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C8U8V8
VERSION CREATED ON / VERSION / STATUS
19 Nov 2024 / 1.2 / Approved
EXTERNAL REFERENCE / VERSION

MQP Level 3

Working Instruction for Reliability, Availability, Maintainability and Inspectability (RAMI) Analysis

This document defines the management requirements relating to RAMI analysis on the ITER Project. It covers RAMI analysis activities during the design development phases of systems and equipment. It does not cover the reliability management of systems that have been commissioned and entered the operations phase. This document does not cover specific details on how to perform RAMI analysis; this is covered in the accompanying RAMI Programme, a core technical document for this process.

The ITER RAMI analysis process applies to all systems that are part of permanent installations at the ITER Facility.

It applies to IO staff and third parties performing any of these activities on the ITER project.

Approval Process			
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Previous Versions Reviews	**Izquierdo J. *** **Fimbel C.**	**28 Oct 2024:recommended v1.1** **29 Oct 2024:recommended v1.1**	**IO/DG/SID/CID** **IO/DG/CP/CIC/INP**
Approver	**Orlandi S.**	**22 Nov 2024:approved**	**IO/DG/CP**
Information Protection Level: Non-Public - Unclassified *RO: Khomutnikov Aleksei*			
Read Access	**GG: MAC Members and Experts, AD: ITER, AD: External Collaborators, AD: External Management Advisory Board, AD: Nuclear Safety Inspectors, AD: OBS - Quality Management Division (QMD), AD: DA, AD: Auditors, AD: ITER Management Assessor, project administrator, RO**		

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Change Log			
Working Instruction for Reliability, Availability, Maintainability and Inspectability (RAMI) Analysis (C8U8V8)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v0.0	In Work	10 Sep 2024	
v1.0	Revision Required	19 Sep 2024	First issue of the document based on the exchanges C8U94U and CBJ3HC
v1.1	Revision Required	18 Oct 2024	1. RACI matrix added 2. The RAMI process output propagation chapter is added to explain how the study results can be applied when preparing MIIP, SRD, DCM, operating and testing manuals. 3. The RAMI input is described for the case when RAMI analysis is driven by configuration change 4. SysRO role is specified as a system owner responsible for all stages of the system development 5. RAMI Major Risk Register is changed to the IO Risk and Opportunities Register 6. MoM is added as a kick-off meeting output. A dedicated checklist is created 7. The kick-off meeting topics are specified 8. Other minor modifications as per reviewers' comments
v1.2	Approved	19 Nov 2024	The role of SIRO was defined throughout the RAMI process; the RAMI updates driven by PCR, DR, NCR were detailed as per Y.Vanpoperynghe comments. See also "v1.1 Q&As" file attached

Table of Contents

1 Purpose

This MQP Level 3 defines the management requirements for Reliability, Availability, Maintainability, and Inspectability (RAMI) analysis.

2 Scope

This Working Instruction (WI) defines the management requirements relating to RAMI analysis on the ITER Project. It covers RAMI analysis activities during the design development phases of systems and equipment and system updates driven by project evaluation and nonconformances found (PCR, NCR, DR). This document does not cover specific details on how to perform RAMI analysis; this is covered in the accompanying RAMI Programme [2], a core technical document for this process.

The ITER RAMI analysis process applies to all systems that are part of permanent installations at the ITER Facility.

It applies to IO staff and 3rd parties performing any of these activities on the ITER project.

3 Definitions and acronyms

Acronym	Term	Definition
A	Availability	Ratio of operating time to the sum of operating time and downtime during experimental campaigns, assuming that required external resources are provided
ALARA	As Low As Reasonably Achievable	As per [7]
	Basic Function	Bottom-level system function identified as per the IDEFØ methodology
C	Criticality	Product of Occurrence and Severity, used to rate the risk level of a component failure
DCM	Design compliance Matrix	As per [25]
DR	Deviation request	As per [22]
DIRO	Design Integration Responsible Officer	See [18] for a list of DIRO
FMECA	Failure Modes, Effects & Criticality Analysis	Method using both the functional breakdown and RBD as input
FA	Functional Analysis	Schematic representation of all the functions that a system is intended to perform
IDEFØ	Integration Definition Function Modelling language Ø	Format used to describe the top-down functional breakdown of a system using blocks for functions, with their input, output, controls, and mechanisms
I	Inspectability	Capacity of a system to be monitored, accessed, and diagnosed (in the Iter RAMI process, it is assessed in terms of access constraints condition monitoring, etc. but not calculated as a probability)
IDM	ITER Document Management (system)	
IO	ITER Organization	
M	Maintainability	Capacity of a system to be repairable (in the Iter RAMI process, it is quantified in terms of access constraints and availability of spares… but not calculated as a probability)
MIIP	Maintenance & In-Service Inspection Plan	As per [14]

MLD	Mean Logistics Delay	Refers to the logistic delay in executing a corrective maintenance action, specifically to the time required to get the spare part needed to replace the faulted item. If no spare is provided on-site, its procurement depends on whether the units are procurable in the market (COTS components) or not (CUSTOM components)
MoM	Minutes of Meeting	
NCR	Nonconformity Report	As per [23]
PBS	Plant Breakdown System	
PCR	Project Change Request	As per [21]
R	Reliability	Probability that a device will perform its function without failure over a specified length of time and under given conditions
RAMI	Reliability Availability Maintainability Inspectability	
RAMI RO		In the context of this WI, it's a person ensuring the ITER RAMI transverse function and acting on behalf of TF-M as per [7]
RBD	Reliability Block Diagram	Diagrammatic method for modeling a complex system to calculate its reliability and availability based on the properties and configuration of its components' reliability and maintainability.
RH	Remote Handling	
RO	Responsible Officer	
SIRO	System Integration Responsible Officer	As per [26]
SMART	Specific, Measurable, Achievable, Relevant, Trackable	
SME	Subject Matter Expert	In terms of this WI, it means the persons experienced in maintenance
SOA	Sign off Authority	Sign off Authority for project documents as per [3]
SRD	System Requirements Document	As per [18]
SysRO	System Responsible Officer	System RO oversees the system's full life cycle. It is, by default, the Project Leader of the delivered system. Project Leader (System RO) may nominate qualified staff(s) for System RO duties with associated responsibilities and authority to one or more employees of the ITER Organization who have the competence to accomplish the tasks under her/his Organization Breakdown Structure (OBS). Refer to [18]
TF-M	Transverse Function Officer accountable for Maintenance	As per [7]
WI	Working Instruction	

4 References

[1] Design Development Procedure (U34DDZ)
[2] ITER RAMI Analysis Programme (28WBXD)
[3] Sign-Off Authority for Project Documents (2EXFXU)
[4] Project Requirements (27ZRW8)
[5] RAMI Analysis Report Checklist (Y2LYQA)
[6] Template for RAMI Analysis Summary Reports (2N3SS9)
[7] Nominative list of TF Officers (B6ZAYS)
[8] Guidelines for ALARA Implementation (W6655F)
[9] Working Instruction for the Preparation of System Maintenance & In-Service Inspection Plans (YH3TFW)
[10] ITER RAMI reports overview (B9TVWP)
[11] IO Risks and Opportunities Register
[12] Design Development Procedure (U34DDZ)
[13] Design Verification & Validation Procedure (R3KD8C)
[14] Maintenance and Maintainability Design Plan (7WSRDW)
[15] Remote Handling Compatibility Procedure (2NRTWR)
[16] Procedure for Inspection and Testing (TVL3Y5)
[17] WI - Management of operational documentation (5EYHR7)
[18] Procedure for SRDs/SSRDs creation and revision (25DSU2)
[19] Deviation request to MQP documents describing responsibilities modified for the 2023 Re-organization (8Z7X9Q)
[20] List of DIRO (5J4L25)
[21] Project Change Procedure (22F4E5)
[22] Procedure for the management of Deviation Request (2LZJHB)
[23] Procedure for Management of Nonconformities (22F53X)
[24] RAMI Kick-Off Meeting Check List (BBMRN9)
[25] Design Compliance Matrix Procedure (473LQM)
[26] Assignment of the System Integration Responsible Officers (SIROs) (8E6WQ9)

5 Workflow

5.1 Flowchart

Figure 1 presents the workflow for developing the RAMI report, with the main steps described in the subsequent sections.

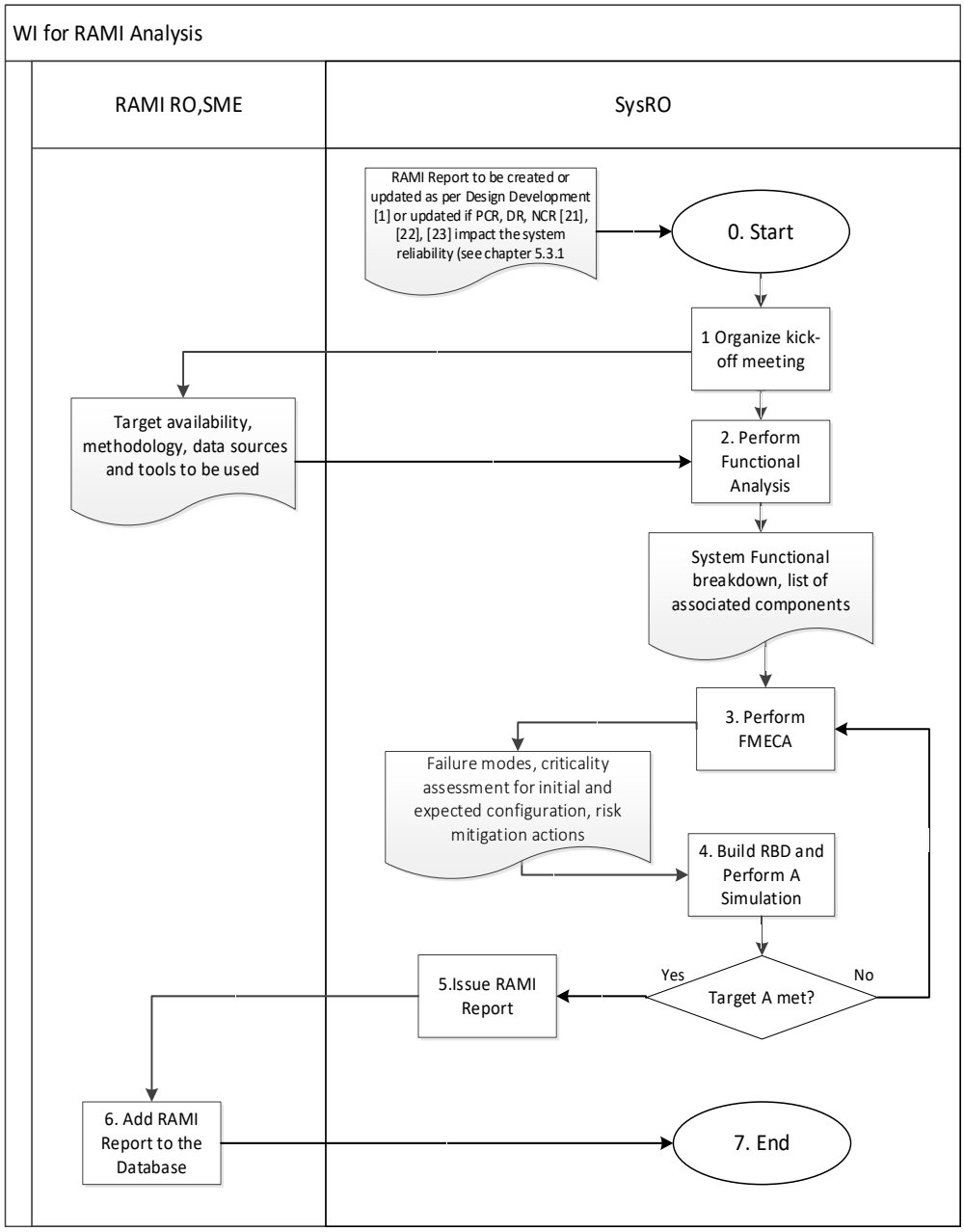

Figure 1 - RAMI Analysis Workflow

5.2 Responsibilities

Following current WI, RAMI RO is responsible for:

- Defining methodologies to perform FMECA, RBD, and Availability simulation, RAMI Analysis Summary Report;
- Reviewing RAMI Analysis Summary Report authored by SysRO;
- Updating the IO RAMI reports database [10] and IO Risks and Opportunities Register [11].

The SysRO is responsible for:

- Launching the RAMI Analysis as discussed in 5.3.1;
- Organizing the dedicated kick-off meeting;
- Performing the RAMI Analysis following [2] and [6];
- Involving the SME where required to ensure the summary report completeness;
- Propagating the RAMI Analysis Summary Report outputs.

5.3 Description of steps

5.3.1 Activity 0: Start

RAMI analysis is initiated at the Conceptual Design phase and shall be updated at each design phase (Preliminary and Final Design phases) along with the system's design development.

In addition, RAMI analysis may be impacted in case of change (PCR, DR, NCR) – see section 6.3In such a case, RAMI documentation shall be updated to verify that the system's target availability is still met.

SysRO will launch the RAMI analysis process as per this WI.

5.3.2 Activity 1: Organize a kick-off meeting

Each revision of the RAMI analysis summary report begins with a kick-off meeting, which SysRO shall organize. The list of mandatory attendees includes RAMI RO and (preferably) the person assigned to perform the study. Other SMEs can also attend if needed. During the meeting, the SysRO shall describe the system and the system's maturity. RAMI RO shall describe the RAMI process, applicable methodology, data sources and tools. SysRO and RAMI RO shall confirm the target availability value from Project Requirements [4] or specific documents prepared by their Project/Program or other entities on its behalf, define the inputs for the system functional analysis, list the major constraints related to the systems Inspectability and Maintainability (access rules, time required to access the components, safety considerations that shall be considered while calculating the time required to access and repair/replace the system’s components, etc.).

All decisions shall be recorded in MoM (see Chapter 7) following [24].

5.3.3 Activity 2: Perform system functional analysis

The SysRO shall assign the person who will perform the study (from now on in the text – the author).

The author shall perform the system's functional analysis (FA) based on the IDEFØ language per [2].

The FA identifies the functions the system intends to perform and the associated components to be analyzed at the following step of the study. It forms the basis for assessing failure modes and building the Reliability Block Diagram (RBD) for the availability simulation.

5.3.4 Activity 3: Perform Failure Modes Effects Criticality Analysis (FMECA)

The author performs an FMECA to identify system/component failure modes for proper risk mitigation actions targeting following the RAMI Programme [2].

Following [2], the risks shall be categorized as Major (where mitigation actions are required), Medium (mitigation actions are recommended), and Minor (mitigation actions are optional).

The definition of mitigation actions should follow the principles of SMART and represent the most important output of the RAMI process since they provide sufficient input for system design, maintenance, and operations throughout the system lifecycle.

The author shall prove that the mitigation actions result in the absence of Major risks in the system's expected configuration.

The main output of the FMECA is the identification of failure modes, with the criticality category assigned as per [2], together with associated risk mitigation actions to reduce the overall level of risk through design, test, operational, or maintenance-related actions.

The ALARA principles shall be considered while reviewing the mitigation actions aimed at reducing the time required to access and repair the components [7].

The Major risks for which criticality wasn’t mitigated shall be recorded in [11].

SysRO shall be assigned to these records. Unresolved criticality shall be considered an exception due to the imperfections of modern technologies or the cost of mitigating risks that significantly exceed the effect of a single SSC failure. It thus shall be considered as a Project risk.

5.3.5 Activity 4: Build RBD and perform Availability simulation

The author shall build a mathematical reliability model according to [2] to evaluate the system's predicted availability performance.

The author applies the data from the study's previous steps and runs initial and expected configurations to get the Reliability and Availability values.

If target availability isn't reached, mitigation actions from FMECA should be re-analyzed, and a new model will be built.

5.3.6 Activity 5: Review the RAMI Report

A consolidated list of RAMI actions shall be demarked and included in the System RAMI Analysis Report produced as per the standard template for RAMI reports [6].

RAMI RO shall perform the report review as per the RAMI Programme [2] and the RAMI summary report checklist [5].

In addition, other SMEs can be asked to review the report.

5.3.7 Activity 6: Add RAMI report to the database and propagate the output

Once the SysRO Line Manager approves the report, the RAMI RO shall add the report to the IO RAMI reports database [10] and IO Risks and Opportunities Register [11].

5.3.8 Activity 7: End - Propagate the RAMI report output

SysRO, as a system owner, is responsible for proper RAMI output propagation.

The RAMI Analysis Report is an input for further system design development at the CDR and PDR. At the same time, at FDR, it confirms the proper allocation of design, maintenance, operations, and testing features to manage the project risks within its lifecycle.

The DCM is authored by SysRO and reviewed by the SIRO as per the [3]. RAMI RO is consulted as much as needed in this compliance verification.

According to [9], the MIIP shall detail the maintenance activities to be carried out within the system lifecycle.

The maintenance-related activities listed in FMECA as risk mitigation actions shall be used as input for the MIIP. The SysRO is responsible for the MIIP development; RAMI RO and DIRO can be consulted as reviewers.

The risk mitigation actions that concern operations and testing shall be used as input for the system operations manual and test procedures [16], [17].

6 Interactions with other processes

6.1 Operations and Maintenance

The preventative maintenance and inspection considerations, defined as failure effects criticality mitigation, shall be used for the MIIP production as per the Working Instruction for the Preparation of System Maintenance & In-Service Inspection Plans [9].

In addition, the list of spares recommended to limit MLD shall be referenced in the system MIIP required spare parts list.

The RAMI Analysis Summary Report produces an output for the possible design and provides provisions for further system operations to increase target availability [17].

6.2 Inspection and Testing

The RAMI Analysis Summary Report can produce provisions for the planning, monitoring, and executing inspections and testing under [16].

6.3 Configuration management

In case of PCR [21], DR [22] or nonconformance [23], SysRO shall assess the impact of the change on the documents in his/her scope that allow to verify that system requirements such as availability target are still met. Therefore, the impact on RAMI Analysis Summary Report shall be assessed by SysRO in case of change (PCR, DR or NCR).

In addition, RAMI RO or other SME on his behalf is systematically involved in the PCR impact assessment to check that the impact on system availability has been properly assessed by SysRO.

Moreover, SIRO liaises with RAMI RO to check that the impact of NCR or DR [22], [23] on the RAMI analysis has been properly assessed by the SysRO.

As general guidance, the RAMI reassessment shall be launched in the following cases:

a. System changes its designation (functionality),
b. Deterioration of environmental conditions (humidity, ambient temperature, dust, radiation, etc), which may lead to a reduction in the service life of equipment or an increase in the time required for its repair (e.g., accessibility),
c. Changing the approach to forming a pool of spare parts for the main system's components, which may lead to unexpected logistics delays,
d. Increasing the duty cycle of the system's components,

e. Changing the service life of components, changing the time required to repair components, using components that have these values different from the original, and changing the number of identical components,

f. Changing operating instructions, concept of operations, or testing of system parts that may lead to the above changes.

6.4 Internal Interactions (Design Control)

The RAMI Analysis Summary Report produces an output (operational risks mitigation actions, see 5.3.4) for the design reassessment as per the Design Development Procedure [12], the Design Verification & Validation Procedure [13], and the Maintenance and Maintainability Design Plan [14].

The availability targets defined in the PR [4] shall be propagated in the SRDs and sub-SRDs as per [3] and [18] and used as the reference for the RAMI Analysis Summary Reports review.

The RAMI analysis summary report demonstrates that the RAMI requirements are met. It is a design justification document and shall be presented in the Design Compliance Matrix written as per [3].

Remote Handling compatibility is a specific maintainability demonstration established via the Remote Handling Compatibility Procedure [15]. Existing RH Plant Definition Forms (PDF) and RH Task Definition Forms (TDF) may reference the mitigation actions outlined in the RAMI Analysis Summary Report where relevant.

7 Records

Record	Author(s) (R)[1]	Reviewer(s) (C)	Approver (A)	Informed (I)
MoM - RAMI Analysis kick-off meeting	SysRO	-	-	RAMI RO, person assigned to perform the study
RAMI Analysis Summary Report[2] (per [3])	SysRO or assigned person	RAMI RO, SME, SysRO if not an author	SysRO Line Manager	SIRO
RAMI Reports Database	RAMI RO			SysROs
IO Risks and Opportunities Register	RAMI RO			SysROs

Table 2 - RAMI process records table

Record	Template UID	Place to store, UID	Doc type and UID	Naming convention	Retention period[3]
MoM - RAMI Analysis kick-off meeting	BBMRN9	IDM, PBS folder	[DR]-Minutes of Meeting	MoM of [SYSTEM NAME] RAMI Analysis kick-off meeting	Life of the project
RAMI Analysis Summary Report	2N3SS9	IDM, PBS folder	[PRO-IO-DM]-Engineering Analysis	[SYSTEM NAME] RAMI Analysis Summary Report	Life of the project
RAMI Reports Database	N/A	ITER RAMI ANALYSIS PROGRAMME	[PRO-IO-DR]-Report *	ITER RAMI reports overview	Life of the project

[1] Responsible (Doer), Accountable (Approver), Consulted (Contributor/Reviewer/Attendee), Informed (User)
[2] It's possible to split the RAMI analysis report to several separate documents
[3] External standards and regulations may govern the retention period. The responsible team in charge of records shall consult the Legal, Safety, and Quality Assurance Division to ensure a proper definition of retention periods)

IO Risks and Opportunities Register	N/A	ITER RAMI ANALYSIS PROGRAMME	Risk	[SYSTEM NAME] RAMI Project Risk	Life of the project

Table 3 - RAMI Output Documents Summary