

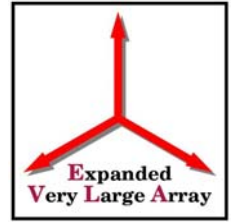
---

# Scientific Impact of Descopes

Rick Perley



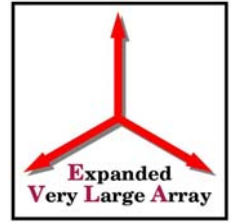
# The Problem



- Contingency is about 7% of Cost to Complete, while 15% would be comfortable.
- If contingency drops significantly, it will be necessary to consider descope 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

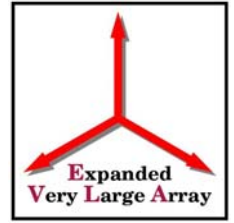


We have considered:

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.



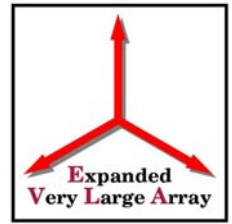
# Bandwidth Reduction



- 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.
- Taking this option would create a significant risk for completion of the WIDAR correlator.



# Band Descope



- Costs of the four bands that could be descope:

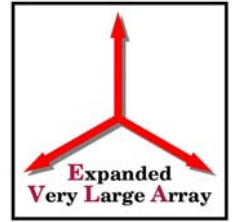
	Total	Parts Only
1. S-Band	\$1.4M	\$1.0M
2. X-Band	\$1.0M	\$0.8M
3. Ku-Band	\$1.3M	\$1.1M
4. Ka-Band	\$1.2M	\$1.0M

- I consider the scientific implications of each band listed.



# S-Band

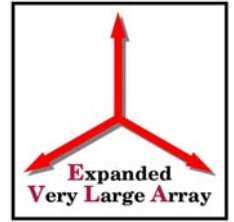
(2 – 4 GHz)



- 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
  - Nearly 1.5 times the efficiency.
  - Better  $T_{\text{sys}}$ .



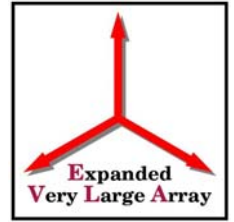
# Examples of Key Lost S-Band Science



- 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)



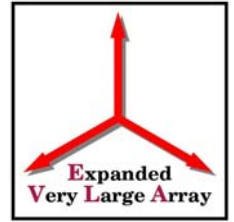
- This is a key ‘thermal science’ band.
  - Transition zone (from optically thick to optically thin) for the highest EM HII regions.
  - Dozens of molecular and atomic spectral transitions.
  - Lowest frequency where precise dust emission observations can be made (lowest optical depth to dust extinction).
  - 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

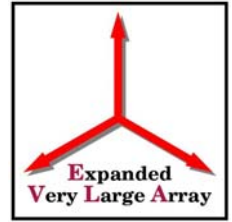
(8 – 12 GHz)



- 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  $z \sim 2$  to 3 lies in this band.
  - $\text{H}_2\text{O}$  masers for  $z$  between 0.8 and 1.8.



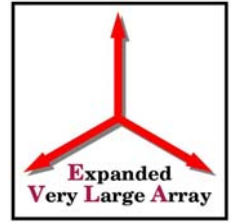
# Ka-Band (26.5 – 40 GHz)



- 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<sub>2</sub>O and O<sub>2</sub> emission. Good efficiency (>40%) , excellent Tsys (<50K).
- Testing of the designed horn/polarizer is about to begin.



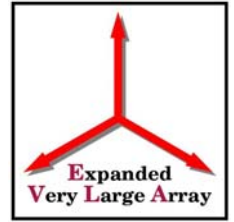
# Ka-Band Science



- 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.



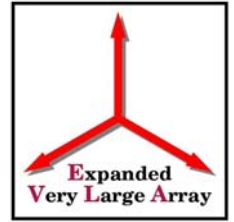
# Summary View of Band Descopees



- Full Frequency Coverage is a Primary Requirement of this project.
- The science impact of band descopees 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.



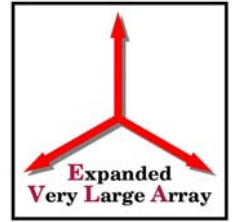
# Retain Legacy X-Band?



- 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.



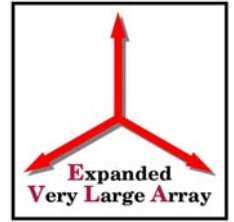
# Solar Mode Descope



- 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?
- Should we defer implementing the coupler-fed scheme?



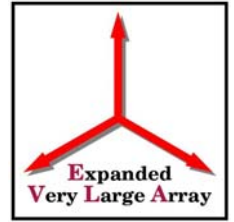
# Number of Antennas Descope?



- 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:  $N_{\text{EVLA}}/27$ .
  - 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 Descope

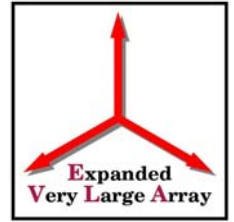


- Software in three major areas:
  - M&C
  - SSS
  - Post-Processing (CASA)
- We consider M&C as sacrosanct. Its functions are critical, and the group is of just-sufficient size.
- CASA group is also of just-sufficient size; algorithmic group sub-critical – two more positions needed.
- Can we look at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





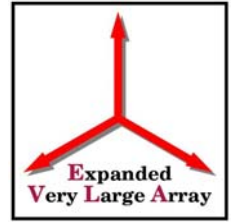
# Descopes in SSS?



- 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.