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The Improvement of Quality Control Checklist in Bogie Assembly for Kuala Lumpur Additional Vehicle (KLAV 27) Project

Nurul Farah Nabilah binti Mohamad Kadri[1], Mustapha Kamil bin Omran[1]*, Mohd Noor Fathullah bin Mohd Noordin[2]

[1]Department of Transportation Engineering Technology, Faculty of Engineering Technology.
Universiti Tun Hussein Onn Malaysia, 84600 Panchor, Johor, MALAYSIA.

[2]Hartasuma Sdn Bhd,
Lot 29, Jalan Sungai Pinang 4/8, Taman Perindustrian Pulau Indah, 42920 Pulau Indah, Selangor, MALAYSIA.

*Corresponding Author Designation

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Abstract: The absence of quality checklist at every station of the bogie assembly might cause some errors that could even lead to fatality. The purpose of this paper is to propose an improved quality checklist for bogie assembly for every station and focusing on the bogie assembly process for Kuala Lumpur Additional Vehicle 27 (KLAV 27) project. The method that is used in this study is Six Sigma's DMAIC to propose an improved quality control checklist at each station of bogie. At the end of the study, there are six improved quality control checklists for each station of bogie assembly was produced which overcame the problems that occurred such as delayed in bogie assembly process. Therefore, the bogie assembly process is more efficient and produces quality products.

Keywords: Bogie Assembly, Quality Control, Six Sigma's DMAIC

1. Introduction

Many organisations are striving for enhanced process performance and product quality in order to achieve their bottom-line goals of income, sustainability, share of the market, and competitiveness. Manufacturing faults can be blamed to produce low-quality items. If these manufacturing faults are not remedied, they can generate additional expenses while contributing no value to the manufacturing process or product, and as a result, they can often cause a delay in the production lead time [1]. This study is based on Bombardier-Hartasuma Consortium (BHC) ongoing project, which is Kuala Lumpur Additional Vehicle 27 (KLAV 27) where they provide 27 train sets for the LRT Kelana Jaya Line.

Corresponding author: mustapha@uthm.edu.my

Hartasuma Sdn Bhd main role in KLAV 27 project is assembling the bogie for the 27 train sets and it requires quality checklist for every station at bogie assembly area. The current practice at Hartasuma for bogie assembly is that the quality control checklist is filled at the end of the bogie assembly process at station six. The problems arising from the assembling process, which consists of six stations, are the redoing work from the production team that causes the delay of the bogie assembling process [2]. Based on the problem that occurred, the delays can affect the costs and time overrun. The quality control for the bogie assembling is important for its quality assurance for the customers. It monitors actions to verify that they are in accordance with the plans and specifications [3]. The existence of a quality checklist at every station helps to identify and determine from minor to major problems occur at each station. Therefore, it can reduce the time consuming to identify the problems that occurred.

The following are the objectives of this paper: -

i. To analyse the quality control issues in the overall bogie assembly process.
ii. To propose an improved quality control checklist for the quality improvement of the bogie assembly.
iii. To get validation on the improved quality control checklist for the quality improvement of the bogie assembly.

1.1 Kuala Lumpur Additional Vehicle 27 (KLAV 27) Project.

Hartasuma Sdn Bhd (HSB), a leading local integrated rolling stock and rail services provider, is scheduled to complete the provision of new 108 light rail transit (LRT) cars for the Kelana Jaya line. This project is being done in collaboration with Alstom S.A., a worldwide producer of rolling stock. The Bombardier-Hartasuma Consortium (BHC) was awarded this contract in 2017 as part of the RM1.72 billion Kuala Lumpur Additional Vehicle (KLAV) 27 project. Datuk Seri Dr Wee Ka Siong, the transport minister (2020-2022), watched the train's final assembly, notably the bogies assembly process, at HSB's production site in Pulau Indah, Selangor. In July 2023, he said, 27 additional light rail transit (LRT) trains will commence service on the Kelana Jaya LRT route [4]. The bogie assembly process consists of six stations at Hartasuma plant in Pulau Indah.

1.2 Inspection Checklist in Quality Control

A checklist is a brief to-do list that the person in charge must go through before completing work. A checklist has several advantages, including improves clarity and productivity which the results of using a daily checklist that help to complete tasks more efficiently. One of the leading causes of project failure is rework. As a result, checklists can assist decrease reworks by identifying facts about the project that may have fallen through the cracks. Splitting a project or job into checklists not only provides the technicians with a clear path, but also makes it easy to identify missing actions at one of the stations of the bogie assembly, resulting in no rework at the completion of the inspection.

1.3 Six Sigma’s DMAIC to Improve the Quality of the Production Process

This review evaluates a Six Sigma DMAIC case study implementing the methodology to enhance production process quality. The study defines problem statements, project goals, and scope, collects data, and identifies key metrics to quantify performance [5]. Analyse data to identify root causes of quality issues [6]. Process mapping, diagrams, Pareto analysis identify quality factors [7]. The case study progresses to the "Improve" phase, where the project team develops and implements solutions, testing them using controlled experiments. The "Control" phase monitors and sustains improvements using control charts and audits [8]. The case study showcases Six Sigma DMAIC's effectiveness in improving production process quality through structured approach, statistical tools, and sustainability through the "Control" phase. It serves as a valuable example for organizations implementing this methodology.

2. Methodology

This section explains the process in making the internal checklist, which is the checklist for each station for the bogie assembly. Not just that, the inspection flow for bogie assembly after the application of internal checklist is also included in this section.

2.1 Using DMAIC in Producing Quality Control Checklist for Bogie Assembly

The acronym DMAIC stands for the five steps of the Six Sigma improvement process. It is an acronym that stands for Define, Measure, Analyse, Improve, and Control. DMAIC provides organisations with a structured framework for identifying issues, measuring performance, analysing data, implementing improvements, and establishing control mechanisms. Each phase of DMAIC has its own set of goals and tasks and DMAIC steps for producing quality control checklist for bogie assembly are as below:

i. Define: The project stage involves defining goals, identifying problems, and establishing scope. In this project, a quality checklist for each station at bogie assembly was identified, making it difficult to identify root causes during inspection.
ii. Measure: Phase focuses on data collection, quantifying process performance, identifying major bogie assembling procedures, and constructing quality control checklist.
iii. Analyse: Analyse phase analyses data to identify root causes of problems, focusing on bogie assembly processes and potential improvements.
iv. Improve: This stage focuses on generating and implementing solutions to root causes, using a quality control checklist for each station.
v. Control: Control phase ensures sustained improvements in earlier stages using a quality control checklist for future projects.

2.2 Preparing Content for Checklist

As this study provided a checklist for each station for bogie assembly, the station name must be included on the checklist. The bogie serial number and bogie type for each produced bogie must also be specified in the checklist for future reference. The description column will list all the essential procedures at each station, and the reference column will list the serial numbers for each component of the bogie.

The notes column clearly outlines the critical steps for each primary procedure, ensuring that no important steps are overlooked. The images can also be included in the checklist for easier reference and explanation. The status of each component can also be specified in the checklist at the end of the checklist table. If there are any essential remarks, they must be written below the tables, and all checklists must be completed by technicians and quality inspectors at the station before moving on to the next station.

2.3 The Inspection Flow for Bogie Assembly after the Application of Internal Checklist

The internal inspection of the bogie assembly should be done after each station is completed in bogie assembly. This is crucial as it saves time to locate the missed procedure during the inspection at the end of the bogie assembly process. Therefore, Figure 1 below shows the inspection flowchart for bogie assembly at Hartasuma.

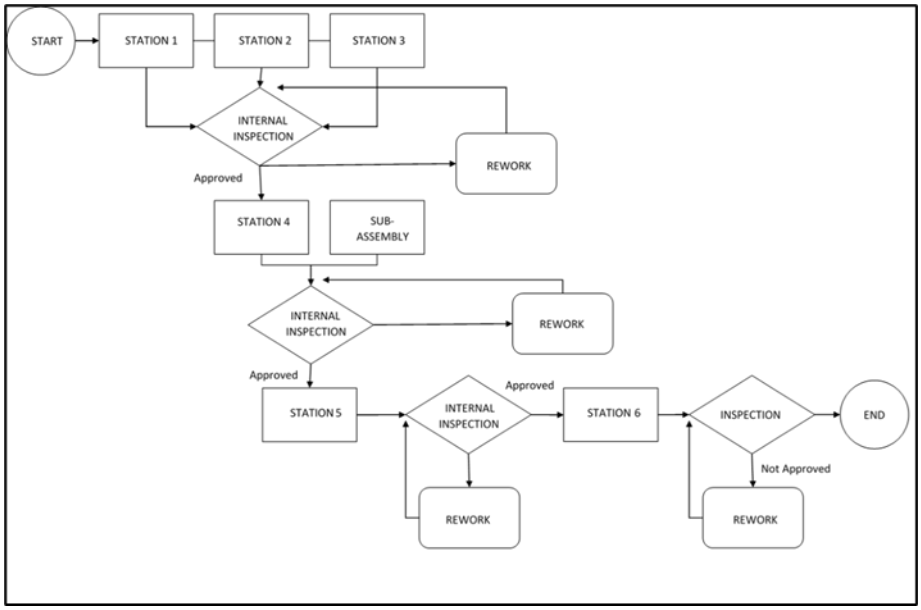


Figure 1: Flowchart of inspection for bogie assembly

2.4 Validation for the Improved Quality Control Checklist

Validation is vital and required in the completion of a project to validate the work that has been done and to keep the project on schedule. The industrial supervisor reviewed the enhanced quality control checklist for each station of bogie assembly in this project to validate the method and contents of the improved quality control checklist.

3. Results and Discussion

From the study, the outcomes are shown in this section where the quality control process and problems occurred that delayed the bogie assembling process can be identified and the improved checklist can be used for the quality improvement of the bogie assembly.

3.1 Six Sigma's DMAIC in Analysing Problems in Bogie Assembly Process

In this project, the DMAIC steps for bogie assembly process are as below:

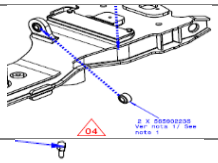
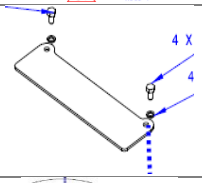
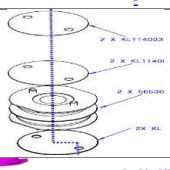
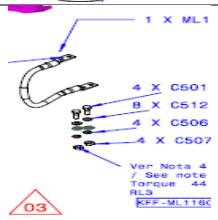
i. Define: In this project, the problem that has been identified was there was no quality checklist for each station at the bogie assembly. The current quality checklist for bogie assembly is filled out at the end of the bogie assembly process which makes it hard and took a long time to identify the root of the problem during inspection.
ii. Measure: The major procedures in bogie assembling are identified to start constructing the quality control checklist. The important notes and torque value were identified for every major procedure in each station of bogie assembly.
iii. .Analyse: In this phase, the process of bogie assembly at each station and all the possible problems at each station are analysed. The major procedures at each station were identified through manuals and the important notes were also identified.
iv. Improve: An improved quality control checklist is produced for every station of the bogie assembly to monitor the quality specifically. Therefore, there are no missed procedures at each station due to human error.
v. Control: The quality control checklist can be used for the upcoming projects as the process is almost the same for bogie assembly.

3.2 The Improved Quality Control Checklist for Bogie Assembly

The issue that always occurred in bogie assembly process such as missed looking and missed procedures during the assembly as the quality control checklist were used at the end of the process of bogie assembly.

Therefore, in this project, a specific checklist for each station is proposed as a solution to the problem. Based on the previous quality control checklist, the latest checklist will be specified for each aspect that is needed for each station. Therefore, there will be a total of six quality control checklists during the bogie assembly process.

Table 1: Quality control checklist for station 1

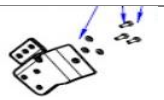
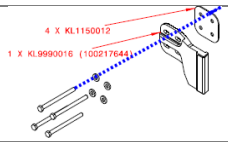
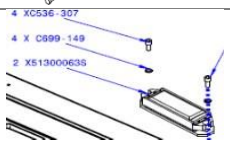
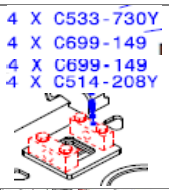
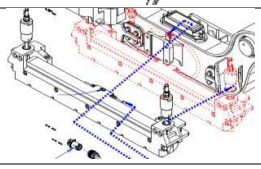
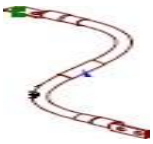
NO	DESCRIPTION	REFERENCE	NOTES	PICTURE	STATUS
1	Bearing Installation (Bolster)	Serial Number	-		
2	Friction Plate Installation	Serial Number	Apply adhesive thread locking medium blue		
3	Secondary Suspension Assembly	Serial Number	Including shim		
4	Grounding Cable Assembly (Bolster to Car Body)	Serial Number	The key bolts and nuts are identified, Check the torque guide, as well as the risk level RL		

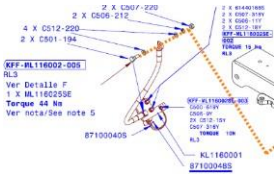
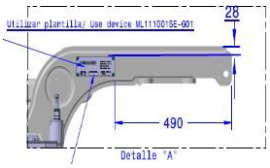
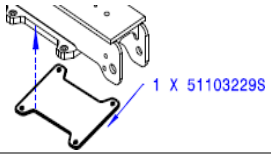
NOTE:

1. *Please make sure all installation follows the instruction from Method Sketch*
2. *Please make sure all bolt and nuts are torqued and ready to torque seal.*
3. *Please make sure that after all the installation completed the technician and quality inspector need to fill in the name and sign before the part is moved to the next station*

TECHNICIAN 1: **TECHNICIAN 2:** **CHECKED BY:** **DATE:**

Table 2: Quality control checklist for station 2

NO	DESCRIPTION	REFERENCE	NOTES	PICTURE	STATUS
1	Assembly Of Bases and Supports	Serial Number	Apply Loctite 222		
2	Adjustable Stop Assembly	Serial Number	Torque 95 N-m 70.5 FT / LB		
3	Side Bearing Installation	Serial Number	Apply adhesive thread locking medium blue		
4	Block Support Installation	Serial Number	Apply Torque 115Nm		
5	Track Brake Installation	Serial Number	Install with completed sub system		
6	Grounding Cable Installation	Serial Number	1. Grounding brush to frame 2.Grounding cable frame to Yoke 3.Grounding cable frame to bolster 4.Grounding cable frame to power collector LHS 5.Grounding cable frame to power collector RHS 6.Grounding cable track brake to frame LHS and RHS		

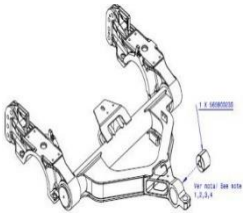
7	Grounding Brush Installation	Serial Number	Apply Electrical Joint Compound for electrical joints	
8	Classification Plate Installation	Serial Number	Please refer to document for installation process and Use drilling template	
9	Friction Plate Installation	Serial Number	Torque 34 N-M = 25.5 ft/ lb	

NOTE:

1. *Please make sure all installation follows the instruction from Method Sketch*
2. *Please make sure all bolt and nuts are torqued and ready to torque seal.*
3. *Please make sure that after all the installation completed the technician and quality inspector need to fill in the name and sign before the part is moved to the next station*

TECHNICIAN 1: **TECHNICIAN 2:** **CHECKED BY:** **DATE:**

Table 3: Quality control checklist for station 3

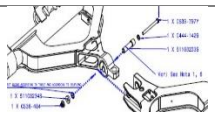
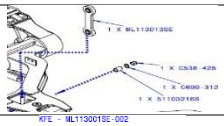
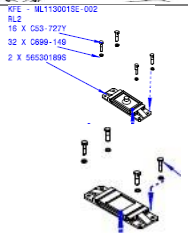
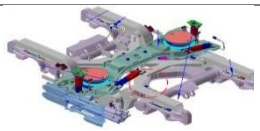
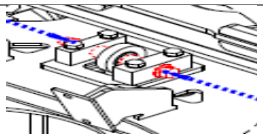
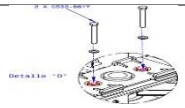
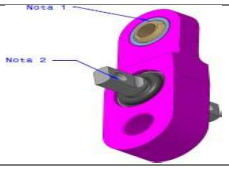
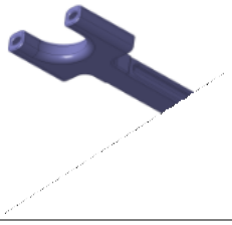
NO	DESCRIPTION	REFERENCE	NOTES	PICTURE	STATUS
1	Yoke Spherilastik Bushing Installation	Serial Number	1. Thoroughly clean the surface of the hub and the area where the hub will be installed 2. Apply an even coat of Loctite 592 sealant part number to the bushing 3. Place the bushing with the indicated press in equipment at a pressure between 2000-7680 psi max. while the sealer is fresh. 4. Remove any grease or oil residue before and after placing the bushing with an alkaline agent (example: alcohol)	 	

NOTE:

1. *Please make sure all installation follows the instruction from Method Sketch*
2. *Please make sure all bolt and nuts are torqued and ready to torque seal.*
3. *Please make sure that after all the installation completed the technician and quality inspector need to fill in the name and sign before the part is moved to the next station*

TECHNICIAN 1: **TECHNICIAN 2:** **CHECKED BY:** **DATE:**

Table 4: Quality Control Checklist for station 4

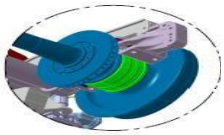
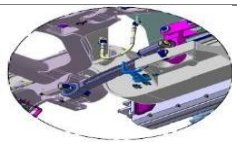
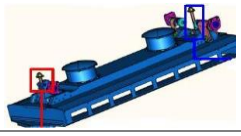
NO	DESCRIPTION	REFERENCE	NOTES	PICTURE	STATUS
1	Yoke Assembly	Serial Number	Select shim and record the shim ……. Mm with completed safety pin installation		
2	Vertical Link Installation	Serial Number	Vertical link bottom side		
3	Resilient Pad Installation	Serial Number	Apply Kopr-Kote anti seize (JET LUBE)		
4	Frame Installation	Serial Number	Attach frame to yoke and completed lifting pin installation		
5	Vertical Link Mounting to Frame (Upper Side)	Serial Number	Completed installation vertical link upper side		
6	Bolster Connect To Frame	Serial Number	Apply torque up to station 5		
7	Vertical Lever Bearing Installation (Preassembly)	Serial Number	Please refer to document		
8	Steering Mechanism Bearing Installation (Preassembly)	Serial Number	Please follow the note instruction		

NOTE:

1. *Please make sure all installation follows the instruction from Method Sketch*
2. *Please make sure all bolt and nuts are torqued and ready to torque seal.*
3. *Please make sure that after all the installation completed the technician and quality inspector need to fill in the name and sign before the part is moved to the next station*

TECHNICIAN 1: **TECHNICIAN 2:** **CHECKED BY:** **DATE:**

Table 5: Quality control checklist for station 5

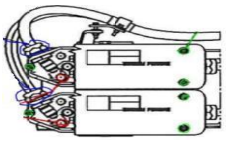
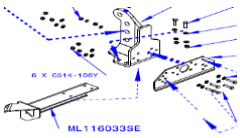
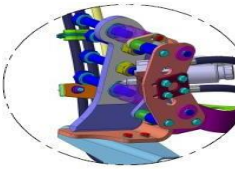
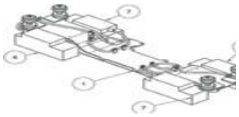
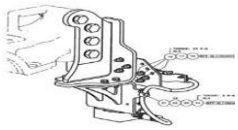
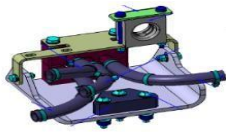
NO	DESCRIPTION	REFERENCE	NOTES	PICTURE	STATUS
1	Wheelset Installation	Serial Number	1. Apply lubricant to rubber donut 2. Places 3mm shim on all four sides of the yoke on the eyebrow of the yoke and the wheel set		
2	Steering Mechanism Installation	Serial Number	Record shim RHS …….mm Record shim LHS …….mm		
3	LIM installation	Serial Number	Assembly step 9 to assembly step 13		

NOTE:

1. *Please make sure all installation follows the instruction from Method Sketch*
2. *Please make sure all bolt and nuts are torqued and ready to torque seal.*
3. *Please make sure that after all the installation completed the technician and quality inspector need to fill in the name and sign before the part is moved to the next station*

TECHNICIAN 1: **TECHNICIAN 2:** **CHECKED BY:** **DATE:**

Table 6: Quality control checklist for station 6

NO	DESCRIPTION	REFERENCE	NOTES	PICTURE	STATUS
1	Brake caliper installation	Serial Number	Remove brake plates from the caliper and reinstall the security pin		
2	Power collector assembly	Serial Number	Assembly step 3 to assembly step 8. Assembly completed with sub system		
3	Tachometer installation	Serial Number	Tachometer bracket installation		
4	Wheel flange lubrication h & k car	Serial Number	Assembly completed with sub system		
5	Antenna bridge installation	Serial Number	Alstom scope		
6	Proximity sensor	Serial Number	Alstom scope		
7	Loose items	Serial Number	Install completed with sub system		

NOTE:

1. *Please make sure all installation follows the instruction from Method Sketch*
2. *Please make sure all bolt and nuts are torqued and ready to torque seal.*
3. *Please make sure that after all the installation completed the technician and quality inspector need to fill in the name and sign before the part is moved to the next station*

TECHNICIAN 1: **TECHNICIAN 2:** **CHECKED BY:** **DATE:**

3.3 The Description of The Proposed Quality Control Checklist for Bogi Assembly

Based on Table 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6, the quality control checklist for each station contains the major procedures for every stations. The description section shows the major procedures for each station while the reference section is for the serial number for each part of the specific procedure. This serial number is important as it is easier to check again if there are any problems during inspections.

The notes section explains in detail the important steps that need to be taken for some procedures and is referred to the manual. Some of the notes are precaution steps for certain procedures and cannot be missed during the assembly of the bogie. The pictures in the quality control checklist make it easier for the technician to know the location of the procedure and the important steps that need to be taken carefully at the bogie. The status section is where the technician must put a 'tick' once the procedure has settled.

Extra precaution notes for important steps at the end of the quality control checklist remind the technicians for the quality control precautions. The two technicians that are in charge need to sign the quality control checklist and then to be checked by the quality control engineer to approve the quality control checklist. The details in the quality control checklist for every station make it easier to recheck the bogie part if there are problems during the inspections. Not just that, it also ensures no procedures are missed and maintaining the quality of the bogie at the best possible level.

3.4 Validation by the Industrial Supervisor on the Improved Quality Control Checklist for Each Station of Bogie Assembly

The improved quality control checklist was checked and validated by the author's industrial supervisor, Ts Mohd Noor Fathullah bin Mohd Noordin which is the Assistant Manager of Engineering Department in Hartasuma.

4. Conclusion

The first objective was to analyse the quality control issue in the overall bogie assembly process. The problems that arose during the bogie assembly process was the redoing works after the inspection which takes time and increased the costs which resulted in delayed for KLAV 27 project. There was no proper quality control checklist at all six stations of the bogie assembly. The quality control checklist was only filled out at the end of the bogie assembly which was at station 6. The technicians needed to redo the works that they overlooked at the earlier stations at the end of the process which takes a lot of time to locate the missed procedures.

The second objective for this project is to propose an improved quality control checklist for the quality improvement of the bogie assembly. At the end pf this project, there were six quality control checklists produced for each station which specifically for each station. The quality control checklist contains major procedures that cannot be missed and important notes to be taken. This helps the technicians to assemble the bogie properly without redoing work and helps to avoid delays for KLAV 27 project.

The last objective is to validate the improved quality control checklist from the industrial supervisor regarding the contents of the quality control checklist so that it aligns with the standards and manual.

The improved quality checklist is recommended to be put at every station of the bogie assembly so that the quality of production is increased and even avoids delays. After the changes are implemented, they should be monitored to see if they have a good impact on the manufacturing process and generate revenue for the company. It can be done by developing a control strategy that specifies what data, how, when, and who should control it. Not just that, the improved quality control checklists also recommended to be use in the upcoming project as it is practical for other projects too.

This results in creating a good name for the company as well as resulting in many mega projects in the future with the high quality of the bogie production.

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