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DISCOS

throughout the years

Evolution and modernization of the Italian single-dish radio telescopes control software

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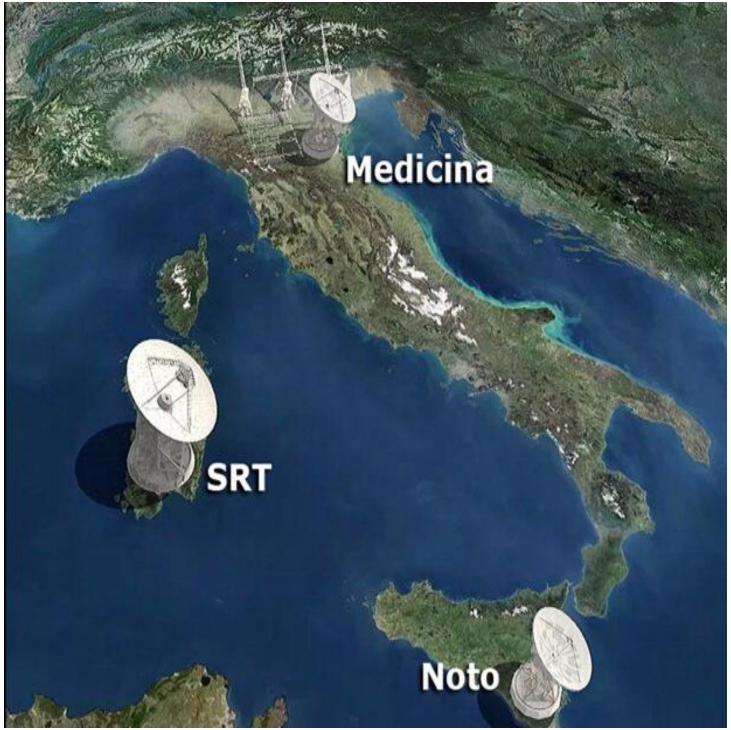
USC-C General Assembly – 9 - 13 March 2026 – Trieste

DISCOS

- ***D**evelopment of **I**talian **S**ingle-dish **CO**ntrol **S**ystem*
- Control software for the INAF single-dish radio telescopes
- Distributed architecture based on *Alma Common Software* (*ACS*)
- Controls and coordinates all the telescope subsystems
- Supports single-dish and VLBI observations

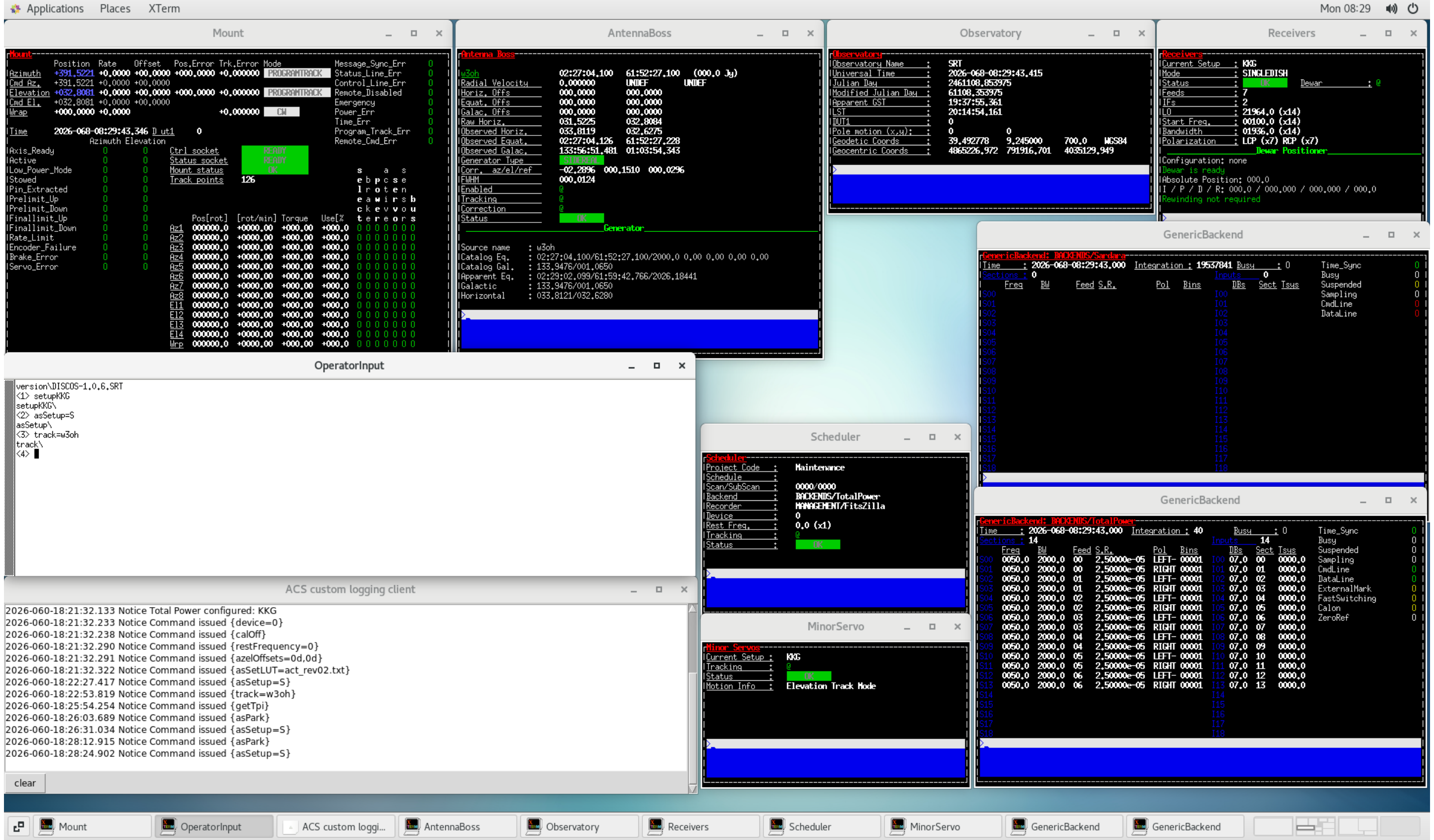


Origins of DISCOS

- 2007: *ESCS* (*Enhanced Single-dish Control System*) developed for the Medicina and Noto radio telescopes
- Early 2010s: Development of *Nuraghe*, the control software for the Sardinia Radio Telescope
- *Nuraghe* reused a significant portion of the existing *ESCS* core
- Mid 2010s: Convergence of the two projects into a unified system

DISCOS Architecture

- Control system organized as distributed software components
- Components run inside ACS containers
- Components communicate through CORBA-based middleware
- Each component controls a specific telescope subsystem
- Separation between control logic and hardware interfaces



```
Mount
         Position  Rate    Offset   Pos.Error Trk.Error Mode           Message_Sync_Err  0
Azimuth  +391.5221 +0.0000 +00.0000 +000.0000 +0.000000 PROGRAMTRACK   Status_Line_Err   0
Cmd Az.  +391.5221 +0.0000 +00.0000                                    Control_Line_Err  0
Elevation +032.8081 +0.0000 +00.0000 +000.0000 +0.000000 PROGRAMTRACK  Remote_Disabled   0
Cmd El.  +032.8081 +0.0000 +00.0000                                    Emergency         0
Wrap     +000.0000 +0.0000                    +0.000000 CW             Power_Err         0
                                                                       Time_Err          0
Time     2026-068-08:29:43.346 D ut1     0                             Program_Track_Err 0
                    Azimuth Elevation                                  Remote_Cmd_Err    0
Axis_Ready          0        0     Ctrl socket     READY
Active              0        0     Status socket   READY
Low_Power_Mode      0        0     Mount status    OK             s     a   s
Stowed              0        0     Track points    126            e b p c s e
Pin_Extracted       0        0                                    l r o t e n
Prelimit_Up         0        0                                    e a w i r s b
Prelimit_Down       0        0                                    c k e v v o u
Finallimit_Up       0        0        Pos[rot]  [rot/min] Torque  Use[%  t e r e o r s
Finallimit_Down     0        0     Az1 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
Rate_Limit          0        0     Az2 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
Encoder_Failure     0        0     Az3 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
Brake_Error         0        0     Az4 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
Servo_Error         0        0     Az5 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
                                   Az6 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
                                   Az7 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
                                   Az8 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
                                   El1 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
                                   El2 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
                                   El3 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
                                   El4 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
                                   Wrp 000000.0 +0000.00 +000.00 +000.0 0 0 0 0 0 0 0
```

```
Antenna Boss

w3oh                  02:27:04.100   61:52:27.100   (000.0 Jy)
Radial Velocity       0.000000       UNDEF          UNDEF
Horiz. Offs           000.0000       000.0000
Equat. Offs           000.0000       000.0000
Galac. Offs           000.0000       000.0000
Raw Horiz.            031.5225       032.8084
Observed Horiz.       033.8119       032.6275
Observed Equat.       02:27:04.126   61:52:27.228
Observed Galac.       133:56:51.481  01:03:54.343
Generator Type        SIDEREAL
Corr.  az/el/ref      -02.2896  000.1510  000.0296
FWHM                  000.0124
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.   : 02:29:02.099/61:59:42.766/2026.18441
Galactic       : 133.9476/001.0650
Horizontal     : 033.8121/032.6280
```

```
Observatory
Observatory Name    :   SRT
Universal Time      :   2026-068-08:29:43.415
Julian Day          :   2461108.853975
Modified Julian Day :   61108.353975
Apparent GST        :   19:37:55.361
LST                 :   20:14:54.161
DUT1                :   0
Pole motion (x,y):  :   0            0
Geodetic Coords     :   39.492778    9.245000     700.0     WGS84
Geocentric Coords   :   4865226.972  791916.701   4035129.949
```

```
Receivers
Current Setup   : KKG
Mode            : SINGLEDISH
Status          : OK       Dewar        : @
Feeds           : 7
IFs             : 2
LO              : 21964.0 (x14)
Start Freq.     : 00100.0 (x14)
Bandwidth       : 01936.0 (x14)
Polarization    : LCP (x7) RCP (x7)
__________________Dewar Positioner__________________
Configuration: none
Dewar is ready
Absolute Position: 000.0
I / P / D / R: 000.0 / 000.000 / 000.000 / 000.0
Rewinding not required
```

```
GenericBackend: BACKENDS/Sardara
Time       : 2026-068-08:29:43.000  Integration : 19537841 Busy      : 0    Time_Sync   0
Sections : 0                                        Inputs       0          Busy        0
     Freq    BW      Feed S.R.         Pol   Bins       DBs  Sect Tsys      Suspended   0
S00                                               I00                       Sampling    0
S01                                               I01                       CmdLine     0
S02                                               I02                       DataLine    0
S03                                               I03
S04                                               I04
S05                                               I05
S06                                               I06
S07                                               I07
S08                                               I08
S09                                               I09
S10                                               I10
S11                                               I11
S12                                               I12
S13                                               I13
S14                                               I14
S15                                               I15
S16                                               I16
S17                                               I17
S18                                               I18
```

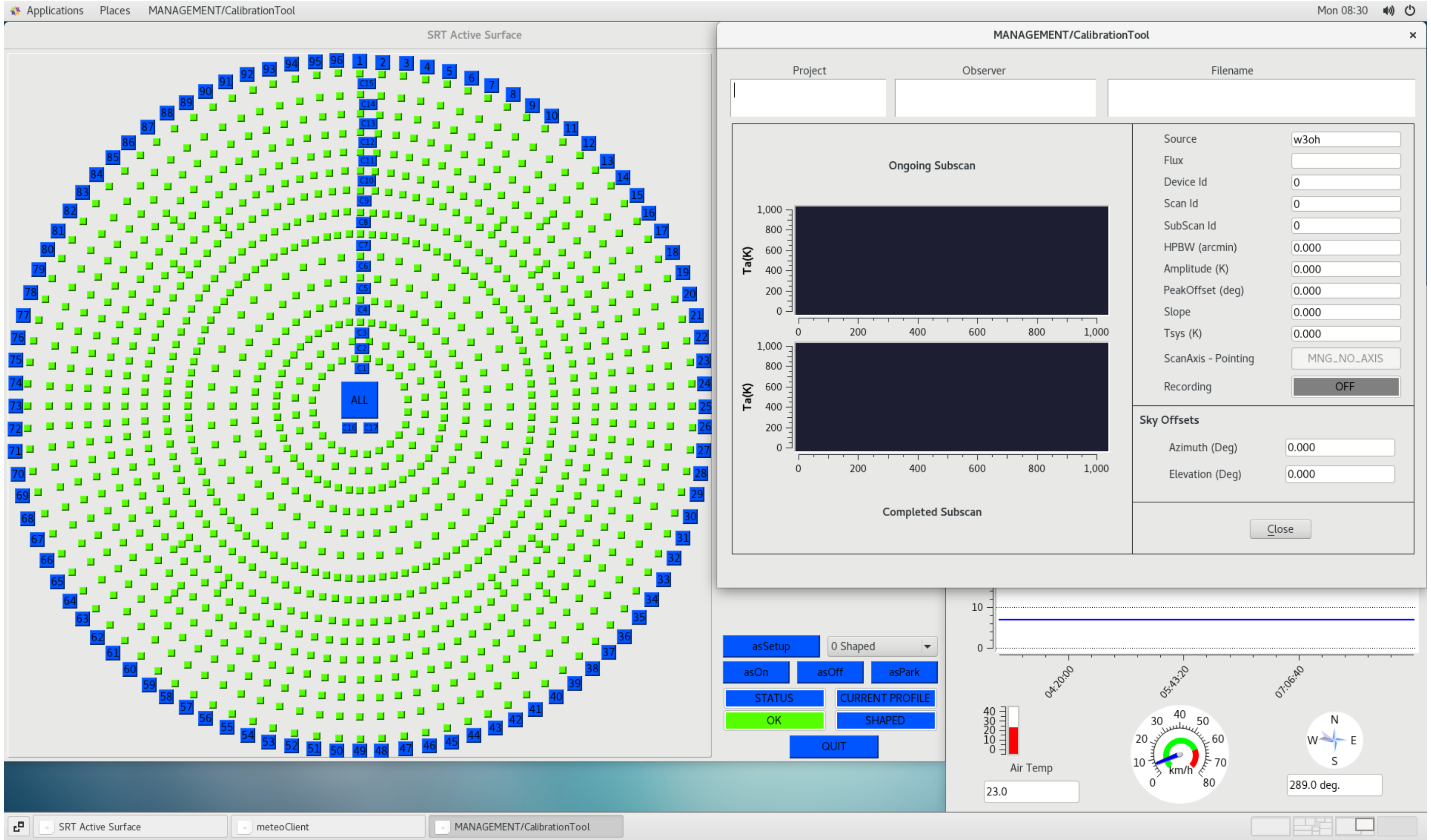
```
version\DISCOS-1.0.6.SRT
<1> setupKKG
setupKKG\
<2> asSetup=S
asSetup\
<3> track=w3oh
track\
<4>
```

```
Scheduler
Project Code   :   Maintenance
Schedule       :
Scan/SubScan   :   0000/0000
Backend        :   BACKENDS/TotalPower
Recorder       :   MANAGEMENT/FitsZilla
Device         :   0
Rest Freq.     :   0.0 (x1)
Tracking       :   @
Status         :   OK
```

```
Minor Servos
Current Setup :   KKG
Tracking      :   @
Status        :   OK
Motion Info   :   Elevation Track Mode
```

```
GenericBackend: BACKENDS/TotalPower
Time       : 2026-068-08:29:43.000  Integration : 40     Busy      : 0    Time_Sync      0
Sections : 14                                    Inputs      14           Busy           0
     Freq    BW      Feed S.R.         Pol   Bins       DBs  Sect Tsys    Suspended      0
S00  0050.0  2000.0  00   2.50000e-05  LEFT- 00001  I00 07.0 00   0000.0  Sampling       0
S01  0050.0  2000.0  00   2.50000e-05  RIGHT 00001  I01 07.0 01   0000.0  CmdLine        0
S02  0050.0  2000.0  01   2.50000e-05  LEFT- 00001  I02 07.0 02   0000.0  DataLine       0
S03  0050.0  2000.0  01   2.50000e-05  RIGHT 00001  I03 07.0 03   0000.0  ExternalMark   0
S04  0050.0  2000.0  02   2.50000e-05  LEFT- 00001  I04 07.0 04   0000.0  FastSwitching  0
S05  0050.0  2000.0  02   2.50000e-05  RIGHT 00001  I05 07.0 05   0000.0  Calon          0
S06  0050.0  2000.0  03   2.50000e-05  LEFT- 00001  I06 07.0 06   0000.0  ZeroRef        0
S07  0050.0  2000.0  03   2.50000e-05  RIGHT 00001  I07 07.0 07   0000.0
S08  0050.0  2000.0  04   2.50000e-05  LEFT- 00001  I08 07.0 08   0000.0
S09  0050.0  2000.0  04   2.50000e-05  RIGHT 00001  I09 07.0 09   0000.0
S10  0050.0  2000.0  05   2.50000e-05  LEFT- 00001  I10 07.0 10   0000.0
S11  0050.0  2000.0  05   2.50000e-05  RIGHT 00001  I11 07.0 11   0000.0
S12  0050.0  2000.0  06   2.50000e-05  LEFT- 00001  I12 07.0 12   0000.0
S13  0050.0  2000.0  06   2.50000e-05  RIGHT 00001  I13 07.0 13   0000.0
S14                                               I14
S15                                               I15
S16                                               I16
S17                                               I17
S18                                               I18
```

```
2026-060-18:21:32.133 Notice Total Power configured: KKG
2026-060-18:21:32.233 Notice Command issued {device=0}
2026-060-18:21:32.238 Notice Command issued {calOff}
2026-060-18:21:32.290 Notice Command issued {restFrequency=0}
2026-060-18:21:32.291 Notice Command issued {azelOffsets=0d,0d}
2026-060-18:21:32.322 Notice Command issued {asSetLUT=act_rev02.txt}
2026-060-18:22:27.417 Notice Command issued {asSetup=S}
2026-060-18:22:53.819 Notice Command issued {track=w3oh}
2026-060-18:25:54.254 Notice Command issued {getTpi}
2026-060-18:26:03.689 Notice Command issued {asPark}
2026-060-18:26:31.034 Notice Command issued {asSetup=S}
2026-060-18:28:12.915 Notice Command issued {asPark}
2026-060-18:28:24.902 Notice Command issued {asSetup=S}
```



MANAGEMENT/CalibrationTool

Project

Observer

Filename

Source w3oh

Flux

Device Id 0

Scan Id 0

SubScan Id 0

HPBW (arcmin) 0.000

Amplitude (K) 0.000

PeakOffset (deg) 0.000

Slope 0.000

Tsys (K) 0.000

ScanAxis - Pointing MNG_NO_AXIS

Recording OFF

Sky Offsets

Azimuth (Deg) 0.000

Elevation (Deg) 0.000

Close

0 Shaped

Air Temp 23.0

289.0 deg.

Challenges in the evolution of DISCOS

- Hardware dependency
- Testing and simulation
- Reproducible environments
- Deployment automation
- CI/CD workflows
- Legacy technologies
- ACS/CORBA coupling
- Modern interfaces
- System resilience

Challenge #1: Hardware Dependency

Problem:

- Testing the control software required access to real telescope subsystems
- Hardware availability limited by observing schedules
- Difficult debugging and experimentation
- Slow development and testing cycles

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- Slow development and testing cycles

Solution:

- Python based simulators of telescope subsystems
- Run DISCOS without telescope hardware
- Decouples software development from telescope availability
- Enables Test-Driven Development (TDD) and automated testing workflows

Challenge #2: Reproducible Environments

Problem:

- Difficult to reproduce the full telescope software environment
- Large number of services and dependencies
- Manual configuration of servers and development machines
- Inconsistent environments across installations

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Problem:

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- Manual configuration of servers and development machines
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Solution:

- Automated environment provisioning
- Infrastructure configuration managed through Ansible
- Unified setup for telescope machines and development environments
- Rapid provisioning of virtual machines for testing and development

Challenge #3: Testing the Deployment Infrastructure

Problem:

- Deployment relies on automated Ansible procedures
- Changes in roles or dependencies may break the setup
- Validation previously required manual provisioning of test VMs
- Manual testing made the feedback loop slow and error-prone

Challenge #3: Testing the Deployment Infrastructure

Problem:

- Deployment relies on automated Ansible procedures
- Changes in roles or dependencies may break the setup
- Validation previously required manual provisioning of test VMs
- Manual testing made the feedback loop slow and error-prone

Solution:

- Continuous Integration pipeline using GitHub Actions
- Automatic provisioning of test environments
- Automated validation of the deployment workflow
- Ongoing transition from virtual machines to containers

Challenge #4: Legacy Middleware Coupling

Problem:

- DISCOS communication built on ACS/CORBA middleware
- Interactions with components requires a full ACS runtime environment
- Heavy dependencies for external clients and integrations
- Limited interoperability with modern software ecosystems

Challenge #4: Legacy Middleware Coupling

Problem:

- DISCOS communication built on ACS/CORBA middleware
- Interactions with components requires a full ACS runtime environment
- Heavy dependencies for external clients and integrations
- Limited interoperability with modern software ecosystems

Solution (ongoing work):

- Introduction of a new ZeroMQ-based communication layer
- ACS runtime no longer required for external clients
- Enables flexible access to telemetry and system state
- Allows development of internal and third-party monitoring and control tools

Challenge #5: System Resilience

Problem:

- Many DISCOS components mapped 1:1 to hardware devices
- Components could not start if the corresponding hardware was unavailable
- Hardware failures could prevent parts of the control system from running
- Limited ability to expose hardware status and availability information

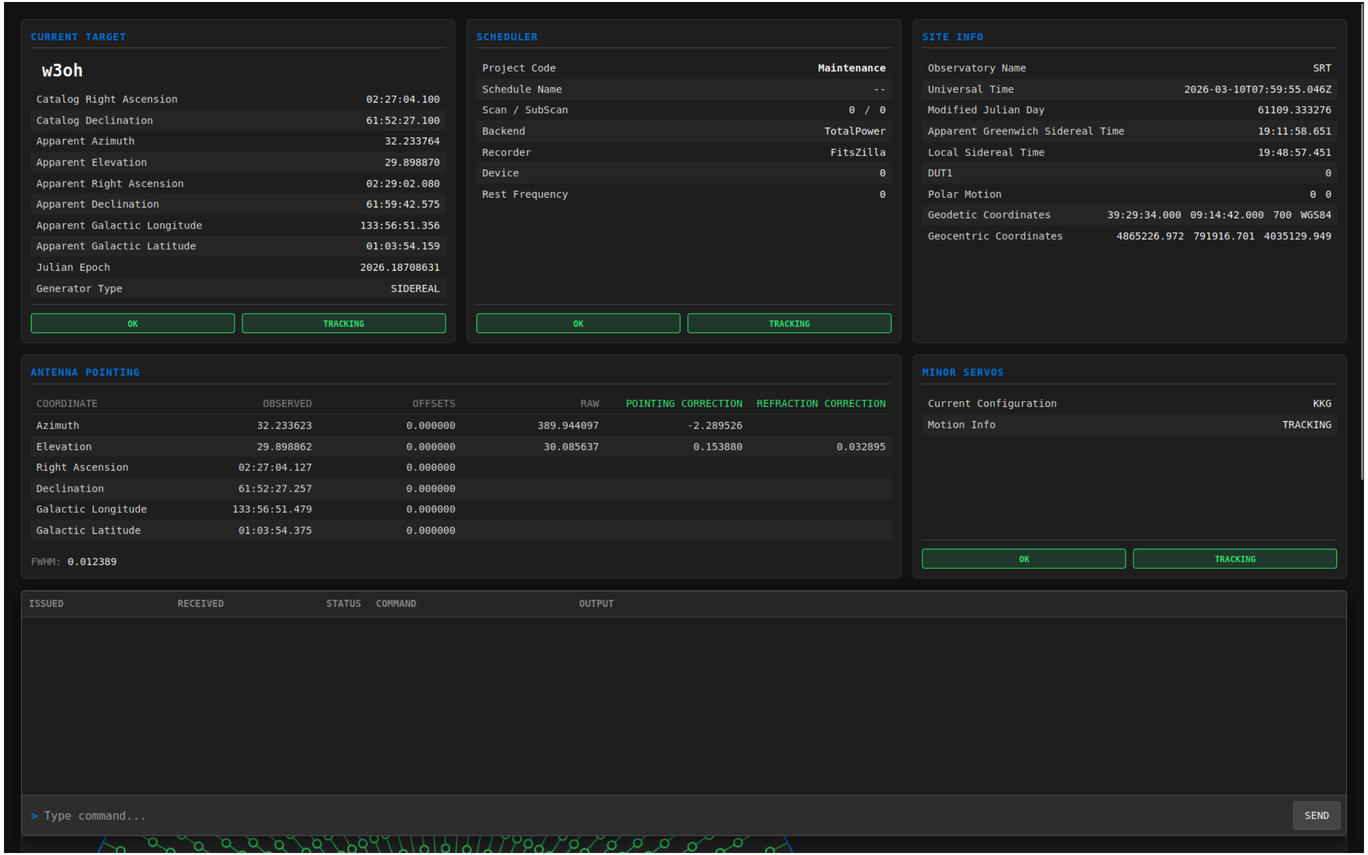
Challenge #5: System Resilience

Problem:

- Many DISCOS components mapped 1:1 to hardware devices
- Components could not start if the corresponding hardware was unavailable
- Hardware failures could prevent parts of the control system from running
- Limited ability to expose hardware status and availability information

Solution (ongoing work):

- Components designed to start independently from hardware availability
- Graceful handling of missing or unreachable devices
- Explicit reporting of hardware status and connection state
- Increased robustness of the distributed control system



CURRENT TARGET

w3oh

Catalog Right Ascension	02:27:04.100
Catalog Declination	61:52:27.100
Apparent Azimuth	32.233764
Apparent Elevation	29.898870
Apparent Right Ascension	02:29:02.080
Apparent Declination	61:59:42.575
Apparent Galactic Longitude	133:56:51.356
Apparent Galactic Latitude	01:03:54.159
Julian Epoch	2026.18708631
Generator Type	SIDEREAL

SCHEDULER

Project Code	**Maintenance**
Schedule Name	--
Scan / SubScan	0 / 0
Backend	TotalPower
Recorder	FitsZilla
Device	0
Rest Frequency	0

SITE INFO

Observatory Name	SRT
Universal Time	2026-03-10T07:59:55.046Z
Modified Julian Day	61109.333276
Apparent Greenwich Sidereal Time	19:11:58.651
Local Sidereal Time	19:48:57.451
DUT1	0
Polar Motion	0 0
Geodetic Coordinates	39:29:34.000 09:14:42.000 700 WGS84
Geocentric Coordinates	4865226.972 791916.701 4035129.949

ANTENNA POINTING

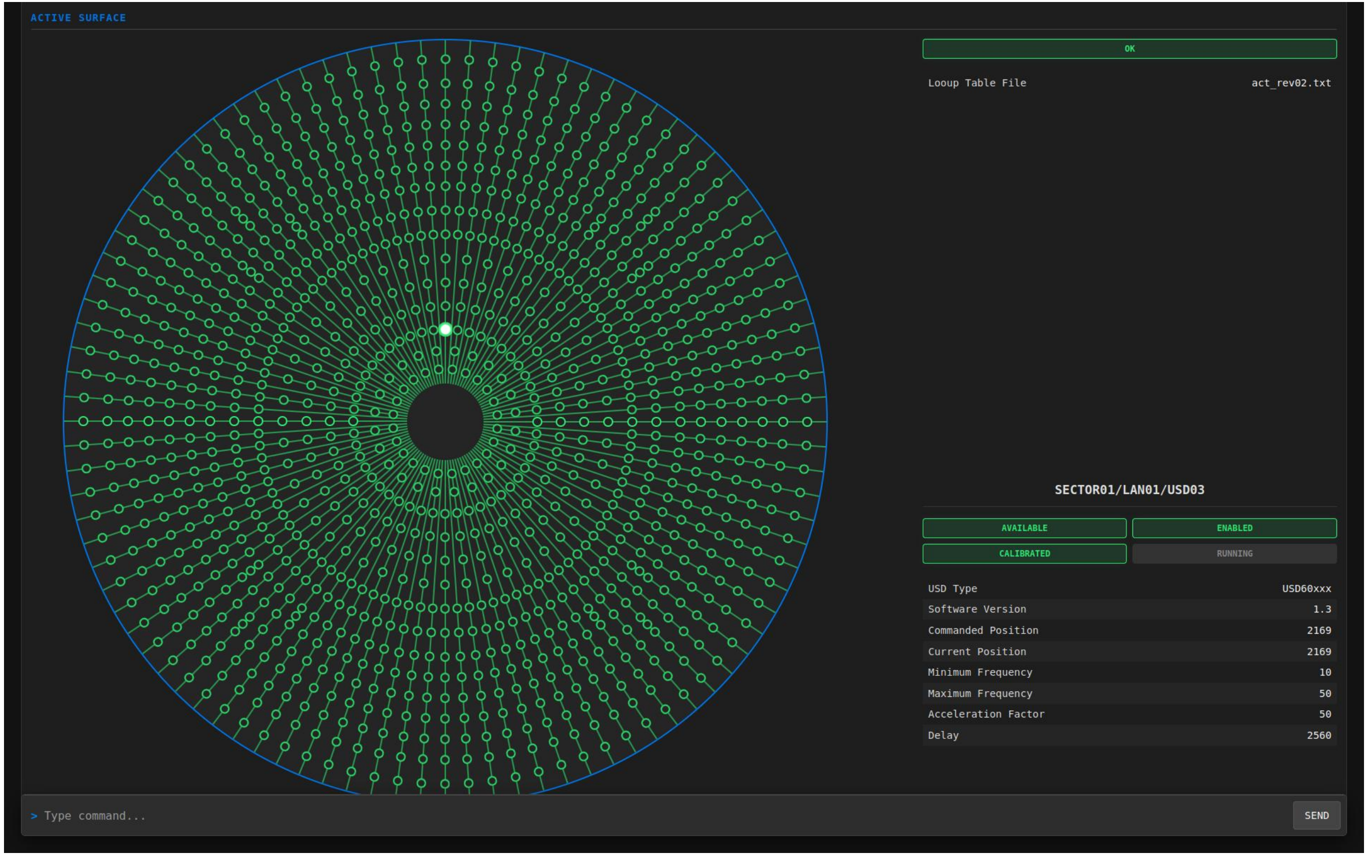
COORDINATE	OBSERVED	OFFSETS	RAW	POINTING CORRECTION	REFRACTION CORRECTION
Azimuth	32.233623	0.000000	389.944097	-2.289526	
Elevation	29.898862	0.000000	30.085637	0.153880	0.032895
Right Ascension	02:27:04.127	0.000000			
Declination	61:52:27.257	0.000000			
Galactic Longitude	133:56:51.479	0.000000			
Galactic Latitude	01:03:54.375	0.000000			

FWHM: 0.012389

MINOR SERVOS

Current Configuration	KKG
Motion Info	TRACKING

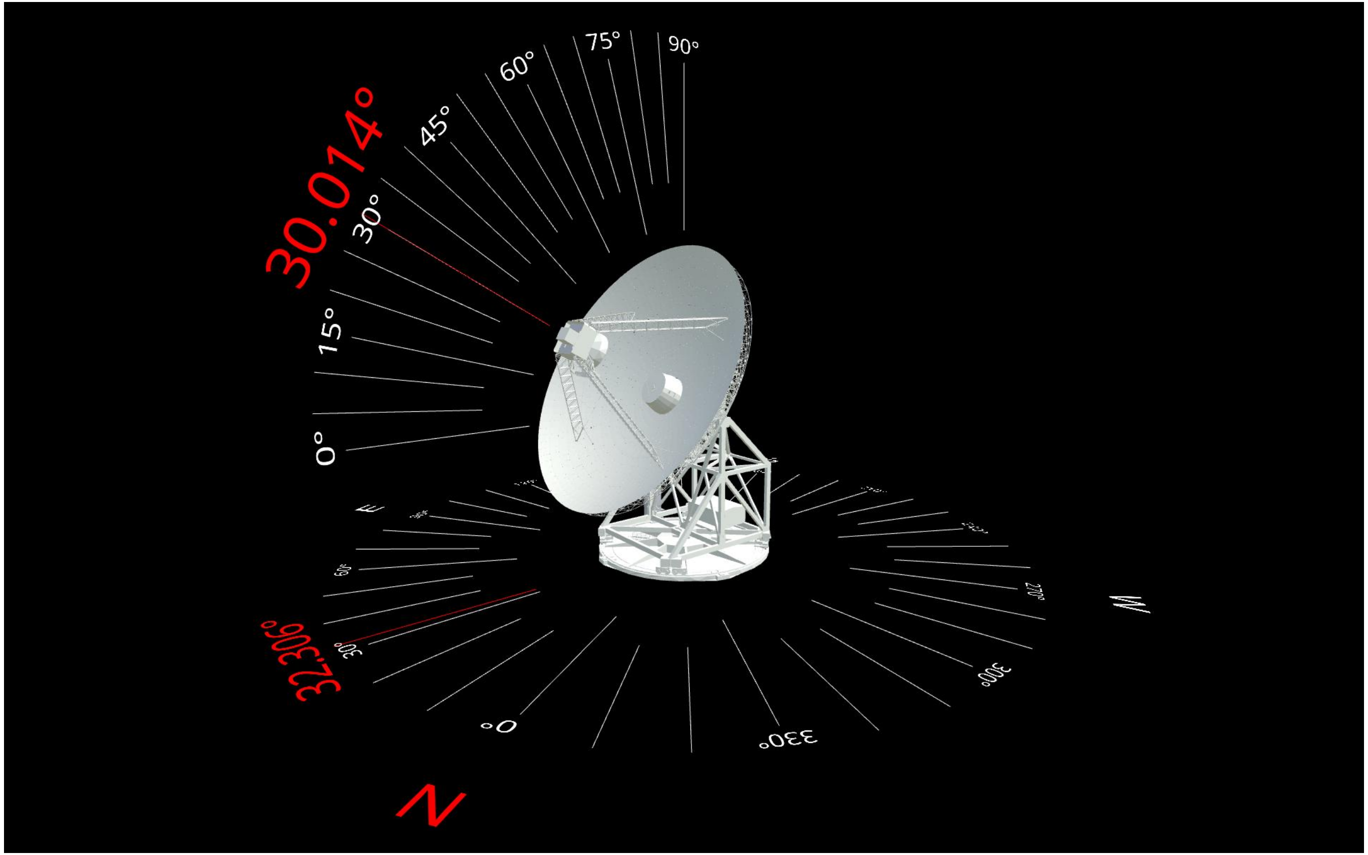
ISSUED	RECEIVED	STATUS	COMMAND	OUTPUT



Looup Table File	act_rev02.txt

SECTOR01/LAN01/USD03

USD Type	USD60xxx
Software Version	1.3
Commanded Position	2169
Current Position	2169
Minimum Frequency	10
Maximum Frequency	50
Acceleration Factor	50
Delay	2560



75°
90°
60°
45°
30.014°
30°
15°
0°
E
60°
32.306°
30°
0°
330°
300°
270°
W
N

Source code and resources

DISCOS organization on GitHub
github.com/discos

DISCOS Simulators
github.com/discos/simulators

DISCOS Deployment
github.com/discos/deployment

DISCOS Client / telemetry tools
github.com/discos/discosclient

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Thank you for the attention