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Assistance and Design Features in Cargo Electric Vehicles for Developing Countries

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Abstract: ***Electric vehicles (EVs) have the potential to reduce negative effects on the environment and are increasingly used in developing countries like India in the logistics sector. The purpose of this paper is to aid business operations in the logistics sector through better vehicle ergonomics as well as driver training methods.***
The introduction of Electric Mini Trucks in India aims to be a game changer by eradicating many of the existing issues faced with ICE Mini Trucks such as health related conditions caused by the vibrations, poor ride quality and driver discomfort. For an Electric Vehicle to be used in a safe and effective manner some additional design characteristics have to be kept in mind to adjust for the lack of formal training for most vehicle drivers who are already operating under road conditions that are cognitive overloads. Hence, in addition to the normal range anxiety, the thermal monitoring of the battery pack and energy consumption have to be reported with proven continuous feedback mechanisms.
In this study, we conducted field interviews before, during and after driver's shifts in multiple scenarios of driving such as: Day/Night driving, Urban/Semiurban Driving, Dry/Hot/Rainy weather condition and vehicle parameters such as range, load capacity, energy consumption, max deviation from optimal temperature and Idle time were monitored in the scenarios given above. Driver parameters such as comfort and drivability were also measured to track safety conditions of the driver.

I. INTRODUCTION

In the developed world including the much-touted example of Norway, most of the adoption of EV's have been in passenger and personal vehicles, even after more than two decades of awareness and incentives. The electrification of Cargo Vehicles and Trucks still remains minimal.

In developing countries, while the overall EV adoption has been slow, with EV sales in India is approaching the 500,000 units mark in FY23,[1]the registration records show that a remarkable 1% of them are in the commercial category. This skewed adoption augurs well for the Indian Cargo delivery sector as more government incentives and corporate supply chain mandates are going to drive the commercial EV adoption industry. It is projected that by2025 there will be more than 50% penetration in Commercial EV's for the logiscthan Passenger EV's across the globe. This is where EV Minitrucks industry in India can take a leadership role worldwide and companies working in this sector can capture markets in other developing areas.

However, the smooth adoption of EV's depends on driver efficiency, public perception of safety and the ability to deliver cargo. While to a person looking from outside, there is very little difference between an EV and an ICE vehicle such as the lack of exhaust pipe, but for the operator there are many changes that one needs to be aware of and this is made more complicated by the fact that they often lack formal training for the drivers. This is most displayed in the difference between the trips and deliveries that we noticed between drivers of normal and electric vehicles through the research we conducted. We were able to analyze pain points of drivers of EV's and finally suggest driver assistance systems and ergonomics that can enhance the driver safety and comfort, reduce downtime, and increase fleet effectiveness. The driver assistance features included EV range training, route management and break scheduling, and package placement analysis. The objective of this paper is to develop an understanding of the driver assistance features needed for Electric Minitruck Cargo fleets in India. Further, the paper extrapolates on how EV fleets can improve their operations by making changes to their SOP (Standard Operating Procedure).

The field study involved obtaining data from a questionnaire and the collected data by contrasting what was done by normal cargo delivery accompanying the drivers for a period of time and that led to more detailed understanding of the safety issues like a) The Working hours are often more than 16 hours b) And getting approx. 3-4 hours of sleep per night because of back pain and stressful economic situation at their homes.

[1] Federation of Indian Automobile Dealer - 2022 Report

In undertaking this study, the author took a wholistic look at what comprised a delivery operation and anlayzed in depth that the role of the drivers, which was a critical yet overlooked component by those planning the daily operations.This paper also attempts to define what training may be required to enhance practical driving experience of drivers. This paper outlines the features needed for a combination of in vehicle and training modules for driver assistance. The solution is engineered in a way that helps make the SOP more efficient, as well as increase the package deliveries per day, thereby helping add value to their business solution.

II. BACKGROUND

This pandemic gave a boost to e commerce and logistics and now the next trend of EV led deliveries is taking shape. It is estimated that by 2030 more than 50% of deliveries worldwide will be on electric vehicles and will include all vehicles from Mini Trucks to smart delivery carts for office parks to e-bikes to traverse small restaurant pickup.

In countries like India, the driver is exposed to poor traffic conditions and extreme weather conditions like heat and rainfall that make driving conditions very difficult. Incentivizing and alternatively penalizing on the deliveries forces a driver to make unsound traffic decisions per our survey.

It is important to understand the cognitive and physical loads on the driver first and foremost and then developing training and coping mechanisms to assist driver perform their job in a safe and effective manner. As EV's are unique, and they have a very different way of being driven than ICE's, drivers must also understand how to utilize the benefits provided by electric vehicles.

The main issue that drivers face is their inability to approximate range on a single charge and heating of the battery pack. According to a study[2], there are several health issues faced by cargo drivers in India, where approximately 70% of them face lower back pains, 50% of them face knee problems and 30% of them encounter shoulder problems. Another study[3], states that over 55% of truck drivers faced issues with vibrations in their vehicles. Similarly, a study[4] conducted on Indian Mini Trucks, mentioned that vehicles rarely adhere to the 95% percentile ergonomic requirement. We also noticed that several of Mini-Truck drivers have complaints regarding their driving conditions and the drivability of their vehicles.

III. METHOD

We ran tests to decide how drivable the Electric Mini Trucks are and infer what improvements can be made to increase their deliveries in an efficient manner. Structurally, EV's do not have as many vibrations as ICE vehicles, so the trade off of smoother rides gives rise to other vehicle issues both while active driving like range issues but also passive issues like formal training on how to drive EV's efficiently, but only in a way that they had always been driving normal cargo trucks.

We also looked at route and operations as part of this study to see if EV's operate better with a different delivery route that has different charging options en-route as the vehicle is able to get better range figures and the driver is also able to manage the thermal conditions better due to the new driving style, firstly they will be able to allow more transportation of goods as well as increase the life expectancy of their battery all leading to less issues with the vehicle, but most importantly with Battery and BMS system. As stated in a study[5], the battery capacity reduces at a much greater level at higher temperatures compared to when it is at lower temperatures. This means that a batteries life could also increase, thereby reducing costs for the business as well.

We conducted a thorough survey that aimed at identifying drivers' issues while driving an EV and how they managed any issue that previously arose. We identified drivers of commercial trucks who have been driving for at least a year and assessed what they will need to improve their experience in the future. In a further randomized test, we informed a group of the findings we have made and asked them if these interventions will be useful. All the participants were drivers with at least one year experience driving electric commercial vehicles and drive over a hundred kms daily. Part of the goal is to also identify what all drivers will need to know about their EV in general and retrofitted EV in particular, so that after suggested changes are implemented, they are able to benefit from it effectively. For the purpose of this research, drivers were interviewed at various times in person and on the phone (during breaks) and this was compared with data coming from the vehicle and their delivery numbers.

From the vehicle we assessed 5 parameters: Range Driven, Max Temperature deviation from Optimal Temp, Load of Vehicle, Grades and Incline Driven and Energy Consumption.

[2] (Anuj S. Mehta, 2019)
[3] (Mozafari, 2015)
[4] (Subhasini, 2012)
[5] (Shang, 2018)

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From non-vehicle logs we assessed total deliveries made by the vehicle, the total distress calls made by the driver, the daily run time of the vehicle, the pre charging that needed to be done on the vehicle

Each participant was asked to participate for a week and the sequence of conditions was the same for every participant, beginning with pre-shift, post-shift questions. The primary data collected through the Data Acquisition Interface OBC. Basing it on Scientific procedures, we decided to do 3 different tests to determine the outcomes and then used a standardized mean of the data to provide the final result.

The data is in the appendix sheet of this document

1) Table 1 - Data Collection per EV before training or any ergonomic improvement.
2) Table 2 - Data Collection per ICE vehicle
3) Table 3 - Data Collection per EV vehicle after training and ergonomic improvements
4) Test 1-3 was in city conditions during the day with an ambient temperature of 30C.
5) Test 4-6 was in rural conditions during the day with an ambient temperature of 35C.
6) Test 7-9 was in city conditions during the night with an ambient temperature of 30C.

In this study, we conducted field interviews before, during and after driver's shifts in multiple scenarios of urban and rural driving. The findings inform the design of small manual inspections and usage of vehicle information systems and the author intends to do further research on this topic during his further studies

IV. RESULTS

From the data analysis it is clear that the performance of the vehicles and satisfaction of drivers in an EV show a marked improvement after intervention measures in both their driving comfort feedback and also in the packages delivered.

The system that we used is a standalone hardware that can work in real time. The proposed electric truck is equipped with ECUs that transmit sensor information about the state of the vehicle such as temperature speed, rpm, state of charge etc. That information can be collected and shown either through an LCD display or is displayed on the phone. By doing so, it is possible to easily and safely monitor car parameters while driving. By reducing range anxiety, the driver is more comfortable in driving the vehicle and making late evening deliveries. In addition to the normal range anxiety, the thermal monitoring of the battery pack and braking issues need to be paid attention to. This total solution could result in an efficient process for the business and drivers.

Test 1-3 was in city conditions during the day with an ambient temperature of 30C.
Test 4-6 was in rural conditions during the day with an ambient temperature of 35C.
Test 7-9 was in city conditions during the night with an ambient temperature of 30C.

Table 1 - Data Collection per EV before training or any ergonomic improvement.

Parameters	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
Range (Km)	110	110	110	100	100	100	110	110	110
Load Capacity (kg)	1843	1622	1741	1775	1533	1575	1643	1434	1714
Max deviation from optimal temp (c)	25	20	21	23	26	24	22	22	21
Total time spent in stopped state (min)	83	106	95	101	88	93	105	99	99
Total Vehicle time spent in driving state	340	359	367	375	382	349	342	371	369
Drivability Rating of vehicle in a day (/10)	6	5	8	7	6	6	8	6	7
Driver Tiredness Index (/10)	7	7	6	7	9	8	7	6	7
Package delivery %	88	76	70	90	92	80	85	78	83

Table 2 - Data Collection per ICE vehicle

Parameters	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
Range (Km)	200	200	200	200	200	200	200	200	200
Load Capacity (kg)	1823	1900	1823	1711	1673	1723	1842	1800	1854
Max deviation from optimal temp (c)	15	17	12	20	16	19	13	14	16
Total time spent in stopped state (min)	88	109	100	104	99	92	88	66	87
Total Vehicle time spent in driving state	333	349	368	335	380	31	341	345	389
Drivability Rating of vehicle in a day (/10)	7	7	7	7	7	7	7	7	7
Driver Tiredness Index	9	8	9	10	9	9	8	7	6
Package delivery %	91	90	95	99	98	91	91	91	89

Table 3 - Data Collection per EV vehicle after training and ergonomic improvements

Parameters	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
Range (Km)	120	120	120	110	110	110	120	120	120
Load Capacity (kg)	1843	1622	1741	1775	1533	1575	1643	1434	1714
Max deviation from optimal temp (c)	20	18	21	24	20	22	18	19	16
Total time spent in stopped state (min)	67	55	78	54	57	55	53	57	62
Total Vehicle time spent in driving state	323	364	401	366	332	355	366	384	389
Drivability Rating of vehicle in a day (/10)	9	9	9	9	9	9	9	9	9
Driver Tiredness Index	5	5	4	5	3	3	5	6	6
Package delivery %	95	96	99	98	93	92	99	97	88

A. Breaking down the Results

As we look at the data, certain points become quite evident. In the first table, we see that the ICE engine vehicle has the most range, but that will not be considered, as the EV battery is rated only at 150km. When we look at the comparison initially between the ICE and the EV vehicle, from a driver's standpoint, it seems like the drivers prefer the ICE because, they may already be used to driving such vehicles with an engine, so are more accustomed to it. But we also see that there is more tiredness among the drivers that use the ICE due to the manual transmission and also the vibrations from the motor. This is exactly what EV's try and minimize. The comparison between Table 1 and Table 3 paints a better picture for vehicle improvement. Post-training, the drivers understand how the power delivery in electric vehicles work, and the better positioning of the battery has helped the vehicle from stopping grounding out on bumps and made the vehicle more drivable. Now looking at the performance of the vehicle, we see that almost all parameters have become better in the improved vehicle. Deviation from optimal temperature is still, however, better in the ICE vehicle, and this is because the temperature doesn't affect motors as much as higher temperatures affects battery performance.

The range of the EV has also increased. Especially for the rural areas, the range has increased by a great percentage. The drag coefficient changed due to the change in the battery configuration that we implemented, but this has also occurred due to the less aggressive way of driving that was taught during our training programs.

The increase in the qualitative data is testament to the massive increase that has occurred in the new driving style that enables better driver conditions in the vehicle and reduces the risk of musculoskeletal disorders caused due to vibrations. The ergonomic improvements inside the cabin, which include larger seats and re-arrangement of the gear selector also added to the quality of the interior and reduced the pain that the drivers go through. Because of the vehicle being electric, the drivers did not have to change gears constantly and therefore could reduce their strain and reduce their tiredness as well.

V. CONCLUSION

The upskilling of vehicle operators both through training and better monitoring mechanisms is key finding of our research.

The issues that the drivers faced can be clubbed into the following categories

1) Lack of training in the the difference between operating a ICE Mini-Trucks and EV Mini-Trucks
2) Lack of understanding the different metrics used to monitor an EV in operation

Both the above can be solved with better IoT systems for reporting the vehicle features and also an on-the-job training program that will help drive across various road conditions and understand and co-relate the data that is being given by the vehicle. With this the vehicle operator has peace of mind and is not worried about the range and hence do not make extra stops for charging, the vehicle is able to make more deliveries in an efficient manner and the battery life of the vehicle is prolonged, increasing its business viability. The interior buck ergonomics is also improved and, the driver is able to enjoy a better ride condition and reduce the risk of any negative externalities from driving these trucks for long hours in a day.

APPENDIX 1 - DEFINITIONS

[1] EV- Electric Vehicle
[2] Converted EV- Retrofitted standard car to Electric powertrain
[3] Cargo Vehicle- Trucks with Gross Vehicle Weight above 2000Kgs
[4] ADAS- Advanced Driver Assist Systems
[5] Cargo – Carrying over 1000kg of cargo
[6] ICE- Internal Combustion Engine

APPENDIX 2 - BIBLIOGRAPHY

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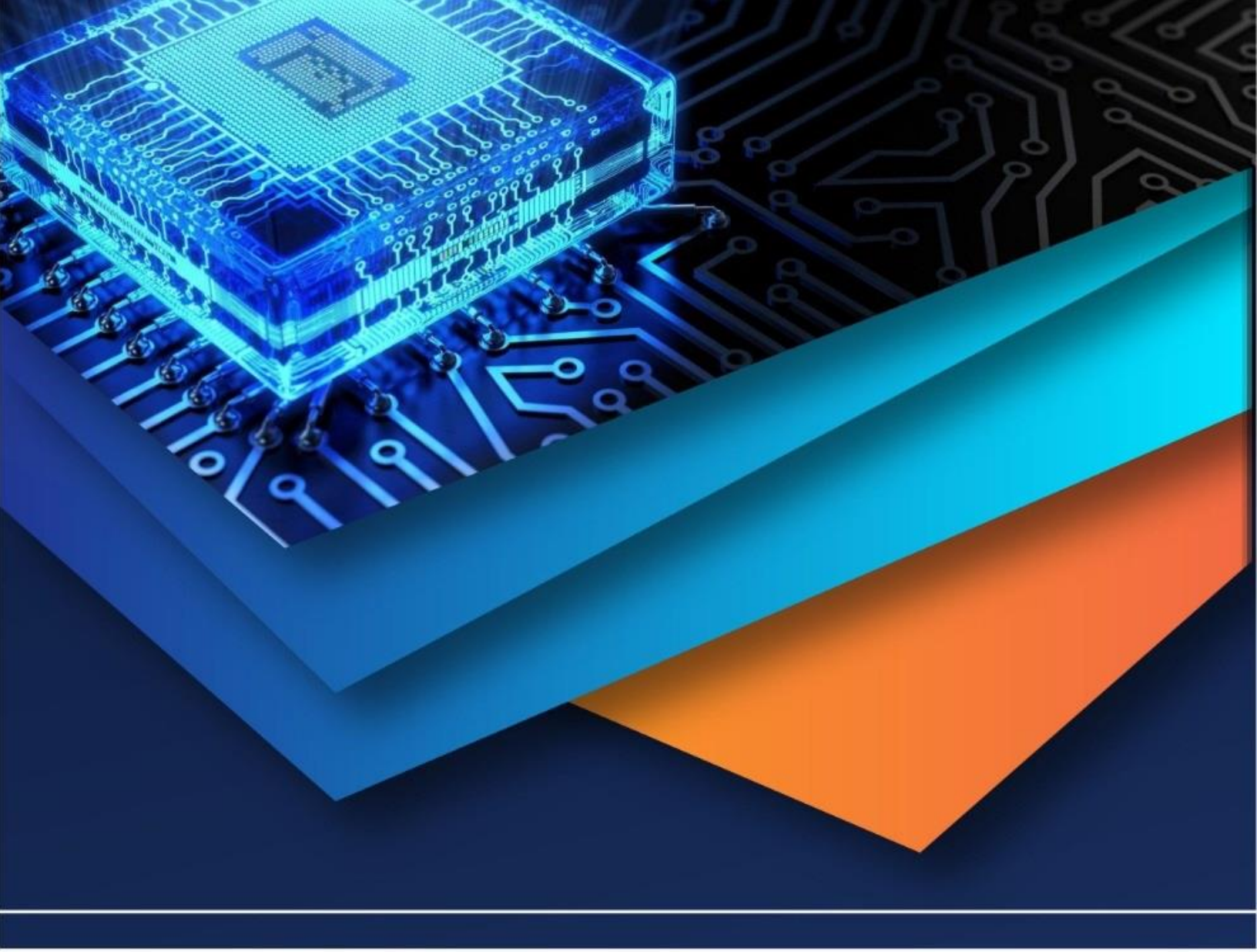

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