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Route Optimization and Transit Time Study in Outbound Finished Vehicle Logistics: A Master-Data and Telematics-Based Study at Škoda Auto Volkswagen India Private Limited, Chakan

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Abstract - **With finished vehicle logistics, freight cost, billing accuracy and the reliability of the delivery to the dealer rely on the alignment between the enterprise system's data for the route, distance, and lead time and what the trailers actually do on the road. This was an applied industrial research study to observe the outbound movements of car carrier from Chakan (Pune) plant of Škoda Auto Volkswagen India Private Limited (SAVWIPL) to dealer network in four logistics zones. The targets for the objectives were to audit and standardise the routes with those followed by Logistics Service Providers (LSPs); verify plant-to-dealer distance; recalibrate Estimated Times of Arrival (ETAs) with AIS-140 GPS telematics; and benchmark the freight rates with Tata Motors and Mahindra & Mahindra. The study was conducted over a six-month period of on the job experience (from 5 January 2026 to 3 July 2026) comprising four phases: TMS/ERP master data extraction, GIS and odometer distance verification, analysis of 178 telematics trip records and normalisation of the rate sheets to rupees per car-kilometre.**

A total of 126 priority dealer sites and 31 main delivery corridors were included in the audit. There were 6 corridors in the Transportation Management System (TMS) that were not accounted for and 18 corridors where there was an inter-transporter route variation; all 31 were standardised as Standard Operating Corridors (SOCs) whilst 32 km discrepancies were rectified. Transit times in 14 selected cities with higher deviation from the ETAs had increased by 0.4 to 2.8 days compared to their ETAs; post-recalibration, the deviation from the ETAs decreased from 4.02% to 3.91% for the entire system. SAVWIPL's freight rate of ₹5.03 per car-km was around 4.6% higher than that of Tata Motors (₹4.81) and 2.9% higher than that of Mahindra & Mahindra (₹4.89). To sum up, the key thing that freight governance and delivery predictability requires are accurate master data, standardised corridors, and ongoing telematics-based master data validation. Management is recommended to institutionalize a master route and distance governance standard, implement SOCs and move towards volume consolidated freight contracting, and enable ETA recalibration based on telematics.

Keywords - Route Optimization, Transit Time Study, Finished Vehicle Logistics, Master Data, GPS Telematics (AIS-140), ETA Recalibration, Freight Benchmarking

I. INTRODUCTION

The outbound transfer of newly built cars from the OEM factories to dealer yards constitutes the very critical link in the automotive value chain, known as finished vehicle logistics (FWL). Vehicles are driven by third-party Logistics Service Providers (LSPs) on dedicated multi-deck car carrier trailers under dimension and safety regulations that have been laid down by the Ministry of Road Transport and Highways (MoRTH), such as the AIS-140 telematics regulation [1]. The value of logistics' cost in India is usually estimated to be around 13-14% of GDP, while the government's initiatives like PM Gati Shakti and the National Logistics Policy target around 8% of GDP, and the share of road freight is high, hence improvement of the efficiency of road freight is a stated national goal [2]. Meanwhile, dealers in a fiercely competitive passenger vehicle market [3] can anticipate a consistent arrival schedule and delivery with minimal risk of damage, and the

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automotive logistics market, which is valued at approximately USD 8.3 billion and is projected to reach a total of USD 15.7 billion by 2033 at an average growth rate of 9.5% a year, is growing rapidly.

In October 2019, the three Volkswagen Group Indian entities were combined into a new company called Škoda Auto Volkswagen India Private Limited (SAVWIPL), which now runs six brands: Škoda, Volkswagen, Audi, Porsche, Lamborghini and Bentley. More than 278 authorised dealerships are present in the North, South, East and West logistics zone to which its Chakan (Pune) plant provides vehicles. The total income for FY26 was ₹22,338 crore, whereas the profit after tax came out to be only ₹139.40 crore, so if even logistics inefficiencies, inaccurate master data or higher freight rates, it will have a direct impact on profit. However, with the passage of time, the company's enterprise route, distance and leadtime data had deviated from reality: some active corridors were not present in the Transportation Management System (TMS), LSPs used different routes for the same origin/destination pair, recorded distance and distance/leadtime were not accurate and the ETAs generated by the system were different from the actual transit time.

The project is reported in this paper during on-the-job training in the Vehicle Logistics Department of SAVWIPL for six months, from 5 January to 3 July 2026. It includes four tasks: auditing and standardizing outbound routes, calibration of plant and dealer distances, recalibration of transit time estimation from GPS telematics and benchmarking of freight rates with Tata Motors and Mahindra & Mahindra. The study does not include any real-time dynamic rerouting, automated dispatch algorithms or software implementation on the road dispatches for Chakan. The project also provided data on the operation to an academic AI route mapping collaboration with the Pimpri Chinchwad College of Engineering (PCCE), not included here.

II. SECTOR AND ORGANISATIONAL CONTEXT

The Indian FVL sector comprises four interacting groups: OEMs that govern dispatch, route compliance, and carrier performance; LSPs that operate car-carrier fleets and, increasingly, rail auto-racks; dealership networks that need predictable lead times; and TMS and GPS-telematics infrastructure that links plant yards to dealer bays. Table I summarises the competitive structure using Porter's Five Forces.

TABLE I. PORTER'S FIVE FORCES: INDIAN FINISHED VEHICLE LOGISTICS

Force	Intensity	Principal drivers
Competitive rivalry	High	OEM rate benchmarking; standardised equipment, so LSPs compete on speed, damage ratios, and telematics
Buyer power (dealers)	Moderate–High	Tight inventory turns, zero-damage tolerance, demand for ETA transparency
Supplier power (LSPs)	Moderate	Specialised multi-deck fleets, driver shortages, diesel and toll inflation
Threat of new entrants	Low–Moderate	Capital cost of car carriers, OEM compliance audits, backhaul density
Threat of substitutes	Low–Moderate (evolving)	Rail auto-racks (AFTO scheme, BCACBM wagons) and coastal Ro-Ro shipping

Macro-environmental forces reinforce the case for data- The need for data to guide route governance is driven further by the case of macro-environmental factors. The policy measures such as PM Gati Shakti, the National Logistics Policy, the Unified Logistics Interface Platform and Bharatmala are designed to reduce the costs and transit time of the logistics chain, while the introduction of FASTag tolling and e-Way Bills provide a way to create digital stamps along the journey. The rising costs of diesel and tolls, and the shortage of drivers, are squeezing the margins of logistics operators, and dedicated rail auto-racks, under Bharatmala, are becoming a substitute on long hauls. There are three sector challenges directly related to this study: mismatches between legacy data and routes, ETA deviations due to highway, toll, border delays, and non-uniform practices of transporters.

SAVWIPL's assets are the multi-brand portfolio and the localised MQB-A0-IN platform. With the domestic passenger-vehicle market share increasing from approximately 1.7% in FY22 to approximately 2.5% in FY26, it is set to reach 5% by 2030. The same goal will be achieved in Tier-2 and Tier-3 cities, resulting in longer delivery routes and higher penalties for route, distance, and ETA. The logistics data discrepancies and the different practices of the carriers discussed here are its major shortcomings in this area.

III. LITERATURE REVIEW AND THEORETICAL BACKGROUND

A. Literature Review

The historical development of the Vehicle Routing Problem (VRP) is traced by Laporte [4] and classical and recent methods to build efficient vehicle routes are described by Cordeau et al. [5] and Toth and Vigo [6] respectively. Much of this work assumes a fixed road network and a fixed speed for each road, while real corridors are frequently congested, have border crossings and seasonal disruption, and practical routing must take into account stochastic delay, real-time constraints and required waypoints. Bowersox et al. [7] and Chopra and Meindl [8] consider transportation as a fundamental logistics decision and demonstrate that inaccurate ETAs lead to an increase in safety stock and a decrease in service, thus causing the problem. In the world of freight, volume-consolidation logic is being used in transport negotiation, which can be achieved through collaboration among carriers, as demonstrated by Wang and Kopfer [9] who demonstrate a reduction in transport cost through load

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consolidation; NITI Aayog and RMI [2] point to the cost burden of road-dominated freight and why efficiency gains are needed. Most of these sources in this study are conceptual and are combined in a live OEM outbound network with a master-data audit, telematics validation and rate benchmarking.

B. Theoretical Background

The study is based on four concepts. First of all, VRP and network graph theory represent the road network as nodes and direction of road segments as links, allowing missing segments, detours, redundant kilometres, etc. to be identified and replaced by standardised corridors which will reduce cost, enhance the use of carrier assets and reduce emissions.

Second, lead-time predictability theory is that unplanned transit delay causes disruption in routine scheduling downstream, and that using observed transit to construct a timing profile for a stock placement process leads to better stock placement and dealer service levels. Third, that decisions should be based on field telematics, not on lookup tables: If there is a mismatch between the GPS's coordinates, timestamps and geofence entries and the system's entries, discrepancies are detected and master-data is updated following the Plan-Do-Study–Act cycle.

Fourth, freight benchmarking and cost-parity analysis involves normalising tariff structures (base distance rate, fuel surcharge and other ancillary fees) to a common unit of measurement (in this case the rupee per car-kilometre) to help identify systematic tariff differences, and potential over-billing, due to inaccurate distance measurement, which can then be incorporated into procurement discussions.

IV. MATERIALS AND METHODS

A. Research Objectives

This study evaluates route, distance, and transit-time practices in SAVWIPL's outbound network to achieve five objectives: (1) audit the routes stored in the TMS against those used by LSPs and prepare standardised corridors; (2) verify plant-to-dealer distances and correct discrepancies that affect freight billing; (3) analyse actual transit times from GPS telematics and recalibrate system ETAs; (4) benchmark SAVWIPL's freight rates against those of Tata Motors and Mahindra & Mahindra; and (5) formulate practical recommendations for master-data governance, carrier compliance, and freight contracting.

B. Research Design and Data Collection

A study was conducted for six months in applied, plant-based within the Vehicle Logistics Department. The scope included 126 priority dealer locations (out of 278+ dealerships), 31 primary delivery corridors (out of Chakan) and 178 GPS tracked trailer trips in four zones. Route and distance data was retrieved from SAP/TMS Master tables, compared to routes reported by LSPs, measured on ground with GIS tools, Google Maps API and ground trip logs (including odometer readings). Plant gate-out and geofenced delivery timestamps in AIS-140 telematics records were used to calculate the transit times, and they were then cross validated with trip manifests, e-Way Bills and FASTag toll timestamps. End-to-end trips with verified timestamps only were saved through stratified purposive sampling. Freight analysis was carried out using the rate sheets available on SAVWIPL and available competitor tariff data, which was normalised in rupees per car-km for short, medium and long haul distance slab [10].

TABLE II. PROJECT TASKS, METHODS, AND OUTPUTS

Task	Method and data	Output
Route audit and standardisation	TMS/SAP routes compared with LSP routes, corridor by corridor; SOC design	31 SOCs; 6 missing links integrated
Distance calibration	System km versus GIS, Google Maps API, and trip-log km for 126 dealers; delta-km computation	32 discrepancies corrected; verified distance matrix
ETA recalibration	178 AIS-140 trips; gate-out versus geofence delivery; delay-factor classification	Lead times for 14 cities; deviation 4.02% to 3.91%
Freight benchmarking	Rate sheets of SAVWIPL, Tata Motors, and Mahindra & Mahindra normalised to ₹/car-km by distance slab	Parity matrix: ₹5.03 versus ₹4.81 and ₹4.89

C. Analytical Framework and Limitations

Descriptive statistics and variance measures were used: absolute kilometre variance between system and verified distance, transit variance (days) between baseline ETA and actual arrival, and percentage rate differential between OEMs. Delay causes were categorized as border crossing, highway construction, toll gate or seasonal weather. There are some limitations in the study. It includes only one origin (Chakan) and does not include the Chhatrapati Sambhajinagar plant, import ports and regional stockyards. The 126 dealers and 178 trips sampled are not necessarily representative and low-density Tier-3 and newly commissioned dealers were not comprehensively audited. LSPs typically manage telematics devices, which also experienced signal loss and battery drain as well as occasional tampering. There are enough sources of variance that static lead-time parameters are not able to account for it, such as monsoon washouts, winter fog and unannounced diversions. Competitor rate analysis was based on readily available rate cards and did not account for rebates, fuel-surcharge formulas, spot rates or backhaul arrangements. Last, the scope was restricted to road transport and not inbound logistics or rail.

V. DATA ANALYSIS AND DISCUSSION

A. Audit and Standardise Outbound Routes

TABLE III. ROUTE AUDIT RESULTS

Parameter	Result
Primary delivery corridors audited	31
Corridors missing from the TMS	6
Corridors with inter-transporter route variation	18
Corridors standardised as SOCs	31
Missing route links integrated into SAP/TMS	6

The integrated SAP/TMS allows for the automatic inclusion of route links.Integrated SAP/TMS – missing route links are integrated.

As can be seen in Table III, approximately one out of every five primary corridors (6 of 31) was not listed in the TMS and LSPs had to choose ad-hoc, unapproved routes to run; and 18 corridors (over half) were operated by either multiple carriers or the same carrier on varying highway routes between the

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same origin-destination pair. Avoidance of tolls or return load resulted in erratic transit patterns, safety-compliance issues, and broad transit time variation. This resulted in an SOP for each of the 31 lanes, including highway network, required waypoints, bypasses and state border crossings. The six missing links have been digitised and installed in the SAP/TMS master database and SOCs have been incorporated into transporter service level agreements with geofenced deviation protocols.

B. Verify Plant-to-Dealer Distances

TABLE IV. DISTANCE CALIBRATION RESULTS

Parameter	Result
Priority dealer locations audited	126 (of 278+ dealerships)
Verification sources	GIS tools, Google Maps API, trip logs, odometer readings
Major kilometre discrepancies found	32
Discrepancies rectified in master data	32
Deliverable	Verified distance matrix for freight invoicing

A comparison of distances recorded on the systems with verified distances from the highway found 32 large discrepancies, about one for each four locations audited. Most of the errors were static overstatements or old tables, making freight cost calculations inaccurate, setting up transporter billing issues and leading to admin hassle when reconciling. 32 were corrected with GIS and odometer baselines, and provided an auditable distance matrix for procurement and finance to verify carrier invoices. In this study, the value of the correction (in rupees) was not calculated, so it is a natural step to calculate it.

C. Recalibrate Transit Time and ETA

TABLE V. TRANSIT-TIME AND ETA RESULTS FROM GPS TELEMATICS

Parameter	Result
GPS-tracked trips analysed (AIS-140)	178
Logistics zones covered	4
High-deviation destination cities	14
Actual transit time versus system ETA	+0.4 to +2.8 days
Concentration of deviations	East: Guwahati, Patna; North: Jammu, Chandigarh
Main delay factors	Highway bottlenecks, toll points, state-border checks, seasonal conditions (monsoon washouts, winter fog)
Overall arrival deviation	4.02% before; 3.91% after recalibration

As can be seen in Table V, actual car-carrier transit times were 0.4 to 2.8 days longer than legacy ETAs in 14 cities, most notably on East and North zone lanes where there are no static lead-time parameters in place to account for highway bottlenecks, border checks, or seasonal conditions. These cities' lead-time parameters were adjusted at their dispatch system, and outbound arrival deviation of the cities was reduced from 4.02% to 3.91%, by 0.11 percentage point. The overall improvement is a relatively small amount which masks what is going on on the poorest lanes; following lane-by-lane deviation on a rolling basis would help determine if the recalibration is continuing as seasons change.

D. Benchmark Freight Rates

TABLE VI. WEIGHTED AVERAGE FREIGHT RATE BENCHMARK

OEM	Rate (₹/car-km)	SAVWIPL premium (₹)	SAVWIPL premium (%)
SAVWIPL	5.03	–	–
Tata Motors	4.81	0.22	4.6

SAVWIPL's rate of ₹5.03 per car-km is ₹0.22 (4.6%) higher than Tata Motors and ₹0.14 (2.9%) higher than Mahindra & Mahindra. The reason is assigned to smaller dispatch lot sizes, kilometre inflation of the master data and multi-transporter rate agreements that are based on several rate providers. Please note that the comparison should be treated with some caution due to the fact that the rebate levels offered by the OEMs, fuel-surcharge systems, and trailer loading configurations are not necessarily identical. Despite this, the benchmark can still be used in conjunction with the GIS verified corridor distances to support standardised LSP rate cards and volume-consolidation targets in procurement.

E. Challenges Encountered and Mitigation

TABLE VII. CHALLENGES AND MITIGATION ACTIONS

Challenge	Mitigation
Missing routes and inaccurate master distances	End-to-end audit of 126 dealers using GIS, Google Maps API, and odometer records; 6 links digitised, 32 distances corrected
LSP route inconsistency (18 of 31 lanes)	SOCs for all 31 lanes, built into SLAs with geofenced deviation protocols
ETA deviations of +0.4 to +2.8 days	Delay factors isolated from 178 trips; lead times recalibrated for 14 cities
Telematics gaps (network dropouts, battery drain, tampering)	Only complete trips used; data cross-validated with manifests, e-Way Bills, FASTag, and gate logs
Confidentiality of freight data	Rates normalised to ₹/car-km across distance slabs and paired with verified distances

The analysis of the difficulties reveals that most of the challenges were related to data quality and lack of visibility of third-party and competitor information, thus making cross-validation of the data with independent data sources like manifests, e-Way Bills, FASTag and gate logs the core of the method.

VI. FINDINGS, CONCLUSIONS AND SUGGESTIONS

A. Findings

All 31 primary corridors were mapped as SOCs and 6 were missing in the TMS and 18 had inter-transporter variations—these were all integrated. A total of 32 discrepancies of 326 priority dealer locations were resolved, providing a true foundation for freight billing. The actual transit time was 0.4-2.8 days shorter than the ETAs provided by the system in 178 telematics trips, with the majority of those trips clustered in the 14 cities in the East and North zones; a recalibration of the system reduced the overall deviation in arrival times from 4.02% to 3.91%. SAVWIPL's weighted average freight of ₹5.03 per car-km was approximately 4.6% higher than that of

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Tata Motors and 2.9% higher than that of Mahindra & Mahindra.

B. Conclusions

This study fulfilled its objectives. First, data integrity is the foundation for freight governance: having a TMS route & distance table matched up with the verified ground truth data from GIS eliminates billing disputes and prevents leakage due to kilometre inflation. Second, telematics also closes the planning–execution gap: transit times differ from theoretical models due to infrastructure and border realities, and there is a need for regular analysis of the GPS data to ensure ETAs remain predictable. Third, route standardisation also provides for cost parity - standardized corridors reduce duplications of mileage, improve an OEM's rate negotiating position, and safeguard operating margins. In conclusion, it is all about master data, standardised corridors and the constant validation of telematics, which are prerequisites for efficient finished vehicle logistics.

C. Suggestions

To maintain these gains, SAVWIPL should put in place a roadmap of actions, developed in a phased way and in a collaborative manner, as summarised in Table VIII.

For Logistics & IT (master data): Move 32 corrected distances + 6 integrated links into formal change control and add a rule so that any manual entry or new dealer added on-boarding is automatically cross-checked distances in GIS prior to activation.

For Transport Operations and LSPs: Ensure compliance with the 31 Socs is a key part of the empanelled LSP's SOP with geofence checkpoints triggering compliance alerts when a trailer deviates from the corridor by more than 15km.

Move from a lead-time matrix to a GPS integrated control tower which dynamically updates the ETAs for 14 high deviation cities based on live AIS-140 feeds, while maintaining buffer times for East and North corridors like Guwahati and Jammu and GPS tracking in the dealer portal.

Bill carriers are using GIS verified distances only, and seek to renegotiate on volume-tier incentives rather than spot rates with the goal of closing the rate gap to competition.

TABLE VIII. PHASED IMPLEMENTATION ROADMAP

Phase	Timeline	Key actions
1. Master-data cleansing and TMS integration	Month 1	Cross-functional task force; load verified distance matrix (126 dealers, 31 corridors); automated validation rules
2. Carrier route lock-in and SLA restructuring	Month 2	SOP addendum to all LSPs; geofence alerts for deviations beyond 15 km
3. Dynamic control-tower rollout	Month 3	Telematics feeds linked to dealer portal; buffer-time logic for East and North corridors
4. Commercial renegotiation	Month 4	Billing on verified distances; volume-tier incentives in LSP contracts

D. Implications of the Study

The findings of this study have implications for all the primary stakeholders:

- Finance and Procurement: Verified distances and corridor data prevent billing disputes, provide an audit trail for invoice verification and improve negotiation power with LSPs.
- Dealers: More accurate ETAs enable dealerships to better manage their Pre-Delivery Inspection (PDI) bays, customer handovers, and even reduce their buffer inventories and yard dwell times.
- Logistics Service Providers: Fixed corridors and clear distance baselines enable performance to be measured and disputes avoided in relation to compensation.
- Standard Corridors eliminate redundant mileage and deadhead running, boost fleet utilization and level the playing field with competitors in terms of costs..

E. Future Scope of the Study

The master-data baseline and telematics dataset developed here allows for further investigation:

Multi Plant Expansion: Add functionality to extend framework to Chhatrapati Sambhajinagar plant and stock yards for multi drop routing for CBU/ CKD luxury vehicles.

Multimodal Rail Integration: Evaluate the feasibility, variability of lead time and total freight cost of converting long-haul corridors (Pune–Delhi, Pune–Guwahati) to AFTO rail rakes and estimate the Scope 3 emission reduction.

EV Logistics: Research payload, axle-load and thermal-safety for carrying heavier battery electric vehicles.

Predictive ETA Models: Use machine-learning models like gradient boosting or LSTM networks instead of historical averaging to process live weather, traffic and toll-wait data.

Financial Quantification: Value the billing leakage eliminated as a result of the distance corrections and the savings suggested by the rate benchmark.

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