ngVLA 18m Antenna Reference Design

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ngVLA Array Concept

The ngVLA will be a synthesis radio telescope constituted of approximately 214 reflector antennas each of 18 meters diameter, operating in a phased or interferometric mode. It will operate over a frequency range extending from 1.2 GHz to 116 GHz.

The signal processing center of the array will be located at the Very Large Array site, on the plains of San Agustin, New Mexico. The array will include stations in other locations throughout the state of New Mexico, west Texas, eastern Arizona, and northern Mexico.

Operations will be conducted from both the VLA Control Building and the Array Operations Center in Socorro, NM.

Table 2: ngVLA Key System Parameters

Parameter	Value
Antenna Diameter	18m Main Array, 6m Short Baseline Array, 18m Total Power
Number of Antennas	214 x 18m, 19 x 6m
Antenna Optics	Offset Gregorian, Feed Low, Shaped
Frequency Range	1.2 GHz – 50.5 GHz, 70 GHz – 116 GHz
Front Ends	Single Pixel Feeds, Dual Linear Polarization
Instantaneous Bandwidth	Up to 20 GHz / pol.

General Dynamics Mission Systems Antenna Concept

The reference design of the ngVLA antenna is being developed by General Dynamics Mission Systems. The design is to a specification developed by the ngVLA project team with an optical design advanced by the National Research Council of Canada. A parallel study into a composite design concept with National Research Council of Canada is also underway, and both costed designs will be delivered in the fall of 2018.

The GDMS concept is scaled from the successful 13.5m MeerKAT antenna design. The offset Gregorian optics are constituted of an aluminum segmented main reflector and single piece subreflector. These are supported with a steel radial truss structure and feed arm. A central cavity in the backup structure eliminates interference with the pedestal while moving the azimuth axis closer to the reflector surface. This reduces the need for counterweight ensuring fast slew and settle times.

The mount concept is a pedestal and turnhead concept based on construction and operations cost. The servo system relies on a gear box drive for azimuth rotation and a jack screw for elevation.

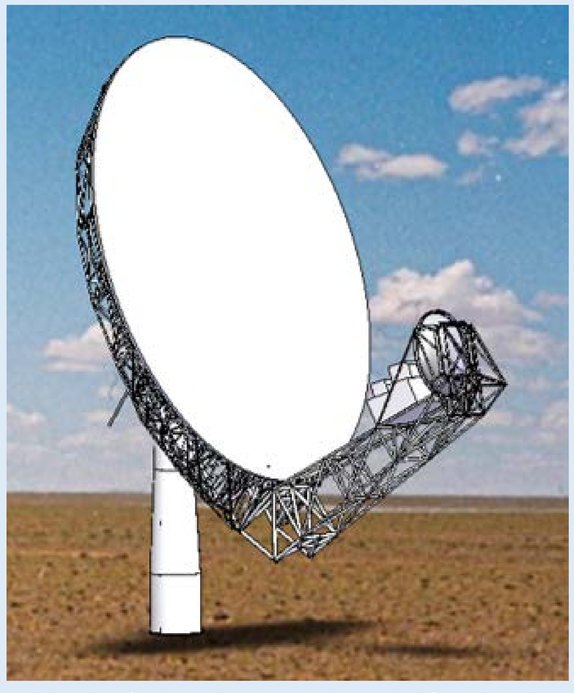


Figure 1: Front View of the General Dynamics Mission Systems 18m Reference Design Antenna

Abstract

The next-generation Very Large Array (ngVLA) is an astronomical observatory planned to operate at centimeter wavelengths (25 to 0.26 centimeters, corresponding to a frequency range extending from 1.2 GHz to 116 GHz). The observatory will be a synthesis radio telescope constituted of approximately 214 reflector antennas each of 18 meters diameter, operating in a phased or interferometric mode. The telescope will also include a short baseline array of 19 6m aperture antennas.

We provide an overview of the reference design for the ngVLA Antenna. The reference design is a low technical risk costed concept that will form the basis of the Astro2020 Decadal proposal. NRAO is also exploring leading-edge technology development in parallel to the reference design, to ensure that novel technologies are considered in the conceptual design down-select.

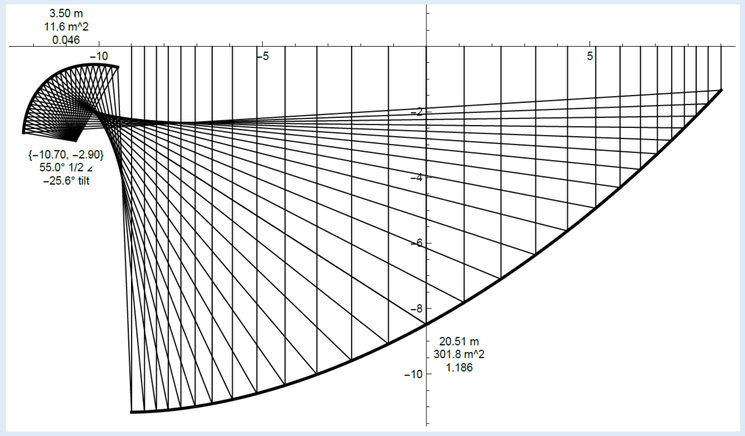
Optical Design

The antennas will be constituted of a shaped paraboloidal reflector, with a subtended circular aperture of 18m diameter. The optical configuration is an offset Gregorian feed-low design supported by an Altitude-Azimuth mount.

The subreflector will be supported so that neither it nor any of its supporting structure obstructs the aperture of the primary reflector. The off-axis geometry minimizes scattering, spillover, and sidelobe pickup, and the feed-low design facilitates maintenance and reduces shadowing in the core of the array.

The wide subtended angle of the subreflector leads to very compact feed designs that can be combined into a limited number of cryogenic dewars, reducing operations costs. The design employs shaped reflectors, with a near uniform illumination pattern, optimized for single pixel feeds.

The reference optical design was developed by Lynn Baker in collaboration with the National Research Council of Canada.



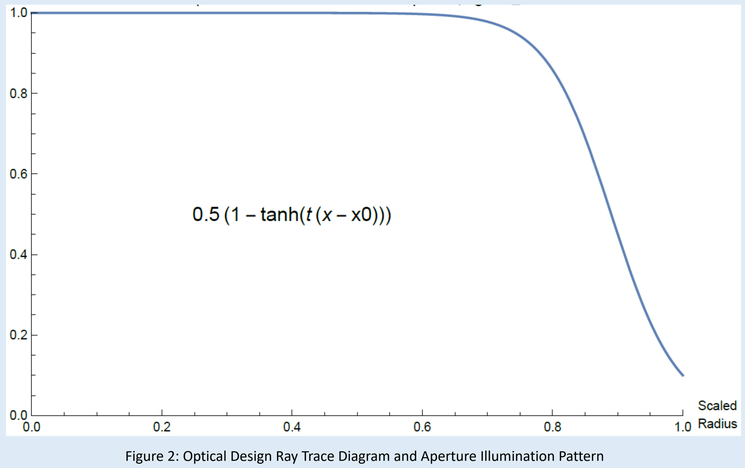


Figure 2: Optical Design Ray Trace Diagram and Aperture Illumination Pattern

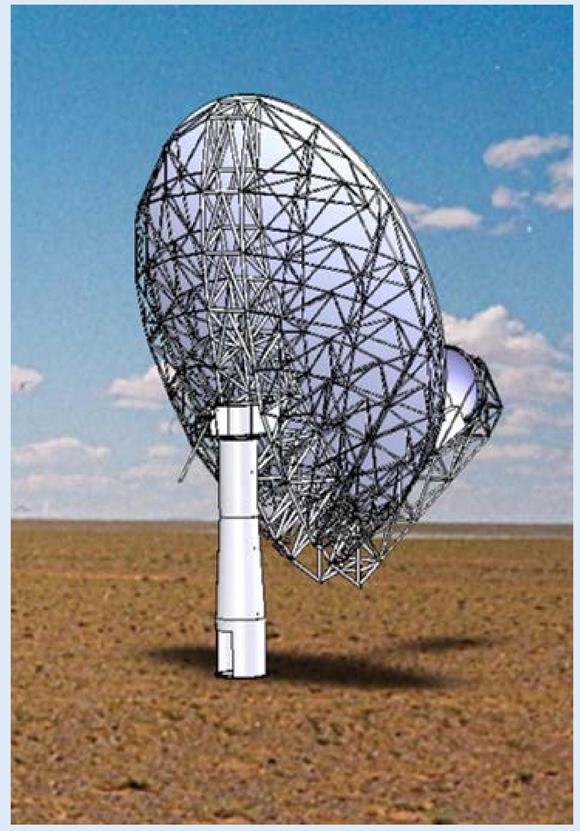


Figure 3: Rear View of the General Dynamics Mission Systems 18m Reference Design Antenna. The backup structure employs a radial pattern with a central cavity to eliminate interference with the pedestal. The azimuth bearing supports a turnhead and jackscrew for the elevation drive.

Key Performance Parameters

Parameter	Summary of Requirement
Frequency Range	1.2-116 GHz
Diameter	18m
Number of Antennas	214
Surface Accuracy	**Precision Operating Conditions** 160 µm RMS (λ/16 @ 116 GHz), primary and subreflector combined. **Normal Operating Conditions** 300 µm RMS, primary and subreflector combined.
Pointing Accuracy	**Precision Operating Conditions:** (4 deg angle, 15 min time) Absolute pointing: 18 arc sec RMS Referenced pointing: 3 arc sec RMS **Normal Operating Conditions:** (4 deg angle, 15 min time) Absolute pointing: 35 arc sec RMS Referenced pointing: 5 arc sec RMS
Tracking Range	Azimuth: ± 270 deg Elevation: 12 deg to 88 deg
Movement Rate	Slew: Azimuth 90 deg/min, Elevation 45 deg/min. Tracking: Azimuth 7.5 deg/min, Elevation 3.5 deg/min.

Further Information

R. Selina et. al. *ngVLA Antenna: Preliminary Technical Specifications*. ngVLA Doc. 020.25.00.00.00-0001-SPE. Rev B. 2018.
L. Baker. *ngVLA Optical Reference Design*. ngVLA Doc. 020.25.01.00.00-0001-REP. Rev A. 2018.

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