

Summary Report / EVLA FE PDR

This report is a summary of the findings of the EVLA FE PDR Review Panel and the responses by the Task Leader. The report is based on a top level presentation of the design plans conducted on February 12 and 13 at Socorro. The purpose of the review was to answer 3 principal questions:

1. Are the top level performance requirements complete and adequate?
2. Have the correct design solutions been selected for study and development during the EVLA design phase: Are there important alternate solutions that are not being studied?
3. Has an adequate procurement plan been identified for the subsystem?

Members of the Review Panel attending were the following:

German Cortes, NAIC
Eugene Lauria, CDL
Roger Norrod, GBT
Bruce Veidt , HIA
Peter Napier, Project Manager
Rick Perley, Project Scientist
Jim Jackson, Hardware Systems Engineer
Gareth Hunt, Software Systems Engineer
Terry Cotter, LO/IF Task Leader
Paul Lilie, Receivers/Feeds Task Leader
Bill Sahr, Monitor and Control Task Leader
Jim Ruff, Antenna Task Leader

OMTs

The single greatest concern expressed about OMTs was over band edge degradation and other performance issues with the planned 2:1 bandwidth ratio. In response, the Task Leader reports three lines of attack: 1) The short quad-ridge OMT (Lilie), 2) A completely symmetric OMT (CV), and 3) Scaling and optimizing the ridge profile for the traditional QR OMT, as the Australians have done (fallback)

The BW ratio causes waveguide in the receivers to be used close to cutoff frequency where the waveguide resistance will go up which in turn will cause higher receiver temperatures. However, the length of such waveguide is very short. The loss in the quad-ridge OMT will be the largest component, and this should be less than 0.1 dB. Furthermore, the OMT will be cooled. Raising the lower band-edge further above cutoff is unacceptable because doing so would allow more propagating modes at the high end of the band.

Trapped or unwanted modes may occur in the OMT because of discontinuities at the transition to the feed. The resulting resonances will cause nulls or "suckouts" across the band. Making the OMT longer will make the suckouts smaller, but there may be more of them. In circular waveguide, the TM₀₁ cutoff occurs at 1.31 times the cutoff of the dominant TE₁₁ modes. Therefore, any bandwidth above 1.31:1 will involve multiple modes. In the quad-ridge structure, some of these modes may be trapped, that is, able to propagate in the quad-ridge section, but cut off near where the ridges end. At those frequencies where the length of the propagating region is a multiple of a half-wavelength, a high-Q resonance will be possible. If there is coupling from the desired TE₁₁ modes to these trapped modes, a suck-out will occur. These may be unavoidable. The CV group's OMT design reportedly assumes this intermode coupling is due to discontinuities and asymmetries in the OMT, and aims to avoid them.

The (first order) chain of defense for the trapped mode performance concern is thus:

- a. The size of the subreflector drives the size of the feeds.
- b. The size of the feed circle then determines the number of feeds which can be accommodated, dominated by the size of the L, S, and C band feeds.

(We can't afford to replace the subreflector and/or move the feed circle.)

- c. The desired frequency range, divided by the number of feeds, gives the frequency range that each feed (and front end) must cover.
- d. The only type of OMT we believe capable of covering this range (2:1) is the quad-ridge design.
 - d1. An undesirable feature of this design may be the presence of several very narrow "suck-outs", of the order of 1.5 dB deep and 1 MHz wide.
 - d2. These suck-outs will be at known frequencies, which will probably differ by a few MHz from antenna to antenna.
 - d3. It may be possible to tailor the location of these suck-outs somewhat to avoid sensitive regions of the spectrum.
- f. Alternative OMTs (~1.5:1 maximum frequency range) would require abandonment of ~40% of the spectrum below X-band.

In response to concern about port-to-port isolation of the feeds and polarization stability, isolation will be maximized to the extent that it does not degrade performance. Again, this may be dominated by OMT performance. Stability should be dependent only on the dimensions of metal structures and so quite stable. Also, insertion loss will be minimized to the extent practicable.

A reviewer commented that ATNF inserts its couplers in the feeds. EVLA plans to use the couplers after the feeds because earlier insertion introduces an asymmetry in the feed which can influence cross-polarization performance, etc. Additionally, the use of individual couplers is of use in the solar observing mode.

Feed circle

There was concern that the proximity of the high frequency feeds to the large L and S band feeds may cause shadowing. "Detailed calculations need to be made to confirm that the significant axial defocusing of the L and S band feeds and the lateral translation of the L band feed do not cause unacceptable loss of performance." Also, ray tracing should confirm that the upper part of the receiver cabin does not occlude the beam. The design team are making the requested calculations to verify the design.

Head room, RFI

One reviewer pointed out a curiosity that L-band FAA radar causes receiver saturation at GBT and filters had to be installed. Why doesn't the comparable radars in Albuquerque at 1310 and 1330 MHz cause saturation of the VLA? The difference may be because of reflections by surrounding elevations at GB, but in any case, the design team is surveying RFI levels at the VLA and "headroom" is planned for throughout the signal chain design. Known RFI levels will be propagated through the L-band design to look for nonlinearities.

The design will be reviewed to look for RFI intermods. RFI shielding of the feed cone segments will be considered. The strategy after the 1st stage will be to avoid RFI.

Special filters will no doubt be needed, but we don't know enough about the RFI environment and observers' needs to specify them at this stage. The design will provide for later inclusion. Cooled filters are awkward in some ways, especially if they must be switched in and out. But they also have advantages--improved performance, temperature stability, and avoidance of long, lossy transmission lines.

We need to specify the signal level below which intermods are acceptable.

Block Mixers

The proposal to reduce cost for the upper frequencies through use of block mixers as proposed by Bob Hayward is now part of the plan.

Dewar windows

The design team is currently looking for dewar window material that will hold a vacuum and have a suitably low dielectric constant.

Isolators

An alternative to isolators may be necessary at S-band.

MMICs

LNA and pre-amp designs are being closely coordinated with CDL. Bob Hayward is investigating the use of MMICs with CDL and Sander Weinreb.

M&C

The design team agrees with the reviewers' recommendations to keep the design simple and straight forward. Data transmission from the Front Ends to the MIB will be by means of the SPI bus which will be clocked only during data transfers. Also, the design team is considering a regularly scheduled Blank Time period to perform functions such as turning noise diodes on and off.

Feeds

Data for the S-band feed will be developed across the band. Performance of the L-band feed will be made more uniform across the band. Feed mounting designs will be reviewed for RFI and weather tightness.

Reducing debris from feed heaters will be evaluated, but heating windows by conduction is not considered to be practical.

Verifying orthogonality and ellipticity with an array are best done through astronomical observations, so no additional calibration is planned.

Requirements

The overall bandpass ripple and flatness requirements have been divided between subsystems and the information added to the Project Book.

Procurement

The 65" L-band feed is needed for the test antenna, so

that the procurement cycle must begin soon. Build versus buy will be decided on a case-by-case basis.

Receivers

Combining high frequency receivers in a single dewar will not be considered because the change would save less than 2% of the feed circle space and require a complete redesign of Q-band.

Careful attention is planned for shielding and isolation of 28 GHz LO at Ku-band. Shielding 12 - 18 GHz from the 14 GHz fundamental will also require careful attention.

Cal values should be reasonably uniform. However, the expense of an adjustable attenuator would not be justified. It could make the cal values identical at one frequency, but there would still be individual idiosyncracies (including a contribution from the attenuator) making the values differ at other frequencies. It must be noted that the wide bandwidth of these receivers will require that frequency-dependent cals will have to be measured and applied.

LNA concerns, such as InP vs GaAs and splitting stages, will be addressed by CDL.

Solar design

To provide for solar observations, step attenuators will be available to switch in under system control. The recovery from saturation will be fast compared with slew times.

The max solar flare value should be 10,000 SFU, not 100,000. With input at the 100,000 level, the LNAs would be driven well into compression, so that an attenuator following the LNAs would not be sufficient to allow solar observing.

WVR

Defending a decision to build the WVRs is not part of this PDR. The EVLA involvement is simply not to preclude use of the WVRs. The M&C design provides an adequate data rate for the WVRs.

For the panel,

Clint