Pedestrian Safety based on Laserscanner Data

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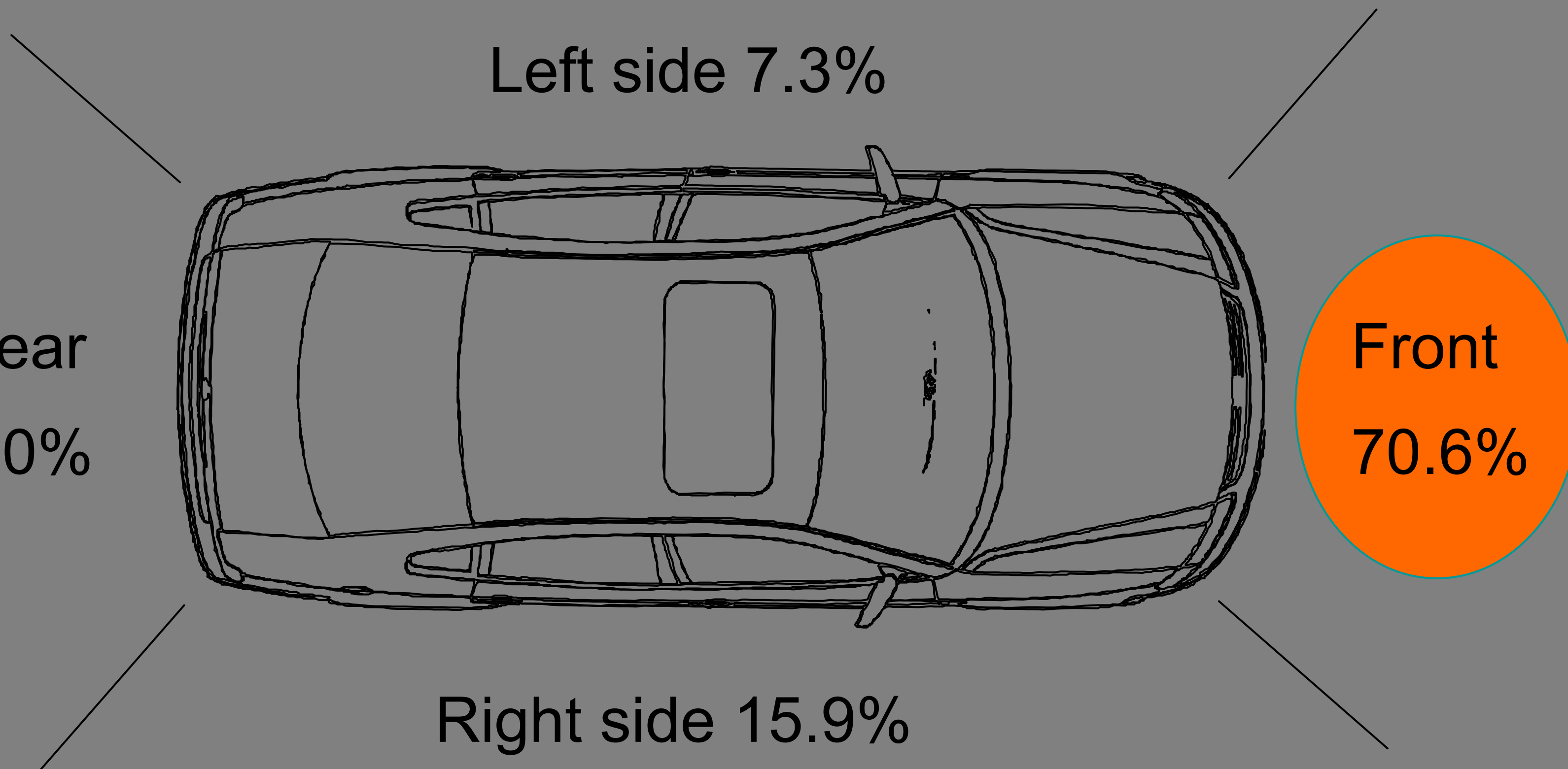
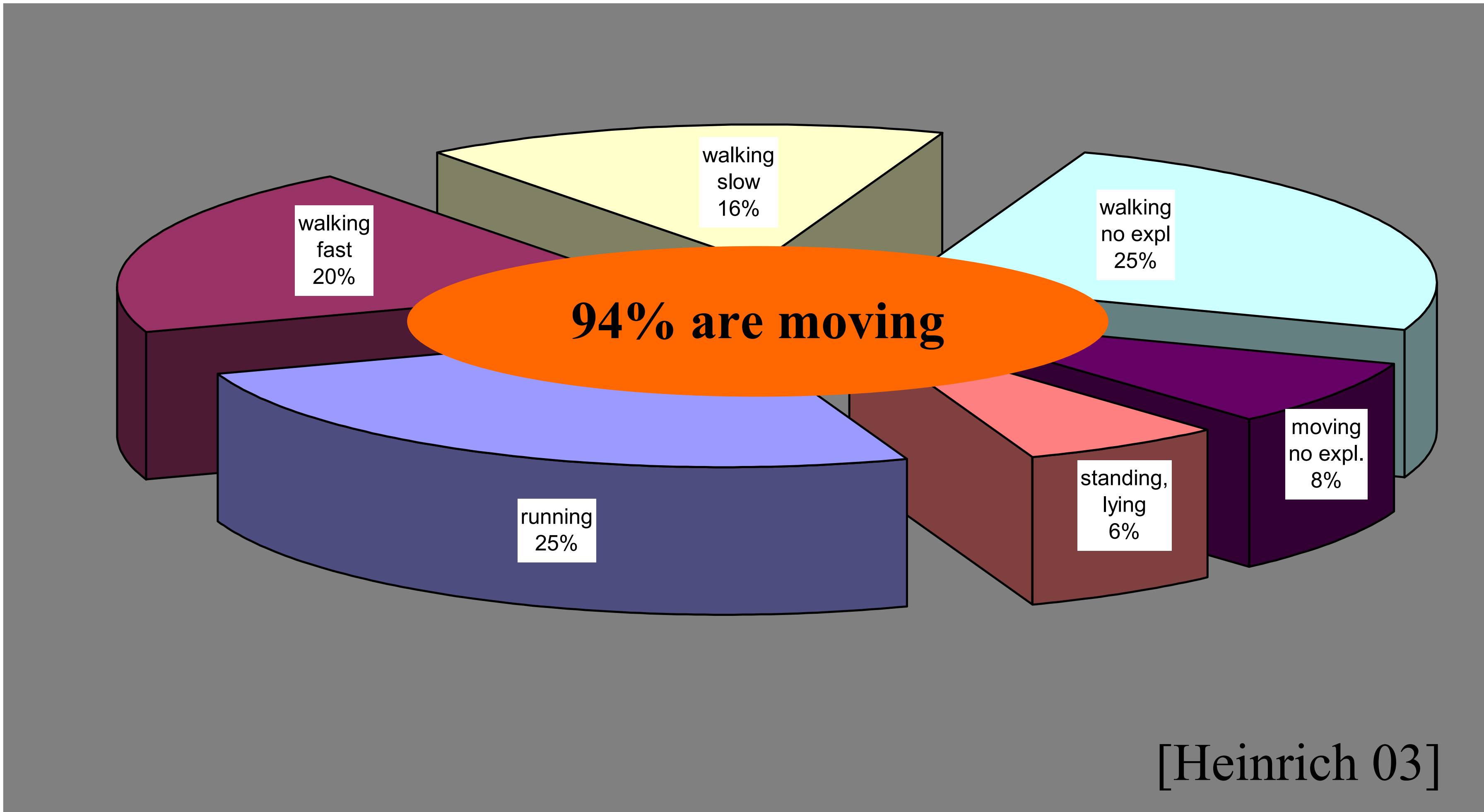
IBEO Automobile Sensor GmbH

Accident Statistics – Car-to-Pedestrian Crashes

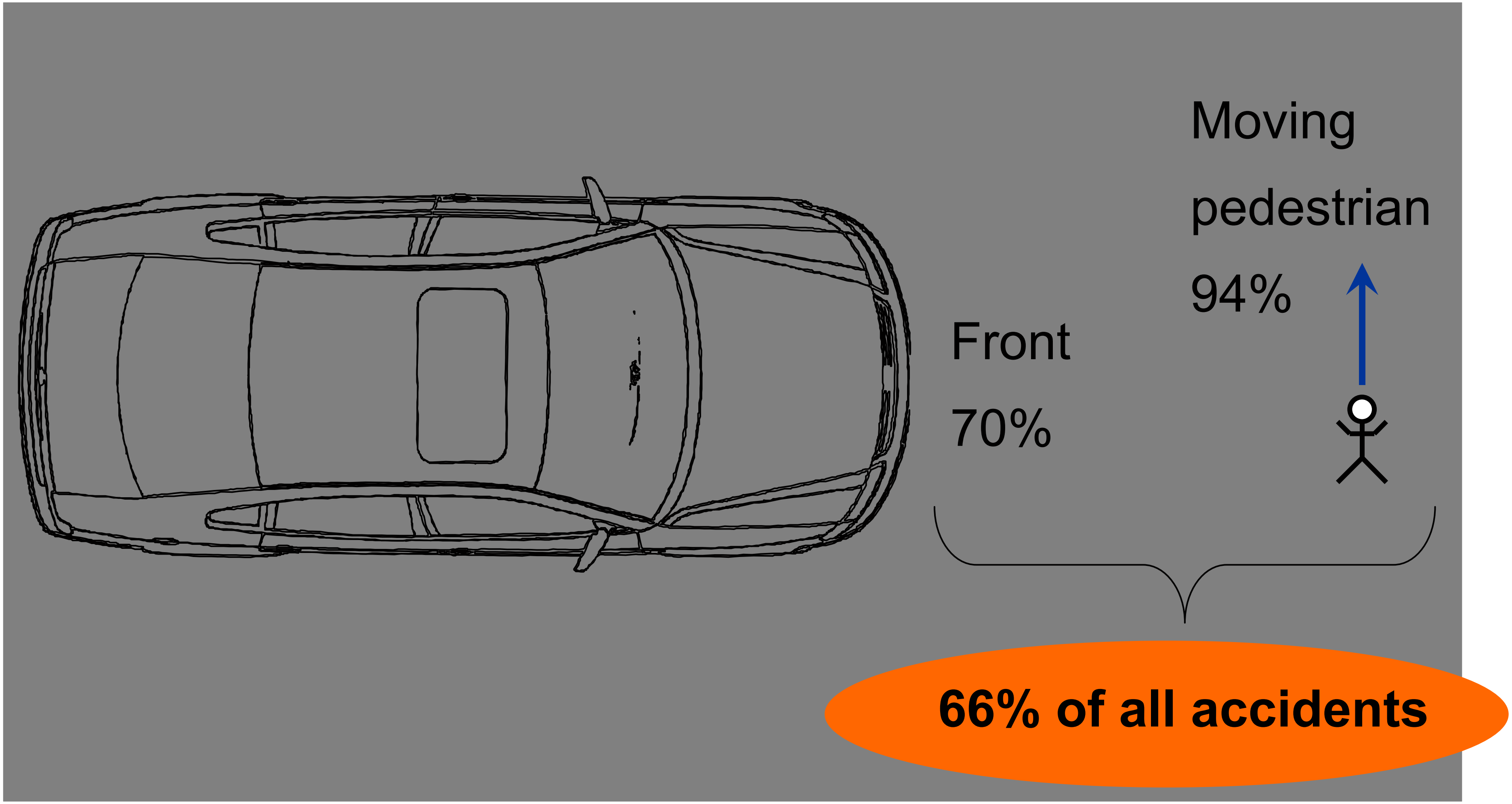


[Heinrich 03]

Accident Statistics – Pedestrian Velocity Distribution



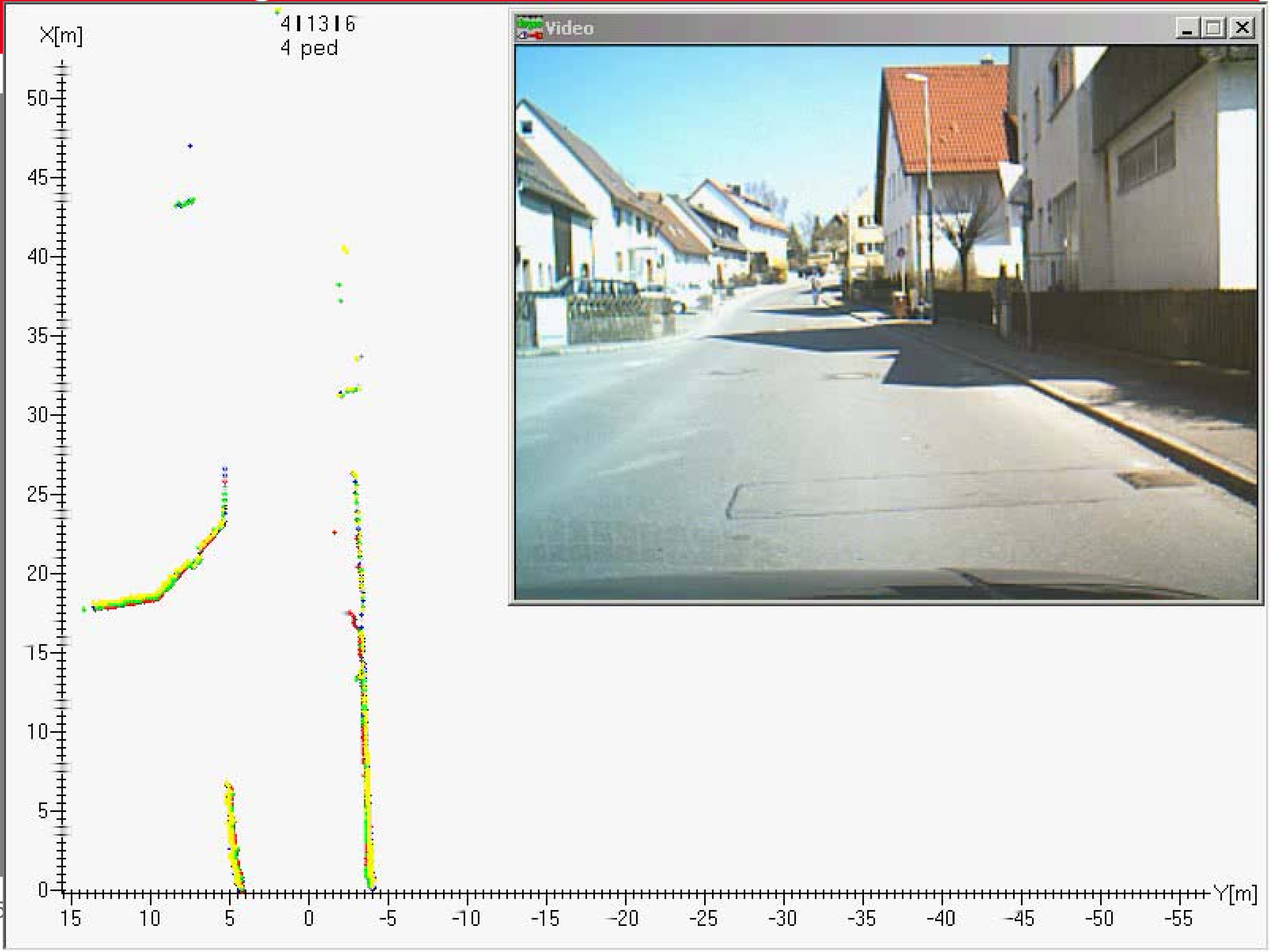
Accident Statistics – Conclusions



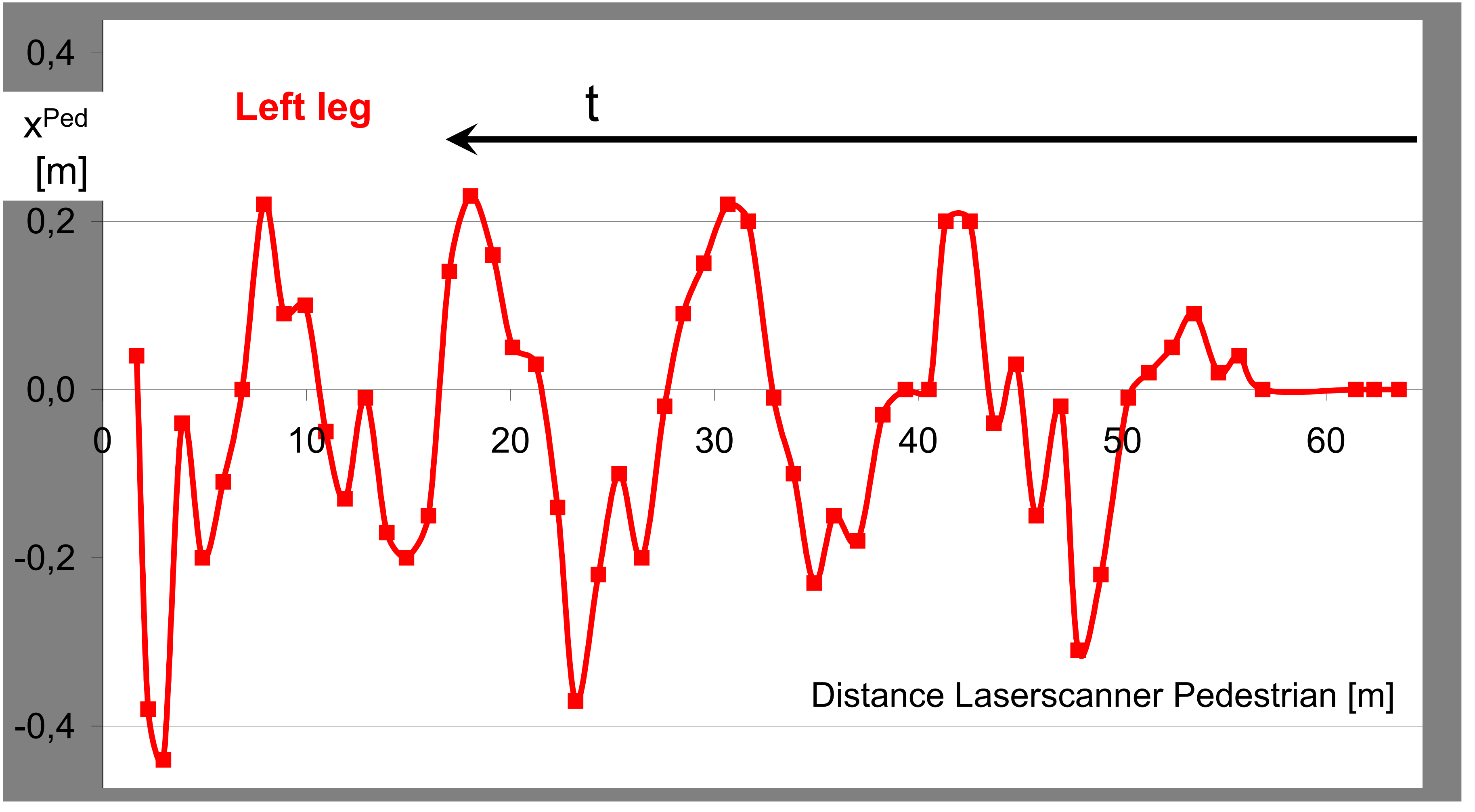
Pedestrian Recognition based on Laserscanner Data

- Pedestrians are classified by their typical size in the Laserscanners range profile
- The absolute velocity is an important criteria to distinguish between dynamic and static objects with the same size, such as pedestrians and posts
- Additionally, the characteristic movement of the legs helps to obtain a more reliable classification

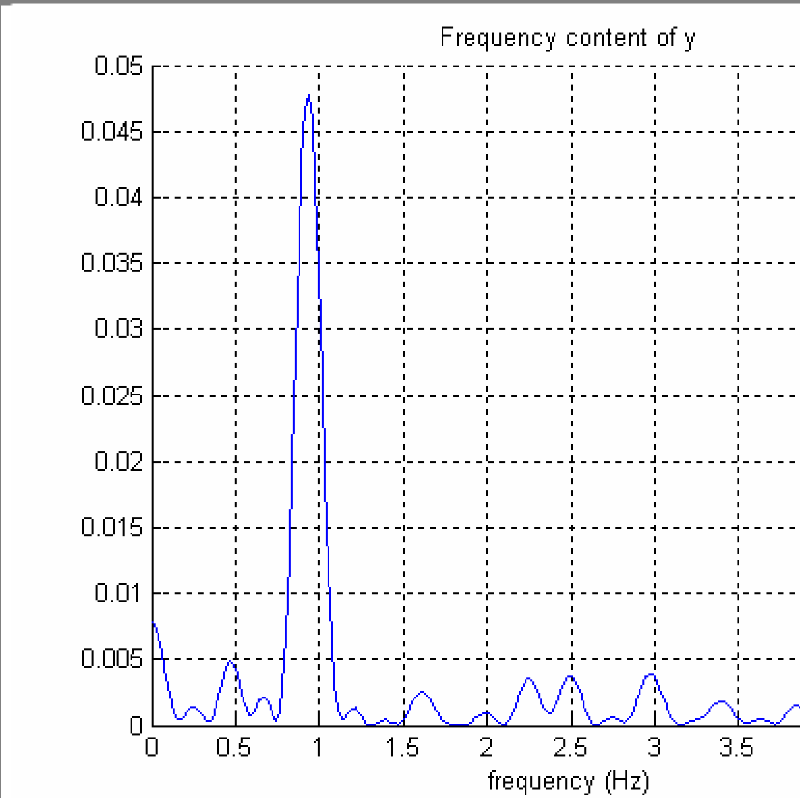
Pedestrian recognition - Scenario IV



Pedestrian – Scenario IV - Movement left leg

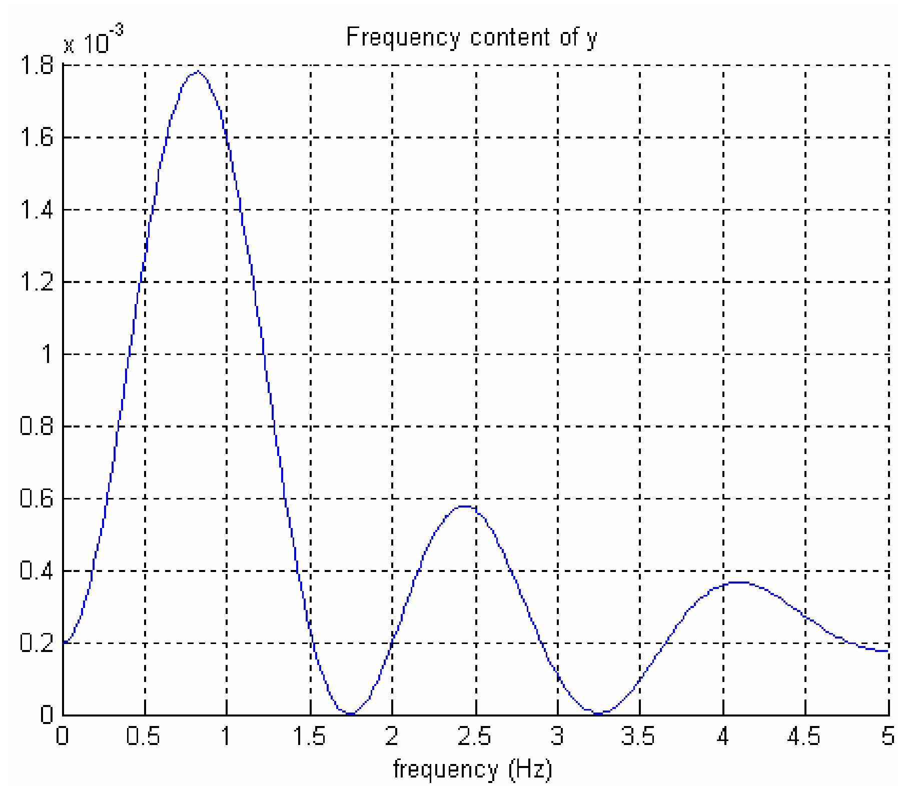


Pedestrian – Scenario IV - Movement left leg



After 5 seconds - 50 Measurements

10 m in front of the car



First second - 10 Measurements

50 m in front of the car

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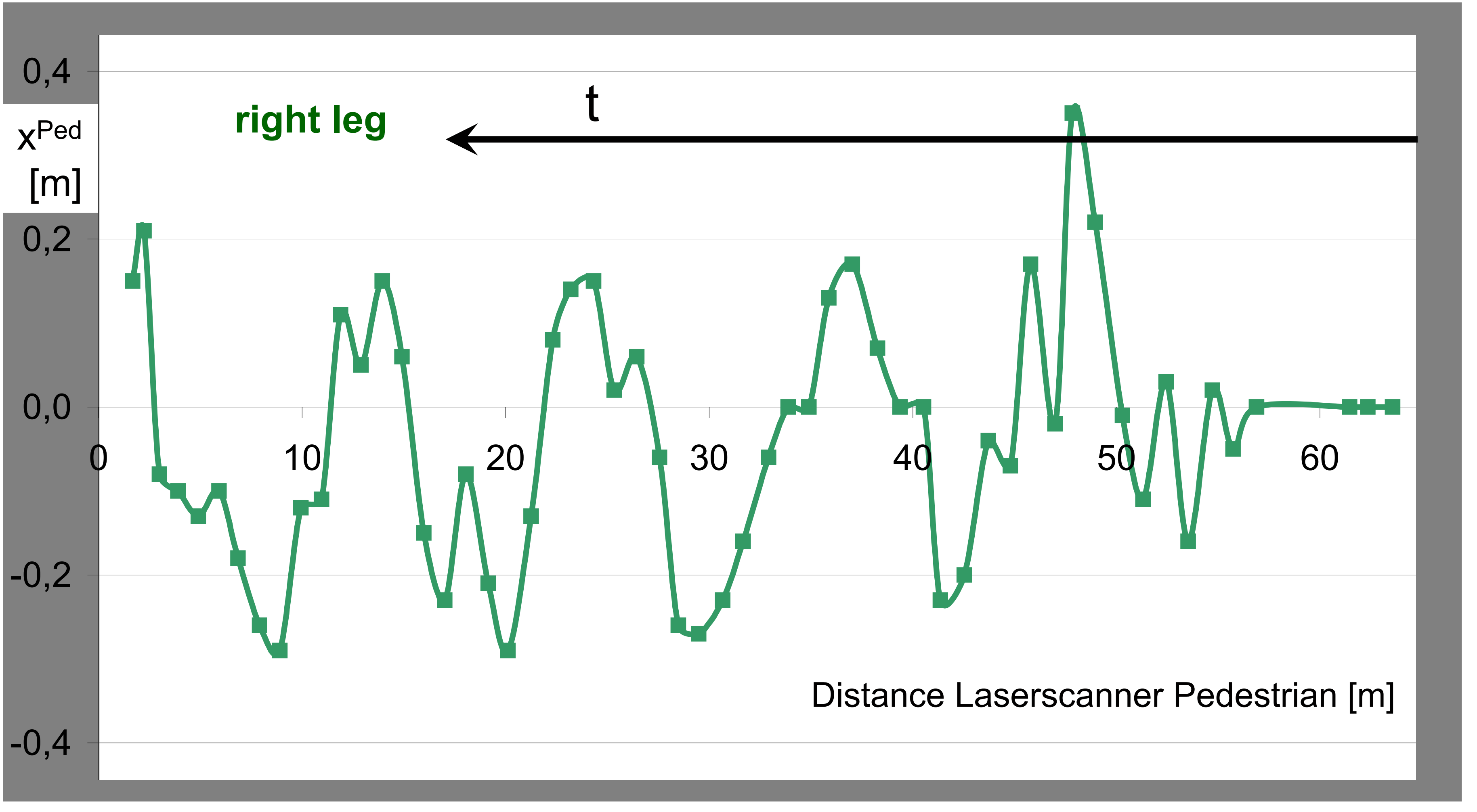
Pedestrian – Scenario IV - Movement right leg



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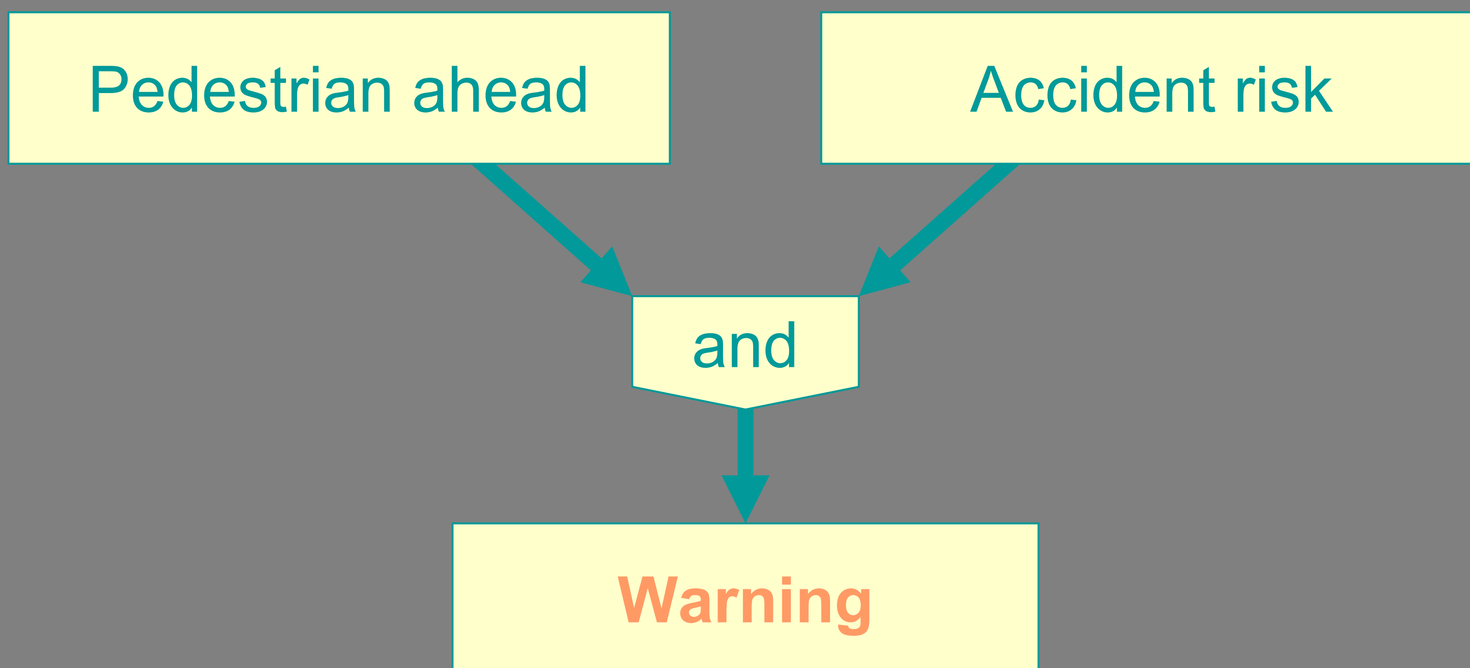
Strategies

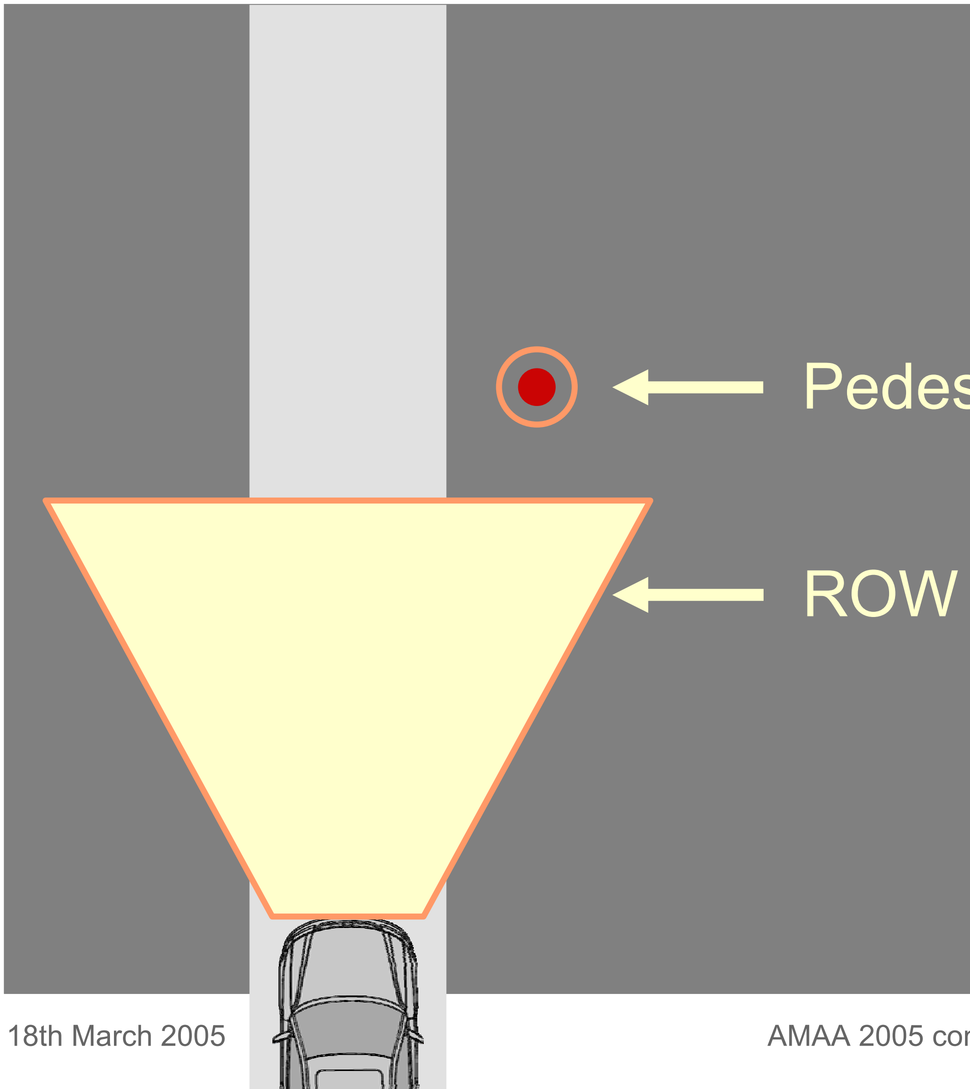
- **Pedestrian Warning**
  - Warning to assist the driver avoiding the accident
- **Pedestrian Protection**
  - Automated action to minimize the consequences of the car-to-pedestrian crash

Pedestrian Warning



→ **Region Of Warning (ROW)**

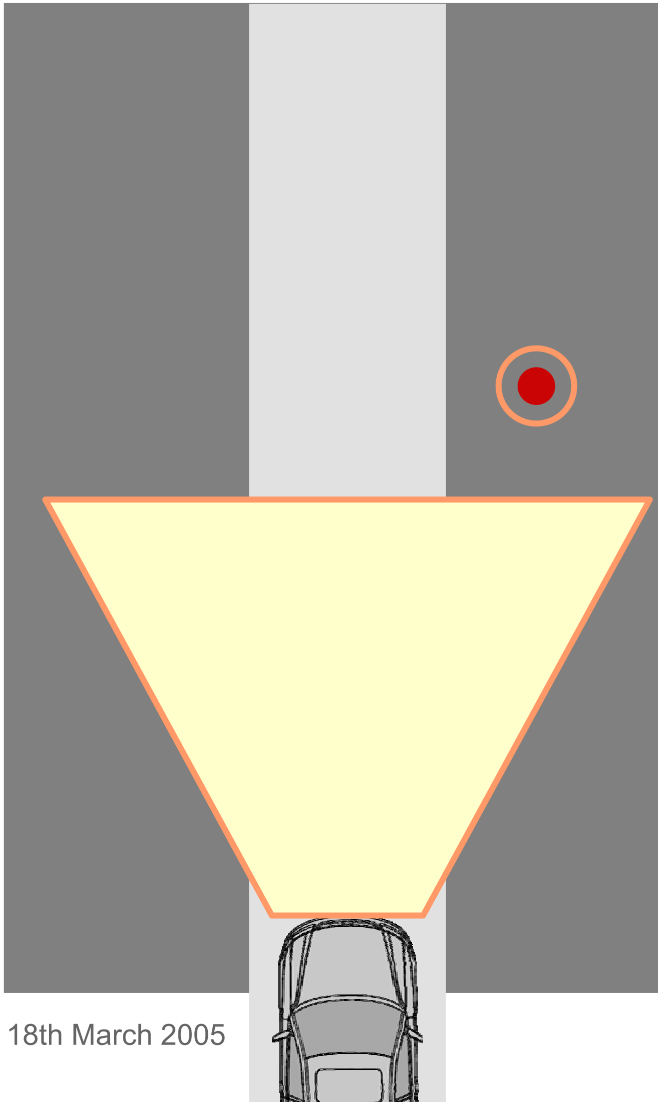
Pedestrian Warning



Examples

1. **Pedestrian waits**

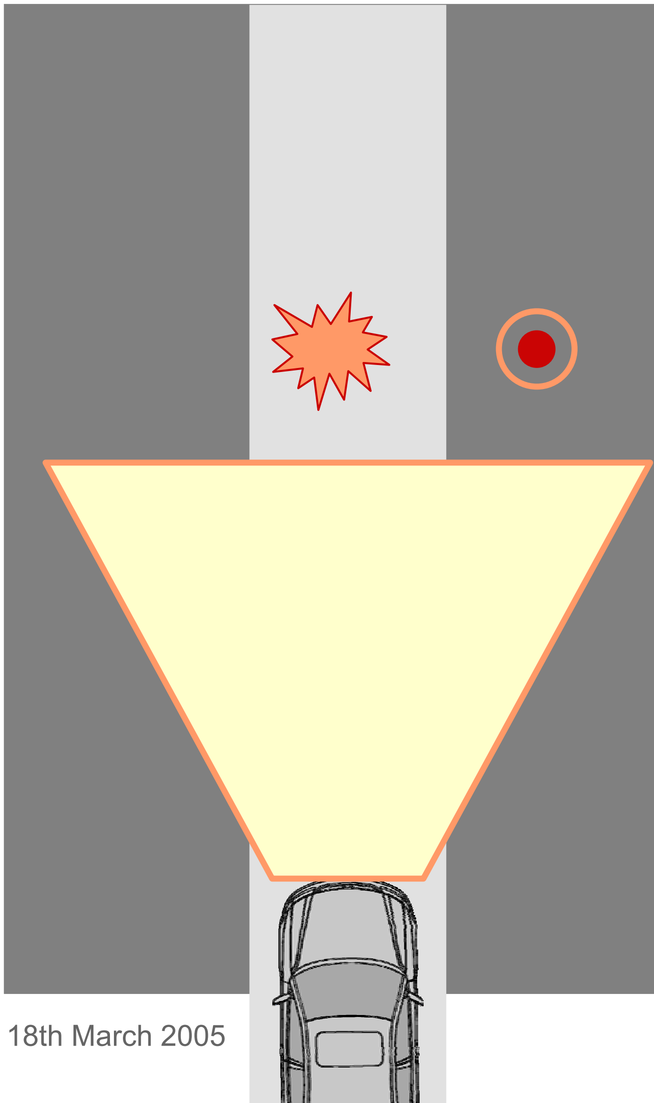
Pedestrian Warning



Examples

1. Pedestrian waits
2. **Pedestrian runs left**

Pedestrian Warning



Examples

1. Pedestrian waits
2. Pedestrian runs left
3. **Pedestrian walks left**

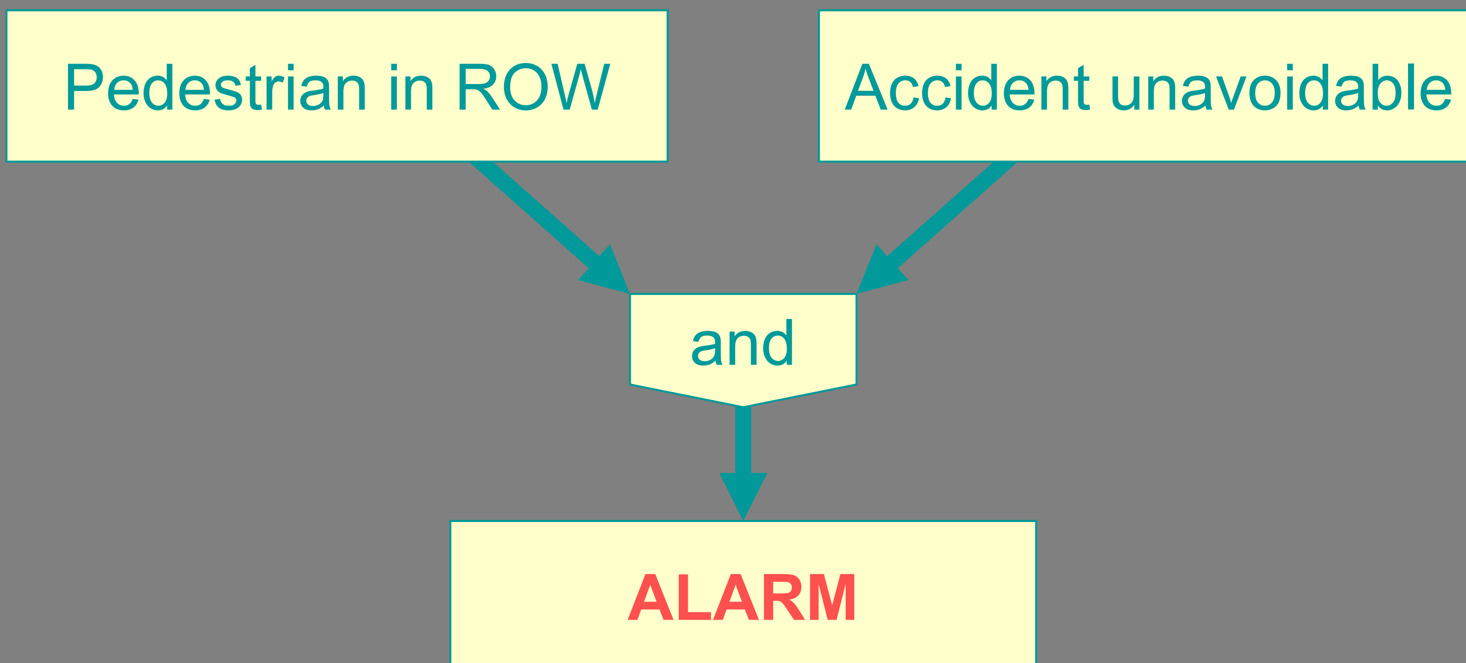
Pedestrian Warning – Summary

- Assist the driver to avoid car-to-pedestrian crashes
- Warning is needed more than 2 s before the potential car-to-pedestrian crash to enable the driver to react
- This introduces an amount of false warnings

Pedestrian Protection – Objectives

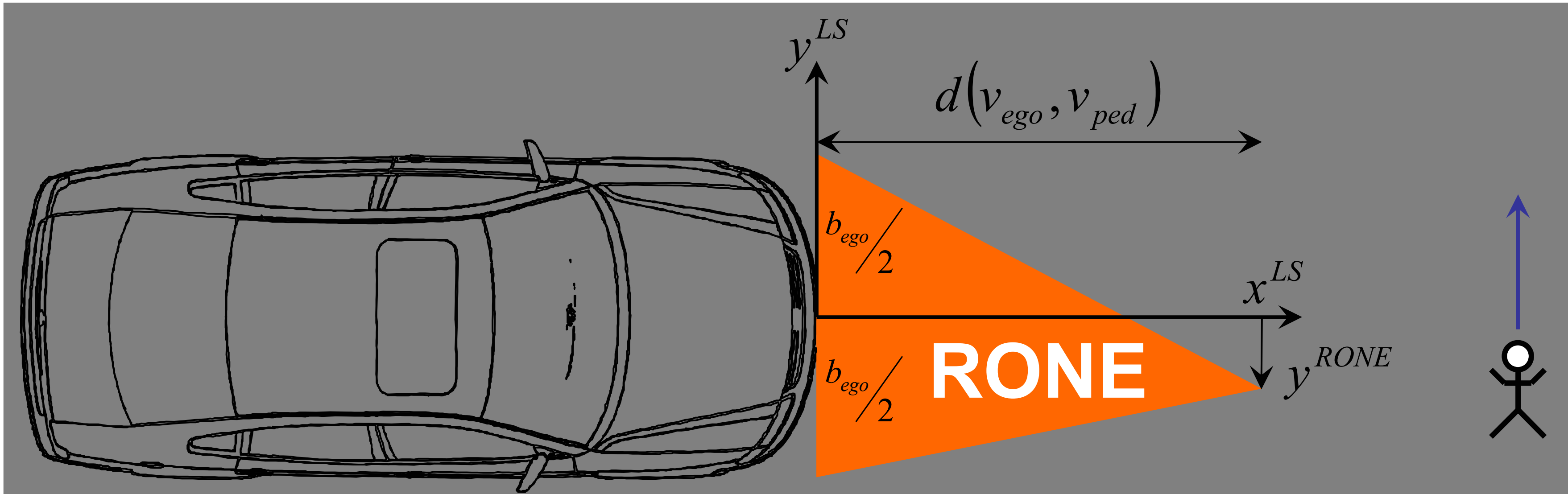
- Alarm up to 300 ms before an unavoidable car-to-pedestrian accident
- Application output:
  - Time To Collision (TTC)
  - Point of First Contact (PFC)

Pedestrian Protection



➔ **Region Of No Escape (RONE)**

Pedestrian Protection – RONE



$$T_{TTC} = -\frac{v_{ped,y}}{-a_{ego,y} + a_{ped,y}} + \sqrt{\left(\frac{v_{ped,y}}{-a_{ego,y} + a_{ped,y}}\right)^2 + \frac{b_{ego}}{-a_{ego,y} + a_{ped,y}}}$$

Pedestrian Protection – RONE

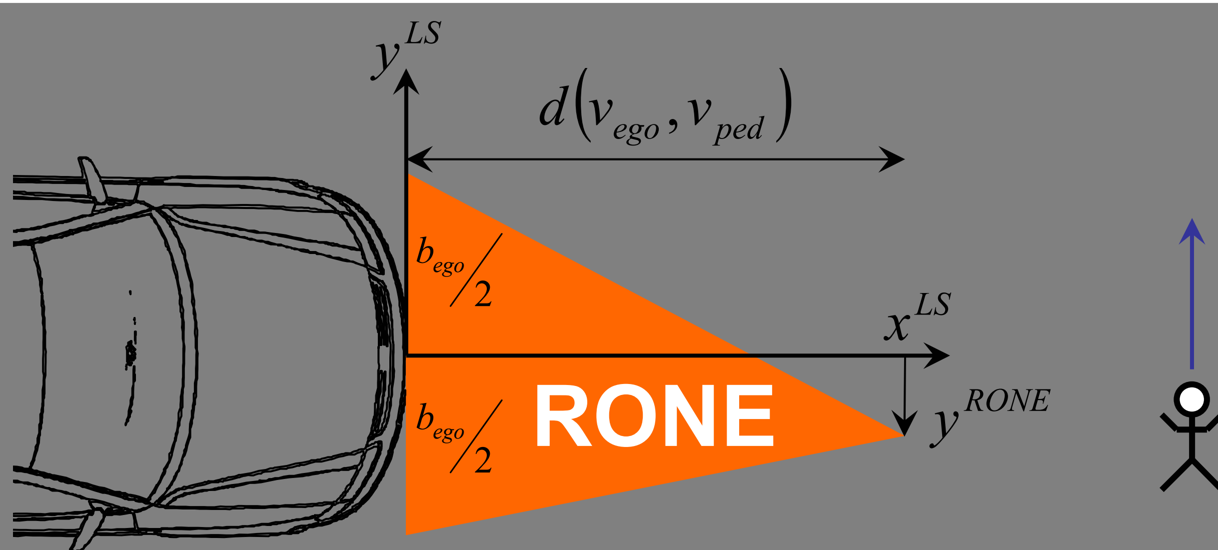
Assumptions:

$$a_{ego,y} = -10\ m/s^2$$

$$a_{ped,y} = 10\ m/s^2$$

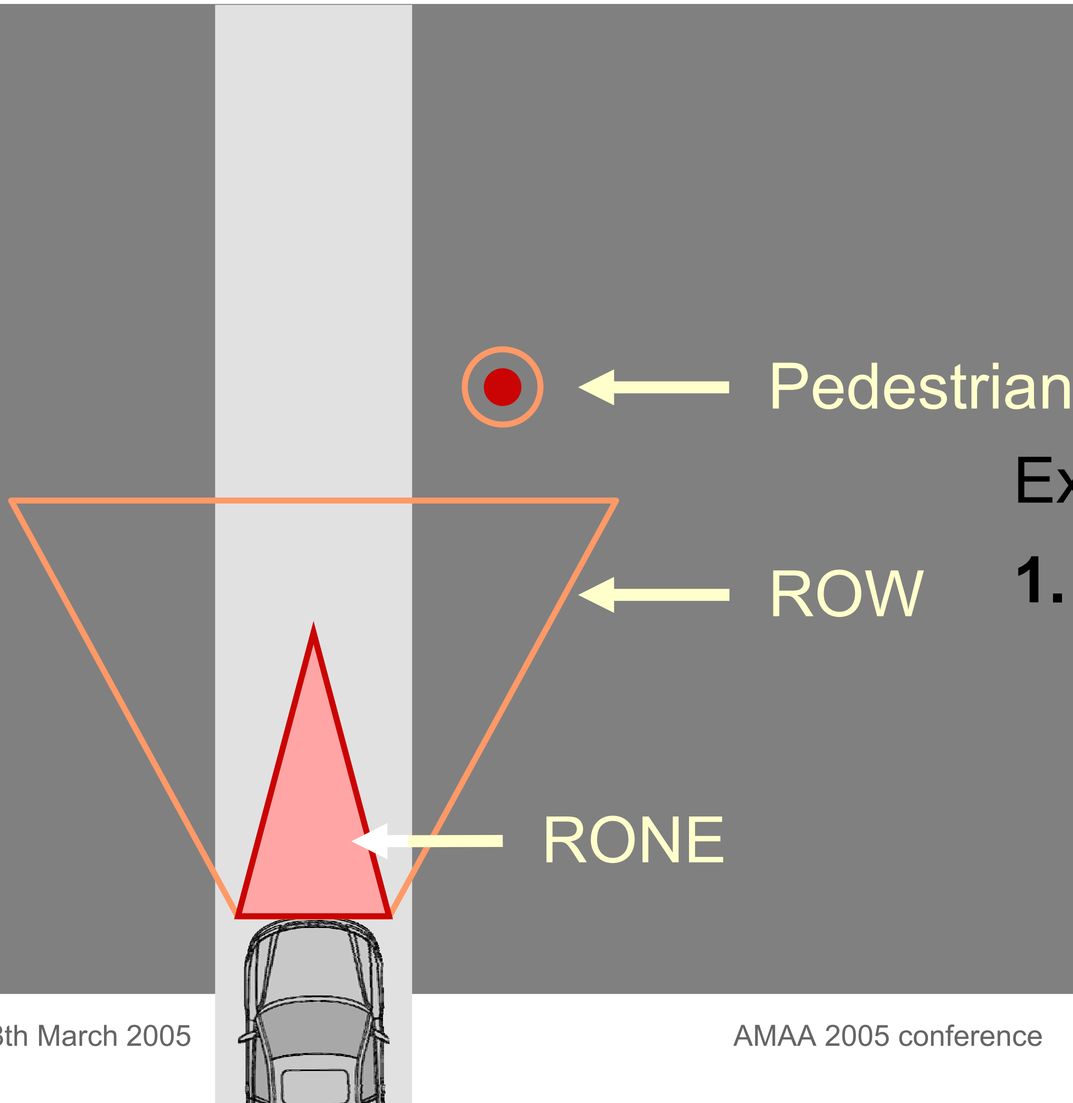
$$b_{ego} = 1{,}6\ m$$

$$v_{ped,y} = 2\ m/s$$



$$d(v_{ego}, v_{ped}) = (v_{ego,x} - v_{ped,x})\,T_{TTC} \Rightarrow \begin{cases} d(v_{ego} = 5\ m/s) = 1\ m \\ d(v_{ego} = 10\ m/s) = 2\ m \\ d(v_{ego} = 15\ m/s) = 3\ m \end{cases}$$

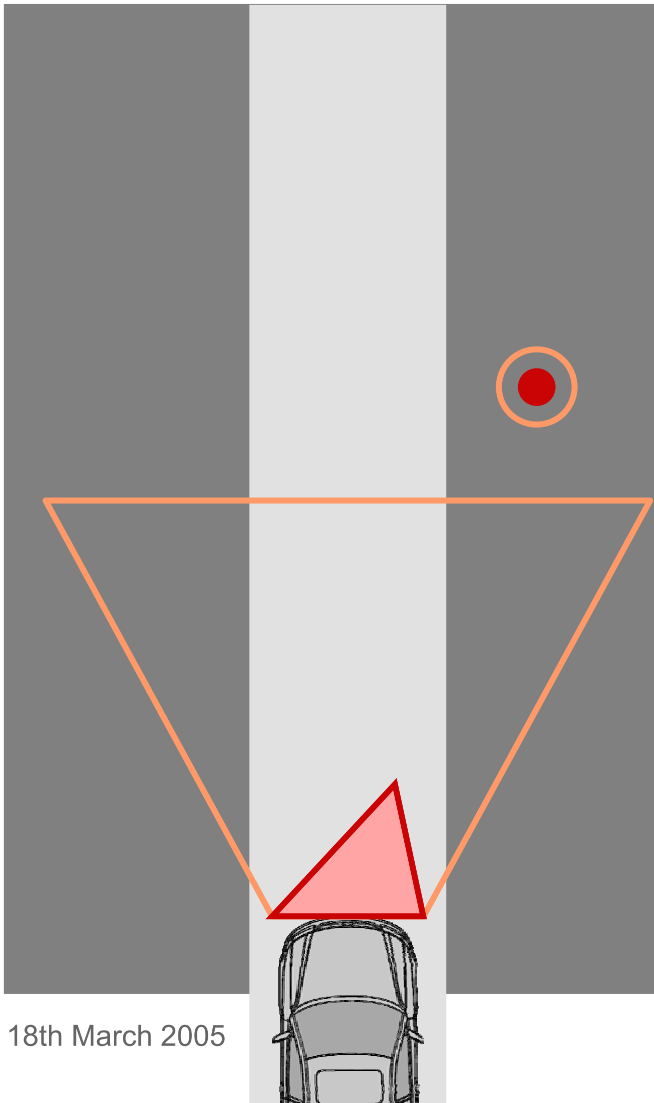
Pedestrian Protection



Examples

1. **Pedestrian waits**

Pedestrian Protection



Examples

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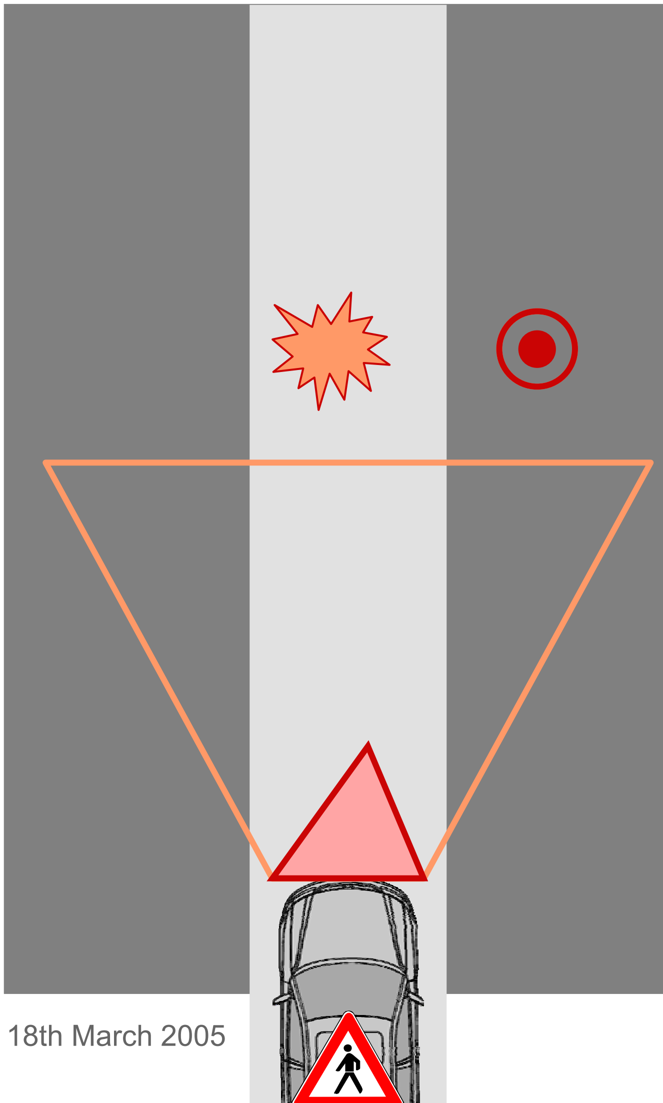
2. **Pedestrian runs left**

Pedestrian Protection

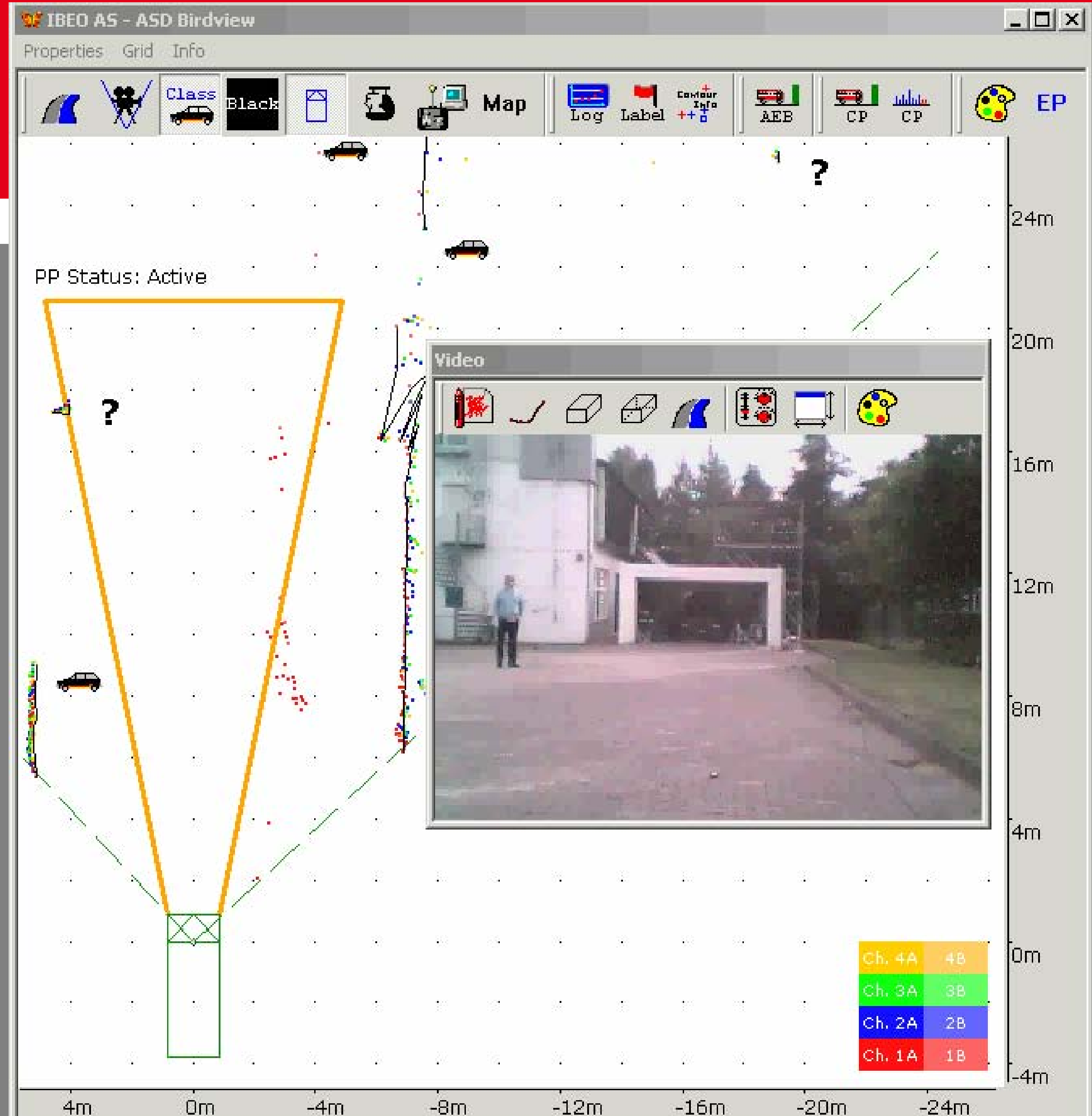


Examples

1. Pedestrian waits
2. Pedestrian runs left
3. **Pedestrian walks left**

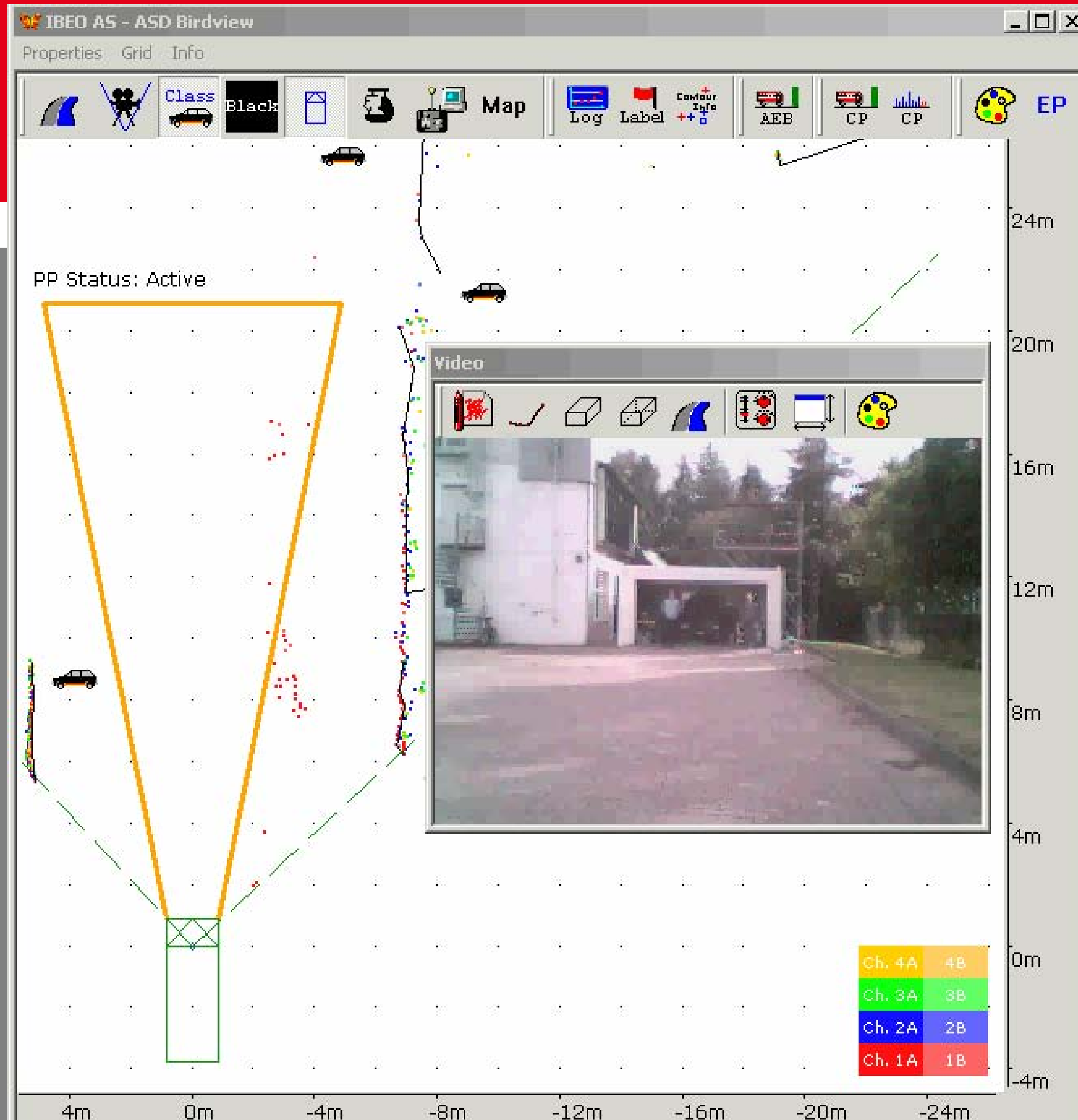
Scenario 1

- Demo mode: 36 kph virtual velocity
- Negative test: No collision with pedestrian.
- Pedestrian runs along RONE boundary



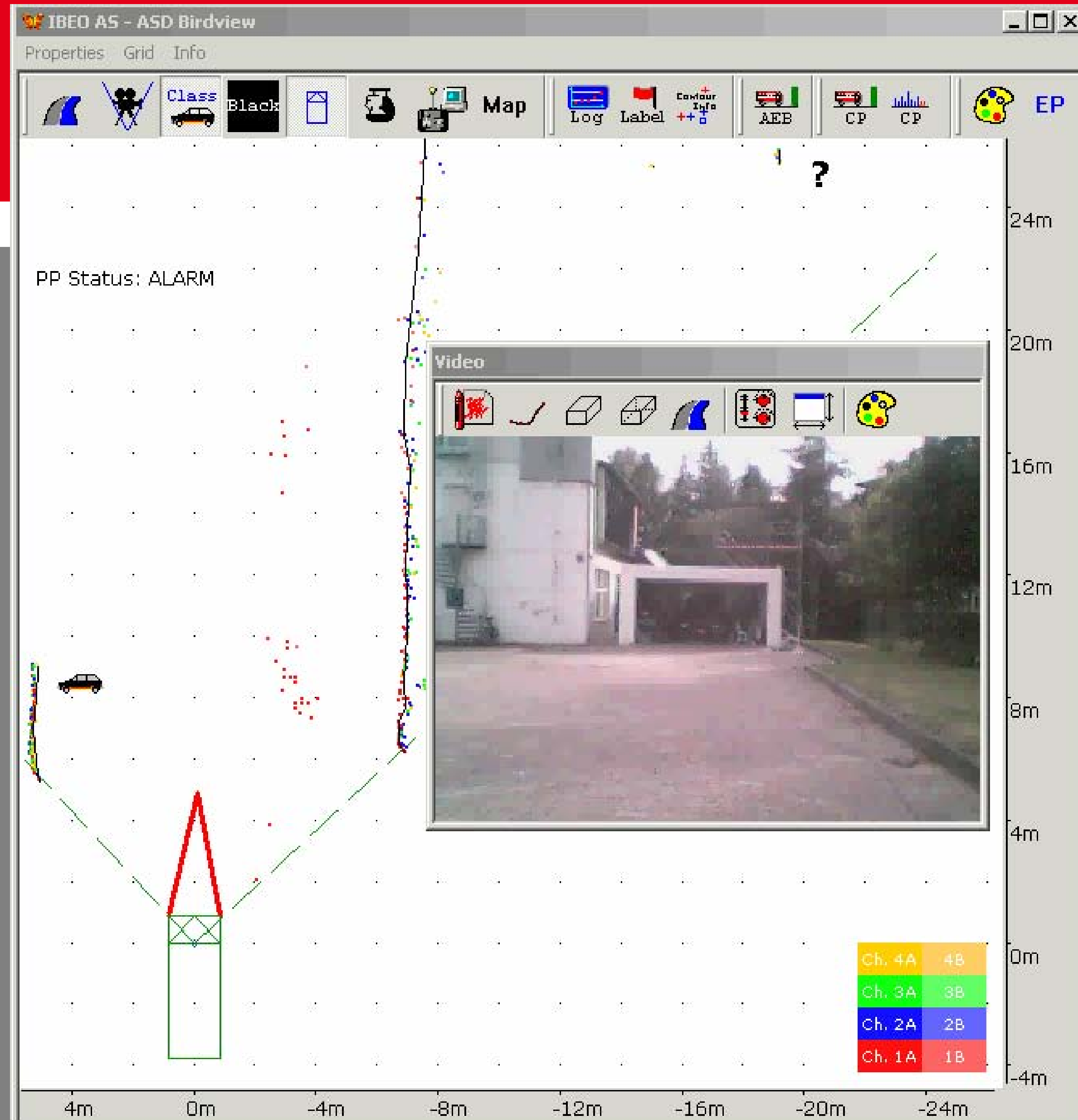
Scenario 2

- Demo mode: 36 kph virtual velocity
- Negative test: Two pedestrians in range
- Most relevant pedestrian alternates



Scenario 3

- Demo mode: 36 kph virtual velocity
- Positive test: Frontal crash with running pedestrian



Pedestrian Protection – Summary

- Alarms up to 300 ms before an unavoidable car-to-pedestrian accident
- Detection scenarios cover ⅔ of all car-to-pedestrian accidents
- Long pre-warn time allows reversible actuators
- Function proven by statistical analysis

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Thank you for your attention!