FROM FLATLAND TO FULL SPECTRUM

Liberating Transport Research Across Dimensions, Geographies, and Behaviour

WCTRS 50th Anniversary Manifesto • 1-Page Summary

> *For fifty years, transport science has operated in flatland, two-dimensional networks, planar equity models, hydrologically blind infrastructure, theories built in and for the Global North, and behavioural assumptions that treat human complexity as noise. We have built an extraordinary science of surfaces. It is no longer sufficient. We call for a full-spectrum liberation: the reconstruction of transport science across dimensions, geographies, and human realities simultaneously.*

THE DIAGNOSIS

Seven unstated assumptions imprison the field: (1) the Lane Assumption, rendering non-lane-based and volumetric traffic unrepresentable; (2) the Interaction Models Assumption, encoding longitudinal models in a spherical world; (3) the Fundamental Diagram Assumption, defining capacity for surfaces, not volumes; (4) the Equilibrium Assumption, imposing fixed-network convergence on self-organising systems; (5) the Homogeneous-Agent Assumption, reducing dimensional heterogeneity to parametric variation; (6) the Geographic Assumption, treating Global South complexity as deviation from a Northern norm; (7) the Fixed-Network Assumption, treating infrastructure as static when climate forces dynamically reshape topology, capacity, and accessibility.

THREE INTERLOCKING LIBERATIONS

Dimensional Liberation: From 2D to full volume. Build 3D flow field models on manifolds, n-body interaction potentials replacing interaction models, and volumetric phase-space characterisation replacing the fundamental diagram. Replace equilibrium with process-based science using neural networks and evolutionary dynamics. Use physics-informed ML not to augment existing theory but to discover the governing equations of volumetric and mixed traffic from observational data.

Geographic Liberation: From periphery to centre. The world's most complex traffic environments are in the Global South, mixed, non-lane-bound, multi-modal, climate-exposed. These are the general case; Northern motorway traffic is the special case. Build theory from the most complex environments outward. Position Global South institutions as theory generators, not data providers.

Behavioural Liberation: From engineering assumption to human reality. Technology does not transform transport; human adaptation to technology does. Three interaction dynamics must be modelled: humans exploiting autonomous systems (strategic behavioural gaming), autonomous systems learning to predict and accommodate human behaviour (intent prediction and trust calibration) and independently designed autonomous platforms interacting with each other (cross-platform coordination failures).

THE PATHWAY

Phase 1 — Foundations (2026–2036): Discover governing equations of non-lane-bound traffic through physics-informed neural equation discovery. Establish Mixed Traffic Net across 10+ Global South cities. Build first-generation coupled hydro-transport simulations using neural operators. Develop prototype 3D interaction models from drone swarm and ecological flocking data. Launch naturalistic studies of human–AV strategic adaptation, intent prediction, and cross-platform coordination. Establish reverse research partnerships with Global South universities as intellectual leads

Phase 2 — Integration (2036–2051): Operationalise volumetric microsimulation and real-time 3D traffic prediction for airspace management. Deploy interpretable, causal behavioural AI for mixed-mode governance with formal safety verification. Develop meta-learning and federated transfer across geographies. Scale coupled multi-hazard digital twins for climate-vulnerable cities. Model co-evolutionary behavioural gaming at population scale and trust dynamics bifurcation. Global South-developed models become defaults in major simulation platforms.

Phase 3 — Full Spectrum (2051–2076): Volumetric flow theory is the default science; lane-based models survive as historical special cases. Interpretable behavioural AI becomes governing infrastructure embedded in regulation and airspace management. Investigate generational behavioural transformation in autonomy-native populations, system resilience under catastrophic failure, autonomous–autonomous co-evolutionary pathologies, and the irreducible uncertainty floor of human behavioural prediction. The Global South is the permanent scientific centre; theory built from the most complex cases, validated across all contexts.

THE COMMITMENT

> *We will ask of every model: In how many dimensions does it operate? Whose behaviour does it encode? Whose geography generated its theory? What watershed does it ignore? Whose access does it measure, and whose does it render invisible? Research that cannot answer these questions is research the next fifty years cannot afford.*