Maunakea Spectroscopic Explorer: a unified approach for delivering project objectives

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ABSTRACT

Projects supported by culturally and geographically diverse teams need robust tools that achieve scientific and technical deliverables through real-time collaboration and effective document management. Given limited resources, the optimal mix of tools is cost-effective, succinct, flexible, and intuitive. It enables all phases of the project, and it facilitates the creation of a comprehensive set of documentation to support science operations.

The Maunakea Spectroscopic Explorer (MSE) is an international project with scientists and engineers working in different time zones across the world. MSE's unified approach to project control and facilitation integrates the software platforms, manual processes, and project management tools used to develop project deliverables, which include a detailed set of configurable documents representing the project's programmatic, scientific, and technical performance objectives. MSE's Configuration Management and Reviews Plan (CMRP) defines those documents and describes the mechanisms by which the project controls their quality and integrity. Those mechanisms include MSE's configuration management processes as well as the tools supporting those processes: software for collaboration, documentation, and project management; the MSE document naming and numbering system; the document index lists and version control process that trace the deliverables' development throughout the life of the project; and project management tools, including a responsibility assignment matrix and document approval and release processes.

Keywords: collaboration, software platform integration, document development, configuration management, version control, RACI matrix, remote work, manual processes

1. INTRODUCTION

The Maunakea Spectroscopic Explorer (MSE) is the first of the future generation of massively multiplexed spectroscopic facilities. MSE is designed to enable transformative science, being completely dedicated to large-scale multi-object spectroscopic surveys, each studying thousands to millions of astrophysical objects. At a minimum, MSE will use an 11.25 m aperture telescope to feed 4,332 fibers over a wide 1.52 square degree field of view. It will have the capabilities to observe at a range of spectral resolutions, from R~3,000 to R~40,000, with all spectral resolutions available at all times across the entire field. Alternate facility architectures are under evaluation with insight from participants' national strategic planning priorities along with technical feasibility. Engineering development is supported by a culturally and geographically diverse design team that is centrally coordinated and managed by the Project Office. The MSE Project deeply respects Maunakea's cultural importance and storied past. We are cognizant that the decisions we make today are intertwined with the future of Maunakea and its cherished summit.

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This paper discusses the software platforms and manual processes the PO employs in its unified approach to project management, facilitation, and control. To illustrate how those mechanisms advance the creation, organization, and development of the MSE documentation included in the project deliverables, the paper draws examples from the Configuration Management and Review Plan (CMRP)[2] discussed in the 2020 SPIE meeting.

2. SOFTWARE PLATFORMS

Comprised of scientists and engineers from across the globe, MSE's project teams need collaboration tools that are available regardless of day, time, or the user's location. Given the PO's limited resources, those tools must also be affordable to establish, maintain, and administer. They must be sufficiently flexible to meet a wide range of evolving needs, thus minimizing the number of disparate platforms required to execute the project, and, subsequently, minimizing the costs for the project's overall software footprint. Lastly, the tools must robustly support the stringent document management processes MSE teams rely upon in achieving the project's scientific and technical objectives throughout all phases of the project and resulting in a thorough set of documentation that underpins MSE's successful scientific operations.

The MSE project relies on three major platforms to support collaboration, communications, archiving, and project reviews: Microsoft 365 (MS 365), DocuShare, and Redmine. MS 365 offers a real-time collaboration platform unavailable on DocuShare, and licenses include access to business-standard Microsoft Office software. DocuShare and Redmine are legacy platforms, both of which offer functionalities (Table 1) that could be replicated in the MS 365 domain, but it would not be cost effective to do so given the project's current resources. Combined, the three platforms offer sufficient functionalities to support the project effectively and affordably.

Table 1. The most significant characteristics and functionalities MSE uses across the three platforms

Characteristics/Functions	MS 365	DocuShare	Redmine
Real-time collaboration	X		
File Access Control with Check-in and Check-out	X	X	
Revision History with Timestamps and Metadata	X	X	
Version Index to Access and Restore Desired Version	X	X	
Task Assignment, Approval, and Tracking	X	X	X
Wiki	X	X	X
Guest/Anonymous Access	X		
Subscription/Licensing Fees	X	X	
Vendor-hosted Storage/Software as a Service Subscription	X		

- **Real Time Collaboration**: multiple users can work on a file simultaneously, online or offline
- **File Access Control with Check-in and Check-out:** the ability to limit, track, and direct how files are changed
- **Revision History with Timestamps and Metadata:** a history of when and by whom a document was changed, and the ability to include comments about changes to the file in the document's revision history
- **Version Indexing to Access and Restore Versions:** the ability to locate a specific version of a file and restore it
- **Task Assignment, Approval, and Tracking:** the ability to assign users tasks associated with the project's review and approval workflow, and to track progress and updates on those tasks

- **Wiki:** collaborative web pages where users can add, edit, or delete content
- **Guest/Anonymous Access:** users can access the platform without a paid seat and/or access a file without first authenticating into the platform that hosts it
- **Subscription/Licensing Fees:** charges for using the software
- **Vendor-hosted Storage/Software as a Service Subscription:** the ability to rent cloud-based storage/software

2.1 Microsoft 365

Microsoft 365 (MS 365) offers the proven reliability, affordability, and flexibility to support real-time collaboration among far-flung team members working on multiple computer platforms. A Software as a Service (SaaS) solution, MS 365 is continuously available. Hosted by Microsoft rather than on local company-owned servers, SaaS maintenance and upgrades require no scheduled outages, are invisible to users and administrators, and require no specialized IT staff to execute. As an SaaS subscription, MS 365 domains require no contract or license fees to establish. The MSE MS 365 domain includes custom email addresses, custom websites, cloud storage, and myriad productivity applications, including browser and desktop versions of the universal business standard of office products: Microsoft Word, Excel, PowerPoint, etc. Fees are calculated per user and the applications and functionality each user requires. In addition, MS 365 allows free guest access to a subset of a domain's applications. This allows MSE to use MS 365 to collaborate with users outside the domain without incurring additional costs.

As the next generation of the Canada-France-Hawaii Telescope (CFHT), the MSE project has adopted MS 365 over legacy CFHT software solutions to support the project's core collaboration needs. Although Microsoft hosts MS 365, the PO customizes and administers the MSE domain. The intuitive nature of the software, its simple interface, and the abundance of customer support and online guidance make it possible for the PO to manage MSE's MS 365 domain without diverting resources from CFHT's dedicated IT staff. Currently, two members of the PO serve as MSE domain administrators on a part-time basis. Managing the fundamental aspects of the software, including security, customizations, troubleshooting, and writing usage guidelines, requires anywhere from two to ten hours per week between the two PO members.

Although it includes myriad applications, the MSE project relies primarily on SharePoint and Outlook. SharePoint provides MSE's primary collaboration platform, and Outlook provides customized emailing and calendaring functionalities. SharePoint allows users to advance work effectively with documents online or offline. Once users are connected online, SharePoint seamlessly integrates and synchronizes any changes they made to a document offline, which enables multiple users to edit the same files simultaneously. SharePoint's cloud-based nature makes it possible for all users to access not only to the most recent version of a file, but also to previous versions, i.e., a window into the work's evolution. Posting, developing, and sharing documents in the cloud eliminates issues commonly associated with emailing files: slowing the pace of collaboration by imposing serial rather than simultaneous work, limiting the size of files that can be shared, and risking data integrity by creating multiple copies of the same document.

Figure 1. The focus areas of MSE's Microsoft 365 domain

MSE's MS 365 domain is organized around specific focus areas, e.g., project management, science, engineering, subsystems, and PO administration (Figure 1). By default, each focus area has its own email address, calendar, and SharePoint site, as well as a custom security group that allows administrators to control which users can access the focus area and what they can see and do in it. For example, some users may have access to a focus area's SharePoint site but not be included in the custom email address for that site. MSE's SharePoint sites are customized to meet the evolving needs of the project. For example, aligned with the project's expansion, an MSE Community site is under development to host information, documents, and templates available to all MSE SharePoint users, including those with paid seats and those with free, guest access.

Access to sensitive information can be tailored from the site level down to an individual file. And, when necessary, temporary access to a SharePoint document can be granted to anyone with a link to that file, even if they are not an internal or external user. Although the MSE project rarely uses the functionality that allows a person to see a file in SharePoint without first authenticating into the domain, it can be appropriate for situations where external collaborators need temporary access to a file, e.g., a sign-up sheet for a meeting, but have no need for a user account in the MSE domain. In this example, users anonymously accessing SharePoint allows for quick, spontaneous work without the bottlenecks of sending a file via email or the overhead of tracking multiple email replies. Note that the MSE project creates a preset, automatic expiration for links that allow people to see a file in SharePoint without first authenticating.

The Outlook-integrated custom email address and calendar created for each focus area are used as needed. For example, the PO focus area has a custom email address, and mail sent to that email address goes to all MS 365 users assigned to the security group for the PO focus area. The PO uses its focus area's custom calendar to organize meetings, record project events, and post holidays. However, the PO is the only focus area using calendar functionality, and only a few focus areas, including the PO, use their custom email address to contact the people in their respective security groups. Of the primary MS 365 functionalities the MSE project has implemented, only SharePoint sites are accessible to guest users. Only a user with a paid MS 365 subscription in the MSE domain can access the Outlook calendars.

For added protection, the project creates a local backup of the MSE domain contents every two weeks. Each backup persists for six months to ensure the project can restore anywhere from an individual file to the full complement of SharePoint site content, emails, and calendars. In addition to the security group, email address, calendar, and SharePoint site created for each focus area, MS 365 includes additional collaboration tools as standard applications, notably, Microsoft Teams, which provides instant messaging and video conferencing capabilities. However, the project is using Slack and Zoom for those needs, and the PO currently does not have the resources to explore integrating Teams functionality.

2.2 DocuShare®

DocuShare® is a Xerox© solution for enterprise content management and was MSE's original platform for file sharing and document archiving. Currently, DocuShare serves as the system of record for all officially approved versions of documents at each phase of the project. Conceptually, DocuShare creates a "container" for each document, and that container holds all approved versions of that document, displaying the most recent by default. Where DocuShare is the repository for the final, approved version of a document in each respective project phase, SharePoint is the platform for work-in-progress versions of documents that are under collaborative development.

Organized after the project's Work Breakdown Structure (WBS) (Figure 2), MSE's filing system implementation in DocuShare is not intended to be flexible. However, DocuShare allows multiple instances of the same document at different WBS branches for ease of cross-reference. As the first web-based document management tool offered to the market in 1997, DocuShare does not lend itself to ease of access or collaboration. Users must authenticate into the system to access files, and a user must download a document to work on it, and then upload the document to share changes. Other users cannot see the document developing in real-time, and users cannot work on a file with other users contemporaneously. Because DocuShare is the repository for all officially approved versions of project documents, only

administrative members of the PO have access to upload and manage documents in DocuShare. Access for all other users is "read only."

Although it would be possible to recreate the DocuShare WBS file structure, access control, and archive functionalities in SharePoint, migrate the content from DocuShare into SharePoint, and then decommission DocuShare, there is no immediate plan to do so due to human resource constraints. As a result, the project is incurring the extra costs of DocuShare licensing and maintaining the local server, plus the opportunity costs of having CFHT IT staff perform upgrades and maintenance.
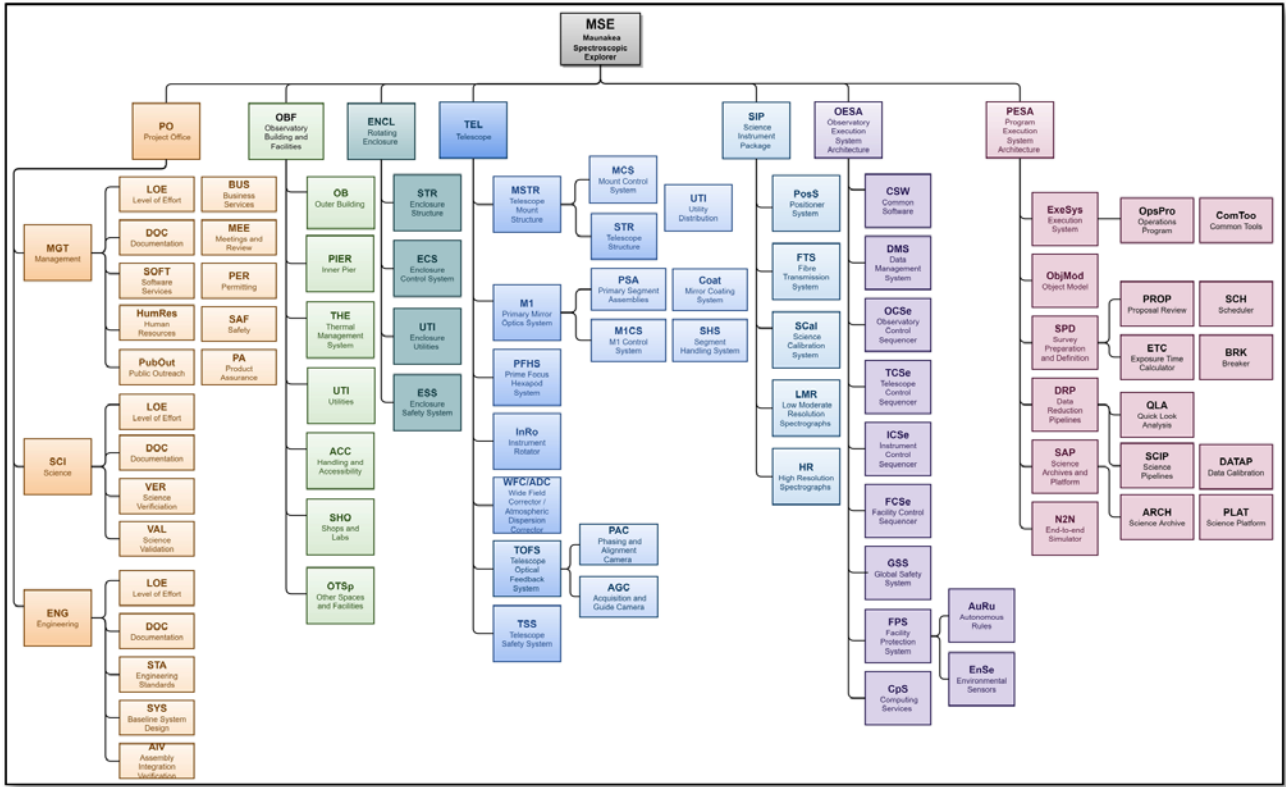
Figure 2. The Work Breakdown Structure (WBS)

2.3 Redmine

Redmine is an open-source, web-based tool designed to manage software development. Hosted on CFHT's server, the PO uses Redmine exclusively to manage the project issue log, to facilitate tracking of review items in formal project phase reviews, and to host the Science Wiki for the 400+ members of the Science Team. Given its free and open-source origin, Redmine's user interface can be unintuitive for customization, and there is no Redmine customer service team to provide assistance outside of user-supported forums. However, considering that there is no licensing fee for hosting a large and expanding science team and that the easy-to-use issue tracking functionality is an excellent fit for MSE's issue tracking, review process, and science communications, the PO has no intention of replacing Redmine with SharePoint.

3. MANUAL PROCESSES

MSE's rigorous document management processes ensure consistent quality and accuracy in the project's deliverables. Three notable tools are the document naming and numbering system, version control, and document index lists. Together with MSE's change control procedures, these tools ensure documents are correctly identified and their revisions tracked throughout the life of the project, resulting in a comprehensive set of documentation underpinning MSE's successful scientific operations. SharePoint and DocuShare play critical roles in the document management processes, which are thoroughly defined in the CMRP. Before going further, however, it is important to cover some basic concepts and terms.
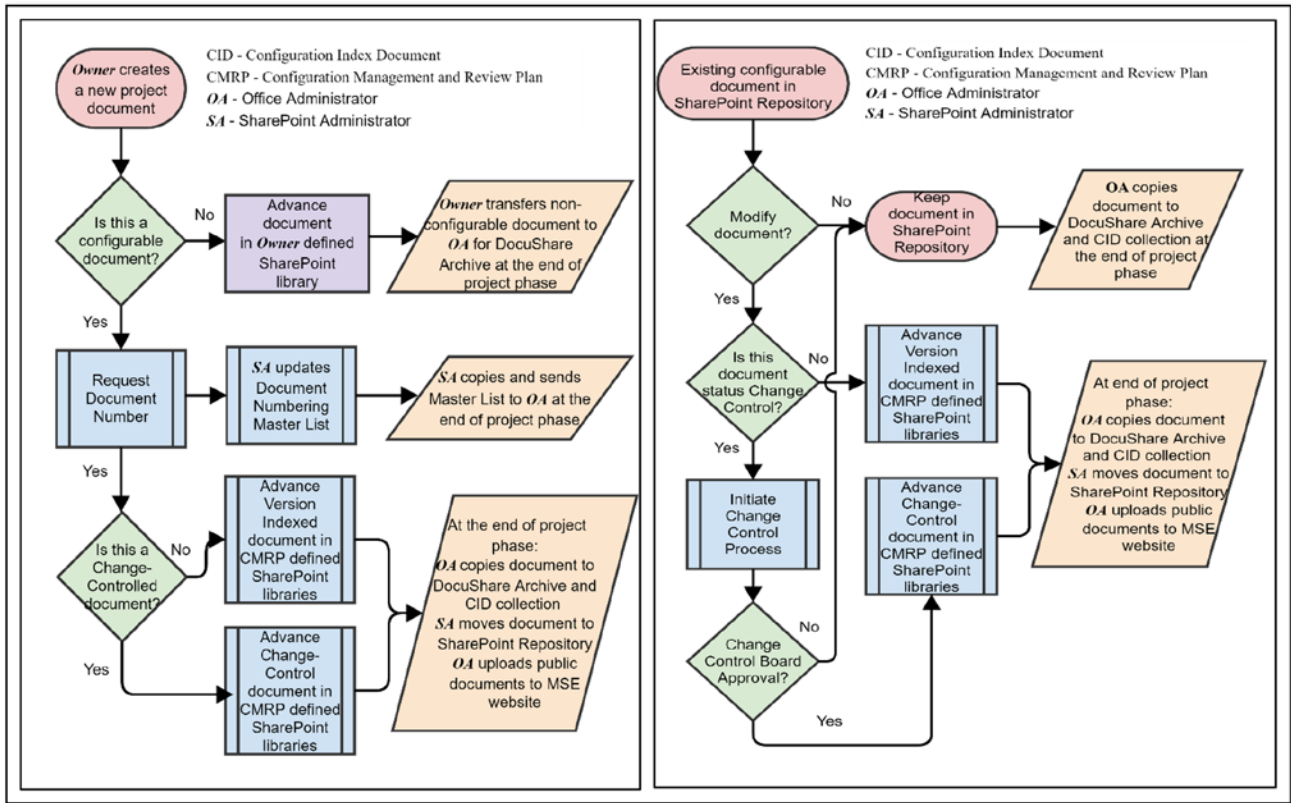
Figure 3. The workflow when creating a new document at any project phase is on the left. On the right is the workflow of configurable documents in SharePoint at any project phase.

Created during the project development phases, configurable items are the building blocks of the MSE observatory. Collectively, the configurable items uniquely describe the observatory in its design architecture along with the science operations envisaged. Configurable items also capture the pertinent processes and procedures associated with science development, engineering design, and programmatic assessment adopted for MSE. Figure 3 presents the workflows associated with the document development described below.

For the MSE Project, the observatory configuration is principally managed by a set of configurable documents listed in the CMRP. Examples of configurable documents encapsulating hardware or software designs include design requirements documents, interface control documents, design description and analysis reports, records of the review processes and their approval procedures, etc. In addition, each MSE subsystem has a discrete set of configurable project management and programmatic documents, including health and safety plans, product assurance plans, risk registers,

cost sheets, schedules, etc. Every configurable document receives a global name identifier with a designated document name and a unique number according to MSE's document numbering process. A document retains the same global name identifier throughout the life of the project. Non-configurable documents are also essential components of the project's corporate memory and developmental history. Non-configurable documents are documents of record associated with the planning and execution of the project at the managerial and strategic level. They include annual budget documents, vendor contracts, project brochures, funding proposals, etc.

3.1 Document Naming and Numbering

A project document could be configurable or non-configurable, depending on its content and purpose. Regardless, all project documents are archived in DocuShare, but only configurable documents are assigned official document names and numbers. All configurable documents must conform to the document naming and numbering conventions detailed in the CMRP, and a high-level overview of those conventions is described below.

Figure 2 shows the Work Breakdown Structure (WBS). The WBS is the system decomposition of MSE project work into functional components, or *work elements*. The WBS is used for work share and cost estimates. Work elements are grouped into seven main branches, and each work element is associated with a letter code. For example, the MSE.PO branch is split into three disciplines: Management (MGT) , Science (SCI), and Engineering (ENG). A *global name* identifier is a reference code used for each configurable document linked to the project, except for Interface Control Documents (ICDs) and Cost Sheets.

Based on the WBS work elements, the convention for global names is:

WBSCode-nnn-###
- **WBS Code:** Code of Work Breakdown Structure element
- **nnn:** Document type
- **###:** Identifier number, which contains three digits

The WBS Code for a document about public outreach would be MSE.PO.MGT.PubOut, where a code for a document about human resources would be MSE.PO.MGT.HumRes. Similarly, the code for a document about science verification would be MSE.PO.SCI.VER, while the code for a document about engineering standards would be MSE.PO.ENG.STA. The method is the same for all other branches and disciplines. Examples from each branch include

- MSE.OBF: Observatory Building and Facilities
    - MSE.OBF.PIER: Inner Pier
    - MSE.OBF.OTSp: Other Spaces and Facilities
- MSE.ENCL: Rotating Enclosure
    - MSE.ENCL.STR: Enclosure Structure
    - MSE.ENCL.UTI: Enclosure Utilities
- MSE.TEL: Telescope
    - MSE.TEL.MSTR: Telescope Mount Structure
        - MSE.TEL.MSTR.MCS: Mount Control System
        - MSE.TEL.MSTR.UTI: Utility Distribution
    - MSE.TEL.PFHS: Prime Focus Hexapod System
- MSE.SIP: Science Instrument Package
    - MSE.SIP.PosS: Positioner System
    - MSE.SIP.SCal: Science Calibration System
- MSE.OESA: Observatory Execution System Architecture
    - MSE.OESA.FCSe: Facility Control Sequencer
    - MSE.OESA.GSS: Global Safety System
- MSE.PESA: Program Execution System Architecture

- MSE.PESA.ObjMod: Object Model
- MSE.PESA.N2N: End-to-End Simulator

A *document type* reflects the nature of the document and its purpose. There are thirteen document types:

- **DWG**: Drawing – *An engineering drawing such as mechanical drawing, electrical drawing, flow chart, or architectural drawing, etc., in .pdf format. The associated computer aided design files are managed in their native formats by their own specialized design software.*
- **ICD**: Interface Control Document – *A document defining the interface design requirements between two systems.*
- **MEE**: Meeting-related documents – *A document associated with the planning, organization, and execution of formal meetings such as system-level and subsystem-level reviews, etc. However, this item is not intended for weekly meeting or progress meeting at the lower subsystem levels.*
- **MGT**: Management document – *One of many documents relating to managerial aspects such as cost sheet for costing, contracts, call for bids, risk registers, Work Breakdown Structure Dictionary, work package agreements, proposals, annual budgets, etc., except for a schedule document, which has its own type.*
- **MOD**: Model or simulation file - *Native files of computer aided design models and/or other* categories *of simulation files such as Zemax, Mathcad, ANSYS FEA files, etc. MOD files are deposited in DocuShare for configuration management purposes.*
- **PLA**: Plan – *This can be a science (e.g., validation), technical (e.g., verification), safety, operations or managerial (e.g., Microsoft Project or product assurance) plan; or a document describing a procedure such as a maintenance procedure, calibration procedure, or an observing procedure. However, documents associated with planning and execution of project meetings are not included.*
- **REQ**: Requirements – *An engineering document stating the performance, functional, and operational requirements for a system or subsystem.*
- **RPT**: Report – *A document stating the current design development status of the system or subsystem, or containing findings, conclusions, and recommendations of topic(s) under examination or capturing technical discussion or analysis on specific topic(s).*
- **SCH**: Schedule – *A document outlining the chronological progression of events and/or milestone information associated with the developmental timeline of a system or subsystem. For example, a .pdf document extracted from the Project's Microsoft Project work plan.*
- **SPE**: Specification - *A document related to a purchased item containing its composition, design description, stated functions, and/or performance, e.g., a material datasheet.*
- **STD**: Standard – *A document stating the requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that materials, products, processes, and services are fit for their intended purpose. Standards are often established by external authorities for product assurance purposes.*
- **SYS**: System – *Systems engineering documents such as performance budget, configuration index documents, compliance matrix, change request, waiver, verification cross-reference, etc.*
- **TMP**: Template – *Project Office-prepared template files for design requirements documents, interface control documents, HARA reports, cost sheets, etc.*

The *identifier number* is a unique three-digit number that distinguishes documents with the same WBS code and the same nature. For example, there may be a series of plans and reports that share the same prefix "MSE.PO.ENG.AIV." Therefore, the way to differentiate them is by their sequence numbers. The identifier number starts with 001 and increments by one when a new document with the same WBS code and the same type is created. For example, if there were three AIV reports, they would be numbered sequentially as MSE.PO.ENG.AIV-RPT-001, MSE.PO.ENG.AIV-RPT-002, and MSE.PO.ENG.AIV-RPT-003.

As stated earlier, the numbering scheme for interface control documents and cost sheets differ from the *global name* convention explained above. An Interface Control Document (ICD) specifies the interface design requirements between

two subsystems. Hence, both subsystems' WBS Codes are present in the document name. The subsystem that has been assigned the responsibility to specify the interface requirements by the PO is the interface leader. Consequently, in the document name, the interface leader's WBS code comes first, and then the follower's WBS code. The global name convention for ICDs is:

WBSCode1-WBSCode2-ICD

- **WBSCode1:** WBS Code of the leading subsystem (leader) involved in the interface.
- **WBSCode2:** WBS Code at the following subsystem (follower) involved in the interface, but without its MSE prefix.

Interface Control Documents require no sequence number because each ICD subsystem combination is unique and contains all interface information between two interfacing subsystems. For example, *MSE.SIP.PosS-SIP.FTS-ICD* is the global name for the ICD describing the interface between the Positioner System (leader) and the Fiber Transmission System (follower).

Cost Sheets are organized at the lowest level of the WBS. Each element has its own cost sheet, which is currently an Excel file, and the naming convention is **WBSCode-CostSheet**. For example, the global name of the cost sheet for the Observatory Building and Facilities, Other Spaces and Facilities work element is *MSE.OBF.OTSp-CostSheet.xlsm*

Considering that there are over 450 possible global names (not including interface combinations and sequentially numbered documents), providing each new configurable document with an appropriate global name identifier is a highly controlled process. In the future, the PO may develop an online tool automating the creation and tracking of global names and interface control document names. Until then, for new configurable documents, document owners/creators must request a global name from the SharePoint Administrator, the role responsible for maintaining the *Document Numbering Master List*, an Excel spreadsheet containing custom formulas that ensure every configurable document has a unique global name. For example, one formula checks new global names for interface control documents to make sure that a mirror version does not exist already. That is, the formula displays a warning if a new global name is transposed from an existing interface control document, e.g., "System A → System B" already exists as "System B → System A."

3.2 Version Control

To manage configurable and non-configurable documents, the project uses SharePoint to develop documents and DocuShare to archive the final versions at each project phase. Configurable documents are either version-indexed or under change control. Both types of documents are tracked throughout their respective life cycles in SharePoint and DocuShare, but changes to version-indexed documents do not need to be reviewed and approved by a formal Change Control Board. For the purposes of demonstrating how documents move between SharePoint and DocuShare during development and archiving, this paper will focus on version-indexed documents since the workflow is the same outside of the formal change control process.
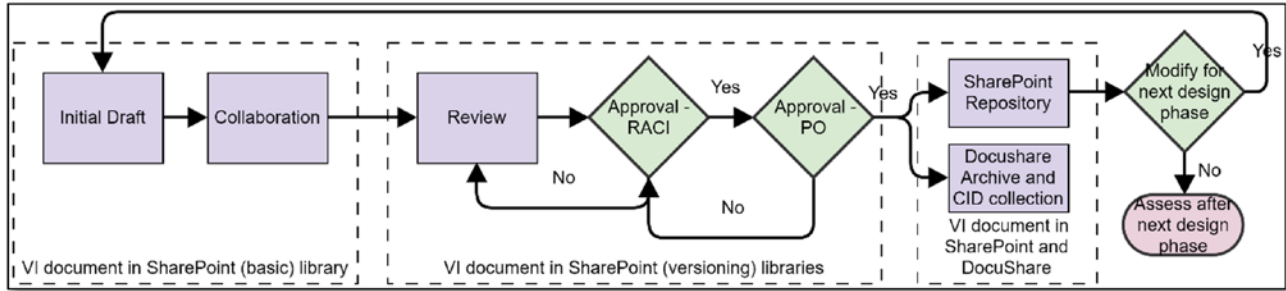
Figure 4. Workflow showing the stages of document development

A newly created version-indexed document may have up to six stages leading to its first release, as illustrated in the workflow diagram in Figure 4. Executed by people identified in the RACI assignment matrix (see Appendix A. RACI Responsibility Assignment Matrix) for that document, those stages include:

1. **Initial Draft** – Accountable person appoints person Responsible for producing initial draft
2. **Collaboration** – The Responsible person (lead author) works collaboratively with co-authors to advance document for review readiness
3. **Review** – Lead author releases document, receives feedback from Consulted person(s) and additional subject-matter experts as directed by Accountable person, and revises document for Approval stage
4. **Approval RACI** –Accountable person approves document, notifies Informed person(s), and submits document to PO representatives for final review and approval (PO representatives differ depending on the nature and purpose of the document)
5. **Approval PO** – Once document is approved, lead author, Accountable person, and PO representatives sign cover page signature block
6. **SharePoint Repository and DocuShare Archive** – Approved and formally released document moves to SharePoint Repository and, in parallel, is archived in DocuShare in its native file format

The PO uses a series of SharePoint libraries to manage the development of configurable documents: Collab, Review, Approve, and Repository (Figure 4). In the collaboration (Collab) library, document changes are not controlled formally. Collaborating authors can work on a file simultaneously, and SharePoint's automatic version history functionality tracks changes by author and timestamp. When a file is being edited in a collaboration library, SharePoint automatically saves a new version of the file every 10 minutes (and often more frequently depending on the pace of editing) for as long as the file is being changed. A user can view previous versions of a document, and even restore a previous version. However, an author cannot attach metadata comments to a specific version to explain what changes were made and why.

Figures 5, 6, and 7 show the user interfaces of the collaboration library "PM Doc Collab" which contains a document, *Automatic Versioning in Collab Library.docx.* Figure 5 lists the contents of the library, and Figure 6 shows the version history SharePoint automatically recorded. The version history starts when the document was first created, and then SharePoint made new versions of the document, one after seven minutes of editing and another five minutes after that. Although SharePoint automatically records the change history of the document by timestamp and author, it does not include the ability to add comments to the versions that are automatically created.
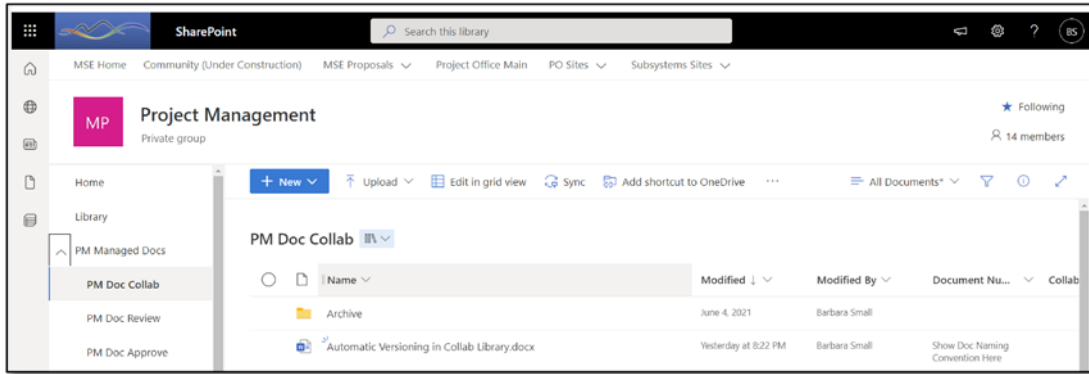
Figure 5. User interface of a SharePoint collaboration library named "PM Doc Collab" in the Project Management SharePoint site of the MSE MS 365 domain

Figure 6. User interface of a SharePoint collaboration library named "PM Doc Collab" in the Project Management SharePoint site of the MSE MS 365 domain

Hovering the mouse over the version's timestamp prompts the context-sensitive menu to appear, and from that menu, a user can choose to view, restore, or delete any of the versions SharePoint creates (Figure 7).

Figure 7. A user can view, restore, or delete any document version SharePoint creates.

When the draft of a configurable document is ready to be reviewed, it moves from the collaboration library into a "Review" library. "Review" libraries and "Approve" libraries incorporate SharePoint's version control functionality: a setting that requires a person to "check out" a file – like a library book – before being able to change it. While a document is checked out to a user, no one else can change it. Once the user has finished reviewing the document, they must check the document in before any edits will be visible to other users. The check-in process includes a step to add

comments in the version history's metadata and to save the file as a minor or major version. A user could refrain from editing the file, but still use the check out and check in process to add comments to a particular version's metadata. Alternatively, if the user does not want to edit the document or make any comments in the version history, they can discard the check out, and the version that existed before the check out will persist as the most current version.
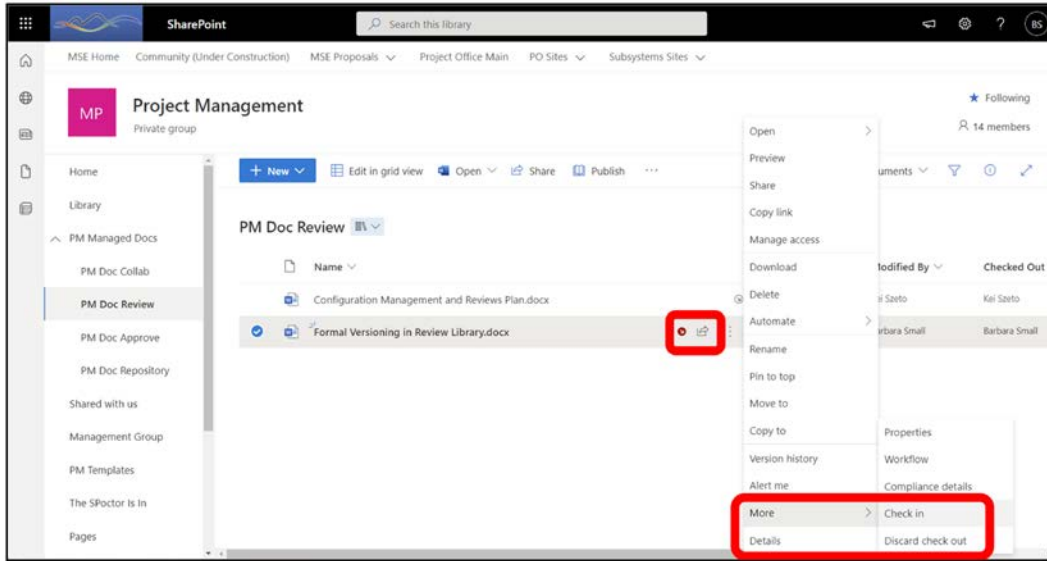

Figure 8. An icon of an arrow in the center of a red dot indicates that the document has been checked out. A user can check in the document and record comments about that version or discard the check out completely.

In Figure 8, the document *Formal Versioning in Review Library.docx* is checked out. No one except the user who has checked out the document can change it. The left side of Figure 9 shows the pop-up interface the user sees when checking in the document. Here, the user can add comments in the version history's metadata. Note that the user can choose to check the document in as a minor or a major version depending on the progression of the review process. The right side of Figure 9 shows the SharePoint library interface after the document has been checked in.
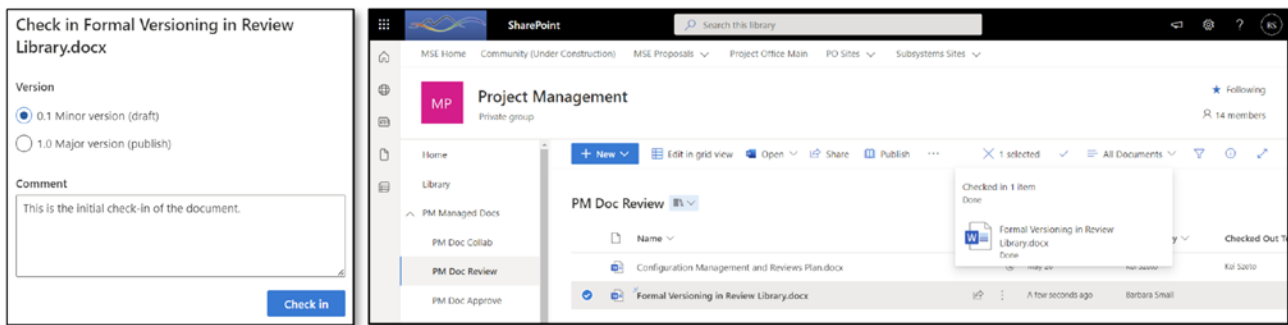

Figure 9. The check-in pop-up and the resulting change in the SharePoint library interface

Using SharePoint's version control setting ensures that any changes to a document in the Review or Approve library are made deliberately and that, when the user checks in the document, the metadata records the timestamp of the check in, the user's name, and the user's comments about that version. In the example in Figure 10, the metadata shows that the user updated the minor version of the document twice and then created a major version. In the Review library, checking

in a document as a major version indicates that the document is ready to move into the Approve library, where the RACI assigned Accountable person will either request additional work and move the document back to the Review library, or approve the document.

Figure 10. Metadata view of a document under formal version control

Note that throughout the process, the document's cover page reflects the status of the document (Figure 11). Draft documents exist in Collaboration libraries only. Once the draft is complete, the document moves into the Review library, and the status on the title page transitions to "Under Review." Once the review is complete, the document moves to the Approve library, and the header status becomes "Pending Approval." Once the document is approved, its status is changed to "Released," and the process of archiving a copy of the approved version in DocuShare and moving the SharePoint version into the "Repository" library begins. This is where document index lists come into effect.

Figure 11. Changes to document cover page as a document evolves

3.3 Document Index Lists

There are two types of document index lists: the Configuration Index Document (CID) and the Project Document Index (PDI). Both are integral parts of the configuration management process. The CID and PDI represent the project's status in science, engineering, and management development at a selected time specified by the PO, which is typically at the end of each project phase.

The CID list includes the configurable documents describing the project's scope as represented by the system performance, cost, and schedule for delivering an observatory that meets MSE's stakeholder aspirations in science operations and science data products. Each CID is divided into three document categories: science, engineering, and programmatic. Science configurable documents delineate the MSE science case into science requirements and operation concepts at the system-level. Engineering configurable documents describe the system architecture and performance and the system decomposition into subsystems and the corresponding requirements and interfaces. A subsystem's engineering documents include its design requirements, interface control documents, design reports, performance analysis, operations, etc. Programmatic configurable documents capture the processes and procedures derived by the PO or by the design teams to plan, execute, manage, deliver, and operate the observatory system or individual subsystems. Programmatic configurable documents include management plans to ensure safety, product assurance, reliability, etc. Detailed descriptions of all configurable documents are contained in the CMRP.

The PDI (Figure 12) contains the CID and pertinent non-configurable documents, typically documents-of-record of management representing project history and corporate knowledge, e.g., statements of work, work package agreements, contracts, annual budgets, proposals, etc. The non-configurable documents are selected at the discretion of the project manager in consultation with the PO team.

When a document is created in SharePoint or uploaded to DocuShare, either system assigns internally a unique, software-generated file locator such that the document can be found within the file structure by its locator. Moreover, both systems treat subsequent revisions of the same document as individual files, assigning each successive version its own locator but "stacking" them so that the most recent version is available to the users as the default version along with the associated version history. A document's unique, software-generated file locator is that document's URL in its respective platform, SharePoint or DocuShare. Each document in the CID and PDI contains a hyperlink to its DocuShare URL file locator specific to a version corresponding to a project phase or a selected time.

| Document Category[b] | Document Title[c] | Project Review[a] | |
		Document Type[d]	CoDR
	L0 Configuration Index Document	SYS	VI
Requirement	Science Requirements Document	REQ	CC
Supplemental	Detailed Science Case	RPT	VI
	A Concise Overview of the Maunakea Spectroscopic Explorer	RPT	VI
Verification	Science Commissioning and Validation Ideas	PLA	VI

| Document Category[b] | Document Title[c] | Project Review[a] | |
		Document Type[d]	CoDR
	L1 Configuration Index Document	SYS	VI
Requirement	Observatory Architecture Document	REQ	CC
	Operations Concept Document	REQ	CC
	Observatory Requirements Document	REQ	CC
Design	Telescope Optical Design Report	RPT	VI
	Sensitivity Budget Allocation Document	SYS	VI
	Observing Efficiency Budget Allocation Document	SYS	VI
Supplemental	N^2 Diagram	SYS	VI
	Fibre Diameter Optimization	RPT	VI
	Telescope Focus Location Decision Matrix	RPT	VI
	Education and Public Outreach Working Group Report	RPT	VI
Operations	Science Calibration Plan	PLA	VI
	Sky Subtraction Requirement Analysis	SYS	VI
Quality Control	Document Numbering Master List	STD	VI
	Review Committee Report Template	TMP	-
Programmatic	Issue Log and Action List	PLA	VI
	Project Cost Book (cost sheets collection)	MGT	VI
Project Review	Review Plan	PLA	VI
	Review Committee Report	RPT	VI

Non-Configurable Documents

PO Annual Budgets Collection

Work Package Agreements Collection

Proposal Collections:

   CFI proposals collection

   DT INSU proposals collection

   NSF proposals collection

Background Documents:

   Fibre core diameter trade-off collection

   Inter-spectra separation collection

[a]Status at the end of each review, the project reviews are described in Section 4, and the status is described in Section 3.1.

[b]Document categories are described in Section 3.6.

[c]Document titles and contents are described in Section 6.

VI = Version Indexed, i.e. current version is deposited in the document container and identified by its locator.

CC = Change Control, i.e. document is under change control.

dDocument type is described in Section 9.5.

Figure 12. Sample Project Document Index (PDI) where each document title is a hyperlink to the DocuShare repository

4. CONCLUSION

Effectively supporting a large, international project requires a hearty framework of software platforms and well-defined processes. In light of project efficiency, it is imperative that those platforms are flexible, intuitive, and affordable. Given that the project documents detailed in the CMRP form the building blocks of the MSE observatory, the selected software platforms must adequately facilitate the processes for tracking configurable documents as they evolve throughout the life of the project. Those processes lead to the creation of discrete sets of configurable and non-configurable documents that reflect the work of each project phase's scientific, technical, and programmatic development at the system and subsystem levels. Through a combination of new and legacy platforms, custom tools, and meticulous manual processes, the MSE project's unified approach for delivering project objectives ensures the integrity of deliverables at each stage of the project, leading to a comprehensive set of documents to support the successful science operations of the Maunakea Spectroscopic Explorer.

APPENDIX A. RACI RESPONSIBILITY ASSIGNMENT MATRIX

In the context of configurable documents, the RACI responsibility assignment matrix defines the roles and responsibilities of the team members. RACI is the acronym of the following roles:

- **Responsible (R)** – The author who develops the document. If there are multiple authors, the Accountable person will assign a lead Responsible person. The Responsible person seeks advice from and maintains two-way communication with Consulted person through the development of the document. The Responsible person maintains one-way communication with Informed person(s) through the development of the document.

- **Accountable (A)** – The Accountable person maintains final approval of the document and maintains its delivery schedule. There is only one Accountable person per document, and that person answers to the Project Manager.

- **Consulted (C)** – Advisor on the contents of the document prior to final decisions. The Consulted person(s) is the subject matter expert who provides advice to the Responsible person through the development of the document.

- **Informed (I)** – Need-to-know person(s) on the contents of the document after a final decision. The Informed person(s) receives information for the Responsible person through the development of the document.

Depending on the nature of the document, the RACI matrix designations are assigned by the Project Manager, Project Scientist, and/or Project Engineer. Below is a summary of responsibilities with respect to the RACI Matrix:

1. A configurable document is assigned an 'A' person and at least one 'R' person as its author. The 'A' and 'R' responsibility could be assigned to the same person.

2. If there are multiple 'R' authors, then a lead author is designated by the 'A' person.

3. The lead author is responsible to coordinate the first three stages (Initial Draft, Collaboration, Review) of the document development, including soliciting feedback from the reviewing members, including all designated 'C' persons.

4. The 'A' person is responsible to interact with the 'I' persons during the Approval – RACI stage.

ABOUT THE MAUNAKEA SPECTROSCOPIC EXPLORER

The mission of the MSE Project is to realize a dedicated facility that enables a diverse suite of large-scale spectroscopic surveys of millions of astrophysical objects at a range of wavelengths, spectral resolutions, redshifts, and spatial scales.

The MSE Project is hosted by the Canada-France-Hawaii Telescope Corporation, and supported by contributing organizations in Canada, France, Hawaii, Australia, China, India, South Korea, Texas, the UK, and the US. The MSE collaboration recognizes the cultural importance of the Maunakea summit to a broad cross-section of the Native Hawaiian community, and is committed to equity, diversity, and inclusion.

Statements of MSE's mission, cultural respect, and equity, diversity, and inclusion are available on https://mse.cfht.hawaii.edu.

REFERENCES

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[2] Szeto K., "Configuration Management and Reviews Plan," MSE.PO.MGT.DOC-PLA-001, MSE project document (July 2022)