ngVLA Maintenance & Operations

JVLA Perspective

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ngVLA Operations Concept – JVLA Perspective

Evolution of VLA to JVLA

- **1957** – Discussions begin on a concept to build a US-based aperture synthesis radio telescope capable of making radio pictures over the entire Northern sky with a resolution comparable to that of optical instruments.
- **1972** – Budgeting for the VLA construction was approved.
- **1981** – The Very Large Array was completed
- **1982** – VLA staff began to envision improvements to the electronics and expanding the frequency coverage.
- **1990** – NSF turned down an NRAO proposal for an upgraded VLA
- **2000-2001** – Funding for an expanded VLA was approved and construction to turn the VLA to a high resolution imaging instrument with many frequencies over a broad bandwidth began.
- **2012** – The Jansky VLA was completed.
- **2015** – Discussions on the next generation VLA begun

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Purpose of Operations

Operations' role is to manage the operational aspects of the instrument and to do so at as close to peak efficiency as is possible in terms of effort and cost to maximize the science output. It must be done in a way that:

- **is practical**
- **is cost effective**
- **is sustainable**
- **is reliable**
- **successfully meets its mission goals**
- **accounts for the human factor**
- **provides a work environment that is safe for employees, users and visitors.**

JVLA spends approximately 80% of the operations budget on personnel and 10% on power costs, leaving 10% for all other support of the instrument.

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Maintenance and Array Operations

Current Efforts for Observing and Maintenance

Currently, the JVLA operates 365 day a year, for a total of 8760 hours. Of this, the JVLA spends:

- 66% on Science Observations
- 17% on Testing and Commissioning
- 10% on Scheduled Maintenance periods (no overlap with observing)
- 7% on unscheduled-able time due to weather, gaps between observations
- > .5% on shutdowns for major holidays (no observing, but staff is present on the site for security and safety reasons)

Track work is performed continuously during normal working hours, including science observations, so that type of maintenance, which is significant, is not reflected above. Likewise, repair of modules and other bench work is done concurrent with observing.

I expect the science percentage will stay the same for at least a few more years until commissioning efforts slow down, then science observing will increase to ~ 75%.

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Maintenance and Array Operations.

JVLA maintenance operations include these categories of activities:

- Engineering Management
- Systems Engineering
- Logistics (Planning & Scheduling)
- Telescope Maintenance
  - Cryogenics
  - Front End
  - LO/IF
  - Mechanical
  - Servo System
- Correlator
- Data Transmission (including Fiber Optics)
- Site Management
  - Safety & Security
  - Buildings
  - Grounds, Roads and Access
  - Support Equipment
  - HVAC
  - Fabrication & Machining
  - Water, Wastewater Systems
  - Electrical
  - Railroad System
  - Materials Management

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Maintenance and Array Operations

And, requires the following staffing for maintenance activities:

Staff Groups – 92 employees (19 Engineers)

- Management – 3 Division Head, 3 Deputy DH
- Auto – 1 lead, 2 mechanics
- Cryogenics – 1 engineer, 4 techs
- Correlator – 2 engineers
- Data Acquisition – 1 engineer, 1 tech
- Electrical – 1 engineer, 5 techs (electricians, HVAC)
- Facility Engineering – 2 engineers, 3 machinists
- Front End – 2 engineers, 6 techs
- Grounds/Custodians - 1 lead, 1 ground, 4 custodians
- LO/IF – 2 engineers, 5 techs
- Mechanical – 1 lead, 5 techs, 6 mechanics
- Servo – 1 engineer, 3 techs; Fiber – 3 techs
- Systems Engineering – 6 engineers, 1 tech
- Track – 1 lead, 9 equip. operators
- Array Operations – 6 operators

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Maintenance and Array Operations

A few things regarding operations costs we have learned from JVLA operations that may impact ngVLA

- Keep power costs under control
  - Rates have increased from $.06 kWh to $.11/kWh since 2004
  - Usage has also increased, mostly due to additional cryogenic compressors.
    Cryogenics compressors alone are responsible for 30% of the power bill.

- Reduce visits to the antennas and the site to decrease downtime and manpower requirements
  - Determine how to decrease manpower effort needed to service antennas
  - Remote resets should be designed in for all modules
  - Develop remote array operations capabilities to enable combining operator functions

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Maintenance and Array Operations

What is JVLA doing to address the issue reducing power and making manpower effort more efficient?

Power

Installed power meters on two antennas – one antenna to monitor power as a control and the other antenna will have tests and modifications to it.

We are investigating:

- Variable Frequency Drivers (a type of motor controller that **drives** an electric motor by varying the **frequency** and **voltage** supplied to the electric motor)with the goal of reducing cryo power usage by 30% in a steady state operation. Tests were done to determine if the cryogenics would perform satisfactorily if power could be stepped from 60Hz to 30Hz.
- The use of Multi-Layer Insulation around the 50K radiation shield.

Results are encouraging and more testing is planned.

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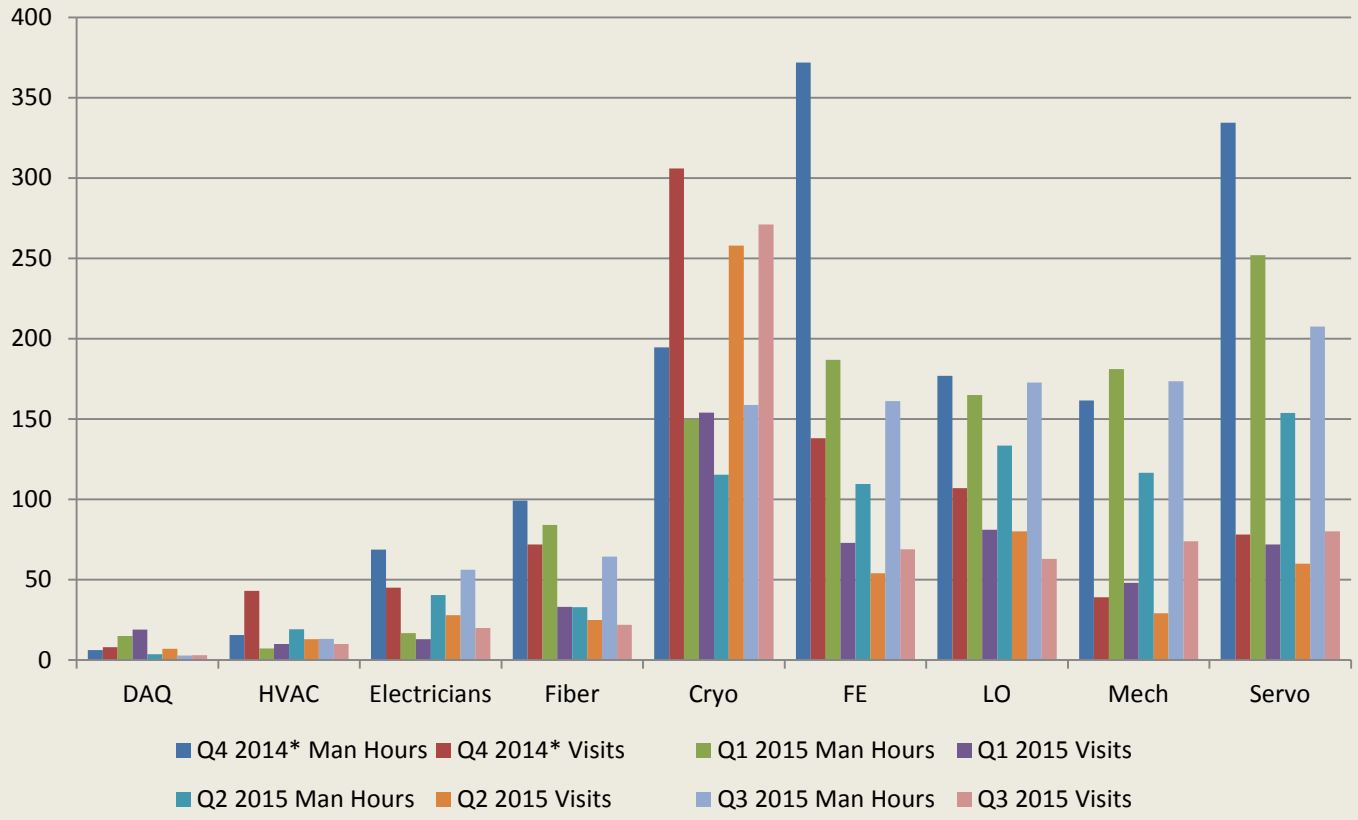
Maintenance and Array Operations

Manpower

Graphical Display of Antenna Visits and Time spent by Major Groups in 2014



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Maintenance and Array Operations

Manpower

What the graph indicates is which systems require more manpower effort and give us a clue as to which systems need to be improved on in terms of servicing and reliability. It is early days for the collecting and analysis of this information, but we do see some trends.

We have also begun to implement remote array operations on the JVLA on some operator shifts by moving them to the Socorro offices in the hope of ultimately conserving manpower and costs (eliminate operator shuttle) and cross-training some operational tasks with VLBA.

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ngVLA – Some thoughts on how to evolve an efficient and cost effective operations concept

Power Costs

- Tap into proposed solar, wind power lines and/or investigate grants for solar arrays (examine RFI impact)
- Negotiate fixed rates into the future with local electric companies if feasible
- VFDs and design modules to be compatible with them
- Design in energy efficiency everywhere (i.e. insulation, high efficiency HVAC systems)
- Use energy efficient vehicles for transportation
- Staggered slewing of antennas to spread out the power needs, but determine impact on science and reference pointing-type modes

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ngVLA – Some thoughts on how to evolve an efficient and cost effective operations concept

Infrastructure

- Leases – negotiate for public land where possible at low annual cost
- Road Maintenance – stay as close to state and county maintained roads
- Fiber – attach to existing lines when possible, so annual costs can be shared
- Analyze JVLA Site facilities to determine which of the existing structures will be needed, which can be mothballed
- Avoid designing customized vehicles – modify commercially available ones to suit maintenance activities
- Build in high reliability and enough redundancy to eliminate dedicated maintenance days
- Consider placing critical equipment (e.g. correlator) in a location where easily accessed 24/7 by support personnel
- Cell phone communications as much as possible to reduce satellite phone and radio expenses

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ngVLA – Some thoughts on how to evolve an efficient and cost effective operations concept

Manpower

- Cross-train existing personnel as some JVLA skills are phased out and ngVLA ones are required
- Cross-train personnel for tasks that cross group boundaries
- Ensure personnel are always fully engaged in maintenance and repair activities
- Ensure the array can be operated from a variety of places and not restricted to one site
- Define local regions of the array - use 2-man teams who live in a quadrant for maintenance and support (VLBA-ish), rather than send out teams from further out
- Design antenna to have easy access to equipment as is practical at ground level (or nearly so) to minimize need for aerial lifts in remote locations

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ngVLA – Some thoughts on how to evolve an efficient and cost effective operations concept

Maintenance Operations

- Balance costs of transporting antennas vs building enough extra units to avoid the need to reconfigure
- Overhaul and retrofit in place
- Modify management structure to adapt to a more distributed operations environment
- Ensure remote reset, reboot, power-cycle capability of remote equipment
- Self-lubricating (or at least, minimal) of mechanical parts
- Modularize as much as possible and make it simple for even less-skilled employees to swap out bad components
- Design good methodologies for requesting repairs, reporting problems and documenting maintenance and preventive maintenance efforts. Schedule and assign as much as possible in advance to economize efforts.

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ngVLA – Some thoughts on how to evolve an efficient and cost effective operations concept

Maintenance Operations *cont.*

- Have a method and the expertise available to triage problems daily
- Don't lose the wisdom acquired during construction phases by failure to record and document problems and their solutions
- Make it hard for the antennas that are remotely located to be vandalized (i.e. copper theft).
- Make it easy for people to do the right thing whether it be documenting, reporting, performing tasks efficiently, monitoring so that tasks are done safely and correctly
- Establish effective communications at all levels. This becomes a critical factor if the ngVLA is a dispersed instrument. The success of the VLA and JVLA, in part, was due to the having the right engineering, science, computing and management people in close proximity to each other for formal and informal communications.

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