

Development of 3-wheel EV vehicle Durability Mode Through Local Measurement in India

- A Field-Data-Driven Approach to Durability Test Procedure Development -

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India's three-wheeler market shows strong and growing demand due to limited public transportation infrastructure and government EV transition policies such as FAME 2 and PLI. Based on this outlook, the company is pursuing its first 3-wheel EV development to expand its presence in the Indian market. As a new entrant without prior 3-wheeler development experience, establishing a reliable, field-validated durability strategy was critical within limited time and resources.

This study developed a real-vehicle-based Test and Development Procedure (TDP) reflecting actual customer usage conditions in India, following the four-stage research flow illustrated in **Fig. 1** durability target establishment, road ratio and route configuration, vehicle sensorization and measurement, and TDP development.

① Durability Target Establishment (local survey, competitor benchmark, market research); ② Road Ratio & Route Configuration (local survey and m-tab survey utilization, route design reflecting 3-wheeler driving pattern and road surface characteristics); ③ Vehicle Sensorization & Measurement (vehicle sensorization for local data acquisition and analysis); ④ Real-Vehicle Durability TDP Development (development of three TDP types via data analysis techniques).

In the first stage, a durability target was established through a Delhi field survey combining driver interviews, used-vehicle condition assessments, and a competitor market report, which revealed durability-related defects such as battery degradation and brake failure in aged low-speed three-wheelers. Considering the company's premium positioning and conservative risk approach relative to competitor durability policies, a corresponding durability target was adopted.

In the second stage, since no official statistics existed for three-wheeler road-usage ratios, local survey results were combined with four-wheeler survey data as a reliable proxy to derive representative road-type driving ratios, consistent with independent local interview findings. Measurement routes covering urban, highway, national, and unpaved roads were configured in the Bengaluru region based on typical commuting and passenger-transport driving patterns.

In the third stage, vehicle sensorization was performed on a benchmark vehicle sharing the same suspension architecture, incorporating IMU sensors, strain gauges, and accelerometers for body inertial loads, chassis displacement, and vibration measurement. Field data were collected under a fully loaded condition using local professional drivers, covering both the company's route and the partner company's (TVS) durability test route.

In the fourth stage, Peak-Over-Threshold (POT) analysis of front spring displacement data confirmed the TVS route's overall suitability as a durability test basis, with strong coverage particularly for unpaved-road loading. Rainflow counting, superposition, and histogram optimization were applied to derive three complementary TDP conditions—combined real-road, unpaved real-road, and Rig (3-poster)—each offering a different balance between test fidelity and duration. Rig-based reproducibility was validated through joint testing with the Korea Automotive Technology Institute, confirming a high correlation with real-vehicle data.

In conclusion, this study successfully established a real-vehicle, field-data-driven durability TDP tailored to actual Indian usage conditions, supporting the company's first 3-wheel EV development. This framework provides a practical and time-efficient foundation for durability validation in emerging vehicle markets under constrained development schedules.

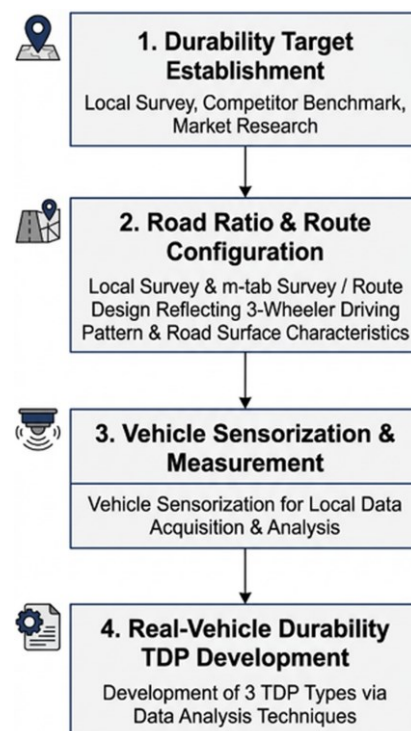


Fig. 1 Overall Research Flow of 3-wheel EV Durability Mode Development