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Determine The Lifespan for Components in Automatic Platform Gate (APG) And Platform Screen Door (PSD) for Klang Valley MASS Rapid Transit (KVMRT) Putrajaya Line Project

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Abstract: KVMRT Putrajaya Line is a project developed to meet the needs of consumers for public transport in Malaysia. The project is divided into two phases, namely Phase 1 and Phase 2. Phase 1 is expected to operate at the Mid-June of 2022 while Phase 2 is expected to operate in 2023. This study only focuses on Phase 2 as all information and data are taken from Phase 2. APG and PSD operations require a lot of cycle motion due to the high rate of train operation throughout the day. Since the APG and PSD require a lot of cycle motion, the components found on both structures must have a long lifespan to accommodate the operation of the APG and PSD. The objectives of this research are to identify the components that involved in operation of APG and PSD. Then, to analyze the lifespan of each component based on the performance shown in APG and PSD and to develop the maintenance scheduling of operating period for APG and PSD based on the lifespan of components used There are two levels of APG and PSD testing, namely the Partial Acceptance Test (PAT) and System Acceptance Test (SAT). The PAT requires both structures to reach 240 cycles while the SAT requires 1000 cycles to pass the test. Based on the results, The two structures of the components show almost the same lifespan but slightly different. In conclusion, three objectives for research have been achieved with the lifespan for the components involved in the operation of APG and PSD can be determined through testing processes conducted.

Keywords: Automatic Platform Gate (APG), Platform Screen Door (PSD), Partial Acceptance Test (PAT), System Acceptance Test (SAT)

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1. Introduction

Urban railway technology in this modern age is evolving with the existence of several projects related to this railway. The existence of these projects is able to increase demand in some places to grow. Among the projects that are showing results is the Klang Valley Mass Rapid Transit (KVMRT) Putrajaya Line project which is one of the mega projects in Malaysia. The construction of this MRT project provides an advantage by providing great opportunities to the development of the country to boost the economy through the public transport system [1]. One of the important structures is the platform where passengers wait for the train. safety to prevent passengers from falling into the track. The structures used are Automatic Platform Gate (APG) and Platform Screen Door (PSD) [3]. APG and PSD are structures for the edge railway station platform to prevent passengers from falling onto railway tracks [4][5]. APG is a gate height platform door structure found in elevated stations while PSD has a full-height door structure found in underground stations. There are many benefits to the use of this APG and PSD such as prevention of collision with persons on the tracks, fewer delays caused by safety incidents, and minimal requirement of the number of station staff and train crew. The efficiency for this APG and PSD depends on the condition of the components found in the APG and PSD [2].

The efficiency of this APG and PSD is determined by the conditions of the components employed. The lifetime components that are necessary for the operation of APG and PSD determine the effectiveness of both types of structures. Electronic Locking Devices (ELD), Door Control Units (DCU), Gate Control Units (GCU), Junction Boxes, and Limit Switches are crucial components that allow APG and PSD to function correctly [4]. As a result, the longevity of the components employed determines how long APG and PSD can operate. The component lifespan can be used to determine the maintenance schedule [5]. Thus, the objectives for this research project are to identify the components that involved in operation of APG and PSD, to analyze the lifespan of each component based on the performance shown in APG and PSD and to develop the maintenance scheduling of operating period for APG and PSD based on the lifespan of components used [5].

1.1 Problem Statement.

Due to the high rate of train operation throughout the day, APG and PSD operations necessitate a lot of cycle motion. Because the APG and PSD require a lot of cycle motion, the components on both structures must have a long lifespan in order to support the APG and PSD's functioning. Important components used in APG and PSD operations, such as ELD, GCU, DCU, and limit switches, have a time limit before being replaced. Furthermore, because the Putrajaya Line MRT project is not yet operational, the APG and PSD structures are still being tested. As a result, the APG and PSD operations are still insecure due to problems with crucial components being damaged frequently. The Partial Acceptance Test (PAT) and System Acceptance Test (SAT) are the two tiers of APG and PSD testing (SAT). To pass the PAT, both structures must complete 240 cycles and the SAT requires 1000 cycles. Problems arise when both structures fail the PAT and SAT, leading the project's completion process to stall. As a result, the goal of this study is to investigate and assess the component lifespan in APG and PSD in order to achieve optimal and complete operation based on specified maintenance schedules.

1.2 Project Scope

The scope of this study has been determined to meet all of the objectives. To begin, the KVMRT Putrajaya Line project is included in the scope of this study. In general, the KVMRT Putrajaya Line is still under construction, and most of the systems, including APG and PSD, are still in the testing stage. The components provided on APG and PSD in this project serve as a baseline for APG and PSD's future operational efficacy. The effectiveness of components in APG and PSD will be examined in this study, which will include former projects such as the MRT Sungai Buloh - Kajang Line (SBK) and some international projects that can be utilized as examples.

2. Materials and Methods

This research has a flow chart. This flow chart covers the procedures performed to complete this research. Firstly, the testing process will be carried out on APG and PSD. the PAT process will be conducted first and then the SAT. The gap between PAT and SAT took 14 days. It aims to ensure that the components involved in the operation of the APG and PSD to pause to avoid damage that will cause the failure of the operation of the APG and PSD. Both types of testing took seven days to complete and two random stations were selected namely from the elevated station and underground (UG) station. Then the performance of the components involved will be recorded when the PAT and SAT passed or failed. If passed, the data that has been recorded will be analyzed and a verification report will be done. Meanwhile, if it fails, it will do the failed testing again until it passes and the same process will be followed after that. Figure 1 shown the flow chart for this research:

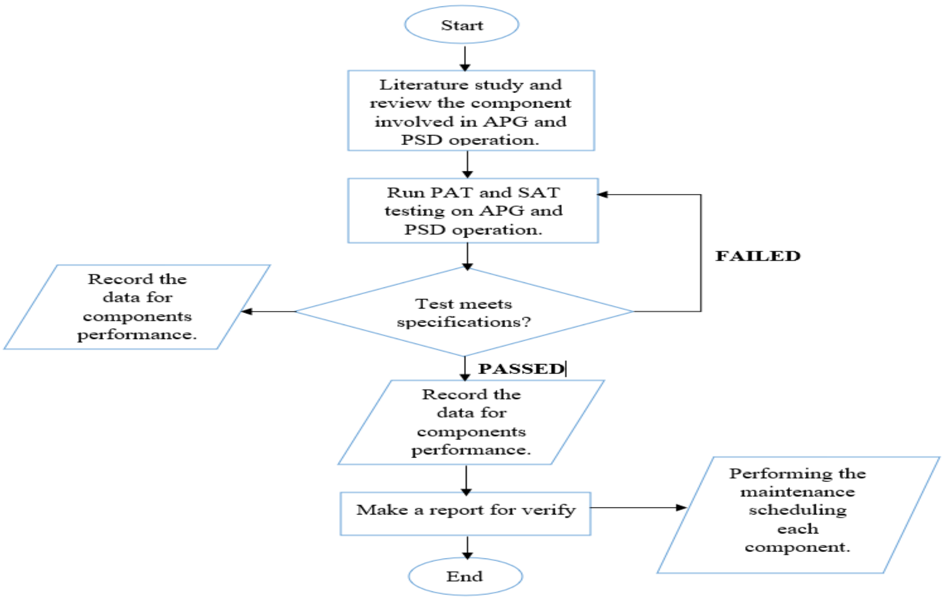

Figure 1: Flow chart's research

2.1 Testing process flow for APG and PSD

The testing step is an important step before formal testing is done. This testing process can discover any operational faults on the APG and PSD, allowing for maintenance work to be performed. Figure 2 depicts the process flow's testing steps:

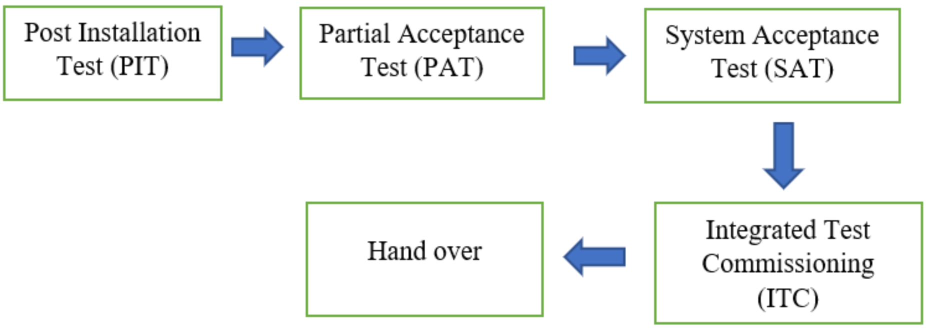

Figure 2: Process flows for testing steps

PAT and SAT are the testing processes used by APG and PSD at current time. Both tests use the same procedure, but the number of cycles addressed differs. Both forms of testing are done to see how APG and PSD work in a certain cycle. This technique also considers how well the components utilised in APG and PSD operations can survive extreme conditions. Passing the PAT requires 240 cycles, whereas passing the SAT requires 1000 cycles.

The criteria for passing the PAT and SAT is when all APG and PSD procedures and statuses pass the set targets. Failure to pass these criteria causes maintenance to be performed on APG and PSD. Table 1 shows the criteria for PAT and SAT:

Table 1: Criteria of PAT and SAT for APG and PSD

Criteria	Status
Pass.	Completed and achieved successful result in full.
Pass with Minor Outstanding Items.	Overall test has been passed however additional actions are required to fully complete the test.
Fail.	Failed any part of the test.

2.2 Components that involved in APG and PSD operation.

The arrangement of components involved in APG and PSD according to the standard drawing that has been sketched by the industry. Figure 3 and figure 4 show the arrangement of components involved in APG and PSD:

Figure 3: Arrangement components in APG

Figure 4: Arrangement components in PSD

2.3 The amount of time taken to complete the targeted cycle.

The number of cycles enforced influences the working efficiency of components depending on the testing stage, namely PAT and SAT. As a result, the time data collected for PAT and SAT will be compared to the Electric Train Test (ET), which takes a lengthy time to run and is used to test the operation of APG and PSD. The KVMRT Putrajaya Line is now undergoing APG and PSD testing before going live. As a result, the data obtained and evaluated for this study are PAT and SAT. The findings of this study will be used to plan maintenance for the project's long-term success. The train testing phase will begin in June 2022, and the maximal operation of APG and PSD will be demonstrated throughout the day.

i) Partial Acceptance Test (PAT) cycles time taken.

The calculation for the time taken for PAT to complete the cycles as follows:

$$Number\ of\ cycles\ target = 240\ cycles$$

$$1\ cycle = 20\ seconds\ or\ 0.33\ minutes \qquad Eq.1$$

$$100\ cycles = 100 \times 0.33 \qquad Eq.2$$

$$= 33\ minutes$$

$$Time\ taken\ to\ complete\ the\ targeted\ cycle = Number\ of\ cycle\ target\ \times time \qquad Eq.3$$

$$= 240\ \times 0.33$$

$$= 79.20\ \ minutes\ (per\ day).$$

Therefore, the total time taken to complete 240 cycles are 79.20 minutes. In the duration time, the efficiency components will be test to determine the lifespan.

ii) System Acceptance Test (SAT) cycles time taken.

The calculation for the time taken for SAT to complete the cycles as follows:

$$Number\ of\ cycles\ target = 1000\ cycles$$

$$1\ cycle\ = 20\ seconds\ or\ 0.33\ minutes \qquad Eq.4$$

$$100\ cycles\ = 100 \times 0.33\ minutes \qquad Eq.5$$

$$= 33\ minutes$$

$$Time\ taken\ to\ complete\ the\ targeted\ cycle = Number\ of\ cycle\ target\ \times time \qquad Eq.6$$

$$= 1000\ \times\ 0.33$$

$$= 330\ minutes\ \ or\ 5\ hours\ 50\ minutes\ (per\ day).$$

Therefore, the total time taken to complete 1000 cycles are 5 hours 50 minutes. In the duration time, the efficiency components will be tested to determine the lifespan.

3. Results and Discussion

Results related to this research are discussed in this section. It covers how to collect data, analyze data, and translate the analyzed data into actual data. Then, maintenance scheduling is also one of the results for this research because it is planning for the future.

3.1 Data collection for PAT and SAT based on a station targeted.

The data collected based on PAT and SAT performed on APG and PSD were implemented. Generally, the PAT and SAT steps have a specific time period targeted based on the current state of the APG and PSD structures. Duration to complete the PAT is three days (minimum) to seven days (maximum) while for the SAT is seven days (minimum) and one month (maximum). The duration depends on the structure of the APG and PSD. The duration described involves APG and PSD. Therefore, table 2 shows the duration of PAT and SAT as well as the gap between PAT and SAT on APG and PSD:

Table 2: Duration of PAT & SAT and gap between PAT & SAT

	Duration (day)	
	Min	Max
PAT	3	7
SAT	7	30
Gap between PAT and SAT for each station are 7- 14 days.		

Thus, the data taken for this study for each station is seven days for PAT and SAT. This can ensure that the data taken is easy to analyze to determine the results of the study.

3.2 Output lifespan components based on the PAT and SAT on APG.

The data gathered by a random station (elevated station) for the output performance components on PAT and SAT for APG structure is shown in the tables below. The data was obtained during a seven-day period.

Table 3: Output components performance based on PAT for APG

Components	No of day No of cycles running on ASG						
	1	2	3	4	5	6	7
ELD (solenoid)	38	80	113	128	163	240	240
Limit switch	55	102	115	163	171	200	240
JB	12	240	240	240	240	240	240
GCU	100	141	240	240	240	240	240

Table 4: Output components performance based on SAT for APG.

Components	No of day No of cycles running on ASG						
	1	2	3	4	5	6	7
ELD (solenoid)	34	95	169	250	414	867	1000
Limit switch	67	143	254	333	519	651	1000
JB	1000	1000	1000	1000	1000	1000	1000
GCU	236	1000	1000	1000	1000	1000	1000

3.3 Output lifespan components based on PAT and SAT on PSD.

The tables below show the data collected by a random station (UG station) for the output performance components on PAT and SAT for PSD structure. The data taken and collected was seven days duration.

Table 5: Output components performance based on PAT for PSD

Components	No of day No of cycles running on ASG						
	1	2	3	4	5	6	7
ELD (solenoid)	33	102	114	130	171	228	240
Limit switch	54	110	112	159	180	240	240
JB	240	240	240	240	240	240	240
DCU	240	240	240	240	240	240	240

Table 6: Output components performance based on SAT for PSD

Components	No of day No of cycles running on ASG						
	1	2	3	4	5	6	7
ELD (solenoid)	29	101	177	300	436	772	1000
Limit switch	69	142	255	378	623	815	1000
JB	1000	1000	1000	1000	1000	1000	1000
DCU	20	1000	1000	1000	1000	1000	1000

3.4 Analysis components performance based on PAT and SAT for APG

The purpose of the component performance analysis based on PAT for APG was to see if each component function could work properly. The rate of operation level under minimal and maximum conditions will be determined by the partial testing carried out. The APG operation testing takes into account the cycles completed. Based on the performance components of the APG based on the PAT and SAT, the number of cycles completed will define the level of operation. Figures 5 and 6 provide graphs based on PAT and SAT for component performance output:

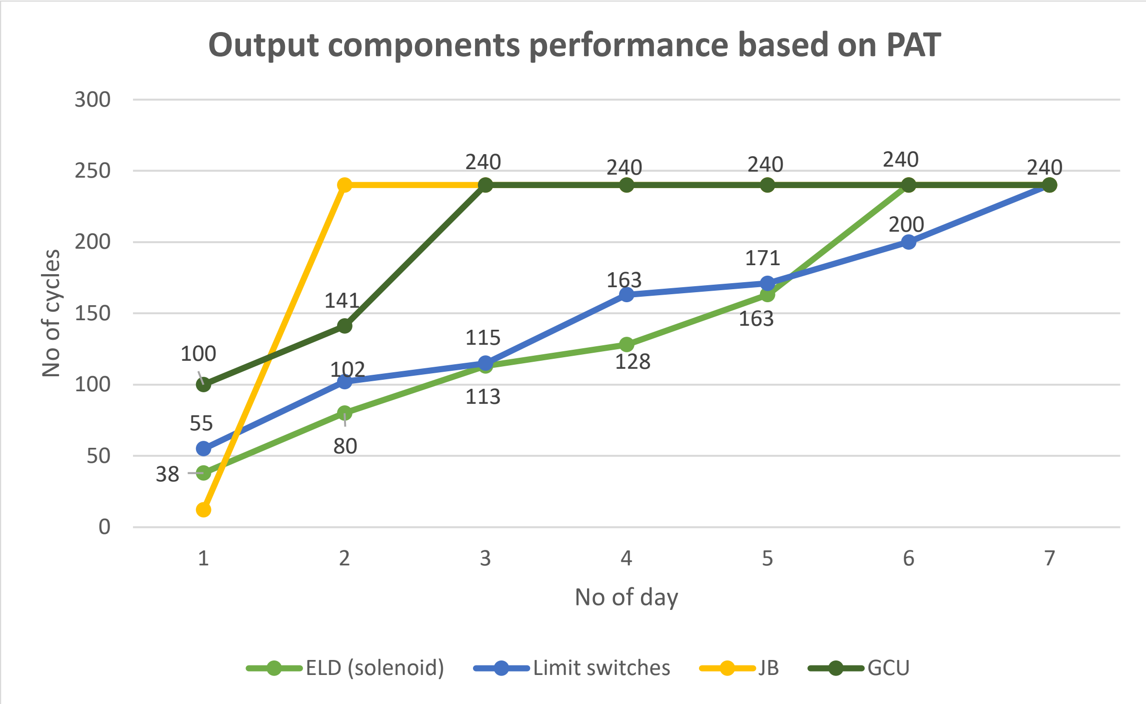

Figure 5: Output components performance based on PAT for APG

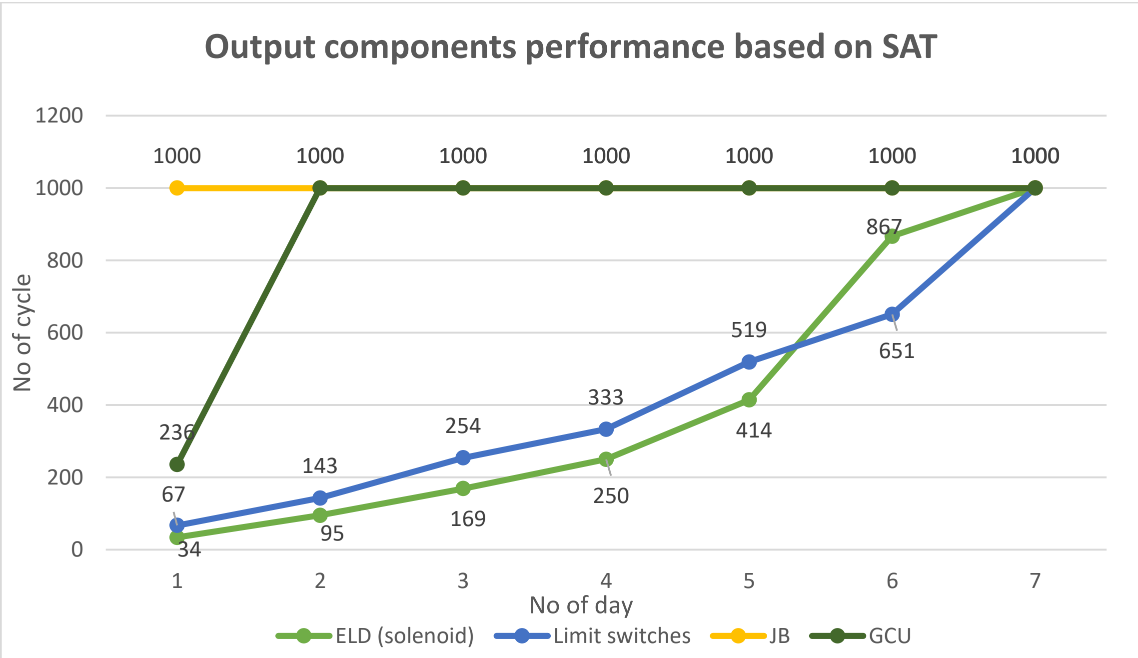

Figure 6: Output components performance based on SAT for APG

Figures 5 and 6 depict the performance of each component in terms of PAT and SAT for APG operation. As can be observed from these graphs, JB and GCU are consistent components in terms of PAT and SAT performance for APG operation. These three components are the most important in ensuring that APG and ADCL run smoothly. For both tests, the data obtained for JB and GCU performance was seen from the consistency from Day 1 to Day 7. The APG cycle for the Automatic Screen Door (ASG) for PAT only reached 236 on Day 1 because JB had a difficulty with a short circuit on their side, forcing the APG cycle to be delayed.

Then there's the ELD and limit switch, which make sure the APG opens and closes without a hitch. Both of these components are included in each ASG of the APG. In terms of output performance, the PAT and SAT graphs show that ELD and limit switches have improved from Day 1 to Day 7. Most ASG experience cycle failure owing to a physical fault with the ELD, which is damaged and cannot pull or push appropriately, as well as ELD alignment, which is compromised by repeated cycles and must be re-troubleshooted before re-cycling. The limit switch is the most delicate component after that, and it frequently fails due to its lack of continuity. The limit switch for PAT and SAT is largely to blame for the ASG's cycle failure on the APG. Looking at the graphs for the PAT and SAT switch limitations, the performance output improved slightly from Day 1 to Day 7, but not significantly.

3.5 Analysis components performance based on PAT and SAT for PSD.

PSD is a structure used in UG stations. Each PSD door is called an Automatic Screen Door (ASD). The performance analysis based on PAT and SAT to determine the effectiveness of each performance components for PSD operations. The data collected and analyzed are ASD data recorded when PAT and SAT on PSD were conducted over a period of seven days. As usual, PAT and SAT are conducted to ensure that the PSD performance works well. Both types of testing are objective in each PSD operation. Thus, the output performance components for PSD will be analyzed and evaluated through the PAT and SAT. Figures 7 and figure 8 show the graphs for components performance output based on PAT and SAT:

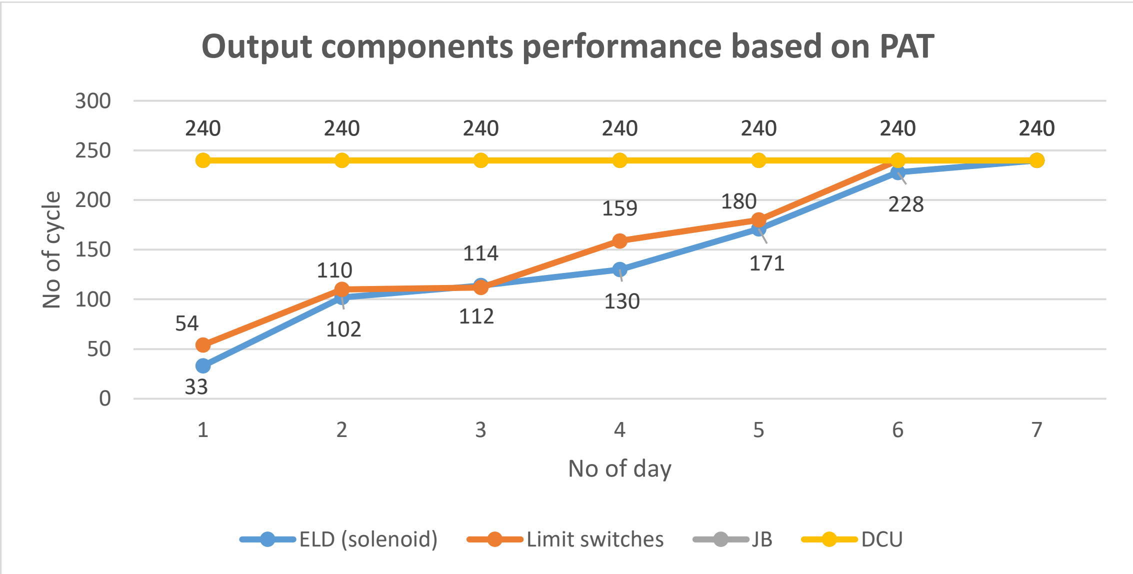

Figure 7: Output components performance based on PAT for PSD

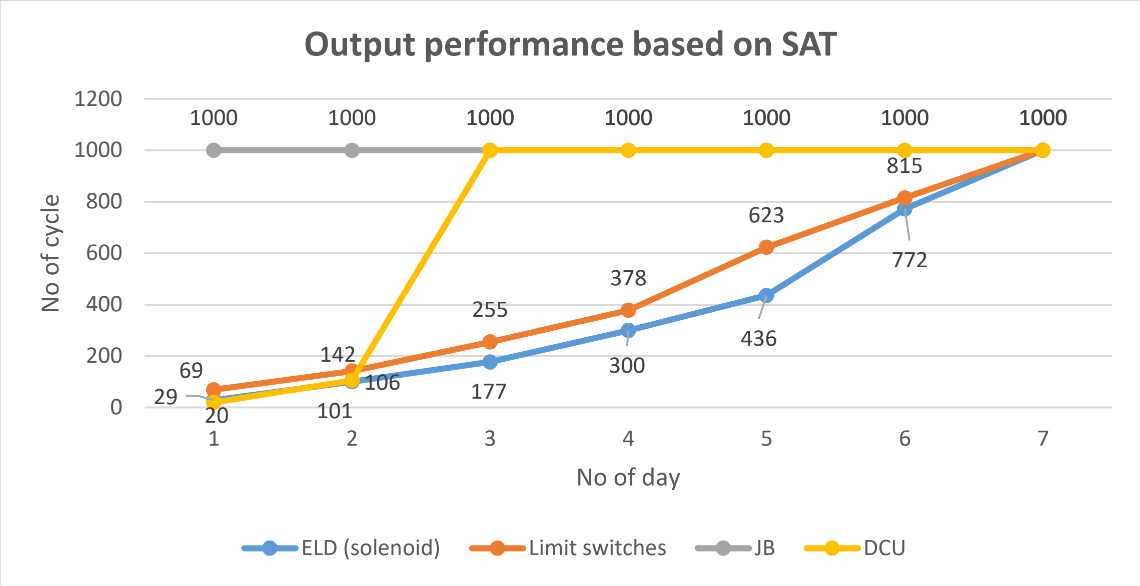

Figure 8: Output components performance based on SAT for PSD

Figures 7 and 8 depict the performance of each component in terms of PAT and SAT for PSD operation. JB and DCU are consistent components in terms of performance on PSD operations through PAT and SAT, according to the patterns in both graphs. The output DCU performance for PAT reveals that ASD for PSD is consistent for seven days in a row, however DCU performance for SAT reveals that DCU fails to work on 20 cycles. This occurs when ASD fails to receive a directive from DCU, causing PSD to malfunction. The DCU's concern is that the cabling system has been broken, preventing the PSD's signaling system from being sent to the DCU for action. Meanwhile, JB has a very consistent trend from its performance for PAT and SAT. The trend graph shows that ASD can complete 240 cycles for PAT and 1000 cycles for SAT without any problems from JB.

Then there's an ELD and a limit switch on each ASD for PSD. The trend graph for ELD and limit switch output performance shows that both components have improved in terms of performance from Day 1 to Day 7. When it comes to failures caused by cycles done on a specific number, ELD and limit switches, like APG, share the same issue. The failure of these two components allows ASD to encounter "obstacle detection," which causes the cycle to fail to complete during PSD operation. As a result, PAT and SAT are critical measures in ensuring that PSD preparation runs well in the future.

3.6 Output result of lifespan components involved in APG and PSD.

The actual results for the lifespan of each component engaged in the APG and PSD operation have been done based on the tests that have been implemented, based on the analysis that has been done on the performance of the components involved. The tests revealed that the components involved, such as the ELD, limit switch, JB, GCU (APG), and DCU (PSD), function similarly in APG and PSD operations. The following formula is used to calculate the component's lifespan:

$$The\ lifespan\ components = \Sigma Total\ hours\ PAT\ cycles\ targeted + \Sigma Total\ hours\ SAT\ cycles\ targeted \qquad Eq.7$$

Table 7: Lifespan components in APG operation

Components.	Lifespan (per hour).	Estimation of actual lifespan based on the train operations (day).
ELD.	19.40	150
Limit switch.	22.07	60
JB	46.50	345
GCU	42.22	300

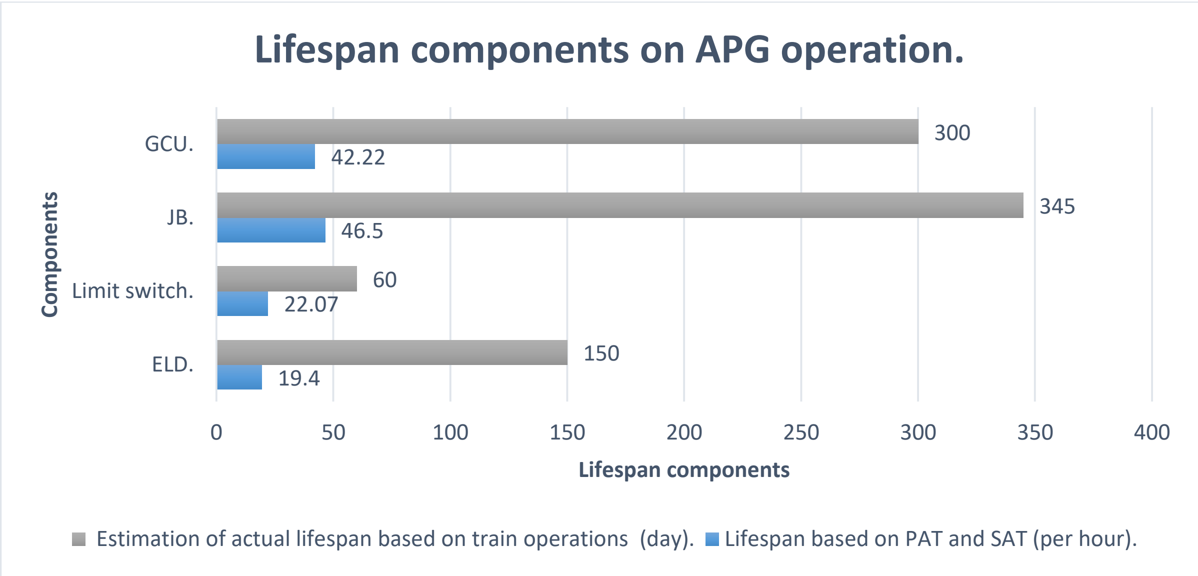

Figure 9: Analysis of lifespan components in APG operation

Table 8: Lifespan components in PSD operation

Components.	Lifespan (per hour).	Estimation of actual lifespan based on the train operations (day).
ELD.	21.08	155
Limit switch.	24.07	80
JB	47.74	350
DCU	42.35	340

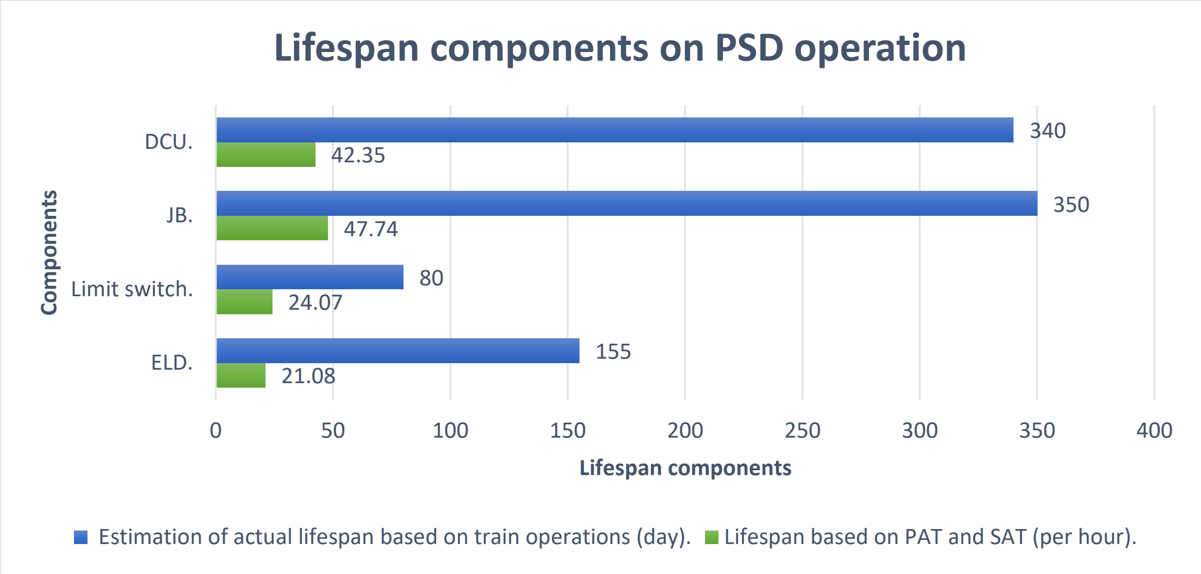

Figure 10: Analysis of lifespan components in PSD operation

3.7 APG and PSD maintenance scheduling task intervals.

Maintenance scheduling is critical to the success of any project. In general, the KVMRT Putrajaya Line 2 is scheduled to open in 2023. This project's study data is solely focused on step testing. According to the level of output performance indicated by the PAT and SAT completed, each component engaged in the operation of APG and PSD has a lifespan. As a result, the findings of data analysis for APG and PSD operations using PAT and SAT will define the maintenance scheduling of each component involved based on their unique performance outputs. Monthly Task, Quarterly Task, Half-Yearly and Yearly Task are the four types of maintenance tasks for this research. Throughout the PAT and SAT, the performance of each component engaged in the operation of APG and PSD is critical. The maintenance schedule for each component involved in APG and PSD functioning is shown in Table 9:

Table 9: APG and PSD maintenance scheduling task intervals.

Components	Maintenance activities	Maintenance category
ELD	1) Functional check of ELD.	Quarterly.
	2) Checking ELD alignment on ASG and ASD.	Monthly.
	3) Functional check of ERM Box Operator Lock.	Monthly.
	4) ASG and ASD Obstacle Detection System Inspection and Functional Check.	Half-Yearly.
	5) Checking and replacement of Electromagnetic Lock.	Yearly.
	6) Checking and replacement of ELD.	Yearly.
Limit switch	1) Checking continuity of limit switch.	Quarterly.
	2) Checking and replacement of limit switch.	Yearly.
	3) Checking and replacement of EEG bypass switch.	Yearly.

JB	1) Checking APG and PSD System Insulation and Bonding.	Monthly.
	2) Visual Check & Clean Rectifier Module of PDU.	Quarterly.
	3) Visual Inspection and Cleaning of APC.	Half-Yearly.
	4) Inspection of noise level.	Half-Yearly.
	5) Checking and replacement of DC/AC Module.	Yearly.
	6) Checking and replacement of AC/DC Module.	Yearly.
	7) Checking and replacement of Insulation Monitoring Device (IMD).	Yearly.
	8) Checking and replacement of JB.	Yearly.
GCU & DCU	1) Inspection and functional check of Signalling Loop.	Monthly.
	2) Fault History, Lamp Test and Fuse box check of APC.	Monthly.
	3) Functional check of Emergency Open Indicator Light (EOIL) and PMG Open Indicator Light (POIL).	Monthly.
	4) Functional check of Gate Open Indicators Light (GOIL) and Door Open Indicators Light (DOIL).	Monthly.
	5) Functional Check of Local Control Key Switch (LCKS).	Half-Yearly.
	6) Checking and replacement of GCU and DCU.	Yearly.

3.8 Discussion

The final results of this research are based on performance outcomes each component involved in APG and PSD to determine the lifespan of each component. Two types of testing conducted, namely PAT and SAT on APG and PSD are the actual data taken during this research. Cycles were performed by each ASG (APG) and ASD (PSD) according to a targeted cycle taken over a period of seven days. Maintenance scheduling framed in this research is the final results for this study. Each recorded data was analyzed through a case methodology conducted. Each component involved has characteristics in terms of physical, system, power and signaling system. Thus, the results show that the lifespan of the components involved is a comprehensive study. Then, the maintenance scheduling on the components found in APG and PSD is the result of data that have been analyzed through PAT and SAT performed on APG and PSD. This maintenance scheduling is the result of a comprehensive study covering the performance of each component, production and manufactured components, the level of efficiency components and the stock issued by the manufacturer of the components involved. Changes in maintenance scheduling may occur when the project is fully operational in the future.

4. Conclusion

The longevity of the components involved in the operation of APG and PSD may be established by testing techniques, which has achieved three this research objectives. The components that make up the APG and PSD are the most important in ensuring that the APG and PSD can function properly. ELD, limit switch, JB, GCU, and DCU are the components. The level of performance of APG and PSD is then determined by the PAT and SAT testing process. The performance of each component engaged in the operation of APG and PSD can be measured as a consequence of both types of testing to determine the component's lifespan level. Finally, the data of each component's lifespan can be used to create maintenance schedules for long-term plans. Maintenance schedule can ensure that APG and PSD are always in good working order and that all components engaged in operations are well maintained. Physical, signaling, and power failures account for the majority of component failures.

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