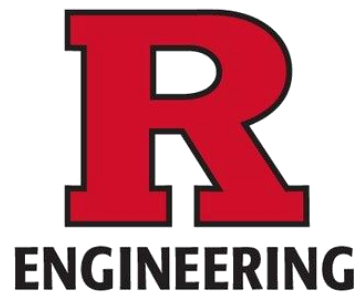


# RUTGERS


Center for Advanced Infrastructure  
and Transportation



## NJDOT 26<sup>th</sup> Annual Research Showcase

### Oral Presentation

2024-10-23



# Towards UAS-based Real-time Video Streaming and Data Analytics for Estimating Highway Traffic Flow Characteristics

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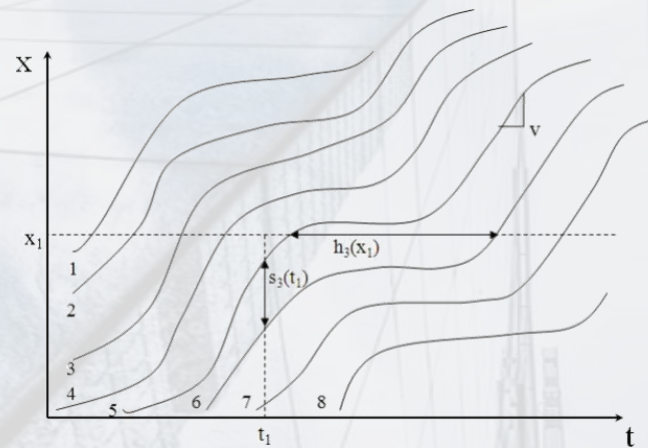
Intelligent Transportation Systems Resource Center  
New Jersey Institute of Technology



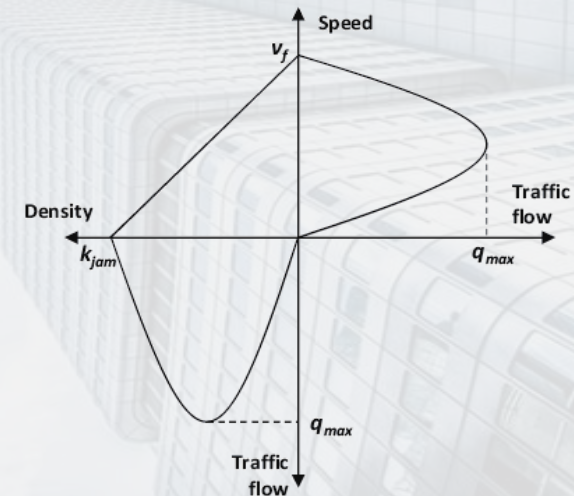


Remote monitoring of traffic flow

Traffic flow characteristics:  
fundamental diagrams

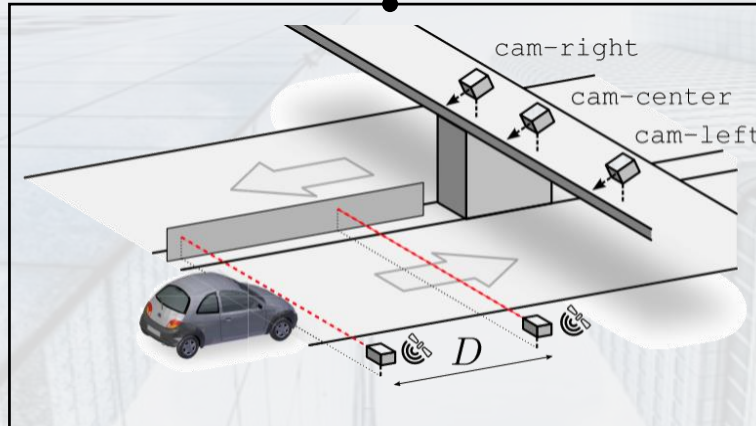


Space-time diagram



Speed-flow-density diagram





**High** meter-to-pixel ratio

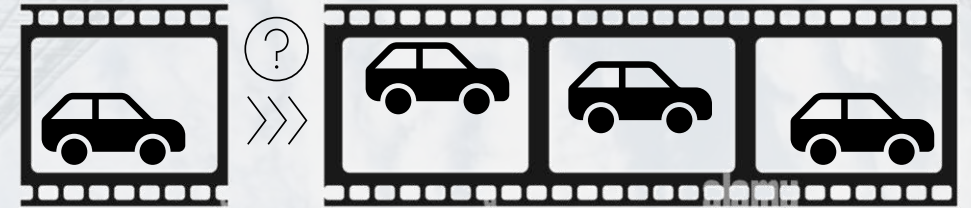
**Medium** meter-to-pixel ratio

**Low** meter-to-pixel ratio

*Systems are primarily categorized based on data collection scenarios*

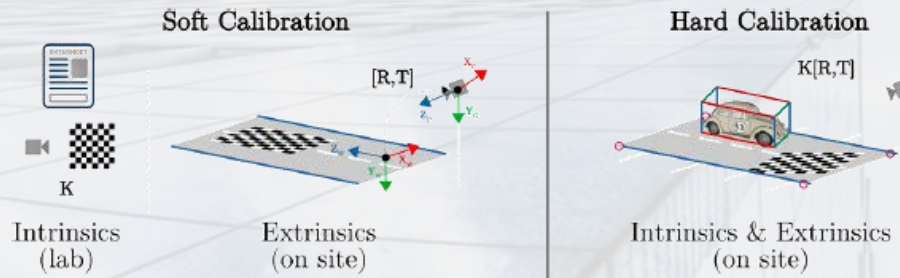


**Hardware:**  
Limited live  
streaming

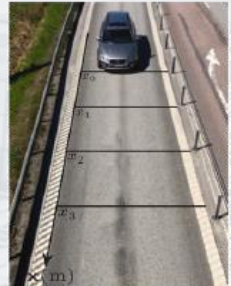
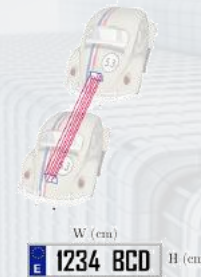


Impossible speed estimation

**Software:**  
Lacking  
Feasibility &  
validation

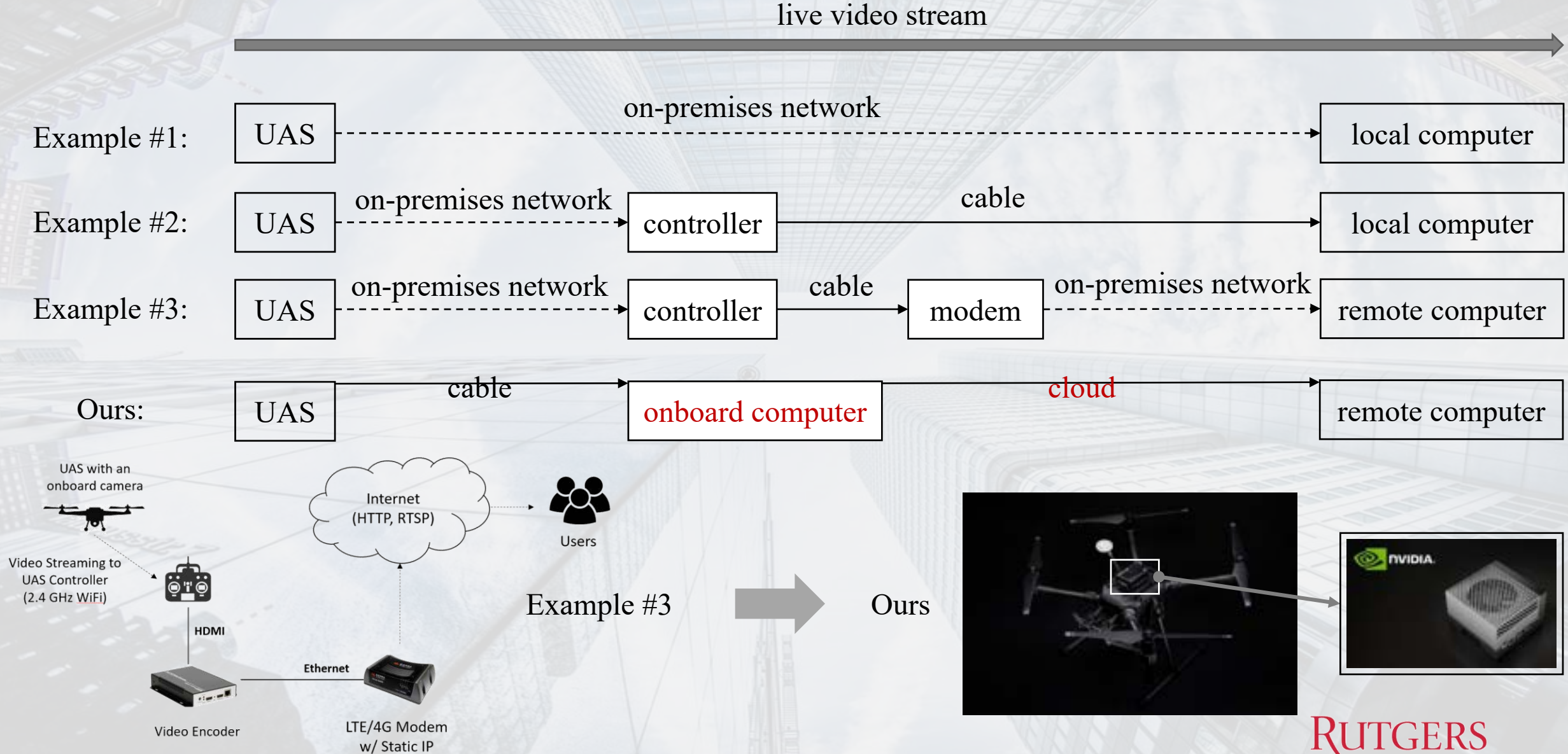


Calibration-dependent: not feasible

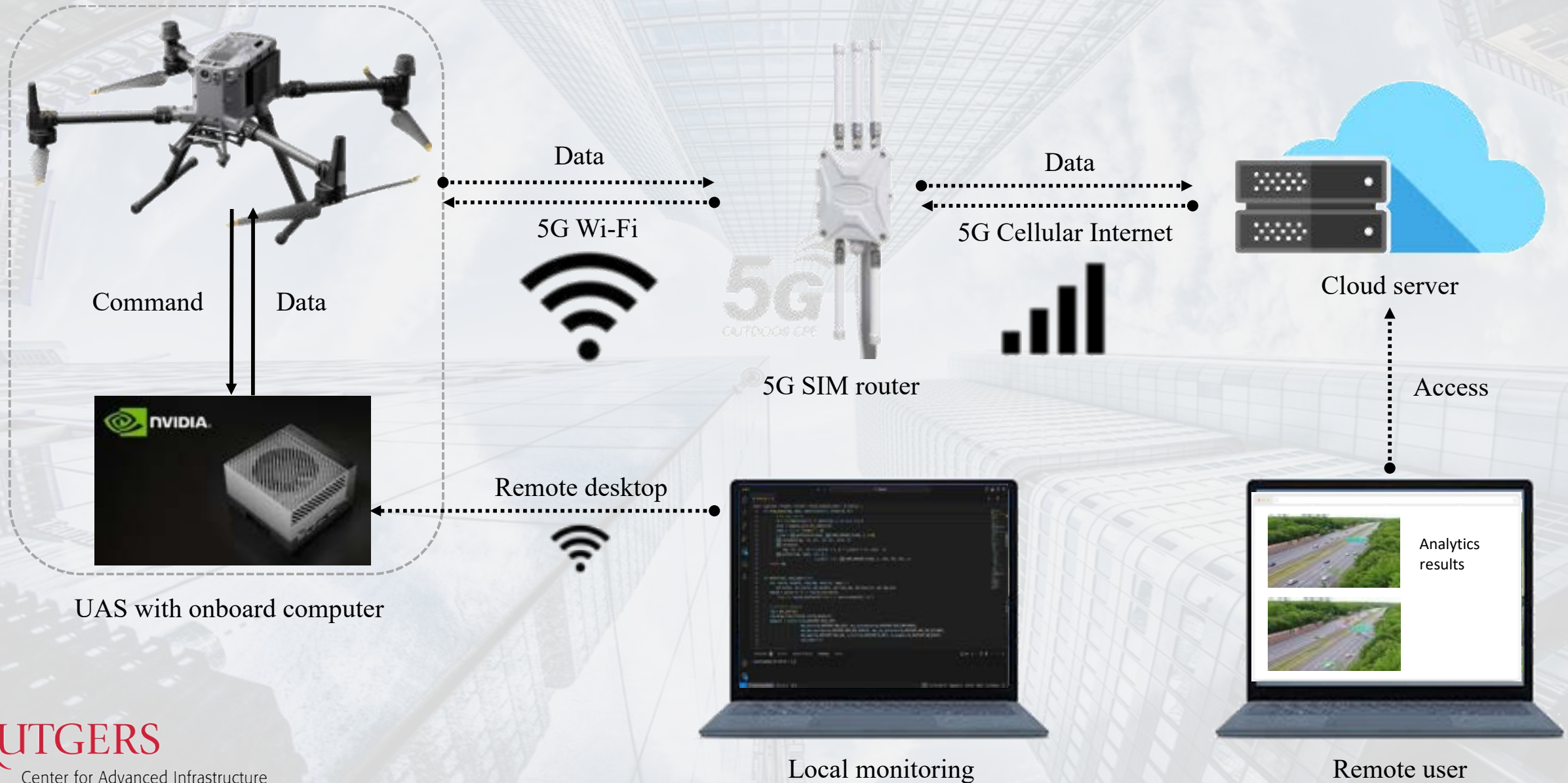


Reference-dependent: less validated











## Data Retrieve

- Via DJI's SDK

## Vehicle Localization

- Dataset preparation
- Vehicle detection (YOLO)
- Vehicle tracking (DeepSORT)

## Speed Estimation

- Lane markup detection
- Image rectification
- Speed estimation by scaling





## Similarly distributed training dataset

Training dataset should look similar to testing dataset

Typical training  
dataset  
(VisDrone)



Testing Dataset



Similarly distributed  
dataset (VAID)



| Dataset Name               | VAID   | CARPK        | Kaggle Ariel Car                                    | VisDrone  |
|----------------------------|--|--------------|---|---|
| Number of Images           | 5994   | 1448         | 154   | 6,471   |
| Number of object instances | ?  | 89,777       | ?   | ?   |
| Image Resolution           | 1137 x 640   | 1280 x 720   | 1920 x 1080   | 960x540   |
| Number of Classes          | 7  | 1            | 4   | 11  |
| Annotation Format          | Bounding box corner coordinates (x1, x2, y1, y2)       | Bounding box | YOLO (x, y, w, h)                                   | YOLO (x, y, w, h)                                 |
| Tracking support           | Yes (images sourced from <b>multiple</b> drone videos) | No           | Yes (images sourced from <b>single</b> drone video) | Maybe (images sourced from too many drone videos) |



Two classes:  
Car & Truck

| Class | # Image | # Instance | mAP50 | mAP50-95 | Precision | Recall |
|-------|---------|------------|-------|----------|-----------|--------|
| All   | 12      | 166        | 0.831 | 0.528    | 0.827     | 0.735  |
| car   | 12      | 133        | 0.934 | 0.572    | 0.748     | 0.955  |
| truck | 12      | 33         | 0.728 | 0.485    | 0.907     | 0.515  |



One class:  
Vehicle

| Class   | # Image | # Instance | mAP50 | mAP50-95 | Precision | Recall |
|---------|---------|------------|-------|----------|-----------|--------|
| vehicle | 12      | 166        | 0.976 | 0.654    | 0.942     | 0.972  |

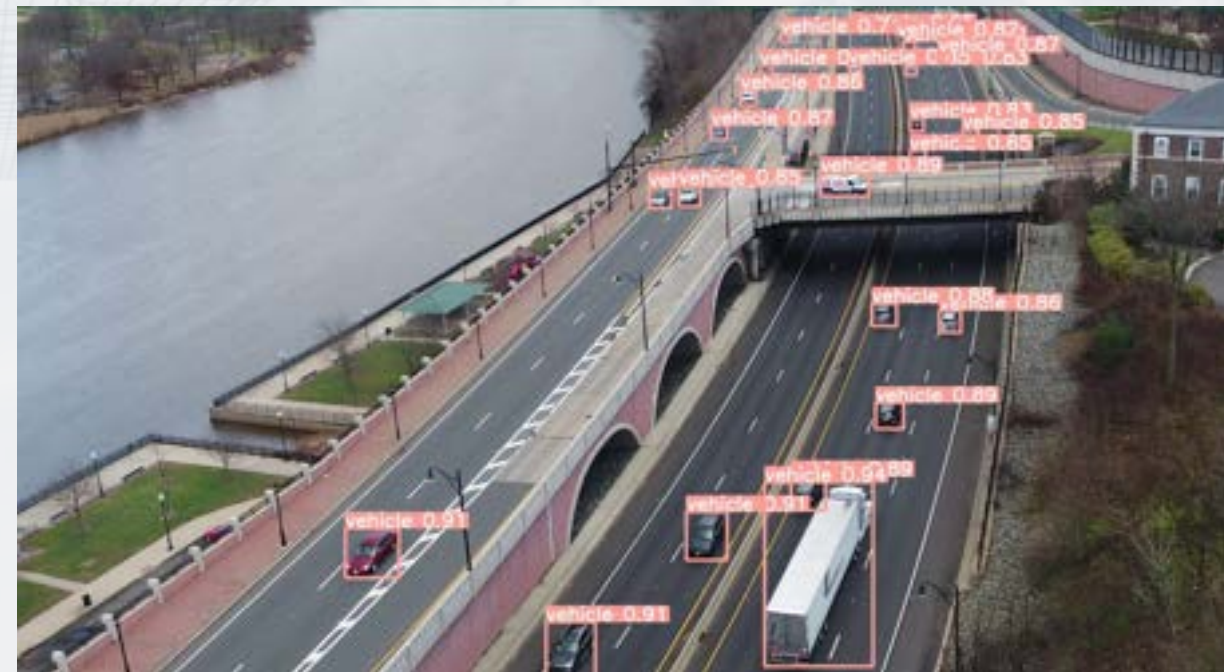
*Object detection model like YOLO requires 1.5K images for each class;  
an imbalanced dataset usually suffers from limited performance*



Previous Model



Current Model



*Truck can be better detected (bottom right)*



Previous Model



Current Model



*Reduced false positives (bottom left)*

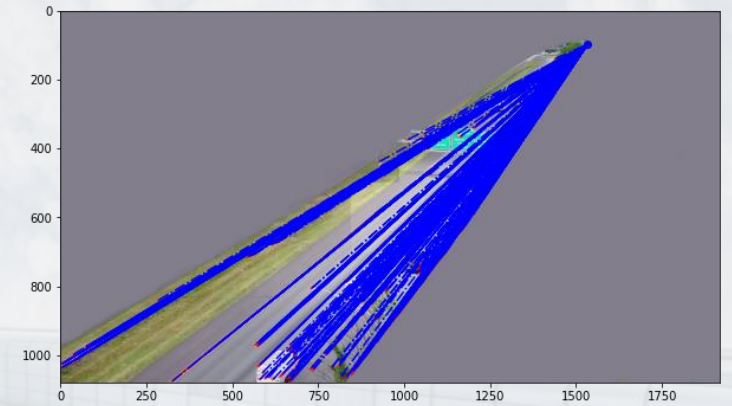




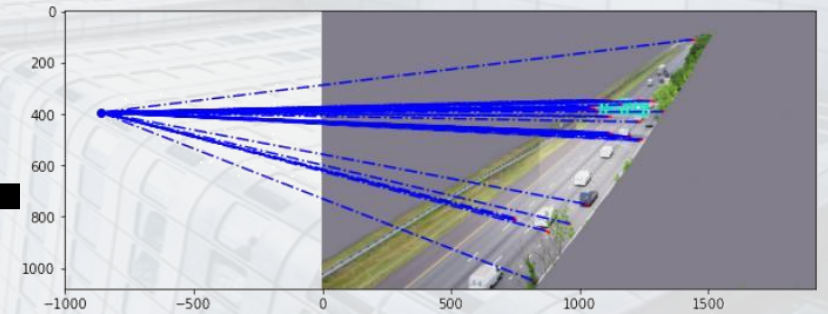
**Preprocessed Image**



**Find Vanishing Points**



**Rectified Image**








$$speed = \frac{\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} * markup \text{ real length}}{markup \text{ pixel length} * fps}$$




Web Application Interface showing Drone Perceived Vehicles and Original Video.

Drone Perceived Vehicles

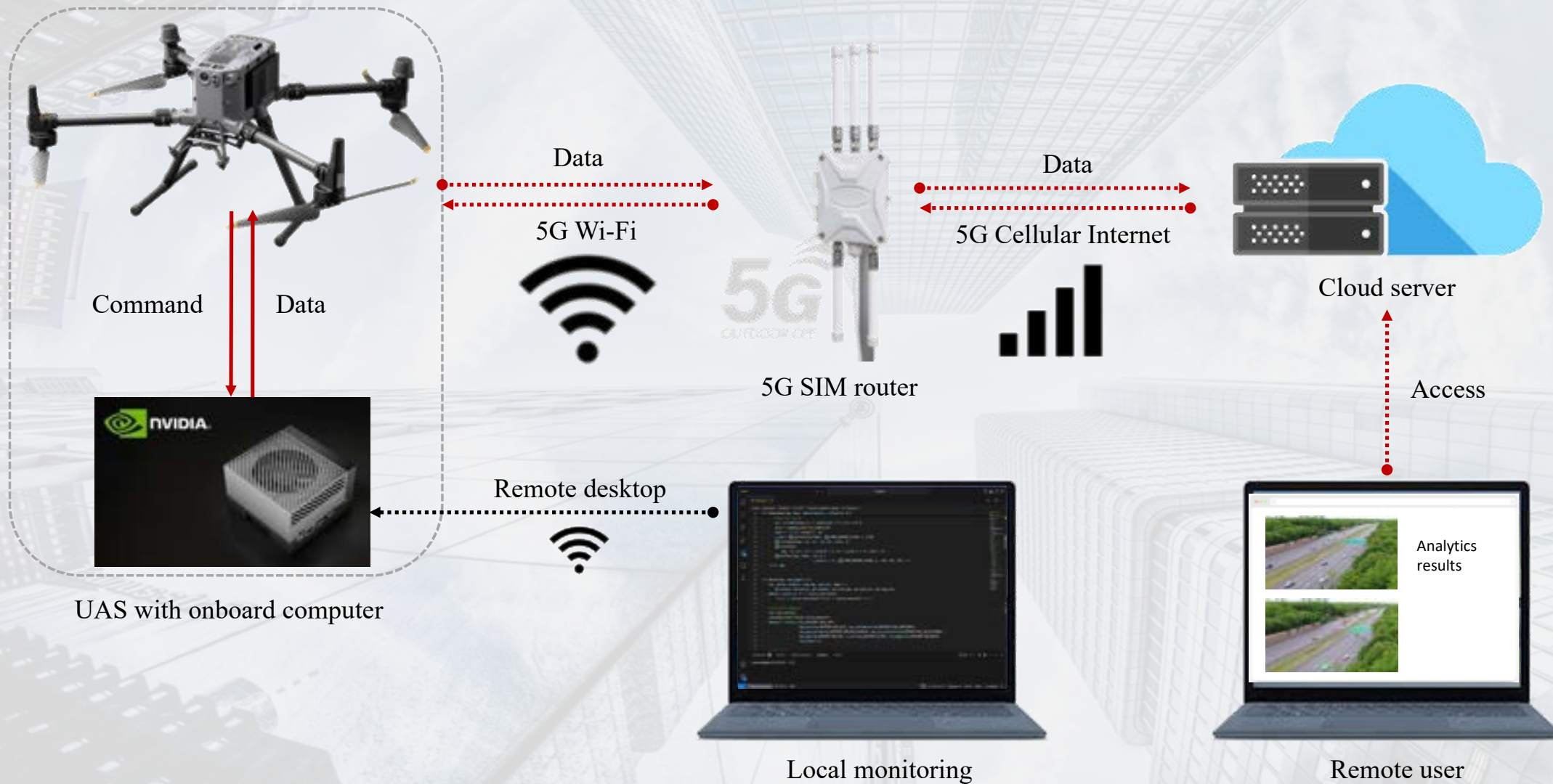


12/29/2023, 11:30:21 PM EST  
Vehicle Count: 20  
Maximum Speed: 60 mph

Original Video



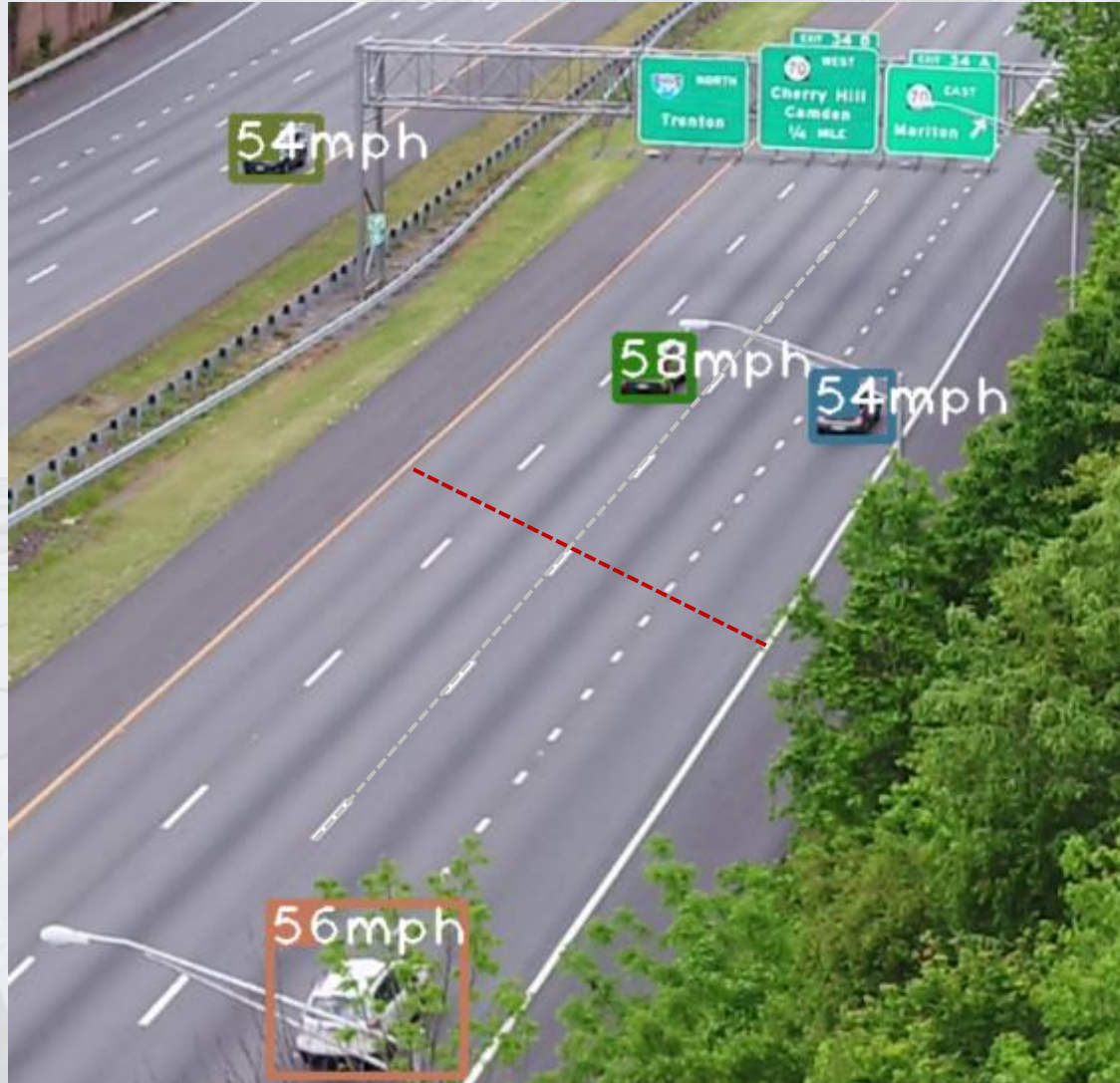






Density:  
#vehicles/km

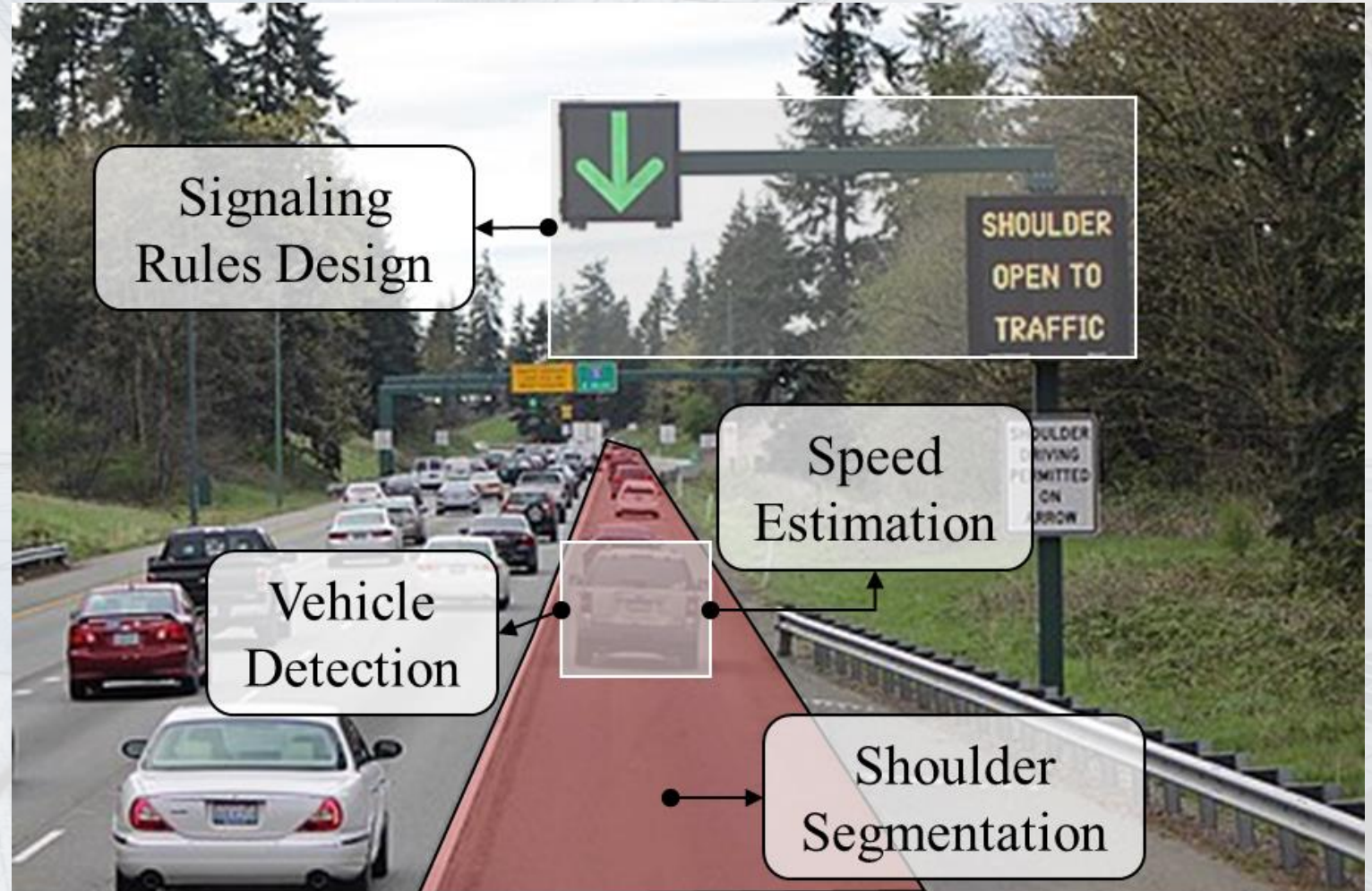
Flow:  
#vehicles/hour



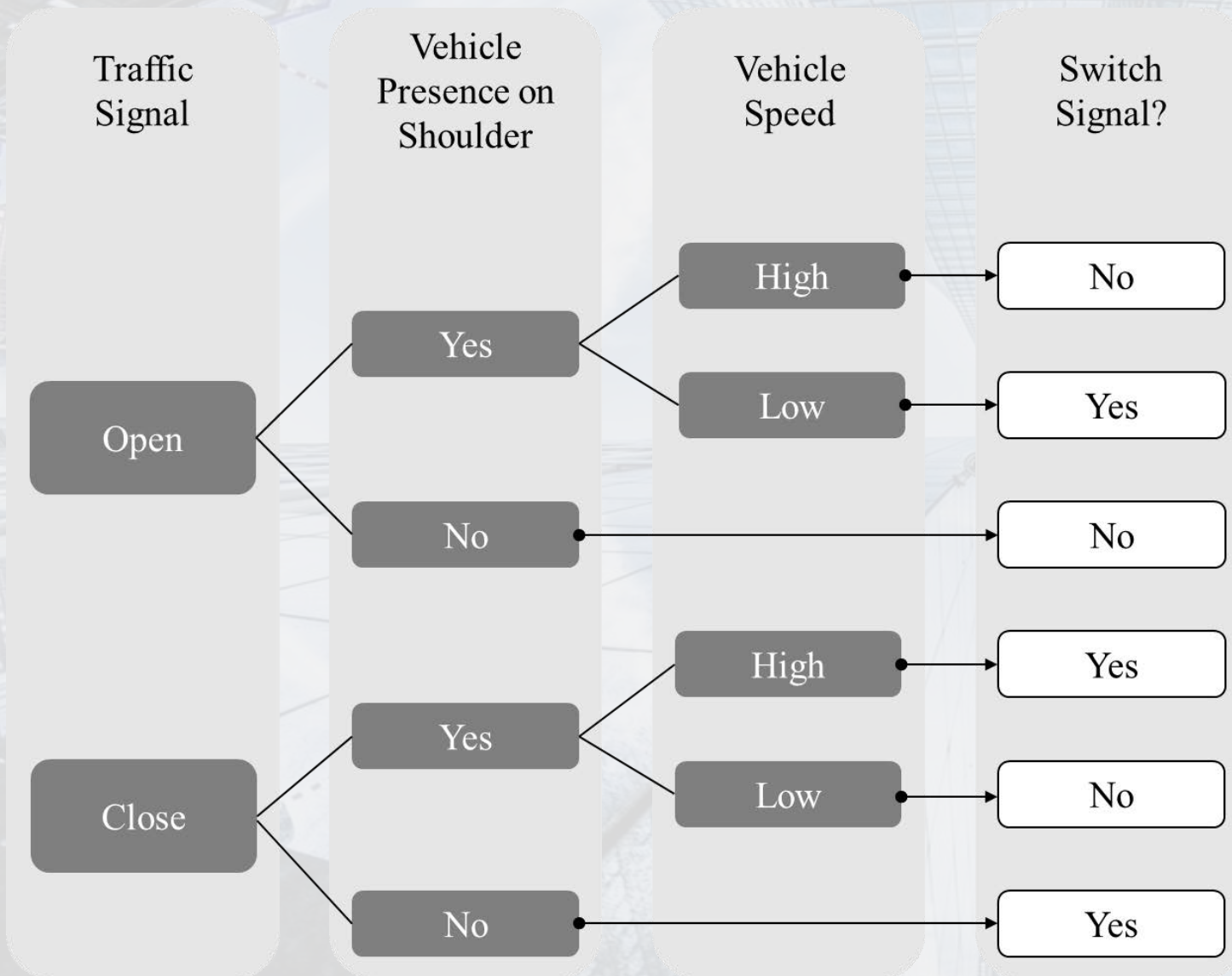
Lane markup:  
enables measurements  
of each lane

Image rectification:  
enables distance estimation









Other considerations  
e.g., pedestrian











**Questions?**

Thanks for your attention!