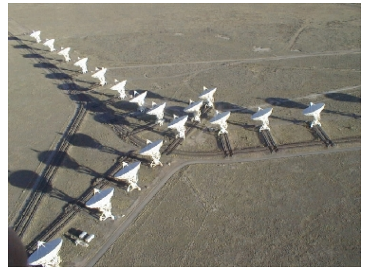

Scientific Impact of Descopes

Rick Perley

The Problem

- Contingency is about 7% of Cost to Complete, while 15% would be comfortable.
- If contingency drops significantly, it will be necessary to consider descoping aspects of the EVLA.
- We can consider descopes in one or both:
  - Hardware
  - Software
- Alternatively, there are some ‘delay’ options.
- I review here the impact of these options on the scientific productivity of the EVLA.

Hardware Descopes

We have considered:

1. Removal of one or more bands
   – X, Ku, S, Ka are the possibilities
2. Reduction of bandwidth from 16 to 8 GHz.
3. Reduce number of outfitted antennas.
4. Removal of special solar observing hardware.

Bandwidth Reduction

- Significant savings still possible, but less than the $4M estimated a year ago.
  - Savings mainly in DTS, much of which is currently under order.
- Scientific impact: 40% loss of continuum sensitivity per unit time at Ku, Ka and Q bands, ~ 20% at U-band.
- Instantaneous spectral line coverage cut in half.
- Bandwidth in S-band (with 8-bit sampling) also cut in half.
  - Similar impact in C and X bands if we elected to, or are required to, utilize the 8-bit digitizers (due to high RFI).
- Taking this option would create a significant risk for completion of the WIDAR correlator.

Band Descopes

- Costs of the four bands that could be descoped:

		Total	Parts Only	Savings
1.	S-Band	$1.4M	$1.0M	$0.4M
2.	X-Band	$1.0M	$0.8M	$0.2M
3.	Ku-Band	$1.3M	$1.1M	$0.3M
4.	Ka-Band	$1.2M	$1.0M	$0.2M

- I consider the scientific implications of each band listed.

S-Band
(2 – 4 GHz)

- This band will become the band of choice for imaging non-thermal sources.
- Likely better than twice the continuum sensitivity of L-band:
  - Twice the total bandwidth,
  - At least three times the available (RFI-free) bandwidth
  - Perhaps 25% better efficiency
  - Better Tsys.

Examples of Key Lost S-Band Science

- Deep blank fields.
- Detailed polarization imaging and rotation measure analysis of non-thermal sources.
- Bi-static radar measurements of planets using Arecibo transmitter.
- Zeeman splitting measurements using stacked recombination line observations.

U-Band
(12 – 18 GHz)

- This is a key ‘thermal science’ band.
  - Transition zone (from optically thick to optically thin) for the highest EM HII regions.
  - Dozens of molecular and atomic spectral transitions.
  - Lowest frequency where precise dust emission observations can be made (lowest optical depth to dust extinction).
  - Lowest frequency (= highest redshift) for key high frequency molecular studies (e.g. CO 1-0 at z – 5.8).
  - Moderate redshift (z = 0.2 to 0.8) observations of water vapor masers.
- Also a good band for non-thermal imaging.

X-Band
(8 – 12 GHz)

- A transition band between thermal and non-thermal science – valuable for both.
- X-band bistatic radars for planetary studies.
- Essential for complete frequency coverage science:
  - The spectral trough between thermal and dust emission for z~2 to 3 lies in this band.
  - H_2O masers for z between 0.8 and 1.8.

Ka-Band
(26.5 – 40 GHz)

- Early in the project, this band was identified for accelerated development – rich science mine!
- Relatively unexplored spectral region, esp. good for thermal emission processes.
- Hundreds of molecular spectral transitions.
- Low sky emission – between H_2O and O_2 emission. Good efficiency (>40%) , excellent Tsys (<50K).
- Testing of the designed horn/polarizer is about to begin.

Ka-Band Science

- The key band for thermal science!
- HII regions, dusty obscured disks, star forming regions.
- Hundreds of spectral transitions.
- Hi-z lines.
- Excellent continuum sensitivity – far better than Q-band, even for optically thick thermal emission.

Summary View of Band Descopes

- Full Frequency Coverage is a Primary Requirement of this project.
- The science impact of band descopes is enormous.
- Experience indicates that five years or more would be needed to recover a descoped band.
  - A proper ‘R&D’ budget could shorten this considerably.
- Modest savings gained by simply buying the components, and assembling later.
- Probably better to cut one band completely than to defer assembly for all three (or four) bands.

Retain Legacy X-Band?

- The VLA has a good X-band system – operating from 7.8 – 8.8 GHz.
- It has been argued that simply leaving this legacy system in place would be sufficient.
- However:
  - Continuum sensitivity will be less than half that of C-band.
  - Only useful for spectral observations of transitions lying between 8 and 8.8 GHz.
- The legacy X-band would be lightly used.

Solar Mode Descope

- Not a lot of money (~$200K)
- Scientific impact limited to the ‘solar community’ and solar science.
- Solar community use of VLA is now very light, but
  - We are in solar minimum
  - Higher useage would surely follow greater capability.
- Only two bands (L-band and one other, currently not identified) budgeted for special solar mode systems.
- Success of FASR funding another factor. If FASR funded, would the EVLA be an attractive instrument for solar research?

Number of Antennas Descope?

- A suggestion has been made to reduce the number of EVLA-outfitted antennas.
- Savings limited – in many areas we have already bought 'in bulk' for the whole project.
- Very strong science impact:
  - Point-source sensitivity reduced by ratio: $N_{EVLA}/27$.
  - Imaging capability (particularly for complex fields) reduced by a greater fraction – # baselines rise as N^2.
- This descope would damage all bands, all observers, all programs, all science.

Software Descopes

- Software in three major areas:
  - M&C
  - SSS
  - Post-Processing (CASA)
- We consider M&C as sacrosanct. Its functions are critical, and the group is of just-sufficient size.
- CASA group is also of just-sufficient size; algorithmic group sub-critical – two more positions needed.
- Can we look at SSS for descope opportunities?

Descopes in SSS?

- Priority 2 and 3 SSS requirements already deferred into operations.
- Approximately $1M of EVLA contingency already utilized to hire two programmers for SSS.
- NRAO E2E Operations Division will provide two extra positions to enable us to meet Priority 1 requirements.
- Descoping from the staffing levels described would result in Priority 1 requirements not being met within construction.

Summary

- Advertised scientific productivity of EVLA requires all hardware and software deliverables to be met.
- Removing frequency bands has strong science consequences. Other hardware descopes either save little money, or impact all science drastically.
- Decreasing software staffing also has strong impact on EVLA science – especially for non-expert users.
- Recovering from descopes (lost bands, or lost SSS positions) will take many years.
- If future contingencies are insufficient, and descoping required, we will present the viable options to the EVLA Science Advisory Committee for discussion.