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MWA Project

Systems Engineering Management Plan (SEMP)

MWA Project

MWA Consortium

 DRAFT

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Table of Contents

List of Figures

No table of figures entries found.

List of Tables

1. INTRODUCTION

1.1 IDENTIFICATION

This Systems Engineering Management Plan (SEMP) identifies and describes the plans, processes, policies and approaches that will be used by the MWA Project during execution of the project life-cycle.

This plan is subordinate to and consistent with the Project Management Plan (PMP) (cf. ref [2]) and will be used by the Project to provide the primary direction and guidance to the technical teams responsible for conducting the project scope of work.

The SEMP will be subject to configuration control and form part of the project baseline. Accordingly, the SEMP shall require approval by the MWA Board.

1.2 SCOPE

This document describes the Systems Engineering Management Plans and Procedures to manage and integrate key engineering activities in accordance with sound engineering practices. These activities include the development of requirements, design, review, production, verification, and deployment of the MWA radio-telescope and its supporting elements through the project lifecycle.

The deliverable artefacts for the project are fundamentally:

- A Mission System – the MWA radio-telescope; and
- Support System – comprising on-site infrastructure to support ongoing operations of the MWA radio-telescope.

1.3 DOCUMENT OVERVIEW

This document is structured as follows:

- Section 1 Introduction
- Section 2 Referenced Documents
- Section 3 ...

TBD

2. REFERENCED DOCUMENTS

2.1 STANDARDS

[1] MIL-STD-461F, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, US Department of Defense, 10 December 2007.

2.2 MWA DOCUMENTS

[2] MWA-XXX-XXX - Project Management Plan (PMP), MWA Project, XX October 2009, Revision XXXX.

[3] MWA-XXX-XXX - Configuration Management Plan (CMP)), MWA Project, XX October 2009, Revision XXXX.

[4] MWA-XXX-XXX - Test and Evaluation Management Plan (TEMP)), MWA Project, XX October 2009, Revision XXXX.

[5] MWA-XXX-XXX - Operational Management Plan (OMP)), MWA Project, XX October 2009, Revision XXXX.

2.3 OTHER DOCUMENTS

[6] ANSI/EIA- 632, GEIA Standard, Process for Engineering a System, 1998, Government Electronics and Information Technology Association, Arlington, VA.

[7] RFI Standards for Equipment to be Deployed on the MRO, 18 August 2008, CSIRO, ASKAP.

3. ACRONYMS AND DEFINITIONS

The following list of acronyms, abbreviations and definitions are used within this document.

3.1 ACRONYMS AND ABBREVIATIONS

Table 1 contains the acronyms and abbreviations used within this document.

Table 1 Acronyms and Abbreviations

Term	Meaning
CCB	Change Control Board
CDR	Critical Design Review
CE	Commissioning Engineer
CMP	Configuration Management Plan
DA	Design Authority
ECO	Engineering Change Order
ICD	Interface Control Document
MRO	Murchison Radio-astronomy Observatory
MWA	Murchison Wide-field Array
PDF	Portable Document Format
PDR	Preliminary Design Review
PE	Project Engineer
PM	Project Manager
PMP	Project Management Plan
PS	Project Scientist
QM	Quality Manager
RF	Radio Frequency
RTM	Requirements Traceability Matrix
SEMP	Systems Engineering Management Plan
SEWG	Systems Engineering Working Group
SME	Subject Matter Expert
SOW	Statement of Work
TEMP	Test and Evaluation Management Plan
TRR	Test Readiness Review
VCRM	Verification Cross Reference Matrix

3.2 DEFINITIONS

Table 2 contains definitions of terms that are used within this document.

Table 2 Definitions

Term	Description
Acceptance	Formal acceptance by the project sponsors.
Data-pack	A set of artefacts usually provided prior to a Design Review.
Design Authority	A person or organisation responsible for the design to approved specifications and authorised to certify documents, drawings, design, certificates, etc in accordance with procedures identified in the CMP.
Instrument	Unless specifically stated otherwise, the term Mission System or Instrument are synonymous with the MWA radio-telescope – irrespective of the number of tiles.
Mission System	Synonymous with Instrument.
Operations	Phase of the Project in which the Instrument has been completed and accepted and the day-to-day instrument operations are undertaken.
Practical Completion	The point at which the Instrument has successfully undergone in-field verification testing thereby commencing the System Commissioning and Early Science phase of the project.
Product	Products are considered to be the Mission System and Support Systems.
Project	The MWA project.
Support System	Supporting and interfaced elements of the Instrument that are not directly considered part thereof. This includes, *inter alia*, the power distribution system, on-site infrastructure, verification test tools and utilities.

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4. SYSTEM OVERVIEW

The Murchison Wide-field Array is a radio telescope comprised of the following major sub-assemblies based on the nominal design:

- 512 Tiles – each tile consists of 16 dipole antennas and 1 beam-former; two steered, analogue RF signals, one for each polarization, are output.
- 64 Receivers – each receiver processes the RF signals from 8 tiles and converts these signals into digital packets that contain coarse amplitude and frequency information.
- 1 Signal Processor – the information from the receivers is further divided in frequency space, correlated across all tile baselines, and accumulated in 1 second bins.
- 1 Real Time Computer – the output data from the correlator is processed by real time software to yield real-time imaging and archived data sets.

A more detailed overview of the MWA System may be found in the PMP [2], Section 4.

5. ENGINEERING MANAGEMENT

Overall management and control for the MWA project is described in the MWA PMP (cf. ref. [2]). Essentially the Project Management Office (PMO) is the guiding organisation that plans, manages and monitors and controls the project in accordance with the PMP and its subordinate plans, including the SEMP.

System Testing and Evaluation (including Verification or Acceptance testing) are described in the Test and Evaluation Management Plan (TEMP) (cf. [4]) which is subordinate to this plan.

Configuration Management and Change Control for the project will be governed by the Configuration Management Plan (CMP) [3] – a plan that pertains to both project and product work-artefacts. As such, this plan is subordinate to the PMP.

Section 7.1, Structure of Project Plans, of the PMP [2] describes the plan hierarchy for the project.

5.1 ENGINEERING ORGANISATION

The Project Engineer (PE) is a member of the PMO, and shall be the Design Authority (DA) for the Project. Accordingly, the PE will have the overall technical responsibility for the project and is required to ensure the technical requirements of the Mission and Support Systems have been defined and are met.

The PE will work with the technical teams within those various contributing organisations and shall have the authority to direct their activities and resources as necessary.

Moreover, the PE shall be responsible for engineering management across the Project including conducting the system delivery in accordance with the Systems Engineering process described herein. This covers aspects such as requirements capture and analysis, design reviews and audits, verification testing and technical configuration management, along with identifying resource requirements to deliver the technical scope of the project within the project's approved budget and schedule.

The PE shall report to the Project Manager (PM), the lead of the PMO, as shown in the Organisational Chart listed in section 6 of the PMP [2]. The Project Manager will have overall responsibility for the project delivery including, scope, schedule, cost, quality and risk.

In the following sections organisations contributing to the MWA deliverables are listed. The main point of contact between the PMO and these organisations will be through the respective Team Leads (previously referred to as work-packaged managers).

5.1.1 Curtin University

- Receiver packaging via PSI
- System Integration and Deployment
- Site Infrastructure and Support System elements
- EMC Compliance

- Operations and Logistics
- Receiver analogue system and enclosure (transferred from ANU)

5.1.2 MIT Haystack Observatory

- Dipole antenna design and fabrication via Burns Industry
- Beam-former design and fabrication via Burns Industry
- Correlator firmware
- Clock subsystem via ???

5.1.3 MIT Kavli Institute for Astrophysics and Space Research

- Monitor and Control software
- Hardware verification planning and support

5.1.4 Harvard-Smithsonian Center for Astrophysics

- Real Time Computer
- Real Time Software

5.1.5 Raman Research Institute

- Poly-phase Filter Board design and fabrication
- Receiver digital system

5.1.6 University of Western Australia

- Monitoring and Control system design and implementation

5.1.7 Commonwealth Scientific Industrial Research Organization

- Correlator hardware design and fabrication

5.2 TECHNICAL MANAGEMENT FUNCTIONS

Technical management shall be lead by the Project Engineer with overall responsibility for:

- The day to day coordination of the engineering effort;
- DA for the project with ownership of the requirements and associated Mission System and Support System architectures;
- Responsible for identifying and flowing procurement requirements to the PM;
- Responsible for approval of engineering artefacts;
- Coordinating with and reporting to the PM on a daily basis;
- Derivation of requirements, flow-down/flow-up of requirements to/from the respective functional groups;
- Technical management of any SE issues relevant to subcontractors or suppliers; and

- Responsible for identifying and flowing procurement requirements to the PM.

5.3 TECHNICAL COORDINATION

The PE will coordinate the project technical effort of the engineering groups in order that schedule, cost, and performance goals are met. This coordination will take place through regularly scheduled tele-conferences and travel by the PE to each of the contributing organisations.

The PE will provide technical leadership and consultation via the tele-conferences and face-to-face meetings, which will also provide the necessary opportunities for reporting on and reviewing progress against project schedule. The PE will oversee the tracking of requirements through development, generation and review of Interface Control Documents (ICDs) and other controlled project artefacts and the test and evaluation efforts of the project.

It is anticipated that weekly teleconferences will be sufficient to maintain control over the engineering activities with a monthly review cycle. These timings may be varied as needed.

The Commissioning Engineer (CE) will work in concert with the PE and engineering teams to ensure that the above objectives are met, assist in the assurance of functionality and interoperability of the various sub-systems and coordinating the Test and Evaluation programme as described in the MWA Test and Evaluation Management Plan (TEMP) [4].

6. SYSTEMS ENGINEERING PROCESS

Key elements of good Systems Engineering principles and practices may be found in EIA-632 Process for Engineering a System [6]. For the MWA project, key elements to be adopted to help ensure systematic engineering delivery of the Mission and Support Systems include:

- Creating high-level System Requirements by engaging project stakeholders and, in particular, the Project Scientist.
- Decomposing the System Requirements into more detailed requirements and flowing these down to the subsystem level.
- Conducting trade-off studies and gap analyses for:
    - designs, technology assessments or where potential options exist so that a preferred solution may be selected; and
    - Flowing requirements back-up subject to change control measures.
- Conducting technical reviews of requirements, designs, drawings and key engineering artefacts ahead of their approval.
- Undertaking risk identification, assessment and identifying mitigation strategies via updates to the project Risk Register.
- Build and maintain a Requirements Traceability Matrix (RTM) to ensure requirements are not overlooked during system definition and realisation phases.
- Build and maintain a Verification Cross Reference Matrix (VCRM) to ensure requirements are verified in the test and evaluation programme and therefore been subject to formal acceptance testing.
- Supporting procurement via requirements and Statement of Work (SOW) definition, design review and subcontractor technical oversight along with deliverable review and acceptance.
- Undertaking testing (and planning thereof) for unit testing, integration testing and formal Acceptance testing as appropriate and conducting appropriate Test Readiness Reviews (TRRs) prior to their execution.
- Conduct an informal design review of the Mission System design post 32-T demonstration (akin to a Preliminary Design Review) to assess system status ahead of development for 512-T phase of the project.
- Conduct a Critical Design Review for the Mission and Support Systems prior to 512-T build-out focusing on areas of identified immature design status following the 32-T review.
- Ensuring key project and engineering artefacts are subject to configuration management as outlined in the CMP [3].

6.1 REQUIREMENTS

The 32-tile prototype instrument has been created and prototyped in a fairly ad-hoc manner and in the absence of a project planning framework, however this demonstrator does serve as a model from which to define the requirements for a full 512-tile Instrument. Therefore the typical process of “customer involvement” at the requirements phase will be strongly augmented by a review of the design, test results and analysis of the 32-tile prototype system; a process akin to a PDR.

Starting with these System Requirements, a flow-down of these plus other non-functional requirements (e.g., EMC compatibility) will be generated. Each component consists of several sub-assemblies (e.g., antenna and beam-former) which may necessitate its own requirements document. Formal flow-down of requirements will typically end at the sub-system level.

A standing Systems Engineering Working Group (SEWG) chaired by the PE and having the PM, CE and PS as principal members plus other SMEs are required, shall be responsible for documenting and maintaining the requirements down to the subsystem level. Individual contributing organisations shall be responsible for further decomposition as necessary.

A RTCM will be maintained to ensure System Requirements are mapped down to their derivative artefacts.

It should be noted that non-functional requirements may also be a source of System Requirements such as those pertaining to reliability and maintainability of the system in the field, amongst others. The SEWG will therefore consider, at appropriate system review points (such as System Requirements Review or the respective Design Reviews), such requirements and design elements.

6.2 INTERFACE CONTROL DOCUMENTS

Given the dispersed nature of the development aspects of the Project, it is essential that ICDs are generated, reviewed and controlled across the project in order to define and control the physical, electrical, mechanical and data interfaces between the subsystems.

The ICDs and other key engineering documentation will typically be written by the contributing institutions under the direction of the PE, reviewed by the SEWG and signed-off by the PE as the project DA. Note the PE will consult with the PM on the bases that design decisions and requirements may materially affect project scope, cost, schedule and risk.

7. SOFTWARE MANAGEMENT

Software reliability and maintainability and performance is achieved through standard practices of structured coding, appropriate documentation and peer review and unit testing of both software and documentation.

TBD.

8. HARDWARE MANAGEMENT

TBD

9. TEST AND EVALUATION

The Test and Evaluation programme, including formal verification acceptance testing, is described in the Test and Evaluation Management Plan (TEMP) [4] – a subordinate plan to the SEMP.

10. CONFIGURATION MANAGEMENT

Configuration management aspects of the engineering sub-programme of the MWA project are outlined in the CMP [3]; a subordinate plan to the PMP as it covers both project and engineering aspects.

11. SYSTEM REVIEWS AND AUDITS

At each major step in the design and fabrication process being conducted on the individual subsystems, a formal peer review may be held and chaired by the PE or delegate.

In the early stages of the design, the ability to meet the flowed-down technical requirements is of principal importance. At later stages, considerations of testability and maintainability in the field environment gain importance. In all cases explicit statements of requirements, goals and success criteria will define the agenda.

During regular visits, the PE may audit the various organisations to assure their processes and documentation is consistent with Project expectations.

The PE will write (in close collaboration with the MWA engineering teams) the top level System Requirements, Interface Requirements and Preliminary Designs documents. The PMO will review and approve these documents, and oversee the conduct of the System Requirements Reviews, Design Reviews and TRR planning and execution.

As more detailed documents may be derived by the engineering teams, the PE will review and report the results to the PMO. A description of a review framework is outlined in Appendix A.

Appendix A Review Process Framework for Controlled Engineering Documents

Distribution of documentation to be reviewed will typically be via email. The review meeting may be conducted as either face-to-face or via teleconference as the level of review demands. The principle steps in the proposed process are as follows:

- Prepare documents

  The documents are prepared by the Author who then requests the Reviewer to conduct the review.

- Announce review

  The Reviewer identifies and assigns members of the review group, issues a Review Notice email and distributes it to the review group. This notice includes:

  - Review group assignments
  - Date, time and location of review meeting.
  - Expectations of review group members.

- Distribute review material and request comments

  The review notice and copy of document materials are sent electronically to the review group members and posted for comment from the entire MWA collaboration group. Comments are collated a week prior to the review meeting and distributed to the review group members.

- Review meeting

  At the review meeting, the document is presented by the Author (or their representative) and reviewed for completeness. Generally this meeting will be open to all MWA collaborators, but it is expected that at least the engineering team directly involved should attend.

- Review record and report

  The Reviewer or delegate shall record the comments, actions, resolutions etc. as agreed in the discussion with the review group members and obtains group consensus for recommendations and changes to the documents. A report is generated that captures these items and recommends the document for approval contingent upon the recommendations.

- Resolve actions and update document

  The Author is then responsible for updating the document according to the review report.

- Document Sign-off and Release

  The updated document is then submitted to the Reviewer to check that the changes required are undertaken then passes the final candidate artefact to the PE for approval. The PE then follows the sign-off and release procedures as outlined in the Configuration Management Plan in order to to release a new version of the controlled document.

  Once released, the Configuration Manager shall release a notice to MWA collaboration indicating that a new artefact has been updated in the configuration management repository.