GMNS[1]: A Specification for Sharing Routable Road Networks
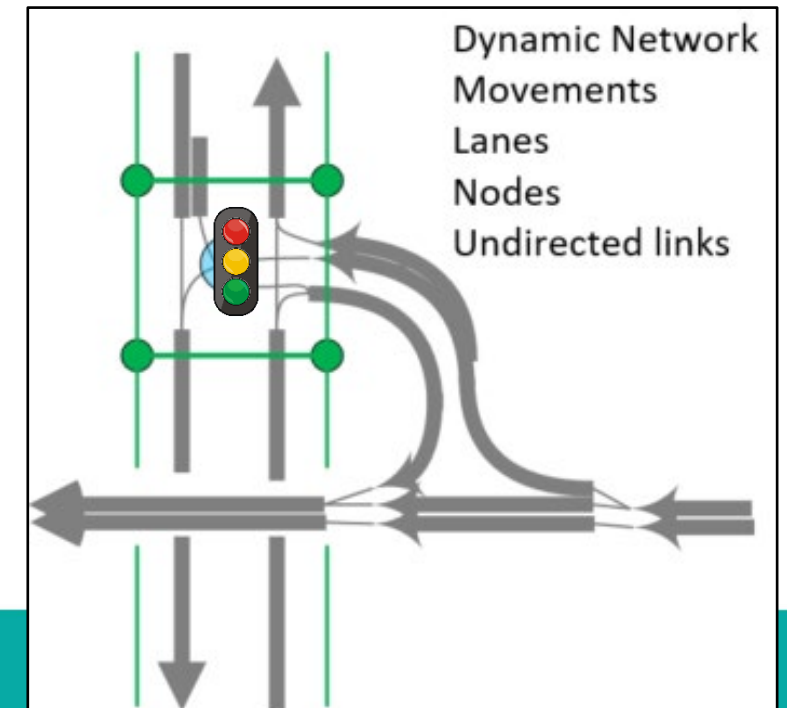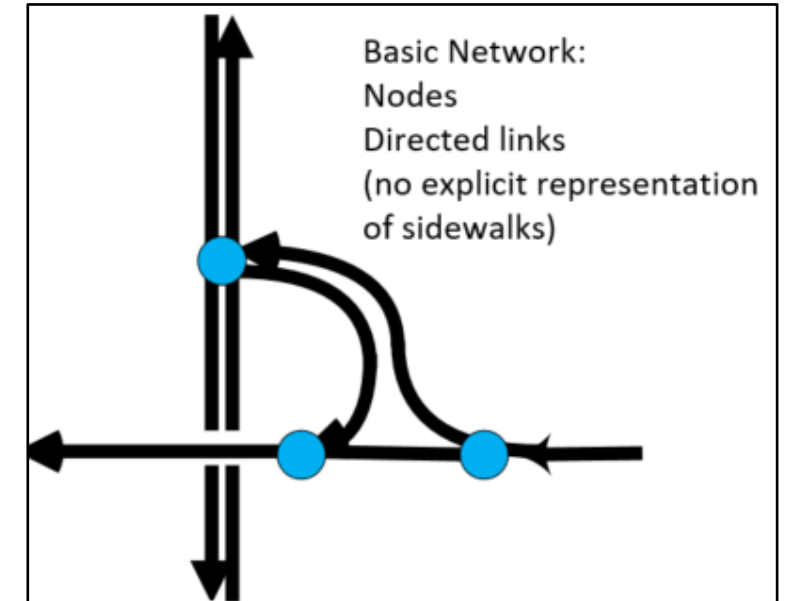
8 January 2023

[1]General Modeling Network Specification

Origins

- Recognized need in the travel modeling community
  - Zephyr Foundation 2017 "shark tank"
  - Winner: to develop a "General Travel Network Format Specification"
- FHWA interest in developing a routable network specification that would aid in multi-resolution and multi-modal network modeling
- Efforts came together in 2018
  - FHWA funding for staff support (Office of Planning)
  - Zephyr Foundation provided a project management group, interested stakeholders (MPO and industry) volunteering their time to provide guidance and some development support

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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)

Basic Network:
Nodes
Directed links
(no explicit representation of sidewalks)

Dynamic Network
Movements
Lanes
Nodes
Undirected links

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:
   - physical roads
   - intersections
   - traffic controls
   - tolls
   - 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

- Any GMNS element can have user defined fields
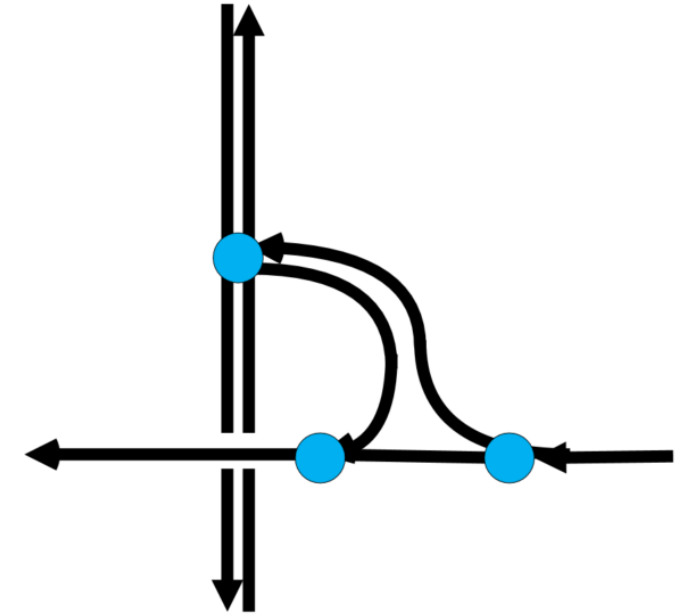
Link— a directed or undirected line object in a network, defined by the nodes it travels from and to.

- 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

- Any GMNS element can have user defined fields

- Links are directed for vehicle travel, undirected for pedestrian travel

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Segments and Lanes

Segment—portion of a link defined by linear references

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

Turn pockets are defined via segments.

Lanes
-1
1
2
3
4 (bike)

Segment 1

Segment 2
left-turn lane

Segment 3
left and right turn lanes

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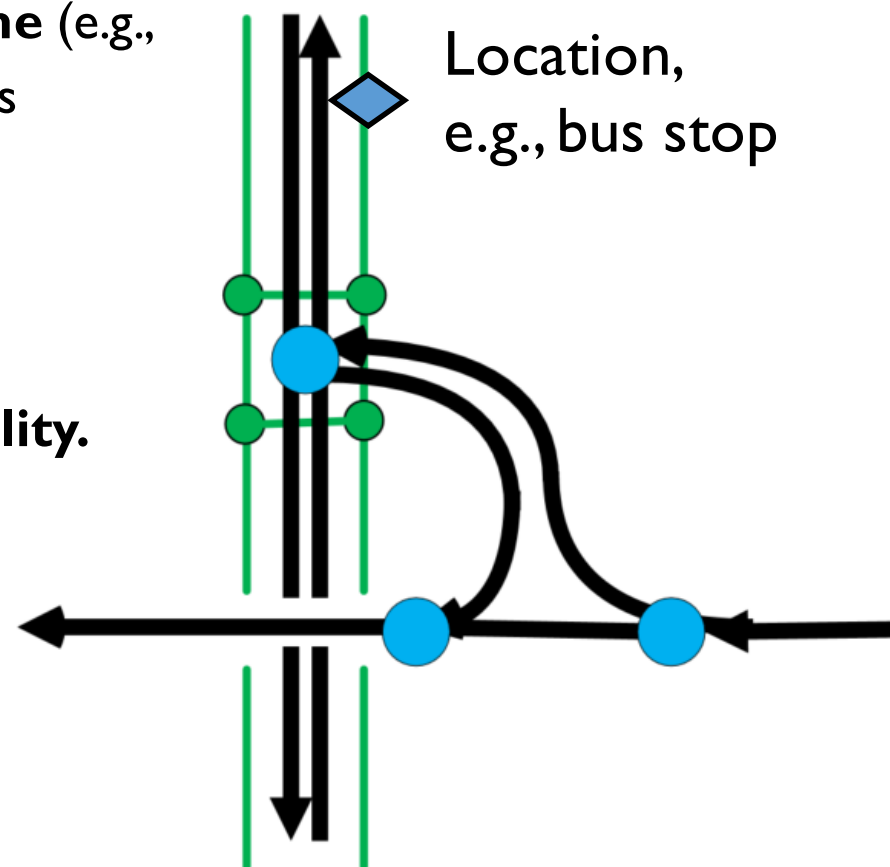
Links include fields for **ped_facility, bike_facility.**

Sidewalks and crosswalks may optionally be handled via their own undirected links. Parent-child relationships:

- Sidewalk with associated road

- Crosswalk and intersection nodes

Separated bike facilities may also be handled as their own pairs of directed links

Parent-child

Location, e.g., bus stop
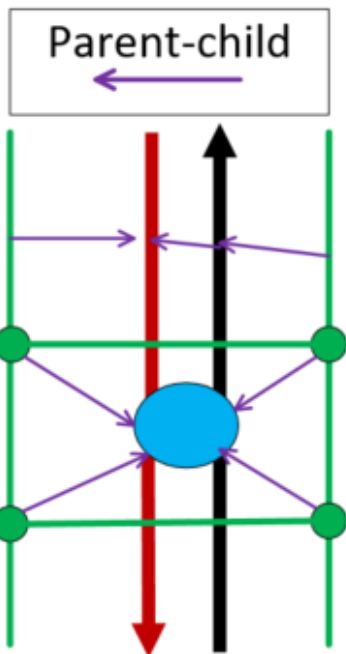
Multimodal example

- Color coding
  - General purpose
  - Auto and bike lane
  - Bike
  - Pedestrian (undirected)

- East-west street with conventional bike lanes

- North-south street with protected two-way sidepath

- Bike and pedestrian paths entering from the north
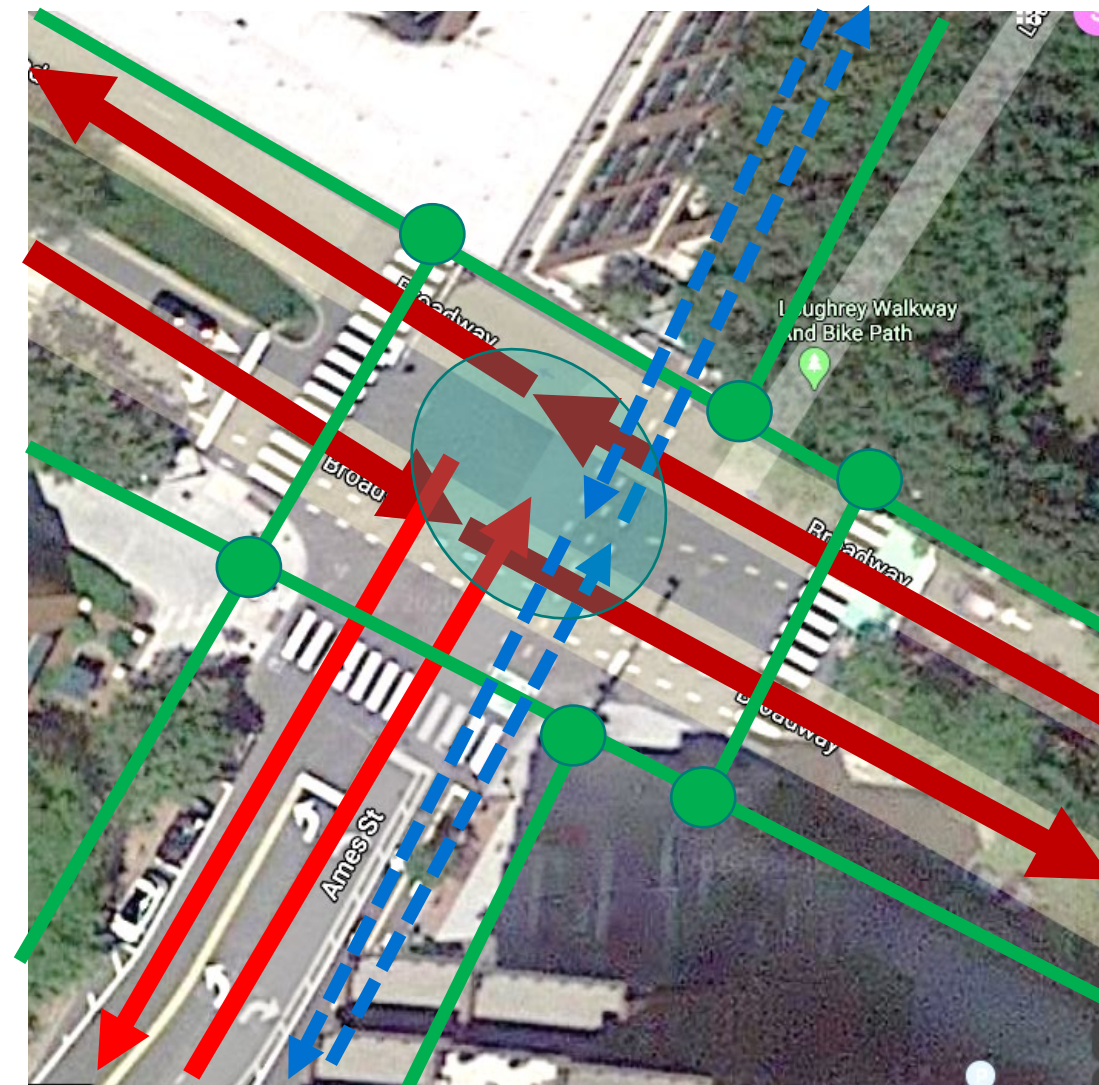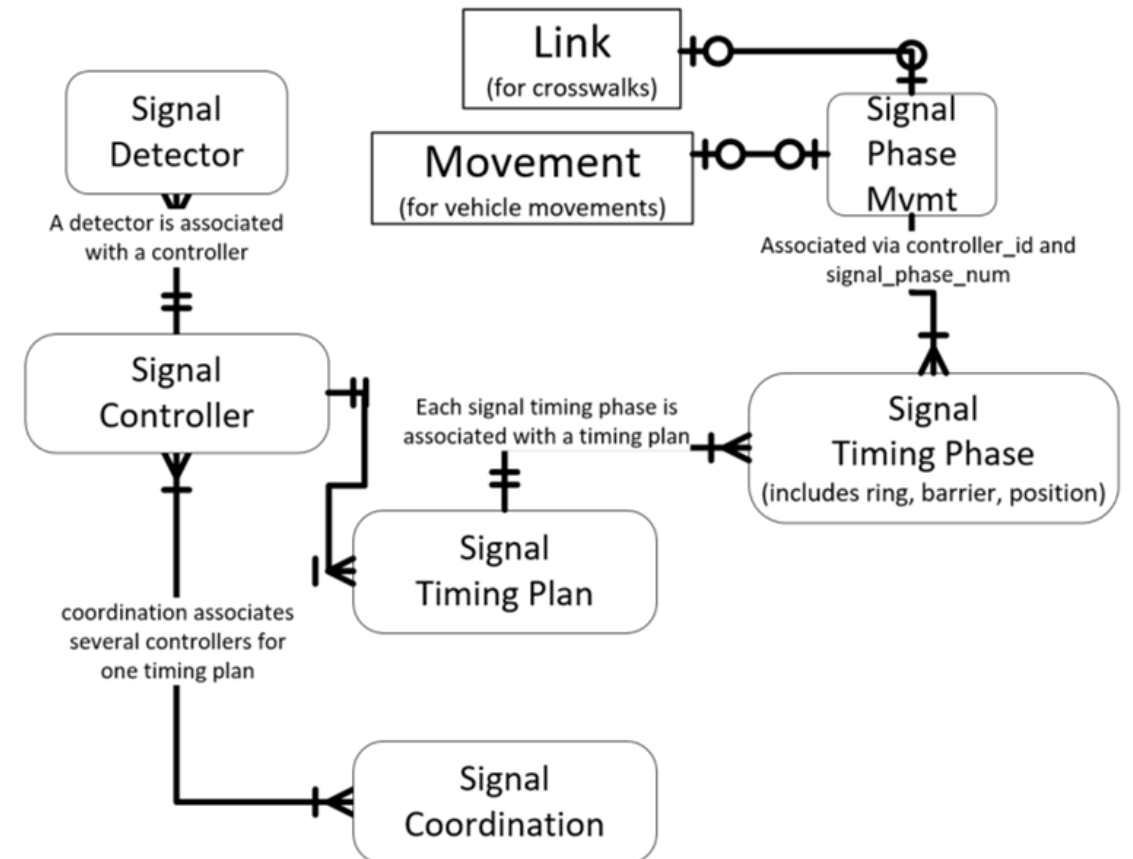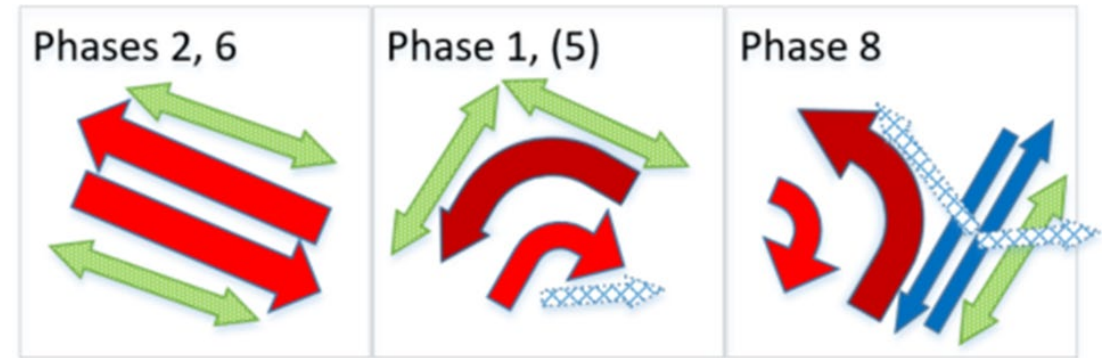
Movements

- Movements define connections and traffic control types (none, yield, stop, signal) between inbound and outbound links or lanes at an intersection.

- Example:
  - Pedestrian movements in green
  - General traffic (red) and bike (blue) movements are shown from the south

Selected Movements from Ames St.

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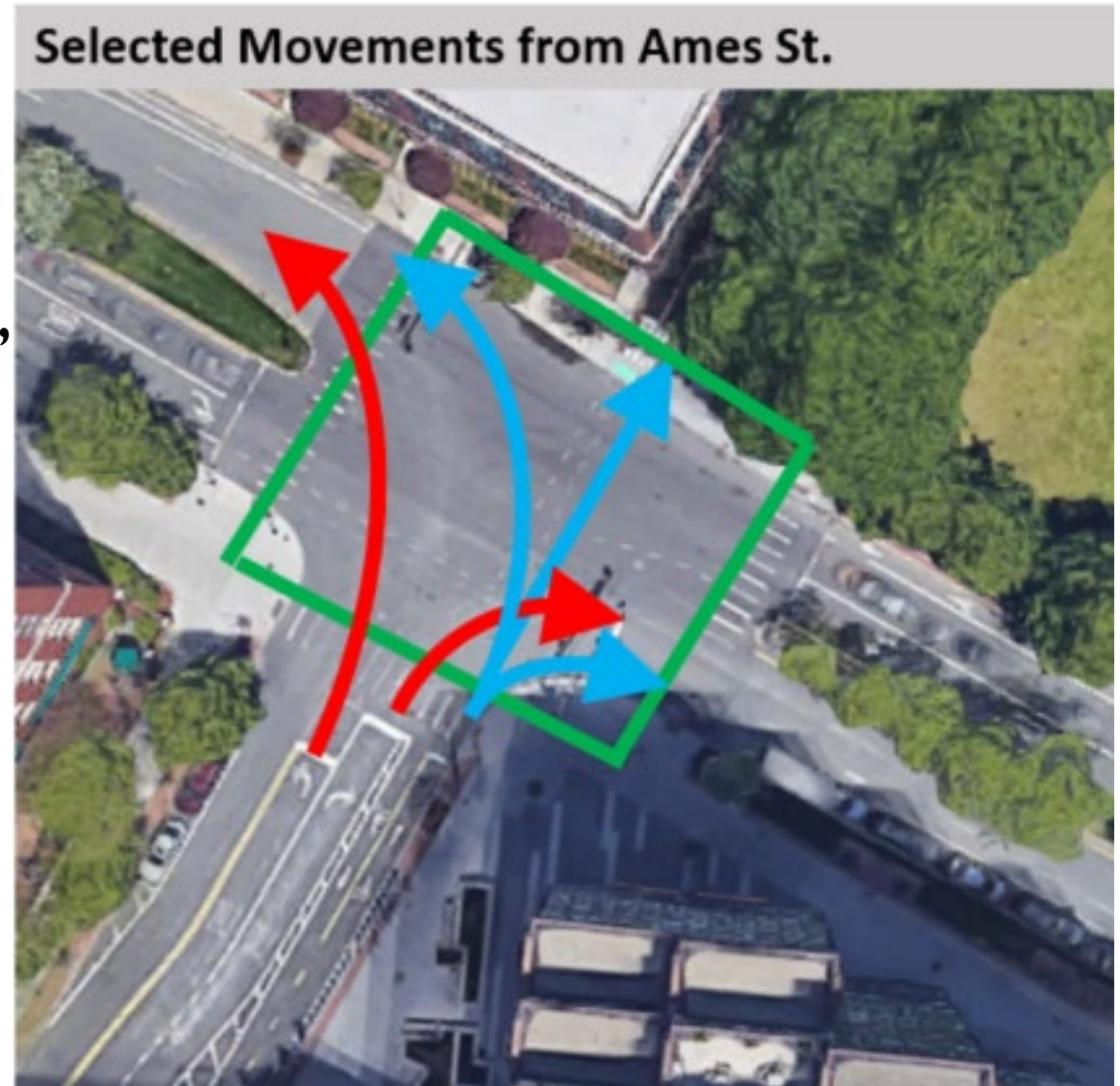
Traffic signals

- **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

Time of day

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

Lane

Link_id	lane_num	allowed_uses
12	1	AUTO
12	2	AUTO, TRUCK, BUS
12	3	AUTO, TRUCK, BUS
12	4	SHOULDER

Lane_TOD

link_id	Lane_num	TOD	allowed_uses
12	4	Wkdy_PM_Peak	AUTO, BUS

Time_Set_Definitions

TOD	M	T	W	Th	Fr	Sa	Su	Hol	Start	End
Wkdy_PM_Peak	1	1	1	1	1	0	0	0	1500	1900

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Work in progress

- Inclusion of lane offsets (important for microsimulation)
- Improved multi-modal examples
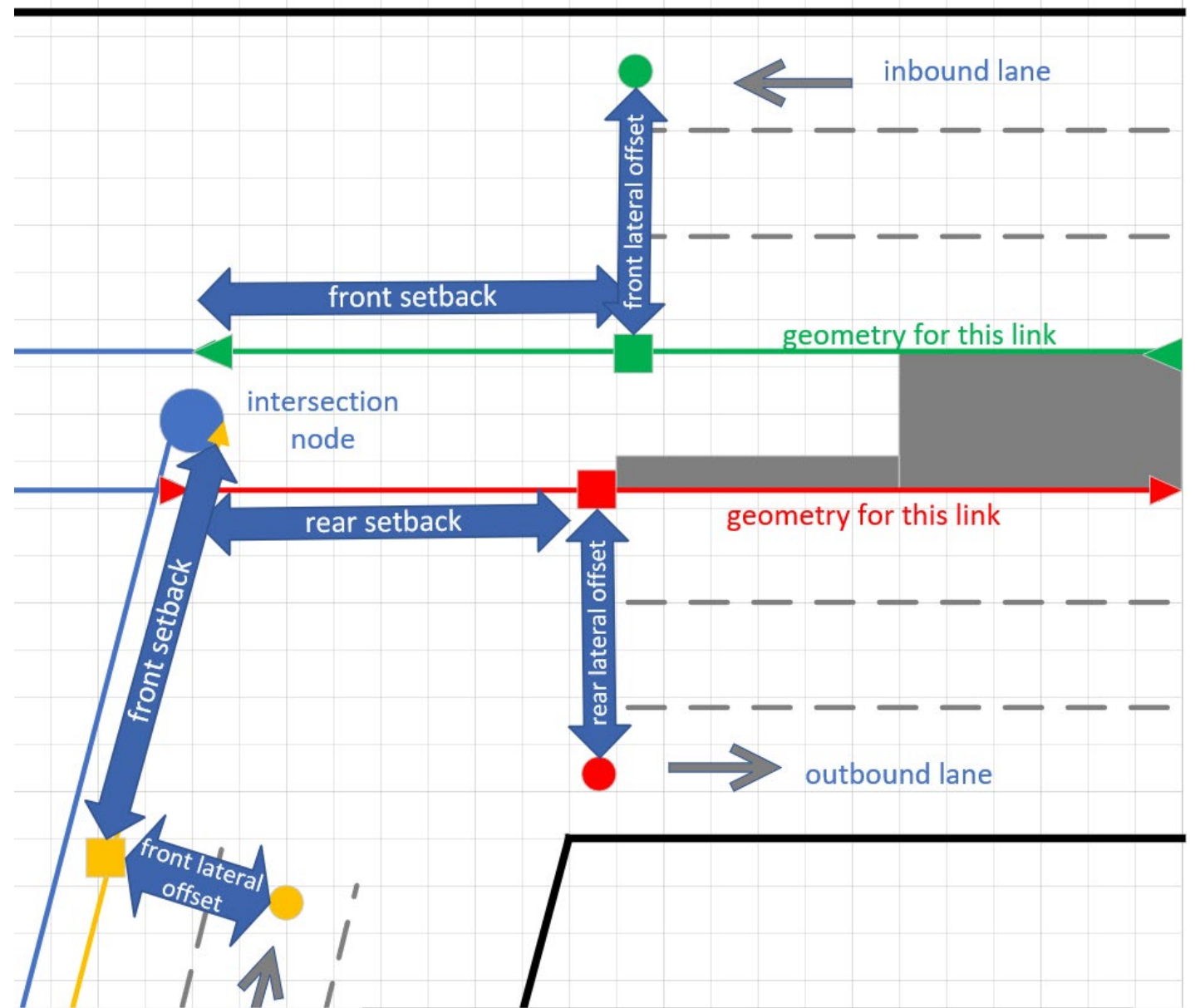
It takes a community…
tools that work with GMNS

We improve the specification by using it

Network synthesis:
> **osm2gmns** for nodes, links, movements
> **signal4gmns** for traffic signals

Multiresolution network expansion:
> **net2cell**

Validation tools:
> **gmnspy** for format validation (does the network conform to the spec?)
> Graph validation (is the network connected?)

Shortest path and routing:
> **path4gmns,** with connection to **DTALite**
> **AequilibraE**

With thanks to Xuesong Zhou, Pedro Camargo, Elizabeth Sall and others

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For more information

The specification (in markdown and json), examples, and validation tools are available on GitHub: https://github.com/zephyr-data-specs/GMNS

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