GMNS: A Specification for Sharing Routable Road Networks

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Motivation

During the 2017 TRB Planning Applications Conference, the Zephyr Foundation sponsored a "shark tank" to identify projects of interest to the transportation modeling community. The winner was to develop a "General Travel Network Format Specification".

FHWA was also interested in developing a routable network specification that would aid in multi-resolution and multi-modal network modeling.

Starting in 2018, the Zephyr and FHWA efforts came together to develop the General Modeling Network Specification (GMNS). FHWA provided funding for staff support and the Zephyr Foundation provided a project management group (PMG), where interested stakeholders volunteer their time to provide guidance and some development support.

General Modeling Network Specification (GMNS) will

- Support multi-resolution modeling projects
- Encourage more consistent practices by state and local governments for coding facilities, to ease automated processing of public data
- Support multi-modal (car, truck, transit, pedestrian, bike) improvements
- Bring time-varying varying networks into transportation planning, to better incorporate the effects of transportation system management and operations (e.g., varying lane configurations and tolls)

Several other specifications and modeling systems informed the development of GMNS

- **AequilibraE.** Open-source Python package for transportation modeling, including static routing . www.aequilibrae.com
- **DTALite and NeXTA.** Dynamic traffic assignment and network visualization github.com/asu-trans-ai-lab/DTALite
- **TRANSIMS and MATSim.** Agent-based routing and simulation models matsim.org
- **ARNOLD.** FHWA All Road Network of Linear-Referenced Data
- **OpenDrive.** Detailed description of road networks. opendrive.org
- **OpenStreetMap.** Community developed map of the world openstreetmap.org
- **SharedStreets.** Data sharing for urban networks and curb use. sharedstreets.io

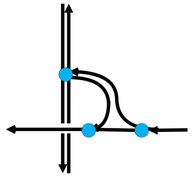
High-level requirements

1. GMNS is a data specification, not tied to any specific software tool.
2. GMNS Is extensible, not universal. The only required files are nodes and links, to support static network assignment.
3. Extensions include data needed for dynamic, multi-modal networks.
4. GMNS reflects infrastructure, services and policies, including physical roads, intersections, traffic controls, tolls and time-of-day restrictions.
5. GMNS is human and machine readable.

Required elements

Node— a point that connects links

- Required fields: node_id, x_coord, y_coord
- Optional fields: name, node_type, ctrl_type, zone_id, parent_node_id



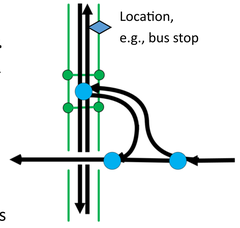
Link—a directed or undirected line object in a network, defined by the nodes it travels from and to. Links for vehicle travel are directed.

- Required fields: link_id, from_node_id, to_node_id, directed
- Optional fields: name, geometry_id, geometry, parent_link_id, dir_flag, length, grade, facility_type, capacity, free_speed, lanes, bike_facility, ped_facility, parking, allowed_uses, toll, jurisdiction, row_width

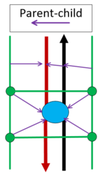
Multimodal accommodation

The **allowed_uses** field indicates what may flow on a **link** or **lane** (e.g., walk, bike, bus, truck, auto, hov2, hov3+), as well as non-travel uses (shoulder, parking)

Location—a point that is associated with a specific location along a link, using a linear reference



Links include fields for **ped_facility, bike_facility.**



Sidewalks and crosswalks may optionally be handled via their own undirected links.

Parent-child relationships:

- Sidewalk with associated road
- Crosswalk and intersection nodes

Elements for dynamic networks

Photo source: FHWA

Time of Day—Link, Lane, Segment, Movement, and Traffic Signal timing characteristics may all vary by time-of-day and day-of-week.

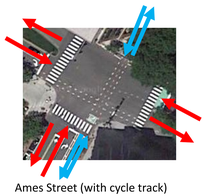
Lane— Lanes are numbered left to right with 1 as the left-most through lane. Left turn lane is –1. A bike lane is a lane with allowed_uses = BIKE

Segment—portion of a link defined by linear references

Turn pockets are defined via segments. For example

- Segments 2, 3: left turn
- Segment 3: right turn

Movement—Movements define connections and traffic control types (none, yield, stop, signal) between inbound and outbound links or lanes



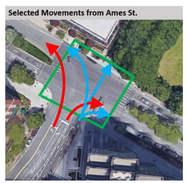
Ames Street (with cycle track)

Example:

General traffic links in red

Bike links in blue

All streets have sidewalks



Traffic signals

Signal_controller—association of one or more intersections whose signals use the same controller

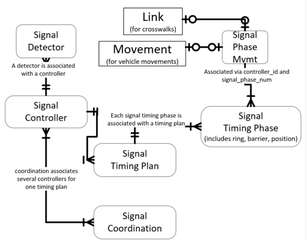
Signal_phase_mvmt—signal_phase mapped to its associated traffic movements and pedestrian links (e.g., crosswalks)

Signal_timing_phase—timing and concurrency information for each signal phase

Signal_timing_plan—timing plan for the signal, by controller, time period

Signal_coordination—coordination for several signal controllers, associated with a timing plan

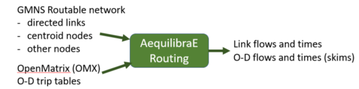
Signal_detector— traffic detector associated with a controller, a phase and a group of lanes



Applications

Static routing using open-source tools

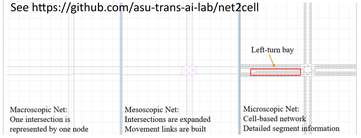
Routing applied to daily and peak hour trips from several regional networks; converted to GMNS before input into AequilibraE.



Multi-resolution modeling

Using GMNS to connect different levels of detail in networks

See https://github.com/asu-trans-ai-lab/net2cell



Workflow using GMNS and open-source software

Step	Description	Software	Input Files	Output Files
0	OpenStreetMap® (OSM) data download	OSM	N/A	map.osm
1	Convert OSM data to GMNS	OSM2GMNS	map.osm	node.csv, link.csv, poi.csv
2	Path finding using GMNS	Path4GMNS	node.csv, link.csv	path output
3	Expand macroscopic network data to micro, meso	net2cell	node.csv, link.csv	Meso-, and micro-networks in node.csv and link.csv
4	Zone-to-zone travel demand	grid2demand	node.csv, link.csv, poi.csv, poi_trip_rate.csv	demand.csv, zone.csv, accessibility.csv, input_agent.csv
5	Traffic signal for timing	Vol2timing, Sigma-X	node.csv, link.csv, movement.csv	Phasing timing data
6	AMS simulation	A/B Street, DTALite	demand.csv, node.csv, link.csv, input_agent.csv	agent.csv, link_performance.csv
7	Visualization	QGIS, NeXTA	node.csv, link.csv, movement.csv, zone.csv, demand.csv	N/A

Maryland I-95 traffic network statistics for different modeling resolutions

Network Type	Number of Nodes	Number of Links
Original OpenStreetMap® Network	1,389,653	177,400 OSM Ways
Converted Macroscopic Network	21,099	45,826
Converted Mesoscopic Network	86,882	119,999
Converted Microscopic Network	1,202,959	1,689,994

We thank the FHWA Office of Planning, the Zephyr Foundation, and volunteers on the Zephyr Project Management Group for their support of the effort. The specification (in markdown and json), examples, and validation tools are available on GitHub:

https://github.com/zephyr-data-specs/GMNS