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# Seven-layer socio-technical EV navigation software platform feasibility and appropriateness protocol

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**We use this protocol and it's working**

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## Abstract

The proposed seven-layer taxonomy demonstrates methodological applicability as both a diagnostic and comparative benchmarking instrument, enabling transparent cross-platform evaluation while preserving contextual sensitivity to infrastructure-constrained environments. The results indicate that effective EV navigation assessment extends beyond routing precision to the interaction between technical performance, user behavior, infrastructure realities, and policy structures, thereby supporting informed platform selection, capability gap identification, and adaptive deployment strategies within evolving electric mobility ecosystems.



## Materials

Licencing & Policy Layer: Software licencing and data compliance, interoperability standards, policy-driven scalability.

Predictive & AI Layer: Historical energy usage pattern, weather, road, and grid forecasting models, driver fatigue and stress detection, charging demand prediction, real-time risk assessment.

Application & Integration Layer: Navigation application APIs, in-vehicle information systems (IVIS), smartphone sensor data, vehicle-to-grid (V2G), grid-to-vehicle (G2V), optical interface readiness, voice and user interface (UI) feedback loop, offline/low-data mode.

Behavioral & Cognitive Layer: User preferences, driving style, anxiety indicators, trip purpose and criticality, time flexibility.

Infrastructure & Grid Layer: Charging station location and availability, charging station type and compatibility, operational status, loadshedding schedule, grid health, off-grid charging initiatives.

Environmental & Geographic Layer: Elevation profile, ambient temperature, wind speed and direction, road surface conditions, traffic congestion, urban and rural topography.

Vehicle Data Layer: State-of-charge (SoC), battery health and temperature, vehicle mass and load, motor efficiency and regeneration mode, auxiliary load.



## Licencing & Policy Layer

- 1 Protection of Personal Information Act (POPIA) compliance and information technology (IT) integration regulations, charging protocol compatibility across networks, legacy systems, alignment with South Africa's EV policy landscape.

## Predictive & AI Layer

- 2 Personalized energy forecasting based on previous trips, predictive modeling for weather, road, and outage timing, biometric and behavioral indicators for risk adaptation, predicts wait times and station queue lengths, charging time, live estimation of trip risk, stress, and route feasibility.

## Application & Integration Layer

- 3 ABRP, HERE, GraphHopper, Google Maps integration, global positioning system (GPS), accelerometer, gyroscope for user behavior analysis, V2G, G2V, vehicle-to-infrastructure (V2I) readiness, including fiber Bragg grating (FBG) sensor integration, familiarity, tone, real-time prompts, audio-visual cues for rerouting, crucial in rural and loadshedding-affected areas.

## Behavioral & Cognitive Layer

- 4 Preferred networks, detour tolerance, maximum trip duration, aggressive vs conservative patterns learned via AI, inferred from behavior or surveys - range anxiety effects, business, leisure, or emergency purpose informs route logic, schedules and hard stops constrain decision flexibility.

## Infrastructure & Grid Layer

- 5 Live availability via GridCars, Rubicon, and ChargeCars APIs, combined charging system (CCS) CHArge de Move (CHAdeMO), alternating current (AC) type 2, fast vs slow charging, online/offline status, maintenance schedules from public maps, integrated Eskom and municipal outage data, voltage fluctuations affecting charging reliability, solar/battery stations for rural and loadshedding-prone areas.

## Environmental & Geographic Layer

- 6 Affects battery performance and range, influences aerodynamic drag and energy consumption, road quality, wet/dry surfaces affecting traction and energy use, real-time and forecasted data from Google Maps, HERE APIs, differentiate regenerative braking potential, speed, acceleration and charging access.



## Vehicle Data Layer

- 7 Real-time battery level essential for accurate range estimation, impacts battery efficiency, degradation, and usable capacity, influences energy consumption, especially on inclines, determines energy use and recovery during braking, includes heating/cooling system consumption, route grade and altitude changes sourced from geographic information system (GIS) (e.g., SRTM data).