Computing and Software:

Technical Requirements

020.50.00.00.01-0001-REQ

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Change Record

Version	Date	Author	Notes/Changes
A	07/30/2019	Hiriart	First release for ngVLA Reference Design.
A.01	05/01/2022	Hiriart	Intermediate draft update.
A.02	06/09/2022	Hiriart	Draft version prepared for System CDR, with review from internal stakeholders.
A.03	06/12/2022	Kusel	Minor quality & formatting updates. Draft version released for System CDR.

Table of Contents

1 Introduction

1.1 Purpose

This document presents the L2 Computing and Software requirement specification, with the purpose of guiding further analysis and design activities by the ngVLA Computing and Software IPT and the NRAO Data Management and Software department.

1.2 Scope

The scope of this requirement specification are all the software and computing systems involved in the end-to-end operations of the ngVLA system. In this version of the document, the main goal has been to identify important cost or performance-driving requirements from the System Requirements document [AD02] and other applicable documents, specifying requirements when enough information is available for doing so, or identifying areas that require further analysis and research when not. This document does not present an exhaustive derivation of L2 subsystem requirements, as this is the goal of the Software PDR.

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.

Reference No.	Document Title	Rev / Doc. No.
AD01	Stakeholder Requirements	020.10.15.01.00-0001
AD02	System Requirements	020.10.15.10.00-0003
AD03	Science Requirements	020.10.15.00.00-0001

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.

Reference No.	Document Title	Rev / Doc. No.
RD01	Size-of-Computing Estimates for ngVLA Synthesis Imaging	ngVLA Comp. Memo #4
RD02	A Notional Reference Observing Program	020.10.15.05.10-0001
RD03	Baseline HPG runtime performance for imaging	ngVLA Comp. Memo #7
RD04	Requirements Management Plan	020.10.15.00.00-0001

RD05	Proposal Process Concept	020.10.05.05.00-0011
RD06	Observation Preparation Concept	020.10.05.05.00-0010
RD07	Observation Execution Concept	020.10.05.05.00-0013
RD08	Telescope Support Concept	020.10.05.05.00-0008
RD09	Operations Maintenance Concept	020.10.05.05.00-0007
RD10	Data Processing Concept	020.50.55.00.00-0001
RD11	Observing Mode Calibration Strategy	020.10.05.05.00-0006

3 Overview of Subsystem Requirements

3.1 Document Outline

The requirements specified in this document have been organized by functional area. In general, the functional requirements can be organized in sections that follow the data flow that supports the end-to-end operation of the telescope:

1. Proposal Management. Users apply for telescope time by submitting proposals, which go through a process of review, prioritization and time allocation. The output is the set of proposals selected to be observed.
2. Observation Preparation. The proposals are transformed in scheduling blocks, a data structure specifying the manner how the scientific goals in the proposal will be accomplished in one or more observations.
3. Observation Scheduling. The scheduling blocks are selected to be observed depending on environmental conditions such as weather, antenna availability, etc.
4. Observation Execution. The scheduling blocks are executed by the telescope, resulting in raw (or partially calibrated, as some calibrations are applied during the observation) scientific data.
5. Monitoring and Control. The instructions specified in the scheduling blocks are translated into a series of commands to the hardware elements of the telescope. This system also gathers engineering data to monitor the status of the telescope.
6. Maintenance and Telescope Support. Engineering data are archived and analyzed to support maintenance and support operations.
7. Data Transfer, Archival and Archive Observatory Interfaces. The raw data are transferred to the Science Operations Center and ingested in the Science Archive. The observatory provides several services to end users to query the Science Archive curated data, retrieve datasets, interact with analysis and visualization tools, and submit custom post-processing workflows.
8. Data Processing. The raw data are calibrated to remove instrumental signatures and processed to generate image cubes and other high-level science products.
9. Data Analysis and Visualization. The observatory provides analysis and visualization services for science products.

Besides these, there are requirements that affect more than one of the functional areas identified above. These cross-functional areas are:

10. High-level Data Products

11. Calibration
12. Radio Frequency Interference (RFI)
13. Cybersecurity
14. Sub-array Operations

The ngVLA Computing and Software system will not be developed entirely from the ground up. Existing and under-development systems used by VLA and ALMA will be adapted and expanded to be used by ngVLA. These "inherited" systems are:

- NRAO Proposal Management System
- CASA and PIPELINE data processing systems
- CARTA visualization system
- NRAO Science Archive
- Several components developed by the Science Ready Data Products project, such as the TTA tools; and user interfaces to interact with the Science Archive contents and trigger post-processing workflows or data analysis and visualization interfaces

The requirements for these inherited systems are in different degrees of completion and formalization. Re-engineering the requirement specifications for existing systems for which there are no complete specifications is out of the scope of this document. Instead, based on the known capabilities of these already operational systems, this document aims to identify the "delta" requirements necessary to upgrade them for ngVLA use. On the other hand, requirement specifications for inherited systems which have already performed formal requirement reviews, such as the TTA tools system and SRDP, are included in this document for completeness in Appendices 1 and 2.

3.2 Subsystem General Description

Figure 1 shows the subsystems contained in the Computing and Software Subsystem. These are:

(a) **50.05 Proposal Management System (PMN)**: This subsystem supports the ngVLA telescope time allocation processes, including the solicitation of proposals for each observing cycle, the proposal submissions from PIs, the review process and time allocation, approval and closeout processes. It supports these processes through the Telescope Time Allocation system, a common NRAO system for all its supported telescopes. The ngVLA Proposal Management system extends the TTA system to comply with its specific requirements. The PMN system supports the transformation of the proposals that have been awarded observation time each observing cycle into scheduling blocks as well.

(b) **50.10 Online SW Subelement (ONL)**: The online subsystem selects scheduling blocks and executes them in a sub-array. It coordinates all operations necessary to perform observations, resulting in archived science data. The system reads configurations and calibrations from the telescope configuration database and applies them in the corresponding telescope systems. It continuously monitors the state of the telescope, saving the monitoring data and alarms in the Engineering database. This database also includes integrated logs generated by all software components as they perform their operations.

(c) **50.15 Offline SW Subelement (OFF)**: This subsystem is responsible for all post-observation operations performed on the collected science data, including the generation of derived data products, support for quality assurance activities, and the provision of interfaces to search for and retrieve data products.

(d) **50.20 Data Stores (DST)**: The data stores included in this package are logical and are deployed into physical storage systems and databases depending on their requirements. They may be consolidated or segregated as necessary.

(e) **50.25 Monitor & Control System (MCL)**: This system is composed of software components necessary to connect the high-level software with the telescope hardware. It provides a level of isolation between a high-level model of the array and the low-level details involved in accessing its hardware, using protocols such as OPC UA.

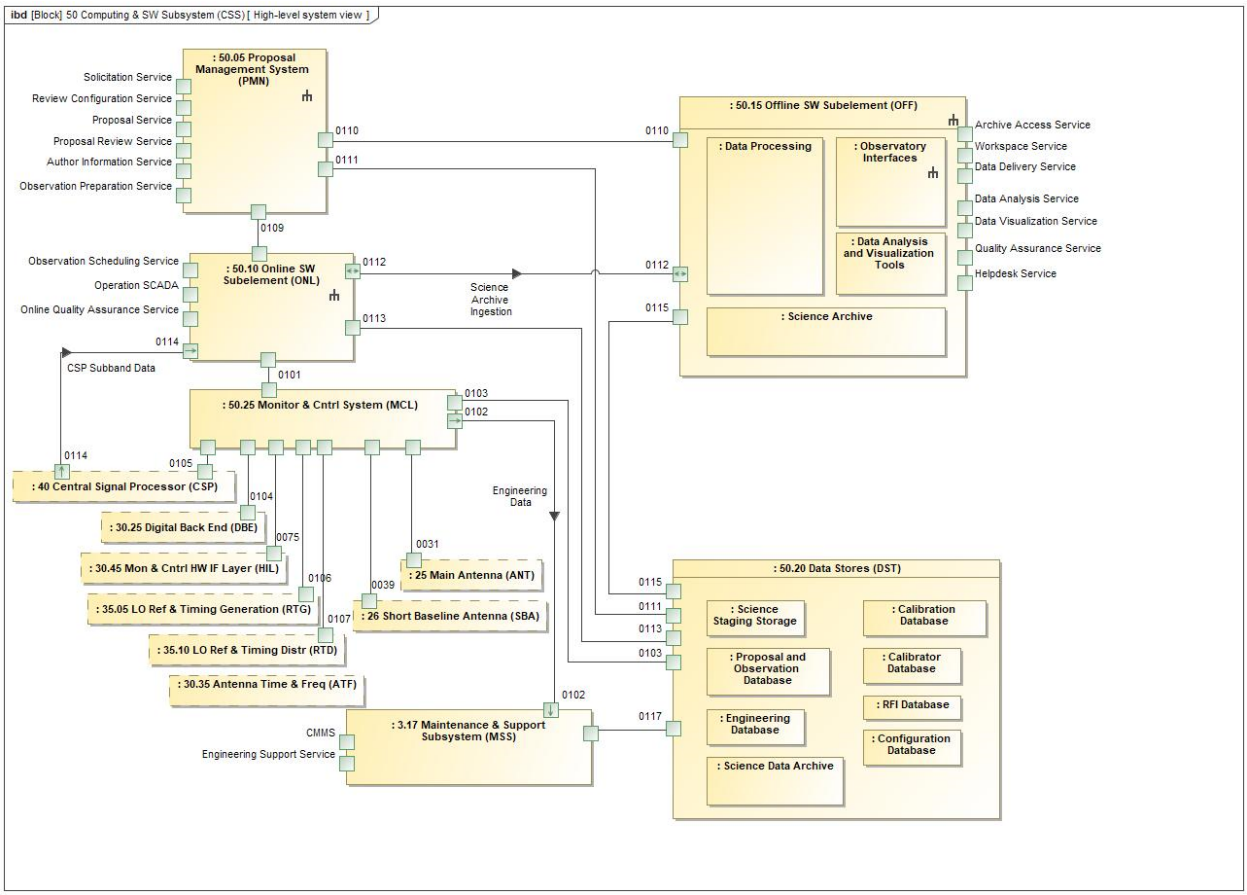

Figure 1: Internal block diagram of the Computing & Software System. This diagram shows a high-level view of the entire system. External user interfaces are shown as unconnected ports (e.g. Solicitation Service, Review Configuration Service, etc.), and connected ports represent the internal interfaces. The diagram also shows the main data streams (CSP Subband Data from the CSP, Science Data for archival

ingestion, and Engineering Data). This diagram also shows the (external) H/W components that the system interacts with, through the Monitor and Control System.

Figure 1 also shows the main system data flows. The PMN system handles the proposal management processes through several services. Proposals are eventually transformed into a set of scheduling blocks, which are read and executed by the ONL subsystem. The ONL subsystem commands the telescope hardware by means of the MCL subsystem. The scheduling block execution results in sub-band data being sent from the CSP to the ONL subsystem, which then processes it and sends the science data for ingestion into the OFF subsystem. The MCL subsystem captures engineering data which is sent to the Engineering Database and the MSS subsystem. Once the science data is received by the OFF subsystem, it is processed to generate high-level products.

3.3 Key Requirements Summary

The following requirements are identified as key requirements, either because they drive the telescope performance or cost, or because they imply decisions that may be difficult or costly to modify at later stages of the project (i.e., they represent architectural choices). Also included are requirements that impose significant new functionality over the existing inherited software systems, driving the cost of modifying or extending these systems for ngVLA.

Name	Req. #	Req. Text
Visibility Data Rate	CSS9002	The system shall be able to support an average input data rate for interferometric data of 7 GVisibilites per hour, and peak data rate of 120 TVisibilities per hour. This corresponds to 7.6 GBytes/ average, and 132.6 GB/s peak, assuming 4 bytes per visibility.
Computing throughput required for synthesis imaging	CSS9016	The system shall be able to sustain an interferometric post-processing throughput of 60 PFLOPS/s, assuming that the distribution of observations that the system is required to post-process generates a computational load similar to the Reference Observing Program. This figure includes an additional 20% of capacity for re-processing.
Quick Look Image Pipeline Products	CSS9016	For triggered observations, there shall be a standard data reduction performed resulting in a continuum image, processed in a time duration equal to or less than the observation duration.
Raw Visibility Archive Data Growth	CSS8018	The Science Archive shall be able to support an input rate for raw visibility data of 20 PB/month. If data backup requirements are included, the Science Archive data growth up to 40 PB/month for raw visibility data.
Data Processing Reliability	CSS9006	The Offline Subsystem shall tolerate failures in the hardware elements (computing nodes, storage nodes) involved in a post-processing execution without losing all the data computed prior to the failure.

Tools for Visibility Processing – Supported Platforms	CSS10002	A data processing tool kit shall be provided for users to generate high-level data products for non-standard modes using user-provided computing resources that conform to observatory-defined standards.
Tools for Data Analysis	CSS10001	The system shall provide data analysis resources (both software tools and compute capacity) for users to inspect and analyze the telescope generated data (i.e. raw data) and high-level data products. These tools will be provided as remote services and downloadable software, for a list of supported platforms (the list is TBD, probably will be similar to the platforms currently supported by CASA).

Requirement CSS9002 establishes the visibility data rate and CSS9016 derives the necessary computing throughput in order to process the input data without unbounded accumulation of unprocessed datasets. This derivation is documented in [RD01] and it's based on the distribution of science cases defined in the Reference Observing Program [RD02]. These requirements imply a number of computer nodes in the order of hundreds to thousands, which impose a much larger level of parallelization that the current NRAO processing system (CASA) supports. Consequently, besides substantial development costs on CASA (or its successor ngCASA), the cost of the required hardware will be a major contributor in the project's construction and operation budget. A system of 60 PFLOPs/second is a super-computer class facility.

Several activities are currently on-going to explore ways to reduce the hardware costs in the data processing center:

- Investigating the application of GPUs on gridding and in the computation of convolution kernels
- Exploring the application of visibility averaging (in particular baseline-dependent averaging) at different stages in the signal path
- Investigating the application of different wide-field correction algorithms (i.e., w-stacking)

As documented in [RD01], the required computing throughput relies on an estimation of the parallelization efficiency parameter that hasn't been measured yet. A conservative value has been assumed, which at the moment carries a significant level of uncertainty. A meaningful measurement of this parameter requires testing on a large cluster. The project is working on prototyping the required software to perform these measurements. The implementation of this prototype, and early results from testing on VLASS datasets, are reported in [RD03].

Besides these throughput-related requirements, CSS9016 establishes a requirement over the latency of the generation of quick-look images for triggered observations. This processing will be allocated either in the CSP Backend Cluster (CBE) or the processing cluster in the Data Processing Center, depending on the size-of-computing requirements imposed by quick-look imaging. If these are low enough the process could be allocated on the CBE, avoiding the additional latency of transferring the data to the Data Processing Center.

The cost of archiving the raw data, defined in CSS8018, is a major contributor for the cost of project as well, although this is mainly an operational cost. This requirement is a direct consequence of STK1100.

The cost of the required storage systems is highly sensitive to the behavior of Moore's Law in the next years. Depending on its behavior, the project may need to re-evaluate the decision of saving the raw visibilities in the archive.

CSS9006 is a consequence of the large number of nodes required by the data processing center. Given that the probability of one or more nodes failing during processing becomes considerable, the data processing system needs to be able to tolerate probable failures, e.g., through a combination of checkpointing and the ability to move pending processing to another available node. In fact, the large number of nodes may impose many other important requirements of the processing system. A more flexible processing approach than the current execution-block based processing that has been so far the norm may be needed in order to avoid moving data unnecessarily, and optimize operations given constraints imposed by I/O interfaces and memory systems. This has been captured in CSS9018 and CSS8003 (these are preliminary, not shown yet in the table), which impose requirements for scan-based processing, storage and retrieval. The need to break down the processing unit is further enforced by CSS13016, on storing and reusing calibration data between observations. The project is actively working on elaborating these requirements further.

Another consequence of the large number of nodes needed to process the raw visibilities is that most users won't have the computational resources required to perform calibration and imaging processing in their home institutions and will need to rely in the high-level products generated by the project, or use the re-processing observatory interfaces (see CSS9009). On the other hand, constructing the necessary massive-scale parallelization software capabilities, which most probably will require hardware-level optimizations and acceleration, makes difficult and unnecessary to deliver a visibility processing package capable of running in many different platforms. The intention of CSS10002 is to restrict the number of supported platforms to only the ones that are necessary.

Besides the key requirements mentioned above, there are other areas that should be mentioned, but which are not elaborated enough to be discussed in this version of the document. The project is actively working on these research topics with the target of incorporating the relevant discussions in the software CDR and PDR. These areas are:

- Impact and advantages of performing data averaging
- Self-calibration requirements
- Effect of antenna pointing offsets on calibration and full polarization wide-field imaging
- Wide-field imaging requirements and Full-Stokes primary beam measurements
- On-the-fly (or online) calibration and post-processing (or offline) calibration requirements, in particular requirements for phasing/beamforming observing modes
- Radio Frequency Interference requirements

4 Requirement Management

The Computing and Software IPT follows the ngVLA Requirement Management Plan as defined in [RD04]. For this version of the document, the primary source of L1 requirements has been the System Requirements document [AD02]. Following the convention for other ngVLA requirement specifications,

in cases where an L1 system requirement is directly applicable, the requirement has been copied and "<req. spec. number>, copy" has been written in the "Source" column in the requirement table.

In addition, several "conceptual narrative" documents [RD05-RD10] were written by groups of experts organized by the ngVLA Operations IPT, as a way to facilitate the capture and analysis of detailed requirements involving mostly software systems (although they affect other operational systems as well). These documents have been analyzed preliminarily in this version of the document, pending the completion of their respective review process.

Other documents from where requirements were derived directly are identified in the Source column of the requirement tables. For example, the Observing Mode Calibration Strategy document [RD11] was the source for several requirements in the Calibration section.

5 Proposal Management Requirements

This section specifies additional proposal management requirements on top of those defined in the TTA tools requirement specification.

Parameter	Req. #	Value	Traceability
NRAO Proposal System Integration	CSS0000	The system shall include tools for the preparation of proposals, based on the TTA system.	[SYS2201, STK2502, TTA-1]
Scientific Proposal Evaluation	CSS0001	A tool shall be available for proposal evaluation and ranking, and shall permit the anonymization of proposals during evaluation.	[SYS2213, copy]
Technical Proposal Evaluation	CSS0002	The proposal evaluation tool shall include technical simulation tools to verify the observing resources required (sub-arrays, time) to support the science requirements.	[SYS2214, copy]
Observing Time Calculator	CSS0003	The system shall provide users with a tool to calculate the required science subarrays and associated observing time based on the proposal scientific and/or technical requirements.	[SYS2215, copy]
Proposal Award Model	CSS0004	The proposal evaluation tools shall support an award model of allocated time by subarray to an observation.	[SYS2216, copy]
Subarray Support	CSS0005	The proposal tools and scheduling system shall support, at a minimum, a set of predefined science subarrays.	[SYS2217, copy]

Parameter	Req. #	Value	Traceability
Proposal Attributes	CSS0006	The system shall support an extensible list of proposal attributes such as regular, triggered, monitoring, sponsored, large and legacy (see 020.10.05.00.00-0004-PLA), and joint (with other observatories).	[SYS2218, copy]
Proposal Submission – Standard Observing Modes	CSS0007	The proposal submission interface shall allow the user to specify their scientific requirements for Standard Observing Modes, without specifying the technical implementation to those requirements.	[SYS2211, copy]
Proposal Submission – Non-Standard Observing Modes	CSS0008	The proposal submission interface shall allow the user to define their technical observation parameters when requesting Non-Standard Observing Modes.	[SYS2212, copy]

6 Observation Preparation

Parameter	Req. #	Value	Traceability
Support for rapid response and triggered use cases	CSS1000	The ngVLA observation preparation tool suite shall be prepared to support triggered and rapid response use cases, given that over the coming decade there will be a significant growth in transient source detecting instruments requiring rapid follow-up. The following use cases are mentioned in 020.10.05.05.00-0010-PLA: * Follow-along * Rapid-response * Triggered Proposal Observing * Rapid ToO (This requirement needs further analysis and elaboration.)	[020.10.05.05.00-0010-PLA]
Scheduling block inter-dependencies	CSS1001	The ngVLA observation preparation system shall support scheduling block inter-dependencies, in order to optimize dynamic scheduling. These inter-dependencies have the form of IF statements, e.g., execute SB #1 IF SB #2 has completed.	[020.10.05.05.00-0010-PLA]

Parameter	Req. #	Value	Traceability
Manual creation and editing of Scheduling Blocks	CSS1002	A mechanism shall be available to create and edit scheduling blocks bypassing the proposal review process for commissioning and maintenance purposes, as well as non-standard calls for proposals and director's discretionary and target of opportunity requests.	[020.10.05.05.00-0010-PLA]
Manual creation and editing of non-standard observing mode SBs	CSS1003	An ability to manually create and edit scheduling blocks for non-standard observing modes and modes not yet commissioned shall be supported. This basic functionality is essential for commissioning and performing cutting edge science.	[020.10.05.05.00-0010-PLA]
Instrument resource tool	CSS1004	The observation preparation system shall include a tool to create, edit, and maintain instrument resources (e.g., receiver tunings, CSP configurations).	[020.10.05.05.00-0010-PLA]
Astronomical pointings tool	CSS1005	The observation preparation system shall include a tool to create, edit, and maintain astronomical pointings to be used during an observation. This includes pointings defined in astronomical coordinates of Right Ascension and Declination or Galactic Latitude and Longitude, as well as horizontal coordinates, such as telescope azimuth and elevation for spacecraft and nearby objects.	[020.10.05.05.00-0010-PLA]
Standard calibrator database	CSS1006	The observation preparation tool shall include a tool to create, edit, and maintain an observatory database of standard calibrators that includes information on the calibrator properties (source structure, flux density, polarization properties, etc.) This tool and database would need to be able to integrate with both the observation preparation process, as well as used for post-observation calibration.	[020.10.05.05.00-0010-PLA]
Observation planning visualization tools	CSS1007	The observation preparation tool shall include visualization tools for observation planning, e.g., source uptime plots, uv-coverage plots, sky maps with locations of sources and calibrators.	[020.10.05.05.00-0010-PLA]

Parameter	Req. #	Value	Traceability
Observation planning calculators	CSS1008	The observation preparation system shall include tools for observation planning, for example time calculators, source distance calculators, antenna shadowing, coordinate converters (e.g., local azimuth/elevation to right ascension/declination).	[020.10.05.05.00-0010-PLA]
Scriptable interface	CSS1009	The observation preparation system shall include a scriptable interface, to allow expert users to automate all functions related with scheduling block preparation.	[020.10.05.05.00-0010-PLA]
Bulk editing of Scheduling Blocks.	CSS1010	The observation preparation system shall include a tool to allow for bulk editing of scheduling blocks (and proposal data structures as well). Examples of use cases that will be supported by this interface are to expire/purge non-eligible schedules from the queue after a semester or ToO period ends, or to put projects on hold that require certain resources that might be temporarily unavailable.	[020.10.05.05.00-0010-PLA]
Automated validation of standard observations	CSS1011	The observation preparation system shall include a tool to perform automated validation of standard observations. The definition of the validation parameters will strongly depend on technical telescope observation parameters and limitations. For example, validation parameters can include: scan intent compatibility with pipeline processing, verification of instrument setups, antenna wrap/shadowing, scheduling constraints, target source elevation, realized on-source target time with respect to sensitivity requirement.	[020.10.05.05.00-0010-PLA]
Limited automated validation of non-standard observations	CSS1012	The observation preparation system shall include a tool to manually validate non-standard observations. Non-standard observations do not conform to fully commissioned observing modes, therefore a limited subset of validation would be performed compared to standard observations. For example, pipeline processing or instrument setup parameters might be relaxed.	[020.10.05.05.00-0010-PLA]

Parameter	Req. #	Value	Traceability
Helpdesk integration	CSS1013	The observation preparation system shall support the interaction between observatory staff validating schedules and the user preparing a schedule, in case clarifications of intentions are needed. This interaction can occur through a helpdesk system. To ease this interaction, integration between the observatory user helpdesk system and the observation preparation system is desired.	[020.10.05.05.00-0010-PLA]

7 Observation Scheduling

Parameter	Req. #	Value	Traceability
Proposal Attributes	CSS2000	The Online Subsystem shall support an extensible list of proposal attributes such as regular, triggered, monitoring, sponsored, large and legacy, and joint (with other observatories).	[SYS2218]
Observation Scheduling GUI	CSS2001	The observation scheduling system shall include a GUI to display completed and scheduled projects to the Operator, and to initiate manual overrides and schedule changes.	[SYS2223]
Observation Interrupt	CSS2002	It shall be possible to interrupt and cancel an in-progress observation through the observation scheduling system GUI in the Operator Console.	[SYS2224]
Observation Time Model	CSS2003	The observation preparation, execution, and scheduling tools shall support a scientific operations model of allocated time by subarray to an observation.	[SYS2226]
Observation Scheduling Criteria	CSS2004	The automatic observation scheduling system shall account for the system status, current and expected weather, project priority and percent complete, expected RFI, hour angle and frequency equity, source position limits, stringency of scientific observation requirements, and cadence (for recurring observations), when automatically scheduling observations.	[SYS2227]

Parameter	Req. #	Value	Traceability
Observation Scheduling Priority	CSS2005	The automatic scheduling system shall prioritize scheduling based on (1) scientific ranking priority, (2) band availability, (3) subarray extent, and (4) project completion percentage.	[SYS2228]
Observation Scheduling	CSS2006	System observations shall be automatically scheduled by an observation scheduling system, though manual overrides to scheduling shall also be possible.	[SYS2302]
Observation Execution Logs	CSS2007	The system shall automatically generate execution logs, including the issuance of commands associated with an observation, to provide a record of system actions and to enable system debugging.	[SYS2310]
Testing Scheduling Block Selection	CSS2015	The Online System shall allow dynamic or manual selection of Scheduling Blocks to be executed in a subarray for the purpose of software testing, commissioning, or science verification and validation.	[SYS0606, SYS2302, SYS2814]
Accessible Field of View	CSS2016	The Online System shall allow observations at elevations of 12° to 88°, relative to the local horizon, and at all Azimuth angles.	[SYS1102]
Antenna Shadowing	CSS2017	The Online System shall account for antenna shadowing when scheduling observations.	[SYS1302]
Amplitude and Phase Coherence Over Multiple Observations	CSS2018	The observatory scheduling process shall be capable of executing an observing strategy in which the flux density scale and positional (phase) reference frames are aligned over multi-epoch observations.	[CAL0305]

Parameter	Req. #	Value	Traceability
Ionospheric Delay Measurement	CSS2019	The pipeline shall be capable of measuring and correcting for ionospheric delay fluctuations using frequency-switched (where required) band 1 observations of a phase calibrator located on-axis. Goal is to achieve this over an arbitrary field in which the brightest source may not be located on-axis. The schedule shall ensure sufficient time on calibrator to achieve the necessary solution accuracy from CAL0303.	
Ionospheric Disturbance Measurement	CSS2020	The scheduler shall ingest and utilize a real-time spatio-temporal map of ionospheric disturbances on ~5 minute timescales over the array.	[CAL0307]
Scheduler Start/Stop/Restart	CSS2021	The scheduler shall be designed to make informed decisions about scheduling and early termination of observing blocks based on weather conditions, and to account for previously stopped observations in the ranking process.	[CAL0309]
Interplanetary Medium Monitoring	CSS2022	The scheduler shall ingest and utilize real-time estimates of conditions in the interplanetary medium to avoid observing certain projects too close to the Sun.	[CAL0310]
Antenna Re-Calibration Following Maintenance	CSS2024	ngVLA observing procedures shall optimize a global schedule to minimize any idle time between antenna maintenance (e.g. frontend swap) and re-calibration, and in turn reintegration to the array.	[CAL0612]
Subarray Support	CSS2026	The proposal tools and scheduling system shall support, at a minimum, a set of predefined science subarrays.	[SYS2217]
Atmospheric Phase Monitor	CSS2027	An atmospheric phase monitor (APM) at the Central Cluster shall be available, and shall interface with the scheduling system.	[SYS2504]

Parameter	Req. #	Value	Traceability
Automatic Scheduling Block Selection	CSS2029	The Online Subsystem shall dynamically select the Scheduling Block to be executed in a sub-array, based on a pool of candidate Scheduling Blocks and the current conditions of the sub-array and its environment, including the weather conditions.	[SYS2302]
Manual Scheduling Block Selection	CSS2030	The Online Subsystem shall provide an interface for the Operator to select the Scheduling Block to be executed in a sub-array.	[SYS2223]
VLBI Observations	CSS2031	The Online Subsystem shall provide an interface to execute VLBI observations in a sub-array. A VLBI observation shall be specified in VEX format, and the system shall provide a way to synchronize the observation with other participating observatories.	[SYS0006]
Observation Execution Abortion	CSS2032	The Online Subsystem shall provide a way for the Array Operator to abort a running observation in a sub-array. The observations running in other sub-arrays shall not be affected by this abortion.	[SYS2224, SYS3004, STK0902]
Manual Sub-array Management	CSS2033	The Online Subsystem shall provide an interface for the Array Operator to create and destroy sub-arrays.	[SYS2302]

8 Observation Execution

8.1 Antenna Pointing and Tracking

Parameter	Req. #	Value	Traceability
Slew Time	CSS3200	The system shall be capable of slewing antennas to any position within the accessible field of view in less than 2 minutes of time.	[SYS1103]
Antenna Motion	CSS3201	6m and 18m antennas shall be capable of slewing 3 degrees in 7 seconds in precision conditions, including time to settle within offset pointing error.	[CAL0207]

Parameter	Req. #	Value	Traceability
Antenna Pointing	CSS3202	The Online Subsystem shall control the pointing of antennas belonging to a sub-array during an observation. The subsystem shall allow to partition the sub-array in portions that point to different directions (this is necessary for calibration observations such as interferometric pointing and sky holography).	
Online Antenna Pointing Calibration	CSS3203	The Online Subsystem shall automatically compute pointing calibration coefficients from the data acquired in pointing scans and apply these coefficients on subsequent antenna movements.	[SYS2303]
Online Antenna Focus Calibration	CSS3204	The Online Subsystem shall compute focus calibration coefficients from the data acquired in focus scans and apply these coefficients on subsequent antenna sub-reflector settings.	

8.2 Frequency Tuning and Selection

Parameter	Req. #	Value	Traceability
Sub-Band Step Size	CSS3400	Sub-band center frequency selection shall have a granularity of 250 MHz or smaller.	[SYS0907]
Band Switching Time	CSS3401	Switching between any receiver bands shall be achievable within 20 seconds, with a goal of less than 10 seconds. Switching between frequency bands 1 and 2 on 18m antennas shall be achievable within 7 seconds including settling time, with the ability to cycle bands every 5 minutes.	[SYS0908, CAL0206]
Frequency Selection	CSS3402	If the receiver bandwidth exceeds the instantaneous processed bandwidth, the Online System shall allow the selection of discontinuous sub-bands for transmission and processing. For example, transmitting both the top and bottom of the 70–116 GHz band.	[SYS0905]
Fixed Analog Tunings	CSS3403	While supporting the Frequency Selection requirement, the Online Subsystem shall provide access to a set of fixed tunings supported by the hardware.	[SYS0906]

Parameter	Req. #	Value	Traceability
Frequency Tuning	CSS3404	The Online Subsystem shall command the sub-array electronic system to down-convert and process the specified observation frequency range(s).	[SYS0801, SYS0806]

8.3 Online Calibration

Parameter	Req. #	Value	Traceability
Closed-loop calibration	CSS3600	During phased array modes the Online System shall calculate antenna-based delay and phase corrections based on concurrent cross-correlations products and/or WVR measurements.	[SYS0205, SYS4310]
Open-loop calibration	CSS3601	During phased array modes the Online System shall apply atmospheric and instrumental antenna gain corrections based on solutions periodically obtained from a calibrator.	[SYS0204]
Polarization correction coefficients	CSS3602	During phased array modes the Online System shall transmit correction coefficients to the CSP to align polarization angles to a common frame before combining them for beamforming.	[SYS0207]

8.4 Beamforming

Parameter	Req. #	Value	Traceability
Beamforming coefficients	CSS3800	The Online Subsystem shall compute beam-forming weights and pass them to the CSP during an observation.	
True-delay beamforming	CSS3801	The Online System shall steer beams applying a delay and phase model calculated in the direction of each beam phase center.	[SYS0206]
Phase-delay beamforming	CSS3802	The Online System shall steer beams applying a single delay and phase model at boresight followed by a phase correction for each beam at each subband center.	[SYS0206]
Number of beams	CSS3803	The Online System shall support up to 10 true-delay (VLBI/PST) or up to 50 phase-delay (PSS) beams distributed across 10 or less sub-arrays.	[SYS0203]
Beamforming coefficients update rate	CSS3804	The Online System shall update beamforming model and weights at the cadence of the delay model,	[SYS0206]

8.5 Sub-array Management

Parameter	Req. #	Value	Traceability
Number of Sub-arrays	CSS4000	The Online System shall support creating and observing 10 different sub-arrays simultaneously. Array configuration and observing parameters are meant to be independent for each sub-array, as far as DBE and CSP resources are available.	[SYS0601]
Reconfiguration of Antennas in a Sub-array	CSS4001	The Online System shall provide an interface to add or remove a subset of antennas from an existing sub-array, without modifying the sub-array phase center.	[SYS0607, SYS0602]
Single Antenna Sub-array	CSS4002	The Online System shall allow for a single antenna sub-array.	[SYS0603]

8.6 Delay and Phase Tracking

Parameter	Req. #	Value	Traceability
Delay and Phase Tracking	CSS4200	The Online Subsystem shall command the sub-array electronic systems to perform delay and phase tracking during an observation. It shall calculate a delay and phase model per sub-array and transmit to the CSP.	
Doppler Correction	CSS4201	The Online Subsystem shall shift the observing frequency to account for a constant (not dynamic, a.k.a. as Doppler setting) Doppler effect.	
Near-Field delay corrections	CSS4202	The Online System shall add to the delay model calculation corrections for near-field objects.	[SYS0109]
Differential delay and phase model	CSS4203	For phased array modes the Online System shall compute a differential delay and phase model per beam using the sub-array boresight model as the reference.	[SYS0203]
Delay and phase model update rate	CSS4204	The Online System shall update the delay and phase models every 10 seconds.	[SYS5700]
Mosaic imaging	CSS4205	The Online System shall support mosaicking observations by means of discrete pointings.	

Parameter	Req. #	Value	Traceability
On-the-fly mapping	CSS4206	The Online System shall support interferometry modes while scanning the sky at 10 times (10x) the sidereal rate.	[SYS0106, SYS5701]

8.7 Signal Conditioning and Distribution

Parameter	Req. #	Value	Traceability
Signal Path Attenuation	CSS4400	The Online Subsystem shall command the sub-array electronic system to set optimal attenuator gains.	[SYS1203]
CSP Antenna Input Distribution	CSS4401	The Online Subsystem shall manage the distribution of antenna inputs into the CSP, both for the connected antennas and the un-connected antennas.	
Unconnected Antennas Data Transmission	CSS4402	The Online Subsystem shall manage the data transmission for the unconnected antennas, starting and stopping the transmission of data packets from the antennas.	
Fringe Rotation	CSS4403	The Online Subsystem shall issue the necessary commands to the sub-array electronic system to perform fringe rotation during an observation.	
LO Offsetting	CSS4404	The Online Subsystem shall command the sub-array electronic systems to perform LO offsetting.	
Timing Synchronization	CSS4405	The Online Subsystem shall command the sub-array electronic systems so their local clocks are synchronized in time.	
Return to Phase	CSS4406	The Online Subsystem shall issue the necessary commands to the sub-array electronic systems to return to phase i.e. when returning to a given frequency after observing in a different frequency the visibility phase should be as if the system would have been observing in the first frequency all the time.	

8.8 CSP Supervisory Control

Parameter	Req. #	Value	Traceability
CSP resources usage tracking	CSS4600	The Online System shall provide a software library to represent the CSP resources that are currently assigned to different sub-arrays.	[CSS4000]
Functional mode switching time	CSS4601	The Online System shall switch from one functional operational mode to another in 10 seconds or less.	[SYS0009]

8.9 CSP Backend

Parameter	Req. #	Value	Traceability
Concurrent interferometric and phased beam spectral tunings	CSS4800	The Online System shall allow for interferometric spectral windows and phased beams having different center frequencies and resolution.	[SYS0209]

8.9.1 Interferometry Operating Mode

Parameter	Req. #	Value	Traceability
Interferometric mode maximum data rate	CSS4801	The CBE shall ingest CSP data products and output formatted visibilities at a maximum rate of 265.2 GB/sec. This corresponds to twice the peak input data rate estimated in CSS9002, assuming that 8 bytes visibilities will be required instead of the 4 bytes per visibility assumed in CSS9002, in order to support higher dynamic range use cases when necessary.	[CSS9002]
Visibilities flagging	CSS4802	The CBE shall annotate the output data products with flags that qualify the data (e.g. RFI detection and excision.)	[SYS0702, SYS0705]
Variable time resolution	CSS4803	The CBE shall average visibilities in time according to a different integration duration per baseline.	[SYS0104]
Flagging data format	CSS4804	The CBE shall have a flagging table that contains all flagging information affecting the science data.	[SYS0702]

Parameter	Req. #	Value	Traceability
Visibilities subband stitching	CSS4805	The CBE shall stitch together the consecutive subbands that create a spectral window. That is, two or more subbands concatenated as a single data product item.	
Temporal resolution	CSS4806	The CBE shall time average visibilities with an integration duration that is a multiple of the CSP dump duration.	[SYS2001]
Spectral averaging	CSS4807	The CBE shall average CSP spectral channels with an averaging parameter selectable per spectral window.	[SYS1402, SYS1403]
Interferometric data products selection	CSS4808	The CBE shall output interferometry products based on a parameter that selects between auto-correlation only products, cross-correlation only products or both.	[SYS0103]
Variable spectral resolution	CSS4809	The CBE shall handle and process observations that include spectral windows with different spectral resolutions.	[SYS1403]
Visibilities data scaling	CSS4810	The CBE shall encode visibility values in 4 or 8 bytes depending on the maximum real or imaginary value across all channels in a spectral window.	

8.9.2 VLBI Operating Mode

Parameter	Req. #	Value	Traceability
Record VLBI beam-channels	CSS4820	The CBE shall function as a back-end recorder for VLBI beam-channels in VDIF format produced by the CSP.	[CSS50504]
VLBI mode maximum data rate	CSS4821	The Online System shall record VLBI beams at a maximum data rate of 256 Gbps per beam.	[SYS0501, SYS0504, SYS0505]

8.10 Telescope Configuration Management

Parameter	Req. #	Value	Traceability
Persistent Configuration Data	CSS5000	The Online Subsystem shall persistently store system configuration data. This configuration data includes the array center position, the antenna locations, the cable and electronic delay model, alarm thresholds, and other parameters. Configuration data shall be kept under version control.	[SYS2406, STK1300]
System Re-configuration	CSS5001	The Online Subsystem shall allow to change configuration parameters and apply these changes in the affected systems automatically.	[SYS3114]
Sideband Separation Coefficients	CSS5002	The Online Subsystem shall keep sideband separation coefficients in the telescope configuration database and upload them during DBE initialization.	[SYS1704]

9 Monitoring and Control Requirements

Parameter	Req. #	Value	Traceability
Safe Restart	CSS6000	All subsystems shall restore the Standby (Default) Mode in the event of network or power outages.	[SYS2309]
Engineering Console	CSS6001	The system shall include an engineering console for each subsystem and LRU to communicate system status and assist in real-time diagnosis.	[SYS2407]
Monitor Data Stream	CSS6002	The system shall stream monitor data at variable rates (0.1 sec to 10 min) for automated use by predictive maintenance programs and for direct inspection by engineers and technicians.	[SYS2408]
Variable Monitor Data Rates	CSS6003	The system shall be capable of varying the data rate for a monitor point, or set of monitor points, when a defined condition (defined by any monitor point) is met.	[SYS2409]
Remote Updates	CSS6004	The system shall permit the update of individual LRU firmware and software to be performed remotely via a network connection.	[SYS3223]

Parameter	Req. #	Value	Traceability
Local Control	CSS6005	Local control of an antenna and housed subsystems shall not depend on the availability of remotely accessed networked systems.	[SYS3224]
Identify Failures Physically	CSS6006	Maintenance significant items, where possible, shall identify a failed state via physical display (e.g. LED).	[SYS3234]
Report Failure Information	CSS6007	Maintenance significant items shall report failures and failure isolation information and configuration information, via the M&C system.	[SYS3235]
Report Predicted Failures	CSS6008	Maintenance significant items, where possible, shall report fault prediction sensor data via the M&C system.	[SYS3236]
Failure Information Source	CSS6009	Maintenance significant items shall report failure information in line with failure isolation as identified in a FMECA analysis.	[SYS3237]
Report Failures	CSS6010	All failure data shall be recorded in a FRACAS system.	[SYS3238]
Monitor Archive	CSS6011	Monitor data and alerts shall be archived at their generated rate (SYS2408) the full life of the instrument. (SYS2801)	[SYS3103]
Fast Read-Out Modes	CSS6012	Fast-read out modes shall be available for remote engineering diagnostics of all LRUs (i.e., an on-board oscilloscope function)	[SYS3105]
Hot Swaps of LRUs	CSS6013	Hardware and software shall be designed to accommodate and recover from hot swaps with minimal interaction required by the maintenance and operations personnel.	[SYS3111]
Subsystem Automation	CSS6014	Individual antennas and subsystems within the array shall perform system configuration and monitoring functions without the need for human intervention. It is a goal that each subsystem be capable of reaching the operationally-ready Standby state after a full power cycle without human intervention.	[SYS3114]
Safety Weather Monitoring	CSS6016	Parameters that affect the health/safety of the array (wind, temperature) shall have redundant monitoring.	[SYS2502]
Weather Archive	CSS6017	Weather data from all weather stations shall be added to the monitor data stream (SYS2408) and archived for the life of the instrument.	[SYS2503]

Parameter	Req. #	Value	Traceability
Version Control for Software and Firmware	CSS6019	All custom software and firmware delivered as part of the system shall be version controlled via a configuration management process.	[SYS3602]
Antenna Allocation to Subarrays	CSS6020	The Online System shall allow an idle antenna to enter or an allocated antenna to exit an existing subarray, while preserving the phase center of the array and without interrupting the current observation.	[SYS0602, SYS0603]
Monitor Database	CSS6021	A monitor database shall be provided to store system status and history for each monitor point in the array. The monitor database shall be easily searchable, filterable, and accessible in a way that provides appropriate functions needed by observatory staff to evaluate the performance of the array and perform tasks such as predictive maintenance.	[SYS3402]
RFI Database	CSS6022	An RFI database shall be provided to store signal parameters for previously identified interference sources.	[SYS3403]
Quality Control Database	CSS6023	A quality control database shall be provided to record repairs, test data, and associated information on each LRU.	[SYS3404]
System Configuration Database	CSS6024	A system configuration database shall be provided to record the configuration of the system at the LRU level and higher, tracking the location of each serialized device and the versions of software deployed.	[SYS3405]
Tracking Rates	CSS6026	The antenna and any motion control loops shall support tracking rates of 10x sidereal for elevations below 70° (2.5'/sec), with rates scaling by cos(El) to 1x sidereal (0.25'/sec) at 88°.	[SYS0107]
Temporal Accuracy	CSS6027	Data Product timestamps must be referred to an absolute time standard (e.g., GPS or TAI) with an error of less than 10 ns (goal of 1 ns).	[SYS2002]
Timestamp Corrections	CSS6028	Timestamps may be applied or corrected retroactively (i.e., it is not necessary for it to be known in real time.) Any timestamp corrections shall be made through a metadata table that is incorporated into the data model.	[SYS2003]

Parameter	Req. #	Value	Traceability
Data Quality Inspection Tool	CSS6029	A data quality inspection tool shall be provided for users to inspect the data quality of a performed observation.	[SYS3502]
Azimuth Wrap	CSS6030	The Online System shall manage the azimuth wrap to allow time for unwinding the axis between observations when necessary. The azimuth range is no less than 540 degrees, with a +/- 90 degree range of overlap about true north.	[SYS1105]
Autonomous Operations	CSS6031	The monitoring and control systems shall initialize and configure themselves and their connected elements to become operationally ready autonomously. Monitoring shall start as soon as possible, also autonomously.	[STK1506]
Line Replaceable Unit Serial Number	CSS6032	Each Line Replaceable Unit (LRU) shall be identified by a unique serial number.	[SYS2403]
Ethernet M&C Protocol	CSS6033	The Monitoring and Control protocol shall be based on Ethernet.	
Automatic Re-configuration	CSS6034	The system shall detect when an LRU has been replaced and re-configure itself automatically.	[STK1506]
Low level access to MIB boards	CSS6035	The system shall provide low level access to the MIB boards, in order to support effective troubleshooting operations.	
Self-diagnostic Operations	CSS6036	The system shall incorporate self-diagnostic operations.	[SYS2405]
Safety Critical Operations	CSS6037	The monitoring and control system shall not be responsible of safety critical operations involving possible damage to personnel and equipment.	[SYS2700]
Oscilloscope Function	CSS6038	The system shall provide an oscilloscope function, which allows to sample a monitor point with high frequency for an interval of time. The system shall provide the capability to trigger this function both manually and automatically.	

10 Maintenance and Telescope Support

Parameter	Req. #	Value	Traceability
Performance Analysis and Automated Maintenance Scheduling	CSS2008	Array software systems shall provide a continual and automated analysis of array status and health, providing the key source of automatically generated maintenance tickets and automated maintenance scheduling.	
Preventative Critical Maintenance	CSS2011	The system shall enable preventive maintenance on availability-critical items without interrupting observing operations.	[SYS2603]
Automatic maintenance scheduler	CSS7000	The system shall continuously analyze the array status, automatically generate maintenance activity tickets, and maintain the maintenance schedule.	[SYS2405, SYS3110]
Concurrent software versions	CSS7001	It shall be possible to run multiple software versions in all systems with multiple instances concurrently, for testing and commissioning purposes.	[STK1501, STK1402]
Single Baseline Data Display	CSS7002	Graphical interfaces shall be provided to display single baseline fringe amplitude and phases in near real-time.	
Calibration Data Display	CSS7003	Graphical interfaces shall be provided to tabulate and display common antenna calibration coefficients (delays, TSYS, PDIFF, etc.), and flag values that are possible outliers. The threshold for flagging shall be user tunable (e.g., 1-sigma, 3-sigma, etc.).	
Operator Console	CSS7004	An operator console shall be provided that provides visibility and control of scheduled maintenance and observations, as well as displays of the array configuration, weather, and system status alerts.	
Operator Interface Location	CSS7005	It shall be possible for authorized personnel to access the operator interface software from any approved workstation in the Observatory.	
Operator Log Interface	CSS7006	An interface shall be provided for an Operator to append information to the automatically generated system execution logs (SYS2310).	

Parameter	Req. #	Value	Traceability
Maintenance Tiers	CSS7007	Maintenance tasks shall be classified in tiers to assign the level of skill or maintenance visit required. It is a goal that site-based maintenance be limited to lower levels, with high-skill work generally performed at the Repair Center by specialized staff and equipment under a higher degree of environmental and process control.	[SYS3201]
Criteria for Scheduling Maintenance	CSS7008	Tools shall be provided for the automation of preventive and corrective maintenance scheduling, based on a combination of the severity of existing issues, required preventive maintenance, and predictions of pending problems.	[SYS3203]
Manual Reporting of Failures and Anomalies	CSS7009	The system shall permit the reporting of failures and anomalies by operators, data analysts, post-processing pipelines, and users, to a centralized issue tracking system and database.	[SYS3205]
Operations and Maintenance: Transfer of Deliverables	CSS7010	All procedures, test equipment, and test software shall be delivered to the Operations and Maintenance staff prior to full operations.	[SYS3211]
Provision of Predictive Tools	CSS7011	The system shall include automated tools to predict the location and nature of failures in support of maintenance scheduling.	[SYS3221]
Maintenance Scheduling Tools	CSS7012	The maintenance scheduling tool shall include an interface for authorized personnel to reprioritize issues, manipulate the schedule, and ascertain the status of scheduled work.	[SYS3222]
Automated Reporting of Failures and Anomalies	CSS7013	The online system shall automatically log issues to the issue tracking database.	[SYS3225]
LRU Alerts	CSS7015	When an LRU is out of specification, the online system shall generate a prioritized alert for processing by the operator and maintenance scheduler.	[SYS3102]
Issue Tracking Tool	CSS7016	Prior to the start of system-level AIV and site deployments, the project shall have in place an issue tracking tool that tracks open action items/punch list for the online system.	[SYS3911]

Parameter	Req. #	Value	Traceability
Quality Control of Deliverables	CSS7017	Stand-alone and integrated acceptance testing of software shall occur before delivery to or installation on the array, and after maintenance of LRUs.	[SYS3702]
Design Life	CSS7018	The system shall be designed for an expected operational life of no less than 20 years, where the operational life is defined to start at the full operations milestone and close-out of the construction project.	[SYS2801]
Cost Optimization	CSS7019	The system shall be designed to minimize total life-cycle costs over the projected design life, extending through system decommissioning/disposal.	[SYS2802]
Sustainability	CSS7020	Sustainability and long-term environmental impact shall be considered in any material or design trade-study.	[SYS2803]
Part Selection for Maintainability	CSS7021	Individual component selection criteria shall include the projected continuity of support for the component or interchangeable equivalents over the system design life.	[SYS2805]
DMS Integration	CSS7022	The ngVLA project shall adopt existing NRAO Data Management & Software (DMS) policies, with ngVLA facility integration into Observatory infrastructure and standards, in order to promote reuse and maintainability.	[SYS4201]
Database Entry Traceability	CSS7023	Calculated parameters which are entered into databases should, whenever possible, also store the software version they were generated with. This should provide easier traceability in the event that an issue with a particular software version is discovered, allowing observatory staff to find affected observations.	[SYS3400, SYS3401, SYS3402, SYS3403, SYS3404, SYS3405]
Software Version History	CSS7024	The online system version control system shall not remove tags or equivalent versioning mechanisms which identify software versions described in Database Entry Traceability. If a new version control system is adopted, the software version tags shall be transferred to the new version control system, or the old repository maintained for a minimum period of time (5 years?).	

Parameter	Req. #	Value	Traceability
Autonomous antennas	CSS7025	The system shall include a supervisory system for controlling the antennas, evaluate its performance, calibrate the antennas, and solve routine problems, preferably with limited intervention.	[SYS2304, STK1506, SYS3114]

11 Science Data Transport, Archival and Observatory Interfaces

Parameter	Req. #	Value	Traceability
Archival of Reduced Calibration Products	CSS8000	The raw data and reduced calibration products for calibration observations expected to be processed through automatic pipelines shall be archived. These calibration data shall be defined in the Observatory Calibration Plan.	[ngVLA Data Processing Concept]
Archive access performance	CSS8001	All data products stored in the Archive shall be made available to users through high availability (e.g., TBD MTTF), high user capacity (e.g. TBD simultaneous users), low latency (e.g., < TBD ms round-trip operations). This requirement is incomplete, the metrics and constraints are yet to be defined.	[ngVLA Data Processing Concept]
Data Product Restriction Protocol	CSS8002	All archived data products shall be made available to users with appropriate restriction protocols. Any calibrator data (scans) stored in the Archive shall be made available with no access restriction.	[ngVLA Data Processing Concept]
Scan-based Storage and Retrieval	CSS8003	Data shall be stored in the Archive and retrieved on a per-scan (as opposed to per Execution Block) basis. This is required in order to efficiently manage disk space, and provide access to only the scientifically required data.	[CSS9010.2, ngVLA Data Processing Concept]
Scan Sequence Record	CSS8004	For the purposes of interpolation, selecting calibration scans, and identifying all relevant scans that comprise a science observation, a record shall be available of the scan sequence (possibly non-contiguous) obtained by the online system in service to one project execution.	[ngVLA Data Processing Concept]

Parameter	Req. #	Value	Traceability
Archive Backup	CSS8005	A full backup (a minimum of two copies) of all archived data shall be incorporated into the design. The copies shall not be collocated/co-managed to reduce the risk of simultaneous failures, and individual archive copies shall have internal redundancy to survive multiple disk errors.	[SYS0735, copy]
Independence of Local Workflows wrt Off-Site Data Storage and Processing	CSS8006	If the data storage and/or processing capabilities are off-site (e.g. in the cloud on the open science grid or XSEDE & successor system), then the connectivity to these systems shall not impact the workflow of the DC staff interacting with the data/pipelines/archive.	[ngVLA Data Processing Concept]
Ingestion of PIDR products	CSS8007	Final PI-produced SRDP products shall be ingested into the ngVLA archive.	[CSS9010.7, ngVLA Data Processing Concept]
Data Delivery via Observatory Archive	CSS8008	Data products shall be delivered to the Principal Investigators through an Internet-accessible Observatory Science Data Archive.	[SYS0730, copy]
Archive Products - Low-Level	CSS8009	All low-level data products shall be archived for the life of the facility.	[SYS0731, copy]
Archive Products - High-Level	CSS8010	All high-level data products, such as calibration tables and image cubes (TBC), shall be archived for the life of the facility (as defined in SYS2801).	[SYS0732, copy]
Proprietary Data Rights	CSS8011	The archive shall permit the enforcement of a proprietary period for both low-level and high-level data products, permitting public access only after the proprietary period lapses.	[SYS0733, copy]
Archive Batch Reprocessing	CSS8012	The archive shall include an interface for batch re-processing of visibilities to replace or add high-level data products.	[SYS0734, copy]
Archive Image Selection	CSS8013	The system shall include an interface for users to request limited reprocessing of data within supported Standard Observing Modes.	[SYS0737, copy]
Archive User Reprocessing	CSS8014	The archive user interface shall allow users to inspect and select image data for download.	[SYS0736, copy]

Parameter	Req. #	Value	Traceability
Proprietary Period	CSS8015	The proprietary period shall be settable on a per-class, per-project and per-scan basis.	[SYS0738, copy]
External Data Products	CSS8016	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.	[SYS0740, copy]
Proprietary Period Trigger	CSS8017	The proprietary period counter shall start once the data products have undergone any automated or manual quality inspections and are made available to the principal investigator.	[SYS0743, copy]
Raw Visibility Archive Data Growth	CSS8018	The Science Archive shall be able to support an input rate for raw visibility data of 20 PB/month. If data backup requirements are included, the Science Archive data growth shall be 40 PB/month for raw visibility data.	[CSS9002, CSS8005, STK1100]
Visibility data transfer data rate	CSS8019	The system shall be able transfer an average data rate of raw visibility data of 60 Gpbs between the Central Electronic Building and the Data Processing Center.	[CSS9002]

12 Data Processing Requirements

Parameter	Req. #	Value	Traceability
Pipeline Product Reproducibility	CSS9000	In order to support the scientific needs for reproducibility we require that reprocessing and restore capabilities are supported. • Reprocessing: All data taken in SMDR will remain compatible with newer versions of the pipeline so that reprocessing of older datasets is always possible with the current production pipeline. Any manual flagging of the data or manual changes to the continuum data will be stored to allow them to be picked up in pipeline reruns. It is desired but not required that older data from non-SMDR processing modes (scripted, pipeline assisted, etc.) can be reprocessed. • Restore: The ability to restore stored calibration & flagging tables made with prior versions of the pipeline using the most recent pipeline version will need to be ensured. These restored products should yield scientifically equivalent products; exact (bitwise) reproduction is not required. It is desired but not required that calibrated data from non-SMDR processing modes (scripted, pipeline assisted, etc.) are also restorable.	
Preview Images for Triggered Observations	CSS9001	The system shall produce and provide rapid access to "Preview" images, quickly reduced continuum imaging products available to PIs soon after completed triggered observations (1 hr. for a 1 hr. observation), so as to inform/trigger follow-up observations using the ngVLA and/or other telescopes across the electromagnetic spectrum.	[SCI0020, SYS0722]

Parameter	Req. #	Value	Traceability
Visibility Data Rate	CSS9002	The system shall be able to support an average input data rate for interferometric data of 7 GVisibilites per hour, and peak data rate of 120 TVisibilities per hour. This corresponds to 7.6 GBytes/ average, and 132.6 GB/s peak, assuming 4 bytes per visibility.	[SYS0752, CSS9005]
Pulsar Timing Data Rate	CSS9003	The system shall support an input data rate for pulsar timing data of 130MB/s.	[SYS0301, SYS0302, SYS0303, SYS0304, SYS0305, SYS0306]
Pulsar Search Data Rate	CSS9004	The system shall support an input data rate for pulsar search data of 820 MB/s.	[SYS0401, SYS0402, SYS0403, SYS0404, SYS0405]
Synthesis Imaging Performance	CSS9005	The Offline Subsystem shall be able to calibrate and produce imaging data products from interferometric data with a throughput that matches or exceeds the input data rate.	[SYS0752]
Data Processing Reliability	CSS9006	The Offline Subsystem shall tolerate failures in the hardware elements (computing nodes, storage nodes) involved in a post-processing execution without losing all the data computed so far.	[SYS0752]
SRDP Integration	CSS9007	The ngVLA Offline Subsystem shall be based on the architecture developed by the SRDP project.	[STK2500]
External Processing	CSS9008	The Offline Subsystem shall support the capability of using external (i.e., non-Observatory) computing resources, in order to support Large and Legacy scale projects.	[SYS0757]
Reprocessing capacity	CSS9009	The Offline Subsystem shall incorporate enough processing capacity to service re-processing requests. This extra capacity shall be 1.2 times the processing power necessary to generate the standard products.	[SYS0736, SYS0734, SYS0752]

Parameter	Req. #	Value	Traceability
Principal Investigator Observing Mode Status Level	CSS9010	The levels of products and QA provided by ngVLA shall depend on the "Principal Investigator Observing Mode Status Level" for the observation, which should be determined at the time of proposal submission and clearly specified in the proposal call documentation.	[ngVLA Data Processing Concept]
Standard Mode Data Reduction (SMDR)	CSS9010.1	For Standard Mode Data Reduction (SMDR) Observing Mode Status Level, the system must provide reliable QA and SRDP products produced through a fully-automated Data Reduction (DR) pipeline with no staff intervention.	[ngVLA Data Processing Concept]
Scan-based Processing	CSS9010.2	Data shall be stored in the Archive, retrieved, and processed on a per-scan (as opposed to per Execution Block) basis. Each scan shall be self-describing, so it can be processed without additional data.	[ngVLA Data Processing Concept]
Non-standard Mode Data Reduction (NSDR)	CSS9010.3	For Non-standard Mode Data Reduction (NSDR) Observing Mode Status Level, the system shall provide reliable QA and SRDP products produced via a semi-automatic or "manually modified" pipeline run that requires relatively minor staff intervention.	[ngVLA Data Processing Concept]
Shared Risk Observing (SRO)	CSS9010.5	For Shared Risk Observing (SRO) Observing Mode Status Level, the system shall provide QA performed on a best-effort basis; observatory calibrated via scripts or manually modified pipeline runs, reference imaging (may not be SRDP) on best-efforts basis and may not meet PIs stated goals.	[ngVLA Data Processing Concept]
New Mode Test Observations	CSS9010.6	For New Mode Test Observations (NMTO) Observing Mode Status Level, the system shall use test online software, coarse QA, significant PI post-observing involvement, possibly onsite (like EVLA OSRO), products produced by PIs with assistance from observatory staff on a resource-limited basis.	[ngVLA Data Processing Concept]

Parameter	Req. #	Value	Traceability
Principal Investigator Data Reduction (PIDR)	CSS9010.7	For Principal Investigator Data Reduction (PIDR) Observing Mode Status Level, the observatory shall perform only initial QA; all data reduction & SRDP product generation performed by PI's using automated pipelines and well-defined QA criteria.	[ngVLA Data Processing Concept]
Native Archive Format	CSS9015	The Data Processing system shall work directly with the native archive format so that there is no need for it to import/fill/interpret into another data structure.	[ngVLA Data Processing Concept]
Computing throughput required for synthesis imaging	CSS9016	The system shall be able to sustain an interferometric post-processing throughput of 60 PFLOPS/s, assuming that the distribution of observations that the system is required to post-process generates a computational load similar to the Reference Observing Program. This figure includes an additional 20% of capacity for re-processing.	[CSS9002]
Quick Look Image Pipeline Products	CSS9017	For triggered observations, there shall be a standard data reduction performed resulting in a continuum image, processed in a time duration equal to or less than the observation duration.	[SYS0722, copy]
Scan-based Processing	CSS9018	Data processed on a per-scan (as opposed to per Execution Block) basis. This is required in order to facilitate flexible processing.	[ngVLA Data Processing Concept]

13 Data Analysis and Visualization

Parameter	Req. #	Value	Traceability
Visibility Processing Software Package	CSS10000	The Offline Subsystem shall provide a software package for visibility processing.	[STK1202]

Parameter	Req. #	Value	Traceability
Tools for Data Analysis	CSS10001	The system shall provide data analysis resources (both software tools and compute capacity) for users to inspect and analyze the telescope generated data (i.e. raw data) and high-level data products. These tools will be provided as remote services and downloadable software, for a list of supported platforms (the list is TBD, probably will be similar to the platforms currently supported by CASA).	[SYS0761, SYS2201]
Tools for Visibility Processing – Supported Platforms	CSS10002	A data processing tool kit shall be provided for users to generate high-level data products for non-standard modes using user-provided computing resources that conform to observatory-defined standards.	[CSS9008, CSS9016, SYS3506, copy]
Cube image sizes	CSS10003	The system shall support cube image sizes of the order of 1000 TBytes. This figure is based on the science cases from the ROP: the maximum image linear size of 10000 pixels, with 10^6 channels, 4 polarizations, and 4 bytes per pixel.	

14 Calibration

Parameter	Req. #	Value	Traceability
Delay Model Accountability	CSS13002	Real-time applied delays shall be stored so they can be un-applied if needed during post-processing.	[CAL0315]
Coordinate Equinox	CSS13003	System shall adopt J2000.0 but with flexibility to change in future.	[CAL0302]
Default Bandpass Calibration	CSS13005	Default bandpass calibration shall apply bandpasses from a calibration database with compensation for time-variable opacity, without including bandpass scans in science observation scheduling blocks, nor using calibrators from the data to measure the bandpass.	[CAL0501]
Calibration Database: Bandpass	CSS13006	The observatory shall supply bandpasses satisfying CAL0502 and CAL0503 in a calibration database, updating solutions where appropriate (e.g. if the advertised accuracy is no longer satisfied due to slow degradation over time or a step change arising from antenna maintenance).	[CAL0504]

Parameter	Req. #	Value	Traceability
Default Polarization Calibration	CSS13007	Default polarization calibration shall apply leakages from a calibration database and measure crosshand bandpass phases using the instrumental noise diodes, without including polarization calibration scans in science observation scheduling blocks, nor using calibrators from the data to measure polarization parameters.	[CAL0602]
Calibration Database: Polarization Leakages	CSS13008	The observatory shall supply absolute leakages satisfying CAL0603 and CAL0604 in a calibration database, updating solutions where appropriate (e.g. if the advertised accuracy is no longer satisfied due to slow degradation over time or a step change arising from antenna maintenance).	[CAL0605]
Calibrator Database: Polarization Calibrators	CSS13009	The observatory shall maintain a register of sources used for leakage, circular polarization, and feed alignment calibrations in a calibrator database, including their polarimetric properties. This Information shall be used only for guidance, not for calibration purposes; for example, to determine if they exhibit variability (in which case they should be avoided).	[CAL0606]
Calibrator Database: Source Ingest	CSS13010	The system shall support ingestion of new calibrator models into the calibrator database, noting that these may be time-dependent and so must be stored in a manner suitable for examining light curves and changes in source structure.	[CAL0704]
Standard Observing Mode Calibration	CSS13011	A calibration strategy shall be provided for each standard observing mode, and the adopted strategy shall be enumerated in the data model.	[SYS4301]
Antenna Pointing Calibration	CSS13012	The system shall enable the use of contemporaneous cross-correlation visibilities to determine and apply antenna pointing corrections.	[SYS4311]
Storage and Retrieval of Calibration Parameters	CSS13013	Parameters for standard observing modes determined by calibration (such as bandpass coefficients and delays) shall be stored in a calibration database and automatically retrieved and applied.	[SYS4330]

Parameter	Req. #	Value	Traceability
Automated and Triggered Remeasurement of Parameters in Subarrays	CSS13014	It shall be possible to initiate the measurement of system calibration parameters with both automated and operator-triggered tools, using either the full array or a subarray.	[SYS4331]
Calibration Efficiency	CSS13015	Overheads for system calibration shall be minimized, with a goal of 90% of time spent on source for Standard Observing Modes.	[SYS1061]
Calibration Recall	CSS13016	The system shall store and recall prior calibration corrections and apply them if their projected accuracy (given time elapsed) still meets the requirements for a given observation; i.e. a scheduling block need not always include its own calibrators.	[SYS1063]
Polarization Calibration Efficiency	CSS13018	Polarization calibration shall permit the use of cataloged solutions (e.g. leakages) where these meet the requirements of the mode. It is a goal that cataloged solutions support the polarization calibration requirements for all Standard (Interferometric Continuum) Observing Modes.	[SYS1065]
Estimated Dynamic Range Per Channel	CSS2023	Spectral line proposals shall specify the required dynamic range in a single spectral channel. This shall be used by the observatory to decide if the default bandpass calibration procedure is suitable or if custom bandpass calibration is required (note that an "enhanced" bandpass calibration procedure may yet need to be defined, depending on the outcome of future investigations).	[CAL0505]
Calibrator Search and Characterization	CSS2025	The system shall facilitate rapid (~minutes) blind search and characterization (e.g. histogram of amplitude ratios over binned baseline lengths) of complex gain calibrators within 3 degrees of any (accessible) sky coordinate. The system shall prioritize re-detection of promising (minimally-variable) previously known calibrators from the calibration database.	[CAL0701]

14.1 Interferometric Observing Mode Strategy

Parameter	Req. #	Value	Traceability
Pointing and Focus Calibration	CSS13050	Pointing and focus calibration shall rely on reference pointing scans in high frequency bands (likely bands 4–6), reduced rapidly online and applied in real time.	[020.10.05.05.00-006-PLAvA]
Complex Gain Calibration	CSS13051	For complex gain calibration, the system shall observe a calibrator nearby the target source(s) in all scheduling blocks belonging to the same project in the same spectral windows.	[020.10.05.05.00-006-PLAvA]
Bandpass Calibration	CSS13052	For bandpass calibration, the system shall access and apply a stored calibration from the Calibration Database, at least for low-resolution "continuum mode". Setups with higher resolution, or those with very broad lines will likely require observation of a bandpass calibrator in the SB.	[020.10.05.05.00-006-PLAvA]
Spw-to-spw Phase Offsets	CSS13053	In order to calibrate the spw-to-spw phase offsets, the system shall use the bandpass calibrator if observed, otherwise the system shall use the time average of gain calibrators, with a heuristic to check for any drifts with time.	[020.10.05.05.00-006-PLAvA]

Parameter	Req. #	Value	Traceability
Polarization Calibration	CSS13054	For polarization calibration, when calibrating full stokes (including true V), the system shall: 1. For standard low-resolution "continuum mode" setups, the system shall access the leakages from the calibration database (if they are stable), and access crosshand phases from the instrument (either from a observing a calibrator which will give the antenna terms or using the time-multiplexed noise diode calibrated against a source on the sky); for polarization angle, the system shall observe a brief scan on a position angle calibrator (this is an observatory mode). 2. For high spectral resolution setups (or to populate the calibration database for low-resolution setups) the system shall measure leakages by observing a polarization calibrator over a wide range of parallactic angles; for polarization angle, observe a brief scan on a position angle calibrator.	[020.10.05.05.00-006-PLAvA]
Opacity Tracking Within an Individual SB	CSS13055	For opacity tracking within an individual SB, the system shall use the switched power system.	[020.10.05.05.00-006-PLAvA]
Atmospheric Delay Calibration	CSS13056	For atmospheric delay calibration, the system shall use the following strategies: • wet tropospheric: WVR system, 1 second timescales • dry tropospheric: traditional gaincal, 5 minute timescales • plus ionospheric calibration at low frequencies (band 1).	[020.10.05.05.00-006-PLAvA]

Parameter	Req. #	Value	Traceability
Delay Model Recording	CSS13057	All critical information about the delay model (not merely the version of Calc/Solve, etc.) shall be recorded in the science data model. This includes tables containing both the static values and the time-dependent terms (such as precession, nutation, ocean and atmospheric loading, etc.), along with the total value.	[020.10.05.05.00-006-PLAvA]
Ionospheric Faraday Rotation Correction	CSS13058	In order to enable the correction for ionospheric Faraday rotation (lower bands only, up to band 2) the system shall ingest GPS-derived Vertical Total Electron Content (VTEC).	[020.10.05.05.00-006-PLAvA]
Absolute Amplitude Calibration	CSS13059	For absolute amplitude calibration, the switched power system shall be used to remove electronics gain variations during an observation. For setting the absolute flux scale, a table of lab-measured Tcal values can be used along with measured gain values (Jy/K) for each antenna/band. These Tcal values will be tied regularly to the celestial flux scale by the observatory calibrator monitoring program to produce a column of correction factors to apply to the Tcal values that is updated regularly (monthly, or whenever a front-end is changed), and accessed and applied during offline calibration.	[020.10.05.05.00-006-PLAvA]
Astrometric Calibration	CSS13060	For astrometric calibration, the system shall populate the Calibrator Database with ICRF grid sources with accurate positions determined (at least initially) by NASA Goddard or other VLBI community efforts. The coordinate equinox will be J2000 for now [CAL-0302], but could be changed in the future to a new IAU adopted frame.	[020.10.05.05.00-006-PLAvA]

Parameter	Req. #	Value	Traceability
Recording of Target Fields for Calibration Solutions	CSS13061	For all observed calibrators, the target fields to which the corresponding calibration solution should be applied shall be recorded in the data model in order to prevent confusion downstream in the pipeline heuristics, especially when there are multiple groups of targets each assigned a separate complex gain calibrator and check source. For cases of multiple calibrators per intent, the field combination heuristics should be specified in the data model. For cases of multiple scans per field for a given calibration intent (such as flux or bandpass), the solution interval and interpolation method to be used should be specified in the data model. The pipeline can of course choose to apply different heuristics via advanced (experimental) recipes, but the data model should contain the choices that were originally envisioned.	[020.10.05.05.00-006-PLAvA]

14.2 Pulsar Timing and Search Modes Calibration Strategy

The calibration strategies are the same for the Pulsar Timing and Pulsar Search Observing Modes.

Parameter	Req. #	Value	Traceability
Polarization Calibration	CSS13070	Cross-hand phases can be determined either from observations of a strong calibrator, or from the switched power signal (or equivalent calibration signal as in the Interferometric Mode). Relative polarization gains can be determined from the phasing calibrator (if unpolarized or of known polarization) or from the switched power signal.	
Real-time array phasing	CSS13071	In order to phase the array for the Pulsar Timing Observing Mode, the system shall perform interferometric observations of a sufficiently strong complex gain calibrator nearby the target source. The system shall compute phase and delay solutions in near real-time and apply them to the antenna signals before summation. The latency of the solutions is TBD, although 3 seconds seems plausible.	

Parameter	Req. #	Value	Traceability
Flux Calibration of the Summed Array Data	CSS13072	Ideally, the flux scale of the summed array data will be computed from the interferometric observations of the calibrator used for phasing (assuming its flux density is known) and the recorded digital gain factors (rescaling, bit selection, etc.). In case of unknown gains applied to the phased-array signal, the switched power signal present in the summed data can be used to estimate the flux scale.	

14.3 VLBI Phased Array Calibration Strategy

Parameter	Req. #	Value	Traceability
VLBI real-time array phasing	CSS13080	For VLBI, the phasing procedures shall be the same as CSS13071.	[CSS13071]

14.4 Observatory-Facing (Non-PI) Observing Mode Strategy

Parameter	Req. #	Value	Traceability
Observatory-Facing (Non-PI) Observing Modes	CSS13090	The system shall support Observatory-Facing (Non-PI) observing modes, which are used to measure the calibration models that populate the Calibration Database. Several examples are of these observing modes are defined as sub-requirements.	[020.10.05.05.00-006-PLAvA]
Calibrator Surveys	CSS13090.1	Continuum observations in one or more frequency bands of a large number of potential calibrator fields to determine accurate positions and flux-density measurements for the calibrators in the Calibrator Database.	[020.10.05.05.00-006-PLAvA]
Antenna Positions	CSS13090.2	Observing mode to measure accurate antenna positions and axis offsets.	[020.10.05.05.00-006-PLAvA]
All-sky Pointing Calibration	CSS13090.3	All-sky pointing observations to determine pointing models for each receiver band.	[020.10.05.05.00-006-PLAvA]

Parameter	Req. #	Value	Traceability
Holographic Measurements for Each Antenna	CSS13090.4	The complex beam pattern of each antenna will need to be measured in at least one receiver band and at least one polarization in order to determine surface deformation, and in all receiver bands and both polarizations to determine receiver feed illumination offsets.	[020.10.05.05.00-006-PLAvA]
Bandpass, Delay, and Polarization Leakage	CSS13090.5	Observing mode to measure per-antenna, per-receiver band quantities that will populate the Calibration Database, and be used during pipeline calibration and imaging. The primary quantities are: the complex bandpass response as a function of frequency for the most commonly-used spectral setup(s); the basic delay model for each baseband, and the polarization leakage terms as a function of frequency.	[020.10.05.05.00-006-PLAvA]
Full Polarization Beam Pattern Measurements of Each Antenna	CSS13090.6	To support full polarization calibration and imaging, the beam pattern of each antenna in all polarization co-products and cross-products will need to be measured in each receiver band on celestial targets at several antenna elevations and parallactic angles, for storage in the Calibration Database.	[020.10.05.05.00-006-PLAvA]
Gain Curves	CSS13090.7	Gain curves as a function of antenna and elevation.	[020.10.05.05.00-006-PLAvA]
Feed Offsets	CSS13090.8	Feed offsets for each receiver band (for which these quantities haven't been previously measured by the all-sky pointing observing mode).	[020.10.05.05.00-006-PLAvA]
Pulsar Period Determination	CSS13090.9	For subsequent pulsar imaging, it is necessary to have an accurate period for a pulsar if online binning is being used to accumulate data prior to dumping integrations.	[020.10.05.05.00-006-PLAvA]

15 Radio Frequency Interference

Parameter	Req. #	Value	Traceability
RFI avoidance in scheduling algorithm	CSS14000	The Observation Scheduling algorithm shall consider RFI environment constraints, such as the position and frequencies of known interferers.	[ngVLA Memo 71]
External interface to the scheduled observation queue	CSS14001	The system shall expose an internal interface to the scheduled observation queue, providing observation metadata such as observation time, frequency band, and approximate pointing position. This interface can be used to coordinate operations with external entities that transmit in the ngVLA-observed spectrum.	[ngVLA Memo 71]
DBE 1-sec time series snapshot	CSS14002	The system shall capture on demand a 1 second snapshot of the time series data from the DBE and transmit it over to the RFI Manager for analysis.	[ngVLA Memo 71]
Remote updates to DBE RFI algorithms	CSS14003	In order to enable updating RFI detection, flagging and excision FPGA blocks in the DBE, the system shall enable changes to the FPGA personality and be able to query the active FPGA personality.	[ngVLA Memo 71]
CSP RFI action mode (discard/weight adjustment)	CSS14004	The system shall allow to select either to use RFI flags to discard data in the CSP, or to adjust the weights.	[ngVLA Memo 71]
Weight stream to the CBE	CSS14005	The CBE shall receive real-time generated data weights along with the averaged visibilities.	[ngVLA Memo 71]
Remote updates to CSP RFI algorithms	CSS14006	In order to update the CSP RFI algorithms, the system shall enable changing the CSP FPGA personalities remotely (over the network interface).	[ngVLA Memo 71]
CSP dual recording option	CSS14007	As an option, the system shall allow to transmit two streams from the CSP to the CBE: * the raw visibilities without RFI excision * RFI-processed visibilities This dual recording mode should be only available within the constraints of the CSP-to-CBE interface data rate limit.	[ngVLA Memo 71]

Parameter	Req. #	Value	Traceability
CBE RFI-processing emphasis in modeling and subtraction	CSS14008	The CBE shall implement RFI-processing algorithms emphasizing modeling and subtraction. (Calculations with the VLA suggest that for RFI correlated across the main array core, and time and frequency resolution of order 10-100 ms and 10-100 kHz will be required.)	[ngVLA Memo 71]
CBE cluster sizing for RFI	CSS14009	The CBE cluster shall be sized to allow for modeling/subtraction algorithms as well as algorithms to mine real-time antenna-based information for the RFI manager.	[ngVLA Memo 71]
CBE option to adjust weights	CSS14010	The CBE shall incorporate a way to (optionally?) adjust weights to account for potentially higher errors on intervals of data where RFI has been excised.	[ngVLA Memo 71]
CBE dual recording option	CSS14011	As an option, the system shall allow to archive two streams from CBE: * the raw visibilities without RFI excision * RFI-processed visibilities These two streams don't need to be archived long-term, but must be retained for a period to permit mode commissioning and data quality checks in operations.	[ngVLA Memo 71]
Transient detection system future option	CSS14012	The system shall allow the design and integration of a real-time imaging system to detect transient as a future option.	[ngVLA Memo 71]
RFI Manager interface to offline processing algorithms	CSS14013	An interface shall be provided between the offline RFI-processing system and the RFI manager, as an aid to tune the algorithms. A-priori knowledge of weak RFI can help differentiate such signals from astronomical spectral lines.	[ngVLA Memo 71]
Transport large data files from antennas to RFI Manager	CSS14014	The Online System shall provide an interface to transport large data files (gigabytes) from DBE to the Array Operation Center through the M&C network. The bandwidth used by each transference must have a networking priority lower than other M&C activity on the communication channel.	[CSS14002]

Parameter	Req. #	Value	Traceability
Enable/disable RFI mitigation features	CSS14015	The Online System shall provide a configuration mechanism to enable and disable RFI mitigation actions that have an effect on the data. Actions that have an action are those that either flag the data, remove the datum (excision) from the data stream or modify its value (e.g. clipping).	[SYS4102]

16 Cybersecurity

Parameter	Req. #	Value	Traceability
IT Security	CSS6018	All network-connected systems shall be engineered and deployed in accordance with current best practices in IT Security, as defined by the NSF-funded Center for Trustworthy Scientific Infrastructure and the AUI Cyber Security Policy.	[SYS2702, copy]

17 Software Development Operations

Parameter	Req. #	Value	Traceability
Simulation Support	CSS16000	The ngVLA development infrastructure shall incorporate a telescope simulation capability, in order to support development, testing, integration and verification activities.	
Consistent Deployment	CSS16001	The ngVLA development infrastructure shall keep all the necessary artifacts to deploy a consistent system under version control. This include the source code, configurations data for both software and hardware, and external libraries.	
Simulated Observation Execution	CSS16002	The system shall simulate the execution of observation instructions when commanded, and shall generate the associated execution logs for verification.	
Test Fixtures	CSS16003	Test fixtures and procedures shall be provided for verification of the software subsystems.	[SYS2811]

Parameter	Req. #	Value	Traceability
System Verification Tools	CSS16004	Tools shall be provided to automate test execution and test reporting as part of array element verification. Such tools shall include near real-time (<10 sec. lag) data display for interactive diagnosis by engineers.	[SYS2813]
Testing of Software and Firmware	CSS16005	All software and firmware developed by the project shall be delivered with automated unit, integration, and regression testing suites.	[SYS2814]
Software Development Tools	CSS16006	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.	[SYS2815]
ICD API and Software Definition	CSS16007	All Application Program Interfaces (API) or other software interfaces shall be defined in ICDs.	[SYS2816]
ICD Automated Conformance Testing	CSS16008	Automated test results demonstrating conformance to API ICDs shall be delivered with the software.	[SYS2817]
VLA Interference	CSS16009	It is a goal to minimize interference with VLA operations during the construction and transition phase.	[SYS2819]
AIV and CSV Concepts	CSS16010	The system shall provide any ancillary features necessary to conform to the Observatory-approved and released AIV Concept and CSV Concept.	[SYS2820, SYS2838]
Incremental Delivery to Operations	CSS16011	Operational capabilities and observing modes shall be made available in stages during the transition from construction through to the commencement of full operations.	[SYS2830]
Delivery with High-Level Data Product Pipeline	CSS16012	Delivery of a commissioned standard observing mode shall include an operational high-level data product pipeline before it is offered for regular use through PI proposals.	[SYS2831]
Science Operations API	CSS16013	A science-oriented API (scripting interface) for calling high-level array functions, prior to the widespread use of Scheduling Blocks (SBs), shall be delivered.	[SYS2832]
Observing Simulator	CSS16014	Simulators to enable the development of observing scripts without the real system shall be delivered.	[SYS2833]

Parameter	Req. #	Value	Traceability
External Calibrator Data Interface	CSS16015	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.	[SYS2835]
Units	CSS16018	Design materials, documentation, and graphical user interfaces shall use SI (metric) units. Imperial units may also be shown for clarity.	[SYS6003]
Electronic Document Format	CSS16019	Documents and drawings of record shall be delivered in PDF. Native, editable file formats shall also be delivered.	[SYS6005]

18 Verification

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

Verification by Analysis: The fulfillment of the specified performance shall be demonstrated by appropriate analysis (hand calculations, finite element analysis, thermal modeling, etc.), which will be checked by the ngVLA project office during the design phase.

Verification by Inspection: The compliance of the developed system is determined by a simple inspection or measurement.

Verification by Demonstration: The compliance of the developed feature is determined by a demonstration.

Verification by Test: The compliance of the developed system with the specified performance shall be demonstrated by acceptance tests.

Req. #	Parameter/Requirement	A	I	D	T
CSS0000	NRAO Proposal System Integration		*		
CSS0001	Scientific Proposal Evaluation			*	
CSS0002	Technical Proposal Evaluation			*	
CSS0003	Observing Time Calculator			*	
CSS0004	Proposal Award Model		*		
CSS0005	Subarray Support		*		
CSS0006	Proposal Attributes		*		
CSS0007	Proposal Submission – Standard Observing Modes			*	
CSS0008	Proposal Submission – Non-Standard Observing Modes				*
CSS5000	Persistent Configuration Data	*			
CSS5001	System Re-configuration			*	

Req. #	Parameter/Requirement	A	I	D	T
CSS5002	Sideband Separation Coefficients			*	
CSS3200	Slew Time				*
CSS3201	Antenna Motion				*
CSS3202	Antenna Pointing				*
CSS3203	Online Antenna Pointing Calibration				*
CSS3204	Online Antenna Focus Calibration				*
CSS4400	Signal Path Attenuation				*
CSS4401	CSP Antenna Input Distribution				*
CSS4402	Unconnected Antennas Data Transmission				*
CSS4403	Fringe Rotation				*
CSS4404	LO Offsetting				*
CSS4405	Timing Synchronization				*
CSS4406	Return to Phase				*
CSS3400	Sub-Band Step Size				*
CSS3401	Band Switching Time				*
CSS3402	Frequency Selection				*
CSS3403	Fixed Analog Tunings				*
CSS3404	Frequency Tuning				*
CSS4000	Number of Sub-arrays				*
CSS4001	Reconfiguration of Antennas in a Sub-array				*
CSS4002	Single Antenna Sub-array				*
CSS4200	Delay and Phase Tracking				*
CSS4201	Doppler Correction				*
CSS4202	Near-Field delay corrections				*
CSS4203	Differential delay and phase model				*
CSS4204	Delay and phase model update rate				*
CSS4205	Mosaic imaging				*
CSS4206	On-the-fly mapping				*
CSS3800	Beamforming coefficients				*
CSS3801	True-delay beamforming				*
CSS3802	Phase-delay beamforming				*
CSS3803	Number of beams				*
CSS3804	Beamforming coefficients update rate				*
CSS3600	Closed-loop calibration				*
CSS3601	Open-loop calibration				*
CSS3602	Polarization correction coefficients				*
CSS4600	CSP resources usage tracking				*
CSS4601	Functional mode switching time				*
CSS4800	Concurrent interferometric and phased beam spectral tunings				*
CSS4801	Interferometric mode maximum data rate				*
CSS4802	Visibilities flagging				*
CSS4803	Variable time resolution				*
CSS4804	Flagging data format				*
CSS4805	Visibilities subband stitching				*

Req. #	Parameter/Requirement	A	I	D	T
CSS4806	Temporal resolution				*
CSS4807	Spectral averaging				*
CSS4808	Interferometric data products selection				*
CSS4809	Variable spectral resolution				*
CSS4810	Visibilities data scaling				*
CSS4820	Record VLBI beam-channels				*
CSS4821	VLBI mode maximum data rate				*
CSS50501	Visibility Data Format	*			
CSS50502	Pulsar Timing Profile Data Format	*			
CSS50503	Offline Pulsar Search Data Format	*			
CSS50504	VLBI Data Format	*			
CSS9000	Pipeline Product Reproducibility				*
CSS9001	Preview Images for Triggered Observations				*
CSS9002	Visibility Data Rate				*
CSS9003	Pulsar Timing Data Rate				*
CSS9004	Pulsar Search Data Rate				*
CSS9005	Synthesis Imaging Performance				*
CSS9006	Data Processing Reliability				*
CSS9007	SRDP Integration	*			
CSS9008	External Processing				*
CSS9009	Reprocessing capacity	*			
CSS9010	Principal Investigator Observing Mode Status Level	*			
CSS9010.1	Standard Mode Data Reduction (SMDR)	*			
CSS9010.2	Scan-based Processing	*			
CSS9010.3	Non-standard Mode Data Reduction (NSDR)	*			
CSS9010.5	Shared Risk Observing (SRO)	*			
CSS9010.6	New Mode Test Observations	*			
CSS9010.7	Principal Investigator Data Reduction (PIDR)	*			
CSS9015	Native Archive Format		*		
CSS9016	Computing throughput required for synthesis imaging				*
CSS9017	Quick Look Image Pipeline Products				*
CSS9018	Scan-based Processing	*			
CSS2008	Performance Analysis and Automated Maintenance Scheduling				
CSS2011	Preventative Critical Maintenance				
CSS7000	Automatic maintenance scheduler				*
CSS7001	Concurrent software versions				*
CSS7002	Single Baseline Data Display			*	
CSS7003	Calibration Data Display			*	
CSS7004	Operator Console			*	
CSS7005	Operator Interface Location			*	
CSS7006	Operator Log Interface			*	
CSS7007	Maintenance Tiers	*			
CSS7008	Criteria for Scheduling Maintenance			*	
CSS7009	Manual Reporting of Failures and Anomalies			*	

Req. #	Parameter/Requirement	A	I	D	T
CSS7010	Operations and Maintenance: Transfer of Deliverables		*		
CSS7011	Provision of Predictive Tools		*		
CSS7012	Maintenance Scheduling Tools			*	
CSS7013	Automated Reporting of Failures and Anomalies				*
CSS7015	LRU Alerts				*
CSS7016	Issue Tracking Tool		*		
CSS7017	Quality Control of Deliverables		*		
CSS7018	Design Life	*			
CSS7019	Cost Optimization	*			
CSS7020	Sustainability	*			
CSS7021	Part Selection for Maintainability	*			
CSS7022	DMS Integration	*			
CSS7023	Database Entry Traceability		*		
CSS7024	Software Version History		*		
CSS7025	Autonomous antennas	*			
CSS16000	Simulation Support		*		
CSS16001	Consistent Deployment		*		
CSS16002	Simulated Observation Execution			*	
CSS16003	Test Fixtures		*		
CSS16004	System Verification Tools			*	
CSS16005	Testing of Software and Firmware		*		
CSS16006	Software Development Tools		*		
CSS16007	ICD API and Software Definition		*		
CSS16008	ICD Automated Conformance Testing				*
CSS16009	VLA Interference	*			
CSS16010	AIV and CSV Concepts		*		
CSS16011	Incremental Delivery to Operations	*			
CSS16012	Delivery with High-Level Data Product Pipeline	*			
CSS16013	Science Operations API				*
CSS16014	Observing Simulator				*
CSS16015	External Calibrator Data Interface				*
CSS16018	Units		*		
CSS16019	Electronic Document Format		*		
CSS6000	Safe Restart				*
CSS6001	Engineering Console			*	
CSS6002	Monitor Data Stream			*	
CSS6003	Variable Monitor Data Rates				*
CSS6004	Remote Updates			*	
CSS6005	Local Control	*			
CSS6006	Identify Failures Physically			*	
CSS6007	Report Failure Information			*	
CSS6008	Report Predicted Failures			*	
CSS6009	Failure Information Source	*			
CSS6010	Report Failures	*			
CSS6011	Monitor Archive	*			

Req. #	Parameter/Requirement	A	I	D	T
CSS6012	Fast Read-Out Modes			*	
CSS6013	Hot Swaps of LRUs			*	
CSS6014	Subsystem Automation	*			
CSS6016	Safety Weather Monitoring	*			
CSS6017	Weather Archive	*			
CSS6019	Version Control for Software and Firmware	*			
CSS6020	Antenna Allocation to Subarrays				*
CSS6021	Monitor Database			*	
CSS6022	RFI Database	*			
CSS6023	Quality Control Database			*	
CSS6024	System Configuration Database			*	
CSS6026	Tracking Rates				*
CSS6027	Temporal Accuracy	*			
CSS6028	Timestamp Corrections		*		
CSS6029	Data Quality Inspection Tool			*	
CSS6030	Azimuth Wrap	*			
CSS6031	Autonomous Operations			*	
CSS6032	Line Replaceable Unit Serial Number		*		
CSS6033	Ethernet M&C Protocol		*		
CSS6034	Automatic Re-configuration				*
CSS6035	Low level access to MIB boards			*	
CSS6036	Self-diagnostic Operations	*			
CSS6037	Safety Critical Operations	*			
CSS6038	Oscilloscope Function			*	
CSS13002	Delay Model Accountability		*		
CSS13003	Coordinate Equinox		*		
CSS13005	Default Bandpass Calibration				*
CSS13006	Calibration Database: Bandpass				*
CSS13007	Default Polarization Calibration				*
CSS13008	Calibration Database: Polarization Leakages				*
CSS13009	Calibrator Database: Polarization Calibrators				*
CSS13010	Calibrator Database: Source Ingest				*
CSS13011	Standard Observing Mode Calibration		*		
CSS13012	Antenna Pointing Calibration				*
CSS13013	Storage and Retrieval of Calibration Parameters				*
CSS13014	Automated and Triggered Remeasurement of Parameters in Subarrays				*
CSS13015	Calibration Efficiency				*
CSS13016	Calibration Recall				*
CSS13018	Polarization Calibration Efficiency				*
CSS2023	Estimated Dynamic Range Per Channel	*			
CSS2025	Calibrator Search and Characterization	*			
CSS13050	Pointing and Focus Calibration				*
CSS13051	Complex Gain Calibration	*			
CSS13052	Bandpass Calibration				*

Req. #	Parameter/Requirement	A	I	D	T
CSS13053	Spw-to-spw Phase Offsets				*
CSS13054	Polarization Calibration				*
CSS13055	Opacity Tracking Within an Individual SB				*
CSS13056	Atmospheric Delay Calibration				*
CSS13057	Delay Model Recording				*
CSS13058	Ionospheric Faraday Rotation Correction				*
CSS13059	Absolute Amplitude Calibration				*
CSS13060	Astrometric Calibration				*
CSS13061	Recording of Target Fields for Calibration Solutions				*
CSS13090	Observatory-Facing (Non-PI) Observing Modes			*	
CSS13090.1	Calibrator Surveys			*	
CSS13090.2	Antenna Positions			*	
CSS13090.3	All-sky Pointing Calibration			*	
CSS13090.4	Holographic Measurements for Each Antenna			*	
CSS13090.5	Bandpass, Delay, and Polarization Leakage			*	
CSS13090.6	Full Polarization Beam Pattern Measurements of Each Antenna			*	
CSS13090.7	Gain Curves			*	
CSS13090.8	Feed Offsets			*	
CSS13090.9	Pulsar Period Determination			*	
CSS13070	Polarization Calibration				*
CSS13071	Real-time array phasing				*
CSS13072	Flux Calibration of the Summed Array Data				*
CSS13080	VLBI real-time array phasing				
CSS2000	Proposal Attributes				*
CSS2001	Observation Scheduling GUI			*	
CSS2002	Observation Interrupt				*
CSS2003	Observation Time Model	*			
CSS2004	Observation Scheduling Criteria	*			
CSS2005	Observation Scheduling Priority				*
CSS2006	Observation Scheduling				*
CSS2007	Observation Execution Logs			*	
CSS2015	Testing Scheduling Block Selection			*	
CSS2016	Accessible Field of View				*
CSS2017	Antenna Shadowing				*
CSS2018	Amplitude and Phase Coherence Over Multiple Observations				*
CSS2019	Ionospheric Delay Measurement				*
CSS2020	Ionospheric Disturbance Measurement				*
CSS2021	Scheduler Start/Stop/Restart				*
CSS2022	Interplanetary Medium Monitoring				*
CSS2024	Antenna Re-Calibration Following Maintenance	*			
CSS2026	Subarray Support				*
CSS2027	Atmospheric Phase Monitor				*
CSS2029	Automatic Scheduling Block Selection				*

Req. #	Parameter/Requirement	A	I	D	T
CSS2030	Manual Scheduling Block Selection				*
CSS2031	VLBI Observations				*
CSS2032	Observation Execution Abortion				*
CSS2033	Manual Sub-array Management				*
CSS8000	Archival of Reduced Calibration Products	*			
CSS8001	Archive access performance				*
CSS8002	Data Product Restriction Protocol	*			
CSS8003	Scan-based Storage and Retrieval	*			
CSS8004	Scan Sequence Record				*
CSS8005	Archive Backup	*			
CSS8006	Independence of Local Workflows wrt Off-Site Data Storage and Processing	*			
CSS8007	Ingestion of PIDR products				*
CSS8008	Data Delivery via Observatory Archive			*	
CSS8009	Archive Products - Low-Level	*			
CSS8010	Archive Products - High-Level	*			
CSS8011	Proprietary Data Rights	*			
CSS8012	Archive Batch Reprocessing				*
CSS8013	Archive Image Selection				*
CSS8014	Archive User Reprocessing			*	
CSS8015	Proprietary Period	*			
CSS8016	External Data Products			*	
CSS8017	Proprietary Period Trigger	*			
CSS8018	Raw Visibility Archive Data Growth	*			
CSS8019	Visibility data transfer data rate	*			
CSS10000	Visibility Processing Software Package		*		
CSS10001	Tools for Data Analysis		*		
CSS10002	Tools for Visibility Processing – Supported Platforms		*		
CSS10003	Cube image sizes			*	
CSS6018	IT Security	*			
CSS1000	Support for rapid response and triggered use cases	*			
CSS1001	Scheduling block inter-dependencies				*
CSS1002	Manual creation and editing of Scheduling Blocks				*
CSS1003	Manual creation and editing of non-standard observing mode SBs				*
CSS1004	Instrument resource tool			*	
CSS1005	Astronomical pointings tool			*	
CSS1006	Standard calibrator database			*	
CSS1007	Observation planning visualization tools			*	
CSS1008	Observation planning calculators			*	
CSS1009	Scriptable interface			*	
CSS1010	Bulk editing of Scheduling Blocks.			*	
CSS1011	Automated validation of standard observations			*	
CSS1012	Limited automated validation of non-standard observations			*	

Req. #	Parameter/Requirement	A	I	D	T
CSS1013	Helpdesk integration			*	
CSS14000	RFI avoidance in scheduling algorithm				*
CSS14001	External interface to the scheduled observation queue				*
CSS14002	DBE 1-sec time series snapshot				*
CSS14003	Remote updates to DBE RFI algorithms				*
CSS14004	CSP RFI action mode (discard/weight adjustment)				*
CSS14005	Weight stream to the CBE				*
CSS14006	Remote updates to CSP RFI algorithms				*
CSS14007	CSP dual recording option				*
CSS14008	CBE RFI-processing emphasis in modeling and subtraction	*			
CSS14009	CBE cluster sizing for RFI	*			
CSS14010	CBE option to adjust weights				*
CSS14011	CBE dual recording option				*
CSS14012	Transient detection system future option	*			
CSS14013	RFI Manager interface to offline processing algorithms				*
CSS14014	Transport large data files from antennas to RFI Manager				*
CSS14015	Enable/disable RFI mitigation features				*

19 Appendix 1: TTA Tools Project Requirements

The Telescope Time Allocation (TTA) Tools project is an inherited system that will be used by ngVLA. It aims to deliver a general framework to handle the proposal management process for the VLA, Greenbank and ngVLA telescopes. It provides common abstract software elements and an "anti-corruption" interface that defines extension points for each telescope to complete their specific application. The TTA requirements are included in this section for completeness.

19.1.1 Charter

Parameter	Req. #	Value	Traceability
Develop TTA System	TTA-1	Develop a new suite of software tools to support the submission, scientific and technical review, and time allocation of proposals for the NRAO telescopes, consistent with the requirements for observing preparation given NRAO's commitment to SRDP.	

19.1.2 Level 0

19.1.2.1 Functional Requirements

Parameter	Req. #	Value	Traceability
Proposal	TTA-L0-17	The suite of Tools satisfying TTA-1 will support preparation and submission of proposals.	[TTA-1]

Parameter	Req. #	Value	Traceability
Review	TTA-L0-18	The suite of Tools satisfying TTA-1 will support proposal review.	[TTA-1]
Time Allocation	TTA-L0-19	The suite of Tools satisfying TTA-1 will support Time Allocation Committee Meeting.	[TTA-1]
Solicitation	TTA-L0-21	The suite of Tools satisfying TTA-1 will support specification of an observing proposal solicitation.	[TTA-1]
Directors Review and Time Award	TTA-L0-22	The suite of Tools satisfying TTA-1 will support Directors Review and Time Award.	[TTA-1]
SRDP	TTA-L0-24	For telescopes where SRDP are in scope, sufficient information must be gathered such that observations and reduction could be executed based solely on the information entered into this suite of tools and additional observatory information such as scheduling.	[TTA-1]
Equitable and Fair Reviews	TTA-L0-25	Best practices for ensuring an equitable and fair review process shall be supported by the tool suite.	[TTA-1]
Double Blind Reviews	TTA-L0-25.1	TTA Tools shall support a dual anonymous process where authors will not know who is reviewing proposals and vice versa.	
Proposal Vetting	TTA-L0-27	TTA Tools shall support a dual anonymous process where authors will not know who is reviewing proposals and vice versa.	[ttaToolsSysDescription-3.3]
Review Configuration	TTA-L0-28	Prior to the beginning of the review process a TTA Group member will configure TTA Tools to support Science, Technical and Data Management Reviews.	[TTA-L0-18]

19.1.2.2 Non-Functional Requirements

Parameter	Req. #	Value	Traceability
User Experience	TTA-L0-1	The look and feel of NRAO software should be similar across the different facilities if at all possible.	[TTA-1]
Code reuse	TTA-L0-1.1	To the extent that it is efficient to do so, the implementation is expected to draw from the ALMA tools as well.	[TTA-L0-1]
Technology	TTA-L0-1.2	The TTA system will be a web-based tool.	[TTA-L0-1]

Parameter	Req. #	Value	Traceability
User Interface	TTA-L0-1.3	The user interface will follow the design and functionality of the ALMA OT.	[TTA-L0-1]
Proposal Submission Experience	TTA-L0-1.4	If possible, proposal submission via the TTA system should be similar for any NRAO instrument.	[TTA-L0-1]
Support Expert Users	TTA-L0-2	Permit expert users to override defaults.	[TTA-1]
Support collaborative Proposal Development	TTA-L0-23	TTA users must be able to easily share proposal information throughout the proposal process.	[TTA-1]
Supported Telescopes	TTA-L0-3	The following telescopes must be supported: VLA, VLBA, GMVA, HSA, GBT, and ngVLA.	[TTA-1]
GBT	TTA-L0-3.1	The GBT shall be supported by this system.	
HSA	TTA-L0-3.2	The High Sensitivity Array shall be supported by this system	
VLA	TTA-L0-3.3	The VLA shall be supported by this system	
GMVA	TTA-L0-3.4	The GMVA shall be supported by this system	
VLBA	TTA-L0-3.5	The VLBA shall be supported by this system	
ngVLA	TTA-L0-3.6	This system shall support the proposed ngVLA telescope.	
Allocate telescope time	TTA-L0-4	Proposal process allocates telescope time instead of sensitivity.	[TTA-1]
Support SRDP Operations	TTA-L0-5	Capture desired scientific products as part of proposal.	[TTA-1]
Support novice observer	TTA-L0-6	Decrease requirement of detailed telescope knowledge at the proposal stage.	[TTA-1]
Observing Prep Software Interface	TTA-L0-7	Identify the requirements for the interface between the TTA system and the project preparation tools, in anticipation of the timely development of new project preparation tool.	[TTA-1]
Support Observatory Metric Analyst	TTA-L0-8	TTA shall provide proposal and observation data for metric analysis and reporting.	[TTA-1]
Metrics Data	TTA-L0-8.1	The system must persist historical data used for metric calculations.	[TTA-L0-8]

Parameter	Req. #	Value	Traceability
Calculated Metrics	TTA-L0-8.2	The system must calculate and store metrics.	[TTA-L0-8]
Metric Data Access	TTA-L0-8.3	TTA data must be accessible for generating novel metrics reports without the need for UI modifications.	[TTA-L0-8]
Simplify Proposal and Observing Process	TTA-L0-9	Capture scientific intent and technical details at proposal stage.	[TTA-1]

19.1.2.3 TTA Reqs from SRDP

Parameter	Req. #	Value	Traceability
Image Product Specification	TTA-SRDP-10	The parameters of the SRDP products shall be explicitly specified in the observing proposal.	[SRDP-L0-2]
Opt out of SRDP Images	TTA-SRDP-10.1	Projects shall be able to opt out of SRDP Imaging at the proposal submission stage with a brief description of why SRDP imaging is not appropriate for the project.	
Parameterization	TTA-SRDP-10.2	Parameters for SRDP products shall specify image characteristics (as opposed to processing instructions).	
Spatial Resolution	TTA-SRDP-10.2.1	The desired spatial resolution shall be specified as part of the observing proposal.	
Spectral Resolution	TTA-SRDP-10.2.2	The desired spectral resolution shall be specified as part of the observing proposal.	
Multiple Phase Centers	TTA-SRDP-10.2.3	If multiple phase centers are specified, the proposal shall specify if they are to be mosaiced or imaged independently.	
Multiple Executions	TTA-SRDP-10.3	Combined imaging of multiple executions of the same scheduling block in the same configuration shall be supported.	
Time Critical Processing	TTA-SRDP-11	The proposal tool shall allow telescope users to designate projects for time critical processing.	[SRDP-L0-8]
Critical Product Specification	TTA-SRDP-11.1	The proposal submission tool shall allow the telescope user to specify which data products should be treated as time critical: calibrated visibilities, quick-look images, or science-ready images.	

Parameter	Req. #	Value	Traceability
Observing Restrictions	TTA-SRDP-11.2	Time critical processing shall conform to standard observing templates, and specify the characteristics of the desired imaging products.	
Data Management Plan	TTA-SRDP-12	Large Projects process shall submit a data management plan and data release policy for data products generated during execution of the project in the observing proposal. Description of the data products and approximate size shall be included in all future proposals.	[SRDP-L0-9]
Support for Combined Products	TTA-SRDP-7	The proposal tool shall support the specification of products requiring combined imaging.	[SRDP-L0-7.2]
Display of related observations.	TTA-SRDP-7.1	Observations for combined products should be grouped together.	
Consistency of observation.	TTA-SRDP-7.2	The observing tool shall ensure that the spatial and spectral coordinates of the observation are consistent between the different epochs of observation.	
Ratio of Observing Times	TTA-SRDP-7.3	Total integration times for each configuration shall be set according to observatory determined ratios.	
Opt out of SRDP Calibration	TTA-SRDP-8	The SRDP Proposal process shall allow the user to "opt out" of the standard calibration process, with documentation to justify the decision. Such proposals shall inhibit automatic trigger of the Standard calibration pipeline.	[SRDP-L0-1]
Required Information	TTA-SRDP-9	SRDP compliant proposals shall include adequate information for creation of scheduling blocks and observing scripts.	[SRDP-L0-1]

19.1.3 Level 1

19.1.3.1 Functional Requirements

19.1.3.1.1 Solicit

Parameter	Req. #	Value	Traceability
Proposal Solicitation	TTA-L1-1	The process begins when the observatory announces a solicitation to use observatory resources, typically a call for proposals to request time on one or more of Associated Universities Inc. (AUI) North American (NA) telescopes.	[TTA-L0-21]

Parameter	Req. #	Value	Traceability
Semester Proposal Classes	TTA-L1-1.11	Currently the Proposal Classes are "Regular" or "Large". These have the following configurable attributes: 1. Size of the proposal title. 2. Size of the abstract. 3. Size of the scientific justification 4. Available semesters to execute the observations.	[TTA-L0-21, TTA-L0-17, ttaToolsSysDescription-3.1.1.1]
Facility-Capability Mapping	TTA-L1-1.12	For now, we will assume a one-to-one mapping between Facilities and Capabilities for simplicity.	[TTA-L0-3, TTA-L0-3.1, TTA-L0-3.2, TTA-L0-3.3, TTA-L0-3.4, TTA-L0-3.5, TTA-L0-3.6, TTA-L0-21, TTA-L0-9, ttaToolsSysDescription-3.1]
Specification Constraints	TTA-L1-1.14	Capabilities are composed of Specification Constraints; these are essentially restriction on the available resources.	[TTA-L0-21, TTA-L0-3, TTA-L0-3.1, TTA-L0-3.2, TTA-L0-3.3, TTA-L0-3.4, TTA-L0-3.6, ttaToolsSysDescription-3.1]
Open Solicitation	TTA-L1-1.15	After validation, the call for proposals is officially "opened" by the TTA Group through a provided interface. That is, the user can now create and submit a proposal for the solicitation in question. At this point all "validation proposals" are removed from the system and no further changes to the solicitation parameters are permitted.	[TTA-L0-21]
Unique Identifier	TTA-L1-1.16	A global unique identifier, referred to as a serial number, shall be associated with a proposal when it is created.	[TTA-L0-21, ttaToolsSysDescription-3.1.1.1,3.1.1.2]
Execution Period	TTA-L1-1.17	The solicitation shall specify the nominal execution period or the period over which the observations will be performed.	[TTA-L0-21, ttaToolsSysDescription-3.1.1.1,3.1.1.2]

Parameter	Req. #	Value	Traceability
Call Period	TTA-L1-1.18	The solicitation shall specify the call period or the period over which users may create, edit, and submit a proposal.	[TTA-L0-21, TTA-L0-8.1, TTA-L0-8.2, ttaToolsSysDescription-3.1.1.1,3.1.1.2]
Science Categories	TTA-L1-1.19	The solicitation shall specify the list of science categories for selection by the user. There is not necessarily a one-to-one correspondence between science category and review panel.	[TTA-L0-21, TTA-L0-1.4, ttaToolsSysDescription-3.1.1.1,3.1.1.2]
Support Multiple Solicitations	TTA-L1-1.2	The system shall support multiple concurrent proposal solicitations.	[TTA-L0-21, TTA-L0-8.1, ttaToolsSysDescription-2.2.1]
Semester Proposal Solicitation	TTA-L1-1.20	The system shall support semester solicitations, these periodic solicitations is the most used in operations of AUI/NA Telescopes.	[TTA-L0-3, TTA-L0-3.1, TTA-L0-3.2, TTA-L0-3.3, TTA-L0-3.4, TTA-L0-3.5, TTA-L0-21, ttaToolsSysDescription-3.1.1.1]
DDT Proposal Solicitation	TTA-L1-1.21	The system shall support solicitations for Directors Discretionary Time, allowing for immediate review and scheduling of out of cycle proposals.	[TTA-L0-3.1, TTA-L0-3.3, TTA-L0-3.5, TTA-L0-3.6, TTA-L0-21, TTA-L0-2, ttaToolsSysDescription-3.1.1.2]
Sponsored Proposal Solicitation	TTA-L1-1.22	The system shall support solicitations for sponsored proposals. Although not subject to the standard review these projects should have traceability in the system (unless they are closed).	[TTA-L0-3.1, TTA-L0-3.5, TTA-L0-21, ttaToolsSysDescription-3.1.1.3]
Resident Shared Risk Observing	TTA-L1-1.23	Resident Shared Risk Observing shall be supported through special capabilities.	[TTA-L0-3.3, TTA-L0-3.5, TTA-L0-21, ttaToolsSysDescription-3.1.1.4]

Parameter	Req. #	Value	Traceability
Demo Proposal Solicitation	TTA-L1-1.24	The system shall support the creation of proposals for testing or training purposes that are not intended to be observed.	[TTA-L0-21, ttaToolsSysDescription-3.1.1.5]
DDT Proposal Classes	TTA-L1-1.25	Currently the DDT Proposal Classes are "Exploratory", "Target of Opportunity", or "EPO". These have the following configurable attributes: 1. Size of the proposal title. 2. Size of the abstract. 3. Size of the scientific justification 4. Available semesters to execute the observations.	[TTA-L0-21, TTA-L0-2, TTA-L0-8.2, ttaToolsSysDescription-3.1.1.2]
Demo Capabilities	TTA-L1-1.26	Usually the capabilities are based on the current or upcoming solicitation.	[TTA-L0-6, TTA-L0-21, ttaToolsSysDescription-3.1.1.5]
Demo Configuration	TTA-L1-1.27	In setting up a proposal solicitation the TTA Group lead will want to specify that this is not an official call and thus no review or time allocation processes will be created.	[TTA-L0-6, TTA-L0-21, ttaToolsSysDescription-3.1.1.5]
Demo Notifications	TTA-L1-1.28	Notifications to the PI and TTA members shall be configurable as part of the solicitation configuration. This shall include suppression or redirection of notifications.	[TTA-L0-21, ttaToolsSysDescription-3.1.1.5]
Demo Closeout	TTA-L1-1.29	At the end of the workshop, the proposals may be removed from the system and shall not be linked to the users account (i.e., show up in their personal list of proposals).	[TTA-L0-21, ttaToolsSysDescription-3.1.1.5]
Solicitation Configuration	TTA-L1-1.3	Many components of the solicitation will be configurable and the configuration history should be stored.	[TTA-L0-21, ttaToolsSysDecription-3.1]
Configure Solicitation	TTA-L1-1.4	Prior to the call for proposals the TTA Group will specify the parameters for the observing call.	[TTA-L0-21, ttaToolsSysDescription-3.1.1.1, 3.1.1.2]

Parameter	Req. #	Value	Traceability
Facility	TTA-L1-1.4.6	Each Facility will have the following configurable attributes: 1. The technical justification cues. 2. If triggered observing is available and the list of triggered criteria. 3. A list of constraints.	[TTA-L0-21, ttaToolsSysDescription-3.1.1.1,3.1.1.2]
Capabilities	TTA-L1-1.4.7	A configurable list of Capabilities shall be selected by the TTA Group. For example, on-the-fly mapping single-dish or single-field interferometry. Each of these is connected to a Facility (e.g., GBT and VLA). For each Capability the TTA Group will select the configurable list of resources and their constraints; that is, the Specification Constraints. For example, a list of the receivers for each Capability (e.g., L,S,X) and their constraints (e.g., frequency range).	[TTA-L0-21, TTA-SRDP-9, TTA-SRDP-10.2, TTA-SRDP-10.2.1, TTA-SRDP-10.2.2, TTA-SRDP-10.2.3, TTA-SRDP-10.3, TTA-L0-9, ttaToolsSysDescription-3.1.1.1]
Capability Configuration	TTA-L1-1.4.7.1	Capabilities defined in a file and may be imported and exported.	[TTA-L0-21, TTA-L0-9, ttaToolsSysDescription-3.1.2.2]
Validate Capabilities	TTA-L1-1.4.8	Once a Solicitation has been created the TTA Group may create test proposals to validate that the Capabilities are functioning correctly.	[TTA-L0-21, ttaToolsSysDescription-3.1.1.1]
Notification Groups	TTA-L1-1.5	There shall be notification groups that are configurable. The notifications will be a function of the Solicitation.	[TTA-L0-21, ttaToolsSysDescription-3.1.2.5]
External Solicitation	TTA-L1-1.6	There also exist solicitations from external facilities where time is allocated by an external TAC.	[TTA-L0-21, ttaToolsSysDescription-2]
Solicitation Capabilities	TTA-L1-1.7	For each solicitation the Capabilities define the resources that are available.	[TTA-L0-21, TTA-SRDP-9, ttaToolsSysDescription-2, 3.1.2.1]

Parameter	Req. #	Value	Traceability
Solicitation Proposal Process	TTA-L1-1.8	For each solicitation, the Proposal Process describes how the proposal is handled by the observatory.	[TTA-L0-17, TTA-L0-28, TTA-L0-21, ttaToolsSysDescription-2]
Solicitation Facilities	TTA-L1-1.9	A Solicitation is composed of...the various ways a Facility can be operated.	[TTA-L0-21, TTA-L0-3, TTA-L0-3.1, TTA-L0-3.2, TTA-L0-3.3, TTA-L0-3.4, TTA-L0-3.5, TTA-L0-3.6, ttaToolsSysDescription-3.1]

19.1.3.1.2 Propose

Parameter	Req. #	Value	Traceability
Download proposal information	TTA-L1-12	Users must be able to download a PDF version of the proposal at each stage of the proposal process.	[TTA-L0-23, TTA-L0-17]
Permissions	TTA-L1-14	All authors on a proposal should have read/write privileges and there should be no locking for editing; we assume the collaborators are communicating about the proposal.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]
Administration Permissions	TTA-L1-15	Appropriate administrators (e.g., TTA Group) will also have read/write privileges to be able to provide technical and scientific support.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]
UX	TTA-L1-16	Container for user interface requirements.	[TTA-L0-17, TTA-L0-6, TTA-L0-2]
View Multiple Proposals	TTA-L1-16.1	Many users will be working on multiple proposals at once, so an interface to allow them to see all of their proposals and the current state of the proposals should be provided.	[TTA-L0-17, TTA-L0-2, ttaToolsSysDescription-2.1.1]
Previously Submitted Proposals	TTA-L1-16.2	Users should also be able to view and access previously submitted proposals.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]

Parameter	Req. #	Value	Traceability
Submit Proposal	TTA-L1-16.3	Before the deadline the PI (or any author) should be able to submit the proposal through an option in the interface.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]
Submission Verification	TTA-L1-16.4	Once submitted a verification dialog should immediately appear providing the assigned proposal ID and the time of submission.	[TTA-L0-17, TTA-L0-2, TTA-L0-6, ttaToolsSysDescription-2.1.1]
Author Notification	TTA-L1-16.5	All authors should be notified of the submission.	[TTA-L0-17, ttaToolsSysDescription]
Proposal Deadline	TTA-L1-16.6	After the proposal has been submitted, any author should be able to continue to edit and submit the same proposal up until the deadline.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]
Withdraw Proposal	TTA-L1-16.7	Only TTA group members can withdraw a proposal once submitted.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]
TTA Group Withdraw	TTA-L1-16.8	A TTA Group member shall be able to withdraw a proposal at any stage. That is, the withdraw functionality is global.	[TTA-L0-17, ttaToolsSysDescription-2.2.3]
Log In	TTA-L1-16.9	A proposal begins when a registered user logs into the proposal tool and selects “semester” or "DDT" for the solicitation.	[TTA-L0-17, ttaToolsSysDescription-3.2.1.1, 3.2.1.2]
Create Proposal	TTA-L1-2	A proposal requesting time on one or more telescopes for a semester solicitation is the most common method of accessing AUI NA telescopes.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]
Abstract Status	TTA-L1-2.1	When a proposal is given positive a disposition the following information shall be public: Proposal ID, title, PI, Co-Is, science category, proposal type (e.g., Large), Approved hours, abstract, and the date/time submitted.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.5.a]
Re-Submission	TTA-L1-2.2	A method of specifying if this is a RE-SUBMISSION should be available.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.10]

Parameter	Req. #	Value	Traceability
Select Solicitation	TTA-L1-2.3	The first action in the proposal tool must be to select the solicitation which sets the capabilities and the proposal process. The solicitations consist of "semester", "DDT", and "Special".	[TTA-L0-17, TTA-L0-8, TTA-L0-8.1, TTA-L0-8.2, TTA-L0-8.3, ttaToolsSysDescription-3.2.2.1]
Special Solicitation	TTA-L1-2.3.1	A "Special" solicitation is for proposals that are reviewed by an external TAC or a sponsored proposal.	[TTA-L0-17, TTA-L0-21]
Enter Proposal Information	TTA-L1-2.4	A registered, authenticated user must be able to enter all of the information required to create a proposal.	[TTA-L0-17]
Proposal Information Ownership	TTA-L1-2.4.1	All authors shall be able to modify all fields in the proposal.	[TTA-L0-17, TTA-L0-23]
Enter Proposal Title	TTA-L1-2.4.2	A text entry field defining the proposal TITLE shall be provided (word limit applies).	[TTA-L0-17, ttaToolsSysDescription-3.2.2.4]
Enter Related Proposal	TTA-L1-2.4.3	A method of indicating any previous RELATED PROPOSALS shall be provided. To reduce the probability of mistakes, the title of any related proposal shall be displayed.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.9]
Enter Science Category	TTA-L1-2.4.4	Authors will specify a single SCIENCE CATEGORY from the list of categories defined for the observing cycle, through a drop down or similar interface.	[TTA-L0-17, TTA-L0-8.1, TTA-L0-8.2, TTA-L0-8.3, ttaToolsSysDescription-3.2.2.7]
Enter Proposal Abstract	TTA-L1-2.4.5	A text entry field used to enter a proposal ABSTRACT shall be provided (word limit applies).	[TTA-L0-17, ttaToolsSysDescription-3.2.2.5]

Parameter	Req. #	Value	Traceability
Validate Proposal Information	TTA-L1-2.4.6	All text entry fields shall be validated for content to ensure the integrity of the proposal system. Text entry widgets shall accept Unicode input unless otherwise specified. Text fields may indicate that they have a word limit, in this case the limit should only be applied during the validation stage (although a warning could be produced earlier) to allow users flexibility when drafting entries.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.12]
Enter Proposal Review Category	TTA-L1-2.4.7	The system will allow authors to select a solicitation for which the proposal is in response.	[TTA-L0-17]
Enter Scientific Justification	TTA-L1-2.4.8	Authors shall be able to attach and update a SCIENTIFIC JUSTIFICATION for each proposal.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.6]
Scientific Justification Format	TTA-L1-2.4.8.1	The justification must be submitted in a PDF format and is subject to a page limit specified at the proposal solicitation definition phase.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.6]
Scientific Justification Validation	TTA-L1-2.4.8.2	The system will automatically validate the scientific justification conformance with requirements (Font, number of pages, etc.)	[TTA-L0-17, ttaToolsSysDescription-3.2.2.6]
Enter Student Project Information	TTA-L1-2.4.9	Observations related to students THESIS PROJECT shall be indicated. This is a check box or similar mechanism.	[TTA-L0-17, TTA-L0-8.1, TTA-L0-8.2, TTA-L0-8.3, ttaToolsSysDescription-3.2.2.8]
Enter Student Project Details	TTA-L1-2.4.9.1	If selected the student author should be identified, their projected graduation date retrieved from the Account System, and a check that a thesis plan is on record for the student performed.	[TTA-L1-2.4.9, TTA-L0-17, TTA-L0-8.1, TTA-L0-8.2, TTA-L0-8.3, ttaToolsSysDescription-3.2.2.8]
Manage Allocation Requests	TTA-L1-2.5	A method to add and remove Allocation Requests from the proposal shall be provided.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.11]

Parameter	Req. #	Value	Traceability
Allocation Request Information	TTA-L1-2.5.1	At the Allocation Request level, the capabilities of the solicitation must be defined. The resources that can be specified are given by the REQUEST SPECIFICATION. For each REQUEST SPECIFICATION the set of capabilities must be defined. The set of capabilities is defined as the set of Front Ends, Back Ends, and SRDPs offered to the proposer, as well as the validation constraints to be used when validating these OBSERVATION SPECIFICATION components. It is expected that the Capabilities will changes slowly from one semester to the next so provision to modify a previous semester's Solicitation to create new Solicitation shall be made.	[TTA-L0-17, TTA-SRDP-7, ttaToolsSysDescription-3.3.1.1]
Generate Proposal ID	TTA-L1-2.6	A sequential PROPOSAL ID shall be generated for all proposals at submission.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.2]
Proposal ID Algorithm	TTA-L1-2.6.1	The proposal ID shall be constituted by the unique solicitation identifier specified in the solicitation followed by a dash and then at least three-digit proposal ID number (e.g. 19A-023). If more than three digits are required to uniquely identify all proposals additional digits shall be used.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.2]
Author List Entry	TTA-L1-2.7	For each proposal a list of associated authors shall be entered through the proposal tool. Author information is maintained in the NRAO account system (see x4.1) and shall be referenced from the proposal. The information associated with the authors at the time of submission must be persisted.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.3.a]
Default PI	TTA-L1-2.7.1	Exactly one author shall be designated as PRINCIPAL INVESTIGATOR, by default the author initially creating the proposal shall be designated as the PI.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.3.c]

Parameter	Req. #	Value	Traceability
User Account	TTA-L1-2.7.2	Provision shall be made to easily create user accounts for authors that do not yet have an account.	[TTA-L0-17, TTA-L0-6, ttaToolsSysDescription-3.2.2.23.b]
Author Information	TTA-L1-2.7.3	When an author is added to a proposal all of the information in the author's profile should be associated with the proposal (e.g., this version of the profile is connected to the proposal). This profile information for all authors on the proposal should be updated when the proposal is submitted.	[TTA-L0-17, TTA-L0-8.1, TTA-L0-8.2, TTA-L0-8.3, ttaToosSysDescription-3.2.1.1]
Designate Contact Author	TTA-L1-2.7.4	Exactly one author shall be designated as the Contact Author; by default, the author initially creating the proposal.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.3.d]
Contact Author Email	TTA-L1-2.7.4.1	An e-mail address must be associated with the Contact Author's information in the account sub-system.	[TTA-L0-17]
Final Proposal Version	TTA-L1-23	The last version of the proposal submitted will be the final version.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]
Modification after Deadline	TTA-L1-24	After the deadline and any specified grace period has passed the proposal may no longer be modified.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]
Author Permission	TTA-L1-26	Collaborators may be added to the proposal as Co-Investigators without any direct permission.	[TTA-L0-17, ttaToolsSysDescription-2.1.1]

Parameter	Req. #	Value	Traceability
Proposal States	TTA-L1-27	The software shall maintain a state for each Proposal throughout the proposal life-cycle. The following set of states is the minimum set to be made available to telescope users: 1. DRAFT: The proposal has been created but not yet submitted. 2. SUBMITTED: The proposal has been submitted. At this stage the proposal can still be modified and submitted again. 3. IN REVIEW: The proposal has been submitted and can no longer be modified. 4. COMPLETED: The proposal has been reviewed and time allocated. A disposition letter has been sent. 5. WITHDRAWN: The proposal has been withdrawn after submission. Once a proposal is withdrawn it becomes stale; that is, the proposal cannot go to any other state.	[TTA-L0-17, ttaToolsSysDescription-2.2.2]
Create Proposal from Existing	TTA-L1-29	It shall be possible, with best efforts, to create a new draft from a proposal in the WITHDRAWN or COMPLETED state.	[TTA-L0-17, ttaToolsSysDescription-2.2.4]
Authenticate User	TTA-L1-3	The system shall authenticate users and ensure that only authorized modifications to the proposal are made.	[TTA-L0-17]
Proposal Migration	TTA-L1-30	Migration of existing proposals. At a minimum the user should have access to past (PST) proposal PDFs. We need a data model first to decide how best to import current data.	[TTA-L0-17, TTA-L0-8, TTA-L0-8.1, TTA-L0-8.2, TTA-L0-8.3, ttaToolsSysDescription-2.3.1]

Parameter	Req. #	Value	Traceability
External TAC Proposal	TTA-L1-33	The process starts when the TTA Group is notified by an external facility that a proposal has been approved by their TAC for observations on an AUI/NA telescope. The TTA Group will create a Proposal and the corresponding Allocation Dispositions. A notification is then sent to the PI informing them to fill in the appropriate information; that is, the Allocation Requests. After the proposal is validated the Project can be created.	[TTA-L0-17, TTA-L0-3.1, TTA-L0-3.3, TTA-L0-3.5, TTA-L0-8, ttaToolsSysDescription-3.2.1.3]
Notifications	TTA-L1-34	Notifications shall be sent for successful submission of a proposal to the authors and the TTA group. Included should be the PROPOSAL ID, Proposal Class, TITLE, PI, CO-IS, SCIENCE CATEGORY, TIME SUBMITTED, and for each Allocation Disposition: the ALLOCATION REQUEST ID, the Facility, and if the proposal is TRIGGERED.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.13]
External TAC Proposal Notification	TTA-L1-35	For External TAC proposals, a notification should be sent to the PI after the TTA Group has created a proposal informing them to complete the proposal.	[TTA-L0-17, ttaToolsSysDescription-3.2.2.14]
Vetting	TTA-L1-36	It shall be possible for TTA members to identify proposals that require vetting and either indicate that they have been verified or move the proposal to the withdrawn state.	[TTA-L0-27, ttaToolsSysDescription-3.3]
Solicitation Vetting	TTA-L1-37	Proposals submitted for a semester solicitation should be vetted to check that they are indeed appropriate for such a solicitation...A TTA Group member shall be able to flag such a proposal and move it to the WITHDRAWN state.	[TTA-L0-27, ttaToolsDesciprtion-3.3.1.1]

Parameter	Req. #	Value	Traceability
Science Category Vetting	TTA-L1-38	During the vetting process TTA members shall be able to view a subset of proposal content and modify the SCIENCE CATEGORY prior to marking the proposal as verified.	[TTA-L0-27, ttaToolsSysDescription-3.3.1.1]
Solicitation Types	TTA-L1-39	Tracking and required vetting of proposals shall be configurable as part of solicitation configuration.	[TTA-L0-17, ttaToolsDescription-3.3.1.1, 3.3.1.2]
Validate Proposal	TTA-L1-4	The system shall validate proposals throughout the proposal process to prevent incorrect or inconsistent values from being stored. (Dup-L1-1.2.8)	[TTA-L0-17, TTA-L0-6]
Check Solicitation Boundary	TTA-L1-40	There shall be a mechanism to check that the time of proposal submission is within the boundaries of the specified solicitation dates. For semester solicitations this is typically within one month leading up to the deadline; that is, users have about one month to create, edit, and then submit the proposal. There shall be a configurable grace period. For DDT proposals the system shall manage the date ranges automatically without requiring the author's input.	[TTA-L0-17, ttaToolsSysDescription-3.3.2.1]

Parameter	Req. #	Value	Traceability
Science Category Vetting Interface	TTA-L1-42	There shall be an interface to aid a TTA Group member to vet the SCIENCE CATEGORY of all proposals submitted for a semester solicitation. The interface should show: (a) PROPOSAL ID (b) TITLE (c) ABSTRACT The user shall be able to filter by the SCIENCE CATEGORY. There shall be a way to select a different SCIENCE CATEGORY before saving. There shall be a mechanism to save the SCIENCE CATEGORY for all proposals. The history of the SCIENCE CATEGORY shall be maintained; that is, there shall be a way to view the original SCIENCE CATEGORY.	[TTA-L0-27, ttaToolsSysDescription3.3.2.2]

19.1.3.1.3 Review Configuration

Parameter	Req. #	Value	Traceability
Science Review Panel Configuration	TTA-L1-46	Prior to the beginning of the review process a TTA Group member will configure the science review panels (SRPs).	[TTA-L0-25.1, TTA-L0-28, ttaToolsSysDescription-3.4.1.1]
Feasibility Review Configuration	TTA-L1-47	Prior to the beginning of the review process a TTA Group member will configure the system to assign zero or more reviewers to evaluate the feasibility of each Allocation Request.	[TTA-L0-6, TTA-SRDP-12, TTA-L0-28, ttaToolsSysDescription-3.4.1.2]
Feasibility Review Assignments	TTA-L1-48	To manage assignments the software shall support a mechanism to specify groups of reviewers that can be applied to one or more Allocation Requests.	[TTA-L0-28, ttaToolsSysDescription-3.4.1.2]
Starting SRP Configuration	TTA-L1-49	The starting configuration should be defaulted to a previous cycle's values.	[TTA-L0-25.1, TTA-L0-28, ttaToolsSysDescription-3.4.1.1]

Parameter	Req. #	Value	Traceability
SRP Definition	TTA-L1-50	Each SRP consists of a SCIENCE CATEGORY, SRP members, and an SRP chair. (A chair pro tem may be assigned at a later time.) There shall be two or more reviewers, consisting of SRP members and SRP chairs, assigned to each Proposal. A reviewer can only be on one SRP.	[TTA-L0-25.1, TTA-L0-28, ttaToolsSysDescription-3.4.1.1]
Data Management Review Configuration	TTA-L1-51	The structure of data management reviews is similar to technical reviews, except that they will mostly likely only be performed on a small sub-set of Allocation Request. This determination will likely depend on reasonable logical combinations of TOTAL REQUESTED TIME, ESTIMATED PROCESSING, and ESTIMATED DATA VOLUME. It is very likely that these criteria will evolve over time, so reasonable effort shall be made to provide flexibility in the software.	[TTA-SRDP-12, TTA-L0-28, ttaToolsSysDescription-3.4.1.3]
Review Panel Setup Access	TTA-L1-52	Only members of TTA Group shall be able to view and modify the Review Panel Setup.	[TTA-L0-25.1, TTA-L0-28, ttaToolsSysDescription-3.4.2.1]
Review Configuration File	TTA-L1-53	It shall be possible to execute a configuration file. For example, for testing purposes a TTA Group member will want to automatically configure the system using a previous configuration file.	[TTA-L0-28, ttaToolsSysDescription-3.4.2.2]
Applying Configuration File Changes	TTA-L1-54	Changes to the number of reviewers, panels, or science categories shall not require a software update.	[TTA-L0-28, ttaToolsSysDescription-3.4.3.1]

19.1.3.1.4 Review

Parameter	Req. #	Value	Traceability
Semester Solicitation Review	TTA-L1-43	Proposals submitted for a semester solicitation will be reviewed by a panel-based, dual-anonymous review process.	[TTA-L0-18, TTA-L0-25, TTA-L0-25.1, ttaToolsSysDescription-3.4]

Parameter	Req. #	Value	Traceability
DDT Solicitation Review	TTA-L1-44	Proposals submitted for a DDT Solicitation are reviewed by a local observatory site committee, typically organized by the scheduler.	[TTA-L0-25, TTA-L0-18, ttaToolsSysDescription-3.4]
Special Solicitation Review	TTA-L1-45	Proposals submitted for a "special" solicitation are not evaluated by the NRAO review process...but such reviews are handled outside of the TTA Tools and are therefore out of scope.	[TTA-L0-25, TTA-L0-18, ttaToolsSysDescription-3.4]
Review Process	TTA-L1-55	The details of the review process varies depending on the proposal solicitation.	[TTA-L0-18, ttaToolsSysDescription-3.5]
Feasibility Review Output	TTA-L1-84	For each Allocation Request the Feasibility reviewer enters COMMENTS FOR THE PI and INTERNAL COMMENTS. The COMMENTS FOR THE PI will be visible to the PI but also to SRP and TAC members. The INTERNAL COMMENTS will only be visible to the SRP, TAC and TTA Group.	[TTA-L0-18, TTA-SRDP-12]
Feasibility Review	TTA-L1-85	Feasibility reviews are assessments of each Allocation Request. Technical reviews are assessments technical feasibility and accuracy of the information provided in the technical justification often performed by observatory staff. Data Management reviews are assessments of the feasibility and impact of the processing associated with each allocation request. Jointly we will refer to these as Feasibility Justifications.	[TTA-L0-18, TTA-SRDP-12]
Feasibility PDF Generation Options	TTA-L1-86	The generation of the PDF for feasibility reviews should have the following options: (a) Full proposal. (b) Only the Allocation Request. (c) Only the ALLOCATION ID, PI, TITLE, and TECHNICAL JUSTIFICATION.	[TTA-L0-18]

19.1.3.1.5 Allocate

Parameter	Req. #	Value	Traceability
Special Solicitation Allocate Process	TTA-L1-100	Special solicitations in support of sponsored time require creation of dispositions by the local schedular. The software shall support this activity.	[TTA-L0-19]
Panel Allocate Process	TTA-L1-98	The software shall support a panel based allocation process (informally known as the TAC process).	[TTA-L0-19, TTA-L0-25]
Observatory Site Allocate Process	TTA-L1-99	The software shall support an observatory site allocation process, where the director (or designee) determines the allocation disposition.	[TTA-L0-19]

19.1.3.1.6 Approve

Parameter	Req. #	Value	Traceability
Director's Review Report	TTA-L1-114	A TTA Group member is responsible for producing a Director's Review report which is based on all proposals, the NORMALIZED LINEAR-RANK SCORE, and the Allocation Dispositions. The TTA Tools shall generate various metrics (tables and plots), and csv-formatted spreadsheets that will be included with the report.	[TTA-L0-22, TTA-L0-4]

19.1.3.1.7 Close

No requirements currently.

19.1.3.1.8 Create Projects

No requirements currently.

19.1.3.2 Non-Functional Requirements

Parameter	Req. #	Value	Traceability
Configurability	TTA-L1-11	The TTA system must use configuration files, interfaces, services, agents, etc. to avoid hard coded values.	[TTA-L0-28, TTA-L0-21]

20 Appendix 2: Science Ready Data Products Project Requirements

Cross-functional project that aims to develop requirements/architecture/software to enable the generation of data products that can be directly used for science, without the need of expert data reduction.

20.1 Charter

Parameter	Req. #	Value	Traceability
SRDP Charter	SRDP-1	Change the way that radio astronomy is conducted. The primary objective is to maximize the scientific impact of the NRAO interferometers.	
Provide expertise	SRDP-1.1	Provide expertise required to perform data processing so users may focus more on their science and less on data reduction.	
Broaden radio astronomy user community	SRDP-1.2	Broaden the radio astronomy user community by decreasing the barriers to using NRAO's interferometers.	
Curate rich archive	SRDP-1.3	Curate a rich archive of images for archival study.	

20.2 Level 0

Parameter	Req. #	Value	Traceability
Standard Calibration	SRDP-L0-1	The system shall support automated science-quality assured calibration for supported observational modes.	[SRDP-1.2, SRDP-1.1, TTA-1]
VLA Standard Calibration	SRDP-L0-1.1	VLA interferometric observation shall be supported by the calibration pipeline.	
Automatic Trigger	SRDP-L0-1.1.1	When a conforming observation is complete, and necessary meta-data for successful calibration is available, the observation shall be automatically triggered for calibration (as opposed to waiting for a request from the user).	
Inclusion of auxiliary calibration data	SRDP-L0-1.1.2	Auxiliary data such as calibrator fluxes, antenna positions, and known defective equipment shall be automatically considered as part of the calibration and should not require any additional effort on the part of the telescope user.	

Parameter	Req. #	Value	Traceability
Curation and Reproducibility	SRDP-L0-10	The system shall support modern standards of open access to data and reproducible processing.	[SRDP-1.3]
Documentation	SRDP-L0-10.1	Processing performed by CASA and the pipeline shall be described in a publicly accessible, and preferably referenceable location.	[SRDP-L0-10]
Reproducibility	SRDP-L0-10.2	The SRDP shall be structured to provide the means that the observatory has the full history of the processing done in producing a particular product and the means to reproduce the result if necessary.	
Commissioning and Validation	SRDP-L0-11	The system shall support a robust and reliable process for the testing, validation, and delivery of capabilities.	[SRDP-1 (trace)]
Partial Testing	SRDP-L0-11.1	Throughout the SRDP project, the heuristics and operations teams shall be able to test, commission, and validate portions or the entire system prior to release for general use.	
Candidate Testing	SRDP-L0-11.2	SRDP workflows shall be executable with candidate versions of the software. The products generated by this software shall not be exposed as SRDP products in the standard data discovery interfaces.	
Partial Execution	SRDP-L0-11.3	It shall be possible to execute portions of the SRDP workflows to optimize testing.	
Retention of execution state	SRDP-L0-11.4	It shall be possible to modify the system without losing the current execution state, or in such a way that the state information can be recaptured.	
Modification of execution environment	SRDP-L0-11.5	The execution environment may need to be modified, for example using a non-standard destination directory to accumulate outputs from a regression testing run.	
Interfaces	SRDP-L0-12		
Weblog Interface	SRDP-L0-12.1	The Weblog interface shall be refined and augmented by the SRDP project to provide utility and usability.	

Parameter	Req. #	Value	Traceability
Archive Interface.	SRDP-L0-12.2	SRDP shall provide an archive interface to serve as a user's primary means of finding, creating and accessing science-ready products. The archive interface shall provide data and product discovery capabilities, product inspection facilities, and an interface through which custom products may be requested.	
Helpdesk Interface	SRDP-L0-12.3	The Helpdesk shall be updated to allow for automatic updating and simplification of SRDP workflows.	
Operations Interface	SRDP-L0-12.4	Operations interfaces shall be used by operations staff to monitor and control the flow of SRDP generation throughout the product lifecycle.	
Proposal Submission and Observation Planning.	SRDP-L0-12.5	SRDP shall provide requirements for the PST and OT interfaces, which shall capture the scientific intent of the user, ensuring the intent is preserved in all downstream processing so that correct products are generated.	
Proprietary Data	SRDP-L0-13	The SRDP system shall respect all observatory policies regarding proprietary data.	
Proprietary Period	SRDP-L0-13.1	The proprietary period for products generated by SRDP shall be tied to the underlying data products.	
Quality Assurance	SRDP-L0-14	The SRDP Project shall determine the [scientific quality] limits of the product and ensure that unwanted artifacts are not present. In cases where the user is working directly with the operations staff on a particular product, the user shall be involved in the QA process to determine if the product is suitable for their needs.	
Archive Contents Policy	SRDP-L0-15	Products generated through the SRDP processes shall have undergone a standard process and shall be designated with a QA approval, as appropriate.	
Archive Contents Policy - Large Projects	SRDP-L0-15.1	The QA approval flag shall cite the project as the authority for the quality assurance.	

Parameter	Req. #	Value	Traceability
Archive Contents Policy - Large projects	SRDP-L0-15.2	Large projects going through the NRAO submission process shall submit a data management plan as part of the observing proposal.	
Archive Contents Policy - Ingestion of user generated products	SRDP-L0-15.3	User generated products shall only be ingested into the archive if compliant with provisions in the large projects use case.	
Computing Resource Management	SRDP-L0-16	The SRDP system shall support the appropriate and equitable use of computing resources.	
Cyber Security	SRDP-L0-16.1	The SRDP system shall conform to all applicable NRAO information and cyber security standards.	
Remote Processing	SRDP-L0-16.2	The SRDP system shall provide means to utilize resources external to the NRAO local environment.	
User authentication	SRDP-L0-16.3	For any usage of the SRDP system, the user shall have a valid NRAO account, and to be properly authenticated through the myNRAO portal. The only exception to this is support for anonymous download of existing products from the archive.	
Usage patterns and quotas	SRDP-L0-16.4	The SRDP systems shall develop metrics to provide an accurate picture of usage patterns, with a provision to enforce storage quota and other processing constraints.	
Standard Imaging	SRDP-L0-2	The system shall produce and populate the archive with quality assured images suitable for scientific research.	[SRDP-1.3, SRDP-1.2, TTA-1]
Homogeneous image set	SRDP-L0-2.1	Objective is a homogeneous set of images in the archive to support telescope and archive users.	
VLA Standard Imaging	SRDP-L0-2.2	Interferometric imaging of VLA data shall be supported by the Imaging pipeline.	[SRDP-L0-2]
Calibration Validation	SRDP-L0-2.3	Standard imaging products shall provide a quick check of the calibration quality and default image.	[SRDP-L0-2]

Parameter	Req. #	Value	Traceability
Resource Constraints	SRDP-L0-2.4	The definition of standard image products shall balance the requirements of the telescope use, the desire for a rich and homogenous archive, and resource constraints both in the generation and storage of products.	[SRDP-L0-2]
PI Driven Imaging	SRDP-L0-3	The system shall support targeted generation of science quality assured images as requested by a science user. Images will be quality assured (in conjunction with the user) and delivered to both requester and archive.	[SRDP-1.3, SRDP-1.1, SRDP-1.2]
Use of Custom Calibration	SRDP-L0-3.1	The workflow shall allow for optimized imaging to use a custom calibration created through the recalibration workflow, where the associated image product shall be ingested only if a validated calibration is in the archive.	
Archive Use	SRDP-L0-4	Science ready data products shall be supported in the NRAO archive.	
Data Discovery	SRDP-L0-4.1	The archive shall support the discovery of science products that are of scientific interest to the user.	[SRDP-L0-3]
Dedicated Search for Large Projects	SRDP-L0-4.1.1	The archive interface shall provide a dedicated search interface that allows searching on the project meta-data as well as on the standard meta-data. This service may also be used by the project to describe the data, link to relevant publications, or otherwise provide branding and context for the results.	[SRDP-L0-9]
Data Product Visualization	SRDP-L0-4.2	The interface shall allow the user to explore data without needing to download large quantities of data.	[SRDP-L0-8]
No Scientific Analysis Required	SRDP-L0-4.2.1	Scientific analysis through this interface may be considered depending on user feedback, but is not currently a requirement.	
Data Selection	SRDP-L0-4.3	The archive shall allow the selection of one or more sets of products.	[SRDP-L0-6]
List creation	SRDP-L0-4.3.1	Authenticated users shall be able to produce lists of products that are persisted across sessions.	
Archive Annotations	SRDP-L0-4.3.2	It shall be possible to generate annotation or tags in the archive.	

Parameter	Req. #	Value	Traceability
Appropriate Data Presented	SRDP-L0-4.3.3	The Archive interface shall clearly identify data sets for which the necessary prerequisite products are available.	[SRDP-L0-3]
Combined Imaging	SRDP-L0-4.3.4	The archive user shall be able to specify the creation of combined images from data sets in the archive.	[SRDP-L0-7.3]
Data Processing	SRDP-L0-4.4	The system shall allow the creation of data processing jobs through the archive interface.	
Triggering of recalibration use case.	SRDP-L0-4.4.1	Generation of calibration for data sets lacking prior calibration shall be easily requested through Archive Interface and trigger the recalibration use case.	
Job Cancellation	SRDP-L0-4.4.2	If the user determines that a suitable product cannot be produced, this shall be noted in the helpdesk ticket and the request canceled, removing it from the list of pending projects	[SRDP-L0-3]
Data Delivery	SRDP-L0-4.5	The system shall provide methods for easy download of one or more products from the archive.	
Image Subsets	SRDP-L0-4.5.1	Delivery of subsets, of images shall be supported.	[SRDP-L0-8]
Product Curation	SRDP-L0-4.6	The archive shall support curation of data products.	
Erroneous calibrations	SRDP-L0-4.6.1	Erroneous archival calibrations shall be identified as no longer valid to prevent inadvertent use.	[SRDP-L0-6.1]
Data Object Locators	SRDP-L0-4.6.2	Individual data products, and the processing history, shall have permanent data locators to allow citation in publications.	[SRDP-L0-10]
Serve Large Project Data	SRDP-L0-4.6.3	SRDP shall host reasonable volumes of data products for large projects. The large project shall deliver a set of data products with at least meta-data conforming to a standard set defined by the SRDP project.	
Restoration	SRDP-L0-5	The system shall be able to return previously calibrated and flagged data sets to the state at the end of the calibration pipeline.	[SRDP-1.1, SRDP-1.2]
Measurement Set Only	SRDP-L0-5.1	The system shall allow users to download uncalibrated measurement sets.	

Parameter	Req. #	Value	Traceability
Flags Only	SRDP-L0-5.2	The system shall allow the user to select to only apply flags (no calibration) to a measurement set.	
Recalibration	SRDP-L0-6	The system shall support the recalibration of data sets.	[SRDP-1.1]
Batch Recalibration	SRDP-L0-6.1	Staff members shall be able to identify datasets affected by pipeline errors for batch recalibration with an updated pipeline when a problem is identified.	
Combined Imaging	SRDP-L0-7	The system shall support generation of images from multiple configurations of a telescope.	[SRDP-1.2, SRDP-1.1]
ALMA Total Power	SRDP-L0-7.1	Combination of ALMA 12-m, 7-m, and total power data shall be supported.	
Proposal Based Combined Imaging	SRDP-L0-7.2	A telescope user shall be able to specify products requiring combined imaging	
Archival Combined Imaging	SRDP-L0-7.3	Generation of images from multiple archival data sets shall be supported.	
Time Critical Observations	SRDP-L0-8	The system shall provide accelerated access to projects designated as time critical.	[SRDP-1.1]
Time Critical Products	SRDP-L0-8.1	The standard calibration and imaging use cases shall be invoked for time critical projects as well. Both the clearly identified rapid reduction, and the later improved reduction shall be archived.	[SRDP-L0-8]
Large Projects	SRDP-L0-9	Ingest and curation of products created by large projects shall be supported.	[SRDP-1.3]
Special Data Structures	SRDP-L0-9.1	The SRDP Operations group shall evaluate each approved Large Project to capture and support specialized structures needed within the archive to make provenance of the eventual products more traceable.	
Commensal Projects	SRDP-L0-9.2	Commensal projects shall identify the products and the release process as part of the negotiations with NRAO as the project is initiated.	

20.3 Level 1

Parameter	Req. #	Value	Traceability
Pipeline	SRDP-L1-1	The standard CASA pipeline will be used for processing.	[SRDP-L0-1, SRDP-L0-5]
Create Measurement Set	SRDP-L1-1.1	The pipeline shall operate on Measurement Sets.	[SRDP-L0-5.1]
Apply Calibration Tables	SRDP-L1-1.3	The pipeline shall apply calibration tables based on the instruction stored with the calibration results.	[SRDP-L0-5]
Restore Flagging State	SRDP-L1-1.4	The pipeline shall restore the flagging state.	[SRDP-L0-5.2]
VLA Calibration Pipeline	SRDP-L1-1.5	The standard pipeline shall support calibration of VLA interferometric data.	[SRDP-L0-1.1, SRDP-L0-6]
Calibrations shall represent observatory recommended best practices at the time of execution (and thus will evolve over time).	SRDP-L1-1.5.1		[SRDP-L0-1]
Congruency with user calibrations	SRDP-L1-1.5.2	SRDP Calibrations shall be congruent to calibrations which could be performed by an individual user.	[SRDP-L0-1]
Weblog	SRDP-L1-1.6		[SRDP-L0-1]
Hierarchal Display of Calibration	SRDP-L1-1.6.1	The calibration record shall be hierarchical in nature to support both summary and detailed views in order to support a wide range of expertise in the user community.	[SRDP-L0-1]
Data Driven Documents	SRDP-L1-1.6.2	To facilitate remote exploration of data within the archive interface, the calibration record shall make use of "Data Driven Documents" or other similar visualization technology where possible.	[SRDP-L0-1]
Display of Physical Quantities	SRDP-L1-1.6.3	Where possible, physical quantities shall be displayed in the Weblog as well as the normalized scores.	[SRDP-L0-1]
Combined Imaging	SRDP-L1-1.6.4	Diagnostic plots for Combined Imaging shall be included in the weblog.	[SRDP-L0-7.2]

Parameter	Req. #	Value	Traceability
Imaging Pipeline	SRDP-L1-1.7	The pipeline shall support generation of images.	[SRDP-L0-3, SRDP-L0-2, SRDP-L0-2.3]
Imaging of Multiple Execution Blocks	SRDP-L1-1.7.1	Combined imaging of multiple executions of the same scheduling block in the same configuration shall be supported by the imaging pipeline when requested.	[SRDP-L0-2, SRDP-L0-2.1]
Option to omit execution blocks	SRDP-L1-1.7.1.1	When combined imaging of multiple executions is requested the SRDP project shall provide the capability to omit the imaging of the individual executions.	
VLA Standard Image Products	SRDP-L1-1.7.2	The standard imaging pipeline shall produce commonly used types of images.	[SRDP-L0-2.2, SRDP-L0-2.4]
Stokes I Continuum	SRDP-L1-1.7.2.1	A full bandwidth Stokes I continuum image shall be produced per receiver band, combining multiple pointings in a mosaic, when specified by the project.	
Spectral index Maps	SRDP-L1-1.7.2.2	For fractional bandwidths greater than a threshold value, spectral index maps shall be generated.	
Spectral Cubes	SRDP-L1-1.7.2.3	For spectral imaging projects, cubes shall be generated and archived at the spectral resolution specified by the telescope user, provided that the products do not exceed reasonable limits on size and computation resources.	
Combined Imaging	SRDP-L1-1.7.3	The pipeline shall support generation of images from multiple configurations of a telescope.	[SRDP-L0-7]
Individual Epoch Images	SRDP-L1-1.7.3.1	As each configuration is completed the data shall be calibrated and imaged independently using the resolution and pixel size most appropriate for the configuration, but with phase-center, field of view, and spectral axis of the common objective.	
Image Specification	SRDP-L1-1.7.3.2	The combined Image shall use the same spatial and spectral axes as for the individual configurations.	[SRDP-L0-7.2]
Normalization Calibration	SRDP-L1-1.7.3.3	The Combined Imaging process shall allow the PI to specify an additional recalibration step to normalize flux scales, correct weighting issues, or otherwise normalize the data.	[SRDP-L0-7.2]

Parameter	Req. #	Value	Traceability
Total Power Combination	SRDP-L1-1.7.4	For standard products, the Combined Imaging process shall incorporate current best practices for combining ALMA interferometric and total power data shall be used (currently feather).	[SRDP-L0-7.2]
Total Power Options	SRDP-L1-1.7.4.1	Multiple options may be presented for PI driven imaging cases.	[SRDP-L0-7.3]
Quick Imaging Pipeline	SRDP-L1-1.7.5	For time critical processing the option for a lightly cleaned image, shall be supported. Quick-look images are optimized for speed rather than maximum quality.	[SRDP-L0-8]
Latency	SRDP-L1-1.7.6	The goal shall be to make standard SRDP images available to the telescope user within 30 days of the required data being acquired at the telescope.	[SRDP-L0-2]
Pipeline Intervention	SRDP-L1-10	Processes to simplify improved products when required, both for the PI and the Observatory shall be in place, as well as a mechanism for designating the resulting products as the primary results for the observation.	[SRDP-L0-1, SRDP-L0-6]
Reuse of flags from previous calibrations	SRDP-L1-10.1	Any flags applied shall be captured in such a manner that the flags can be re-used by subsequent recalibrations (see section 3.6).	[SRDP-L0-1]
Reuse of manual interventions	SRDP-L1-10.2	The system shall maximize the utility of interventions in recalibration by facilitating the reuse of manually generated information.	[SRDP-L0-1]
Metrics	SRDP-L1-11		[SRDP-L0-1]
Calibration Latency	SRDP-L1-11.1	The latency between the completion of the observation and the delivery of products shall be measured.	[SRDP-L0-1]
Calibration Failures	SRDP-L1-11.2	Categories for failure shall be identified and metrics derived in order to allow the Observatory to address common failure modes.	[SRDP-L0-1]
Download Metrics	SRDP-L1-11.3	It should be possible to track downloads from the archive by project, download date, email, IP of downloader, and download size.	

Parameter	Req. #	Value	Traceability
Proprietary Download Metrics	SRDP-L1-11.4	It must be possible to know who has downloaded files from what projects and how many times, in cases where a proprietary project is accidentally public or the wrong user was authorized.	
Calibration Failure Metrics	SRDP-L1-11.5	Metrics must be kept regarding the fraction of observations that a) skip the SRDP pipeline, b) successfully pass through the pipeline, and c) fail in the pipeline.	
Product Specification	SRDP-L1-12		[SRDP-L0-6]
Image Product Specification	SRDP-L1-12.1	The archive interface shall allow the user to specify the desired scientific properties of an image to be created (field of view, spectral extent, spectral and spatial resolution, and polarization). Reasonable defaults shall be presented to the user and invalid options hidden.	[SRDP-L0-3]
Image Pipeline Parameter Specification	SRDP-L1-12.2	Imaging pipeline parameters shall be optionally specified through the product specification interface.	[SRDP-L0-3]
Parameter types	SRDP-L1-12.2.1	Parameters shall be scientific in nature and not tied to a specific implementation of the imaging process	[SRDP-L0-3]
Product Specification Validation	SRDP-L1-12.3	Requests for products shall be automatically validated by the system.	[SRDP-L0-3, SRDP-L0-6]
Data Availability	SRDP-L1-12.3.1	Validation shall include a check that the data is available.	[SRDP-L0-3, SRDP-L0-6]
Well-formed request	SRDP-L1-12.3.2	Validation shall include a check that the request is well formed.	[SRDP-L0-6, SRDP-L0-3]
Data Access Permission	SRDP-L1-12.3.3	Validation shall check that the user has permission to access the data.	[SRDP-L0-3, SRDP-L0-6]

Parameter	Req. #	Value	Traceability
Unique Image Product	SRDP-L1-12.3.4	The workflow management system shall initiate a check for identical reductions to ensure that duplicate images are not produced. If for any reason the request is deemed invalid, the reason shall be displayed clearly through the interface and the user shall be provided the opportunity to either modify the request or automatically transfer the issue to the associated helpdesk ticket.	[SRDP-L0-3]
Unique Calibration Product	SRDP-L1-12.3.5	If no optional parameters for recalibration specified, a check shall be performed to determine if a valid calibration is already available in the archive. If so, jump to the restore use case instead.	[SRDP-L0-6]
Validation Failure	SRDP-L1-12.4	If for any reason the product request is deemed invalid, the reason shall be specified on the associated helpdesk ticket, helpdesk ticket marked for manual follow-up, and the process should wait for manual resolution by operations staff.	[SRDP-L0-3, SRDP-L0-6]
Recalibration Product Specification	SRDP-L1-12.5	The user shall be able to modify the calibration process as part of the product specification.	[SRDP-L0-6, SRDP-L0-4.4.1]
Pipeline Version	SRDP-L1-12.5.1	The pipeline version (including CASA versions if applicable) to be used.	[SRDP-L0-6]
Calibration Products	SRDP-L1-12.5.2	The desired calibrated products (i.e. calibration tables, calibrated measurement set, flagging information)	[SRDP-L0-6]
Optional: Flagging specification	SRDP-L1-12.5.3	The user may specify additional flagging information to be applied prior to calibration.	[SRDP-L0-6]
Optional: Calibration strategy	SRDP-L1-12.5.4	Alternative calibration strategies may be supplied by the user.	[SRDP-L0-6]
Optional: Pipeline Parameters	SRDP-L1-12.5.5	The user may specify different pipeline parameters than the defaults.	[SRDP-L0-6]
Manual Product Specification Review	SRDP-L1-12.6	If the requested product is large (either in number of data sets to be processed, or implied processing time), the request shall be flagged for manual review by the SRDP operations staff.	[SRDP-L0-6]

Parameter	Req. #	Value	Traceability
Reproduction of specification	SRDP-L1-12.7	The interface shall provide a mechanism for the user to easily reproduce the same specification at a later date.	[SRDP-L0-6]
Download of processing script	SRDP-L1-12.8	The system shall allow SRDP staff to download equivalent scripts for test purposes.	[SRDP-L0-11.1]
Combined Image Specification	SRDP-L1-12.9	The system shall support specification of additional information for combined images.	[SRDP-L0-7.3]
Parameter Validation	SRDP-L1-12.9.1	Parameters selected for Combined Imaging shall be suitable for all data sets, and should be validated both for applicability and to ensure that the implied requested re-gridding is within tolerance. For example, the channel width shall not be smaller than that of the coarsest spectral resolution data.	
Axis Specification	SRDP-L1-12.9.2	For PI driven combined imaging the spatial and spectral co-ordinates of the product cannot be deduced from the parent project and shall be explicitly set by the user.	
Stage Data for Further Processing	SRDP-L1-13	The restore use case can be used to prepare data for further processing (such as the PI driven imaging use case).	[SRDP-L0-5, SRDP-L0-6]
Use of recalibrated data	SRDP-L1-13.1	The calibration product from the recalibration process shall be made available to the user that created it as the basis for a subsequent imaging or other processing step.	[SRDP-L0-6, SRDP-L0-3.1]
Use of custom calibration	SRDP-L1-13.2	The system shall support the execution of jobs utilizing non-standard calibrations.	[SRDP-L0-3.1]
Documentation	SRDP-L1-14		
CASA Publication	SRDP-L1-14.1	Produce a refereed article describing the CASA package in an appropriate scientific journal.	[SRDP-L0-10.1]
Pipeline Publication	SRDP-L1-14.2	Produce a refereed article describing the CASA Pipeline in an appropriate scientific journal.	[SRDP-L0-10.1]
Product Curation	SRDP-L1-15		[SRDP-L0-4.6.2]

Parameter	Req. #	Value	Traceability
DOI Conformance	SRDP-L1-15.1	Standards for the use of Digital Object Identifiers (DOIs) as persistent identifiers for astronomical data sets are still being developed in the community, and the SRDP project shall conform to best practices as they emerge.	[SRDP-L0-10]
Verification Testing	SRDP-L1-16	The system shall be verified prior to each delivery to the project.	[SRDP-L0-11]
Written test plan	SRDP-L1-16.1	The primary method of verifying the testability of the system shall be the development of a written test plan as part of the development of each L1 functional requirement.	[SRDP-L0-11]
Test Environment	SRDP-L1-16.2	A separate test environment shall be supported.	[SRDP-L0-11.2]
Product Archive	SRDP-L1-18		[SRDP-L0-4]
Collections	SRDP-L1-18.1	Meta-data specific to the large project, as agreed with the user (but in addition to the standard set defined for SRDP) shall also be stored in the archive.	[SRDP-L0-9.1, SRDP-L0-4.1.1]
Universal Metadata	SRDP-L1-18.1.1	Any Specialized Structures created to support Large Projects shall incorporate additional layers or views on the existing project structures to ensure that data remains discoverable through the non-specialized archive interfaces as well.	[SRDP-L0-9.1, SRDP-L0-4.1.1]
Product Archive Interface	SRDP-L1-18.2	The archive interface shall present an interested user a dynamic form with fields that may be used to search and filter contents of the archive.	[SRDP-L0-4.1]
Tabular View	SRDP-L1-18.2.1	Data Discovery Archive search results shall be returned in a table with an initial view of default fields.	[SRDP-L0-4.1]
Customizable Columns	SRDP-L1-18.2.1.1	The fields of the tabular view shall be user configurable and for logged in users that shall persist across searches.	[SRDP-L0-4.1]
Sorting of Tabular View	SRDP-L1-18.2.1.2	The tabular interface shall support sorting of results one each column.	[SRDP-L0-4.1]
Scriptable Interface	SRDP-L1-18.2.2	The archive interface shall provide a scriptable interface to registered users.	[SRDP-L0-4.1]
Results Export	SRDP-L1-18.2.2.1	Search results from the scriptable interface shall be exportable to a CSV file or other file format.	[SRDP-L0-4.1]

Parameter	Req. #	Value	Traceability
Display of Processing Options	SRDP-L1-18.2.3	For each selected data product, the set of relevant processing options shall be presented.	[SRDP-L0-4.4, SRDP-L0-4.3.3, SRDP-L0-4.3.4]
Data product context and visualization.	SRDP-L1-18.3	The archive shall support exploration, visualization, and context for data products prior to download.	[SRDP-L0-4.2]
Image Thumbnails	SRDP-L1-18.3.1	The archive interface shall display image thumbnails in context with other catalogs and survey results.	
Product provenance	SRDP-L1-18.3.2	The archive interface shall display provenance of the data product including links to the original data, other versions of the product as well as information on how the products were created (processing job information, pipeline version, weblogs, etc.)	[SRDP-L0-4.2]
Publications and related materials	SRDP-L1-18.3.3	The archive interface shall display related publications, abstract for the project, etc.	[SRDP-L0-4.2]
Online data exploration	SRDP-L1-18.3.4	The archive interface shall provide online exploration of the data through a web enabled viewer (Such as CARTA or Aladin Lite).	[SRDP-L0-4.2]
User Specified Lists	SRDP-L1-18.4	The archive interface shall allow registered users to create a personal list of products that they want to investigate.	[SRDP-L0-4.3.1]
List Persistence	SRDP-L1-18.4.1	These lists shall be persisted across login sessions and multiple lists shall be supported.	[SRDP-L0-4.3.1]
Manner of Persistence	SRDP-L1-18.4.2	Persistence shall either be specified at the level of the query (in which case the result may change each time the query is executed) or at the level of the results (in which case the result is fixed).	[SRDP-L0-4.3.1]
List Objects	SRDP-L1-18.4.3	Lists of products generated within the archive shall be references to permanent objects already stored in the archive, and shall not point to temporary objects on disk.	[SRDP-L0-4.3.1]
Product Annotation	SRDP-L1-18.5	The archive shall support annotation and tags assignments on data products.	[SRDP-L0-4.3.2]
Scope of Annotations	SRDP-L1-18.5.1	Annotation and tags shall be free form, and only visible to the user that creates them.	[SRDP-L0-4.3.2]

Parameter	Req. #	Value	Traceability
Product Manipulation	SRDP-L1-18.6	The archive shall provide a class of lightweight product manipulation tasks.	[SRDP-L0-4.4]
Cutout Capability	SRDP-L1-18.6.1	The generating of a spatial or spectral "cutout" from a product shall be supported.	[SRDP-L0-4.4]
Moment Generation	SRDP-L1-18.6.2	Generation of a moment image, to be created "on the fly" as part of the data delivery process shall be supported.	[SRDP-L0-4.4]
Retrieve Raw Data from Archive	SRDP-L1-2	Raw Data shall be automatically staged from the Archive.	[SRDP-L0-5, SRDP-L0-6]
Helpdesk	SRDP-L1-4	The system shall use a helpdesk system to interact with Archive and Telescope users.	[SRDP-L0-1, SRDP-L0-6]
Create Helpdesk Ticket	SRDP-L1-4.1	If an error occurs during the restoration case processing, a helpdesk ticket with the relevant information shall be generated for staff troubleshooting and follow-up.	[SRDP-L0-5]
Ticket applies to top level process	SRDP-L1-4.2	When errors occur in processing a helpdesk ticket shall be created for the top level process.	[SRDP-L0-5]
PI Feedback on Products	SRDP-L1-4.3	The helpdesk interface shall allow the PI to provide feedback on the calibration for a particular observation and request an improved calibration be performed.	[SRDP-L0-1]
Archive User Feedback on Products	SRDP-L1-4.4		[SRDP-L0-3, SRDP-L0-6]
No ticket for observatory operations	SRDP-L1-4.5	Product generation processes initiated by the observatory shall not generate helpdesk tickets.	[SRDP-L0-6]
Deliver Data	SRDP-L1-5	Restored data shall be delivered to the requester through the standard data delivery process.	[SRDP-L0-5, SRDP-L0-1, SRDP-L0-6]
Access to products	SRDP-L1-5.1	The user shall be able to access the product, weblog, and quality assessment results through the archive interface.	[SRDP-L0-1, SRDP-L0-3]
User Notification	SRDP-L1-5.2	When the requested product has passed quality assurance, the user shall be notified via helpdesk.	[SRDP-L0-3]

Parameter	Req. #	Value	Traceability
User assessment of product	SRDP-L1-5.3	If the user is not satisfied with the product (for whatever reason), they shall have the ability to return to their request or helpdesk ticket through a provided link, modify as necessary and resubmit. A simple mechanism shall be provided to request more assistance through a linked helpdesk ticket mechanism.	[SRDP-L0-3, SRDP-L0-6]
Limitation of Observatory Commitment	SRDP-L1-5.3.1	Strategies shall be provided to limit, or curtail the use of observatory facilities as an open-ended resource commitment for the observatory, both in computing and staffing resources.	[SRDP-L0-3]
Download of Multiple Products	SRDP-L1-5.4	The user shall be able to download multiple products bound together through a "shopping cart" or similar mechanism.	[SRDP-L0-4.5]
Delivery Mechanism	SRDP-L1-5.5	Multiple mechanisms shall be made available for delivery of archive data products.	[SRDP-L0-4.5]
Download from URL	SRDP-L1-5.5.1	Download via a password protected URL that can be directly accessed.	
Download Script	SRDP-L1-5.5.1.1	A download script (similar to ALMA's) shall be provided.	
Download Manager	SRDP-L1-5.5.2	A download manager capable of starting, pausing, and resuming download.	
Media Shipping	SRDP-L1-5.5.3	Delivery via media shipping	
Automatic Staging	SRDP-L1-5.5.4	Automated staging of data to the users work area either in Socorro or Charlottesville.	
Product Integrity	SRDP-L1-5.6	The data product delivery process shall provide mechanisms to ensure that data corruption through the delivery process is detected.	
Proprietary Data	SRDP-L1-5.7	The system shall authenticate the user and verify authorization to access data prior to data download.	[SRDP-L0-13]
Workspace System	SRDP-L1-6		[SRDP-L0-1, SRDP-L0-2, SRDP-L0-3, SRDP-L0-4, SRDP-L0-5, SRDP-L0-6, SRDP-L0-7, SRDP-L0-8]

Parameter	Req. #	Value	Traceability
Manual Intervention	SRDP-L1-6.1	When manual intervention for recalibration is required, the process shall be executed by the operations staff. The staff member shall work with the user to identify and resolve the issue and then resubmits the job for the user. At this point the process will re-enter the standard workflow.	[SRDP-L0-6]
Automatic Initiation of Standard Calibration	SRDP-L1-6.10	The workflow system shall automatically start the execution of standard calibration jobs.	[SRDP-L0-1.1.1]
Inhibit Calibration Jobs	SRDP-L1-6.10.1	It shall be possible for a user to inhibit the automatic creation of calibration jobs. For instance, after a move, prior to new antenna positions being available.	[SRDP-L0-1.1.2]
Job Cancellation	SRDP-L1-6.11	The user shall be able to cancel jobs and remove all associated helpdesk tickets.	[SRDP-L0-4.4.2]
Time Estimate	SRDP-L1-6.12	The user shall be provided an estimate of the total latency in product creation.	
Workspace Interfaces	SRDP-L1-6.13	The workspace system shall provide interfaces to allow review and control of the activities in the workspace.	
User Interface	SRDP-L1-6.13.1	An interface that allows users to interact with their active and historical processing requests shall be provided.	[SRDP-L0-12.2]
Operations Interface	SRDP-L1-6.13.2	An interface providing internal overview and control of all existing workspace activities and their state for use by internal operational staff.	[SRDP-L0-12.4]
Authentication and Authorization	SRDP-L1-6.14	The system shall authenticate the user and verify authorization prior to creation of a workspace request.	[SRDP-L0-13]
Support for HT-Condor and Open Science Grid	SRDP-L1-6.15	The workspace system shall support the optional submission of jobs to open science grid through the high throughput condor system.	[SRDP-L0-16.2]
Job Completion	SRDP-L1-6.16	A request is not complete until the user is satisfied with the result of the processing.	[SRDP-L0-1.1.1]
Multiple Attempts	SRDP-L1-6.16.1	Multiple revisions of the parameters are permitted and must be kept with the request.	

Parameter	Req. #	Value	Traceability
Transient Failures	SRDP-L1-6.16.2	If a job fails for some transient reason, it should be possible to re-execute it without losing information about the failed execution	
Product Request Status	SRDP-L1-6.2	The archive interface shall provide status information for the user on each job, links to completed jobs, as well as the weblog for the job.	[SRDP-L0-6]
Batch Job Management	SRDP-L1-6.3	Batch submission of jobs shall be throttled to prevent overwhelming processing resources.	[SRDP-L0-6.1]
Standard Imaging Job Initiation	SRDP-L1-6.4	The standard imaging process shall automatically be triggered for observations supported by SRDP once the standard calibration has passed quality assurance.	[SRDP-L0-2]
Automatic Trigger of Combined Imaging	SRDP-L1-6.5	When the single epoch calibration and imaging for all configurations are complete, the data from all configurations shall be imaged jointly.	[SRDP-L0-7.2]
Time Critical Processing	SRDP-L1-6.6	The Time Critical flag shall persist throughout the lifecycle of the project and be made available to the data processing subsystems.	[SRDP-L0-8]
Priority Processing	SRDP-L1-6.6.1	Processing of time critical proposals shall begin as soon as data is available.	[SRDP-L0-8]
Immediate Notification	SRDP-L1-6.6.2	The workflow manager shall notify the PI immediately when calibration or imaging products are available, with specific notice that the products have not been quality assured.	[SRDP-L0-8.1]
Processing Error	SRDP-L1-6.6.3	In cases of reduction failure, a high priority notification to operations shall be made so that appropriate manual mitigation can be done. Note that this may occur outside of normal business hours.	[SRDP-L0-8]
Custom Workflows	SRDP-L1-6.7	Large Project processing shall allow use of custom or modified pipelines to process the data and the project team shall be directly involved in the quality assurance process.	[SRDP-L0-9]
Computing Resources	SRDP-L1-6.7.1	The SRDP system shall allow use of NRAO computing resources for the processing of the large project data provided that required computing resources does not exceed the available resources (including prior commitments).	

Parameter	Req. #	Value	Traceability
Job Specification Review	SRDP-L1-6.8	Once a job is created on archived data, the archive interface shall provide the user an option to modify the input parameters and review the job prior to submission to the processing queue.	[SRDP-L0-4.4]
Resource Recovery	SRDP-L1-6.9	Results from reprocessing archive data are temporary and the automated system shall have the ability to automatically enforce the data retention policy.	[SRDP-L0-4.4]
Warning prior to removal	SRDP-L1-6.9.1	Warnings shall be issued to the user 10 and three days prior to data removal.	
Product Ingestion	SRDP-L1-7	Once produced products should be ingested to the archive and their meta-data cataloged.	[SRDP-L0-1, SRDP-L0-6]
Product Integrity	SRDP-L1-7.1	To ensure the integrity of the product a checksum or other mechanism shall be used to ensure that the archived product matches the one produced by the processing both on ingest and on export	[SRDP-L0-4.6]
Image Products	SRDP-L1-7.2		[SRDP-L0-3]
Minting of DOI	SRDP-L1-7.3	The user shall have the option to create a DOI at the time of Archive Ingestion.	[SRDP-L0-3]
Derived Products	SRDP-L1-7.4	Images or other products derived from calibrated measurement sets shall only be ingested if the calibration products used to produce them are ingested.	[SRDP-L0-6]
Calibration Products	SRDP-L1-7.5	Once a science-quality calibration has been generated for a particular observation, the calibration products, flagging information, and logs shall be ingested to the archive.	[SRDP-L0-1, SRDP-L0-6]
Provenance Information	SRDP-L1-7.6	The archive shall store sufficient meta-data to provide provenance for the calibrated products, and to promote identification of suspect products based on defects found at later times.	[SRDP-L0-1]
Recalibration Ingestion	SRDP-L1-7.7	Results from recalibration shall only be placed in the archive and made available to other users if only default parameters were specified, or if additional flags were specified to correct an issue not found during initial quality assurance.	[SRDP-L0-6]

Parameter	Req. #	Value	Traceability
User Acceptance of Products	SRDP-L1-7.8	When the archive user is satisfied with the product a "validation button" shall be provided to trigger the ingest of the products to the archive and the request closed.	[SRDP-L0-3]
Quality Assurance	SRDP-L1-8	Every product shall be assessed for quality, and those products for which the initial calibration are not judged to be of science quality should be identified for further intervention.	[SRDP-L0-1, SRDP-L0-6, SRDP-L0-14]
Quality Metrics	SRDP-L1-8.1	Quality metrics shall be clearly identified and scores derived to simplify comprehension.	[SRDP-L0-1]
Staff Designation	SRDP-L1-8.10	Ops staff will be designated for performing QA on standard calibration and imaging processes, and will be able to reassign to other ops staff.	[SRDP-L0-14]
Large Project Staff Designation	SRDP-L1-8.10.1	Large projects shall be able to designate their own users to perform QA on their processes.	[SRDP-L0-4.6.3]
QA Authority Tracking	SRDP-L1-8.2	The archive shall record and present the group or project that performed QA on each product.	[SRDP-L0-14]
Large Project Authority	SRDP-L1-8.2.1	Large project data in the archive shall be marked as having received QA from the project team.	[SRDP-L0-9, SRDP-L0-4.6.3]
Image Quality Assurance	SRDP-L1-8.3	All image products should be quality assured prior to ingestion to the archive.	[SRDP-L0-2]
Flux Scale	SRDP-L1-8.3.1	Standard image products shall have a well understood flux scale.	
Calibration Quality Assurance	SRDP-L1-8.4		[SRDP-L0-14]
Archive User Specified Products	SRDP-L1-8.5	Quality assurance processes for user specified images shall maintain the same minimum level of quality as the standard automated products. Any issues with the quality of the product images shall be corrected by the operations staff member, in communications with the requesting user as necessary.	[SRDP-L0-3]
User Quality Inspection	SRDP-L1-8.5.1	User review of the products shall be accommodated either through download of the data products or a temporary staging to the NRAO cluster.	[SRDP-L0-4.4, SRDP-L0-14]

Parameter	Req. #	Value	Traceability
Some Jobs Require QA	SRDP-L1-8.6	Workspaces shall permit some categories of processing to be designated as requiring QA.	[SRDP-L0-14]
Human inspection for QA	SRDP-L1-8.7	Processing requests that require QA shall have to undergo a human inspection prior to being delivered to the requester or ingested into the archive.	[SRDP-L0-14]
QA Interface	SRDP-L1-8.8	There will be a QA interface that will show requests requiring QA and allow designated users to pass/fail requests.	[SRDP-L0-14]
Parameter Revision	SRDP-L1-8.8.1	The QA interface will allow permitted users to revise the parameters of a request and submit new processing.	[SRDP-L0-14]
Deliver Only Passing	SRDP-L1-8.8.2	Only the final QA-passed results will be delivered to the requesting user or ingested into the system.	[SRDP-L0-14]
Facilitate Communication	SRDP-L1-8.9	The QA interface will facilitate communication between the user performing QA and the user who submitted the processing request.	[SRDP-L0-12.3]
SRDP Compliance	SRDP-L1-9	The SRDP shall provide standard science-quality calibration only for observations that conform to SRDP standards.	[SRDP-L0-1]
Compliant VLA Calibration	SRDP-L1-9.1	Compliant projects for the Pilot are: A and B ranked continuum projects at K band and above.	[SRDP-L0-1]