



How Many Operational Design Domains, Objects and Events?

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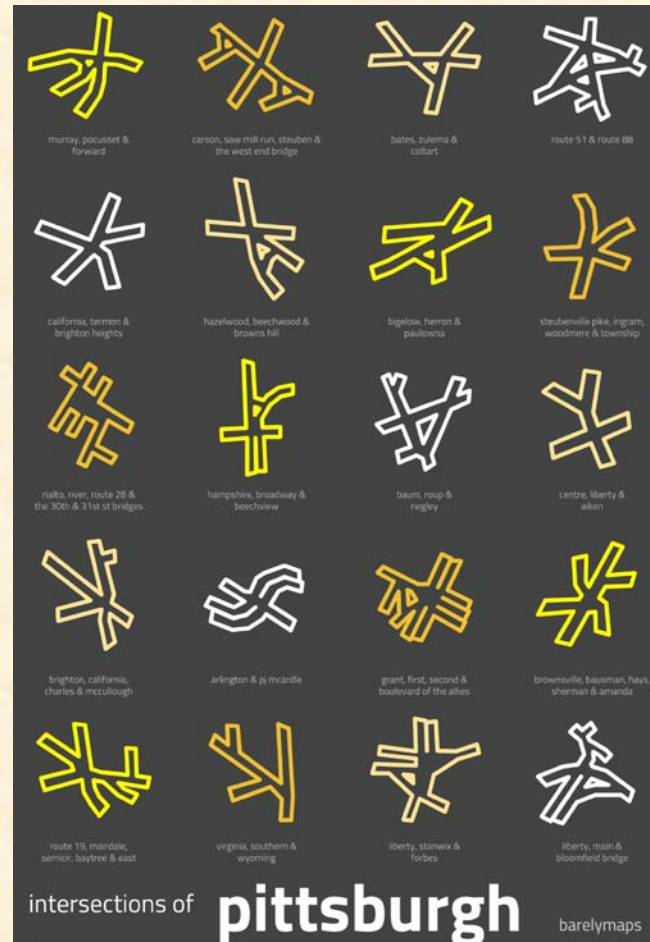
**Edge
Case
Research**

Introduction & Terminology

- **Operational Design Domain (ODD)**
 - Environment in which the vehicle operates
- **Object and Event Detection and Response (OEDR)**
 - Things that happen
 - Obstacles and roadways
- **Maneuvers**
 - Things the vehicle does
 - Turns, enter/exit traffic streams, ...
- **Fault management**
 - How faults are mitigated



Won't Geo-Fencing Solve This?



What Is Following Distance In Snow?

■ Canton Ave., the steepest street in the world*

- Half concrete, half cobblestone
- Cars slide backwards down hill in snow



(*) Guinness Book lists Baldwin Street in New Zealand as steepest, with 35% grade, but Canton Ave has 37% grade for 6.5m

[https://en.wikipedia.org/wiki/Canton_Avenue]

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Have You Trained on All Street Signs?

- **STOP: Except Right Turn.** Wait... where's the turn?



Why Did the Pedestrian Not Cross the Street?

■ Classification:

- Is this a person?
- Is King Friday a baby?

■ Behavior prediction:

- Is it about to cross the street?

■ Fredosaurus Rex Friday XIII

- Mr. Rogers fans entry for Pittsburgh Dinosaur Parade



Events: The Pittsburgh Left

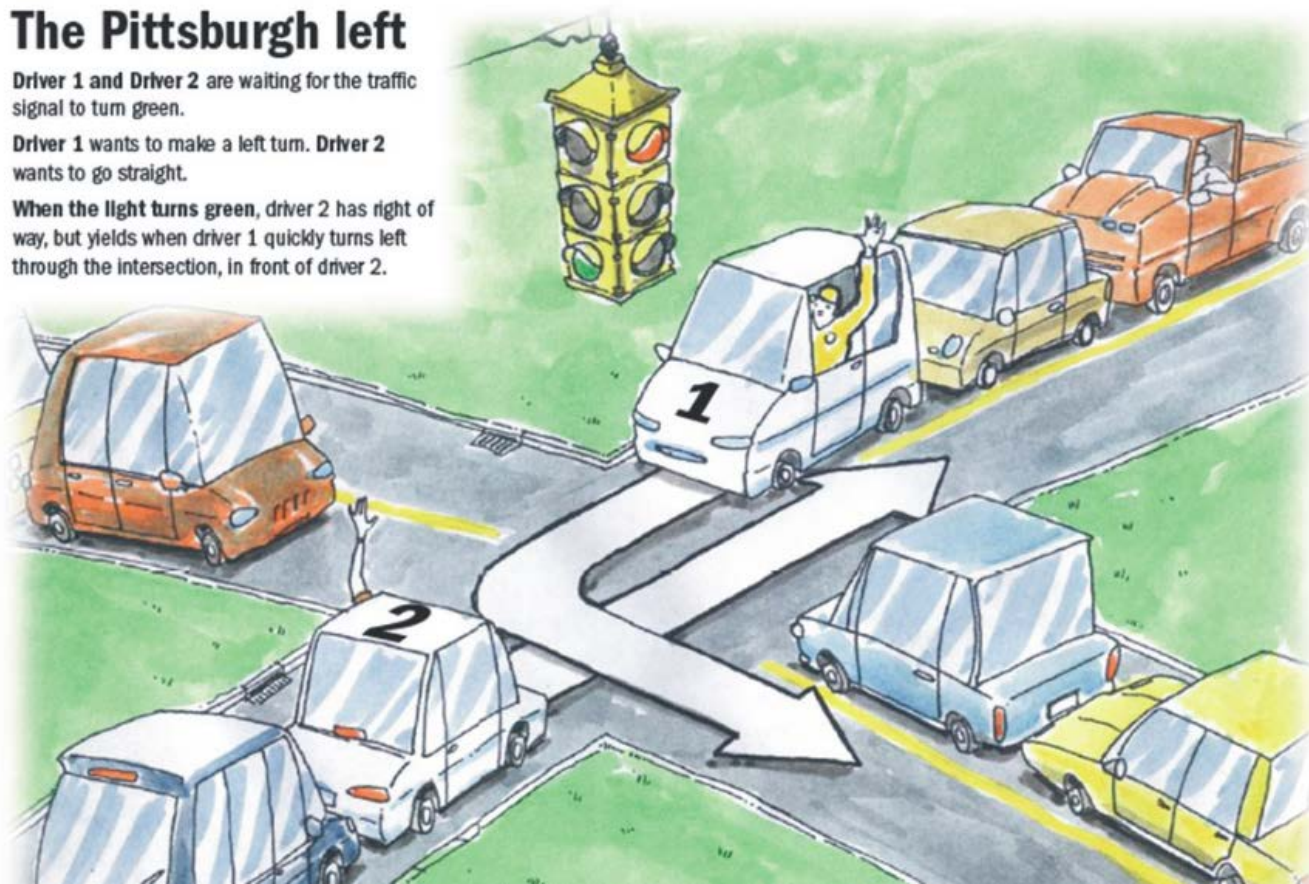
What jagoff was the first person to call it "A Pittsburgh Left?"

The Pittsburgh left

Driver 1 and Driver 2 are waiting for the traffic signal to turn green.

Driver 1 wants to make a left turn. Driver 2 wants to go straight.

When the light turns green, driver 2 has right of way, but yields when driver 1 quickly turns left through the intersection, in front of driver 2.



Have To Handle Cross-Product Of:

■ ODD

- Terrain, weather, nav aids, road rules, ...

■ OEDR

- People, vehicles, distractors (metal bridge joints), spills, balloons, ...
- Weird behaviors, crashes, wildlife, ...

■ Manuevers

- Mode transitions, unusual traffic flow, ...

■ Fault management

- Vehicle equipment faults, infrastructure faults, ...
- Violations of ODD/OEDR/maneuver assumptions, ...



Cross left through
55 mph traffic for tunnel.
(Steep hill; no merge lane)
But first, stop.

[Google Street View]

Can We Really Tackle the Complexity?

- **Need to consider (ODD × OEDR × Manuevers × Faults)**
- **Limit the cross-product space**
 - Geofencing is only a coarse start!
- **Deal with deviation from defined cross product**
 - Safe when environment forces you out of your design space
 - Design system to be robust when things go sideways
- **Build a system that knows when it is surprised**
 - Have to deal with “unknown unknowns”