

SkyFlow-to-UC:

Satellite Data-Driven Traffic Digital Twin for Space-to-Ground Mobility

FORUM8

14th CPWC

OUSH

PROJECT BACKGROUND AND GOAL

From Aerial Observation to Executable Ground Traffic

Observation data reveal vehicles. Evaluation and decisions need dynamic scenes that can be replayed, generated, and tested. SkyFlow-to-UC feeds processed trajectories or traffic parameters into SUMO, then synchronizes the vehicles with UC-win/Road.





SPACE-TO-GROUND

SYSTEM ARCHITECTURE AND TWO MODES

One Console, Two Complete Traffic Workflows

01 Input and Setup
Trajectory CSV
Road and traffic parameters

02 Unified Console
GUI setup
JSON and logs

03 SUMO Core
Trajectory replay
Traffic generation

04 TraCI Link
Vehicle states
Dual-client sync

05 UC-win/Road
3D replay
Ego-vehicle feedback

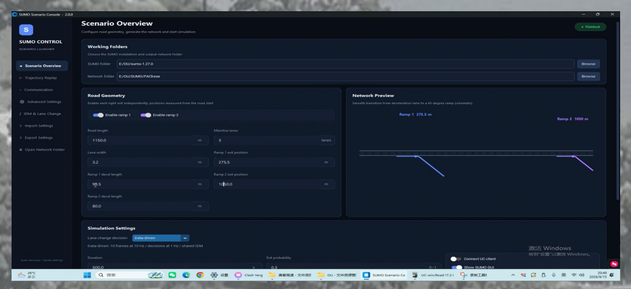
Mode A: Complete Trajectory Replay

Mode B: Complete Traffic Generation

Both modes share the same network generation, communications, SUMO runtime, and UC 3D mapping foundation.

SUMO SCENARIO CONSOLE v2.0.0

GRAPHICAL CONFIGURATION AND ONE-CLICK START



- **Road** Length, lane width, two ramps
- **Traffic** Flow rate, style, exit probability
- **Replay** CSV mapping, coordinates, timing
- **Link** TraCI, UC plugin, and ports
- **Evidence** JSON, logs, and safe shutdown

MODE A · COMPLETE TRAJECTORY REPLAY

1. **Select trajectory** CSV / TXT
2. **Map fields** ID, time, X/Y
3. **Calibrate coordinates** Mirror and offset
4. **Choose timing** Raw frames or interpolation
5. **Synchronized replay** SUMO / UC

The source CSV stays unchanged. Complete means that each vehicle ID is created, updated, and hidden throughout the selected time and area.

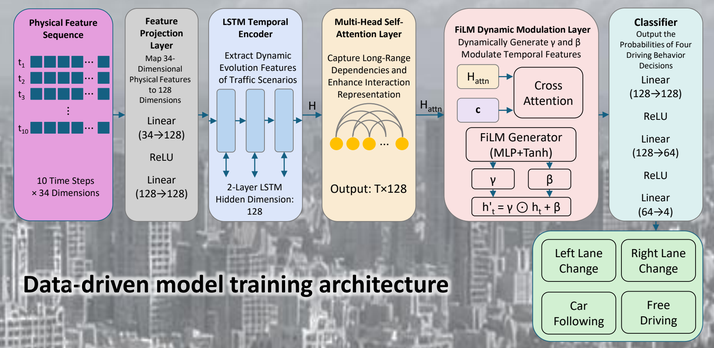
MODE B · CONTROLLABLE TRAFFIC GENERATION

- **Vehicle entry**
  Create vehicles using lane intervals and available headway
- **Longitudinal following**
  IDM updates speed, safe spacing, and braking
- **Lane-change decision**
  Rule-based or data-driven intent
- **Safety filter**
  Lane bounds, front gap, rear TTC, cooldown
- **Route completion**
  Stay on the main road or enter an exit ramp early

DATA-DRIVEN LANE CHANGE

Model Intent, Rule-Based Execution

MODEL INTENT WITH DETERMINISTIC SAFETY FILTERS



35
Traffic-state features
Vehicle motion and nearby traffic

10
Consecutive history frames
10 Hz over one second

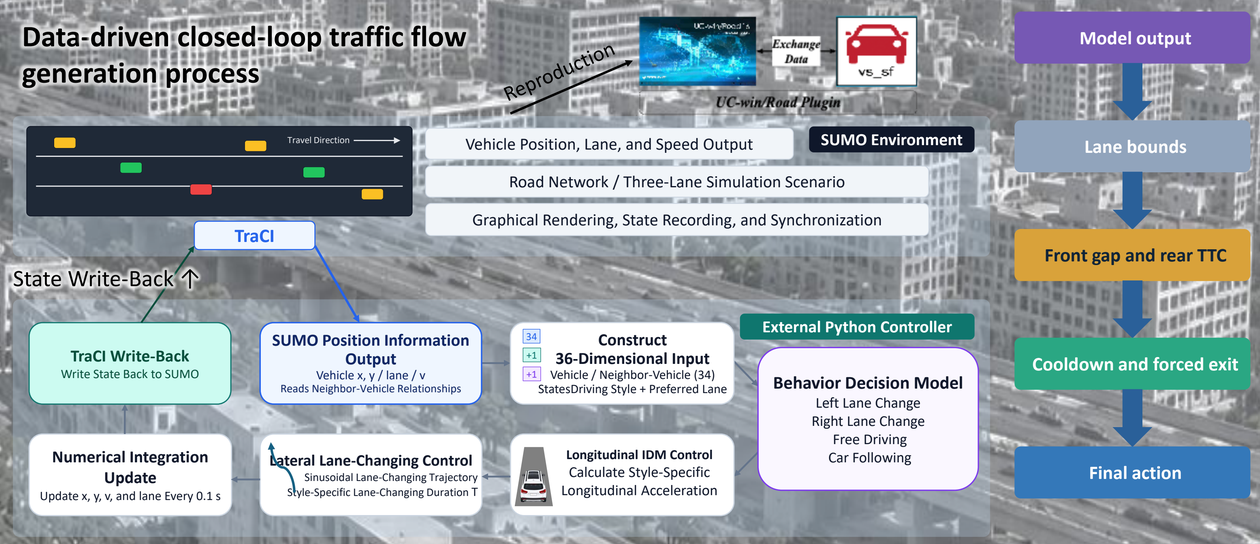
4
Intent classes
Left / right / follow / free driving

1 Hz
Batch inference
Runs on NumPy CPU without PyTorch

Data-driven model training architecture

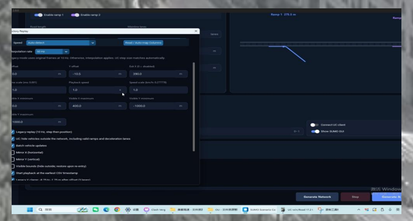
Export consistency check: all 12 sample classes matched. Maximum logit error was 1.58×10^{-6}. This verifies deployment consistency, not fixed accuracy on new roads.

Data-driven closed-loop traffic flow generation process

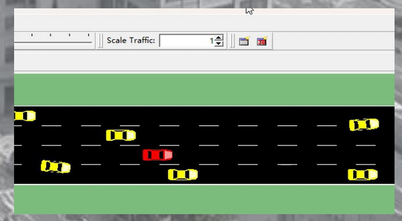


DEMONSTRATION AND EVIDENCE

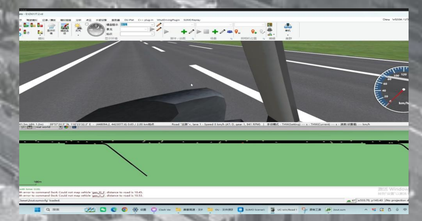
Show Input, Runtime, Synchronization, and Response Together



1 Input and validation
Version v2.0.0, CSV or parameters, validation passed



2 SUMO runtime
Continuous entry, following, lane changes, ramps



3 UC synchronization and response
Start Replay, uc_ego, background response

Use only real screenshots and logs: matching vehicle IDs, connection status, model_decisions.csv, uc_ego, and background-traffic response