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Effectiveness Study of KTMB Track Inspection Methods to Improve Track Quality

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Abstract: Contactless-Laser Detection enhances railway inspection capabilities, using Track Gauge, Amber Geismar, and EM120T to monitor infrastructure condition and prevent breakdowns. However, inconsistencies in inspection results can affect maintenance decisions and decision-making. The main objective for this study is to analyze the effectiveness of track inspection method and suggestion for future improvement of track inspection method used to KTMB which has been involve with analyzation data of three inspection method (Track Gauge, Amber Geismar and EM120T) at KM 421.550 to KM 421.670 (UKM to Bangi). Static track inspection data will be collected using Track Gauge to measure gauge, cant, twist, and surface. Amber Geismar can measure surface parameters, but surface parameters are unavailable. Dynamic track inspection data will be collected using EM120T machinery, creating graphs and exception reports. OIE (overall inspection effectiveness) is used for evaluation. The study demonstrates EM120T as the most efficient approach for track inspection, enabling quick assessment of seven parameters. A reliable conversion multiplier converts static data from Track Gauge and Amber Geismar. The analysis focuses on railway track locations, including straight lines and gradients, to determine the impact of inspection results. The multiplier may change if inspections are conducted at curves. The study used unmaintained tracks and recommended acting on inspection findings after maintenance. The application of a multiplier to convert static and dynamic track data can be enhanced. The results may be strengthened if the obtained multipliers vary slightly, but a significant gap can make it easier for inspectors to conduct track inspections in different categories.

Keywords: Track Inspection, Prevent Breakdowns, Permanent Way Inspector

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1. Introduction

The railway line's track geometry deteriorates due to the continuous rolling of locomotives and long-term train loads, causing deformed rails, couplings, and sleepers. This leads to increased labor costs and a decrease in net profit. To improve line detection, various inspection equipment has been introduced, including contactless-laser detection. These methods are used to inspect railway infrastructure and prevent rail failures. Revenue trains' tracks are inspected weekly by foot or by riding over the track in a vehicle at a speed that allows for noncompliance with standards. In rare cases, a qualified person must inspect the track from a revenue vehicle, allowing a full view of the railway track. All inspections must be performed by a qualified person.

This study aims to analyze the effectiveness of three track inspection methods (Track Gauge, Amber Geismar, and EM120T) at KM 421.550 to KM 421.670 (UKM to Bangi). The study collects static data using Track Gauge, measuring gauge, cant, twist, and surface, while Amber Geismar measures surface parameters. Dynamic data is collected using EM120T machinery, creating graphs and exception reports. The study demonstrates EM120T as the most efficient approach for track inspection, enabling quick assessment of seven parameters. The study recommends acting on inspection findings after maintenance and enhancing the application of a multiplier to convert static and dynamic track data.

The following are the objective of this paper's: -

i. To identify the parameters of track inspection currently used by KTMB.
ii. To measure each track inspection method implemented by KTMB.
iii. To analyze the effectiveness of track inspection method and suggestion for future improvement of track inspection method used to KTMB.

1.1 Various Type of Inspections

However, with the continuous rolling of locomotives and long-term train loads, the track geometry of the railway line continues to deteriorate. The subgrade and ballast bed continue to produce deformed rails, fastenings and sleepers, resulting in continuous changes in the technical status of the line equipment [1]. The continuous increase in railway mileage has caused a corresponding increase in labour costs and decrease in net profit. To improve the line detection ability, different inspection equipment has been put into maintenance work.

When Contactless-Laser detection was introduced to railway inspection, various inspection methods have been used for inspecting the health of railway infrastructure or as a preventive measure against rail failures [2]. Tracks used by revenue trains shall be inspected weekly by foot inspection, or by riding over the track in a vehicle at a speed that allows detection of noncompliance with these standards. In the unusual event that a walking or riding inspection cannot be performed, a qualified person must inspect the track from a revenue vehicle in a position that allows full view of the roadbed. Inspections must be performed by a qualified person [3].

1.2 Conversion Multiplier

Multiplier methods, introduced in 1969, are robust and efficient in solving constrained engineering optimization problems by minimizing unconstrained problems using cost and constraint functions. They are useful for optimum design and control of large-scale dynamic systems. Since then, several modifications and extensions have been developed, making it crucial to review the theory and computational procedures of these methods to develop more efficient and effective ones for engineering applications. Recent methods, such as continuous multiplier update, exact penalty, and exponential penalty methods, are also discussed [4]. This is crucial for ensuring accurate measurements across different systems, ensuring efficient communication and understanding between different regions. Conversion multipliers are a valuable tool for engineers and railway workers.

Conversion is a multi-step process involving multiplication, division, selection of significant digits, and rounding [5]. By understanding how to use them, engineers and railway workers can communicate effectively and ensure that their projects are completed safely and efficiently. The conversion multiplier can be used to convert static track inspection data to dynamic track inspection data for the purpose of safety analysis. By knowing the conversion multiplier, engineers can estimate the dynamic loading on a railway track based on the static inspection data. This information can be used to identify potential safety hazards and to ensure that the railway track is safe for operation.

2. Materials and Methods

2.1 Materials

Static track inspection data involves site works activity, joint inspection with PWI and gangers, using Track Gauge (Fig. 1 (a)) for gauge, cant, and twist measurements, while Amber Geismar shown in Fig 1. (b) can inspect gauge, cant, twist and surface (but not being used in this study). Dynamic track inspection data involves EM120T machinery illustrates in Fig. 1 (c), generating graphs and exception reports for PWI to address track geometry irregularities:

a. Track Gauge
b. Amber Geismar
c. EM120T

(a) (b) (c)

Figure 1: (a) Track Gauge, (b) Amber Geismar, (c) EM120T

2.2 Methods

Inspections can be conducted using dynamic or static methods, such as visual or sensory, machinery, or instruments, to determine if interventions are necessary for equipment, process, or plant dependability and safety and environmental objectives. Three types of equipment (Track Gauge, Amber Geismar, EM120T) has a different outcome in term of parameters that been observed. Results are discussed using graphs and overall evaluation based on cant, gauge, and twist results. OIE (overall inspection effectiveness) is a simple statistic for evaluating inspection performance [6]. The conversion multiplier has been introduced based on the most effective inspection method which is EM120T.

2.3 Equations

The average value from the parameters (gauge, cant and twist) is used for calculation of the multiplier to convert static track inspection data to the nearest dynamic track inspection data. The formula of calculation as being illustrated below:

$$\frac{static\ inspection\ data}{dynamic\ inspection\ data} = conversion\ multiplier \qquad \text{Eq. 1}$$

Guidelines:

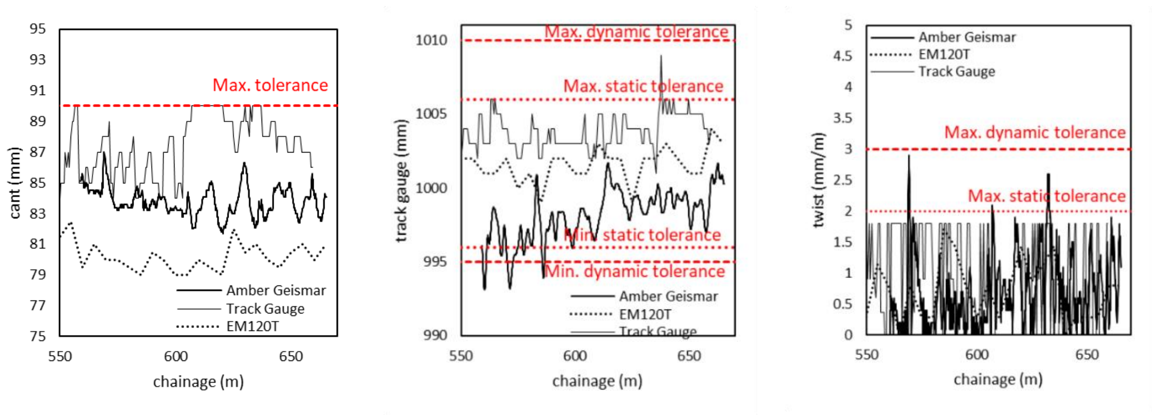
Static track inspection data = Track Gauge/Amber Geismar/combined static track inspection

Dynamic track inspection data = EM120T

3. Results and Discussion

The results of the inspections system's analysis in KTMB will be discussed in detail. Track Gauge, Amber Geismar, and EM120T are the three separate equipment being utilized, which are grouped into two distinct inspection methods (static and dynamic track inspection). Based on the created graph, the outcome will be discussed. This chapter also contained an overall assessment based on the results of three pieces of equipment's cant, gauge, and twist measurements (Track Gauge, Amber Geismar and EM120T).

3.1 Results



(a) (b) (c)

Figure 2: (a) cant graph, (b) gauge graph, (c) twist graph.

Based on Fig. 2, For cant, EM120T, which is a machinery type of inspection has a better result than others because it shows the real situation of the cant when the train passing on the curve. Meanwhile, for gauge, Track Gauge and Amber Geismar are passive measurements, prone to human error, while dynamic methods use data logging and dedicated software to reduce error factors and provide more practical results. Then, twist inspection data are not able to detect directly by using Track Gauge since it needs to be calculated using the formula that been created in railway industry [7]. Also, Amber Geismar is unable to experience the twist problem since the twist is related with the train bogie.

3.2 Discussions

Dynamic track inspection is the most efficient gauge inspection method, faster than Amber Geismar and Track Gauge. It is suitable for curve monitoring and cant inspection, but requires unloaded measurement [8]. EM120T is the most effective due to its safety, shorter inspection periods, and dynamic approaches. It ensures smooth train operation and safety during train passing, saving time and resources. The result for EM120T (dynamic track inspection) is slightly different compared to static track inspection (Track Gauge and Amber Geismar) which has identical data.

3.3 Tables of the Conversion Multiplier

The multiplier is calculated for easier dynamic value determination using static track inspection method. Results may differ slightly due to EM120T load as presented in the following:

Table 1: Conversion multiplier based on EM120T

Parameters	Proposed multiplier based on dynamic track inspection (EM120T)		
	Track Gauge	Amber Geismar	Static track inspection
Gauge	1.002	0.997	0.999
Cant	1.087	1.041	1.064
Twist	1.224	0.965	1.095

Table 1 displays the calculation of conversion multipliers for static track inspection (Track Gauge and Amber Geismar) to the nearest value of dynamic track inspection (EM120T). Track Gauge produces 1.002, 1.0087, and 1.224 multipliers for gauge, cant, and twist, respectively. Amber Geismar produces 0.997, 1.041, and 0.965 multipliers for gauge, cant, and twist, respectively. The combined value for Track Gauge and Amber Geismar is 0.999, 1.064, and 1.095, which can be used to get the nearest value of dynamic track inspection.

Table 2: Conversion of gauge using multiplier.

Chainage	Gauge (static)	Multiplier	Gauge (dynamic)	EM120T (actual)	Difference (between actual and dynamic)
790	994.5	1.002	996.5	997	0.5
795	999	1.002	999.9	1001	1.1
800	996	1.002	997.9	999	1.1
805	999	1.002	1000.9	1000	0.9
810	995	1.002	996.9	999	2.1
815	993	1.002	994.9	997	2.1
820	996.5	1.002	996.5	998	1.5
825	996	1.002	997.9	999	1.1
830	997.5	1.002	999.5	1000	0.5
835	994	1.002	995.9	997	1.1

The gauge multiplier used in Table 2 is 1.002, based on the conversion from track gauge to EM120T. The gauge (static) result differs from the EM120T (actual) result, and the multiplier remains constant for all locations. The gauge (dynamic) result is calculated by multiplying the old gauge result by multiplier.

Table 3: Conversion of cant using multiplier.

Chainage	Cant (static)	Multiplier	Cant (dynamic)	EM120T (actual)	Difference (between actual and dynamic)
790	5.5	1.087	5.978	6	0.022
795	3	1.087	3.261	6	2.739
800	1.5	1.087	1.631	2	0.369
805	3	1.087	3.261	4	0.739
810	4.5	1.087	4.892	5	0.108
815	1	1.087	1.087	0	1.087
820	4	1.087	4.348	5	0.652
825	2	1.087	2.174	5	2.826
830	6	1.087	6.522	9	2.478
835	6.5	1.087	7.066	7	0.066

According to table 3, the cant multiplier used is 1.087, which is the result of converting Track Gauge to EM120T. (see table 1). As you can see, the results for the cant (static) and EM120T are different. Additionally, all chainages utilize the same multiplier. The cant (static) result is multiplied by the multiplier to determine the cant (dynamic) result. The cant measurement of the EM120T train, which is utilized as a reference, is represented by the EM120T data.

3.4 Figures of the application conversion multiplier

The conversion multiplier converts gauge and cant measurements from static track inspection data to dynamic data. This subtopic simulates the proposed multiplier in real-time location Shah Alam to Batu Tiga, focusing on Track Gauge data conversion into EM120T data:

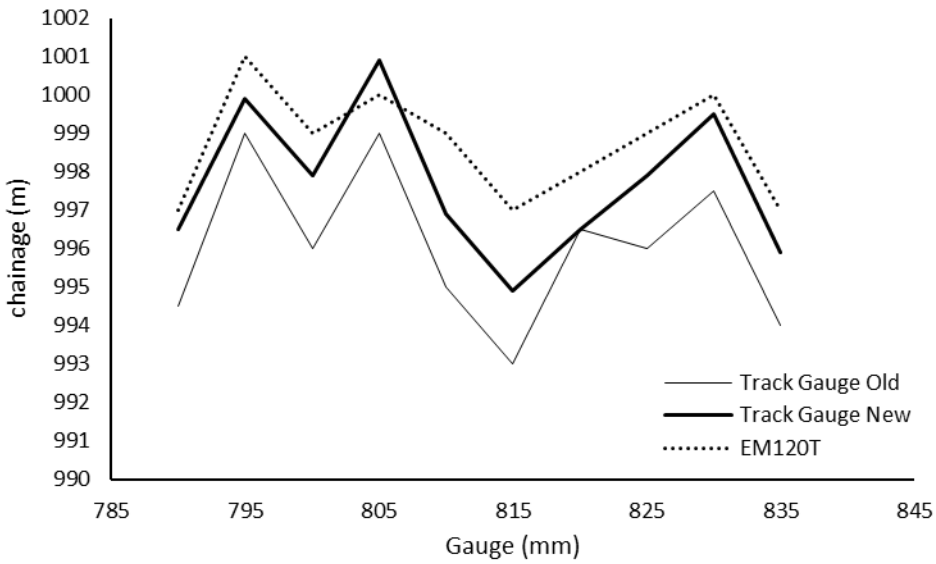


Figure 3: Projected graph of gauge using conversion multiplier.

As you can see in Fig. 3, the new gauge result is very close to the EM120T data. There are changes from gauge (static) data to gauge (dynamic) data which result almost the same with EM120T (actual) gauge inspection data for certain location which is most of the of the result only 2 mm and lesser compared to EM120T data. This means that the conversion multiplier is useful and that the railway tracks in this location are compatible. However, this result is only an indicator for PWI and still not valid to use in any inspection works.

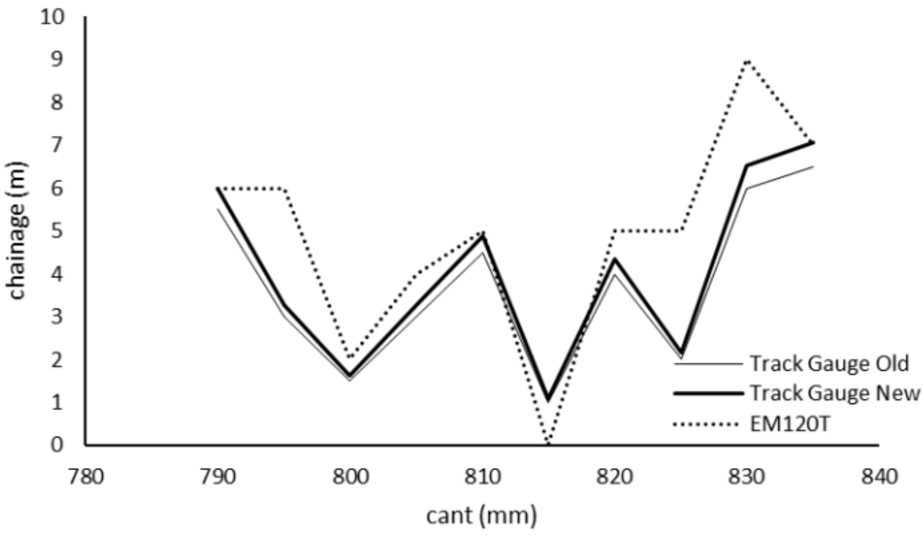


Figure 4: Projected graph of cant using conversion multiplier.

Based on Fig. 4, in comparison to the cant (static) result, the cant (dynamic) result has undergone a modest alteration and is now more similar to the EM120T (actual) result which is dynamic track inspection. Mostly, the difference between new cant result and EM120T are less than 1 mm which means the conversion multiplier can help the PWI to get the dynamic track inspection from static track inspection but its only as reference and not for the trackwork usage.

4. Conclusion

Malaysia railway operator KTMB has implemented various inspection methods to maintain track structure. Track Gauge, Amber Geismar, and EM120T are effective in measuring and dimensioning the inspected track. However, it is crucial to use the most effective method for precise track data for PWI further action. The study demonstrates that EM120T (dynamic track inspection) is the most effective method, as it can inspect all seven track parameters within a short time compared to Track Gauge and Amber Geismar. Additionally, a reliable multiplier has been generated to convert static track inspection data from Track Gauge and Amber Geismar to dynamic track data recorded by EM120T. This would help assist PWI during unavailability of EM120T and provide a new manual for fast action.

The multiplier is still in its early stages, but it can be improved by conducting examinations in various locations, such as straight lines or gradients, to determine the reasons behind different outcomes. Comparing the multiplier at different sites and analyzing the reasons behind different outcomes can help understand the reasons behind different outcomes. The study used only unmaintained tracks, so it is recommended to act on inspection findings after maintenance is completed. The compactness of the ballast may impact cant and twist results, so the conversion multiplier may be different. The application of a multiplier to convert static track inspection data to dynamic track inspection data can be enhanced by analyzing data at various track geometry and under different circumstances.

The conclusions in this thesis are further strengthened if the obtained multipliers vary slightly. However, if the conversion multiplier shows a significant gap, it will be easier for PWI to conduct track inspections in accordance with their different categories.

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