

## FP7- Grant Agreement no. 283393 – *RadioNet3*

Project name: Advanced Radio Astronomy in Europe

Funding scheme: Combination of CP & CSA

Start date: 01 January 2012

Duration: 48 month



### **Deliverable 6.5**

**Report from the TWS Workshop 3:**

***'Metrology at Radio Astronomy Antennas'***

**At Chalmers University, Gothenburg, Sweden**

**September 1-2, 2014**

Due date of deliverable: 2014-11-30

Actual submission date:

Deliverable Leading Partner: ISTITUTO NAZIONALE DI ASTROFISICA (INAF), IT

# 1. Document information

Document name: Report from the TWS Workshop 3

Type Report

WP 6 (ERATec)

Authors

## 1.2 Dissemination Level

Dissemination Level		
<b>PU</b>	Public	X
<b>PP</b>	Restricted to other programme participants (including the Commission Services)	
<b>RE</b>	Restricted to a group specified by the consortium (including the Commission Services)	
<b>CO</b>	Confidential, only for members of the consortium (including the Commission Services)	

## 1.3 Content

1. Document information .....	3
1.2 Dissemination Level.....	3
1.3 Content.....	4
2. Report .....	5
2.1 Scientific Summary .....	5
2.2 Meeting Programme .....	7
2.3 Participant list .....	8
2.4 Meeting Photo .....	9
2.5 Information of the EC financial contribution.....	9

## 2. Report

### 2.1 Scientific Summary

After Michael Linqvists introduction to the Onsalala space Observatory and Reinhard Kellers welcome on behalf of RadioNet Jaap Baars gave a comprehensive overview to metrology problems since the days of Groote Reeber. Besides the different surface measurement methods he also stressed the need of finding the best focus as well as getting the telescope pointed accurately.

After coming together for the group picture of the workshop the group listened to Gianpaolo Serra's talk of the metrology results of the Sardinia Radio Telescope near Cagliari on the island of Sardinia, Italy. Mainly photogrammetry measurements lead to adjust the surface to a RMS of about 300um. After applying and testing holography measurements at the Medicina telescope which has been improved for application at the SRT to adjust the surface to 150um rms. Inclinometers on the elevation axis provide information of the azimuth rail.

Jose Antonio Lopez Perez showed results of mainly holographic measurements at Ku-Band (TV-Band) on the 40m Yebes telescope in Spain. Iterative measurements and adjustments led to a surface RMS improvements from 485um down to 195um.

Robert Laing presented results of the very challenging holography measurements of the ALMA 12m-antenna surfaces. To reach the challenging specifications of 25um under primary operation conditions near field holography at about 100GHz is used with an earth bound transmit. To get more elevation points in the surface measurements interferometric holography was used at 230 and 345GHz on bright Quasars using additional water vapor phase corrections. After all the RMS vary between 10.5 and 21um depending on the antenna. Aging after 2 years decreases one sample antenna from 10.9 to 13.5um rms.

Richard Prestage reported on the frequent combined with-phase and phase-retrieval holography measurements at the GBT in Greenbank, USA. Two room temperature commercial LNBs are used with 10 kHz filters, one pointing directly to the sky and one in the primary focus. The OOF holography is now installed like pointing or focusing routines in the daily observations since several years. The active surface is then adjusted continuously and thus RMS can be kept down to 130um instead of 230um without this procedure.

A special effect of mainly gravitational deformation of radio telescopes on VBLI baselines was presented by Pierguido Sarti. Based on former works at Haystack in the 1980ies he showed how the different deformations of a dish reflector influence the path length.

The last talk of the first day was given by Axel Nothnagel showing laser scanning results of the Effelsberg 100m telescope. After stressing some problems that need to be overcome deformation data of the 100m with impressive resolution were demonstrated and the different panels could be separated. In two campaigns with different laser models and improved mounting mechanics an impressive accuracy in the mm regime could be demonstrated.

At the evening the usual social dinner gave a lot of opportunities to talk to colleagues of other institutes and the vivid noise level indicated this.

The second day started with the first industry talk of Sylvere Froidevaux on time and frequency referencing based on Masers. After explaining the principles of Maser he compared stability of several frequency references. He stresses the importance of having stable environmental conditions around a maser. For compensation of frequency drifts

internal and external correction can be offered to improve performance. Many tips to improve performance were given for the users.

Wolfgang Schaefer continued this task with first explaining specifications for time and frequency distribution and showing means to achieve these. Synchronization or combination of several clocks is an important topic today to improve clock stability. Locking a maser to GPS is only one possibility to do so. Many detailed investigations were made with respect to thermal behavior. At the end he gave a personal outlook on the best clocks worldwide being tested or under constructions.

After the coffee break Alan Roy gave a short introduction on the science background of the mm-wave VLBI experiment he addressed in his talk. He explained the tight specification of clock stability influencing cabling and temperature compensation of the equipment. To test the coherence of the entire timing system a comb tone generator was added. Overall a lot of problems in accurate timing and data synchronization were faced at 1mm wavelength.

The last session of the workshop showed contributions from industry to metrology. Francesco Rampini first introduced his company before describing the dynamic metrology system of the ALMA antennas. The mechanical FEM model was verified with laser ranger and inclinometer measurements with good agreement.

Robert Laing in his second presentation presented the validation of thermal and dynamic metrology of the ALMA antennas via optical pointing and interferometric pointing. With 83 thermal sensors appointing model is fed to improve the antennas pointing. At the end the antennas are tested with offset pointing without seeing any significant offset error. Foundation tilts could be monitored and compensated with tilt meters. The only question left open is how to include wind conditions into metrology.

After lunch Martin Suess introduced metrology techniques at MTM. He stresses the importance of the right measures i.e. 'RMS' well defined. Distinguishing between causes and consequences makes a difference in how to approach metrology but usually result in the same correction. Gravity can easily compensated by FEM models prediction via lookup table. At the end he suggested to use metrology but install a switch off for measurements under perfect conditions.

The last talk of the workshop was given by Heiko Paluszek on optical measurement procedures. Depending on the accuracy needed and time available the choice of instrument is made. Easiest way is taking laser trackers as they are accurate but need retro reflectors. If this is not possible laser scanners can be used or for large scale scanning Photogrammetry is used for mirror surface measurements.

Overall the workshop invoked some very vivid discussions showing that the topic chosen was a very interesting one. Several contacts have been invoked and people assured that this workshop was very informative for the community. Especially incorporation of industry was very welcome in the community and found to be very fruitful. At the end we thanked the organizers for the perfect organization and Chalmers University for providing us with lunch and coffee.

## 2.2 Meeting Programme

### **Monday, September 1; Beginn 12:00h**

12:00h Coming together at a Lunch Snack

- Welcome Address (Michael Lindqvist, OSO / Reinhard Keller, MPIfR)

13:00h Metrology challenges at new radio telescopes:

- Summary of metrology problems (J. Baars, MPIfR?)

14:30h Coffee Break

15:00h Measurement of the optical behavior of radio telescopes:

- The metrology system of the Sardinia Radio Telescope (Giampaolo Serra, OAC-  
INAF, Cagliari)
- Holography at the 40-m Yebes telescope (Jose Antonio Lopez Perez, Centro  
Astronomico de Yebes)
- Combination of with-phase and phase-retrieval holography. (Richard Prestage,  
NRAO)
- Laser Ranging (Axel Nothnagel, Univ. Bonn)
- VLBI observation biases induced by antenna gravitational flexures (Pierguido Sarti,  
IRA-INAF Bologna)

20:00h Workshop Dinner

### **Tuesday, September 2; End at 15:00h**

9:00h Measurement of time and frequency at radio telescopes:

- Constant frequency references (Froudeveaux, T4science)
- Time reference systems (Wolfgang Schäfer, timetech?, TBC)
- Time and frequency distribution for mm-Wave VLBI (Alan Roy, MPIfR)

13:00h Lunch

14:00h Metrology from industries

- Metrology systems for radio astronomy at EIE Group (Gianpietro Marchiori (EIE  
group, ?, TBC)
- Metrology systems for radio astronomy at MTM (Mr. Zimmerer, MTM)
- Overview about the state-of-the-art techniques for antenna alignment and as-built-  
documentation (Heiko Paluszek Sigma3D)

16:00h End of workshop

All presentations, the agenda and this report can be found on the ERATec wiki pages:

<http://www.radionet-eu.org/radionet3wiki/doku.php?id=na:eratec>

### 2.3 Participant list

	A	B	C	D	E
1	Surname	Name	Institute	Country	Present
2	Aderhold	Norbert	MPI für Radioastronomie	Germany	✓
3	Adzri	Proven Emmanuel	GSSTC	Ghana	NO
4	Baars	Jacob W. M. (Jaap)	MPI for Radioastronomy, Bonn	Germany	✓
5	Bach	Uwe	MPIFR	Germany	✓
6	Bergstrand	Sten	SP Technical Research Institute of Sweden	Sweden	✓
7	Björklund	Per	Department of Earth and Space Sciences	Sweden	NO
8	Bolli	Pietro	INAF-OAA	Italy	✓
9	Froidevaux	Sylvère	T4science	Switzerland	✓
10	Haas	Rüdiger	Chalmers University of Technology	Sweden	✓
11	Helldner	Leif	Onsala Space Observatory	Sweden	✓
12	Hobiger	Thomas	Chalmers University of Technology	Sweden	✓
13	Kallio	Ulla	Finnish Geodetic Institute	Finland	
14	Keller	Reinhard	MPIFR	Germany	✓
15	Kraus	Alex	MPIFR	Germany	✓
16	Kylenfall	Ulf	Onsala Space Observatory	Sweden	✓
17	Laing	Robert	ESO	Germany	✓
18	Lindqvist	Michael	Onsala Space Observatory	Sweden	✓
19	Lopez-Perez	Jose Antonio	Yebeo Observatory	Spain	✓
20	Marchiori	Gianpietro	EIE GROUP	Italy	?
21	Mariotti	Sergio	INAF-IRA	Italy	✓
22	Nothnagel	Axel	IGG, Bonn University	Germany	✓
23	Olberg	Michael	Onsala Space Observatory	Sweden	✓
24	Paluszek	Heiko	sigma3D	Germany	✓

25	Pantaleev	Miroslav	Onsala Observatory	Sweden	✓
26	Pettersson	Lars	Onsala Space Observatory	Sweden	NO
27	Poppi	Sergio	INAF-OACagliari	Italy	✓
28	Prestage	Richard	NRAO	USA	✓
29	Roy	Alan	MPIFR	Germany	✓
30	Saba	Andrea	OA Cagliari INAF	Italy	✓
31	Sarti	Pierguido	IRA- INAF	Italy	✓
32	SchÄrfer	Wolfgang	TimeTech GmbH	Germany	✓
33	Serra	Giampaolo	OAC/INAF	Italy	✓
34	Spetz	Jörgen	SP Technical Research Institute of Sweden	Sweden	✓
35	Suess	Martin	MT Mechatronics	Germany	✓
36	Whale	Mark	Chalmers	Sweden	✓
37	Wieching	Gundolf	MPIFR	Germany	✓
38	Wolfgang	Schaefer	TimeTech GmbH	Germany	✓
39	Zimmerer	Hans-Thomas	MT Mechatronics GmbH	Germany	✓
	DAHLGREN	MAGNUS	ONsala SPACE OBSERVATORY		✓
	RAMPINI	FRANCESCO	EIE GROUP	ITALY	✓



## 2.4 Meeting Photo



## 2.5 Information of the EC financial contribution

Following people benefitted from the EC funds. Due to generosity of Chalmers University local cost could be kept at a low level, only the social dinner was claimed from RadioNet. Travel expenses have been 79% of the total amount spent for this Workshop.

<i>Name</i>	<i>Institute</i>	<i>Invited</i>	<i>Talk</i>	<i>Promised</i>	<i>Given</i>
Wolfgang Schäfer	timetech	X	X	500,00 €	1.085,50 €
Heiko Paluszek	Sigma3D	X	X	500,00 €	638,95 €
Jose A. Lopez-Perez	OAY	X	X	500,00 €	- €
Alessandro Navarrini	IRAM	X		500,00 €	- €
Sylvaine Froidevaux	74science	X	X	1.000,00 €	780,00 €
Richard Prestage	NRAO	X	X	500,00 €	- €
Axel Notnagel	UniBonn	X	X	500,00 €	- €
Sergio Mariotti	INAF			500,00 €	492,00 €
Robert Laing	ESO		X		- €
Norbert Aderhold	MPIfR			500,00 €	500,00 €
Alex Kraus	MPIfR	X	X	500,00 €	728,52 €
Roberto Ambrosini	INAF	X	X	500,00 €	- €
Pietro Bolli	INAF	X	X	500,00 €	525,40 €
Karl-Heinz Mack	INAF		X	500,00 €	- €
Michael Linqvist	OSO	X	X	500,00 €	- €
Reinhard Keller (4 MPIfR participants)	MPIfR		X	500,00 €	2.707,46 €
Pierguido Sarti	INAF	X	X		812,52 €
Dinner in Gothenburg (local cost)	OSO				2.200,00 €
<b>Total</b>		<b>12</b>	<b>13</b>	<b>8.000,00 €</b>	<b>10.470,35 €</b>

### Copyright

© Copyright 2014 RadioNet3

This document has been produced within the scope of the RadioNet3 Projects.

The utilization and release of this document is subject to the conditions of the contract within the 7<sup>th</sup> Framework Programme, contract no, 283393