ngVLA Memo #69

Remote Service Station Study

K. Renda, M. Luce, A. Erickson

December 6, 2019

Abstract

This study will attempt to identify the number and locations of Remote Service Stations (RSSs) that would provide ample support for ngVLA antennas outside the core and the ngVLA central Maintenance Center. Additionally, this study will contrast RSSs cost against transport for maintenance teams to repair the antennas over the design life of ngVLA. From this analysis, it was determined that paying for maintenance team overnight trip costs is slightly more cost efficient than purchasing and outfitting RSSs for the routine maintenance of ngVLA over its 20 year design life.

1 Objectives

The purpose of this study is to:

- Identify the number and locations of RSSs to support ngVLA antennas outside the core
- Contrast RSS cost versus transport cost for maintenance teams

2 Assumptions

In order to reduce the number of variables within this analysis, several assumptions were made:

- Long Baseline Array (LBA) sites are not to be included in the study
- All failures that occur on antennas are from line replaceable units
- All salaries, tools, and travel equipment necessary for repairs are the same for RSS and overnight trip scenarios
- Land cost of RSS buildings is assumed to be $0
- Each failure that occurs on each antenna is equal to the total number of required visits to the antenna
- All trips must be completed within a single 10 hour work-day for the RSS scenario
- There are four technicians per maintenance team that are transported by one vehicle

2.1 Number of Failures per Antenna

As listed in ngVLA 020.10.15.10.00-003-REQ-A System Requirements, the mean time between failure (MTBF) of each antenna is 2,190 hours. Additionally, requirement SYS2801 states that ngVLA is being designed for an expected operational life of no less than 20 years.

In order to find the total number of failures each antenna would have over the course of its 20 year design life, the assumption has been made that all LRU failures are best fit by the exponential reliability model $R(t) = e^{-\lambda t}$, where $\lambda = \frac{1}{MTBF}$. Using this and the design life of ngVLA in hours, there are estimated to be 80 failures at every antenna.

3 Potential RSS Locations

Based on the current ngVLA configuration, there are 18 antennas that are located outside a 150 mile radius (a 3 hour one-way trip) of the core. All of the antennas within the 150 mile radius can be visited and repaired within a 10 hour work-day. Two of the 18 antennas located outside the 150 mile radius of the core are accessible to maintenance teams stationed at the core. These two antennas are just slightly further along the routes used to service the spiral arm antennas and therefore do not require an RSS. Of the remaining 16 sites, three of these are LBA sites (Los Alamos, Kitt Peak, and Fort Davis) which are also excluded from this RSS analysis.

For the remaining 13 antennas, there are two locations suitable for RSSs outside the core: Plains, TX and site M112 (the closest site to the border of Mexico). The RSS in Plains, TX would be responsible for 7 antennas and the RSS at site M112 would be responsible for 5 antennas. Both of these locations allow round-trip drive times up to 6 hours long for the repair of an LRU.

The RSS antenna allocation described in the previous paragraph leaves one antenna unaccounted for. Site M116, located just outside Ozona, TX, is outside any potential service area. With RSSs placed at the aforementioned locations, site M116 would still require a three day trip for any repair. Therefore site M116 will be removed from the RSS and overnight trip scenarios to be costed individually in Section 6 of this document.

4 Modeled Costs of RSSs

A 2,000 sf warehouse was used for the cost analysis of purchasing or leasing an RSS in Plains, TX and at site M112. Since there is no major city near site M112, warehouse prices were examined in El Paso, TX. There were also no warehouses of similar size found in Plains, TX so cost is based on warehouses found in Midland, TX. Internet, phone, electricity, cooling, and water costs are estimated to be $1,500 per month per RSS.

Table 1: RSS Costs

Site	Purchased	Leased
Plains, TX	$657,000	$1,480,000
Site M112	$585,000	$1,080,000

The total costs for purchasing both RSSs is approximately $1,242,000 for the 20 year design life of ngVLA. The costs for leasing both RSSs is approximately $2,560,000 for the 20 year design life of ngVLA.

Dollar values are approximate and given in base year 2019.

NOTE: A major risk to having RSSs is that as a Federally Funded Research and Development Center we cannot purchase insurance for items stored within a warehouse, so there would be additional costs for security that have not been accounted for in this cost analysis. There is expected to be 10% of spares per antenna serviced stored within a RSS, totaling up to $240,000 of parts and materials that will be stored in RSSs for the 12 antennas they collectively service.

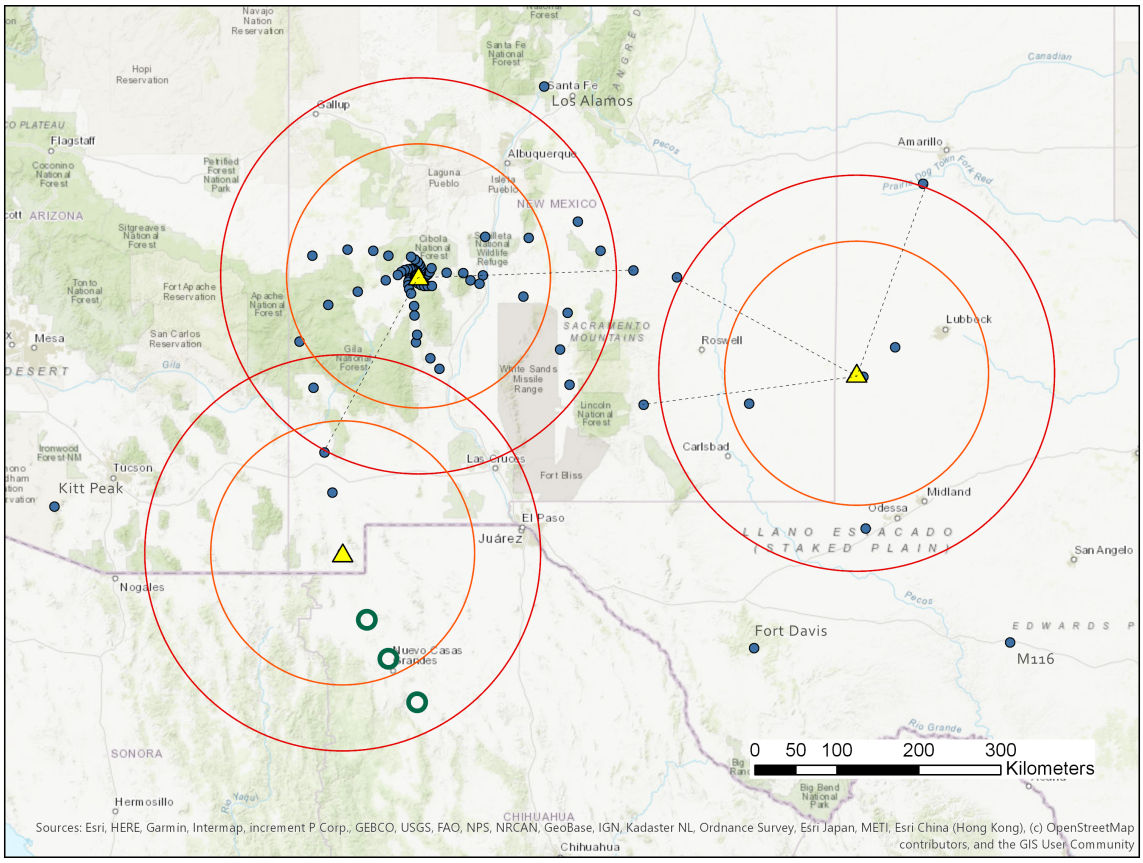

Figure 1: Potential locations of RSSs and the ngVLA central Maintenance Center are indicated by yellow triangles. Sites located within Mexico are indicated by a green ring around the site. The smaller radius circle around each potential RSS location and the Maintenance Center indicates a 100 mile radius. Similarly, the larger radius circle indicates 150 mile radius from the service station. Dotted lines from the core and potential RSS location to specific antennas signify repair ownership.

All ngVLA antenna locations shown are based off of the Revision C of the Reference Array Configuration as described in ngVLA 020.23.00.00.00-0002-DSN Array Configuration: Reference Design Description. All images and drawings of ngLVA antenna locations in this document are approximate. All information about the location of ngVLA antennas is subject to change and further revision.

5 Modeled Costs of Overnight Trips

An alternative to purchasing or leasing RSSs is to treat each failure at the 12 antennas outside a 150 mile radius from the core as a "Tiger Team" antenna visit. With 80 projected failures per antenna over its 20 year design life, each of the 12 antennas will require 4 maintenance team visits per year. Therefore, there will be 48 overnight trips per year to service these 12 antennas. The average hotel rate for New Mexico is estimated to be $100. Hotels in western Texas were estimated to cost 10% more than hotels within New Mexico. Each technician in the maintenance team is to have their own hotel room for one night for each repair trip. Additionally, the GSA mileage rate for 2019 is $0.58 per mile and the GSA per diem rate is $55.

In order to estimate the expected total miles per visit, arbitrary mileage zones were chosen to be at 200 miles and 300 miles from the core. The driving distance from the hotel to the antenna is assumed to be included in the estimated total mileage from the core. There are 4 antennas that fall at about 200 miles

from the core, and the remaining 8 are considered to be at 300 miles from the core. For 80 trips to each of the 12 antennas outside the ngVLA core, the total costs of overnight stays is estimated to be $1,010,560 for the 20 year design life of ngVLA. This gives an average design life overnight trip service cost for each of the 12 antennas to be $84,214 for the 20 year design life of ngVLA.

NOTE: One risk to servicing antennas through overnight stays is the potential degradation of personnel morale from excessive travel. While this risk can not be accounted for monetarily, it can still have an effect on the overall success of servicing antennas via overnight trips.

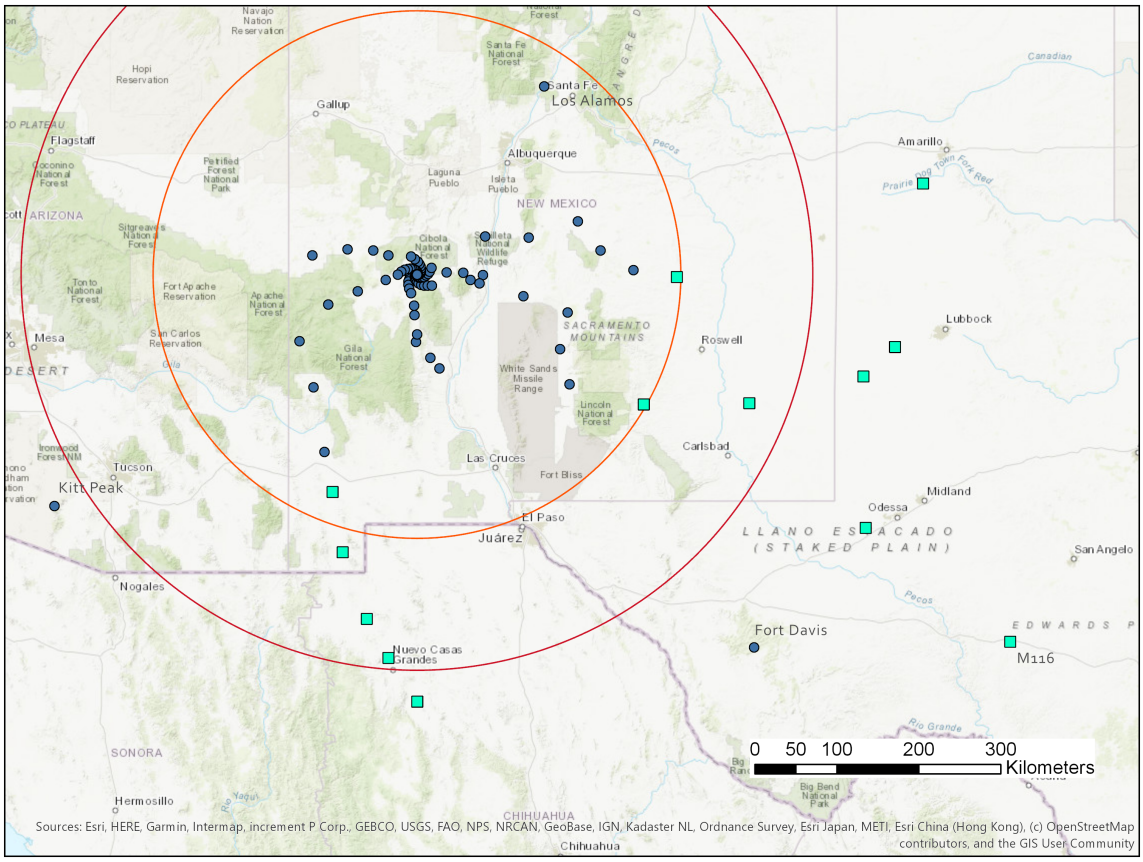

Figure 2: The 12 antenna sites that would require overnight visits are indicated by a teal square. Site M116 is also labeled and marked with a teal square to show distance comparison. The smaller radius circle around the ngVLA core indicates a 200 mile radius. Similarly, the larger radius circle indicates 300 mile radius from the ngVLA core.

All ngVLA antenna locations shown are based off of the Revision C of the Reference Array Configuration as described in ngVLA 020.23.00.00.00-0002-DSN Array Configuration: Reference Design Description. All images and drawings of ngLVA antenna locations in this document are approximate. All information about the location of ngVLA antennas is subject to change and further revision.

6 Modeled Cost of Servicing Site M116

The cost of site M116 was calculated following the same method used for the overnight trips, with the caveat that the trip to this antenna site would take three days. The first day is for driving to M116, another day is for repairs, and the final day is for driving back to the core. Similar to the overnight trip scenario, servicing M116 would require maintenance teams to visit the antenna 4 times per year. Site M116 is estimated to be 450 miles from the ngVLA core. Using the same hotel, per diem, and mileage rates the total cost for servicing site M116 for the 20 year design life of ngVLA is $156,160. This cost must added to the RSS costs and overnight stays costs to achieve an accurate representation of the total service cost for each of the scenarios. Dollar values are approximate and given in base year 2019.

7 Conclusions

If RSSs are to be used for ngVLA, it is fiscally prudent to purchase the land that will house each RSS. With that being said, Internet, phone, and utility costs over a 20 year span contribute a significant amount to the total purchasing cost of an RSS. Ultimately, it is slightly more cost efficient to pay for overnight trip costs than it is to purchase and outfit RSSs for the maintenance of the 12 antennas outside a 150 mile radius from the ngVLA core.

Table 2: Modeled Cost Comparison over 20-year period

Purchased RSSs	Leased RSSs	Overnight Lodging
$1,242,000	$2,560,000	$1,010,560

Dollar values are approximate and given in base year 2019.