description of work

Develop a scalable prototype for broadband data acquisition. This is an engineering effort that will focus on using off-the-shelve components in a scalable architecture. It will concentrate on assembling PC components and addressing interface issues. This work will be done by the team at Metsähovi. It will definitely involve some low-level software development. There are a number of control software issues linked with this, including interfacing to the existing control at the telescopes and interfacing calibration data flow, which will be addressed by MPI.

Establish a transportation protocol for broadband e-VLBI. This amounts into research into existing protocols for data transport as well as looking what new protocols are possible within the context of existing protocol layers. This will be implemented by writing specific drivers that allow testing these protocols. This specialist software effort will be carried out at the UniMan group at the Jodrell Bank Observatory, who will also attempt to write an interface between such an algorithm and the dedicated fibre links used by e-MERLIN.

Interface e-VLBI public networks with LOFAR and e-MERLIN dedicated networks, is completed by engineering work by the LOFAR team at ASTRON. These interfaces will probably be based on FPGA components. Software drivers are to be established which will allow LOFAR antennas ate EVN sites to communicate to the LOFAR central processor.

In order to allow a **Broadband science demo,** the group at Onsala will push for a broadband connection to the e-MERLIN correlator. The quality and throughput of this connection will be measured and monitored. In order to use this link, the prototype data acquisition system will need to be interfaced to the Onsala telescope. The responsibility for the tests and scientific pilot observing is also at Onsala.

e-VLBI workflow and routing software. This task deals with establishing a Grid collaboration for FABRIC and modifying existing workflow and resource allocation mechanism for e-VLBI specifically. The group at Poznań has the expertise to do this, as well as producing new methods to direct the data flow for VLBI.

Correlator software for standard computing requires the combination of expertise in scientific software development and correlation algorithms available at JIVE. This is a massive software effort, not just to develop new algorithms and port them to standard cluster environments, but also to define interfaces for model parameters, output format and progress monitoring.

JIVE is also responsible for **Demonstration of distributed correlation** which also requires the astronomical expertise to setup VLBI experiments, debug the output and do the downstream processing.

Deliverable No[1]	**Deliverable title**	**Delivery date[2]**	**Nature[3]**	**Dissemination Level[4]**
DJ1.1	Data acquisition requirements document	2	R	PU
DJ1.2	Protocols strategic document	2	R	PU
DJ1.3	Visualization software	4	P	PU
DJ1.4	Correlator design specification	5	R	PU
DJ1.5	Overall design document	6	R	PU
DJ1.6	eVLBI-Grid design document	6	R	PU

[1] Deliverable numbers in order of delivery dates: D1 – Dn
[2] Indicate the month of delivery. This should be relative to the start date of the *I3*, month 1 marking the first month of the project.
[3] Please indicate the nature of the deliverable using one of the following codes:
- **R** = Report
- **P** = Prototype
- **D** = Demonstrator
- **O** = Other

[4] Please indicate the dissemination level using one of the following codes:
- **PU** = Public
- **PP** = Restricted to other programme participants (including the Commission Services).
- **RE** = Restricted to a group specified by the consortium (including the Commission Services).
- **CO** = Confidential, only for members of the consortium (including the Commission Services).

DJ1.7	eVLBI fringes PC-EVN	7	D	PU
DJ1.8	LOFAR connection strategic document	7	R	PU
DJ1.9	Data acquisition design document	8	R	PU
DJ1.10	eVLBI-Grid interface document	10	R	PU
DJ1.11	Protocols performance report	13	R	PU
DJ1.12	Software correlator core	14	P	PU
DJ1.13	Software data product	15	P	PU
DJ1.14	Data acquisition interface document	18	R	PU
DJ1.15	LOFAR station interface report	18	R	PU
DJ1.16	Software for workflow management	18	P	PU
DJ1.17	Software for correlation on cluster	23	P	PU
DJ1.18	Data acquisition test report	23	R	PU
DJ1.19	Data acquisition prototype at telescope	23	P	PU
DJ1.20	Overall broadband demonstration	23	D	PU
DJ1.21	Software cluster correlation	23	P	PU
DJ1.22	First fringes software correlator	23	D	PU
DJ1.23	Software to collect distributed output	24	P	PU
DJ1.24	Software to create data product from distributed correlation	27	P	PU
DJ1.25	Software routing	29	P	PU
DJ1.26	eMERLIN interface available	30	P	PU
DJ1.27	Fringes with new routing	31	D	PU
DJ1.28	Software distributed correlation	33	P	PU
DJ1.29	First fringes Grid correlator	34	D	PU
DJ1.30	First fringes on FABRIC	35	D	PU
DJ1.31	Final report	36	R	PU

Milestones[1] and expected result

Of the above deliverables, several reflect reports that discuss the options and prepare decisions for implementation. These are notably

DJ1.1 - Requirements document data acquisition

DJ1.2 - Strategic document broadband protocols

DJ1.4 - Design document correlator algorithms

DJ1.6 - eVLBI – Grid design document

These will accumulate into an overall design document DJ1.5, which will describe all the interfaces in the project.

Justification of financing requested

[1] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Almost all the financing is for manpower, mostly in hardware and software engineering efforts. To accommodate travel for regular face-to-face meetings across the project a fixed amount per man-year is requested. There will be two prototype hardware components, one for data acquisition and one for interfacing between dedicated and public networks, each at 30k€. An additional 10k€ is requested for interfacing the Onsala telescope for one of the tests.

6. PROJECT RESOURCES ANF BUDGET OVERVIEW

6.1 Overall budget for the full duration of the I3

We include here a copy of the A3.1 and A3.2 forms from the CPFs, this is the financial information for the duration of the contract.

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number: 026642 | Proposal Acronym: EXPReS

Financial information - whole duration of the project

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities: RTD activities (1)	Coordination / Networking activities (2)	Specific service activities (3)	Consortium Management activities (4)	Total (5)=(1)+(2)+(3)+(4)	Total receipts
1	JIVE	AC	Eligible costs	*Direct Costs (a)*	395.000,00	173.000,00	936.667,00	176.750,00	1.681.417,00	
				of which subcontracting	,00	,00				
				Indirect costs (b)	79.000,00	34.600,00	187.333,00	35.350,00	336.283,00	
				Total eligible costs (a)+(b)	474.000,00	207.600,00	1.124.000,00	212.100,00	2.017.700,00	
			Requested EC contribution		474.000,00	207.600,00	1.124.000,00	212.100,00	2.017.700,00	
2	AARNET PTY LTD	FC	Eligible costs	*Direct Costs (a)*		3.200,00	8.000,00	2.480,00	13.680,00	
				of which subcontracting		,00	,00	,00		
				Indirect costs (b)		800,00	2.000,00	620,00	3.420,00	
				Total eligible costs (a)+(b)		4.000,00	10.000,00	3.100,00	17.100,00	
			Requested EC contribution			4.000,00	10.000,00	3.100,00	17.100,00	
3	DANTE	FC	Eligible costs	*Direct Costs (a)*		7.769,00		3.615,00	11.384,00	
				of which subcontracting		,00		,00		
				Indirect costs (b)		2.331,00		1.085,00	3.416,00	
				Total eligible costs (a)+(b)		10.100,00		4.700,00	14.800,00	
			Requested EC contribution			10.100,00		4.700,00	14.800,00	
4	PSNC	AC	Eligible costs	*Direct Costs (a)*	131.667,00	2.167,00		2.583,00	136.417,00	
				of which subcontracting		,00		,00		
				Indirect costs (b)	26.333,00	433,00		517,00	27.283,00	
				Total eligible costs (a)+(b)	158.000,00	2.600,00		3.100,00	163.700,00	
			Requested EC contribution		158.000,00	2.600,00		3.100,00	163.700,00	
5	SURFnet	FC	Eligible costs	*Direct Costs (a)*		1.955,00		2.330,00	4.285,00	
				of which subcontracting		,00		,00		
				Indirect costs (b)		645,00		770,00	1.415,00	
				Total eligible costs (a)+(b)		2.600,00		3.100,00	5.700,00	
			Requested EC contribution			2.600,00		3.100,00	5.700,00	
6	ASTRON	FC	Eligible costs	*Direct Costs (a)*	154.000,00	2.759,00	6.896,00	2.138,00	165.793,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	1.241,00	3.104,00	962,00	5.307,00	
				Total eligible costs (a)+(b)	154.000,00	4.000,00	10.000,00	3.100,00	171.100,00	
			Requested EC contribution		77.000,00	4.000,00	10.000,00	3.100,00	94.100,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number	026642	Proposal Acronym	EXPReS

Financial information - whole duration of the project

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities: RTD activities (1)	Coordination / Networking activities (2)	Specific service activities (3)	Consortium Management activities (4)	Total (5)=(1)+(2)+(3)+(4)	Total receipts
7	CNIG-IGN	FC	Eligible costs	*Direct Costs (a)*	,00	3.333,00	83.333,00	2.583,00	89.249,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	667,00	16.667,00	517,00	17.851,00	
				Total eligible costs (a)+(b)		4.000,00	100.000,00	3.100,00	107.100,00	
			Requested EC contribution			4.000,00	100.000,00	3.100,00	107.100,00	
8	CSIRO	FC	Eligible costs	*Direct Costs (a)*	,00	5.600,00	8.000,00	2.480,00	16.080,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	1.400,00	2.000,00	620,00	4.020,00	
				Total eligible costs (a)+(b)		7.000,00	10.000,00	3.100,00	20.100,00	
			Requested EC contribution		,00	7.000,00	10.000,00	3.100,00	20.100,00	
9	NRF	FCF	Eligible costs	*Direct Costs (a)*	,00	5.833,00	8.333,00	2.583,00	16.749,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	1.167,00	1.667,00	517,00	3.351,00	
				Total eligible costs (a)+(b)		7.000,00	10.000,00	3.100,00	20.100,00	
			Requested EC contribution		,00	7.000,00	10.000,00	3.100,00	20.100,00	
10	INAF	FCF	Eligible costs	*Direct Costs (a)*	,00	3.200,00	88.000,00	2.480,00	93.680,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	800,00	22.000,00	620,00	23.420,00	
				Total eligible costs (a)+(b)		4.000,00	110.000,00	3.100,00	117.100,00	
			Requested EC contribution		,00	4.000,00	110.000,00	3.100,00	117.100,00	
11	MPG	AC	Eligible costs	*Direct Costs (a)*	65.833,00	3.333,00	175.000,00	2.583,00	246.749,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	13.167,00	667,00	35.000,00	517,00	49.351,00	
				Total eligible costs (a)+(b)	79.000,00	4.000,00	210.000,00	3.100,00	296.100,00	
			Requested EC contribution		79.000,00	4.000,00	210.000,00	3.100,00	296.100,00	
12	TKK	AC	Eligible costs	*Direct Costs (a)*	156.667,00	3.333,00	31.667,00	2.583,00	194.250,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	31.333,00	667,00	6.333,00	517,00	38.850,00	
				Total eligible costs (a)+(b)	188.000,00	4.000,00	38.000,00	3.100,00	233.100,00	
			Requested EC contribution		188.000,00	4.000,00	38.000,00	3.100,00	233.100,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number	026642	Proposal Acronym	EXPReS

Financial information - whole duration of the project

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities				Total	Total receipts
					RTD activities (1)	Coordination / Networking activities (2)	Specific service activities (3)	Consortium Management activities (4)	(5)=(1)+(2)+(3)+(4)	
13	CORNELL	FC	Eligible costs	*Direct Costs (a)*	,00	5.833,00	41.667,00	2.583,00	50.083,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	1.167,00	8.333,00	517,00	10.017,00	
				Total eligible costs (a)+(b)		7.000,00	50.000,00	3.100,00	60.100,00	
			Requested EC contribution		,00	7.000,00	50.000,00	3.100,00	60.100,00	
14	UMK	AC	Eligible costs	*Direct Costs (a)*	,00	3.333,00	20.833,00	2.583,00	26.749,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	667,00	4.167,00	517,00	5.351,00	
				Total eligible costs (a)+(b)		4.000,00	25.000,00	3.100,00	32.100,00	
			Requested EC contribution		,00	4.000,00	25.000,00	3.100,00	32.100,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number	026642	Proposal Acronym	EXPReS

Financial information - whole duration of the project

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities				Total	Total receipts
					RTD activities (1)	Coordination / Networking activities (2)	Specific service activities (3)	Consortium Management activities (4)	(5)=(1)+(2)+(3)+(4)	
15	OSO	AC	Eligible costs	*Direct Costs (a)*	74.167,00	10.000,00	25.000,00	3.917,00	113.084,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	14.833,00	2.000,00	5.000,00	783,00	22.616,00	
				Total eligible costs (a)+(b)	89.000,00	12.000,00	30.000,00	4.700,00	135.700,00	
			Requested EC contribution		89.000,00	12.000,00	30.000,00	4.700,00	135.700,00	
16	SHAO	AC	Eligible costs	*Direct Costs (a)*	,00	5.833,00	62.500,00	2.583,00	70.916,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	1.167,00	12.500,00	517,00	14.184,00	
				Total eligible costs (a)+(b)		7.000,00	75.000,00	3.100,00	85.100,00	
			Requested EC contribution		,00	7.000,00	75.000,00	3.100,00	85.100,00	
17	UDEC	FC	Eligible costs	*Direct Costs (a)*	,00	5.645,00	24.194,00	2.500,00	32.339,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	1.355,00	5.806,00	600,00	7.761,00	
				Total eligible costs (a)+(b)		7.000,00	30.000,00	3.100,00	40.100,00	
			Requested EC contribution		,00	7.000,00	30.000,00	3.100,00	40.100,00	
18	UNIMAN	AC	Eligible costs	*Direct Costs (a)*	156.666,00	34.583,00	133.750,00	2.583,00	327.582,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	31.334,00	6.917,00	26.750,00	517,00	65.518,00	
				Total eligible costs (a)+(b)	188.000,00	41.500,00	160.500,00	3.100,00	393.100,00	
			Requested EC contribution		188.000,00	41.500,00	160.500,00	3.100,00	393.100,00	
19	VeA/VIRAC	AC	Eligible costs	*Direct Costs (a)*	,00	3.333,00	33.333,00	2.583,00	39.249,00	
				of which subcontracting	,00	,00	,00	,00		
				Indirect costs (b)	,00	667,00	6.667,00	517,00	7.851,00	
				Total eligible costs (a)+(b)		4.000,00	40.000,00	3.100,00	47.100,00	
			Requested EC contribution		,00	4.000,00	40.000,00	3.100,00	47.100,00	
TOTAL			Eligible costs		**1.330.000,00**	**343.400,00**	**2.032.500,00**	**271.100,00**	**3.977.000,00**	
			Requested EC contribution		**1.253.000,00**	**343.400,00**	**2.032.500,00**	**271.100,00**	**3.900.000,00**	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.2

Proposal Number	026642	Proposal Acronym	EXPReS

Estimated breakdown of the EC contribution per reporting period

Reporting Periods	Month x - month y	Estimated Grant to the Budget	
		Total	in which first six months
Reporting Period 1	M1 - M12	1.200.000,00	
Reporting Period 2	M13 - M24	1.400.000,00	650.000,00
Reporting Period 3	M25 - M36	1.300.000,00	
Reporting Period 4	M37 - M48		
Reporting Period 5	M49 - M60		
Reporting Period 6	M61 - M72		
Reporting Period 7	M73 - M84		

6.2 Budget for the first reporting period plus 6 months.

We include here a copy of the A3.3 forms from the CPFs, this is the financial information for the first 18 months of the contract.

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.3

Please use as many copies of form A3.3 as necessary for the number of partners

Proposal Number: 026642 — Proposal Acronym: EXPReS

Financial information - Reporting period 1 + first 6 months of period 2

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (Reporting period 1 + first 6 months of period 2)		Costs and EC contribution per type of activities: RTD activities (1)	Coordination / Networking activities (2)	Specific service activities (3)	Consortium Management activities (4)	Total (5)=(1)+(2)+(3)+(4)	Total receipts
1	JIVE	AC	Eligible costs	*Direct Costs (a)*	125.000,00	45.833,00	258.333,00	58.333,00	487.499,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	25.000,00	9.167,00	51.667,00	11.667,00	97.501,00	
				Total eligible costs (a)+(b)	150.000,00	55.000,00	310.000,00	70.000,00	585.000,00	
			Requested EC contribution		150.000,00	55.000,00	310.000,00	70.000,00	585.000,00	
2	AARNET PTY LTD	FC	Eligible costs	*Direct Costs (a)*	,00	960,00	1.600,00	800,00	3.360,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	240,00	400,00	200,00	840,00	
				Total eligible costs (a)+(b)	,00	1.200,00	2.000,00	1.000,00	4.200,00	
			Requested EC contribution		,00	1.200,00	2.000,00	1.000,00	4.200,00	
3	DANTE	FC	Eligible costs	*Direct Costs (a)*	,00	1.538,00	,00	769,00	2.307,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	462,00	,00	231,00	693,00	
				Total eligible costs (a)+(b)	,00	2.000,00	,00	1.000,00	3.000,00	
			Requested EC contribution		,00	2.000,00	,00	1.000,00	3.000,00	
4	PSNC	AC	Eligible costs	*Direct Costs (a)*	41.667,00	667,00	,00	834,00	43.168,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	8.333,00	133,00	,00	166,00	8.632,00	
				Total eligible costs (a)+(b)	50.000,00	800,00	,00	1.000,00	51.800,00	
			Requested EC contribution		50.000,00	800,00	,00	1.000,00	51.800,00	
5	SURFnet	FC	Eligible costs	*Direct Costs (a)*	,00	602,00	,00	752,00	1.354,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	198,00	,00	248,00	446,00	
				Total eligible costs (a)+(b)	,00	800,00	,00	1.000,00	1.800,00	
			Requested EC contribution		,00	800,00	,00	1.000,00	1.800,00	
6	ASTRON	FC	Eligible costs	*Direct Costs (a)*	50.000,00	897,00	2.069,00	690,00	53.656,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	403,00	931,00	310,00	1.644,00	
				Total eligible costs (a)+(b)	50.000,00	1.300,00	3.000,00	1.000,00	55.300,00	
			Requested EC contribution		25.000,00	1.300,00	3.000,00	1.000,00	30.300,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.3

Please use as many copies of form A3.3 as necessary for the number of partners

Proposal Number	026642	Proposal Acronym	EXPReS

Financial information - Reporting period 1 + first 6 months of period 2

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (Reporting period 1 + first 6 months of period 2)		Costs and EC contribution per type of activities: RTD activities (1)	Coordination / Networking activities (2)	Specific service activities (3)	Consortium Management activities (4)	Total (5)=(1)+(2)+(3)+(4)	Total receipts
7	CNIG-IGN	FC	Eligible costs	*Direct Costs (a)*	,00	1.083,00	25.000,00	833,00	26.916,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	217,00	5.000,00	167,00	5.384,00	
				Total eligible costs (a)+(b)	,00	1.300,00	30.000,00	1.000,00	32.300,00	
			Requested EC contribution		,00	1.300,00	30.000,00	1.000,00	32.300,00	
8	CSIRO	FC	Eligible costs	*Direct Costs (a)*	,00	1.600,00	4.000,00	800,00	6.400,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	400,00	1.000,00	200,00	1.600,00	
				Total eligible costs (a)+(b)	,00	2.000,00	5.000,00	1.000,00	8.000,00	
			Requested EC contribution		,00	2.000,00	5.000,00	1.000,00	8.000,00	
9	NRF	FCF	Eligible costs	*Direct Costs (a)*		1.667,00	1.667,00	833,00	4.167,00	
				of which subcontracting		,00	,00	,00	,00	
				Indirect costs (b)		333,00	333,00	167,00	833,00	
				Total eligible costs (a)+(b)	,00	2.000,00	2.000,00	1.000,00	5.000,00	
			Requested EC contribution			2.000,00	2.000,00	1.000,00	5.000,00	
10	INAF	FCF	Eligible costs	*Direct Costs (a)*	,00	1.083,00	41.667,00	833,00	43.583,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	217,00	8.333,00	167,00	8.717,00	
				Total eligible costs (a)+(b)	,00	1.300,00	50.000,00	1.000,00	52.300,00	
			Requested EC contribution		,00	1.300,00	50.000,00	1.000,00	52.300,00	
11	MPG	AC	Eligible costs	*Direct Costs (a)*	,00	1.083,00	83.333,00	833,00	85.249,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	217,00	16.667,00	167,00	17.051,00	
				Total eligible costs (a)+(b)	,00	1.300,00	100.000,00	1.000,00	102.300,00	
			Requested EC contribution		,00	1.300,00	100.000,00	1.000,00	102.300,00	
12	TKK	AC	Eligible costs	*Direct Costs (a)*	50.000,00	1.083,00	25.000,00	833,00	76.916,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	10.000,00	217,00	5.000,00	167,00	15.384,00	
				Total eligible costs (a)+(b)	60.000,00	1.300,00	30.000,00	1.000,00	92.300,00	
			Requested EC contribution		60.000,00	1.300,00	30.000,00	1.000,00	92.300,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.3

Please use as many copies of form A3.3 as necessary for the number of partners

Proposal Number	026642	Proposal Acronym	EXPReS

Financial information - Reporting period 1 + first 6 months of period 2

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (Reporting period 1 + first 6 months of period 2)		Costs and EC contribution per type of activities: RTD activities (1)	Coordination / Networking activities (2)	Specific service activities (3)	Consortium Management activities (4)	Total (5)=(1)+(2)+(3)+(4)	Total receipts
13	CORNELL	FC	Eligible costs	*Direct Costs (a)*	,00	1.667,00	16.666,00	833,00	19.166,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	333,00	3.334,00	167,00	3.834,00	
				Total eligible costs (a)+(b)	,00	2.000,00	20.000,00	1.000,00	23.000,00	
			Requested EC contribution		,00	2.000,00	20.000,00	1.000,00	23.000,00	
14	UMK	AC	Eligible costs	*Direct Costs (a)*	,00	1.083,00	4.167,00	833,00	6.083,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	217,00	833,00	167,00	1.217,00	
				Total eligible costs (a)+(b)	,00	1.300,00	5.000,00	1.000,00	7.300,00	
			Requested EC contribution		,00	1.300,00	5.000,00	1.000,00	7.300,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

I3

A3.3

Please use as many copies of form A3.3 as necessary for the number of partners

Proposal Number	026642	Proposal Acronym	EXPReS

Financial information - Reporting period 1 + first 6 months of period 2

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (Reporting period 1 + first 6 months of period 2)		Costs and EC contribution per type of activities: RTD activities (1)	Coordination / Networking activities (2)	Specific service activities (3)	Consortium Management activities (4)	Total (5)=(1)+(2)+(3)+(4)	Total receipts
15	OSO	AC	Eligible costs	*Direct Costs (a)*	16.667,00	1.083,00	8.333,00	1.250,00	27.333,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	3.333,00	217,00	1.667,00	250,00	5.467,00	
				Total eligible costs (a)+(b)	20.000,00	1.300,00	10.000,00	1.500,00	32.800,00	
			Requested EC contribution		20.000,00	1.300,00	10.000,00	1.500,00	32.800,00	
16	SHAO	AC	Eligible costs	*Direct Costs (a)*	,00	1.667,00	20.833,00	833,00	23.333,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	333,00	4.167,00	167,00	4.667,00	
				Total eligible costs (a)+(b)	,00	2.000,00	25.000,00	1.000,00	28.000,00	
			Requested EC contribution		,00	2.000,00	25.000,00	1.000,00	28.000,00	
17	UDEC	FC	Eligible costs	*Direct Costs (a)*	,00	1.452,00	8.064,00	645,00	10.161,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	348,00	1.936,00	155,00	2.439,00	
				Total eligible costs (a)+(b)	,00	1.800,00	10.000,00	800,00	12.600,00	
			Requested EC contribution		,00	1.800,00	10.000,00	800,00	12.600,00	
18	UNIMAN	AC	Eligible costs	*Direct Costs (a)*	50.000,00	9.417,00	37.500,00	667,00	97.584,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	10.000,00	1.883,00	7.500,00	133,00	19.516,00	
				Total eligible costs (a)+(b)	60.000,00	11.300,00	45.000,00	800,00	117.100,00	
			Requested EC contribution		60.000,00	11.300,00	45.000,00	800,00	117.100,00	
19	VeA/VIRAC	AC	Eligible costs	*Direct Costs (a)*	,00	1.083,00	8.333,00	667,00	10.083,00	
				of which subcontracting	,00	,00	,00	,00	,00	
				Indirect costs (b)	,00	217,00	1.667,00	133,00	2.017,00	
				Total eligible costs (a)+(b)	,00	1.300,00	10.000,00	800,00	12.100,00	
			Requested EC contribution		,00	1.300,00	10.000,00	800,00	12.100,00	
TOTAL			Eligible costs		**390.000,00**	**91.300,00**	**657.000,00**	**87.900,00**	**1.226.200,00**	**,00**
			Requested EC contribution		**365.000,00**	**91.300,00**	**657.000,00**	**87.900,00**	**1.201.200,00**	

6.3 I3 management level description of resources and budget

There are 19 partners within EXPReS – in this section we describe the role of the other partners and the resources they bring to the project.

JIVE is the coordinating partner and plays a large role in nearly all aspects of the EXPReS project. JIVE is responsible for the overall management of the project (NA1) and together with Jodrell Bank Observatory, the Outreach, Dissemination & Communication activity (NA4). In addition, to the contribution requested by the commission, JIVE will also add additional resources to NA1 & NA4 corresponding to at least 4 FTEs (Coordinator, part-financing of: EXPReS Programme Manager & 2 administrative assistants – NA1 & NA4). JIVE also brings significant resources to SA1 – in particular the project will be led by Dr. Arpad Szomoru. Dr. Zomoru has played a major role in realising a limited real-time capability for the correlator at JIVE and has also been involved in developing new ways of improving remote control of telescope networking devices and the study of ways in which to improve networking performance. The EC contribution will fund 3 new positions (Software engineer, Network engineer and Support Scientist) but JIVE staff will be heavily involved in the project, matching at the level of at least 33% (~ 3 FTEs). JIVE is an active participant in NA2, NA3 and SA2. Like the other partners, the travel associated with these activities is partially funded via the institute's own resources. JIVE leads JRA1 (FABRIC) and matches the EC contribution at the one to one level. The leader of JRA1, Huib Jan van Langevelde has significant experience in organising distributed software projects such as FABRIC. The data processor at JIVE is an essential resource required by the EXPReS project. This will provide e-VLBI data to astronomers and will also be an important element in testing new telescope network connections. The use of the data processor for EXPReS is supported in financial terms by JIVE and the JIVE funding partners.

Jodrell Bank Observatory (UniMan) is also a major player in EXPReS, playing a key role within NA4, SA1, JRA1. They also bring experienced and skilled personnel to EXPReS that are not funded by EXPReS (e.g. within SA1 and JRA1). Establishing a link between the FP6 RadioNet I3 and FP6 EXPReS I3 (in terms of Public Outreach, Dissemination & Communication, NA4), should bolster the impact of both activities. JBO brings the e-MERLIN telescope network and the 76-m Lovell telescope to the EXPReS project – these will greatly expand the scientific capabilities of the e-VLBI network. Key personnel include Drs. R. Spencer & S.T. Garrington.

CNIG-IGN provides the leader of SA2 (Dr. F. Colomer). He will have a major role to play in organising the expanded participation of telescopes within the EXPReS e-VLBI network. This man-power is supported by the IGN. The IGN also provides the new 40-m radio telescope. Built at a cost of 20 Meuro the telescope will be an important addition to the EXPReS e-VLBI network, especially at high frequencies. Key personnel involved include Dr. F. Colomer.

MPIfR is an active partner within JRA1 bringing considerable expertise to that activity. In addition, it pasrticipates in SA2, aiming to connect the giant 100-m Effelsberg radio telescope to the EXPReS e-VLBI network. This telescope is the most sensitive telescope in the world and it is essential that it is connected to JIVE in order for the e-VLBI network to realise its full potential. Key personnel involved include Dr. Walter Alef.

MRO participates in JRA1. The Finnish group have a long tradition of engineering excellence in VLBI. They recently designed and developed a disk based recording system (PC-EVN) that is in use in various places around the world. They also bring considerable expertise in the areas of computing (both hardware and software) and networking. In addition, MRO expects to connect the radio telescope at Metsahovi to JIVE and the e-VLBI EXPReS network. Key personnel involved include the engineers Mr. A. Mujunen and Mr. J. Ritakari.

PSNC brings a wealth of high-performance computing and networking expertise to EXPReS. This is particularly important for JRA1 and the ambitions to use distributed computing to process e-VLBI data.

OSO plays a key role in NA3 via the eVSAG chairman – Dr. J. Conway (senior scientists and lecturer at OSO). In addition, Onsala also brings the 20 and 25-m telescopes to EXPReS and plays a role in high-speed networking within JRA1.

ASTRON plays a key role in JRA1 – in particular the resources and expertise associated with the LOFAR project will also filter into the EXPReS project. ASTRON also provides the WSRT radio telescope – a 90-m equivalent telescope that boosts the sensitivity of the EXPReS e-VLBI network. Key personnel are Dr. M. de Vos and Dr. W. Baan.

SURFnet, DANTE, AARNET – these networking partners will ensure that the EXPReS project is well served in terms of our ability to capitalise on the most recent developments in national, European and Global networking. The use of switched light paths in EXPReS may be essential in order to realise the very hightest data rates. These partners will be especially active in NA2 and SA2.

Other partners: INAF, NAIC, HRAO, VIRAC, ShAO, TIGO, NCU, CSIRO are major facilities in their own right – the connection of the associated radio telescopes will greatly enhance the scientific capabilities of the e-VLBI network. These partners are mostly active in SA2 – aiming to link to JIVE at data rates of up to 1 Gbps. The bulk of the connectivity costs (and associated man-power in testing etc) is borne by the institutes themselves. Key personnel are Drs. F. Mantovani, C. Salter, J, Jonas, T. Tzimious and Profs. Hong & Kus.

7. Ethical issues

There are no ethical issues associated with the EXPReS I3 project.

8. Other issues

EC contribution to telescope network connections

For clarity it should be noted that the total contribution of the EC with respect to high-speed network provisioning for the telescopes included within the EXPReS project, amounts to a relatively small fraction of the expected total costs (the EC contribution is expected to be ~ 10%). The aim is to ensure that in case of each individual telescope, the remaining costs are covered either by the institute (or its parent body), local community and regional funding, national funding or some combination of all of these possibilities. The total cost of network provisioning is ~ 8 Million Euro. It is hoped that the EC's contribution of 800 kEuro will act as a catalyst in releasing funds from the various other sources of support.

Complimentarity with other projects funded under FP6

Some FP6 IST Research Infrastructure projects are complementary to EXPReS e.g. GN2 was funded under the first FP6 Call and is the network component that is absolutely essential to the success of the EXPReS project (see also section 3.3 of this document). Other complimentary projects include RadioNet, an FP6 I3 that is also funded by the Research Infrastructures programme. The aims of RadioNet are to organise the radio astronomy community in Europe, and to produce a focused, coherent and integrated project that will significantly enhance the quality and quantity of science performed by European astronomers using *existing* facilities. Most of the radio astronomy institutes that participate in EXPReS are also partners within RadioNet, and the networking partners are part of GN2 and several other FP6 projects. There is no overlap between the milestones and deliverables associated with EXPReS and those of RadioNet. EXPReS brings a new and largely experimental technique to users, an e-VLBI service that will hopefully emerge as a reliable and robust astronomical tool during the term of the EXPReS contract. At the conclusion of the EXPReS project, it is thought that the e-VLBI network may be mature enough to be included in the list of operational astronomical facilities in Europe that will be adopted by RadioNet under the next FP7 programme. It is not unlikely that a fully-fledged e-VLBI facility might benefit from transnational access in FP7, for example. Currently the EXPReS and RadioNet activities are separate and there is little overlap between them – this is particularly true for SA1, SA2 and JRA1. The networking activities NA3 and NA4 complement the networking activities of RadioNet, in particular one aim is to ensure that the EXPReS Outreach Office & RadioNet Outreach Office cooperate with each other and EXPReS benefits from the considerable level of RadioNet expertise in this area. Many of the EXPReS radio astronomy partners are also involved in the Square Kilometre Array Design Study (SKADS) currently in the final stages of contract negotiations. The SKA is a 1 Billion Euro project, a next generation radio telescope that is expected to be built in the first half of the next decade and become operational in the second. It will be a distributed telescope similar in scale to the European VLBI Network and may also include SKA stations located across the globe. The data rates associated with the SKA are phenomenal and it is hoped that the experience European scientists and engineers have in realising the EXPReS e-VLBI network will also advance the SKA – especially in the possible use of public rather than provate networks.

Appendix A - Consortium description

A.1 Participants and Consortium

Joint Institute for Very Long Baseline Interferometry in Europe (JIVE)

JIVE was created by the European Consortium for VLBI and is a member of the European VLBI Network (EVN). Its primary task is to operate the EVN MkIV VLBI Data Processor (correlator). JIVE also provides a high-level of support to astronomers and the Telescope Network. JIVE is hosted by ASTRON (the Netherlands Foundation for Research in Astronomy) in Dwingeloo, The Netherlands. JIVE is funded by the national research councils and national facilities including: Netherlands Organisation for Scientific Research (NWO), Particle Physics and Astronomy Research Council (PPARC), Italian National Institute of Astrophysics (INAF), Onsala Space Observatory (OSO), National Geographical Institute (IGN), Max Planck Institute for Radio Astronomy (MPIfR), Netherlands Foundation for Research in Astronomy (ASTRON). JIVE's mission is to (i) maintain and develop the EVN data processor at JIVE, (ii) support astronomers and the network of radio telescopes in Europe, (iii) develop new technology for VLBI (both hardware and software), (iv) advance VLBI observing techniques and apllications; (v) conduct cutting edge astronomy using VLBI and other astronomical facilities. JIVE staff are also active in supervising both PhD students at Universities and local postdocs.

JIVE provides three key personnel to the EXPReS project. These include:

Dr. M.A. Garrett (EXPReS Coordinator)
Dr. Michael A. Garrett is Director of the Joint Institute for VLBI in Europe (JIVE). He was born in August 1964 and raised in the small town of Saltcoats, located on the southwest coast of Scotland. He was educated locally at the schools of St. Mary's and St. Andrew's Academy. In 1982 he registered as a student at the University of Glasgow, graduating in 1986 with a 1st class Hons. Degree in Astronomy & Physics. He was awarded the "J.J. Thompson" prize in Physics in his final year of study. In October 1986 he started his PhD studies at the University of Manchester, Jodrell Bank, UK under the supervision of Dr. Dennis Walsh. In May 1990 he completed his PhD thesis, entitled: "A Study of the Gravitational Lens System, 0957+561" and was appointed as a Research Associate at the Max-Planck Institute for Radio Astronomy in Bonn. At the end of the year he returned to Jodrell Bank serving in several different positions over the next 5 years, including temporary lecturer at the University of Manchester. In April 1996 he joined JIVE in the Netherlands, and served as head of the EVN Support Group between 1999-2002. He has also served as chairman of the EVN Technical & Operations Group (2000-2002) and coordinated various EC funded projects. In May 2003 he was appointed Director of JIVE.

Dr. Garrett's main scientific interest is the development of Very Long Baseline Interferometry (VLBI) as a sensitive, *real-time* and *wide-field* astronomical instrument. His personal research is focused on very deep, radio observations of the first luminous objects in the early Universe, studying the relation between the faint radio, sub-mm & infra-red emission associated with these newly forming galaxies. In addition to the global properties of such distant galaxies, he is also interested in using high resolution radio telescope arrays to reveal details of the vigorous star formation processes that often dominate these systems. Dr Garrett is also involved in radio observations of many other diverse astrophysical phenomena, including: X-ray binary systems, Giant Flares in Magnetars, Supernovae & Supernova remnants, Gamma Ray Bursts, Gravitational lenses & Active Galactic Nuclei. He serves on a number of scientific advisory committees (including the International Square Kilometre Array Science Advisory Group), has co-edited several conference proceedings and authored over 100 research papers that have appeared in a wide variety of Scientific journals.

Dr. Arpad Szomoru (Leader of SA1)
Dr. Arpad Szomoru has been at the forefront of developing the e-VLBI technique in Europe. An experienced astronomer, Dr. Szomoru is also a gifted software engineer and the success of various e-VLBI tests made over the last few years has hinged on his ability to modify elements of the EVN correlator in order that it can process (within various limitations) real-time e-VLBI data. He has also been one of several people interested in understanding the various bottlenecks that have so far limited sustained e-VLBI observations to data rates of few tens of Mbytes per second. He will be one of the key personnel in ensuring the success of the EXPReS project. Dr Szomoru's CV follows:

Name: Arpad Szomoru, e-mail: szomoru@jive.nl , Date of birth: 21 July 1953

WORKING EXPERIENCE, EDUCATION

-1973: Gymnasium B (high school); 1984-1989: Study of Astronomy with secondary subject Computer Science, degree January 1989, Univ. of Groningen.; 1989-1994: Ph.D. Research titled "Void Galaxies", advisors Prof. Dr. J. van Gorkom and Prof. Dr. R. Sancisi. Graduated December 2 1994.

1995: Administrative staff member, Univ. of Groningen. Responsible, among others, for assembling and editing the report for the VSNU (Vereniging van Samenwerkende Nederlandse Universiteiten) visitation committee: "Quality Assessment of Research", which was used for the assesment of research and education at the Kapteyn Institute.

1995-1999: UCO/Lick Observatory, UCSC - Postdoctoral Research Fellow. Research into the properties of interstellar dust particles in "cirrus"clouds, sponsored by the NASA Long-Term Space Astrophysics Research Program.

1999-2000: Programme/System analyst, Logica B.V. Groningen.

2000-now: Senior Software Scientist at JIVE, responsible for maintenance and development of correlator control code, heavily involved in deployment and adaptation of disk-based playback systems at JIVE and development of eVLBI.

PUBLICATIONS IN REFEREED JOURNALS

Weinberg, D.H., Szomoru, A. Guhathakurta, P. and van Gorkom, J.H. 1991, *On the distribution of HI dwarf galaxies*, Astrophysical Journal Letters, 372, L13

Szomoru, A., van Gorkom, J.H., Gregg, M. and de Jong, R.S. 1993, *The first HI discovered galaxy in the Boötes void*, Astronomical Journal 105, 464

Szomoru, A. Guhathakurta, P., van Gorkom, J.H., Knapen, J.H., Weinberg, D. and Fruchter, A., 1994, *Properties of an HI selected galaxy sample*, Astronomical Journal, 108(2), 491

Szomoru, A., van Gorkom, J.H., Gregg, M., 1996, *An HI survey of the Boötes void. I. The data*, Astronomical Journal, 111, 2141

Szomoru, A., van Gorkom, J.H., Gregg, M. and Strauss, M.,1996, *An HI survey of the Boötes void. II. The analysis*, Astronomical Journal, 111, 2150

Bravo-Alfaro, H., Szomoru, A., Cayatte, V., Balkowski, C. and Sancisi, R., 1997, *The HI distribution of spiral galaxies in the cluster A262*, Astronomy and Astrophysics Supplement Series, 126, 537

Szomoru, A. and Guhathakurta, P., 1998, *Optical spectroscopy of Galactic cirrus clouds: extended red emission in the diffuse interstellar medium*, Astrophysical Journal Letters, 494, L93

Filippenko, A.V., Matheson, T., Guhathakurta, P. and Szomoru, A., 1999, *Possible Supernova in NGC3198*, IAU Circ., 7150, 2

Szomoru, A. and Guhathakurta, P., 1999, *Extinction curves, distances, and clumpiness of diffuse interstellar dust clouds*, Astronomical Journal, 117, 2226

Schilizzi, R.T. et al., 2001, *The EVN-MarkIV VLBI Data Processor*, Experimental Astronomy, v. 12, Issue 1

Dr. Huib Jan van Langevelde is a senior member of JIVE staff and leader of JRA1 within EXPReS. His CV follows:

Huib Jan van Langevelde. PhD, Leiden University, 1992; post-doc, Sterrewacht Leiden, 1992-1993; JIVE Support scientist, NRAO Socorro New Mexico, USA, 1994-1997; Head science operations and software development, JIVE Dwingeloo, 1998 – current. Huib played a leading role in the design and development of the EVN correlator at JIVE. Supervised 2 PhD students and 6 master students and was involved in 3 more PhD projects. Managed

various international astronomy software projects (including ALBUS), member of the NOVA education committee.
Recent publications include:
Vlemmings W.H.T., van Langevelde H.J., P.J. Diamond P.J. *"The magnetic field around late-type stars revealed by the circumstellar H_2O masers"*, 2005 accepted for A&A, astro-ph/0501628
van Langevelde H.J., Garrett M.A., Parsley S., Szomoru A., Verkouter H., Olnon F.M., Reynolds C., Biggs A., Kramer B., Pogrebenko S., *"eEVN: a Pan-European radio telescope"*, 2004 submitted for the proceedings of SPIE 2004
Phillips C., van Langevelde H.J., *"The extended Methanol Maser Emission in W51"*, 2003 submitted to appear in the PASP conference proceedings of the VLBA 10th Anniversary Meeting, astro-ph/0401562
Van Langevelde H.J., Vlemmings W., Diamond P.J., Baudry A., Beasley A.J., *"VLBI astrometry of the stellar image of U Herculis, amplified by the 1667 MHz OH maser"*, 2000, A&A 357 945-950.

Other JIVE personnel involved in EXPReS include: Drs. Cormac Reynolds, Friso Olnon, S. Pogrebenko. In addition several University PhD students joint funded by JIVE and the Kapteyn Institute (U of Groningen) will also be involved in EXPReS including Julianne Sansa Otim.

Dr. Friso M. Olnon
Born: August 9, 1945 in Amsterdam.
Studied Astronomy at the Universities of Amsterdam and Leiden.
Ph.D. in Astronomy in January 1977.
1977-1979: worked at the Max-Planck-Institut für Radioastronomie in Bonn on large surveys in molecular lines with various radio telescopes.
1979: University of Leiden as a member of the Project Science Team for the IRAS satellite, responsible for the spectrometer software and the operational planning of the galactic research program.
After the IRAS mission, November 1984: started work in Dwingeloo to work on ASTRON's reduction package for the WSRT data and from 1992 on its successor AIPS++.
April 1998-present: Joint Institute for VLBI in Europe, primary responsable for the correlator control software.

Dr. Sergei Pogrebenko
1973 - Master degree in electronics, Moscow University for Physics and Technics,
Moscow, USSR; 1985 - PhD in Radio Astronomy, Space Research Institute of the Academy of Sciences of the USSR, Moscow, USSR
Working history: 1973-1976 Development engineer, Special Astrophysical Observatory of the Academy of Sciences of the USSR, Zelenchukskaja, USSR; 1976-1988 Research Scientist, Space Research Institute of the Academy of Sciences of the USSR, Moscow, USSR; 1988-1993 Senior Scientist, Institute of Applied Astronomy of the Academy of Sciences of the USSR, St.Petresburg, USSR; 1993-present: Senior development engineer, Joint Institute for VLBI in Europe.
Major publications:
"Processing System for Space VLBI", N.Kardashev, G.Tsarevski, S. Pogrebenko, L. Gurvits, M. Popov, Proc. QUASAT Workshop, Austria, ESA SP-213, p. 123, 1984
"Measurements of the Dynamics of Air Mass Motion in the Venus Atmosphere with Balloon Probes - VEGA Project", Sagdeev, R.Z.; Kerzhanovich, V.V.; Kogan, L.R.; Kostenko, V.I.;

Linkin, V.M.; Matveenko, L. I.; Nazirov, R. R.; Pogrebenko, S. V.; Strukov, I. A.; Preston, R.; Purcell, G. H., Jr.; Hildebrand, C.; Blamont, J.; Boloh, L.; Laurans, G.; Spencer, R. E.; Golt, J.; Grishmanovskii, V. A.; Kozlov, A. N.; Molotov, E. P.; Yatskiv, Y. S.; Martirosyan, R. M.; Moiseev, I. G.; Rogers, A. E. E.; Biraud, F.; Boichaut, A.; Kaufmann, P.; Mezger, P.; Schwarz, R.; Ronang, B. O.; Nicolson, G. 1990SvAL, 16, 357S
"First evidence of planetary water maser emission induced by the comet/Jupiter catastrophic impact", C. Cosmovici, S. Montebugnoli, A. Orfei, S. Pogrebenko, P. Colom, Planet. Space. Sci. Vol. 44 N.8, 735-739, 1996
"The EVN-MarkIV VLBI Data Processor", R.T. Schilizzi, W.Aldrich, B.Anderson, A.Bos, R.M.Campbell, J.canaris, R.Cappallo, J.L.Casse, A.Cattani, J.Goodman, H.J. van Langevelde, A.Maccaffferri, R.Millenaar, R.G.Noble, F.Olnon, S.M.Parsley, C.Phillips, S.V.Pogrebenko, D.Smythe, A.Szomoru, H.Verkouter and A.R.Whitney, Experimental Astronomy, 12: 49-67, 2001.
"VLBI Tracking of the Huygens Probe in the Atmosphere of Titan",
S. V. Pogrebenko, L. I. Gurvits, R. M. Campbell, I. M. Avruch,
J.-P. Lebreton, C. G. M. van't Klooster, Proc. Int. workshop "Planetary Probe Atmospheric Entry and Descent Trajectory Analysis and Science", Lisbon, Portugal, 5-9 October 2003 (ESA SP-544, February 2004).

AARNET

AARNet Pty Ltd (APL) is the company that operates Australia's Academic and Research Network (AARNet). It is a not-for-profit company limited by shares. The shareholders are 38 Australian universities and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).
AARNet provides high-capacity leading-edge Internet services for the tertiary education and research sector communities and their research partners. AARNet serves over one million end users who access the network through local area networks at member institutions.

AARNet is currently building its next generation Network (AARNet3), based on lighting up fibre infrastructure spanning Australia from Perth to Brisbane and connecting members and instruments (including radio-telescopes) to 10Gbps circuit paths on major trunk routes. The national infrastructure is complemented by dual 10Gbps circuits from Australia, through Hawaii to Seattle, Palo Alto and Los Angeles on the US west coast. Arrangements are currently being finalised for capacity going west from Perth to Singapore and Europe as well as north to Hong Kong, Korea, China, and Japan.

AARNet has been effective in making representations to government on policy, legislation, strategy and programs to improve the telecommunications facilities and services available not only to the education and research sector but also to the whole Australian community.

Mr. George McLaughlin
George McLaughlin is the Director of International Developments for AARNet. He joined AARNet in 1995 initially overseeing the sale of AARNet's commercial customer base to Telstra. He guided the establishment of AARNet Pty Ltd as a separate legal entity responsible for managing and developing the AARNet network; and has been the driver for positioning AARNet as one of the world's leading research and education network organisations.
George has been instrumental in establishing international connectivity from Australia to the global R&E networks. From a "right to use" (IRU) a 155Mbps circuit between Australia,

Hawaii and the US West coast in 2001, to the current dual 10Gbps circuits (SX TransPORT – Trans-Pacific Optical Research Testbed). He serves on various national and international committees associated with telecommunications and advanced networking.
George is a graduate of the Royal Institute of Chemistry. He has worked in the chemical, pharmaceutical, engineering, precious metal and information technology industries, has authored more than 50 research papers, and has been elected as a Fellow of the Royal Society of Chemistry. He is one of the Vice-Chairs of APAN, the Asia Pacific Advanced Network consortium.

DANTE (Europe)

DANTE is a non-profit organisation that plans, builds and manages dedicated, high-bandwidth data communications networks to serve the international connectivity needs of the European National Research and Education Networks (NRENs). Since its inception in 1993, DANTE (Delivery of Advanced Network Technology to Europe) has designed and implemented a series of increasingly powerful pan-European research networks, the latest of which, GÉANT, has placed Europe as a global leader in the research connectivity race. Owned by the European NRENs and working in cooperation with the European Union, DANTE has been fundamental to the success of pan-European research networking over the last 12 years.

DANTE is involved in activities that serve the international data communications needs of the European research and education community. To this end, DANTE manages a number of projects designed to enhance research connectivity, both within Europe and with other parts of the world. Current projects managed by DANTE include:

GÉANT: The world's most advanced and reliable research and education network connects over 3 million users in more that 3500 institutions across Europe. It provides international connections to North America, Latin America and Japan.
GÉANT2: The successor network to GÉANT provides cutting-edge technologies, improved services, and extends the geographical reach of GÉANT.

ALICE: Has created the RedCLARA research network for Latin America. It also provides a direct link to GÉANT in Europe.

EUMEDCONNECT: Has created a regional research network for the Mediterranean and North Africa and a direct connection to GÉANT from the Mediterranean region.

TEIN2: Creating the first regional R+E network for South East Asia, with direct connections to GÉANT in Europe.

DANTE's work with European NRENs has been a fundamental to realising the EU's vision of a European Research Area. The organisation exists to ensure that those working in research and education in Europe have state-of-the-art network communications tools. This allows them to collaborate in pioneering research, producing groundbreaking results for the benefit of the European community. As well as planning and building research networks, DANTE is committed to a comprehensive programme of research. This will benefit the research networking community as well as the commercial marketplace. Much of today's consumer communications technology was developed via Research Networks. DANTE is developing new technologies and improving the service provided to network users. Current research topics include: developing network monitoring tools, providing roaming and mobility services, challenging network security threats, developing tools to allocate Bandwidth-on-demand, building a test-bed for testing new technologies.

DANTE was established in 1993 in Cambridge, UK with a mission to plan, build and operate the pan-European networking backbone for Europe's NRENs and research and educational facilities. Its location in Cambridge was chosen as a result of an international competition. Although DANTE is based in the UK, it is a truly European company, with a global outlook. It is owned by 15 of Europe's National Research and Education Networks and its work is organised into projects that receive co-funding from the European Union. Our working partners include NRENs from across all world regions. DANTE has also had a conscious policy of recruiting from across the globe throughout its ten-year history.

The main contact person for EXPReS at DANTE is Dr. John Chevers. Dr Chevers is chairman of the EVN-NREN group (NA2). His CV follows:

Dr. John Chevers (eVSAG chairman)

John Chevers is Project Manager at DANTE for User Support. He Joined DANTE in August 2004. His BSc in Physics was followed by an MSc in Optoelectronics at London University, before moving to Glasgow. He completed his PhD at the University of Strathclyde in 2000, and subsequently worked for four years as a scientist and project coordinator at Marconi Optical Components and Bookham Technology, developing optoelectronic modules for the telecoms industry.

Other key personnel involved in the EXPReS project at DANTE include: Michael Enrico, Maarten Buchli, Toby Rodwell, Dai Davies.

POZNAN SUPERCOMPUTING AND NETWORKING CENTER

PSNC is affiliated to the Institute of Bioorganic Chemistry of the Polish Academy of Sciences (Instytut Chemii Bioorganicznej PAN) and is responsible for the development and management of PIONIER, the national research network in Poland – which is connected to the GEANT2 network with the speed of 10Gbit/s. The PIONIER itself is an advanced optical network based on its own fibers, own DWDM transmission equipment and own 10 Gigabit Ethernet communication channels. What makes PIONIER different from other fiber-based networks is the fact that the fiber was built by the research and for research. Currently PIONIER has over 3200km of its own fiber cable lines (with an average of 16 to 24 fibers in each relation) and also available fiber pipes for future fiber generations. Today PIONIER connects 21 MANs (city networks) in Poland, 18 of them connected directly by fiber with 10 Gigabit Ethernet channel, including also the city network in Poznań – POZMAN, operated by PSNC.

Another activity of PSNC is to deliver computational, visualization and storage infrastructure for research and development purposes. Nowadays the HPC infrastructure includes larger SMP machines (both scalar and vector architectures) and 64-bit clusters with a peak performance of 3+ TFlops. The storage infrastructure is connected with the SAN network, equipped with disk arrays and tape systems of 80 TB capacity.

The main research areas covered by PSNC concern grid activity (resource management, security, accounting and user account management, workflows), supporting users' mobility, networking, management and accessing remote facilities, especially labour equipments. Therefore we have been participating in several national and international R&D projects, e.g.: GridLab (IST-2001-32133), CrossGrid (IST-2001-32243), GridStart (IST-2001-34808), EGEE, CoreGRID, HPC Europa, GridCord, InteliGrid, PROGRESS (in co-operation with SUN Microsystems), Virtual Laboratory, SGIgrid – "High Performance Computing and Visualisation with the SGI Grid for Virtual Laboratory Applications" (in co-operation with Silicon Graphics), Clusterix – "National Cluster of Linux Systems", connecting 12 universities and HPC centres in Poland. The history of PSNC participation in network-related IST projects includes:

- ATRIUM - (IST-1999-20675) - participant [http://www.alcatel.be/atrium]
- SEQUIN (IST-1999-20841)- participant [http://www.dante.net/sequin/]
- 6-NET - (IST-2000-32603) - participant [http://www.6net.org]
- MUPBED (511780) – participant [http://www.ist-mupbed.org]
- GN2 (511082) – participant [http://www.GÉANT2.net].

We have substantial knowledge and expertise in leading projects on the national and international level, like GridLab (the IST project coordinated by PSNC), PROGRESS (a national project with 5 partners), PortaOptica (in the final negotiation phase), KMD – National Data Storage (with 10 partners).

Another example worth mentioning and closely connected to the RING project proposal is the Virtual Laboratory (VLab), a national based project (http://vlab.psnc.pl) which has been developed in PSNC. The VLab is a framework architecture aiming to provide remote access to various kinds of unique and therefore expensive scientific laboratory equipments. The main goal of the VLab was to embed remote facilities in grid environments, closely supporting the experimental processes with the computing and visualization infrastructure. Another purpose concerned the concept of Dynamic Measurement Scenarios (DMS). DMS allows defining the measurement workflow in a way which is convenient for the user: from pre-processing, through executing the experiment, to the post-processing and visualization tasks. The Virtual Laboratory is not only a set of mechanisms to submit, monitor and execute jobs. It is also a possibility to give access to the resources of the digital library, communication, and e-Learning systems. The VLab project introduced two different instruments: NMR spectroscope and radio telescope.

Dr. Norbert Meyer

Dr. Norbert Meyer received the M.Sc. degree in Computer Science from the Poznań University of Technology in 1993, and the Ph.D. degree at the same university. Currently he is Head of the Supercomputing Department in Poznań Supercomputing and Networking Center (http://www.man.poznan.pl). His research interests concern resource management in the GRID environment, GRID accounting (Global Grid Forum), data management, technology of development graphical user interfaces and network security, mainly in the aspects of connecting independent, geographically distant Grid domains. Norbert Meyer conceived the idea of connecting Polish supercomputing centres, the vision of dedicated application servers and distributed storage infrastructure. Norbert Meyer is co-author of the CERT POL-34 organization (http://cert.pol34.pl). He is the workpackage leader and member of the Steering Group of the CrossGrid project (IST-2001-32243). He participated in several national projects concerning the HPC technology, e.g. being co-author of the projects entitled "Creating an access environment for computational services performed by cluster of SUNs" (co-founded by the State Committee for Scientific Research and SUN Microsystems) as well as "VLAB – High Performance Computing and Visualisation for Virtual Laboratory Applications".

Norbert Meyer is co-author of many project proposals, e.g. industry Grid solutions, eRegion

(Technology Exchange and Information Services for Cross Border Regional Co-operation), Clusterix - National CLUSTER of LInuX Systems project. An example of a production Grid is a project proposal done in co-operation with IBM, which concerns the deployment of utility computing in Poland. Norbert Meyer was leading an international project of GUI development for mobile network analysers, done in co-operation with Tektronix (at Poznań University of Technology). He is also author and co-author of several reports and papers (50+) in conference proceedings.

Marcin Lawenda graduated from the Poznań University of Technology and received his M.Sc. in Computer Science (Parallel and Distributed Computation) in 2000. He currently works for Poznań Supercomputing and Networking Center on the project manager position in the Virtual Laboratory project. He is also a Ph. D. candidate in the Computer Science Department of Poznań University of Technology. ML is the workpackage leader of a national project grid technology oriented and research grant of the Ministry of Scientific Research and Information Technology (http://vlab.psnc.pl/gen_info.html). His research interests include parallel and distributed environments, scheduling and Grid technologies. He is also author and co-author of several reports and papers (20+) in conference proceedings and journals, working in PSNC for 7 years. He has been a member of the Polish Information Processing Society since 2000.

Marcin Okoń graduated from the Poznań University of Technology and received the M.Sc. in Computer Science in 2002. His research interests include software engineering, distributed systems design and implementation, scheduling, database modelling. Since December 2002 he has been participating in the Virtual Laboratory project.

Dominik Stokłosa currently works for Poznań Supercomputing and Networking Center on the Virtual Laboratory Project (http://vlab.psnc.pl). His research interests include the Software Engineering area, distributed environment computing, task scheduling and new Java related technologies. He is also interested in design patterns and refactoring.

Marcin Garstka received an M.Sc. degree in Computer Science from the Poznań University of Technology in 1997. He is the Deputy Manager of Network Division at the Poznań Supercomputing and Networking Center. He takes an active part in the development and maintenance of the PIONIER network. His research interests concern computer networks, routing and management.

SURFNET

SURFnet is the national research and education network in the Netherlands SURFnet is set up to develop and operate an advanced data communications infrastructure for the Dutch Research and Higher Education community. SURFnet is a not-for-profit company and is 100% user owned. Today SURFnet connects some 150 institutions in higher education and research in The Netherlands. Approximately 750,000 staff and students of universities, polytechnics, public and commercial research institutes, scientific libraries and academic hospitals use the network on a daily basis.

SURFnet continually strives to push the edge by translating results in network research and developments in network technology into new infrastructure services for its user community. Within the government sponsored GigaPort Next Generation Network project SURFnet is currently building SURFnet6 as a hybrid optical and packet switching infrastructure. The architecture of SURFnet6 is a paradigm shift with previous SURFnet network generations.

SURFnet6 will be realised in partnership with Nortel Networks, Avici Systems and Telindus as a truly hybrid optical and packet switching infrastructure covering the whole of the Netherlands. The basis of SURFnet6 is an agile all optical DWDM network based on SURFnet owned dark fiber reaching out to the premises of the customers. In addition to being the carrier for the SURFnet IP services, the SURFnet6 optical infrastructure will offer the connected organisation direct point to point light paths connections. Via NetherLight, a SURFnet build and operated open light path exchange in Amsterdam, SURFnet6 will be connected to other networks across the globe. The new SURFnet6 network will be fully operational as of the end of 2005.

Kees Neggers is Managing Director of SURFnet bv. He was involved as an initiator and Board member in several International network related organizations such as RARE, TERENA, Ebone, Internet Society and RIPE NCC. Currently he is active in the set up of GLIF, the Global Lambda Integrated Facility. Present positions held in Internet related international activities include: Chairman of the RIPE NCC Executive Board; European Co-Chair of the CCIRN; Chairperson of the Global Lambda Integrated Facility (GLIF); Member of the Board of the IEEAF.

Erik-Jan Bos graduated from Delft University of Technology in 1987 as an Electrical Engineer. Right after his graduation he joined "SURFnet Operations" on a part-time basis. Since 1989 Erik-Jan has been working for SURFnet on a full-time basis, in the department of Network Services. This department is responsible for the development and operations of SURFnet's network. As of September 2000 Erik-Jan is head of SURFnet Network Services.
In 2000, Erik-Jan was one of the founders of NetherLight in Amsterdam, the advanced open optical exchange infrastructure and proving ground for network services optimized for high-performance applications. NetherLight currently is one of the main hubs in the Global Lambda Integrated Facility.
Currently, in the GigaPort Next Generation project, Erik-Jan is the project leader for Networks for Research and for Research on Networks. In Networks for Research, SURFnet is currently building SURFnet6, the country-wide hybrid optical and packet switching infrastructure enabling both IP services and light path services on the powerful and flexible optical infrastructure. Research on Networks supports the further development of SURFnet6.
Erik-Jan also heads the GLIF-TEC group that brings together the global community of light path providers and users and is an active member of the Internet Engineering Task Force (IETF), the Internet Engineering and Planning Group (IEPG), and Réseaux IP Européens (RIPE), as far as lower layer Internet technology is concerned.

ASTRON

ASTRON's goal is to enable discovery in astronomy. It aims to provide front-line observing capabilities for Dutch and international astronomers across a broad range of frequencies and techniques. ASTRON expects this strategy regularly to result in astronomical discoveries that significantly affect our understanding of the content, the structure and the evolution of the Universe. The programme to implement this strategy has two principal elements:
(i) the operation of front line observing facilities, including especially the Westerbork Radio Observatory and (ii) a strong technology development program, encompassing both

innovative instrumentation for existing telescopes and the new technologies needed for future facilities. In addition, ASTRON is active in the international science policy arena. Wherever appropriate ASTRON enters into cooperative arrangements with international organizations to help achieve these goals.

Astronomy is an observational science, relying on remote sensing of the distant Universe to advance understanding of its content and evolution. ASTRON operates The Westerbork Radio Observatory, one of the largest radio telescopes in the world. The WSRT and LOFAR in the near futur- are dedicated to explore the universe at radio frequencies, from GHz down to very low frequencies. In addition to its use as a stand-alone radio telescope, the Westerbork array participates in the European Very Long Baseline Interferometry Network (EVN) of radio telescopes. ASTRON is the host institute for the Joint Institute for VLBI JIVE in Europe. Its primary task is to operate the EVN MkIV VLBI Data Processor (correlator). JIVE also provides a high-level of support to astronomers and the Telescope Network. Together with the UK, ASTRON operates optical telescopes in La Palma (ES) and the JCMT in Hawaii, USA.ASTRON has contributed to the construction of different instruments for the European Southern Observatory, Very Large Telescopes, four 8-m telescopes located in the Atacama desert in Chile.

To these ends, ASTRON's headquarters facility in Dwingeloo maintains a well equipped R&D division specialising in the design, prototyping and qualification of:

- low noise, ambient and cryogenic radio receiver systems (0.2 - 345 GHz),
- very high speed digital electronics,
- antennas, especially in the array environment,
- advanced instrumentation for use at optical and infrared wavelengths,
- algorithm and software engineering for instrument control and for imaging.

ASTRON is currently developing and constructing the Low Frequency Array (LOFAR). LOFAR is a next generation radio telescope operating at very low frequencies (between 10-200 MHz) and will be distributed across the Netherlands. The 100 Million Euro project is due to be completed in 2009. In addition to astronomy, LOFAR also includes a multi-disciplinary sensor network addressing topical problems in agriculture, meteorology, particle physics, water management and other areas of great importance to society.

Dr Willem Baan is the Director of the WSRT, since February 1 1998. Willem graduated from Delft University with a degree in Aerospace Engineering, before moving to MIT for an MSc and PhD in Plasma and Theoretical Astrophysics. After MIT, he went to the Institute for Advanced Study (Princeton) and then onto Pennsylvania State University before going to what is still the world's largest radio telescope: the 305m Arecibo Telescope on the Island of Puerto Rico. As a radio astronomer, Baan is best known for his work on the megamaser phenomenon, which occurs in a variety of active galaxies. OH megamasers are part of the population of (super) luminous FIR galaxies, many of which display intense starburst and AGN activity. The amplifying molecular gas lies either in a high excitation nuclear region but can also be part of the larger scale (torus) structure irradiated by some central FIR source. It appears as though H_2CO megamasers are part of this same population, whereas the H_2O megamaser emission is thought to originate in compact disks surrounding massive nuclear sources (or black holes). Willem is also very much involved in Spectrum Management issues relating to radio astronomy. He was Chairman of the Inter-Union Commission on the Allocation of Frequencies for Radio Astronomy and Space Research (IUCAF). He actively participates in ITU-R Study Group 1 (spectrum management) and 7 (science services) and has been one of the leaders of the radio astronomy efforts at recent ITU-R World Radio communication Conferences. He was also the principal player in the establishment of the Puerto Rico Coordination Zone by the USA Federal Communication Commission in November 1997. He has written over 100 refereed publications that have appeared in various journals, including Nature.

Dr. Marco de Vos, Position: Director of R&D
Marco de Vos was born in Dordrecht, The Netherlands on February 11th, 1965. He received his M.Sc. degree in Astronomy in 1988 at Leiden University and a Ph.D. degree in 1993 at Groningen University on the development of an optical interferometer. In 1993 he joined the R&D division of ASTRON, the Dutch knowledge institute for astronomical instrumentation. Initially he developed astronomical analysis software. He was project manager of the Telescope Management System development for the Westerbork Synthesis Radio Telescope. In 1998 he became leader of the R&D expertise group Software and Image Processing, in 2004 he started a new expertise group on Scientific Computing. He has been involved in the LOFAR program from its early phases, from 2001 as System Engineering Manager. In 2005 he became Director of R&D at ASTRON. His main research interests are in the field of system modeling, distributed development and wide area sensor networks. He is a member of the USA EVLA Advisory Panel, the Knowledge and Innovation Network Northern Netherlands and several program committees.
Selected publications:
Optical Interferomety with SCASIS, PhD Thesis, C.M. de Vos, 1993;
The SKA End-to-End Simulation Environment, C.M. de Vos,
Proceedings NFRA SKA Symposium Technologies for Large Antenna
Arrays', 1999; Cluster Computing and Grid Processing for LOFAR, C.M. de Vos, K. v.d. Schaaf, J.D. Bregman, CCGrid 2001; A very high capacity optical fibre network for large-scale antenna constellations: the RETINA project , A.M.J. Koonen, H. de Waardt, D. Kant, C.M. de Vos, et al NOC 2001; Strategies for end-to-end modeling of next generation mm/radio-telescopes, C.M. de Vos, K. van der Schaaf, M. Loose, G. van Diepen, SPIE workshop on integrated modeling, Lund, Sweden, 2002; Networks and Processing for the LOFAR telescope, C.M. de Vos, URSI 2002; Architecture for Wide Area Sensor Networks, C.M. de Vos, ESI/Philips Architecting Event, 2003;
Spin-off oppurtunities of sensor technology from astronomical instrumentation, C.M. de Vos, CIC seminar "Intelligent devices", 2004.

Other ASTRON personnel involved in EXPReS are Dr. A.R. Foley.

INSTITUTO GEOGRAFICO NACIONAL

CNIG/IGN is the host organization for the Observatorio Astronomico Nacional, the Spanish National Facility for Radioastronomy. OAN operates a 14-m cm/mm wave dish at Yebes (Spain) since 1976. The observatory is specialized in studies of star formation and evolution, interstellar medium, galaxy structure and dynamics, and astrochemistry. OAN has recently constructed a new 40-m telescope, which is being commissioned, and will join the European VLBI Network in 2006. The telescope will become a key instrument for the expansion of the EVN studies to higher frequencies, as it will operate till 116 GHz (2,6 mm wavelength).

OAN participates actively in international projects such as IRAM, ALMA, SKA, and the far-infrared satellite Herschel.

The observatory is involved in technology development for cm – mm-wave techniques with laboratories for design and construction of cryogenic HEMT amplifiers for radioastronomy receivers. More than 200 amplifiers have been constructed, to equip receivers for the 14-m, 40-m, IRAM, ALMA, Bordeaux, Nancay, Paris telescopes,and EMCOR and PRONAOS projects. The staff conducts holographic studies to enhance the antenna surface quality, for the 40-m and also for antennas at IRAM and ESA.

Dr. Francisco Colomer
Born in 1966 in Valencia (Spain). Graduated in 1989 from University of Valencia, got his PhD in Astronomy and Space Sciences from Chalmers University of Technology (Sweden) in 1996. He spent half of the PhD time at Harvard-Smithsonian Center for Astrophysics (USA). Since 1998 he is permanent staff at Observatorio Astronomico Nacional (OAN-IGN). Currently coordinates the overall VLBI activities for Astronomy and Geodesy. Active researcher in the field of studies of spectral line emission in evolved stars using very long baseline interferometry, with more than 40 publications in refereed journals. Project Manager at OAN/IGN of FP6 financed contracts (RADIONET, SKA-DS, EXPReS). Responsible of the Specific Support Activity #2 in EXPReS.

Dr. Pablo de Vicente
Graduated from Universidad Complutense de Madrid in 1986. Spent predoctoral fellowships at IRAM (France) and Max-Planck Institut für Radioastronomie (Germany). He got his PhD at UCM in 1994. He is coordinator of the technical aspects of VLBI at OAN/IGN, including the new 40-m radiotelescope at Yebes, which will be linked to GEANT thanks to EXPReS. Member of the EVN Technical Operations Group (TOG).

Dr. Rafael Bachiller
Graduated in Astrophysics and Fundamental Physics from Universidad Complutense de Madrid (Spain) in 1979, got his PhD at Université de Grenoble in 1985, and from Universidad Complutense de Madrid in 1986, when he became permanent staff at Observatorio Astronomico Nacional (OAN-IGN). He is Director at OAN since 2002. Active researcher in the field of star formation, in particular studying mm- and submm-wave spectral lines, with more than 150 refereed publications. Member of the board of EXPReS and RADIONET. Vice-chairman of the board of the European VLBI Network (EVN). President of the Spanish commission for ALMA.

CSIRO
Add text for CSIRO

Dr. Anastasios Tzioumis
Birthdate/place: 1/5/1952 in Tripolis, Greece.
Citizenship: Dual national of Greece and Australia (both passports).
Marital status: Married with four children
Email: Tasso.Tzioumis@csiro.au
Work designation**:** Principal Research Scientist
EDUCATION

Primary and Secondary education in Greece. Completed in 1970.
B.Sc. (First class Honours), Physics, 1977, University of Sydney.
B.E. (First class Honours), Electrical, 1979, University of Sydney.
Ph.D. "VLBI studies of compact radio sources", University of Sydney, 1987
APPOINTMENTS
1978 -- 1979 Engineer, Overseas Telecommunications Commission (Australia).
1979 -- 1981 Professional Assistant, Electrical Engineering, Uni. of Sydney.
1981 Full time Tutor, Electrical Engineering, University of Sydney.
1982 -- 1986 Commonwealth Postgraduate Scholar, Department of Astrophysics, School of Physics, University of Sydney.
1987 -- 1990 Post-doctoral fellow. Jodrell Bank. UK
1990 -- present Australia Telescope National Facility, CSIRO, Australia
History within ATNF:
1990 -- 1992 Research Scientist
1993 -- 1996 Senior Research Scientist
(1994 -- 1997 Scientific Assistant to the Director)
1997 -- present Principal Research Scientist
1998 Group leader, Electronics group, Narrabri
1998 – present LBA Operations Manager
2000 – present Spectrum Management Coordinator
2004 – present eVLBI Project manager
HONORARY APPOINTMENTS:
Asia Pacific Telescope (APT) secretary, 1992-2001
URSI Commission J editor, 1990-1996 (2 triennia)
Visiting researcher ("no-fee-consultant) at JPL, NASA since 1983
Visiting Fellow, Istituto di radioastronomia, CNR, Bologna, Italy, 3 months, 1996.
Chair, IAU working group on Interference Mitigation, 2000-- present
SKA Task Force on Radio Quiet Zones, 2004-- present
Delegate, WP7D, International Telecommunication Union, 2000 --present

RESEARCH INTERESTS: Very Long Baseline Interferometry (VLBI) techniques and applications, Active Galactic Nuclei (AGN), Active Galaxies and Quasars, Gravitational lenses, X-ray binary stars, Intra-day variability (IDV), Imaging techniques RFI mitigation and management

PUBLICATIONS: Over 45 refereed publications in last 5 years (1999-2004)

NATIONAL RESEARCH FOUNDATION – HARTEBEESTHOEK RADIO ASTRONOMY OBSERVATORY

The Hartebeesthoek Radio Astronomy Observatory (HartRAO) is a National Facility of the National Research Foundation. Its main objective is to provide facilities for radio astronomy and space geodesy to the South African and international research communities.

HartRAO has a staff complement of 45, of which 10 are staff scientists and 12 are engineers and technicians. The remaining staff members are operators and other facility support and management personnel. There are currently 10 research students on site at HartRAO.

A new aspect of HartRAO is the Karoo Array Telescope (KAT) project, which has associated with it a team of engineers and scientists engaged on a contract basis. Currently this team has 10 members in addition to the individuals seconded from the HartRAO staff complement. This number will grow in the short term because we are currently recruiting digital and RF engineers.

The primary instrument at HartRAO is the 26-metre antenna with cassegrain optics and equatorial mount geometry. The dish surface has recently been upgraded to extend its operating frequency up to at least 22 GHz.

All receiver systems are permanently mounted on the antenna in the secondary focus cabin. Currently there are dual-polarization cryogenic receiver packages for the following observing wavelengths: 18cm, 13cm, 6cm, 5/4.5cm and 3.6cm. In addition there is an uncooled dual polarization 2.5 cm receiver package. The construction of an uncooled dual-polarization 1.3cm receiver has just commenced. This system will be used to test the performance of the antenna at 22GHz prior to the construction of a cryogenic receiver.

Backend hardware includes continuum radiometers, a correlation spectrometer, a pulsar timing instrument, a Mk-4 VLBI formatter, and a variety of VLBI recording systems (including Mk V disk recorder).

All telescope systems are under computer control and all observations are made in an unattended mode (except VLBI). A dynamic queue-scheduler manages the automated observations.

The observatory user base includes staff scientists, South African university researchers and students, researchers from the rest of Africa, and the international astronomical and geodetic VLBI community. Local universities using the facility include: Rhodes, North West, Johannesburg, Witwatersrand, UNISA, Kwazulu-Natal and the NASSP consortium based at Cape Town. This university user base will increase because of the KAT project, which will require input from the various engineering faculties around the country.

The observational program includes: single dish long-term monitoring projects (including maser spectroscopy, pulsar timing and continuum flux monitoring), radio continuum mapping, and VLBI (astronomical and geodetic). HartRAO is an associate member of the European VLBI Network, and participates in all of the EVN sessions.

In addition to the radio telescope HartRAO also operates a satellite laser ranger, an IGS GPS receiver and a water vapour radiometer. The Observatory supports an active science awareness and outreach programme aimed at scholars and the adult public.

Prof. Justin Leonard Jonas
Date & Place of Birth: 12 November 1958, London UK
Qualifications: BSc, MSc and PhD (Rhodes)
Current positions: Managing Director Hartebeesthoek Radio Astronomy Observatory, National Research Foundation; Professor & Head of Department, Department of Physics & Electronics, Rhodes University; Project Scientist South African SKA Project Office.
Research interests: Galactic interstellar medium and its radio signatures, Cosmic Microwave Background radiation, Radio Pulsars, Digital signal processing and data analysis as applied to radio astronomy.

ISTITUTO DI RADIOASTRONOMIA

The Istituto di Radioastronomia (IRA) is one of the institutes created by the Italian National Research Council (CNR) that starting from year 2005 is part of the National Institute for Astrophysics (INAF). It has a staff of about 100, astronomers, electronic engineers-physicists, software specialists, technical and administrative support. In addition, people from the University Astronomy and Physics Departments are affiliated with the Institute. The Institute headquarters are in Bologna. Other sections of the institute are located in Firenze, Medicina Noto and Cagliari.

The new Institute is aimed to:
1) the design and management of the large Italian radioastronomical facilities;
2) the design and fabrication of instrumentation operating in bands from radio to infrared and visible;
3) the pursuit of research activities in many areas from observational radioastronomy, galactic and extragalactic, to cosmology, geodesy and Earth observations.

Major activities at the various sites include:
Bologna - The headquarters are responsible for the Institute management and the interface with the INAF Central Administration in Rome. A large fraction of the astronomical research activity is done here, with major areas in cosmology, extragalactic astrophysics, star formation and geodesy. The headquarters have a strong interaction with the University and represent an important facility for educational activities at medium (master degrees) and high levels (PhD). Computer science activities are also performed.
Medicina radioastronomy station is associated with Bologna headquarters. It hosts the Northern Cross and the 32m VLBI radiotelescope, and houses the core of laboratories for the development of radioastronomy instrumentation.
Arcetri site in Florence is devoted to the design and development of radio and infrared technologies, including participation in national and international projects such as ALMA, TNG, LBT.
Major research fields are extragalactic astrophysics and star formation.Noto site in Sicily island - The Department deals with the management of the second 32m VLBI radiotelescope. The staff is also involved in the development of microwave and digital instrumentation.Astronomical research activity is mainly focused on evolved star radio-emission analysis. Studies are also carried out on extragalactic objects.
Future Site in San Basilio, Cagliari, Sardinia island, in the frame of the SRT 64m Antenna project, the permanent staff is hosted by the local Astronomical Observatory that also is involved to the SRT

Dr. Franco Mantovani
Date and place of birth: 26 July 1947, Bologna

Education
1963-1967 Istituto Tecnico Industriale, Terni, Italy, Leaving Certificate 1967
1967-1972 Universita' degli Studi, Bologna, B.Sc in Physics 1972

Career/Employement

1972-1980	Teacher in High Schools
1977-1982	Associate Scientist, Istituto di Radioastronomia
1981	Research Fellowship in Radio Astronomy, MPIfR, Bonn
1982-1990	Scientist, Istituto di Radioastronomia
1991-2005	Senior Scientist, Istituto di Radioastronomia
2005	Director, INAF-Istituto di Radioastronomia

Specialisation main field: AGN, Evolution of radiosources
other: spectral lines VLBI, Astrometry
current Compact Steep Spectrum Sources, mas scale polarimetry

Honours, Awards, Fellowship, etc...

1983	Visting Professor, MPIfR, Bonn
1985-	Scheduler 32-m Radio Telescope Medicina, Italy
1987-1990	Network Scientist EVN
1991-1994	Member EVN PC
1993-1996	Member Consiglio Scientifico, Istituto di Radioastronomia
1995-1998	Adjunct Professor, Dept. of Physics, University of Ferrara
1999	Member Board of Directors EVN
1999	Member Board JIVE
2000	Member ISSC
2000	INTAS Expert
2000	Scientific Supervisor of Marie Curie training Fellowship

Publications: Number of paper in referee journals: 60, Number of communications to scientific meetings: 80, Books: 3; Brochures :2

Dr. Mauro Nanni
Physics Master Degree at the Bologna University in year 1980. Permanent position at the Institute of Radioastronomy in Bologna (CNR) starting from 1982; Senior Technologist starting from 1997.

He has worked to the development of software for data reduction and image analysis of the data of the “Norther Cross” radiotelescope on Vax minicomputer. In the national Astronet project he has coordinated the Astronomical Database WG for the realization of DIRA package. Moreover he works in the field of the astronomical archives of images (AVO and Skyeye projects) and collaborate in the realization and management of the EVN VLBI-GPS technical data archive

He has projected the network of the CNR Campus of Bologna where he coordinates the campus computer science commission. He has worked in the national commission of the CNR and today of the INAF for the development and the management of infrastructures and the services of net.

Starting from 2001 he is participating to the realization of the Italian network for the E-Vlbi. He take care the relationships with the Region Emilia Romagna the INAF and the GARR for the fiber connection between the Medicine radiotelescope and the Garr Pop network. Starting from 2005 he is a member of the scientific board of the CyberSar project. The target of this project is to set up and connect, by a optical switched network, the “grid clusters” of the scientific sites of the region Sardegna.

MAX-PLANCK-INSTITUT FUER RADIOASTRONOMIE

Founded in 1966, construction of the 100-meter radio telescope in Bad Münstereifel-Effelsberg, operations starting 1972, institute building finished 1973. Institute extensions completed in 1983 and 2002. Jointly with Steward Observatory, University of Arizona development and operation of the 10-meter submillimeter telescope (Heinrich-Hertz-Telescope). In 2001 start of the APEX project.

Main work areas are radio- and infrared Astronomy. Technological efforts in the institute cover then whole spectrum from radio-, over (sub)millimeter-, to infrared wavelengths. There is also an effort in theoretical astrophysics.

Exploration of the physics of stars, galaxies, and the universe as a whole in the institute concentrates particular on star formation, young stellar objects, stars in the late stages of their evolution, pulsars, the interstellar medium of our Milky Way and external galaxies, the Galactic Center and its environment, magnetic fields in the universe, radio galaxies, quasars and other active galaxies, dust and gas at cosmological distances, galaxies in the early epochs of the universe, cosmic rays, astroparticle physics as well as the theory of star formation and active galactic nuclei.

The institute is heavily involved in a number of big international projects:

- The US-American/German Stratospheric Observatory for Infrared Astronomy (SOFIA),
- the Atacama Pathfinder Experiment (APEX); development and operation of a Submillimeter telescope in the Chilean Atacama desert under MPIfR leadership),
- the US/European Atacama Large Millimeter Array (ALMA),
- the Far-Infrared and Submillimeter Telescope satellite observatory HERSCHEL (formerly known as FIRST),
- an upgrade of the Effelsberg 100-meter radio telescope,
- the conception of a next generation radio telescope with a collecting area of one square kilometer (Square Kilometer Array; SKA),
- the Very Large Telescope Interferometer (VLTI) in Chile,
- the Large Binocular Telescope (LBT) in Arizona, and
- the continuation of Very Long Baseline Interferometry (VLBI) to millimeter wavelengths and to extremely high angular resolution using antennas in space.

International collaborations (selection):

- Institute for Radioastronomy at Millimeter Wavelengths (IRAM), a joint operation of the Max-Planck-Gesellschaft, the French Centre National de la Recherche Scientifique (CNRS), and the Spanish Instituto Geographico Nacional (IGN)

- The Submillimeter Telescope Observatory (SMTO) operating the Heinrich-Hertz-Telescope, in collaboration with the University of Arizona (SMTO)
- European VLBI Network (EVN) with membership from various European nations
- Very Long Baseline Array (VLBA)
- Global mm-VLBI Array, a collaboration of several institutions in Europe and the US
- APEX, a collaboration with the Ruhr-University of Bochum, the Onsala Space Observatory (Sweden), and the European Southern Observatory (ESO)

Dr. Walter Alef
Born: 11 February1954 Hürth-Kalscheuren, Germany
School: 1960-1964 Kath. Volksschule Roisdorf (Rheinland); 1965 - 1972 Ernst-Moritz-Arndt Gymnasium, Bonn.
University: 1972-1986 Rheinische Friedrich-Wilhelms-Universität Bonn; 1982 Diploma thesis: VLBI-Untersuchungen der Radioquelle 3C84 und Entwicklung eines Hybrid-Bildrekonstruktionsprogramms; 1986 PhD Thesis: Techniken für die VLBI-Beobachtung schwacher Objekte.
Employments: 1984-1986 staff scientist at the geodetic Institute, University of Bonn; 1987-present: staff scientist at the Max-Planck-Institute for Radioastronomy; 1998-present: manager of the correlator group of the MPIfR.
Other: 2003-present: Chairman EVN-Technical Operations Group; 2004-present: Administrator of the MPIfR part of JRA ALBUS in FP6 Radionet

METSÄHOVI RADIO OBSERVATORY

The Metsähovi Radio Observatory is a separate research institute of the Helsinki University of Technology since May 1988. It operates a 14 m diameter radio telescope at Metsähovi, Kylmälä, Finland, about 35 km west from the university campus. The institute also has premises in the Electrical Engineering Faculty building, Otakaari 5, Espoo.

The main users of the station are the Helsinki University of Technology, the University of Helsinki, and the University of Turku. In the same area, near Metsähovi Radio Observatory, there are also the buildings of the Metsähovi Observatory (University of Helsinki; optical astronomy) and the Metsähovi Space Geodetic Station (Geodetic Institute; geodesy).

The Metsähovi Radio Observatory has been operational since 1974. The upgrading of the telescope was done in 1992-1994. The radome has been replaced with a new one and new surface panels have been installed. The surface accuracy of the present telescope is 0.1 mm (rms).

The Metsähovi Radio Observatory is active in the following fields:
research in radio astronomy, development of instruments needed in radio astronomy, development of methods for radio astronomical measurements, space research, and education

The activities at Metsähovi are concentrated on millimeter and microwaves. The frequencies used are 2-150 GHz, corresponding to the wavelengths in the range of 13.0 cm-2.0 mm. The research in technology includes development of microwave receivers, development of receiving methods, development of data acquisition and data processing and development of antenna technology.

The objects of radio astronomical research are: solar millimeter and microwave radiation, variable quasars, active galaxies, molecular line radiation, and very long baseline interferometry (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 further. Our focus has been on maximizing the applicability of Commercially Available Off-the-Shelf (COTS) technology for VLBI data acquisition applications. Metsähovi has pioneered in the use of VSI (VLBI Standard Interface), the internationally-agreed interfacing standard for VLBI data acquisition.

Around 15 scientists, engineers, research assistants, and supporting personnel from the Helsinki University of Technology work at the institute. In addition about 10 students perform radio astronomical observations under guidance of Metsähovi permanent staff. Five of the employees are directly paid by Helsinki University of Technology, and the others paid by research projects financed mainly by the Academy of Finland.

The other users of the station are the radio astronomy group from the University of Helsinki and the radio astronomy group from the University of Turku.

Metsähovi participates in the education given at the Helsinki University of Technology by organizing courses and exercises for students. Graduate students can study for a licentiate's or doctor's degree at Metsähovi.

Mr. Ari P. Mujunen
Born: 6 December, 1963, Kuopio, Finland; Finnish citizen
Education: 8/1992 M. Sc., Electrical Engineering, Helsinki University of Technology, "Applying ER modelling and data dictionary techniques in software production automation"
Employment: 10/2002-present: Laboratory Engineer, HUT, Metsähovi Radio Observatory; 1/1997-9/2002 Researcher, HUT, Metsähovi Radio Observatory; 10/1995-12/1996 Research Associate, HUT, Metsähovi Radio Research Station; 1/1995-9/1995 Research Associate, Joint Institute for VLBI in Europe, The Netherlands; 1992-1994 Research Assistant, HUT, Metsähovi Radio Research Station; 1991-1992 Software Methodology Analyst, Tietosavo Oy, Finland; 1981-1991 Part-time Systems Analyst, Tietosavo Oy, Finland.
Technical skills: experience in analysing, designing, implementing, testing, and documenting complex software projects, such as 1997-1998 AMS HRDL: The design and implementation of High-Rate Data Link data acquisition and archival system for Alpha Magnetic Spectrometer during the Space Shuttle flight STS-91 (a collaboration with NASA, CERN, ETHZ, and MIT). From 1998-present: the development of new radiotelescope control, data acquisition, and observation management system at Metsähovi Radio Observatory. Proficiency in SA/SD methodologies, ER data modelling, data dictionaries, and relational database design. Experience with radio astronomical hardware and its computer control, especially with VLBI data acquisition hardware. Experience in designing digital hardware systems, programmable logic devices (VHDL), and interfacing device driver software to such systems. Proficiency in C, C++, COBOL, Ada, and Pascal, knowledge of Algol, BASIC, Clu, Eiffel, FORTRAN, Java, Modula-2, and Simula. Proficiency in various flavors of UNIX

including BSD 4.3 and Linux,programming knowledge of Ingres, GCOS-6, VMS, MacOs, and MS-DOS.

Mr. Jouko Ritakari
Born: 15 June, 1956, Savonranta, Finland; Finnish citizen
Education: 5/1980 M. Sc., Electrical Engineering, Helsinki University of Technology
Employment: 1987-present: Researcher, HUT, Metsähovi Radio Observatory; 1983-1987 Research Scientist, Technical Research Centre of Finland; 1979-1982 Systems Analyst, Nokia Oy.
Technical skills: Data communication system design and implementation. Data acquisition systems, both hardware and software. Examples of projects: 1980-1982 Design of one of the first local area networks for the SKOP banking system; 1984-1986 Design of one of the first campus networks, the Otaniemi local area network;1989-1990 Design of a wide area data network for the city of Helsinki; 1992 Internet connections for the data networks of Helsinki and Vantaa; 1995 Design of a wide area data network for the schools of Helsinki; 1997-1998 AMS HRDL: The design and implementation of High-Rate Data Link data acquisition and archival system for Alpha Magnetic Spectrometer during the Space Shuttle Flight STS-91 (a collaboration with NASA, CERN, ETHZ, and MIT); 2000-present: Specification and development of next generation VLBI data acquisition systems at Metsähovi Radio Observatory. Experience with radio astronomical hardware and its computer control, especially with VLBI data acquisition hardware. Experience in designing digital data acquisition hardware using programmable logic devices.

ARECIBO OBSERVATORY

The Arecibo Observatory is part of the National Astronomy and Ionosphere Center (NAIC), a national research center operated by Cornell University under a cooperative agreement with the National Science Foundation (NSF). The Observatory is the site of the world's largest single-dish instrument, the 305-m diameter Arecibo radio
telescope. This operates on a continuous basis, 24 hours a day, every day, providing observing time to astronomers and aeronomers from all over the world.

The Observatory is recognised as one of the most important national centers for research in radio astronomy, planetary radar and terrestrial aeronomy. Use of the Arecibo Observatory is available on an equal, competitive basis to all scientists from throughout the world. Observing time is granted on the basis of the most promising research as ascertained by a panel of independent referees who review the proposals sent to the Observatory by interested scientists. Numerous students use the telescope to perform observations that lead to their master and doctoral dissertations.

Construction of the Arecibo Observatory began in the Summer of 1960. Three years later the Arecibo Ionospheric Observatory (AIO) was in operation, the formal opening ceremony taking place on November 1, 1963. The Arecibo site offered the advantage of being located in Karstterrain, with large limestone sinkholes which provided a natural geometry for the construction of the 305-m reflector. On October 1, 1969 the National Science Foundation took over the facility and the Observatory was made a national research center. On September 1971 the AIO became the National Astronomy and Ionosphere Center (NAIC).

In 1974, a new high precision surface for the reflector (the current one) was installed together with a high frequency planetary radar transmitter. The second and major upgrade to the telescope was completed in 1997. A ground screen around the perimeter of the reflector was installed to shield the feeds from ground radiation. The
Gregorian dome with its subreflectors and new electronics greatly increased the capability of the telescope. A new more powerful radar transmitter was also installed. Modern VLBI equipment was acquired, and presently both Mk-4 and Mark-5 recording capabilities are available in collaboration with the European VLBI Network (EVN), the Global Array, and the High Sensitivity Array (HSA).

About 135 persons are employed by the Observatory. A scientific staff of about 20 divide their time between original research and assistance to visiting scientists. Engineers, computer experts, and technicians design and build new instrumentation and keep it in operation. A large maintenance staff keeps the telescope, its associated instrumentation, and the site in optimal condition.

Dr. Christopher John Salter
Date of Birth: 4th December 1942, Nationality: British
Academic Qualifications: Ph.D. in Radio Astronomy, University of Manchester
Present Position: Senior Research Associate, Arecibo Observatory; also, Adjunct Professor, Dept. of Astronomy & Space Sciences, Cornell University.
Career History:
Sept. 1965 - May 1970: Graduate student, Jodrell Bank, Manchester University, UK;
May 1970 - July 1972: Royal Society European Programme Fellow at the University of Bologna, Italy; July 1972 - July 1977: Research & Statistics Officer, Dacorum District Council, UK; July 1977 - June 1980: Research Fellow, Max Planck Institut fuer Radioastronomie, Bonn, Germany; June 1980 - Apr. 1981: System Scientist, Very Large Array (VLA), NRAO, Socorro, NM, USA; Apr. 1981 - Sept. 1981: Visiting Fellow, Istituto di Radioastronomia, CNR, Bologna, Italy; Sept. 1981 - Sept. 1983: Visiting Professor, Tata Institute of Fundamental Research (TIFR), Bangalore, India; Sept. 1983 Oct. 1985: System Scientist, NRAO, Tucson, USA; Oct. 1985 - Oct. 1987: Astronomy staff, IRAM, Granada, Spain; Oct. 1987 - Oct. 88; Visiting Fellow, Jodrell Bank, Manchester University, UK; Oct. 1988 - Oct. 1990: Visiting Professor, Tata Institute of Fundamental Research (TIFR), Bangalore, India; Oct. 1990 - Sept. 1992: Senior Research Associate, NRAO, Green Bank, WV, USA; Sept. 1992 - Present: Senior Research Associate, NAIC, Arecibo Observatory, PR, USA. From Sept. 1992 - May 2004, Head of the Radio Astronomy Department at the Observatory. From Sept. 1996 - present, Adjunct Full Professor, Dept. of Astronomy & Space Sciences, Cornell University.

TORUN CENTRE FOR ASTRONOMY

The Torun's Nicolaus Copernicus University (www.uni.torun.pl) directly continues traditions of the Stefan Batory Vilnius University - the second oldest in Poland. After 2nd world war the city of Vilnius has been given to communist Lituenia and the academic staff from Stefan Batory University was transported to present central Poland. In fact the astronomers had the major voice to decide on new location and the dedication of the university to Nicholas Copernicus. The most famous astronomers of Vilnus time were Marcin Odlaniecki-Poczobut (1728-1810), Jan Sniadecki (1756-1830), Wladyslaw Dziewulski (1878-1962), Wilhelmina Iwanowska (1905-1999). .

Inauguration of The Nicolaus Copernicus University (NCU) in Torun took place in 1945. First observations were made at a new site the Astronomical Observatory located in Piwnice near Torun in 1949. At present the Torun Centre for Astronomy (TCfA) is a formal organizational structure (www.astri.uni.torun.pl). It is a part of Faculty of Physics, Astronomy and Applied Informatics.

The aim of the Centre is to provide education in subject of astronomy and to conduct research in the domain of modern astronomy. The Centre consist of two departments: Astronomy and Astrophysics and Radio Astronomy. It is located in village Piwnice 12 km north from Torun town.

TCfA employs 20 academic staff, with 4 full professors positions and 35 engineers, technicians and other workers. We have 70 undergraduates studying in system of 3 (licencjat degree) and then 2 years (master degree in astronomy) and 15 Ph.D. students. This its staff and experience, with wildly developed international co-operation TCfA is

Radio astronomy in Poland was initiated in the mid fifties independently at Torun's Copernicus and Cracow's Jagiellonian Universities. The dedicated hard work of Torun's team of scientists and engineers over last three decades placed us among developed European radio observatories.

The Department of Radio Astronomy (www.astro.uni.torun.pl) is an educational and research division of the Centre for Astronomy, conducting study of the Universe by means of radio waves. Since 1981 the Department (known also as Torun Radio Astronomy Observatory) is a part of world wide network of radio observatories participating in VLBI (Very Long Baseline Interferometry). With the new 32 m. telescope and modern sophisticated instrumentation, Torun VLBI station is the unique place in eastern Europe. International collaboration and involvement in various European research projects is the major activity of this department. The research concentrates on observations and theoretical interpretation of physical processes in compact active regions of radio galaxies and quasars, the timing of pulsars, the search for new planetary system and the Solar System studies. In addition, the development of instrumentation for radio astronomy (ultra low noise receivers, spectrometers, frequency converters, digital electronics, control systems) is also significant part of our activities. Since 1997 the Department of Radio Astronomy is a part of Torun Centre for Astronomy at Faculty of Physics, Astronomy and Informatics of the Nicolaus Copernicus University. From 1998 the Department undertakes additional function of the National Facility with the major aims to serve Polish astronomers and to emphasize the international cooperation

The 32m antenna with its high quality auxiliary instrumentation provides Polish astronomers with the unique tool to study the Cosmos. The telescope is part of the European and world-wide network of interferometers - VLBI. It allows our antenna to be a part of the synthesis radio telescope which has an equivalent aperture size of ~10 thousand kilometres. This new instrument and the involvement of Polish radio astronomers into international co-operation resulted in the flowering of radio research. VLBI studies of distant galaxies and quasars, the search for new planetary systems around pulsars, the study of interstellar and stellar molecules are the subjects to be mentioned here. The importance of the Torun 32m has been widely recognized among the astronomical community. The size of the antenna, geographic position (important extension to the east) and a highly professional team of scientists and engineers make the EVN addition of Torun the significant improvements to the European VLBI Network. Radio astronomy is a very challenging area of modern research for a country like Poland. The instrument is intended for use by all Polish astronomers as a national facility.

Prof. Andrzej Kus

Date of birth: 21st June 1944 in Cracow Poland. Marital status: Married since 1968, with two grownup children. Secondary qualification: In 1962 a degree from the High School.

Undergraduate Education: Study at the NCU (Nicolaus Copernicus University) Torun at Institute of Astronomy - Physics Faculty, for master degree in Astronomy 1962-1967. Supervision from Prof. W.Iwanowska and Prof. S.Gorgolewski, Master thesis in Radio Astronomy, Graduated from the University in 1967 with the best mark. Received the Ph.D. degree in Physics from the NCU Torun in 1975. The thesis - "The 5C7 Deep Survey of Radio Sources" - is based on results obtained during the study at Cambridge University.
Academic qualifications: Mgr. (Magister = Master of Science) in astronomy from the Nicolaus Copernicus University (NCU), Torun Poland in 1967. Ph.D. in Physics at the Nicolaus Copernicus University received in 1975 a habilitation degree (Dr. hab.) 1989 and Docent position at the Nicolaus Copernicus University since May 1990. Professor position and the Chair of Radio Astronomy from April of 1991, Professor title (received from President of Poland) in June 2003. Director of Torun Radio Astronomy Observatory, Nicholaus Copernicus University 1992-1996. Head of the Radio Astronomy Department of the Torun Centre for Astronomy, Faculty of Physics and Astronomy, Copernicus University, from January 1st 1997. Director Torun Centre for Astronomy from January 1st 2001. Experience in fields of: radio astronomy techniques - especially in interferometry, VLBI, mm VLBI, aperture synthesis, low noise receivers, antennas, extra galactic radio astronomy - physics of radio galaxies and quasars, spectroscopy of OH masers. Teaching experience: Lectures for undergraduates on : Extra Galactic Astronomy, Extra Galactic Radio Astronomy, Radio Astronomy, Astronomy and Astrophysics, tutorials in radio astronomy. Supervision of Ph.D. students.

ONSALA SPACE OBSERVATORY

Onsala Space Observatory is the Swedish national facility for radio astronomy, hosted by Chalmers Technical University. Onsala operates 20m and 25m antennas at its site near Gothenborg, and is a 25% partner in the APEX 12m diameter submillimetre antenna in Chile. The antennas are used both as single instruments and and in combination with other European antennas for VLBI both at centimetre and millimeter wavelengths. A recently installed 1Gbit/s fibre link to the university and thence to the GEANT backbone has allowed Onsala to participate in the first experiments in e-VLBI. In May 2004 Onsala was the first European antenna to demonstrate joint real-time trans-atlantic e-VLBI together with an antenna belonging to MIT. Onsala has in the last decade taken a leading role in establishing a European millimetre array project that was later merged with the US effort to form ALMA, whose innovative layout was designed by an Onsala staff scientist, after strong international competition. This design is now being built in Chile. In addition, receiver bands for ALMA and APEX are being built at Onsala by the group for Advanced Receiver Development. Also being built for ALMA are Water Vapour radiometers which are vital for achieving
correction for atmospheric propagation effects. Onsala radio astronomers are part of the University's Radio and Space Science department and have good cross-disciplinary links with groups using radio techniques for Earth remote sensing and space geodesy. Onsala/Chalmers University runs an established international Masters Programme in Radio-Astronomy and Space science with 24 students per year, many of whom continue to do PhDs in astronomy and other subjects at Onsala and worldwide.

Dr. John Conway is one of the key personnel at Onsala associated with EXPReS. Dr. Conway is chairman of the eVSAG (NA3). A short CV follows:

Dr. John Conway. PhD University of Manchester, 1988, Postdoc California

Institute of Technology, Pasadena, USA. 1989 - 1991: Postdoc National Radio Astronomy Observatory (NRAO), Socorro, USA, 1992 - 1994. Postdoc, JIVE fellow, Onsala Space Obs, Sweden, 1995; Staff Astronomer, Swedish National Facility for Radio Astronomy, Onsala Space Observatory, Sweden 1996 - June 2002; Associate Professor, Onsala/Chalmers Technical University, June 2002 to present. Has been primary supervisor for three PhD students and played a major role as secondary supervisor for four other PhD students. Recent publications include: Yi,Booth, Conway and Diamond 2005 AA 432,531, Sio Maser in TX Cam; Pestalozzi, Elitzur,, Conway, Booth 2004, A Circumstellar Disk in a High-Mass Star-forming Region, ApJL 603, 113; Pihlstr\"{o}m, Conway and Vermeulen, 2003, The presence and distribution of H I absorbing gas in sub-galactic sized radio sources, AA 404, 871.

Dr. Michael Lindqvist

Date of Birth: 6th May, 1960, Place of Birth: Vänersborg, Sweden

Education and degrees: Doctor of Philosophy, Chalmers Tekniska H¨ogskola, December 1991. Supervisor Dr. A. Winnberg.

Thesis: A study of circumstellar envelopes: OH/IR stars in the galactic centre and carbon-bearing molecules in the envelopes of oxygen-rich stars.

Subsequent career: Friend of VLBI at Onsala Space Observatory National Facility, November 2002-present; Research engineer at Onsala Space Observatory National Facility, September 2000-present; NASA/NICMOS fellowship at Onsala Space Observatory National Facility, January 1997 – August 2000; Assistant telescope scientist at Onsala Space Observatory National Facility, March 1996-December 1996;

ESA external fellowship at Sterrewacht Leiden, The Netherlands, March 1994- February 1996; Human Capital and Mobility Fellowship at Sterrewacht Leiden, The Netherlands, July 1993 – February 1994.

Another key person at Onsala is Dr. Michael Olberg.

SHANGHAI ASTRONOMICAL OBSERVATORY

Shanghai Astronomical Observatory (SHAO) is an institute of the Chinese Academy of Sciences (CAS).

The observatory's main research activities fall into four divisions: astro-geodynamics, astrophysics, very-long-baseline-interferometry (VLBI), and the technical laboratories.

Its observing facilities include a 25m radio telescope used for VLBI, a 1.56m optical telescope, and a 60cm satellite laser-ranging system (SLR). There are also three technical laboratories, researching hydrogen atomic clocks, VLBI techniques, and optical astronomy.

The Shanghai Center for Astro-geodynamics Research (SCAR) engages in measurement and analysis of the component motions of the Earth, and researches into their dynamical mechanisms, using astronomical data. In particular, modern space geodesy techniques are used. The research topics include the rotational and orbital motions of the Earth, as well as the mass motions of the Earth’s spheres, such as the atmosphere, hydrosphere, lithosphere, mantle, and core. The Center is especially involved in studies of mechanisms by which the Earth’s rotation varies, and interactions between the motions of the various spheres.

The division of astrophysics was formerly the second division of SHAO. It has a long history in Chinese observational astronomy, dating back to its famous now one hundred year old

40cm refractor. For many years, the central theme of the division's research was stellar clusters and the structure of the Milky Way. However, during recent years the division has broadened its interests significantly, with its research now touching on almost all major topics in modern astrophysics.

Some thirty scientists and a similar number of postgraduate students cooperate in a broad program of research supported by funds from the National Natural Science Foundation, the Department of National Science and Technology, and the Chinese Academy of Sciences, as well as contracts with and grants from other government agencies. Our scientific investigations are organized into four groups and two observational laboratories.

The VLBI division manages the Chinese VLBI Network (CVN) of the National Astronomical Observatories of China (NAOC), which consists of two VLBI stations near Shanghai and Urumqi, and a two-station VLBI correlator in SHAO. There are also two new VLBI stations being built near Beijing and Kunming which will start taking VLBI taking VLBI observations in 2006.

The current VLBI division consists of two groups: the Sheshan VLBI station and the VLBIlaboratory.

The Sheshan group takes VLBI observations at the Sheshan station, which include observations for the European VLBI Network (EVN), the International VLBI Services for Astronometry and Geodesy (IVS), the VLBI Space Observatory Programme (VSOP), the Asia-Pacific Space Geodynamics Program (APSG), as well as observations related to aircraft navigation. Its duties are to maintain the station; to carry out upgrades on the VLBI system (e.g. the MK4 and MK5 recording systems, feel system, as well as C and L band receivers), and to participate in VLBI technical development. Some members of the group also study the radio jets of AGN with VLBIobservations.

The VLBI laboratory is the technology development center of the Chinese VLBI Network (CVN). The purpose of the lab is to develop new VLBI technologies, both in hardware and software, and to expand on VLBI applications. The laboratory built a two-station VLBI correlator and developed a CVN disk-based recording system. Presently, the laboratory is developing Digital BBC in collaboration with European colleagues, a new 5-station VLBI correlator, and a real-time VLBI system.

The VLBI division also has taken on the responsibility of building the VLBI systems for the new Beijing and Kunming stations. These systems consist of VLBI receivers, VLBI recording systems, and hydrogen masers.

SHAO is responsible for the VLBI and SLR networks of the National Astronomical Observatory of China (NAOC). It also hosts the central office of the Asia-Pacific Space Geodynamics Program (APSG), as well as a partner group of the Max Planck Institute for Astrophysics (MPA).

Prof. Xiaoyu Hong
Born 15 November 1961 in Fujian Province, China. Nationality: Chinese

Education: Sep 1978–July 1982, PhysicsDept.,Xiamen University, Bachelor; Sep 1987–July 1990 Astrophysics, Beijing University, Master; Sep 1990–Oct 1993 Shanghai Astronomical Observatory (ShAO), Ph. D.
Working Experience: Aug 1982–Aug 1987 ChongqingYangtz Ship Company, Teacher; Oct 1993–Aug 1995 ShAO, CAS, Assistant Professor; Aug 1995–Dec 1998 ShAO, CAS, Associate Professor; Dec 1998–present ShAO, CAS, Professor; March 1999–present SeshanVLBI Station of ShAO, CAS, Chief; July 1999–present VLBI Dept. of ShAO, CAS, Chief; July 2001-March 2003 ShAO, CAS, Assistant Director;
March 2003-present ShAO, CAS, Deputy Director.
Publications: 2004, A&A, in press, X. Y. Hong, D. R. Jiang, L. I. Gurvits, M. A. Garrett, S. T. Garrington, R. T. Schilizzi, N. D. Nan, H. Hirabayashi, W. H. Wang, and G. D. Nicolson "A relativistic helical jet in the gamma-ray AGN 1156+295";
2002, ApJ. 577, 69, Jiang, D. R.; Zhou, J. F.; Hong, X. Y.; Gurvits, L. I.; Shen, Z.-Q.; Chen, Y. J. "The Milliarcsecond-Scale Jet in the Quasar J1625+4134"; 2002, evlb.conf., 103, Hong, X. Y.; Jiang, D. R.; Venturi, T.; Wang, W. H.; Tao, A.; Schilizzi, R. T. "Nuclear structures in ã--ray loud blazers"; 2001, A&A., 380, 123, Wang, W. H.; Hong, X. Y.; Jiang, D. R.; Venturi, T.; Chen, Y. J.; An, T. "An accelerated jet in DA193?"; 2001, IAUS., 205, 116, Hong, X. Y.; Jiang, D. R.; Schilizzi, R. T.; Nicolson, G.; Shen, Z. Q.; Wang, W. H. "VLBI observations of a sample of 15 EGRET-detected AGNs at 5 GHz".

OBSERVATORIO GEODESICO TIGO

The Geodetic Observatory TIGO is a Chilean-German cooperative project of currently four institutions:
- Universidad de Concepción (www.udec.cl)
- Universidad del Bío Bío (www.ubb.cl)
- Instituto Geografico Militar (www.igm.cl)
- Bundesamt für Kartographie und Geodäsie (www.bkg.bund.de).

The project is supervised by a Directive Board which consists of the highest representatives of each Chilean institution and the responsible persons for TIGO of BKG. The Annual Report of TIGO is reviewed by the Directive Board at its annual meeting. The Scientific Board of TIGO coordinates science related activities on its frequent meetings.

TIGO is no legal person. By Chilean law the Universidad de Concepción as legal person is responsible for TIGO.

Dr. Hayo Hase was born in 1963 in Oldenburg i.O., Germany
1983-1990 study of geodesy at Bonn University, degree Dipl.-Ing.; 1990-1994 scientific employee at the VLBI-group of Geodetic Institute Bonn University, installation and operation of VLBI-station O'Higgins, Antarctica; 1994-2001 scientific employee at the Bundesamt für Kartografie und Geodäsie (BKG), design, construction and installation of the Transportable Integrated Geodetic Observatory (TIGO) at Wettzell, Germany; 1999 doctorate thesis "Theorie und Praxis globaler Bezugssysteme", Technical University Munich, degree Dr.-Ing.; 2002-2003 scientific employee of BKG, Head of TIGO in Concepción, Chile; 2003-present scientific official of BKG, Head of TIGO in Concepción, Chile

JODRELL BANK OBSERVATORY (UniMan)

Jodrell Bank Observatory, part of the School of Physics and Astronomy of the University of Manchester owns and operates the 76-m Lovell Telescope (LT) and the 7-element MERLIN/VLBI National Facility. Radio astronomy was pioneered at Jodrell Bank in the 1940's-50's, being famous for its work on radar echoes from meteors and from the Sputnik launcher. There are around 100 staff and students on site at Jodrell Bank, 30 km south of the city of Manchester. Current research is involved with all aspects of modern radio astronomy, including investigations of the properties of pulsars, radio stars, radio galaxies and quasars, starburst galaxies, mircoquasars, gravitational lensing and cosmology. Both single dish and interferometer systems have been developed at Jodrell Bank, including the development of radio-linked interferometers resulting in MERLIN. The LT and MERLIN are integral components of the EVN, indeed JBO was one of the founding members of the EVN.

MERLIN is currently undergoing a ~ 10 Million Euro upgrade. The telescopes of e-MERLIN, as the upgraded instrument will be known, will be connected with fibre-optic cables each transmitting up to 30Gbps of data; new receivers, new digital transmission equipment and a new broadband correlator will enable observations a factor of 10-30 more sensitive than the current array. e-MERLIN will be operational in 2009. In addition, JBO recently commissioned a 2.5 Gbps fibre link to Manchester and from there onto the UK's research network; this link was recently used for e-VLBI tests at JIVE, including the first e-VLBI science. JBO staff have extensive experience in digital hardware, software and, more recently, data transmission standards and protocols. A key goal of EXPReS is to include the e-MERLIN telescopes transparently within the EXPReS e-VLBI network.

Key Jodrell Bank personnel associated with EXPReS include:

Dr Ralph E. Spencer is Reader in Radio Astronomy at the University of Manchester. His PhD (1970) was in cosmic ray physics He has worked on the development of interferometers for radio astronomy since the 1970's, leading work on the development of phase stable radio linked interferometers with 100 km baselines. This work led to the development of the MERLIN array of 7 telescopes now operated as a National Facility by the University of Manchester for PPARC. His interest in VLBI started in the late 1970's and was responsible for running VLBI operations at Jodrell Bank Observatory until the mid 1990's, when the National Facility took over. European development of the 1 Gbps MkIV tape VLBI system was led by him until 2001. The electronics in this system now feed signals to the 1 Gbps Mk5 disc recorder used in routine operations. A pioneering demonstration at IGRID 2002 showed the feasibility of using the internet at high data rates for VLBI, and work on this has continued with recent developments using switched light paths provided by the UKLight project. The ESLEA project, exploiting UKLight will enable up to 1 Gbps real time operations in e-VLBI. He is head of the fibre optic group at Jodrell Bank which has developed the use of fibres in radio astrronomy for data transport at rates up to 120 Gbps. His astronomy research has concentrated on the properties of microquasars. He has over 200 publications. Ralph is a Fellow of the Royal Astronomical Society and a Member of the New York Academy of Sciences.

Dr Simon Garrington is the project manager for e-MERLIN, a 12Million Euro project to upgrade the MERLIN network of radio telescopes spread across the UK. This has involved the installation of approx 100 km of new optical fibre to connect the remote telescopes to dark fibre trunks that have been leased from various providers. Along with the fibre connections, the project includes new receivers, signal processing and transmission electronics and a new central correlator capable of handling 240 Gb/s input. He is also a lead investigator of AstroGrid, the UK Virtual Observatory project, a lead member of ALBUS, an FP6-funded software project and a task leader for SKADS, the Square Kilometre Array Design Study. He has developed software for radio interferometry and continues to be involved in MERLIN and VLBI operations at Jodrell Bank Observatory. His research uses arrays of radio telescopes (EVN, MERLIN, VLBA, VLA) to address a range of topics from young stars to distant galaxies and he has over 100 scientific publications, including well-cited work on radio galaxies and quasars.

Other key personnel at Jodrell Bank are Paul Burgess (Snr. Scientific Officer) and Dr. A. Gunn.

VENTSPILS INTERNATIONAL RADIO ASTRONOMY CENTRE (VIRAC)

VIRAC was founded in 1994 as non-profit research company with limited responsibility. From December 2004 it is known as the research institute of Ventspils University College (VeA). With the aim to attract reasonable research and renovation funding, VIRAC is developing research activities in two directions (a) radio astronomy and VLBI (based on the ex-soviet union RT-32 radio telescope) and (b) satellite data management systems (based on RT-16 radio telescope). Educational activities together with Ventspils University College, University of Latvia and Riga Technical University are of high importance for both research directions. The administrative staff of VIRAC consists of 10 persons. Research staff consists of 16 persons (including 10 persons with doctors degree in astronomy, physics, mathematics or engineering). The Director of VIRAC is asoc.prof. dr.habil.phys. Juris Zagars, President of the Research Council is prof. dr.habil.sc.ing. Zigurds Sika, Chef Engineer is dr.sc.ing. Valery Bezrukov, Coordinator for VLBI activities is dr.phys. Ivars Shmelds.
The VIRAC institute operates a 32-meter fully steerable, Cassagrain type, parabolic, centimetre-wave range antenna (RT-32) and a 16-meter diameter antenna (RT-16). The first one is restored and in use after heavy damage caused by the Soviet army before its transfer to Latvia after withdrawal of soviet troops from Latvia. The antenna system is of Cassagrain type and the shortest working wavelength is about 3 cm. The institution has the following receivers at the moment:10.7GHz HEM transistor, Tnoise= 80K(system), f = 44 MHz;
12.0 GHz HEM transistor, Tnoise= 80K(system), f = 44 MHz; 327 MHZ, Transistor, Tnoise= 120K, f = 2MHz.

The implemention of the following receivers are under way (they could be ready for use on september, october 2005): 5010 MHz, HEM transistor, Tnoise= 65 K (expected), f = 250 MHz, 1280 MHz, HEM transistor, Tnoise 100 K (system), f = 400 MHz

There are three active obsevational programmes running at VIRAC now: the investigation of the antenna properties itself, observations of methanol masers at 12,2 GHz frequency and observations and mapping of the solar active regions. Currently the main users of the facility are the VIRAC staff. In the longer term the Institute hopes to play a role in the integration of radio astronomy networks of Europe and the world, bringing a high-level contribution to these networks. In particular, VIRAC aims to achieve a VLBI capability within the next 12 months VIRAC is now integrated into the Ventspils University College and it has the excellent opportunity of training young Latvian astronomers.

VIRACS' Dr. Valery Bezrukov (Chief Engineer of VIRAC) is the main person involved in the EXPReS project. His CV follows:

CV of dr.sc.ing. Valery Bezrukov, Chief Engineer of VIRAC
Data of birth: December 04, 1950
Education:1959 – 1968, Secondary school , Latvia; 1968 – 1974: Riga Technical University, Department of Power and Electrical Engineering , Latvia.
Degree: Engineer of electromechanic: 1988 – 1992 Postgraduate study at VNIIElektromash, St. Petersburg, Russia. Degree: Cand.Tech.Sc: 1993 Latvian Academy of Science Institute of Physical EnergeticsDegree: Dr.sc.ing.
Work experience: 1974 – 1988, Researcher, Latvian Academy of Science Institute of Physical Energetics, Div. electrical machines. Since 1992: Senior researcher, Latvian Academy of Science Institute of Physical Energetic, Lab. of modelling of electromagnetic processes
1994 – 2004: Senior researcher at Ventspils International Radio Astronomy Centre
since 2004: Senior researcher and Chief engineer of Ventspils International Radio Astronomy Centre.
Research**:** 1974 – 2005: Control systems of synchronous electrical machines; since 1992: Development of wind energetics and estimate of wind energy potential in Latvia; since 1994: Control systems of electric drives of the radio telescope RT-32 and RT-16. Language skills:Latvian – good, English – basic, Russian – excellent.

A.2 Sub-contracting

None of the work associated with EXPReS is foreseen to be subcontracted.

A.3 Third parties

None of the work is foreseen to be carried out using financial resources or resources in kind by third parties.

A.4 Third country participants

EXPReS includes the participation of several third countries, including the USA, South Africa, China, Chile & Australia. The participation of the organisations associated with these countries is essential in order for EXPReS to realise its full potential. This is because the technique of Very Long Baseline Interferometry (VLBI) relies on combining together radio astronomy data from telescopes that are widely separated – the larger the separation between the telescopes, the better the angular resolution of the VLBI image. For many decades, radio astronomers located in all the major continents have collaborated together in order to form a global VLBI network. The aim of EXPReS is to create a real-time e-VLBI global array of radio telescope and this, by its very nature, requires the full participation of radio astronomy (and networking) organisations outside of the EU.

For example, in terms of the optimum geographical distribution of the e-VLBI array, the participation of NAIC in the USA will permit European astronomers to access an e-VLBI network that includes the largest radio telescope in the world – the 300-m telescope in Arecibo. This will permit not only very high resolution images to be made but will also boost the sensitivity of the array. The participation of HRAO in South Africa provides the the EXPReS e-VLBI array with a baseline coverage that extends to the South hemisphere, permitting detailed images of low-declination radio sources to be made. By including China the array also extends to the east, creating a baseline of 9000 km between Yebes (ES) and Shanghai (CN). The TIGO antenna located in Chile provides a very long baseline to the south west of the central European core of the e-VLBI array. By combining data from these non-EU sites it will be possible for astronomers to achieve milliarcsecond resolution, enabling them to resolve the radio emission associated with galactic and indeed many extragalactic sources. Without the participation of these non-EU organisations, the resolution of the e-VLBI array will be degraded by at least a factor of 5.

The participation of AARNet and ATNF in Australia provides astronomers with the opportunity to monitor equatorial radio sources through a full 24 hour observing period – these sources would otherwise only be visible from Europe for a few hours each day. Since the centre of the Milky Way is located at these low declinations, many of the most interesting sources are located at these latitudes and it is often important to be able to measure continuous changes in the radio source structure over times scales of many hours and days. High speed connections will also exercise the ability of European astronomers to interact with Australian facilities, a scenario of remote observing that may need to be used for next generation radio telescopes such as the SKA, especially if it is located in the southern hemisphere.

The inclusion of these non-EU facilities greatly enhances the scientific capabilities of the e-VLBI array and ensures that European astronomers will be able to conduct first-rate science. In addition, each of these third country institutes bring a level of expertise to the EXPReS consortium that will be important in order to realise all of the project goals.