Title: SRDP System Engineering Mgmt. Plan	***Authors***: Treacy, Kern	6/29/2018
Document No. 530-SRDP-010-MGMT		***Revision***: 1.01

Science Ready Data Products

System Engineering Management Plan

Project 530

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Change Record

VERSION	DATE	REASON
1.0	4/16/2016	Released on content in draft Ver .07, 3/23/2018 Approved as part of document set defined in 530-SRDP-033-MGMT SRDP CoDR Package Approval by SharePoint workflow
1.01	6/29/2018	Edits from CoDR RIDs

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1. Introduction

1.1 Background

The SRDP project (in collaboration with existing observatory management structures) will develop and implement the software tools, scientific heuristics, and operations management structures to deliver science quality data products to the NRAO user community, both as it exists now, and the foreseen expansion of the community to include non-traditional radio astronomers.

High level goals, objectives, and a description of the SRDP project can be found in the Project Charter. A detailed description of the programmatic project elements is addressed in the Project Management Plan (PMP), while the lifecycle phases are described in SRDP Lifecycles Phases and Concepts [RD03]. The SRDP System Concepts Document [RD10] describes the high level goals, use cases, assumptions, constraints, and other drivers for project requirements and operations planning.

1.2 Reference Documents

[RD01] SRDP Project Charter 530-SRDP-001-MGMT
[RD02] SRDP Project Management Plan 530-SRDP-003-MGMT
[RD03] SRDP Lifecycle Phases and Concepts 530-SRDP-009-MGMT
[RD04] SRDP Stakeholder Register 530-SRDP-005-MGMT
[RD05] SRDP Requirements Verification Traceability Matrix (RVTM)
[RD06] SRDP Requirements Committee Terms of Reference 530-SRDP-012-HEUR
[RD07] SRDP Stakeholder Requirements 530-SRDP-015-MGMT
[RD08] 2016 June 6 DMSD Software Development Processes, Ver. 0.3
[RD08] SOP for Project Reviews Process PMD00219
[RD09] Design Reviews Template PMD00155
[RD10] SRDP System Concept 530-SRDP-014-MGMT
[RD11] SRDP Project Lexicon and Acronym List 530-SRDP-028-MGMT
[RD12] SRDP Scope Statement 530-SRDP-032-MGMT

1.3 Scope of this Document

Systems Engineering disciplines within NRAO are captured in Standard Operating Procedures (SOPs) which follow the INCOSE Systems Engineering Handbook process definitions (4th Edition). This Systems Engineering Management Plan (SEMP) describes the execution of systems engineering processes applied throughout the SRDP project lifecycle. INCOSE Processes are defined in four groups: Technical Processes, Technical Management Processes, Agreement Processes, and Organizational Project Enabling Processes. In the interest of due diligence, each of these will be addressed as applicable or not to SRDP. A tailoring process is used in conjunction with the PMD Engagement Model to assess the level at which processes are applied to the project, the extent to which processes shall be documented, and descriptions of how they shall be executed or otherwise satisfied.

- The System Engineering Technical Processes listed in Section 2 are taken directly from the INCOSE Systems Engineering handbook. Each of these shall be addressed in the SEMP.

- The INCOSE Technical Management Processes include project planning, assessment and control, decisions, risk, configuration management, information management, measurement, and quality.

Most of these areas are defined under the Project Management Plan; with the exception of configuration management and information management, which will be addressed within the SEMP.

- Agreement Processes include the Acquisition Process and the Supply Process. Acquisition for SRDP is limited to a few items that are to be under departmental procurements and will be referenced in the Procurement subsidiary of the SRDP Project Management Plan. The INCOSE Supply process defines a formal mechanism for developing and managing an agreement under a customer / vendor relationship. SRDP deliverables are all internal to NRAO and will be managed under acceptance of project documents that define the project baseline and acceptance reviews which validate the deliverables.

- Organizational Project Enabling Processes provide observatory tools and support to ensure projects have the necessary resources for successful and consistent execution. These resources include management processes for lifecycle models, infrastructure, programs and portfolios, human resources, quality, and knowledge bases. The results from projects frequently contribute to the evolution of these organizational resources, continuously improving organizational maturity and capability. SRDP will exploit any knowledge, lessons learned, or process improvements to enhance these organizational assets.

Requirements management is critical to a successful outcome and spans multiple processes. A more detailed description is given in Section 3 Requirements Management and Release Planning. Rolling Wave Planning will be used with planning horizons aligned to DMS subsystem releases for completion of each SRDP deployment. SRDP requirements will be defined at the stakeholder level (L0) during the project initiation phase and decomposed to lower level requirements (L1/L2) for each deployment. This rolling wave planning strategy at the project level presents an opportunity for an adaptive implementation within the DMS group. SRDP deployment planning requires close alignment between the overall project schedule and DMS regarding the work breakdown, deployment releases, and also with verification and validation processes within each planning horizon to ensure project objectives are met.

Reviews and associated processes shall be defined within the SEMP; including entrance and exit criteria, RIDs, and other required protocols.

The period of performance for the SRDP Project Lifecycle begins with the Initiation Phase, includes multiple deployments, and ends with a transition to normal observatory operations. Following the transition to operations; the SRDP project office will be disbanded, with further capability and enhancements managed under Observatory operations processes.

The Systems Engineering processes naturally inform the operational processes, which are defined in the SRDP Operations Plan (TBD).

2. Systems Engineering Technical Processes

The SRDP project will develop some new processes, but will also enhance processes related to development, deployment, and operational tasks which are already in place at NRAO. The execution of Systems Engineering processes defined within SRDP closely align with many existing observatory processes and will make use of existing resources and organizational assets within departments contributing to the project. Some of these existing processes and assets SRDP shall use include: risk management, configuration management, algorithm research, hardware infrastructure, data processing, user support, and the NRAO Helpdesk.

2.1 Business or Mission Analysis

The Mission Analysis process provides an assessment of the organizational drivers behind the SRDP project, an analysis of potential opportunities and benefits SRDP presents for NRAO and the user community, and initiates the project lifecycle upon approval to move forward. The need for SRDPs has been recognized for some time and the project drivers have already been described in [RD01] and [RD02]. Preliminary work on ALMA, VLA, and VLASS pipelines has already provided momentum to launch the SRDP effort in a more coherent way.

The decision to move forward with the SRDP project has already been made. Key outputs of this process for SRDP are captured in the SRDP Project Charter [RD01] and the Lifecycle Phases and Concepts document [RD03]. Evidence of successful execution of this process exists with accepted versions of these documents.
At the time of this writing, [RD01] has been released and the other relevant documents are in development.

2.2 The Requirements Hierarchy

Requirements at the highest level in the form of primary science drivers are defined in the Project Charter [RD01]. Use cases are coupled with observatory policies, operational constraints, assumptions, and other non-functional criteria in the System Concept Document [RD10] which provides a narrative description the Level 0 (L0) Requirements. This narrative is translated without decomposition to the Stakeholder Requirements Document [RD07], where a format is incorporated to add tracking, metrics, and other attributes. General references to L0 Requirements are relevant to both the narrative in the System Concept and the itemized Stakeholder Requirements Document. Further decomposition to system and system element level requirements results in Level 1 (L1) and Level 2 (L2) requirements respectively. The overall hierarchy is as follows:

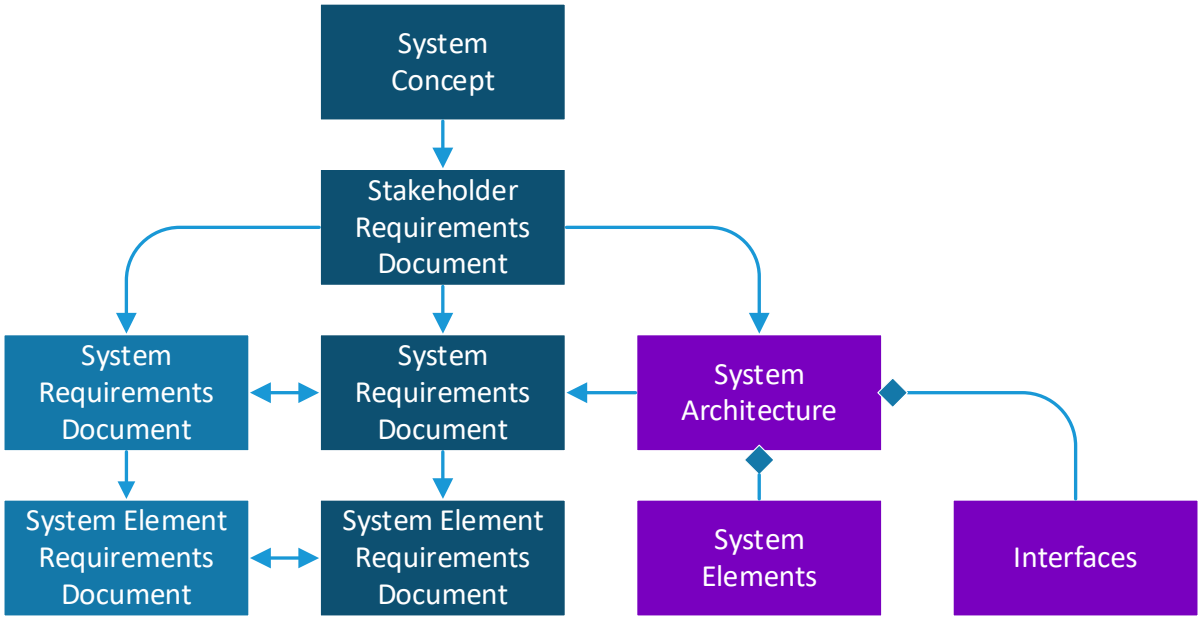
- Science Drivers and high-level goals
- L0 System Concept Document (narrative)
- L0 Stakeholder Requirements
- L1 System Level Requirements
- L2 System element / task level requirements

The trackable requirements hierarchy reflects a bi-directional, parent-child relationship between requirement levels as follows:

- **L0** or Stakeholder Requirements, describe the features and capabilities of the system without reference to any specific implementation or design. The set of L0 requirements define the scope of the SRDP project and are expected to evolve slowly (if at all) during the project. L0 requirements take the form of use cases, descriptions of desired capabilities, or general descriptions of processes in the System Concept Document [RD10] and are expressed as formal requirements in the Stakeholder Requirements Document [RD07].
- **L1** or System Requirements define specific technical or operational capabilities that are necessary to achieve the functionality and capabilities defined by the L0 requirements. In the SRDP project we will take an iterative approach to the L1 requirements, reviewing and refining them at each phase of the project. L1 requirements define the delivered capabilities of the project.
- **L2** or system element requirements are derived from the L1 requirements and define the functionality and capability required by each system element to achieve the capability defined by the L1 requirement. The L2 requirements define the deliverables from the work packages to the

project. Many L2 requirements (particularly heuristic requirements) will require detailed analysis, prototyping and testing, this detailed definition is the responsibility of the SRDP Heuristics group. The Project Scientist is responsible for the definition of L2 requirements from the L1.

Stakeholder requirements are reproduced in the SRDP *Initial* Requirements Verification Traceability Matrix (I-RVTM). The SRDP RVTM [RD05] is progressively elaborated to trace relationships and dependencies between stakeholder (L0), system (L1), and system element (L2) requirement levels. Measures of Effectiveness (MOE), Key Performance Parameters (KPP), and Measures of Performance (MOP) are associated with the requirements as appropriate. The SRDP Project Scientist is responsible for the technical content of the requirements and the SRDP Project Manager is responsible for the proper articulation, documentation, and tracking of the requirements at all hierarchal requirement levels.



2.2.1 Stakeholder Needs and Requirements Definition

Stakeholder requirements are elicited by the SRDP Requirements Committee under the Terms of Reference [RD06] and captured in the System Concept document [RD10]. These requirements are defined as the L0 requirements for the SRDP project. A Minimum Viable Product (MVP) is defined for L1 requirements for each planning wave as described in this document under Sec 3 Release Planning and Requirements Management. For tracking and traceability, the System Concept narrative is translated (without decomposition) into specific requirement statements in the Stakeholder Requirements Document [RD07]. These are assigned unique identifiers and other attributes to facilitate tracking through the lower levels of the requirements hierarchy, but do not otherwise alter the requirements.

2.2.2 System Requirements Definition

For each successive wave of implementation, Stakeholder Requirements (L0) are decomposed to System Requirements (L1) by the SRDP Requirements Committee under the leadership of the Project Scientist. A Minimum Viable Product (MVP) is defined for each planning wave as described in this document under Sec 3 Release Planning and Requirements Management. Typically, system requirements are also

implementation agnostic. Since SRDP is seeking to reuse existing NRAO tools and infrastructure, system requirements will unavoidably contain reference to specific architectural elements. Alternatively, proposed L1 requirements may be verified against the L0 requirements to ensure that the scope of the SRDP project is not violated.

System requirements, including Measures of Performance (MOP), are captured in the SRDP *Updated* RVTM (U-RVTM). Work packages will be assigned to NRAO departments and captured in the SRDP N^2 diagram to identify inter-departmental and system interfaces to assess the need for generation of interface control documents (ICDs). The need for ICDs describing Intra-departmental interfaces will be determined by department staff.

2.2.3 System Element Requirements Definition

System element requirements are decomposed from the System Level Requirements (L1) by the department responsible for the work package. Iteration with the SRDP Project Scientist, SRDP Operations Manager, or both may be necessary for proper elucidation of the L2 requirements. The U-RVTM will be amended by the Project Manager to capture the relation between the L2 and L1 requirements, as well as MOPs to be used for validation.

System Element requirements, and if needed decompositions thereof will be tracked using the Jira package, in accord with the DMS and other departmental processes.

2.3 Architecture Definition

The functional architecture of how actors interact with the SRDP capabilities is developed in the System Concept document [RD10]. The workflows and interaction between the use cases is further refined through the requirement definition process described in section 2.2.

The computing subsystems architecture is a DMS delivery to the project. Much of the architecture needed to implement these data products either exist at a high level or is in the DMS capability roadmap. DMS shall provide revised architectural documentation to convey how existing DMS elements are incorporated or modified to implement SRDP capabilities.

Technical Performance Measures (TPMs) are identified for each architectural system element and interface to be verified. TPMs are listed in the SRDP RVTM and relevant interfaces shall be shown on the architectural diagram.

These two architectures (the SRDP workflows and the DMS technical) must work in concert to deliver the SRDP capabilities. The external interfaces identified in the System Concept [**RD10**] are the contact points between the two architectures.

2.4 Design Definition

Any additional design that is needed will be exposed through the process of requirements decomposition. New design or process changes are the responsibility of DMS and to some extent NAASC and VLA Operations, if telescope operations are impacted in response to the requirements flow down. TPMs will be defined for any new design or interface that requires testing, which are tracked and recorded in the SRDP RVTM [RD05].

2.5 System Analysis

Within the SRDP project, two primary forms of analysis are required. For each rolling wave a gap analysis is performed to identify the highest priority capabilities missing from the previous wave of development. This may include new functionality, or corrective maintenance to address shortcomings in previously specified functionality. This analysis informs the definition of the L1 requirements for the current execution cycle.

The secondary form of analysis is the definition of heuristics and algorithms required to meet the L1 requirements. The heuristics group, led by the project scientist, applies their domain expertise to develop and test the procedures that will be implemented in the DMS software. In practice this development is often done in close collaboration with the DMS implementation team.

Analysis of the L1 requirements, the ensuing design and decomposition to L2 requirements are the responsibility of the DMS team and covered as part of their processes.

2.6 Implementation, Integration, and Verification

Implementation of SRDP capabilities in observatory maintained software (see System Concepts **[RD10]** document for specific interfaces) is to be achieved by resources under direction of their Data Management and Software department line managers. DMS Software delivers the software tools while; SIS is responsible for High Performance Computing (HPC) resources, and software deployment. Decisions such as if to provide HPC resources within the observatory or outsource is at the discretion of DMS.

Verification is performed within DMS on the L2 requirements during their development iterations. JIRA will be used to track implementation and verification of tasks that are related to SRDP functionality and JIRA dashboards will be used by SRDP to monitor successful verification at the L2/task level.

Departments are responsible for integration of elements within a work package and verification of the subsystem functionality. A test environment shall be prepared for use by the SRDP team in performing the Commissioning and Validation use case defined in the System Concepts document.

2.7 Commissioning and Validation

The SRDP Project Scientist is responsible for validation of requirements specific to SRDP. The scientific suitability of the system for use will be assessed and a recommendation for use made to the SRDP Project Director. The SRDP Operations Manager will review the suitability of the system for operational readiness (Operational Readiness Review / ORR), including the modification and testing of any operational processes as necessary. A joint recommendation for deployment will be made to the Project Director based on the finding of both the Project Scientist and Operations Manager.

Validation of SRDP capability is expected to be an ongoing process, in cadence with delivered capability defined over the life of the SRDP Roadmap [RD10]. Validation is directly against the System Requirements (L1) and only implicitly against the Concepts and Use Cases described in RD10 and ultimately, the Science Drivers as described in Sec 3.2 Therefore, project level testing is based on the progressive validation of L1 requirements. Final validation is achieved when all of the L1 requirements have been met and the scientific suitability of the system for use has been satisfied through successful scientific commissioning of the capability described in the Concepts and Use Cases. The progressive delivery of capability paced with progressive validation allow early delivery of capability and corrections to be applied against the road map and test plan in order to ensure the correct capability is being delivered.

The SRDP validation task fits within the much larger framework of validating DMS capabilities for general release. Some SRDP requirements may describe functionality that is already planned or very similar to other requirements. The CASA Test Manager reviews the validation needed for new or modified capability within CASA, and determines the best person to perform validation. The SRDP Project Scientist shall work closely with the CASA Test manager to assure the SRDP capabilities in CASA are adequately validated.

Trackable L0 requirements are itemized in the Stakeholder Requirements Document, where partial and progressive fulfillment of L0 requirements can be assessed and further tracked in the Requirements Verification and Traceability Matrix (RVTM). Metrics in the RVTM will reflect a fractional completion based on the number of validated requirements associated with each L0 requirement. Because additional L1 requirements may be derived from a L0 requirement in successive waves the completion fraction may decrease between waves.

2.8 Deployment

SRDP capabilities are deployed based on the cyclical requirement cycle, based on provisions in the Roadmap defined in Section 3.1. The Roadmap partitions requirements by priority and logical order needed to build capability into release planning. Within a cycle, capabilities may be deployed and made available to users as the L1 capabilities are validated. Within one of the annual SRDP deployment cycles, there will be multiple verification and validation events on intermediate code releases to assure that integrity is built in as the code base evolves prior to conducting an Operations Readiness Review.

2.9 Operation

The SRDP Project Office will define operational scenarios and recommend process changes needed to deliver data products. Most of these will be introduced gradually as they are identified, since the rolling wave planning does not provide the full scope of operational needs in advance. SRDP has an Operations Manager that will work closely with existing systems and processes to socialize production of science Ready Data Products.

2.10 Maintenance

Processes developed for the SRDP project phase are primarily focused on requirements elicitation, decomposition, and validation. The production of data products will mature and become part of the normal operational routine. Maintenance will include bug fixes, stability through upgrades, streamlining code execution, improvement of user interfaces, and increased execution efficiencies. All of these activities are already performed by NRAO software developers and telescope operations staff, so the addition of SRDP to maintenance processes does not need any special attention or direction.

2.11 Transition

SRDP is initially managed as a project, establishing roles and processes that will routinely deliver and serve data products to the operational environment. SRDP processes will mature over time until reaching the point where integration into the existing operational environment can be done smoothly. Process ownership is not a distinct project milestone, but is based on a metrics assessment of increasing data quality and process maturity. The SRDP project introduces the following new permanent roles; a Project Scientist, a Requirements Committee, and an SRDP Operations manager. These permanent roles will continue after the other project office positions are retired. The SRDP transition will be managed by a gradual decline in the Project Director and Project Manager involvement, until such time as these positions are no longer needed.

No forward planning for disposal of SRDP project artifacts is required. Data products defined under this project will be permanently archived in the NRAO archive. The evolution of software, data formats, and storage is a routine aspect of observatory planning; so retirement of SRDP pipelines and data products present nothing unique that should be noted. Hardware supporting the processing and archive will be routinely upgraded throughout the SRDP lifecycle as part of normal operational planning. Significant upgrades may be established and managed as separate projects.

3. Release Planning and Requirements Management

The SRDP project will deliver capability through successive deployment phases as generally described in the Lifecycle Phases and Concepts [RD03]. A Rolling Wave project planning strategy is used to accommodate progressive decomposition of requirements throughout the project life cycle. Since requirements drive the definition of the work, requirements are progressively decomposed, and scope is progressively elaborated from high level requirements, to System Level requirements, to low level requirements and tasks within DMS. The SRDP project maintains a project lexicon and acronym list to avoid ambiguous semantics [RD11].

3.1 SRDP Roadmap and Release Planning

During the Initiation Phase, the following steps are taken:

- The Requirements Committee defines high level requirements for capabilities that will be delivered within the project performance period. Capabilities are translated to Level 0 Requirements (L0).
- The SRDP Roadmap and Release Plan are established, projecting capability targets for specific deployments following a general pattern as described in the diagram below. A high level Roadmap is provided in the System Concept Document [RD10]. The capability will be described in more detail at the beginning of each planning wave as L0 requirements are decomposed to L1 requirements for implementation within the current planning horizon.
- Capabilities described for deployments within the project Execution phase are defined within the SRDP Roadmap and partitioned to planning waves as shown below.

Within each planning wave leading to a deployment, the following steps will be taken:

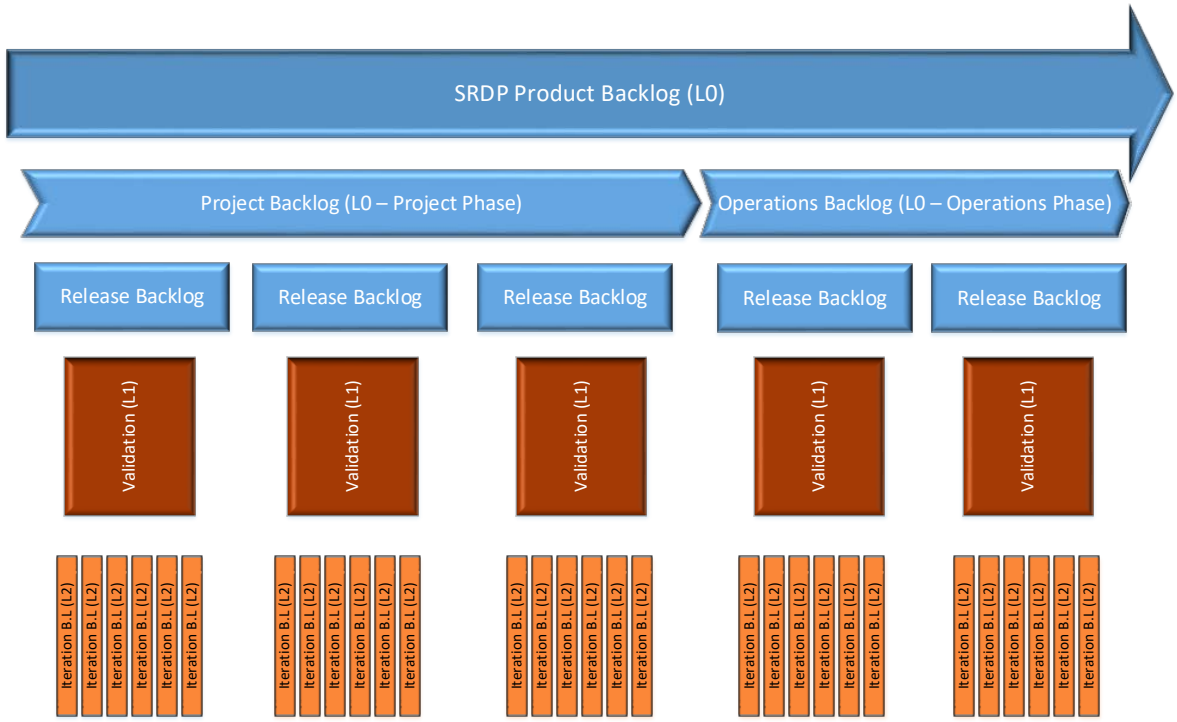
- A subset of L0 requirements that define associated SRDP capability shall be identified and prioritized for delivery within each deployment phase.
- Selected L0 requirements and capabilities for each deployment phase are further broken down to separate features and L1 / L2 requirements. L2 requirements are translated to tasks within DMS and tracked in Jira against the associated L2 requirements. The design & planning stage for

each wave shall be jointly decided between the SRDP Project Scientist and the Deputy AD for DMS Software, then submitted to the SRDP Project Director. Development planning shall establish realistic targets for the requirements and features to be implemented within a deployment phase. These are rank ordered by required dependencies and priority, classified by MSCW (Must have, Could have, Should have, Won't have) rules and entered into the backlog for the pending planning wave.

- A threshold for Minimum Viable Product (MVP) is set and agreed upon by the parties listed above, establishing criteria for a successful ORR and authority to proceed to release the code for use to SRDP Operations. Deployment Phases must be aligned to the CASA and AAT/PPI release cycles.
- Note that Stories are implemented to realize features, which are not shown here because these are managed internal to DMS.

3.2 Backlog Relationships

As high level requirements are broken down from Stakeholder Requirements (L0) to L1 and L2, the work needed to implement those requirements can be defined in detail. The requirements and work that is scheduled and prioritized for completion within a cycle is managed in the backlog. Backlogs are defined at various levels and with different cycle lengths. The Release Backlog however, contains a minimum level of prioritized requirements which must be completed before a feature or capability can be declared ready for use. A threshold is assigned within the rank ordered list of requirements for a release cycle (within the release backlog) that defines the SRDP Minimum Viable Product (MVP) which must be achieved to declare the release is ready for use. The MVP is the minimum basis for an Operations Readiness Review (ORR). Implementation of features and capability may of course exceed this threshold for a particular release. The backlog relationships are reflected in the (somewhat oversimplified) diagram below:



The overall product backlog identifies capability (L0) that is reflected in the long term roadmap for SRDP and spans the boundary between the SRDP Project phase (Project Backlog) and SRDP transition to Observatory Operations (Operations Backlog). As requirements are broken down from L0 to L1 to L2, associated work is related to L2 requirements, performed and verified within the Iteration Backlogs. L2 requirements are verified through multiple development iterations, advancing the functionality to the point of validation, assessment of Operational Readiness (ORR) and released for use. Iterations are performed within DMS and Validation is performed under the SRDP Project Scientist. The number of actual iterations per validation is not fixed, but is adjusted based on complexity of the task.

3.3 Requirements and Work Elements

SRDP software development work is requirement-driven as well as discovery driven. Capabilities are defined within the System Concept, translated to L0 requirements, decomposed to L1 requirements at the system level, then to L2 requirements and tasks within subsystems. It is expected that during the process of decomposition, low level requirements are discovered; derived from higher level requirements out of necessity to complete the work. It is incumbent upon DMS to manage derived requirements in order to inform the test process and ensure their work remains within scope. SRDP requirements are tracked in order to ensure that all the work needed to satisfy project objectives is assigned and validated. SRDP requirements are only a subset of overall requirements supplied to the software development cycle, therefore it is difficult for the SRDP Project to track any derived requirements that may lead to out of scope work. This is a risk the project recommends for DMS to monitor closely.

Scope is allocated and prioritized within a fixed cycle release by the following priority:

- Minimum Viable Product (MVP)– critical for a release
- Target Capabilities – essential but not critical for a release
- Maximum Capabilities – Desirable as time permits

Any scope that is not completed in the current cycle shall be rescheduled and reprioritized for subsequent cycles. The MVP is not intended for descoping capability, but to allow flexible rescheduling in order to preserve integrity of release deadlines.

3.4 Project Quality Management

As defined in [RD02] we define project quality management as the process by which the quality of the project deliverables is ensured. Following INCOSE standard processes Measures of Effectiveness (MOEs) are defined to determine the success of the project in addressing the three key science drivers. Measures of Performance (MOPs) and Measures of Suitability (MOSs) will be developed as part of the SRDP project to permit metric based management of the Level 1 requirements definition process.

Note: Processes for the Data Product Quality Management and Data Process Quality Management are addressed separately as a function of operations and are subject to review at the time of the Operations Readiness Review.

3.4.1 Measures of Effectiveness (MOE) and Key Performance Parameters (KPP)

The primary objective of the SRDP project is to maximize the science impact of the NRAO telescopes. Strategically three key science drivers have been identified to achieve this mission. For each of the three drivers we identify one or more MOEs that will be used to track the effect of the SRDP project and identify which are the Key Performance Parameters (KPPs).

Science Driver: Allowing current users to focus more on science and less on data reduction,

MOE-1 Fraction of projects which opt-out of SRDP processes
MOE-2 (KPP) Requested use or downloads of project products.
MOE-3 Latency between observation and first publication

Science Driver: Broadening our user community by decreasing the barriers to using NRAO Interferometers.

MOE-4 (KPP) Number of users requesting science ready products from archive
MOE-5 Number of registered users (PI and Co-I) and deviation from historical trends.
MOE-6 Number of observing proposals submitted in each cycle.

Science Driver: Creating a rich archive of science ready images and products for archival study.

MOE-7 Number of secondary publications based on data in the archive.
MOE-8 Quantity of science ready products available in the archive.
MOE-9 (KPP) Download rate of science ready products from the archive.

3.5 Requirements Traceability

Requirements traceability mirrors the requirements hierarchy as described in Section 3.2.

The SRDP Requirements Committee has developed eleven use cases, to satisfy the three key science drivers. These use cases, coupled with associated constraints, assumptions, observatory policies, and other criteria as described in Sec 3.2. are captured in narrative in the Systems Concept Document [RD11]. This narrative has been translated without further decomposition, into the Stakeholder Requirements Document [RD07], strictly for the purpose of tracking and validation metrics. The highest level of validation is against these use cases and associated criteria, as articulated in [RD11]. Validation will be over an extended period of time, reflecting the progressive delivery of capability as reflected in the SRDP Roadmap. As the itemized L0 stakeholder requirements directly reflect the use cases and criteria in [RD11], the degree of validation will be tracked as a function of percent complete for the set of itemized L0 Stakeholder Requirements in [RD07] that map back to each of the use cases, concepts, and other criteria in [RD11].

Requirements shall be traced from L0, to L1, to L2 through use of the RVTM. L2 requirements will be tracked in Jira within DMS, therefore Jira tickets references will be incorporated into RVTM tracking. The traceability shall be bi-directional, to assure there are no gaps in the verification and validation processes.

L0 requirements scheduled for delivery in the current wave will be decomposed to L1 requirements by the Requirements Committee prior to start of the development cycle, reviewed, and conveyed to the development team. The L1 System Level Requirements Document will initially define requirements for the first development cycle, The same Requirements Document will be updated by version, for each of the subsequent development cycles.

4. Infrastructure Management

The SRDP will largely rely on the existing NRAO DMS and Operations infrastructures with mostly minor modifications. "NRAO infrastructure" also includes staffing resources, organizational policies, computing resources, departmental processes, etc. Planned deviations from existing infrastructure will be documented here.

5. Quality Assurance Process

Quality Assurance for SRDP is generally defined under Project Quality Management. A distinction is made between several measures of quality:

- Project quality management as described in section 3.4 above.
- Data Process Quality Management: This is the quality management of the process of delivering products to the user community. This process will be developed by the SRDP project as part of the operations plan and implemented by SRDP operations with the intention of continuous improvement throughout the operational life. Metrics for data process quality management will be based on ensemble scores from the Data Product Quality Management Process.
- Data Product Quality Management applies to the delivered data products. The objective of this process is to ensure the quality of every delivered data product. This is a process developed by the SRDP project and implemented as part of SRDP operations. The Data Product Quality Management will be described in a separate document as part of the SRDP project implementation.

6. Configuration Management

Science Ready Data Products are a produced through multiple deployed software tools and operational processes working jointly to create complex data sets and images. As software and processes evolve, changing configurations have the potential to interact in ways that produce undesired results. Since L1/L2 requirements are progressively defined, the verification and validation of results is also a continuing process. In order to reproduce both desired and undesired results, it is critical to manage configuration across all software and process elements involved with producing a given result, including the test environments. Configuration Management of the deployed software is done inside of DMS by SIS, whereas configuration control of the operational processes are managed under SRDP Operations.

DMS shall maintain a configuration table that captures current release versions for all the software in general use including the test environments, maintain release histories, backward compatibility criteria, and known conflicts.

Configuration Management is tightly coupled with overall project change management, where baselined configuration changes are subject to approval.

7. Review Management Plan

Reviews of a project provide expert feedback and serve as check points to ensure the project is prepared to move to the following stage. For the SRDP project we identify two types of reviews, lightweight internal reviews designed to act as checkpoints while being minimally disruptive to day to day activities, and more substantial external reviews, demarking major transitions in the project lifecycle. Internal reviews are at the discretion of the Project Director, where other stakeholders at the directorate level may also request various internal reviews. Reviews will follow the NRAO guidelines established with RD08 and RD09, tailored as needed to satisfy review criteria.

7.1 External Reviews

External reviews bring expert knowledge from the broader community to a project. In the SRDP project they will be used as decision gates before moving to the subsequent step in the project. These represent an enormous opportunity for the project to benefit from outside expertise, as well as a substantial

investment in effort both by the project and by the reviewers. To optimize the return on this investment for each external review a separate review plan, committee charge, and agenda will be created by the SRDP project. At least two external reviews are currently planned for the SRDP project, described in the sections that follow. In addition to these reviews, it is expected that feedback will be provided by standing committees of the NRAO such as the Users Committee, and CASA Users Committee as part of their annual charge.

7.1.1 Stakeholder Requirements Review (StRR)

The StRR will be an external event, coordinated by the Project Director and Project Manager. Once the Requirements Committee has developed the Use Cases and System Concepts, the Project Director will distribute the document for review by the NRAO User Committee and the CASA User Committee. The review period will open with appointment of reviewers, distribution of the document, followed by a period of comment and submission of Review Item Discrepancies (RIDs). RIDs will be submitted to the Jira tracking system and managed by the SRDP Project Manager. RIDs will be assigned within NRAO for response and resolution prior to the review, which will be a videoconference. During the review, open RIDs will be addressed with agreement on final resolution and time period for completion of open action. The review will conclude with successful completion of all outstanding RIDs.

7.1.2 Conceptual Design Review

The conceptual design review marks the end of the initiation phase of the project and the transition to the implementation phase. This review is scheduled for Q2 FY18. Although a precise charge will be developed in conjunction with stakeholders closer the date of the review, it is expected that the charge to the committee will encompass:

- Is the scope of the project well defined, achievable, and matched to stakeholder expectations? Do sufficient measures exist to effectively evaluate the progress of the project?
- Are the project management and system engineering plan likely to achieve the project goals?
- Does the system architecture support the objectives of the project?
- Are the requirements well formulated and understood by the project team?
- Is the operations concept realistic and appropriate to the mission of the SRDP project?

Reviewing Body: Appointed by NRAO Director
Inputs: Project Management Plan and subsidiary documents, Stakeholder Register, baseline documents for scope, schedule, budget, and risk; Lifecycle Concepts (particularly the Operations Concept), Systems Engineering Management Plan, Change and Configuration Control Plans, DMS Management and Process documents, architectural definition, Level 0 and Level 1 Requirements
Output: Recommendations from review committee and decision to proceed to implementation.

7.1.3 Project Transition Review

The goal of the SRDP project is to launch SRDP as part of the observatory operations. At termination of the project, SRDP will simply be part of the observatory operations model. This review will serve as a final gate before the project office is dissolved. The charge will be defined much later in the process but can be expected to include:

- Are the SRDP processes sufficiently defined and mature that progress will continue to be made without a dedicated project office?
- Have the technical objectives of the SRDP project been achieved?

Reviewing Body: Appointed by NRAO Director
Inputs: Metrics demonstrating readiness for Operations, Operations Plan including ongoing support and requirements management.

Output: Recommendations from review committee and decision to proceed with handover to operations

7.2 Internal Reviews

Internal reviews will be used by the SRDP project, to formalize the process of building consensus, transfer of responsibility from one portion of the project to another, and recording the objectives and decisions made by the project for the subsequent steps. These reviews are intended to be as lightweight and non-disruptive as possible while still being consistent with the above objectives. These reviews are accepted by the project director and made available to all stakeholders.

7.2.1 Cycle Planning Review

Reviewing Body: SRDP Requirements Committee
Inputs: Status update from previous cycle of development
Output: Level 1 targets for the next cycle of development.

This review is conducted once per cycle by the Requirements committee. The current status of the project is presented (L1 requirements which have been met, overall assessment of L0 status). The committee is charged to define the L1 requirements for the ensuing cycle of development.

7.2.2 Operational Readiness Review

The ORR is a gateway review before SRDP implementations are put into general production use. The Operations Readiness Review must be completed with a successful outcome prior to going live with a production release.

Reviewing Body: SRDP Director (and designees)
Inputs: Status (including verification and validation) of capabilities to be made available in production mode to the community. All software with operational dependencies have been integrated into operational processes
Outputs: Decision that implementation is ready for deployment, punch list of items to be addressed prior to deployment, or recommendation that software not be deployed.

7.2.3 Deployment Review

Reviewing Body: Project Director
Inputs: Operational experience of not less than three months of new cycle.
Outputs: Update to planned scope of current or subsequent cycle development targets.

The deployment review formalizes the feedback from the operations side of the SRDP project to the requirements and implementation phases. The timing of the review is such that feedback can still be considered for the cycle currently under implementation.