Civil and Infrastructure Subsystems Requirements Specification

020.60.00.00.00-0003-REQ

Status: **RELEASED**

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Change Record

Version	Date	Author	Affected Section(s)	Reason
01	2022-03-10	Selina	All	Initial draft for System CDR.
02	2022-03-11	Kusel	All	Edits and additions throughout draft.
03	2022-03-16	Selina	7.1.4, 14.1	Updated ESD standards for building spaces.
04	2022-03-28	Selina		Incorporating input from K. Swift.
A	2022-03-29	Lear	All	Formatting, copy edits. Prepared PDF for signatures and release.

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1 Introduction

1.1 Purpose

This document presents a preliminary set of Level 2 subsystem requirements that guide the design and development of the Civil & Infrastructure subsystems: the Array Infrastructure, the ngVLA Site Buildings, Operations Buildings, Science Data Center, and Science Operations Building. The Visitor Center Building is not included.

Requirements described in this document are derived from applicable ngVLA System Requirements and System-Level Specification documents as listed in the Applicable Documents table. The building specifications are closely tied to the Operations Concept [RD01] and maturing Operations Plan [AD10] for the facility, as these structures must support the operational staffing levels and operational support functions that will reside and be conducted in each space. As supporting infrastructure for the array, both the buildings and array infrastructure are also strongly influenced by interface-driven requirements from subsystems they house or provide services to. These interface driven requirements are still evolving and will continue to be refined through the system PDR. The engineering process and requirements hierarchy that govern this specification are defined in [AD01] and [AD02] respectively.

The content of these requirements is at the subsystem level, conforming to the system architecture [AD06], but aims to be implementation agnostic within the subsystem boundaries. Some assumptions about the subsystem may be given, but only to the degree necessary to unambiguously define the subsystem requirements.

1.2 Scope

The scope of this document is the specification of multiple subsystems managed by the Civil & Infrastructure IPT, including the Array Infrastructure sub-system (CI 020.60.00.00.00) and the identified buildings required to support the facility and operations concept: the ngVLA Site Buildings (CI 020.61.10.00.00), Operations Buildings (CI 020.65.00.00.00), Science Data Centre (CI 020.61.05.00.00) and Science Operations Building (CI 020.61.15.00.00). For each subsystem, this includes:

- Assumptions on which the requirements are based.
- Definition of environmental conditions to be used in the definition of requirements.
- A complete set of requirements for the subsystem needed for the development, operation and maintenance of the subsystem, including interface requirements that are derived from the applicable list of ICDs.
- Numbering of all requirement and establishment of traceability to higher level requirements.
- Verification requirements and their traceability to the subsystem main requirements.
- Identification of Key Performance Parameters (KPPs) at the subsystem level.

The Level 2 Subsystem Requirements, along with detailed explanatory notes, are found starting in Section 6. The notes contain elaborations regarding the meaning, intent, and scope of the requirements. These notes form an important part of the definition of the requirement. In many cases, the notes contain an analysis of how the numeric values of requirements were derived to ensure correct interpretation of the requirements and to resolve ambiguity.

In cases where the requirements analysis is incomplete, such values are marked with TBD or TBC, which need to be resolved before the final specification is published.

2 Related Documents and Drawings

2.1 Applicable Documents

The following documents apply to this Requirements Specification to the extent specified. In the event of a conflict between the documents referenced herein and the content of this Requirements Specification, the content of the highest-level specification (in the requirements flow-down) shall be considered the superseding requirement for design elaboration and verification.

Ref. No.	Document Title	Rev./Doc. No.
AD01	ngVLA Systems Engineering Management Plan	020.10.00.00.00-0001-PLA
AD02	ngVLA Requirements Management Plan	020.10.15.00.00-0001-PLA
AD03	ngVLA System Requirements	020.10.15.10.00-0003-REQ
AD04	L1 System Environmental Specifications	020.10.15.10.00-0001-SPE
AD05	L1 System EMI/RFI Requirements	020.10.15.10.00-0002-REQ
AD06	System-Level Architecture Model	020.10.20.00.00-0002-DWG
AD07	L1 Safety Specification	020.80.00.00.00-0001-REQ
AD08	L1 Security Plan & Requirements	020.80.00.00.00-0003-REQ
AD09	ngVLA Electronics Specifications	020.10.15.10.00-0008-REQ
AD10	Operations Plan	020.10.05.00.00-0003-PLA

2.2 Applicable ICDs

The following ICDs define the external boundary of this subsystem and are applicable to its specification:

Ref. No.	Document Title	Rev./Doc. No.
AD20	Antenna to Array Infrastructure ICD	020.10.40.05.00-0030-ICD
AD21	Short Baseline Antenna to Array Infrastructure ICD	020.10.40.05.00-0038-ICD
AD22	Environmental Monitoring to Array Infrastructure ICD	020.10.40.05.00-0072-ICD
AD23	Array Infrastructure to Operations Buildings ICD	020.10.40.05.00-0082-ICD
AD24	Array Infrastructure to ngVLA Site Buildings ICD	020.10.40.05.00-0083-ICD
AD25	Array Infrastructure to Monitor & Control ICD	020.10.40.05.00-0084-ICD
AD26	Array Infrastructure to Central Fiber Optic ICD	020.10.40.05.00-0085-ICD
AD27	ngVLA Site Buildings Combined ICD	020.10.40.05.00-0095-ICD
AD28	ngVLA Operations Buildings Combined ICD	020.10.40.05.00-0086-ICD
AD29	ngVLA Data Center Combined ICD	020.10.40.05.00-0089-ICD

2.3 Reference Documents

The following documents are referenced within this text or provide supporting context:

Ref. No.	Document Title	Rev./Doc. No.
RD01	Operations Concept	020.10.05.00.00-0002-PLA
RD02	Array Configuration Design Description	020.23.00.00.00-0002-DSN
RD03	Size-of-Computing Estimates for ngVLA Synthesis Imaging	ngVLA Computing Memo #4

3 Overview of Subsystems

3.1 Array Infrastructure (INF)

The Array Infrastructure subsystem will support system operations, including scientific and array operations, array maintenance and engineering, and array development. Five primary components have been identified as elements of the Array Infrastructure, shown in Figure 1:

1. **Antenna Foundations** serve as physical anchors to support stability requirements for the antennas in the ngVLA system. This category also includes the foundations necessary to support other system elements like the glycol chiller, transformer pads, and weather station pads.
2. **Operations roads** provide unrestricted access to operational facilities, antennas, and other array infrastructure to support maintenance and operational activities.
3. **Utility Trenches** house electrical and fiber cabling between the array facilities and antennas, with specific focus to the Plains of San Agustin. Interfacing with existing power and fiber infrastructure will likely be necessary outside of Plains.
4. **Fiber Utility** identifies the components required to support fiber installation and maintenance. Interfacing with existing fiber systems will be necessary outside of the Plains. FIB will inform the high-level design of fiber infrastructure but INF will be responsible for the construction of underground and pole-strung fiber as part of broader civil construction contracts.
5. **Electrical Utility** identifies the elements required to support electrical service installation, support, and maintenance, as well as central generator back up capabilities and associated switch gear.

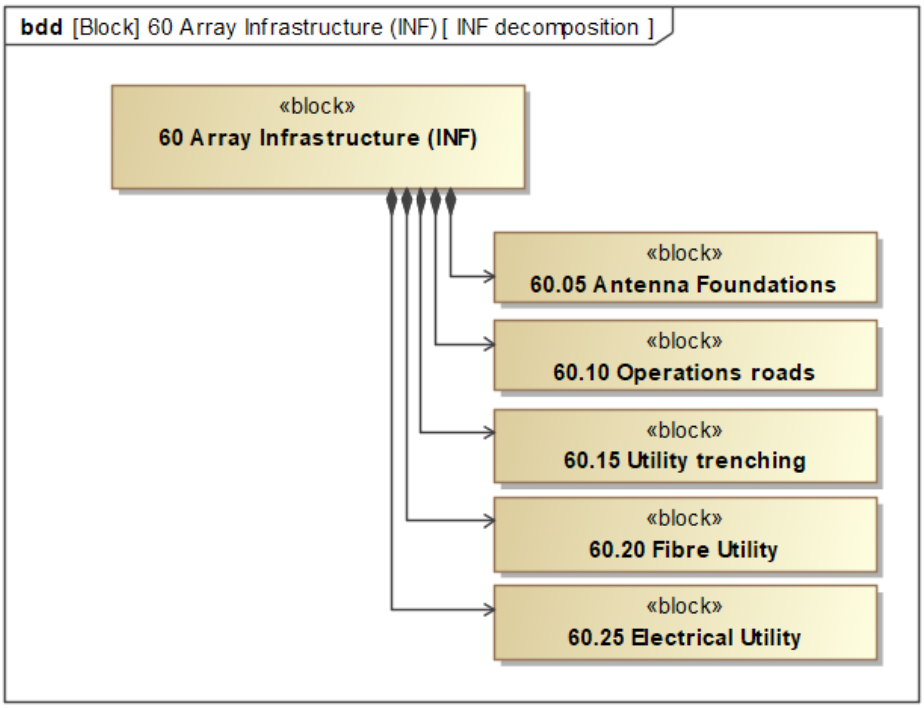

Figure 1: Array Infrastructure subsystem decomposition.

Array Infrastructure interfaces to other subsystems, and associated ICD information, are shown in the context diagram in Figure 2 (on the next page).

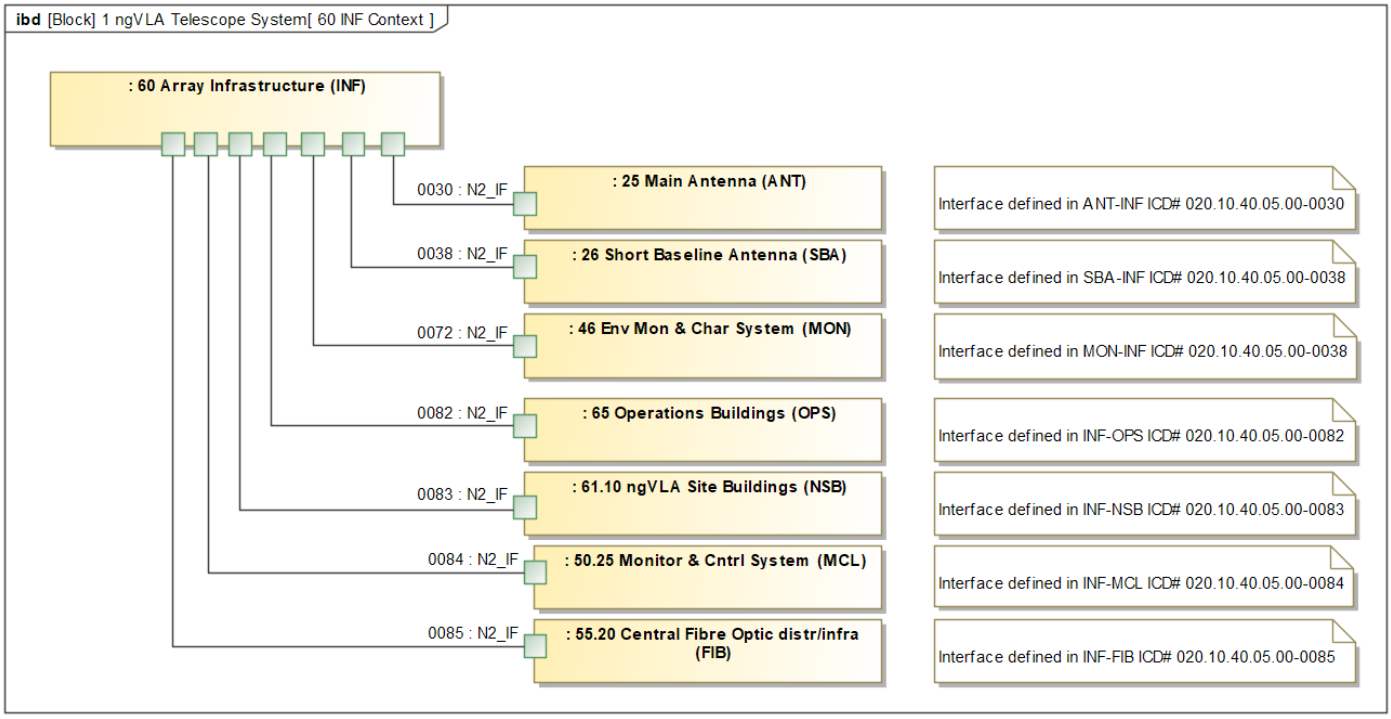

Figure 2: Array Infrastructure context diagram.

3.2 Buildings (BLD)

Various buildings are needed to support operations across the system as shown in Figure 3 below. These include buildings to support the hosting of telescope equipment, maintenance operations, science operations, and outreach activities.

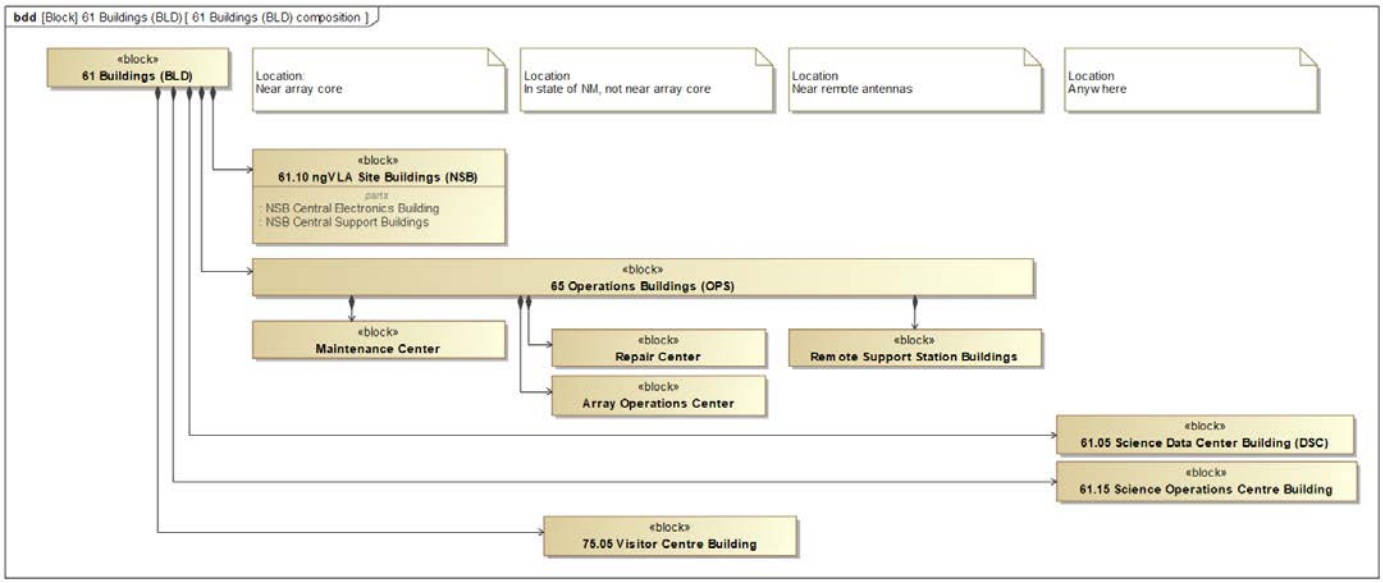

Figure 3: Buildings decomposition and location.

3.2.1 ngVLA Site Buildings (NSB)

The major facility for NSB is the Central Electronics Building that will house the central signal processor, central IT infrastructure, and time and frequency generation and distribution equipment.

The ngVLA Site Buildings also include Central Support Buildings to support maintenance operations on site, such as a warehouse, heavy equipment storage, garages, and security facilities.

NSB interfaces to other subsystems, and associated ICD information, are shown in the context diagram in Figure 4. These interfaces pertain mainly to the interfaces to the Central Electronics Building:

1. Interfaces between array infrastructure and the Central Electronics Building, including power supply interfaces and fiber utilities.
2. Central Electronics Building interfaces to hosted equipment for the supply of space, power, cooling, etc.

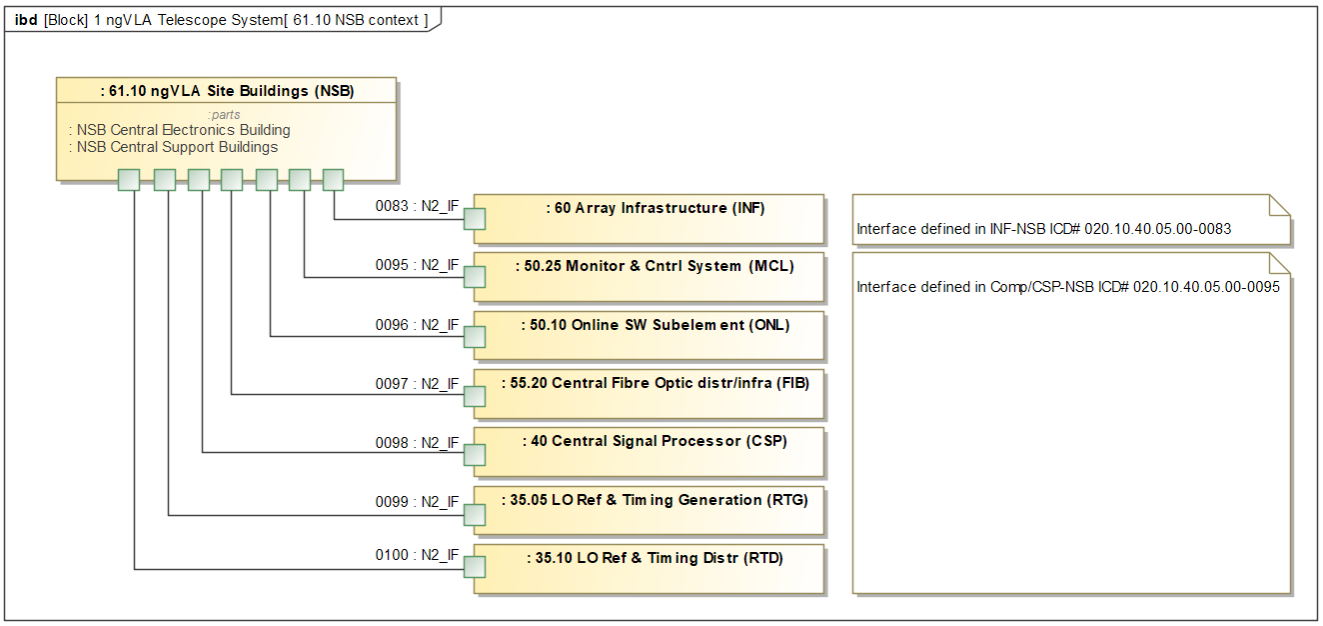

Figure 4: ngVLA Site Buildings context diagram.

3.2.2 Operations Buildings (OPS)

Operations buildings encompass a wide range of buildings to support array operations and maintenance across the full physical extent of the array. These include:

- Near the array core:
  - Maintenance Center
- Within the State of New Mexico:
  - Array Operations Center
  - Repair Center
- At LBA stations and remote mid-baseline antenna sites:
  - Remote Support Station Buildings

The **Maintenance Center** will serve as a central duty station for safety, security, and maintenance personnel, as well as maintenance activities and ready spare storage. The Maintenance Center will include garages for equipment and vehicles.

The **Array Operations Center** provides office and laboratory space, as well as storage and transfer capabilities, and computing infrastructure operations staff. It will be co-located with the Repair Center.

The **Repair Center** is collocated with the Array Operations Center. It will serve as the location for diagnostic, repair, and test activities for electronic LRUs and other equipment. Parts that fail will be sent to the Repair Center for repair, and then will be returned to the Maintenance Center as ready spares.

The **Remote Support Stations** will include all the operations buildings that are required for the long baseline antennas and for antennas in remote locations that cannot be serviced from the Maintenance Center.

OPS interfaces to other subsystems, and associated ICD information, are shown in the context diagram in Figure 5.

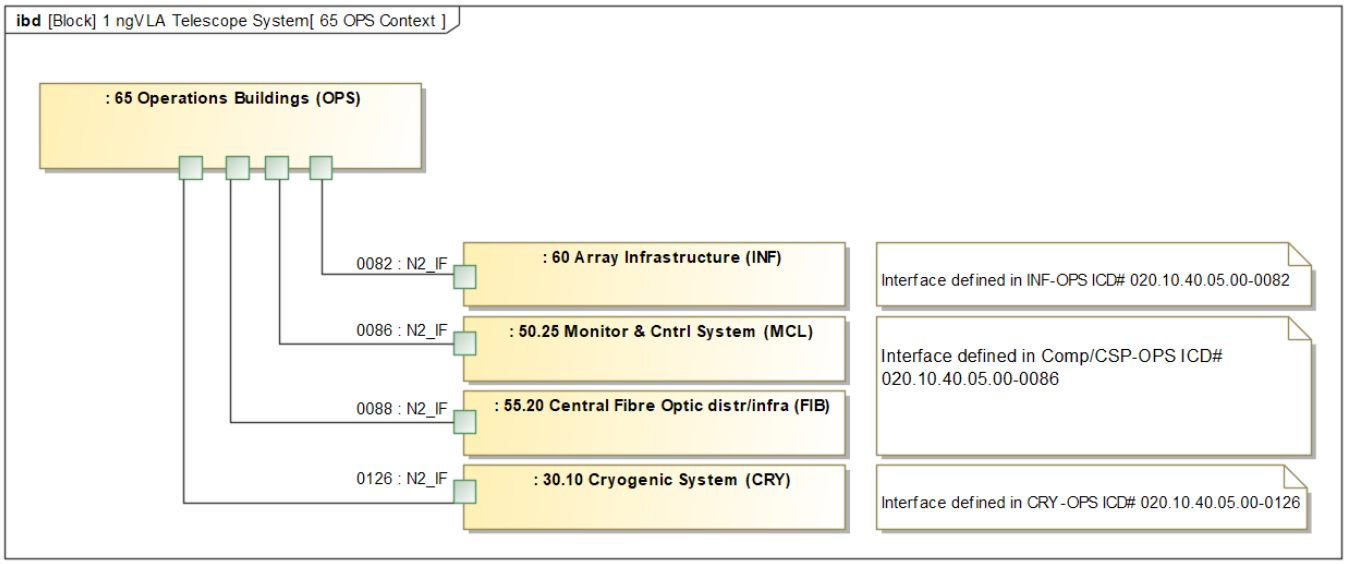

Figure 5: Operations Building context diagram.

3.2.3 Science Operations Center (SOC) and Data Centre Building (DSC)

The **Science Operations Center and Data Center Building** will likely be located in a large metropolitan area. It hosts mainly two activities:

1. ngVLA Science Operations Center: This facility supports research, development, and software operations staff and will primarily consist of office space. It will host staff that do not need regular access to the antenna sites, such as staff scientists, firmware and software engineers and staff responsible for the maintenance of the data center.
2. Science Data Center: This facility will house high performance computing equipment for the offline processing system that is responsible for post-processing data products. It will also include the storage equipment required for data archiving.

DSC interfaces to other subsystems are shown in the context diagram in Figure 6. The managed interfaces are mainly related to the hosting requirements of the computing equipment including space, power and cooling interfaces.

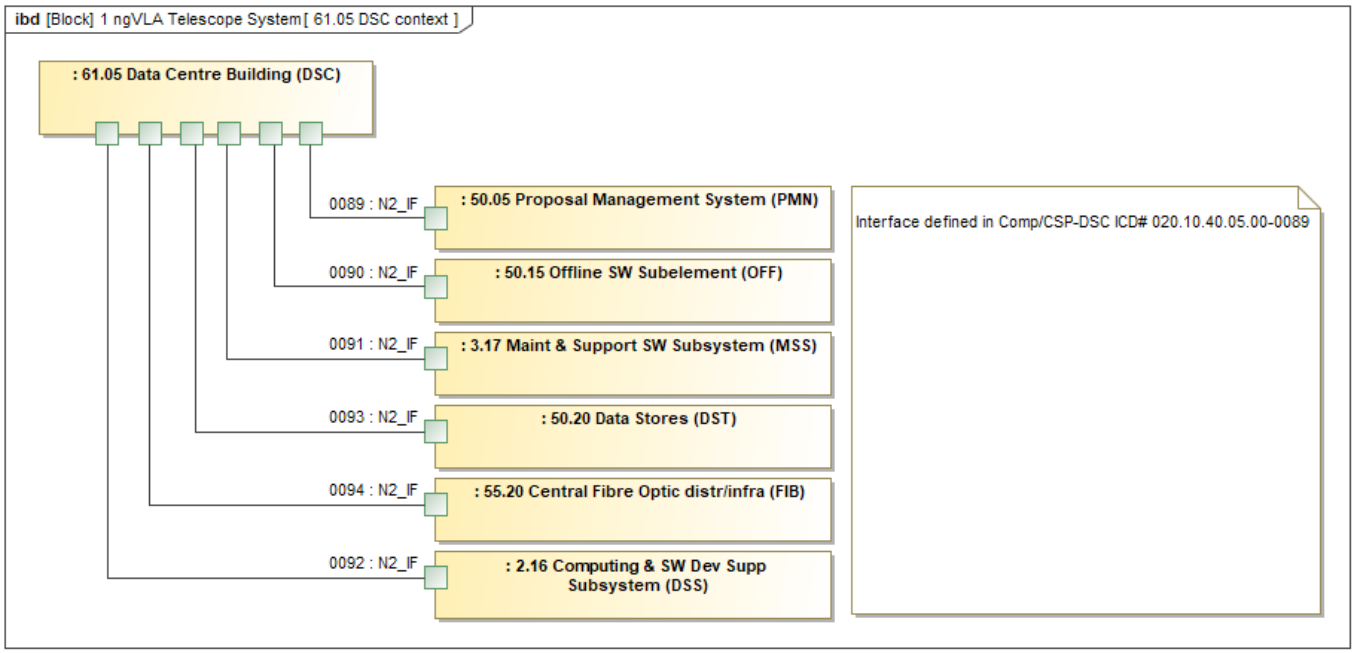

Figure 6: Data Science Center Building context diagram.

3.2.4 Visitor Center

The visitor center supports public outreach and engagement with the ngVLA facility and radio astronomy more broadly. The Visitor Center will be located on the plains of San Agustin, accessible from Highway 60, but not adjacent to the array core. Locating this building at a distance from the core, while still maintaining proximity to the array, will minimize radio frequency emission impact to the array while still providing an immersive public interaction experience with the array.

The requirements for the Visitor Center will be documented and managed separately from this Requirements Specification.

4 Requirements Management

4.1 Requirements Definitions

Consistent with the Requirements Management Plan [AD02], the following definitions of requirement "levels" are used in the ngVLA program. This requirements document in this document are at the L2 subsystem level.

Requirement Level	Definition
L0	User requirements expressed in terms applicable to their needs or use cases (Science Requirements or Stakeholder Requirements)
L1	Requirements of the System, expressed in technical functional or performance terms (System Level Requirements)
L2	Requirements that define a specification for an element of the system, presuming a system architecture (Subsystem Requirements)

4.2 Requirements Flow Down

Figure 7 shows the relationships between these Subsystem (L2) requirements and the System (L1) requirements from which they are derived. Only relevant requirements and context documents are shown.

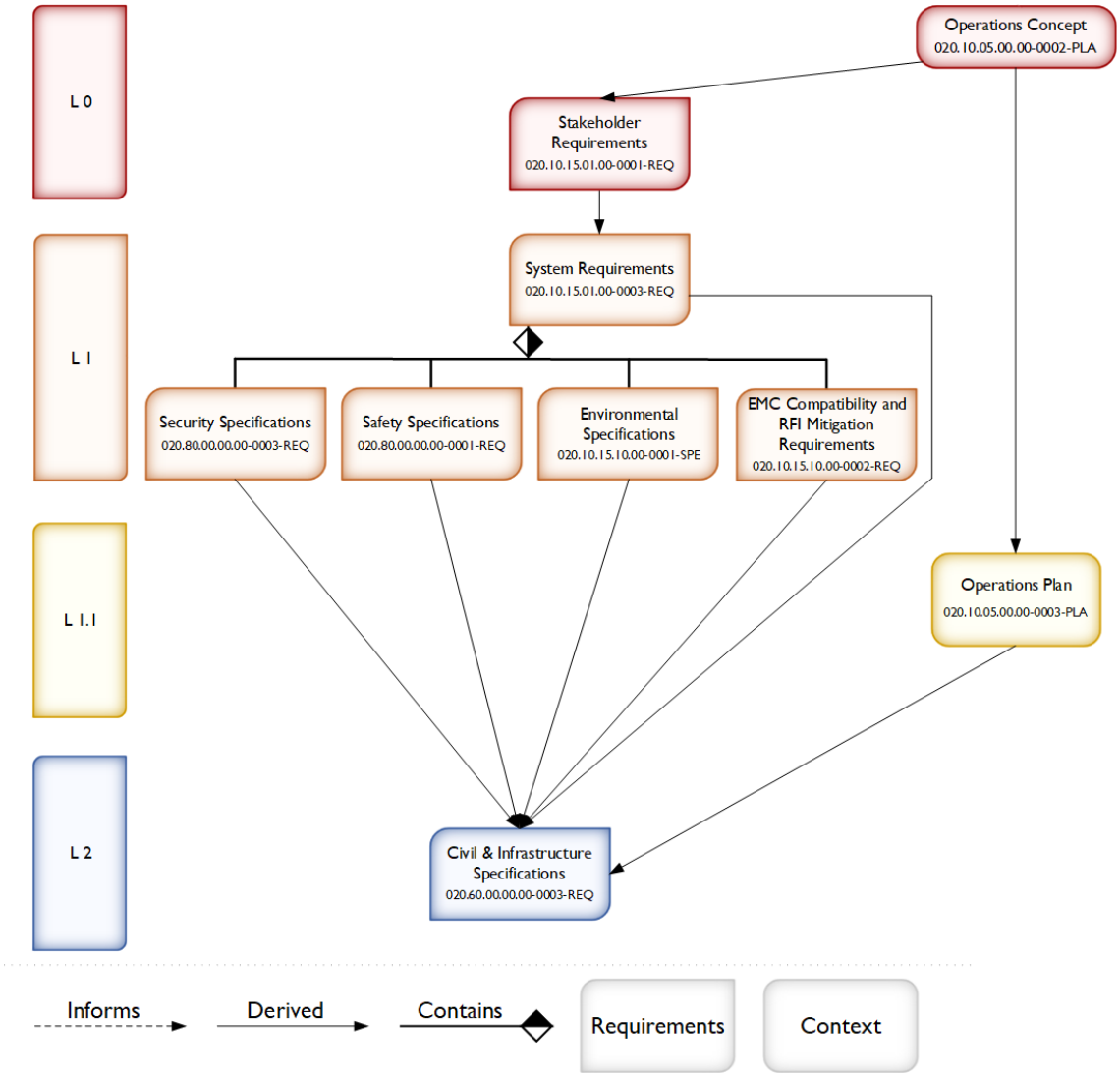

Figure 7: Requirements flow-down to the Civil & Infrastructure Subsystems Requirements Specification.

Individual subsystem specifications (Level 2) flow from the Level 1 requirements, and may not always be directly attributable to a single system requirement. For example, specifications at the system level may be apportioned to multiple subsystems, or a subsystem spec may be in support of multiple higher-level requirements. Completeness of the Level 2 requirements is assessed at the requirements review of each subsystem.

The civil and infrastructure requirements are unique in that a large portion of the building requirements are functional, and traceable in their specification to the Operations Plan for the facility. These operational requirements were captured at a high level, first as described in the Operations Concept and subsequently captured in the Stakeholder and System Requirements. The Operations Plan adds detail within the requirements and constraints established at the L0 and L1 level.

Many array infrastructure requirements are traceable to interface specifications, since specifications like antenna foundation stiffness are designed to support higher level requirements such as antenna pointing. Sizes and locations of the electrical and fiber optic infrastructure have similar interface-driven requirements.

While this is a top-down design process, the process is still iterative rather than a "waterfall" or linear process. The feasibility and cost of requirements implementation lead to trade-offs that feedback to higher-level requirements. The end goal is to build the most generally capable system that will support the Key Science Goals within the programmatic constraints of cost and schedule. Maintaining enumerated traceability between system requirements and subsystem requirements ensures that this trade-off process can be managed in a controlled way.

4.3 Verb Convention

This document uses "shall" to denote a requirement. The verb "should" denotes desired but not strictly required parameters. "Will" denotes a future happening. Desired but not required features are noted as "desirable" or "goals."

5 Assumptions

The following assumptions are made in the definition of these subsystem requirements:

- Hardware requirements apply to a properly functioning system under the standby conditions [AD04] unless explicitly stated otherwise.
- Hardware requirements assume that all system parts that would normally be in place during observations are working within their respective specifications (e.g., HVAC) unless explicitly stated otherwise.

6 Environmental Conditions and Environmental Protection Requirements

6.1 Array Infrastructure (INF) & Site Buildings (NSB)

6.1.1 Operating Environment

Parameter	Req. #	Value	Traceability
Solar Thermal Load	INF0360	Exposed to full sun, 1200W/m^2	ENV0360
Wind	INF0361	0 m/s ≤ W ≤ 30 m/s average	ENV0361
Temperature	INF0362	–25 C ≤ T ≤ 45 C	ENV0362
Precipitation	INF0363	Up to 5 cm/hr over 10 mins	ENV0363
Ice	INF0364	Equivalent to radial ice of 2.5 mm	ENV0364
Relative Humidity	INF0365	0 ≤ RH ≤ 100%; condensation permitted	ENV0365

The array infrastructure (INF) and site buildings (NSB) shall be designed to operate normally within the "standby" conditions defined in the System Environmental Specifications [AD04]. The standby conditions are adopted to reflect the fact that the supporting infrastructure systems must remain functional within the full range of conditions under which the array will operate or will resume operation.

6.1.2 Survival Conditions

Parameter	Req. #	Value	Traceability
Wind	INF0341	0 m/s ≤ W ≤ 50 m/s average	ENV0341
Temperature	INF0342	–30 C ≤ T ≤ 50 C	ENV0342
Radial Ice	INF0343	2.5 cm	ENV0343
Rain Rate	INF0344	16 cm/hr over 10 mins	ENV0344
Snow Load, Equipment & Buildings	INF0346	100 kg/m^2 on horizontal surfaces	ENV0346
Hail Stones	INF0347	2.0 cm	ENV0347

The array infrastructure and site buildings shall be built to withstand the survival conditions as described in the System Environmental Specifications [AD04] and the standards of local building codes, whichever is most demanding.

Survival conditions shall be withstood with no more than cosmetic or minor damage (defined as <1% of construction cost).

Graceful degradation in performance specifications is expected and permissible from the Standby conditions to the Survival conditions. E.g., HVAC systems may continue to function but fail to maintain the prescribed stability once the standby conditions are exceeded.

6.1.3 Storage Conditions

Parameter	Req. #	Value	Traceability
Storage Temperature	NSB0372	0 C ≤ T ≤ 30 C	ENV0372
Storage Relative Humidity	NSB0373	10 ≤ RH ≤ 90%	ENV0373

The ngVLA site buildings include storage areas for spares and consumable supplies used in array operation and maintenance. These areas shall maintain an indoor environment consistent with the storage conditions environment in the System Environmental Specifications [AD04].

6.1.4 Lightning

Parameter	Req. #	Value	Traceability
Lightning Protection, Structure	INF0511	The antenna, buildings, and housed equipment shall be protected from both direct and nearby lightning strikes, achieving Protection Level I as defined in IEC 62305-1/3. [AD02]	ENV0511
Lightning Protection, Electronics Systems	INF0512	The building and antenna electrical and electronics systems shall be protected against Lightning Electromagnetic Impulse (LEMP) in accordance with IEC 62305-4. [AD02]	ENV0512
Lightning Protection, Personnel	INF0513	A safety hazard analysis shall be performed for anticipated preventive maintenance tasks that may place personnel at risk in the event of direct or nearby lightning strikes.	ENV0513

Given the extent of the array and the prevailing environmental conditions, direct and nearby lightning strikes, causing a lightning electromagnetic pulse (LEMP), should be anticipated and mitigated in the antenna foundation design.

The lightning protection system shall be designed to achieve Protection Level I as defined by IEC 62305-1—Protection Against Lightning [AD02]. This level assures protection against 99% of strikes, with a residual risk of damage for strikes with parameters outside the defined range.

6.1.5 Seismic

Parameter	Req. #	Value	Traceability
Seismic Protection	INF0521	The system shall be designed to withstand a low-probability earthquake with up to 0.2g peak acceleration in either the vertical or horizontal axis.	ENV0521

Low probability has been defined as a 2% probability of an event exceeding this magnitude over a 50-year period, consistent with data available from the USGS Seismic Hazard Model [RD01]. Equipment shall be designed to survive this standard in any operational condition and orientation.

Buildings shall also conform to the relevant building code requirements for seismic protection consistent with their final site locations and jurisdictions.

6.1.6 Vibration

Parameter	Req. #	Value	Traceability
General Vibration	INF0531	All Line replaceable units packaged for transportation, shall be designed to withstand persistent vibration with a power spectral density defined in Figure 1. Line Replaceable Units shall be tested to this vibration specification along all three axes as defined in the MIL-STD-810H Method 514.8 Procedure I for General Vibration, for a period of 60 minutes.	ENV0531

An assessment will need to be performed on the array infrastructure design to determine if it has line replaceable units. Examples might include controller units for the generator and transfer switch, or other serviceable components in the design.

The vibration mitigation requirement is especially applicable to all mechanical connectors. All cables shall be mechanically supported to mitigate vibration loosening of connectors. This specification is not intended to preclude the use of commercial equipment in the array infrastructure design. Alternative standards may be proposed for commercial off-the-shelf devices.

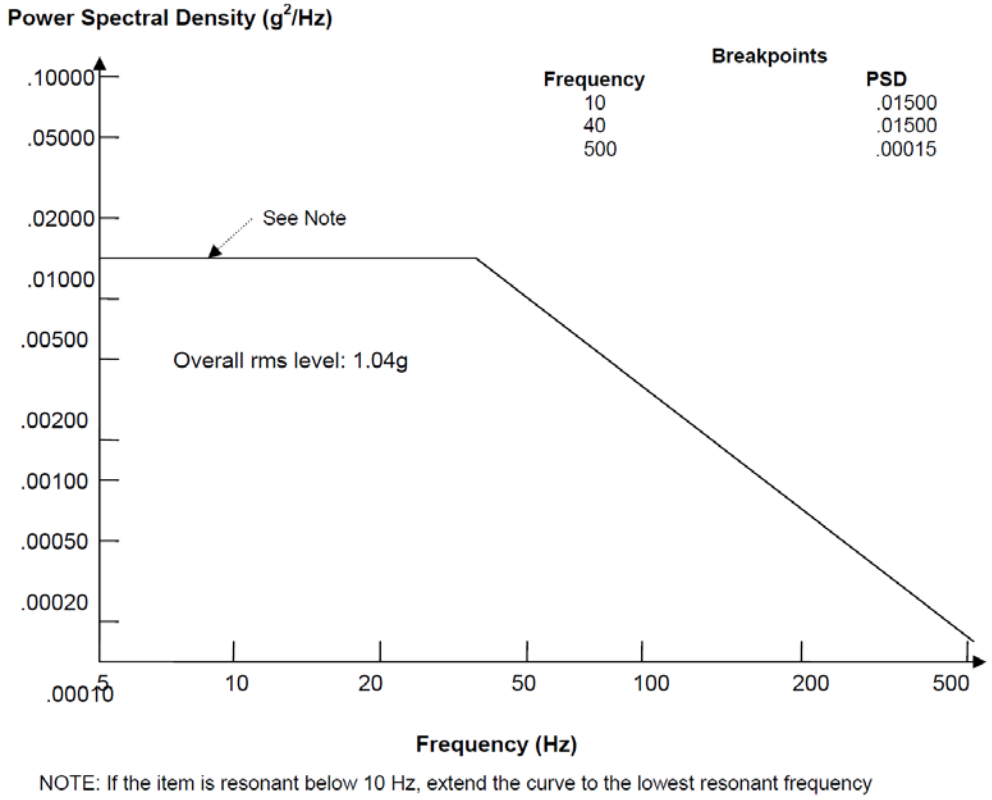

Figure 8: Power spectral density of design spectra for vibration mitigation. Adopted from ALMA-80.05.02.00-001-B-SPE.

6.1.7 Dust

Parameter	Req. #	Value	Traceability
Equipment Protection	INF0541	Exposed equipment shall be protected against windblown dust, ashes, and grit.	ENV0541
Building Protection	INF0542	Building envelopes shall be tight enough to mitigate penetration of dust. All air circulation penetrations shall be filtered.	ENV0542

6.1.8 Fauna

Parameter	Req. #	Value	Traceability
Rodent Protection	INF0551	Exposed equipment shall be designed to prevent rodent damage. At a minimum this may involve protecting all cables with flexible or rigid conduit or equivalent. Any penetration within enclosures and raceways shall mitigate the risk of rodent damage.	ENV0551

Parameter	Req. #	Value	Traceability
Large Mammal Protection	INF0552	Exposed equipment shall be protected against damage by large mammals such as cattle.	ENV0552

Note that the large mammal protection requirement needn't be met by all exposed equipment directly. For example, if a fence is provided around each antenna, equipment within the fence envelope can be built assuming that the fence provides adequate large mammal protection.

6.1.9 Solar Radiation

Parameter	Req. #	Value	Traceability
Maximum Solar Flux	INF0561	All equipment exposed to outside environment shall be designed for a maximum diurnal solar flux of 1200 W/m^2 from 0.3–60 μm.	ENV0561
Maximum UV Radiation	INF0562	All equipment exposed to outside environment shall be designed for a maximum diurnal UV radiated flux of 100 W/m^2 from 280–400 nm.	ENV0562

6.1.10 Rain/Water Infiltration

Parameter	Req. #	Value	Traceability
Rain/Water Infiltration	INF0571	Exposed equipment enclosures shall be designed to withstand rainfall intensity up to 16 cm/hr., with droplets sized 0.5 to 4.5mm, at a wind velocity of 15 m/s from the vertical to horizontal direction.	ENV057

The survival rain rates correspond to 50-year events as defined in [RD02].

6.1.11 Corrosion Protection

Parameter	Req. #	Value	Traceability
Corrosion Protection	INF0591	Exposed equipment shall be designed to prevent corrosion that may impact the performance or structural integrity of the equipment over the system design life.	ENV0591

6.1.12 Mechanical Shock

Parameter	Req. #	Value	Traceability
Mechanical Shocks	INF0582	Line Replaceable Units packaged for transportation shall survive mechanical shock levels from handling as defined in the MIL-STD-810H Method 516.8 Logistic Transit Drop Test, modified to use the drop heights specified in Table 1.	ENV0582

Mass of Package	Height of Drop	Number of Drops
0 kg to 25 kg	75 cm	Drop on each face and corner. Total of 26 drops.
25 kg to 50 kg	75 cm	Drop on each corner. Total of 8 drops.
50 kg to 100 kg	35 cm	Drop on each bottom edge and bottom face. Total of 5 drops.
> 100 kg	25 cm	Drop on each bottom edge and bottom face. Total of 5 drops.

Table 1: Modified drop heights for logistic transit drop test.

Note that this specification applies to the line replaceable unit in its packaging for transportation. This specification is not intended to preclude the use of commercial equipment in the array infrastructure design. Alternative standards may be proposed for commercial off-the-shelf devices.

6.2 Operations Buildings, Science Data Center, and Science Operations Center

6.2.1 Survival Conditions

The facilities encompassed by the Operations Buildings (OPS), Science Data Center (SDC) and Science Operations Center (SOC) shall be designed to the environmental conditions established by local building codes at the respective sites.

As of 2022, NM-based buildings shall conform to the design environment established in the New Mexico Commercial Building Code (NMAC 14.7.2), which is an extension of the 2015 International Building Code (IBC 2015).

6.2.2 Storage Conditions

Parameter	Req. #	Value	Traceability
Storage Temperature	OPS0372	0 C ≤ T ≤ 30 C	ENV0372
Storage Relative Humidity	OPS0373	10 ≤ RH ≤ 90%	ENV0373

The OPS buildings include storage areas for spares and consumable supplies used in array operation and maintenance. These areas shall maintain an indoor environment consistent with the storage conditions environment in the System Environmental Specifications [AD04].

7 Common Requirements

The following specifications apply to all civil and infrastructure subsystems.

7.1 Radio Frequency Interference (RFI) and Electromagnetic Compatibility (EMC) Requirements

7.1.1 Emission Requirements

Parameter	Req. #	Value	Traceability
RFI Emission	INF0310	Any ngVLA infrastructure deployed within 10km of an ngVLA antenna shall conform to the system Radio Frequency Interference radiated emission limits documented in [AD05].	EMC0310

This requirement is most relevant to the array infrastructure and equipment integrated into the ngVLA site buildings. However, due consideration should also be given to the operations buildings, in particular the maintenance center and remote support station (RSS) buildings, depending on their final location.

Any ngVLA support buildings or infrastructure deployed more than 10 km from an antenna may conform to relevant FCC emission limits only.

7.1.2 Electromagnetic Emission Design Requirements

The following requirements apply to any ngVLA infrastructure deployed within the 10km radius where INF0310 applies. These requirements shall be fulfilled *as a minimum* to support the emission requirements for the design, but the designer may propose alternatives if quantitative evidence is provided that the alternatives are at least as effective as the specification. Shielding requirements may be computed as described in AD05 Section 3.

Parameter	Req. #	Value	Traceability
Drive System Shielding	INF0320	Any drive motors or actuators shall be shielded and all motor leads, both power and control, shall be filtered.	EMC0320
Relay Contact Arcing	INF0321	All relay contacts and actuators shall be properly bypassed with snubber circuits, shielded, and/or filtered.	EMC0321
Amplifiers & Oscillators	INF0322	All electronic amplifiers and oscillators shall be mounted in shielded enclosures that will provide effective shielding of radio frequency energy.	EMC0322
Silicone Controlled Rectifiers	INF0323	Silicon-controlled rectifier switching devices shall not be used unless phase controlled and zero current crossing switching techniques are used.	EMC0323
Gaseous Discharge Devices	INF0324	No gaseous discharge devices shall be employed in active circuits, except for lightning and ESD protection.	EMC0324
Static Discharge Mitigation	INF0325	Means shall be employed to reduce static electricity and the consequent radio frequency noise generated in any rotating machinery.	EMC0325

Parameter	Req. #	Value	Traceability
Display Shielding	INF0326	All displays (LCD, plasma, LED, CRT) shall have fully enclosed RFI shields, including an RFI shield in front of the display. This requirement may be waived if the screen is powered off during typical operation and is used for maintenance purposes only. It must be possible to monitor and turn off such emitting devices remotely (via the M&C System).	EMC0326
Digital Equipment Shielding	INF0327	All digital equipment, whether a simple logic circuit, embedded CPU, or rack mounted PC shall be shielded and have its AC or DC power line and communication line(s) filtered at the chassis.	EMC0327

The goal of these requirements is to limit the use of devices that are likely to cause harmful emission levels, and shield the remaining necessary emitters. This list is not comprehensive, and the designer should exercise due diligence in limiting the harmful emissions generated by his/her design. Design for RFI emission mitigation is expected to be a significant effort in most electronic components of the ngVLA.

7.1.3 EMC Immunity

Parameter	Req. #	Value	Traceability
COTS Immunity Standards	INF0401	Commercial off-the-shelf (COTS) equipment shall conform to IEC product family standards for immunity standards, or to the generic standard IEC 61000 – Part 6: Generic Standards if no product family standard is given.	EMC0401
COTS Certification	INF0402	All commercial equipment shall have a CE mark or FCC compliance identification.	EMC0402

All ngVLA equipment shall exhibit complete electromagnetic compatibility (EMC) among components (intra-system electromagnetic compatibility). Prevention of electromagnetic interference (EMI) between subsystems (inter-system electromagnetic compatibility) is also critical.

The Array Infrastructure is expected to consist of commercial off-the-shelf equipment. Commercial-off-the-shelf equipment will be accepted in the system where it does not degrade the overall system functionality and ensures that the performance criteria established in AD05 Section 4 is maintained at the subsystem and system level.

The requirements listed in this section aim to ensure that otherwise acceptable COTS components are not made ineligible due to testing compliance with ngVLA EMC standards. These COTS standards are applicable to electromagnetic immunity only, with emission requirements applicable to all equipment present during observations at the ngVLA antenna sites.

7.1.4 Electrostatic Discharge (ESD) Requirements

Parameter	Req. #	Value	Traceability
ESD Low Air Discharge	INF0471	Enclosed systems shall conform to MIL-STD-461G CS118 with an air discharge level up to 8kV while meeting performance criteria A. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted.	EMC0471
ESD High Air Discharge	INF0472	Enclosed systems shall conform to MIL-STD-461G CS118 with an air discharge level up to 15kV while meeting performance criteria B. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted.	EMC0472
ESD Direct Contact Discharge	INF0473	Enclosed systems shall conform to MIL-STD-461G CS118 with a direct contact discharge level up to 8kV while meeting performance criteria A. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted.	EMC0473
ESD Protected Spaces	INF0474	All building spaces used for electronics assembly, maintenance and repair shall be ESD protected areas as defined in MIL-HDBK-263B.	SYS2610
ESD Protected Spaces Flooring	INF0475	Flooring in ESD protected areas shall use ESD-rated flooring tiles and tile adhesives, with connections to the building earth ground consistent with the manufacturer recommendations.	SYS2610
ESD Protected Spaces Humidity Control	INF0476	ESD protected areas shall have humidity control to maintain a local water vapor content of 40% ≤ RH ≤ 90%	SYS2610

The ESD air-discharge and direct contact thresholds assume the devices are enclosed in any provided enclosures, as they would be found in the operational environment. Test locations are any accessible point outside of a closed cabinet (e.g., door handles or panels).

Service personnel will be provided with wrist bands at site service points and at all repair locations to prevent the occurrence of ESD to equipment within racks or enclosures during service.

The building spaces where electronics maintenance, repair and AIV take place must be tailored to provide ESD protected spaces. ngVLA will eventually establish an ESD protection program consistent with the relevant MIL standards and the sensitivity of the devices repaired in each space. However, all electronics repair spaces are known to require ESD compliant flooring and humidity control, so these requirements are captured here at a global level applicable to all electronics assembly, repair and maintenance spaces.

7.2 Safety and Security Requirements

This section defines all design requirements necessary to support the Level-1 Safety and Security requirements. The system-level safety [AD07] and security [AD08] specifications are incorporated by reference.

Parameter	Req. #	Value	Traceability
Safety Specification	INF2700	All designs shall comply with the Level-1 System Safety Specification (020.80.00.00.00-0001-REQ, [AD07]).	SYS2700
Safety Interlocks	INF2705	Any electro-mechanical components (generators, transfer switches, uninterruptible power supplies) shall include interlocks so that no computer command may result in human safety issues or equipment damage.	SYS2705
Security Specification	INF2703	All designs shall comply with the Level-1 System Security Specification (020.80.00.00.00-0003-REQ, AD14).	SYS2703

7.3 Life Cycle Requirements

This section defines the System Life Cycle requirements, including design & development, AIV and CSV as derived from [AD03].

Parameter	Req. #	Value	Traceability
Design Life	INF2801	The infrastructure and facilities shall be designed for an expected operational life of no less than 30 years.	SYS2801
Cost Optimization	INF2802	The infrastructure and facilities shall be designed to minimize total life-cycle costs over the projected design life, extending through system decommissioning/ disposal.	SYS2802
Sustainability	INF2803	Sustainability and long-term environmental impact shall be considered in any material or design trade-study.	SYS2803
Critical Spares	INF2812	Critical spares for all serviceable systems shall be identified and provided with sufficient inventory to support the facility for its operational life. Critical spares are defined as parts that are likely to be obsoleted over the operating life, are unlikely to have market substitutes, and cannot be produced/ordered in small volumes.	SYS2812

The provision of critical spares is especially important on services that can impact system availability that are constructed with commercial off-the-shelf parts. Examples include controllers for generators, transfer switches, and uninterruptible power supplies, and building fire panel boards (if an electrical shut-off feature is included).

7.4 Configuration and Document Management Requirements

This section defines Configuration Management requirements and Documentation requirements, derived from [AD03].

Parameter	Req. #	Value	Traceability
Identification by Serial Numbers	INF3600	All configuration items (e.g., line replaceable units, sub-assemblies) shall be uniquely identifiable to facilitate status and location tracking across the Observatory. Identification for LRUs shall be both visible and electronic.	SYS3600
Version Control for Software and Firmware	INF3602	All custom software and firmware delivered as part of the infrastructure and building services shall be version controlled via a configuration management process, with backup binary files provided.	SYS3602
As-Built Drawings	INF6001	As-built drawings shall be provided for all facilities, infrastructure and systems.	SYS6001
As-Built Building Information Model	INF6006	The Central Electronics Building and Data Center Building shall be developed and delivered with a Building Information Model in line with ISO 19650 or equivalent standard.	SYS6001
Operations and Maintenance Manuals	INF6002	Operations and Maintenance Manuals shall be provided for integrated equipment and services.	SYS6002
Units	INF6003	Design materials and documentation shall use both Imperial and SI (metric) units.	SYS6003
Language	INF6004	The language used for written documentation shall be English.	SYS6004
Electronic Document Format	INF6005	Documents and drawings of record shall be delivered in PDF. Native, editable file formats shall also be delivered.	SYS6005

The ngVLA project has broadly standardized on the use of SI units in documentation. However, building trades in the US favor imperial units, with all building supplies typically specified in imperial units. It is acceptable for the array infrastructure and all site buildings to use imperial units in the construction drawing and specifications, but all interface documentation and drawings should include both metric and imperial units to avoid confusion within the project. The choice of primary vs secondary units is at the discretion of the engineer, but the choice must be clear in the drawing title block or associated specifications.

8 Array Infrastructure Subsystem Requirements

8.1 Functional and Performance Requirements

Parameter	Req. #	Value	Traceability
Provision of Antenna Foundations	INF0001	The Array Infrastructure subsystem shall provide all antenna foundations at the station locations called for in the in the Array Configuration [RD02].	[AD06]
Provision of Ancillary Foundations	INF0002	The Array Infrastructure subsystem shall provide all ancillary foundations and under-ground infrastructure required to support the array operations, inclusive of ancillary environmental monitoring and characterization equipment.	[AD06]
Provision of Utility Trenching	INF0003	The Array Infrastructure subsystem shall design and provide all utility trenching for electrical and communications lines within the Plains of San Agustin, as well as "last mile" connections for mid-baseline and long-baseline antenna stations.	[AD06]
Provision of Fiber Utility to Antenna Stations	INF0004	The Array Infrastructure sub-system shall provide all underground fiber-optic communications infrastructure and above ground termination enclosures on the Plains of San Agustin as well as "last mile" connections for each mid-baseline and long-baseline antenna stations.	[AD06]
Provision of Electrical Utility to Antenna Stations	INF0005	The Array Infrastructure sub-system shall provide electrical service infrastructure to all buildings and antennas within the Plains of San Agustin as well as "last mile" connections for each mid-baseline and long-baseline antenna stations.	[AD06]
Provision of Electrical Backup Service	INF0006	The Array Infrastructure sub-system shall provide generator backup capacity sufficient for three days of continuous operation for all antennas and buildings on the Plains of San Agustin.	SYS2603, SYS2607
Provision of Electrical Service Disconnects	INF0007	The Array Infrastructure sub-system shall provide distributed electrical service disconnects to enable maintenance and repair of any high-voltage distribution line without interrupting power to more than 10% of the antennas in the array.	SYS2603
Provision of Maintenance Access	INF0008	The Array Infrastructure sub-system shall provide service roads suitable for year-round access to each antenna site by a two-wheel drive service truck.	SYS3903
Provision of Physical Security Infrastructure	INF0009	The Array Infrastructure sub-system shall provide any physical security infrastructure (e.g., fencing and lighting) necessary to secure each antenna site.	SYS2704

The locations of each antenna station are provided in the Array Configuration Design Description [RD02] and associated configuration coordinates file.

8.2 Interface Requirements

In this section, requirements are derived from the applicable ICDs as listed in Section 2.2. As stated in the SEMP [AD01], ICDs define the interface, but do not contain any requirements. All interface requirements that drive the design and verification of the subsystem shall be listed in this section.

8.2.1 INF to ANT Interface Requirements

The following requirements flow from the INF to Antenna (ANT) ICD [AD20]. While the ICD provides a full specification of the interface between these two subsystems, we highlight the following requirements as they define the overall scope and function of the INF subsystem.

Parameter	Req. #	Value	Traceability
Antenna Foundation Specification	INF2011	The Array Infrastructure subsystem shall provide antenna foundations to each antenna in the Array Configuration, consistent with the interface definition given in [AD20], accounting for local soil conditions in the detailed design.	[AD20]
Ancillary Foundation Specification	INF2012	The Array Infrastructure subsystem shall provide all ancillary foundations and under-ground infrastructure required to support the antenna and provide a complete pad design consistent with [AD20].	[AD20]
Fiber Utility to Antenna Station Specification	INF2014	The Array Infrastructure sub-system shall provide underground fiber-optic communications infrastructure and above ground termination enclosures at each antenna station consistent with [AD20].	[AD20]
Electrical Utility to Antenna Specification	INF2015	The Array Infrastructure sub-system shall provide electrical service infrastructure at each antenna station consistent with [AD20].	[AD20]

8.2.2 INF to SBA Interface Requirements

The following requirements flow from the INF to Short Baseline Antenna (SBA) ICD [AD21]. While the ICD provides a full specification of the interface between these two subsystems, we highlight the following requirements as they define the overall scope and function of the INF subsystem.

Parameter	Req. #	Value	Traceability
Antenna Foundation Specification	INF2111	The Array Infrastructure subsystem shall provide antenna foundations to each antenna in the Array Configuration, consistent with the interface definition given in [AD21], accounting for local soil conditions in the detailed design.	[AD21]
Ancillary Foundation Specification	INF2112	The Array Infrastructure subsystem shall provide all ancillary foundations and under-ground infrastructure required to support the antenna and provide a complete pad design consistent with [AD21].	[AD21]

Parameter	Req. #	Value	Traceability
Fiber Utility to Antenna Station Specification	INF2114	The Array Infrastructure sub-system shall provide underground fiber-optic communications infrastructure and above ground termination enclosures at each antenna station consistent with [AD21].	[AD21]
Electrical Utility to Antenna Specification	INF2115	The Array Infrastructure sub-system shall provide electrical service infrastructure at each antenna station consistent with [AD21].	[AD21]

8.2.3 INF to MON Interface Requirements

The following requirements flow from the INF to Environmental Monitoring & Characterization Systems (MON) ICD [AD22]. The MON subsystems include: Weather Stations, the Atmospheric Phase Monitor, an all-sky Cloud Monitor, a Lightning field-strength Monitor, an RFI Monitor, Remote Site Monitoring, and a Satellite Holography System. While the ICD provides a full specification of the interface between these subsystems, we highlight the following requirements as they define the overall scope and function of the INF subsystem.

Parameter	Req. #	Value	Traceability
Weather Station Infrastructure	INF2211	The Array Infrastructure subsystem shall provide foundations, power and data communications infrastructure to each weather station, consistent with the interface definition given in [AD22], accounting for local soil conditions in the detailed design.	[AD22]
API Infrastructure	INF2212	The Array Infrastructure subsystem shall provide foundations, power and data communications infrastructure to each Atmospheric Phase Interferometer antenna station, consistent with the interface definition given in [AD22].	[AD22]
Ancillary Foundation & Utility Specification	INF2213	The Array Infrastructure subsystem shall provide all ancillary foundations and under-ground infrastructure (power, fiber, etc.) required to support the MON subsystems consistent with [AD22].	[AD22]

8.2.4 INF to NSB Interface Requirements

The specification of the required infrastructure to support the ngVLA site buildings is documented in the INF to ngVLA Site Buildings (NSB) ICD [AD24]. The derived requirements that support this interface will be added in a future release of this document.

Parameter	Req. #	Value	Traceability
Redundant Services	INF2411	Redundant electrical services shall be provided to the Central Electronics Building (CEB) to enable service of switchgear and transformers without downtime to the CEB.	[AD24]

8.2.5 INF to OPS Interface Requirements

The specification of the required infrastructure to support the operations buildings is documented in the INF to Operations Buildings (OPS) ICD [AD25]. The derived requirements that support this interface will be added in a future release of this document.

8.2.6 INF to MCL Interface Requirements

The specification for the interface between the Array Infrastructure and the Monitor & Control System are documented in the INF to the Monitor & Control System (MCL) ICD [AD25]. The derived requirements that support this interface are enumerated here.

Parameter	Req. #	Value	Traceability
Hardware Interface	INF2511	Remote monitoring of status and control of array infrastructure components shall be achieved via the use of (a) the ngVLA standard Hardware Interface PCBs, or (b) the OPC-UA protocol over Ethernet.	[AD25]

No other interface standards are permitted for monitor and control of array infrastructure components. While the use of the standard HIL device or the OPC-UA protocol limit the available field buses and component selection for devices such as generators and automatic transfer switches, this limitation ensures robust compatibility and integration with the overall M&C system.

8.2.7 INF to FIB Interface Requirements

The specification for the interface between the Array Infrastructure and the Central Fiber-optic Infrastructure systems are documented in the INF to Central Fiber Infrastructure (FIB) ICD [AD26]. The derived requirements that support this interface will be added in a future release of this document.

8.3 Reliability, Availability and Maintainability Requirements

This section defines all RAM requirements and Logistic Support requirements derived from [AD03].

Parameter	Req. #	Value	Traceability
Array Infrastructure Availability	INF2606	The Array Infrastructure System shall be designed for less than 0.5% downtime. It is a goal that the ngVLA Array Infrastructure should contribute less than 0.25% system downtime.	SYS2606

SYS2606 allocates up to 1% downtime to common service infrastructure. We allocate this system-level budget equally to the array infrastructure and central electronics building services in these specifications.

8.4 Other Requirements

Parameter	Req. #	Value	Traceability
Grassland Impact	INF4000	The design and construction of utility corridors and roads shall minimize the impact on grasslands and water within the Plains of San Agustin.	SYS4000
Sustainable Roads	INF4001	Road widths and lengths shall be minimized to reduce the destruction of top soil. The road design shall aim to avoid the collection of water into new ditches or arroyos that will exacerbate soil erosion.	SYS4001
Existing Roads	INF4002	Existing ranch roads shall be assessed for suitability in both construction and operations. It is a goal to reuse existing roads where possible.	SYS4002
Fences	INF4003	Any fences shall not impede the flow of cattle and wildlife within and between neighboring ranches, or significantly increase the travel distance to water sources.	SYS4003
Ranching Impact	INF4004	The project shall aim to reduce the environmental impact to cattle ranching as well as hunting/outfitting, which are both mainstays of local ranches.	SYS4004
VLA Interference	INF2819	It is a goal to minimize interference with VLA operations during the construction and transition phase.	SYS2819

9 ngVLA Site Building Subsystem Requirements

9.1 Functional and Performance Requirements

Parameter	Req. #	Value	Traceability
Provision of a Central Electronics Building	NSB0001	A central electronics building shall be provided to house central electronics systems inclusive of the central signal processor, time and frequency references, and time and frequency distribution equipment.	[AD06]
Outfitted Facilities	NSB0002	All facilities shall be outfitted with the furnishings, tools, equipment, computing, and information technology equipment necessary to fulfill the intended function.	SYS3800
Facility Sustainability	NSB0003	All new facilities shall be Leadership in Energy and Environmental Design (LEED) certified, with a goal of achieving Gold-level certification or higher, as applicable to new construction as defined in LEED v4.1 or newer.	SYS3801
Controlled Visitor Access	NSB0004	Facilities shall be provided for controlled visitor access between the visitor center and array core or nearby antennas.	SYS3803
Provision of Warehouse	NSB0005	A central warehouse shall be provided and sized for the central storage and distribution of components, consumables, and critical spares.	SYS3820
Warehouse Inventory System	NSB0006	The central warehouse shall include provisions for the controlled inventory of all housed components, spares, and consumables.	SYS3821
Warehouse Space – AIV	NSB0007	The project shall deliver warehouse capabilities needed to store electronics and other assemblies delivered by the IPTs that require safe keeping prior to antenna integration.	SYS3822
Location of Warehouse	NSB0008	The Warehouse shall be located near the array site in order to facilitate logistics, but sufficiently far away to mitigate RFI at the Array Core. It may be co-located with the Maintenance Operations Center.	SYS3874
Provision of Guard Booth	NSB0009	To maintain site security at the additional buildings near the core of the array, a guard booth shall be provided to support a constant security presence by security staff.	SYS3880
Provision of Support Buildings	NSB0010	As required, additional buildings near the array core shall provide for the storage and maintenance of heavy equipment that cannot be easily delivered or driven from the nearby Maintenance Center and to support the maintenance and repair staff temporarily on-site.	SYS3881
Facility Space for AIV	NSB0011	The project shall provide adequate space needed for pre-deployment activities, equipment maintenance and storage, and AIV staff office space.	SYS3885
Workspace for CSV	NSB0012	Dedicated workspace shall be provided in the local control room at the array site for CSV activities.	SYS3887

Parameter	Req. #	Value	Traceability
Workspace for CSV Operators	NSB0013	The remote control room needed for CSV activities shall contain a sufficient number of IT-supported workstations, in addition to the main multi-monitor control console needed by an operator.	SYS3888
Workspace for Operations	NSB0014	All facility sizes and their associated areas shall be designed to accommodate the staffing levels for full operations as described in the Operations Plan [AD10]	[AD10]

The operations workspace requirement, as well as CSV and AIV workspace requirements can be considered placeholders until the associated AIV, CSV and Operations plans are developed. Subsequent releases of this requirements specification should provide precise design occupancy requirements for each building. A preliminary estimate (TBC) of occupancy in the NSB facilities is shown in Table 2.

Occupant Type	Count
Management, Single Occupant Offices	1
Engineering, Mix of Single and Multi-Occupant Offices	2
Technical, Open Lab & Shop Space	10
Technical, Primarily Off-Site	84
Sub-total	97

Table 2 - Preliminary occupancy estimate for the NSB facilities (TBC).

It is assumed that most technical staff will be stationed at the off-site Maintenance Center (an element of the OPS subsystem) for their primary duty station. These off-site staff will primarily be engaged in maintenance around the array, but there should be adequate facilities to support their activities on site (e.g., restrooms, garbage collection, and cafeteria)

9.2 Interface Requirements

In this section, requirements are derived from the applicable ICDs as listed in Section 2.2. As stated in the SEMP [AD01], ICDs define the interface, but do not contain any requirements. All interface requirements that drive the design and verification of the subsystem shall be listed in this section.

9.2.1 NSB to INF Interface Requirements

The specification of the required infrastructure to support the ngVLA site buildings shall be documented in the INF to ngVLA Site Buildings (NSB) ICD [AD24]. The derived requirements that support this interface will be elaborated in a future release of this document.

Parameter	Req. #	Value	Traceability
Redundant Services	NSB2411	The Central Electronics Building (CEB) shall include any service disconnects necessary to transfer between redundant electrical services as an integral part of the uninterruptible power supply switchgear.	[AD24]

9.2.2 NSB to MCL Interface Requirements

The specification for the interface between the Central Electronics building and the Monitor & Control System shall be documented in the NSB Combined ICD [AD27]. The derived requirements that support this interface are enumerated here.

Parameter	Req. #	Value	Traceability
Hardware Interface	NSB2711	Remote monitoring of status and control of array infrastructure components shall be achieved via the use of (a) the ngVLA standard Hardware Interface PCBs, or (b) the OPC-UA protocol over Ethernet.	[AD27]

No other interface standards are permitted for monitor and control of array infrastructure components. While the use of the standard HIL device or the OPC-UA protocol limit the available field buses and component selection for devices such as generators and automatic transfer switches, this limitation ensures robust compatibility and integration with the overall M&C system.

9.2.3 NSB to ONL Interface Requirements

The specification for the interface between the Central Electronics Building and the Online System shall be documented in the NSB Combined ICD [AD27]. The derived requirements that support this interface are enumerated here.

Parameter	Req. #	Value	Traceability
Shielded & Environmentally Controlled Space	NSB2721	The CEB shall include space in a shielded and environmentally controlled room to house electronic rack(s) for the Online System consistent with the specifications in [AD27].	[AD27]
EMC Shielding Level	NSB2722	The CEB shielded space that houses the online system racks shall provide 100 dB of attenuation over the frequency range of 1.2 to 12 GHz.	[AD27], EMC0310, EMC0311
Provision of UPS service	NSB2723	The CEB shall provide an uninterruptible power supply service to the online system racks with a minimum of 5 minutes run time.	[AD27]

9.2.4 NSB to FIB Interface Requirements

The specification for the interface between the Central Electronics Building and the Central Fiber-optic Infrastructure (FIB) shall be documented in the NSB Combined ICD [AD27]. The derived requirements that support this interface will be enumerated in a future version of this specification.

9.2.5 NSB to CSP Interface Requirements

The specification for the interface between the Central Electronics Building and the Central Signal Processor (CSP) shall be documented in the NSB Combined ICD [AD27]. The initial set of derived requirements that support this interface are enumerated here.

Parameter	Req. #	Value	Traceability
Shielded & Environmentally Controlled Space	NSB2731	The CEB shall include space in a shielded and environmentally controlled room to house electronic rack(s) for the CSP consistent with the specifications in [AD27].	[AD27]
EMC Shielding Level	NSB2732	The CEB shielded space that houses the CSP racks shall provide 100 dB of attenuation over the frequency range of 1.2 to 12 GHz.	[AD27], EMC0310, EMC0311
Provision of UPS service	NSB2733	The CEB shall provide an uninterruptible power supply service to the CSP racks with a minimum of 5 minutes run time.	AD27
Power provision quality	NSB2734	The CEB shall supply power quality levels as defined in the system EMC specification [AD05].	SYS2607

9.2.6 NSB to RTG Interface Requirements

The specification for the interface between the Central Electronics Building and the LO Reference & Timing Generation (RTG) system shall be documented in the NSB Combined ICD [AD27]. The initial derived requirements that support this interface are enumerated here.

Parameter	Req. #	Value	Traceability
Environmentally Controlled Space	NSB2741	The CEB shall include space in an environmentally controlled room to house electronic rack(s) for the RTG consistent with the specifications in [AD27].	[AD27]
Environmental Stability	NSB2742	The environmental control system in the CEB shall regulate the inlet temperature to the RTG racks to ± 1°C over 20 minutes (TBC).	[AD27]
Provision of UPS service	NSB2743	The CEB shall provide an uninterruptible power supply service to the RTG racks with a minimum of 5 minutes run time.	[AD27]
Power provision quality	NSB2744	The CEB shall supply power quality levels as defined in the system EMC specification [AD05].	SYS2607

It is assumed that the RTG electronics will meet the detrimental emission threshold requirements through shielded enclosures and racks. Should the CEB need to provide shielded space, this will be reflected in future releases of these requirements.

The UPS service size is specified to ensure sufficient time for system transfer and orderly shutdown in the event of an electrical distribution failure. Primary frequency and time references may require more robust backup power, but providing this is the responsibility of the RTG system (e.g. via RTG-provided local batteries).

It is also assumed that the RTG electronics will need a high degree of thermal stability to support their performance requirements. The 1° and 20 minute specification is a placeholder only, but is intended to provide a sense of the anticipated thermal regulation required. RTG may also require further environmental shielding and regulation (e.g. vibration, magnetic, ESD, power regulation) that will be detailed in [AD27].

9.2.7 NSB to RTD Interface Requirements

The specification for the interface between the Central Electronics Building and the LO Reference & Timing Distribution (RTD) system shall be documented in the NSB Combined ICD [AD27]. The derived requirements that support this interface are enumerated here.

Parameter	Req. #	Value	Traceability
Environmentally Controlled Space	NSB2751	The CEB shall include space in an environmentally controlled room to house electronic rack(s) for the RTD consistent with the specifications in [AD27].	[AD27]
Environmental Stability	NSB2752	The environmental control system in the CEB shall regulate the inlet temperature to the RTD racks to ± 1° C over 20 minutes (TBC).	[AD27]
Provision of UPS service	NSB2753	The CEB shall provide an uninterruptible power supply service to the RTD racks with a minimum of 5 minutes run time.	[AD27]
Power provision quality	NSB2754	The CEB shall supply power quality levels as defined in the system EMC specification [AD05].	SYS2607

It is assumed that the RTD electronics will meet the detrimental emission threshold requirements through shielded enclosures and racks. Should the CEB need to provide shielded space, this will be reflected in future releases of these requirements.

It is also assumed that the RTD electronics will need a high degree of thermal stability to support their performance requirements. The 1° and 20 minute specification is a placeholder only, but is intended to provide a sense of the anticipated thermal regulation required.

9.3 Reliability, Availability and Maintainability Requirements

This section defines all RAM requirements and Logistic Support requirements derived from [AD03].

Parameter	Req. #	Value	Traceability
CEB Availability	NSB2606	The CEB UPS, HVAC and other critical services that support the housed electronics shall be designed for less than 0.5% downtime. It is a goal that the CEB services should contribute less than 0.25% system downtime.	SYS2606
CEB Preventive maintenance	NSB2603	The CEB power supply system and HVAC system shall enable preventive maintenance without interrupting cooling or power to the CSP and computing rack areas.	SYS2603

SYS2606 allocates up to 1% downtime to common service infrastructure. We allocate this system-level budget equally to the array infrastructure and central electronics building services in these specifications.

9.4 Other Requirements

Parameter	Req. #	Value	Traceability
VLA Interference	NSB2819	It is a goal to minimize interference with VLA operations during the construction and transition phase.	SYS2819

10 Operations Buildings Subsystem Requirements

10.1 Functional and Performance Requirements

Parameter	Req. #	Value	Traceability
Outfitted Facilities	OPS0001	All facilities shall be outfitted with the furnishings, tools, equipment, computing, and information technology equipment necessary to fulfill the intended function.	SYS3800
Facility Sustainability	OPS0002	All new facilities shall be Leadership in Energy and Environmental Design (LEED) certified, with a goal of achieving Gold-level certification or higher, as applicable to new construction as defined in LEED v4.1 or newer.	SYS3801
Provision of a Maintenance Operations Center	OPS0003	A Maintenance Operations Center shall provide office space and common areas for projected safety, security and maintenance personnel.	SYS3810
Maintenance Center – Support Equipment	OPS0004	The Maintenance Center shall include space for the requisite tools, equipment and vehicles to support expected preventive and corrective maintenance activities.	SYS3811
Maintenance Center – Ready Spares	OPS0005	The Maintenance Center shall include space for the storage and inventory of LRUs.	SYS3812
Provision of a Repair Center	OPS0006	A Repair Center shall be provided to host staff and equipment necessary for the transfer, diagnosis, repair, and test of electronic LRUs and other equipment.	SYS3830
Provision of an Array Operations Center	OPS0007	An Array Operations Center (AOC) shall provide sufficient space to host off-site array operations and a comparable complement of office space, laboratory space, storage and transfer capabilities, and computing infrastructure as in the existing DSOC.	SYS3840
Provision of Remote Support Stations	OPS0008	Remote Support Stations (RSS) shall be provided and located to support operations across the main array and long baseline array.	SYS3860
Remote Support Station Sizing	OPS0009	Each RSS shall have a footprint to support workbenches, organized tools, supplies, and inventory including spare LRUs required for routine maintenance of a group of antennas.	SYS3861
Location of the Maintenance Operations Center	OPS0010	The Maintenance Operations Center shall be located near the array site in order to facilitate logistics, but sufficiently far away to mitigate RFI at the Array Core.	SYS3870

Parameter	Req. #	Value	Traceability
Location of the Array Operations Center	OPS0011	The Array Operations Center shall be located within a two hour drive of the array site in order to facilitate logistics while providing an attractive location to recruit array operations personnel.	SYS3871
Location of the Repair Center	OPS0012	The Repair Center shall be located within a two hour drive of the array site in order to facilitate logistics while providing an attractive location to recruit array operations personnel. It may be co-located with the Array Operations Center.	SYS3873
Facility Space – AIV	OPS0013	The project shall provide adequate space needed for pre-deployment activities, equipment maintenance and storage, and AIV staff office space.	SYS3885
Workspace – CSV-Operators	OPS0014	The remote control room needed for CSV activities shall contain a sufficient number of IT-supported workstations, in addition to the main multi-monitor control console needed by an operator.	SYS3888
Workspace – Operations	OPS0015	All facility sizes and their associated areas shall be designed to accommodate the staffing levels for full operations as described in the Operations Plan [AD10].	[AD10]

The Remote Support Station locations and requirements are TBC depending on further analysis of the maintenance model. It is possible the RSSs could serve as depots and work areas for teams that periodically visit the remote antennas. Depending on the remoteness of the site, this use of the RSSs could require temporary living quarters and the needs for housekeeping visits when unoccupied. The associated requirements for the RSSs will be elaborated based on the evolving Operations Plan.

The operations workspace requirement, as well as CSV and AIV workspace requirements can be considered placeholders until the associated AIV, CSV and Operations plans are developed. Subsequent releases of this requirements specification should provide precise design occupancy requirements for each building. A preliminary estimates (TBD) of occupancy in the OPS facilities are shown in Table 3 through Table 5.

Occupant Type	Count
Management, Single Occupant Offices	6
Engineering, Mix of Single and Multi-Occupant Offices	11
Technical, Open Lab & Shop Space	43
Technical, Primarily Off-Site	84
Administrative & Support, Mix of Single and Multi-Occupant Offices	29
Sub-total	173

Table 3: Preliminary occupancy estimate for the Maintenance Center (TBC).

Occupant Type	Count
Management, Single Occupant Offices	4
Array Operations, Multi-Occupant Offices	13
Science/Engineering, Mix of Single and Multi-Occupant Offices	50
Administrative & Support, Mix of Single and Multi-Occupant Offices	13
Sub-total	98

Table 4: Preliminary occupancy estimate for the Array Operations Center (TBC).

Occupant Type	Count
Management, Single Occupant Offices	10
Engineering, Mix of Single and Multi-Occupant Offices	54
Technical, Open Lab & Shop Space	58
Administrative & Support, Mix of Single and Multi-Occupant Offices	24
Sub-total	146

Table 5: Preliminary occupancy estimate for the Repair Center (TBC).

10.2 Interface Requirements

In this section, requirements are derived from the applicable ICDs as listed in Section 2.2. As stated in the SEMP [AD01], ICDs define the interface, but do not contain any requirements. All interface requirements that drive the design and verification of the subsystem shall be listed in this section.

10.2.1 OPS to INF Interface Requirements

The specification for the interface between the Operations Buildings and the Array Infrastructure (INF) shall be documented in the OPS Combined ICD [AD23]. The derived requirements that support this interface will be enumerated in a future version of this specification.

10.2.2 OPS to MCL Interface Requirements

The specification for the interface between the Operations Buildings and the Monitor & Control System (MCL) shall be documented in the NSB Combined ICD [AD27]. The derived requirements that support this interface will be enumerated in a future version of this specification.

10.2.3 OPS to FIB Interface Requirements

The specification for the interface between the Operations Buildings and the Central Fiber-optic Infrastructure (FIB) shall be documented in the NSB Combined ICD [AD27]. The derived requirements that support this interface will be enumerated in a future version of this specification.

11 Science Data Center Subsystem Requirements

11.1 Functional and Performance Requirements

Parameter	Req. #	Value	Traceability
Outfitted Facilities	DSC0001	All facilities shall be outfitted with the furnishings, tools, equipment, computing, and information technology equipment necessary to fulfill the intended function.	SYS3800
Facility Sustainability	DSC0002	All new facilities shall be Leadership in Energy and Environmental Design (LEED) certified, with a goal of achieving Gold-level certification or higher, as applicable to new construction as defined in LEED v4.1 or newer.	SYS3801
Provision of the Data Center	DSC0003	A data center shall be provided to house the computing resources for the post processing system, data archive system, and other ancillary software systems.	[AD06]
Data Center Staff Space	DSC0004	The data center shall include office space and diagnostic laboratory space for support staff directly engaged in the management and maintenance of the data center and computing resources consistent with the full operations staffing level described in the Operations Plan [AD10]	[AD10]

The operations workspace requirement can be considered a placeholder until the associated Operations plan is released. Subsequent releases of this requirements specification should provide precise design occupancy requirements for each building. A preliminary estimate (TBC) for the data center occupancy is shown in Table 6.

Occupant Type	Count
Management, Single Occupant Offices	3
Engineering, Mix of Single and Multi-Occupant Offices	6
Technical, Open Lab & Shop Space	12
Administrative & Support, Mix of Single and Multi-Occupant Offices	4
Sub-total	25

Table 6: Preliminary occupancy estimate for the DSC (TBC).

11.2 Interface Requirements

In this section, requirements are derived from the applicable ICDs as listed in Section 2.2. As stated in the SEMP [AD01], ICDs define the interface, but do not contain any requirements. All interface requirements that drive the design and verification of the subsystem shall be listed in this section.

11.2.1 DSC to PMN Interface Requirements

The specification for the interface between the Data Center Building and the Proposal Management System (PMN) shall be documented in the DSC Combined ICD [AD29]. The derived requirements that support this interface will be enumerated in a future version of this specification.

Parameter	Req. #	Value	Traceability
Environmentally Controlled Space	DSC2911	The DSC shall include space in an environmentally controlled room to house electronic rack(s) for the PMN consistent with the specifications in [AD29].	[AD29]
Provision of UPS service	DSC2912	The DSC shall provide an uninterruptible power supply service to the PMN racks with a minimum of 5 minutes run time.	[AD29]

11.2.2 DSC to OFF Interface Requirements

The specification for the interface between the Data Center Building and the Offline Software Subsystem (OFF) shall be documented in the DSC Combined ICD [AD29]. The derived requirements that support this interface will be enumerated in a future version of this specification.

Parameter	Req. #	Value	Traceability
Environmentally Controlled Space	DSC2921	The DSC shall include space in an environmentally controlled room to house electronic racks for the OFF consistent with the specifications in [AD29].	[AD29]
Provision of UPS service	DSC2922	The DSC shall provide an uninterruptible power supply service to the OFF racks with a minimum of 5 minutes run time.	[AD29]

The majority of the equipment housed within the DSC is expected to be the offline software subsystem computing resources. Present estimates are for a 50 PFLOP/sec computing cluster [RD03]. Such a system is expected to include thousands of compute nodes housed in approximately 200 (TBC) racks. The space, power and cooling requirements for the OFF subsystem are expected to be design drivers for the DSC.

11.2.3 DSC to MSS Interface Requirements

The specification for the interface between the Data Center Building and the Maintenance & Support SW Subsystem (MSS) shall be documented in the DSC Combined ICD [AD29]. The derived requirements that support this interface will be enumerated in a future version of this specification.

Parameter	Req. #	Value	Traceability
Environmentally Controlled Space	DSC2931	The DSC shall include space in an environmentally controlled room to house electronic rack(s) for the MSS consistent with the specifications in [AD29].	[AD29]
Provision of UPS service	DSC2932	The DSC shall provide an uninterruptible power supply service to the MSS racks with a minimum of 5 minutes run time.	[AD29]

11.2.4 DSC to DST Interface Requirements

The specification for the interface between the Data Center Building and the Data Stores (DST) shall be documented in the DSC Combined ICD [AD29]. The derived requirements that support this interface will be enumerated in a future version of this specification.

Parameter	Req. #	Value	Traceability
Environmentally Controlled Space	DSC2941	The DSC shall include space in an environmentally controlled room to house electronic racks for the DST consistent with the specifications in [AD29].	[AD29]
Provision of UPS service	DSC2942	The DSC shall provide an uninterruptible power supply service to the DST racks with a minimum of 5 minutes run time.	[AD29]

11.2.5 DSC to FIB Interface Requirements

The specification for the interface between the Data Center Building and the Central Fiber Infrastructure (FIB) shall be documented in the DSC Combined ICD [AD29]. The derived requirements that support this interface will be enumerated in a future version of this specification.

11.2.6 DSC to DSS Interface Requirements

The specification for the interface between the Data Center Building and the Computing & Software Development Support Subsystem (DSS) shall be documented in the DSC Combined ICD [AD29]. The derived requirements that support this interface will be enumerated in a future version of this specification.

Parameter	Req. #	Value	Traceability
Environmentally Controlled Space	DSC2961	The DSC shall include space in an environmentally controlled room to house electronic rack(s) for the DSS consistent with the specifications in [AD29].	[AD29]
Provision of UPS service	DSC2962	The CEB shall provide an uninterruptible power supply service to the DSS racks with a minimum of 5 minutes run time.	[AD29]

12 Science Operations Center Subsystem Requirements

12.1 Functional and Performance Requirements

Parameter	Req. #	Value	Traceability
Outfitted Facilities	SOC0001	All facilities shall be outfitted with the furnishings, tools, equipment, computing, and information technology equipment necessary to fulfill the intended function.	SYS3800
Facility Sustainability	SOC0002	All new facilities shall be Leadership in Energy and Environmental Design (LEED) certified, with a goal of achieving Gold-level certification or higher, as applicable to new construction as defined in LEED v4.1 or newer.	SYS3801
Provision of a Science Operations Center	SOC0003	A Science Operations Center (SOC) shall be provided to house the scientific operations staff constituted of scientists, data analysts, computing, software, and IT positions, and some administrative and management staff. The facility shall primarily consist of office space and supporting computing infrastructure.	SYS3850

Parameter	Req. #	Value	Traceability
Visitor Support Functions	SOC0006	The Science Operations Center shall be outfitted to support external users visiting the facilities for shared risk observing, data processing, and workshops/trainings.	[AD10]
Location of the Science Operations Center	SOC0004	The Science Operations Center shall be located at a site that facilitates personnel recruitment, such as an attractive metropolitan area.	SYS3872
Science Operations Center Size	SOC0005	The science operations center shall be sized to support the full operations staffing level described in the Operations Plan [AD10]	[AD10]

The visitor support functions are presently being elaborated in the User Support and Outreach Operations Concept and will be captured in the Operations Plan. The associated facility requirements associated with this use case can then be added to future releases of this specification.

The operations workspace requirement can be considered a placeholder until the associated Operations plan is released. Subsequent releases of this requirements specification should provide precise design occupancy requirements for each building. A preliminary estimate (TBC) for the data center occupancy is shown in Table 7.

Occupant Type	Count
Management, Single Office	9
Science Operations, Mix of Single and Multi-Occupant Offices	57
Software Dev, Mix of Single and Multi-Occupant Offices	49
Administrative & Support, Mix of Single and Multi-Occupant Offices	23
Sub-total	138

Table 7: Preliminary occupancy estimate for the Science Operations Center (TBC).

13 Key Performance Parameters (KPPs)

Key Performance Parameters (KPPs) identify critical subsystem capabilities or characteristics that may either have a detrimental impact on the effectiveness of efficiency of the system if not met, or could have a very large positive impact if the specification is exceeded. Subsystem KPPs typically support System KPPs and there should be traceability between them. Each KPP must have a threshold range and objective value. The responsible engineer designs the subsystem to meet the objective value, but performance within the threshold range is considered acceptable. During the design phase, there should be a concerted effort to optimize the KPPs. If the responsible engineer finds that the minimum threshold level of a KPP cannot be achieved the project office shall be notified immediately.

Key Performance Parameter	Req. #	Traceability L1 Req. #
KPP name / description: RFI Emission Objective value: Consistent with tables in [AD05] Threshold range: Consistent with tables in [AD05]	INF0310	EMC0310
KPP name / description: Array Infrastructure Availability Objective value: <0.25% downtime Threshold range: <0.5% downtime	INF2606	SYS2606
KPP name / description: EMC Shielding of CCB Objective value: 100 dB Threshold range: 80 dB	NSB2722	EMC0310
KPP name / description: CEB Availability Objective value: <0.25% downtime Threshold range: <0.5% downtime	NSB2606	SYS2606

Table 8: Subsystem Key Performance Parameters.

14 Verification

The design will be verified to meet the requirements by analysis (A), inspection (I), demonstration (D), or test (T), each defined below.

Verification by Analysis: The compliance of the subsystem to the requirement is demonstrated by appropriate analysis (hand calculations, finite element analysis, modeling and simulation, etc.).

Verification by Inspection: The compliance of the subsystem to the requirement is determined by a simple inspection of the subsystem or of its design documentation.

Verification by Demonstration: The compliance of the subsystem to the requirement is determined by a demonstration.

Verification by Test: The compliance of the subsystem to the requirement is determined by means of a test with and associated analysis of test data.

Multiple verification methods are allowed over the course of the design phase. The primary (final) verification method to be used for the product during the qualification phase prior to its Critical Design Review is identified below.

14.1 Verification Methods

Req. #	Parameter/Requirement	A	I	D	T
INF0360	Operation: Solar Thermal Load	*			
INF0361	Operation: Wind	*			
INF0362	Operation: Temperature	*			
INF0363	Operation: Precipitation				*
INF0364	Operation: Ice	*			
INF0365	Operation: Relative Humidity	*			
INF0341	Survival: Wind	*			
INF0342	Survival: Temperature	*			
INF0343	Survival: Radial Ice	*			
INF0344	Survival: Rain Rate	*			
INF0346	Survival: Snow Load, Equipment & Buildings	*			
INF0347	Survival: Hail Stones	*			
NSB0372	Storage Temperature		*		
NSB0373	Storage Relative Humidity		*		
INF0511	Lightning Protection, Structure		*		
INF0512	Lightning Protection, Electronics Systems		*		
INF0513	Lightning Protection, Personnel		*		
INF0521	Seismic Protection	*			
INF0531	General Vibration				*
INF0541	Equipment Protection		*		
INF0542	Building Protection		*		
INF0551	Rodent Protection		*		
INF0552	Large Mammal Protection		*		
INF0561	Maximum Solar Flux		*		
INF0562	Maximum UV Radiation		*		
INF0571	Rain/Water Infiltration				*
INF0591	Corrosion Protection		*		
INF0582	Mechanical Shocks				*
OPS0372	Storage Temperature		*		
OPS0373	Storage Relative Humidity		*		
INF0310	RFI Emission				*
INF0320	Drive System Shielding		*		
INF0321	Relay Contact Arcing		*		
INF0322	Amplifiers & Oscillators		*		
INF0323	Silicone Controlled Rectifiers		*		
INF0324	Gaseous Discharge Devices		*		
INF0325	Static Discharge Mitigation		*		
INF0326	Display Shielding		*		
INF0327	Digital Equipment Shielding		*		
INF0401	COTS Immunity Standards		*		
INF0402	COTS Certification		*		
INF0471	ESD Low Air Discharge		*		
INF0472	ESD High Air Discharge		*		
INF0473	ESD Direct Contact Discharge		*		
INF0474	ESD Protected Spaces		*		

Req. #	Parameter/Requirement	A	I	D	T
INF0475	ESD Protected Spaces Flooring		*		
INF0476	ESD Protected Spaces Humidity Control			*	
INF2700	Safety Specification		*		
INF2705	Safety Interlocks		*		
INF2703	Security Specification		*		
INF2801	Design Life		*		
INF2802	Cost Optimization		*		
INF2803	Sustainability		*		
INF2812	Critical Spares		*		
INF3600	Identification by Serial Numbers		*		
INF3602	Version Control for Software and Firmware		*		
INF6001	As-Built Drawings		*		
INF6002	Operations and Maintenance Manuals		*		
INF6003	Units		*		
INF6004	Language		*		
INF6005	Electronic Document Format		*		
INF6006	Provision of Building Information Model		*		
INF0001	Provision of Antenna Foundations		*		
INF0002	Provision of Ancillary Foundations		*		
INF0003	Provision of Utility Trenching		*		
INF0004	Provision of Fiber Utility to Antenna Stations		*		
INF0005	Provision of Electrical Utility to Antenna Stations		*		
INF0006	Provision of Electrical Backup Service			*	
INF0007	Provision of Electrical Service Disconnects			*	
INF0008	Provision of Maintenance Access		*		
INF0009	Provision of Physical Security Infrastructure		*		
INF2011	Antenna Foundation Specification				*
INF2012	Ancillary Foundation Specification		*		
INF2014	Fiber Utility to Antenna Station Specification		*		
INF2015	Electrical Utility to Antenna Specification		*		
INF2111	Antenna Foundation Specification				*
INF2112	Ancillary Foundation Specification		*		
INF2114	Fiber Utility to Antenna Station Specification		*		
INF2115	Electrical Utility to Antenna Specification				*
INF2211	Weather Station Infrastructure		*		
INF2212	API Infrastructure		*		
INF2213	Ancillary Foundation & Utility Specification		*		
INF2411	Redundant Services		*		
INF2511	Hardware Interface		*		
INF2606	Array Infrastructure Availability	*			
INF4000	Grassland Impact		*		
INF4001	Sustainable Roads		*		
INF4002	Existing Roads		*		
INF4003	Fences		*		
INF4004	Ranching Impact		*		
INF2819	VLA Interference		*		

Req. #	Parameter/Requirement	A	I	D	T
NSB0001	Provision of a Central Electronics Building		*		
NSB0002	Outfitted Facilities		*		
NSB0003	Facility Sustainability		*		
NSB0004	Controlled Visitor Access		*		
NSB0005	Provision of a Warehouse		*		
NSB0006	Warehouse Inventory System			*	
NSB0007	Warehouse Space – AIV		*		
NSB0008	Location of the Warehouse		*		
NSB0009	Provision of a Guard Booth		*		
NSB0010	Provision of Support Buildings		*		
NSB0011	Facility Space – AIV		*		
NSB0012	Workspace – CSV		*		
NSB0013	Workspace – CSV-Operators		*		
NSB0014	Workspace – Operations		*		
NSB2411	Redundant Services		*		
NSB2711	Hardware Interface		*		
NSB2721	Shielded & Environmentally Controlled Space		*		
NSB2722	EMC Shielding Level				*
NSB2723	Provision of UPS service			*	
NSB2731	Shielded & Environmentally Controlled Space		*		
NSB2732	EMC Shielding Level				*
NSB2733	Provision of UPS service			*	
NSB2734	CSP power supply quality				*
NSB2741	Environmentally Controlled Space		*		
NSB2742	Environmental Stability		*		
NSB2743	Provision of UPS service			*	
NSB2744	RTG power supply quality				*
NSB2751	Environmentally Controlled Space		*		
NSB2752	Environmental Stability				*
NSB2753	Provision of UPS service			*	
NSB2745	RTD power supply quality				*
NSB2603	CEB Preventive Maintenance		*		
NSB2606	CEB Availability	*			
NSB2919	VLA Interference		*		
OPS0001	Outfitted Facilities		*		
OPS0002	Facility Sustainability		*		
OPS0003	Provision of a Maintenance Operations Center		*		
OPS0004	Maintenance Center – Support Equipment		*		
OPS0005	Maintenance Center – Ready Spares		*		
OPS0006	Provision of a Repair Center		*		
OPS0007	Provision of an Array Operations Center		*		
OPS0008	Provision of Remote Support Stations		*		
OPS0009	Remote Support Station Sizing		*		
OPS0010	Location of the Maintenance Operations Center		*		
OPS0011	Location of the Array Operations Center		*		
OPS0012	Location of the Repair Center		*		

Req. #	Parameter/Requirement	A	I	D	T
OPS0013	Facility Space – AIV		*		
OPS0014	Workspace – CSV-Operators		*		
OPS0015	Workspace – Operations		*		
DSC0001	Outfitted Facilities		*		
DSC0002	Facility Sustainability		*		
DSC0003	Provision of the Data Center		*		
DSC0004	Data Center Staff Space		*		
DSC2911	PMN: Environmentally Controlled Space		*		
DSC2912	PMN: Provision of UPS service			*	
DSC2921	OFF: Environmentally Controlled Space		*		
DSC2922	OFF: Provision of UPS service			*	
DSC2931	MSS: Environmentally Controlled Space		*		
DSC2932	MSS: Provision of UPS service			*	
DSC2941	DST: Environmentally Controlled Space		*		
DSC2942	DST: Provision of UPS service			*	
DSC2961	DSS: Environmentally Controlled Space		*		
DSC2962	DSS: Provision of UPS service			*	
SOC0001	Outfitted Facilities		*		
SOC0002	Facility Sustainability		*		
SOC0003	Provision of a Science Operations Center		*		
SOC0004	Location of the Science Operations Center		*		
SOC0005	Science Operations Center Size		*		
SOC0006	Visitor Support Functions		*		

15 Appendix

15.1 Abbreviations and Acronyms

Acronym	Description
AD	Applicable Document
AIV	Acceptance, Integration, and Verification
ANT	18m Main Array Antenna
BLD	Buildings Subsystem
CDR	Conceptual Design Review
CSP	Central Signal Processor
DSC	Data Center
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
FDR	Final Design Review
FIB	Central Fiber Infrastructure Subsystem
IPT	Integrated Product Team
I/F	Interface
ICD	Interface Control Document
INF	Array Infrastructure Subsystem
IPT	Integrated Product Team
KPP	Key Performance Parameter
LRU	Line Replaceable Unit
MCL	Monitor & Control System
MOE	Measure of Effectiveness
MON	Environmental Monitoring & Characterization Systems
MOP	Measure of Performance
ngVLA	Next Generation Very Large Array
NRAO	National Radio Astronomy Observatory
NSB	ngVLA Site Buildings
ONL	Online Software Subsystem
OPS	Operations Buildings
PE	Project Engineer
PFLOPS	Peta Floating Point Operations per Second
RD	Reference Document
RFI	Radio Frequency Interference
RTD	LO Reference & Time Distribution Subsystem
RTG	LO Reference & Time Generation Subsystem
SBA	6m Short Baseline Antenna
SOC	Science Operations Center
TBC	To Be Confirmed
TBD	To Be Determined
TPM	Technical Performance Measure
TPT	Template

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