SEVENTH FRAMEWORK PROGRAMME

Grant agreement for: Combination of CP & CSA[*]

Annex I - "Description of Work"

Project acronym: NEXPReS

Project full title: " NEXPReS- Novel EXplorations Pushing Robust e-VLBI Services "

Grant agreement no: 261525

Date of preparation of Annex I (latest version): 2010-07-08

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Date of approval of Annex I by Commission: 2010-07-08

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Part A

Workplan Tables

A1:
Project summary

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per project

General information

Project title [3]	NEXPReS- Novel EXplorations Pushing Robust e-VLBI Services		
Starting date [4]	01/07/2010		
Duration in months [5]	36		
Call (part) identifier [6]	FP7-INFRASTRUCTURES-2010-2		
Activity code(s) most relevant to your topic [7]	:		
Free keywords [8]		Radio Astronomy, VLBI, radio telescopes, bandwidth on demand, streaming computing, high-speed storage, distributed sensor networks	

Abstract [9]

The objective of “Novel EXplorations Pushing Robust e-VLBI Services” (NEXPReS) is to offer enhanced scientific performance for all use of the European VLBI Network (EVN) and its partners. The proposed activities will allow the introduction of an e-VLBI component to every experiment, aiming for enhanced robustness, flexibility and sensitivity. This will boost the scientific capability of this distributed facility and offer better data quality and deeper images of the radio sky to a larger number of astronomers. In the past years, e-VLBI has been successfully introduced for real-time, high-resolution radio astronomy. Due to limitations in connectivity, bandwidth and processing capacity, this enhanced mode cannot be offered to all astronomers yet, in spite of its obvious advantages. By providing transparent buffering mechanisms at telescope and correlator it will be possible to address all the current and future bottlenecks in e-VLBI, overcoming limited connectivity to essential stations or network failures, all but eliminating the need for physical transport of magnetic media. Such a scheme will be far more efficient, and ultimately greener, than the current model, in which complex logistics and a large over-capacity of disks are needed to accommodate global observations. It will require high-speed recording hardware, as well as software systems that hide all complexity. Real-time grid computing and high bandwidth on demand will be addressed as well, to improve both the continuous usage of the network and prepare the EVN for the higher bandwidths which will ensure it will remain the most sensitive VLBI array in the world. The proposed programme will strengthen the collaboration between the European radio-astronomical and ICT communities. This will be essential to maintain Europe's leading role in the global SKA project.

A2:
List of Beneficiaries

Project Number [1]	261525	Project Acronym [2]	NEXPReS

List of Beneficiaries

No	Name	Short name	Country	Project entry month[10]	Project exit month
1	JOINT INSTITUTE FOR V.L.B.I. IN EUROPE (J.I.V.E.)	JIVE	Netherlands	1	36
2	STICHTING ASTRONOMISCH ONDERZOEK IN NEDERLAND	ASTRON	Netherlands	1	36
3	ISTITUTO NAZIONALE DI ASTROFISICA	INAF	Italy	1	36
4	MAX PLANCK GESELLSCHAFT ZUR FOERDERUNG DER WISSENSCHAFTEN E.V.	MPG	Germany	1	36
5	THE UNIVERSITY OF MANCHESTER	UMAN	United Kingdom	1	36
6	CHALMERS TEKNISKA HOEGSKOLA AB	OSO	Sweden	1	36
7	VENTSPILS AUGSTSKOLA	VENT	Latvia	1	36
8	FUNDACION GENERAL DE LA UNIVERSIDAD DE ALCALA	FG-IGN	Spain	1	36
9	NORDUNET A/S	NORDUnet	Denmark	1	36
10	SURFnet bv	SURFnet	Netherlands	1	36
11	INSTYTUT CHEMII BIOORGANICZNEJ PAN	PSNC	Poland	1	36
12	DELIVERY OF ADVANCED NETWORK TECHNOLOGY TO EUROPE LIMITED	DANTE	United Kingdom	1	36
13	AALTO-KORKEAKOULUSAATIO	AALTO	Finland	1	36
14	TECHNISCHE UNIVERSITAET MUENCHEN	TUM	Germany	1	36
15	COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION	CSIRO	Australia	1	36

A3: Budget Breakdown

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One Form per Project

Participant number in this project [11]	Participant short name	Fund. % [12]	Ind. costs [13]	Estimated eligible costs (whole duration of the project)						Requested EU contribution
				RTD (A)	Coordination (B)	Support (C)	Management (D)	Other (E)	Total A+B+C+D+E	
1	JIVE	75.0	T	554,200.00	426,000.00	0.00	326,700.00	1,356,400.00	2,663,300.00	1,581,240.00
2	ASTRON	75.0	A	339,044.00	0.00	0.00	2,500.00	222,877.00	564,421.00	334,390.00
3	INAF	75.0	T	259,000.00	0.00	0.00	0.00	0.00	259,000.00	158,250.00
4	MPG	75.0	S	0.00	0.00	0.00	0.00	135,375.00	135,375.00	135,375.00
5	UMAN	75.0	T	126,524.00	0.00	0.00	0.00	204,540.00	331,064.00	219,113.00
6	OSO	75.0	T	386,648.00	0.00	0.00	0.00	63,360.00	450,008.00	287,088.00
7	VENT	75.0	F	86,025.00	0.00	0.00	0.00	0.00	86,025.00	52,144.00
8	FG-IGN	75.0	A	0.00	0.00	0.00	12,250.00	0.00	12,250.00	0.00
9	NORDUnet	75.0	A	0.00	0.00	0.00	0.00	214,825.00	214,825.00	129,145.00
10	SURFnet	75.0	A	0.00	0.00	0.00	0.00	80,000.00	80,000.00	0.00
11	PSNC	75.0	T	354,400.00	0.00	0.00	0.00	0.00	354,400.00	184,800.00
12	DANTE	75.0	A	0.00	0.00	0.00	29,600.00	29,600.00	59,200.00	0.00
13	AALTO	75.0	T	312,760.00	0.00	0.00	0.00	54,000.00	366,760.00	229,605.00
14	TUM	75.0	T	0.00	0.00	0.00	0.00	136,520.00	136,520.00	109,425.00
15	CSIRO	75.0	A	0.00	0.00	0.00	0.00	79,425.00	79,425.00	79,425.00
Total				2,418,601.00	426,000.00	0.00	371,050.00	2,576,922.00	5,792,573.00	3,500,000.00

Note that the budget mentioned in this table is the total budget requested by the Beneficiary and associated Third Parties.

*** The following funding schemes are distinguished**

Collaborative Project (if a distinction is made in the call please state which type of Collaborative project is referred to: (i) Small of medium-scale focused research project, (ii) Large-scale integrating project, (iii) Project targeted to special groups such as SMEs and other smaller actors), Network of Excellence, Coordination Action, Support Action.

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project, and it cannot be changed. The project number **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

2. Project acronym

Use the project acronym as indicated in the submitted proposal. It cannot be changed, unless agreed during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry info force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a detailed justification on a separate note.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Activity code

Select the activity code from the drop-down menu.

8. Free keywords

Use the free keywords from your original proposal; changes and additions are possible.

9. Abstract

10. The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

11. The number allocated by the Consortium to the participant for this project.

12. Include the funding % for RTD/Innovation – either 50% or 75%

13. Indirect cost model
- **A: Actual Costs**
- **S: Actual Costs Simplified Method**
- **T: Transitional Flat rate**
- **F :Flat Rate**

Workplan Tables

Project number

261525

Project title

NEXPReS—NEXPReS- Novel EXplorations Pushing Robust e-VLBI Services

Call (part) identifier

FP7-INFRASTRUCTURES-2010-2

Funding scheme

Combination of CP & CSA

WT1
List of work packages

Project Number [1]	261525	Project Acronym [2]	NEXPReS

LIST OF WORK PACKAGES (WP)

WP Number [53]	WP Title	Type of activity [54]	Lead beneficiary number [55]	Person-months [56]	Start month [57]	End month [58]
WP 1	Management	MGT	1	48.00	1	36
WP 2	EVN-NREN	COORD	12	6.00	1	36
WP 3	eVSAG	COORD	8	6.00	1	36
WP 4	Communication	COORD	1	21.60	1	36
WP 5	Cloud Correlation	OTHER	1	120.00	1	36
WP 6	High Bandwidth on Demand	OTHER	1	123.00	1	36
WP 7	Computing in a Shared Infrastructure	RTD	1	117.00	1	36
WP 8	Provisioning High-Bandwidth, High-Capacity Networked Storage on Demand	RTD	13	163.20	1	36
			Total	604.80		

Project Number [1]	261525	Project Acronym [2]	NEXPReS

List of Deliverables - to be submitted for review to EC

Deliverable Number [61]	Deliverable Title	WP number [53]	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D1.1	Appoint Programme Manager	1	1	1.00	O	PU	1
D1.2	Appoint Project Assistant	1	1	1.00	O	PU	1
D1.3	Form Board	1	1	1.00	O	PU	1
D1.4	Create Project contact lists	1	1	1.00	O	PU	1
D1.5	Conclude Consortium Agreement	1	1	1.00	R	PU	1
D1.6	Form Management Team	1	1	1.00	O	PU	1
D1.7	Convene Advisory Board	1	1	2.00	O	PU	3
D1.8	Convene Management Team	1	1	1.00	O	PU	3
D1.9	Period 1 Report to EC	1	1	13.00	R	PP	12
D1.10	Period 2 Report to EC	1	1	13.00	R	PP	24
D1.11	Period 3 Report to EC	1	1	13.00	R	PP	36
D2.1	EVN-NREN meeting 1	2	12	1.00	O	PU	9
D2.2	EVN-NREN meeting 2	2	12	1.00	O	PU	22
D2.3	EVN-NREN meeting 3	2	12	1.00	O	PU	32
D2.4	Presentation on regions of increasing interest to Radio Astronomy and Networking	2	12	3.00	R	PU	19
D3.1	eVSAG meeting 1	3	8	3.00	O	PU	16

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D3.2	eVSAG meeting 2	3	8	3.00	O	PU	32
D4.1	Appoint Communications Manager	4	1	1.00	O	PU	1
D4.2	Online Resources	4	1	4.60	O	PU	1
D4.3	Meeting Support	4	1	6.00	O	PU	36
D4.4	Display	4	1	3.00	O	PU	3
D4.5	Visual Guide/Elements	4	1	1.00	O	PU	6
D4.6	Publish Print Items	4	1	3.00	O	PU	9
D4.7	Publish Print Items	4	1	2.00	O	PU	23
D4.8	Project “Fact Sheet” (1, JIVE)	4	1	1.00	R	PU	1
D5.1	Mixed e-VLBI/ recorded-VLBI at stations	5	1	3.00	R	PU	3
D5.2	Metrics, selection criteria and user feedback	5	1	4.00	O	PU	4
D5.3	Definition of specifications monitoring and remote control	5	14	3.00	R	PU	4
D5.4	Automated job scheduling	5	1	8.00	R	PU	9
D5.5	VDIF Mark5 conversion software	5	1	11.00	O	PU	15
D5.6	Control systems and scheduling mechanisms for 4-Gbps recording equipment	5	1	8.00	O	PU	18
D5.7	Unattended correlation	5	1	11.00	R	PU	19
D5.8	Monitoring, remote control	5	14	21.00	O	PU	22

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
	and client software including the authorization and authentication layer						
D5.9	Control systems and scheduling mechanisms for 4-Gbps at correlator	5	1	11.00	O	PU	23
D5.10	Corner-turning platform	5	1	8.00	O	PU	24
D5.11	FS-integrated remote control system	5	14	2.00	O	PU	28
D5.12	Automated delayed correlation	5	1	12.00	O	PU	29
D5.13	Real-time correlation with simultaneous recording at the correlator	5	1	6.00	O	PU	30
D5.14	Report on tests with Wettzell & Effelsberg stations	5	14	2.00	R	PU	36
D5.15	Streamlined data reduction pipelines & user access	5	1	10.00	O	PU	36
D6.1	Proof-of-concept system for reserving and provisioning On-demand networking capacity	6	1	35.00	P	PU	20
D6.2	Operational use of BoD on at least one e-VLBI connection	6	1	17.00	R	PU	36
D6.3	Configuration of 10 Gbps BoD	6	1	16.00	R	PU	24

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
	for the LOFAR archive network						
D6.4	BoD scheduling interface for LTA	6	1	8.00	R	PU	30
D6.5	Demonstration of BoD for an operational LTA	6	1	4.00	D	PU	33
D6.6	Demonstration of integrated BoD testing and validation	6	1	30.00	D	PU	30
D6.7	Demonstration of international BoD connectivity at 4 Gbps	6	1	8.00	D	PU	18
D6.8	Demonstration of international BoD connectivity at 10 Gbps	6	1	5.00	D	PU	30
D7.1	Workflow Manager requirements from telescope operators (OSO)	7	6	7.00	R	PU	4
D7.2	Workflow Manager requirements from correlator operators (JIVE)	7	1	7.00	R	PU	4
D7.3	Workflow Manager implementation (PSNC)	7	11	18.00	O	PU	18
D7.4	Demo of automated correlation (JIVE/OSO/PSNC/VENT)	7	1	39.00	D	PU	24
D7.5	Real-time middleware components (PSNC)	7	11	18.00	O	PU	24
D7.6	Demo of real-time correlation (JIVE/OSO/PSNC)	7	1	14.00	D	PU	34

Deliverable Number [61]	Deliverable Title	WP number [53]	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D7.7	Demo of global correlation (JIVE/OSO/ PSNC/CSIRO)	7	1	14.00	D	PU	36
D8.1	Interface design document of storage element API (AALTO)	8	13	5.90	R	PU	6
D8.2	Hardware design document for simultaneous I/O storage elements (AALTO)	8	13	6.00	R	PU	8
D8.3	Design document of storage element allocation methods (INAF)	8	3	11.80	R	PU	10
D8.4	Design document of transparent local/remote application programming interface for storage elements (	8	13	15.30	R	PU	15
D8.5	Performance and integration test report of simultaneous I/O storage elements (OSO)	8	6	20.00	R	PU	21
D8.6	Test report of storage element allocation methods (INAF)	8	3	17.00	R	PU	22
D8.7	Test report of transparent local/remote application programming interface for storage elements (UMAN	8	5	20.00	R	PU	22
D8.8	Design document of	8	1	13.50	R	PU	26

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
	integration system of allocation methods with transparent multi-Gbps access (JIVE						
D8.9	Integration test report of LTA and pipeline integration (ASTRON)	8	2	21.30	R	PU	32
D8.10	Demonstration tests of the integrated system (JIVE)	8	1	29.00	D	PU	32
D8.11	Final report on Networked Storage on Demand (AALTO)	8	13	3.30	R	PU	35
			Total	604.70			

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per Work Package

Work package number [53]	WP1	Type of activity [54]	MGT
Work package title	Management		
Start month	1		
End month	36		
Lead beneficiary number [55]	1		

Objectives

WP1, Management of the Consortium, focuses on the management of the project at all levels. The primary purpose of this activity is to ensure that the project as a whole is fulfilling its expectations and requirements both internally and externally. The activity will be responsible for managing communications to and between the Commission, the project's Consortium Board (hereafter the Board), and the activity leaders. It will monitor the finances and the progress on deliverables. When necessary it will prepare changes to the overall project plan or spending profile. Most importantly, period reports and associated deliverables will be coordinated and delivered by the Project Office.

The design of the management activities is based on the experiences of the successful EXPReS project. EXPReS, completed in autumn 2009, showed that the e-VLBI community is able to execute a large project across multiple communities and geographical locations. Not only will NEXPReS benefit directly from the lessons learned during EXPReS, but also the continuity of the management group itself will ensure the best possible use of those experiences.

JIVE will host the NEXPReS Project Office. Huib Jan van Langevelde, Director of JIVE, will be the Project Coordinator and act as the project's official representative to the European Commission. Van Langevelde, aided by the NEXPReS Board, will provide high-level guidance to the project. The Project Coordinator will be assisted by a Programme Manager and a Project Assistant (0.5 FTE). These two positions will also be located at the Project Office. The Programme Manager will be responsible for the day-to-day management of the project.

The Management Team will consist of the Project Coordinator, the Programme Manager (representing all of the networking activities), and the four leaders of the service and joint research activities. The Management Team will be responsible for carrying out the project responsibilities as outlined in the contract and as issued by the Project Coordinator and the Board.

Description of work and role of partners

WP1's activities will focus around the formation of the project and reporting the project's activities to the Commission. To that end, work will cluster at the beginning of the project and at each of the period reviews. JIVE is the only partner in WP1; all work will be conducted by the Project Office.

Task 1: Project Formation. Finalize contractual documents, distribute financial sheets, establish Board lists.

Task 2: Review 1. Collect data to create period report (text), Collect data to create period report (financial), submit to Commission, in-person review.

Task 3: Review 2. Collect data to create period report (text), Collect data to create period report (financial), submit to Commission, in-person review.

Task 4: Review 3. Collect data to create period report (text), Collect data to create period report (financial), submit to Commission, in-person review.

Task 5: Board and Project Meetings (in conjunction with WP4). Identify location of meeting, begin logistic process, announce meeting, form agenda, produce meeting summary.

Task 6: Ongoing communication within the project of management issues

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JIVE	48.00
	Total	48.00

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D1.1	Appoint Programme Manager	1	1.00	O	PU	1
D1.2	Appoint Project Assistant	1	1.00	O	PU	1
D1.3	Form Board	1	1.00	O	PU	1
D1.4	Create Project contact lists	1	1.00	O	PU	1
D1.5	Conclude Consortium Agreement	1	1.00	R	PU	1
D1.6	Form Management Team	1	1.00	O	PU	1
D1.7	Convene Advisory Board	1	2.00	O	PU	3
D1.8	Convene Management Team	1	1.00	O	PU	3
D1.9	Period 1 Report to EC	1	13.00	R	PP	12
D1.10	Period 2 Report to EC	1	13.00	R	PP	24
D1.11	Period 3 Report to EC	1	13.00	R	PP	36
		Total	48.00			

Description of deliverables

D1.1) Appoint Programme Manager: Appoint Programme Manager [month 1]

D1.2) Appoint Project Assistant: Appoint Project Assistant [month 1]

D1.3) Form Board: Form Board [month 1]

D1.4) Create Project contact lists: Create Project contact lists [month 1]

D1.5) Conclude Consortium Agreement: Conclude Consortium Agreement [month 1]

D1.6) Form Management Team: Form Management Team [month 1]

D1.7) Convene Advisory Board: Convene Advisory Board [month 3]

D1.8) Convene Management Team: Convene Management Team [month 3]

D1.9) Period 1 Report to EC: Period 1 Report to EC [month 12]

D1.10) Period 2 Report to EC: Period 2 Report to EC [month 24]

D1.11) Period 3 Report to EC: Period 3 Report to EC [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS101	Prepare Period 1 Report to EC	1	13	
MS102	Prepare Period 2 Report to EC	1	25	
MS103	Prepare Period 3 Report to EC	1	36	

WT3:
Work package description

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per Work Package

Work package number [53]	WP2	Type of activity [54]	COORD
Work package title	EVN-NREN		
Start month	1		
End month	36		
Lead beneficiary number [55]	12		

Objectives

NEXPReS deals with e-VLBI and e-LOFAR, and is therefore inherently a project that utilizes the shared network infrastructure deployed between the project partners, across Europe and around the world. Furthermore, NEXPReS participants represent an expanding class of users who push the network infrastructure to the limits in terms of capacity and responsiveness. For this reason, it is important to support a dedicated forum in which network providers and network users can meet to discuss current activities and future plans. We believe it is natural for DANTE, the European backbone network provider, to lead this effort, because of its close ties with the radio astronomical community and its involvement with many international network-intensive projects.

The EVN-NREN forum brings together experts from the radio astronomy community (beyond the EVN) and the NRENs. Most of the NEXPReS telescopes are EVN members that have committed telescope time to the common observing programme. Observations are scheduled in cooperation with the individual telescopes that have commitments independent of the EVN. The business of the EVN is conducted through their Consortium Board of Directors and includes such activities as overall policy and scheduling. For its future operations the International LOFAR Telescope is implementing a similar structure and many of the telescope sites are involved in LOFAR as well. NRENs are the national research and education networks, a general term to describe network providers, generally operating in a single country, whose focus is on providing network connectivity to academic institutes as well as researching networking technology itself.

The EVN-NREN Forum will bring together experts from their respective communities to talk about NEXPReS and the network. The EVN-NREN Forum will hold face-to-face meetings to encourage discussions, while a mailing list will be used to support discussions outside of the meetings. As needed, the EVN-NREN Activity Leader will facilitate discussions, identify potential problems to be presented to the Forum members and support the submission of evolving objectives to other project activities or the Board as necessary.

In the forum recent developments that are relevant for the NEXPReS programme can be discussed. It can serve as a platform for experts to evaluate the work in other activities, such as WP6 on Bandwidth on Demand. The EVN-NREN Forum will also provide an opportunity to identify geographic regions that are of interest to radio astronomy but remain under-connected in terms of network. This discussion will require both rationalization of needs as well as coordinated future planning. In the near term regions of interest will include Sicily, Portugal, Russia and Africa.

In order to encourage communication, the face-to-face EVN-NREN meetings will be co-located with other meetings. Furthermore, an effort will be made to hold the meetings at both astronomy and networking events.

Setting up and using such communication channels may seem straightforward, but this is only because of the momentum generated during previous projects. Over the past years astronomers and network representatives have established a direct method of communicating, and it is critically important to keep it alive and functioning.

Description of work and role of partners

All members of NEXPReS will participate in WP2.

Task 1: EVN-NREN Meeting 1. Site selection, organization, programme development, advertisement, logistics, summary report. Initial plan for first meeting is to be held early in first period to highlight current users and technology developers of dynamic light paths.

Task 2: EVN-NREN Meeting 2: Meeting co-located with mid-term meeting, program, logistics, summary report.

Task 4: EVN-NREN Meeting 3. Site selection, organization, programme development, advertisement, logistics, summary report. Initial plan is to hold final meeting close to the end of the project to assess progress in the field and determine what additional work is required for e-VLBI to effectively use the networks both in the short and long-term future.

Task 4: Produce a presentation on the status of networking in relation to Radio Astronomy locations of interest. Focus on those who are quite close to operational participation and those who are significantly unprepared.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JIVE	3.00
12	DANTE	3.00
	Total	6.00

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D2.1	EVN-NREN meeting 1	12	1.00	O	PU	9
D2.2	EVN-NREN meeting 2	12	1.00	O	PU	22
D2.3	EVN-NREN meeting 3	12	1.00	O	PU	32
D2.4	Presentation on regions of increasing interest to Radio Astronomy and Networking	12	3.00	R	PU	19
		Total	6.00			

Description of deliverables

D2.1) EVN-NREN meeting 1: EVN-NREN meeting 1 [month 9]

D2.2) EVN-NREN meeting 2: EVN-NREN meeting 2 [month 22]

D2.3) EVN-NREN meeting 3: EVN-NREN meeting 3 [month 32]

D2.4) Presentation on regions of increasing interest to Radio Astronomy and Networking: Presentation on regions of increasing interest to Radio Astronomy and Networking [month 19]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS202	Select location for EVN-NREN meeting 2	12	19	
MS203	Select location for EVN-NREN meeting 3	12	29	
MS201	Select location for EVN-NREN meeting 1	12	6	

WT3:
Work package description

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per Work Package

Work package number [53]	WP3	Type of activity [54]	COORD
Work package title	eVSAG		
Start month	1		
End month	36		
Lead beneficiary number [55]	8		

Objectives

The e-VLBI Science Advisory Group, eVSAG, coordinates the discussions linking the science and technology of e-VLBI with possible operational and policy impacts. This will be done by encouraging communications through existing channels and regular meetings. In the EVN all operational and policy changes are to be enforced by the Consortium Board of Directors, taking advice from an operations group and a scientific programme committee. By having member overlap with these groups the eVSAG will be able to prepare the policy and operational changes that the new observational capabilities demand.

Recent and rapid improvements in technology have created gaps between the organizational processes of VLBI and technical capabilities. For example, e-VLBI observations are currently scheduled weeks in advance for 24 hour periods while, in principle, the advances made would allow the telescopes to participate at any moment via adaptive and flexible schedules. The eVSAG will continue discussions initiated during the EXPReS project, addressing topics like the adaptive global scheduling of e-VLBI. Rreal-time VLBI operations also require a different scheme for manning telescopes and correlator, which call for a discussion of the operational model; it may be more optimal, also for the astronomers, to have more frequent observing runs rather than the long dedicated sessions.

NEXPReS will bring some fairly significant operational changes to the EVN. One of the tasks of the eVSAG will be to explain the activities of NEXPReS and its implications for the community at large. Some of these discussions will also be relevant for e-LOFAR operations, also represented in the forum. It can be expected that many of these topics will have implications for the operational model of the SKA.

Efforts will be made for eVSAG meetings to be held concurrently with larger meetings. Symbiotic meetings can help to ensure a critical mass, which is important for establishing common ground. Discussions will continue over mailing lists and via existing e-VLBI and VLBI community resources. As was the case in EXPReS, the eVSAG will also organize an end-of-project science and technology meeting.

eVSAG will be led by Dr. Francisco Colomer of FG. Colomer is well suited for this activity based on his previous experience in leading network connectivity efforts and hosting the end-of-project science and technology meeting for EXPReS.

Description of work and role of partners

Task 1: Establish mailing list, announce work package.

Task 2: Meeting 1 prep: identify symbiotic meeting, coordinate participation, create program, summarize meeting (in conjunction with WP4).

Task 3: End of Project Science/Technology meeting: site selection, organization, programme development, advertisement, logistics, and summary report (in conjunction with WP4).

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JIVE	3.00
8	FG-IGN	3.00
	Total	6.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D3.1	eVSAG meeting 1	8	3.00	O	PU	16
D3.2	eVSAG meeting 2	8	3.00	O	PU	32
		Total	6.00			

Description of deliverables

D3.1) eVSAG meeting 1: eVSAG meeting 1 [month 16]

D3.2) eVSAG meeting 2: eVSAG meeting 2 [month 32]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS301	Select location for eVSAG meeting 1	8	13	
MS302	Select location for eVSAG meeting 2	8	29	

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per Work Package

Work package number [53]	WP4	Type of activity [54]	COORD
Work package title	Communication		
Start month	1		
End month	36		
Lead beneficiary number [55]	1		

Objectives

The Communication activity will act via the Outreach Officer based at JIVE to support the internal and external communication needs of the project. These needs will include items such as dissemination of project results, interaction with the scientific press, coordination with astronomy organizations and outreach to non-scientists. The activity will provide materials to the other Work Packages to help streamline the effort required to host meetings.

An important objective will be the creation of outreach materials. A website will be maintained and contain sections for both public and private materials. It may host user-generated content and work in conjunction with other web-based services in order to facilitate communication. A project display board will be created and made available to all project members to provide a backdrop for public events. These items will be created in concert with additional physical and electronic PR-materials to help advertise and showcase the project's activities.

This Communications activity is an absolutely essential component of the proposed programme. Without this activity the return of the programme to the ICT community and the public at large will be minimal. With a specific mission to provide an observational facility for astronomers, the EVN and JIVE lack resources to provide any external communications beyond communication to the astronomy users. To this end, this activity will work with other activities, specifically, WP2 (EVN-NREN) and WP3 (eVSAG), to ensure multi-disciplinary participation. This activity will also work closely with the in-place radio-astronomy community (most commonly JIVE and EVN) to ensure that outreach and dissemination can be leveraged.

The project will plan activities adequately resourced devoted to dissemination for specialised constituencies and general public, in particular for awareness and educational purposes. The dissemination plan deliverable has to consider adequate messages about the objectives of the project and its societal and economic impact. The tools to be used should include web-based communication, press releases, brochures, booklets, multimedia material, etc. The 'dissemination material' should be regularly updated to provide the latest version of the project status and objectives. Electronic and/or paper versions of this 'dissemination material' will be made available to the Project Officer beforehand for consultation and upon its final release.

The project will actively participate in the concertation activities and meetings related with the e-Infrastructures area. The objective is to optimise synergies between projects by providing input and receiving feedback from working groups addressing activities of common interest (e.g. from clusters and projects). Projects may offer advice and guidance and receiving information relating to 7th Framework programme implementation, standardisation, policy and regulatory, EU Member States initiatives or relevant international initiative.

All dissemination materials will acknowledge the EC’s role in sponsoring the project by explicit statements of the Commission and the project number. Where appropriate to the material presented, the logos of the European Union, the EC/e-Infrastructures, FP7 and related will be shown.

Description of work and role of partners

All work in WP4 will be organized by JIVE with the majority being executed by JIVE. In some cases, partners will be asked to assist on specific tasks (e.g., localization) or LOC related activities.

Task 1: Prepare online resources for project: web page (DNS entry in the .eu domain), project wiki, email lists, etc.

Task 2: Print Products and Materials: create logo, identify visual themes for first project brochure, select printer, determine which partners will receive materials, proof and print. Execute this twice, once early in the project, once during the second half of the project.

Task 3: Project display: design, share, proof and print the large display stand.

Task 4: Meeting communications: help advertise meetings (print and online efforts) as meetings are identified.

Task 5: General communication to public: opportunistically contact and spread the word of NEXPReS activities via all available channels (e.g., project "Fact Sheet" for use by the EC, press releases)

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JIVE	21.60
	Total	21.60

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D4.1	Appoint Communications Manager	1	1.00	O	PU	1
D4.2	Online Resources	1	4.60	O	PU	1
D4.3	Meeting Support	1	6.00	O	PU	36
D4.4	Display	1	3.00	O	PU	3
D4.5	Visual Guide/Elements	1	1.00	O	PU	6
D4.6	Publish Print Items	1	3.00	O	PU	9
D4.7	Publish Print Items	1	2.00	O	PU	23
D4.8	Project "Fact Sheet" (1, JIVE)	1	1.00	R	PU	1
		Total	21.60			

Description of deliverables

D4.1) Appoint Communications Manager: Appoint Communications Manager [month 1]

D4.2) Online Resources: Online Resources [month 1]

D4.3) Meeting Support: Meeting Support [month 36]

D4.4) Display: Display [month 3]

D4.5) Visual Guide/Elements: Visual Guide/Elements [month 6]

D4.6) Publish Print Items: Publish Print Items [month 9]

D4.7) Publish Print Items: Publish Print Items [month 23]

D4.8) Project "Fact Sheet" (1, JIVE): Project "Fact Sheet" (1, JIVE) [month 1]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS401	Design Display	1	1	
MS402	Design Visual Guide/Elements	1	3	
MS403	Design Print Items	1	6	
MS404	Design Print Items	1	20	

WT3:
Work package description

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per Work Package

Work package number [53]	WP5	Type of activity [54]	OTHER
Work package title	Cloud Correlation		
Start month	1		
End month	36		
Lead beneficiary number [55]	1		

Objectives

Through the EC-funded EXPReS project e-VLBI with the EVN has evolved from a labour-intensive, demonstration-type research effort into a world spanning production facility, connecting telescopes from widely different arrays on all continents in real-time to the central correlator. With a reliability surpassing traditional recorded VLBI, and in the last years, competitive sensitivity and resolution, the progress of e-VLBI has led to a wealth of scientific papers. This was due not in the last place to the new and powerful rapid response capability of the e-EVN.

Currently, ten to twelve 24-hour e-VLBI sessions are scheduled throughout the year, augmented with ad-hoc or triggered Target-of-Opportunity observations, as the need dictates. This schedule has worked very well during the past years, and, especially in the case of the core EVN stations, observing sessions have become routine and perfectly reliable.

In spite of this, the full potential of e-VLBI still has to be achieved, with the bulk of VLBI observations still conducted through the recording and shipping of magnetic media. A number of technological, logistical and organizational obstacles prevent the full deployment of e-VLBI; the principal aim of this Service Activity will be to remove these obstacles.

This Service Activity will deal with transforming the complete VLBI observational chain, from scheduling, setting up and actual observing to buffering, streaming and real-time/delayed correlation. It aims to remove the current strict distinction between disk-based and electronic VLBI, to create a system in which all observations benefit from having a real-time component, while retaining the option to re-correlate the data at a later time with more telescopes and/or different correlation parameters. This system should be completely transparent to the user, and provide the flexibility to modify observational parameters on the fly based on the real-time results. In this way the reliability, robustness and flexibility provide by e-VLBI will become available for VLBI as a whole, and greatly enhance the scientific capability of the EVN.

4 Gbps recording/transmitting will be an essential component of WP5, in order to take advantage of the higher observing bandwidths that will become available to the EVN within the next few years, and prepare the EVN for the even higher operational data rates that will follow. This will involve combining the data from 4- and 1-Gbps capable telescopes, both through recording and through the real-time correlation of selected sub-bands. Here too, flexibility, in recording mode, playback and recording/transmitting modes, and the choice of correlator platform will be essential to realize the scientific potential of the future EVN.

WP5 will coincide with an ongoing project, funded through a variety of EVN-internal and external sources, which aims at developing a next-generation EVN correlator, capable of handling data streams from tens of stations at tens of Gbps, per station. Consequently we expect a strong interaction between the development of a new correlator control system and this activity.

In order to measure the success of this work package in a quantitative and qualitative manner, a set of indicators will be defined by month 4, to be used as a metric throughout the project. These indicators will address scalability, ease of use, openness, interoperability and robustness of the delivered services. Part of this deliverable will explore commercial solutions and hardware selection criteria. It will also take into account user feedback and its integration into the service during its deployment.

Description of work and role of partners

Task 1: Flexible buffering (JIVE, AALTO)

This task will implement the configuration and use of buffering at the stations and at the correlator.

Buffering at stations:

At the stations the function of buffering will be to safeguard against loss of data in case of network failures, and to enable delayed transfer in the case of low connectivity. To start, for all Target of Opportunity and scheduled e-VLBI observations, a mixed e-VLBI/recorded-VLBI mode will be provided, that will allow astronomers to complement their e-VLBI runs at a later time by including stations with lower connectivity at the full bandwidth. This can be done with existing hardware, but will need software modifications in various control systems.

The next step will be an expansion of recording capability, by means of the deployment of digital Base Band Converters (dBBCs) and possibly 4-Gbps capable Mark5C systems. Here too, control systems and scheduling mechanisms will have to be modified and developed. Towards the end of the project, storage at the stations will be entirely taken over by high-speed simultaneous read/write buffering systems.

Buffering at correlator:

At the correlator data will be buffered in order to allow re-correlation at a later time with stations that have insufficient connectivity to participate in real-time observations, or with different correlation parameters. As real-time correlation with simultaneous recording at the correlator is only possible using Mark5B units (that is, until the advent of a permanent high-capacity storage system, as investigated in WP8), we will seek an EVN-wide agreement on the upgrade from Mark5A to B (or C) at all stations, before the end of the first year of the project. This upgrade has been on hold for some time, but as the dBBCs are now actually in production, we expect it to speed up considerably. Changes in scheduling and control software will be needed to implement this mode of operation. Extra playback units will be needed to accommodate delayed playback, possibly into a software correlator, and simultaneous real-time operations.

At a later stage, higher data rates will have to be accommodated from a limited number of stations (possibly 5 stations at 4 Gbps in year 2 of the project, up to 10 stations in year 3). These high data rates will have to be recorded, while lower-bandwidth sub-bands will be split from the main data stream and correlated in real-time.

The correlation of the full data stream, on a software correlator or next-generation hardware correlator, will take place as soon after the observations as possible; this means that the extra playback units mentioned previously will have to be capable of handling 4 Gbps data streams. Modifications of the control code will be needed, as well as extra scheduling tools, and an expansion of the routing facilities of the local network at JIVE. Towards the end of the project, high-speed recording/playback buffers will be installed, which will make it possible to record at 4 Gbps (and higher) while simultaneously correlating the full 4 Gbps, possibly sped down to fit the capacity of the correlator.

Task 2: Implementation of VDIF standard (JIVE)

VLBI knows a bewildering multitude of data acquisition systems and formats. Through the EXPReS project, large advances were made in interfacing these systems in real-time. Eventually this led to the worldwide acceptance of a common data format tailored for real-time operations, called the VLBI Data Interchange Format (VDIF). Work is currently ongoing to define a common data transmission protocol, tentatively called the VLBI Transport Protocol (VTP).

This task will deal with implementing these new standards in all EVN operations, so that the network will be able to seamlessly cooperate with any other VLBI network. For the current EVN MarkIV hardware correlator, this means that conversion software will have to be installed on the Mark5 units feeding data into it. In order to assure that the EVN stations produce VDIF data and thus become compatible with VDIF-enabled correlators, translation software will have to be developed for the Mark5A and B currently in use. Once the EVN switches to dBBCs this problem will cease to exist, as the dBBC is VDIF-compliant. As different hardware will be capable of producing incompatible data (in spite of being able to decode the standardized data header, the hardware may be unable to actually accept the data in that specific format) a corner-turning platform will be developed, either standalone or integrated in the playback/recording hardware.

Task 3: Continuous quality monitoring & Station Remote Control (TUM, MPG, JIVE) e-VLBI operations (as compared to traditional VLBI) have the big advantage that failures can be identified in near real-time. However, the diagnostics that can be performed by the correlator centre are currently limited to checks using the received station data (e.g. through fringe checks or log file monitoring). There is no direct access to the field system control parameters (e.g. source coordinates etc.) at the moment.

In some cases, the correlator staff cannot directly address the causes of failure, and station personnel have to be notified, which is not always possible. To deal in a more efficient way with such situations, we intend to extend the capabilities of the field system remote control prototype developed within the EXPReS project to allow monitoring and remote control of the station field systems (FS) for e-VLBI operations.

Station monitoring & remote control

An RPC-based client/server solution will be developed for station monitoring and remote control by the correlator. As a first step, the remote control prototype will be turned into an operational system. This system will then be integrated into the regular FS distribution. Client monitoring and remote control software for the correlator will be developed, and finally a remote control server interface will be designed and implemented.

Further extensions will be made to the existing station-log file monitoring tools, and the feedback of these data into correlator operations and into publicly accessible web pages. Fringe checks will be performed in an automated, near-continuous manner, with appropriate feedback and warning mechanisms. Likewise, network monitoring will become an integral part of e-VLBI operations. This last item will have considerable overlap with the work done in WP 6.

Authentication & authorization

An authentication & authorization layer will be implemented that allow the stations to control access to their local resources. The authorization scheme should:

- Grant rights to individuals and/or roles

- Grant rights for certain periods of time only (e.g. only for e-VLBI sessions)

- Configure access rights on a finely grained level (e.g. allow monitoring only, or allow/deny changing source coordinates etc.)

Task 4: Automated network-dependent correlation (JIVE)

This task will concentrate on operational matters. When a job is started, the control system will have to be able to determine what stations can support what data rate in real time, and schedule remote and local buffering, observing modes and real-time correlation. This involves interfacing with monitoring tools and folding currently independent scheduling tools into the main control code. As we move from occasional e-VLBI sessions to all-e operations, evenly spread throughout the year, automated procedures will become more and more important. This will progress through remote operations to fully unattended correlation, and will involve tuning and optimizing current and future control systems, with reliable feedback mechanisms to alert operators in case of emergencies. The large number of different observing modes enabled by NEXPReS will also necessitate a system to automate delayed correlation, by scheduling and executing a correlation job the moment all data has arrived, be it electronically or via disk packs. Finally, data reduction pipelines will have to be streamlined and further automated in order to allow the end users to interactively make timely decisions on the need for additional data from poorly connected outstations, the need to redo the correlation or possibly reschedule an entire observation.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JIVE	87.00
4	MPG	9.00
13	AALTO	9.00
14	TUM	15.00

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
	Total	120.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D5.1	Mixed e-VLBI/recorded-VLBI at stations	1	3.00	R	PU	3
D5.2	Metrics, selection criteria and user feedback	1	4.00	O	PU	4
D5.3	Definition of specifications monitoring and remote control	14	3.00	R	PU	4
D5.4	Automated job scheduling	1	8.00	R	PU	9
D5.5	VDIF Mark5 conversion software	1	11.00	O	PU	15
D5.6	Control systems and scheduling mechanisms for 4-Gbps recording equipment	1	8.00	O	PU	18
D5.7	Unattended correlation	1	11.00	R	PU	19
D5.8	Monitoring, remote control and client software including the authorization and authentication layer	14	21.00	O	PU	22
D5.9	Control systems and scheduling mechanisms for 4-Gbps at correlator	1	11.00	O	PU	23
D5.10	Corner-turning platform	1	8.00	O	PU	24
D5.11	FS-integrated remote control system	14	2.00	O	PU	28
D5.12	Automated delayed correlation	1	12.00	O	PU	29
D5.13	Real-time correlation with simultaneous recording at the correlator	1	6.00	O	PU	30
D5.14	Report on tests with Wettzell & Effelsberg stations	14	2.00	R	PU	36
D5.15	Streamlined data reduction pipelines & user access	1	10.00	O	PU	36
		Total	120.00			

Description of deliverables

D5.1) Mixed e-VLBI/recorded-VLBI at stations: Mixed e-VLBI/recorded-VLBI at stations [month 3]

D5.2) Metrics, selection criteria and user feedback: Metrics, selection criteria and user feedback [month 4]

D5.3) Definition of specifications monitoring and remote control: Definition of specifications monitoring and remote control [month 4]

D5.4) Automated job scheduling: Automated job scheduling [month 9]

D5.5) VDIF Mark5 conversion software: VDIF Mark5 conversion software [month 15]

D5.6) Control systems and scheduling mechanisms for 4-Gbps recording equipment: Control systems and scheduling mechanisms for 4-Gbps recording equipment [month 18]

D5.7) Unattended correlation: Unattended correlation [month 19]

D5.8) Monitoring, remote control and client software including the authorization and authentication layer: Monitoring, remote control and client software including the authorization and authentication layer [month 22]

D5.9) Control systems and scheduling mechanisms for 4-Gbps at correlator: Control systems and scheduling mechanisms for 4-Gbps at correlator [month 23]

D5.10) Corner-turning platform: Corner-turning platform [month 24]

D5.11) FS-integrated remote control system: FS-integrated remote control system [month 28]

D5.12) Automated delayed correlation: Automated delayed correlation [month 29]

D5.13) Real-time correlation with simultaneous recording at the correlator: Real-time correlation with simultaneous recording at the correlator [month 30]

D5.14) Report on tests with Wettzell & Effelsberg stations: Report on tests with Wettzell & Effelsberg stations [month 36]

D5.15) Streamlined data reduction pipelines & user access: Streamlined data reduction pipelines & user access [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS501	Definition of specifications monitoring and remote control	1	4	
MS502	Automated job scheduling	1	9	
MS503	Unattended correlation	1	19	
MS504	Control systems and scheduling mechanisms for 4-Gbps at correlator	1	23	

WT3:
Work package description

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per Work Package

Work package number [53]	WP6	Type of activity [54]	OTHER
Work package title	High Bandwidth on Demand		
Start month	1		
End month	36		
Lead beneficiary number [55]	1		

Objectives

e-VLBI observations require very high bandwidths on stable, dedicated connections, both to deliver sufficient throughput and quality and in order to not adversely affect other network users. But radio telescopes do not observe in VLBI mode 24/7. The EVN telescopes for example only dedicate part of their time to VLBI, each being an independent instrument with its own observation program. A particular source may not be visible at the same time to all participating telescopes in a global observation. Moreover, the data generated by these telescopes can be processed in several correlator facilities or nodes around the globe. As a consequence, static, dedicated connections as are currently used for e-VLBI are not the most efficient way to make use of the networking resources. A more dynamic way of allocating the necessary bandwidth between participants in an observation could greatly enhance the flexibility and efficiency of e-VLBI. Within Europe some research networks are currently sufficiently over-provisioned to support a few e-VLBI streams, but the combined traffic flow from the participating telescopes into a correlator does exceed the available production bandwidth, and dedicated, on-demand paths will become even more of a necessity with the higher output rates of the future.

New instruments such as LOFAR and Apertif, which are being developed in consortia led by ASTRON, will generate Petabytes of data per year, to be stored in a Long Term Archive (LTA). The LTA is distributed over several European data centres (LTA sites). Data transport will typically occur in bursts of 1 to 100 TB, and there will be occasional data transfer between LTA sites. An average bandwidth of over 5 Gbps into the LTA is required to allow continuous observation, in addition to recovering from backlogs. The LTA use pattern requires periods of guaranteed high bandwidth interleaved with relatively long periods without data transfer on any given connection. This network usage pattern can be planned in advance to a large extent. Astronomers will access the data in the LTA in an ad hoc pattern, transferring data from LTA sites to computing centres or research institutes for analysis. Network load from this will be more unpredictable. Both sending data to and processing data from the LTAs will benefit from being able to use dynamically switched 10 GE (or better) connections.

Both e-VLBI and the new LOFAR and Apertif instruments are precursors to the SKA project. Learning how to handle the enormous data flows generated by these new instruments in an efficient way will be of great benefit and will help to maintain the European lead in this important area of astronomy.

Several NRENs already provide dynamic allocation of circuits, based on either lightpaths or Ethernet VLANS with QoS. SURFnet offers dynamic lightpaths using the DRAC technology, and Internet2 uses DCN. Typically these systems allow users through a web service to request, or reserve in advance, a dedicated circuit. SURFnet is executing the Gigaport3 project, which will greatly enhance the hybrid networking capabilities available within the Netherlands, and is an indispensable partner in this proposal. The DRAC system is being made available as open-source by NORTEL. Using DRAC, SURFnet will allow applications such as e-VLBI to directly request network resources. The global nature of e-VLBI and the new generation telescope archives require connections that cross borders and hence involve multiple NRENs or network administrations. Several projects dealing with so-called cross-domain allocation of circuits exist. The GÉANT2 research activity “AutoBAHN” has developed infrastructure to allocate connections from NREN to NREN via the GÉANT2 backbone. This work will be continued in GÉANT3, and in partnership with the NRENs, Bandwidth-on-Demand (BoD) will be offered as a service. Other efforts are also underway to interconnect different systems; within the Open Grid Forum (OGF) work done by the GLIF collaboration, AutoBAHN, DCN and DRAC are being made to inter-operate using internationally developed protocols. One of the tasks of this WP will be to take this emerging technology, which still in many ways is experimental, one step further and fully integrate BoD in e-VLBI and LTA operations. Our goal is to leverage these emerging protocols and standards and build e-VLBI as a client application of these systems. We will need to design an architecture that is able to inter-operate with several of these systems, as the installed base of these platforms amongst the enviosoned networking paths will dictate which standards we need to be able to interface with. Other important criteria for selection of these systems and overall design will be scalability (ability to handle the multi-Gb/s flows required for e-VLBI), robustness (both in terms of availability, and possibly the ability to self-heal by configuring alternative routing) and openness. As one of the first large-scale inter-domain BoD users, we will be in a unique position to compare the quality of the different BoD systems and contrast it to our current static networking setup. This feedback will be used to both improve the results of the NEXPReS network, and shared with our networking partners. It is furthermore important to ensure that the complexity of setting up international BoD does not affect the reliability of e-VLBI, and another task within this work package will be to develop automated testing and validation of the requested paths.

To enable new science with the EVN, higher sensitivity is needed, which equates to higher bandwidths from the telescopes to JIVE. Currently the bandwidth for e-VLBI is limited to 1024 Mbps due to the MkIV formatters in use at the telescopes and the MkIV EVN correlator. The 1 Gbps lightpaths in use at this time are already a bottleneck, and in several cases the connectivity from telescope to JIVE already exceeds 1 Gbps to support operations at the highest throughput that is currently available. The new on-demand paths should initially support at least 1024 Mbps operations. In the near future, we expect the data rate of the participating telescopes to increase substantially when new digital back-ends (dBBCs) and recording equipment (Mark5C) are adopted. We expect that several participating telescopes will be able to produce data at more than 4 Gbps during this project. Projects that are aimed at the development of a next generation correlator will make it feasible to observe at data rates of 10 Gbps and beyond, and will also provide the necessary correlator capacity to match.

Description of work and role of partners

Task 1: Integration of e-VLBI with Bandwidth-on-Demand (JIVE, SURFnet, NORDUnet, OSO, CSIRO)

A prerequisite for using BoD will be to perform the necessary network configuration changes to make BoD available at the telescopes, JIVE, and possibly correlation nodes (c.f. WP7). SURFnet and NORDUnet will start to provide the first on-demand paths to OSO, CSIRO (by way of AARnet) will be arranging the long-distance paths both to and from the Australian telescopes and correlator facilities. JIVE, in close collaboration with SURFnet, NORDUnet and the GN3 Project, will develop a user interface for BoD that interfaces with the various BoD systems currently in use. It will be tailored towards use by astronomers and VLBI operators, enabling them to reserve network resources at the same time as observation time at the telescopes is reserved. Such reservations can be made months in advance, but also within hours of the observation when scientifically interesting events warrant a target-of-opportunity VLBI observation.

Milestone 601 will announce the "Overall BoD system architechture" which describes the BoD application in terms of requirements, functionality and evaluation criteria. This will include the selection of the underlying BoD systems based on scalability, reach (participating NRENs and paths to radio telescopes), openness (public specification and standard track), interoperation with other BoD systems and expected robustness. Milestone 602 will mark the evaluation of the e-VLBI and LTA application under development, based on the collected quality metrics and user feedback.

Task 2: On-demand access for large archives (ASTRON, SURFnet)

The Long-Term-Archives are the logical outcome of a new breed of interferometric instruments that can image large areas of the sky at once. The ability to re-examine the recorded data will allow a more efficient use, and therefore increase the scientific output of these instruments. Access to and from the LTAs can be best provided by high capacity (10 Gbps or more) on-demand paths. SURFnet and ASTRON will initially implement this within the Netherlands. The BoD-scheduler software will need to have an interface to the astronomical observation scheduler so that timely transferring of data to the archive is ensured, freeing storage capacity for new observations. LTAs for these projects will be distributed throughout Europe, and will require international on-demand connectivity as well. Collaboration with projects such as AutoBahn will be sought to make these connections possible.

Task 3: Testing and validation of on-demand circuits (UMAN, JIVE)

Once a dynamic path has been requested, it needs to be tested automatically to ensure proper performance in advance of the observation. Such a test involves setting up the path in question, running synthetic traffic through it that matches the real use as close as possible, and then releasing the networking resources again until the scheduled observation. Testing the path at the moment of reservation will allow direct validation of the intended path. Another automated test, a few days before the scheduled observation, will allow ample time for NRENs to react in case new problems might have occurred. During the actual observation the system will monitor the data streams to detect any irregularities. The software for testing the paths will be developed by UMAN, and together with JIVE they will integrate this in the e-VLBI BoD control software.

Task 4: Multi Gbps on demand for e-VLBI (JIVE, SURFnet, NORDUnet, OSO)

JIVE, SURFnet, NORDUnet and possibly other NRENs will enhance the BoD system to support speeds of up to 4 Gbps, later 10 Gbps to keep up with the sensitivity increases at the EVN and other telescopes.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JIVE	48.00
2	ASTRON	18.00
5	UMAN	21.00
6	OSO	6.00
9	NORDUnet	15.00
10	SURFnet	6.00
12	DANTE	3.00
15	CSIRO	6.00
	Total	123.00

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D6.1	Proof-of-concept system for reserving and provisioning On-demand networking capacity	1	35.00	P	PU	20
D6.2	Operational use of BoD on at least one e-VLBI connection	1	17.00	R	PU	36
D6.3	Configuration of 10 Gbps BoD for the LOFAR archive network	1	16.00	R	PU	24
D6.4	BoD scheduling interface for LTA	1	8.00	R	PU	30
D6.5	Demonstration of BoD for an operational LTA	1	4.00	D	PU	33
D6.6	Demonstration of integrated BoD testing and validation	1	30.00	D	PU	30
D6.7	Demonstration of international BoD connectivity at 4 Gbps	1	8.00	D	PU	18
D6.8	Demonstration of international BoD connectivity at 10 Gbps	1	5.00	D	PU	30

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
		Total	123.00			

Description of deliverables

D6.1) Proof-of-concept system for reserving and provisioning On-demand networking capacity: Proof-of-concept system for reserving and provisioning On-demand networking capacity [month 20]

D6.2) Operational use of BoD on at least one e-VLBI connection: Operational use of BoD on at least one e-VLBI connection [month 36]

D6.3) Configuration of 10 Gbps BoD for the LOFAR archive network: Configuration of 10 Gbps BoD for the LOFAR archive network [month 24]

D6.4) BoD scheduling interface for LTA: BoD scheduling interface for LTA [month 30]

D6.5) Demonstration of BoD for an operational LTA: Demonstration of BoD for an operational LTA [month 33]

D6.6) Demonstration of integrated BoD testing and validation: Demonstration of integrated BoD testing and validation [month 30]

D6.7) Demonstration of international BoD connectivity at 4 Gbps: Demonstration of international BoD connectivity at 4 Gbps [month 18]

D6.8) Demonstration of international BoD connectivity at 10 Gbps: Demonstration of international BoD connectivity at 10 Gbps [month 30]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS604	Proof-of-concpt for reserving BoD	1	20	
MS605	10 Gbps BoD for LOFAR/LTA	1	24	
MS606	Demonstration of integrated BoD testing	1	30	
MS603	Demonstration of international 4 Gbps BoD	1	18	
MS601	Overall BoD system architecture	1	4	description of this milestone inline with Task 1 (space limitations here)
MS602	Evaluate BoD application architecture	1	10	description of this milestone inline with Task 1 (space limitations here)

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per Work Package

Work package number [53]	WP7	Type of activity [54]	RTD
Work package title	Computing in a Shared Infrastructure		
Start month	1		
End month	36		
Lead beneficiary number [55]	1		

Objectives

In the past years, large international efforts have gone into the development of the Grid. While Grid-computing clearly has great potential for batch-type processing, the real-time nature of e-VLBI has proven to be a real obstacle for an effective use of this infrastructure. Moreover, the complexity involved in obtaining sufficient resources across national and institutional boundaries, in combination with the lack of uniformity of these resources, makes the whole process particularly unsuited for e-VLBI. In the EXPReS JRA called FABRIC, an attempt has been made to distribute correlation over a Grid-like infrastructure. While the principle has been successfully demonstrated, a truly operational system is still unfeasible, for an important part because of restrictions imposed by the current Grid middleware.

While some (larger) telescopes within the EVN and the global VLBI network are heavily oversubscribed and therefore not regularly available to do VLBI, some of the (smaller) telescopes have more operational room for VLBI. This means that a subset of the telescopes could do VLBI on a regular basis to do surveys and astrometric monitoring programmes of, for example, galactic maser sources, and observations of transient sources. Since such a programme would involve only a small number of telescopes and would only need a moderate amount of bandwidth, it is very suitable for software correlation. This development may be important for some Space applications, which traditionally have used software correlators and may require extended long monitoring using a small number of telescopes.

While telescope time may be available for such observations, staff support is in short supply. So it is important to minimise the additional load on telescope operators. In order to achieve this, observations, data transport and correlation will need to be automated as much as possible. Another scarce resource is the VLBI disk pool. By correlating these observations in real-time we can make sure these observations don't put any additional pressure on this resource. This will also further reduce the load on telescope personnel by avoiding the logistics of disk shipment. A very high level of automation and an inherently distributed architecture may be attractive in the long run for application to the SKA, as it may be desirable to move the processing to the place where energy is cheap (and green).

In this research activity “Computing in a Shared Infrastructure”, the lessons learned in FABRIC will be put to use in order to create an automated, distributed correlator using the global, shared infrastructure of the EVN and its associated global partners. This will allow us to take advantage of the available telescope time to give scientists the chance to do the kind of observations illustrated above.

In order to facilitate this, a real-time infrastructure that integrates network and computing resources is needed. In this research activity we intend to develop some the necessary components of such an infrastructure. Many disciplines could benefit from "stream processing", where large data flows need to be analysed in real-time. Therefore we intend to develop components that are fairly generic, to ensure that this complement to standard Grid-computing will be applicable outside astronomy as well. We also intend to collaborate with the VLBI community outside Europe and integrate another popular software correlator (DiFX) within this framework.

For this work package, we want to take advantage of clusters "near" the e-VLBI network (a new cluster at JIVE, and existing clusters present at PSNC, OSO, VENT and Curtin University of Technology), as well as the network infrastructure that was built up during the EXPReS project.

This work package will foster existing collaborations in this area with the University of Amsterdam in the Netherlands and particularly Curtin University, Perth, Australia.

Description of work and role of partners

Task 1: Transparent distributed correlation (JIVE/OSO/PSNC/VENT)

For this task we will enhance the software correlator and Workflow Manager (WfM) developed in FABRIC to create a highly automated correlation facility for VLBI surveys and monitoring programmes, and leverage the Workflow Manager to minimize the impact on telescope and correlator operators. Initially we will do this by recording the data on disk packs and correlating the data directly from these disk packs without shipping them.

In order to achieve this we will:

- Formulate requirements for the workflow from both the telescope operators view and correlator operators view (OSO/JIVE).

- Design and implement multi-user support in the Workflow Manager (PSNC). We are planning to use the Workflow Manager as an interface and access point to the correlation platform. The WfM will allow different users to manage and control a distributed correlation process.

- The software will be used by different actors at the same time, i.e. telescope or correlator operators. The WfM will be equipped with an authorization mechanism.

- Separate views for different roles will be implemented in the Workflow Manager: for correlator operators and telescope operators.

- All the requirements gathered by OSO and JIVE will get incorporated into the Workflow Manager

- Implement feedback mechanisms in software correlator (JIVE): In order to be able to diagnose problems in an early stage some real-time feedback about the ongoing correlation will need to be provided. Minimally this includes:

- fringe plots

- progress monitor

- Integrate DiFX correlator with Workflow Manager and VLBI broker (PSNC/CSIRO)

- Development of generic monitoring perspective in Workflow Manager (PSNC). The Workflow Manager as a tool to manage the correlation platform and telescope operations during observations using the software correlation platform should be equipped with means to check the current status of the platform and its subcomponents. The Workflow Manager will be extended with the following functions:

- listing of all active and already executed VLBI experiments

- possibility to stop/delete VLBI experiments

- presentation of feedback from different correlation platform components

- notification mechanism to present events with the possible actions in case of failures. Implementation of defined behaviour which will be undertaken by default in order to minimize the interaction with telescope / correlator operators

- Deploy Workflow Manager and VLBI broker (JIVE/OSO/PSNC/VENT/CURT).

The Workflow Manager will be rolled out at the sites where telescope operators and correlator operators work. The VLBI broker will be rolled out at the compute clusters at the partner institutes and integrated with the job control systems installed at those clusters.

We will track the developments in WP6 (in particular task 3: “Continuous monitoring & Station Remote Control) and tap into the feedback mechanism provided whenever it makes sense to do so.

Task 2: VLBI survey/monitoring test observations (OSO)

The goal of this task is to use the automated correlation facility developed in task 1 and demonstrate that it can be used to achieve (some of the) science goals. When the results from task 3 become available, we will correlate the data in real-time. The telescope network operations envision a 'background project' of source astrometry/monitoring with 'interrupts' for observation of transients.

Tools for semi-automatic generation of telescope schedules for the background observations (given source lists, required monitoring intervals, Doppler shift spectral coverage and resolution, etc) are required and will be developed.

A mechanism is required at telescopes for executing scheduling interrupts based on detected transients and returning to the background schedule upon completion. An intelligent system for receiving automatic alerts on transients is required i.e. from satellite data or LOFAR, deciding whether e-VLBI observations are worthwhile (based on pre-set user supplied criteria), automatically generating the detailed telescope schedule, distributing to telescope and executing.

Communication of background and interrupt schedule to the software correlator so that source positions and correlation parameters (spectral coverage and resolution, data integration time, polarisation properties) can vary continuously as required for astronomical goals

To demonstrate the ICT tools developed we propose to run two five day long test observations using three or four antennas observing either in the 18cm wavelength band (observing OH masers) or 5cm (to allow observing methanol masers). These test observations will exercise all the required astronomical modes. The background project would take spectral line monitoring and spectral line astrometry observations of a large group of sources and also do continuum monitoring observations on a group of intra-day variable source. In addition, interrupt observations automatically generated from alerts from LOFAR or from elsewhere could be undertaken.

Task 3: Real-time stream processing on a shared computing infrastructure (PSNC/JIVE/VENT)

Correlation of radio astronomy signals is different from many other HPC challenges, in that the number of operations per byte of input data is extremely low. This means for good real-time performance minimizing I/O is extremely important. The traditional Grid approach where data is transferred to a storage element (SE), which is then transferred to local storage on the cluster when the job is actually run, causes a lot of overhead and slows down correlation. On top of that, existing tools to transfer data to an SE expect the data to be on disk in the first place.

Our goal is to eliminate this overhead by streaming data directly into the correlator, either from a high-performance disk buffer (see WP8) or in real-time, directly from the data acquisition system at the telescopes. To achieve this goal we will:

- Develop the capability to start real-time jobs on shared computing infrastructure (PSNC/VENT). The results from FABRIC have shown us that traditional approach of submitting jobs in the Grid environment is not well suited for correlating VLBI data. The nature of the VLBI, where data is streamed continuously, forces us to submit multiple jobs within a short period of time. This has a significant impact on the overall performance of the computational resources. All effort within this task will be put to design and deploy a generic solution, which will allow us to reduce the overheads and which later could be reused within different clusters to effectively correlate radio astronomical signals.

- Develop the capability to set up high-bandwidth network connections between data sources (disk buffers and telescopes) and shared computing infrastructure (PSNC). Successful real-time correlation also requires high bandwidth network connections between data sources and computing resources. Since cluster computational resources can be assigned dynamically for every VLBI experiment, a set of tools integrated with the correlation platform are required which will allow us to set up network connections for data transfer on demand. The work within this task will focus to provide this functionality for the entire distributed correlation platform.

- Implement real-time correlation capability in a software correlator (JIVE). Some adjustments to the software correlator will be needed to be make true real-time correlation possible:

- Time in the correlator management layer will have to be tied to wall-clock time.

- Additional buffering will be required to deal with different round trip times to the telescopes and network jitter. We will make those adjustments and test the functionality, first locally with data generators, and later with actual telescope data.

- Deploy middleware and updated software correlator (PSNC/JIVE). The implemented correlation platform and its components will be integrated with the updated version of the software correlator. All the components will be installed within a prepared distributed correlation infrastructure.

For the bandwidth-on-demand aspects we will build on the services provided by WP6 through a close collaboration.

Task 4: Distributed correlation (OSO/JIVE)

In VLBI, the observed spectrum is split up in multiple smaller bands. In principle, these different parts of the frequency spectrum can be trivially processed in a parallel fashion. However the traditional VLBI data formats have been optimized for storage. Data streams corresponding to different parts of the frequency spectrum were multiplexed into a single data stream, which was then recorded on tape or disk. In order to do a truly distributed correlation, the data has to be de-multiplexed, which is computationally expensive. However, a new standard data format has been agreed upon by the VLBI community that is optimized for network transport and no longer requires multiplexing the data into a single data stream.

Our goal is to leverage this new data format to distribute the correlation over multiple sites in a real-time fashion. In order to achieve this goal we will:

- Implement reading of streamed VDIF/VTP data in the software correlator(s) (JIVE).

The software correlator does not yet understand the new VDIF data format and has its own “proprietary” transport protocol.

- Develop control interfaces for streaming VDIF data for legacy data acquisition systems and/or new VDIF-capable data acquisition systems (OSO). For control of the data transmission, the data acquisition systems need informing, more than is done at present, about the format of the data multiplexing, and where each channel should be transmitted to. This will involve:

- Updating the current correlation control system to be aware of VDIF

- Implementation of extra control commands to cater for the transmission of multiplex- format information and channel to correlator mappings.

- Develop software to glue back together the distributed correlation output in a form suitable for the standard off-line post-processing pipeline(s) (JIVE). We will extend the software that converts correlator output into MeasurementSet format such that it can handle several correlator output files each containing part of the spectrum and convert them into a single MeasurementSet.

- Deploy the developed software at telescopes and compute clusters (OSO/JIVE)

Task 5: Global correlation (JIVE/CSIRO)

Curtin University of Technology, as an international collaborator of the EVN and JIVE, will offer an opportunity to test an extension of a local European distributed correlation facility to global scale, addressing aspects of routine global long-haul data transfer that will arise as part of projects such as the Square Kilometre Array. Through our collaboration, the Australian partners will offer access to a computing cluster and the DiFX software correlator, running on that cluster, to undertake e-VLBI observations that use European or Australian radio telescopes, or possibly a combination of European and Australian telescopes. Thus, the Australian facility will be combined into a distributed and international correlation facility that offers both the SFXC and DiFX software correlators and could assist in providing continuous global coverage of astronomical events that require real-time monitoring and observation feedback, due to the geographical distribution of radio telescope and correlator assets in Europe and Australia.

- Undertake long haul connectivity tests between telescopes in Australia, New Zealand and Europe, in order to determine feasible data rates that could be supported in real-time correlation;

- Work with Australian, New Zealand and European NRENS to optimise connectivity to support this work;

- Undertake a global distributed correlation test observation, using telescopes in Australia, New Zealand and Europe in order to continuously monitor a strong radio source;

- Attempt a global distributed correlation for science targets that require rapid response and extended monitoring, such as X-ray binaries, using telescope and correlator assets that are available at short notice.

Meetings

We will plan a face-to-face kick-off meeting as soon as possible after the start of the project. We also plan to have face-to-face developer meetings around the deployment/integration phases of the project. The travel budget includes funds to support travel of partners outside NEXPReS, in particular from Australia.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JIVE	42.00
6	OSO	24.00
7	VENT	15.00
11	PSNC	36.00
	Total	117.00

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D7.1	Workflow Manager requirements from telescope operators (OSO)	6	7.00	R	PU	4
D7.2	Workflow Manager requirements from correlator operators (JIVE)	1	7.00	R	PU	4
D7.3	Workflow Manager implementation (PSNC)	11	18.00	O	PU	18
D7.4	Demo of automated correlation (JIVE/OSO/PSNC/VENT)	1	39.00	D	PU	24
D7.5	Real-time middleware components (PSNC)	11	18.00	O	PU	24
D7.6	Demo of real-time correlation (JIVE/OSO/PSNC)	1	14.00	D	PU	34
D7.7	Demo of global correlation (JIVE/OSO/PSNC/CSIRO)	1	14.00	D	PU	36
		Total	117.00			

Description of deliverables

D7.1) Workflow Manager requirements from telescope operators (OSO): Workflow Manager requirements from telescope operators (OSO) [month 4]

D7.2) Workflow Manager requirements from correlator operators (JIVE): Workflow Manager requirements from correlator operators (JIVE) [month 4]

D7.3) Workflow Manager implementation (PSNC): Workflow Manager implementation (PSNC) [month 18]

D7.4) Demo of automated correlation (JIVE/OSO/PSNC/VENT): Demo of automated correlation (JIVE/OSO/PSNC/VENT) [month 24]

D7.5) Real-time middleware components (PSNC): Real-time middleware components (PSNC) [month 24]

D7.6) Demo of real-time correlation (JIVE/OSO/PSNC): Demo of real-time correlation (JIVE/OSO/PSNC) [month 34]

D7.7) Demo of global correlation (JIVE/OSO/PSNC/CSIRO): Demo of global correlation (JIVE/OSO/PSNC/CSIRO) [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS709	Face-to-face meeting to start preparation/integration for final demo	1	28	
MS701	Workflow Requirements	1	4	
MS703	Workflow Manager	1	18	
MS705	Real-time Middleware Components	1	24	
MS704	Identify telescopes and compute clusters for upcoming correlation demonstrations	1	21	
MS707	Identify elements that are mature enough for integration into WFM	1	12	
MS708	Face-to-face meeting to start preparation/integration for first demo of automated integration	1	15	

Project Number [1]	261525	Project Acronym [2]	NEXPReS

One form per Work Package

Work package number [53]	WP8	Type of activity [54]	RTD
Work package title	Provisioning High-Bandwidth, High-Capacity Networked Storage on Demand		
Start month	1		
End month	36		
Lead beneficiary number [55]	13		

Objectives

This JRA has two distinct aims with a common storage component. On one hand it will explore ways to implement on-demand networked storage that can match the multi-Gbps bandwidth and Petabyte-class capacity requirements of VLBI in a distributed manner. On the other hand, it will address the use of such high-capacity storage systems for the data archives of the future.

Among scientific instruments, VLBI is unique in the sense that any single observation necessarily generates globally distributed data sets at multi-Gbps rates, resulting in petabytes of data to be processed at the correlation stage. Correlation, by its nature, has to have the data of all observing stations of a given observation time available for comparison. The existing correlation infrastructure can provide real-time processing of data up to 1 Gbps from a set of fully connected stations, or batch processing of data sets from any set of stations, physically shipped on magnetic media, but nothing in between these two. This situation can be amended in this JRA by applying best-effort transfer tactics and graceful fallback to near real-time data transfers. The goal is to equip e-VLBI with the required intermediate solution to instantly increase the quality of the existing e-VLBI services, decrease the turn-around time for scientific results, add previously lacking data re-processing capability, and increase overall e-VLBI service availability and robustness. To maximally utilize network capacity and transfer VLBI data as soon as possible after or already during an observation for processing (near real-time VLBI) and to minimize the amount of physical media shipments and the impact of network problems, flexible storage space needs to be allocated, at observing stations, at correlators, and/or at well-connected network nodes.

Several emerging new instruments such as the SKA Pathfinders LOFAR and Apertif (and e-VLBI), but eventually also the future SKA telescope itself, will need data storage facilities that differ radically from the traditional centralized data archive systems currently in use. With datasets measuring terabytes and total required capacities of Petabytes, archives will need to be distributed over data centres located in different countries at different institutes. These institutes in turn may use different storage systems, and as an additional complication, the datasets themselves will not be final data products, but are expected to be re-processed several times as calibration or analysis algorithms are improved over time. In order to effectively use such a distributed storage system, with the additional requirement that data can be processed at the scientist's home institutes if needed, this work package will utilize high-speed storage facilities to provide points of presence of the archive, distributed over the network. These points of presence will provide low latency access points to the archive from where to process data sets.

Storage located at VLBI stations is required whenever data is acquired at a rate greater than the available real-time bandwidth of the network connection of a given station. Technological advances in VLBI data acquisition, the migration to software-defined digital radio (digital BBCs) and 10 Gbps Ethernet technology (10 GE) have made 4 Gbps rates possible and are pushing towards 8 Gbps—these enable high-sensitivity observations but at the same time are often difficult to sustain in networks in real-time. Local 4-8 Gbps storage ensures that all stations making a given scheduled simultaneous observation can store all the associated data and subsequently make use of the full capacity of their available networks to transfer the observation as quickly as possible for correlation. In many cases this requires simultaneous input/output in the data storage units (save one observation, send others to correlation), and several alternative schemes to support concurrent high-bandwidth I/O will be investigated in Task 1 of this WP.

Storage located at the correlators makes it possible to wait for the data of stations with restricted network bandwidths or even stations using physical shipments. It also enhances real-time e-VLBI by making it possible to save real-time data received for possible re-correlations, which can be used to optimize the correlation result. This storage needs to be partitioned and managed in a way where new write and read streams can be established concurrently, based on bandwidth and data amount. These management methods will be developed in Task 2 and they can naturally be applied to the smaller-scale station-located storage as well.

Since both station-located and correlator-located storage systems may become congested, in either network bandwidth or storage capacity, it can be worthwhile to explore the ways in which well-networked generic storage can be used as intermediate storage for VLBI data when it is travelling from the VLBI stations towards the correlators. This would have to extend the methods of Task 2 to handle multiple architectures and organisational units.

Description of work and role of partners

Task 1: Transparent multi-Gbps access to both local and remote storage elements (AALTO, JIVE, ASTRON)

Evaluate the requirements set by WP5 Task 1, which requests methods for remote configuration of the storage and the buffering at the stations and at the correlators. Devise a common and secure application programming interface that allows remote access to the data on the storage element, and also allows remote control of the storage element behaviour. In particular, behaviours such as the following will have to be investigated and considered in the interface design:

- receive and forward data streaming with remotely adjustable time delay and data rate

- receive streams and perform pure short-term buffered streaming with a small memory footprint

- receive streams and perform disk-buffered streaming and/or medium-term data storage

- Long Term Archiving (LTA) of input streams, support for Task 6

- output streams from the LTA and/or the high-capacity medium-term data storage

- output streams may be multi-homed for shared infrastructure computing (WP7).

The API will consist of two components,

- a slow-speed secure Remote Control API, and

- a high-speed Data Streaming API.

Suitable existing protocols will be evaluated for each API component. There further exists a high potential for synergy between all service and research activities of NEXPReS, especially with WP7, shared infrastructure computing. All activities can make use of a different facet of the capabilities offered by storage on demand. WP5 emphasizes the local/remote aspect, WP6 the high-speed continuous streaming aspect, while WP7 will exploit the on-demand and dynamic allocation capabilities of WP8. Synergies with WP7 will be taken into account in the API design. Peer-to-peer autonomous operation and decentralized control of storage nodes may subsequently be investigated.

The storage element has to be able to accept data formats most common in VLBI. Current high-speed streaming protocols such as VDIF-based VTP, Tsunami and UDT should be supported by the API. Emerging 10GE-connected data acquisition and data processing hardware (Italian dBBC FILA10G, US DBE2, UniBoard) use their own network IP encapsulation. Co-operation with these parties will be necessary and AALTO will provide VDIF assistance to these parties.

The API should allow easy addition of other existing data acquisition systems and software as well as upcoming 10GE-based data acquisition systems, so that these are recognized and supported by the storage system. In addition, the design of the Remote Control API has to be suitable for control from existing correlation processes (JIVE) as well as future software correlators and shared infrastructure computing.

Task 2: Multi-Gbps storage elements with simultaneous input and output streaming (AALTO)

This task explores the various methods to realize 1 Gbps and 4 Gbps storage subsystems (“storage elements”), which can support simultaneous input and output to provide the back-end for Task 1. Techniques such as using multiple RAID configurations, multiple nodes, and non-mechanical disks (SSDs) will be compared for performance and cost. Main focus is on cost-effective, high-density stationary storage, though the option of physical shipments will be taken into account in comparisons. Optimal combinations and configurations will be identified and recommended to stations for use in the following Tasks. A small number of hardware components may be evaluated. The output of the technical study will be used in Task 4 to build larger scale demonstration systems.

Task 3: Bandwidth, capacity, and concurrency-aware allocation methods of storage elements (INAF, AALTO)

Builds a model for a heterogeneous network with stations, storage elements and correlators. Includes properties of the elements and network paths in the model. Develops a strategy and an algorithm for allocating and de-allocating identified storage elements across the network, based on their properties (bandwidth, service availability like BoD or QoS, storage capacity, concurrency tolerance) and the desired access pattern (time, duration, bandwidth, direction, amount of data, expected lifetime). The properties (except for bandwidth of the storage elements developed in this WP) are extracted from existing estimates from past EVN e-VLBI sessions and from information gathered in WP6 in its network testing and validation tasks. Simulates the best algorithms using the model, applying the actual metrics of a sample real-world VLBI session as input.

Assesses the practical feasibility and expected theoretical performance of the algorithms and developed strategies. The model and algorithms evolved during analysis and simulation are provided as a guideline implementation for the next implementation Tasks.

Task 4: Prototype implementation for multi-Gbps access to both local and remote storage elements (AALTO, OSO, UMAN, JIVE, PSNC)

Implements the remote control and data streaming application programming interfaces devised under Task 1 and adds support for at least one high-speed data streaming protocol. The implementation of the interface encompasses functionalities of both the controlled storage nodes and the controlling servers.

Implement the underlying API code for the controlled storage nodes. Also implement remote control code for the controller nodes that steer local and remote storage nodes. Using a controller node that resides at only one correlator site (JIVE), run remote control tests against a local storage node. These tests on the prototype software implementation are performed outside of the production correlator pipeline.

Assembles several prototype storage element hardware platforms using the components recommended under Task 2. For the most common subset of currently available data acquisition systems, implements behaviours from Task 1 in the API and ensures storage node hardware meets the demands (DAQ connectivity, bandwidth, capacity). Evaluates the performance of the hardware platform and API locally at those stations participating in this Task, which opt to build storage node platforms (OSO, AALTO, JIVE).

Assesses functionality of concurrent streaming, stream recording, and remote control. Perform international testing with several stations over real-life networks. Testing is lead and supervised by UMAN.

Task 5: Integration of storage element allocation methods with transparent multi-Gbps access (JIVE, ASTRON, AALTO, INAF)

Takes the results of Task 2 and Task 3 to sequence the access patterns of VLBI systems and Long Term Archives on the network of storage elements according to the allocation algorithms (AALTO). Takes the result of Task 4 local testing at JIVE and studies approaches for integrating the remote control software into the production correlator pipeline (JIVE) and LOFAR/Apertif data processing (ASTRON). Tests data stream feed into Mark5 playback units and the correlator (JIVE). Finally integrates the remote control functionality, access pattern sequencing and allocation algorithms into the pipeline.

Task 6: Integration of storage elements of Task 1 into Long Term Archive front-end and the investigated online data stream processing pipeline (ASTRON)

Building on the interface design of task 1 and the prototype implementation of task 4, create a connection between LTA storage facilities and storage elements as local points of presence for data retrieval. Create an interface from the local point of presence to local processing facilities and adapt a processing pipeline to interact with the point of presence.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	JIVE	24.00
2	ASTRON	28.80
3	INAF	30.00
5	UMAN	10.80
6	OSO	10.80
11	PSNC	12.00
13	AALTO	46.80
	Total	163.20

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D8.1	Interface design document of storage element API (AALTO)	13	5.90	R	PU	6
D8.2	Hardware design document for simultaneous I/O storage elements (AALTO)	13	6.00	R	PU	8
D8.3	Design document of storage element allocation methods (INAF)	3	11.80	R	PU	10
D8.4	Design document of transparent local/remote application programming interface for storage elements (	13	15.30	R	PU	15
D8.5	Performance and integration test report of simultaneous I/O storage elements (OSO)	6	20.00	R	PU	21
D8.6	Test report of storage element allocation methods (INAF)	3	17.00	R	PU	22
D8.7	Test report of transparent local/remote application programming interface for storage elements (UMAN	5	20.00	R	PU	22
D8.8	Design document of integration system of allocation methods with transparent multi-Gbps access (JIVE	1	13.50	R	PU	26
D8.9	Integration test report of LTA and pipeline integration (ASTRON)	2	21.30	R	PU	32
D8.10	Demonstration tests of the integrated system (JIVE)	1	29.00	D	PU	32
D8.11	Final report on Networked Storage on Demand (AALTO)	13	3.30	R	PU	35

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
		Total	163.10			

Description of deliverables

D8.1) Interface design document of storage element API (AALTO): Interface design document of storage element API (AALTO). NOTE: person months for this entry arbitrarily lowered from to 5.9 to deal with errors in the NEF system. Thi project still expects 6 person months. [month 6]

D8.2) Hardware design document for simultaneous I/O storage elements (AALTO): Hardware design document for simultaneous I/O storage elements (AALTO) [month 8]

D8.3) Design document of storage element allocation methods (INAF): Design document of storage element allocation methods (INAF) [month 10]

D8.4) Design document of transparent local/remote application programming interface for storage elements (: Design document of transparent local/remote application programming interface for storage elements (AALTO) [month 15]

D8.5) Performance and integration test report of simultaneous I/O storage elements (OSO): Performance and integration test report of simultaneous I/O storage elements (OSO) [month 21]

D8.6) Test report of storage element allocation methods (INAF): Test report of storage element allocation methods (INAF) [month 22]

D8.7) Test report of transparent local/remote application programming interface for storage elements (UMAN: Test report of transparent local/remote application programming interface for storage elements (UMAN) [month 22]

D8.8) Design document of integration system of allocation methods with transparent multi-Gbps access (JIVE: Design document of integration system of allocation methods with transparent multi-Gbps access (JIVE) [month 26]

D8.9) Integration test report of LTA and pipeline integration (ASTRON): Integration test report of LTA and pipeline integration (ASTRON) [month 32]

D8.10) Demonstration tests of the integrated system (JIVE): Demonstration tests of the integrated system (JIVE) [month 32]

D8.11) Final report on Networked Storage on Demand (AALTO): Final report on Networked Storage on Demand (AALTO) [month 35]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS801	Hardware decision for subsequent prototyping and integration tests (AALTO)	13	8	
MS802	Review of prototype test results, decision of the architecture and scope of subsequent integration t	1	15	

Project Number [1]	261525	Project Acronym [2]	NEXPReS

List and Schedule of Milestones

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS101	Prepare Period 1 Report to EC	WP1	1	13	
MS709	Face-to-face meeting to start preparation/ integration for final demo	WP7	1	28	
MS102	Prepare Period 2 Report to EC	WP1	1	25	
MS103	Prepare Period 3 Report to EC	WP1	1	36	
MS202	Select location for EVN-NREN meeting 2	WP2	12	19	
MS203	Select location for EVN-NREN meeting 3	WP2	12	29	
MS301	Select location for eVSAG meeting 1	WP3	8	13	
MS302	Select location for eVSAG meeting 2	WP3	8	29	
MS401	Design Display	WP4	1	1	
MS402	Design Visual Guide/Elements	WP4	1	3	
MS403	Design Print Items	WP4	1	6	
MS501	Definition of specifications monitoring and remote control	WP5	1	4	
MS502	Automated job scheduling	WP5	1	9	
MS503	Unattended correlation	WP5	1	19	
MS504	Control systems and scheduling mechanisms for 4-Gbps at correlator	WP5	1	23	
MS404	Design Print Items	WP4	1	20	
MS604	Proof-of-concpt for reserving BoD	WP6	1	20	
MS605	10 Gbps BoD for LOFAR/LTA	WP6	1	24	

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS606	Demonstration of integrated BoD testing	WP6	1	30	
MS603	Demonstration of international 4 Gbps BoD	WP6	1	18	
MS601	Overall BoD system architecture	WP6	1	4	description of this milestone inline with Task 1 (space limitations here)
MS602	Evaluate BoD application architecture	WP6	1	10	description of this milestone inline with Task 1 (space limitations here)
MS701	Workflow Requirements	WP7	1	4	
MS703	Workflow Manager	WP7	1	18	
MS705	Real-time Middleware Components	WP7	1	24	
MS704	Identify telescopes and compute clusters for upcoming correlation demonstrations	WP7	1	21	
MS801	Hardware decision for subsequent prototyping and integration tests (AALTO)	WP8	13	8	
MS802	Review of prototype test results, decision of the architecture and scope of subsequent integration t	WP8	1	15	
MS707	Identify elements that are mature enough for integration into WFM	WP7	1	12	
MS708	Face-to-face meeting to start preparation/ integration for first demo of automated integration	WP7	1	15	
MS201	Select location for EVN-NREN meeting 1	WP2	12	6	

WT5:
Tentative schedule of Project Reviews

Project Number [1]	261525	Project Acronym [2]	NEXPReS

Tentative schedule of Project Reviews

Review number [65]	Tentative timing	Planned venue of review	Comments, if any

WT6:
Project Effort by Beneficiary and Work Package

Project Number [1]	261525	Project Acronym [2]	NEXPReS

Indicative efforts (man-months) per Beneficiary per Work Package

Beneficiary number and short-name	WP 1	WP 2	WP 3	WP 4	WP 5	WP 6	WP 7	WP 8	Total per Beneficiary
1 - JIVE	48.00	3.00	3.00	21.60	87.00	48.00	42.00	24.00	276.60
2 - ASTRON	0.00	0.00	0.00	0.00	0.00	18.00	0.00	28.80	46.80
3 - INAF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	30.00
4 - MPG	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	9.00
5 - UMAN	0.00	0.00	0.00	0.00	0.00	21.00	0.00	10.80	31.80
6 - OSO	0.00	0.00	0.00	0.00	0.00	6.00	24.00	10.80	40.80
7 - VENT	0.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00	15.00
8 - FG-IGN	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	3.00
9 - NORDUnet	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	15.00
10 - SURFnet	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	6.00
11 - PSNC	0.00	0.00	0.00	0.00	0.00	0.00	36.00	12.00	48.00
12 - DANTE	0.00	3.00	0.00	0.00	0.00	3.00	0.00	0.00	6.00
13 - AALTO	0.00	0.00	0.00	0.00	9.00	0.00	0.00	46.80	55.80
14 - TUM	0.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	15.00
15 - CSIRO	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	6.00
Total	48.00	6.00	6.00	21.60	120.00	123.00	117.00	163.20	604.80

WT7:
Project Effort by Activity type per Beneficiary

Project Number [1]	261525	Project Acronym [2]	NEXPReS

Indicative efforts per Activity Type per Beneficiary

Activity type	Part. 1 JIVE	Part. 2 ASTRON	Part. 3 INAF	Part. 4 MPG	Part. 5 UMAN	Part. 6 OSO	Part. 7 VENT	Part. 8 FG-IGN	Part. 9 NORDUne	Part. 10 SURFnet	Part. 11 PSNC	Part. 12 DANTE	Part. 13 AALTO	Part. 14 TUM
1. RTD/Innovation activities														
WP 7	42.00	0.00	0.00	0.00	0.00	24.00	15.00	0.00	0.00	0.00	36.00	0.00	0.00	0.00
WP 8	24.00	28.80	30.00	0.00	10.80	10.80	0.00	0.00	0.00	0.00	12.00	0.00	46.80	0.00
Total Research	66.00	28.80	30.00	0.00	10.80	34.80	15.00	0.00	0.00	0.00	48.00	0.00	46.80	0.00
3. Consortium Management activities														
WP 1	48.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Management	48.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Work Packages for Coordination activities														
WP 2	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00
WP 3	3.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
WP 4	21.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Coordination	27.60	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	3.00	0.00	0.00
4. Other activities														
WP 5	87.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	15.00
WP 6	48.00	18.00	0.00	0.00	21.00	6.00	0.00	0.00	15.00	6.00	0.00	3.00	0.00	0.00
Total other	135.00	18.00	0.00	9.00	21.00	6.00	0.00	0.00	15.00	6.00	0.00	3.00	9.00	15.00
Work Packages for Support activities														
Total Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Total	276.60	46.80	30.00	9.00	31.80	40.80	15.00	3.00	15.00	6.00	48.00	6.00	55.80	15.00

WT7:
Project Effort by Activity type per Beneficiary

Activity type	Part. 15 CSIRO	Total
1. RTD/Innovation activities		
WP 7	0.00	117.00
WP 8	0.00	163.20
Total Research	0.00	280.20
3. Consortium Management activities		
WP 1	0.00	48.00
Total Management	0.00	48.00
Work Packages for Coordination activities		
WP 2	0.00	6.00
WP 3	0.00	6.00
WP 4	0.00	21.60
Total Coordination	0.00	33.60
4. Other activities		
WP 5	0.00	120.00
WP 6	6.00	123.00
Total other	6.00	243.00
Work Packages for Support activities		
Total Support	0.00	0.00
Total	6.00	604.80

WT8:
Project Effort and costs

Project Number [1]	261525	Project Acronym [2]	NEXPReS

Project efforts and costs

Benefi-ciary number	Beneficiary short name	Estimated eligible costs (whole duration of the project)							Requested EU contribution (€)
		Effort (PM)	Personnel costs (€)	Subcontracting (€)	Other Direct costs (€)	Indirect costs OR lump sum, flat-rate or scale-of-unit (€)	Access costs (€)	Total costs	
1	JIVE	276.60	1,358,600.00	7,500.00	301,275.00	995,925.00	0.00	2,663,300.00	1,581,240.00
2	ASTRON	46.80	328,965.00	2,500.00	31,350.00	201,606.00	0.00	564,421.00	334,390.00
3	INAF	30.00	150,000.00	0.00	11,875.00	97,125.00	0.00	259,000.00	158,250.00
4	MPG	9.00	56,250.00	0.00	375.00	78,750.00	0.00	135,375.00	135,375.00
5	UMAN	31.80	175,366.00	0.00	31,550.00	124,148.00	0.00	331,064.00	219,113.00
6	OSO	40.80	267,580.00	0.00	13,675.00	168,753.00	0.00	450,008.00	287,088.00
7	VENT	15.00	68,750.00	0.00	2,938.00	14,337.00	0.00	86,025.00	52,144.00
8	FG-IGN	3.00	12,250.00	0.00	0.00	0.00	0.00	12,250.00	0.00
9	NORDUnet	15.00	127,500.00	0.00	625.00	86,700.00	0.00	214,825.00	129,145.00
10	SURFnet	6.00	45,000.00	0.00	0.00	35,000.00	0.00	80,000.00	0.00
11	PSNC	48.00	216,000.00	0.00	5,500.00	132,900.00	0.00	354,400.00	184,800.00
12	DANTE	6.00	37,000.00	0.00	0.00	22,200.00	0.00	59,200.00	0.00
13	AALTO	55.80	206,925.00	0.00	22,300.00	137,535.00	0.00	366,760.00	229,605.00
14	TUM	15.00	85,000.00	0.00	325.00	51,195.00	0.00	136,520.00	109,425.00
15	CSIRO	6.00	42,500.00	0.00	2,500.00	34,425.00	0.00	79,425.00	79,425.00
Total		604.80	3,177,686.00	10,000.00	424,288.00	2,180,599.00	0.00	5,792,573.00	3,500,000.00

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It cannot be changed unless agreed so during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

53. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

54. Type of activity

For all FP7 projects each work package must relate to one (and only one) of the following possible types of activity (only if applicable for the chosen funding scheme – must correspond to the GPF Form Ax.v):

• **RTD/INNO =** Research and technological development including scientific coordination - applicable for Collaborative Projects and Networks of Excellence

• **DEM =** Demonstration - applicable for collaborative projects and Research for the Benefit of Specific Groups

• **MGT =** Management of the consortium - applicable for all funding schemes

• **OTHER =** Other specific activities, applicable for all funding schemes

• **COORD =** Coordination activities – applicable only for CAs

• **SUPP =** Support activities – applicable only for SAs

55. Lead beneficiary number

Number of the beneficiary leading the work in this work package.

56. Person-months per work package

The total number of person-months allocated to each work package.

57. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

58. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

59. Milestone number

Milestone number:MS1, MS2, …, MSn

60. Delivery date for Milestone

Month in which the milestone will be achieved. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

61. Deliverable number

Deliverable numbers in order of delivery dates: D1 – Dn

62. Nature

Please indicate the nature of the deliverable using one of the following codes

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

63. Dissemination level

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)

• **Restreint UE =** Classified with the classification level "Restreint UE" according to Commission Decision 2001/844 and amendments

• **Confidentiel UE =** Classified with the mention of the classification level "Confidentiel UE" according to Commission Decision 2001/844 and amendments

• **Secret UE =** Classified with the mention of the classification level "Secret UE" according to Commission Decision 2001/844 and amendments

64. Delivery date for Deliverable

Month in which the deliverables will be available. Month 1 marking the start date of the project, and all delivery dates being relative to this start date

65. Review number

Review number: RV1, RV2, ..., RVn

66. Tentative timing of reviews

Month after which the review will take place. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

67. Person-months per Deliverable

The total number of person-month allocated to each deliverable.

NEXPReS: Novel Explorations Pushing Robust e-VLBI Services

Proposal full title: **N**ovel **EX**plorations **P**ushing **R**obust **e**-VLBI **S**ervices

Proposal acronym: NEXPReS

Type of funding scheme: Combination of Collaborative Project and Coordination and Support Action: Integrated Infrastructure Initiative (I3)

Work programme topic and subtopic addressed: INFRA-2010-1.2.3

Name of the coordinating person: Dr. Huib Jan van Langevelde

List of participants:

#	Participant organisation name	Short name	Country
1	Joint Institute for VLBI in Europe (JIVE) (Coordinator)	JIVE	EU (NL)
2	Stichting Astronomisch Onderzoek in Nederland	ASTRON	NL
3	Istituto Nazionale di Astroficica	INAF	IT
4	Max Planck Gesellschaft zur Foerderung der Wissenschaften E.V.	MPG	DE
5	The University of Manchester	UMAN	UK
6	Chalmers Tekniska Hoegskola AB	OSO	SE
7	Ventspils Augstskola	VENT	LV
8	Fundacion General de la Universidad de Alcala	FG	ES
9	NORDUnet A/S	NORDUnet	DK
10	SURFnet bv	SURFnet	NL
11	Instytut Chemii Bioorganicznej Pan	PSNC	PL
12	Delivery of Advanced Network Technology to Europe Limited	DANTE	EU (UK)
13	Aalto	AALTO	FI
14	Technische Universitaet Muenchen	TUM	DE
15	Commonwealth Scientific and Industrial Research Organisation Australia Telescope National Facility	CSIRO	AU

Condensed Table of Contents

B 1. Concept and objectives, progress beyond state-of-the-art, s/t methodology and work plan

B 1.1 Concept and project objective(s)

1.1.1. Motivation

The prime motivation for "Novel EXplorations Pushing Robust e-VLBI Services" (NEXPReS) is to offer enhanced scientific performance for all users of the European VLBI Network (EVN) and its partners by introducing an e-VLBI component to every experiment, aiming for enhanced robustness, flexibility and sensitivity. This work will build on the achievements of the FP6 project Express Production Real-time e-VLBI Service (EXPReS), which introduced the concept of real-time VLBI for studying transient phenomena. Based on the success of e-VLBI we propose to boost the scientific capacity of the distributed facility and offer better data quality and deeper images of the radio sky for a larger number of astronomers.

1.1.2. Background

Very Long Baseline Interferometry (VLBI) is an astronomical technique in which radio telescopes hundreds or thousands of kilometres apart cooperate to form a single telescope. By processing the digitized signals in a central, dedicated super-computer, astronomers are able to produce images of the sky with a resolution that surpasses that of the best optical telescopes, even the Hubble Space Telescope. The technique can be used to study a wide variety of astronomical phenomena, from the energetic outflows associated with black holes in the centres of galaxies at cosmological distances to the details of the dynamical processes in star forming regions in our Galaxy. Besides observing natural phenomena like exploding stars and gravitational lenses, VLBI has also been applied to measure the detailed position of man-made spacecraft on their journeys through the solar system, for example during the descent of the Huygens spacecraft to the surface of Saturn's moon Titan.

In Europe, VLBI research is facilitated by the EVN, a consortium of radio telescopes operating in three observing sessions per year, which offers open access to all astronomers worldwide. The central correlator facility is located at the Joint Institute for VLBI in Europe (JIVE), in Dwingeloo, the Netherlands. The JIVE foundation is funded by the research councils of 8 countries, mostly European, but also including China. Apart from processing the raw signals into the product used by astronomers, JIVE also takes responsibility for user support in setting up and analyzing VLBI experiments. Its staff is also closely involved in defining and implementing the continuous enhancements to the European VLBI facility, needed to stay on the forefront of science.

In order to study significant samples of astronomical sources and to probe deeper into the universe, it is of vital importance that VLBI arrays offer the highest possible sensitivity. The sensitivity of the total array is primarily set by the size of the antennas that participate, while the number and location of telescopes is also important for the quality of the images that result. In this respect Europe has an advantage, because it harbours some of the largest telescopes on the planet. Another important factor determining the sensitivity is the bandwidth of the signal that is used in the observations. When more frequency space can be sampled at the telescopes and transported to the central correlator for processing, deeper images of the universe can be obtained.

Traditionally, data were recorded on tape reels and physically shipped to the correlator. Since the start of the century this technology has been replaced with disk based recording systems. Nowadays a typical EVN experiment records 1 Gbps data-rates at 12 telescopes for 12 hours, resulting in 5.5 terabytes of data at every station, resulting in a petabyte flow of data into the correlator during every session. It is the ambition of the EVN to boost this data flow by at least an order of magnitude.

With the advent of PC-based disk recorders it also became possible to experiment with real-time connectivity, streaming the data directly into the correlator through the Internet. There have been a number of such experiments around the world, but it is in Europe where the first operational e-VLBI service for astronomy was implemented. During the past few years e-VLBI has evolved from an experimental technique, connecting a small number of telescopes in real-time at modest bandwidth, into an operational astronomical service with competitive sensitivity and imaging capabilities. The project has been supported by the EC through the FP6 Integrating Activity EXPReS, which has stimulated a large-scale collaboration between EVN technical staff and the National Research and Education Network providers (NRENs).

One of the initial arguments for the development of e-VLBI was the wish to use VLBI for transient phenomena, to be able to observe variable sources on the timescale that they vary. Indeed, opening up the parameter space accessible to VLBI has produced some very interesting results and has presented the community with various new science themes in the area of Galactic black hole candidates and the study of the elusive Gamma Ray Bursts, the most energetic events in the Universe.

However, e-VLBI is a technique not limited to providing rapid response science. Because of its real-time nature it is more robust than traditional VLBI, as technical failures are noticed immediately and addressed instantaneously. Even though the network connections add a layer of complexity, the operational stability has still improved. Various demonstrations have proven e-VLBI works on intercontinental baselines, showing fringes between telescopes on different continents simultaneously and routinely.

The EXPReS project has made extensive use of dedicated connections, sometimes in synergy with the European LOFAR project, and has thrived by their availability. However, it is clear that in the future this kind of connectivity should be more dynamically accessible. Technological developments also promise larger and larger bandwidths, with the 10 Gbps standard already operational in many places; obviously VLBI can benefit greatly from the sensitivity enhancement this enables.

Besides reducing the delivery time to the astronomer, e-VLBI can also help enhance the flexibility of observations by avoiding the complex logistics that are involved in shipping scarce recording media. Currently e-VLBI is realized as a large-scale collaboration with connectivity providers and as a result it is hard to evaluate the economics of real-time VLBI in comparison to the transport of magnetic media. But clearly, in the long run, real-time connectivity via the shared e-infrastructure will be cheaper and more environmentally friendly.

One way in which e-VLBI is less flexible than recorded VLBI is that its current operations do not allow re-correlations, which are needed to accommodate large numbers of telescopes or spectral line experiments that need mixed bandwidths. It will be essential to introduce buffering of the VLBI data in various stages in order to combine the best aspects of recorded and real-time operations.

Besides the connectivity aspects, the European LOFAR telescope has a number of other technological interests in common with VLBI. Designed to observe the low frequency sky with a large number of dipole antennas, e-LOFAR is largely a software telescope that can also benefit from the NEXPReS work packages on distributed computing and cloud storage. Both the low frequency and traditional VLBI facilities are recognized pathfinders for the development of the SKA. Long-haul connectivity aspects will be important for next generation radio telescopes, as well as fast dissemination of large scientific data sets to the user community.

1.1.3. NEXPReS technological objectives

The next step — to be made in NEXPReS — in the development of e-VLBI is the deployment of a transparent caching system that allows all scientific VLBI experiments to benefit from the increased sensitivity, flexibility and robustness of real-time VLBI. The ideal situation is an array that works continuously with real-time connections, something that applies to LOFAR in the near term and that is anticipated for SKA. But even for the radio telescopes of the future a caching mechanism between digitization and transport, or between transport and correlation, can be anticipated. LOFAR operations, for example, include a mode in which a short data segment can be frozen in order to re-focus the telescope elements on a transient event. This technique will access unknown territories in astrophysics, and there are both scientific and operational motivations to extend this capability to other interferometers.

For the VLBI array of the near-future it is clear that a caching mechanism can overcome all of the limitations that currently prevent one from deploying e-VLBI for all scientific experiments. We intend to build an operational system over the next 3 years in which all telescopes in all experiments will stream their data to JIVE in real-time. During the experiment, the real-time result is inspected at the correlator and made available to the astronomer, and at the same time the data is also buffered at the correlator and at the telescope. If the infrastructure has insufficient capacity at the time of the experiment, the transport can be completed later, either through direct connectivity or by traditional VLBI practices. Ideally, the end of the observation completes the correlation, the processing of the incoming signals. But there could be a variety of reasons why the data buffered at the telescope or correlator would be needed for further processing; technical failure of the correlator or transport layers could be an obvious reason. Another reason could be that the astronomer wants to reprocess the data to obtain higher spectral resolution or a different phase centre for his observations. Finally, other scientific reasons for such reprocessing might exist, for example the availability of better source or geodynamic parameters. In the case of very special once-off events it may be desirable to keep a copy of the data for a much longer time, for example when monitoring a spacecraft landing on a solar system body.

1.1.4. NEXPReS scientific motivation

The proposed developments will make a huge impact on VLBI science; where EXPReS had the single objective to enable real-time VLBI, NEXPReS will reach the entire VLBI user community. The users will benefit directly from the improvements in reliability that NEXPReS introduces. In practice this means that they will get better data quality from their experiments, with more telescopes delivering good, error-free data for a larger fraction of the time. The importance of this is demonstrated by the popular saying amongst users that "getting bad data is worse than getting no data at all".

In addition, the new system will allow more efficient use of the telescope infrastructure as VLBI will no longer be limited by the complex logistics needed to make recording media available. This efficiency gain will result in more hours for science observations. It will in principle become possible to allocate VLBI time in a dynamic fashion, facilitating for example high frequency observations when atmospheric conditions are more favourable or simply postponing observations when specific telescopes are not able to observe due to bad weather.

Clearly, the proposed work will enhance the e-VLBI system for real-time observations, the branch of radio astronomy that focuses on transient sources. While new science themes have been addressed over the last few years, the observations have necessarily been compromised by the trade-off between real-time results and full sensitivity on unique transient events. By caching data at the telescopes, the NEXPReS project will be able to offer the best of both worlds: real-time results and full sensitivity. Providing this capability is one of the first objectives of the proposed Service Activities.

The proposed system will also enable new operational modes in other VLBI science areas. By having both a real-time component and the ability to process the recorded data at a later time, spectral line e-VLBI will become possible; currently this is not practical because not all the required high-resolution products can be formed at once. A very interesting application is the astrometric monitoring of Galactic maser sources, directly measuring the distance and kinematics of star-forming regions of evolved stars, through which the detailed structure of the Galaxy can be obtained. Other applications involve rapidly variable quasars and triggers of radio transients from other telescopes, e.g. LOFAR. Such observations could be carried out in a continuous programme with the smaller telescopes of the EVN if sufficient (distributed) correlator resources could be made available, as is addressed in one of the Joint Research Activities.

An important requirement for the associated demonstrations is the further automation of the entire VLBI process. A truly responsive and flexible array will need to be highly automated. The system will also allow re-processing of the data observed with improved correlator parameters, for example new source coordinates of a transient not available when the observations were processed in real-time. Based on the real-time results the data could be reprocessed with improved coordinates or other model components resulting in enhanced precision and sensitivity. All these new capabilities in this research infrastructure will be subject to the same open access policy that the EVN has adopted in the past; the facility is open for the best science proposal from anybody, irrespective of whether they are from the EVN member countries or not.

With sufficiently high capacity storage, one could even start considering archiving the original VLBI recordings. This would certainly happen for once-off events like the VLBI campaigns on solar system spacecraft. JIVE and VLBI telescope staff around the world successfully monitored the Huygens descent on Titan, yielding important data on the atmospheric conditions of this moon of Saturn. Similar experiments are envisioned in collaboration with ESA for future missions (e.g. BepiColombo, ExoMars, EJSM). This is one important area of scientific research where Europe can keep its lead over the US by expanding its e-VLBI capabilities.

But the most important scientific motivation of NEXPReS is to keep the real-time capabilities in step with the planned sensitivity upgrade of the EVN. The EVN is making a serious investment in its bandwidth and digitization equipment to reach 4 Gbps in 2010 and data rates up to 64 Gbps in the longer term. At the same time JIVE has acquired funding to start the development of a next generation, large capacity correlator. The work proposed in NEXPReS is absolutely crucial for the transport of the data in this new super-sensitive VLBI network. It will enable astronomers to study fainter objects and reach further into the distant Universe. Such a revolution of the

VLBI network is scientifically essential for high-resolution follow-up of new source samples that will be obtained with new telescopes such as EVLA, e-MERLIN, LOFAR and Apertif.

The increased bandwidth as well as connections to new stations must be implemented using dynamic methods. This topic is not only relevant for VLBI but also for the longer LOFAR baselines, which already share some connectivity with the higher frequency VLBI operations. Dynamically allocated connections will allow one to share this resource, not only between radio astronomy facilities, but with all scientific user communities.

The increasing data rates and data volumes produced by telescopes have a strong impact on the way astronomical research is done. The current operational model is that the astronomers themselves do the calibration and analysis of radio astronomical observations. For SKA and its pathfinder experiments this will change into a situation where the calibration and a large part of the image analysis has to be done by automatic processing pipelines running on specialised hardware, subsequently storing it at dedicated data centres. With the large, global facilities of the future, several such data centres will exist all over the world. Another impact of archive developments is that users can not only work on the data for which they requested the observations, but, in principle can access all suitable raw data that are present in the archive. Such re-processing implies additional large traffic of data from archives to data centres, and of new results back to the archive to be stored there. The infrastructure to be developed in the NEXPReS project, with dynamically allocated high bandwidth connections and storage buffers as local points of presence for scientific groups, will be used to demonstrate the capability to support this type of user interaction with the astronomical archives of the future.

Where in the past the e-VLBI activities developed by our consortium have concentrated on providing new capabilities for real-time science, the NEXPReS project will enhance the scientific impact of all VLBI observations. Clearly the envisioned system should have no problem to operate with the funding it will acquire on its (unique) scientific merits. The partners in the European VLBI Network have already shown serious commitment to adopt these new developments, for example by contributing telescope time and other resources for tests and science observing beyond the funded project. Transforming the EVN into a predominantly real time connected array has been discussed as a cornerstone in its future outlook and it can be expected that the work planned in NEXPReS will accumulate into an operational system in 2013 to be used for years thereafter. Although the development of computing, caching and connectivity is not known precisely, it is not hard to imagine that e-VLBI is not only superior in scientific capabilities, but also more economic.

Because of all of the above aspects, both LOFAR and the e-VLBI effort in Europe have been formally recognized as pathfinders for the development of the SKA telescope. As a continental-scale project, EXPReS has contributed to Europe's lead in the global SKA effort, both in R&D and science infrastructures. The work proposed in NEXPReS will allow us to maintain this lead and insures that Europe continues to have cutting-edge observational facilities at the same time that new large-scale pathfinder facilities (e.g. ASKAP, MeerKAT) are realised on other continents.

Not only will NEXPReS feed into the R&D of the SKA, but it is also our goal that some of the operational aspects of SKA and e-VLBI will be merged. In user support, data archiving and various other operational areas, there is, for example, an ambition to house services for both the European user communities of SKA and VLBI at JIVE. As both require serious infrastructure for computing, storage and connectivity we think the case for sustaining this infrastructure beyond NEXPReS is very strong.

1.1.5. NEXPReS activities

Several aspects of the caching mechanism will be addressed in the first Service Activity, WP5 - "Cloud Correlation". The focus will be on the development of a system capable of simultaneous buffering, transmission and correlation of data and making it available for operations from an early stage on. This could be done, for example, by inspecting part of the data from normal VLBI observations in real-time, yielding important feedback on the network performance in all experiments. The early deployment of buffering at the stations is also extremely important for the class of so-called "Target of Opportunity" (ToO) observations, which are currently already done in e-VLBI mode; a caching mechanism will enable these to make use of the real-time results without compromising the final sensitivity and image fidelity.

The other crucial improvement that VLBI must make is upgrading its sensitivity. While the EVN is actively implementing new digital components to enhance its acquisition system, partly based on results from the EXPReS Joint Research Activity FABRIC, the needed connectivity enhancements are addressed in WP6 ("High Bandwidth on Demand”). Up to now, operational connectivity has been based mostly on static connections, often dedicated lightpaths between telescopes and correlators or links shared with LOFAR. In NEXPReS these connections should become dynamically allocated, freeing up the resources when there is no ongoing e-VLBI. The fact that we are implementing a caching mechanism for the scientific operations fits this mode of operation. At the same time it is the way forward to access more and more bandwidth.

We propose two Joint Research Activities in NEXPReS. The first will focus on distributed computing. In FABRIC we explored distributed software correlation based on Grid computing. An important result from this activity has been the establishment of functional correlation software that runs on standard computing platforms, such as Linux clusters. At the same time other VLBI centres have developed and deployed software correlators too. However, the required transition of Grid standards to allow real-time scheduling has not occurred. Our team has concluded that the viable implementation of software correlation has to happen in the radio astronomy domain. With the computing resources some of our partners have, a distributed correlation system will be tested that can cater for some small-scale astrometric and monitoring campaigns. This “Computing in a shared infrastructure” will be addressed in WP7.

The second Joint Research Activity, WP8 (“Provisioning High-Bandwidth, High-Capacity Networked Storage on Demand”), will focus on the methods for fast storage and caching that e-VLBI of the future requires. Such systems are not just relevant for VLBI operations, but also for storage of the output of the telescopes of the future. The SKA and SKA pathfinders will produce vast amounts of data per day. These will need to be made available world-wide; for some time-critical applications access in real-time will be needed. This aspect will be researched for the Apertif and LOFAR projects.

While the Service and Joint Research Activities address aspects that are new compared to EXPReS, it is important that the Network Activities provide continuity for our interdisciplinary collaboration. WP2, the EVN-NREN forum, will continue to be the place where network providers meet with operators of VLBI and LOFAR telescopes and correlators to discuss matters of connectivity and protocol. This highly successful platform will also be the place where connections to new stations will be discussed and planned.

NEXPReS also calls for a review of the operational procedures in the EVN and Global VLBI arrays. The e-VLBI Science Advisory Group (eVSAG, WP3) will continue to advise the EVN on adapting the procedures in the EVN to the new technological possibilities. In the past eVSAG mostly considered policy options for real-time science. In the future we expect the focus to shift towards operational issues, such as implementing dynamical scheduling and procedures for deciding whether certain observations require additional correlation passes.

Continuity is also important for the efficient management of the NEXPReS office (WP1) and the outreach office (NA4). Both these take shape as Network Activities and will be based on the existing EXPReS implementation, with their centre of gravity at JIVE. Not only has this office been extremely successful in implementing, monitoring and reporting the progress in e-VLBI, it has played an absolutely crucial role in connecting the astronomy community to the networking and computer science community. As a relatively small organisation with a specific mission in radio astronomy, JIVE normally does not have the resources to allow specific outreach on subjects such as technological advances.

1.1.6. Relation to the call

Although some of the organisation of NEXPReS builds on previous experiences in FP6, we stress that it reaches for new technological goals, has broader scientific objectives, and most importantly, is expected to reach a larger user community.

Addressing the specific objectives of the INFRA-2010-1.2.3, Virtual Research Communities, call it should be recognized that:

- We attribute the highest possible value to the multi-disciplinary nature of our existing and proposed collaboration. The success of EXPReS has been the intimate linking of the astronomical community with network providers. This project will bring more network and computing experts into the astronomy domain, which is absolutely crucial for future radio-astronomical facilities. It is very important that Europe continues to foster this cross-fertilization. In addition, the e-VLBI application in its proposed form will continue to push the edge of technology, not only in networking but also in streaming computing and fast storage techniques.

- Clearly the proposed work-programme aims to implement new services to increase the scientific capabilities of the VLBI networks. The proposed software services will greatly enhance the capability of VLBI telescopes to operate as a single facility. In addition it will be an important step in establishing a truly global real-time VLBI facility, ensuring world-class science for the next decade.
- The collaboration of radio telescopes to form a continent-sized virtual telescope is an almost classical example of how remote sensors can be combined into a large-scale research infrastructure. We want to secure the network itself as a dynamic component of this facility and add a storage component to enhance the operational characteristics. By connecting components in real-time we create additional scientific capabilities, and open the way towards higher sensitivity.
- The proposed work is absolutely essential for the continued existence of the real-time VLBI facility in Europe, as it will allow us to turn the whole network into an e-Infrastructure. In the long run this will be the most economic and green option for doing VLBI around the world and as such it is an important stepping-stone for science facilities of the future. Astronomy has an important role in showing mankind its origin and role in the cosmos and attracting young people to science. Pushing the technology of this field of science will benefit Europe's scientific and economic potential.
- VLBI is a bottom-up international collaboration between radio-astronomy services around Europe and the programme will allow the partners to offer a world-leading e-VLBI service centred on the European infrastructure. By enabling new services also relevant for LOFAR and other new radio-astronomical facilities, it will continue to give astronomers access to a world-class facility.

This latter point is particularly relevant in preparation for the SKA, the radio-astronomy facility on the ESFRI list. Without a central European body for radio astronomy, the collaboration that has given Europe a leading edge in the definition of the SKA has in fact started from the collaboration in VLBI. JIVE is the only legal entity in this domain that is truly international in nature. Long baseline interferometry, not only in the form of VLBI but also in e-MERLIN and LOFAR, is the area in which Europe can do world-class science. Therefore we are convinced that the proposed programme is relevant for strengthening the scientific, technological and organisational programme leading to the SKA.

B 1.2 Progress beyond the state of the art

The proposed Service Activities will push the existing operational VLBI infrastructure beyond the current state of the art. Currently EVN operations are implemented in 3 sessions of dedicated observations using mostly conventional disk recording, augmented with more frequent "e-VLBI days" for real-time science. Thus, e-VLBI is limited to a selected set of user experiments, mostly those requesting real-time results. Although e-VLBI has the potential to deliver high-quality data with greatly simplified logistics, there are a number of limitations (transport capacity, number of on-line telescopes, correlator capacity) that prevent the use of e-VLBI for every experiment. Moreover, when the digitized bandwidth increases, there is a possibility that even for transient sources we will have to revert to recorded VLBI in order to deliver the maximum data rate and corresponding maximum sensitivity.

A large number of developments in radio astronomy are currently ongoing. In the USA, the completely refurbished EVLA is now the most sensitive short-baseline radio interferometer in the world. In Australia and South Africa SKA precursors are being built, called the ASKAP and MeerKat telescope arrays, which will provide extremely wide fields of view but limited bandwidth in the case of the ASKAP, small fields of view with much higher bandwidths in the case of MeerKat. In the UK, the eMerlin facility will provide high bandwidth and sensitivity on baselines up to a few hundreds of kilometers. LOFAR, located mainly in the Netherlands but with outstations in several European countries (often referred to as eLOFAR, or International LOFAR Telescope (ILT)) , will observe at hitherto unprobed low frequencies using the sparse aperture array technology. The focus of the EVN in the coming years will be on long-haul high-bandwidth data transport, which combined with transparent and flexible buffering will further enhance the real-time rapid-response capabilities developed in EXPReS. Its global baselines and high frequency range already place the EVN in a unique position with respect to existing radio-astronomical facilities, and increasing not only the bandwidth and sensitivity but also the frequency capability of the network will only strengthen this position.

The work proposed in WP5 ("Cloud Correlation") is required to make optimal use of the excellent connectivity infrastructure and large telescopes that exists in Europe. Offering caching of the data-streams, all VLBI experiments will benefit from the increased robustness and flexibility that our Service Activities will provide. By transforming the complete VLBI observational chain it will introduce better efficiency and enable new operational modes with a direct impact on scientific capabilities. Most importantly the users will benefit from improved data quality and eventually the reduced logistical burden. This is an essential next step in the virtualization of the VLBI infrastructure.

The deployment of the shared, networked e-VLBI infrastructure appears to be successful already. However, the success achieved in EXPReS is based on heterogeneous connections, which will need to be upgraded as the infrastructure matures. Service Activity WP6 (“High Bandwidth on Demand”) focuses not on connectivity, but on the methods to effectively use existing connections and efficiently utilize the greater network infrastructure. By implementing bandwidth on demand (BoD) mechanisms NEXPReS will investigate how the e-Infrastructure can move away from the current situation in which static links are used. Static links are stable, effective and reliable, but are an inefficient allocation of the scarce international network infrastructure. BoD should provide a mechanism by which the shared infrastructure can be used more efficiently while providing maximal network capacity when needed. This will help the ongoing drive towards connecting more telescopes at ever increasing bandwidth by providing a rational use case. Such a use case will be relevant not only for the telescope operators, but also for other users of the infrastructure.

In the end, increased bandwidth between telescopes and correlator constitutes the most important improvement beyond the state of the art in radio astronomy, as increasing the bandwidth directly improves the sensitivity of the VLBI array. This development will be absolutely vital for maintaining the status of the EVN as the most sensitive VLBI array in the world. Introducing a continent-wide and even worldwide array with BoD methods will place recently demonstrated connectivity techniques into the operational domain for the very first time. As before, VLBI can be the showcase application for the demonstration of new networking techniques.

The work in the Joint Research Activities explores the options for developing the VLBI e-Infrastructure even further. WP7 (“Computing in a Shared Infrastructure”) focuses on permanently available arrays that will address new areas in science by deploying distributed correlation. We propose to develop methods, which will require high performance computing in real-time, using computer clusters that are available at radio-astronomical centres. This will be relevant for Grid processing, which currently is oriented towards the (strictly non-real-time) batch processing of single user applications. The methods that will be developed in this context will be applicable for real-time Grid applications in other areas.

In WP8 (“Provisioning High-Bandwidth, High-Capacity Networked Storage on Demand”) we propose to invest in the development of a high capacity, high-speed storage system tuned to the needs of radio astronomy. From an application’s point of view, one way to simplify the shared e-infrastructure is to view it as a combination of computational, network and storage resources. At the moment, the storage component is the weakest, both in terms of overall capacity and performance. While not trivial, one can contemplate the deployment and use of 10 Gbps network connections and their associated compute points. However, for applications like e-VLBI, the data-rate/compute ratio is such that storage systems become the limiting factor.

WP8 will investigate ways in which a high capacity, high performance storage system can be integrated into e-VLBI operations. As 4 Gbps receivers are to be deployed in the near future, the storage system will need to be able to simultaneously read and write at these speeds at the very minimum. The end goal will be a system that can act as a network line speed (10 Gbps) buffer. This means that a system will have to be developed which can simultaneously write a 10 Gbps data stream, transmit part of or all of this stream in real-time, or delayed, to a correlator operating in real time, and read the whole data stream at a lower rate to a correlator with insufficient real-time capacity. The development of such a system, not commercially available at this time, will certainly be of great interest to other demanding applications. The storage system should be integrated into the existing e-VLBI operations, effectively hiding the details from the end-user. It will be defined as a standard platform, which will be folded into the latter stages of work packages 5 and 6.

In addition to dynamic storage, WP8 will also investigate the needs of longer-term storage as they relate to dynamic usage of the data. For the radio telescopes of the future worldwide, distributed data nodes will be required, without compromising the access speed for scientific users. The required performance is of the same order of magnitude as that needed in VLBI. Therefore the work package will also address more general issues in distributed storage that are relevant for a larger class of scientific problems, starting with bandwidth and data life-cycle aware allocation of large user data structures for future radio telescopes. Once in place, the system will be applicable to other fields and use cases.

B 1.3 Methodology and associated work plan

B 1.3.1 Methodology

NEXPReS is a programme in which 15 institutes cooperate. Compared to the FP6 EXPReS project, the programme has moved from a focus on connectivity of remote telescopes to dynamic allocation of resources for networking, storage and computing. The expertise to accomplish these new objectives can largely be found in a subset of the original EXPReS partners. This way the implementation of this Integrated Infrastructure Initiative will greatly benefit from the effective structure that was established in the EXPReS project. While shifting towards new areas in technology, the proposed project is also a necessary step to consolidate the highly successful collaboration in the area of VLBI that it created. In the past, the establishment of interdisciplinary forums has proven to be the key ingredient for successfully introducing new operational e-Infrastructure facilities. This is the reason that, while the Service Activities and Joint Research Activities have new topics and address new technological issues, the Networking Activities remain largely identical and have the same objectives and leadership as before.

The EVN has a long tradition of bottom-up collaboration, starting in the early seventies of the last century. By necessity collaboration in VLBI was initiated even before such partnerships were deemed to be politically desirable, a fact also demonstrated by the long-standing collaboration with China. JIVE was established in 1996 in order to catalyse the necessary collaboration in operations and user support. Technological developments are more evenly distributed within the EVN, with expertise in many areas being contributed by all partners. The EVN has proven to function extremely effectively in this distributed model, with JIVE taking on some of the central responsibilities.

This same structure is reflected in the NEXPReS proposal; central coordination, management and outreach are implemented at JIVE, while the leadership of the other Network Activities is shared with experienced officers from other partners. Similarly the Service Activities that interact with the operations of the network and the EVN correlator are largely run from JIVE. Following the usual EVN model, the other partners contribute their expertise to the technology development in the Joint Research Activities.

The VLBI community has proven many times in the past to be able to successfully collaborate in such distributed enterprises. Contacts on a personal level have been absolutely essential in small, joint projects and, as a consequence, the technicians of the EVN have often known each other personally for many years and meet regularly throughout the years. The success of the collaboration in e-VLBI and other innovative radio astronomy projects (e.g. LOFAR) can also be attributed to the fact that we have always been able to bring new people with new expertise into our system.

The work in the Joint Research Activities is largely divided into tasks that can proceed relatively independently, following the above practices. By identifying capable managers that control the project process, but also have in-depth knowledge in the relevant areas, we are confident that we can address any upcoming issues. The work in the SAs is a bit more complex in the sense that it aims to offer and improve new operational services over the duration of the project. These activities must therefore be directly integrated in the operational environment that is mostly concentrated at JIVE. Although it is a challenge to introduce new methods without disturbing the ongoing VLBI campaigns, such an operation has been carried out by the same team successfully with the introduction of e-VLBI, retrofitting a large number of components without ever jeopardizing the ongoing operations. Both leaders of the SAs have also responsibilities in EVN operations and are used to working closely together, which will be necessary considering the existing interdependencies between the two SAs.

NEXPReS will continue the pattern of open science and open source development that is common in the scientific community. Non-project members will have visibility into the project and have the opportunity to comment (for example through eVSAG and EVN-NREN meetings). Software will be created with a preference to open source software licenses for new code when possible. More over, publications on the progress of the project should be accessible to the public community. These three factors provide the opportunity for peer review and community support as the project proceeds. The NEXPReS Consortium Agreement will be based on the DESCA template http://www.desca-fp7.eu/ and the foreground will follow EC-GA Article II.26. - Article II.29 with the following additions given in the May 2008 Version 2.0 copy of the DESCA Template.

The role of the management in this is largely that of facilitating the work. Although professional tools are available to steer the project, the emphasis is on monitoring progress and providing help when problems are encountered. There are several understood points of risk that the project believes can be addressed.

First, there may be limited availability of high bandwidth data acquisition systems and correlators. We note that the dBBCs are in production, have been ordered at many stations, first generation 4 Gbps DAQ available for prototyping. Further, next generation EVN correlator is under development (UniBoard, ExBox). Finally, VLBI operations can still be tested with few systems.

The limited availability/affordability of 4-10 Gbps connections is a concertn, but the availability of R&E as well as commercial 100 Gbps technology should rapidly decrease costs. The 100 Gbps are currently in test internationally and will be deployed over the next few years.

The adoption rate of BoD within Europe is partially out of the project's control. However, DANTE and several NRENs with particular interest in BoD service are involved as partners in NEXPReS; this ensures that we will be able to demonstrate BoD integration with at least a subset of the European telescopes. Further, the maturation of BoD will help address the cost and availability concerns raised in the previous paragraph.

Finally, the widespread, full-fledged adoption of continuous, buffered e-VLBI may be initially too costly. However, the VLBI community persists over long periods. All needed mechanisms, tools, soft- and hardware can be developed; deployment can occur in a phased, multi-part roll out. While EVN investment in existing disk pool is being depreciated and components become cheaper. It is important to note that the JIVE Board has endorsed and backed JIVE's participation in this project. JIVE's Board has a large overlap (~80%) with the EVN Board. Further, many of the partners in NEXPReS are also participants in JIVE and the EVN, either directly or via close professional cooperation. These communications and support have been established prior to the submission of the proposal to ensure that all parties understand, agree upon and support the project both as a standalone action as well as for its pace in the larger set of activities in the field of astronomy.

B 1.3.2 Networking Activities and associated work plan

Please refer to WT3: Work Table Description for a detailed overview of all networking activities (work packages 1 to 4).

B 1.3.3 Service Activities and associated work plan

Please refer to WT3: Work Table Description for a detailed overview of all service activities (work packages 5 and 6).

B 1.3.4 Joint Research Activities and associated work plan

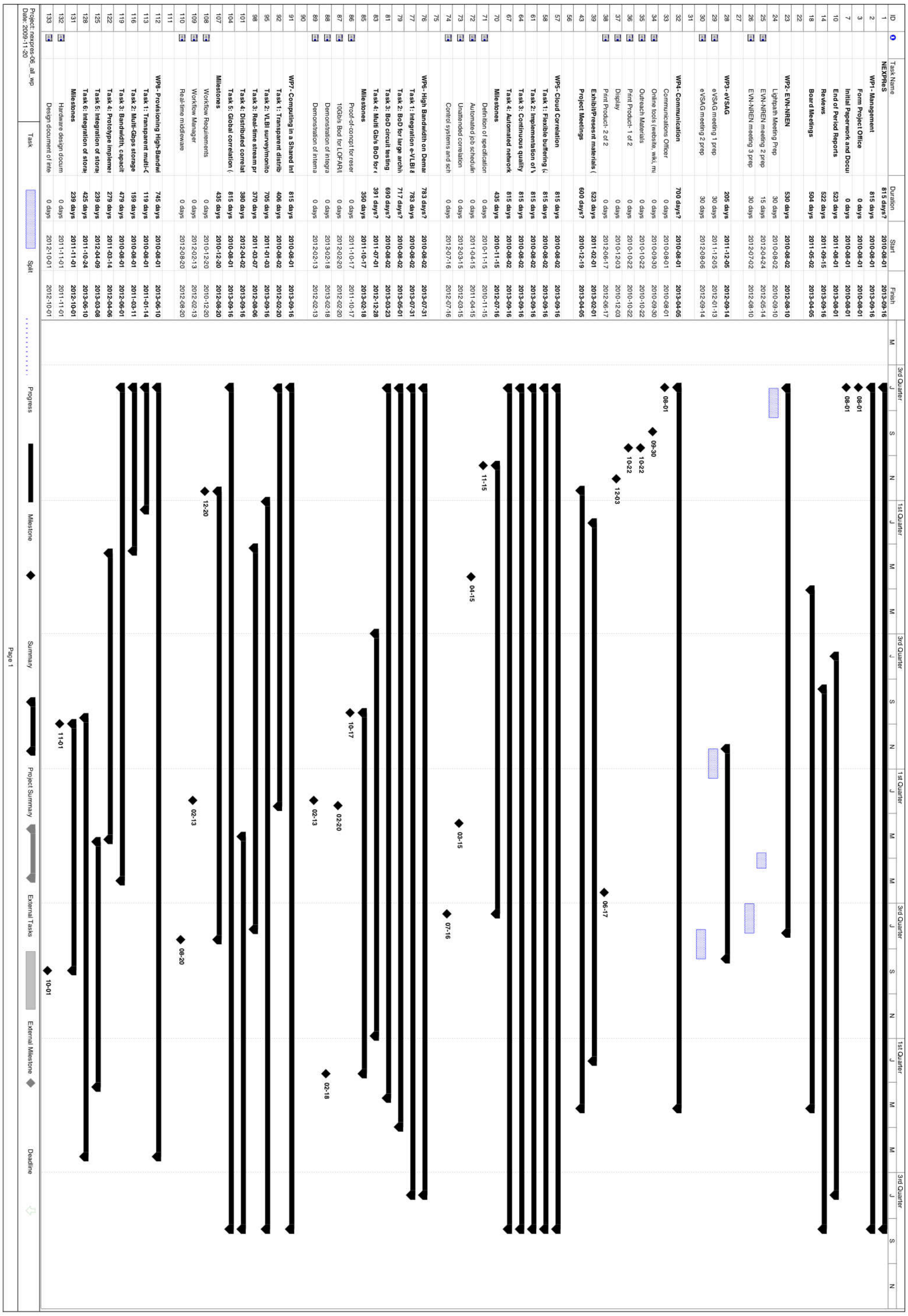
Please refer to WT3: Work Table Description for a detailed overview of all joint research activities (work packages 7 and 8).

1.3.5 Overall strategy and general description

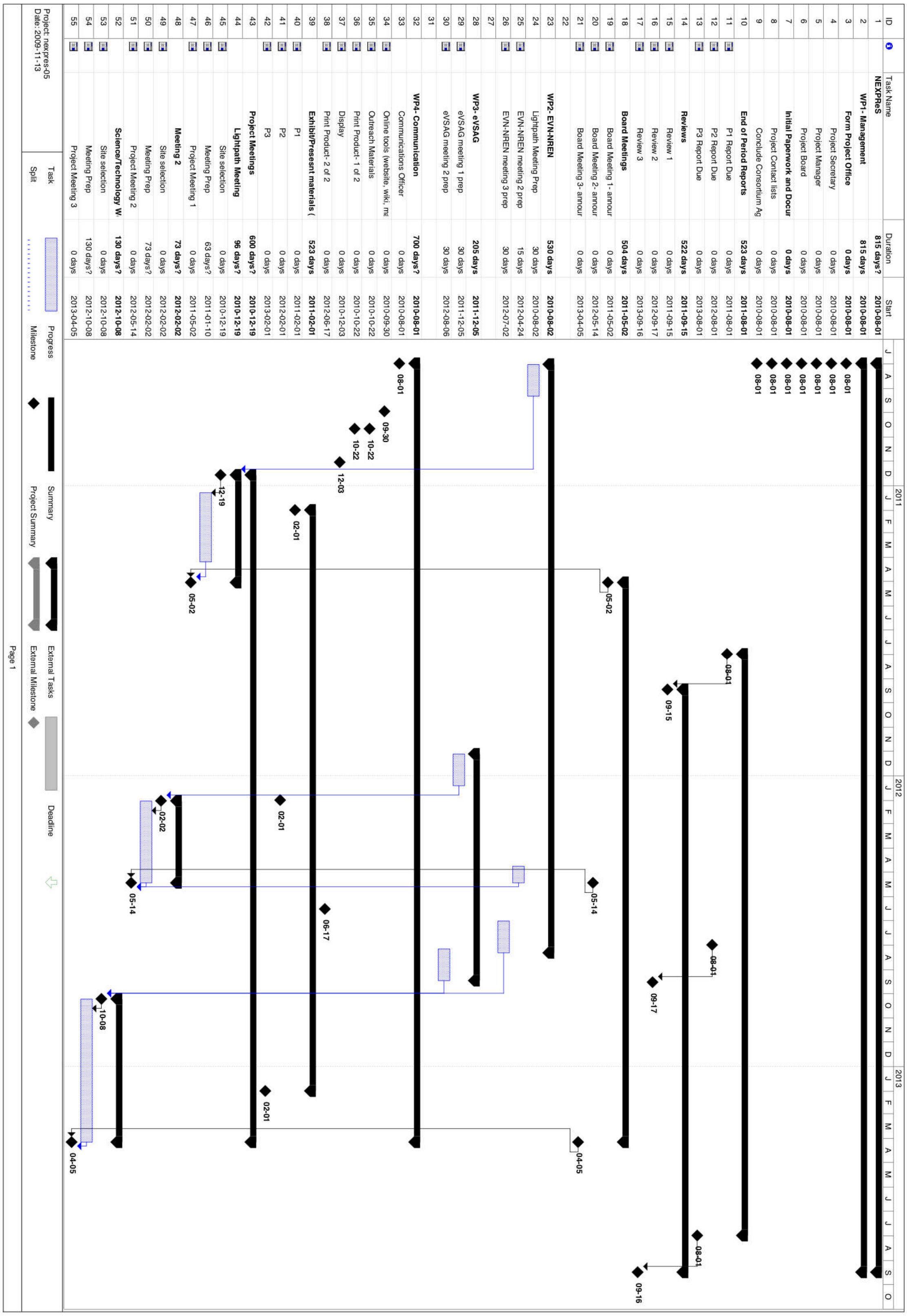
Summary of staff effort is provided in WT6: Project Effort by Beneficiary and Work Package.

1.3.6 Timing of Work Packages and their components

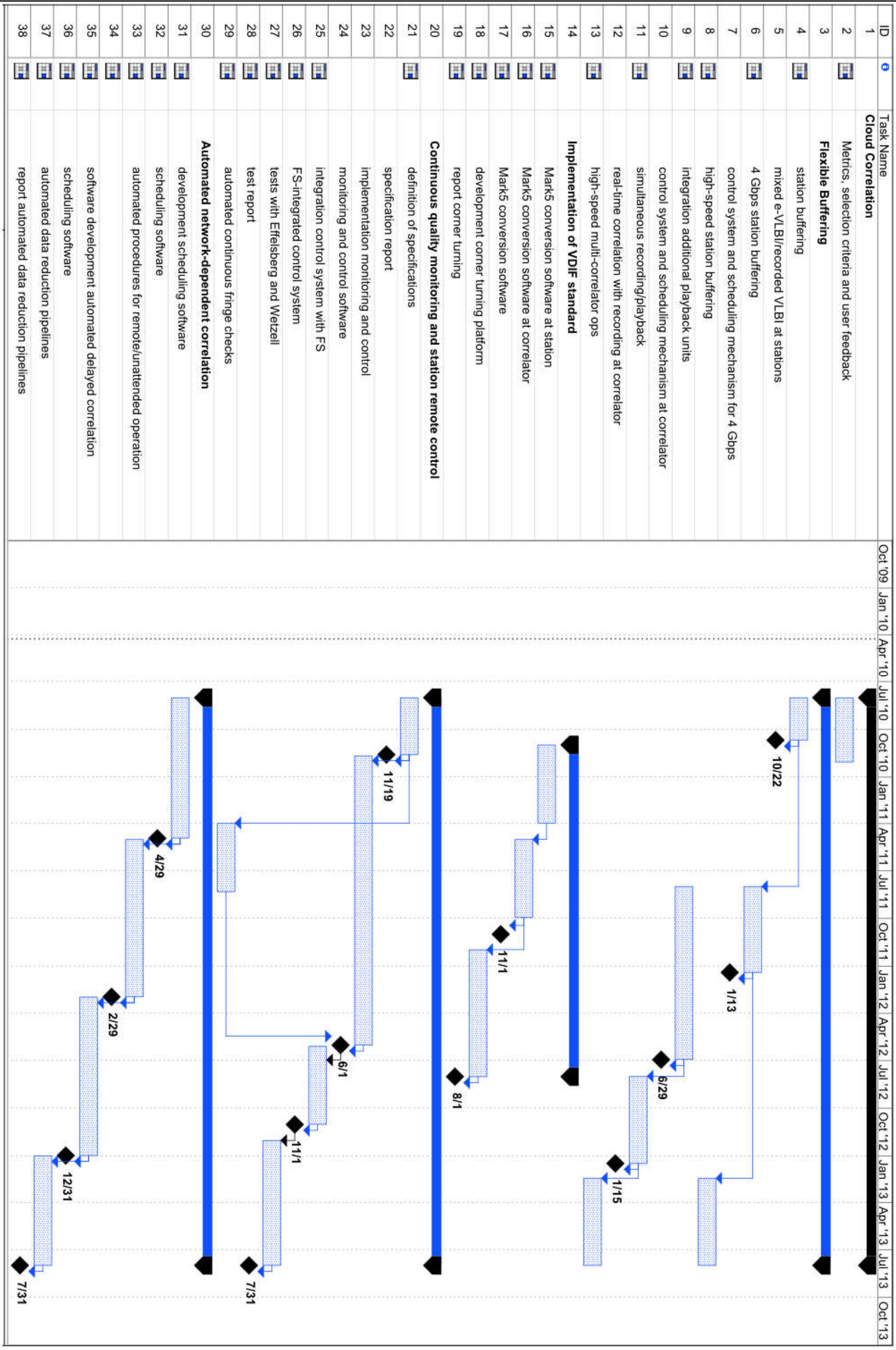
For a list of work packages, please see WT1. Please refer to WT2: List of deliverables for an overview of deliverables and their timing. As a guide, the following pages contain summary views of Gantt charts for the work packages 1-4 (combined) and then the subsequent four work packages individually.



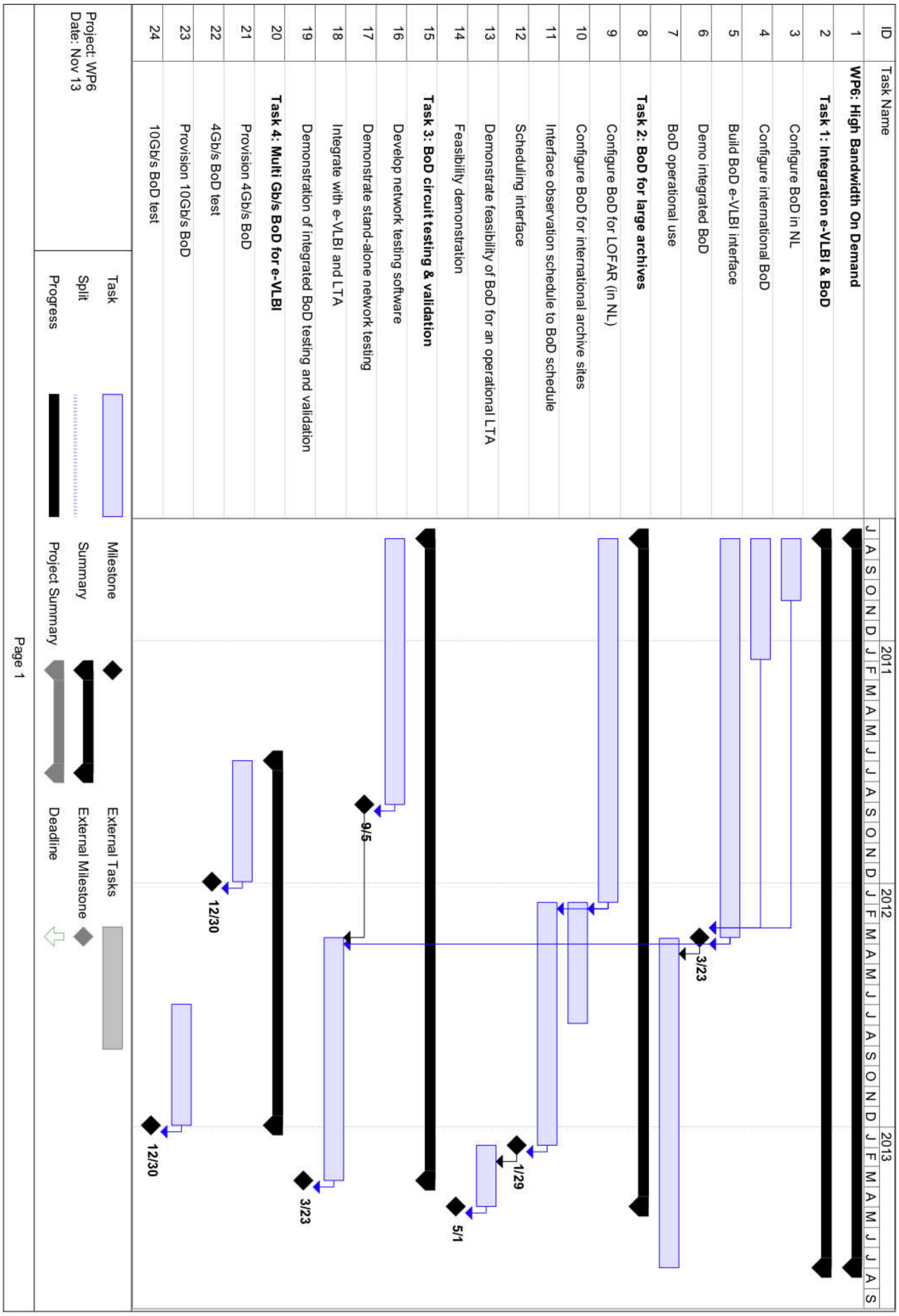
Overall Project Gantt Chart.



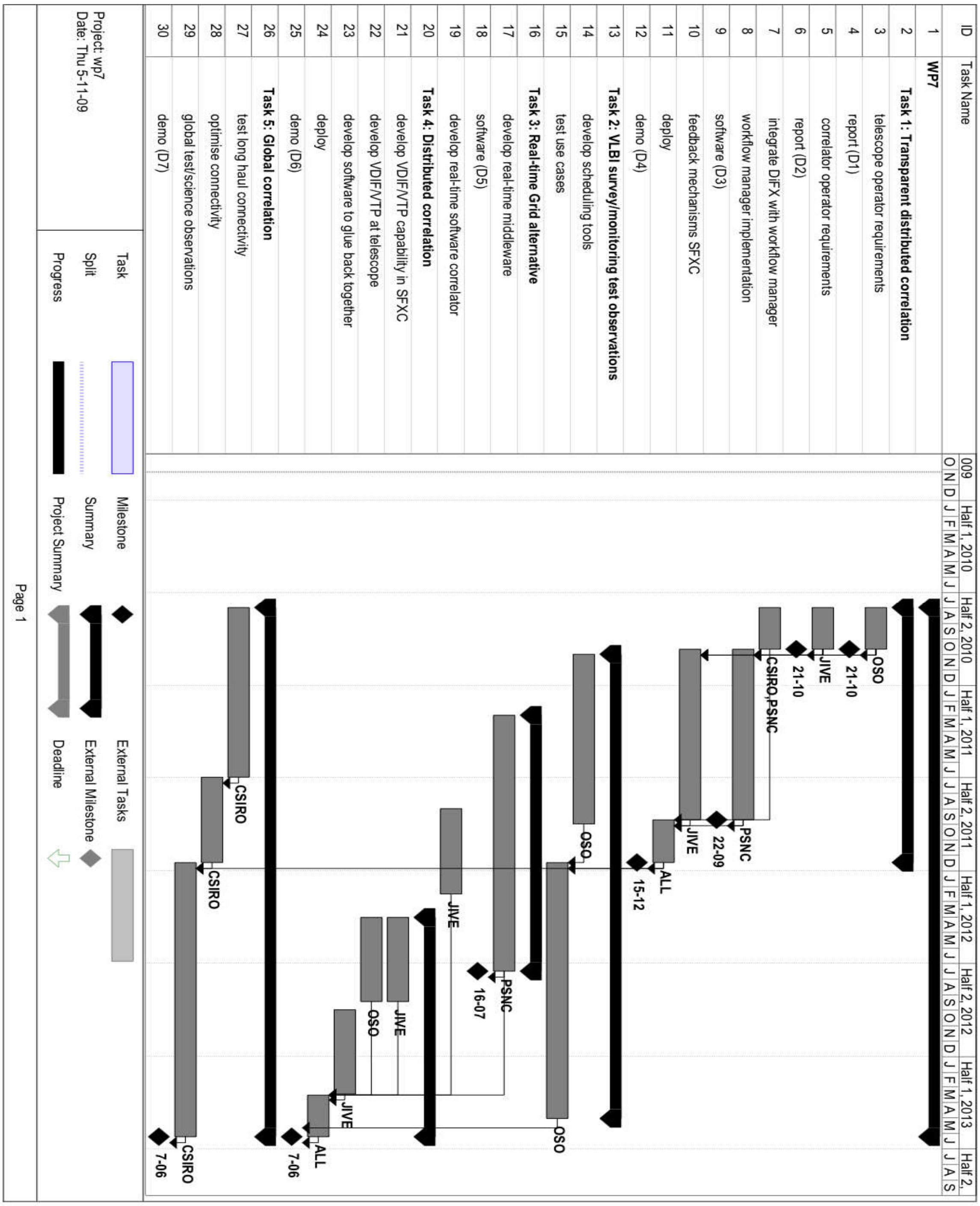
Gantt Chart for WPs 1, 2, 3 and 4



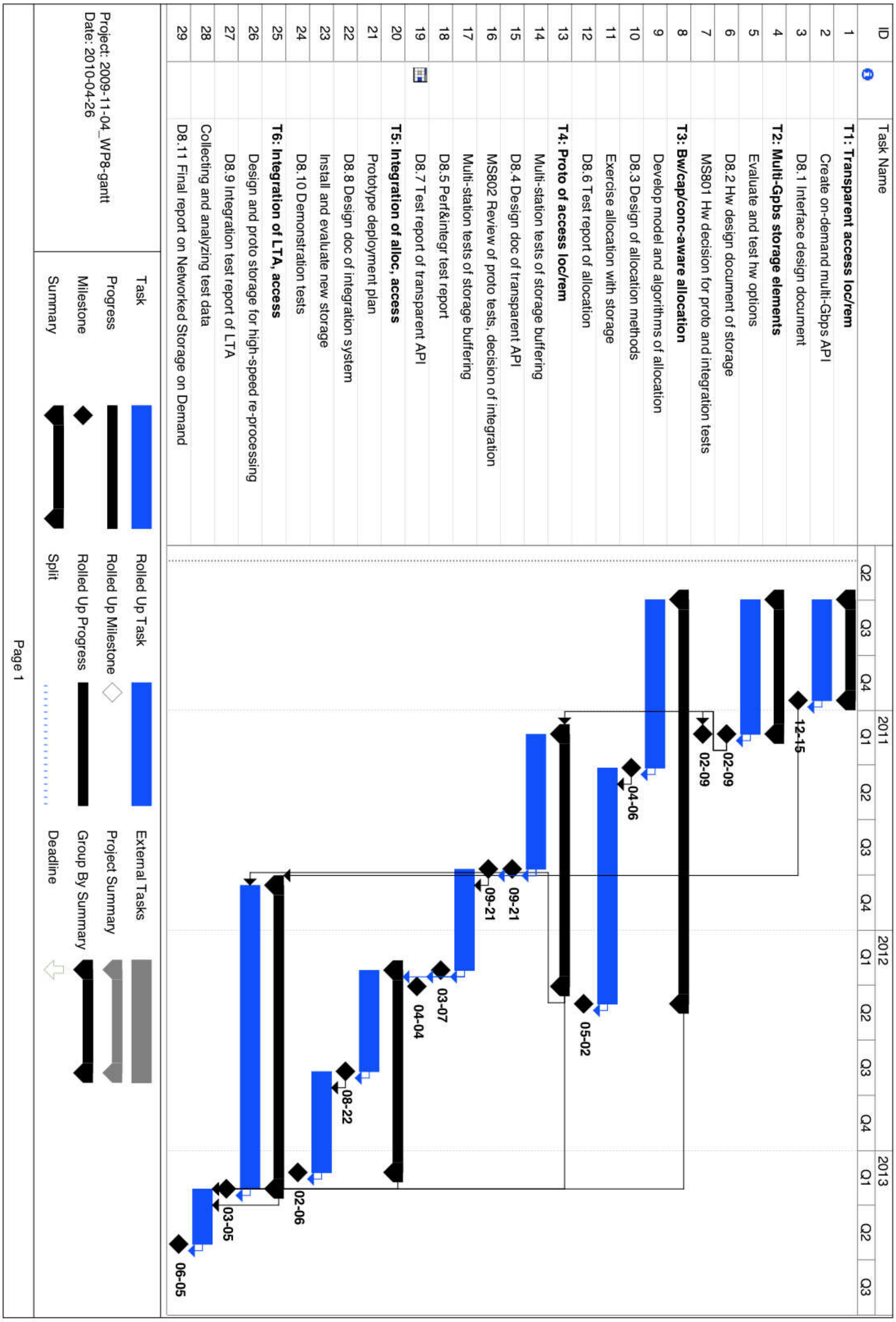
Gantt chart for Service Activity, WP5



Gantt chart for Service Activity, WP6



Gantt chart for WP7



Gantt chart for WP8

B 2. Implementation

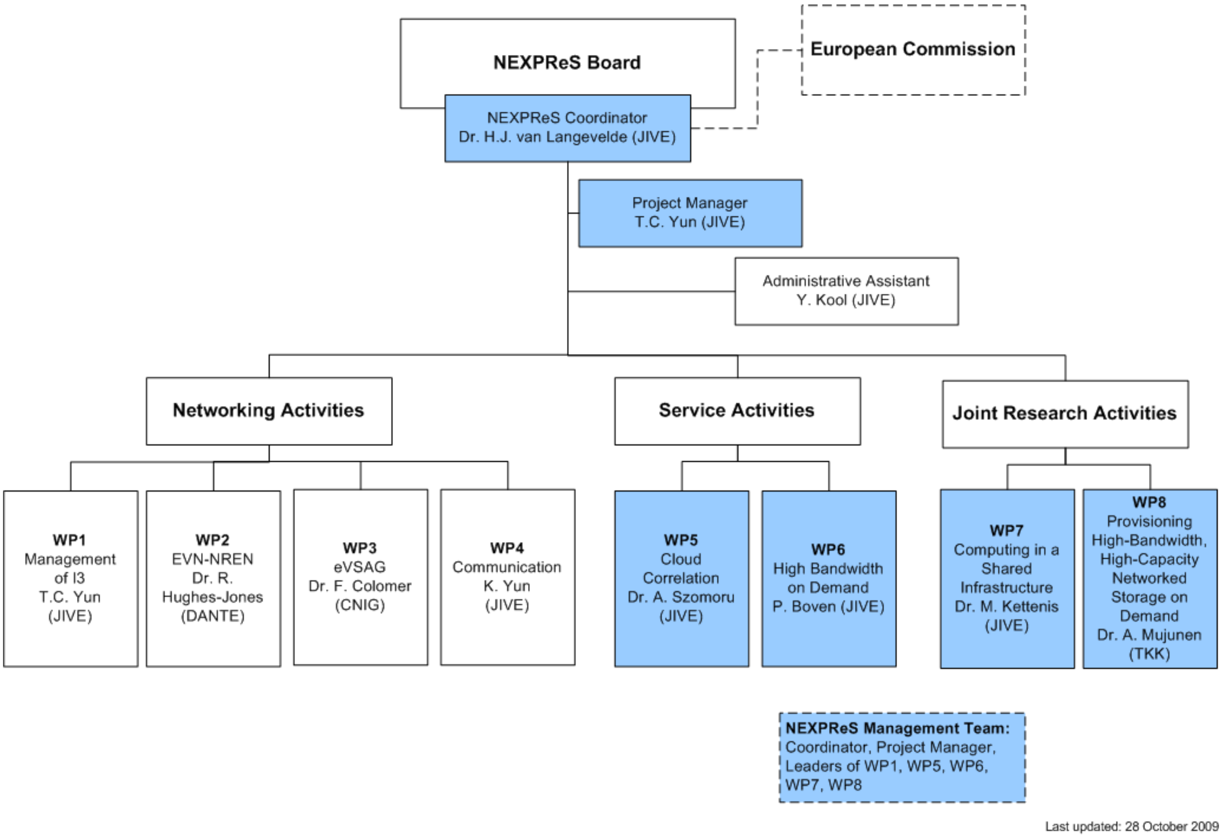
B 2.1 Management Structure And Procedures

2.1.1 Overview

The NEXPReS Project is a partnership between 15 astronomy, networking and computing institutes, which bring a wide range of skills and expertise to the project. The way project partners participate in NEXPReS is laid down in the Consortium Agreement, which defines the participating parties, the structure of the project as described below and additional rights and responsibilities.

The consortium is led by the Project Coordinator (PC), Huib Jan van Langevelde. The Project Office is located at JIVE in the Netherlands. The PC, ultimately responsible for the activities of the project, receives guidance from the NEXPReS Advisory Board (the Board) and carries out actions via the Management Team (MT).

The Board consists of one representative from each of the project partners. Each of the board members will be able to make decisions related to the Project on behalf of their institute. From the Board, a Chairman and a Vice-Chairman will be selected. The Chairman's responsibility will be to chair Board Meetings and officially ask the Board to vote on matters pertaining to the Project. At the start of the project, the PC will act as Chairman pro tem. At the first board meeting, the Board will approve a Chairman and Vice-Chairman. Both the Chair and the Vice-Chair will serve 18-month terms.



NEXPReS Organogram highlights inter-project relationships and the project's relationship with the EC

The purpose of the Board is to identify common ground and work through consensus. In the case where consensus cannot be reached, the Chair can call for a vote. All Board voting will be decided by a simple majority. Any member can request that the vote be held via private ballot. The PC will cast a vote only to break ties. Board members who cannot attend meetings can abstain or ask another board member to cast their vote by writing to the PC in advance of the meeting. Meeting quorum will be two-thirds of the full Board, including proxies/abstentions.

The Management Team consists of the PC, representatives from the Work Packages and the Programme Manager (PM). The leader of WP1-Management of Consortium will represent all four of the Networking Activities. The remaining four work packages (two Service Activities and two Joint Research Activities) will be represented by the respective WP leaders. The MT will work towards the fulfilment of the requirements of the project and act upon decisions of the Board.

The leaders of each WP are responsible for relaying information from the PC and the Board to the partners while providing information on the partners' activities to the Project Office. The activity leaders are responsible for collecting and providing WP deliverables to the Project Office. They also prepare their respective portions of the period reports. WPs are further subdivided into tasks. Tasks compartmentalize work and provide a way to track progress and report on activities that are not tightly linked to one another.

The selected organizational structure closely matches the way in which work is pursued and completed within the project. Regular meetings between WP leaders as well as between all participants will help distribute information.

2.1.2 Finances

The Project Office will receive funds from the Commission on behalf of the entire project and distribute them within the project as outlined in the contract and further clarified by the Board. Each institute will be submit financial documents outlining their costs along with audit certificates as required by EC regulations in order to continue their financial participation in the project as defined by the contract. WP leaders will gather financial information at the WP level and provide it to the Project Office where it will be consolidated to provide a project level overview. The Project Office will monitor the spending of the project as a whole and may propose budgetary changes to the board when these are deemed necessary to meet the objectives of the programme.

The Project Office will maintain a 15% contingency fund to be used at the discretion of the Board to address unexpected events. The expectation is that pre-financing will be distributed in full, with successive distributions dependent on the financial claims provided by each partner over the course of the project. In most circumstances, all funds will be distributed to the project members as outlined in the proposal.

2.1.3 Project Communications

The Project will have multiple types of communication directed both internally and externally. These communications will be organized and managed by the Project Office, mainly via WP4 (“Communications”). Centralizing the organization of meetings will help spread information between parts of the project that do not naturally collaborate, as well as record the activities for reporting.

Externally, communications will fall into two main categories: official communications with the Commission and general communications to the community (research or general public). Commission communications will be defined in the contract, and include regular reports and updates, including annual period reviews. The period reviews will include descriptions of activities as well as financial reporting. Non-Commission communications will be pursued both in an organized manner via known channels as well as opportunistically. The community has fostered a small but growing list of contacts in the general press; scientific and research communication paths are well known and will be used. The project will be accessible for interested parties by a web site with internal communications shielded from the public.

Internally, the project communications will be organized around a set of recurring events. The most obvious are the period reviews. The entire project will be mobilized to produce the required documentation for the reviews including input from the Board via the Board Meetings held prior to the report's submission. Besides the reviews, all-hands meetings and smaller WP-centric or small-group focused meetings will be planned. These will be held off-cycle to ensure that additional communications occur throughout the project period. The Project Office is planning for several larger meetings in which a majority of the project partners will participate:

- Kick-off Meeting
- Board Meeting (annual)
- Network Lightpath Technology Meeting
- End of project Science and Technology Meeting

We expect that several of these meetings can be co-located to ensure increased attendance. Some of these meetings may also be converted to telecons or vidconfs if it is determined that they will be equally productive that way. In addition to the larger person-to-person meetings, the WPs will have regular communications via telecons, vidconfs and mailing lists. The Project Office will not insist on the reporting of the actions of every meeting, instead it will urge that smaller meetings be tracked and announced centrally so that their occurrence can be cross referenced against mailing lists and other existing communications. The project will maintain a collection of all minutes, deliverables and reports on-line.

We also expect partners to participate in a variety of meetings not organized by the Project. The Project Office will collect and track the presentations given at these meetings.

2.1.4 Interaction with Other Projects

NEXPReS resides at the nexus of activities (research and operations) as well as of communities (astronomy, networking, computing, storage). NEXPReS has dedicated forums in the form of WP2 and WP3 for communications with the NREN and EVN operators. Additionally, NEXPReS will interact with other projects (RadioNet, EuroPlanet, PrepSKA) and facilities (LOFAR, Apertif and other SKA pathfinders) to help identify the processes and technologies that will be most useful to the progress of radio astronomy. Some of these interactions occur naturally when scientists and engineers present their findings at meetings and conferences, or when progress reports on e-VLBI are given at (board) meetings of other projects. Occasionally meetings of different projects will be scheduled to take place at the same venue. There is a strong commitment to exchange experiences and good practices in the astronomy community. Several organizations have submitted letters of support indicating their interest in and support for the goals of NEXPReS. These letters are included with this report as an appendix.

B 2.2 Governance and Service Models

NEXPReS will be organized in a manner consistent with other project in the community. A Board, comprised of one representative from each partner in the project, will set the overall direction of the project. The Board will select a chairman who will ensure that the Coordinator implements the decisions of the Board. The Coordinator will be charged with carrying out the desires of the Board and ensure the proper functioning of the project (e.g., distribution of EC funds, reporting to the EC). The Management Team, comprised of the Project Manager and the activity leaders for WP5, WP6, WP7 and WP8, supports the Coordinator in the oversight and control of the project. The details of the interactions between the Board, the Coordinator and the partners are defined in the Consortium Agreement signed between the partners of this project.

B 2.3 Beneficiaries

2.3.1 JIVE

JIVE was created by partners in 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, and funded by nine national research councils and national facilities: Netherlands Organisation for Scientific Research (NWO), Science and Technology Facilities Council (STFC), National Institute for Astrophysics (INAF), National Astronomical Observatories, Chinese Academy of Sciences (NAOC), Onsala Space Observatory (OSO), National Geographical Institute (IGN), Max Planck Institute for Radio Astronomy (MPIfR), Netherlands Institute for Radio Astronomy (ASTRON), and National Center for Scientific Research (CNRS). Although it is established as a Foundation under Dutch law, it is a the only European legal entity in cm radio astronomy. Serving as the central node for the EVN, it is foreseen that JIVE will be transferred into a European Research Infrastructure Consortium (ERIC). 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 technologies for VLBI (both hardware and software), (iv) advance VLBI observing techniques and applications; (v) conduct cutting edge scientific research using VLBI and other astronomical facilities. JIVE staff are also active in supervising both PhD students at Universities and local postdocs. JIVE has built up considerable expertise in managing and administrating (European) projects on behalf of the EVN, in line with the original motivations for the establishment of the institute. For example, the link with Space science, which resulted in spectacular VLBI results during the Huygens landing on Titan, was initiated at JIVE.

JIVE will act as the Project Coordinator for this project, responsible for communicating with the EC and mediating financial transactions between the EC and partners. Additionally, JIVE staff members will lead Work Packages: WP1, T. Charles Yun; WP4, Kristine Yun; WP5, Arpad Szomoru; WP6, Paul Boven; and WP7, Mark Kettenis. JIVE will lead WP5, and be involved in all aspects, the implementation of flexible buffering, implementation of VDIF, quality monitoring and station remote control and automated network-dependent correlation. In WP7 JIVE will formulate requirements and implement components for automated correlator operration and develop the SFXC software correlator to meet the formulated needs. In WP8 JIVE provides correlator/buffer interfacing tools and software for integration of the prototype storage elements into the correlator process.

The biographies of selected individuals are listed below:

Dr. Huib Jan van Langevelde is the director of JIVE and will be the Project Coordinator for NEXPReS. Van Langevelde was the Project Coordinator for the EXPReS Project in which 19 partner institutes connected radio telescopes located around the planet via shared e-Infrastructures to showcase the scientific improvements possible when research hardware was used in conjunction with the infrastructure. Van Langevelde has worked at many radio facilities around the world observing masers, his specialty, as well as investigating data processing techniques. Van Langevelde has an appointment at Leiden University where he supervises several PhD students.

Dr. Arpad Szomoru has been at the forefront of the development of e-VLBI in Europe. An experienced astronomer, Dr. Szomoru is also an accomplished 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 to make it process (within various limitations) real-time e-VLBI data. He has also played an important role in understanding and overcoming the various bottlenecks and hurdles that were encountered during the course of the EXPReS project. He will be one of the key personnel in ensuring the success of the NEXPReS project.

Paul Boven studied applied physics at the University of Twente. He previously worked at SARA, the Dutch national centre for high performance computing and networking where his responsibilities included high level system management and design, sales support and external consultancy. He joined JIVE in December 2006 as the network specialist for the EXPReS project. In the past few years at JIVE he has designed and implemented the JIVE networking facilities to enable real-time e-VLBI, and managed the international connectivity for JIVE. He has led the drive to achieve 1024 Mbps e-VLBI capability for most of the EVN telescopes and pioneered some novel networking uses such as 'Merlincast' (the use of Multicast to duplicate VLBI data streams) and 'Elliptical Robin', a skewed traffic distributor to help make best use of limited networking resources.

Dr. Mark Kettenis is working as Software Project Scientist at the Joint Institute for VLBI in Europe (JIVE). Kettenis received his PhD from the University of Amsterdam in The Netherlands under supervision of Dr. L.G. Suttorp and Prof. Dr. H.W. Capel. In December 2001 he successfully defended his Thesis titled “On the Inhomogeneous Magnetised Electron Gas”. Kettenis joined JIVE in 2004 after working in industry for several years. He has worked on or is currently involved with several projects including ParselTongue, the MkIV hardware correlator, the software correlator and the international VDIF taskforce. He is also core developer of the OpenBSD operating system and long-time contributor to GDB, the GNU debugger.

Kristine Palmquist Yun has a master's degree in information science and previously worked as an information architect, organizing and designing the user experience for complex web sites, and as an information manager for a news company. She joined JIVE in 2006 as the EXPReS public outreach officer and has been responsible for maintaining the EXPReS web site and wiki, writing and issuing press releases, designing brochures and posters and organizing outreach activities.

Zsolt Paragi obtained his PhD in astronomy and astrophysics in 2001 at the Lorand Eotvos University in Budapest, Hungary. He joined the EVN Support Group at JIVE in 2002. From 2006 ha was e-VLBI support scientist at JIVE. As a member of the EXPReS e-VLBI Science Advisory Group, he contributed significantly to the change in observing policy that allowed new type of science projects to be observed by the EVN. He plays an influential role in e-VLBI science. Since 2008 he is senior support scientist at JIVE.

T. Charles Yun spent the past three years at JIVE as the Project Manager for the recently completed EXPReS Project. He was the primary contact for project partners and the main interface to the European Commission. Prior to JIVE, Charles worked for Internet2 where he helped specific research communities take advantage of the shared network infrastructure in the Unites States; one of his communities during this period was radio astronomy. In the distant past, Charles has been a technology consultant, automotive engineer and coffee trader. Charles completed his graduate studies at the University of Michigan, School of Information in 1999.

2.3.2 ASTRON

ASTRON is the Netherlands Institute for Radio Astronomy, and is part of the Netherlands Organisation for Scientific Research (NWO). It provides the front-line observing capabilities of the WSRT and LOFAR radio telescopes for use by Dutch and international astronomers in a wide range of fundamental astrophysical research projects. ASTRON has a strong and broad technology development programme, encompassing both innovative instrumentation for existing telescopes and the new technologies needed for future facilities. ASTRON also conducts a vigorous programme of fundamental astronomical research. ASTRON is involved in large scale software and system development. It coordinates the EC FP7 RadioNet and FP6 SKADS programmes and participates in various other EC projects: EXPReS FP6, and PrepSKA FP7. ASTRON enjoys extensive collaborative contacts with Dutch Universities and Radio Astronomy institutes all over the world. As the lead institute on the LOFAR project, ASTRON participates in bandwidth on demand aspects in WP5 and has a key role on archives in WP8. Besides the key people listed below, important input on the eVSAG (WP3) is expected from ASTRON experts on LOFAR and VLBI science and operations.

In WP6, ASTRON will integrate BoD usage with their Long-Term Archive storage. In WP8 ASTRON will lead the development of applying on-demand storage elements into the framework of long-term buffer platform for archival and data reprocessing purposes.

Dr. Hanno Holties is System Engineer in the Radio Observatory department of ASTRON. He received his PhD in Physics for research on fusion plasmas through numerical simulations. Since 2002 he has been responsible for the software and ICT systems of the Westerbork Synthesis Radio Telescope (WSRT). Within the RadioNet FP6 program, Holties has led a project developing the NorthStar tool supporting astronomical proposal submissions and assessments. This tool is currently in use by telescopes worldwide and it is currently being extended to support optical telescopes as an objective within the OPTICON FP7 program. From 2007 he has been Liaison for the Radio Observatory to the LOFAR development project and is responsible for the design and implementation of the LOFAR Long Term Archive. This activity entails building an archive distributed over European compute centers to be operational in 2010. Besides managing and contributing to the related activities at ASTRON, it involves participating in international working groups and coordinating activities with two major Dutch computing projects (BiG Grid and Target).

Dr. Tom Oosterloo is Senior Astronomer in the Astronomy Department of ASTRON. He received his PhD in Astronomy in 1988 for research titled 'Angular Momentum in Binary Spiral Galaxies' under supervision of Prof. Albada. He has held positions at ESO (Garching), RGO (La Palma), ATNF (Sydney), and INAF-IASF (Milan) as Astronomer and Software Specialist. Oosterloo is the Principal Investigator for the Apertif project, which is an upgrade project for the WSRT enhancing the data taking capabilities resulting in a large increase of the produced data rates. He is member of several astronomical Programme Committees, the ASKAP Survey Science Programme Committee, and has been the ALMA System Scientist for Executive Software. Oosterloo is currently supervising two PhD students and has published over 100 astronomical papers in refereed journals.

Dr. Peter Maat is Optical System Engineer in the Research and Development department of ASTRON. He received his PhD in Applied Physics at the Delft University of Technology for the research on photonic integrated electro-optic switches for optical communication systems. From 2000 to 2003 he worked as research scientist at the R&D lab of JDS Uniphase at Eindhoven, where he worked on the development of source lasers and photonic integrated circuit technology. At ASTRON he leads, as wide-area-network workpackage manager, the development and roll-out of the data transport system for the international LOFAR telescope and is, as leader of the photonic technology development activity at the ASTRON R&D lab, responsible for the initiation and execution of R&D projects for the development of innovative photonic data processing and transport systems for phased array radio telescopes.

Dr. Antonis Polatidis is the Head of the Science Support Group of the Radio Observatory department of ASTRON, since 2009. Following a degree in Physics from the Aristotle University of Thessaloniki, Greece in 1988 he got his PhD in Radio Astronomy from the University of Manchester (Jodrell Bank) in 1993. He held positions at the Onsala Space Observatory, Sweden, the Max Planck Institute for Radio astronomy in Bonn, Germany and at JIVE. His research interests are focused on the parsec-scale structure of active galactic nuclei and the circumnuclear atomic and molecular gas in AGN, Ultra-luminous infra-red and starburst galaxies. Throughout his career he developed an understanding of the technical and operational aspects of VLBI at at his current position he is responsible for the scientific support of the Westerbork synthesis telescope and the International LOFAR telescope.

2.3.3 INAF

The Istituto di Radioastronomia (IRA), member of the Istituto Nazionale di Astrofisica (INAF) operates major national infrastructures (the Medicina and Noto 32-m radio telescopes) and is responsible for design, construction and operation of the Sardinia Radio Telescope, a parabolic 64-metre antenna. IRA is a founding member of the European VLBI Network (EVN) and member of the International VLBI Service for Astrometry and Geodesy (IVS). It is involved in major international ground-based projects such as ALMA, LOFAR and SKA. IRA hosts the Italian ALMA Regional Centre on behalf of the Istituto Nazionale di Astrofisica. IRA has gained expertise in the development of state-of-the-art components for mm/submm receivers including MMICs and has extensive experience in working with cryogenically cooled low-noise amplifier systems. In the framework of the EC funded project FARADAY, IRA prototyped a multi-feed array cryogenically cooled receiver at 22 GHz, and is developing a new generation of multi-purpose digital back-ends for radio astronomy. IRA supports various high-level educational programmes (Courses, Master Thesis and PhDs) in collaboration with several university departments in Bologna, Cagliari and Catania.

For WP8, INAF will participate in the development of tools and integration systems as well as participate in the testing of the systems

Dr. Franco Mantovani is the Senior Scientist of the Istituto di Radioastronomia with main scientific interest in Active Galactic Nuclei, polarimetric interferometry, radio source evolution. Involved in VLBI activities for many years, he was Board member of European VLBI Network, of the International Square Kilometre Array Steering Committee, of the International VLBI Service for Geodesy and Astrometry, of the EXPReS project. He will coordinate the tasks assigned in NEXPReS JRA2 to the Istituto di Radioastronomia.

Dr. Mauro Nanni is the Senior Technologist of the Istituto di Radioastronomia with expertise in software for data analysis and archiving. He coordinated the Astronomical Database WG for the National Astronet project, and worked in astronomical archives projects like AVO and Skyeye. He designed the network of the CNR Campus in Bologna. He is Chairman of the campus computer science commission and member of the CNR and INAF commission for network infrastructures and services. As the responsible person for the Italian network for e-VLBI he managed the IRA participation in the EXPReS project. Similarly, the relationships between the Emilia-Romagna Region, INAF, and GARR (the Italian NREN) for optical fibre connections between the Italian radio telescopes and the GARR network will be managed by him. He is Board member of the CyberSar project aiming to set up and connect the “grid clusters” of the scientific network of the Sardegna Region. He will have an active role in the NEXPReS WP8 activities.

2.3.4 MPG

The Max-Planck-Institut fuer Radioastronomie (MPIfR) is one of 80 independent research institutes of the Max Planck Society (Max-Planck-Gesellschaft - MPG). The institute is primarily active in the areas of radio astronomy and infrared astronomy. The institute operates the 100-m radio telescope in Effelsberg, one of the world's most important facilities in radio astronomy. The MPIfR also leads the operations and further development of the Atacama Pathfinder Experiment (APEX), a 12-m telescope in the Chilean Atacama Desert built in 2005. In 2007 the institute completed the first stage of the international LOFAR station DE-1 at the Effelsberg site. In 2009 the second half of the station was installed. MPIfR staff has been involved in VLBI since the mid 1970s and has been operating five generations of VLBI correlators. Currently, the MPIfR operates a new-generation correlator - a software correlator as a result of an international cooperation with the USA, Australia, Italy and Finland. The MPIfR hosts several technical labs, which develop equipment for mm-cm, mm-submm, infrared, and optical telescopes. In terms of future observational and development activities, the institute takes part in a number of large projects, such as the German-American airborne observatory SOFIA, the Atacama Large Millimeter Array (ALMA), the further upgrade of the 100-m radio telescope in Effelsberg, the planning of the Square Kilometre Array (SKA), optical interferometry facilities (VLTI and LBT), and the further development of VLBI at high resolutions (millimetre wavelengths and space VLBI).

MPIfR personnel has outstanding knowledge in virtually all areas of the VLBI observing technique like e.g. Field System and antenna calibration. In cm-VLBI MPIfR is an important member of the European VLBI network (EVN), the High Sensitivity VLBI Array (HSA) and co-observes regularly with the US VLBA array. The MPIfR organizes the Global mm-VLBI Array (GMVA), a 13-antenna array that observes regularly at 86 GHz and correlates all data thereof.

The MPIfR will contribute as a participant in task 3 of WP5 (Cloud Correlation). The proposed task builds directly on the work done by the MPIfR within the FABRIC JRA of EXPReS. All MPIfR personnel involved in FABRIC will also actively contribute to NEXPReS, hence making optimal use of the experience gained in EXPReS.

Prof. Dr. A. Zensus (Director) will be overall responsible for the participation. He will be a member of the new Board. Dr. Walter Alef (head of the VLBI technology department; actively involved in EXPReS) will be responsible for the administration and organization of the NEXPRES activities at MPIfR. Dr. Helge Rottmann (member of the VLBI technology department, actively involved in the EXPReS JRA: FABRIC) responsible for the development of the DiFX Correlator and of the new digital VLBI Backend - DBBC. He will manage the implementation of task 3 in WP5. Dr. Dave Graham (member of the VLBI technology department). He will assist the project as a technology advisor in all aspects of task 3, particularly with field system integration issues.

2.3.5 UMAN

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

UMAN will design testing systems to test and validate BoD connections in WP6. For WP8, UMAN will participate in the development of tools and integration systems as well as participate in the testing of the systems

Prof. Ralph Spencer is Acting Director of the Jodrell Bank Centre for Astrophysics 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. The European development of the 1 Gbps MkIV tape VLBI system was led by him. 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 has enabled 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 astronomy for data transport at rates up to 120 Gbps. His astronomy research has concentrated on the properties of micro-quasars. Prof. Spencer is a Fellow of the Royal Astronomical Society.

Prof. Simon Garrington is Director of Jodrell Bank Observatory and is project manager for e-MERLIN, a 12 Meuro 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 Gbps input. 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.

Dr Neal Jackson is a Reader in Radio Astronomy at the University of Manchester. His PhD (1989) at Jodrell Bank was in the study of active galaxies using radio and optical observations. Following that he spent 2 years as a postdoctoral fellow at the University of Manchester, and then 3 years as a postdoctoral researcher at Leiden Observatory, Netherlands, working on observational astronomy including radio observations and HST data. He then obtained a lectureship at the University of Manchester. His main research interests are in the study of gravitational lensing, a significant part of which has been VLBI studies of the CLASS radio-loud gravitational lens survey. He is also PI of an e-MERLIN legacy project on gravitational lensing, which is likely to include follow-up observations with other radio arrays including VLBI in order to measure mass distributions in distant galaxies. He also coordinates an EU Marie Curie Training Site.

2.3.6 OSO

Onsala Space Observatory (OSO) is the Swedish National Facility for Radio Astronomy. It is operated by Chalmers University of Technology. The Swedish Research Council evaluates and provides funding for its operation. OSO operates two telescopes at Onsala, a 25-m cm-wave telescope and a 20-m mm-wave telescope. It is one of three partners in the APEX Project, a 12-m sub-mm telescope at 5100 m altitude in Chile. Through this, Sweden has 21% of the APEX observing time (Chilean time subtracted). OSO also has a strong receiver development programme for mm and sub-mm wavelengths. OSO's main purpose is to provide Swedish, and international, astronomers with the possibility to pursue astronomical research in frequency bands in the radio range from about 0.8 GHz up to 1.5 THz. In addition, OSO provides the channel through which Sweden is involved in large international radio astronomy projects, such as the EVN, JIVE, LOFAR, SKA, and ALMA.

OSO will participate in the demonstrations of BoD, including those at high speed, in WP6. In WP7 OSO will formulate requirements and implement components for telescope operations & observation schedules to meet the science goals formulated in the proposal. For WP8, OSO will participate in the development of tools and integration systems as well as participate in the testing of the systems

Dr Simon Casey is a research engineer at Onsala Space Observatory. His undergraduate studies were in technological physics at the University of Manchester, resulting in an MPhys degree in 2004. He completed his PhD work at Jodrell Bank Observatory in 2008, which involved investigating the use of the UDP protocol for high-speed e-VLBI data transport, and observing the effects of missing data on VLBI correlations. He has an in-depth knowledge of modern programming languages, and is also experienced in debugging performance issues in end-hosts.

Dr. John Conway and dr. Michael Lindqvist are the local experts in VLBI and are expected to play a defining role in the NEXPReS activities at Onsala. Both combine a background in astrophysics with a profound understanding of the technical and operational aspects of VLBI. Dr Conway also plays a defining role in Sweden's participation in the e-LOFAR project.

2.3.7 VENT

Ventspils University College (VUC) is one of the leading higher education establishments in Latvia. VUC offers both academic and professional studies in various specialities, particularly in Electronics and Information Technologies. During the academic year 2009/2010 VUC counted 900 full time students. Three research institutes are established at VUC. Two of them – Ventspils International Radio Astronomy Center (VIRAC) and the Research Engineering Centre (REC) will be involved in the NEXPReS. The primary tool of VIRAC for radio astronomical observations is the 32-m diameter radio telescope (RT-32), situated 30 km from Ventspils. This radio telescope, left by Soviet Army after its withdrawal from Latvia, is now being equipped with the necessary equipment in order to take part in VLBI and single dish radio astronomy observations. There are currently 10 scientific staff members at VIRAC and this number is expected to grow. The main objective of REC is to provide advanced problem solving services and to promote technological competitiveness and development of electronics and electrical engineering sector. REC conducts applied research in mathematic modelling, telecommunications, electronics and engineering. The main tool for high performance computing (HPC) in REC is a computational cluster server. Many students are involved in doing their thesis work and other research activities at VIRAC and REC.

VENT will assist PSNC in middleware development win WP7.

Dr. Ivars Smelds (Leading researcher of VIRAC and senior lecturer of VUC) is the main person involved in the NEXPReS project from VIRAC. He is the leader of the VLBI group of VIRAC and is responsible for developing VLBI technologies and their implementation at the Irbene Radio telescope. His research interest lies in the field of interstellar matter as well as in the radio location of natural and artificial bodies in the solar system. Ivars Smelds also has a position as a teacher in VUC.

Dr. Normunds Jekabsons (Leading researcher of REC and senior lecturer of VUC) is the key person involved in the Project's high performance computing (HPC) activities. His current scientific interests are related to Computer

Fluid Dynamics, Mathematical Homogenization over random unit cells in the advanced materials research field, utilization, coding and local development of HPC systems. He is the author of VUC undergraduate and master degree courses on numerical methods, basic computing algorithms and UNIX OS.

2.3.8 FG

FG (Fundacion General de la Universidad de Alcala) coordinates and manages administrative issues related to Third Parties, the European Commission and other bodies on behalf of the University of Alcala. The IGN (Instituto Geografico Nacional), as a third party to FG, operates national facilities at Yebes including the recently commissioned 40-m, millimeter-wave, radio telescope. IGN is particularly involved in RF-technology development including quasi-optics, in its laboratories at Centro Astronomico de Yebes (CAY-OAN). IGN successfully organized the week long Science and Technology of Long Baseline Real-Time Interferometry: The 8th International e-VLBI Workshop as part of the EXPReS project and will build upon the work to organize NEXPReS's eVSAG meetings, including the end of NEXPReS Sci/Tech Workshop.

Dr. Francisco Colomer was born in 1966 in Valencia (Spain) and graduated in 1989 from University of Valencia, after which he moved on to get 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 a permanent staff member at the Observatorio Astronomico Nacional (OAN-IGN). As coordinator of the overall VLBI activities for Astronomy and Geodesy, he is an active researcher in the field of studies of spectral line emission in evolved stars using very long baseline interferometry, with more than 70 publications in refereed journals and 700 citations. He will be responsible for the WP3- the eVSAG in NEXPReS.

Dr. Pablo de Vicente graduated from Universidad Complutense de Madrid in 1986 and spent predoctoral fellowships at IRAM (France) and the Max-Planck Institut für Radioastronomie (Germany). He got his PhD at UCM in 1994. He is the coordinator of the technical aspects of VLBI at OAN/IGN, including the new 40-m radio telescope at Yebes, which was linked to GEANT through the EC project EXPReS. He is a 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 a permanent staff member at the Observatorio Astronomico Nacional (OAN-IGN). He has been the director of OAN since 2002. He is an active researcher in the field of star formation, in particular in the study of mm- and submm-wave spectral lines, with more than 150 refereed publications.

2.3.9 NORDUnet

NORDUnet is the regional research & education network for the 5 Nordic countries (Norway, Finland, Sweden, Denmark, Iceland). NORDUnet has more than 25 years of history in state-of-the-art networking for the research community, and has participated in numerous advanced international initiatives, including EU-funded initiatives. Recent initiatives include strong contributions to 6NET, GN2, GN3, and FEDERICA.

NORDUnet today has a fibre-and-DWDM core infrastructure providing lambda and hybrid networking services and a state of the art 10 Gbps IP network. In addition, NORDUnet hosts the Nordic Data Grid Facility (NDGF), an advanced facility for e-Science and grid computing, several high-level services for the research community, and provides operations and management services through the Nordic University NOC (NUNOC). As such, NORDUnet is a provider of infrastructure for education and (e)science.

In WP6, NORDUnet will participate in the development and testing of interdomain BoD systems and demonstrations of BoD at high speeds.

Lars Fischer – Chief Technology Officer – is responsible for leading development initiatives and projects within NORDUnet. He leads NORDUnet's participation in European projects and initiatives, and its relationship with European NRENs and the European networking community. He also coordinates Nordic e-Infrastructure initiatives in collaboration with Nordic partners and works with Nordic advanced users of e-Infrastructure. Before joining NORDUnet in 2004, Lars spent ten years in the Internet and telecommunications industry as Technical Director at Tele2 and COLT Telecom. Before this, Lars carried out research into programming systems and collaborative computing environments. Lars has worked with advanced networking and computing systems for the past 25 years.

Brian Bach Mortensen – Optical Network Architect – has a PhD in Electronic Engineering (on hybrid electro-optical packet switches). He previously worked at the Technical University of Denmark, and has been work package leader in the MUPBED FP6 project. His work areas are optical networking and control plane technologies.

Alberto Colmenero – Optical Network Architect – joined NORDUnet in 2007 and has since worked on the design and definition of NORDUnet's L2 transport network. He is responsible for architectural service and network evolution of the L1 and L2 network. Alberto has a BSc in Telecommunication Engineering, and during his ten years in the telecommunications industry has worked with the design and implementation of L1, L2 and L3 access and transport networks.

2.3.10 SURFnet

SURFnet is the National Research & Education Network (NREN) organisation in The Netherlands. SURFnet develops and provides innovative services for education and research in the field of network infrastructure, authentication and authorisation and on-line multimedia collaboration services. SURFnet provides access to these services to over one million users in higher education and research in the Netherlands. SURFnet is part of SURF, the collaborative organisation for higher education institutions and research institutes, which together are working on breakthrough innovations in ICT. For more than 20 years SURFnet has been one of the world's leading research network operators. SURFnet contributes mostly to WP6; not only are they a key player in the field of dynamic connectivity, but they are also the connectivity provider for the correlator at JIVE in the Netherlands.

SURFnet will participate in the development and testing of interdomain BoD systems and are a key partner in all e-VLBI observations and demonstrations.

Kees Neggers is one of the founders of SURFnet in the Netherlands and has been one of its Managing Directors since 1988. He received an Electrical Engineering degree from the Eindhoven University of Technology in 1972. Neggers started his carrier as a staff member of an advisory committee on computing infrastructure to the Dutch Minister of Science and Education. He worked at the Computing Centre of the University of Groningen from 1975 until 1984. In 1984, Neggers became one of the managing directors of the University Computing Centre in Nijmegen, where his networking career started. Nijmegen became the Dutch national node in EARN and was one of the drivers towards a national research network in the Netherlands. From there on, Neggers became heavily involved in international research networking. He was among the founders of RARE, ISOC and the RIPE NCC, and served for many years on the Boards of these organizations. During this period he was involved in many initiatives, notably COSINE, CCIRN, Ebone, DANTE, Amsterdam Internet Exchange, the merger of RARE and EARN into TERENA and more recently GLIF, the Global Lambda Integrated Facility.

Peter Hinrich studied Physical Chemistry at the University of Amsterdam. After receiving his degree on the subject of laser spectroscopy of supercooled molecules in 1989 he moved to Leiden University where he received his PhD in Theoretical Chemistry in 1995. After a short period working as a post-doctoral research fellow, he joined SURFnet in 1996, where he started as Account Advisor. Currently, Peter is Community Manager Science and is responsible for the communication between SURFnet and the scientific user community, informing them about possibilities new technology offers and identifying their requirements.

2.3.11 PSNC

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 at 10 Gbps. PSNC employs about 200 people. It is an HPC Centre, Systems and Network Security Centre as well as R&D Centre of New Generation Networks, Grids and Portals. PSNC is also the operator of Poznan Metropolitan Area Network POZMAN. PSNC is the Centre of Excellence of Sun Microsystems Inc. and Microsoft Innovation Centre. The institution has participated and still participates in numerous FP5, 6 and 7 EC projects e.g.: European: RINGrid (031891, PSNC is the project coordinator), DORII (Deployment of Remote Instrumentation Infrastructure - coordinator), GridLab(PSNC was the project coordinator), CrossGrid, EGEE, EXPRES, int.eu.grid and national founded by the Ministry of Science and Higher Education: PROGRESS, Virtual Laboratory, SGIgrid - High Performance Computing and Visualisation with the SGI Grid for Virtual Laboratory Applications, PL-GRID and PLATON.

PSNC has a significant experience in different strategic areas like High Performance Computing, interactivity and visualization, distributed environment, remote instrumentation, software frameworks, workflows or networking required to achieve all the project objectives. The lessons learned from the work on distributed software correlation within FABRIC (JRA of the EC EXPReS project) are a great advantage for the future work. PSNC will use its knowledge and experience participating in the development of new functionality of a real-time distributed correlator, workflows and deployment of the distributed computing infrastructure (DCI) within WP7- Computing in a Shared Infrastructure.

In WP7 PSNC will develop middleware for real-time data-intensive computing & do workflow manager development. For WP8, INAF/UMan/OSO/PSNC will participate in the development of tools and integration systems as well as participate in the testing of the systems

Dr. Norbert Meyer is the head of the Supercomputing Department in PSNC. His research interests concern resource management in 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. He is currently the EU DORII project coordinator, coordinator of the former EU RINGrid project, and National Data Storage. Meyer is author and co-author of more than 60 reports and papers.

Dominik Stoklosa received M. Sc. degree in Computer Science (specialty: software engineering) from the Poznan University of Technology in 2003. In 2009 he finished his postgraduate studies in Project Management at Poznan School of Banking. Since 2003 he has worked for Poznan Supercomputing and Networking Centre. He participated in several national and international projects concerning distributed computing e.g. VLab, RINGrid, DORII. He was also a member of FABRIC team within EXPReS project working on distributed software correlation. Dominik Stoklosa has a practical knowledge of Java based technologies. Since 2007 he is Sun Certified Programmer for Java 2 Platform. He is also a member of Poznan Java User Group.

Damian Kaliszan graduated from the Poznan University of Technology and received his M.Sc. in Computer Science (Computer Integrated Management and Production Systems) in 2001. He was also involved in RINGrid and DORII projects. His research interests include data mining, web and Java related technologies.

Marcin Lawenda currently works for Poznan Supercomputing and Networking Center as a project manager in the Virtual Laboratory project. Marcin Lawenda is the work package leader of a national project on grid technology funded by a research grant of the Ministry of Scientific Research and Information Technology. He was deputy manager of the RINGrid project and quality manager in DORII (http://www.dorii.eu). His research interests include parallel and distributed environments, scheduling and Grid technologies.

Mateusz Pabis finished his Master of Engineering studies at Technical University of Gdansk in 2006 with major in distributed systems architecture. His thesis concerns reliable grand-scale parallel environment. His current professional interests focuses on distributed file systems and distributed computations. He is also interested in grand-scale data mining and data processing. Currently he holds position of Java developer at the High Performance Computing department in PSNC. He was involved in g-Eclipse and the EXPRES projects. After work he takes part in programming contests and studies psychology at Adam Mickiewicz University in Poznan.

2.3.12 DANTE

In partnership with the National Research Networks and in cooperation with the European Commission, DANTE plans, builds and operates advanced pan-continental optical hybrid communication networks for research and education. These provide essential e-infrastructure both across Europe and globally. In EXPReS, DANTE was responsible for co-ordination of the requests for 1-gigabit point-to-point circuits to connect the telescopes. DANTE also led the work on provisioning and analysing the performance of the 4-gigabit Lightpath from Onsala to Jodrell Bank.

DANTE will be our interface to the upcoming GEANT3 BoD services, and liaison to other NRENs.

Richard Hughes-Jones gained his 1st class honours BSc in Physics from the University of Manchester and a PhD in Particle Physics in 1972. He then collaborated on 5 international experiments at the particle physics laboratory CERN in Geneva, including the ATLAS experiment at the LHC, working on real-time Data Acquisition and Network projects with both technical and collaborative roles. Richard joined DANTE in January 2008 as Technical Customer Support manager, taking on the role of helping existing and emerging user communities to get the best out of the network, and also continues as a Visiting Research Fellow at the University of Manchester. Richard is an area director for infrastructure in the Open Grid Forum standards organisation and a co-chair of the Network Measurements Working Group. He is also a co-chair or TNC member of the annual international workshops “Protocols For Long Distance Networks” from 2005 to 2009. He is a programme committee member of the IEEE Real Time Conferences. He has recently been a chapter co-ordinator and contributor to the book “Grid Networks: Enabling Grids with Advanced Communication Technology” published by Wiley. He has been responsible for the design and implementation of several live network demonstrations including the VLBI proof of concept at iGRID2002; the Radio Astronomy stand at the DANTE booth at the European Commission conference to mark the launch of the EU's Sixth Framework Programme in Brussels in 2002 and at the launch of GEANT2 Launch Event in June 2005. He organised and managed the transatlantic networking contributions to the international collaborations that won the SuperComputing Bandwidth Challenges for 2003, 2004 and 2005.

Ann Harding - Network Engineer - has worked for SWITCH since 2007, focusing on service management issues and the development of service-specific key performance indicators. Before joining SWITCH, Ann worked for HEAnet from 2000 to 2007, as a network engineer and, from 2002, as Network Operations Manager. Her main duties were network management, SLA management, change control, problem management and day-to-day operations of the HEAnet NOC. She was HEAnet's Access Port Manager (APM) for GÉANT and GÉANT2 and was co-chair of a TERENA Task Force on Life Cycle and Portfolio Management for NRENs; she continues her involvement in the subsequent Task Force on Management of Service Portfolios (TF-MSP). Ann is currently the activity leader for the GN3 SA2, Multi-Domain Network Service Operation.

Jacek Lukasik, Researcher in PSNC (PIONIER operator). He was involved as a software designer and developer in GÉANT2 project, working on AutoBAHN system production and continues this work in GEANT3 as lead developer on the AutoBAHN service track. His current research areas are dynamic network resource management. He is currently the AutoBAHN subtask leader for Multi-domain Network Connectivity Services Development.

2.3.13 AALTO

Aalto University (formerly known by the short name TKK) is the parent organization for Metsähovi Radio Observatory. Metsähovi Radio Observatory is a long time partner in the EVN and has been participating in VLBI observations since 1991. Metsähovi operates a 14-m mm-wave radio telescope and is a specialist in mm-VLBI and geodetic e-VLBI. Since the early 1990's it has been one of the few institutes in the world where VLBI data acquisition systems have been actively constructed and developed further. Recent and future developments have concentrated on maximizing the applicability of Commercially Available Off-the-Shelf (COTS) technology for multi-gigabit VLBI data acquisition and storage applications. As a partner in industry space technology projects as well as ESA Planck and NASA AMS-02, Metsähovi is an active expert in several networking, computing, VLBI hardware, and data processing projects.

Aalto will collaborate with JIVE on enabling flexible buffering at the stations to safeguard against loss of data in case of network failures and on enabling delayed transfer in the case of low connectivity.

In addition to managing the WP8, Aalto is responsible for developing the basic storage element API and corresponding hardware and software prototype implementations that can be used by other partners in integration and testing tasks of WP8.

Ari Mujunen is a software engineer at Metsähovi Radio Observatory. He has a M.Sc. in EE from Helsinki University of Technology (1992) with software engineering and production as the major subject. Prior to joining MRO in 1992 he has worked for commercial software houses creating software production toolsets for both CAD and business database applications. At MRO, he has written software and created electronic designs for the in-house telescope control and single-dish data acquisition system. For the 1998 STS-91 space shuttle AMS mission MRO was responsible for the ground segment of AMS HRDL (High-Rate Data Link) for which Ari Mujunen wrote the autonomous Linux-based data acquisition software package.

Jouko Ritakari is a hardware engineer at Metsähovi Radio Observatory. He has a M.Sc. in EE from Helsinki University of Technology (1980) with hardware engineering and data communications as the major subject. Prior to joining MRO in 1987 he has worked for Nokia Corporation developing data communication protocols. He has also experience in designing data communication networks and designed several of the largest private networks in Finland. At MRO, he has developed hardware and firmware for high-speed data acquisition systems, starting with the design of hardware for data capture from the AMS-01 instrument in space and participated in testing and controlling the instrument. In 2000-2002 he developed the very high-speed data acquisition board VSIB (speed 512 Mbps) and the universal converter VSIC. Recently he participated in a project to port the DiFX correlator to the Cell processor. Presently he continues protocol research together with Jan Wagner and Guifré Molera Calves, replacing typical very computing-intensive implementations of 10 Gbps Ethernet with a hardware-based UDP/IP packetizer that has zero CPU load.

Jan Wagner is a researcher at Metsähovi Radio Observatory. He has a M.Sc. in Electronics Engineering from Helsinki University of Technology (2007) with Space Technology and Computational Engineering as the major subjects. He has a B.Sc. in Information Technology from Helsinki University (2009). Before joining the MRO team in 2006 he has worked in the embedded computing and electronics industry and at IBM and CERN. Working from previous MRO team achievements, his first task was to provide geodetic VLBI with production real-time e-VLBI data transfer software. Together with J. Ritakari he created a high-speed VLBI correlator prototype based on IBM Cell platforms and designed real-time GPU-based adaptive optics control systems for future telescopes. He designed 10 GE hardware UDP/IP data streaming for 8Gbps e-VLBI using FPGA hardware together with high-speed data acquisition systems. Currently he pursues VLBI HPC computational tasks in ESA/JIVE ExoMars and planetary water detection projects with G. Molera, researching cluster computing for VLBI correlation with A. Mujunen and actively developing our post-10Gbps VLBI data acquisition systems and software together with long-haul UDP/IP networking protocol research for international 10G links.

Mr. Guifré Molera Calvés has been working as a researcher at Metsähovi Radio Observatory since 2006. He has a M.Sc. in Telecommunications Engineering from Technical University of Catalonia, UPC (2006) with Space Technology as his speciality. During this time he has been an active collaborator in international projects as the AMS-02, EXPReS and the upcoming ESA/JIVE ExoMars and PRIDE projects. He has acquired wide experience in high performance computing architectures, software development, FPGA-based designs, networking protocols, and astronomical data analysis. Currently he is writing his PhD thesis, focused on planetary spectroscopy with VLBI equipment and high-accuracy spacecraft tracking with single dish observations.

2.3.14 TUM

The Technische Universitaet Muenchen (TUM) - recognized as one of the first three universities to be promoted as one of the top universities in Germany for graduate schools, clusters of excellence and institutional strategies for universities – covers a large spectrum of fundamental and applied research with studies ranging from engineering, natural sciences, including life and medical sciences, to economics. Responsible for this project is the Forschungseinrichtung Satellitengeodasie (FESG), a research institution in the Faculty of Civil Engineering of TUM and founded in 1983. FESG runs the Geodetic Observatory Wettzell together with the Bundesamt fuer Kartographie und Geodaesie. Specifically, FESG assumes responsibility for operating the Wettzell 20m VLBI telescope for geodetic applications since 1983, participating in regular daily and hourly geodetic observation sessions every week. Beside the strong involvement in VLBI observations FESG is active in precise GNSS (Global Navigation Satellite Systems) applications, including precise orbit modelling, Satellite Laser Ranging, and Earth rotation studies using the worldwide largest laser gyroscope in Wettzell. The FESG is embedded in the Forschungsgruppe Satellitengeodaesie (FGS), a consortium of five leading geodetic institutions in Germany. This group participates in WP5, where they will contribute to the automation of the caching at the telescopes.

Dr. Alexander Neidhardt is the head of the radio telescope group, research scientist and software engineer at Forschungseinrichtung Satellitengeodaesie (FESG), Geodätisches Observatorium Wettzell, TUM, Germany. His fields of work are applied computer science for space geodesy, development of modern, automatic measuring control systems for the geodetic space techniques, especially in combination with the development project of a new satellite laser ranging system at the Geodetic Observatory Wettzell, and improvement of data management systems with hybrid and middleware systems. After studying computer science at Regensburg and Nuremberg, he obtained his PhD as research scientist and software engineer at Fundamentalstation, Wettzell. Since 2008 he is the head of the radio telescope group Wettzell. He is responsible for the design and development of the control system for the new automated laser ranging system Wettzell and a remote control extension to the NASA field system which is successfully tested with the radio telescopes at Wettzell, TIGO Concepcion/Chile and GARS O'Higgins/Antarctica.

2.3.15 CSIRO

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) employs more than six thousand staff in many divisions. The Australia Telescope National Facility (ATNF) is a division of CSIRO that specialises in research and technological developments in radio astronomy. The ATNF operates as open access national facilities the Parkes 64m telescope, the Mopra 22m antenna and the 6 x 22m antennas of the Australia Telescope Compact Array (ATCA). The ATNF also heads the Australian bid to host the Square Kilometer Array (SKA), the next generation radio astronomy instrument. ATNF is building the 36 x 12m Australian SKA Pathfinder (ASKAP) and developing new and innovative technologies for the SKA.

The ATNF also operates a VLBI array, the Long Baseline Array (LBA), which utilises all the ATNF antennas and other telescopes in Australia, such as the Hobart and Ceduna antennas operated by the University of Tasmania and the NASA Tidbinbilla antennas. The VLBI data are correlated on a computer cluster operated by the Curtin University of Technology, utilising the DiFX software correlator developed at Swinburne University of Technology. The LBA is the only substantial VLBI array operating in the Southern Hemisphere.

The LBA partners also conduct a vigorous research and development programme in e-VLBI, in partnership with the Australian NREN AARNet. Recent developments include: connecting the ATNF antennas via 2 x 1 Gbps links; there are 3 computer clusters that operate as DiFX software correlators; recorded VLBI data is also electronically transferred via a Petabyte store operated by ARCS (government funded agency); operating e-VLBI and recording in parallel. The ATNF and AARNet were also key participants in the EXPReS project. So, the ATNF and its LBA partners are already committed to e-VLBI research and ideally suited to complement the activities in Europe planned for NEXPReS. CSIRO participates directly in WP6, but through this Australian connection there will also be synergy with other Australian projects, in particular at AARNET and in the group of Prof. Steven Tingay at Curtin University, Perth, Western Australia. This latter group has considerable expertise on e-VLBI and has developed the DiFX software correlator that has been deployed at multiple sites around the world.

CSIRO's contribution to WP6 will consist of ATNF's participation on the one hand, with their telescopes and correlator facilities, and AARNET participating in building the networking resources within and to Australia. In WP7 CSIRO will provide global baselines and help with integration of the DiFX software correlator.

Dr Tasso Tzioumis is the leader of the e-VLBI project and the VLBI operations coordinator in ATNF. He has been involved in VLBI research for more than 25 years and his scientific research interests range from AGN to X-ray binaries and Supernovae. He is also a trained electrical engineer and is involved in technology developments for radio astronomy, as well as international involvement in the IAU, URSI and ITU. Dr Tzioumis chaired the EXPReS board for the last 18 months and will be coordinating the Australian contributions to NEXPReS .

Dr Chris Phillips heads all technical developments of e-VLBI in Australia. His research interests are mainly in spectral-line observations of masers and massive star formation. He has wide international experience and spent 5 years working at JIVE. He is the main architect of the LBA Data Recorder (LBADR) and all software developments specific to e-VLBI, and will be the main technical person for the Australian NEXPReS participation.

Dr Shaun Amy has research interests in supernovae and it is the key networking person at ATNF. He plays a key role in all network operations and developments and has been a key person for the e-VLBI project. In collaboration with AARNet he will handle all the necessary networking developments for NEXPReS in Australia.

B 2.4 Consortium as a Whole

The proposed NEXPReS programme will bundle expertise in radio astronomy and several ICT areas: networking, storage and computing. Building up this formal interdisciplinary structure is probably the most important aspect of the entire program. There already exist a number of structures (including ones that are EC supported) that have expertise in radio-astronomical instruments, focused on existing or future research infrastructures, but the collaboration in (N)EXPReS is unique in the sense that it enforces collaboration between the two domains. We have learned from the past that this formal structure is essential for keeping a focus on the development work and getting support from organizations outside the funded collaboration.

The NEXPReS partners will bring together essential crafts for carrying out the work described in the Joint Research and Service Activities. In constructing this distribution of work packages we have had our focus solely on bringing the appropriate talents together. Note that a few organizations contribute to the programme without expecting return from the EC funds. These partners are included in order that their effort contributes formally to the project and to make sure they are represented in the management structure. Furthermore, we expect other partners from the radio astronomy community and NRENs to participate in the network activities. In the past the existence of an EC project in this area has been a catalyst for a large number of such interactions

While the project primarily builds on the existing collaborations in traditional VLBI, there is an increasing role for other radio astronomy facilities with a large ICT component. Notably the International LOFAR Telescope (or e-LOFAR) that is currently being commissioned across several European countries, is encountering a number of similar technological issues for its future operations. The facilities already share the same engineering basis and have a largely overlapping user community. Indeed, in some of the forums common problems and common solutions have been discussed in the past. In NEXPReS these ties will only be stronger when operational matters will also start to share the same connectivity infrastructure. This common footing will be an asset for Europe's role in the SKA.

In this project there is a central role for JIVE in managing and implementing most of the Service Activities. This may seem lopsided, but it is in fact very natural. As a joint European facility for VLBI, it is JIVE's mission to provide central services for the entire European VLBI community. This is true in most operational aspects, including user support, but also in, for example, outreach. When JIVE was founded, one of the main objectives was to establish a central legal entity to carry out European projects on behalf of the distributed facility. As such, JIVE has a very long and broad experience in managing EC funds. In the future JIVE is aiming for recognition as a formal European Research Infrastructure Consortium (ERIC).

i. Subcontracting.

The R&D necessary for NEXPReS will all be done in house, combining the expertise from our wide variety of partners. In some cases standard components will be purchased commercially, in other cases the collaborations will tap into other, local expertise, but there is no formal subcontracting foreseen.

ii. Other countries.

The NEXPReS includes one partner from Australia, CSIRO, which is operating the Australian Telescopes and VLBI Network. Although of a smaller scale, this VLBI network is already applying innovative digital techniques and having this partner in our collaboration is essential for technological cross-fertilization. In the past we have pioneered long-haul connectivity with this partner and for similar exercises in WP6 on bandwidth on demand mechanisms, this partner is essential. It is foreseen that the staff at the Australian Telescope National Facility (ATNF) will make a vital contribution to the definition of the global VLBI transport protocol.

Moreover, Australia is one of the two possible sites for the SKA, the other being Southern Africa. The South-African telescope is already a member of the EVN and collaborates through its operational and technical bodies. Through NEXPReS we will also maintain a solid working relation with Australian radio astronomers and engineers. Besides the direct involvement of the CSIRO, this link brings also expertise from other Australian partners into the NEXPReS domain. Important work on software correlation is done at Curtin University in Perth, Western Australia, and provisions are made in WP7 to foster collaborations with this group. Similarly AARNET, the Australian NREN, is playing an important role in enabling long-haul connectivity and has been important in establishing e-VLBI in Australia, both locally and in a global sense.

iii Additional partners.

The NEXPReS programme will be influential beyond the 15 partners that are listed in the work-package. Firstly, it will be an important asset for the EVN as a whole. Most telescope sites in Europe are contributing expertise to the work-programme, but the EVN also has members in South Africa, China and Puerto Rico. Through this consortium, NEXPReS will drive the developments in these places, as well as at new telescope sites; for example, the KVASAR telescope network in Russia which has just recently joined the EVN. Operators from these telescope sites will also participate in the Network Activities in WP2 and WP3.

Similarly, the NEXPReS activities will involve national network providers. The formal structure of NEXPReS includes network partners DANTE (providing the European backbone), SurfNET (providing the central capacity to connect the correlator) and NORDUNET (participating in WP6). However, it is important to recognize the effort and resources provided by the NRENs who support the institutes that participate in the project. We can identify the following *additional* NRENs that connect participants in the development project or telescopes involved in operational e-VLBI:

- AARNet (Australia)
- DFN (Germany)
- FUNET (Finland)
- GARR (Italy)
- JANET (UK)
- LATNET (Latvia)
- PSNC (Poland)
- RedIRIS (Spain)
- SUNET (Sweden)
- APAN (Asia)
- CSTNET (China)
- Internet2 (USA)
- CANARIE (CANADA)
- RedCLARA (South America)

Clearly NRENs are of vital importance for providing connectivity for our activities in order to meet the NEXPReS goals. Contacts with these organizations have been established everywhere on a national level and NEXPReS will stimulate these collaborations to continue. The program in WP3 specifically addresses these partnerships.

One of the important motivations behind NEXPReS is to build up expertise and develop technology for the SKA. Results from NEXPReS will feed into the SKA technology programme by providing contributions to SKA meetings. Managers of several of the institutes' R&D departments are often involved in both programmes. Similarly, at board level there is considerable overlap of facility directors actively participating in both projects. NEXPReS will continue the good practice established in EXPReS to highlight progress at various business meetings. There are also links with the European Space programme, where progress reports on VLBI practices will be presented.

In addition, NEXPReS will establish strong links with a number of institutes that have a leading role in defining technology that is essential for the advance of VLBI. Through the EVN there is a long standing collaboration with the agencies that provide the digitization and recording components for VLBI systems. These play an important part in the ambition to capture larger bandwidths at the telescopes. In the area of distributed computing, JIVE has a nationally funded collaboration with the University of Amsterdam. In WP7 an important role is envisioned for the collaboration with Curtin University, where a similar R&D programme is carried out. Although this collaboration is not applying for funds from NEXPReS directly, a provision is made to make sure that Curtin staff can partake in the international WP7 programme.

Letters of Support

As there are a number of organizations that are formally not part of the NEXPReS collaboration, but that do have an interest in its success, we have received letters of support from the following organizations:

- **Internet2**, the US educational and scientific backbone.
- **PrepSKA**, an FP7 project that will define the technical model for the ESFRI facility SKA and carry out the costing of the design with the global partners.
- **GARR**, the Italian NREN
- **SPDO,** the SKA Programme Development Office
- **AARNET,** the Australian NREN who will contribute effort in establishing dynamic long-haul connectivity
- **ESA,** European Space Agency

B 2.5 Resources to be Committed

The table below lists the Workpackages, the single CP-CSA type of activity they belong to and the respective cost category according to:

- the explanations presented in previous chapters (mainly Section B 1.3)

- the Guide for Applicants for this call (Capacities – Research Infrastructures call FP7-INFRASTRUCTURES-2007-2)(*)

(*) list of cost categories and associated activities (simplified):

- RTD activities: directly aimed at creating new knowledge and new technology it includes the costs of joint research activities.
- Coordination activities: aimed at fostering co-operation between the participants in the project and the scientific communities benefiting from the research infrastructure. It includes the costs of networking activities (including, but not limited to, training, dissemination and communication).
- Management activities: include the maintenance of the consortium agreement, if it is obligatory, the overall legal, ethical, financial and administrative management including for each of the participants obtaining the certificates on the financial statements or on the methodology, the implementation of competitive calls by the consortium for the participation of new participants and, any other management activities foreseen in the project except coordination of research and technological development activities.
- Other activities: any specific activities not covered by the above mentioned types of activity. It includes service activities aimed at the provision of specific research infrastructures related services to the scientific community (amongst those, connectivity services can be funded up to 50%).

Workpackage	CP-CSA type of activity E.g. Networking Activities (NA); Service Activities (SA); Joint Research Activities (JRA);	Cost category E.g. Management;Coordination; Other; RTD
WP 1	NA	Management
WP 2	NA	Coordination
WP 3	NA	Coordination
WP 4	NA	Coordination
WP 5	SA	Other
WP 6	SA	Other
WP 7	JRA	RTD
WP 8	JRA	RTD

Costs will be declared and claimed according to this table. They will be clearly described and distinguished for each activity in the periodic reports.

Please refer to WT6: Project Effort by Beneficiary and Work Package, WT7: Project Effort by Activity type per Beneficiary, and WT8: Project Effort and costs for a summary of costs and distributions within the project.

As is clear from WT8: Project Effort and Costs, the dominating costs in NEXPReS stem from partner personnel costs. It should be noted that the consortium will contribute considerable resources, beyond the level that is required for the given cost models.

The following tables describe in more detail the “Other Direct Costs” associated with each work package, further divided by partner. Note that there are travel costs associated with JIVE to cover the costs for WP2 and WP3 travel and meeting support. JIVE will be providing the administrative and travel support for these work packages as outlined in the DoW. The activities are then subtotaled (NA, SA and JRA) and then a grand total provided.

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WP1 NA1 Management	Travel	Equipment	Materials	Other
JIVE	26,250	0	0	0
TOTAL	26,250	0	0	0

WP2 NA2 EVN- NREN	Travel	Equipment	Materials	Other
JIVE	30,000	0	0	0
DANTE	0	0	0	0
TOTAL	30,000	0	0	0

WP3 NA3 eVSAG	Travel	Equipment	Materials	Other
JIVE	30,000	0	0	0
FG	0	0	0	0
TOTAL	30,000	0	0	0

WP4 NA4 Outreach	Travel	Equipment	Materials	Other
JIVE	900	0	15,200	0
TOTAL	900	0	15,000	0

WP5 SA1 Cloud Correlation	Travel	Equipment	Materials	Other
JIVE	1,375	130,500	0	0
MPG	375	0	0	0
TKK	375	0	0	0
TUM	625	0	0	0
TOTAL	2,750	130,500	0	0

WP6 SA2 High bandwidth on demand	Travel	Equipment	Materials	Other
JIVE	875	40,000	0	0
ASTRON	750	20,000	0	0
UMAN	875	20,000	0	0
OSO	250	0	0	0
NORDUnet	625	0	0	0
SURFnet	0	0	0	0
DANTE	0	0	0	
CSIRO	2,500	0	0	0
TOTAL	5,875	80,000	0	0

WP7 JRA1 Computing shared infrastruc	Travel	Equipment	Materials	Other
JIVE	875	8,000	0	0
OSO	1,250	2,000	0	0
VENT	938	2,000	0	0
PSNC	2,250	2,500	0	0
CSIRO	0	0	0	0
TOTAL	5,313	14,500	0	0

WP8 JRA2 High-speed storage	Travel	Equipment	Materials	Other
JIVE	8,500	9,000	0	0
ASTRON	1,100	9,500	0	0
INAF	1,875	10,000	0	0
UMAN	675	9,500	0	0
OSO	675	9,500	0	0
PSNC	750	0	0	0
TKK	2,925	19,000	0	0
TOTAL	16,500	66,500	0	0

Total NA	87,150	0	15,200	0
Total SA	8,625	210,500	0	0
Total JRA	21,813	81,000	0	0
Overall TOTAL	117,588	291,500	15,200	0
Grand Total	424,288			

We expect considerable *additional* effort during the course of the project. In the GigaPort 3 project SURFnet will further develop dynamic services for the Dutch scientific and educational communities. Although not formally accountable, the results of this engineering effort will be directly applicable to NEXPReS. Another category is the hardware contribution from some of the partners, not listed in the project. A major contribution is expected from SURFnet regarding the connectivity of the correlator at JIVE. Similarly, additional contributions are expected from the DANTE and NORDUnet partners.

Through the link with the EVN a large number of resources are committed to this project. The enormous capital investments and operational budgets of the telescopes themselves are not accounted in this project, yet they are in fact the Infrastructure that is made available in this programme. This not only holds for the radio astronomy partners in NEXPReS but for all associated EVN telescopes in Europe and beyond.

The same arguments hold for the close ties that have been established, one way or the other, with NRENs that support e-VLBI but are not listed as formal members. Through NEXPReS it will be possible to further develop the vital relationships with these partners, whose participation reflects an investment on national levels.

Finally, NEXPReS will catalyse collaborations with other partners in the field. Specifically we mention the commitment of the group of Curtin University, Western Australia, who prefer to stay outside the formal rules of our proposal, but are eager to contribute to the common goals.

B 3. Impact

B 3.1 Strategic Impact

The purpose of the combination of collaborative activities and coordination and support actions proposed in NEXPReS is to further improve the research infrastructures for long baseline interferometry in Europe (VLBI, but also LOFAR). By its very nature this requires a European and often global approach. The continuation of the networking activities established in the past through the EXPReS project will ensure that this e-Infrastructure will be further integrated and consolidated by means of the most advanced ICT methods. The Service Activities will directly boost the scientific capacity of these large-scale facilities, leading to new, exciting scientific research by a larger user community. The R&D activities in the Joint Research Activities will explore new techniques enabling future capabilities in radio astronomy, and provide feedback into the ICT domain. Clearly, the proposed programme has all the qualifications to be considered as an Integrated Infrastructure Initiative, and will give Europe a leading role in the fields of radio-astronomy, long-haul, wide band connectivity, streaming computing and fast storage.

Networking Activities

Networking Activities will foster the cooperative culture established in our community over decades, but also provide a platform for interdisciplinary collaboration between radio astronomers and ICT infrastructure providers. Proper management is a common goal for all participants and this is implemented in WP1.

Other objectives that will be addressed in Networking Activities include the strengthening of virtual communities. This is indeed the main activity of WP3 and WP4, which support the discussion platforms for EVN-NRENs and the e-VLBI Science Advisory Group. Both expert groups are essential for reaching the decisions that enforce and improve both the technical functioning and operational procedures of the infrastructure. Most of the funds are allocated to the organisation of meetings, which will definitely also attract parties from outside the consortium. However, these meetings are just the starting point for discussions and collaborations that will mostly work through e-mail and other means of communication. The EVN-NREN platform (WP2) is important for spreading good practices on high-speed connectivity beyond the NEXPReS partners, as well as discussing options and standards for the future. By associating these meetings with for example e-VLBI workshops, as has happened in the past, this activity plays an important role in disseminating knowledge on e-VLBI practices. This platform will also be the starting point for discussions on connectivity to (potential) new telescope sites. Examples of places where (further improved) connectivity is desired include Portugal, Sicily, Russia, China and the Ukraine. We stress that new connectivity is not a deliverable for which funding is sought in this programme, but that associating with an established EC framework has proven to be a vital catalyst in many countries in the past.

In WP3 the focus will be a on the impact the new NEXPReS services will have on the astronomical operations. As such it will be extremely important for strengthening the collaboration in the EVN in preparing procedures that will be in place during and beyond the programme. The focus will shift from adopting new policies for rapid response science to discussions on operational issues. For example, the new caching mechanism may require improved guidelines for storing and discarding recorded data. One can also imagine that a discussion on more regular, evenly spread observing sessions will be needed. From past experience we have learned that having such an activity in a formal work-package is absolutely essential for making progress in turning over established, old procedures in science operations.

Communication is the title of WP4, where the focus is on internal and external communication of the project. Besides dealing with outreach activities, this activity will also be responsible for managing the materials produced by the project and making them available in the public domain. Web sites are essential in providing information to the scientific community and through this activity we plan to make our programme known at many scientific meetings.

Service Activities

The main objective of the Service Activities in NEXPReS is to provide a new research infrastructure for the scientific radio-astronomy community. In WP5, "Cloud Correlation", this is achieved by augmenting the previously developed telescope connectivity by adding fast, transparent data management, enabling caching of the data, close to the time-critical components in the network. This service will provide end-to-end services throughout the running time of the project with increasing scientific capabilities. Vertical integration is taking place in this work package, where communication, storage and digital components developed in the EXPReS JRA context will be combined into new operational services. Progress will be aided by adopting new international standards for VLBI data content that have recently been established.

Complementary to this, WP6, "High Bandwidth on Demand" will focus on upgrading the network operations to include Bandwidth on Demand mechanisms, making use of shared connectivity resources. Moreover, it will greatly improve the astronomical impact of e-VLBI by providing more raw sensitivity. This activity may involve upgrading or fine-tuning the network components of NEXPReS partners and network providers along the path. This service does depend on mechanisms for dynamic allocation of connectivity that have been developed in the past and have reached a certain level of maturity. Some questions remain about combining different protocols, but we think that large-scale applications like e-VLBI or e-LOFAR will provide an important stimulus towards their unification.

Besides boosting the bandwidth available for e-VLBI and therefore its sensitivity, the Service Activities will cause a tremendous scientific impact by improving the flexibility, robustness and efficiency of the network. The importance of such quality enhancements should not be underestimated, as they address the true bottlenecks between observations and scientific papers. Sampling data at optimal observing conditions, guaranteeing that all telescopes deliver data of the highest quality and checking the results in real-time improves the chances that the observations meet the original astronomical objectives. This, combined with the impact on overall efficiency through the reduction of complex logistics, will make e-VLBI accessible to more astronomers worldwide. These goals are also supported by a number of EVN and nationally funded projects aimed at upgrading both telescopes and the correlator to produce and handle the required data rates.

Joint Research Activities

WP7 and WP8 address innovative techniques and explore new options for future use of radio-astronomical facilities. WP7, "Computing in a Shared Infrastructure", deals with the optimisation of the streaming data applications that are specific to radio astronomy. While it is our aim to make use of middleware protocols that have been developed in the Grid context, we note that these services will have to operate in a different regime. This work will focus on implementing new methodologies and protocols. A specific aim of WP7 will be to test several scenarios by integrating some of the software correlator components at partner institutes into a new virtual service. In order to address distributed computing in a streaming environment, new protocols will have to be developed. We expect the results of this work to feed back into the European ICT community and have a real impact on the development of high-performance streaming computing elsewhere.

Similar arguments hold for the significance of WP8, "Provisioning High-Bandwidth, High-Capacity Networked Storage on Demand". By researching the very specific requirements of radio astronomy in the present and future, it can be anticipated that new protocols and mechanisms will be developed. Although radio astronomy may be very specific in its caching requirements, it is certainly not the only area in science or society where high bandwidth storage is required for the near future. This R&D work has a high likelihood of reaching the scientific community through its link with WP5, from where results will be disseminated throughout the e-Infrastructure.

Apart from the technological imperatives, the role of the Joint Research activities in the e-VLBI community should not be underestimated. In WP7 and WP8 much of the international and interdisciplinary collaboration takes shape. Engineers from many countries have constructed the VLBI facilities in unison with pride and dedication, and this programme offers an opportunity to continue collaborating in this tradition of international excellence. The expertise already abundantly available will be boosted by new expertise and used to foster the global e-VLBI collaboration and work towards future e-Infrastructures.

B 3.2 Plan For The Use And Dissemination Of Foreground

3.2.1 Dissemination of Results

The Project Office will facilitate the dissemination and exploitation of results through several coordinated activities. The project is designed to have several work packages that focus on inter-disciplinary communication. Furthermore, there is a work package dedicated to communications.

WP4- Communications is focused on ensuring that the activities of the project are properly distributed, both within the project and outside. The project will have a presence on the web, where a public site will contain all relevant information for visitors; this will include final deliverables aimed at the public domain. A closed section of the web site is aimed at internal communications; this has proven to be highly successful in the past for sharing documents in progress, but also for setting up meetings and sharing management information. More external communications will be executed through existing contact points in the media, built up over the years through contacts with previous (EC) projects as well as through local initiatives by the Project Office. Efforts will be made to ensure that all partners have sufficient access to local media sources. In addition to the planned activities, there are various opportunities that will be handled when they come up. These often come in the form of presentations, co-sponsorships and invited talks.

Project achievements and milestones will be communicated to the general public and/or astronomy, research and networking communities as appropriate through press releases, EVN newsletter announcements, participation in meetings (e.g., TNC and EC Concertation events) and postings on the NEXPReS web site. Such events include technology breakthroughs and demonstrations, significant scientific publication resulting from NEXPReS technology advances, project completion, etc.

Press releases will be issued by the NEXPReS Communications Office, which will also coordinate related press releases issued by NEXPReS partner institutes. Some partners such as DANTE, TERENA, SURFnet and CSIRO have proven in the past to have significant reach into the astronomy, research and networking communities, as well as successful traction with the public media.

Both WP2- EVN-NREN and WP3- eVSAG are designed to encourage communication and discussion between groups that may not naturally interact with one another. WP2 gathers astronomers and computer network engineers to discuss technology issues and upcoming opportunities on the interface of radio astronomy and connectivity. Discussions in this forum will deal with new methods and equipment for the provisioning of bandwidth on demand, as well as the specific issues in bringing new or enhanced connectivity to telescope sites outside of the consortium. A specific function of this forum will be to provide the astronomical community with the opportunity to bring forward its requirements regarding quality of service issues, like maintenance schedules and downtime.

WP3 focuses on addressing the gaps between current operational radio interferometry practices and potential improvements made possible through new technologies. Here the impact of new technology on the operational model of the EVN and other VLBI networks will be discussed. New opportunities and changes in operational constraints will be brought to the attention of VLBI users and operators. The expertise of this group will feed into the discussion on operations of future telescopes. Meetings held by these two network activities will be coordinated with WP4.

WP5- Cloud Correlation and WP6- High Bandwidth on Demand will contribute to the operational VLBI infrastructure and in this way have an impact on astronomical science. The resulting scientific papers and presentations will contribute to the dissemination of information on the project activities and the science that the project enables.

The two research activities, WP7- Computing in a Shared Infrastructure and WP8- Provisioning High-Bandwidth, High-Capacity Networked Storage on Demand are likely to produce scientific publications by themselves, but will generate additional scientific output through astronomical results when they reach the operational stage.

Together, WPs 5-8 will all generate presentations and reports that will have various levels of relevance to the community active in the field of radio astronomy instrumentation. In conjunction with WP4, these materials will be shared as appropriate.

3.2.1 Intellectual Property

Participants in the Project have the possibility of creating intellectual property that is not only of use to the project, but also of general value to society. Given the academic nature of most partners most of the information exchange will happen in an open atmosphere, but there may be areas in which management of knowledge capital will be important. For this a flexible implementation of intellectual property rights will be necessary. This formal process for use and sharing of intellectual property will be stipulated in the Consortium Agreement. In general, developments within the project will be viewed as shared products, equally available to all project partners. Software that extends existing open source software will remain open source software. There is a preference to place new software under an open source license, but the final decision will be made by the project Board.

B 3.3 Added Value Of The Community Financial Support

The scientific motivation for NEXPReS is to facilitate new astronomical observing opportunities. Humanity carries out astronomical research primarily to satisfy its curiosity about the fate of the universe that it lives in and the laws of physics that govern it. Astronomy has a great appeal to the general public and motivates young people to pursue a career in science and technology. However, there are also numerous examples where pure scientific research has led to important technological results directly, with associated socio-economic impact. The time scales for this feedback are generally long and hard to predict; a recent example is the awarding of the 2009 Australian Prime Minister's Special Prize in Science to Westerbork telescope pioneer John O'Sullivan in recognition for his vital contribution to WiFi.

NEXPReS will certainly make a significant contribution to Europe's leading role in the area of radio instrumentation, thereby strengthening its potential to build the SKA. Compared to other ongoing projects, NEXPReS has the outstanding potential to bring more ICT specialists into the radio astronomy domain and expand the expertise in the astronomical community in cutting-edge network, computing and storage techniques. In addition, it will make the network and distributed computing communities more aware of the specific needs of radio astronomy. With the advent of an increasing number of so-called software telescopes (LOFAR, SKA) this awareness will be urgently needed to bring about synergetic approaches. NEXPReS also has an important link to VLBI Space Science, a field in which Europe has a distinct lead. Through the technological advances of this project European VLBI will be able to continue to play an important role in future planetary space missions.

Moreover, the NEXPReS project has the potential to make a significant impact through the technological developments in its Service and Research Activities. As an example, the Service Activities will implement procedures for dynamically allocated network connections as part of the operational efforts for e-VLBI. This work may be relevant for other science user communities, especially when combined with the high-bandwidth storage requirements that will also be addressed in our programme. Some of these resource allocation solutions may be applicable beyond the scientific community, for example in dispatching large volumes of sensor data for weather or geodynamic monitoring.

In the mid-term, the fast storage system that we will develop in WP8, complemented by the anticipated increase of CPU power, could be commercially relevant. Our choice to use standard off-the-shelf components will help to close in on a set of optimized solutions applicable both in the research/academic and in the commodity/industrial sectors.

The appealing combination of novel technology and cutting-edge science exerts a special attraction on talented people who enjoy working on the interface between science and engineering. Having such people work on public e-Infrastructures with purely scientific objectives will project a positive image of Europe's technology program, an image that will be strengthened by new pictures of astronomical objects made possible through technological innovation.

B4. Ethical Issues

NEXPReS does not believe that there are any ethical issues associated with the project after internal consideration and after referencing the Ethical Guidelines for ICT text.

Appendices

Appendix 1: Financial Identification Form

FINANCIAL IDENTIFICATION

PRIVACY STATEMENT http://ec.europa.eu/budget/execution/ftiers_fr.htm

ACCOUNT NAME

ACCOUNT NAME(1)	Stichting "Joint Institute for V.L.B.I. in Europe (J.I.V.E.)" inzake NEXPReS
ADDRESS	Oude Hoogeveensedijk 4
TOWN/CITY	Dwingeloo
POSTCODE	7991 PD
COUNTRY	Netherlands

CONTACT	Van Langevelde Huib
TELEPHONE	+31 521 596 524
FAX	+31 521 596 539
E - MAIL	nexpressecretary@jive.nl

BANK

BANK NAME	Fortis Bank (Nederland) N.V.
BRANCH ADDRESS	Blaak 555
TOWN/CITY	Rotterdam
POSTCODE	3011 GB
COUNTRY	Netherlands
ACCOUNT NUMBER	24.03.76.242
IBAN(2)	NL92FTSB0240376242

REMARKS:

Project number 261525

Project Acronym NEXPReS

BANK STAMP + SIGNATURE OF BANK REPRESENTATIVE (Both Obligatory)(3)

FORTIS BANK (NEDERLAND) N.V.

J. Mattijs

Senior Banker

19/04/2010

DATE + SIGNATURE ACCOUNT HOLDER : (Obligatory)

DATE 26/4/2010

(1) The name or title under which the account has been opened and not the name of the authorized agent

(2) If the IBAN Code (International Bank account number) is applied in the country where your bank is situated

(3) It is preferable to attach a copy of recent bank statement, in which event the stamp of the bank and the signature of the bank's representative are not required. The signature of the account-holder is obligatory in all cases.

Appendix 1: Scanned copy of the signed Financial Identification Form

Appendix 2: Letter Declaring Interest Bearing Bank Account

JIVE
JOINT INSTITUTE FOR VLBI IN EUROPE

Postbus 2, 7990 AA Dwingeloo, the Netherlands
Oude Hoogeveensedijk 4, 7991 PD Dwingeloo
Tel: +31 (0)521 596500
Fax: +31 (0)521 596539
E-mail: jive@jive.nl
URL: http://www.jive.nl
Bank: 63.04.99.292
VAT No: NL.8070.28.009.B.01
CC/KvK: 41020054

Dwingeloo, 26 April 2010

To Whom It May Concern,

JIVE, the Coordinator for the NEXPReS Project (261525), has opened an interest bearing bank account on behalf of the NEXPReS Project. The account was opened with Fortis Bank and has the account number 24.03.76.242. The full details of the account are available in the Financial Identification form that is submitted with the project documentation.

This account will be used to receive EC funds for the project and will be the account from which funds will be distributed to project members.

Yours sincerely,

Dr. H.J. van Langevelde
Director

Appendix 2: Signed letter declaring that the bank account for NEXPReS is interest bearing