VLBA Sensitivity Upgrade Memo no. 33

4-8 GHz C-Band Upgrade:
Preliminary Design Review for LO/IF and Monitor & Control.

http://www.vlba.nrao.edu/memos/sensi/

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2011 Jan 11

Introduction

The PDR was held in Socorro on 16 December 2010. William Brundage, Vivek Dhawan, Stan Kurtz and Richard Scott served as reviewers.

This memo incorporates the comments of the reviewers, collated and edited by V. Dhawan, additional comments by others during the PDR, and also the responses of the design team. The latter are shown in italics, with the initials of the responder.

The agenda was as follows:

Introduction	Walter Brisken
Description of overall Block Diagram	Jim Jackson
Down Converter design	Terry Cotter
Monitor and Control Configuration	Wayne Koski
Schedule Milestones	Steven Durand

Summary of Review

The scientific goal is well articulated in the MRI proposal: to access important spectral lines, and match the sweet spot in phase stability over 4-8 GHz, to the well-established astrometric and imaging power of the VLBA.

New wide C-band receivers are obviously needed, also the IF converter to allow two independently tunable blocks of 500 MHz per polarization. The addition of MIB-based M&C is a sensible way to modernize, rather than modifying the old VLBA system.

The focus of this PDR was intended to be the IF converter, and M&C aspects. Specific questions were:

-- Do any design decisions rule out scientifically compelling modes of operation?

-- Are there any design concerns? If so, what prototype testing should be done to alleviate these concerns?

-- Is there any negative impact on VLBA subsystems unrelated to this upgrade?

The individual components appear to pose little risk for NRAO, since they use recent EVLA developments. We believe the science potential is adequately enabled by the proposed design. Minor concerns, and recommendations to address them, are detailed below.

However, the new components need to be implanted and tested without undue disruption of science operations. The tight schedule raised some wider questions such as the logistics of antenna outfitting, and compatibility of the monitor & control with the current system during deployment. These more nebulous issues are itemized at the end, to be clarified as the project proceeds.

Detailed Comments & Responses.

1. Downconverter:

1.1. The design with 2 filters is well conceived and allows nearly any pair of observing frequencies to be placed in the IF passband without significant image incursion. We see no major flaw in the inability to cover the 3.9-4.4 GHz band in a single LO setting; nor in the cutoff above 7.9 GHz. Neither setup is critical for continuum, both are accessible for line work via other setups, and no important lines are known in these ranges. Anyway, satellite RFI from 3.7-4.2 GHz implies an avoidance of the low edge, except in special cases.

The two filter design will be implemented since it is the lowest cost with the restricted frequency range of 4.0-7.9GHz. TC.

1.2. Useable IF ranges for some LO settings depend critically on the filter specs, which may require special attention, and verification on the prototype.

Filter Specifications will be closely paid attention to with verification in the prototype. TC

1.3. Intermods: Analysis and testing of the prototype should include a sweep for unanticipated intermodulation products.

Plans are being made to examine all mixer products closely for possible intermodulation products. TC

1.4. RFI: Likewise, a sweep for undesired emission into other VLBA bands is also recommended (D. Mertely's 'echo chamber').

RFI from this module will be measured although interference with others bands is unlikely since no LO will be present to this module when other bands are being observed. TC

1.5. Flat passband: Isolators are recommended between the power divider outputs and the filter inputs, for good input VSWR across the filter skirts and stop band.

Matched out of band filters will be looked into and isolators will be used if necessary. TC

(Note: Matt Morgan at NRAO CDL, Charlottesville, has designed filters that absorb rather than reflect the out-of-band signals. These may not be ripe on the timescale needed here but it would not hurt to check.)

We will contact Matt Morgan and discuss filter designs after we look into commercial sources. SD

Low VSWR at both ends of the long RF and IF coaxial cables is necessary to minimize spectral ripples. Downconverter input and output VSWR of order 1.3 may be difficult to achieve, especially if the front panel IF ports are un-terminated. Could ripple be tested in the Socorro test rack?

Front panel ports are required to be terminated. Testing will be done where possible (probably in the test rack and at Pie Town) to understand and minimize any ripple. TC

1.6. Noise figure of downconverter: Assure by analysis & test that RF input attenuation will not raise the total system noise temperature, more than say 1%, while also providing headroom of order 44 dB (to take full advantage of the 8-bit samplers).

Analysis has been performed using currently selected parts verses current parts in the system. A significant improvement in system temperature was made and the headroom is at least as good as the proposed frontend. TC

1.7 Cross-channel isolation: Assure by analysis & test that combination of RF divider, isolator and/or amplifier and mixer/IF circuit provides adequate isolation to the adjacent channel of order -60dB. [0.1% fringe amplitude contamination - is this too tight?]

Analysis and testing will be performed to insure cross-channel isolation will be adequate. TC

2. Monitor & Control.

2.1. MIB M&C for T405 downconverter seems the right way to go.

I appreciate the confidence indicated with the above statement. WMK

2.2. New M401 with MIB for RF/IF switching seems advantageous and low risk. Likewise the modifications to L107 and M102. The M102 (M402) block diagram shows 5 unused analog ports available on the MUX 3. Does it make sense to add a MUX 4 for future use?

Yes and No. For the "No" aspect:
The M402 is limited by the number of capacitive feed-thru signal lines passing through the RFI barrier plate and thus to connect to a MUX 4 would require rework of the barrier plate and rear panel to add an additional AMP connector for the eight additional analog signals. WMK

For the "Yes" aspect:

First, the committee couldn't be aware of the following as I hadn't fleshed out the M401 design at the time of the PDR. Thus my answer reflects later thinking partly driven by comments made during the PDR.

I've brought out 5 direct connections to the Analog Board at the M401 module. This provides five additional analogs that can be measured directly. Or if the committee thinks, each of these lines could have analog multiplexers (8:1) connected to them for a total of 64 analog signals. A separate module could later be designed that does 64 analogs total which would include what the M402 does now. I believe that I've left additional room to expand analog measurement capacity, while not compromising our ability to carry out the VLBA C-Band Project by adding too much complexity. WMK

2.3. RFI: For the MIB-based controller, we believe there is little risk since the same system was designed for low emissions and has been well tested on the EVLA.

Given the fact that there will be fewer DB-50 cutouts and communication between modules is fiber, I believe that the M401 should show an improvement over the EVLA M301 module that is the base of its design. Regardless, the plan is to RFI test the M401 module. WMK

2.4. If reasonable, test prototype M&C operation, changeover process and compatibility with current M&C and VME computer in the VLBA test bed in Socorro.

This is already happening for the sensitivity upgrade equipment at the sites. We should endeavor to maintain VLB1 as an accurate model for the VLBA antenna electronics. However, testing can be done either at antennas or in the lab and the type of test coupled with other factors should determine where tests are actually performed. WB

2.5. M&C schedule: It would be useful to have an explicit plan for the required software, and clarify which aspects of the M&C are:

* Essential for prototyping (April 2011)

MIB software will need to be in place for prototyped modules. The test rack should send monitor data to the monitor database. Tools for mining this are likely to be of immediate utility. WB

* Convenient during installation (July 2011?)

* Desirable for full operation (early-mid 2012?)

An operator screen (or set of screens) that summarizes monitor points for the new equipment would be good. WB

The GUI used for the VLBA sensitivity project development can be enhanced to display desired status information from the new components. WB

One of the milestones (e.g. mid June 2011) could be the deployment at the PT antenna, with a documented procedure for installation at later sites.

We will add "write installation procedure" to the task list. SD

3. Receiver Schedule:

3.1. Receiver upgrades: C-band amplifier delivery from CDL meets the schedule. Re-use of the current C-band Dewar is a significant saving. However, it seems ambitious to complete prototyping, rework and installation on 10 antennas in ~18 months in light of the following.

This entire project must be done on a best-effort basis with the knowledge that other projects have higher priorities on conflicting resources. The plan is ambitious and success driven. It is clearly in the best interest of the array to see this upgrade to completion in a timely fashion. WB

3.2. Competition with EVLA needs for test equipment and personnel.

See above

3.3. The proposed work on several antennas in parallel should be reconciled with the approved observing proposals at C band (via the scheduling committee).

The call for proposals will contain a statement to proposers that they will need to provide increased justification for a full array of 5 GHz receivers during this upgrade period. There should be enough information available to the schedulers to advise the installation schedule. WB

3.4. These tradeoffs can be assessed by a quantitative argument as to how much the schedule can benefit by the removal of 2 or more old C-band receivers.

See above

4. Miscellaneous system & operations questions.

We realized after the presentations that some of these issues are discussed in VLBA sensitivity upgrade memo #27 by Gareth Hunt, but priorities and timelines need to be added.

4.1. There was mention of cases where the VME system could hang while awaiting response from disconnected (upgraded) modules. Are such issues expected to be minor?

Prompt testing is required to understand the consequences. These issues are expected to be minor with several possible workarounds, the least appealing being making changes to the VME software. WB

4.2. (We were told) the MK5C recorder and RDBE digital backend are under MIB control, and scheduled via a translator (vex2script). Are significant enhancements are needed to SCHED/vex2script for the new C band?

No fundamental changes to SCHED beyond those already being made for the RDBE and mark5C are thought to be needed; only updates to the catalogs that describe frequency settings are likely required. Vex2script is not likely to need any updates as it was designed with this functionality in mind. The executor is where most software changes will be needed. Specifically, the executor will need to set band select switches based on the LO/IF configuration. This is mostly straight forward, effectively mapping the switch topology to software. WB

4.3. Have the new digitizers been checked for RFI? (We realize these are in the RDBE module in the station building, not on the antenna like the EVLA, but do we know their emission levels?)

While this is a bit out of the scope of this PDR, it is a reasonable question that should be addressed. The RDBEs will be housed in an RF tight rack, inside the building. We will retest the RDBE and digitizers for unshielded emissions and recalculate the expected levels in the vertex room. SD

4.4. Is there need for a new Linux site computer in parallel with the VME?

Yes, but this is being installed as part of the VLBA Sensitivity Enhancement Project. This computer will ultimately obsolete the VME, but not in the immediate future. WB

4.5. Any additional software for the use of 2 M&C systems for operations: e.g. Monitor data, alerts, maintenance, & observer logs.

No new software will be needed for the VME-based M&C system, with the possible exception of excluding from the checker screen certain error conditions that will no longer make sense. I defer to Matthias to answer for the new system. WB

4.6. We like the plan to keep some BBC's for TSYS and pointing, which are important for testing without real-time fringes.

This is probably unavoidable until the ACU is converted to the new M&C system. WB