Lane Boundary Guidance System for Snowplows

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DEPARTMENT OF TRANSPORTATION

Challenge and Response

- Safely operating a snowplow in near whiteout conditions.
  - Assist first responders in an emergency
  - Maintain mobility for commerce
  - …Or just a day ending in Y in wind country
- Snowplow Driver Assist System
  - Support snowplow operators in poor visibility conditions
  - Lane guidance with forward obstacle detection
    - (rear facing also has been studied)

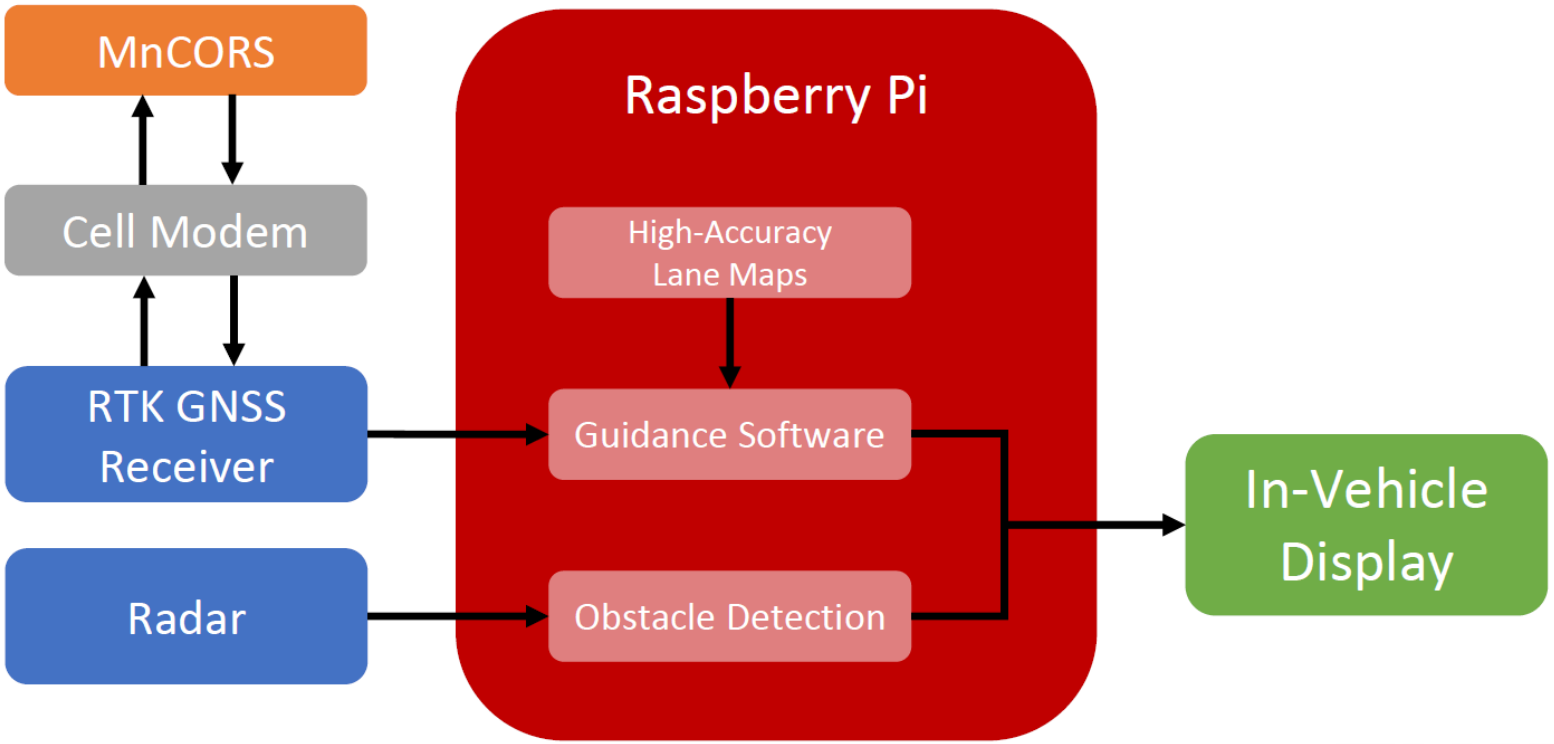
System overview

- System designed to reduce cost
  - Uses off the shelf hardware
  - Approximately $13K system hardware cost per vehicle

System overview

- Simple and understandable system interface
  - Human focused design process
  - Operator feedback through extensive user testing

System Diagram

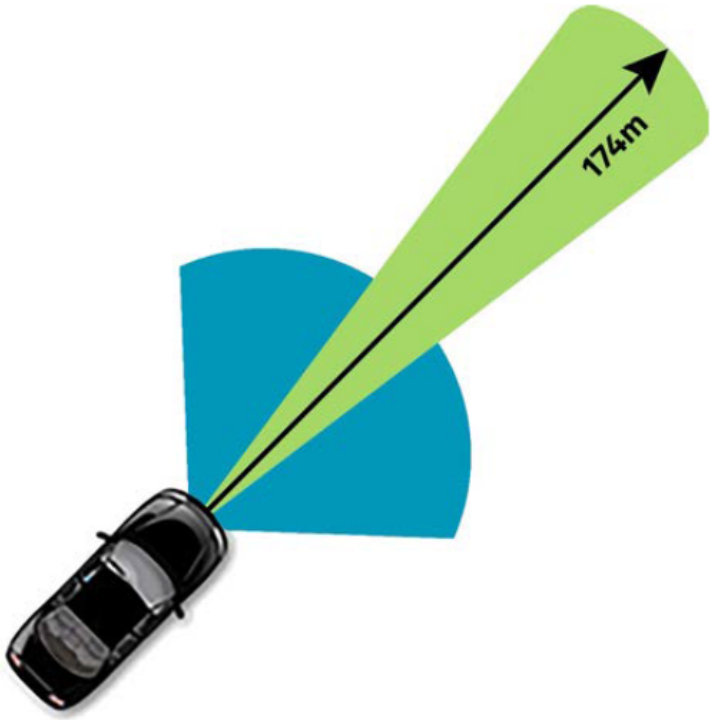


Lane Guidance

- Provide lane position information to driver
- Swift Duro Inertial RTK GNSS receiver
  - Lower cost than previously used Trimble hardware
  - Accurate to ~1-3cm
  - Compare vehicle position to map data
- High-accuracy digital maps
  - Routes mapped in summer (good weather)
  - Capture lane centerlines with ~10cm accuracy

Forward Obstacle Detection

- Warn driver of forward obstacles
- Delphi ESR 2.5 Radar
  - Long range (174m range, 20° FOV)
  - Mid range (60m range, 90° FOV)
- Software processing
  - Target position (left, center, right)
  - Target filtering



Mapping

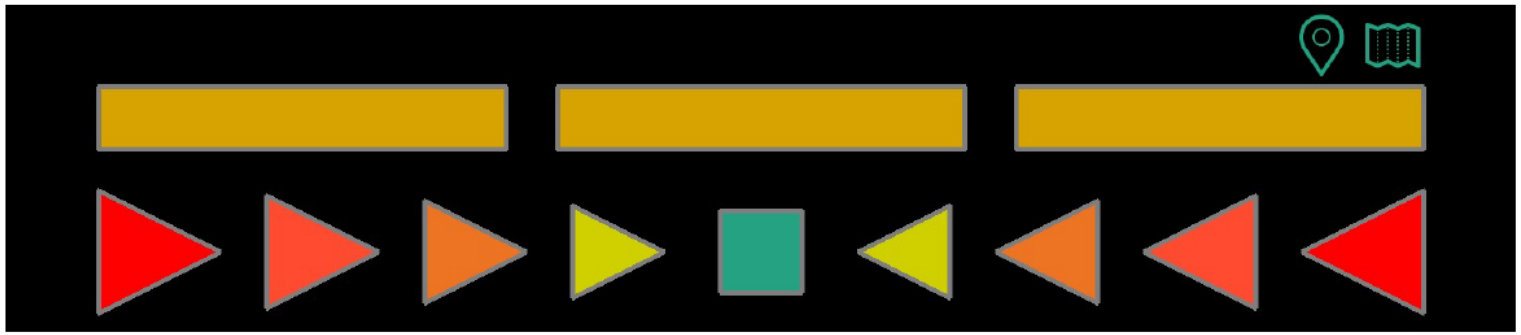
- Digitized routes to support system deployment
  - 100 route-miles for Winter 2020-2021
  - 200 route-miles added for Winter 2021-2022
- Captured lane centerlines
- Accurate to 10cm level
- Excluded protected turn and bypass lanes
  - Information not provided to driver or used by system
  - Resource intensive to generate

Locations

District	Truck Station	Route Name	Start	End	Length
1	McGregor	MN 210	US 169	MN 73 – Cromwell	36
2	Ada	MN 200	US 75 – Hendrum	MN 9 – Ada	14
		US 75	CR 39 – Perley	CR 3 – Shelly	19
3	Paynesville	MN 55	W Stearns Co Line – Brooten	MN 23 – Paynesville	22
4	Morris	MN 28	MN 7 – Beardsley	MN 9 – Morris	39
Metro	Shakopee	MN 25	Green Isle	Belle Plaine	11
		MN 13	MN 19	MN 282	10
		MN 21	MN 19 – New Prague	Meadow Wood Ct. – Jordan	8
6	Dodge Center	MN 56	US 14 – Dodge Center	MN 60 – Kenyon	17
7	Sleepy Eye	US 14	US 71 – Sanborn	MN 4 – Sleepy Eye	22
		MN 4	MN 30	US 14 – Sleepy Eye	21
		MN 4	US 14 – Sleepy Eye	MN 19 – Fairfax	16
		MN 68	MN 67 – Morgan	MN 4	12
8	Willmar	US 71	MN 7 – Blomkest	MN 23 – Wilmar	10
		MN 7	MN 23 – Clara City	US 71 – Blomkest	17
Dakota County	Hastings	CR 42	MN 55	US 61 – Hastings	9
		CR 54	CR 68	CR 91	8
		CR 62	CR 89	MN 316	9
		CR 91	US 61 – Meisville	CR 54	5

Redesigned Driver Display

- LCD screen mounted on dashboard and speaker behind driver
- Lane Guidance
  - Lateral deviation from lane centerline in 1ft increments
  - Approximates left edge of plow blade relative to road centerline
- Forward Obstacle Detection
  - Presence of obstacle ahead of plow with a time-to-collision under 5s
  - Indicates location of hazard – left, right, or directly in front of vehicle
- Status Indicators – GNSS coverage, map coverage

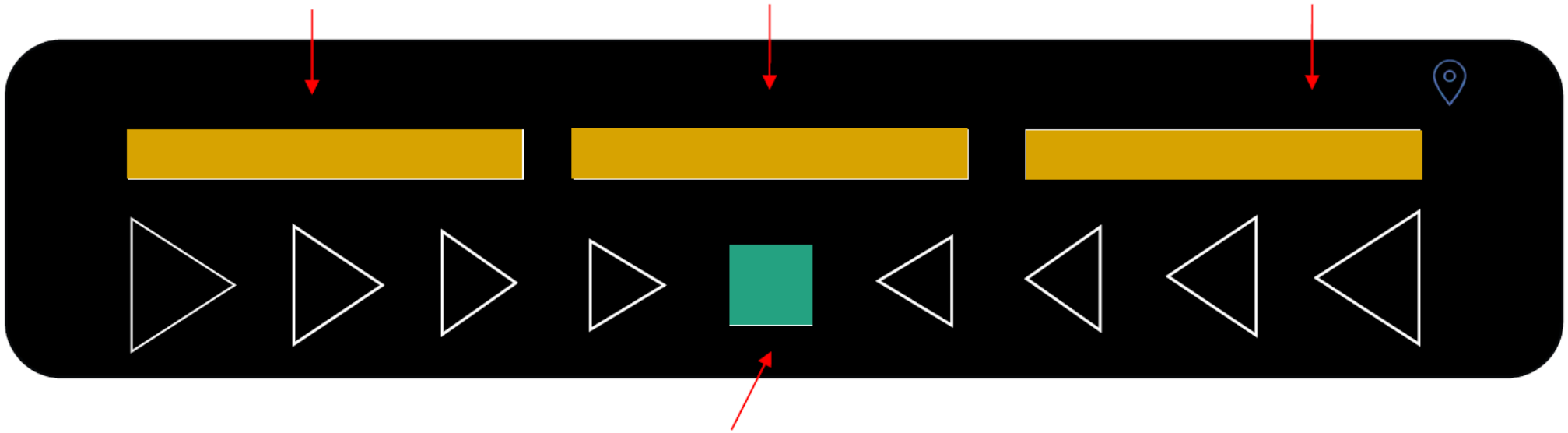


Redesigned Driver Display

A **left hazard bar** indicates a *hazard to the left of the left plow edge*

A **center hazard bar** indicates a *hazard is directly in front of the plow*

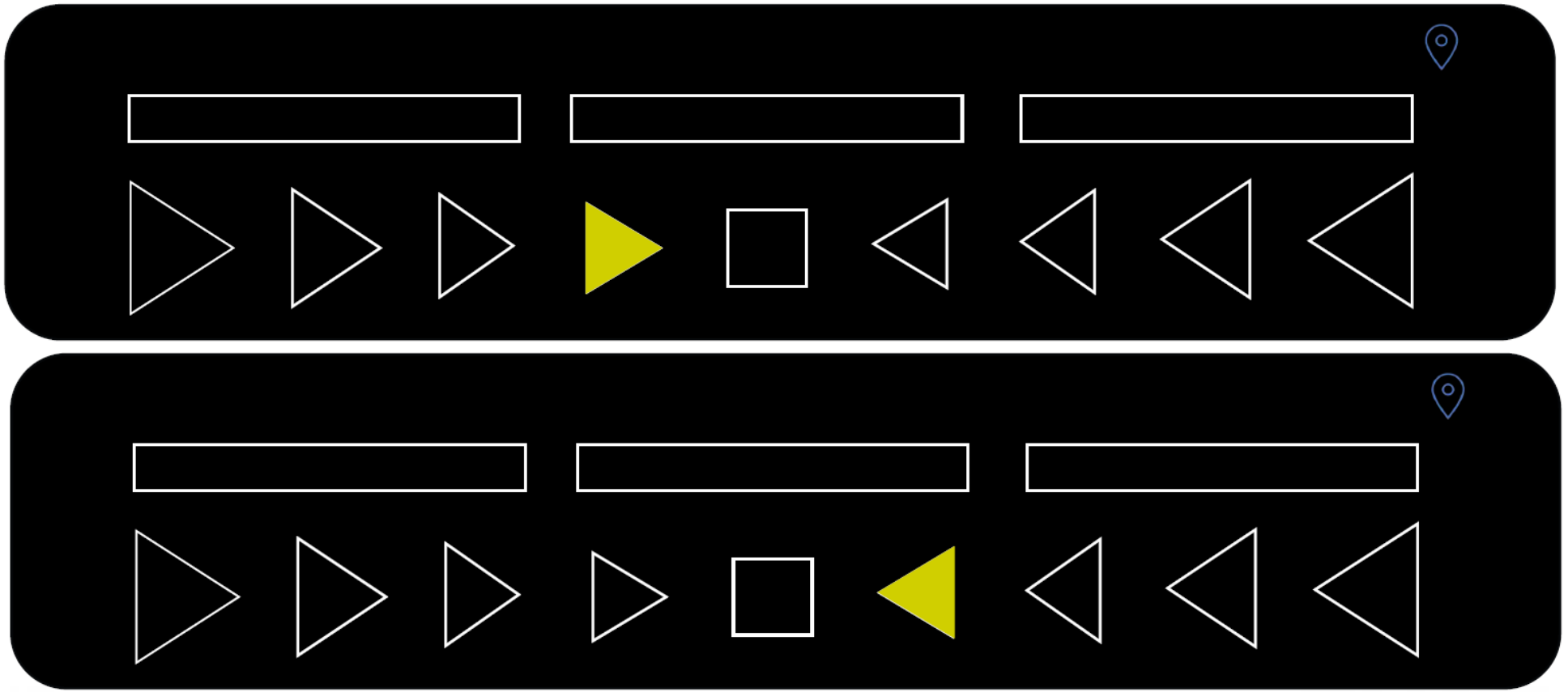
A **right hazard bar** indicates a *hazard to the right of the right plow edge (over wing)*



A **green square** indicates the vehicle is centered within the lane

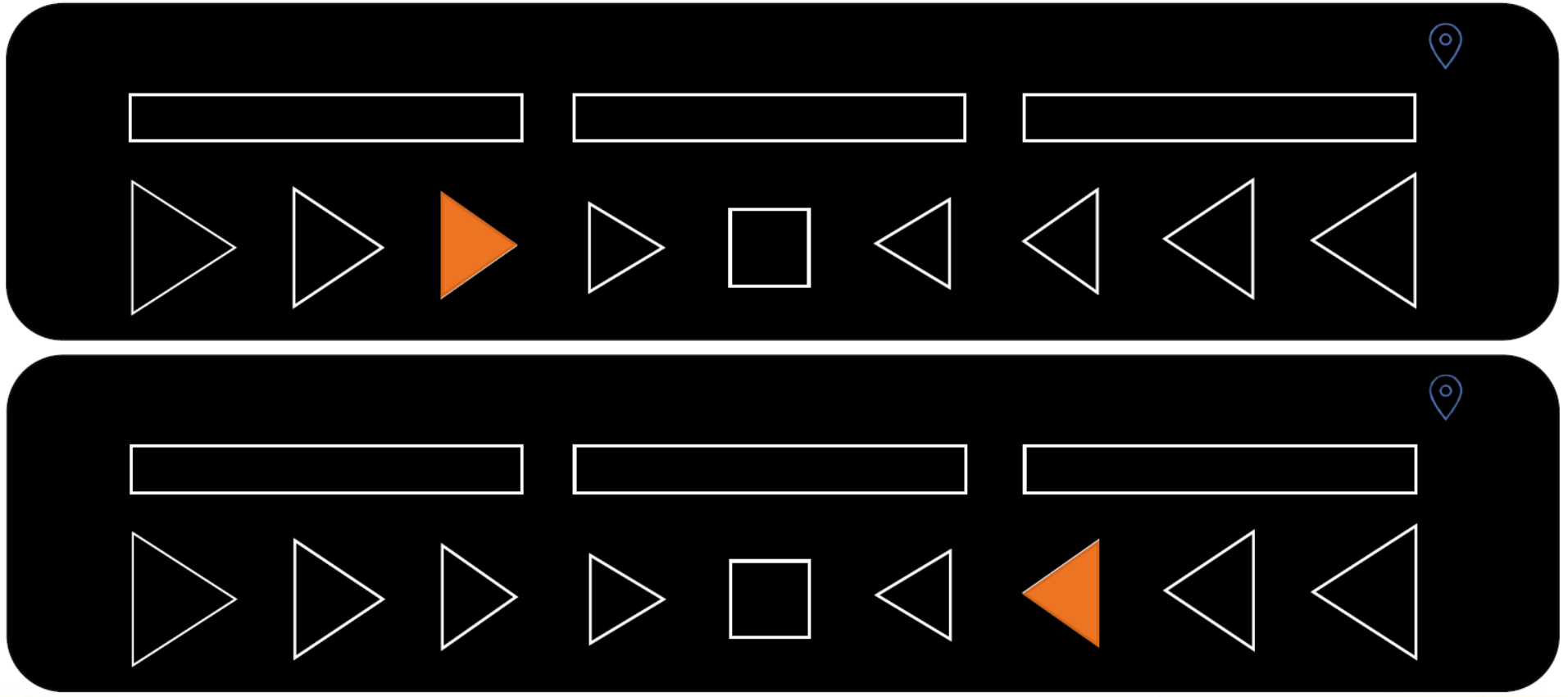
Redesigned Driver Display

A **yellow triangle** indicates *1 ft* deviation to the *left or right*



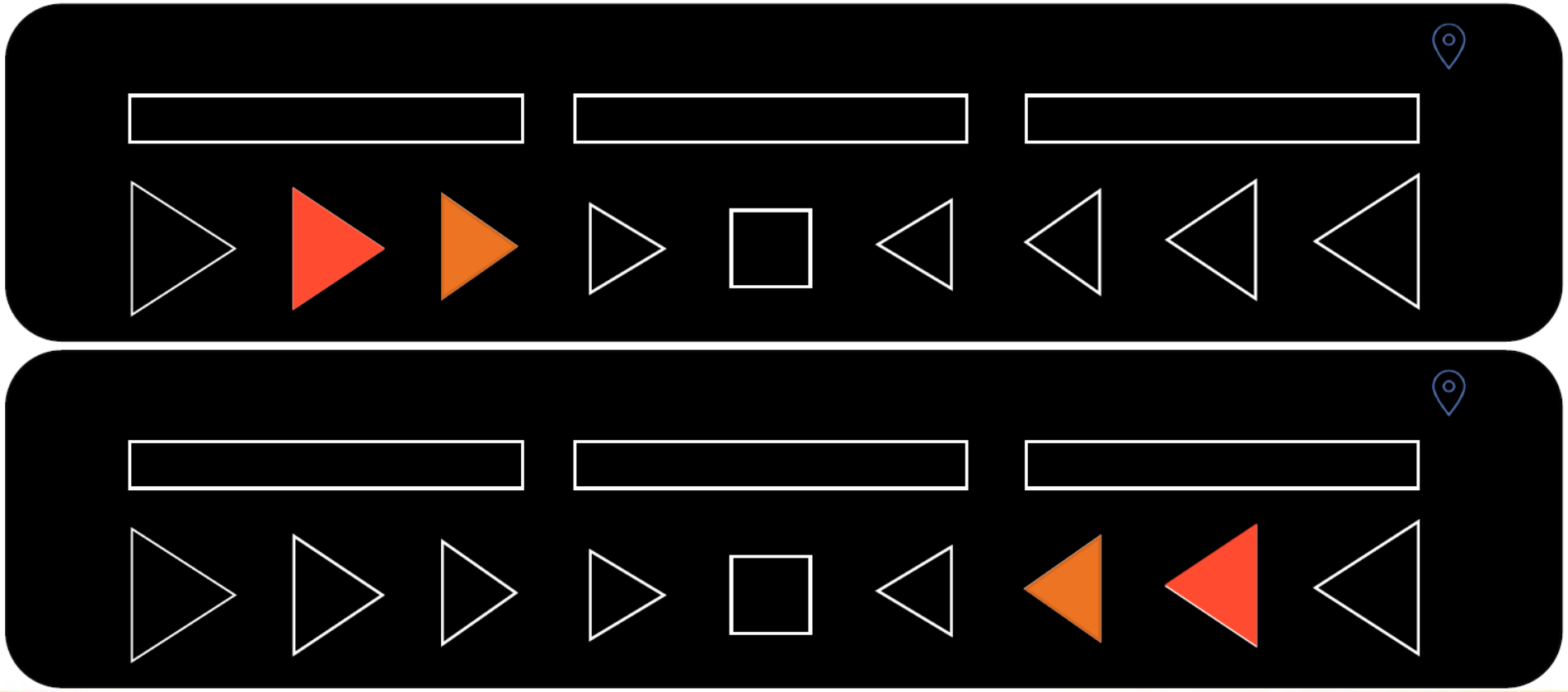
Redesigned Driver Display

An **orange triangle** indicates *2 ft* deviation to the *left or right*



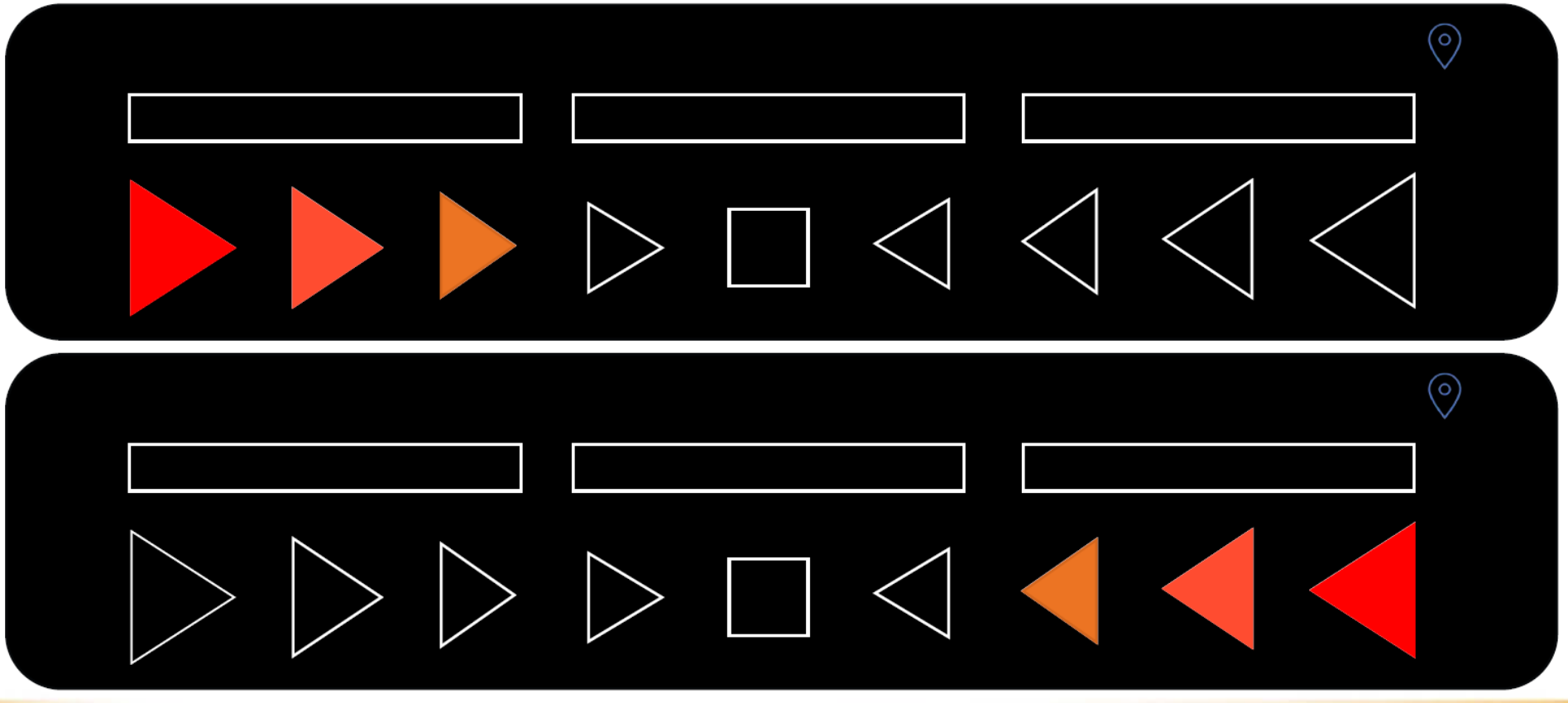
Redesigned Driver Display

The **orange and red-orange triangles** together indicate a *3 ft* deviation to the *left or right*



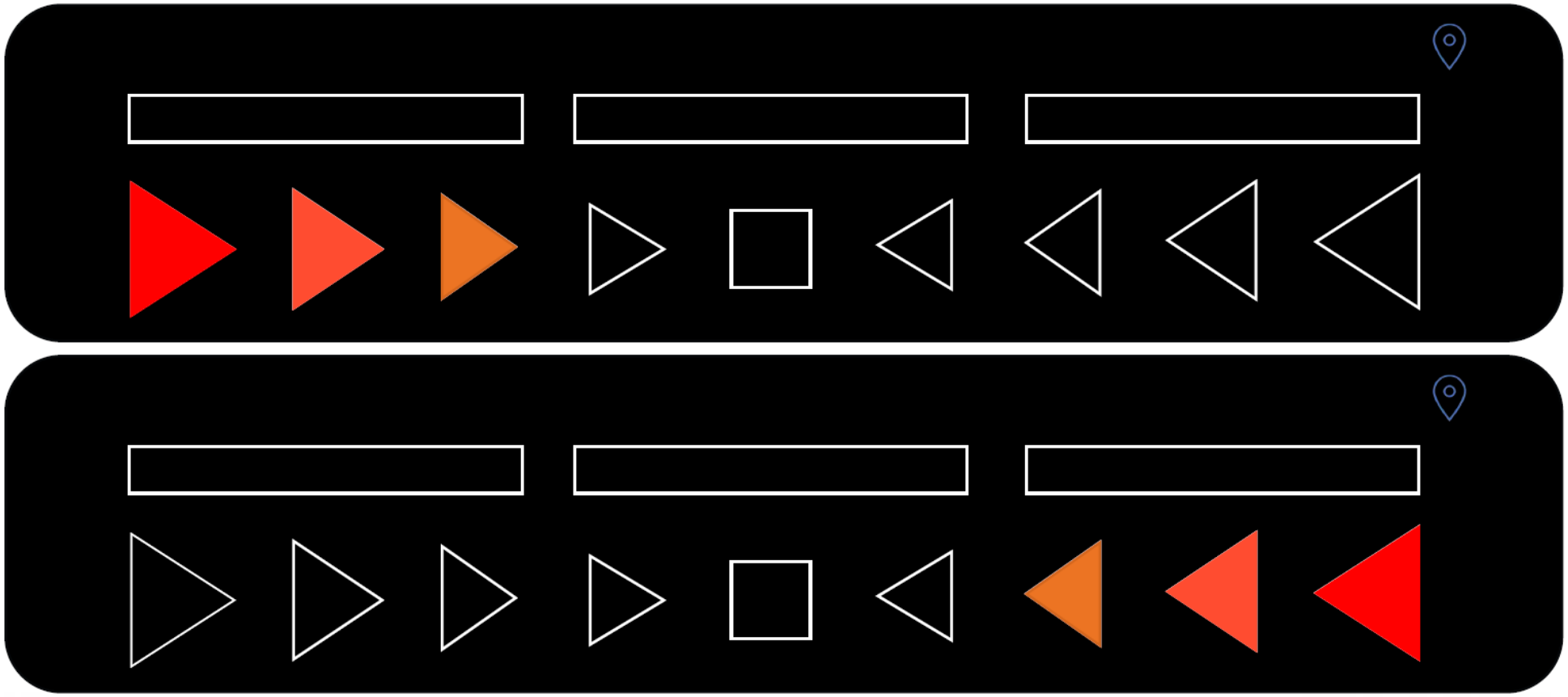
Redesigned Driver Display

The **orange, red-orange, and red triangles** together indicate a *4 ft* deviation to the *left or right*



Redesigned Driver Display

The **orange, red-orange, and red triangles** flash when the deviation has *exceeded 4 ft* from the centerline *to the left or right*



Ongoing actions

- Continue to test and evaluate system
  - Evaluation in all 8 MnDOT Districts and one county
  - Response to modified display
  - Measure driver performance with system on and off
- Software and radar Improvements
- Simplifying mapping process
- Explorer pathways from research to commercial implementation

Thanks to the project teams

- MnDOT
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Thank you!

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