Table 1: ngVLA Key Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna Diameter</td>
<td>6m &amp; 18m</td>
</tr>
<tr>
<td>Number of Antennas</td>
<td>244 x 18m, 12 x 6m</td>
</tr>
<tr>
<td>Antenna Optics</td>
<td>Offset Gregorian, Feed Low, Shaped</td>
</tr>
<tr>
<td>Frequency Range</td>
<td>1.2 GHz – 50.5 GHz, 70 GHz – 116 GHz</td>
</tr>
<tr>
<td>Surface Accuracy (Precision Operating Conditions)</td>
<td>160 µm RMS</td>
</tr>
<tr>
<td>Painting Accuracy (Precision Operating Conditions)</td>
<td>18 arc sec RMS, 3 arc sec RMS</td>
</tr>
</tbody>
</table>

Antenna Design Study

The NRC has conducted design studies for 6m and 18m Offset Gregorian, Feed-low, Azimuth/Elevation antennas for the ngVLA. NRC’s experience is that the technical requirements will not push technical boundaries but that the key challenge will be to deliver a design that can be manufactured in volume, delivered affordably with low maintenance and total lifecycle costs. The designs generated as part of these studies are not expected to be the final design. The specifications for the final antenna design may change based on lessons learned in this design exercise or other parallel activities. The goal is to pursue a novel approach to antenna design, that may offer greater value than traditional manufacturing techniques.

The design work has concentrated on the 18m, Figure 1, as it presents the higher risk/challenge. Lessons learned on the 18m will be applied to the 6m as appropriate.

Primary Reflector Structure

The NRC ngVLA antenna design is based on the Single-piece Rim-supported Composite (SRC) reflector technology developed at NRC over the past decade. The SRC concept has been successfully implemented in the DIVAL antenna, designed to work up to 50GHz, and in the DUAL reflector, designed to work up to 6GHz.

Both of these antennas used a tubular steel frame Back-Up Structure (BUS).

In scaling the concept to 18m, it was found that it was not possible to meet the surface accuracy requirements for 116GHz operating frequency with the discrete attachment points between the BUS and reflector surface. A composite outer BUS (oBUS) was developed to provide continuous support for the reflector surface, Figure 2, enabling much higher surface accuracy under loading to be achieved.

Primary Surface Adjustment

The initial surface accuracy is largely dependent on the accuracy of the mold but in order to achieve and maintain the required surface accuracy NRC has developed a surface adjustment concept that incorporates ~200 adjusters around the perimeter of the primary reflector surface. Figure 4 shows a cross-section of the adjuster concept. Figure 5, a slice of an asymmetrical reflector model, illustrates the improvement that can be made with the adjusters.

Mount

In an earlier design study NRC had explored the ‘wheel and track’ concept for a 15m ngVLA capable antenna, however the cone oBUS developed for the 18m lends itself well to a pedestal/yoke style of mount. Figure 6. The oBUS is mated to a fabricated steel inner Back-Up Structure (IBUS) at 11 discrete points. The elevation axis and elevation drive are both incorporated into the IBUS.

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 244 reflector antennas, each of 18 meters diameter and 19 antennas of 6m diameter, operating in a phased or interferometric mode.

The NRC has conducted a design study for 6m and 18m Offset Gregorian, Feed-low, Azimuth/Elevation antennas for the ngVLA. The goal is to pursue a novel approach to antenna design, that may offer greater value than traditional manufacturing techniques.

We provide an overview of the current status of the NRC 18m antenna design study. The concepts for major antenna elements such as the primary reflector, mount, and drive system are presented. We also describe the major development activities that are presently underway to advance the design.

Axis Drives

The size and pointing requirements of the ngVLA require powerful, stiff axis drive systems. Direct drive systems such as those in use on the ALMA European and Japanese antennas have proven to provide exceptional performance. A trade study is underway to compare direct drives to more conventional gear train drives. The study will consider performance, capital cost and operating costs. For the current design study the NRC team, working with Phase USA, has incorporated direct drives on the ngVLA 18m antenna. The current pedestal and IBUS design are compatible with both drive types so development of the design has carried on in parallel to the drive study.

Future Work

Development is ongoing at NRC in several areas:

- Design and analysis of the multi-piece concept.
- Drive technology trade study.
- Materials testing and characterization.
- Manufacturing process characterization.
- Control system development.
- Prototype planning.

Multi-piece Reflector for Off-plains Antennas

The SRC concept requires that the fully assembled primary reflector be transported to the antenna station. This is feasible for ~12m of the antennas located on the Plains of St. Agaton, for the remaining antennas NRC is developing a method of segmenting the single piece surface for transport and reassembly at the antenna station.

While still on the mould after manufacture a series of attachment flanges are bonded on to the single piece surface. It is then moved to a cutting jig where it is cut into 4 pieces, Figure 9. The cut surface sections can then be transported to the antenna station, Figure 10, where an assembly jig (similar to that in Figure 9) will be used to reconstruct the complete surface and attach the oBUS.