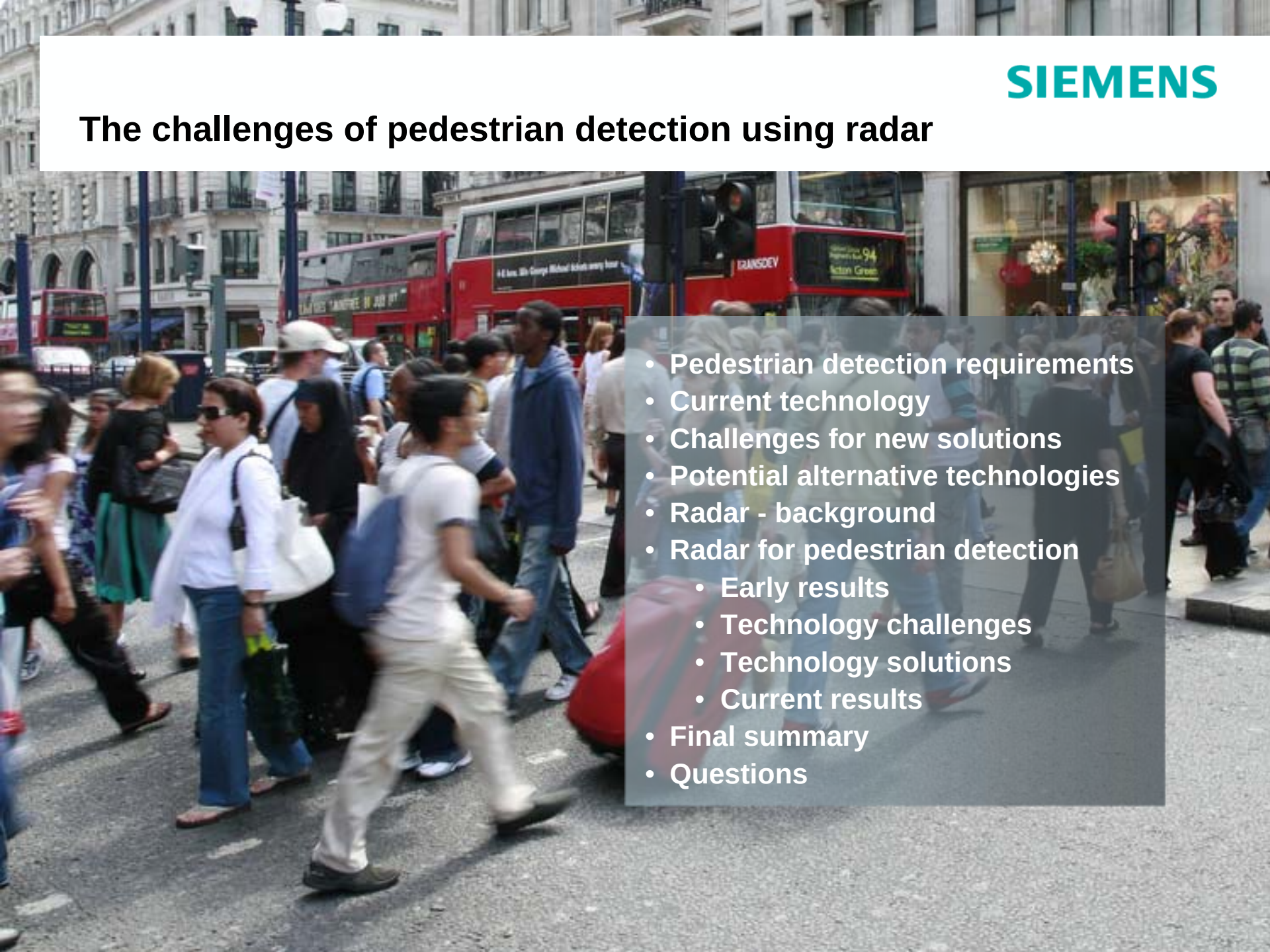
SIEMENS

The challenges of pedestrian detection using radar



- Pedestrian detection requirements
- Current technology
- Challenges for new solutions
- Potential alternative technologies
- Radar - background
- Radar for pedestrian detection
  - Early results
  - Technology challenges
  - Technology solutions
  - Current results
- Final summary
- Questions

Pedestrian detection requirements

Requirements for pedestrian detectors

→ **Formal specifications**

HA Specifications

- TR2506 - On crossing
- TR2507 - Kerbside

DfT publications

- TA 1/02
  (Installation of Puffin crossings)

Pedestrian detection requirements

Requirements for pedestrian detectors

- **Formal specifications**
- **Practical performance requirements**

Reliable detection

- Not affected by environmental conditions
- Static objects as well as people

Compatible with control equipment

- LV and ELV systems

Pedestrian detection requirements

Requirements for pedestrian detectors

- Formal specifications
- Practical performance requirements
- Generic requirements

Easy to install

- Ideally no special tools
- Simple installation concept
- No use of PCs on street

Easy to maintain

- Fit and forget
- No regular maintenance

Pedestrian detection that works well can significantly improve crossing efficiency

Current technology solutions

Above ground video solutions

Advantages

- Flexible detection zones

Disadvantages

- Performance in low light / at night difficult to achieve
  - Can be improved with IR illumination
- False detections due to shadows & changing light levels
- Use of PC set-up tools not ideal in some locations
- Requires regular lens cleaning to maintain performance
- Have a mixed performance and reliability reputation

Pedestrian mats (Kerbside)

Advantages

- Not affected by shadows or other environmental conditions

Disadvantages

- Generally poor wait area coverage
  - Often requires special signage
- Can be difficult / costly to install
  - Requires civils works
  - Not easy to retrofit to existing site
- Long term reliability not proven
  - Only limited installed base so far

Doppler radar (On crossing)

Advantages

- Not affected by shadows or changing light levels
  - Works equally well in daylight and at night
- Relatively easy to install
  - No special tools generally required

Disadvantages

Will only detect moving targets

- Not suitable for kerbside applications

Challenges for new solutions

Key requirements

Reliable detection

- Not affected by shadows or other environmental considerations
  - Fog, rain, wind etc
- Works equally well in daylight and at night
- Easy to install
  - Ideally should not require special tools or the use of a PC
- Should not require frequent on-going maintenance
- Will cover the whole crossing or pedestrian wait area
  - Should not require special signage or pedestrian behaviour to be effective
- For kerbside applications, is able to detect totally static objects including small children and pushchairs

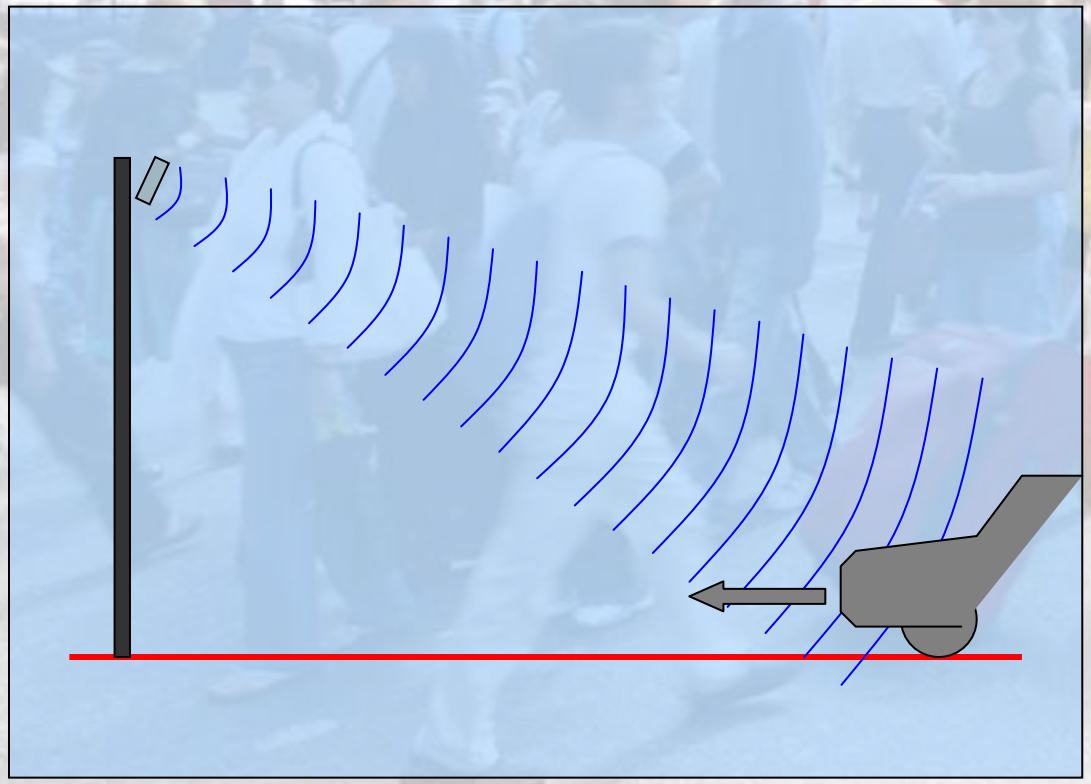
Possible above ground technologies

Technology	Advantages	Disadvantages
Passive Acoustic	• Passive so can be very low power • Accurate zones if multiple sensors used • Immune to changing light levels • Relatively low cost • No significant maintenance required	• Not good for detecting slow / static traffic • Can be affected by environment (rain / snow etc)
Active Acoustic	• Immune to light levels • Relatively low cost • No significant maintenance required	• Difficult to achieve precise detection zone • Heavy rain / wind and snow can severally affect performance
24GHz Radar	• Immune to changing light levels • Relatively accurate zones possible • No significant maintenance required • Costs attractive compared to higher frequency radar solutions	• Active device so needs regulatory approval in all target markets
Passive Infrared	• Passive so can be very low power • Reasonably accurate zones possible • Relatively low cost • No significant maintenance required	• Can be affected by significant sudden temperature shifts • Fog and heavy snow can affect performance
Video	• Many accurate zones possible (if field of view permits) • Can provide visual overview of target area	• Can be badly affected by changing light levels and environmental conditions (Rain, snow etc). • Significant maintenance overhead

Radar - background

Radar has been successfully used in traffic applications for many years

Most existing radar solutions use CW Doppler principals



Operational principals

- Single frequency microwave energy is continuously beamed at target zone

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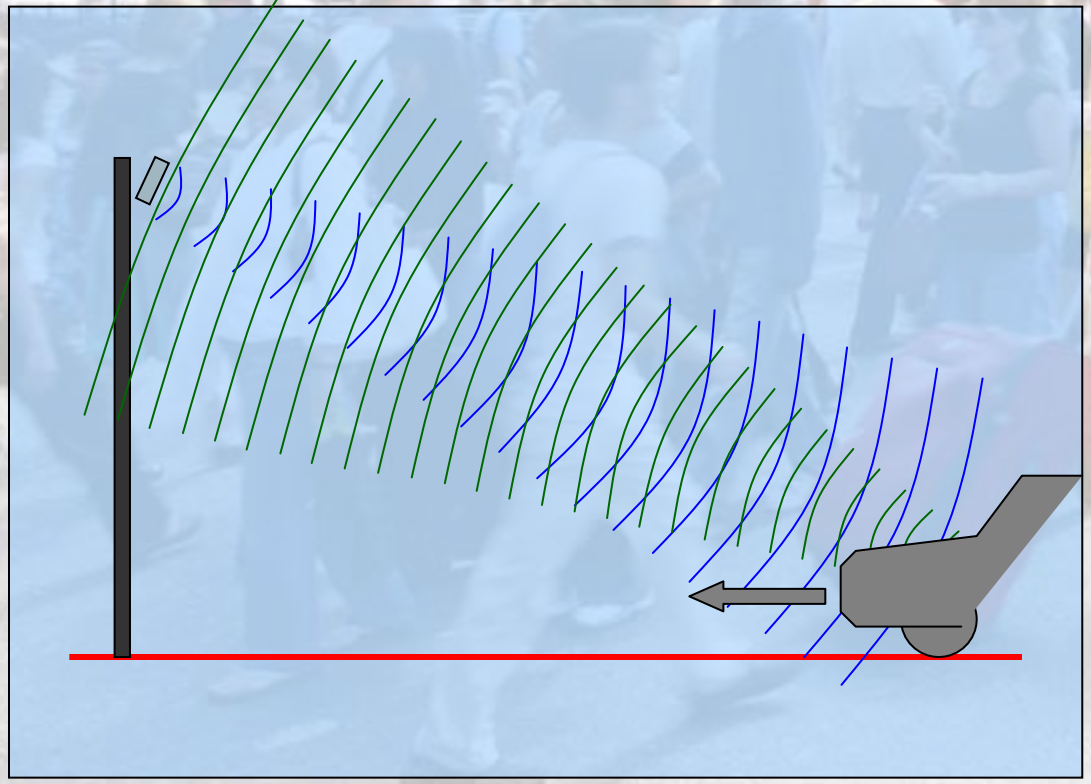

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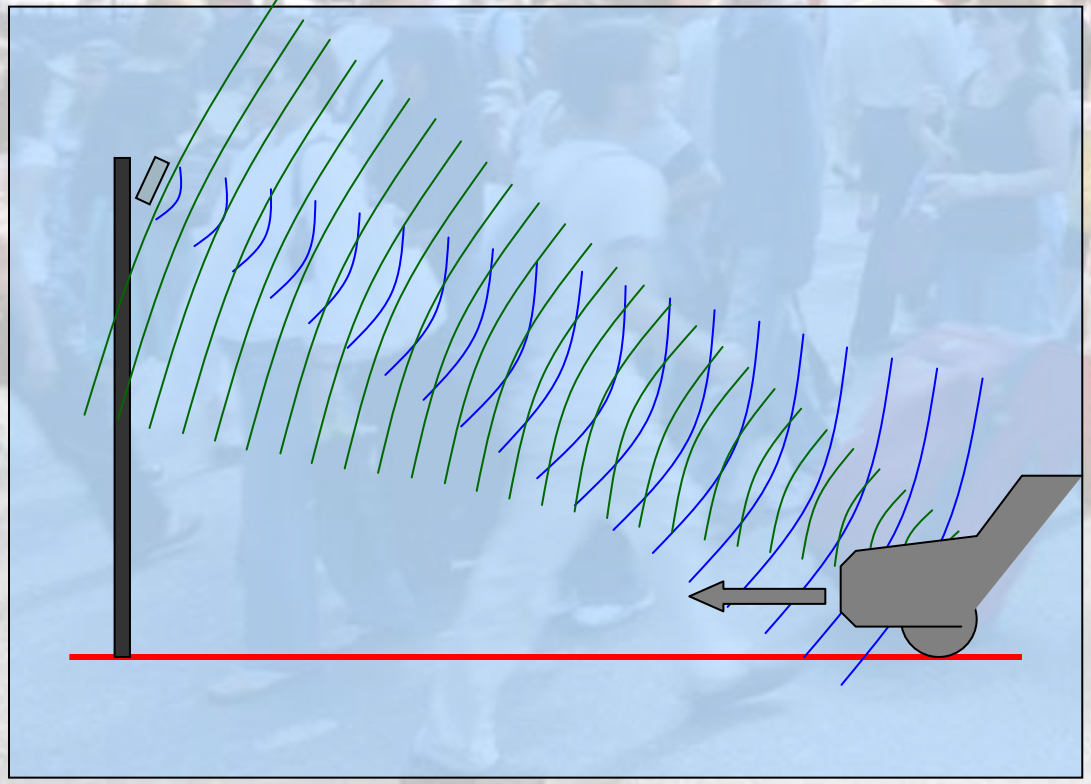

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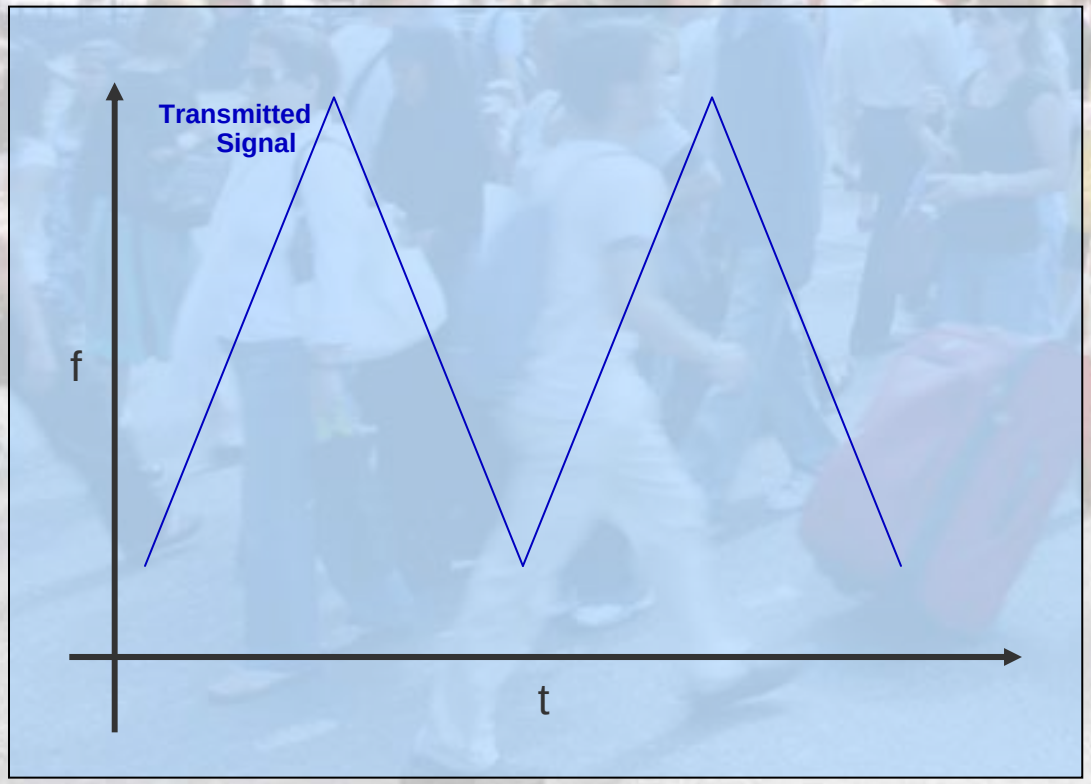
- Doppler radar solutions are relatively simple
  - Ideal for VA detection
  - Also work well for pedestrian on-crossing solutions
- Heimdall on-crossing detectors use Doppler radar principals.

Radar - background

Detection of static targets using radar is more challenging

FMCW techniques offer a viable solution



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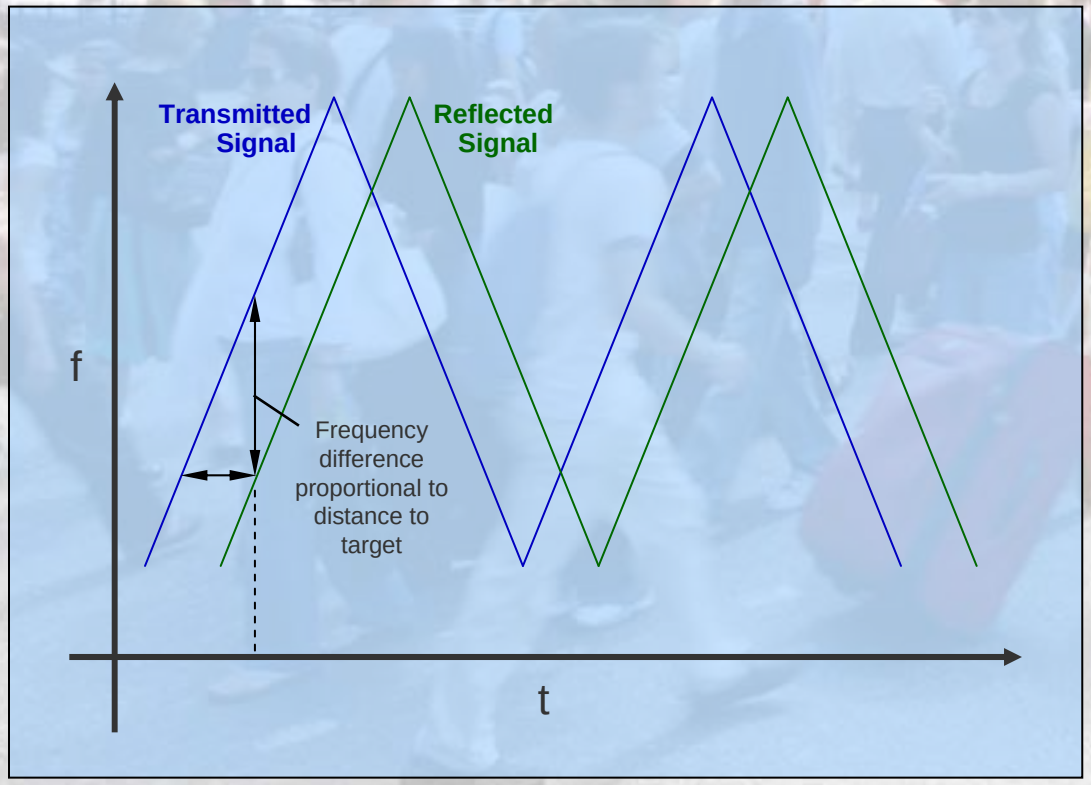

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  - Range resolution and accuracy can be improved by using larger sweep frequencies and faster sweep rates

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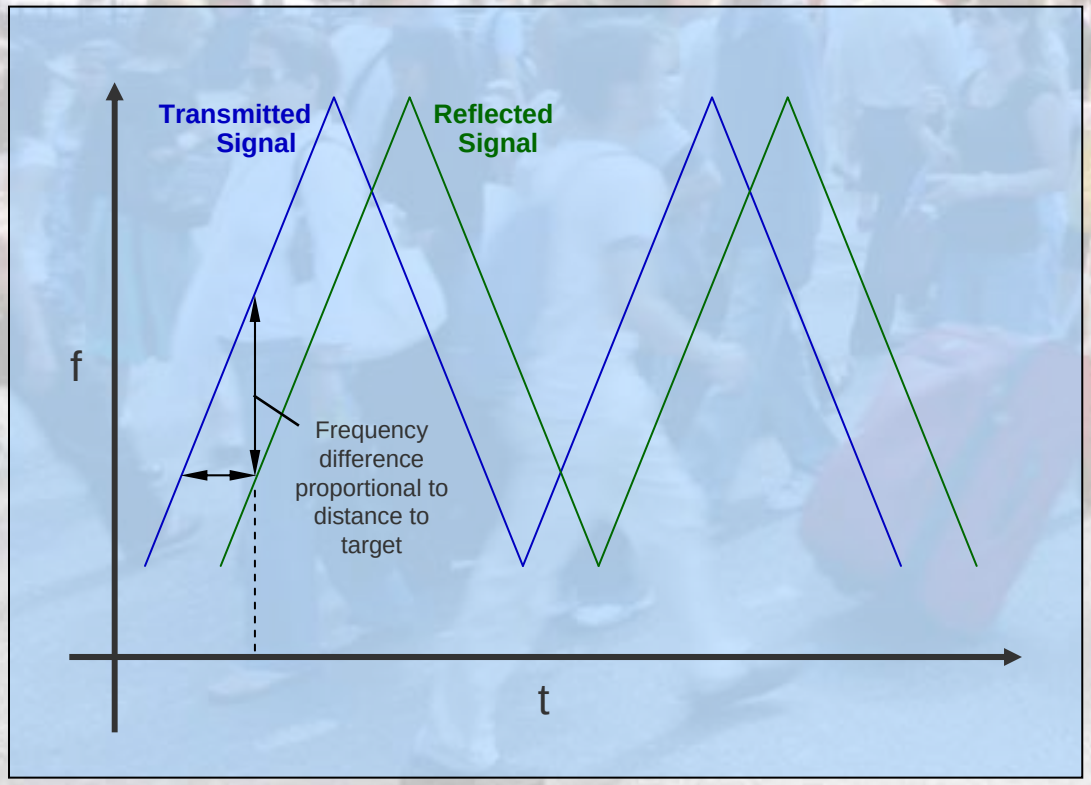

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- Completely static targets can be resolved
  - Moving targets can also be resolved by combining FMCW and Doppler techniques
- In principal FMCW radar seems to provide a good solution for kerbside pedestrian detection

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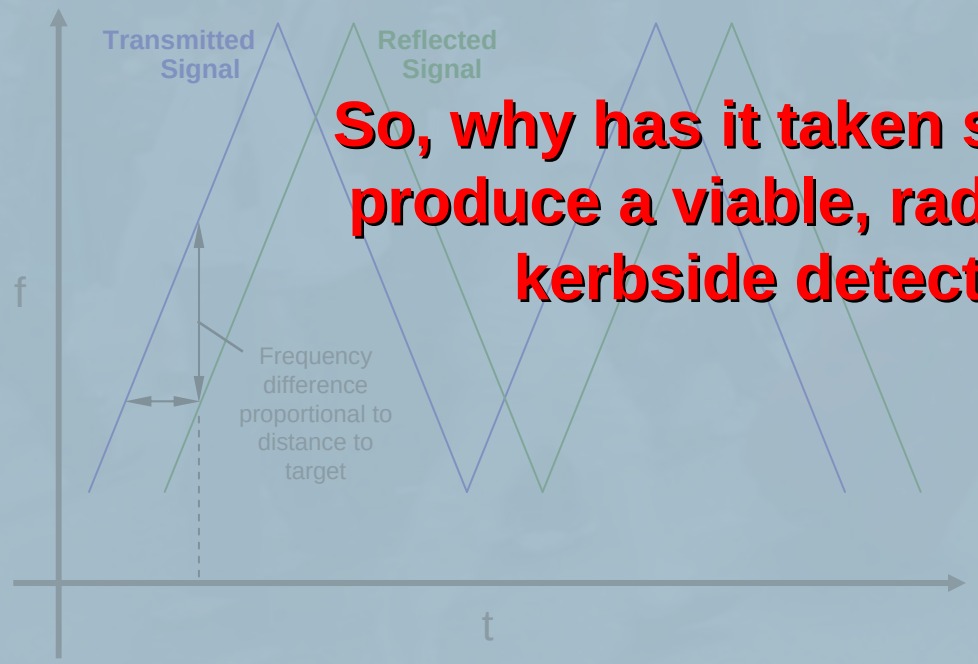

So, why has it taken so long to produce a viable, radar based kerbside detector?

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Heimdall - early results

Early Heimdall development based on 24GHz technology

Choice of 24GHz offers several benefits

- Useable frequency band in many countries
- Reasonable cost position
  - Much cheaper than 77GHz solutions
- Higher frequency than most existing radars used in traffic applications
  - Believed to offer better target resolution than lower frequencies

Successful in delivering a range of detection solutions

- SCOOT / MOVA
- Stop-line
- VA detection

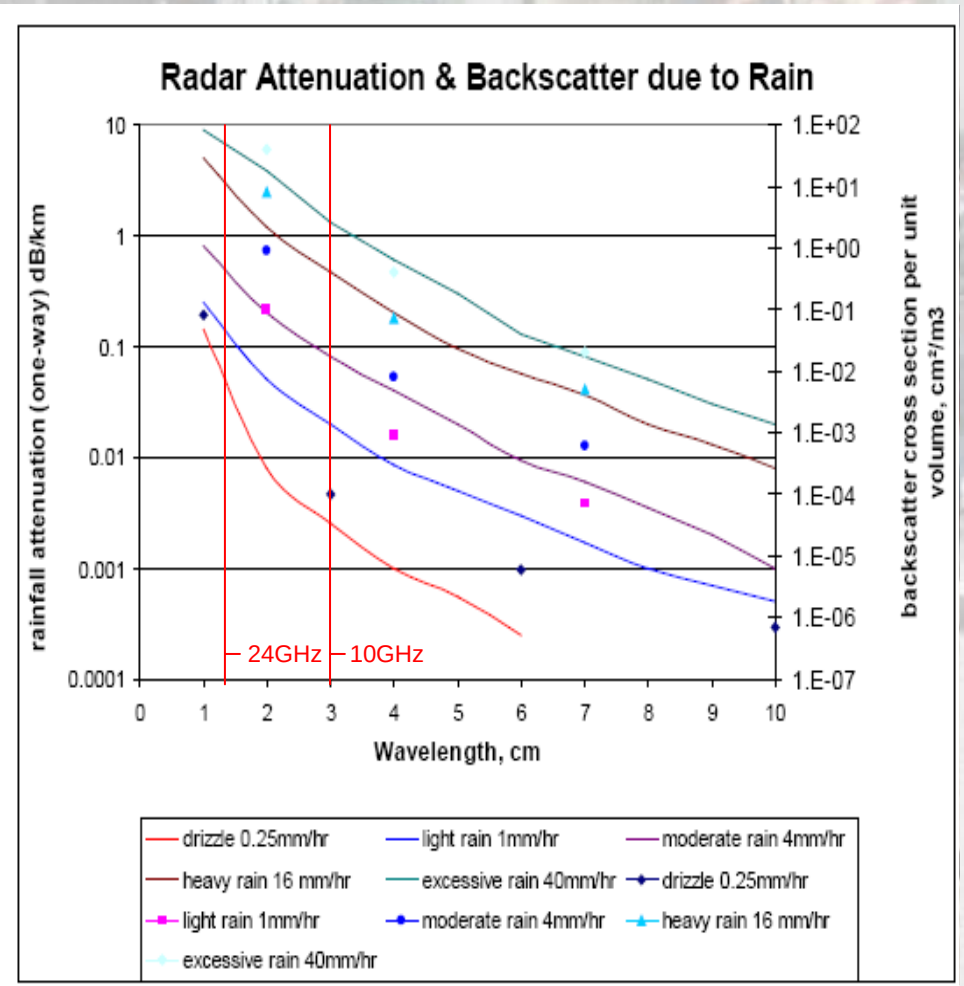
Did not deliver sufficiently good performance to be used in on-crossing and kerbside applications

Kerbside application is the most challenging

Initial performance concerns

Susceptibility to rain

- Rain has no significant impact on range as targets are always relatively close
- Significant ‘backscatter’ encountered at 24GHz
- Major issue for pedestrian detection, when detectors are generally looking down
  - Acts to reduce detector sensitivity



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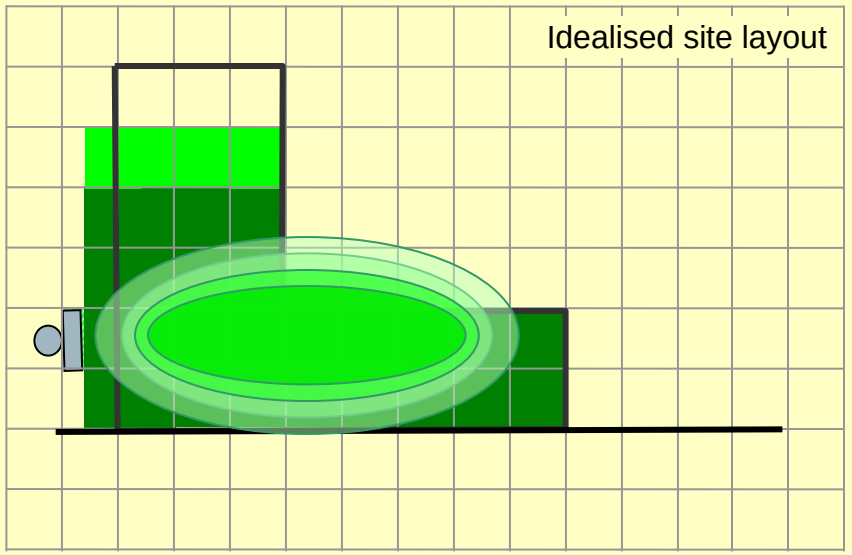
  - Difficult trade-off between zone size and susceptibility to rain
- Required kerbside zone requirements not easy to deliver with simple radar
- Very difficult to achieve good performance ‘close to the pole



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Pole vibration

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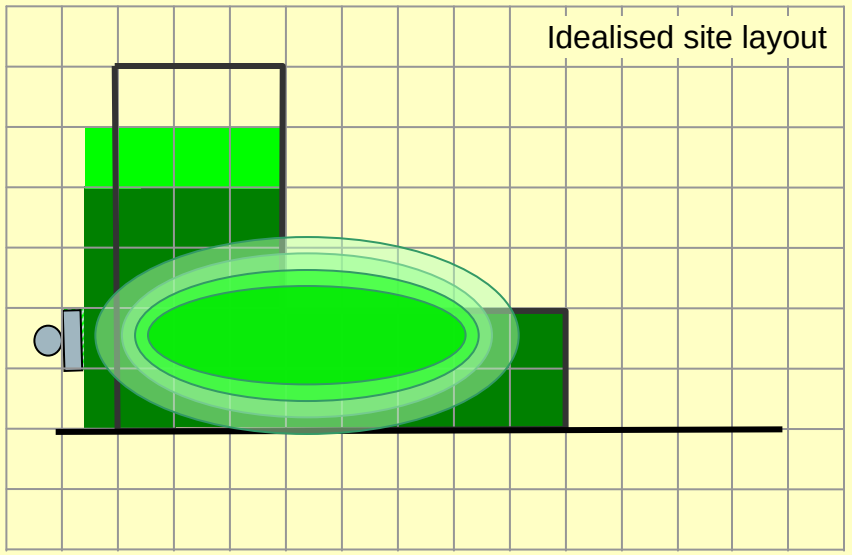

Initial performance concerns - actual performance

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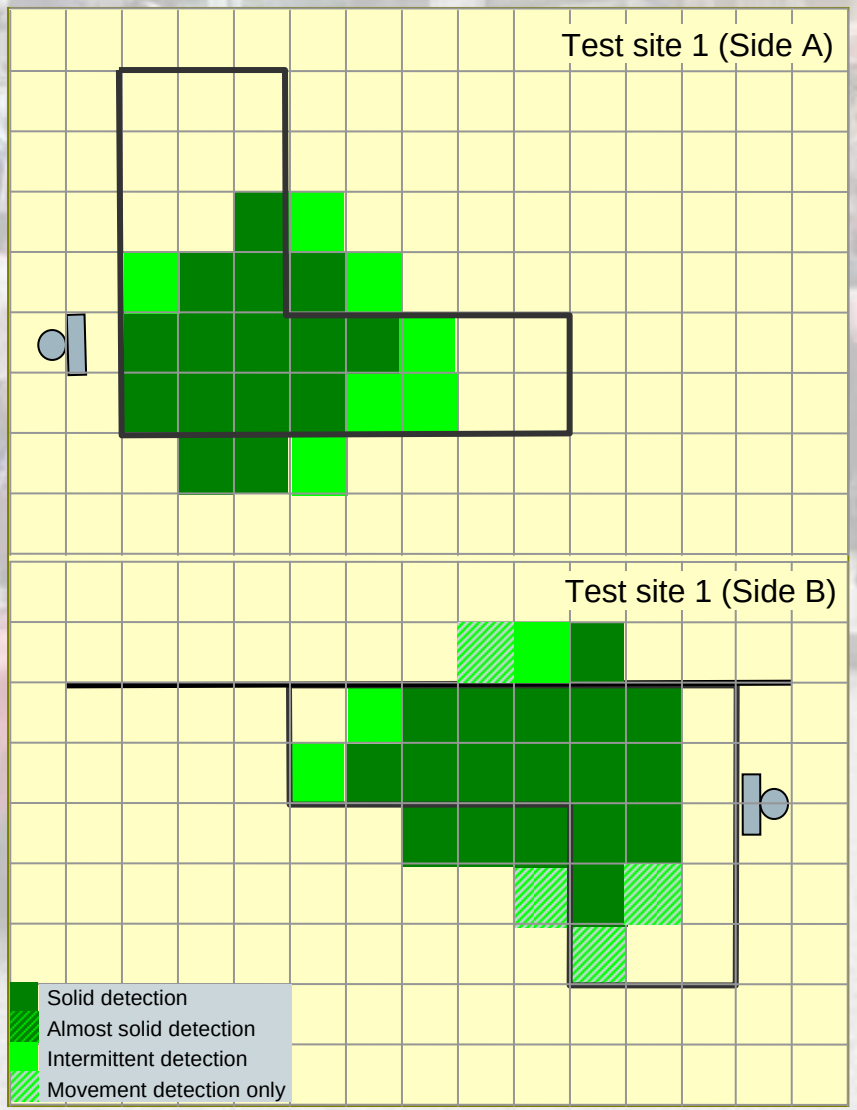


Design changes for success

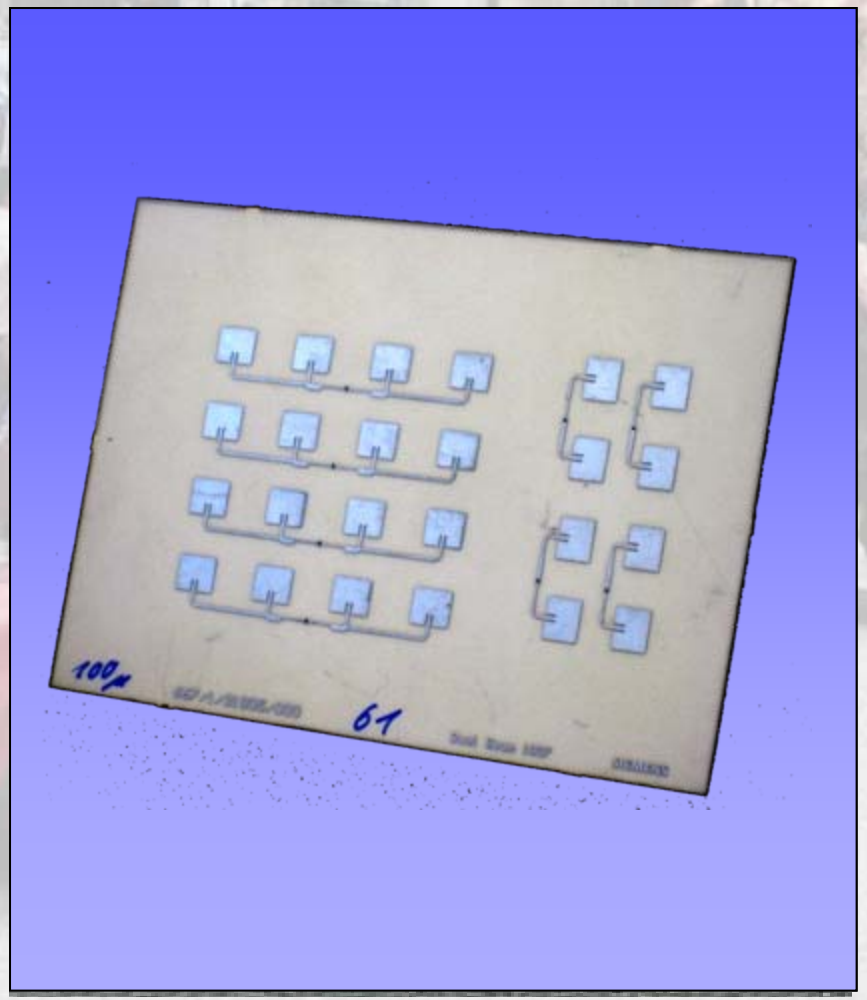
Key to success has been a change in approach for the pedestrian versions of Heimdall

Change in frequency to 13GHz

- Effect of ‘back scatter’ from rain is much reduced
  - Enables bigger zones to be achieved
- Offers higher bandwidth allocation than either 24GHz or 10GHz
  - Improved target resolution
  - Allows better discrimination of ‘pole’ and people

Use of innovative dual antenna design

- Provides much better zone shape for kerbside applications



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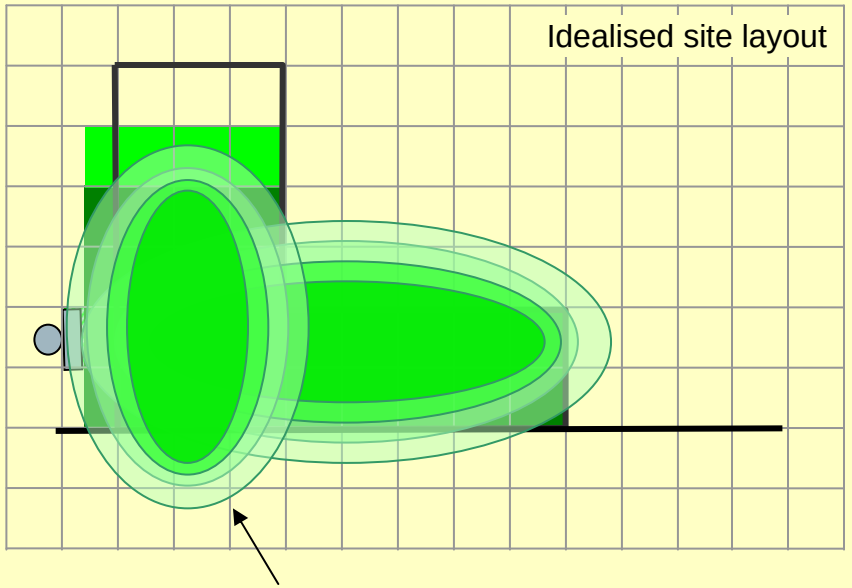
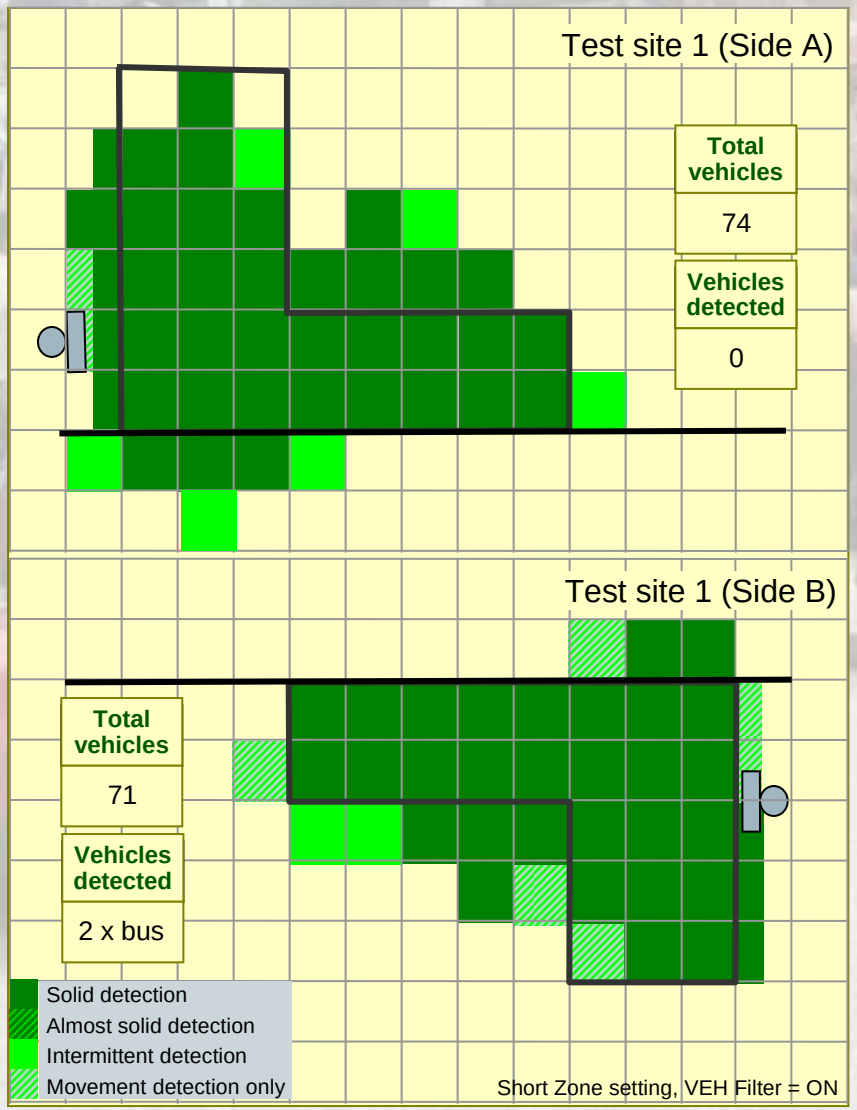


Some concern over detection of vehicles travelling close to the kerb

Actual kerbside performance

Heimdall pedestrian detection now delivers good performance

- Zone sizes adequate for most applications
  - Zone length adjustable with simple DIL switch setting
- Not affected by light levels, shadows etc
- Can reliably detect completely static targets
- False vehicle detection rate very low due to special vehicle rejection algorithm
- Installation and set-up very simple
  - Does not need PC or special software tools to be used ‘on-street’
  - Does require correct sighting to avoid signal head hoods etc
    - Can see through hoods to some extent
    - Only limited ability to adjust zones



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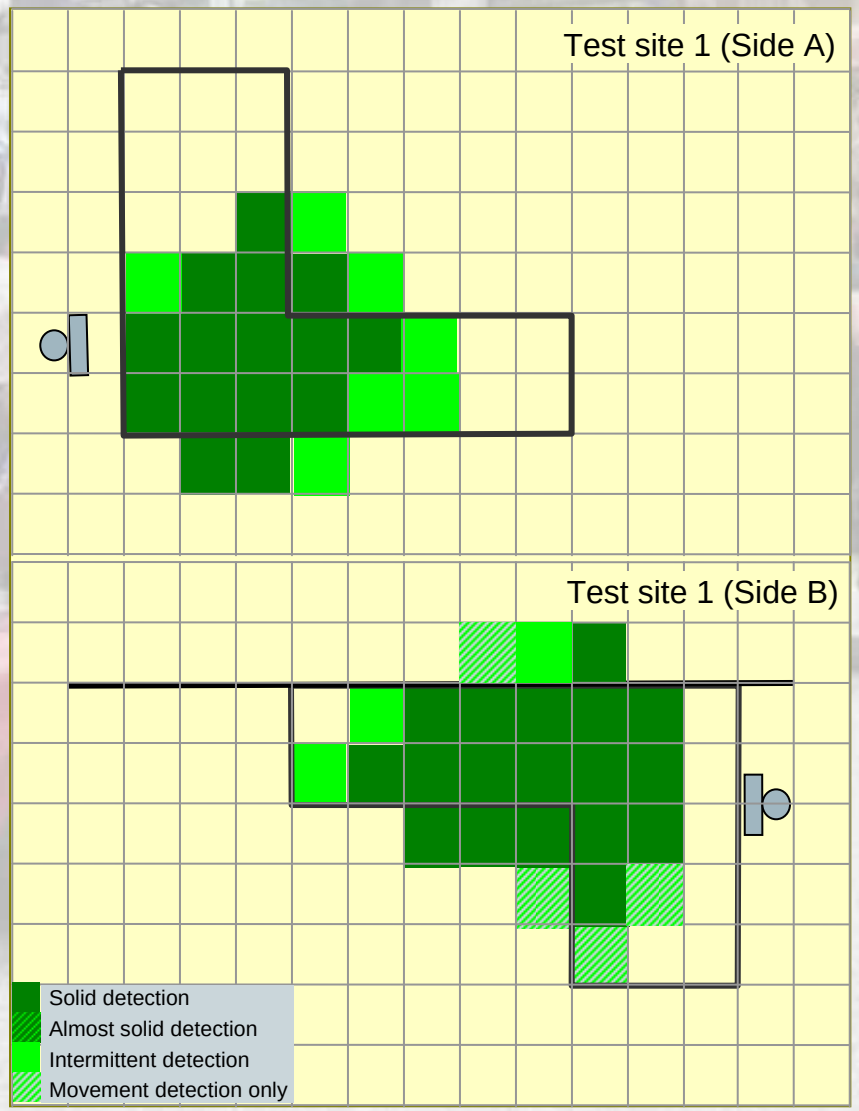

Heimdall range

Heimdall now offers a complete range of vehicle and pedestrian detection solutions

Vehicle types
- Standard vehicle
- Single lane vehicle
- Stop line
- Selectable vehicle speed
- SCOOT / MOVA

Pedestrian types
- On-crossing
- Kerbside

All types use radar principals and offer reliable detection performance under all lighting conditions

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Questions?

SIEMENS

The Challenges of pedestrian detection using radar