

# REVIEW ON THE ITALIAN RADIO TELESCOPE RECEIVERS

## SECTION II

*Part I – Infrastructure*

*G. Zacchioli INAF-IRA*

## ITALIAN RADIO TELESCOPES

MAIN CHARACTERISTICS			
	MED	NOTO	SRT
<b>Inauguration Date</b>	October 18 <sup>th</sup> , 1983	October 28 <sup>th</sup> , 1988	September 30 <sup>th</sup> , 2013
<b>Location</b>	Medicina (Bologna)	Noto (Siracusa)	S. Basilio (Cagliari)
<b>Diameter (m)</b>	32	32	64
<b>Optics</b>	Parab/Cass; Primary/Secondary	Parab/Cass; Primary/Secondary	Shaped&Parab/Greg; Primary/Secondary/BWG
<b>Total Surface Accuracy</b>	700 to 900 micron	350 to 400 micron	305 to 500 micron
<b>Active Surface</b>	No	Yes	Yes
<b>Aperture Efficiency (%)</b>	57/38 C/K-band	57/50/40 C/K/Q-band	52/56 C/K-band
<b>Aperture Gain (K/Jy)</b>	0.16/0.11 C/K-band	0.16/0.14/0.11 C/K/Q-band	0.61/0.66 C/K-band
<b>Pointing Accuracy</b>	0.002° Az/EI	0.002° Az/EI	0.002° Az/EI
<b>Frequency Agility</b>	Yes	Partially Yes	Yes
<b>RX on Primary Focus</b>	0.85m <sup>3</sup> /350kg max; S/X/L-band	0.85m <sup>3</sup> /350kg max; S/X-band	6.7m <sup>3</sup> /1700kg max; P/L/X/Ka-band
<b>RX on Secondary Focus</b>	Up to 9; C <sub>low</sub> /C <sub>high</sub> /K-band	Up to 9; C <sub>low</sub> /C <sub>high</sub> /K/Q-band	Up to 7; K-band
<b>RX on BWG Focus</b>	not applicable	not applicable	Up to 4; C <sub>high</sub> -band

STATUS of MEDICINA and NOTO			
ITEMS	<i>MAINTENANCE</i> Made in Year MED/NOTO	<i>REPLACEMENT</i> Made in Year MED/NOTO	<i>REPAINTING</i> Made in Year MED/NOTO
<b>AZIMUTH AXIS</b>			
Azimuth Track		1996; 2000; <b>2017</b> / 2011	
4 Azimuth Wheel Bogeys (2 Driving/2 Idle)		1996 / 2011	
First Azimuth Driving Wheel Bogie		2014 / Never done	
Second Azimuth Driving Wheel Bogie		<b>2017</b> / Never done	
Azimuth Gears		NEVER DONE	
Concrete Foundation Proofing	1996; 2015 / 2011		
<b>SUBREFLECTOR and PRIMARY RECEIVER Positioner</b>			
Subreflector Hw + Servo Driving System	2014 / 2014	1996 / 1998	
Primary Rx Hw + Servo Driving System	2014 / 2014	1996 / 1998	
<b>MIRROR SURFACE</b>			
Primary Mirror Surface		Never done / 2002	2002; <b>2017</b> / 2014
Subreflector Mirror		Never done / 2002; 2015	2002; 2014 / 2014
<b>ELEVATION AXIS</b>			
Elevation Axis Gear And Pinion		2014 / Never done	
Elevation Gears		NEVER DONE	
<b>SERVOSYSTEM</b>			
Azimuth/Elevation Servosystem		2003 / 2002	
Cabling		2003 / 2002	
<b>MISCELLANEOUS</b>			
Antenna Steel Structure, Painting			2015 / Never done
Elevator	/ 2015	2014 / Never done	
He Pipeline		2012 / Never done	

STATUS of SRT	
ITEMS	<i>MAJOR WORKS</i> Year
<b>NEW BUILDINGS</b>	
Migration of control room and equipment room	2017
<b>ACTIVE SURFACE</b>	
Actuators repair	2017
Alignments and measures	2017

## PERSPECTIVE OF THE SRT

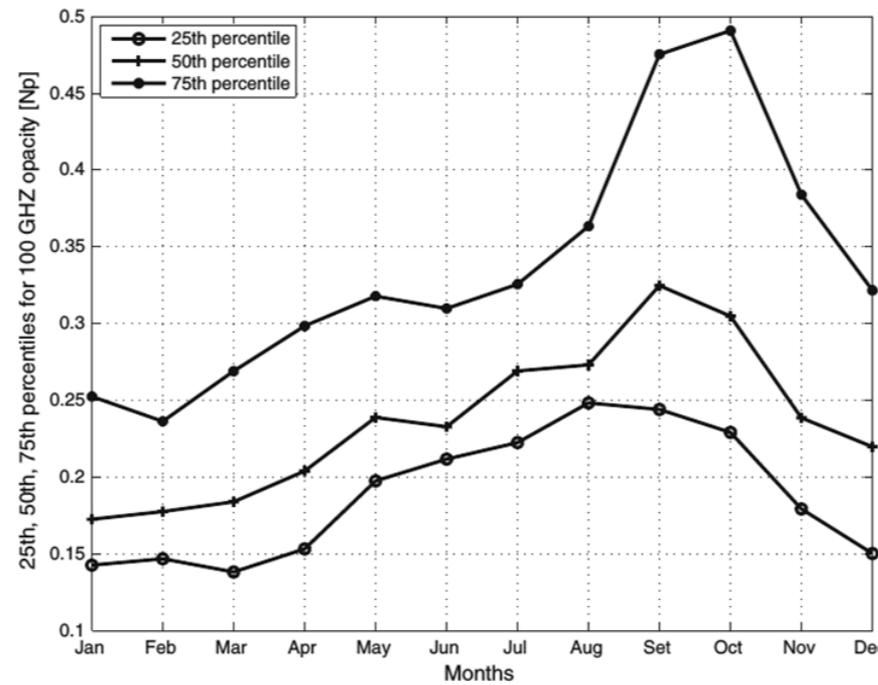
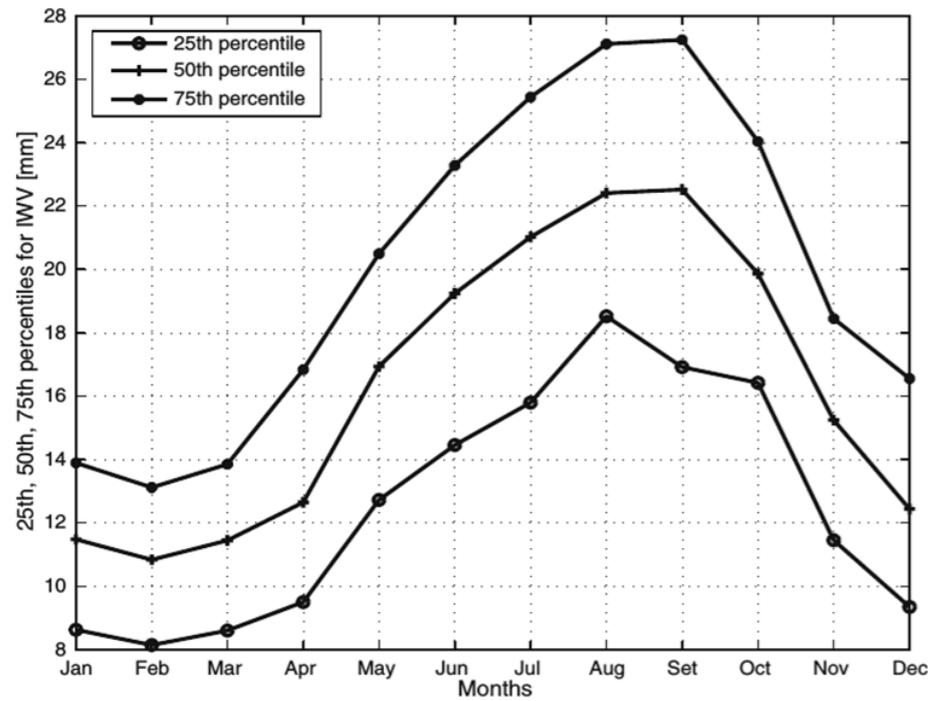
- A commissioning period until end of 2018
- Full Operation in 2019

## AVAILABLE BACK-ENDS and CORRELATOR

	TotalPower	XARCOS	SARDARA	DFB3	DBBC2	DiFX Corr.
<b>Technical Specs</b>						
<b>Features</b>	Continuum; IF distributor	Full Stokes spectr. Zoom mode	Full Stokes spectr.	Pulsar; Spectroscopy	VLBI	- 3 servers
<b>Number of Input</b>	2; 4; 14	8 or 16	2	4	16	- 50TB storage
<b>IF BW (MHz)</b>	300; 730; 1250; 2000	125; 250	300; 500; 1250; 2300	256; 512; 1024	512; 1024; 0.512 to 32 in Baseband mode	- 10G connection + 40G Infiniband
<b>Integration time</b>	1 - 1000 ms	10 s	Up to 0.5 ms	0.1 ms	1 – 60 s	- VDIF standard
<b>Channels</b>	Not applicable	2048	1024 or 16348	2048 to 8192	FW not available	- 720GB/h correlation rate with 3 antennas @ 1Gb/s
<b>Freq. or Time Resolution</b>	Not applicable	Up to 250 Hz	90 KHz	0.008 – 8 ms	1 Hz	
<b>Interface</b>	Ethernet/TCP	Ethernet/TCP	Ethernet/TCP	Ethernet/TCP	FILA10G	
<b>Remarks</b>						
<b>SRT</b>	Calibration; 1 <sup>st</sup> light Multi-feed	no OTF; no Tsys Multi-feed	Mono-feed	ATNF supported	PFB	<i>Not applicable</i>
<b>MED</b>	Calibration; Science; Dual-feed	no OTF; no Tsys Dual-feed	Mono-feed	<i>Not applicable</i>	PFB	Mc; Nt; Sr; Mr; On; Ys; Tr; Ventspils
<b>NOTO</b>	Calibration; Mono-feed	<i>Not applicable</i>	<i>Not applicable</i>	<i>Not applicable</i>	PFB	<i>Not applicable</i>
<b>Status</b>						
<b>SRT</b>	Integrated; all modes	Integrated	Integrated	Dedicated SW	Available	Not available
<b>MED</b>	Integrated; all modes	Integrated	Under commissioning	Not available	Available	Available
<b>NOTO</b>	Under commissioning	Not available	Not available	Not available	Available	Not available

## OPACITY AT THE ITALIAN SITES

SRT site: Precipitable Water Vapour and opacity at 100GHz

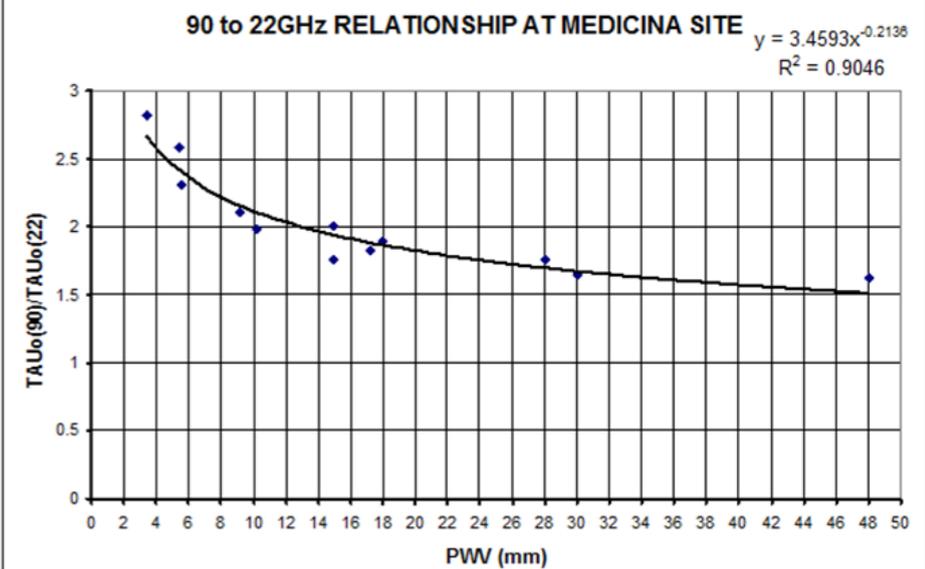
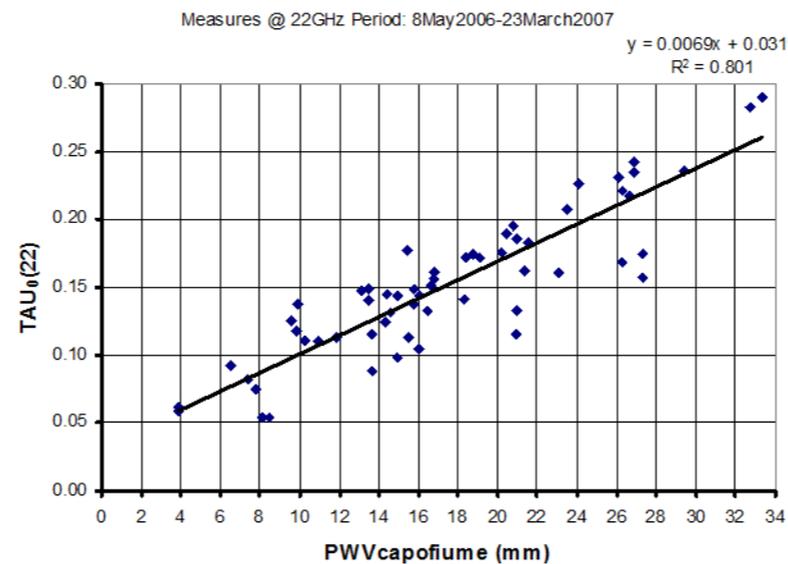
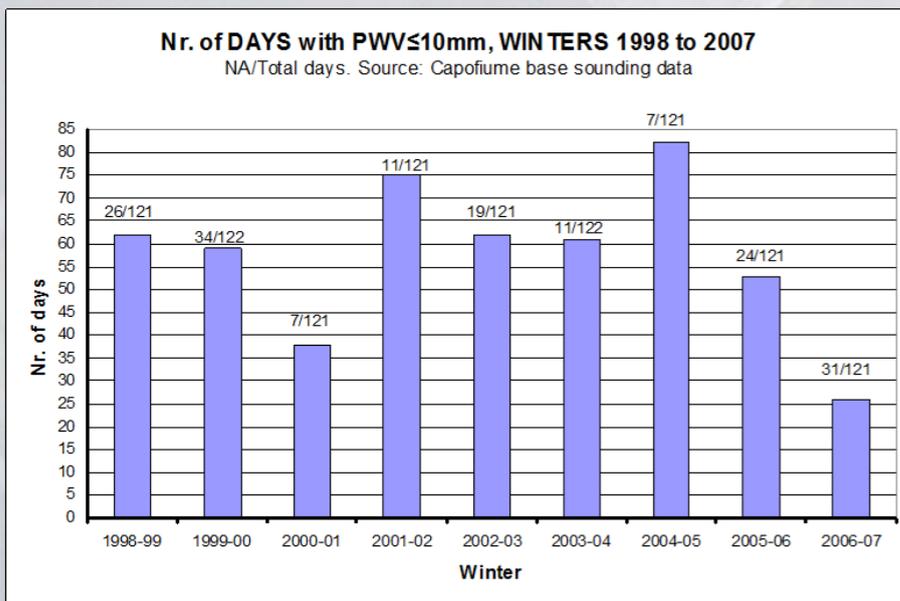


Quantity	Jan	Feb	Mar	Apr	May	Jun
IWV	45	49	43	30	10	5
ILW	54	59	64	59	67	77
$\tau$ (0.3)	100	100	100	100	100	100
$\tau$ (1.4)	100	100	100	100	100	100
$\tau$ (6.7)	100	100	100	100	100	100
$\tau$ (10)	100	100	100	100	100	100
$\tau$ (15)	100	100	100	100	100	100
$\tau$ (18)	100	100	100	100	100	100
$\tau$ (22)	94	94	92	86	70	59
$\tau$ (22.12)	93	93	90	85	66	56
$\tau$ (22.23)	91	91	89	82	63	51
$\tau$ (23.69)	97	98	95	90	82	76
$\tau$ (23.72)	97	98	95	91	83	77
$\tau$ (23.87)	98	98	96	92	85	81
$\tau$ (30)	100	100	100	99	96	97
$\tau$ (42.82)	83	86	85	78	77	82
$\tau$ (43.12)	81	85	83	76	75	80
$\tau$ (88.63)	47	48	49	35	17	12
$\tau$ (90.66)	46	47	48	34	17	11
$\tau$ (100)	34	35	35	25	9	6

$f = 100\text{GHz}$

PWV < 10mm; ILW=0;  $\tau < 0.15$

MED/NOTO sites: Precipitable Water Vapour and opacity at 22 and 90GHz



## OPACITY at 3mm: COMPARISON WITH OTHER SITES

<i>TELESCOPE</i>	<i>Altitude (m)</i>	<i>Data available?</i>
Pico Veleta	2850	Yes
Nobeyama	1349	No
Yebes	931	Yes
Mopra	860	No
GBT	807	Yes
SRT	600	Yes
Parkes	415	Yes
Effelsberg	319	No
KVN	120; 260; 320	Yes
NOTO	78	Yes
VERA	60	No
MED	25	Yes
Onsala25+Onsala20	20	Yes
Tianma	7	No

SITES	$\tau$ / PWV @ 86GHz	$\tau$ / PWV @ 100GHz
Pico Veleta	0.06-0.08 / 2-4mm winter	
GBT	<0.12 / <10mm for 50% time in May-Oct.	
Onsala	0.2	0.3
Yebes	2-14mm summer 0.08-0.09 / 6-8mm winter	
KVN, Yonsei		0.09 January
KVN, Ulsan		0.13 April
KVN, Tamna		0.12 December
SRT	<0.15 / <10mm for 50% time in Jan-Mar	<0.2 / <13mm for 50% time in Jan-Apr
MED/NOTO	<0.25 / $\leq$ 10mm for 50% days on average in Dec-Mar	

## RFI AT THE SITES

### IN ITALY MISE EXPECT THE FOLLOWING SCENARIO (SHOWN ONLY THOSE BANDS OF OUR CURRENT INTEREST)

- 400 MHz → Mobile and wireless applications
- 1452-1492 MHz → Radio mobile 5G;
- 1620 MHz → Iridium Next
- 2300-2400 MHz → Radio mobile 5G
- 3400-3800 MHz → Radio mobile 5G
- 5350-5925 MHz → New total band for the R-LAN Outdoor service (actually, this extended new band is already illegally used by this service)
- 76-81 GHz expected an increase in the use of this band by Short Range Radar mainly for automotive application

### LOCAL PROBLEMS AT THE SITES

- MED:** strong RFI AT 6600MHz from RAI under negotiation;  
 negotiation with local MISE to limit the proliferation of R\_LAN systems in the band 4950-5000MHz;  
 reduce auto-RFI by switching off not used LO (done) and enclosing digital electronics and oscillators inside shielded racks (done)
- SRT:** negotiation with MIRFA for a RFI from military radar at L-band (21cm);  
 new weather radar at 5650MHz;  
 a new station for emergency service, planned to be installed in monte Ixi, can affect P/L-bands;  
 provide a shielding to close vertex dome during observations with primary focus RX;  
 in 2017 move to the new shielded room all back-ends and equipment
- NOTO:** as for MED, negotiation with local MISE to limit R\_LAN systems in the band 4950-5000MHz;  
 21cm band affected by military radar;  
 auto-RFI increased

## HUMAN RESOURCES AND FTE

People Involved in the Receiver Group				Total
IRA	IRA/Noto	OAC	OAA	
9	3	6	4	<b>22</b>

Area of Expertise	FTE				TOTAL FTE per Area
	IRA	IRA/Noto	OAC	OAA	
Group Management	0.7		0.3		1
Front End - Pas. Components			1.5	0.8	2.3
Front End - Active Components	0.2		0.2		0.4
Mechanics and Cooling	0.8	0.4	1	0.65	2.85
Intermediate Frequency	0.65		0.1		0.75
Integration and Test	1.35	0.2	0.6	0.25	2.4
<b>TOTAL FTE</b>	<b>3.7</b>	<b>0.6</b>	<b>3.7</b>	<b>1.7</b>	<b>9.7</b>

<b>EXTERNAL COLLABORATION</b>	
Institution	Name
UniCardif	Pisano G.
CNR-IEIIT	Peaverini O.
UniMilano	Bersanelli M.
UniCagliari	Mazzarella G.
UniMi-Bicocca	Zannoni M.

### OTHER INAF GROUP INVOLVED IN RECEIVER DEVELOPMENT

- **The SKA Group at IRA Medicina**  
involved in several WP of the LFAA Elements for the SKA Project
- **The cryo-waves group at IASF – Bologna**  
Involved in ALMA band 2+3 receiver / STRIP Project (Large Scale Polarization Experiment)

## LABORATORY FACILITIES

### IRA – IRA Noto

- ✓ **Scalar and Vector Analyzers for measurements up to 110GHz; S-param up to 40GHz**
- ✓ **Clean Room (class 10000) for operation on MMIC components + device like:**  
semi automatic Bonding Machine + manual pick & place machine, probe station for RF measurements, chemical extractor fan with ultrasonic bath, ecc....
- ✓ **Cryostat for laboratory measurements (volume of 2.3dm<sup>3</sup>)**
- ✓ **Wedge-bonder Hybon model 572 (25.4x30.3cm work platform)**

### OAC

- ✓ **Vector Network Analyzer for measurement up to 110GHz**
- ✓ **Working Bench for fabrication and maintenance of front-end, including auxiliary devices like:**  
soldering iron, pick & place, hot plate, riveter for via hole (0,4 ÷ 1mm), bonding machine, ultrasonic cleaning machine, RF rigid/flexible cable machining, ecc....
- ✓ **Instruments for measuring electric and magnetic field, testing optical fibers**
- ✓ **Cryostat for laboratory measurements (volume of 38dm<sup>3</sup>)**

### OAA

- ✓ **Vector Network Analyzer for measurement up to 110GHz**
- ✓ **Cryostat for laboratory measurements (volume of 3.7dm<sup>3</sup>)**
- ✓ **Anechoic chamber, volume of about 41m<sup>3</sup>, minimum frequency of 2GHz**

## NORTHERN CROSS

Inauguration year 1964

Composed by two sections East-West (E-W) + North-South (N-S) both steerable in elevation only

Total Collecting area of 27000 m<sup>2</sup>

Designed to operate at 408MHz with 2.5MHz of bandwidth

### E-W ARM

Single cylindric-parabolic antenna 564m long and 35m wide is equipped with 1536 dipoles

### N-S ARM

Linear array of 64 cylindric-parabolic antennas spaced of 10m. Each N-S antenna 23.5m long and 7.5m wide is equipped with 64 dipoles

2005-2009, UE founded a re-instrumentation of part of the NC – N-S Arm as SKA demonstrator. (installation and test of new LF receivers and FO/Coaxial digital links) – **THE BEST 2**

### The Basic Element for SKA Training Demonstrator – The BEST-2

array of 8 N-S Arm cylindric-parabolic antennas, 1400 m<sup>2</sup> – **4 receivers**, connected to 16 dipoles, for each cilinder

- Mechanical Elevation Pointin range **>45 deg** Electrical Azimuth Pointing range **±3.3 deg WRT South**
- Frequency **408MHz** – Istantaneous BW **14MHz**
- Instantaneous Field of View **30 degree<sup>2</sup>** Synthetized beam (pixel) **0.7 degree<sup>2</sup>**
- The total of 32 receivers in the array, by means of the beamforming techniques, provide 24 independent beams (pixels) inside the antenna instantaneous FoV

- **NC sensor selected for the SST programme (Space Debries)**. 2017 will be available a duplication of the BEST-2.
- **THE BEST-4**, an array of 16 N-S Arm cylindric-parabolic antennas, total of 64 receivers in the array; by means of the beamforming techniques, will provide 48 independent beams (pixels **0.35 degrees<sup>2</sup>**) inside the antenna instantaneous FoV of **30 degree<sup>2</sup>**
- **As Back-end** a FPGA-based CASPER hardware is available; After beamforming, the signals from each beam can be simultaneously directed to two different outputs, an high-resolution spectrometer (10 Hz resolution) and a Total Power

## SPACE SCIENCE AT SRT

ANTENNA TIME ALLOCATED TO ASI = 20%

### CURRENT and FUTURE ACTIVITIES

#### □ GROUND STATION FOR DEEP SPACE TRACKING

1° phase: X-band downlink (2017, RX coming from NASA-JPL for Cassini splash down on Saturn on 15<sup>th</sup> Sep.)

2° phase: X/Ka downlink

3° phase: X/Ka down/uplink

#### □ SPACE DEBRIS OBSERVATIONS

ASI is part of Space Surveillance and Tracking consortium

In 2014 a space debris observation at P-band in bi-static mode (with Northern Cross and military transmitter)

In the future use PAF receivers to track the target

#### □ RADIO SCIENCE and NEAR-EARTH objects

*The End*

*Grazie per  
l'attenzione*