Report: EVLA LO / IF Design Review

This report on the responses to the findings of the EVLA LO/IF PDR Review Panel is based on a top level presentation of the design plans conducted on January 22 and 23 at Socorro. Once approved, this report will be consolidated into an issues summary. 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:
Dick Thompson, NRAO CDL
Bill Brundage, NRAO ALMA Project
Rob Long, NRAO ALMA Project
Rick Perley, Project Scientist
Jim Jackson, Hardware Systems Engineer
Gareth Hunt, Software Systems Engineer
Brent Carlson, Correlator Task Leader
Terry Cotter, LO/IF Task Leader
Steve Durand, Fiber Optics Task Leader
Paul Lilie, Receivers/Feeds Task Leader
Bill Sahr, Monitor and Control Task Leader

The Review report is divided into five parts: I) Comments from the Panel Review, II) Comments during the open meeting presentation, III) Questionnair inputs, IV) Conclusions, and V) Addendum letters. Responses to the Panel Report are designated with a bullet (·).

Part I. Comments from the Panel Review

Conduct a study of limitations in the frequency coverage for both the transition phase and the final design. Consider improvements in tunability of the LO synthesizers.

· We are changing the design of both the 1st and 2nd LO. This design will eliminate all frequency coverage issues.

Consider additional alternatives to the method of round trip phase measurement.

· Alternative designs are currently under review for Round Trip Phase measurement.

Firm up specifications in several areas; such as, round trip phase, bandpath flatness (slope and ripple), polarization isolation, bandedges, phase change, image suppression, goals for suppressing internal radiation, interface to front ends, and interfaces among preconverter and IF converter modules.

· Agreed. Specifications are weak and are under going review.

Improve allocation of system specification to subsystems.

· Done. System engineering has allocated the system specifications.

Present more convincing argument for PCAL or remove.

· PCAL has been removed.

Does the transition filter provide adequate dynamic range for DME RFI (1.1 GHz) or is more attenuation required?

· This is not an issue for the transition converter. The transition converter drives the old correlator which has 3 level digitizers.

What improvements are required for the existing B-rack RFI screen?

· We are looking into the B-rack shield and will make improvements as required.

Improve the definition of MIB requirements; such as, for total power, control of LO offsets.

· MIB requirements are being developed. Will work with the DCS group on defining requirements.

Define schedule and manpower requirements more specifically.

· Agreed. Will define the schedule and manpower requirements.

What impact will the loss of "data invalid" have on timing?

· No impact is expected since a flag is being included in the digital data.

Would using an integral number of fringe cycles in the correlator improve RFI mitigation? Brent Carlson notes that if this really *is* a requirement of the correlator, we should find out very soon because it could have a significant impact on the design. His preference would be to dump the correlator rapidly, and do integration on an integral number of fringe cycles in software in the correlator backend. Of course, doing it this way would only have an integration time resolution of the dump time out of the correlator hardware.
This may not be a problem, since this method would probably only be used when the fringe rate is relatively low anyway.

· To be addressed in the software.

Part II. Comments during the open meeting review presentation.

A. System Requirements

-- Measuring fractional dB over a narrow bandwidth may not prove practical; it may be necessary to specify flatness in dB increments over a wider bandwidth.

· Agreed. Measuring fractional dB ripple over very narrow bandwidths is not practical. We should be able to measure the ripple over larger bandwidths with no problem.

-- Need a single LO for opposite polarizations to insure that frequency pairs are tightly locked in phase.

· Agreed. There was an error in the block diagram.

-- 3 dB flatness across band acceptable; 5 dB would be a problem. Also, need SNR specification at bandedges.

· 3 dB will be the flatness specification for the system. We will allow for some degradation at the bandedges.

-- Phase specification should be in change in picoseconds, not just in absolute terms.

· Agreed. Will be included in the project book.

-- What impact does introduction of large signal input such as thermal noise and 10 J sources have on stability levels?

· We do not believe large signal levels will effect stability unless the system goes nonlinear.

-- Should there be uniformity in multipin connector sizes?

· Yes. System engineering should specify "standard" sizes.

-- Need better specification for suppression of images that may result from frequency converters. Brent Carlson points out that if frequency converter images show up in the band after the LO offset/frequency shift, then they wash out rapidly in the correlator since they have opposite frequency sense to the in-band signal of interest. Could this knowledge be used to relax the image suppression specifications, and thus save money? (Although, images would still show up in the phased output, but they would not add coherently.)

· Agreed. Images are not expected to be an issue due to high side injection of the LOs. But the specifications should reflect the required levels.

-- Ripple specification needs clarification to cover the entire front end band and IF bandpass. Short cables runs will help reduce ripple. Need to divide up system wide specification between subsystems. Define ripple, flatness, and slope as maximum peak-to-peak variation per a given bandwidth.

· Agreed. Systems engineering has divided up the top level specifications. These specifications will appear in the project book.

-- Frontend/IF interface *range* of total power and *spectral power* must be specified.

· Agreed. These specifications will appear in the project book.

B. Preconverter modules

-- There appears to be a conflict between interface spectral power specifications for preconverter modules, 62 dBm/Ghz vs 35 dBm/2 Mhz, and there may be less headroom as a result. What headroom is required and what provided for 74 MHz, 327 MHz, L band?

· Discussions with Dan Mertley, Paul Lilie, Bob Hayward, etc. yielded no firm answer on how to handle the narrow band 4- and P-Band front ends, except to express them also in dBm/GHz yielding the -62dBm/GHz spec cited at the PDR. This reviewer (Cotter) believes expressing narrow-band power in this fashion was erroneous and misleading, and the powers from these receivers should have been expressed as:

4-Band (74MHz): -35dBm/2MHz
P-Band (327MHz): -35dBm/50MHz*
L-Band (1-2GHz): -46dBm/1GHz (compatible with dBm/GHz wideband convention)

*However, all VLA documentation shows the P-band pre-mixer levels to be about -45 to -52dBm/50MHz IF.

The MiniCircuits GALI amplifiers selected have a P1dB of about +18dBm.
This yields a gain headroom of:
For Pin = -35dBm, headroom = 53dB
For Pin = -45dBm, headroom = 63dB

Therefore, the discrepancy in P-Band receiver output power needs clarification in order to properly characterize the dynamic range and headroom in the 4/P-Band Converter. Input attenuation prior to the amplifiers can extend the headroom if the contribution to the system noise/SNR is acceptable.
L-Band meets the 60dB headroom spec.

-- Goals and specifications need some sorting out for preconverter modules, and, for that matter, throughout the project.

· Specifications are being addressed in the project book.

-- There may be some confusion between spectral power and total power. What power levels are important and where in the subsystems modules should the levels be monitored?
· The confusion between spectral power and total power exists only with the 4/P Band Converter, which has been addressed above.

L-Band and above, with 1-4GHz bandwidths, are measured and expressed as total power per GHz. 4/P-Band, a fraction of the 1-4GHz IF bandwidth, is narrow-band/spectral power from the correlator point-of-view. Cotter believes total power should be monitored in the L/S/C Band converter, which would also include the 4/P Band powers, and in the Ku-Band Converter. This would serve well for remote diagnostics in isolating problems occurring between the receivers and the Down Converters, and in checking for gain compression due to RFI.

-- One-half the system specification is used in the converter.

· Correct, one half of the system spec is reserved for the front end and one half is reserved for the IF converter combinations.

-- The 74 MHz specification for flatness and bandwidth needs to be
resolved with the system specification.

· Agreed. This specification needs resolution.

-- Does the preconverter design provide for more bandwidth later at 4 and P bands?

· Yes. The development of the IF bandwidth with a combination of low-pass and high-pass filters is currently designed for an IF passband of 1090-1400 MHz, encompassing the RF spectrum from 66 to 376 MHz. Thus, 4- and P- Bands can be observed simultaneously, and their respective bandwidths could be expanded considerably.
The resulting L-Band IF could also be expanded right up to 2GHz (from 1.4GHz), if needed, for a future receiver in the 400-970 MHz range, by simply changing the low-pass filters within the converters (about $150 each, or $600 per converter).

However, it would be problematic to lower the IF much below 1090MHz, corresponding to an RF frequency below 66 MHz, due to the 1024MHz LO.

Additionally, the 400-1000 MHz range receiver could be implemented via a separate, dedicated converter in the future. Components at L-band are relatively inexpensive.

-- What about solar attenuation?

· Since the solar attenuators for 4/P-Band exist on the VLA now (external to receivers), they should be a part of the EVLA baseline plan and will be included in the 4/P-band converter.

-- Is the prime focus systems design compatible with Phase II?

· Yes.

-- If P band is to go from 300 MHz to 1 GHz, the 1 GHz LO needs to be changed.

· Yes. With the current 1024MHz LO scheme, the maximum bandwidth of P-band would be limited to 300 to 976 MHz, and image products could result.

-- Need reject filters for LO in L band?

· The L-Band LO is 13GHz, which appears to present no threat to the L-Band RF or the resulting 11-12GHz IF. The 1024MHz LO is used to convert 4/P-Band to L-Band, and and could leak into the L-Band Converter via the IF's. We have provided for adding additional coaxial LO reject filters in the 4/P-Band Converter IF outputs, and/or adding 1024MHz LO reject filters in the L-Band Converter, if necessary. We may use a switch/relay in the 4/P-Band Converter to disconnect the 1024MHz LO from the mixers (terminate them into a resistive load) when this preconverter is not in use to further isolate leakage power. On the other hand, the IF's from the 4/P converter will be terminated by the L/S/C Band Converter selector switches, offering another level of isolation when the 4/P-Band Converter is not in use.

Since the 1024MHz fixed LO is being generated independently from the 1st LO Synthesizer, fairly good isolation should exist between these two LO sources.

These actions will be evaluated when the prototypes have been built and bench integration begins.
-- Frequency changes should be limited to 2:1; 4:1 too much at one time.

· We are studying the effects of large frequency changes within the system.

-- What is specification on image rejection?

· Current system specification is -25 dBc and we intended to specify it at -30 dBc.

-- Will 2-stage filtering be necessary for 2 MHz correlator subband?
What kind of filter will be used?

· 2-stage filtering will be required for a 2 MHz sub-band. Both stages will be FIR filters with (hopefully) ~1000 taps each. The data will be requantized to 4 bits after the first stage, before going into the second stage. FIRs are linear-phase filters with configurable bandpass characteristics.

-- Are harmonic images a problem?

· Not currently known; all images will be required to meet the specification.

-- A leakage between polarizers of 1/100% is equivalent to 80 dB of isolation. 70 dB isolation acceptable; 60 dB marginal. How is the isolation specification parsed to splitter and mixer? Are isolators needed on LO lines? Polarization (signal) leakage between IF channels and LO leakage between If channels must be specified.

· Our current design goals are 80 dB of isolation. Our specification will be 70 dB Min.

-- Can new receiver design obviate need for transition module?

· The above scheme has been drastically changed by the proposal to down-convert all the high band receivers to Ku-band, then to X-band by the Ku- band converter. This implies the Ku-band converter would not just be a transition converter, but a permanent fixture.

-- How will A rack and other equipment be supported once ceiling is removed for new feed cone structure?

· This item is under review by the Antennas group.

-- Flatness needs to be specified per GHz. Specification of 1 dB per 200 MHz does not extrapolate well to 2 GHz. (See definition above.)

· Agreed. The specification will be reworked.

-- Are isolators needed on LO lines? Polarization (signal) leakage between IF channels and LO leakage between IF channels must be specified.

· The system specifications for cross polarization isolation is 70dB acceptable, 80dB goal, see earlier comment. This establishes 70dB or better as the specification for IF-IF isolation. For LO leakage specs, 60dB LO isolation would be sufficient for the Correlator system. In summary,

IF-IF Isolation: 70dB or better
LO Isolation: 60dB or better

The LO used in each converter passes through a power splitter, a high isolation amplifier, and another power splitter for driving the mixers. The isolation offered by these three major components is at least 20dB each, or about 60dB total. The RF-LO isolation would be about 80dB, due to the added mixer isolation.

-- What does sampler see with 4 band and P band signals? Is enough power provided for sampler to work right? What is the specification for power input requirements to the sampler?

· 1 V peak-to-peak (about 0dBm) input to the samplers is required and will be provided.

-- Gain ratios must be "within reason" (1:4?). Spectral density ratios should be < 1:10.

· Not a problem; the correlator should be able to handle the narrow band signals.

-- May need two different specifications for peak-to-peak power over over the band, one for narrow band and one for wide band.

· Agreed. The narrow band specs need to be different from how the wide band system specs are presented. As stated above, the narrow band performance is primarily developed in the receivers,

while contribution to the wide-band specs will be shared by the
receivers,
preconverters, down converters, and the interconnecting cabling.

-- What are MIB requirements, control and status? How many distributed non-linear threshold detectors are necessary for finding non-linearity?

· MIB requirements are being developed. Will work with the M&C Task Group on defining requirements. The number of distributed non-linear threshold detectors required has not been determined. This will be roughly equal to the number of band-reducing filters in the path.

C. Band switches

-- VSWRs seem high. Need to define rack locations to determine signal line lengths.

· VSWRs are reasonable considering the frequencies involved. Isolators are being provided on the inputs and outputs of modules to reduce inducing ripple. Rack locations are under review and we will try to locate them as close to the high frequency front ends as possible.

-- Why are VSWR and isolation different for different frequencies?

· Degradation at higher frequencies is a problem with all electrical components. As the frequency increases dimensions decrease and tolerances have to be tighter. VSWR and isolation are just two parameters that are affected by an increase in frequency.

-- Are attenuators necessary to address performance differences if interface TP and SP specs are not adequate or tolerance (range) not achieved?

· Attenuators may be required if TP specs cannot be achieved across the wide range of front ends. Given the limited number of COTS amplifiers available at the higher frequencies it maybe necessary to use attenuators to equalize the TP going in to the converters from the various front ends.

-- Isolation of 60 dB may be enough but must be very stable with time, temperature, elevation. Isolation varying 5% over 1 hour unacceptable.

· Agreed. Care will be taken to pick parts that are stable.

-- What are the MIB requirements for the switches?

· MIB requirements are being developed. Will work with the M&C Task Group on defining requirements.

-- Are the switch updates adequate or is failsafe or latching needed?

· For the band switches, the transfer switches, and the LO switches, switch updates should be adequate. Power levels to the various front ends or from the various front ends will not cause damage with these switches. There may, however, need to be fail safe switches within some of the modules to eliminate possibilities of damage.

-- Are there any problems with isolation and band flatness with transfer switch?

· There are no problems with flatness but there is a problem with isolation and the spec will be changed.

D. Baseband Converters

-- What phase jumps can be anticipated with switching attenuators? What is the specification for phase jumps? Do we need a different type of attenuator for tighter control over phase jumps? Typically, 1 dB change of attenuation causes ~1 degree change in phase.

· Digital variable attenuators which are switched during observing are anticipated to introduce +/- 5 deg of phase error up to 20 dB of attenuation and +/- 10 deg of error up to 32 dB of attenuation. Basically, the LSB and low dB bits cause less phase jump than the MSB (16 dB). If the attenuator is used closed loop where switching would occur automatically, the phase error introduced by the attenuator would exceed the error budget available to the attenuators. However, the attenuator will be used open loop in normal observing where no switching occurs and, therefore, no phase error will be introduced by attenuator switching. There may be special cases such as solar observing or observing with intensive RFI where closed loop operation is required, so we will lookout for attenuators with less switch-induced phase error.

-- Use same total power detector as ALMA?

· Yes, The baseline plan is the use the ALMA power detector, but we require continuous ALC and we may not require as many bits.

-- Total power detection over 8 - 12 GHz good idea to have diagnostic information for techs independent of correlator.

· Agreed

-- What granularity is required for attenuation. Don't need fractional dB, but why not if cost the same. What is penalty in S/N for total attenuation? Attenuator must be monotonic.

· Required granularity unknown but fractional dB is available.
LSB's can be idle. S/N penalty is ~15 dB when 32 dB of attenuation is switched in.
Monotonicity is guaranteed by the attenuator vendor.

-- Does the ALC hold a constant voltage for the input to the sampler? What happens in the presence of sudden RFI? Will spacing "go haywire" if ALC suddenly changes by 20 dB?

· ALC to hold constant voltage and equalize among the 4 downconverters. Spacing question will be addressed during testing. This item is under further study.

-- Need to find reasonable software vs. analog feedback control modes for attenuators.

· Agreed. This is a software problem.

-- Should we drop the 2 GHz converter and use 1 GHz only to limit bandwidth of correlator? At 1 GHz, any band can be connected to 8-bit sampler. Or should we keep 4 Gsps sampling? Restated, is 1 GHz sampled bandwidth at 8 bits adequate for all observing or is 2 GHz sampled bandwidth at 3 bits necessary? What total bandwidth per polarization is really required? Brent Carlson reminds that currently, no 8-bit samplers with a 4 GHz input bandwidth, operating at 4 Gs/s are commercially available.

· We are sticking with the baseline plan.

-- What are MIB requirements for down converter and total power detectors?

· Monitor: amplifier biases and switch/amplifier states.
Control: switching, total power detector digitization (4x/module), servo attenuators via loop with total power detector (4x/module, 3x in use at any one time, 4 downconverter modules servoed together for equal output).

-- Are there antenna beam problems with observing at 2 bands at once? (Question assumes the use of dichroics which are not part of design other than not excluding the future addition of dichroics where possible.)

· We have no plans for multiple band observing except for 4 and P band where dichroics are unnecessary. E. Samplers

-- 100 w dissipation per module seems a lot; has cooling been adequately provided for, especially considering need for tight RFI suppression?

· 100w dissipation is a worst possible case. The module design distributes dissipation throughout the module and provides for adequate air flow for this amount of power. The actual dissipation is likely to be closer to 50w.

-- How do we provide for RFI testing when French prototype not scheduled until the end of '02?

· RFI testing can be done on the parts of the design we have available.

-- Provide a test tone or PCAL for diagnostic testing.

· The baseline plan does not provide PCAL.

-- What requirements for MIB?

· MIB requirements are being developed. Will work with the M&C Task Group on defining requirements.

F. Transition Converter

-- Don't build all 108 at once. Build a few as required; may not need to build them all.

· The hardware is identically the DTS receiver module, so we have to build them all anyway, unless we have to expand to a host board. However, the plan for the whole project is to build everything incrementally.

-- What are MIB requirements?

· MIB requirements are being developed. Will work with the M&C Task Group on defining requirements.

-- Use 1/2 filter to set band edge and reduce costs.

· Agreed

-- What are RFI SSNR and headroom concerns?

· We are providing ALC in the system which should address these concerns.

G. DDS

-- Need to settle on name, DDS, FTS, or Fringe Generator.

· Cotter's preference is DDS.

-- Frequency offsets must be stable with respect to time.

· The design guarantees that frequency offsets as stable as the hydrogen maser with respect to time.

H. Central Reference Generator

-- In response to questions about dump timing, Brent Carlson reports that the correlator dump time can be anything since it can be locked to a pulsar (for example), but when not doing pulsars, we would probably normally dump on timebase boundaries (10 msec...) The 10.24 ms came up if we wanted to integrate for an integer number of frequency offset cycles to hit a null in the fringe washing sinc function, though such timing does not take into account the natural fringe rate and so may not be useful. Note transition timing is dominated by the waveguide cycle, 52.083 ms (19.2 Hz).

· We will investigate if there are requirements for 10.24 mstiming.

-- Have fringe rates, phase rotation been adequately provided for?

· Yes, we are providing for fringe rates and phase rotation that exceed the requirements.

-- Would integral reference generator cycles be helpful in the correlator integration time?

· To be of any use, it would have to also be an integral number of fringe cycles which is a function of baseline and time, so no.

-- Need hard specifications for peak-to-peak phase variations.

· Agreed. These specifications are supplied in the Science chapter of the project book and need to translated into engineering requirements.

-- Is there a need for time-of-day at the antenna?

· Yes, it will be provided.

-- Will the IAT clock be replaced as part of the EVLA?

· The current IAT clock falls under the responsibility of the monitor and control group and is used for synchronizing the online system to the "time of day". LO/IF will provide any timing signals required by the new online system.

-- Brent Carlton needs 128 MHz and 1 PPS (UTC, IAT, or GPS?) for correlator.

· We will plan for providing the correlator with 128MHz and 1 PPS and will work with Brent to provide the proper levels.

-- What are requirements for MIB: power monitor, voltage from VXCO, monitor points on PLL, digitally-controlled amplitude?

· MIB requirements are being developed. Will work with the M&C Task Group on defining requirements.

-- VLBI formatter needs 1 pulse every 10 seconds.

· We will provide the required timing for the formatter.

-- Adequate provisions for NM array?

· We plan to provide adequate spare frequency ports that can be expanded for the NM array.

I. Antenna Reference System

-- Is PCAL in budget? Need a stronger justification and plan before PCAL can be considered part of the project.

· PCAL is not part of the baseline plan.

-- What are RFI concerns introduced by comb generators?

· The comb generators are being changed to harmonic mixers within the module to reduce RFI concerns. We believe that we can apply the tuning offsets to the harmonic mixer further reducing RFI concerns.

-- Need to test shielding afforded by antenna.

· Agreed. In order to fully understand the RFI requirements, the antenna shielding needs to be tested.

-- Need to watch out for RFI leaks in and out of bias lines.

· We will use filters for bias lines and test all modules for RFI problems.

-- What are MIB requirements?

· MIB requirements are being developed. Will work with the M&C Task Group on defining requirements.

-- Are all requirements for master timing defined, such as phase ambiguities?

· The requirements for master timing are still under review.

Frequencies will not be divided at the antenna because the continuous re-setting of the dividers would cause blanking of references through the duration of the re-set pulse. As a result of this change, a clean-up loop will be required for the 128 MHz at the antenna.

-- Do we need to change the period of the reference for special transition requirements? Maybe modulate 128 MHz?

· No.

-- Need to define goals for RFI suppression and plan tests to measure compliance.

· Agreed

-- Have you taken adequate advantage of ALMA design?

If we can keep the antenna timing signals to a minimum, we will consider using the ALMA design (although we are still studying it). The ALMA design, as we see it, will require a PLL for each timing signal sent to the antenna.

J. First and second LO System

-- Need RFI protection so that radiation does not exceed harmful levels as we have now with F3 module. Limiting amplifiers to potect from burnout on excessive power?

· Will design to power up at decreased output power.

-- Tuning range is too limited, perhaps because of filter in PLL feed back loop. Need to define frequency coverage, and make sure important frequencies like H1 are covered. Want continuous coverage 1420 - 1250 MHz.

· Examining design to accommodate 1 MHz steps in 1st and 2nd LO.

-- Replace TBDs with real numbers.

· Agreed.

-- SRAM memory should be replaced with memory that survives power outage.

· Agreed.

-- MIB requirements: calibration info, etc.

· MIB requirements are being developed. Will work with the M&C Task Group on defining requirements.

-- Need to disconnect output while switching or install limiter?

· Will design to power up at decreased output power.

-- Have you considered generating all frequencies at CB and bring to antenna separately to avoid use of comb generators at antennas? Combs can cause RFI problems when distributed around the antenna on coax cables.

· Doing so would be more costly.

-- Use separate LO for each antenna to facilitate subarrays?

· Doing so would be more costly.

-- Are more clean up loops necessary to reduce degradation of phase noise in fiber?

· This is under study.

-- Define the number of ways to get to any given sky frequency.

· Agreed. The tuning specifications need to be documented for operations.

-- What is phase stability vs temperature of step recovery diodes and comb generators?

· Harmonic mixers are inherently more stable because they are all on one die. Re-design does not use comb generator. Will measure stability.

-- Need to filter output of comb generators, measure leakage from connectors, define requirements for RFI suppression.

· Agreed

-- Improve B rack shield?

· The B-rack shield needs improvement. We are working on plans to measure it and make improvements.

-- Use conductive paint, torque wrenches on connectors to reduce leakage?

· Agreed.

-- What are provisions for detecting when a diode goes bad and isolation is lost?

· This item concerns the converter modules. We will not be able to tell if a single diode goes bad from the monitor data. We will have to rely on data from experiments.

-- Are more isolators needed on C band converter?

· This item concerns the converter modules. We are establishing new isolation specs. If more isolators are required then we will use them.

-- What about band overlaps such as the one between input and output on C band converter?

· This item concerns the converter modules and will be addressed by the Front End Task Group.

K. RFI issues.

-- A number of RFI issues are listed in in the parts above. The following are additional issues:

-- Non-linear threshold detectors.

· Agreed. We will have power monitors all along the IF chain.

-- Add coupled port in X-band IF Switch/amplifier module for on-line spectrum analyzer 7.5 - 12.5 GHz in one or more antennas.

· Agreed. We will be adding monitor outlets in most of the modules.

L. General

-- Fixed gain blocks are recommended for FE. Range of power levels for different observing bands needs to be better understood to minimize range of attenuation required in IF. Adding attenuation hurts S/N and headroom; the impact needs to be better understood and quantified. 30 dB step attenuator may be necessary for solar.

· Agreed.

-- Not much flexibility in LO lock points with 2.3 GHz separation. There are 10 dB shifts in lock levels between lock frequencies. Can't get to 83 GHz with current IF system. First LO can't get low enough in frequency.

· The new design of the LOs will take care of this.

-- Fixed LO for 75 MHz should be changed for future wider band tuning requirements.

· Will accommodate in the future.

-- Will old front ends on new antennas be modified for limited frequency range? Questioner is concerned that power levels from old receivers may be incompatible with new converter equipment.

· The old front ends will be compatible with the new converters. As a worst case, power levels may be slightly higher and require attenuation in the path.

-- VLBA issues.

· VLBA observing will be provided for.

III. Questionnaire input

A. Barry Clark points out that a specification is needed on total variation across useable baseband (2 GHz or whatever). He suggests 3 dB, but might be willing to "back off." Barry adds that the phase stability specification across the sky should be a combination of ps and degrees to avoid unmeetable specifications at low frequency (0.7ps at 74 MHz = 0.15 deg).

· Agreed. The specifications in the project book will be rewritten to show degrees. We have adopted the 3 dB spec for the band pass.

B. Barry Clark points out the need for a specification on IF converter signal isolation between IF channels on path through common LO lines. 60 dB with medium term variations [was given] but 80 dB needed.
There is a similar worry about the transfer switches.

· Agreed. We have adjusted to specification to accommodate.

C. Barry asks if there are commensurabilities we should take into account. For instance, the FTS will conveniently give an integral number of turns in 8.192 ms, but not in 10.000 ms. The correlator gives a small extra intermod suppression if there are an integral number of offset turns per integration. Should correlator integration times be a multiple of 16.384 ms instead of 10 ms?

· The only benefits to integrating for an integral number of reference and fringe generator cycles are:

1. Better sub-band transition-band aliasing attenuation since we would hit nulls of the sinc function. We will already get really good aliasing attenuation without this (with only 10 cycles, we would get 20 dB etc.). The Task Leader doesn't think it is worth the effort.

2. By integrating for an integer number of reference and fringe cycles, we would potentially cause stationary interference correlation to hit the null of the sinc function. This is useful but limited on short baselines. To elaborate, it would be useful on short baselines because that's where the fringe rate is slowest; but it would be limited because the integration time might have to be excessively long causing imaging problems. This can best be done in the correlator backend if it is really desired (it also has imaging s/w implications etc.)

Another reviewer points out that if sampler-generated intermod products and harmonics are present, then the frequency shift gets rid of some of them, but not all (no matter what you do, unfortunately). Also, if the sampler is operating with this kind of RFI, there is a significant sensitivity loss due to quantization noise. The only possible benefit to an integer number of cycles, is that it could hit nulls in the fringe washing sinc function for anti-aliasing; but it must also take into account the natural fringe rate to do so.

D. Barry reports that for the proposed system in transition, a narrow spectral bandwidth presented to the current correlator is at 64 MHz*n + 32 +/- (f/2) where f depends on band current design, then
4 30 doesn't work
P 30 OK
L 30 exludes HI
C 30 H110alpha marginal (4849)
X 10 H93alpha 8048 doesn't work
H92alpha 8309 doesn't work

Radar 8560 doesn't work

Possible solutions are to add additional mixer in FPGA or use switchable filters to extend range of LO2.

· We will endeavor to make the LOs tunable in less than 5 MHz steps. This should cure all access problems.

IV. Conclusions:

The top level performance requirements for the EVLA LO/IF design are complete and adequate with the following important exceptions:

Tuning range of LO synthesizer.
Need plan for round trip phase.
Need tighter specifications in several areas.
Need to define MIB (M&C) requirements.
Need to define self-RFI suppression requirements.
Maintainability testing needs more attention.

Correct design solutions have been selected except for the following:

The LO synthesizer tuning ranges.

The procurement plan calls for ordering long delivery items as soon as possible. Obsolescence was not addressed.

V. Addendum letters

A. Dear Rick [Perley], [Information in brackets added by W. Brundage.]

I was just writing some final comments when I received your message. I have put a reprint of the paper into the NRAO mail to you. The reference is IEEE Trans. Ant. Prop., AP-30, 450-456, 1982. (Reference can be found in TMS2 Ch. 15). I will look through the material that you sent, but for now, here is what I just wrote.

(1) As values to guide the testing for self-generated RFI, I suggest that you use values of power flux density (W/m^2), rather than the values of spectral power flux density [W/(m^2.Hz)]. I have the following values:

	[2 MHz BW	200 MHz BW	1 GHz BW	2 Ghz BW]
21 cm, -187 dBW/m^2	[-168	-158	-155	-153]
6 cm, -173 dBW/m^2	[-154	-144	-141	-139]
2 cm, -161 dBW/m^2	[-142	-132	-129	-127]
1.3 cm, -157 dBW/m^2	[-138	-128	-125	-123]

These are given in my paper of 1982, but are still OK within a few dBs. They are for the D array with 381 Hz bandwidth, i.e. worst-case values. The flux density values are proportional to sqrt(instrumental bandwidth). Thus to convert them to 2 MHz bandwidth add 19 dB [18.6](i.e. make them less stringent). If you plot them as dBW against log(frequency) you can extrapolate to get approximate values for other frequencies. (Note, to get corresponding values of spectral power flux density, divide flux density by the bandwidth. Thus spfd values are proportional to 1/sqrt(bandwidth).)

[Another reviewer points out that it is important to ensure that these values are a suitably small fraction of the total power (power flux density) seen by the quantizers for 1 GHz BW/8-bit and 2 GHz BW/3-bit. "Suitably small fraction" depends on how much additional sensitivity loss (from quantization noise) is acceptable over what you would get if there were no RFI. E.g., for a 3-bit sampler, the sensitivity loss is ~3.5%, but if 6 dB of RFI power is added, then it functions as a 2-bit converter with a 12% sensitivity loss, since each bit can handle 6 dB of dynamic range.]

(2) For the overall frequency response, limits are needed for both the full band and for 2 MHz bandwidth. I think that 3 dB, and Rick's figure of 0.3 dB, respectively, are about right.

(3) With regard to the input/output band-edge overlap for the C to X conversion, Barry suggested 20 dB isolation is enough since the direct feedthrough component will not have the fringe rotation. I prefer not to rely on fringe rotation for short baselines (E-array at some time?), and u-axis crossing. I would ask for 30 dB isolation if possible.

(4) Whether or not to use ALC of the signals at the sampler in the presence of interference is not clear. For the 8-bit sampler it may be best to keep the gain constant. It also depends on the headroom. I think this question only affects the control software, not the hardware, and is probably best left until one sees how the instrument performs in these circumstances.[i.e., provides choice of analog ALC and software ALC/fixed gain.]

Dick

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For the Panel,

Clint