An Operation Concept for the next-generation Very Large Array

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The Operation Concept

The ngVLA operation concept is currently being considered from three perspectives:

- **Scientific Operations**: The user-facing services provided by the telescope including observation preparation, scheduling, archive access, scientific performance of the array, and the delivered data products.
- **Array Operations**: Operation of the array on a day-to-day basis, describing the degree of general automation, the scheduling approach, and operational overheads.
- **Array Maintenance**: Monitoring of performance, preventive maintenance, and reactive maintenance of the array by engineers and technicians.

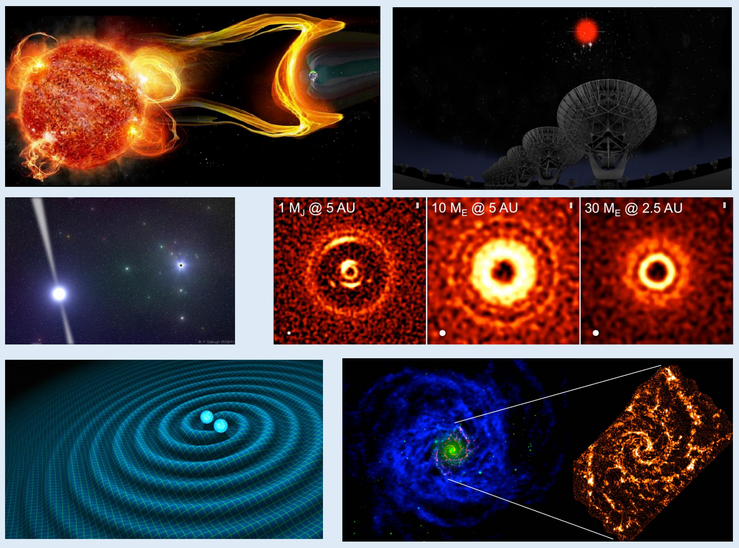

Figure 1: PI-driven key science cases for the ngVLA.

Summary

The next-generation Very Large Array (ngVLA) will be a synthesis radio telescope operating from 1.2 GHz to 116 GHz, consisting of approximately 214 18m reflector antennas operating in a phased or interferometric mode.

The central signal processor will include commensal observing capabilities to permit the division of the array into sub-arrays and the processing of single-dish and single-baseline data in multiple ways, such as concurrent cross-correlation and transient searches.

The facility will be operated as a PI-pointed instrument. Annual calls will solicit proposals that will be assigned rank based on scientific merit and technical feasibility.

Automated pipelines will calibrate the raw data and create higher level data products (typically image cubes) that will be delivered to users. Data will reside on a central archive.

The array will be operated and maintained from four supporting logistics centers.

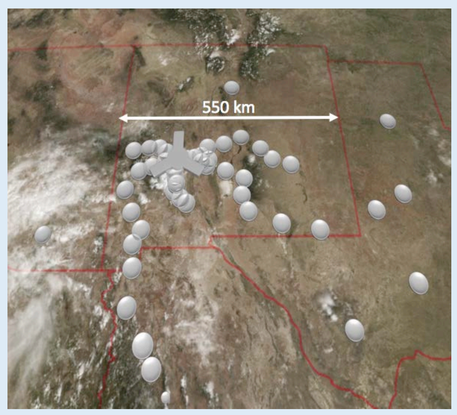

Figure 2: Approximate antenna locations for the ngVLA. Sites span into AZ, TX and northern Mexico.

Driving Requirements

A few high-level requirements for the ngVLA shape the current operation concept. To varying degrees, these requirements are conflicting or competing, and necessary balancing must be achieved.

- ngVLA shall be a PI-driven, general purpose, pointed instrument.
- The system shall provide an order of magnitude improvement in sensitivity and angular resolution over the VLA and ALMA over the operating frequency range.
- The total annual operations budget shall not exceed $75M, or roughly three times the VLA operations budget.

Compared to current instruments, three-fold improvement in operation efficiency is required to provide the operational flexibility of a PI-driven instrument that is ten times the size of the VLA or ALMA.

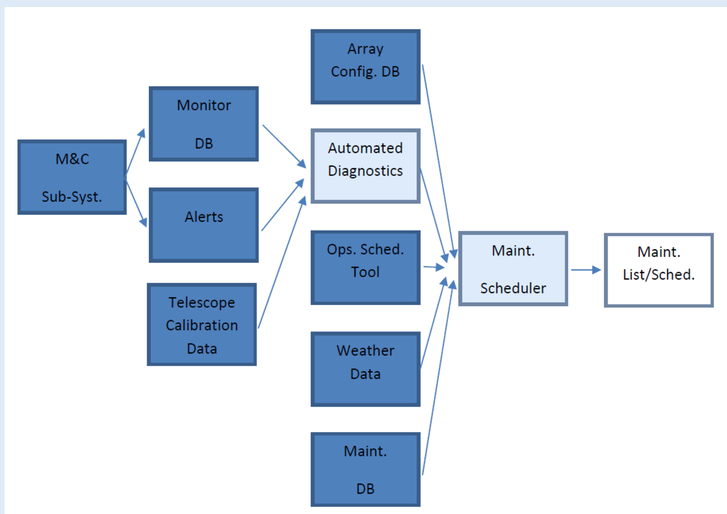

Figure 3: Block Diagram of the inputs/outputs for a the Maintenance Scheduler concept.

Scientific Operations

The ngVLA is envisioned as a PI-driven , general purpose instrument. Consequently, the planned operation model encourages innovation and requires an instrument with the ability to easily adapt to new fields of science. It also fosters a technically engaged user community, which is important for training the next generation of instrument builders and users. Key operation concepts here include:

- The fundamental data products for ngVLA users will be science-ready data products (SRDP; i.e., images and cubes) generated using a calibration and imaging pipeline created and maintained by the project.
- The array will be dynamically scheduled in a similar fashion to the VLA and other modern instruments. Considerations include observing the highest priority and most demanding projects that can be accommodated given the visible radio sky, the array status, and environmental conditions.
- Larger external projects will be accommodated under a Legacy Science Program (LSP) designed to support observing or archival projects that require significant resources (e.g., a dedicated team, computing, software development, etc.) to carry out those observations, non-standard data reduction/processing, and associated analyses. Such projects should provide the greater community with Enhanced Data Products (EDPs), analysis software, tools, etc.

Array Operations

Array operations will be conducted from both the Array Operations Center (AOC) and the ngVLA site. Operation of the array will be supervised from the AOC, with an operator stationed 24-hrs a day. Depending on the degree of human intervention required in array supervision, multiple operators may divide the work load.

- Similar to the VLA, a human operator will oversee the array to address unforeseen challenges. The operator will supervise the scheduling tools and executor, ensuring that the intent of each observation is met and that the array is kept in a safe operating condition. The operator will be provided with an alert screen to indicate array health.
- The degree of automation needs to provide the capability for one or two individuals to monitor the array condition with a 214-element array. Individual ngVLA antennas need to be more autonomous than what is currently state of the art.
- ngVLA will have a concurrent maintenance and observation model. Maintenance will be scheduled dynamically based on need and priority. Likewise, observations will be dynamically scheduled.
- The ngVLA will differ from existing facilities in the degree of sub-array use during observations, as well as sub-arrays assigned for periodic maintenance. Some of the identified science cases require only portions of the array, or want the array sub-divided for concurrent multi-frequency or multi-field observations.

Array Maintenance

Increasing the collecting area and geographical extent of the array by factors of ten, while increasing the operations budget by only a factor of three, will present a significant constraint on both the design and the array maintenance concept. The limit in operations costs effectively caps the staffing level at less than three times the VLA maintenance staff. The maintenance burden per antenna will need to drop by roughly a factor of three , with a reduction in the frequency and duration of maintenance visits. Efficient array maintenance will be the outcome of incorporating maintenance requirements in not just operations, but also in design development.

- Preventive maintenance (PM) schedules must be consistent with the expected staffing level, with antenna systems operating for a year or more between PM visits.
- Consistent with the goal of efficient maintenance interaction, electronics will continue to be packaged as Line Replaceable Units (LRU), where LRU modules are interchanged at the antenna. LRUs will be centrally managed, tested, and repaired from the AOC.
- ngVLA will employ a scheduled maintenance program for the antennas with a goal of minimizing repeat and unscheduled antenna visits.
- Maintenance time could be dynamically scheduled by sub-array, based on adverse local observing conditions.

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