

**Title:****New Control System for the 30-Meter Telescope • Presentation**

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*Author:* Hans Ungerechts

*Contributors:* Walter Brunswig, Juan Peñalver

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*Description - about this document:*

New Control System for the IRAM 30-m telescope (NCS 30m). Presentation.



```

paKo
SOURCE name system longitude latitude velocity
W30H eq J2000.0 02:27:03.881 +61:52:24.57 LSR 0.000
[h] 2.451078 SET Topology low SET doSubmit NO (F)
[deg] 36.766172 61.873492 SET Pointing 1.1 2.2
[rad] 0.64169075 1.07989616 SET Focus -2.22 [mm]

OFFSETS
CATALOG SOURCE iram-J2000-LSR.sou CATALOG LINE model.lin

RECEIVER lineName frequency [GHz] SB /doppler /width /gain [dB] /tempLoad /efficiency /scale
A100 12C0(1-0) 115.271204 LSB Doppler narrow 0.001 -30. 79.2 270.0 0.95 0.95 antenna
A230 12C0(2-1) 230.537990 LSB Doppler narrow 0.010 -20. 79.4 270.0 0.91 0.91 antenna
B100 12C0(1-0) 115.271204 LSB Doppler narrow 0.001 -30. 72.1 270.0 0.95 0.95 antenna
B230 12C0(2-1) 230.537990 LSB Doppler narrow 0.010 -20. 71.3 270.0 0.91 0.91 antenna

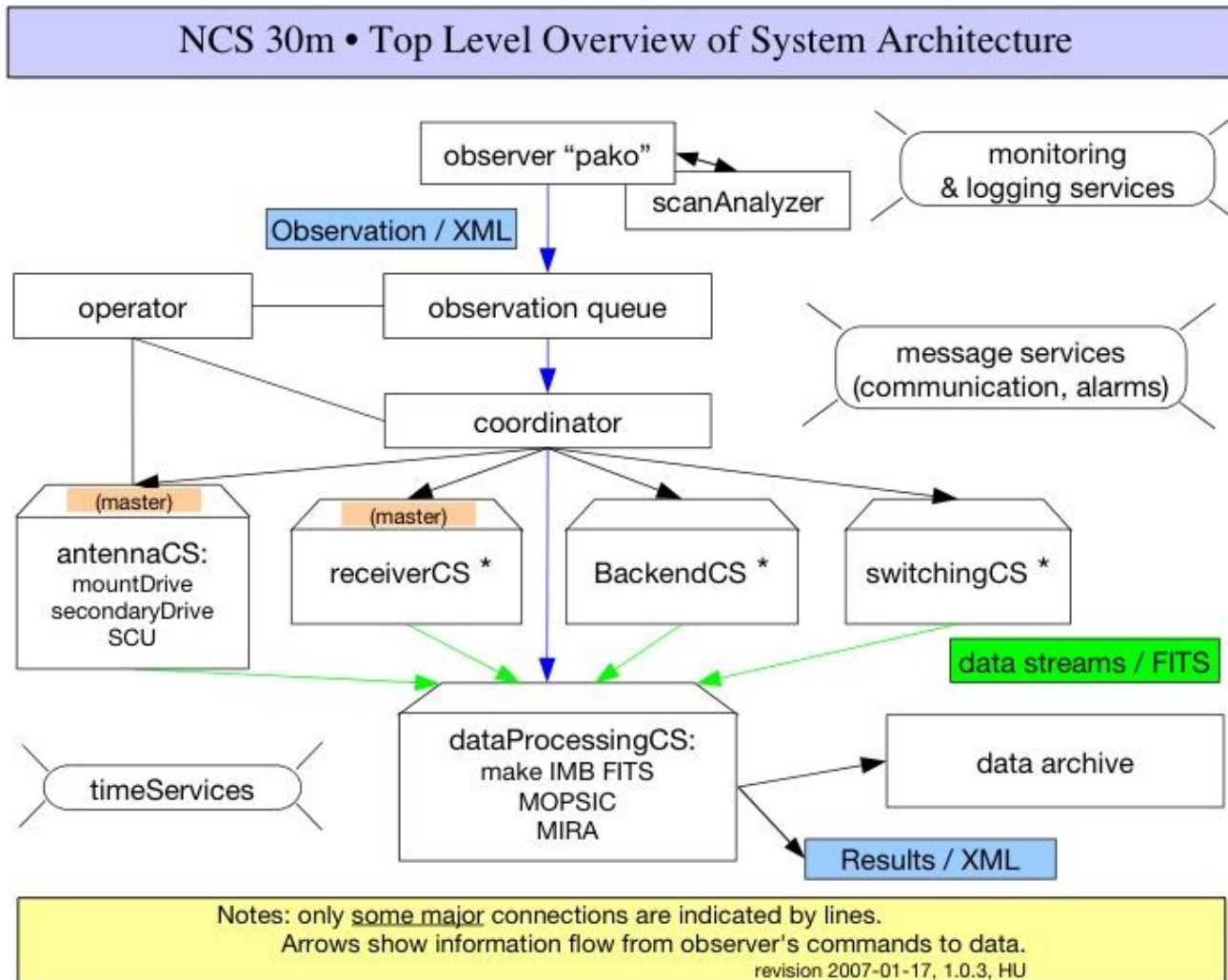
OTFMAP (On-The-Fly OTF Map) [arcsec] SWTOTAL (Total Power)
xStart yStart -300.000 -300.000
xEnd yEnd 300.000 -260.000 /tPhase 0.200
--> lengthOtf 601.332
/system trueHorizon
/reference T
xOffsetR yOffsetR -600.000 -400.000
systemName trueHorizon
/croLoop see below

/nOtf 12
/step dx dy 0.000 5.000
/speed sStart sEnd 10.022 10.022
/tOtf 60.000
/tReference 10.000
/zigzag T

BACKEND nPart resolu. bandw. fShift /receiver /mod /perc
VESPA 1 0.020 40.0 2.0 A100 90.0
VESPA 2 0.020 40.0 2.0 B100 90.0
VESPA 3 0.040 80.0 -2.0 A230 90.0
VESPA 4 0.040 80.0 -2.0 B230 90.0

/croLoop 0

PAKO\START paKo v 1.0.6.1
    
```



## NCS Status Overview

NCS Review Meeting September 2006 + internal follow-up meetings:

Products:

1. "Recommendations by the SAC panel"
2. "Conclusions" (Action Items) by KS from internal + follow-up meetings
3. Review of Priorities, including estimates of cost (human resources)

Commented versions of these 3 documents are attached  
(most recently updated info is in *this* presentation)

Actions mostly prioritized by conclusions in 2. !

TT NCS Winter 2006/2007 (~ 6 periods of 3.5 days \* 6 hours ~ 126 hours)  
more than typical for winter time  
significantly reduced compared to NCS deployment

## Selected items done since May 2006

Remote observing from Granada and Grenoble using VNC.

Modified start of Track subscans.

Additional support for satellites (moons) and solar-system bodies.

Revisions of to-do-items and priorities.

Investigation of tracking quality.

Replaced server for real-time systems (former “vlab1”)  
+ acquired 1 hardware spare.

## General NCS Activities

“internal” improvements of hardware and software:

- upgrade of main file servers (mrt-lx1, mrt-lx3) and RAID system

- revision of handling of interrupts on antenna Mount Drive system (vac1)

- include debug information in antenna Mount Drive data stream (UDP)

and:

- “kibitz” for operators of observer’s use interface (“paKo”)

- warning flags (colors), error messages, alarms

- technical and user documentation

- on-line data processing for nearly all observing modes

## Additional Features

- calibration of signal-image side band ratio
- 100kHz filter bank
- POINTING /AEloop to select directions for pointing subscans **new**
- FOCUS /Direction (X/Y) for tests and optimization
- POINTING /DoubleBeam with wobbler switching **new**
- “rotated wobbler” for OTFMAP with the bolometer (+POINTING and FOCUS)
- special features for VLBI, e. g., VLBI /lastSource **new**
- BACKEND USB to support “visiting backends” for test purposes
- sequence of some commands in PaKo is now enforced to support more consistency checking
- XML description of Observing Modes

## Major “Old CS” Features remaining To Be Done:

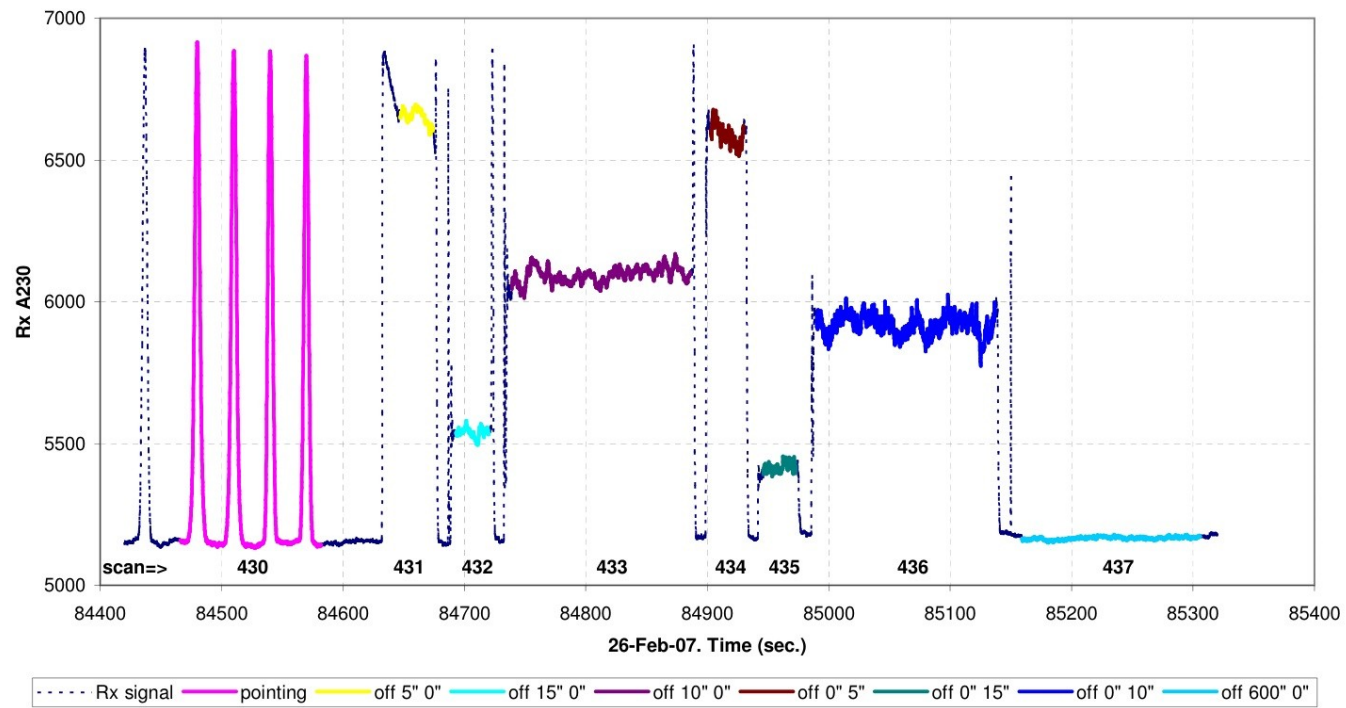
- RASTER observing mode
- Coordinate Systems

## Action Items

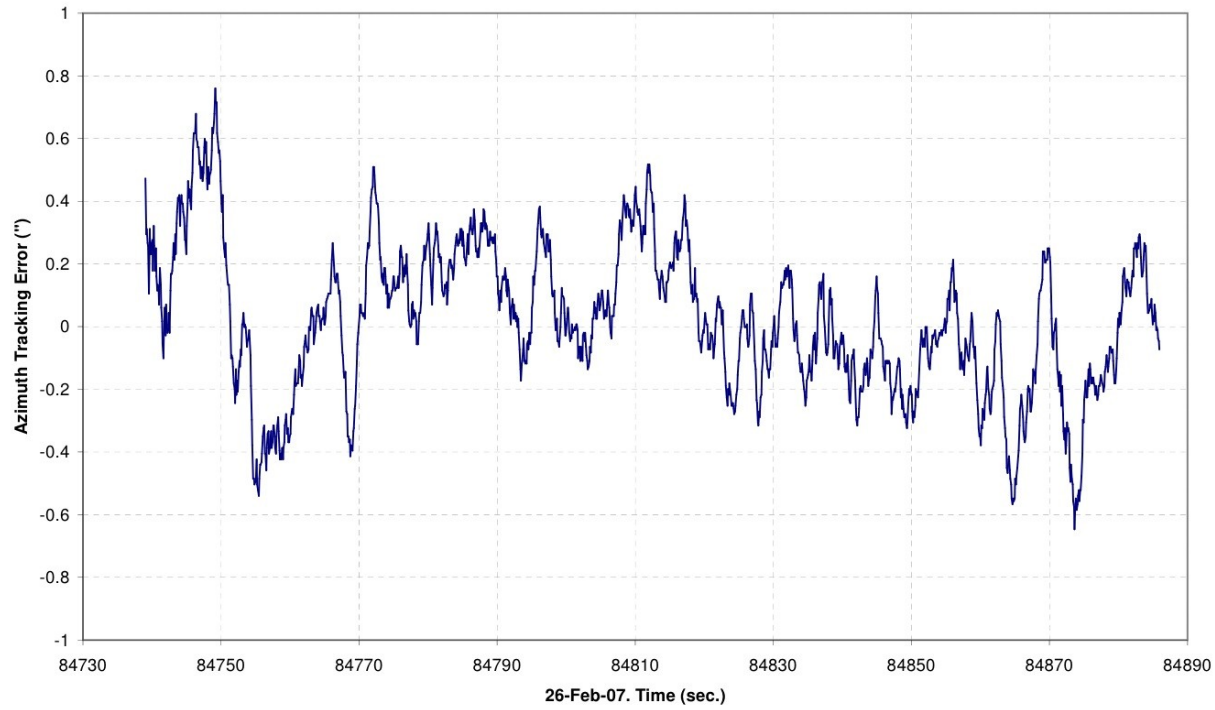
### A) Highest priority Items HH:

- Investigate remaining questions on antenna mount drive control loop: HH      JP,AP
- i) Investigate intermittent oscillation phenomena.  
JP: hardware improved  
remaining: small oscillations (<1") at low speeds
- ii) Investigate wind-speed tracking precision correlation. Ongoing (JP)
- iii) Re-investigate equivalence of translated control loop parameters and code OCS/NCS.  
JP: preliminary OK, TBD: details + check by GP
- iv) Investigate the role of friction compensation.  
JP: done, some suggestions for possible improvements
- v) Independent tracking error check through HPW tracking of planets.  
JP: done. Under < 1". Higher near wind speed limit, see item ii) above.  
(difficulty: unstable atmosphere / wind effects)

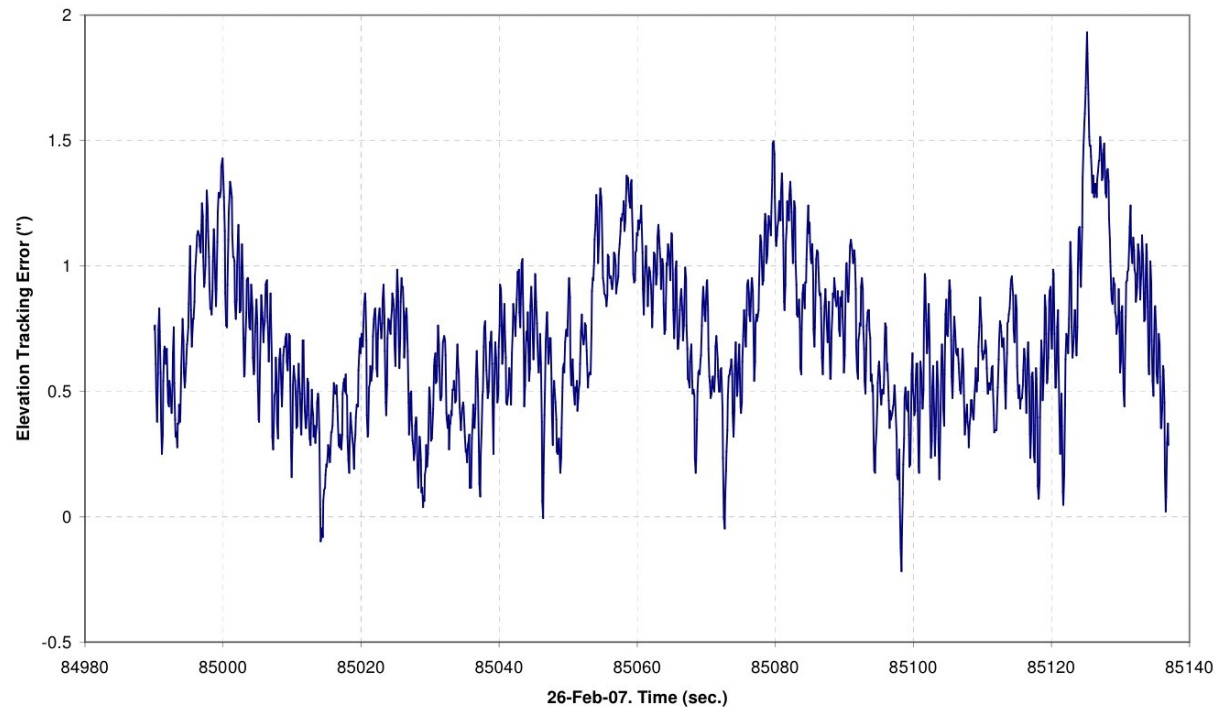
Tracking Saturn at HPW, elev.=69°  
(26-February-2007)



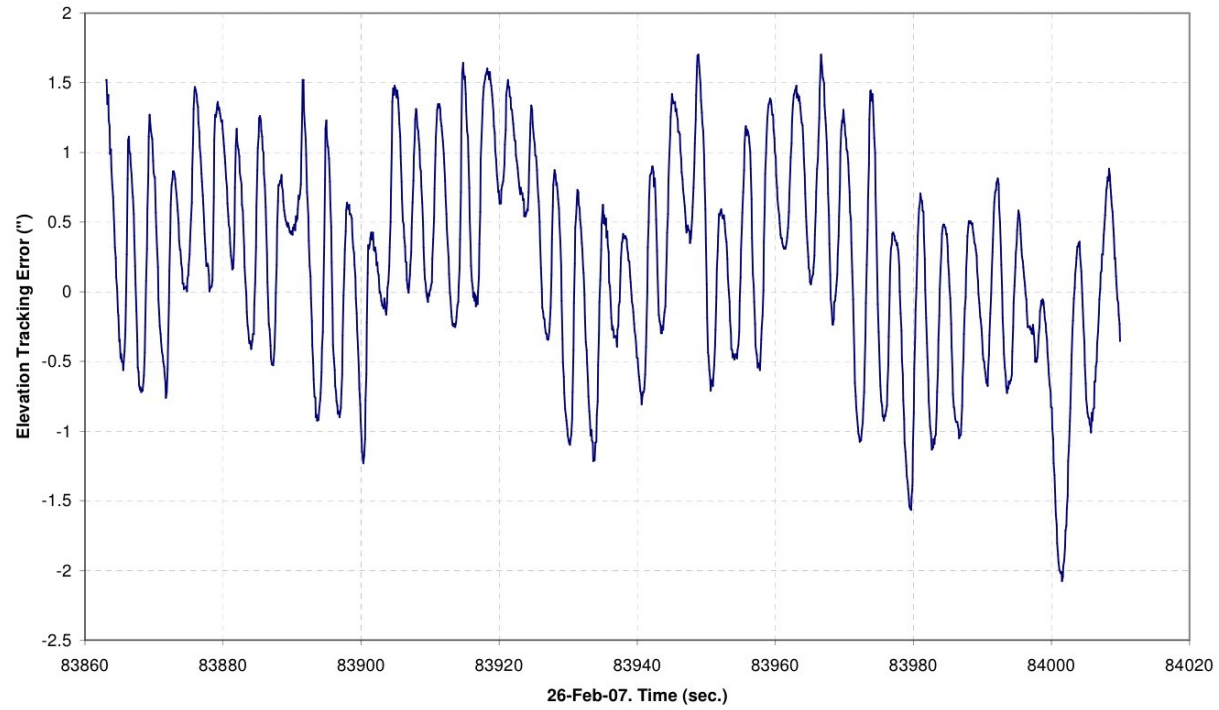
Tracking Error in Azimuth with the Antenna Beam at HPW of Saturn (20.1")  
(Scan 433, Azimuth 188°, Elevation 69°)



Tracking Error in Elevation with the Antenna Beam at HPW of Saturn (20.1")  
(Scan 436, Azimuth 191°, Elevation 68°)



Tracking Error in Elevation with the Antenna Beam at HPW of Saturn (20.1")  
(Scan 426, Azimuth 179°, Elevation 69°)



## A) Highest priority Items HH (continued)

- . Change start of antenna MD subscons: HH AP,AS,WB,HU
  - i) memo on possible solutions at different levels of system (antenna MD, Coordinator, PaKo)  
 HU: done, memo distributed by email.
  - ii) test possible solution for start of “Track” subscons in antenna MD  
 HU: tests done, several iterations and rounds of debugging (AP) following detailed test plan. Finally taken into operation 2007-03-16.
  - iii) decide on solution for OTF subscons  
 HU, WB, AS: prototype at level of coordinator tested TT 2007-04, seems OK, needs detailed analysis. **To be implemented a.s.a.p. (maybe not for all cases!)**
  
- . Recompile priorities for items To Be Done: HH HU  
 HU: done, several iterations, no major changes. Document available at:  
<http://www.iram.es/IRAMES/documents/ncs30mPriorities/Current/PDF/ncs30mPriorities.pdf>
  
- . Make a list of specific incident scenarios. HH HU  
 HU: Draft done. Available at:  
<https://mrt-lx1.iram.es/mainWiki/NcsSwManagementScenarios>  
**To be discussed and to be turned into actual action plans.**

## B) Other Items

- Introduce pre-integration for VESPA. H GP

### To Be Done!

Temporary solution for HERA/ VESPA/ Frequency Switching:  
pre-integration in MIRA.

- Reduce single point failure risk vlab1 H GP  
(server for real-time VME /Linux control systems)

This system did fail between Christmas 2006 and New Year 2007.  
A temporary solution was implemented (file server on other Linux system).  
Vlab1 has been replaced in 2007-03.  
There is now 1 hardware spare as a backup.

- Separate approach for 1-time check webpages M WB  
from on-line monitoring.

WB: description of monitoring pages of interest for observers:  
<https://mrt-lx1.iram.es/mainWiki/OperationNotesObserversMonitoring>  
HU: requests for monitoring are at:  
<https://mrt-lx1.iram.es/mainWiki/RequestsMonitor>  
To be discussed.

- . Finish MIRA/MOPSIC XML output for PAKO feedback. M HW,RZ,HU  
 To Be Done.
- . Develop concept for mapping online monitoring. L JeP,HW,  
 Think and collect infos. RZ AS  
 To Be Done.
- . Read and check feedback wobbler status H WB, JP  
 WB: done.
- . Introduce temporary data consistency checking (2 levels) H WB,HW  
 (for potential problems in trace data streams from antenna MD)  
 New alarms in NCS, ongoing.  
 Checks in data processing software (MIRA, MOPSIC)  
 Preset flag for fast trace data stream prepared in antenna MD,  
 Implemented TT NCS 2007-04
- . Draft a 1st version of observation logging M CT  
 CT: 1st draft done.  
 effort is now integrated into new database and archive project  
 (SL et al., ongoing)

- Use UDP for data streams from filter banks, continuum backends, HERA, secondary control H GP,AS

To Be Done.

- Define clear rules and responsibilities for real-time machines H AP,JP, GP,WB,KS

To Be Done.

- Attach alarm flags to data or allow for retrieve. M AS,RZ, HW,JeP

Make a list of basic flags (antenna business etc).

To Be Done.

- Formalize inclusions of user wishes M RM,HU,CT

To Be Done.

- Update/redefine operator tasks and responsibilities. Formalize and perform training. H RM,JP,MR

revised list of items for operator training has been prepared by MR.

TBD: operator's tasks, AODs.

- Profile time critical packages (IMBFITS, MIRA) H AS, HW, JeP  
ImbFits generation and data processing packages have been profiled, no obvious single bottleneck.  
TBD: optimization of details, related tasks in NCS.

- Draw Data storage and backup scheme. M WB  
WB: Documentation is at:  
<https://mrt-lx1.iram.es/mainWiki/NcsDataDirectoryOrganization>

- Assure test-plans for software upgrades and introduction of new features.

HU: so done formally for:

- changeover of last OS/9 system to Linux
  - gave successful changeover
- modification of start of Track subscans (see above)
  - found “hidden bugs” which were then solved
  - finally successful operation

Done informally for other items, e. g., double-beam pointing.

This is of course to be continued for similar cases.

- Improvement of calibration scheme :

- i) comparison of ATM versions.
- ii) Check load position feedback and timing.
- iii) Elaborate error propagation scheme.
- iv) Indicate errors to users and suppress useless information

WB AS

TBD: Last two points define a future scale effort with one dedicated person required (postdoc).

JeP: item i): differences of calibration scale ATM<sub>1986</sub> vs. ATM<sub>2003</sub> <10% (<5% at 3mm); larger differences for “computation intermediates”. To be continued ...

WB: item ii): Done.

Additionally ongoing: re-furbished hardware by Granada receiver group; new T\_cold lookup table to be determined; new scheme of implementation of T\_cold lookup table is prepared. To be activated a.s.a.p.

- Data processing (MIRA, MOPSIC) use the actual position?

HU: As with the old CS, they use commanded position with the additional check that tracking errors are small.

TBD: need to document the details of the smooth transition trajectories; include numerical description of transition trajectories in trace data streams; and document the details of fast and slow trace data streams, including tracking error.

AP

- Need more discussion about the chunks of data which are concatenated into IMBFITS files (subscans or shorter etc.) HU, ALL  
TBD: discussion in Granada, then HU makes proposal.  
AS has prepared to generate IMBFITS after subscans, except VESPA, WILMA  
More general aspects:  
waiting for GP and AS to get high priority items done (see above).
- Make a plan for a midterm unification of the messaging system after having suppressed all OS/9 systems. WB  
WB: Done. The last OS/9 system has been taken out of operation in 2007-11.  
All messages are now based on the software described in:  
<https://mrt-lx1.iram.es/mainWiki/NcsMessages>  
Further modification to base messages on "more standard schemes" like CORBA are currently not foreseen.
- Check current messaging system (arrival time against message time stamps) WB  
WB: Done. Normally fast.  
Occasional delays up to 1 second, but not causing problems.

- SAC recommendation to standardize hardware interfaces WB,SN,GP
  - WB: has been considered, currently no plans make changes in NCS.
  - HU: for the time being the standard for:
    - the description of setup parameters for hard ware, in particular receivers and backends, is given by the “observations XML files”;
    - data streams: data-stream FITS files;
    - additional: sync messages; hardware signal for switching modes.
- Define a small set of standard observing procedures which are archived and repeated in ~3 months periods to monitor system performance changes.
  - Procedures have been prepared by NM in discussion with RM and HU; they are being used regularly during TT “system check”.

- Comprehensively describe the logic of “master assignment” for the subsystems in the current control software.

WB: In the NCS, the end of a subscan is defined by one of the control systems. This is mostly the antennaControlSystem (antCS), except for the case of calibrations, where it is the receiverControlSystem (rxCS). For each subscan, therefore one of the control systems takes the role of the “masterControlSystem” (masterCS) and other control systems can just wait for events from the masterCS without having to know which control system is currently the masterCS.

For related information, see:

<https://mrt-lx1.iram.es/mainWiki/NcsArchitecture>

## Recommendations by SAC panel

We strongly encourage IRAM in their decision to set up a software management plan, especially including a thorough test plan, if possible also quantitative manpower estimates. It may be useful to sort requirements or requests according to their criticality with respect to 1. the instrumental performance 2. the Observatory operations 3. the observer/operator ergonomics.

Priorities for items to be done, including ratings for cost (man power) and the 3 categories:  
NCS. Priorities. New Control System for the 30m Telescope, v 1.0 - 1.2  
<http://www.iram.es/IRAMES/documents/ncs30mPriorities/>

Formal test plans were elaborated and used for 2 major upgrades:

- changeover of last OS/9 system to Linux
- modification of start of Track subscans
- done informally for other items, e. g., double-beam pointing.
- this is of course to be continued for similar cases.

Additionally: Define a small set of standard observing procedures which are archived and repeated in ~3 months periods to monitor system performance changes. Prepared by NM in discussion with RM and HU.

- IRAM should investigate why the water vapor values differ so much between the different receivers. It could be due to the old atmospheric model. It could also be because the solutions for low opacities at the lower frequencies do not converge well.

see above: action items:

- Improvement of calibration scheme :
  - comparison of ATM versions
  - Check load position feedback and timing WB, tests TT last week October
  - Elaborate error propagation scheme.
  - Indicate errors to users and suppress useless information WB AS

TBD: Last two points define a future scale effort with one dedicated person required (postdoc).

JeP: item i):

differences of calibration scale ATM<sub>1986</sub> vs. ATM<sub>2003</sub> <10% (<5% at 3mm)  
larger differences for “computation intermediates”. To be continued ...

WB: item ii): Done.

Additionally ongoing: re-furbished hardware by Granada receiver group;  
new T<sub>cold</sub> lookup table to be determined; new scheme of implementation  
of T<sub>cold</sub> lookup table is prepared. To be activated a.s.a.p.

- Always use the actual telescope positions to assign coordinates to the final data. It seemed that in some cases the commanded positions are being used. The tracking errors should be monitored by MIRA/MOPSIC for possible flagging (may already be the case).

see above: action items:

HU: As with the old CS, they use commanded position with the additional check that tracking errors are small.

TBD: need to document the details of the smooth transition trajectories; include numerical description of transition trajectories in trace data streams; and document the details of fast and slow trace data streams, including tracking error.

AP

- Reconsider the IMBFITS creation scheme to write the files while observing (as it was the case in the OCS) rather than after the subscan to avoid delays in the on-line data processing and user feedback. At least the envisioned solution of processing the data after each subscan needs to be implemented.

see above: action items:

TBD: discussion in Granada, then HU makes proposal.

AS prepared to generate IMBFITS after subscans, except WILMA and VESPA

More general aspects:

waiting for GP and AS to get high priority items done (see above).

- Consider standardized messaging technologies (e.,g., CORBA) to ensure longer-term support.

see above: action items:

- Make a plan for a midterm unification of the messaging system after having suppressed all OS9 systems. WB

WB: Done. The last OS/9 system has been taken out of operation in 2007-11.

All messages are now based on the software described in:

<https://mrt-lx1.iram.es/mainWiki/NcsMessages>

Further modification to base messages on “more standard schemes” like CORBA are currently not foreseen.

- Check the current messaging system load by comparing arrival times to the actual message time stamps (we have seen delays in the scan status GUI).

see above: action items:

WB: Done. Normally fast.

Occasional delays up to 1 second, but not causing problems.

(WB: delays in “scan status GUI”, i.e., antenna MD data stream viewer, have other reason.

TBD: de-couple from other tasks, i.e., ODP; cp. Review of monitoring)

- Reconsider the file based I/O via XML files compared to a direct (e. g., socket based) communication which is more flexible and does not depend on critical technologies such as NFS.
  - Note: XML is not used for high-volume data streams.
  - UDP is already used for data streams from VESPA, WILMA, and antenna mount drive.
  - Use of UDP for data streams from filterbanks, continuum backends, HERA, secondary control:  
To Be Done.
- Standardize the hardware (especially front-end and backend) interfaces to facilitate adding future instruments. This could be done on the XML scan description level, however, a lower level between VME computers and intermediate control systems would be better.
  - see above: action items:
  - WB: has been considered, currently no plans make changes in NCS.
  - HU: for the time being the standard for:
    - the description of setup parameters for hardware, in particular receivers and backends, is given by the “observations XML files”;
    - data streams: data-stream FITS files;
    - additional: sync messages; hardware signal for switching modes

- Measure and publish the technical observing efficiency as defined by the ratio of actual observing time on the targets (source and reference) over the total wall-clock time for a whole scan. This number will vary with observing modes and details of the setup (e. g., distance between source and reference) and should thus be categorized accordingly rather than quoting an overall single efficiency number.
- As a feedback for the NCS developers, this technical observing efficiency should be continuously monitored for all scans in order to detect possible degradations due to software changes.

HU: this has not yet received high priority.

We have overview statistics from the pools.

The NCS team has started to measure the technical observing efficiency under controlled conditions. Preliminary results are attached below.

The regular test runs of standard observing procedures provide a safeguard against degradations.

- Use the VNC (...) technology as a quick way to enable remote observing until a final setup including automatic data transfer will be established. Regarding VNC it is important to use a recent version (e.g. RealVNC  $\geq 4.1.1$ ) since older versions can slow down the host and/or the clients to a halt. The new versions are very efficient in compressing data and transmitting only changed content so that they could even be used via slow lines. When allowing remote access, IRAM should consider setting up a firewall or private NAT network plus ssh tunnel to protect the control system from intruders.

DONE for Granada and Grenoble. Minor details to be improved.

- Investigate whether the concept of a flexible subsystem based assignment of being the “master” can lead to race conditions (such conditions seem to have occurred in the early phases of deployment due to file system access problems).

Note: problems do not seem to be related to this point.

WB: In the NCS, the end of a subscan is defined by one of the control systems. This is mostly the antennaControlSystem (antCS), except for the case of calibrations, where it is the receiverControlSystem (rxCS). For each subscan, therefore one of the control systems takes the role of the “masterControlSystem” (masterCS) and other control systems can just wait for events from the masterCS without having to know which control system is currently the masterCS.

For related information, see:

<https://mrt-lx1.iram.es/mainWiki/NcsArchitecture>

- We encourage the development of Observatory level tools for
  - the assessment of the quality of the data obtained with the 30m telescope and
  - to set up the archiving policy for that data

WB: Documentation is at:

<https://mrt-lx1.iram.es/mainWiki/NcsDataDirectoryOrganization>

- The new monitoring capabilities of the NCS should be used to derive a data quality parameter that will be used for archive purposes. In addition to obvious parameters like the atmospheric water vapor content and system temperatures, one could, for example, monitor the pointing accuracy and the frequency of how often calibrations were performed.

For these points, also see the new project (Stephane Leon et al.) for a database of observations. **Ongoing.**

## “A la recherche du temps perdu”

“In Search of Lost Time”, also translated as:  
“Remembrance of Things Past”, i.e., the old CS

load:	previous “scanDone” to “loaded”
start:	“loaded” to “backOnTrack”: set /check status of subsystems go to source
newSubscan:	“subscanDone” to “backOnTrack” or “subscansStarted” position change in case of calibrate: mirror movement
finish:	last “subscanDone” to “scanDone” bookkeeping, file organization in case of calibrate: switch to sky

## Continuous, repeated execution from Queue

	load	start	nextSubscan	finish	total	"effTech"	
pointing, total power	1	10.4	2	2.3		0.80	
track, frequency switching	1.7	9.7			6	0.94	
onOff /reference 1800 1800	1.6	19.7		13	8.1	0.63 (0.44)	
onOff /reference 1800 1800 /sym	2	16.2	14.4	2	13.4	10	0.70 (0.52)
onOff /reference -1200 0	1	15.3		6.1	7.8	0.75 (0.58)	
onOff, wobbler switching -120	1	12.8		3	4.8	0.75 (0.56)	
OTF map -200 0 200 0 /ref -600 0	1	10.4	5	7	3.7	0.75	
Calibrate SAC	1.3	10.3	4.9	1.3	8.4	40.4	0.38

Notes: all times are averages and in [sec]

**effTech** := time (ON+REF) / time ("loaded" to "scanDone")  
 for OnOff, effTech are calculated for tSubscan 30 (15) sec

## Slews to source

Note: maximum slew speed                      0.5 deg /sec                      (full turn in 12 minutes)

Measured: (including accelerations)	az.:	240 deg	480+12 sec	0.46 deg/sec
	el.:	46 deg	92+19 sec	0.41 deg/sec
	el.:	46 deg	92+16 sec	0.43 deg/sec
	az.:	225 deg	450+16 sec	0.48 deg/sec

## Single submits to queue

	start	nextSubscan	finish	plot
Pointing, wobbler switching	31.8	2	2.3	16.8
Pointing, total power	34.8	2	2.7	18.6

plot: “scanDone” to “plot seen in browser”:  
make IMBFITS, MIRA, graphic conversion, display

Note 1: in this case, antenna mount drive is stopped between scans

Note 2: “plot” takes longer for target observations, depending on data amount

## How to find more time

Known items on list to be done:

- antenna mount drive “non-stop”
- faster display of most relevant information  
especially for pointing, focus, calibration, tip
- display of data after subscans

Investigate in more detail:

- long “finish”
- 10 sec minimum for “start”
- position changes / transition trajectories

Mid- to Long-term: more sophisticated observing modes, e. g.:

- on-the-fly TIP (is prepared!) & on-the-fly FOCUS (feasibility?)
- continuous OTF mapping
- more sophisticated “Symmetric” option
- observing blocks (sequences of scans executed together) etc.