EVLA Overall System Specifications

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EVLA Design Philosophy

- The EVLA Project has never intended to build an entirely new telescope.
- The design approach has always been to maximize the increase in observational capabilities by combining:
  - Existing infrastructure (array, antennas, people …)
  - Modern technologies
- It was clear early in the design process that an order-of-magnitude improvement in all key observational capabilities was both feasible and practical.

EVLA Science Goals

- An order-of-magnitude improvement at modest cost sounds good, but the expenditure must be justified by the potential science return.
- Important design philosophy – the EVLA, like the VLA, is to be a general-purpose, flexible instrument, for astronomical research.
- A series of meetings resulted in a wide-ranging comprehensive science case, which was included in the proposal to the NSF for Phase I funding.

Top-Level EVLA Technical Goals

An early review of potential capabilities resulted in the following top-level technical goals:

- Complete Frequency Access (300 MHz – 50 GHz) with the best 'G/T' at each band.
- Up to 8 GHz (per polarization) instantaneous BW
- A wide BW, extremely highly linear, full-polarization correlator with at least 16,000 channels, up to 1 Hz resolution, pulsar binning, subarraying, and VLBI-ready capabilities.

Top-Level EVLA Technical Goals

- Improved low-surface brightness imaging capability
- A factor of ten increase in resolution, with excellent imaging capability.
- Be able to incorporate VLBA antennas in the future.
- Improved operations and user interaction capability.

The Two Phases

- An early decision: -- split the project into two phases.
- Phase I: Essentially an upgrade to the VLA.
  - Funding secured (mostly – final word on correlator funding expected shortly)
  - Two components of the original Phase I plan were deferred to Phase II, primarily for budgetary reasons.
- Phase II (Completion Phase): Primarily an expansion.
  - Not yet funded – a proposal is under development.
  - Will be discussed tomorrow

EVLA Technical Goals

- The top-level EVLA goals were presented to meetings of our scientific users, with the questions: What potential science can you foresee? What further capabilities are needed to get the best science from this instrument?
- The responses (in the form of typical and extreme observational programs) enabled a more detailed set of technical goals for the project.
- The more detailed 'Level 2' technical goals are:

Antenna -- Mechanical

- Pointing:
  - Blind: 6" rss between 30 and 70 degrees El.
  - Referenced: 3" rss between 20 and 70 deg. El.
  - OTF: 4" rss at drive rates up to 1 deg/min
  - 8", rss, at rates from 1 to 2.5 deg/min.
- Subreflector Positioning
  - Limits on focus, horizontal, rotation, and tilt positioning, and band change speed which are each about a factor ~2 tighter than current.
- Note: These goals are close to values already achieved – there is no specific EVLA budget for improvement.

Antenna -- Mechanical

- Antenna Slew/Settle
  - < 5 seconds, when angular motion is less than 30 arcminutes.

Driver for the above: Mosaicing and OTF imaging at high frequencies.

- Cassegrain Feed Positioning
  - 5 arcminutes.

Driver: Hi-Fidelity, full-beam imaging (feed illumination offsets place phase gradient across primary beam).

Antenna - Electrical

- Efficiency

Band (GHz)	Required	Target
1.2 – 2.0	0.5	0.55
2.0 – 4.0	0.55	0.60
4.0 – 8.0	0.60	0.65
8.0 – 12.0	0.60	0.65
12.0 – 18.0	0.60	0.65
18.0 – 26.5	0.55	0.60
26.5 – 40.0	0.50	0.55
40 – 50	0.45 – 0.40	0.50 – 0.45

Driver: EVLA Sensitivity Goal of < 1 μJy in 12 hours.

Antenna -- Electrical

- Main-Beam Similarity
  - Power variation < 3% of peak, within FWHP.
  - Phase variation < 0.2 deg (L-band) to 5 deg (X-band and higher) with FWHP.
- Illumination Centroid
  - Centroid within 10 cm of the antenna center.

Driver: Minimization of computing efforts for full-field and mosaic imaging.

Antenna - Electrical

- Polarization
  - Stability (stable weather, within FWHP, 8 hr)
    - RCP and LCP polarization ellipses stable to 0.002 in axial ratio, and 2 degrees in position angle.
  - Ellipticity and Orthogonality
    - RCP and LCP on-axis AR to be 0.9 to 1.0
    - RCP and LCP major axes orthogonal to 10 degrees.
  - ‘Squint’ Stability
    - Separation of R and L beams to remain constant to 6 arcsec.
- Driver: High-fidelity polarimetric imaging.

Antenna - Electrical

- Receivers
  - Tsys
  - Ae/Tsys

Band	Tsys	Ae/Tsys	SEFD
1-2	20	13.5	200
2-4	25	11.8	235
4-8	31	9.4	270
8-12	34	9.4	290
12-18	35	9.1	300
18-28	52	5.7	490
28-40	56	4.8	570
40-50	76-104	3.3-2.1	1310

Antenna-Electrical

- Performance Variation over Frequency:
  - Increase of Tsys within any band, relative to best value, to be less than
    - 3dB over full bandwidth
    - 1 dB within inner 85% of BW
- Driver: To ensure sensitivity goal over wide bandwidth.

Antenna - Electrical

- Receivers
  - Power Linearity
    - Better than 0.5% over input power range of 15 dB.

    Driver: Accurate (relative) flux density calibration
    - Better than 2% over input power range of 50 dB.

    Driver: Solar observing, and tolerance to RFI.
  - Time Response
    - 0.5% power linearity condition to be maintained on 20 ms timescale.

    Driver: OTF imaging and solar flare observations

Antenna-Electrical

- Temporal Phase Stability
  - 1-σ variations < 0.5 ps on timescales < 1 sec.
  - Slope < 0.2 ps/min over durations < 30 min.
    - Variations about this slope < 1.4 ps.
  - Angle-dependent phase changes less than:
    - 0.7 ps for any angle change
    - 0.07 ps for antenna angle changes < 10 degrees.

Driver: Phase-coherent capability at 50 GHz.

Antenna - Electrical

- Receivers – Bandpass Characteristics
  - Amplitude Stability
    - Variations (power) < 0.01% on timescales < 1hr, over frequency scales < $\nu_0/1000$.
  - Phase Stability
    - Phase variations < 5 millideg, on timescale < 1 hr, over frequency scales < $\nu_0/1000$.

Driver: Sensitive absorption line studies (high spectral dynamic range).

Antenna - Electrical

- Receivers – Bandpass Characteristics
  - Gain Slope
    - Power gain variations < 3dB across full bandwidth
    - Gain variations – limits on gain slope which vary with band.
  - Gain Ripples
    - < 0.25 dB on band-dependent frequency scales
  - Phase Ripples
    - < 2 electrical degrees, on band-dependent frequency scales.

Driver: To limit closure errors to reach dynamic range goal of 70 dB.

Antenna - Electrical

- Receivers – Tolerance to Power Spikes
  - Ability to absorb 10 mW for 1 second without permanent physical damage.
  - Driver: To handle RADARSAT-like emission seen through the main beam.

Time Accuracy

- Time
  - System time accurate to 10 nsec.

  Driver: Pulsar timing observations.

Correlator

- Bandwidth
  - Variable, up to 8 GHz per polarization
- Polarization
  - Full polarization capabilities.
- Frequency Resolution
  - Variable, from ~ 1 MHz to 1 Hz.
- Number of Channels
  - At least 16,384
- Time Resolution (dump speed)
  - Better than 10 msec

Correlator

- Pulsar modes
  - Binning capability, with > 1000 bins, each with full spectral capability and 200 μsec time res^{n}.
- Subarray capability
  - At least 5 simultaneous subarrays.
- Phased Array capability
  - Required, for each subarray.
- Linearity (spectral dynamic range)
  - > 50 dB (H_2O masers, tolerance to RFI)

Correlator

- Baseline Range
  - To continental scales
- VLBI capabilities
  - VLBI-ready (tape or real-time)
- RFI tolerance
  - > 50 dB spectral linearity
  - Ability to avoid strong RFI

Driver: To enable the EVLA to achieve its science goals!

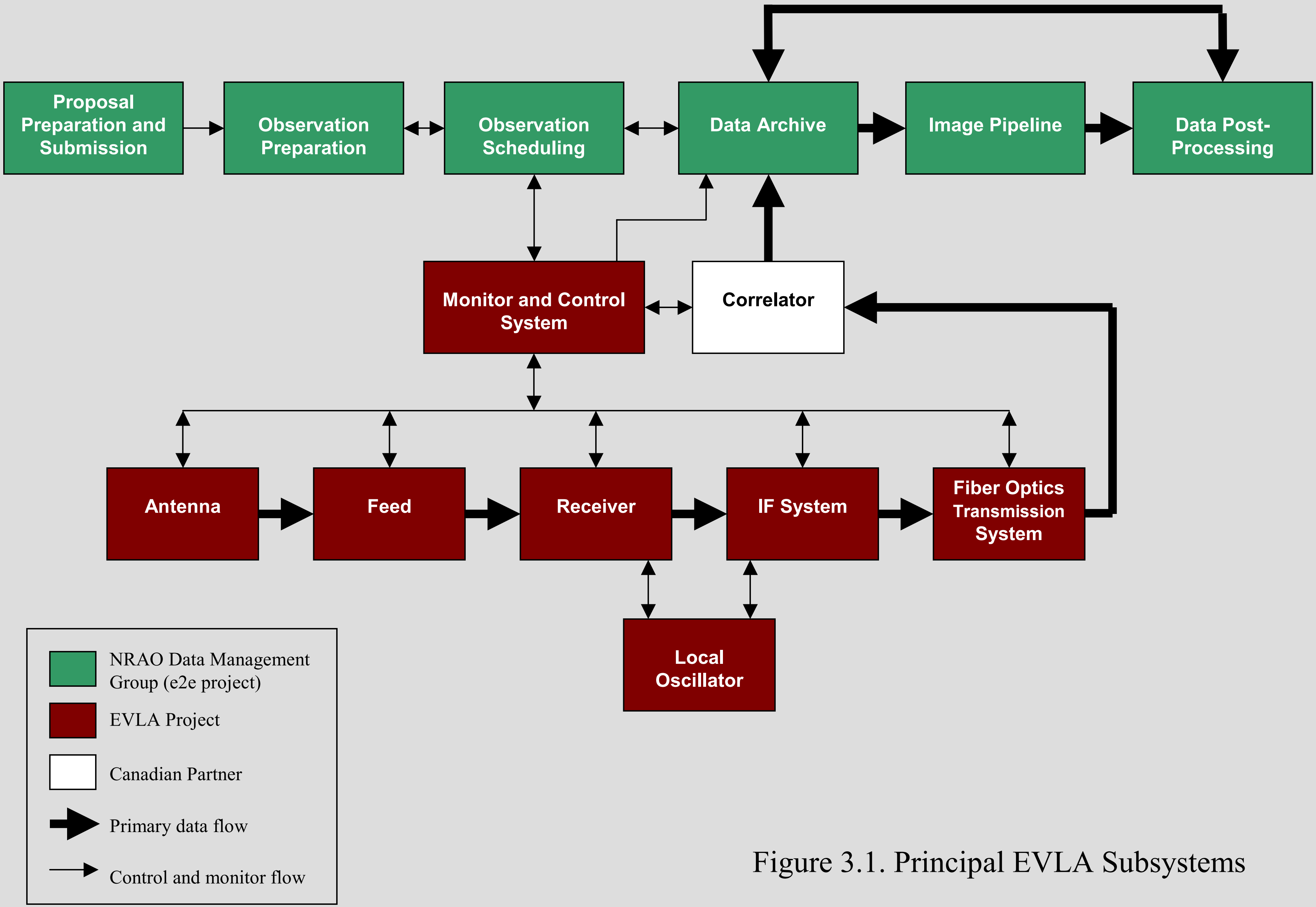

Figure 3.1. Principal EVLA Subsystems

Operational (M&C)

- The specific requirements for the M&C System are given in EVLA Memo #15 (Benson and Owen).
- Key Top-Level Goals:
  - Replace the ModComps, and control current VLA hardware. Continue to use existing control scripts (OBSERVE/JOBSERVE)
  - Control a hybrid VLA/EVLA, during the transition phase.
  - Control the EVLA, the NMA, and fiber-linked VLA Antennas

Operational (M&C)

- Specific Scientific Goals for the M&C System include the following
  - Spectral Line Imaging
  - Mosaicing
  - Observations of solar system objects
  - Solar observing
  - Astrometry
  - Rapid response to transient sources
  - VLBI/VLBA observing

Operational (M&C)

- Specific Scientific Goals for the M&C System include the following (cont.):
  - Pulsar observing
  - Total Power measurements
  - NMA/PT Link/future real-time VLBA
  - Miscellaneous (currently unplanned) items.

Operational (M&C)

- Scientific Goals include:
  - Recommended minimum output data rate
  - Hardware reconfiguration times
  - Subarrays
  - Interferometer model
  - Management of correlator modes and times
  - Special observing modes – phased array, reference pointing, focus, tipping scans, holography, survey modes
  - Support for special hardware: GPS, API, WVR, etc.
  - RFI detection, avoidance, excision
  - Archive of monitor data and observation parameters

Astronomer-Instrument Interfaces

- Part of the e2e project.
  - Proposal Submission and Handling
  - Observation Preparation and Scheduling
  - Observation Control and Feedback
  - Data Archive
  - Pipeline Processing – default images
  - Data Reduction Software