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Application of PS Monitoring System for Power Emergency Repair Vehicles and Optimization of Operation and Maintenance Costs

Yanchang Liu, Xiangyu Wang, Yifan Xu, Tao Lv

Northeast Petroleum University, Qinhuangdao 066004, China

Abstract: Addressing the prominent issues in traditional management modes of power emergency repair vehicles, such as low dispatching efficiency, high fuel consumption, and delayed maintenance warning, this study employs a before-and-after comparative experimental design based on vehicle operation data from a certain companys production and transportation department from 2023 to 2024. It systematically evaluates the application effects of the GPS monitoring system in three core business scenarios: vehicle dispatching optimization, refined fuel consumption control, and maintenance warning. Twenty identical model emergency repair vehicles from a certain fleet were selected as experimental samples, and data on four categories of 12 indicators, including mileage, fuel consumption, maintenance frequency, and violation alarms, were collected for analysis. The results indicate that after the application of the GPS system, the average daily mileage of vehicles increased from 80.2 km to 105.3 km. Fuel consumption per 100 kilometers decreased from 14.2 L to 12.8 L. Average monthly maintenance frequency dropped from 3.2 times to 2.1 times. The number of violations driving alarms decreased from 128 times per month to 48 times per month. This study can provide a replicable and quantifiable operational paradigm for refined vehicle management and control in similar power supply enterprises.

Keywords: Power emergency repair vehicles; GPS monitoring; Fuel consumption management; Operation and maintenance costs.

1. Introduction

Power emergency repair vehicles are core mobile equipment resources for power supply enterprises to ensure the safe and stable operation of the power grid. The operational status of vehicles directly affects the timeliness of repairs, the level of operational safety, and the economic costs of operation [1-2].

Vehicle management generally adopts the traditional manual dispatching mode featuring telephone application by the user unit, manual dispatching by the dispatcher, paper registration by the driver, and monthly summary reports. In the field of logistics and transportation, with the application of GPS technology in route optimization, real-time tracking, and cost control, existing vehicle GPS monitoring systems are relatively mature in fields such as logistics and mining. However, in the specific scenario of power emergency repair vehicles, system application remains at the functional development stage, lacking quantitative benefit evaluation based on long-term operational data and empirical analysis of operation and maintenance management [3-4].

To address this gap, this paper takes 20 emergency repair vehicles from a certain fleet as samples, collecting complete operational data from two periods. The first period spans January to June 2023 before the full application of the GPS system. The second period covers January to June 2024 after the stable operation of the GPS system. A before-and-after comparative experimental study is then conducted.

2. GPS Monitoring System Business Application Scenarios

2.1. Description of GPS Monitoring Modules

Unlike general logistics vehicle management systems, power emergency repair vehicles are characterized by strong task suddenness, dispersed operation points, and high timeliness requirements. Therefore, the system design focuses on strengthening the following three modules. The first module enables real-time positioning and nearby dispatching. The second module facilitates fuel consumption monitoring and driving behavior analysis. The third module provides maintenance intelligent reminders [5-6].

2.2. Description of Business Application Scenarios

After the GPS system went online, the fleet simultaneously implemented three supporting management systems, forming a dual-wheel driven model combining technology with management.

The first scenario involves dynamic dispatching and nearby vehicle assignment. The system records dispatch time, vehicle arrival time, and task completion time, automatically generating attendance reports.

The second scenario concerns fuel consumption quota and driving assessment. The system calculates per-vehicle fuel consumption per 100 kilometers on a monthly basis. For the portion exceeding the quota, the driver bears 20 percent and the fleet bears 80 percent. For the portion saved, 30 percent is rewarded to the driver.

The third scenario addresses preventive maintenance and fault warning. The system automatically collects vehicle fault code data every 500 kilometers. When critical system fault codes are detected, the system automatically generates a maintenance work order and pushes it to the repair shop.

Safety management indicators constitute the fourth category. These include the number of speeding alarms, after-hours vehicle usage alarms, route deviation alarms, and comprehensive alarm density measured as alarms per thousand kilometers. Data originates from GPS platform alarm record exports and monthly safety department bulletins.

3. Experimental Design

3.1. Data Collection Indicators and Sources

This study collects three categories of 12 indicators, forming a complete vehicle operation performance evaluation system.

The first category comprises vehicle utilization indicators. These include average daily mileage calculated as total mileage divided by calendar days, individual vehicle attendance rate determined by actual attendance days divided by required attendance days, and empty running rate measured as empty mileage divided by total mileage. Data originates from the GPS platform mileage statistics module and manual dispatch record stubs.

The second category encompasses fuel economy indicators. These include fuel consumption per 100 kilometers computed as fuel consumption divided by mileage multiplied by 100, monthly fuel consumption per vehicle, and proportion of idling time. Fuel consumption data originates from the financial reimbursement system, mileage data from GPS mileage statistics, and idling duration from OBD data.

The third category covers maintenance cost indicators. These include average monthly maintenance frequency calculated as total maintenance times divided by number of vehicles, cost per maintenance, and failure rate per thousand kilometers determined by number of failures divided by mileage multiplied by 1000. Maintenance data originates from the repair shop work order system and financial settlement vouchers.

3.2. Data Preprocessing

The original data presented three types of issues. Some manual records were missing, with three dispatch forms in January and February 2023 not recording return mileage. These were imputed using the weekly average before and after for the same vehicle. Mileage jumps caused by temporary GPS signal loss were addressed by removing abnormal records with daily mileage less than 5 kilometers or greater than 500 kilometers. Maintenance cost data with cross-month settlements were allocated based on work order completion dates. Statistical analysis tools used were Excel 2021 and SPSS 25.0. Descriptive statistics are presented as mean values with standard deviations. Before-and-after comparisons used paired sample t-tests, with the significance level set at 0.05.

4. Analysis of Experimental Results

4.1. Vehicle Utilization

During the experimental period, the 20 sample vehicles accumulated a total mileage of 312,000 kilometers. This represents an increase of 74,000 kilometers compared to 238,000 kilometers in the control period, reflecting a growth of 31.2 percent. The average daily mileage increased from 80.2 kilometers with a standard deviation of 12.6 kilometers to 105.3 kilometers with a standard deviation of 15.8 kilometers. These results are illustrated in Figure 1.

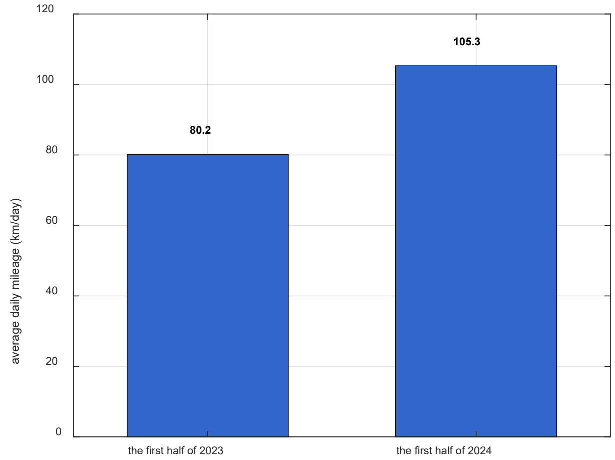

Figure 1. Comparison of Average Daily Mileage

4.2. Fuel Economy

During the experimental period, the fuel consumption per 100 kilometers of the 20 sample vehicles showed a monthly decreasing trend. Fuel consumption registered 13.9 liters per 100 kilometers in January 2024 and dropped to 12.4 liters per 100 kilometers in June, representing a decrease of 12.7 percent. Compared to the control period average of 14.2 liters per 100 kilometers, the experimental period average of 12.8 liters per 100 kilometers represents a decrease of 1.4 liters per 100 kilometers, or 9.8 percent.

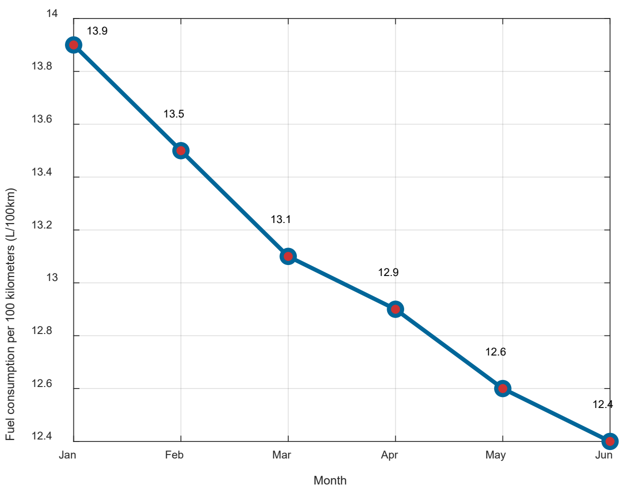

Figure 2. Monthly Change in Fuel Consumption per 100 Kilometers

4.3. Maintenance Costs

During the experimental period, the average monthly maintenance frequency for the 20 sample vehicles was 2.1 times per vehicle with a standard deviation of 0.6 times. This represents a decrease of 34.4 percent from 3.2 times per vehicle with a standard deviation of 0.9 times in the control period. These results are presented in Figure 3.

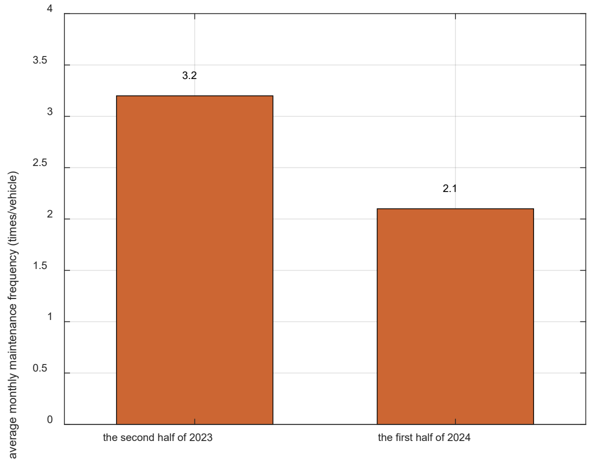

Figure 3. Comparison of Average Monthly Maintenance Frequency

4.4. Violation Driving

During the experimental period, the system recorded a total of 3,562 driving behavior alarms, averaging 593.7 times per month. Speeding alarms accounted for 1,603 times, representing 45 percent of all alarms. After-hours vehicle usage alarms totaled 1,069 times, accounting for 30 percent. Route deviation alarms numbered 890 times, comprising 25 percent of the total.

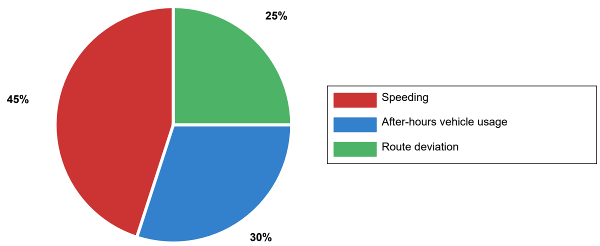

Figure 4. Distribution of GPS Alarm Types

From a temporal trend perspective, the total number of alarms showed a monthly decreasing pattern. Alarms registered 128 times in January 2024 and dropped to 48 times in June, a decrease of 62.5 percent. The most significant decrease occurred in after-hours vehicle usage alarms, which dropped from 41 times in January to 9 times in June, a reduction of 78.0 percent.

5. Conclusion

Based on 12 months of complete operational data from 20 emergency repair vehicles in a fleet of a certain power supply company, this study employed a before-and-after comparative experimental design to systematically evaluate the practical application effects of the GPS monitoring system in the field of power emergency repair vehicle management. The annual direct economic benefit amounted to 126,000 yuan. After deducting the comprehensive system costs, the net benefit in the first year reached 104,000 yuan. The payback period was 4.6 months, yielding an input-output ratio of 1 to 3.1.

References

[1] Zheng Haowen. Exploration of the Application of GPS Technology in Modern Logistics Transportation Management. Logistics Engineering and Management, 2023, 45(7): 45-47.

[2] Xu Jianjun, Huang Lida, Yan Limei, Yi Na. Insulator Self-Explosion Defect Detection Based on Hierarchical Multi-Task Deep Learning[J]. Transactions of China Electrotechnical Society, 2021,36(07):1407-1415.

[3] Yan Limei, LIU Yongqiang, XU Jianjun, et al. Broken string diagnosis of composite insulator based on Grabcut segmentation and filler area discrimination[J]. Power System Protection and Control,2021,49(22):114-119.

[4] Yi, Q. Wang, L. Yan, et al., A multi-stage game model for the false data injection attack from attacker's perspective. Sustainable Energy Grids & Networks 28 (2021).

[5] Na Yi, Jianjun Xu, Limei Yan, Lin Huang. Task Optimization and Scheduling of Distributed Cyber-physical System Based on Improved Ant Colony Algorithm. Future Generation Computer Systems, 109(Aug. 2020),134-148.

[6] Yang Zhao, Jianjun Xu, Jingchun Wu. A New Method for Bad Data Identification of Oilfield Power System Based on Enhanced Gravitational Search-Fuzzy C-Means Algorithm. IEEE Transactions on Industrial Informatics. VOL. 15, NO. 11, NOVEMBER 2019 5963-5970.