

The Improvement on the Visual Painting Inspection Process Flow of Train for Kuala Lumpur Additional Vehicle (KLAV) 27 Project

Umi Umaira Shaari¹ Karthigesu Nagarajoo^{2*}, Mohd Noor Fathullah Mohd Noordin³, Muhammad Zulhilmy Yaman³

¹Department of Transportation Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Hab Pendidikan Tinggi Pagoh, KM1 Jalan Panchor, 84600, Muar Johor, MALAYSIA

²Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Hab Pendidikan Tinggi Pagoh, KM1 Jalan Panchor, 84600, Muar, Johor, MALAYSIA

*Corresponding Author Designation

³Hartasuma Sdn. Bhd, Lot 29, Jalan Sungai Pinang 4/8, Pulau Indah Industrial Park, Phase 2 Pulau Indah, 42920 Port Klang, Selangor, MALAYSIA

*Corresponding Author Designation

DOI: <https://doi.org/10.30880/peat.2023.04.02.119>

Received 28 June 2023; Accepted 13 July 2023; Available online 13 July 2023

Abstract: The project is based on an ongoing Bombardier-Hartasuma Consortium Project, which is Kuala Lumpur Additional Vehicle (KLAV) 27. The problem that occurred in the project is the delay in train delivery to the client that is due to the multiple detail inspection stages and the facility could not provide enough lighting. This project is using DMAIC methodology. This project is applicable to exterior of the train area when performing visual and functional inspectional inspection by using 400 ±20% lux needed. The project aims to prevent project delay and extended work by improving the inspection process flow for train production by analyzing standard acceptance criteria and providing guidelines for visual, safety, and functional inspectional will help shorten the process and reduce time-consuming inspection. Implementing the Rig Platform also will shorten the inspection flow, ensuring no delays and extended work due to multiple stages. At the end of this project, there will be no delay and extended work due to the multiple stages of inspection process.

Keywords: Kuala Lumpur Additional Vehicle 27, Project Delay, Inspection, Rig Platform

1. Introduction

The railway sector relies heavily on quality control in the manufacturing sector, as it improves customer satisfaction, reduces production costs, and boosts profitability. Assembly facilities, such as

*Corresponding author: karthi@uthm.edu.my

2023 UTHM Publisher. All rights reserved.

publisher.uthm.edu.my/periodicals/index.php/peat

the railway sector, are responsible for assembling car bodies from OEM parts. Thorough inspection of painted surfaces is crucial, but human inspectors are expensive and labor-intensive, leading to discrepancies in overall productivity [1].

Railway vehicle coating is crucial for its aesthetic value and corrosion resistance [2]. Quality control is crucial to avoid repainting, which can increase costs and extend delivery times. Railway vehicles must be safe, aesthetically pleasing, and comfortable for passengers. Dependability is the first and most important criterion for a railway network, and coating quality is connected to long-lasting anti-corrosive protection. Coating quality is crucial for railway cars' durability and security, as per the Alstom Transport quality standard, ensuring long-lasting anti-corrosive protection and strength capabilities.

The quality inspection process is crucial for KLAV27 to ensure project deadlines and ensure the project meets quality standards. However, delays in train delivery and the company's facility's inability to provide $400 \pm 20\%$ lux for exterior inspections, as per QPS guidance, have caused issues. Failure to follow the guidance may result in errors and higher costs for repairs. To address these issues, KLAV27 should focus on a clear and manageable inspection process.

This study investigates the overall inspection process flow for the Kuala Lumpur Additional Vehicle (KLAV) 27 project, focusing on the train inspection process flow. It verifies standard acceptance criteria for the selected inspection process, provides a guideline for visual, safety, and functional inspection, and validates the success of solutions to shorten the process and improve train delivery to the client. The scope of the study is applicable to the exterior of the train area during visual and functional inspections by using $400 \pm 20\%$ lux needed.

2. Materials and Methods

2.1 Materials

The data was collected from the observation of the number of defects and the number of days taken during inspection process by the inspector. The inspection process involves analyzing the benefits, challenges, and commonly used tools and techniques in adopting DMAIC methodology on the rig platform. The phases of define, measure, analyze, improve, and control (DMAIC) [3]:

- i. Define: Study on the inspection process flow.
- ii. Measure: The standard acceptance criteria and to provide guidelines on the methodology of performing visual, safety and functional inspection for KLAV27 project.
- iii. Analyze: The factors contributing to project delays due to the train inspection process.
- iv. Improve: The solutions to shorten the process of train production by improving the quality process of inspection flow to improve the train's delivery to the client with implementing the Rig Platform.
- v. Control: The duration of inspection process flow needed.

2.2 Inspection process flow

The inspection will be visually inspected from ground level, standing a minimum of one meter away from the car body. An initial pass of the vehicle will be performed without stepping within the minimum inspection distance. The car is divided into three different appearance zones. Each zone has its own appearance.

Table 1: Description of zone locations [4]

	Zone	Description
1	Critical	Visible from a passenger standpoint within one meter
2	Major	Visible from a passenger standpoint below 60cm and above 2.5m (from top of rail)
3	Minor	All non-visible surfaces (including undercar & car)

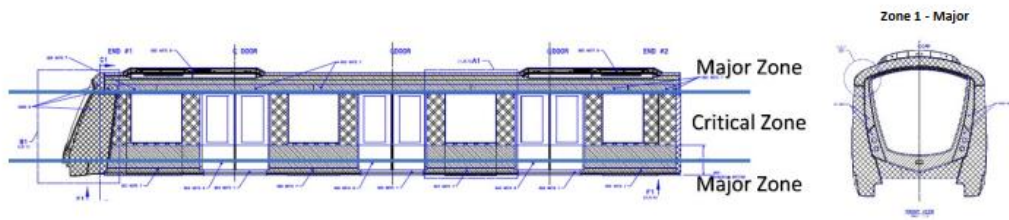


Figure 1: Zone definition [4]

Table 2: Viewing Criteria [4]

	Zone	Viewing Distance Criteria	Time
1	Critical	1 meter, standing at ground level	Walking pace
2	Major	1 meter, standing at ground level	Walking pace
3	Minor	2 meters	Walking pace

Table 2 shows the time given for the inspection of the assembled car is to set a reasonable pace of inspection. When defects are identified, additional time to measure individual defects and classify them is allowed.

2.3 Method

An indicating sticker will be placed at all areas of concern identified by customer for further interpretation using table 3 below. Lighting provided for the visual inspection will be $400 \pm 20\%$ lux. The measurement of lux will be taken in the horizontal position at eye level.

Table 3: Inspection conditions [5]

Inspection Condition	Critical and Major	Minor
1 Method	Un-aided with corrected vision if necessary (No magnification or flashlights)	
2 Distance (m)	1 to 1.5	1 to 1.5 based on accessibility.
3 Height	Standing on the same plane as the bogie/ same level as top of rail	Based on accessibility
4 Inspection	Static at distance defined.	
5 Lighting	400 ± 20% lux illuminant D65 measured at 2m above the location being examined. The light source must be homogeneous to avoid shadowing or glare and not hinder the inspector.	
6 Examination mask	If a defect is found, it must be identified and quantified. A mask containing a circular opening of 400mm in diameter is centered on the defect. Defects are subsequently identified and quantified according to requirements specified. Defects are not acceptable if 2 examinations using the mask are within 1m of each other, center to center	

2.4 Illuminant Standard

The client's train delivery delay was caused by detailed inspection phases, which require 19 days before handover. The company's facility was unable to produce the 400lux required for the external inspection, as per QPS guidelines. Failure to follow the inspection procedure could lead to potential faults and increased repair costs.

Office operations require 200 lux, while visual inspections demand at least 400 lux for scrutiny and attention to detail. Periodic rest is necessary to prevent fatigue. Light level intensity is measured in lux, a standardized unit of measurement. One lux is the amount of light that illuminates a surface one-meter square and one meter away from a single candle [6]. The light source must be homogeneous to avoid shadowing or glare and not hinder the inspector.

The train must be inspected on average natural daylight condition which means 400 lux needed. The illuminant D65, like mentioned in table 3 above means by the standard reference for the color temperature of natural daylight under typical midday conditions [7]. The train checking during the inspection must follow by the natural daylight condition. Illuminant D65 has a reading of 6500K [7], requiring inspection using a lamp with $400 \pm 20\%$ lux, which measures illuminance, brightness, and intensity of light falling on a surface. Kelvin measures color temperature.

2.5 Rig Platform drawing

Rig Platform is the platform that is used during the inspection process of exterior surface. This platform is used to make sure the lux needed is enough to support according to the guidance of Quality Product Specification (QPS).

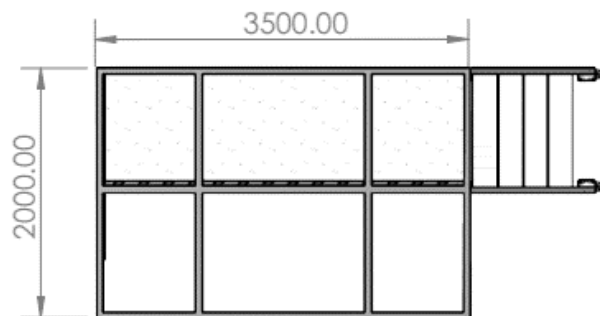


Figure 2: The Rig Platform in top view.

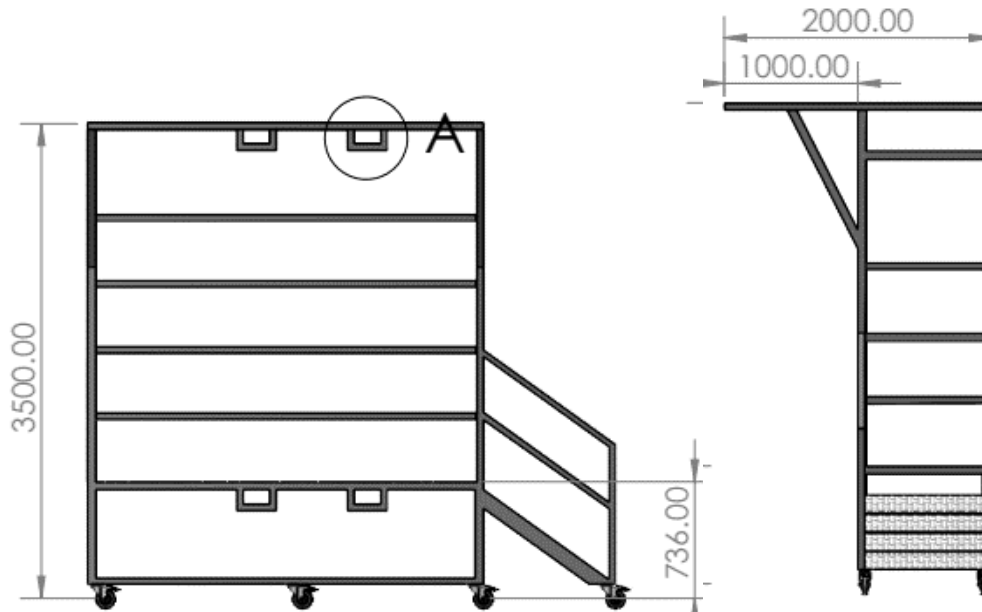


Figure 3: The Rig Platform in front views

Figure 4: The Rig Platform in side views

3. Results and Discussion

3.1 Final design of Rig Platform

The final design of Rig Platform is covered by curtains to prevent over lighting from the outside. Figure 5,6 and 7 below shows the Rig Platform covered by curtains.

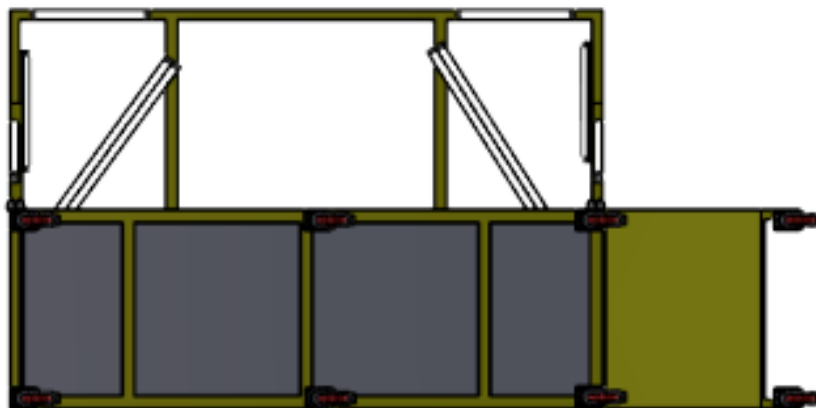


Figure 5: The Rig Platform covered by curtains in top views

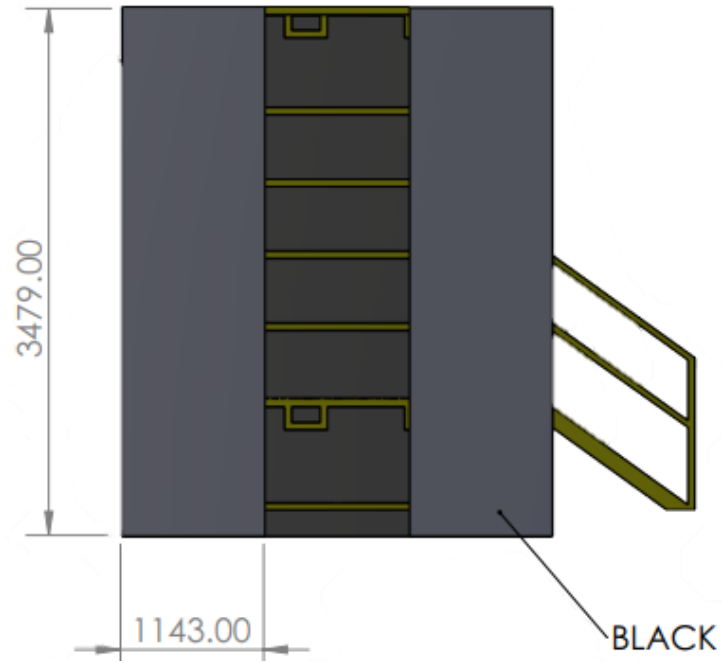


Figure 6: The Rig Platform covered by curtains in front views

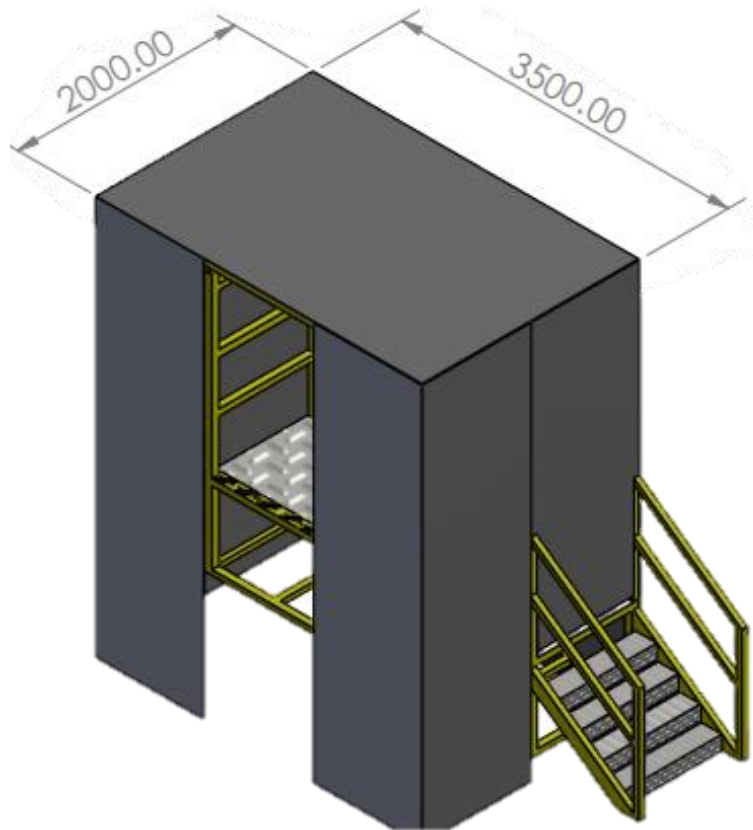


Figure 7: The Rig Platform covered by curtains in top, front, and isometric views

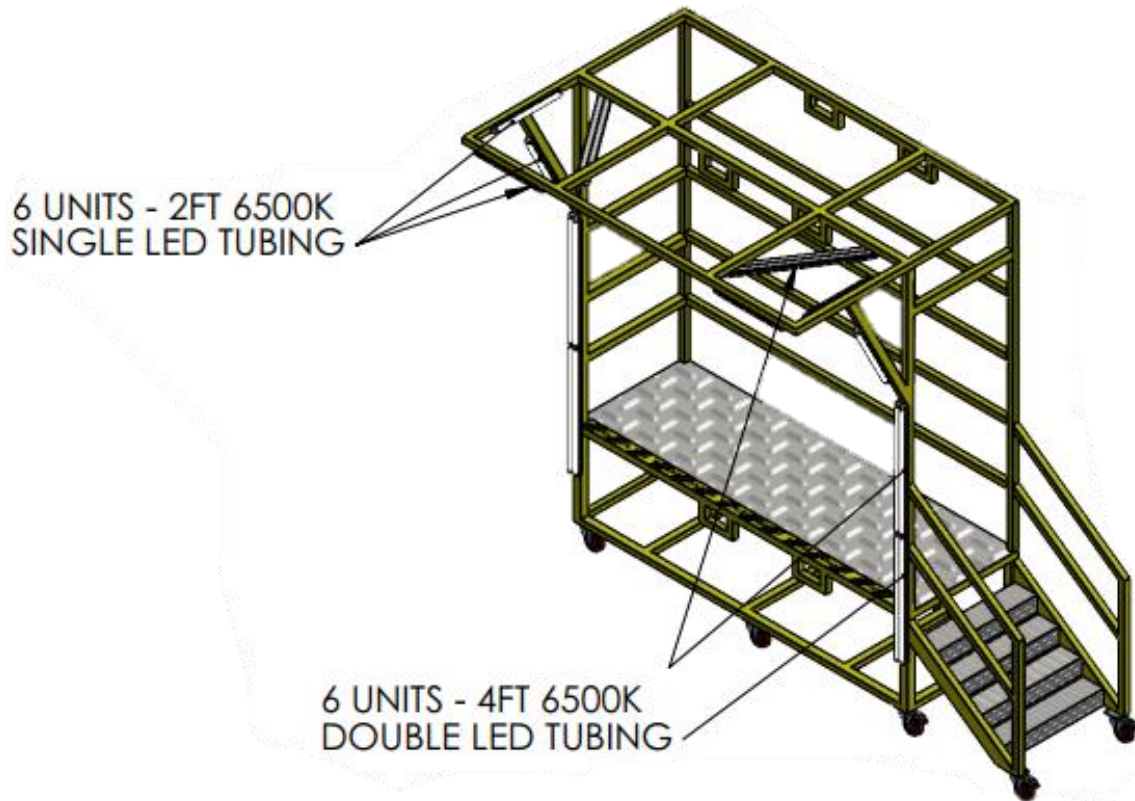


Figure 8: Rig Platform with light positioning

3.2 Comparison inspection method data

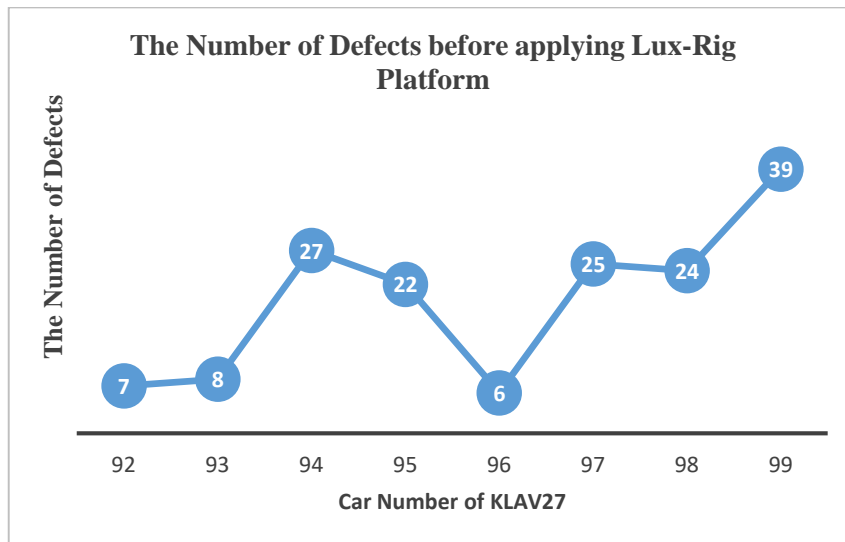


Figure 9: The number of defects before implementing Rig Platform

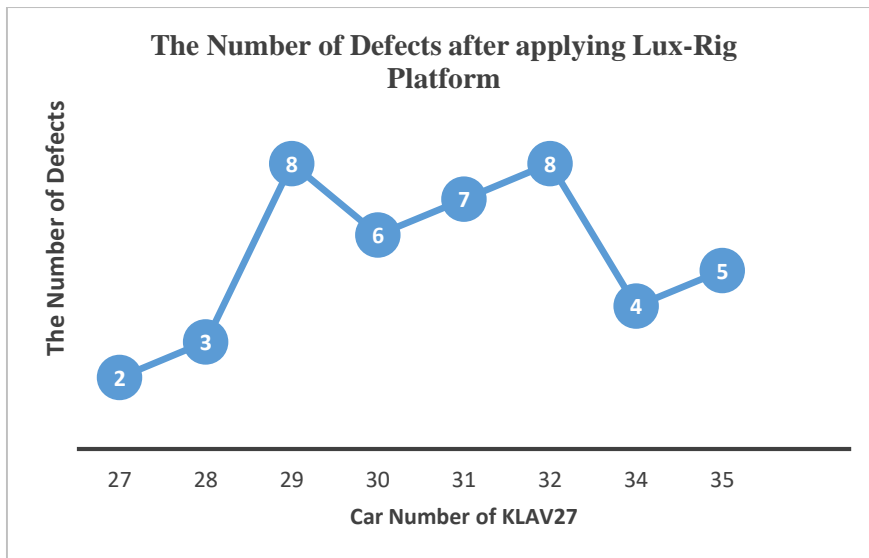


Figure 10: The number of defects after implementing Rig Platform

Figure 9 above shows the data on KLAV27 train for car 92 to 99. The data in Figure 9 shows that the minimum number of defects is 6 while the maximum number of defects is 39. The average number of defects before implementing the Rig Platform is 20. Figure 10 above shows the data on KLAV27 train for car 27 to 35. The data in Figure 10 shows that the minimum number of defects is 2 while the maximum number of defects is 8. The average number of defects after implementing the Rig Platform is 5.

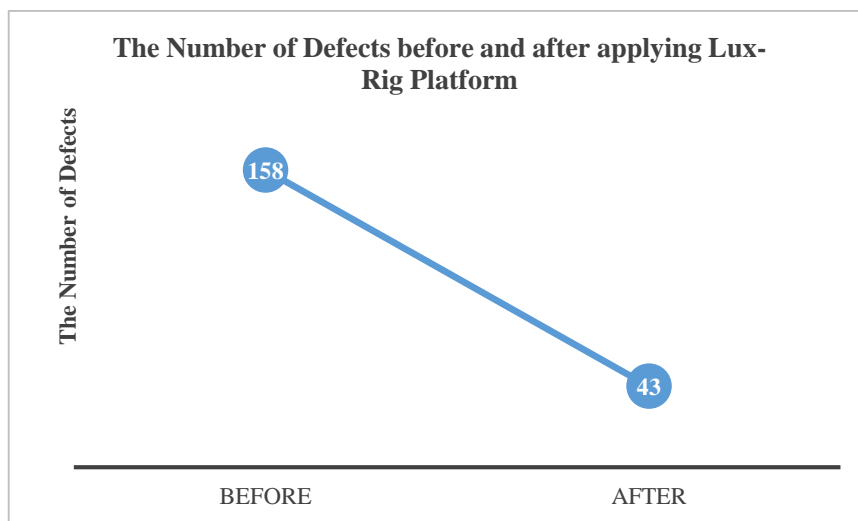


Figure 11: Comparison before and after implementing the Rig Platform

From Figure 11 above, there are many differences between before and after implementing the Rig Platform. The total number of defects before is 158 compared to after implementing the Rig Platform only 43. The Lux-Rig Platform significantly impacts the inspection process by making it smoother and more efficient. The implementation of the platform reduces delays and provides lux that the company cannot provide. It also helps staff adhere to Quality Product Specifications (QPS), preventing errors and higher costs for repairs. The platform's appearance and implementation significantly impact the inspection process, reducing the number of defects and ensuring a more accurate and efficient inspection process.

3.3 The defects

Failures or defects may be seen during the inspection process. There are two classes of defects in this project which are quantifiable and non-quantifiable failures or defects. Quantifiable is something that can be measured while non-quantifiable are not tangible. Table 4 below shows the classification of the defects that occur during the inspection process.

Table 4: Classification of the defects

	Quantifiable defects	Non-quantifiable defects
1	Color variations	Scratches
2	Gloss difference	Damage
3	Metallic paints mottling	Pinholes
4	Sanding failures or marks	Micro-foaming
5	Orange peel	Fingerprints
6	Pollution on surface	Dust and inclusions
7	Etc.	Etc.

3.4 Comparison inspection process flow

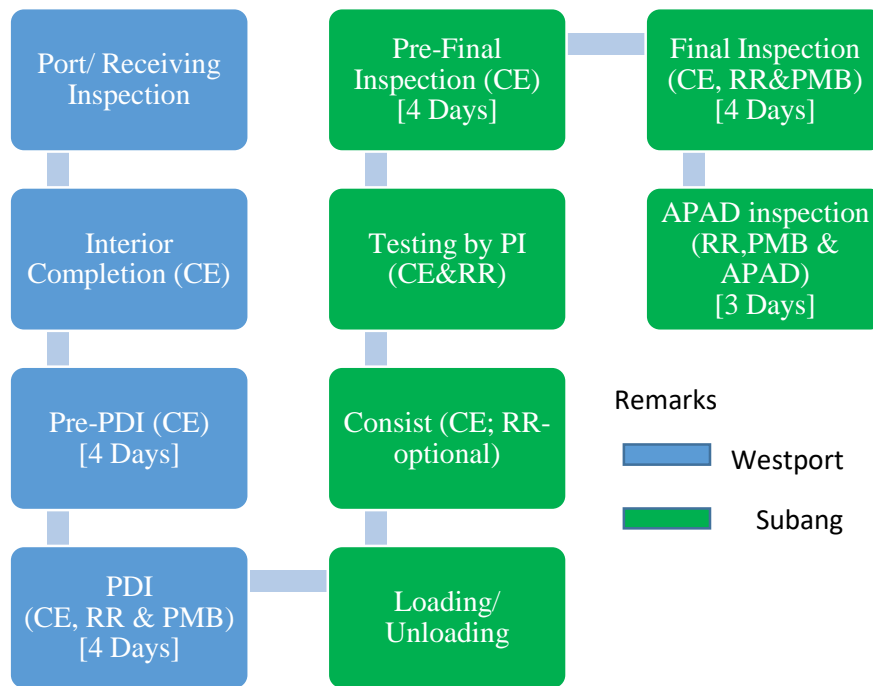


Figure 12: Current inspection process flow [4]

The current inspection process flow has few challenges, which mismatch of inspection alignment between Alstom (Bombardier) and employer. In examples, the paint issue, cosmetics, etc. the multiple detail inspection stages, which not benefit and not value add that cause of 19 days of inspection process taken from start until the handover. This is taking a longer time, which can cause delays.

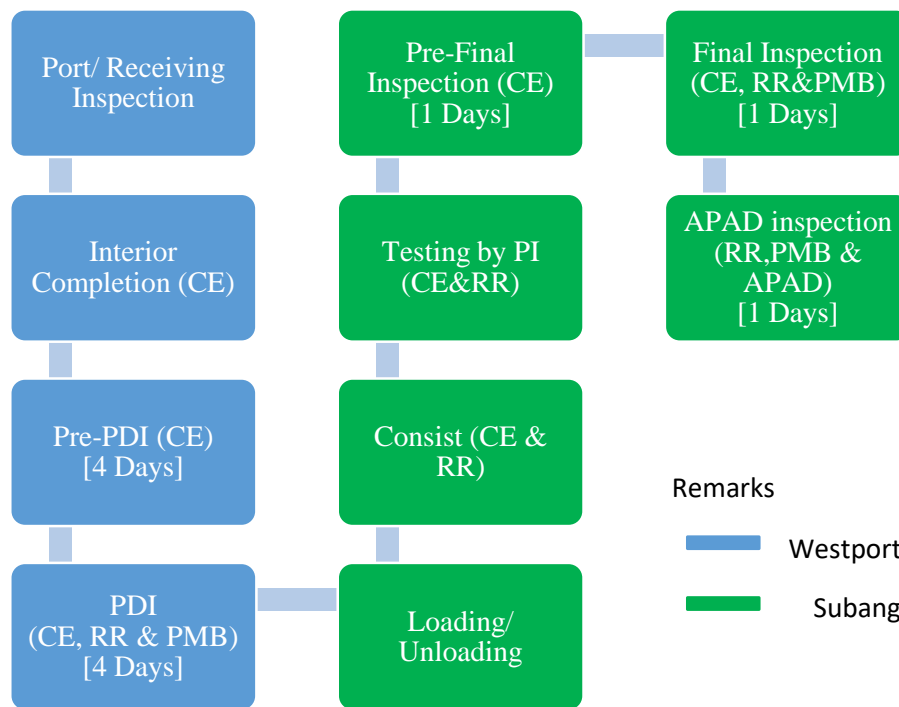


Figure 13: New inspection process flow

The advantages of this new KLAV27 inspection process flow is that the examination will be more thorough at Westport and that an overview inspection will be conducted at the depot before the area being demolished, which is more efficient. If any discovery at Westport required material from AME, Alstom had enough time to seek the material and resolve any issues as soon as possible before handover. So, the overall inspection day will be taken only eleven days till the handover.

Table 5: Comparison table between current and new inspection

	Current Inspection	New Inspection
Criteria (PDI)	100% details inspection	N/A
Criteria (Final Inspection)	100% details inspection	Post testing check/Break-off inspection
PDI Day	4 days	4 days
Final Inspection Day	4 days	1 day
Total Inspection Period	19 days	11 days

4. Conclusion

The outcomes and findings of this study demonstrated that all intended objectives were accomplished. This investigation was done to make sure there is no delay and extended work due to multiple stages of inspection process and to improve the quality process of inspection flow when having the Rig Platform.

The results from the objectives confirmed that by investigated the overall inspection process flow, to measure the standard acceptance criteria that contributes to the project delay, to analyze the factors contributing to project delays due to the train inspection process. By improving the quality process of inspection with implementing the rig platform. From the overall investigation, the research needs to control the duration of inspection process flow needed to make sure when using the Rig Platform, there will be no delay. This investigation followed the DMAIC methodology.

Future research should be conducted using the same car number since each car gives different types of defects and using various additional parameters such as using the same person of inspector. So, the data could be more appropriate.

Acknowledgement

The authors would also like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia and Hartasuma Sdn Bhd for their support.

References

- [1] Sohail Akhtar, Adarsh Tandiya, Medhat Moussa, & Cole Tarry. (2019). *An Efficient Automotive Paint Defect Detection System*. ResearchGate. https://www.researchgate.net.334159250_An_Efficient_Automotive_Paint_Defect_Detection_System
- [2] Amorin, D. C. (1999). *Acceptance Criteria for Painted Surfaces Inside and Outside of Railway Vehicles*. https://www.paintsquare.com/library/articles/Acceptance_Criteria_for_Painted_Surfaces_Inside_and_Outside_of_Railway_Vehicles.pdf
- [3] Ivan Evander Subagyo, Dewi Savitri Saraswati, Trilaksono, T., & Muhammad Setiawan Kusmulyono. (2020, December). *Benefits and Challenges of DMAIC Methodology Implementation in Service Companies: An Exploratory Study*. ResearchGate; Brawijaya University. https://www.researchgate.net/publication/347548422_Benefits_and_Challenges_of_DMAIC_Methodology_Implementation_in_Service_Companies_an_Exploratory_Study
- [4] Muhammad Zulfakar bin Zakaria. (2021). *KLAV27- Inspection Process Flow*
- [5] Berthiaume, J, & Mooney, J. *Quality Inspection Criteria Exterior Painted Surface*.
- [6] Green Business Light UK. (2020). *Read Our Ultimate Guide To Lux vs Lumens vs Watts For Lighting Installations | Warehouse & Factory Lighting*. Green Business Light. <https://greenbusinesslight.com/resources/lighting-lux-lumens-watts/>
- [7] Jacob. (2017, February 9). *What is Color Temperature?* Scott Lamp Company |. <https://www.scottlamp.com/2017/02/09/what-is-color-temperature/>