

# Enhancing VRU Safety in Urban Streets Using LiDAR and Crossing Warning System

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# Background

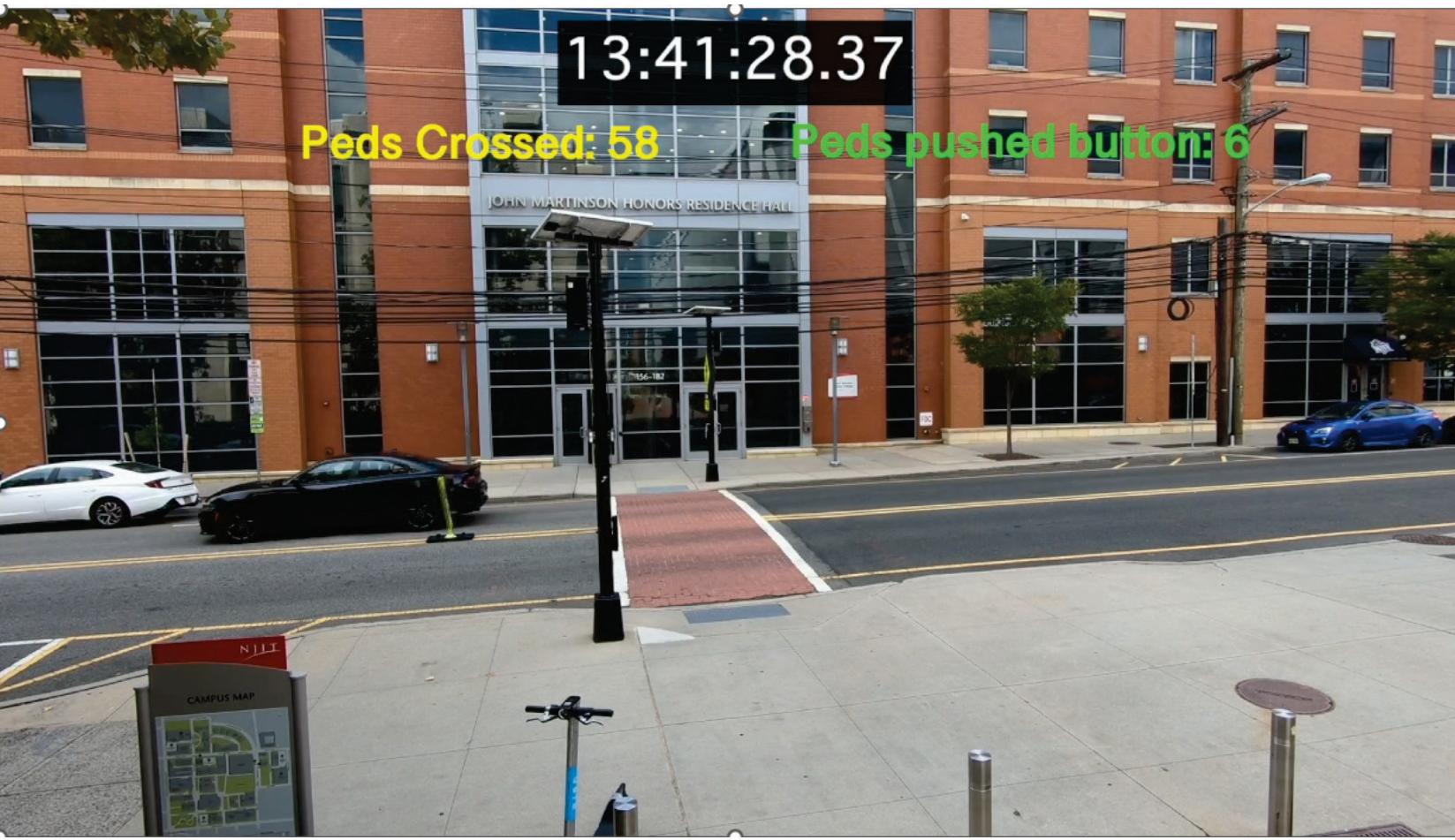
- Mid-block pedestrian crossings pose a high risk for accidents.
- 70% of urban pedestrian fatalities occur in mid-block locations.
- Popular Countermeasures are:
  - Rectangular Rapid-Flashing Beacons (RRFBs)
  - Pedestrian Hybrid Beacons (PHBs)
  - Pedestrian Refuge Islands
  - Raised Crosswalks



# Effectiveness of Rectangular Rapid-Flashing Beacons (RRFB)

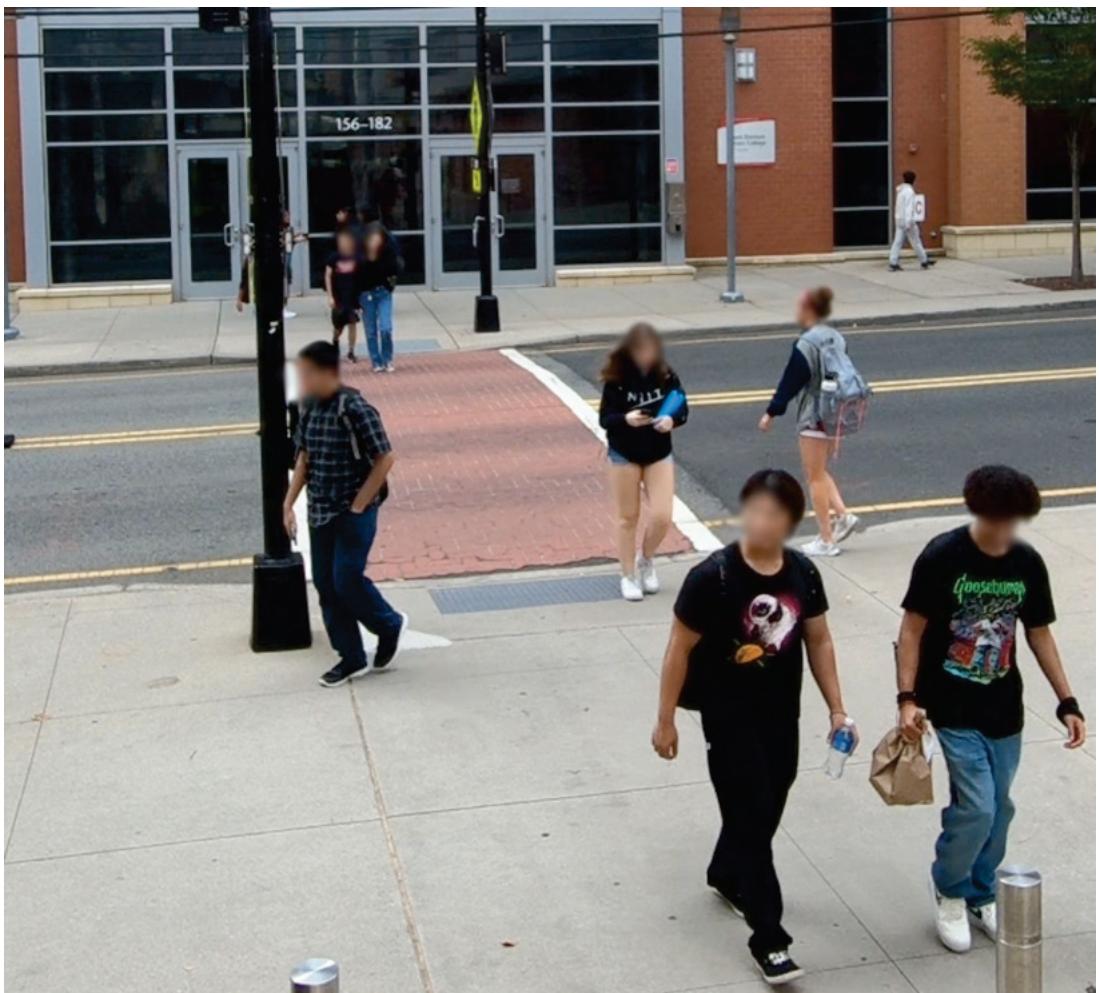
- Enhance the visibility of pedestrians crossing the road at mid-block or uncontrolled crosswalks by emitting bright, attention-grabbing flashes of light when activated.
- Increase the rate of drivers yielding to pedestrians by up to 90% (Teketi and Pulugurtha, 2020).
- Reduce pedestrian crashes by as much as 69% (FHWA, 2018).
- The promising performance only happens when the button is pushed.



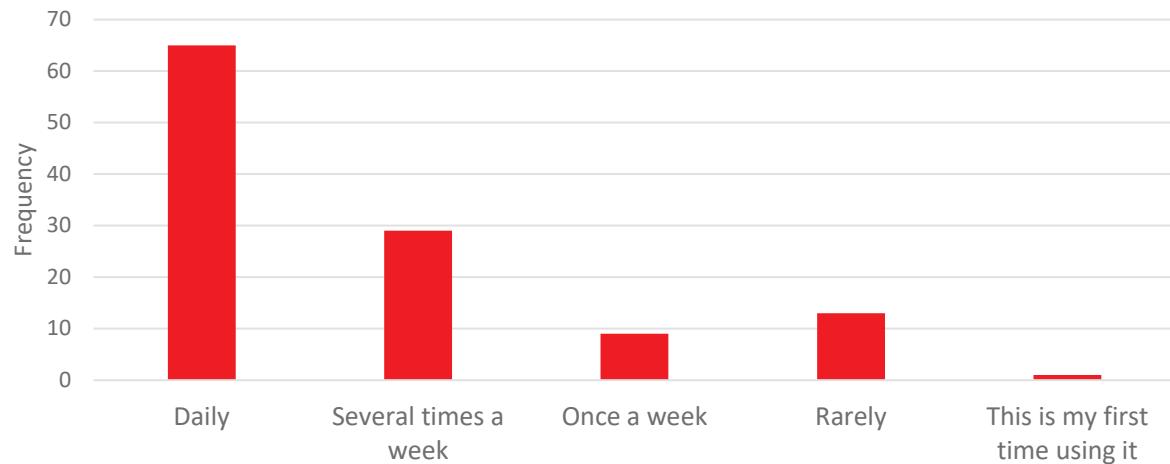


Video recording of 15-minute crossing operations was shown in the live presentation. The video shows that only 6 pedestrians of the 58 who crossed the street used the push button to activate the RRFB.

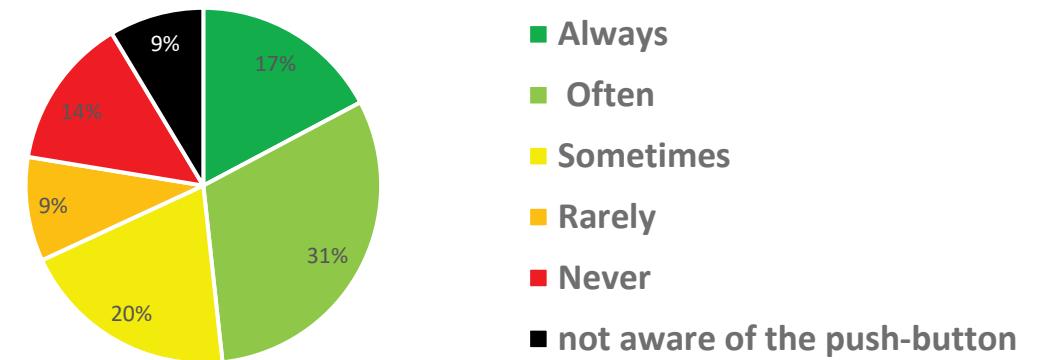
# Survey (116 Respondents)



How frequently do you use this crosswalk?



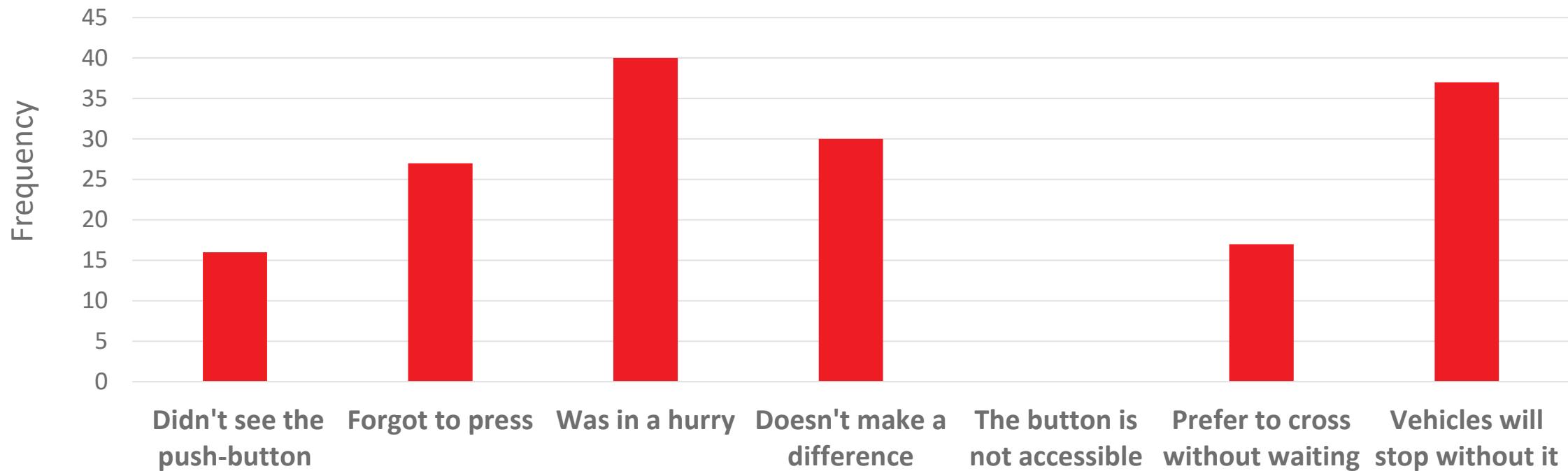
How often do you press the push-button before crossing?



# Survey (116 Respondents)

## Why you might not press the push-button?

(Multiple Choice Available)



# Survey (116 Respondents)

## Reasons for jaywalking

(Multiple Choice Available)

The crosswalk signal doesn't respond quickly



I didn't notice the crosswalk



Waiting at the crosswalk takes too long



Traffic was light, and it felt safe



I was in a hurry



The crosswalk is out of the way



0

10

20

30

40

50

Frequency

# Problem Statement

- Challenge with Existing System:
  - Pedestrian-Activated Rectangular Rapid Flashing Beacon (PA-RRFB) requires manual activation.
  - Inactive beacons compromise safety.
  - Notable amount of jaywalking in the area.
- Proposed Solution:
  - Passive Detection Rectangular Rapid Flashing Beacon (PD-RRFB) using LiDAR technology for automatic pedestrian detection.
  - Detecting jaywalking and warning the drivers.



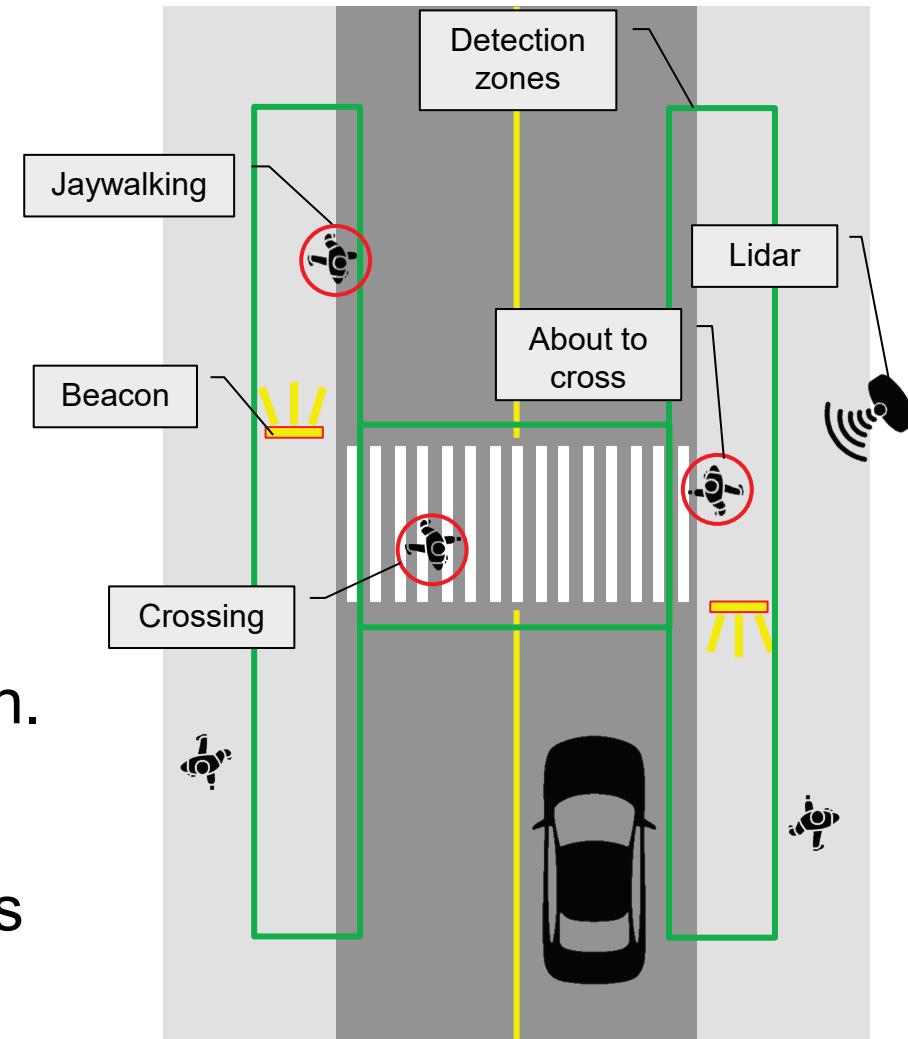
# System Overview

- Components:
  - LiDAR sensor for passive detection.
  - Edge device to process LiDAR data
  - Microcontrollers to process signals and activate the beacon.
  - LED Strobe Flashing Lights.
  - Wireless Communication.
- Key Advantage:
  - Pedestrians are detected in real-time as they approach mid-block crossings.



# System Overview – Cont'd

- Real-time pedestrian detection using Python, Open3D, and clustering algorithms.
- Detection logic based on object dimensions to filter out false positives from vehicles.
- Cooldown period implemented for side-based detection to prevent redundant beacon activation.
- Continuous checking of the crosswalk surrounding area for the presence of pedestrians crossing or jaywalking.



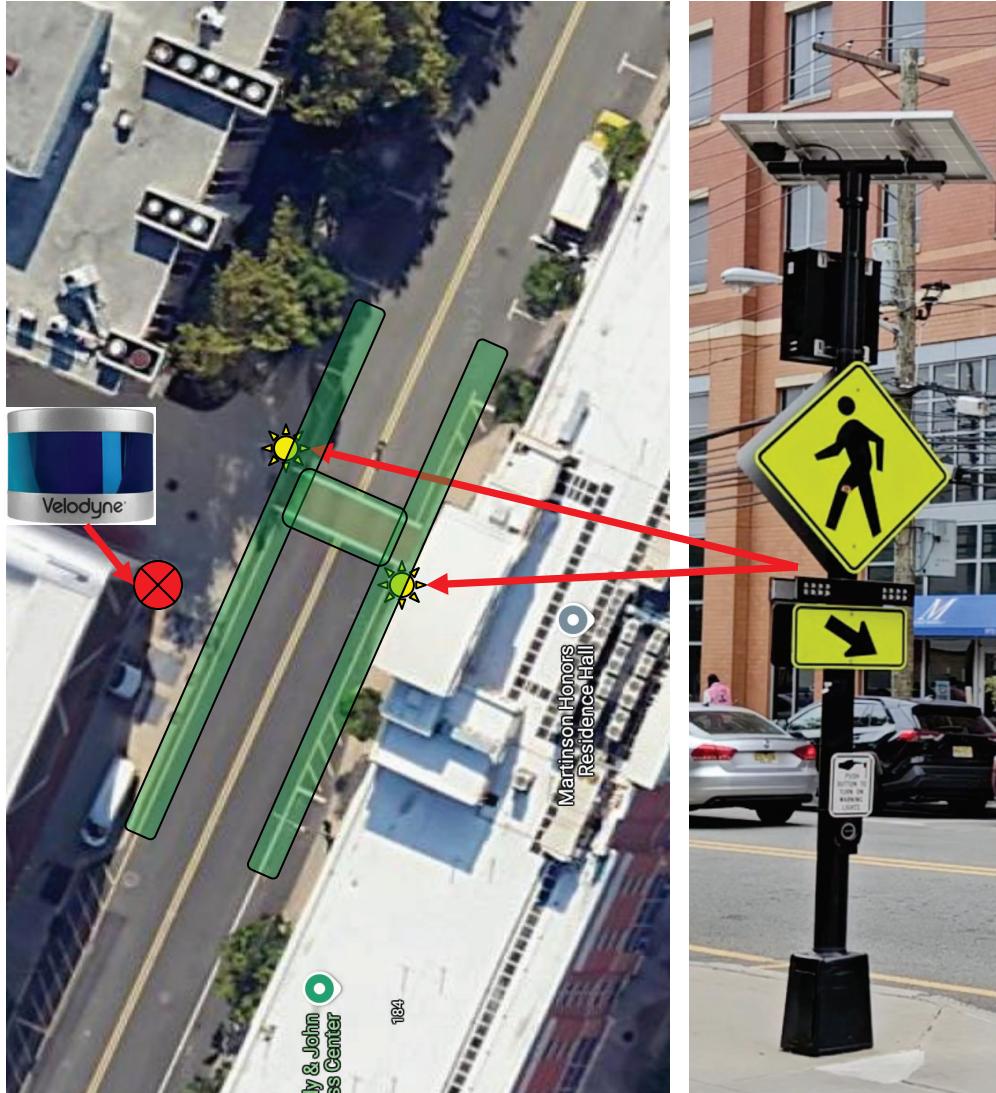
# Pedestrian(s) Detection Approach

- North, South, and Crosswalk detection zones (boxes in Red).
- LiDAR detects points moving together (i.e., cluster)
- Conducts perception to identify pedestrians based on the shape and movement of clusters within the perception zones (boxes in Green)
- Integration of side-based cooldown logic to avoid re-triggering beacons.
- Triggering beacons while pedestrians are still on the crosswalk.



# Field Test Setup

- Location: Newark, NJ, mid-block near NJIT campus.
- LiDAR installed at mid-block location with a beacon system.
- Trigger the beacon using the microcontroller via WiFi
- Objectives:
  - To detect pedestrian(s) who are about to cross the street without pushing the button
  - To automatically activate the flashing beacons
  - To evaluate system performance in reducing vehicle speed and enhancing pedestrian visibility.



# Implementation

- Activated by detecting a Ped Inside of Crosswalk Entrance
- Activated by detecting a Ped Outside of Crosswalk Entrance
- Activated by detecting a Group of Peds
- Activated by detecting Jaywalkers

*(videos shown in the live presentation)*

# Conclusions

- Key Takeaways:
  - LiDAR-based detection is effective in improving pedestrian safety.
  - Expected to result in reduction in vehicle speed and increased pedestrian satisfaction.
  - The system offers a scalable solution for urban areas with high pedestrian traffic.
- Future Work:
  - Expand to more urban locations with heavy pedestrian traffic.
  - Continue data collection to refine detection and response times.
  - Integrate with Connected Vehicle Roadside Unit (RSU) to disseminate ped crossing warnings.

# Questions & Discussion

Thank you for your attention!

We invite your questions and are open to discussion.

Let us know what you think about our project.

