Stakeholder Requirements

020.10.15.01.00-0001-REQ

Status: **RELEASED**

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Change Record

Version	Date	Author	Notes/Changes
01	2018-06-01	Treacy	Initial version for preliminary Stakeholder Requirements Review (StRR)
02	2018-11-05	Treacy	In-progress draft addressing RIDS from preliminary StRR
03	2018-11-19	Zuckerberg, Selina, Hiriart	Addressed gap analysis, updates from RIDs, and major edits throughout for requirements quality. Reformatted to doc.
04	2018-11-26	Zuckerberg, Selina, Hiriart	Added new categories of requirements for organization. Finished major edits from preliminary StRR and team review.
05	2018-12-05	Selina, Hiriart, Zuckerberg	Updated numbering scheme for consistency with Requirements Management Plan. Updated traceability column entries. Minor updates to requirements flow-down strategy narrative.
06	2019-05-30	Lear	Prepared document for review.
07	2019-05-31	Selina	Minor edits for release.
08	2019-07-08	Selina	Addressing comments from MM review.
A	2019-07-09	Lear	Prepared document for approvals & release.
A.01	2019-08-22	Leyba-Newton, Selina	Fixed template for StRR. Updated throughout with requirements capture from the AIV and CSV Concepts.
A.02	2019-08-27	Lear	Finalized template for document update and release.
A.03	2019-08-27	Selina	Clarifications to the introduction and scope of the document. Updated Abbreviations & Acronyms.
A.04	2019-08-29	Hiriart, Selina	Updates to template code. Typographical corrections in a few requirements.
B	2019-09-04	Selina, Murphy	Incorporated comments from EJM and MM. Release for StRR.
B.01	2020-01-16	Selina	Addressing RIDs from StRR. Updates in both template and MagicDraw database.
B.02	2020-01-23	Selina	Additional updates to template.
B.03	2020-02-03	Selina	Incorporated feedback from EJM and LLN before release.
C	2020-02-05	Lear	Minor copyedits; prepared PDF for approval and release.
C.01	2020-03-09	Selina	Added missing Maintenance Operations requirements to address traceability and gap analysis by WG. Minor copyedits.
C.02	2020-04-16	Selina	Other minor additions to close gap analysis to system requirements.
D	2020-05-04	Lear	Minor copyedits; prepared PDF for approval and release.

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1 Introduction

1.1 Purpose

This document aims to present a set of Level 0 stakeholder requirements for the ngVLA that should guide the development of the facility. Stakeholders, in this context, are people with a stake in the form and fit of the delivered facility, such as those who will eventually operate and maintain the array. This document is complimentary to the ngVLA Science Requirements [AD01] which are documented separately. Level 0 stakeholder requirements are expressed in terms applicable to their needs or use cases, and are generally implementation agnostic.

Many requirements flow from the system lifecycle concept [AD02] documents, especially the Operations and Maintenance Concept [AD07]. Input from the Assembly, Integration and Verification (AIV) Concept [AD08] and the Commissioning and Science Validation (CSV) Concept [AD09] is reflected when appropriate, especially as these concepts inform the development and commissioning of new modes and capabilities in the operations phase.

An attempt has also been made to capture other stakeholder requirements from representatives of various stakeholder groups (safety, regulatory compliance, local citizens, etc.). Where possible, traceability for these requirements is provided to a source, but this document should be considered a primary reference for stakeholder-level requirements.

1.2 Scope

The scope of this document is the ngVLA facility over its full lifecycle. This includes not just the scientific instrument, but the supporting infrastructure necessary for full operations.

The emphasis in this document is on requirements that will inform the technical development of the facility. Programmatic and schedule constraints that influence the design and final deliverable are noted, but requirements that primarily pertain to project scope and the conduct of the project are not considered in scope.

For relevant requirements that inform the conduct of the project, please consult the Project Execution Plan [RD01] and its references including AUI/NRAO policies, the NSF Major Facilities Guide [RD02], and the Systems Engineering Management Plan [RD03].

2 Related Documents

2.1 Applicable Documents

The following documents are applicable to this Requirements Specification to the extent specified. An understanding of these documents is necessary to fully comprehend the scope of this Requirements Specification. In the event of 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.

Ref. No.	Document Title	Rev/Doc. No.
AD01	ngVLA Science Requirements (L0)	020.10.15.00.00-0001-REQ
AD02	Lifecycle Stages & Concepts	020.10.05.00.00-0001-PLA
AD03	Requirements Management Plan	020.10.15.00.00-0001-PLA
AD04	Reference Observing Program	020.10.15.05.10-0001-REP
AD05	Safety Requirements (L0)	020.10.15.10.00-0004-REQ
AD06	Land Acquisition and Regulatory Compliance Requirements (L0)	020.70.00.00.00-0001-REQ
AD07	Operations Concept	020.10.05.00.00-0002-PLA
AD08	Assembly, Integration & Verification Concept	020.10.05.00.00-0005-PLA
AD09	Commissioning & Science Validation Concept	020.10.05.00.00-0006-PLA

2.2 Reference Documents

The following documents provide additional supporting context or are referenced in the text, but reading these documents is not necessary to understand the scope of this document.

Ref. No.	Document Title	Rev/Doc. No.
RD01	ngVLA Project Execution Plan	020.05.00.00.00-0003-PLA
RD02	NSF Major Facilities Guide, Sept. 2019	NSF 19-68
RD03	Systems Engineering Management Plan	020.10.00.00.00-0001-PLA

3 Overview of the Stakeholder Requirements

The L0 Stakeholder Requirements along with any explanatory notes are found in Section 6. The system safety and regulatory compliance requirements are documented separately and incorporated by reference:

[AD05]	*ngVLA Safety Requirements (L0)*	020.10.15.10.00-0004-REQ
[AD06]	*ngVLA Land Acquisition and Regulatory Compliance Requirements (L0)*	020.70.00.00.00-0001-REQ

As noted in Section 4.2, this document includes a number of L0 requirements captured from the lifecycle concept documents including the Assembly, Integration, and Verification Concept [AD08], the Commissioning and Science Validation Concept [AD09], and the Operations and Maintenance Concept [AD07].

The Operations and Maintenance Concept is considered a stakeholder document that feeds directly into the design of the facility. The AIV and CSV concepts are solutions to reaching this deployment, and therefore largely provide lower-level requirement input (at the L1 or L2 levels). However, these concepts have proven useful in informing the development and commissioning of new modes and capabilities in the operations phase. Input from this perspective has been captured at the L0 level within the Stakeholder Requirements.

The lifecycle concepts are a tool for requirements elicitation. The goal is to capture the *need* expressed in the concept, but not necessarily the *solution*. For example, the maintenance concept may describe tracking the configuration of the system through barcodes on line replaceable units (LRUs). The *needs* expressed in this statement are (1) packing of serviceable hardware systems into interchangeable LRUs, and (2) the need for a system for tracking the location and configuration of these LRUs throughout the array. The barcode system is a solution to satisfying this need. In this L0 requirements capture, we aim to capture the need only, leaving the solution space open for the detailed design phase.

This approach requires a degree of abstraction in the L0 requirements capture, with detail added at subsequent requirements refinement and derivation at the L1 or L2 level. It may be appropriate to revisit the lifecycle concept documents in the L1 and L2 requirements derivation to ensure the full expressed need is satisfied in context (i.e., requirements validation).

The lifecycle concept documents also establish a number of scope and process requirements. While necessary for implementation of the concept, these choices do not directly influence the delivered facility and system design, and are therefore not captured as part of this requirements specification. Instead, these decisions are captured in relevant scope and process-oriented documents such as the Project Execution Plan [RD01] (in particular, the scope statement for each IPT and WP), and the Systems Engineering Management Plan [RD03].

Since the stakeholder requirements are written in the stakeholder's language (i.e., non-technical), they are typically not verifiable. The verification and validation strategy for ngVLA aims to capture the broad intent or need with stakeholder requirements, with sufficient specificity in the subsequent derivation of system-level L1 requirements to enable their verification. ngVLA performance to the L0 stakeholder requirements will be validated as part of the commissioning effort and the handover to operations.

4 Requirements Management

4.1 Requirement Definitions

Consistent with the Requirements Management Plan [AD03], the following definitions of requirement "levels" are used in this document.

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

4.2 Requirements Flow-Down

The L0 Requirements are fully captured in the following set of documents:

[AD01]	*ngVLA Science Requirements (L0)*	020.10.15.00.00-0001-REQ
	ngVLA Stakeholder Requirements (L0)	020.10.15.01.00-0001-REQ
[AD05]	*ngVLA Safety Requirements (L0)*	020.10.15.10.00-0004-REQ
[AD06]	*ngVLA Land Acquisition and Regulatory Compliance Requirements (L0)*	020.70.00.00.00-0001-REQ

The functional and performance requirements necessary to support the key science goals of the facility are captured in the L0 Science Requirements [AD01]. Other Stakeholder Requirements also influence or dictate design choices. Examples include programmatic requirements, regulatory compliance requirements, and the lifecycle concepts (e.g., the operations and maintenance concept [AD07]) for the facility, and these requirements are captured here.

The Science Requirements and Stakeholder Requirements, including the Safety and Regulatory requirements incorporated by reference, fully encapsulate all known L0 requirements. The System requirements and subordinate specifications fully encapsulate all known L1 requirements. L0 requirements may be directly passed to the L1 level if the requirement is expressed in appropriate functional or performance terms.

Specifications for individual subsystems (L2) flow from the L1 System Requirements, and may not always be directly attributable to a single system requirement (e.g., phase drift 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 L2 requirements is assessed at the requirements review of each subsystem.

Maintaining complete, enumerated, and traceable science requirements, system requirements, and subsystem specifications ensures this trade-off process is complete and well understood by the project team. The effect of a change in a subsystem specification can be analyzed at the system level, and thereafter the impact on a specific scientific program can be ascertained.

The details of the requirements management strategy can be found in [AD03].

5 Constraints

5.1 Programmatic Constraints

The project shall be designed and constructed within the following constraints:

1. *CON001: Construction Budget*: The construction point estimate shall not exceed $1.7B (2018 USD, TBC.)
2. *CON002: Operations Budget*: The annual operations post estimate shall not exceed $80M/yr. (2018 USD, TBC.)
3. *CON003: Community Engagement*: The project and system architecture shall be structured to permit community development and partner contributions.
4. *CON004: Broader Impacts*: Efforts to leverage, measure, and document the Broader Impacts of the program shall be included in the scope of the design and construction effort.
5. *CON005: Site/Location*: It is a goal to center the array near the existing VLA, on the Plains of San Agustin, NM.
6. *CON006: VLA Reuse*: It is a goal to reuse infrastructure and buildings built as part of the VLA or EVLA effort.
7. *CON007: Design & Development Timeline*: It is a goal to conclude design and development activities in a seven-year period ending in 2024.
8. *CON008: Construction Timeline*: It is a goal to begin construction by 2025, and conclude within a ten-year period in 2034.
9. *CON009: AIV Scope*: The project shall include necessary assembly and integration facilities in the project scope. It is a goal to have dual use assembly/integration facilities that fulfill a necessary operations role (e.g., an assembly space in AIV transitions in to the Operations Warehouse or Repair Facility).
10. *CON010: Commissioning Scope*: The commissioning of the observatory shall be within the scope of the construction project, not operations.
11. *CON011: Concurrent Construction & Operations*: The transition from the construction phase to the operations phase will be staged, with a progressive and incremental set of capabilities and infrastructure delivered to Operations. It is a goal to begin early science operations by 2028.

6 Stakeholder Requirements

6.1 Science Operations

Parameter	Req. #	Value	Traceability
Operations Concept	STK0200	The system shall be a proposal-driven, pointed, general-purpose instrument.	[020.10.05.00.00-0002-PLA-C, Sec 1, Para 2]; [020.10.05.00.00-0002-PLA-C, Sec 12.2, Table]

6.2 System Life Cycle

Parameter	Req. #	Value	Traceability
Material Selection & Sustainability	STK0302	The environmental sustainability of materials, and the environmental impact from the construction through to the disposal phase, shall be evaluated in the system lifecycle cost analysis and trade studies.	[020.10.05.00.00-0001-PLA-A, Sec 3.4.3, Para 3]; [020.10.05.00.00-0001-PLA-A, Sec 3.6, Para 2]
Design Life	STK0303	The system shall be designed for an initial operations campaign of 20 years, beginning at the start of full operations (i.e., post system commissioning).	[Directors Office, 2016]
Projected Environment	STK0304	The system shall be designed to survive the environmental conditions expected over the instrument Design Life, and shall survive 50-year events (extreme weather, seismic, etc.) without damage in excess of 1% of construction cost.	[020.10.05.00.00-0001-PLA-A, Sec 3.4.2, Para 2]
Part Selection & Obsolescence	STK0310	The project shall predict elements prone to early obsolescence, and identify plans for replacement. This plan will apply to both the construction and operations phases of the life cycle.	[020.10.05.00.00-0001-PLA-A, Sec 3.4.3, Para 3]

6.3 Integration and Verification

Parameter	Req. #	Value	Traceability
Provision of Assembly Verification Tools	STK0400	Test frameworks (unit tests, hardware simulators, and test racks) for the stand-alone verification of line replaceable units and subsystems shall be provided.	[020.10.05.00.00-0005-PLA-B, Sec 5.2.5, Para 1]
Provision of System Verification Software Tools	STK0402	The system shall provide engineering interfaces to test system functional status without the use of the full end-to-end software system (e.g., tools to generate and execute test scripts for fringe tests; tools to see fringes on a baseline in near real-time).	[020.10.05.00.00-0005-PLA-B, Sec 5.2.2, Para 3]

Parameter	Req. #	Value	Traceability
Spare Parts	STK0403	The project shall deliver critical spares (those likely to become obsolete, too expensive to replace within the operations budget, single points of failure, or sole-source supply) for the operating life of the facility within the scope of construction.	[020.10.05.00.00-0002-PLA-C, Sec 7.1, Para 2]
Testing: Software & Firmware	STK0427	All software and firmware delivered by the project shall be delivered with automated unit, integration, and regression testing suites.	[020.10.05.00.00-0005-PLA-B, Sec 5.2.2, Para 1]
AIV Software Tools	STK0431	Development tools, compilers, source code, and the build system shall be delivered for all project software to enable maintenance over the life of the facility.	[020.10.05.00.00-0005-PLA-B, Sec 5.2.2, Para 3]
ICD: API and Software Definition	STK0432	All Application Program Interfaces (API) or other software interfaces shall be defined in ICDs.	[020.10.05.00.00-0005-PLA-B, Sec 5.2.2, Para 4]
ICD: Automated Conformance Testing	STK0433	Automated test results demonstrating conformance to API ICDs shall be delivered with the product.	[020.10.05.00.00-0005-PLA-B, Sec 5.2.2, Para 4]
ICD: LRUs	STK0434	ICDs shall be delivered for each Line Replaceable Unit in the system.	[STRR RID #33]
Project Documentation	STK0435	Documentation necessary to support the training of operations and maintenance staff, and to execute preventive and corrective maintenance for the operations phase of the facility, shall be delivered prior to the transition to full operations.	
Assembly, Integration, and Verification Concept	STK0536	An Assembly, Integration and Verification Concept shall be documented and approved by the Observatory. The concept shall describe the overall approach of the project to deploy, test and verify instrument capabilities. Any requirements to fulfill the Assembly, Integration and Verification Concept shall be a construction project responsibility.	

6.4 Commissioning and Science Validation

Parameter	Req. #	Value	Traceability
First Look Science Products	STK0500	The project shall prepare and release a set of First Look Science Products, obtained as part of Science Validation activities, before of the start of proposal-driven observations with the array.	[020.10.05.00.00-0002-PLA-C, Sec 5.5, Para2]; [020.10.05.00.00-0006-PLA-B, Sec 2.4.1, Para 4]

Parameter	Req. #	Value	Traceability
Availability for Early Science	STK0501	Proposal-driven observations, or Early Science, shall commence as soon as a commissioned observing mode is available with capabilities in excess of the current VLA.	[020.10.05.00.00-0001-PLA-A, Sec 3.4.1, Para 3], [020.10.05.00.00-0002-PLA-C, Sect 5.0, Para 4., Sect 5.5, Para 3.]
Provision of Commissioning Tools	STK0502	The system shall include software interfaces and diagnostic tools to quantify system performance and status (e.g., tools to plot real time calibration coefficients).	[020.10.05.00.00-0006-PLA-B, Sec 5.1, Para 1]
Transition to Ops: Capabilities and Observing Modes	STK0511	Operational capabilities and observing modes must be made available in stages during the transition from construction through to the commencement of full operations.	[020.10.05.00.00-0006-PLA-B, Sec 2.4.1, Para 2]
Commissioning: Observing Mode SRDP Pipeline	STK0512	Delivery of a commissioned standard observing mode shall include an operational SRDP pipeline before it is offered for regular use through PI proposals.	[020.10.05.00.00-0006-PLA-B, Sec 2.4.1, Para 3], [020.10.05.00.00-0002-PLA-C, Sec 5.3, Para 3]
API & Scheduling Blocks	STK0516	A science-oriented API (scripting interface) for calling high-level array functions, prior to the widespread use of Scheduling Blocks (SBs), shall be delivered.	[020.10.05.00.00-0006-PLA-B, Sec 5, # 5]
Simulators: Development of Observing Scripts	STK0517	Simulators to enable the development of observing scripts without the real system shall be delivered.	[020.10.05.00.00-0006-PLA-B, Sec 5, # 6]
Interactive Shell Access	STK0518	The system shall provide interactive shell access to the calibration and imaging software, running on an observatory-supported OS.	[020.10.05.00.00-0006-PLA-B, Sec 5, # 7]
Contemporaneous Calibrator Data	STK0520	It is a goal for the system to provide interfaces to make use of any contemporaneous flux densities, spectra, and polarization of calibrators in the various ngVLA bands that are already provided by the VLA and/or ALMA.	[020.10.05.00.00-0006-PLA-B, Sec 5, # 9]
Data Access: Visibility Data	STK0523	The system shall provide interfaces to, and tools to process, the visibility data outside of the automatic, non-interactive processing model that is needed for Standard Observing Modes in Full Operations.	[020.10.05.00.00-0006-PLA-B, Sec 5.2.4, Para 2]

Parameter	Req. #	Value	Traceability
Commissioning & Science Validation Concept	STK0524	A Commissioning and Science Validation Concept shall be documented by the project and approved by the Observatory. The concept shall describe the overall approach of the project to commission the instrument capabilities and transition to full operations. Any requirements to fulfill the Commissioning and Science Validation Concept shall be a construction project responsibility.	

6.5 Observing Modes

Parameter	Req. #	Value	Traceability
Standard Modes: Time-Phased Availability	STK0700	By Full Operations the project shall provide a set of standard observing modes that can achieve the ngVLA Key Science Goals.	[020.10.05.00.00-0002-PLA-C, Sec 5, Para 4]
Standard Modes: Generation of Scheduling Blocks	STK0701	For standard observing modes, observing instructions (e.g., scheduling blocks) shall be generated based on the scientific and technical requirements specified by the PI in their submitted proposal.	[020.10.05.00.00-0002-PLA-C, Sec 5, Para 4]
Non-Standard Observing Modes	STK0702	The system, starting with the proposal submission system, shall support non-standard observing modes, when programs require other instrument configurations and/or non-standard and non-automated data processing.	[020.10.05.00.00-0002-PLA-C, Sec 5, Para 5]
Observing Awards: Array Time on Source	STK0703	The observation execution process shall manage allocated time by subarray to an observation. Successful PIs will be awarded array time on source rather than guaranteed satisfaction of a scientific objective such as sensitivity.	[020.10.05.00.00-0002-PLA-C, Sec 5.2, Para 4]
Standard Modes: Observing Strategy	STK0704	The Observatory shall provide a defined observing strategy (including array characterization and quantitatively known calibration overheads within an acceptable margin of error) for all standard modes and capabilities.	[020.10.05.00.00-0002-PLA-C, Sec 5.2, Para 4]
Standard Modes: Flexibility	STK0705	Interfaces for PIs to make changes to the standard observing strategy, when required to meet the scientific objectives, shall be available.	[020.10.05.00.00-0002-PLA-C, Sec 5.2, Para 4]

6.6 Proposal Submission

Parameter	Req. #	Value	Traceability
Proposal Submission Criteria	STK0800	The proposal submission system shall capture the information necessary for scheduling the telescope, configuring the instrument, and collecting the data appropriate to address the scientific goals. For Standard Operating Modes, it shall also capture sufficient information to automatically generate the appropriate Science Ready Data Products (SRDPs).	[020.10.05.00.00-0002-PLA-C, Sec 5, Para 3]
Proposal Submission Tool	STK0801	A proposal tool shall be supplied to allow users to specify the scientific and technical requirements for their projects. Projects can request both telescope time and/or compute resources (i.e., archive reprocessing).	[020.10.05.00.00-0002-PLA-C, Sec 5.1, Para 1]
Proposal Assessment	STK0802	The proposal management system shall provide interfaces for (1) scientific review by science review panels made up of experts from the broad astronomy research community, and (2) technical review by facility experts.	[020.10.05.00.00-0002-PLA-C, Sec 5.1, Para 1]
Mitigating Bias in Proposal Peer Review	STK0803	The ngVLA proposal review interface shall anonymize the proposal for scientific and technical review, with a goal of minimizing reviewer bias in the time allocation process.	[020.10.05.00.00-0002-PLA-C, Sec 5.1, Para 1]
Proposal Attributes	STK0804	The system shall support proposal attributes such as regular, triggered, monitoring, large and legacy (see 020.10.05.00.00-0004-PLA), and joint (with other observatories).	[020.10.05.00.00-0002-PLA-C, Sec 5.1, Para 3]
Proposal Submission Concept	STK0805	The proposal submission process shall minimize the need for PIs to have expert knowledge of the hardware, calibration and data processing issues specific to the ngVLA.	[020.10.05.00.00-0002-PLA-C, Sec 5.1, Para 1]

6.7 Scheduling

Parameter	Req. #	Value	Traceability
Priority in Scheduling Observations	STK0900	The system shall schedule observations based on the scientific rankings of proposals, taking into consideration array status and observing conditions.	[020.10.05.00.00-0002-PLA-C, Sec 5.1, Para 4]
Priority for Triggered Observations	STK0901	A capability to interrupt the execution of the observing program in order to respond to a triggered observation with a higher scientific rank shall be provided.	[020.10.05.00.00-0002-PLA-C, Sec 5.2, Para 3]

Parameter	Req. #	Value	Traceability
Concurrent Maintenance and Observation	STK0902	In order to support concurrent maintenance and observations, it shall be possible to dynamically remove/add antennas from/to an active observation without interrupting the execution of the project.	[020.10.05.00.00-0002-PLA-C, Sec 6.1, Para 1]

6.8 Data Processing

Parameter	Req. #	Value	Traceability
Pipeline Use for Standard Observing Modes	STK1000	The system should, in Full Operations, support 80% or more of the awarded proposals with the delivered set of standard observing modes, for which the calibration and data processing will be undertaken through an automated pipeline developed and run by the Observatory.	[020.10.05.00.00-0002-PLA-C, Sec 5, Para 3]
Computing Resources for Standard Modes: Reprocessing	STK1001	The system shall provide computing resources for data reprocessing, requested by PIs, with capacity to reprocess no less than 20% of recorded observations each year.	[020.10.05.00.00-0002-PLA-C, Sec 5.3, Para 2]
Computing Resources for Standard Modes	STK1002	The system shall provide necessary computing resources for the data processing associated with normal operations using standard modes and capabilities (including the delivery of Science Ready Data Products to PIs).	[020.10.05.00.00-0002-PLA-C, Sec 5.3, Para 2]
Support for Legacy Programs	STK1004	The system shall include interfaces to support generating some or all SRDP for Large and Legacy scale projects, if the project SRDPs can be generated within available compute resources. Large and Legacy scale projects will identify data processing requirements and resources, and may require additional computing resources from non-Observatory sources in order to be scheduled.	[020.10.05.00.00-0002-PLA-C, Sec 5.3, Para 5]
Data Delivery: Process in Place	STK1005	User interface tools to ngVLA data shall permit processing the data in place rather than transferring the data across the Internet for processing and analysis by users.	[020.10.05.00.00-0002-PLA-C, Sec 5.4, Para 5]

6.9 Data Archive

Parameter	Req. #	Value	Traceability
Data Product Types to Archive	STK1100	Raw visibilities, calibration tables, and SRDPs shall be stored and made available to PIs and archival researchers through the Data Archive.	[020.10.05.00.00-0002-PLA-C, Sec 5.3, Para 4]

Parameter	Req. #	Value	Traceability
Data Archive Functionality: Image Selection & Download	STK1101	The Archive user interface shall allow users to inspect and select image data for download.	[020.10.05.00.00-0002-PLA-C, Sec 5.4, Para 1]
Reprocessing & Automated QA via Archive	STK1102	The Data Archive shall provide an interface to allow scientists to initiate reprocessing of ngVLA archived data using Observatory-provided techniques and tools, and shall include automated quality assurance processes.	[020.10.05.00.00-0002-PLA-C, Sec 5.4, Para 1]
Proprietary Period for PI Data	STK1103	PI access to data shall be protected by a proprietary period (nominally a year, but determined by Observatory policy), after which the data and data products are fully and publicly accessible. The proprietary period shall be granular to the level of a scan, and begin when the data products are made available to PIs.	[020.10.05.00.00-0002-PLA-C, Sec 5.4, Para 2]
User Produced Data Products	STK1104	The Data Archive shall have provisions for accepting user-produced data products where those products can be quality assured by the Observatory (such as products from Large projects or Legacy projects). In such circumstances the Observatory will approve the user QA process, not the individual products.	[020.10.05.00.00-0002-PLA-C, Sec 5.4, Para 3]
Proprietary Period for Legacy Program Data	STK1105	It shall be possible to adjust the proprietary period by project and project class. Large and Legacy projects and some other special cases may have a different proprietary period, subject to Observatory-level proprietary policy changes.	[020.10.05.00.00-0002-PLA-C, Sec 5.4, Para 4]
Data Delivery via Observatory Archive	STK1106	Data products shall be delivered to the Principal Investigators through an Internet-accessible Observatory Science Data Archive.	[020.10.05.00.00-0002-PLA-C, Sec 5, Para 3]
Data Provenance	STK9950	The system shall include all the necessary tools and data stores for scientific operations staff to be able to retroactively associate any recorded data with the full state of the system (inclusive of hardware and software versions across sub-systems) used to generate the data set.	[STRR RID #25]

6.10 Support Datastores

Parameter	Req. #	Value	Traceability
System Calibration Database	STK1150	A System Calibration database shall be provided to store antenna-based calibration parameters such as gain curves and polarization D-terms.	[020.10.05.00.00-0006-PLA-B, Sec 2.4.3, Para 1]

Parameter	Req. #	Value	Traceability
Astronomical Calibrator Database	STK9943	An Astronomical Calibrator database shall be provided to store calibrator flux density histories and image models.	[020.10.05.00.00-0006-PLA-B, Sec 5.1, List Item 9]

6.11 Calibration

Parameter	Req. #	Value	Traceability
Storage & Retrieval of Calibration Coefficients	STK1300	The system shall provide for automatic storage and retrieval of system parameters determined by calibration, such as delays or bandpass gains.	[020.10.05.00.00-0002-PLA-C, Sec 5.8, Para 1]
Automated Re-Measurement of Calibration Coefficients	STK1301	Re-measurement of calibration and related scientific performance characteristics of the array, as required to support the Standard Observing Modes, shall be automated and performed as an Observatory function.	[020.10.05.00.00-0002-PLA-C, Sec 5.8, Para 1]
Inclusion of Calibration Pipelines & Supporting Systems	STK1302	The design of online and offline calibration strategies to support standard observing modes, including any supporting hardware and software, shall be a construction project deliverable.	[020.10.05.00.00-0006-PLA-B, Sec 2.4.3, Para1]

6.12 Observational Efficiency

Parameter	Req. #	Value	Traceability
Subarrays for Scheduling	STK1401	The proposal tools and scheduling system shall support, at a minimum, a limited number of predefined science subarrays.	[020.10.05.00.00-0002-PLA-C, Sec 5.2, Para 1]
Observational Efficiency	STK1402	The system shall be designed to maximize the array's resources and time spent on scientific observations (vs maintenance, testing, and development efforts.) Greater than 90% of antennas shall be available for scientific observations 80% of the time. Goal of system availability for scientific observations of 95% of time, with at least 70% of antennas.	[020.10.05.00.00-0002-PLA-C, Sec 6.1, Para 2]
Calibration Efficiency	STK1403	Within the portion of time spent on science observations, the system shall be optimized for time spent on the science target, with consideration given to minimizing operational overheads and calibration level.	[020.10.05.00.00-0002-PLA-C, Sec 5.1, Para 4]

6.13 User Support

Parameter	Req. #	Value	Traceability
Operational User Support	STK1200	The project shall provide tools and interfaces for user support for all aspects of ngVLA use related to proposing, observing, data quality, processing, and data analysis.	[020.10.05.00.00-0002-PLA-C, Sec 5.6, Para 1]
Software Packages Available to User Community: Data Analysis	STK1201	The project shall provide software tools for data analysis by users. The package shall be executable on Observatory compute resources and on external computers.	[020.10.05.00.00-0002-PLA-C, Sec 5.3, Para 6]
Software Packages Available to User Community: Data Processing	STK1202	The project shall provide software tools to the user community for processing ngVLA visibilities. The package shall be executable on Observatory computational resources and on external computers.	[020.10.05.00.00-0002-PLA-C, Sec 5.3, Para 6]
Open Source Software	STK9947	The ngVLA data processing and analysis software shall be developed under an open source license and the source code shall be made available to the community in order to foster community experimentation.	[STRR RID #49]

6.14 Array Operations

Parameter	Req. #	Value	Traceability
Array Operations: Subarray Use	STK1501	The automatic scheduling of array time shall incorporate the use of concurrent subarrays, allowing a more continuous concurrent implementation of scientific observations, maintenance, and testing.	[020.10.05.00.00-0002-PLA-C, Sec 6.1, Para 2]
Operator Interface	STK1502	The system shall include interfaces for human operator(s) to oversee the array. The operator interface shall enable the supervision of array scheduling and observation execution, while also reporting array status and system health.	[020.10.05.00.00-0002-PLA-C, Sec 6.2, Para 1]
Array Operations: Remote & Automated Functions	STK1506	Functions leveraging remote operations and automation of antenna functions shall be implemented when supported by lifecycle cost analysis.	[020.10.05.00.00-0002-PLA-C, Sec 6.2, Para 3]
Operator Interface Location	STK9944	It shall be possible for authorized personnel to access the operator interface software from any approved workstation in the observatory.	[STRR RID #52]

6.15 Maintenance Operations

Parameter	Req. #	Value	Traceability
Provision of Diagnostic Tools	STK5001	The system shall include interfaces for engineers and technicians to monitor the health of the system and remotely diagnose failures and behavior anomalies.	[020.10.05.00.00-0002-PLA-C]
Provision of Predictive Tools	STK5002	The system shall include automated tools to predict the location and nature of failures in support of maintenance scheduling.	[020.10.05.00.00-0002-PLA-C]
Maintenance Scheduling Tools	STK5003	Tools for the prioritization and scheduling of corrective and preventive maintenance activities shall be provided.	[020.10.05.00.00-0002-PLA-C]
Provision of Corrective Maintenance Equipment	STK5004	The system shall include the equipment and vehicles necessary to execute planned preventive and corrective maintenance operations.	[020.10.05.00.00-0002-PLA-C]
Maintenance Concept	STK5005	The facility shall include all ancillary buildings, tools, equipment, and system features necessary to support the facility Maintenance Concept.	[020.10.05.00.00-0002-PLA-C]

6.16 Configuration Management

Parameter	Req. #	Value	Traceability
Remote Access of System Configuration	STK1600	The system configuration shall be remotely ascertainable for each major element (Line Replaceable Unit, Software Module, or equivalent) of the system, even those that do not typically have integrated diagnostic monitoring (e.g., cryogenic refrigerators), so that the facility configuration can be queried and tracked using automated tools.	[020.10.05.00.00-0002-PLA-C, Sec 7.2, Para 3]
Identification by Serial Numbers	STK1602	Individual LRUs, and all other configurable items, shall be uniquely identifiable to facilitate status and location tracking across the Observatory.	[020.10.05.00.00-0006-PLA-B, Sec 5, # 4]
Packaging as LRUs	STK1603	Electronics shall be packaged as Line Replaceable Units (LRUs), where LRU modules are interchanged at the antenna.	[020.10.05.00.00-0002-PLA-C, Sec 7, Para 5]
Configuration Management Tools	STK1604	The project shall provide configuration management tools for tracking the design versions of construction deliverables throughout the system life cycle.	[020.10.05.00.00-0005-PLA-B, Sec 3, Bullet 7]
Version Control: Software & Firmware	STK1606	All software and firmware delivered to the project shall be version controlled via a configuration management process.	[020.10.05.00.00-0005-PLA-B, Sec 5.2.2, Para 1]

Parameter	Req. #	Value	Traceability
Configuration Retrieval	STK9945	All configurable LRUs shall retrieve their hardware parameter configuration automatically after replacement, and upon a change in the parameter in the System Calibration database.	[STRR RID #35]

6.17 Quality Assurance and Quality Control

Parameter	Req. #	Value	Traceability
Quality Control Database	STK1900	A quality control database shall be provided to record repairs, test data and associated information on each LRU. The database should be globally visible to all authorized personnel from any ngVLA location, even out in the field at remote antennas.	[020.10.05.00.00-0002-PLA-C, Sec 9.3, Para 3]
Quality Control	STK1902	Stand-alone acceptance testing of software and hardware deliverables (based on a qualification matrix unique to each deliverable) must occur before delivery to, or installation on, the array.	[020.10.05.00.00-0002-PLA-C, Sec 9.3, Para 3]
Automated QA of Data Products	STK9948	The system shall include an automated quality control check of low-level and high-level data products generated using standard operating modes.	[STRR RID #53]
QA tools for Data Products	STK9949	The system shall include tools for human inspection when the automated QA system identifies faults, or when data products were generated with non-standard modes.	[STRR RID #53]

6.18 Facilities

Parameter	Req. #	Value	Traceability
Inclusion of a Visitor Center	STK2000	An ngVLA Visitor Center shall be provided for public outreach and shall be located near the array, but at some distance from the center of the core to mitigate RFI. It is a goal to renovate and reuse the VLA Cafeteria for this purpose.	[020.10.05.00.00-0002-PLA-C, Sec 8.4, Para 1], [Director's Office, 2018.]
Inclusion of a Maintenance Operations Center	STK2001	A Maintenance Operations center shall be provided as the duty station for safety, security, and maintenance personnel. This center shall serve as the node for maintenance activities and the storage of LRUs, field tools and equipment.	[020.10.05.00.00-0002-PLA-C, Sec 8.5, Para 1]
Inclusion of a Warehouse	STK2002	A central warehouse shall be provided for controlled inventory of all components used for preventive and corrective maintenance.	[020.10.05.00.00-0002-PLA-C, Sec 8.5, Para 3]

Parameter	Req. #	Value	Traceability
Inclusion of a Repair Center	STK2003	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.6, Para 1-2]
Inclusion of an Array Operations Center	STK2004	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.6, Para 1-2]
Inclusion of a Science Operations Center	STK2005	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.7, Para 1-2]
Inclusion of Remote Support Stations	STK2006	Remote Support Stations (RSS) shall be provided and located to support operations across the array extent. 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.	[020.10.05.00.00-0002-PLA-C, Sec 8.8, Para 1-3]
Location of the Maintenance Operations Center	STK2007	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.5]
Location of the Array Operations Center	STK2008	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.6]
Location of the Science Operations Center	STK2009	The Science Operations Center shall be located at a site that facilitates personnel recruitment, such as an attractive metropolitan area.	[020.10.05.00.00-0002-PLA-C, Sec 8.7]
Location of the Repair Center	STK2010	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.6]

Parameter	Req. #	Value	Traceability
Location of the Warehouse	STK2011	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.5]
Inclusion of a Guard Booth	STK2012	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.2 Para 1]
Inclusion of Central Support Buildings	STK2013	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.	[020.10.05.00.00-0002-PLA-C, Sec 8.2, Para 1]

6.19 Logistics

Parameter	Req. #	Value	Traceability
Inventory Tracking System	STK2100	A system shall be provided to electronically track inventory to determine usage rate and location of spare assemblies, component level spares, and consumables.	[020.10.05.00.00-0002-PLA-C, Sec 9.2, Para 1]
Shipping & Receiving Logistics	STK2102	Each facility shall have central shipping and receiving and be integrated with a shipping system between sites.	[020.10.05.00.00-0002-PLA-C, Sec 9.2, Para 2]
Repair & Tracking of LRUs	STK2103	Provisions shall be provided for centralized management, testing, and repair of LRUs from the Repair Center. Repaired LRUs may be stored near the point of service at the Maintenance Center and RSS locations.	[020.10.05.00.00-0002-PLA-C, Sec 9.3, Para 1]
Observatory-Controlled Logistics	STK2105	Observatory-controlled shipping resources shall be provided to enable prioritization, possession, and safe-handling of items during transit (i.e., to be used rather than commercial carriers, when practical).	[020.10.05.00.00-0002-PLA-C, Sec 9.2, Para 2]
Packaging Used for Shipping	STK2106	Shipping cases and packaging shall be provided with ESD protection and mechanical shock absorption.	[020.10.05.00.00-0002-PLA-C, Sec 9.2, Para 2]

6.20 Security

Parameter	Req. #	Value	Traceability
Physical Security Plans	STK2201	Physical security and monitoring for the ngVLA central site and remote sites shall be provided.	[020.10.05.00.00-0002-PLA-C, Sec 9.5, Para 1-2]

Parameter	Req. #	Value	Traceability
Cybersecurity	STK2202	ngVLA IT systems shall be hardened against intrusion consistent with existing NRAO CIS policies.	[020.10.05.00.00-0002-PLA-C, Sec 9.6, Para 1]

6.21 Local Stakeholders

Parameter	Req. #	Value	Traceability
Grassland & Water	STK2400	The project shall minimize the impact on grasslands and water within the plains of San Agustin. Special care will be necessary in the array core given the degree of disturbance.	[J&S Bruton, 09/25/2018 visit by PD.]
Roads	STK2401	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.	[J&S Bruton, 09/25/2018 visit by PD.]
Existing Roads	STK2402	Existing ranch roads shall be assessed for suitability in both construction and operations. It is a goal to reuse existing roads where possible.	[J&S Bruton, 09/25/2018 visit by PD.]
Fences	STK2403	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.	[J&S Bruton, 09/25/2018 visit by PD.]
Ranching Impact	STK2404	The project shall aim to reduce the environmental impact to cattle ranching as well as hunting/outfitting, which are both mainstays of local ranches.	[J&S Bruton, 09/25/2018 visit by PD.]
Core Site	STK2405	The specific location of the array core shall consider the differences in the quality of lands on the Plains for other beneficial uses including ranching.	[J&S Bruton, 09/25/2018 visit by PD.]

6.22 NRAO and Other Facility Integration

Parameter	Req. #	Value	Traceability
SRDP Integration	STK2500	The ngVLA project should extend and reuse the SRDP Observatory-User interfacing architecture for ngVLA.	[SRDP AD, 2018. Director's Office, 2018.]
Facility Integration	STK2501	It is desirable for ngVLA to support joint (e.g., VLB) observations with other NRAO facilities, as well as other global flagship facilities.	[ngVLA PD]
DMS Integration	STK2502	The ngVLA project shall adopt existing NRAO Data Management & Software (DMS) policies, with facility integration into Observatory infrastructure and standards, in order to promote reuse and maintainability.	[DMS AD, 2016]

6.23 Radio Frequency Interference

Parameter	Req. #	Value	Traceability
Self-Interference	STK2600	The system shall be designed to prevent self-interference that will be detrimental to science operations.	[ngVLA PD]
RFI Survival	STK2601	The system shall be designed to withstand, without damage or long-term degradation, the projected RFI environment over the life of the instrument.	[ngVLA PD]
RFI Mitigation	STK2602	The system shall be designed to operate in the projected RFI environment while still achieving the Key Science Goals and the desired operational efficiencies.	[ngVLA PD]
VLA Interference	STK2603	It is a goal to minimize interference with VLA operations during the construction/ transition phase.	[ngVLA PD]

6.24 Non-Traditional Use Cases

Parameter	Req. #	Value	Traceability
SSA Support	STK2800	It is a goal for the ngVLA to support non-traditional use cases related to space situational awareness, such as imaging of geostationary objects.	[Directors Office, 2016]
DSN Support	STK2801	It is a goal for the ngVLA to support non-traditional use cases related to spacecraft operation, such as Deep Space Network (DSN) downlink support for critical NASA missions.	[Directors Office, 2016]

6.25 Future Commensal Systems

Parameter	Req. #	Value	Traceability
Commensal Front Ends	STK2900	The system shall be designed for but not with commensal front ends (e.g., ngLOBO), with interfaces for future commensal receivers and data processing systems incorporated into the design.	[NRL, LWA, 2016]
Commensal Back-Ends	STK2901	The system shall be designed for but not with commensal back-ends (e.g., RealFast, SETI), with interfaces for future commensal back-ends incorporated into the design.	[ngVLA PD]

7 Appendix

7.1 Abbreviations and Acronyms

Acronym	Description

AD	Applicable Document
AIV	Assembly, Integration and Verification
ALMA	Atacama Large Millimeter/submillimeter Array
AOC	Array Operations Center
API	Application Programming Interface
APM	Atmospheric Phase Monitor
AST	Division of Astronomical Sciences (NSF)
AUI	Associated Universities Inc.
CASA	Common Astronomy Software Applications
CDL	Central Development Laboratory
CSV	Commissioning & Science Validation
DMS	Data Management & Software
DSN	Deep Space Network
EMC	Electro-Magnetic Compatibility
ESD	Electro-Static Discharge
EVLA	Expanded Very Large Array Project
FOV	Field of View
FWHM	Full Width Half Max
HPC	High Performance Computing
ICD	Interface Control Document/Definition
IF	Intermediate Frequency
IPT	Integrated Product Team
IT	Information Technology
KPP	Key Performance Parameters
KSG	Key Science Goals
LFM	Large Facilities Manual
LO	Local Oscillator
LRU	Line Replaceable Unit
LSST	Large Synoptic Survey Telescope
MOC	Maintenance Operations Center
MoE	Measure of Effectiveness
MoP	Measure of Performance
MREFC	Major Research Equipment and Facilities Construction (NSF)
MTBF	Mean Time Between Failure
MTTF	Mean Time To Failure
NES	Near Earth Sensing
ngLOBO	Next Generation LOw-Band Observatory
ngVLA	Next Generation VLA
NMTO	New Mode Test Observation
NRAO	National Radio Astronomy Observatory
NSDR	Non-Standard Data Reduction
NSF	National Science Foundation

OS	Operating System
PD	Project Director
PI	Principal Investigator
PM	Preventive Maintenance
PWV	Precipitable Water Vapor
RID	Review Item Discrepancy
RD	Reference Document
RFI	Radio Frequency Interference
rms	Root Mean Square
RSS	Root of Sum of Squares; Remote Support Station
SAC	Science Advisory Council
SB	Scheduling Block
SKA	Square Kilometer Array
SMDR	Standard Mode Data Reduction
SNR	Signal to Noise Ratio
SOC	Science Operations Center
SRDP	Science Ready Data Products
SRO	Shared Risk Observing
STRR	Stakeholder Requirements Review
SWG	Science Working Group
TBC	To Be Confirmed
TBD	To Be Determined
VLA	Jansky Very Large Array
VLASS	Very Large Array Sky Survey
VLB	Very Long Baseline (Interferometry)
VLBI	Very Long Baseline Interferometry
WFIRST	Wide Field InfraRed Survey Telescope
WP	Work Package
WVR	Water Vapor Radiometer