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The Effect of CARTRACK Application on Heavy Equipment Productivity Monitoring at IKN 3A Toll Project

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Abstract: This study aims to analyze the effect of the CARTRACK application on the productivity and operational efficiency of heavy equipment in the IKN 3A Toll Road Project, Karangjoang–KKT Kariangau segment. CARTRACK is a GPS-based telematics system that records real-time data on equipment operation, including effective working hours, idle time, and work volume. A comparative quantitative method was used by evaluating data obtained from two monitoring methods: manual recording using Daily Time Sheets and digital tracking through CARTRACK. Six types of heavy equipment were observed: Excavator, Dump Truck, Truck Mixer, Truck Trailer, Vibratory Soil Compactor, and Crane. Data were processed using productivity and efficiency formulas and analyzed using linear regression. The results indicate that the use of CARTRACK significantly improves both productivity and efficiency. The Dump Truck showed an increase in productivity from 2.05 m^3/hour to 2.98 m^3/hour, while the Crane recorded the highest efficiency gain at 41%. Regression analysis demonstrated a strong positive relationship between effective working hours and productivity, with the highest coefficient of determination ($R^2 = 0.5895$) and correlation coefficient ($R = 0.7678$) for the Dump Truck. These findings confirm that CARTRACK enhances monitoring accuracy and contributes to more efficient and productive heavy equipment operations in large-scale infrastructure projects.

Keywords: Productivity, Efficiency, CARTRACK, Heavy Equipment, Toll Road Project

Introduction

In large-scale infrastructure construction, the efficiency and productivity of heavy equipment operations are vital for ensuring timely project delivery and cost effectiveness. Monitoring such operations presents numerous challenges, particularly in remote or expansive construction environments, such as the Ibu Kota Nusantara (IKN) 3A Toll Road Project in Indonesia. Traditional monitoring methods, including manual recording through daily time sheets, are often prone to human error, time delays, and data inaccuracies (Sugiyono, 2013; Creswell, 2014; Sari, 2023).

Recent developments in telematics have provided more robust and real-time solutions for equipment monitoring and performance assessment. One such solution is the CARTRACK application, a GPS-based telematics system that enables comprehensive tracking of heavy equipment, including operational hours, idle time, and productivity

metrics (Garcia et al., 2022; Supit, 2020; Prima & Hafudiansyah, 2022). These tools are increasingly being adopted in construction management to enhance transparency, accountability, and data-driven decision-making (Rostiyanti, 2008; Hadi, 2020).

Prior research has demonstrated the advantages of telematics systems in increasing productivity and reducing operational inefficiencies. Afriansyah and Oktarino (2020) highlighted the effectiveness of mobile tracking systems in improving time documentation accuracy in mining operations. Similarly, Danar (2023) and Nurrofiah and Latifah (2023) found that mobile-based monitoring significantly improved equipment inspection and maintenance in public infrastructure sectors. Nugraha et al. (2020) and Natalia (2021) also emphasized the role of digital monitoring tools in achieving better operational alignment and match factor optimization.

Despite these advancements, empirical studies that directly compare manual and digital monitoring systems within Indonesia's infrastructure projects remain limited. This study seeks to investigate the impact of the CARTRACK application on heavy equipment productivity and operational efficiency within the IKN 3A Toll Road Project. It conducts a comparative analysis of digital versus manual monitoring systems. The objective is to assess whether CARTRACK implementation contributes to significant performance gains and improved data accuracy. This research aims to enrich the body of knowledge in digital construction management and offer practical recommendations for smart monitoring integration in large-scale projects (Mokolintad, 2023; Mulya, 2024; Kahandanie & Kartika, 2025).

Methodology

This study employed a comparative quantitative approach to evaluate the impact of the CARTRACK telematics system on the productivity and operational efficiency of heavy equipment during the IKN 3A Toll Road Project, specifically along the Karangjoang–KKT Kariangau segment. The research began with a literature review to establish the theoretical foundation connecting equipment productivity, operational efficiency, and digital monitoring systems. Prior studies in equipment management, productivity analysis, and telematics technology (Creswell, 2014; Sugiyono, 2013; Garcia et al., 2022; Natalia, 2021; Supit, 2020) provided the analytical framework for the study.

Primary data were collected from field observations and operational documentation provided by project technical managers. The dataset consisted of effective working hours, total working hours, idle times, and work volumes. These were recorded using two different methods: manual daily time sheets and the GPS-based CARTRACK application. The heavy equipment observed in this study included six types: excavators, dump trucks, truck mixers, truck trailers, vibratory soil compactors, and cranes (Mas'ud & Imron, 2022; Bawelle, 2023; Prima & Hafudiansyah, 2022).

Data compilation was conducted by organizing the raw records into comparable formats, ensuring consistency in units and parameters. Productivity was calculated using a standard productivity formula $P = \frac{Output}{Input}$, and efficiency was calculated using formula $E = \frac{T_{efective}}{T_{total}} \times 100$, as referenced in Sarjono (2001) and Sihasale et al. (2023). To evaluate the correlation between effective working hours and productivity, linear regression analysis

was conducted. The strength and direction of the relationship were measured using the correlation coefficient (R) and coefficient of determination (R^2) (Nugroho, 2023; Kahandanie & Kartika, 2025).

No human or animal subjects were involved in this study, hence ethical approval was not required. All operational data were obtained with permission from stakeholders and used strictly for academic purposes. The methodology is structured to be replicable and adaptable for future assessments of telematics applications in infrastructure development projects.

Result and Discussion

This study compared the productivity and efficiency of heavy equipment between two monitoring methods: manual recording using daily time sheets and automated tracking using the CARTRACK application. Data were collected from the IKN 3A Toll Road construction project, specifically from six types of equipment: excavator, dump truck, truck mixer, truck trailer, vibratory soil compactor, and crane. The measured variables include effective working hours, total working hours, and work volume. All these quantitative comparisons are summarized in Table 1 and Table 2.

Table 1. Summary of the difference in average productivity of heavy equipment (Daily Time Sheet vs. CARTRACK)

No	Types of Heavy Equipment	$\bar{x}$ Productivity		Difference (m^3/hour)	Percentage Increase (%)
		DTS (m^3/hour)	CARTRACK (m^3/hour)		
1	Dump Truck	2,05	2,98	0,93	45
2	Excavator	13,10	20,72	7,62	58
3	Truck Mixer	2,24	3,50	1,25	56
4	Crane	0,99	2,60	1,61	163
5	Vibratory Soil Compactor	5,73	6,66	0,93	16
6	Truck Trailer	2,75	3,40	0,65	24

Table 1 summarizes the productivity results using both manual and CARTRACK-based methods. The data indicate a consistent improvement in productivity across all equipment types when monitored using CARTRACK. For example, the dump truck's productivity increased from 2.05 m^3/hour (manual) to 2.98 m^3/hour (CARTRACK), representing a significant enhancement in material transport efficiency.

Table 2. Summary of differences in average heavy equipment efficiency (Daily Time Sheet vs. CARTRACK)

No	Types of Heavy Equipment	$\bar{x}$ Efficiency		Difference (%)	Percentage Increase (%)
		DTS (%)	CARTRACK (%)		
1	Dump Truck	83,83	90,58	6,75	8
2	Excavator	65,98	85,03	19,05	29
3	Truck Mixer	66,25	93,19	26,95	41
4	Crane	65,64	92,83	27,19	41
5	Vibratory Soil Compactor	66,10	91,33	25,22	38
6	Truck Trailer	66,88	92,68	25,79	39

Table 2 shows the efficiency calculations, with the crane exhibiting the highest efficiency improvement of 41%, primarily due to reduced idle time and more accurate monitoring of operating hours. The average efficiency improvement across all equipment types ranged between 8% and 41% when using CARTRACK.

Linear regression analysis was conducted to evaluate the relationship between effective working hours and productivity. The relationship for all six types of heavy equipment is visualized in Figure 1. The results of the calculation of the gradient (m), constant (c), and coefficient of determination (R^2) are presented in Table 3.

Table 3. Linear regression equation of the relationship between effective hours and productivity

No.	Types of Heavy Equipment	m	c	R^2	R	Linear regression
1	Dump Truck	0.1512	1.4908	0.5895	0.7678	y = 0,1512x + 1,4908
2	Excavator	0.5181	0.0000	0.0828	0.2877	y = 0,5181x + 16,4807
3	Truck Mixer	0.0908	2.3825	0.2444	0.4944	y = 0,0908x + 2,3825
4	Crane	0.0559	2.0365	0.0488	0.2208	y = 0,0559x + 2,0365
5	Vibratory Soil Compactor	0.1080	5.5384	0.5440	0.7376	y = 0,1080x + 5,5384
6	Truck Trailer	0.0233	2.6992	0.4516	0.6720	y = 0,0233x + 2,6992

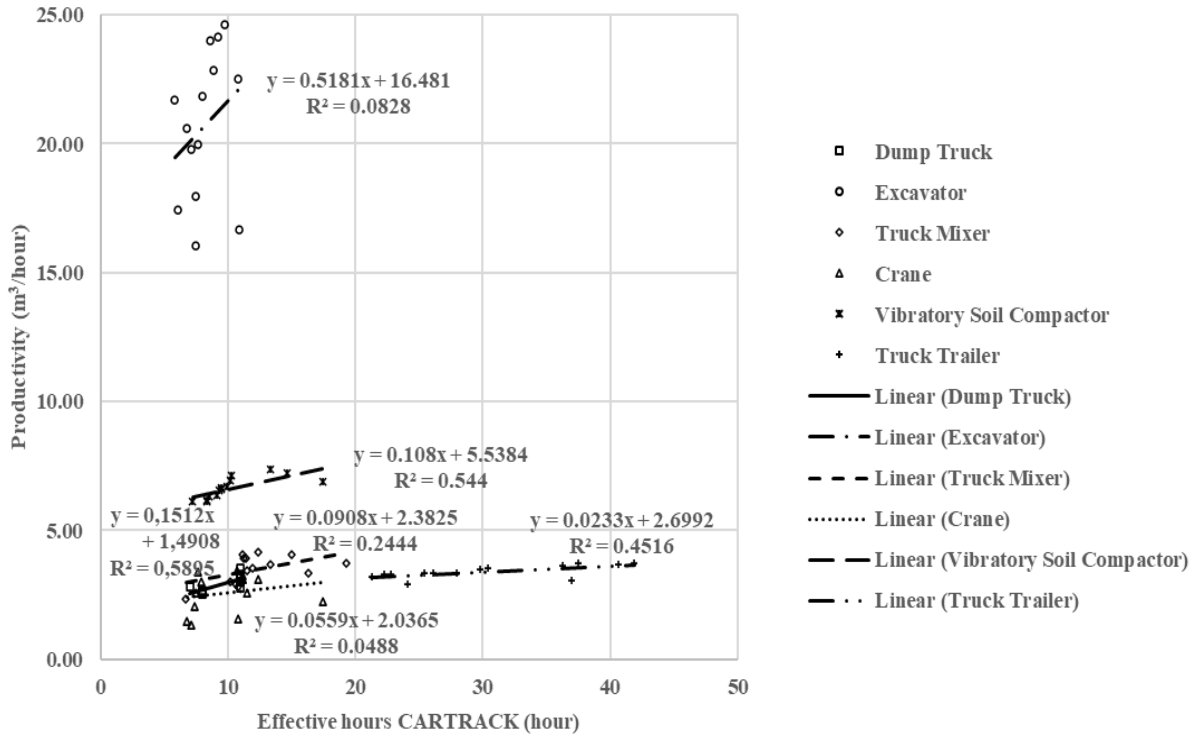

Figure 1. Relationship between effective hours and productivity of six types of heavy equipment based on CARTRACK data

Based on the results in Figure 1 and Table 3, all types of heavy equipment show a positive linear relationship between the independent variable (effective working hours) and

the dependent variable (productivity). The dump truck exhibited the highest coefficient of determination (R^2 = 0.5895) and correlation coefficient (R = 0.7678), indicating a strong positive correlation between the two variables. The regression slope for each equipment type was positive, signifying that an increase in effective working hours is directly associated with increased productivity.

Discussion

The findings of this study demonstrate that the use of CARTRACK as a telematics monitoring system significantly improves both the accuracy of data recording and the operational performance of heavy equipment. By capturing real-time data on idle time, operating time, and output volume, project managers can more accurately assess equipment utilization and identify inefficiencies.

These results are consistent with previous studies emphasizing the role of digital monitoring tools in improving resource efficiency in large-scale construction projects. The positive correlation observed in the regression analysis supports the hypothesis that higher effective working hours lead to increased productivity. This finding highlights the importance of reducing idle time and optimizing equipment operation schedules.

From a practical standpoint, the implementation of CARTRACK provides a data-driven foundation for improving decision-making in equipment allocation, scheduling, and maintenance planning. This could lead to substantial cost savings and project acceleration, particularly in high-budget, infrastructure-heavy projects such as toll roads, bridges, or industrial complexes.

Moreover, the results underline the value of integrating digital solutions into construction management systems to enhance transparency, accountability, and performance evaluation. These contributions are significant for both practitioners in the field and academic researchers studying the digital transformation of the construction industry.

Conclusion

This study confirms that the implementation of the CARTRACK application significantly enhances both the productivity and operational efficiency of heavy equipment in large-scale infrastructure projects. Across all equipment types observed, productivity increased, with a strong positive correlation between effective working hours and productivity—most notably in Dump Trucks, which recorded the highest coefficient of determination (R^2 = 0.5895) and correlation coefficient (R = 0.7678). Additionally, the operational efficiency of heavy equipment improved considerably, with the Crane showing the highest increase at 41%. These results highlight the value of integrating real-time telematics systems such as CARTRACK as a reliable and accountable alternative to manual monitoring methods.

For future research, it is recommended to conduct longitudinal studies across various project types and regions to assess the broader applicability of telematics systems. Furthermore, integrating telematics with project scheduling and cost control systems may provide a more holistic approach to digital construction management. Practically,

construction firms are encouraged to adopt real-time monitoring technologies to enhance data accuracy, decision-making, and overall project efficiency.

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