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Evaluating 3-D sight distance at urban intersections using a LiDAR-based model and considering multiple users

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Introduction

- At-grade urban intersections are considered to be complex due to their:
  - Multiple road users → Reciprocal visibility
  - Conflicting movements → Early perception
  - High traffic volumes → Safe accommodation
  - Dynamic environ → Acknowledged

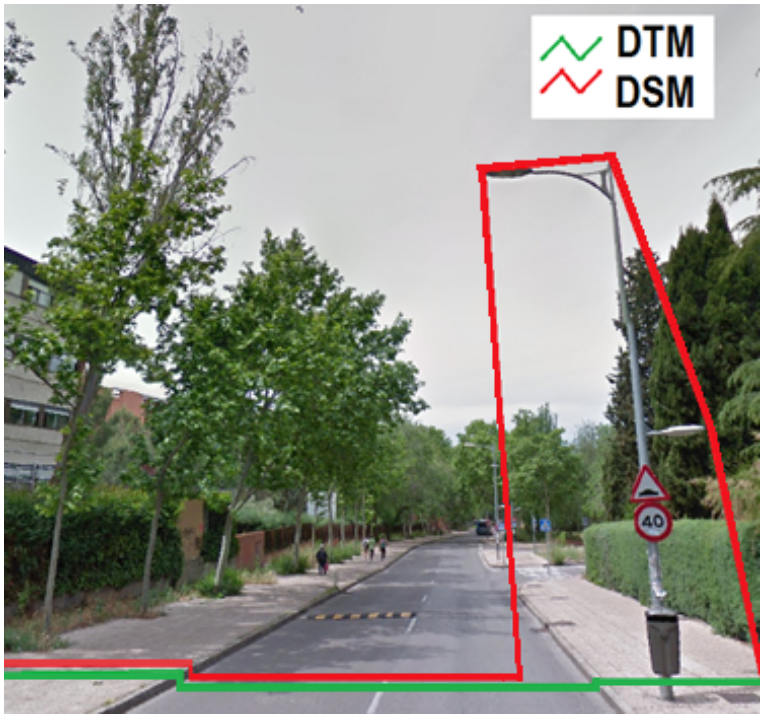
USERS

DESIGNERS

- Correct functioning requires adequate ISD and SSD
- Urban environs changes might alter design ASD
- LiDAR-based systems provide accurate representations of the road scene → allowing 3-D analyses

Background

- Authors reflected 2-D approaches could misestimate ASD
- Some 3-D approaches make use of geospatial data
- Digital models are used to portray road geometry and elements
- Widespread DSM's formats show one elevation per (x,y)

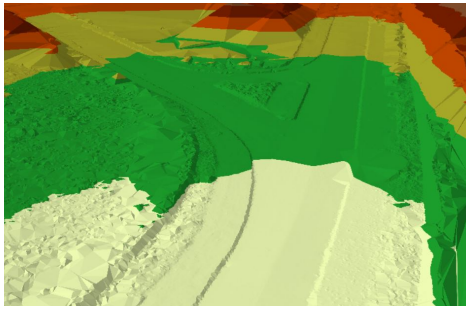


Procedure

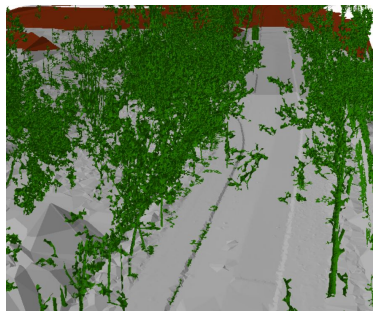
- Repeated launching of line-of-sights using GIS tools
- Requires:
  - Object and target locations → Trajectory
  - Road geometry definition → DTM
  - Roadside obstructions → 3-D objects

Trajectory

Digital Terrain Model

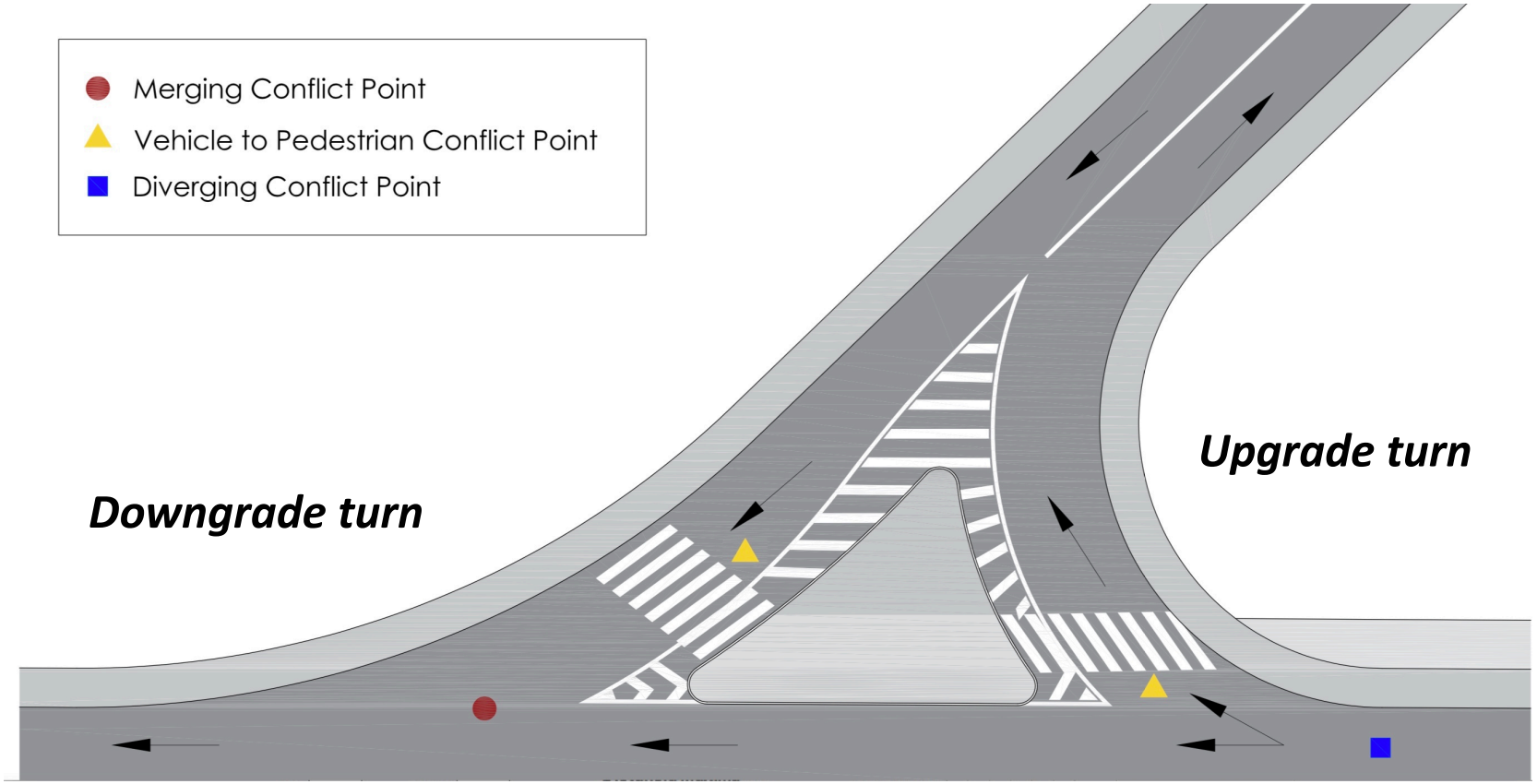


Aboveground elements



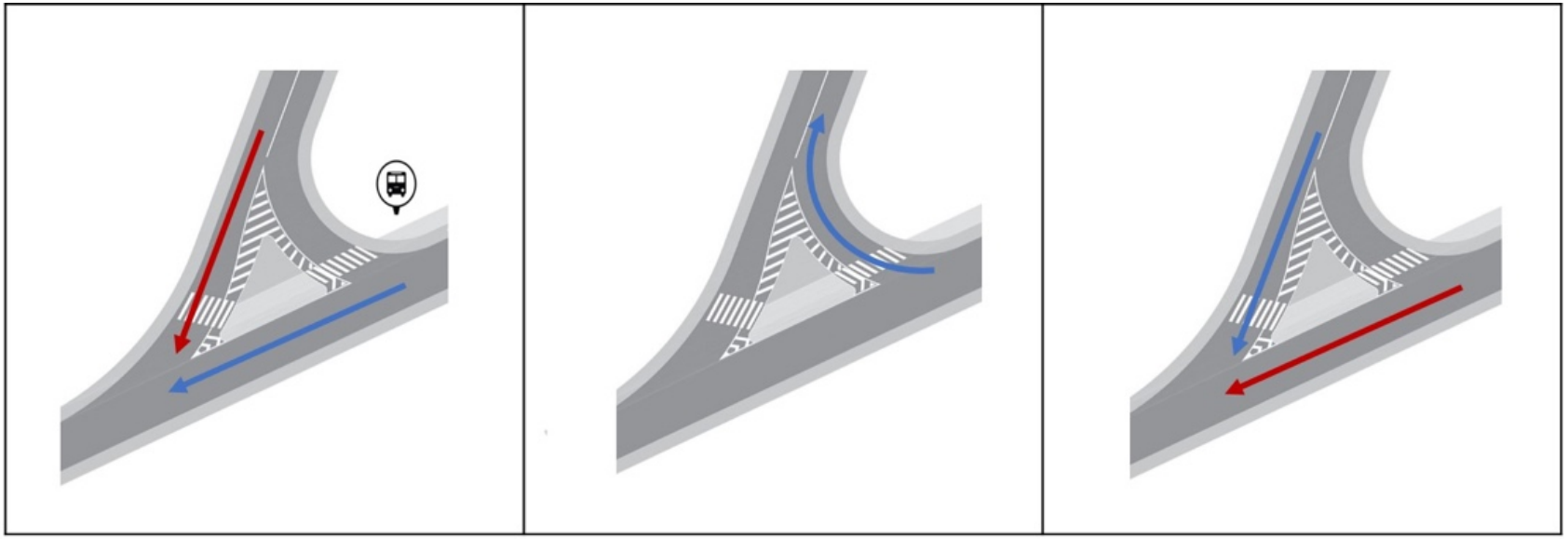
Case study

- 3-way raised-channelized skewed intersection
- Posted speed limits of 40 km/h – university district



Evaluation goals

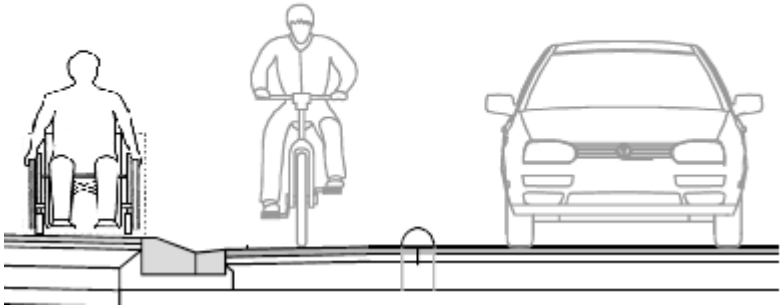
- Assessment of SSD and ISD for drivers & cyclists for all turns; and pedestrians' visibility



- Possible effects of urban furniture elements & effects of their relocation

Evaluation

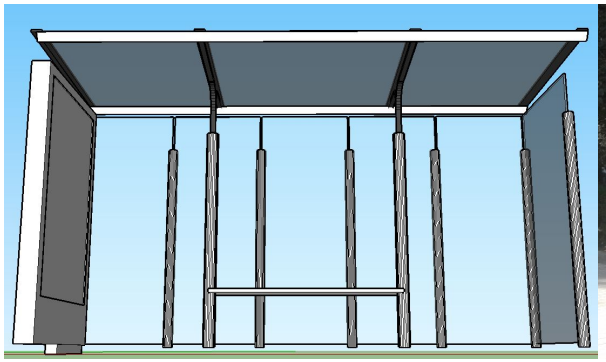
- Definition of observers' trajectories & points to be seen: observers' paths (SSD) and conflict points (ISD)



- Definition of eye height and lane/sidewalk position

  --> Object and target location

- Distinct scenarios varying location of the bus stop-shelter



Evaluation

- Comparison of ASD with SSD & ISD

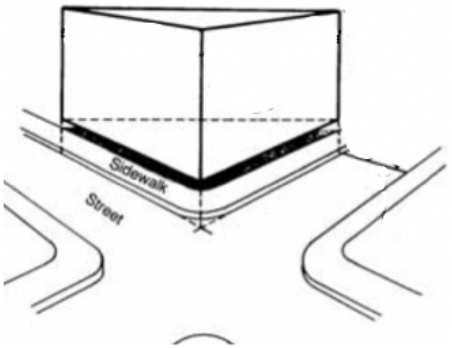
$$SSD = 0.278\,Vt + \frac{V^2}{245\left[\left(\frac{a}{9.81}\right) \pm G\right]}$$

V → *design speed (km/h)*
t → *brake reaction time (2.5 s)*
a → *deceleration rate (3.4 m/s)*
G → *road slope*

$$ISD = 0.28\,V_{major}\,t_g$$

Vmajor → *design speed major road (km/h)*
tg → *minor road vehicle time wrap (s)*

- Verification of clear sight triangles



Results: SSD

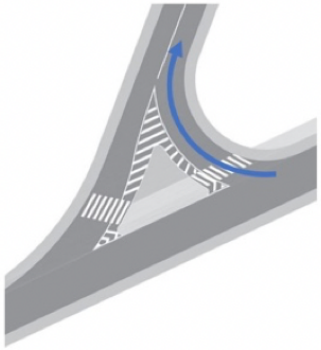
- Values obtained with posted speed limit --> 40 km/h cars and 35 km/h cyclists

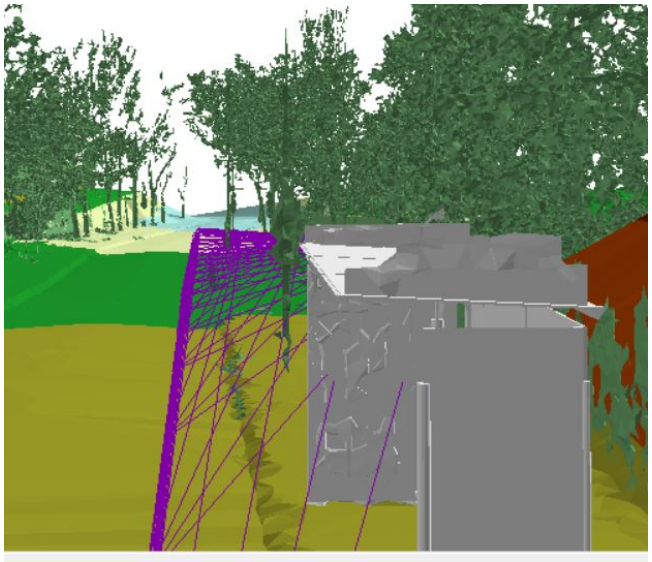
Observer	SSD (m) downward main road	SSD (m) upward minor road	SSD (m) downward minor road
Drivers	49.30	44.01	48.48
Cyclists	40.75	36.74	40.16

- SSD provisioned for observers downward main road & minimal effect of bus stop shelter on ASD
- Second turn not provisioned of SSD –> Horizontal curve
- SSD provisioned for observers downward minor road

Results: SSD

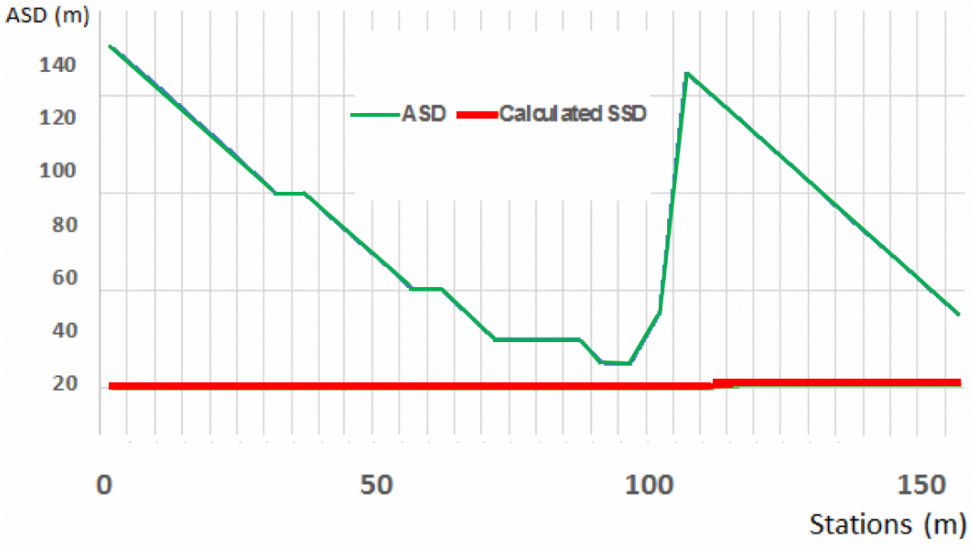
- Second turn

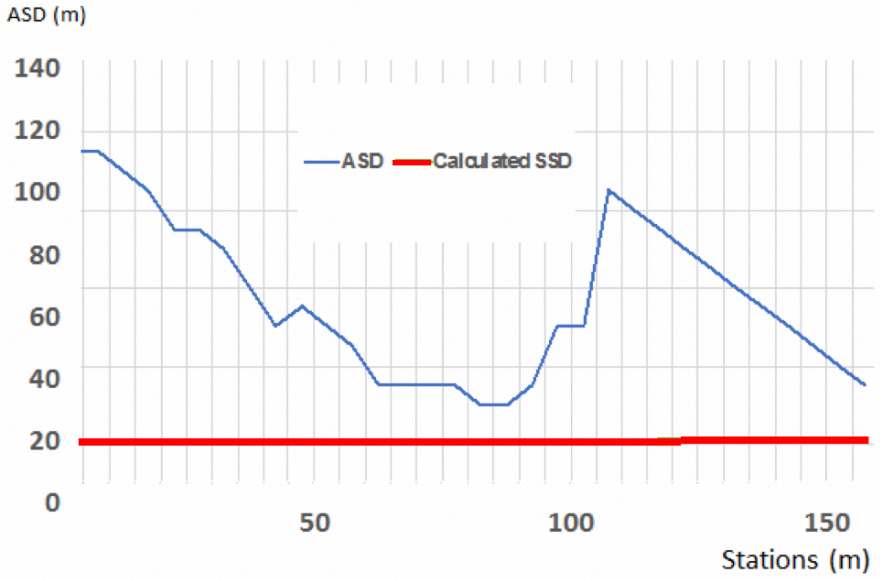




Results: SSD

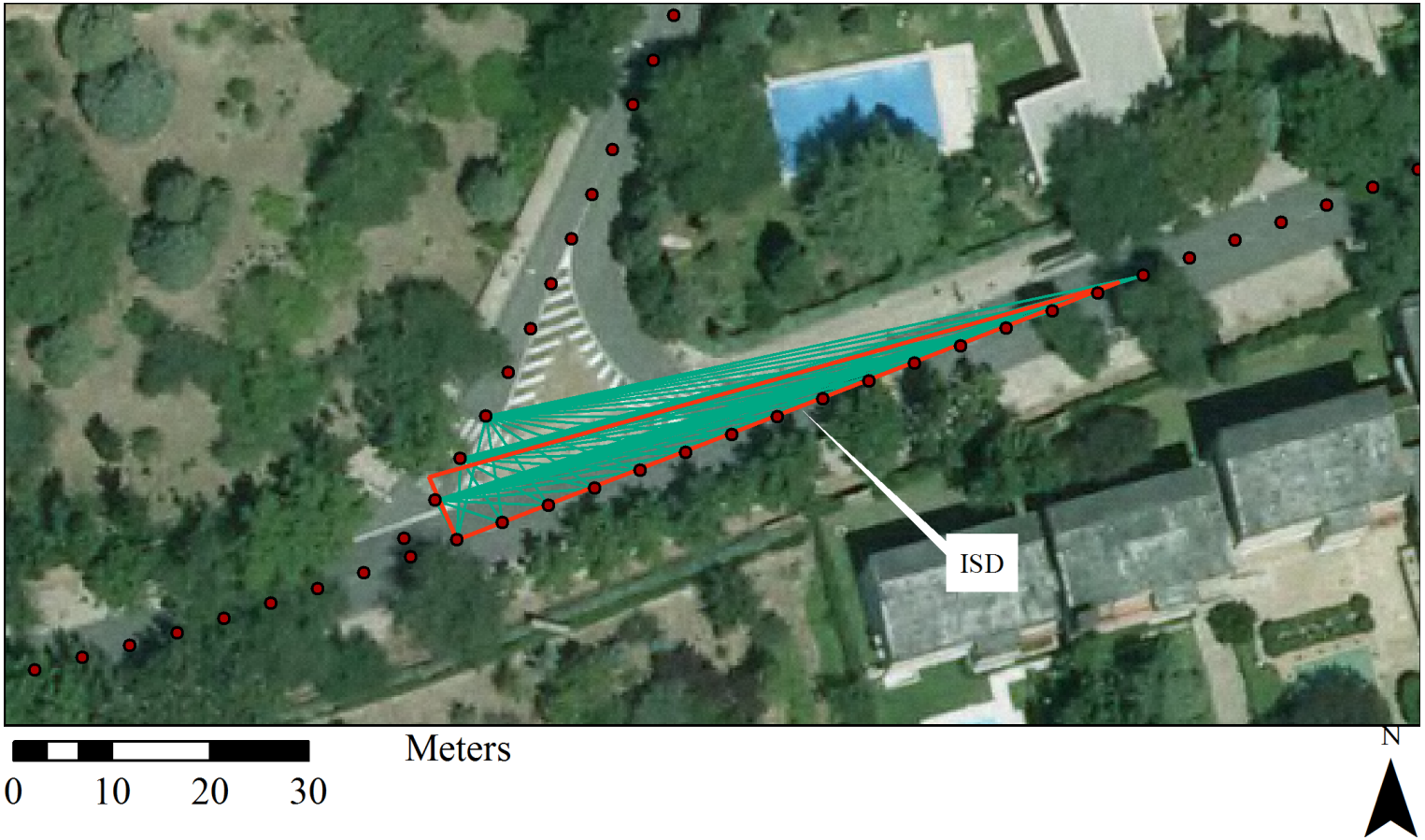
- ASD of cyclists varies based on their lane positioning





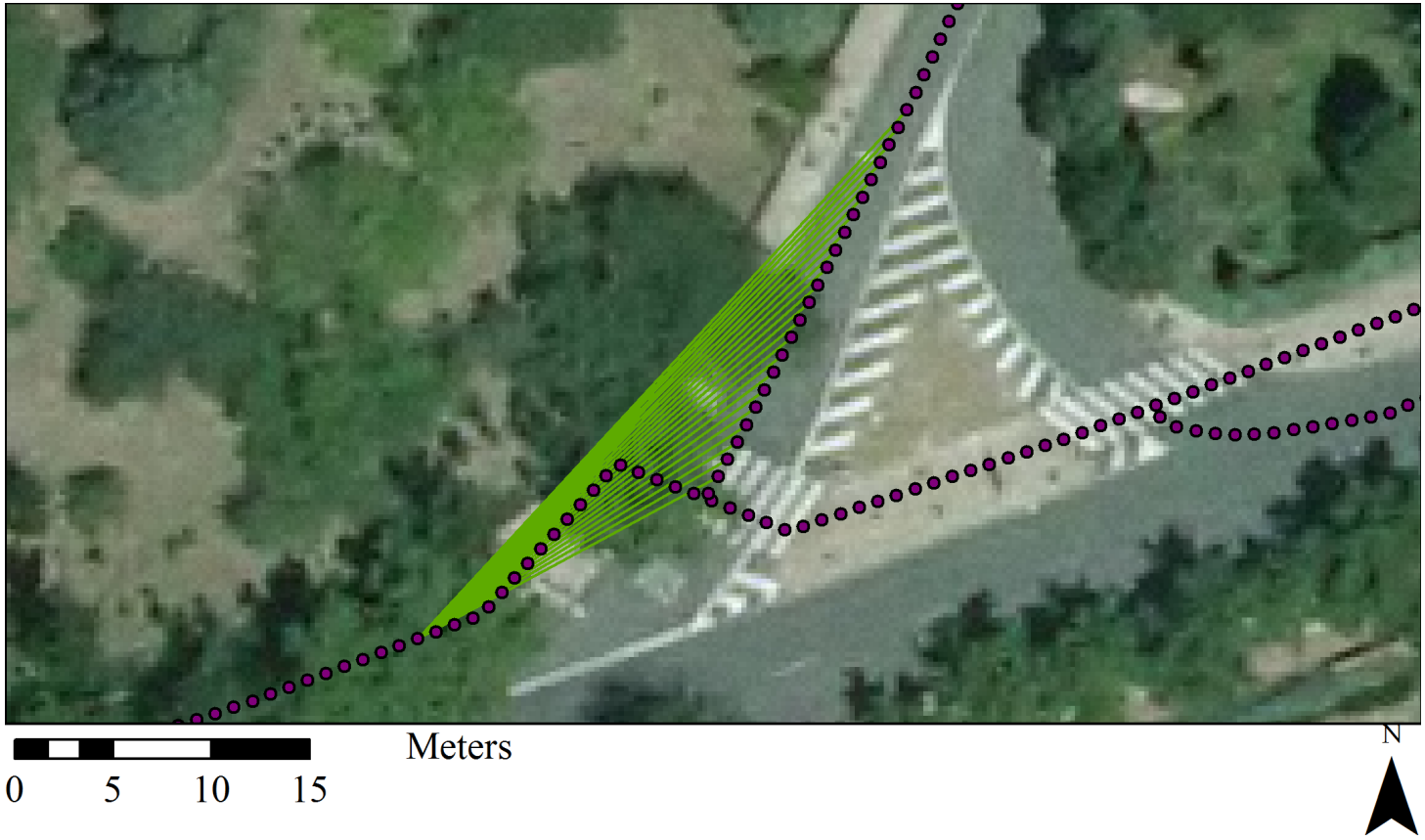
Results: ISD

- Diverging and merging conflict points provisioned – all observers
- Bus stop prevents cyclists spot drivers 10-20 m before the stop sign
- Departure sight triangle provisioned



Results: Pedestrians

- Sightlines projected from pedestrians' path at approaching vehicles
  - Both types of pedestrians are able to spot oncoming traffic



Conclusions

- 3-D procedure enables realistic estimations of ASD
- Elements surrounding urban streets could affect overall visibility → the proposed approach allows evaluation of their positioning in terms of safety
- Importance of evaluating cyclists lane positioning → benefits of distinct trajectories
- Sight distances of mobility impaired pedestrians often obviated
  - Results showed good provisioning for case study; still these might vary given the shown effect of surrounding elements

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