

FNMux

Project Management Plan

F

**Failsafe Network Multiplexer (FNMux)**

**Document ID:TE/FNMux/PMP**

**Version 1.0**

Approval History

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|  | Name | Designation | Signature |
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# Preface

Fail-safe Network Multiplexer (FNMux) developed by Team Engineers (TE), is required to meet the Technical & Operational requirements of the RDSO specification “RDSO/SPN/11/2022” for transporting vital signalling information from interlocking to field using dual redundant OFC media in a fail-safe manner and driving the relays/end equipment in the field. FNMux consists of the following functions

* Exchange of vital signaling digital I/O information from interlocking to field using the dual redundant OFC
* Driving the relays / end equipment in the field

For detailed explanation of each of the above functions and supporting functions refer RDSO Specification RDSO /SPN /211/2022, Effective Date: 24.11.2022 [Ref 1]

## Purpose

The purpose of the document is to provide a plan for system design and development that covers the project lifecycle including hardware, software and project schedules for FNMux. This plan is the basis for the execution and tracking of all design and development activities of FNMux. It shall be used throughout the design and development lifecycle of the Project and shall be kept up to date to reflect the actual accomplishments and plans of the Project. This plan covers the FNMux RAM and Safety activities. Following are included as part of this plan

1. Provide the standards, practices and lifecycle methodology adopted for Design and Development
2. FNMux Organization Structure
3. Procedure for development of TCAS System Requirement Specification
4. FNMux Design tasks and responsibilities
5. FNMux Resource requirements
6. Provide reference documents and guidelines to perform the Design activities
7. Provides interfaces for all different stakeholders of the project.
8. Provides Overall Work Breakdown structure for the project, with Schedule, budget and manpower allocations.
9. Provides Risk analysis for handling the lifecycle of the project.
10. Relationship with Other Plans
11. Training Plan

## Scope

## Schedule

The Project Schedules are identified as part of project deliverables in Work Breakdown Structure and is added as Annexure – A.

## Budget Summary

The Budget for this project may be approved by MD based on the following factors

* Manpower pertaining to design, development, installation, commissioning and field trials given subsequent sections.
* Material requirement for the project shall be available in Engineering department and shall be base for calculation of cost of equipment.

Budget shall be worked out independently and approved by MD and any further changes in budgetary allocations shall be initiated by the PM and shall be approved by MD as and when required.

## Definitions

|  |  |
| --- | --- |
| Terms | Definitions |
|  |  |
|  |  |

Table 1: Definitions

## Acronyms and Abbreviations

|  |  |
| --- | --- |
| ABBREVIATIONS | DESCRIPTION |
| **ADAD** | Application Data Architecture And Design |
| **ADAVR** | Application Data/Algorithm Verification Report |
| **ADPP** | Application Data Preparation Plan |
| **ADRS** | Application Data Requirements Specification |
| **ADTR** | Application Data Test Report |
| **ADTS** | Application Data Test Specification |
| **APVR** | Application Preparation Verification Report |
| **CENELEC** | European Committee for Electrotechnical Standardization |
| **CM** | Commissioning Manual |
| **CMP** | Configuration Management Plan |
| **CPS** | Communication Protocol Specification |
| **CS** | Coding Standards and Guide lines |
| **CU** | Central Unit |
| **DP** | Document Plan |
| **EL** | Field Trial Records |
| **EN** | European Norm |
| **ESS** | Electronic Support System |
| **ESSR** | Electronic Support System Report |
| **FAT** | Factory Acceptance Test |
| **FMECA** | Failure Modes Effects and Criticality Analysis |
| **FNMUX** | Failsafe Network Multiplexer |
| **FRACAS** | Failure Reports and Corrective Actions |
| **FTA** | Fault Tree Analysis |
| **FTP** | Functional Test Procedure |
| **FTR-SL** | Functional Test Reports at System Level |
| **FTR-CL** | Functional Test Reports for Card Level |
| **FTS** | Fail Safety Test Specification and Report |
| **FU** | Field Unit |
| **GASC** | Generic Application Safety Test |
| **HAS** | Hardware Safety Analysis |
| **HDD** | Hardware Design Description |
| **HRS** | Hardware Requirements Specification |
| **HVR** | Hardware Validation Report |
| **HZA** | Hazard Analysis |
| **HZL** | Hazard Log |
| **IM** | Installation Manual |
| **ISO** | International Organization for Standardization |
| **MFPR** | Manufacturing Process Record |
| **MIP** | Manufacturing and Inspection Plan |
| **MM** | Maintenance Manual |
| **OSTR** | Overall Software Test Report |
| **OSTS** | Overall Software Test Specification |
| **PCCL** | Pre-Commissioning Check List |
| **PHA** | Preliminary Hazard Analysis |
| **PMP** | Project Management Plan |
| **QMS** | Quality Management System |
| **QP** | Quality Plan |
| **RAM** | Reliability Availability and Maintainability |
| **RAMA** | RAM Analysis |
| **RAMP** | RAM Plan |
| **RDSO** | Research Design and Standards Organization |
| **RNDV** | Release Note and Deployment Plan |
| **RNVP** | Release Note and Validation Plan |
| **SAD** | System Architecture Description |
| **SADVR** | Software Architecture and Design Verification Report |
| **SCAD** | Source Code of Application Date |
| **SCMP** | Software Configuration Management Plan |
| **SCR** | Software Change Record |
| **SCTR** | Software Component Test Report |
| **SDM** | Software Deployment Manual |
| **SDP** | Supplies Development Plan |
| **SDR** | Software Deployment Records |
| **SDVR** | Software Deployment Verification Report |
| **SHITR** | Software/Hardware Integration Test Report |
| **SHITS** | Software/Hardware Integration Test Specification |
| **SIL** | Safety integrity level |
| **SIS** | Software Interface Specification |
| **SITR** | Software Integration Test Report |
| **SITS** | Software Integration Test Specification |
| **SIVR** | Software Integration Verification Report |
| **SMP** | Software Maintenance Plan |
| **SMR** | Software Maintenance Records |
| **SMVR** | Software Maintenance Verification Report |
| **SPI** | Serial Peripheral Interface |
| **SPN** | Specification Number |
| **SQAP** | Software Quality Assurance Plan |
| **SQAPVR** | Software Quality Assurance Plan Verification Report |
| **SRS** | System Requirement’s Specification |
| **SRSVR** | System Requirement’s verification Report |
| **SSCD** | Software Source Code and Supporting Documentation |
| **SSCVR** | Software Source Code Verification Report |
| **SSP** | System Safety Plan |
| **SSVR** | System Requirement’s Specification |
| **STS** | System Test Specification |
| **STVR** | Software Tools Validation Report |
| **SVR** | Software Validation Report |
| **TTL** | Traceability Table |
| **UM** | User Manual |
| **VAP** | Validation Plan |
| **VP** | Verification Plan |

Table 2: Acronyms and Abbreviations

## References

The following are the reference documents for Verification and Validation of FNMUX:

|  |  |  |
| --- | --- | --- |
| Reference no. | Document Title | Document Description |
| Ref. 1 | RDSO /SPN /211/2022, Date Effective:24.11.2022 | Specification for Failsafe Network Multiplexer (FNmux). |
| Ref. 2 | EN 50126-1:2017  EN 50126-2:2017 | Railway Applications- Specifications and demonstration of Reliability, Availability, Maintainability & Safety. |
| Ref. 3 | EN 50155:2017 | Railway applications - Rolling stock  - Electronic equipment |
| Ref. 4 | EN 50128-2020 | Railway Applications-Communications, Signaling and processing systems-Software for Railway Control and Protection Systems. |
| Ref. 5 | EN 50129:2018 | Railway Applications-Communications, Signaling and processing systems- Safety Related Electronics Systems for Signaling. |
| Ref. 6 | EN50159:2010 | Railway Applications-Communications, Signaling and processing systems - Safety related communication in closed transmission systems. |

Table 3: References

# **System Description – FNMUX**

Fail safe Network Multiplexer system will consist of a distributed multiplexer. modules, connected in a network, constituting a network of fail-safe multiplexer modules for exchange of vital signaling information among fail-safe multiplexer modules. The system architecture shall allow the formation of a scalable centralized unit of modules (FNmux Central Unit -CU) to concentrate I/O from the distributed field modules (FNmux Field Unit -FU). Furthermore, the network protocol and addressing technique adopted shall be such that any pair of vital modules, either in the central unit or in the field unit can be virtually connected from any point to any point. The FNMux Central unit shall also be able to communicate with Data Logger

The main purpose of FNMux is to transfer vital signaling information from FU to CU and from CU to CU meeting SIL4

A picture containing text, screenshot, diagram, colorfulness

Description automatically generated The Figure 1 below gives the FNMUX top level block diagram.

Figure 1: System Overview

# FNMux project Organization structure

## Organization Structure



Figure 2: Organization Structure

## Roles and Responsibilities

### Head Technical/CEO

|  |  |
| --- | --- |
| Role | Project Director |
| Responsibilities | - Design & Engineering Technical Support  - Support of Safety Process documentation  - Project Contractual fulfillment  - Budget reviews and allocations |

Table 4: Roles & Responsibilities of the Project Director

### Project Manager

|  |  |
| --- | --- |
| Role | Project In charge |
| Responsibilities | - Project Contractual fulfillment  - Design & Engineering Process Implementation and approval  -Project Field Trials and project approval  - Project Safety Certification - coordination and support.  - Product Delivery as per SIL4 |
| Key Competencies | - Shall have experience in design as per EN standard  - Shall have experience in design of Embedded systems involving multiple processor architecture  - Shall have experience in development processes associated with safety systems  - shall understand quality, competencies, organizational and management requirements as per EN 50126[Ref 2], EN 50129[Ref5] and ISO 9001:2015. |

Table 5: Roles & Responsibilities of Project Manager

### Hardware Manager/Designer

|  |  |
| --- | --- |
| Role | Hardware Requirements and Design |
| Responsibilities | - Hardware Design & Engineering Process Implementation  - Shall own the System Requirements Specification allocated to the hardware  - Shall maintain traceability between system level requirements and Hardware requirements  - Shall ensure configuration management of Hardware design changes  - Shall develop and maintain hardware and safety documents related to safety process |
| Key Competencies | - Shall be competent in requirements engineering  - Shall understand the safety attributes of FNMUX application domain  - shall understand quality, competencies, organisational and management requirements as per EN 50126[Ref 2], EN 50129[Ref 5] and ISO 9001:2015  - Shall have min 5 years of experience in hardware design |

Table 6: Roles & Responsibilities of Hardware Manager/Designer

### Software Manager/Designer

|  |  |
| --- | --- |
| Role | Software Requirements and Design |
| Responsibilities | - Software Design & Engineering Process Implementation  - Shall own the System/Software Requirements Specification  - Shall maintain traceability between system level requirements and Software requirements  - Shall ensure configuration management of Software design changes  - Shall develop and maintain Software documents related to design including safety and non-safety functions. |
| Key Competencies | - Shall be competent in requirements engineering  - Shall understand the safety attributes of FNMUX application domain  - shall understand quality, competencies, organizational and management requirements as per EN 50126[Ref 2], EN 50128[Ref 4], EN 50129[Ref 5],and ISO 9001:2015.  - Shall be graduate with min 5 years of experience in Software design |

Table 7: Roles & Responsibilities of Software Manager/Designer

### Hardware Design Implementer

|  |  |
| --- | --- |
| Role | Hardware Design & Implementation |
| Responsibilities | - Shall transform the Hardware requirements into acceptable design solutions  - Shall implement and test as per the architecture and design solutions  - Shall apply appropriate design principles and standards  - Shall ensure traceability of hardware requirements to design  - Shall develop and maintain design documents and implement change control for the same |
| Key Competencies | - Shall be competent in hardware design and implementation  - Shall have exposure to safety design principles  - Shall be competent in design principles and design test methods  - shall understand relevant parts of EN 50126[Ref 2], EN 50128[Ref 4], EN 50129[Ref 5] and ISO 9001:2015  - Shall be graduate with min 2 years of experience in Hardware design |

Table 8: Roles & Responsibilities of Hardware Design Implementer

### Software Design Implementer

|  |  |
| --- | --- |
| Role | Software Design & Implementation |
| Responsibilities | - Shall transform the Software requirements into acceptable design solutions  - Shall implement as per the architecture and design solutions  - Shall apply appropriate design principles and standards  - Shall ensure traceability of Software requirements to design  - Shall develop and maintain design documents and implement change control for the same |
| Key Competencies | - Shall be competent in Software design and implementation  - Shall have exposure to safety design principles  - Shall be competent in design principles and design test methods  - shall understand relevant parts of EN 50128[Ref 4]-2011 and ISO 9001:2015  - Shall be graduate with min 2 years of experience in Software design |

Table 9: Roles & Responsibilities of Software Design Implementer

### Software Tester

|  |  |
| --- | --- |
| Role | Software Testing |
| Responsibilities | - Shall transform the System/Software requirements into Test Plan and Test specifications  - Shall test the system/Software as per the Test Plan, Test Specification  - Shall apply appropriate testing principles and standards  - Shall ensure traceability of requirements to Test Cases  - Shall develop and maintain Test documents and implement change control for the same |
| Key Competencies | - Shall be competent in System/Software testing and implementation  - Shall have exposure to safety requirements  - Shall be competent in testing principles and test methods and ability to choose the right method for testing process as per SIL-4  - Shall have the analytical thinking ability and good observation skills  - shall understand relevant parts of EN 50128[Ref 4] and ISO 9001:2015.  - Shall be graduate with min 1 years of experience in Software testing |

Table 10: Roles & Responsibilities of Software Tester/Validator

### Hardware Tester

|  |  |
| --- | --- |
| Role | Hardware Testing |
| Responsibilities | - Shall transform the System/Hardware requirements into Test Plan and Test specifications  - Shall implement as per the Test Plan, Test Specification  - Shall apply appropriate testing principles and standards  - Shall ensure traceability of system/hardware requirements to Test Cases  - Shall develop and maintain Test documents and implement change control for the same |
| Key Competencies | - Shall be competent in System/Hardware testing and implementation  - Shall have exposure to safety requirements  - Shall be competent in testing principles and test methods and ability to choose the right method for testing process for SIL-4  - Shall have the analytical thinking ability and good observation skills  - shall understand relevant parts of EN 50126[Ref 2], EN 50129[Ref 5] and ISO 9001:2015  - Shall be graduate with min 1 years of experience in Hardware testing |

Table 11: Roles & Responsibilities of Hardware Tester/Validator

### Verifier

|  |  |
| --- | --- |
| Role | System, Hardware, and Software Verification |
| Responsibilities | - Shall transform the System/Hardware/Software requirements into Verification Requirements  - Shall apply appropriate verification techniques/measurers mentioned in E.8 of EN50129 [Ref 5]and B.5 of EN50128[Ref 4]  - Shall be responsible for Safety, including Safety Audits and Reviews  - Shall be responsible for Quality Audit  - Shall apply appropriate verification principles and standards  - Shall ensure traceability of requirements to design to Test Cases and results  - Shall develop and maintain Verification documents and implement change control for the same |
| Key Competencies | - Shall be competent in System, Hardware, and Software Verification  - Shall have exposure to safety requirements  - Shall be competent in various verification methods and ability to choose the right method for the verification  - Shall be capable of deriving the types of verification from the given specification  - shall understand relevant parts of FNMUX Specification, CENELEC Standards and ISO 9001:2015.  - Shall have min 3 years of experience in Verification |

Table 12: Roles & Responsibilities of Verifier

### Validation & Safety Manager

|  |  |
| --- | --- |
| Role | Validator |
| Responsibilities | - Shall transform the System, Hardware, and software requirements into Validation Requirements  - Shall apply appropriate validation principles and standards as per E.8 of EN50129[Ref 5] and B.7 of EN50128[Ref 4]  - Shall evaluate all applicable phases of life cycle to validate that the evidence is adequate to fulfil the FNMUX Specification.  - Shall generate a Validation Report based on which Hardware and Software Release is done  - Shall ensure the FNMux system design is safe as per EN50126[Ref 2]  - Shall ensure that the techniques and methods selected for Software development of FNMux are adequate for the SIL-4. |
| Key Competencies | - Shall be competent in System/Hardware and Software Validation  - Shall have exposure to safety requirements  - Shall be competent in various validation methods and ability to choose the right method for the validation  - Shall be capable of deriving the types of validation tools, techniques, and methods from the given specification  - shall understand relevant parts of EN 50126[Ref2] , EN 50128[Ref 4] , EN 50129[Ref 5] and ISO 9001:2015  - Shall be graduate with min 5 years of experience in System Validation. |

Table 13: Roles & Responsibilities of Validator

# Managerial Process Plans

## Resource Allocation and Acquisition Plan

### Following are the materials required for design, development, testing and validation of the system.

| Resource | Acquisition and Allocation |
| --- | --- |
| Two Units of Central Units | On completion of Design, BOMs shall be generated based on which Prototype Manufacturing is done as per the Organizational Production Processes. |
| Four Units of Field Units | On completion of Design, BOMs shall be generated based on which Prototype Manufacturing is done as per the Organizational Production Processes. |
| PCs | Already Available  As on required basis, PM shall request for additional PCs or upgrades if required which may further be approved by MD. |
| Keil Licenses | 2 licenses shall be Procured. |

Table 14: Resource Acquisition Plan

## Product Validation and Assessment

### Product Validation

#### As the project has to follow the development process as per EN50126[Ref 2], EN50128 and EN50129, Product Validation shall be carried out.

#### Verification shall be carried out as part of lifecycle to ensure the product is performing its functionality both with respect to safety and functionality wise.

#### As an added layer, External Validation shall be carried out for FNMux through an independent Verification & Validation team.

#### V&V plan shall be prepared as considering requirement EN50126[Ref 2], EN50128 [Ref 4], and EN50129[Ref 5],EN 50159[Ref 6], RDSO /SPN /211/2022 Dated: 24.11.2022, RDSO/SPN/144/2006 and ISO 9001:2015.

### Independent Safety Assessment (ISA)

#### Independent Safety assessor shall be selected from the RDSO’s approved list of Assessors and PO placed for the assessment work. For FNMux, the associated ISA is BUREAU VERITAS and contact details as given in External Interfaces.

#### Independent Safety Assessor shall be associated with the Project during the lifecycle of the project and shall assess the project in all lifecycle phases.

#### As part of Verification and Validation, application safety case adhering to EN50129[Ref 5]shall be prepared and submitted to the ISA. All the process documentation done, including V & V audit reports shall be presented to the Independent Safety Assessor for audit and assessment purposes.

#### After review of the process and going through the application safety case and witnessing the testing and field trials, the system may be declared by the ISA fit for running in passenger lines of Indian Railway.

## Staffing Plan

Existing identified staff shall be utilized for this project. As and when new recruitment is needed and is inevitable, new staff may be recruited by putting a request to HRD duly approved by Project Director.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Process | Hardware Team | Software Team | Testing | V&V | Safety |
| Required Skills | Circuit Designing | Embedded ‘C’ | Software Testing | V&V | Safety Dept. |
| Relevant Experience | 5 to 6 Years | 3 to 4 Years | 5 to 6 Years | 5 to 6 Years | 5 to 6Years |
| No. of people (required) | 3 | 3 | 3 | 2 | 2 |
| No. of people (available) | 3 | 3 | 3 | 2 | 2 |
| Duration | 2 Years | 2 Years | 2 Years | 2 Years | 2 Years |

Table 15: Manpower Plan

## Training plan

As the project team already has experience in the above-mentioned software and hardware, no additional training is needed. However, refresher training for motivation shall be done periodically which is as part of HR Training program.

A training program shall be conducted for going through the SIL-4 certification process for the FNMux Project. All the personnel involved in the FNMux project shall undergo this training.

As part of Organizational HRD Processes, regular training is organized for the employee’s growth and continued suitability for the organizational requirement. PM shall initiate any such training requirements though HRD.

# Technical process plans

## Process Model

### Project Lifecycle

FNMux project adopts the lifecycle model as specified in “Figure – 8 of System Lifecycle” in EN50126 [Ref 2]

## Technology

### Development Environment

#### The Software platform for Development environment for FNMux system shall be as follows

1. Windows based Workstations
2. Keil Development Environment (uVision)
3. Code Analyzer/Code Tester (like uLink Tracer from Keil)

#### The Hardware Platform for FNMux development environment shall be as given below

1. ARM 7 LPC 2378 Module
2. RAM – 4 MB and above
3. 512 MB Flash
4. Multi channel – R S 232 – 4 channels
5. Parallel Port

### Deployment Environment

#### Deployment Environment is same as development environment.

## Supporting process plans

### Configuration Management Plan

#### A Configuration Management Plan pertaining to Hardware and Software (CMP) shall be generated, reviewed and approved. The requirement of organizational QMS for configuration Management shall be adhered to. The same shall be followed for configuration Management of hardware and software configurable items.

#### Configurable items shall also be clearly specified in the configuration Management Plan.Source code control system shall be maintained for software source code version control. This system shall be responsible for version releases.

### Verification and Validation Plan

#### A Verification and Validation Plan pertaining to V & V of the complete system integrated with hardware and software shall be generated, reviewed and approved. The same shall be followed for V & V of the system.

### Quality Assurance Plan

#### A Quality Assurance Plan pertaining to Software (SQAP) shall be generated, reviewed and approved. The same shall be followed for software quality Assurance.

#### Hardware quality assurance is achieved through the process control based on the defined in Quality Management System and Project V & V documents.

## Specification of System Requirements Phase

## **Architecture and Apportionment of System Requirements**

## **Design and Implementation Phase**

### Hardware V & V

### Process for Verification of integrated Hardware during Design and Implementation phase

### Following are the deliverables of Verification of Design and Implementation Phase

### Process for validation of Hardware during Design and Implementation phase

### Following are the deliverables of Validation of Design and Implementation Phase

## Manufacturing Phase

## Integration Phase

## Software

### Software Verification and Validation

### Planning Phase

### Requirement Phase

### Software Architecture and Design Phase

### Software Component Design Phase

### Software Component Implementation and Testing Phase

### Software Integration Phase

### Software Validation

## FNMUX System Validation

## System Acceptance Phase

# Appendix – A WBS & Schedules

## FNMux Software Life Cycle Phases

| S. No | EN 50126 Life Cycle Phase | Time Line | Remarks |
| --- | --- | --- | --- |
|  | 01-Concept Phase | D+1 Month |  |
|  | 02-System Definition and Operational Context | D+2 Months |  |
|  | 03-Risk Analysis and Evaluation | D+2 Months |  |
|  | 04-Specification of System Requirements | D+4 Months |  |
|  | 05-Architecture and Apportionment of System Requirements | D+5 Months |  |
|  | 06-Design and Implementation | D+6 Months |  |
|  | 07-Manufacturing | D+7 Months |  |
|  | 08-Integration | D+7 Months |  |
|  | 09-System Validation | D+7 Months |  |
|  | 10-System Acceptance | D+8 Months |  |
|  | 11-Operation, Maintenance, and performance monitoring | D+9 Months |  |

| S. No | EN 50128 Life Cycle Phase | Document ID | Remarks |
| --- | --- | --- | --- |
|  | Planning | D+1 Months |  |
|  | Software requirements | D+2 Months |  |
|  | Architecture and Design | D+4 Months |  |
|  | Component implementation and testing. | D+5 Months |  |
|  | Integration | D+6 Months |  |
|  | Overall Software testing/Final Validation. | D+7 Months |  |
|  | System configured by application data/algorithms | D+ 4 Months |  |
|  | Software deployment | D+7 Months |  |
|  | Software Maintenance | D+7 Months |  |

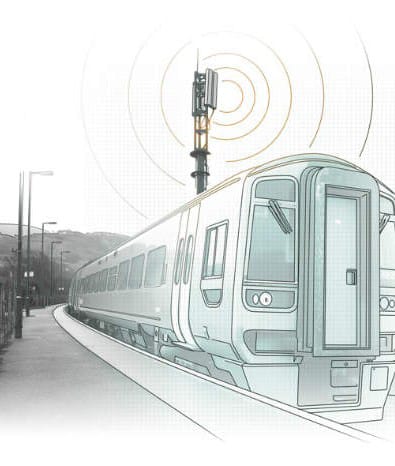
# ANNEXURES

## Annexure – A Personnel Identified with Roles

|  |  |  |
| --- | --- | --- |
| S. No | Role | Name |
|  | Head Technical/CEO |  |
|  | Project Manager |  |
|  | Software Development Manager |  |
|  | Hardware Manager |  |
|  | Verification Manager |  |
|  | Validator & Safety In-charge |  |
|  | Verification Engineer |  |
|  | CM In charge (SCM & HCM) |  |
|  | Hardware Engineer |  |
|  | Hardware Technician |  |
|  | Software Engineers |  |
|  | System integration Tester |  |

Table 16: Personnel Identification with Roles

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