

DISCOS: A common control software for the SRT and the other italian radiotelescopes

 Sergio Poppi
on behalf of the DISCOS team

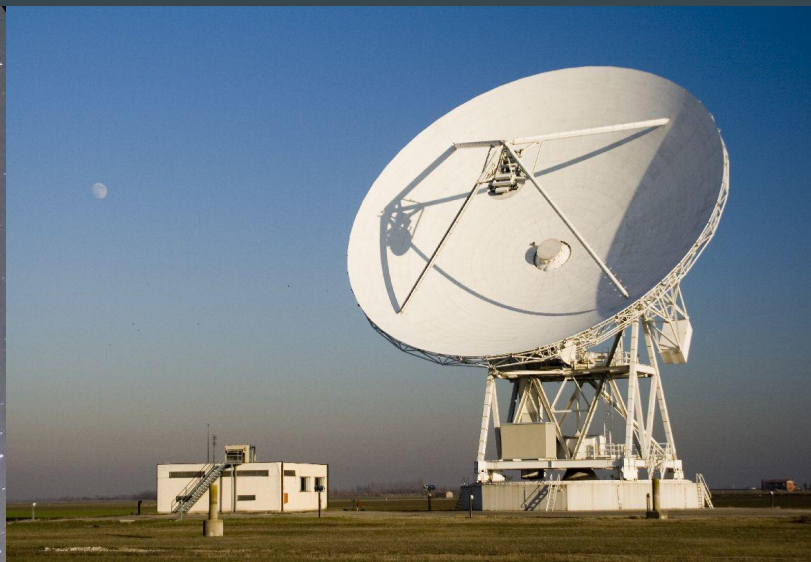
DISCOS Team

- **Carlo Migoni (INAF):** core developer, VLBI integration.
- **Andrea Orlati (INAF):** team leader - project manager - core developer.
- **Marco Buttu (INAF):** core developer, test driven development.
- **Marco Bartolini (INAF):** core developer, continuous integration.
- **Simona Righini (INAF):** astronomical advisor, observations, documentation.
- **Antonietta Fara (INAF):** system administrator.
- **Sergio Poppi (INAF):** core developer, astronomical advisor, observations.



Project History

- 2004 Development SRT Control Software - NURAGHE started
 - team: Giuseppe Maccaferri, Andrea Orlati, Francesco Palagi, Carlo Migoni, Matteo Murgia, Francesco Schillirò (GAI SOFTWARE - SRT)
- Goal:
 - Provide the Sardinia Radio Telescope of control software with enhanced performances.
 - Build a common infrastructure for the three radio telescopes.
- 2007 ESCS Enhanced Single-dish Control System (Medicina and Noto)
 - team: GAI SOFTWARE + Simona Righini, Rashmi Verma, P.Libardi
- 2015 DISCOS: unifies the three development lines.



Telescopes Configurations

	SRT	Medicina	Noto
Main mirror	64 m	32 m	32 m
Optical configuration	Gregorian	Cassegrain	Cassegrain
Mount	Altazimuthal, fully steerable 12 motors + cable wrap	Altazimuthal, fully steerable 4 motors	Altazimuthal, fully steerable 4 motors
Antenna Control Unit (main servo system)	Beckhoff PLC ethernet vendor protocol	VxWorks based PC ethernet vendor protocol	VxWorks based PC ethernet vendor protocol
Primary Focus	three degrees of freedom INAF defined protocol	three degrees of freedom INAF defines protocol	
Secondary Focus	six degrees of freedom ethernet INAF protocol	five degrees of freedom ethernet INAF protocol	five degrees of freedom RS232 vendor protocol
Active Surface	1008 aluminium panels 1116 actuators rs485/ethernet vendor protocol	not available	240 aluminium panels 244 actuators rs232 vendor protocol

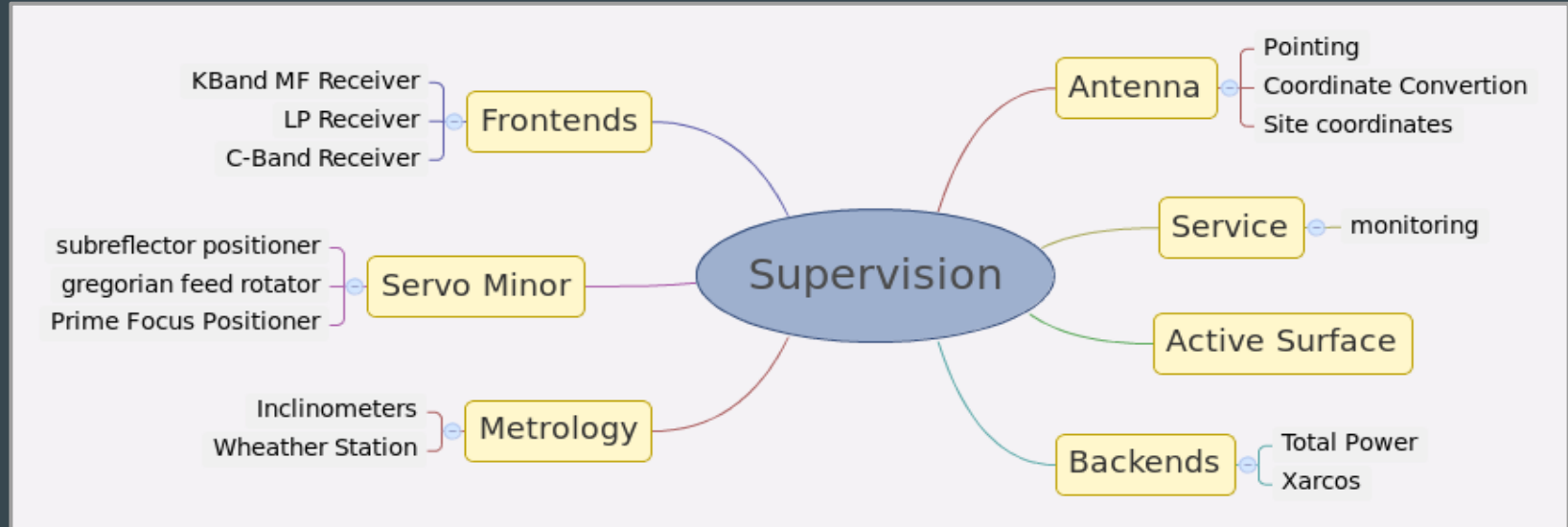
Telescopes Configurations

	SRT	Medicina	Noto
Main mirror	64 m	32 m	32 m
Receievers*	0.305-0.410 1.3-1.8 5.7-7.7 18.0-26.0, 7 feeds GPIB and ethernet INAF protocol	1.35-1.45 1.595-1.715 2.2-2.36 4.30-5.80 5.90-7.10 8.18-8.98 18.0-26.0, 2 feeds GPIB and ethernet and RS232 various protocols	0.317-0.320 1.40-1.72 2.20-2.36 4.70-5.05 8.18-8.58 22.18-22.46 39.0-43.3 GPIB and RS232 various protocols
Backends*	<u>TotalPower (continuum)</u> 0.1-2.1, 1-1000 ms, 14 inputs <u>XARCOS (spectro- polarimetry)</u> 0.0005-0.125, 10 s, 2048 bins, 14 inputs <u>Roach(spectro-polarimetry)</u> 0.512, 10-1000 ms, 8192 bins, up to 14 inputs <u>DFB3(pulsar)</u> 1.024, 1-4000 ms, 8192 bins, 4 inputs DBBC	<u>TotalPower (continuum)</u> 0.1-2.1, 1-1000 ms, 4 inputs <u>XARCOS (spectro- polarimetry)</u> 0.0005-0.125, 10 s, 2048 bins, 14 inputs	<u>TotalPower (continuum)</u> 0.1-2.1, 1 ms, 4 inputs DBBC

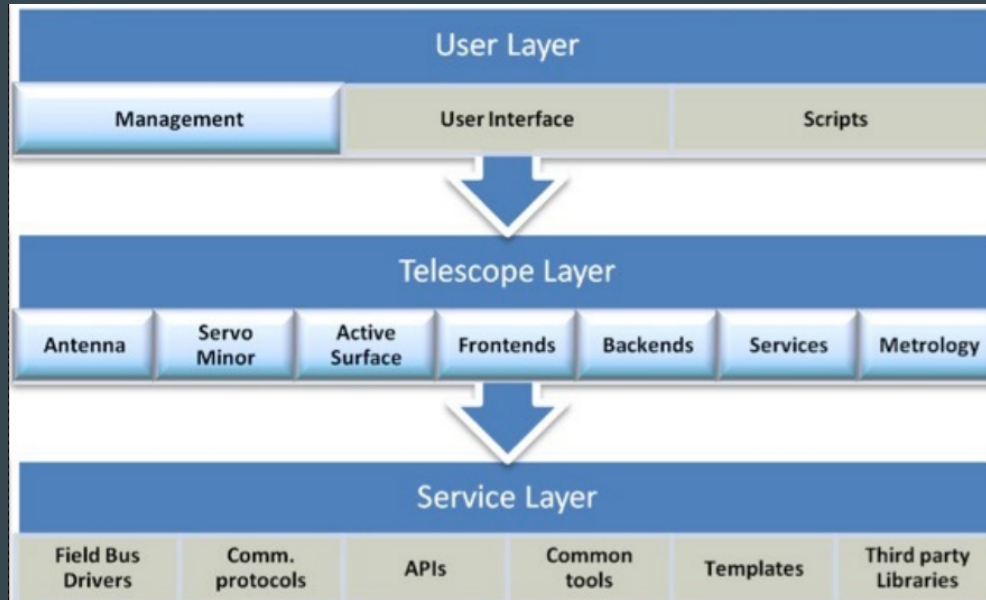
DISCOS features

- Based on ALMA **Common** Software
 - Distributed objects architecture
 - ACS component as the basic unit which performs tasks
 - Components expose interfaces to other components.
- **Common** interfaces design for the three telescopes
- Components organised in subsystems
- Each subsystem has a “boss” component, which has in charge the communications inward and outward the subsystem

DISCOS Design



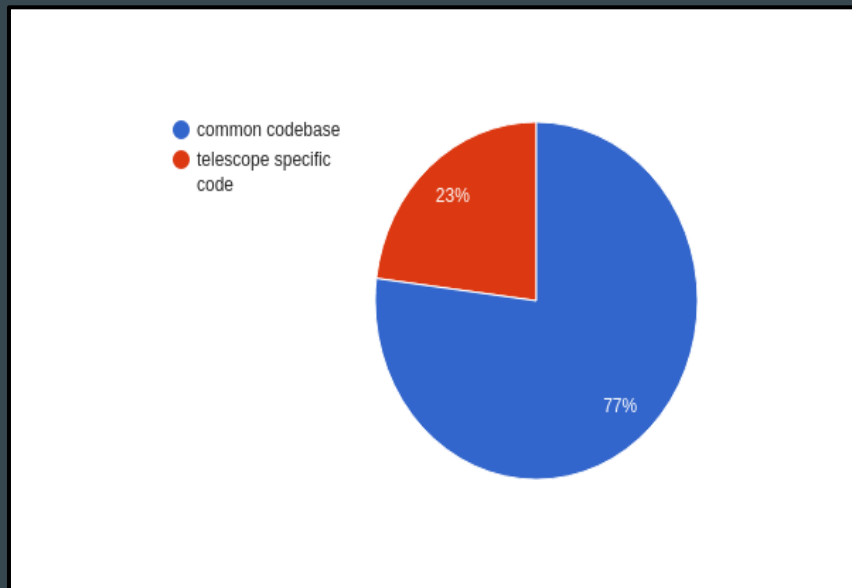
DISCOS Design



DISCOS implementation

- DISCOS - NURAGHE (SRT)
- DISCOS - ESCS (Medicina and Noto)

- A common monolithic codebase (77%):
 - management (scheduling, observing modes)
 - subsystem bosses
 - user interfaces
 - libraries
- Specific code coping differences among telescopes



How big is DISCOS?

Totals grouped by language (dominant language first):

cpp:	383778 (72.59%)
xml:	85988 (16.26%)
ansic:	30854 (5.84%)
python:	26607 (5.03%)
sh:	1328 (0.25%)
fortran:	144 (0.03%)
perl:	14 (0.00%)

Total Physical Source Lines of Code (SLOC) = 528713

generated using David A. Wheeler's 'SLOCCount'.

statistics by www.openhub.net

Maintenance pitfalls

- Big codebase
- Different production lines
- Development and testing during productions

Automatized tasks are needed!

Nightly builds

- **build server: AZDORA**
- Completely automated setup of a virtual machine with ACS installed and configured along with all necessary dependencies
- Jenkins installation for continuous integration



VM MANAGER

Vagrantfile hosted on
github.
com/discos/azdora

Provisioning Scripts

bash
users.sh yum.sh ...

Static Contents Provisioning

ACS.tar.gz qt.tar.gz

CentOS BOX

OS
Customization

ACS Setup

Build Server Jenkins

Common Build
& Test

SRT Build &
Test

MED Build &
Test

NOTO Build &
Test

DISCOS
Releases

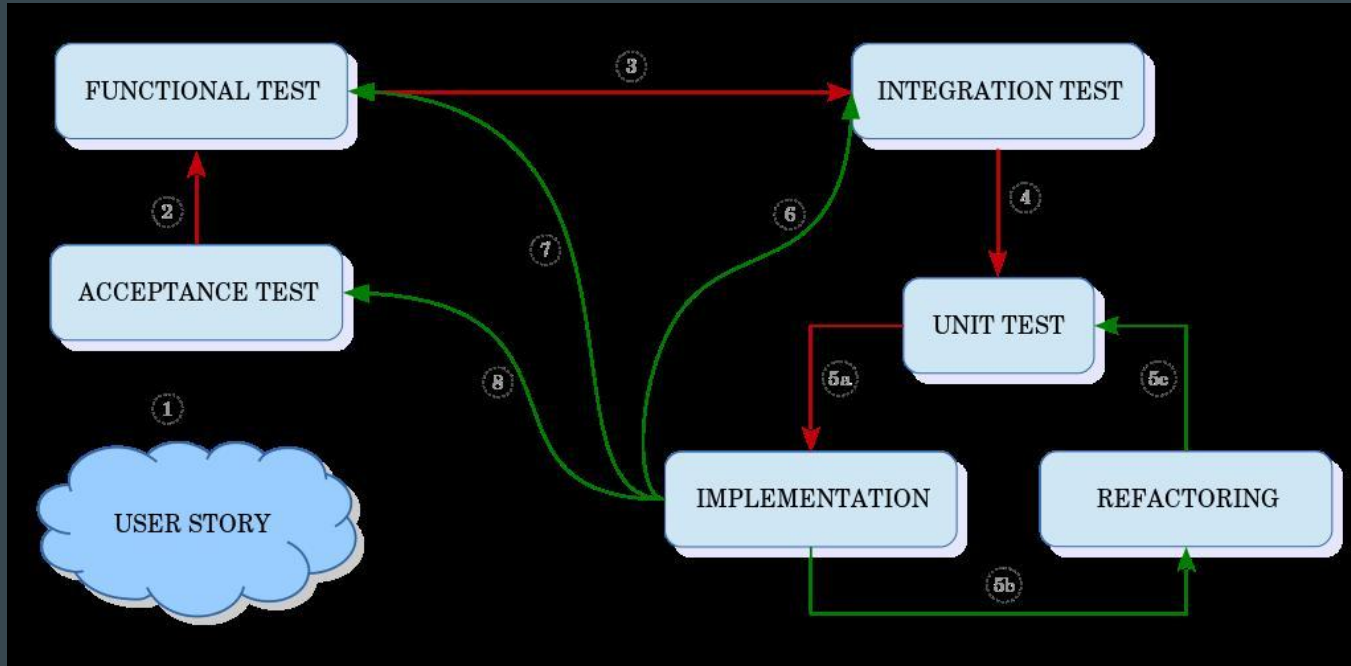
Azdora **WEB**
Interface

MANTIS
BugTracker

developer's
mailbox

Test driven development

- Development of new functionality will be test driven

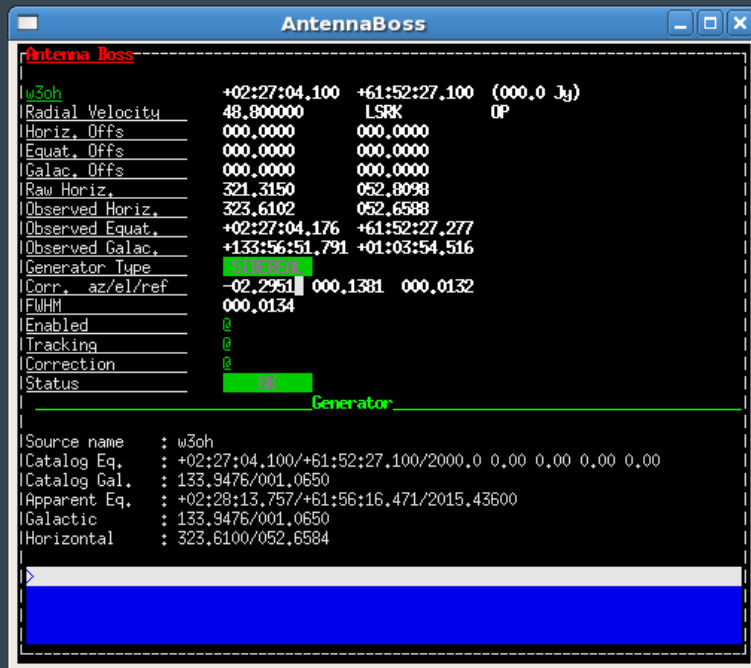


DISCOS at work



Antenna boss

- Shows the informations from “antenna boss”
 - tracking flag
 - observed positions
 - generator of the coordinates
 - Sidereal
 - On the fly
 - Status flag



```
AntennaBoss
-----
Antenna Boss
w3oh          +02:27:04.100 +61:52:27.100 (000.0 Jy)
Radial Velocity 48.800000 LSRK OP
Horiz. Offs     000.0000 000.0000
Equat. Offs     000.0000 000.0000
Galac. Offs     000.0000 000.0000
Raw Horiz.     321.3150 052.8098
Observed Horiz. 323.6102 052.6588
Observed Equat. +02:27:04.176 +61:52:27.277
Observed Galac. +133:56:51.791 +01:03:54.516
Generator Type  SIDEREAL
Corr. az/el/ref -02.2951 000.1381 000.0132
FWHM           000.0134
Enabled        @
Tracking       @
Correction     @
Status         OK
-----
Generator
-----
Source name      : w3oh
Catalog Eq.     : +02:27:04.100/+61:52:27.100/2000.0 0.00 0.00 0.00 0.00
Catalog Gal.    : 133.9476/001.0650
Apparent Eq.    : +02:28:13.757/+61:56:16.471/2015.43600
Galactic        : 133.9476/001.0650
Horizontal      : 323.6100/052.6584
```

Operator input

- It is the console where the users give commands to the system:
 - start and stop schedules
 - system setup



```
OperatorInput
<53> radialVelocity=48,8,LSRK,OP
radialVelocity\
<54> tsys
tsys\
00) 111.397073
01) 109.015391
02) 111.538860
03) 104.120204
04) 112.725521
05) 989.737731
06) 104.833489
07) 106.897704
08) 119.851481
09) 109.515176
10) 104.830085
11) 112.177135
12) 111.535893
13) 177.923244
<55> azelOffsets=0,0d,0,0d
azelOffsets\
<56> radialVelocity=48,8,LSRK,OP
radialVelocity\
<57> █
```

Receivers boss and backend panels

GenericBackend

GenericBackend: BACKENDS/TotalPower

Time : 2015-160-11:58:01.000 Integration : 40 Busy : 0 Time_Sync 0

Sections : 14 Inputs 14

	Freq	BW	Feed	S.R.	Pol	Bins	DBs	Sect	Isus	Busy	Suspended	Sampling	CmdLine	DataLine
S00	0050.0	0300.0	00	2.50000e-05	LEFT-	00001	100	07.0	00	0109.0	0	0		0
S01	0050.0	0300.0	00	2.50000e-05	RIGHT	00001	101	07.0	01	0106.2	0	0		0
S02	0050.0	0300.0	01	2.50000e-05	LEFT-	00001	102	07.0	02	0109.9	0	0		0
S03	0050.0	0300.0	01	2.50000e-05	RIGHT	00001	103	07.0	03	0103.2	0	0		0
S04	0050.0	0300.0	02	2.50000e-05	LEFT-	00001	104	07.0	04	0111.9	0	0		0
S05	0050.0	0300.0	02	2.50000e-05	RIGHT	00001	105	07.0	05	0989.3	0	0		0
S06	0050.0	0300.0	03	2.50000e-05	LEFT-	00001	106	07.0	06	0103.6	0	0		0
S07	0050.0	0300.0	03	2.50000e-05	RIGHT	00001	107	07.0	07	0105.8	0	0		0
S08	0050.0	0300.0	04	2.50000e-05	LEFT-	00001	108	07.0	08	0118.4	0	0		0
S09	0050.0	0300.0	04	2.50000e-05	RIGHT	00001	109	07.0	09	0108.5	0	0		0
S10	0050.0	0300.0	05	2.50000e-05	LEFT-	00001	110	07.0	10	0103.7	0	0		0
S11	0050.0	0300.0	05	2.50000e-05	RIGHT	00001	111	07.0	11	0111.2	0	0		0
S12	0050.0	0300.0	06	2.50000e-05	LEFT-	00001	112	07.0	12	0110.7	0	0		0
S13	0050.0	0300.0	06	2.50000e-05	RIGHT	00001	113	07.0	13	0169.2	0	0		0
S14							114							
S15							115							
S16							116							
S17							117							
S18							118							

Receivers

Receivers

Current Setup : KKG

Mode : SINGLEDISH

Status : OK Dewar : 0

Feeds : 7

IFs : 2

LO : 21964.0 (x14)

Start Freq. : 00100.0 (x14)

Bandwidth : 02000.0 (x14)

Polarization : LCP (x7) RCP (x7)

Dewar Positioner

Configuration: BSC

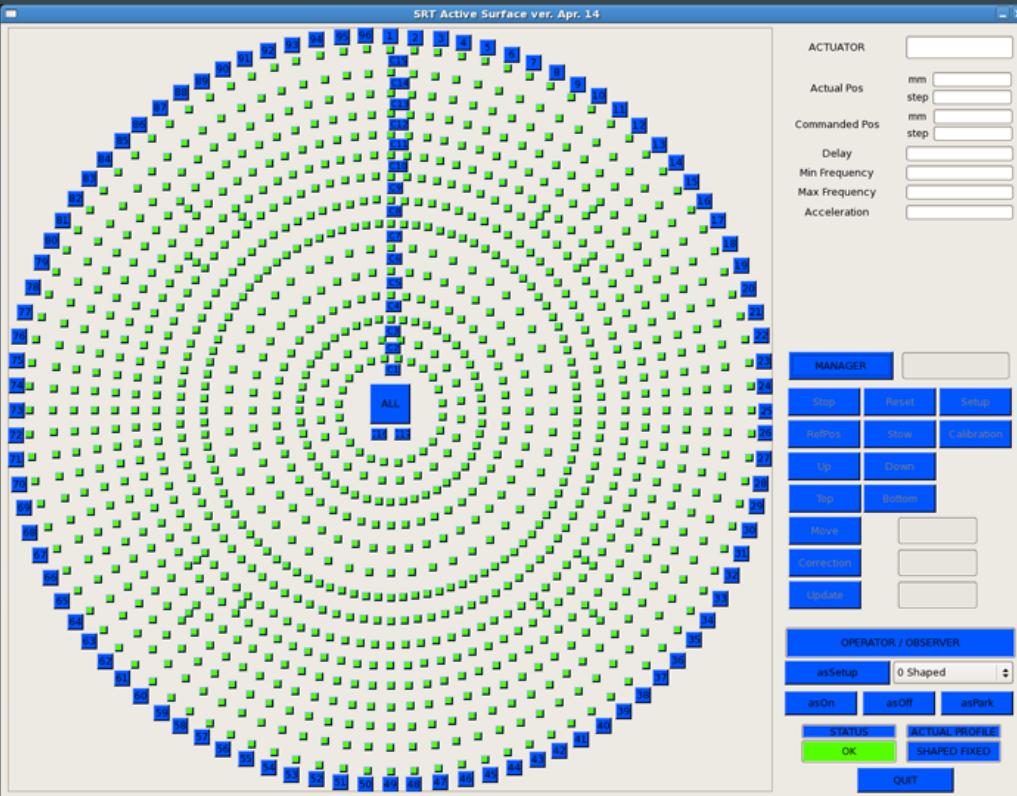
Dewar is ready

Absolute Position: 036.8

I / P / D / R: -19.2 / 056.792 / -00.875 / 000.0

Rewinding not required

Active Surface



Possible configurations:

- Shaped with elevation tracking
- Shaped at fixed elevation
- Parabolic with elevation tracking
- Parabolic at fixed elevation

Minor Servo system

- Fast switching of the receives
 - Primary Focus Positioner for prime focus obs.
 - Gregorian Feeds Rotator
 - M3 Positioner for
 - Subreflector positioner
- Subreflector motion for focus Tracking



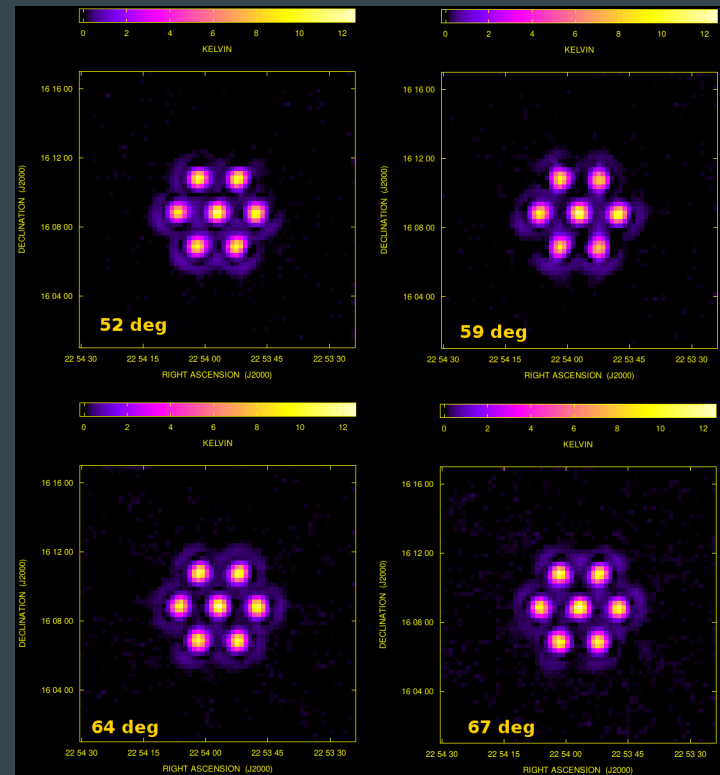
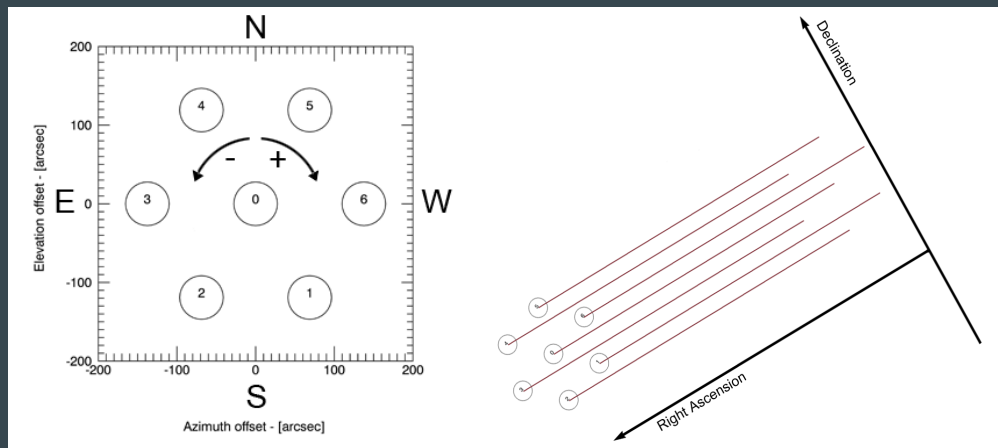
Scheduler

- Schedules are text based
- A schedule generator helps the observer to generate schedules for:
 - sidereal tracking
 - cross scans
 - OTF mapping
 - raster scan mapping
 - beam switching and nodding
- Frequency tracking for spectroscopic backends

(see: M. Bartolini, P. Libardi, S. Righini. ScheduleCreator User Manual" internal report [IRA 466/13](#))

Derotator

- The Multifeed K-band receiver hosts an hardware derotator to follow the parallactic angle
- Derotation during sidereal and OTF



Courtesy of SRT Astronomical Validation

SRT

Data Format

FITS format

- standard data format through converters:
 - GILDAS/CLASS
 - SDFITS
- MBFITS output under development

Index	Extension	Type
<input type="checkbox"/> 0	Primary	Image
<input type="checkbox"/> 1	SECTION TABLE	Binary
<input type="checkbox"/> 2	RF INPUTS	Binary
<input type="checkbox"/> 3	FEED TABLE	Binary
<input type="checkbox"/> 4	DATA TABLE	Binary
<input type="checkbox"/> 5	ANTENNA TEMP TABLE	Binary
<input type="checkbox"/> 6	SERVO TABLE	Binary

Select	<input type="checkbox"/> id	<input type="checkbox"/> xOffset	<input type="checkbox"/> yOffset	<input type="checkbox"/> relativePower
<input type="checkbox"/> All	J	D	D	D
Invert	Modify	Modify	Modify	Modify
1	0	0.000000000000E+00	0.000000000000E+00	1.000000000000E+00
2	1	1.027805000000E-03	0.000000000000E+00	9.700000000000E-01
3	2	5.139030000000E-04	-8.901180000000E-04	9.900000000000E-01
4	3	-5.139030000000E-04	-8.901180000000E-04	9.700000000000E-01
5	4	-1.027805000000E-03	0.000000000000E+00	9.500000000000E-01
6	5	-5.139030000000E-04	8.901180000000E-04	9.700000000000E-01
7	6	5.139030000000E-04	8.901180000000E-04	9.700000000000E-01

VLBI - Field system

- The FS sends commands to DISCOS through an external clients port

```
FIELD SYSTEM
File Edit View Terminal Tabs Help
mk5cn initialized
dscon initialized
dpscon initialized
flags initialized
12:37:46 Log Opened: Mark IV Field System Version 9.11.7
12:37:46 location.SRT      9 25 30 49 650 0
12:37:46 horizon1.0 5 .360
12:37:46 antenna.64 0.51 0.30 0. -90 0.450 0.5 0.90 0.azel
12:37:46 equip.dbsc.mk5c.bs.none.500.30.3.47d.101.60.20.none.41.1.in.8bit.c
dp.3.return.v104.v12.4.15000.15000.15000.15000.32
12:37:46 time. -5.400.597.086.rate
12:37:46 flags.0
12:37:46#antc#Antenna successfully configured!
12:37:46:Boss Initialization Complete
12:37:46:inits
12:37:46#inits/"welcome to the pc field system
12:37:46#inits/"syrun setcl &
12:37:46#inits/antennacconnect
12:37:46#antc#ACU Link enabled!
12:42:37/mk5=personality=mark5c:bank
12:42:37/mk5/personality= 0 ;
12:43:38/mk5=packet=36:0:5008:0:0
12:43:38/mk5/!packet= 0 ;
[]

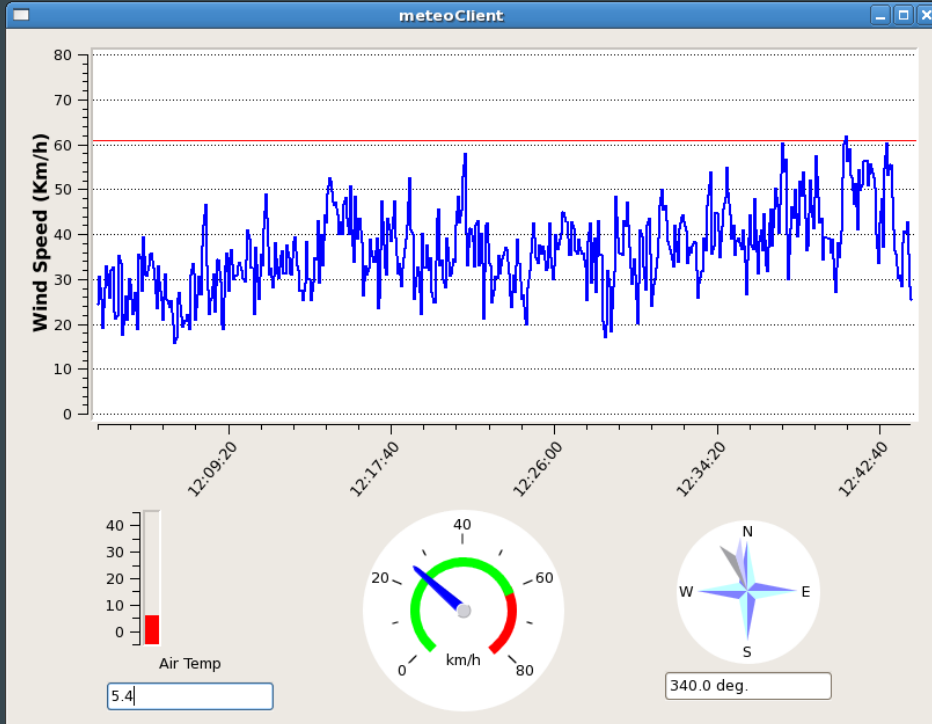
MARK5C
File Edit View Terminal Tabs Help
2015-02-25 11:24:11.51: Processing command 'scan_set'
2015-02-25 11:24:11.51: Reply: !scan_set? 0 : 18 : iJ151_sr_n00016 : 53072442813
6 : 538341050064 ;
2015-02-25 11:24:11.51: Processing command 'scan_set=19'
2015-02-25 11:24:11.51: Reply: !scan_set= 0 ;
2015-02-25 11:24:11.51: Processing command 'scan_set?'
2015-02-25 11:24:11.51: Reply: !scan_set? 0 : 19 : iJ151_sr_n00017 : 53834105026
4 : 546007887608 ;
2015-02-25 11:24:11.51: Processing command 'scan_set=20'
2015-02-25 11:24:11.51: Reply: !scan_set= 0 ;
2015-02-25 11:24:11.51: Processing command 'scan_set?'
2015-02-25 11:24:11.51: Reply: !scan_set? 0 : 20 : iJ151_sr_n00018 : 54600788760
8 : 553673432888 ;
2015-02-25 11:24:11.51: Processing command 'scan_set=21'
2015-02-25 11:24:11.51: Reply: !scan_set= 0 ;
2015-02-25 11:24:11.51: Processing command 'scan_set?'
2015-02-25 11:24:11.51: Reply: !scan_set? 0 : 21 : iJ151_sr_n00019 : 55367343288
8 : 630534363928 ;
2015-02-25 11:24:11.51: Processing command 'scan_set=22'
2015-02-25 11:24:11.51: Reply: !scan_set= 0 ;
2015-02-25 11:24:11.51: Processing command 'scan_set?'
2015-02-25 11:24:11.51: Reply: !scan_set? 0 : 22 : iJ151_sr_n00020 : 63053436392
8 : 707432789864 ;
2015-02-25 11:24:11.51: Processing command 'bank_set=A'
2015-02-25 11:24:11.51: Reply: !bank_set=1 ;
2015-02-25 11:24:11.51: bankswtch_thr3rd/start switch to bank 0
2015-02-25 11:24:11.71: New bank mounting detected: SRT=0003 in bank A
2015-02-25 11:24:11.72: Layout set to Mark5CLayout: detected 0 inconsistencies
2015-02-25 11:24:11.78: DISK: Bus 00/master WDC WD20EFRX-68EUZN0/WD-WCC4M261
2100/80 00A80 3227606528
2015-02-25 11:24:11.85: DISK: Bus 00/slave WDC WD20EFRX-68EUZN0/WD-WCC4M258
9362/80 00A80 3227606528
2015-02-25 11:24:11.95: DISK: Bus 01/master WDC WD20EFRX-68EUZN0/WD-WCC4M260
9419/80 00A80 3227606528
2015-02-25 11:24:12.02: DISK: Bus 01/slave WDC WD20EFRX-68EUZN0/WD-WCC4M258
7777/80 00A80 3227606528
2015-02-25 11:24:12.09: DISK: Bus 02/master WDC WD20EFRX-68EUZN0/WD-WCC4M261
8443/80 00A80 3227606528
2015-02-25 11:24:12.16: DISK: Bus 02/slave WDC WD20EFRX-68EUZN0/WD-WCC4M261
2076/80 00A80 3227606528
2015-02-25 11:24:12.26: DISK: Bus 03/master WDC WD20EFRX-68EUZN0/WD-WCC4M261
0356/80 00A80 3227606528
2015-02-25 11:24:12.36: DISK: Bus 03/slave WDC WD20EFRX-68EUZN0/WD-WCC4M258
9359/80 00A80 3227606528
2015-02-25 11:24:12.36: bankswtch_thr3rd/clearing runtime's transfer mode to no_t
ransfer
2015-02-25 12:42:37.22: Processing command 'personality=mark5c:bank'
2015-02-25 12:42:37.23: Reply: !personality= 0
2015-02-25 12:43:38.05: Processing command 'packet=36:0:5008:0:0'
2015-02-25 12:43:38.05: Reply: !packet= 0 ;
[]

oprin
[0]
[0]

ERRORS
[0]
[0]

Applications Places System [SRT... FIELD... MARK... n151... oprin [ERRORS] NURAGHE CONSOLE VLBI MISC Wed Feb 25, 12:43:41
```

Weather monitor and system logs



The screenshot shows the 'LoggingClient - Online' application window. The top menu includes 'File', 'View', 'Search', 'Drill down', and 'Expert'. Below the menu are controls for 'Log level' (set to Info), 'Discard level' (set to Debug), and buttons for 'Pause', 'Clear logs', 'Filters', and 'Drill down'. A search bar is also present. The main area displays a list of log entries with columns for 'TimeSta...', 'Entry Type', 'Source Obj', and 'Log Message'. The 'Detailed info' panel on the right shows the following data:

LogField	Value
TimeStamp	2015-02-25T01:31:20.061
Entry Type	Error
Source Obj	Antenna
Line	375
Routine	CEngineThread::runLoop()
Host	muraghe-rings.srt.inf.it
Process	FitsZillaContainer
Context	FitsZillaContainer
Thread	FITSENGINE
Log ID	
Priority	
URI	
Stack ID	001139288-bc8e-11e4-8000-000000000000
Stack Level	0
Log Message	Error during file operations (type=2001, code=23)
Audience	
Array	
Antenna	
Additional	/archive/dara/LEAP/20150225/20150225-013119-LEAP-LEAP/

Future development

- ESCS-Noto to be completed
- Graphical user interfaces (web based UI)

Summary

- DISCOS has been designed to be suitable for all the italian radio telescopes
- Different implementations cope with the differences among telescopes
- The growth of the project requires new development techniques

- From the user's point of view DISCOS is a common platform for all the telescopes: the observer will have:
 - same user interfaces
 - same tools
 - same data formats

Questions?

See:

<http://discos.readthedocs.org/>

