Functional Requirements for Lean Six Sigma Quality Installation of Onboard Kavach units using Collaborative Robots

1 Scope

The scope of the document is to provide a detailed framework for the installation of Onboard Kavach units with a focus on Lean Six Sigma quality and the use of collaborative robots. The document aims to streamline the installation process by identifying and eliminating inefficient operations before automation, ensuring that only efficient processes are automated. It emphasizes the use of Lean techniques such as standardized work creation and kaizen to reduce operation time and improve process efficiency. Additionally, the document outlines the integration of collaborative robots to enhance flexibility and efficiency in the installation process, ensuring that tasks are effectively delegated between human operators and robots. The ultimate goal is to achieve a high-quality installation process of Onboard Kavach that is both efficient and reliable, leveraging the principles of Lean and Six Sigma alongside cobot technology.

2 Objective

The prospective vendors shall submit an action plan for their proposed solution. The EOI provides a platform to facilitate interaction with prospective vendors with the Kavach manufacturers and RDSO

3 Technical Requirements

The LOCO KAVACH installation plan enclosed with this document outlines a comprehensive series of activities aimed at installing various components and systems within a locomotive. The process begins with marking the locations for RF and GSM/GPS antennas on the roof of CAB1 and CAB2, followed by the removal of the CAB ceiling to prepare for welding. This is a crucial step as it sets the stage for the subsequent welding of the antenna mounting bases, which includes drilling holes to secure the components. After the welding, weatherproofing measures are taken for the RF cables to ensure durability and functionality in various weather conditions.In addition to the antenna installations, the plan includes the marking and welding of RFID reader mounting brackets,

which are essential for the integration of RFID technology into the locomotive. This is followed by mechanical installation verification through magnetic particle testing, ensuring that all installations meet the required safety and operational standards. The installation of speed sensors and junction boxes is also detailed, with specific instructions for marking locations and welding necessary brackets.

The document further details the installation of various pneumatic and electronic components within the driver's cab and desk. This includes the welding of mounting bases for valves and pressure switches, as well as the wiring for pressure sensors and valves. The internal driver desk cables are laid out meticulously to ensure seamless integration with the onboard systems. The plan also covers the installation of the Onboard Kavach Unit, Radio Units, and other critical components in the machine room, emphasizing the importance of precise marking, welding, and cable laying.

Finally, the installation plan includes a series of inspections and tests to verify the mechanical installations, cabling, and wiring interfaces. These inspections are crucial for ensuring that all components are installed correctly and are functioning as intended. The plan concludes with pre-commissioning checklists and site acceptance tests, which are essential for validating the overall installation and ensuring readiness for operational deployment.

4 Functional Requirements

4.1 Initial Optimization Loop

- Conduct an initial optimization loop to identify and eliminate inefficient operations before automation. This step ensures that only efficient processes are automated, thereby reducing unnecessary complexity and time wastage.
- Use Lean techniques such as standardized work creation and kaizen to streamline processes and reduce operation time

4.2 Task Selection for Automation

- Select candidate tasks for automation based on their complexity and the team's skills. Define a target transfer time to ensure that the automation process is efficient and aligns with the team's capabilities.

- Evaluate the complexity of tasks to determine their suitability for automation, ensuring that the cobot's working time is optimized

4.3 Cobot Working Time Evaluation

Evaluate the cobot's working time by considering the transfer time multiplied by six for low complexity operations. Ensure that the robot's working time is less than the initial cycle time minus the transfer time.

4.4 Process Simulation and Operator Coordination

- Integrate collaborative robots (cobots) to enhance process efficiency, supporting flexibility in the Lean Manufacturing environment.
- Simulate the process sequence to verify that no operator waiting times are generated, coordinating task sequencing between the operator and the cobotto optimize workflow and minimize idle time.

4.5 Implementation and Stabilization

- Implement the optimized process and stabilize the results. This step involves ensuring that the process runs smoothly and consistently, with minimal deviations from the expected performance.
- Use Six Sigma quality principles to monitor process stability and identify areas for further improvement

4.6 Cobot Waiting Time Analysis

- Control the task sequencing between the operator and the cobot to avoid generating operator waiting time, ensuring seamless collaboration.
- Analyze the resulting cobot waiting time to identify inefficiencies and inform further optimization loop

4.7 Lean Techniques Training

- Provide training on Lean techniques, including standardized work creation, kaizen, operation time reduction, and jidoka (man and machine separation). This training equips the team with the necessary skills to identify and implement process improvements autonomously.

- Incorporate Six Sigma training to enhance quality control and process efficiency, focusing on reducing variability and defect.

4.8 Manual Process Improvement

Focus on manual process improvement by optimizing task combinations and relocating sub-components to minimize motion distances. This step aims to reduce cycle time and trigger new ideas for automation.

4.9 Collaborative Process Development

Develop a collaborative process that integrates cobots to achieve a shorter cycle time. This involves setting up a process that is more efficient than the initial one, leveraging the capabilities of both human operators and cobots.

4.10 Feedback and Skill Development

Encourage feedback from team members on the skills gained during the project. This feedback can provide insights into additional success factors and areas for skill development, particularly in Lean-related competencies and soft skills like teamwork and accountability.

5 Evaluation Criteria

- The firm shall have experience in installation of equipment using cobot in locomotives or automobiles or other transport modes for the following activities:
    - Welding
    - Fitting
    - Wiring the cable harness
- The firm shall have personnel experienced in Lean, Six Sigma and Kaizen practices.

LOCO KAVACH INSTALLATION PLAN				
SN	**ACTIVITY**	**CURRENT DURATION (Minutes)**	**HUMAN RESOURCES REQUIRED**	**PRECEDENCE**
1	**Pre-requisite works**			
1.1	**Cab1**	105		
1.1.1	Pneumatic 'T' joint fixing preparations.	15	F1, S1	
1.1.2	Removal of loco pilot chair.	15	F1, S1	
1.1.3	Removal of light assembly.	15	F1, S1	
1.1.4	Removal of loco pilot cab fans.	15	F1, S1	
1.1.5	Removal of foot plate	15	F1, S1	
1.1.6	Removal of side machine room corridor foot plate.	15	F1, S1	
1.1.7	Removal of loco roof	15	F1, S1	
1.2	**Cab2**	105		
1.2.1	Pneumatic 'T' joint fixing preparations.	15	F1, S1	
1.2.2	Removal of loco pilot chair	15	F1, S1	
1.2.3	Removal of light assembly.	15	F1, S1	
1.2.4	Removal of loco pilot cab fans.	15	F1, S1	
1.2.5	Removal of foot plate	15	F1, S1	
1.2.6	Removal of side machine room corridor foot plate.	15	F1, S1	
1.2.7	Removal of loco roof	15	F1, S1	
1.3	**Machine room**	270		
1.3.1	Cable cutting as per requirement	240	F2, S2	
1.3.2	TB box terminations & circular connector's connections	15	F2, S2	
1.3.3	Fabrication work (frames & cutting & preparation)	15	F2, S2	
2	**On Roof Installations**	310		
2.1	**CAB1**	310		
2.1.1	Marking location for RF antenna and GSM/GPS antenna (2+1)-CAB1	15	F1, W1	
2.1.2	Removal of CAB ceiling for welding preparation* (CAB1)	60	R1	
2.1.3	Welding of RF antenna and GSM/GPS mounting bases including drilling of holes (3Nos)	90	F1, W1	2.1.2
2.1.4	Weather proofing for RF Cables (2 Antennas)-CAB1	30	T1, T2	2.1.3
2.1.5	Water leakage test (CAB1)	30	F1, W1	2.14
2.1.6	Install RF antenna and GSM/GPS antenna	40	F1, W1	2.1.5
2.1.7	On roof work inspection and check list filling-CAB1	15	S1	2.1.6
2.1.8	Close CAB ceiling after successful inspection* (CAB1)	30	R1	
2.2	**CAB2**	310		
2.2.1	Marking location for RF antenna and GSM/GPS antenna (2)-CAB2	15	F2, W2	
2.2.2	Removal of CAB ceiling for welding preparation* (CAB2)	60	R2	
2.2.3	Welding of RF antenna and GSM/GPS mounting bases including drilling of holes (3Nos)	90	F2, W2	2.2.2
2.2.4	Weather proofing for RF Cables (2 Antennas)-CAB2	30	T2, T2	2.2.3
2.2.5	Water leakage test (CAB2)	30	F2, W2	2.2.4

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SN	**ACTIVITY**	**CURRENT DURATION (Minutes)**	**HUMAN RESOURCES REQUIRED**	**PRECEDENCE**
2.2.6	Install RF antenna and GSM/GPS antenna	40	F2, W2	2.2.5
2.2.7	On roof work inspection and check list filling-CAB2	15	S2	2.2.6
2.2.8	Close CAB ceiling after successful inspection* (CAB2)	30	R2	2.2.7
3	**Under Frame**	**550**		
3.1	**CAB-1 Frame**	550		
3.1.1	Marking location for RFID Reader placement	10	F3, W3	
3.1.2	Welding RFID Reader mounting bracket	180	F3, W3	3.1.1
3.1.3	Mechanical installation verification (Magnetic particle testing with Shed	60	F3,S2	3.1.2
3.1.4	Install RFID Reader	30	F3, W3	3.1.3
3.1.5	Mark Speed sensor mounting placement	5	F3, W3	3.1.4
3.1.6	Request shed staff to provide Drive pin installation provision* (1 Axle)	120	F3, R3	3.1.5
3.1.7	Installation of Speed sensor (1 No)	30	F3, W3	3.1.6
3.1.8	Marking location for Junction Box (1 No)	5	F3	3.1.7
3.1.9	Welding Junction box mounting bracket and and six routing rod welding (1 No)	15	F3, W3	3.1.8
3.1.10	Fix Junction box	15	F3	3.1.9
3.1.11	Removal of CAB Floor	20	R3	3.1.10
3.1.12	Making Cable entry holes between Driver's Desk to Under truck and Welding (2 Nos)	60	F3, W3	3.1.11
3.2	**CAB-2 Frame**	550		
3.2.1	Marking location for RFID Reader placement	10	F4, W4	
3.2.2	Welding RFID Reader mounting bracket	180	F4, W4	3.2.1
3.2.3	Mechanical installation verification (Magnetic particle testing with Shed	60	F4,S2	3.2.2
3.2.4	Install RFID Reader	30	F4, W4	3.2.3
3.2.5	Mark Speed sensor mounting placement	5	F4, W4	3.2.4
3.2.6	Request shed staff to provide Drive pin installation provision* (1 Axle)	120	F4, R4	3.2.5
3.2.7	Installation of Speed sensor (1 No)	30	F4, W4	3.2.6
3.2.8	Marking location for Junction Box (1 No)	5	F4, W4	3.2.7
3.2.9	Welding Junction box mounting bracket and six routing rod welding (1 No)	15	F4, W4	3.2.8
3.2.10	Fix Junction box	15	F4, W4	3.2.9
3.2.11	Removal of CAB Floor	20	R4	3.2.10
3.2.12	Making Cable entry holes between Driver's Desk to Under truck and Welding (2 Nos)	60	F4, W4	3.2.11
4	**Driver's Cab and Desk Fitment Equipment Welding, Fitments**	**310**		
4.1	**CAB1**	310		
4.1.1	Mark DMI Placement	5	F1, W1	
4.1.2	Shifting CAB Fan	60	F1, W1	4.1.1
4.1.3	CAB Fan wiring	10	T1, T2	4.1.2

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SN	**ACTIVITY**	**CURRENT DURATION (Minutes)**	**HUMAN RESOURCES REQUIRED**	**PRECEDENCE**
4.1.4	Welding DMI Mounting brackets and Cable Entry Hole	30	W1	4.1.3
4.1.5	Mounting of DMI	10	F1, W1	4.1.4
4.1.6	Welding Horn valve, Pneumatic Values and Pressure switch mounting base	15	F1, W1	4.1.5
4.1.7	Welding VEB valve mounting base	15	F1, W1	4.1.6
4.1.8	Valve mounting and Pneumatic Connections for Horn solenoid valve and VEB Valve with manual cock	30	F1, W1	4.1.7
4.1.9	BP Line tapping, BC Line tapping and MR Line tapping and Pressure sensors installation	30	F1, W1	4.1.8
4.1.10	Welding BIU sub system (IRU) mounting frame and door welding work of IRU	30	F1, W1	4.1.9
4.1.11	Mounting BIU sub system	30	F1, W1	4.1.10
4.1.12	Internal Driver Desk Cables Laying	15	T1, T2	4.1.11, 4.2.11
4.1.13	Wiring for Pressure sensors,VEB valve,Horn valve.	15	T1, T2	4.1.12
4.1.14	Wiring interface from terminal blocks to BIU Sub system	15	T1, T2	4.1.13
4.2	**CAB2**	290		
4.2.1	Mark DMI Placement	5	F2, W2	
4.2.2	Shifting CAB Fan	60	F2, W2	4.2.1
4.2.3	CAB Fan wiring	10	T1, T2	4.2.2
4.2.4	Welding DMI Mounting brackets and Cable Entry Hole	30	F2, W2	4.2.3
4.2.5	Mounting of DMI	10	F2, W2	4.2.4
4.2.6	Welding Horn valve and Pressure switch mounting base	15	F2, W2	4.2.5
4.2.7	Welding VEB valve mounting base	15	F2, W2	4.2.6
4.2.8	Valve mounting and Pneumatic Connections for Horn valve and VEB Val	30	F2, W2	4.2.7
4.2.9	Welding BIU sub system (IRU) mounting frame and door welding work of IRU	30	F2, W2	4.2.8
4.2.10	Mounting BIU sub system	40	F1	4.2.9
4.2.11	Internal Driver Desk Cables Laying	15	T3,T4	4.2.10
4.2.12	Wiring for Pressure sensors,VEB valve,Horn valve.	15	T3,T4	4.2.11
4.2.13	Wiring interface from terminal blocks to BIU Sub system	15	T3,T4	4.2.12
5	**Machine Room**	1000		
5.1	Marking locations for Onboard KAVACH Unit,Radio Units, RFID PS units	30	F5	
5.2	Removal of Engine Room Roof	60	R5	
5.3	Welding Onboard KAVACH unit, Radio units, BIU frame, Cab Signal box and RFID PS mounting brackets.	40	F5,W3	5.1
5.4	Onboard KAVACH unit, Radio units, Cab Signal box and RFID PS mounting	30	F5, S2	5.3
5.5	Brake interface unit mounting(LEM)	30	F5, S2	
5.6	Cable laying and Termination to Onboard KAVACH unit from Roof,Driver Desk, and Under Slung completion	120	T3,T4	5.2

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SN	**ACTIVITY**	**CURRENT DURATION (Minutes)**	**HUMAN RESOURCES REQUIRED**	**PRECEDENCE**
5.7	Radio and GPS Cable laying from roof to machine room (CAB1)	60	T3,T4	5.6
5.8	Under Truck Cable laying for speed sensors and RFID readers(CAB1)	60	F5,T3	5.7
5.9	RFID Reader and Speed sensor wiring (CAB1)	30	F5,T3	5.8
5.10	Cable laying and Termination to Onboard KAVACH unit from Roof,Driver Desk, and Under Slung completion	120	T3,T4	5.2
5.11	Cable laying to Onboard KAVACH unit from Brake system (CAB2)	30	T1,T2	5.10
5.12	Radio Cable laying from roof to machine room (CAB2)	60	T1,T2	5.11
5.13	Under Truck Cable laying for speed sensors and RFID readers(CAB2)	60	T5,T3	5.12
5.14	RFID Reader and Speed sensor wiring (CAB2)	30	T3,T4	5.13
5.15	Cable laying for Loco Interface	30	T3,T4	5.14
5.16	Wiring interface from SB panel to Onboard KAVACH Unit	90	T3,T4	5.15
5.17	Engine Room Roof Placement and Closing	60	R	5.16
5.18	CAB 1 Floor Closing	30	R	5.17
5.19	CAB 2 Floor Closing	30	R	5.18
6	**Inspections**	**60**		
6.1	Inspection of Mechanical installation	30	F5,S2	5.17
6.2	Inspection of Cabling, wiring and Interface	30	F5,S2	6.1
7	**Testing**	**360**		
7.1	Internal Pre-Commissioning Check List	120	S2	6.2
7.2	Railway testing PCCL*	120	R, S2	7.1
7.3	Site acceptance test with Test Bench*	120	R, S2	7.2
	Total(Minutes)	1970		
Abbreviations used :				
1	**F - Fitter**	5		
2	**W - Welder**	4		
3	**R - Railway**			
4	**S - Service Engineer**	2		
5	**T - Technician**	4		
		15		
6	**VEB : Vital Emergency Brake**			
7	**BIU : Brake Interface Unit**			
8	**RF : Radio Frequency**			
9	**GSM : Globak System for Mobile**			
10	**GPS : Geo Positional System**			
11	**DMI : Driver Machine Interface**			
12	**LEM : Light Engine Module**			
13	**SB : Switch Board**			

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SN	**ACTIVITY**	**CURRENT DURATION (Minutes)**	**HUMAN RESOURCES REQUIRED**	**PRECEDENCE**
14	**PCCL : Pre-Commissioning Check List**			
15	**IRU: Interface Relay Unit for E70 systems only**			
16	**RFID: Radio Frequency Identification**			