



## Express Production Real-time e-VLBI Service

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# Monthly Report- June 2007

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### Delivery Slip

	Name	Partner	Date	Signature
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### **Section 1.0- Introduction**

This month's report identifies no new obstacles and identifies several completed deliverables and related activities. The summer holiday season is also upon us. We do not expect deviations from plan, but individual communications will likely be a bit slower than usual. The project office will be staffed the entire period.

Of note, the 6th e-VLBI workshop hosted by the Max Planck Institute for Radioastronomy in Bonn was announced last month. EXPReS is working with the organizers to identify several talks that highlight recent activity networking field (in addition to the expected astronomy-specific talks).

### **Section 2.1- NA1 - Management**

The Project Office received the official documents from the First EXPReS Review. These documents will be used as the foundation for the modifications to the DOW and will be submitted shortly. Along with these documents will be the original copies of the financial documents. The final documents should be completed about the same time this report is delivered.

As mentioned in last month's report, the project faced an unavoidable set back with the loss of one of the programmers at JIVE. The most positive news is that the job posting for a replacement has received multiple replies in a short period of time. We hope this bodes well for finding a replacement and integrating the new person's activities into the project. However quickly this happens, there are concerns that there will be delays. The exact duration will depend on how long it takes to find a replacement and some of the specific skills and characteristics of the replacement.

Members of the Management Team, FABRIC and the work packages are actively discussing options. One of the items of concern comes from PSNC as some of their work may be affected by the current situation. PSNC is actively working to find ways to minimize the impact on their portion of the project while maintaining progress.

The Project Office was asked to establish a mailing list for the eVSAG. This was done, and a reminder note was sent to the activity leaders indicating that the lists could be hosted via the JIVE majordomo server. None of the other activities indicated the desire for a new list (most already had lists in place). EVN-NREN did use this as an opportunity to re-invigorate the list they had in place and request new users.

### **Section 2.2- NA2 - EVN-NREN**

In the past month, EVN-NREN has sent several emails to add additional members to its mailing list. The focus of the most recent push has been individuals from non-European networks. These include



networking specialists as well as individuals who have shown ongoing interest in e-VLBI, radio astronomy and distributed computation.

John Chevers reports that he will not be able to participate in the "First Virtual Forum of Global Research Communities" later in July, however, one of his colleagues will present materials. EXPRES has provided several slides for this event. We hope that some of our project's activities will be highlighted.

### **Section 2.1- NA3 - e-VLBI Science Forum**

A call for proposals was sent out June 3rd for observations on June 20th/21st, with deadline June 12. This was a special one off call that used the 'old' proposal rules (needed because under the new system proposals submitted for the standard June 1st deadline could not be reviewed in time for June 20th observation). Two proposals were received and 1 scheduled, with the run going very successfully.

On June 28th the second eVSAG face-to-face meeting occurred with 13 people present in person and one joining by telecon. A 'brainstorming' session was had on new innovative proposal and scheduling policies to best utilize e-VLBI on the EVN from early 2008 onward (when we expect a highly capable array of >8 stations working at 512Gbit/ to be in place). The minutes of this meeting are presently being prepared and will be placed on the EXPRES wiki.

In addition, NA3 leader John Conway collected and shared station reports for most of the EXPRES partners as part of a regular information collecting exercise. There is a huge amount of free form data in the responses. For a full copy, please contact Conway. A few highlights:

Effelsberg: Work has finally begun on digging the trench for laying optical fibre from the Effelsberg telescope to the MPIfR building in Bonn. This will be an MPG-owned link. Approximate cost is ~1 M Euro. Physical laying of the fibre should nominally be completed by 19 October. The link will initially provide 1 x 10 Gbps line and (2 or 3) x 1 Gbps lines, notionally 3 x 1 Gbps for LOFAR and 1 x 1 Gbps for eVBLI.

Yebe: expect to have the 1 Gbps line from Yebe to JIVE working in January 2008. The 40m will also be involved in geodetic VLBI observations;

Onsala: We have a Mark5A, purchased Mark5B+, have 1 Gbps, plan to upgrade to 10 Gbps during the autumn.

Medicina: station is connected to the POP of the Garr/Geant network by an optical fibre with a path 140 Km long. maximum speed is 1 Gbit/sec. Works are in progress to connect the station with a shorter path (40 Km) and a dark fiber. At the beginning of May 2007 we installed a new switch-router ( Extreme Summit X450 ) that will mount optical converter ( GBIC ) for a speed of 10Gbit/sec.

Noto Station: We are trying to establish some contact with the Sicily Local Government and with INFN, to start the construction of the infrastructure.

The Sardinia Local Government promised to take care of the infrastructure, and ensures that the optical fiber connection will be in place at the telescope first light.

Hartebeesthoek: Present capabilities, effectively none. However discussions with the (not yet established) SANREN suggest that a temporary link may well be setup within a timescale of 2-3 months enabling use of spare outbound capacity on current academic bandwidth sufficient to carry up to 128 Mbps.

Irbene: The internet connection 1Gbit/s Irbene - Ventspils University College (Last mile!) is now established. There is 16 Mbit/s on the moment connection from Ventspils to outer world but soon the (during July) 100 Mbit/s will be established (For special purposes the 1Gbit/s link



via the Royal Institute of Technology in Stockholm is possible. However a special agreement could be necessary for big data transfers.

Arecibo: In practice, the actual data connectivity between JIVE and Ar since summer 2005 has never exceeded even 20 Mbps during several test runs. In the near-term future our network provider is upgrading their backbone. They have made an offer to the to upgrade our link to achieve 512-Mbps connectivity is based on a gigabit Ethernet link via Centennial's on-island MPLS (Multi Protocol Layered Switching) network and FIU's AtlanticWave/NLR connection. An essential ingredient of the mix is that UPR will allow us to "borrow" their upgraded commodity Internet bandwidth (300+ Mbps) for short periods,

Note that this information was collected and shared in conjunction with SA2.

The eVSAG also established a formal mailing list through the JIVE majordomo server. This list has been populated and will be archived through a simple username/password system.

### **Section 2.1- NA4 - Public Outreach**

The primary activity for NA4 continues to be the design and optimization of the display stand. A second round of changes and modifications is being discussed.

Behind the scenes, the EXPReS wiki has been receiving a great deal of attention. The core software has been updated to bring the system up to date. In addition, the inner workings have been rationalized. Like all wikis, the EXPReS wiki evolved with some oddly organized sections. Many of the worst offenders have been pruned and moved. There were very few problems with the modifications, but we continue to check for problems.

Related to the website, an online display of EXPReS partners and a visualization of their connection speed is almost complete. The map is based on Google Maps functionality and shows partner antennas along with their connectivity. The final version will be posted online at:  
<<http://www.expres-eu.org/maps/>>.

### **Section 3.1- SA1- Production e-VLBI Correlation**

June saw the first attempts to test the connection to Shanghai operationally for the first time. Although not directly successful, this was a very useful first step towards including Shanghai in science e-VLBI. The problems preventing us from utilizing the full available bandwidth are partly those that have been reported on previously (the unavailability of Streamstor libraries compatible with new Linux kernels and the sub-optimal TCP version we have to use because of this, combined with the very long RTT of more than 300msec), but also the need to by-pass certain security devices inside the Chinese network, for which we only can reserve certain timeslots. Complaints have also been received by the Shanghai Observatory staff after iperf tests during which 930 Mbps (TCP) was streamed from Shanghai to Hong Kong; these tests obviously cause serious disruption on the Chinese network (the old argument for the use of lightpaths).

On the positive side, new libraries have been produced by Conduant, although some software problems have to be dealt with before these libraries will be released. Work on a UDP-based transfer solution has been accelerated and one JIVE staff member is now working full-time in collaboration with software engineers from Manchester University towards a Mark5 implementation.

Just days before this test, an interconnect was created between CSTNET and CERNET, allowing the use of the TEIN2 network via Siberia. This connection, with a much lower RTT, will be tested extensively in the next weeks, although care has to be taken to warn both Chinese networks of possible disruptions.



The e-VLBI session of 25-26 June was a great success, both in terms of operational smoothness and of transfer rates. Although the 12 hours of science observations themselves were done at 256 Mbps (with stretches of 2.5 hours without any human intervention, which is good statistics even for non-e-VLBI operations), some 4 hours were also spent observing a bright calibrator at 512 Mbps, giving the first 6-station 512 Mbps real-time image ever.

Some testing with Australian telescopes also took place. In this case, we need to worry not only about the transfer rates, but also about the software interface between correlator control and stations, and about the conversion of native data format to Mark5B format and how this is handled by the Mark5A+ system at the correlator.

Even without a lightpath from Australia in place, we managed simultaneous data transfer from 3 telescopes in Australia at 64 Mbps. We also could verify that the data is interpreted correctly by the correlator, and that the software interface functions properly. One reason for the better performance compared to China is the use of new Linux kernels in the recording units at the Australian stations. A lightpath to JIVE will be put in place by AARNet on the 9th of July.

Network monitoring at JIVE is now far more sophisticated than in the past, with statistics of individual links being produced continuously. By next month this information will be available on a public webpage as well. This also opens the way for regular monitoring of connectivity, as advised by the EXPReS review panel.

Several deliverables were due in month 16:

D11, Job preparation utilities, is done.

D124, Mark5 hardware upgrade, is partially done, but cannot really be considered delayed. All hardware is available, 7 out of 16 Mark5s have been upgraded (currently sufficient for e-VLBI), the 8th is being upgraded right now and the remaining 8 will be done at a speed of roughly one-two per week, depending on work pressure.

D28, Network protocol decision, is still being decided. A decision cannot be made as long as we do not receive upgraded Streamstor libraries. Simultaneously, a lot of effort is going into making a practical UDP solution. A reasonable estimate for a final decision would be August.

### **Section 3.2- SA2- Telescope Network Connections**

There has been visible progress in fiber provisioning and distribution for several partners. Manchester and MPIfR both report on their activities.

Manchester reports fruitful discussions with NRENs on the provision of a 10 Gbps lightpath between Onsala and Jodrell Bank. Their priority is to achieve a low cost for the connection. Connection between JBO and Manchester at JBO has been delayed while contracts are organised.

Digging for the Effelsberg data fibre has started. DFN will establish a new X-WIN POP at the university of Bonn. This will shorten the required MPIfR fibre and the cost by a significant amount. The tender for work has been finalized and the expected timeline for completion is still October 2007.

Negotiations for the connection to The Netherlands are underway. Offers are available from Lambda-net and DFN. The DFN connection will require the POP at the university which is anticipated for October this year. The connection from the new POP to the Netherlands is expected for November 2007. Until the 10 Gbps P2P from Bonn to Dwingeloo will become available, a 1 Gbps dedicated line to the GÉANT POP in Frankfurt can be used for e-VLBI traffic (see above).

An excerpt of MPI's e-VLBI efforts were reported at the 18th European VLBI for Geodesy and Astrometry (EVGA) Working Meeting, Vienna, April 12 – 13, 2007:



"e-VLBI data transfer from Onsala and Metsähovi to the Bonn correlator", Haas R, Müskens A, Wagner J, Dulfer Ch, Mujunen A, Ritakari J.

and

"Bonn correlator report", Alef W, Müskens A, Bertarini A The proceedings will be published soon. Presentations under: [http://www.evga.org/Meetings/evga2007\\_meeting/agenda.html](http://www.evga.org/Meetings/evga2007_meeting/agenda.html)

#### **Section 4.1- JRA1- FABRIC**

##### *Work Package 1*

During the FABRIC face-to-face meeting in Dwingeloo (April 2007), aspects of QoS were discussed. This topic was raised at the Annual review and is of potential interest to the project. Recently over email, Garstka of PSNC reports that Premium IP service in GEANT is free of cost across the GEANT backbone. However, he found that NRENs may have different policies. Premium IP might be an additional cost service or unsupported depending on the region. They will investigate, but note that a homogeneous solution may not be possible.

Even though Bonn has not yet started with FABRIC (still waiting for the specifications of the Finish hardware), they are taking part in network transmission tests where geodetic VLBI data are transferred using the Tsunami protocol from Onsala and Metsähovi to Bonn for correlation. For those e-VLBI activities a dedicated 1 Gbps line to GEANT is used. Those efforts support the EXPReS/FABRIC project with resources provided by MPIfR and the University of Bonn/geodetic faculty. We expect to hire a software engineer/scientist in August/September 2007.

Onsala reports a highly successful meeting at Arlanda airport in Stockholm on June 12th 2007. John Conway (Onsala), Richard-Hughes Jones (Manchester) and representatives from SUNET and NorduNet participated. The main topics were Onsala's last mile provision at 10G and onward connection from NorduNet with final destination UK for executing the 4Gbps demo.

On the first issue a cost effective solution giving Onsala a permanent connected lightpath to Stockholm at 10G from Oct 2008 was agreed.

On the second NorduNet agreed to the concept of in late 2007/2008 a few days per month 'test time' on 4Gbps lightpath outward from Stockholm at no charge. Network topology was discussed with 4Gbps inputs from either Onsala or Metsähovi arriving at Stockholm being switched onto NorduNet and then being sent to the Netherlands for onward delivery to the UK (and also JIVE and Groningen for possible tests with a LOFAR station at Onsala). NorduNet agreed to contact SurfNET in NL to discuss onward route to UK.

The Onsala iBoB/iADC needed for the 4Gbits/s transmitter has now been ordered from Digicom (a company in the US) with delivery expected end of August. A larger order for 3 combined iBoB/iADC units from Metsähovi was also finalised. Donated Xilinx chips to populate all four iBoB board are being sent from Metsähovi.

Metsähovi confirms the order for the iBoB+iADC boards. 3 sets are going to Metsähovi and one set to Onsala, all for the development of a proto data acquisition system and 4Gbps demo. Metsähovi will also send 3+1 sets of FPGA+firmware PROM chips to Digicom. The chips were obtained from the Xilinx University Program. Development on the Xilinx products will start soon.

Metsähovi has identified candidates for a small 10GE switch for testing 10GE iBoB connections. Currently, Myrinet and/or Sun 10GE PCI Express Ethernet cards in Linux PCs are being considered. Purchasing is timed to the expected arrival of the iBoB boards (end-of-Aug-2007) to take advantage of the continuous price drop.





Metsähovi also reports on interesting progress with the PS3 hardware. The Linux based platform can execute DiFX correlation. The goal is to improve the current 10% hardware efficiency to closer to 80% with some understood optimizations.

Manchester reports that the design of firmware for the iBoBs to be used in connecting to the e-MERLIN correlator is proceeding well. Jonathan Hargreaves attended a recent workshop (25-29 June) at U.C. Berkeley on iBoBs and gained useful information and contacts. Our next priority is to implement 10GE capability.

10 complete iBoBs boards have now been delivered to JBO. We expect to receive and invoice shortly for around 20,000 dollars. 5 Vertex II FPGA's need to be delivered to Berkeley, two of which should be from the Finish group. We will be purchasing mechanical hardware, power supplies and CX4 connectors and cables shortly. We are investigating suitable switches; one will be required in the autumn.

#### *Work Package 2*

As reported previously, Ruud Oerlemans, the software developer working on the Correlator core has left JIVE. This has resulted in a significant slowdown in the ongoing development of the correlator core, especially in the areas that interface with the workflow manager and grid engine. It's likely this will cause some delay in delivering the next versions of the software (DJ1.23, DJ1.24, DJ1.28) and the demos that rely on the software. Oerlemans's former position has been advertised again, and interviews with a couple of promising candidates have been scheduled for early July.

Development of a cluster-aware version of the code is still in full-swing though, with a first version being tested on the DAS-3 cluster in the Netherlands.

The software correlator has been used to correlate the so-called FTP fringe tests for the May/June EVN VLBI session. These FTP fringe tests are short observations that are done before the actual science observations to check whether the telescopes are performing as expected. While running the software correlator on these observations some operational issues with the software surfaced. Most of these have now been addressed. This also prompted us to start work on some visualization tools that allow our support scientists to check whether the telescopes (and implicitly the software correlator itself) are working as expected.

Building on the April group meeting, PSNC indicates progress with communication paths in the grid-VLBI design, specifically between the Broker and Translation nodes. The notification mechanism has been designed and is being prepared. Evaluation, preparation and tests of different architectures for deployment of grid-VLBI components is also underway.

The Correlator Design Specification, deliverable DJ1.4, has been finalized, and made available on the EXPRoS Wiki.

Several presentations have been made regarding WP2 activities. Most recently, presentations were made at the 2nd International Workshop on Distributed Cooperative Laboratories, the 20th Open Grid Forum and the 2nd EGEE User Forum. The full list of presentations is available on the website.

#### **Appendix - EXPRoS Contact Points**

For convenience, a list of the activities and the associated contact points are listed here for reference.

ID	Description	Contact	email
PC	Interim Project Coordinator	Huib Jan van Langevelde	langevelde // jive nl
NA1	Management of I3	T. Charles Yun	tcyun // jive nl
NA2	EVN-NREN Forum	John Chevers	john.chevers // dante org uk
NA3	e-VLBI Science Forum	John Conway	jconway // oso chalmers se



NA4	Public outreach	Kristine Yun	kyun // jive.nl
SA1	Production Services	Arpad Szomoru	szomoru // jive.nl
SA2	Network provisioning	Francisco Colomer	f.colomer // oan.es
JRA1	FABRIC- WP1 FABRIC - WP2	T. Charles Yun Mark Kettenis	tcyun // jive.nl kettenis // jive.nl

### Appendix - Scientific Software Engineer Position Announcement

Copies of the below note have been distributed to a variety of mailing lists frequently used by the project as well as to field-specific distribution groups. The position is available immediately.

Subject: EVNtech: scientific software engineer position at JIVE  
From: Arpad Szomoru <szomoru@jive.nl>

Dear colleagues. Apologies if you receive this email more than once.

The Joint Institute for VLBI in Europe (JIVE) is currently seeking a scientific software engineer.

JIVE operates an advanced 16-station VLBI data processor (correlator) to support astronomical observations made with the European VLBI Network (EVN). JIVE is located in Dwingeloo, in the Netherlands, at the headquarters of ASTRON, which is the host institute for JIVE. Further information regarding JIVE and the EVN can be obtained from [www.jive.nl](http://www.jive.nl) and [www.evlbi.org](http://www.evlbi.org).

The EXPReS project (led by JIVE) aims to connect together some of the major radio telescope facilities in Europe, Asia, Australia, South America, South Africa and the USA by using high speed optical fibre networks, creating a real-time e-VLBI network - a unique astronomical telescope of intercontinental dimensions. EXPReS is partially funded by the European Commission. The EXPReS project involves 19 different international partners (Radio Astronomy Institutes and Research Networks).

EXPReS will upgrade the EVN correlator at JIVE, in order to provide astronomers with a robust, real-time e-VLBI capability. EXPReS will also support various technical and scientific networking activities, support the connection of additional telescopes to the Data Processor at JIVE and conduct research into future high-speed (> 1 Gbps) e-VLBI networks.

In addition research is done into the possibility to distribute the correlation itself over the Grid. As part of the STARE program the SCARIE project has been funded by the Netherlands Organisation for Scientific Research (NWO). In this project JIVE collaborates with SARA and the University of Amsterdam on processing data streams from telescopes on a special high-speed Dutch research network.

This project aims at developing new astronomical observing modes by enhancing the resolution and accuracy of the correlation process. It also touches on topics like high-bandwidth data transport, lightpath switching and Grid computing.

JIVE is inviting applicants for the following appointment, becoming available immediately:

Scientific Software Engineer (EXPReS/SCARIE)

This position involves

- Development, optimisation and parallelisation of correlation software
- Creating an interface to the workflow manager and Grid broker software currently being developed by one of our European partners
- Development of visualisation software

We are seeking an individual with an academic level education in computing science, physics or astronomy, or equivalent experience. Extensive experience with software development in C, C++ and scripting languages (Perl, Python) on Linux/UNIX platforms is required. Experience with High Performance Computing, Grid methods or radio astronomy will be considered an advantage. A good command of written and spoken English is essential.

The appointment will be based at JIVE in the Netherlands and is offered for one





year in the first instance with the possibility of an extension up to a total of two years. The appointees will be in the formal employ of the Netherlands Organization for Scientific Research (NWO) with a competitive salary plus an excellent package of secondary benefits, including relocation expenses.

Please send your application, preferably by email, to:

personnel@astron.nl  
 Ms D. Verweij  
 Joint Institute for VLBI in Europe  
 Postbus 2  
 7990 AA Dwingeloo  
 The Netherlands

Applications including a CV should arrive by June 15, mentioning ref. No. JIVE2007/04. Further information can be obtained from Mark Kettenis (kettenis@jive.nl, +31521596525) or Arpad Szomoru (szomoru@jive.nl, +31521596509).

### Appendix - First Light at Yebes

Paco Colomer, leader of SA2, sent the below announcement to several astronomy lists. This is an important step as Yebes moves closer to operational capabilities and participation in regular e-VLBI astronomical sessions.

THE NATIONAL ASTRONOMICAL OBSERVATORY OF SPAIN INFORMS:

On June 21st 2007, the 40-m diameter radiotelescope at Centro Astronomico de Yebes performed its first astronomical observations. The emission of the Moon was observed at 22 GHz (wavelength of 1.3 cm), frequency at which the first pointing and tracking tests were performed. The receiver, placed at the Nasmyth focus, was designed and built at Yebes with a noise temperature of 20 K. Also scans on the Sun were made (which obviously saturated the receiver) and the atmosphere opacity was determined at 22 GHz by sky-dippings (measure of the receiver noise temperature at different elevations). Also Venus and quasar 3C273 were observed. With these first observations, the new 40-m radiotelescope at Yebes starts a new phase, that of commissioning, which will allow its complete characterization previous to the start of operations. Commissioning will also include primary focus measurements at 12 GHz, the frequency chosen for the fine adjustment of the main reflector surface by holographic techniques.

### Appendix - Deliverables Table

The deliverables table is maintained on the wiki at:

<http://www.jive.nl/dokuwiki/doku.php/expres:management:deliverables2>

The information below is a subset of the entire table made prior to the submission of this report, specifically, months 13 to 24. A copy of the full table is available at the URL above.

D#	AD#	Description	Plan	Actual	Status
D122	DJ1.11a	Interim Protocols performance report 3)	13	15	4
D123	DJ1.4	Correlator design specification	13	16	4
D42	J1.12	Software correlator core	15	6	3
D44	SA1.10	Real-time data processor control software (no document)	15	4	4
D46	NA3.2	eVSAG meeting No. 2	16	15	4
D47	SA1.11	Real-time Pipeline	16	9	4
D11	SA1.2	Job preparation utilities	16		2
D124	SA1.22	Mark5 hardware upgrade	16		
D35	SA1.5	Network Protocol decision: A Simulation model for e-VLBI traffic on network links in the Netherlands, Comparing Simulation and Network Monitoring Results, On Network Monitoring of end-to-end paths used for e-VLBI, UDP-like TCP	16		2
D125	DJ1.5	Overall design document	17		
D43	J1.13	Software data product	17		
D22	J1.5	Overall design document	17		0

D95	SA1.20	Improved network applications	17		0
D126	SA1.23	Use of WSRT synthesis data for e-VLBI calibration	17		
D127	SA1.24	Mark5A code modifications	17		
D128	SA1.25	Mark5B code modifications	17		
D68	J1.16	Software for workflow management	18		2
D48	NA2.03	EVN-NREN meeting No. 2	18		
D49	NA4.05	Generation of new PR material (phase 2: display stand draft graphic and merchandise)	18		2
D50	SA1.12	Visibility monitor	18	4	4
D51	SA1.13	Tested software for operational improvements	18		0
D71	SA1.17	Flexible local GE network	18		1
D129	SA2.06	Feasibility study of the last-mile connection to the nearest NREN node for participant HRAO	18		x
D18	SA2.06	Feasibility study of the last-mile connection to the nearest NREN node for participant HRAO	18		
D130	SA2.14	10 Gbps link upgrade between MERLIN and JIVE	18		x
D55	SA2.14	10 Gbps link upgrade between MERLIN and JIVE	18		
D131	SA2.15	e-VLBI test observations, Metsähovi	18	13	3
D56	SA2.15	e-VLBI test observations, Metsähovi	18	13	4
D132	SA2.17	Construction and equipment of the last-mile infrastructure in AARNET to allow connection of participant CSIRO	18		
D58	SA2.17	Construction and equipment of the last-mile infrastructure in AARNET to allow connection of participant CSIRO	18		
D62	SA2.21	Construction and equipment of the last-mile infrastructure for participant VIRAC	18		
D133	SA2.21	Construction and equipment of the last-mile infrastructure for participant VIRAC	18		
D64	SA2.23	Construction and equipment of the last-mile infrastructure for participant TIGO	18		
D134	SA2.23	Construction and equipment of the last-mile infrastructure for participant TIGO	18		
D135	SA2.24	AARNET connectivity enhancements	18		
D65	SA2.24	AARNET connectivity enhancements	18		
D136	SA1.26	Investigating a 1024M sub-array	20		
D137	SA2.25	Feasibility study of the last-mile connection to the nearest GÉANT node for participant INAF (Sardinia)	20		
D69	SA2.25	Feasibility study of the last-mile connection to the nearest GÉANT node for participant INAF (Sardinia)	20		
D70	SA2.26	10 Gbps link between UniMan and OSO for ultra-VLBI tests	20		
D138	SA2.26	10 Gbps link between UniMan and OSO for ultra-VLBI tests	20		
D139	DJ1.3	Visualization software	21		
D67	J1.15	LOFAR station interface report	21		
D8	J1.3	Visualization software	21		→
D57	SA2.16	Construction and equipment of the last-mile infrastructure for participant Shanghai	21		
D59	SA2.18	Construction and equipment of the last-mile infrastructure for participant Urumqi	21		
D60	SA2.19	Construction and equipment of the last-mile infrastructure for participant Miyun	21		
D61	SA2.20	Construction and equipment of the last-mile infrastructure for participant Kunming	21		
D144	SA2.27	e-VLBI test observations, Effelsberg	21		
D72	SA2.27	e-VLBI test observations, Effelsberg	21		
D66	J1.14	Data acquisition interface document	22		
D27	SA1.4	eMERLIN VSI interfaces design	22		1
D45	SA1.9	Tests using local Jodrell Bank home e-MERLIN telescope	22		?
D145	SA2.28	e-VLBI test observations, Metsähovi / CSIRO	22		
D73	SA2.28	e-VLBI test observations, Metsähovi	22		
D146	SA2.29	e-VLBI test observations, Yebes	22		
D74	SA2.29	e-VLBI test observations, Yebes	22		
D75	J1.17	Software for correlation on cluster	23		2



D79	J1.21	Software cluster correlation	23		
D80	J1.22	First fringes software correlator	23		
D54	SA1.15	VSI Interfaces	23		0
D31	n/a	NA2 annual report No. 2 (as part of EXPReS Ann. Rep No. 2)	24		
D81	NA1.02	Annual report (incl. Financial information) to EC	24		
D83	NA4.06	e-VLBI Demonstration and attendance at Network events.	24		
D52	SA1.14	Test using remote e-MERLIN telescope	24		?
D85	SA1.19	Multiple e-MERLIN telescope tests	24		?
D147	SA2.22	Equipment of the last-mile infrastructure for participant NAIC	24		
D63	SA2.22	Equipment of the last-mile infrastructure for participant NAIC	24		