Measurement of Train Ground Speed by exploring Vehicle Dynamics with Intelligent Data Processing

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What we do at Salford

- CASE Control and Systems Research Centre

  → Engineering 2050 Research Centre
- Rail Related Research
  - Active Control (applied to wheels/wheelsets)
  - Traction, in particular wheel slip control
  - Condition monitoring (vehicles), e.g. FDI and contact conditions
  - Fault tolerant control and operations
  - System optimisation
  - Transport modelling
  - Rail bridges (structures)

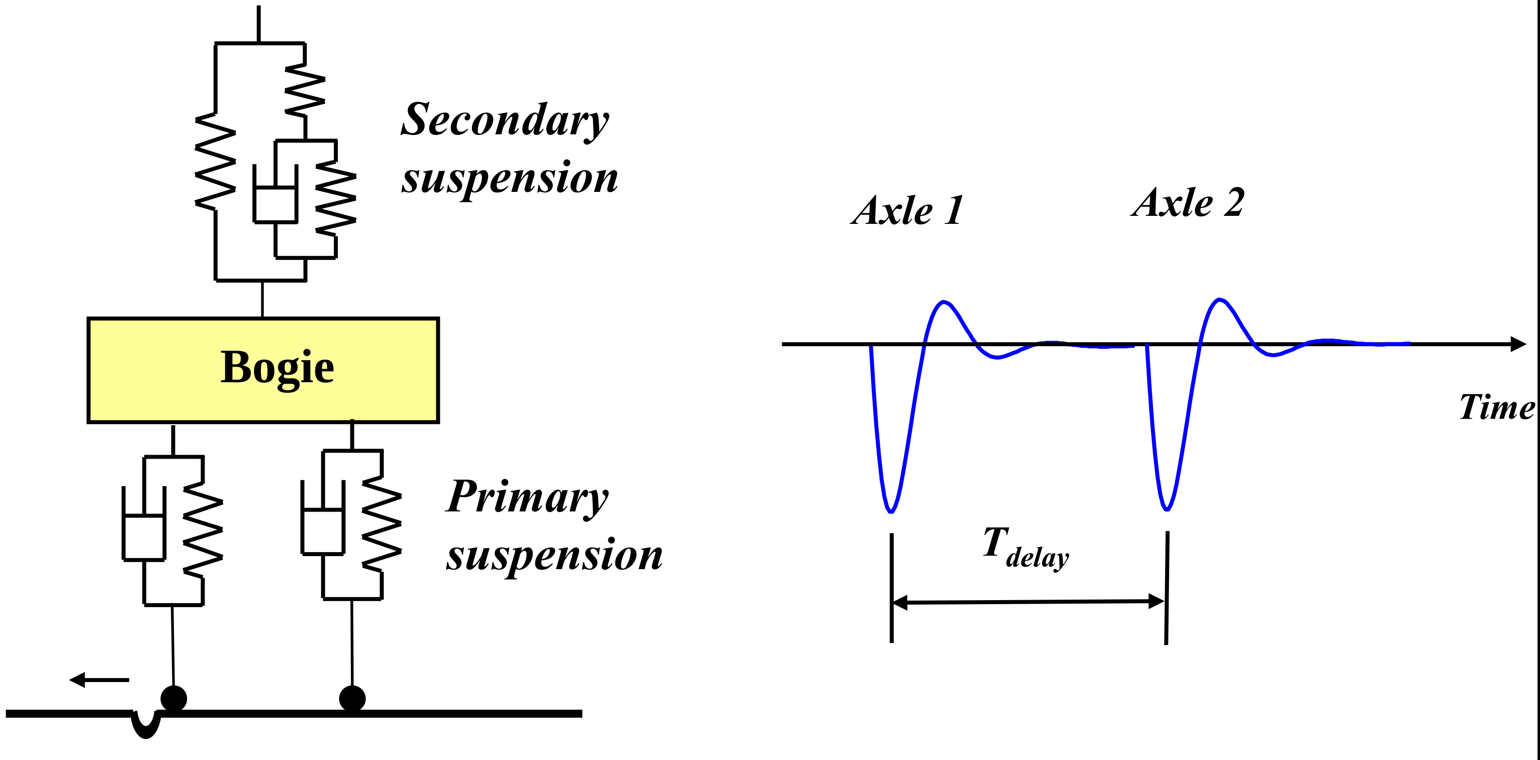
Introduction

- Conventional method
  - Encoders to measure the rotational speed of wheelset axles
- Problem with this method
  - Wheel slip/slide in poor contact condition
  - Variation of wheel diameters
  - Limited pulse number from encoders

Introduction

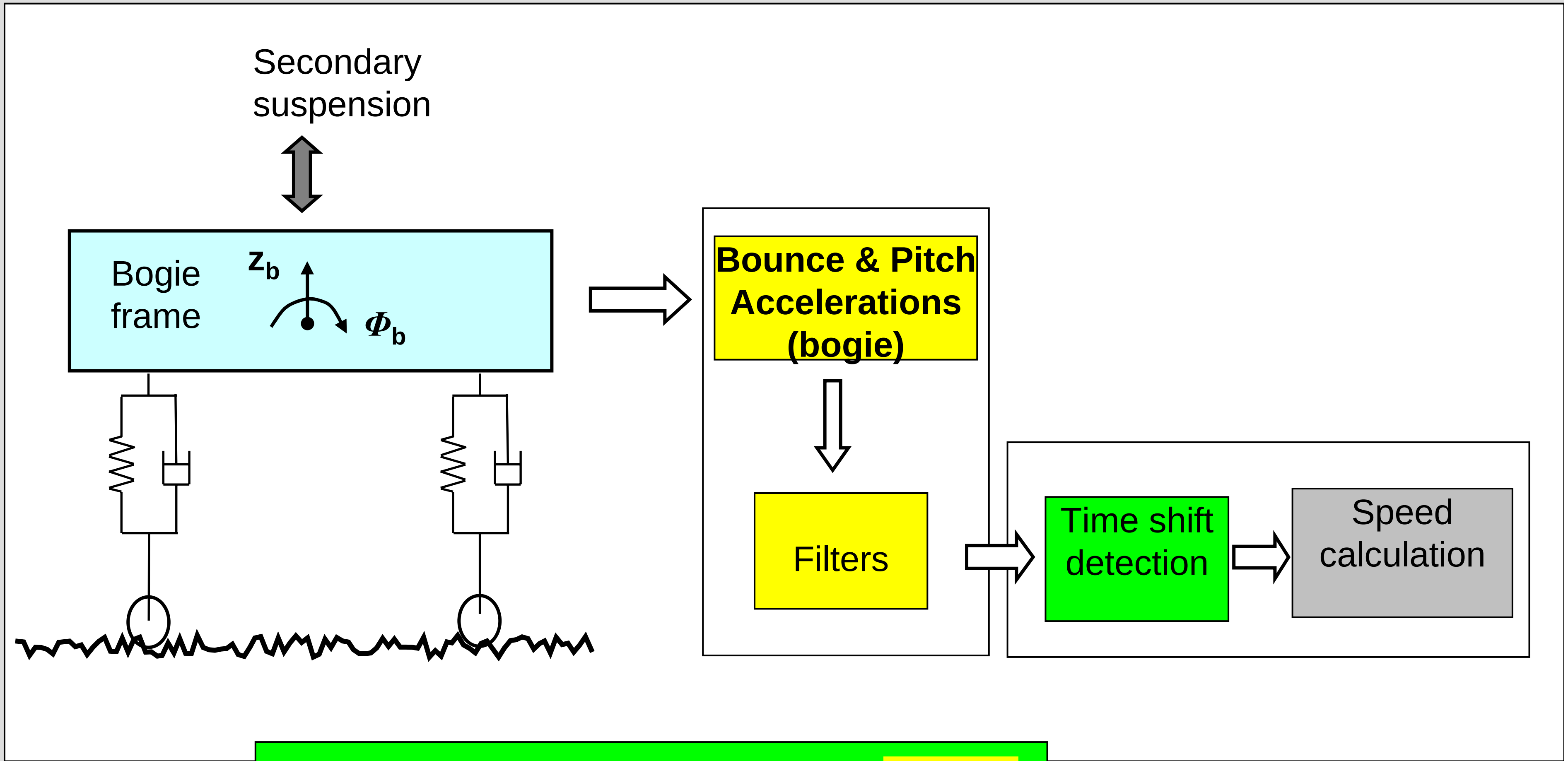
- Alternative methods
  - Radar sensors
  - Eddy current sensors
  - Optical sensors
  - Others

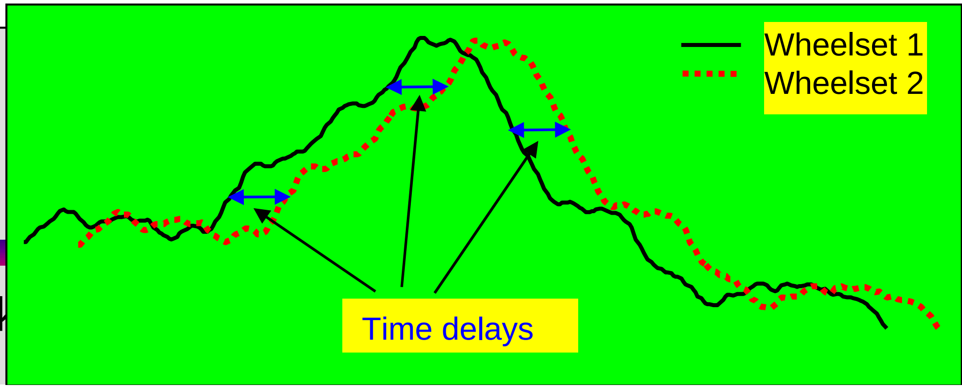
Basic Idea



A bogie travelling over a ditch on the track

Proposed solution

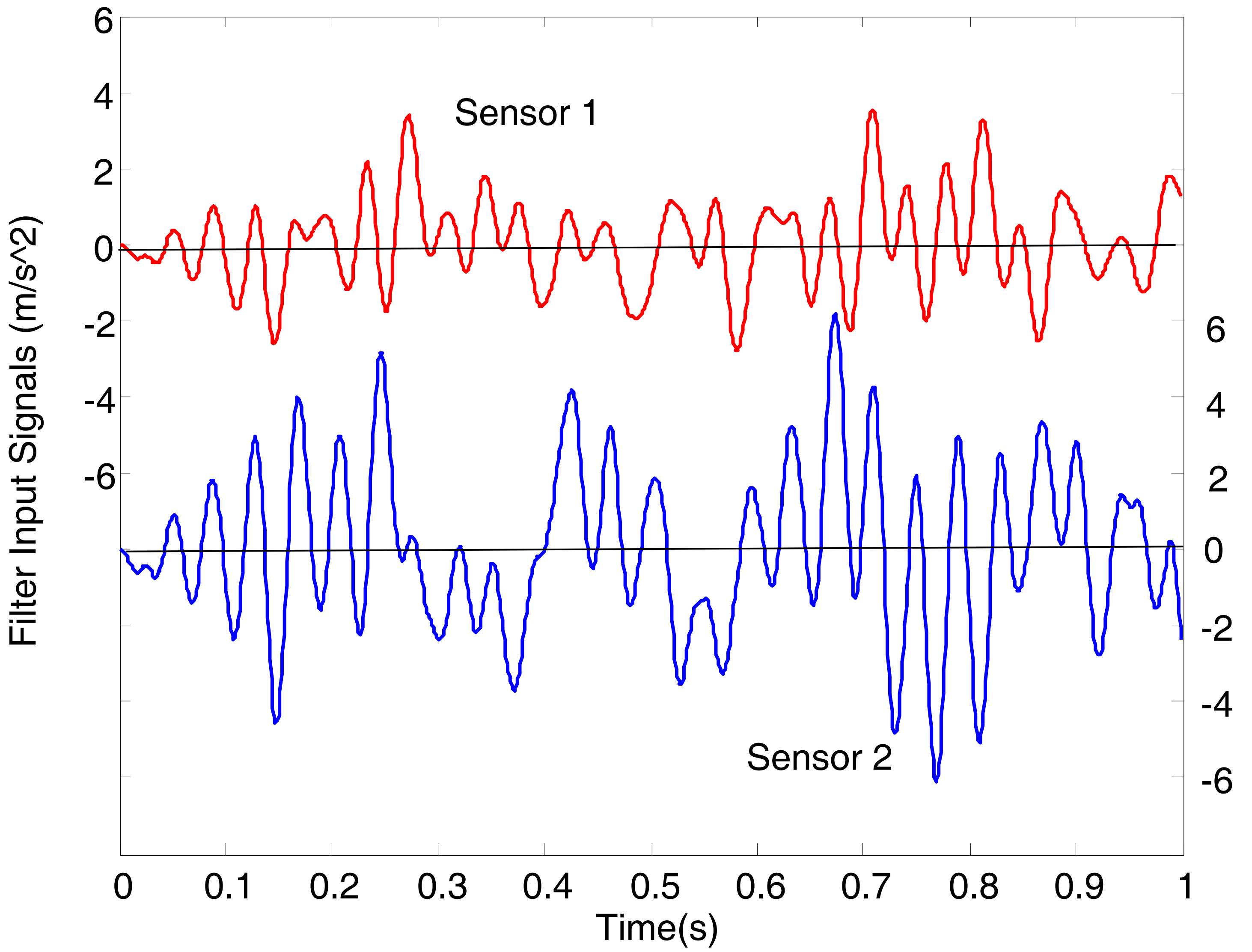




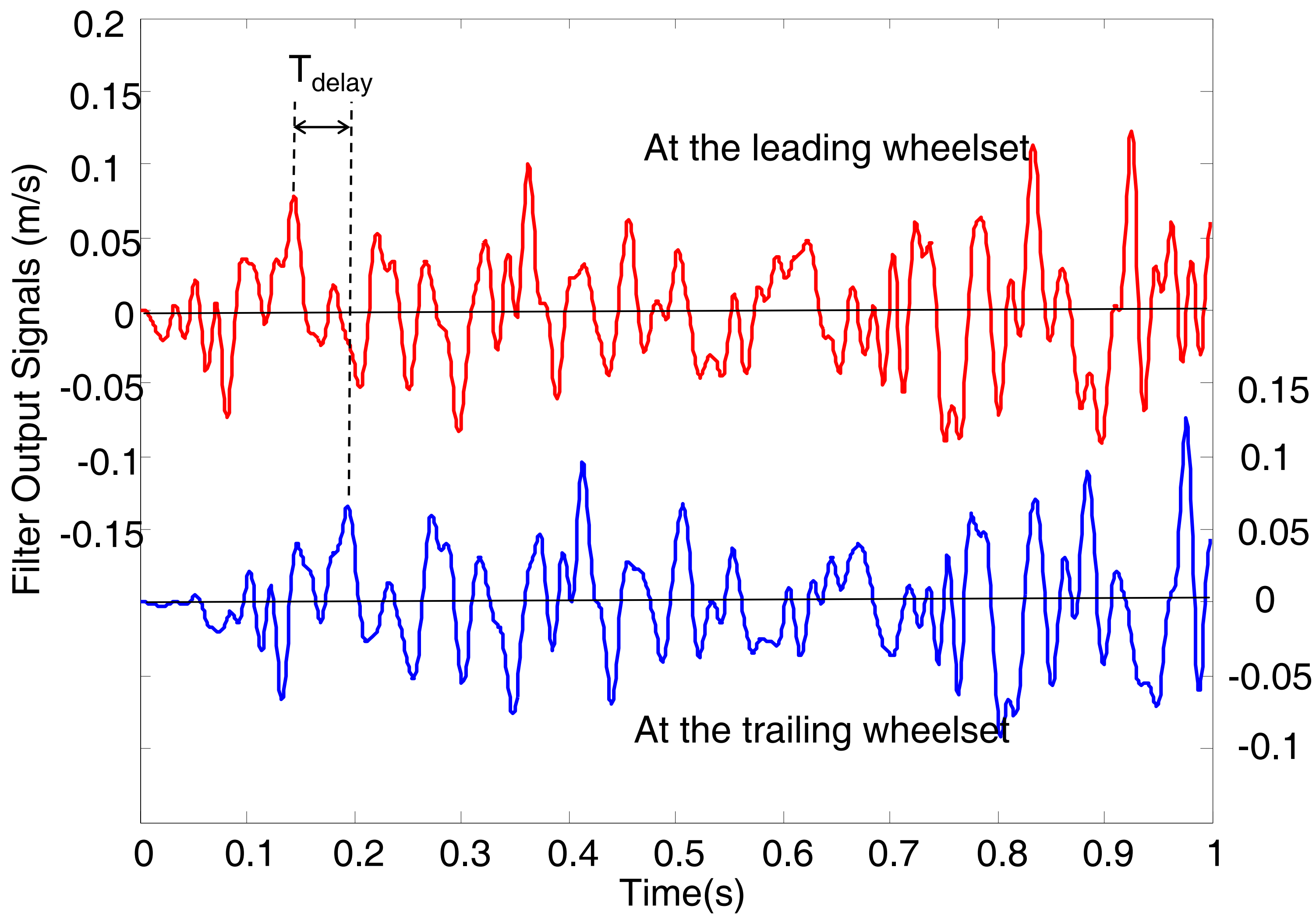
Design Issues

- Design of estimators/filters
  - Estimation accuracy and robustness
  - Complexity
- Track input and sensors
  - Low level/frequency of vibration at very low speed
  - Sensor noises
- Time windows - 2 sets of data (sampled continuously and at a fixed sampling rate)
  - Reliable detection
  - Delay and computation requirement
- Sampling interval
  - Truncation error, more significant at high speed

Simulation Results
– sensor output

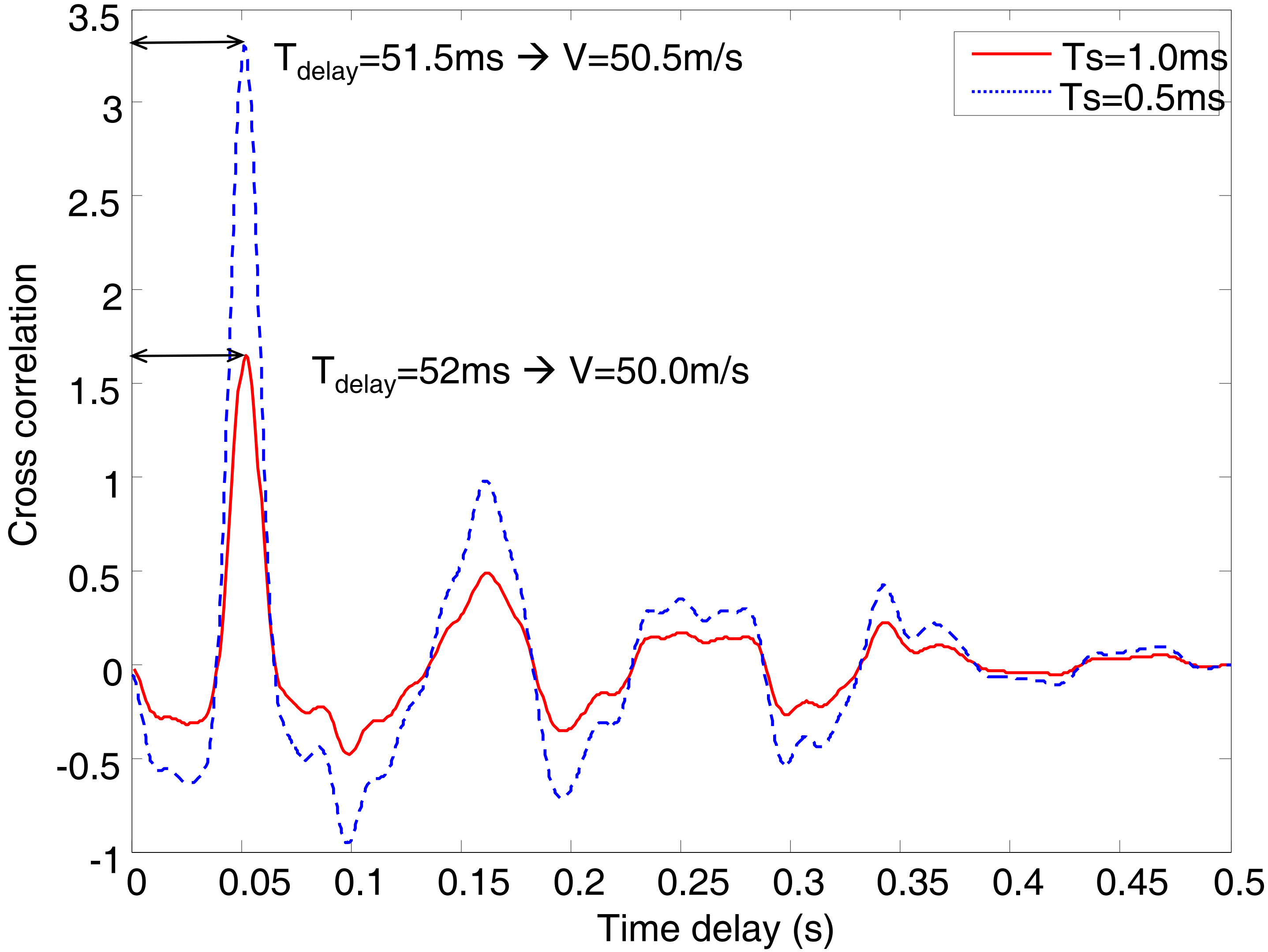


Simulation Results
– after filters

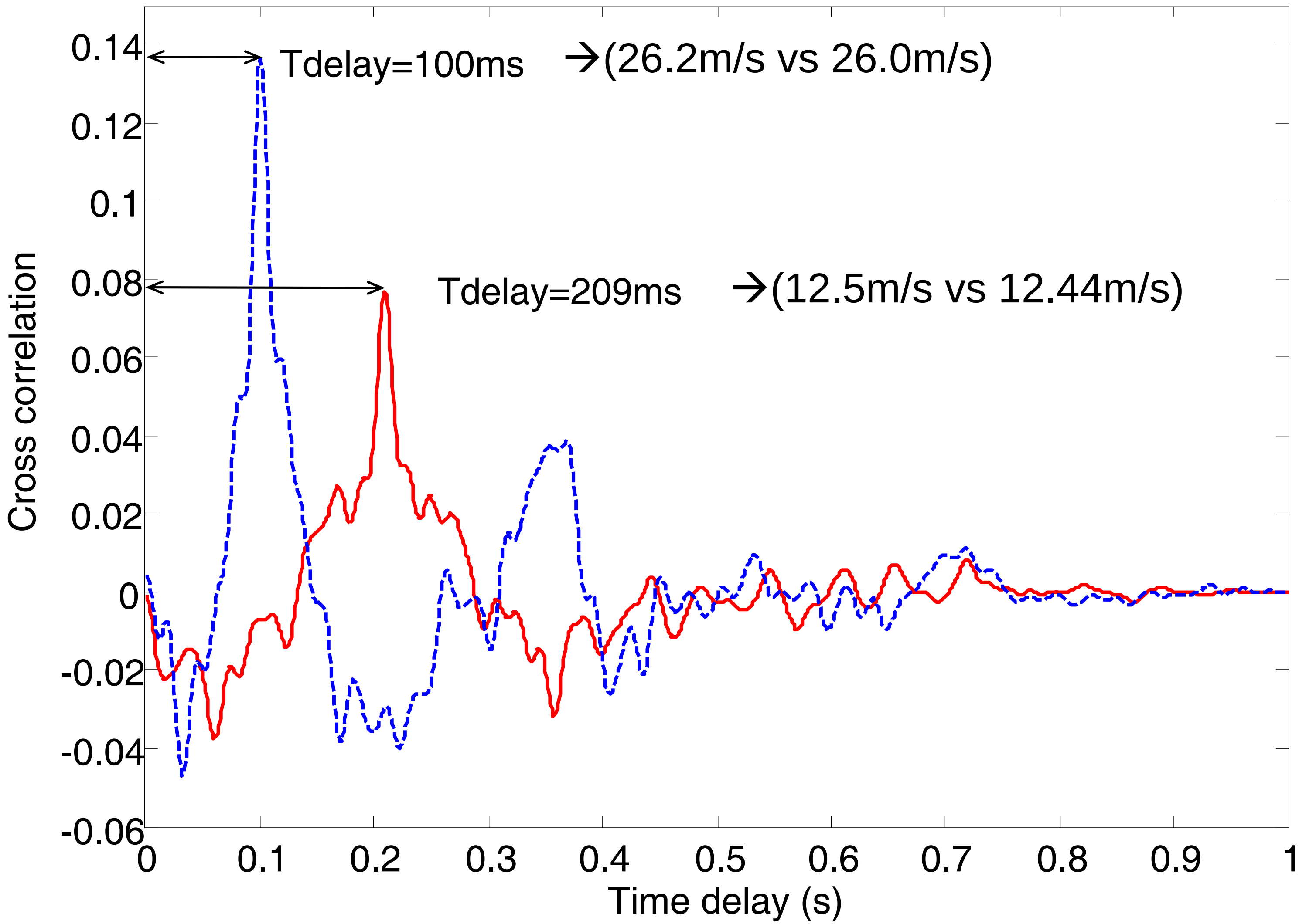


Simulation Results
– time delay

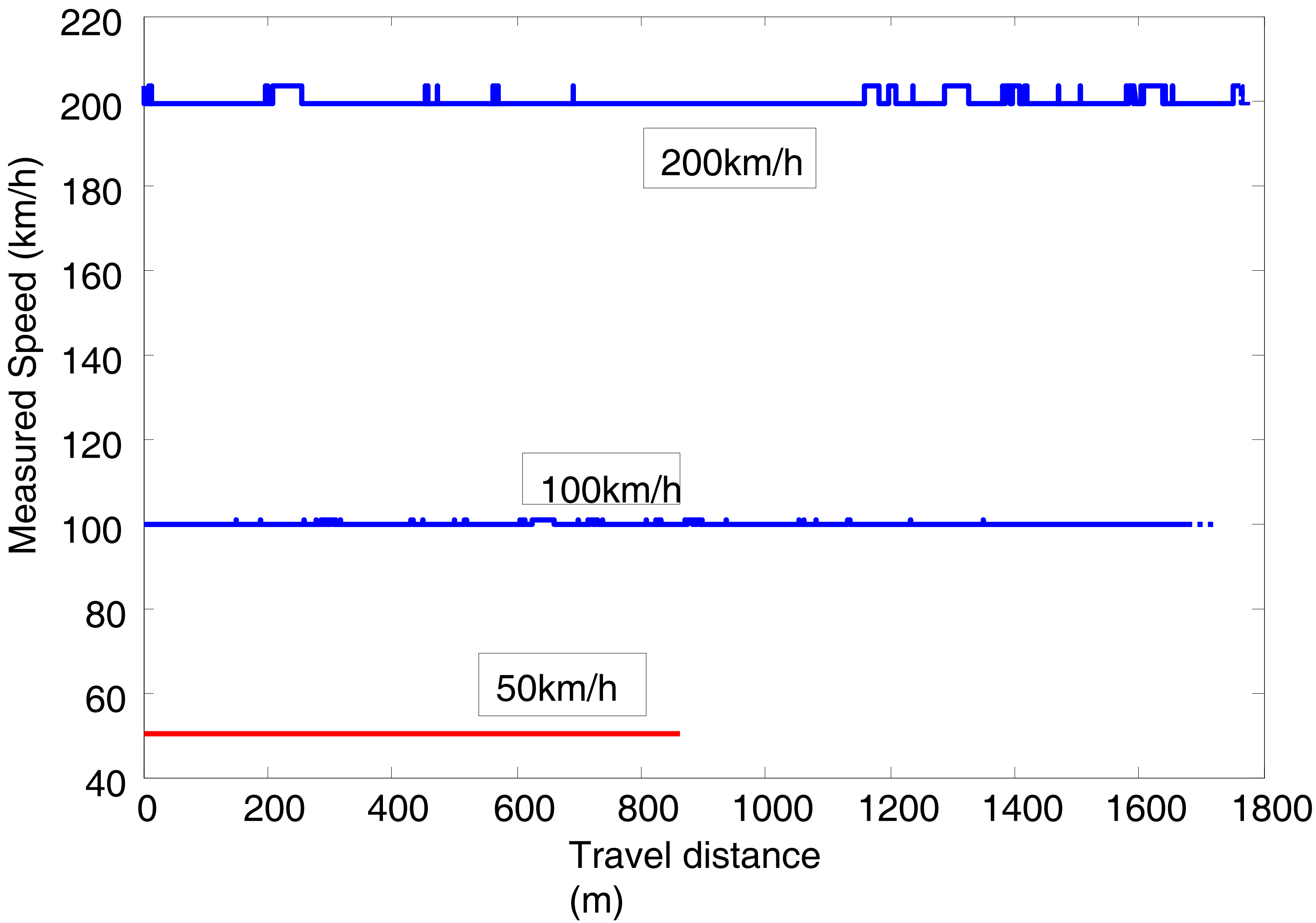
At V = 183.6 km/h (or 51m/s)



Simulation Results
– at different speeds

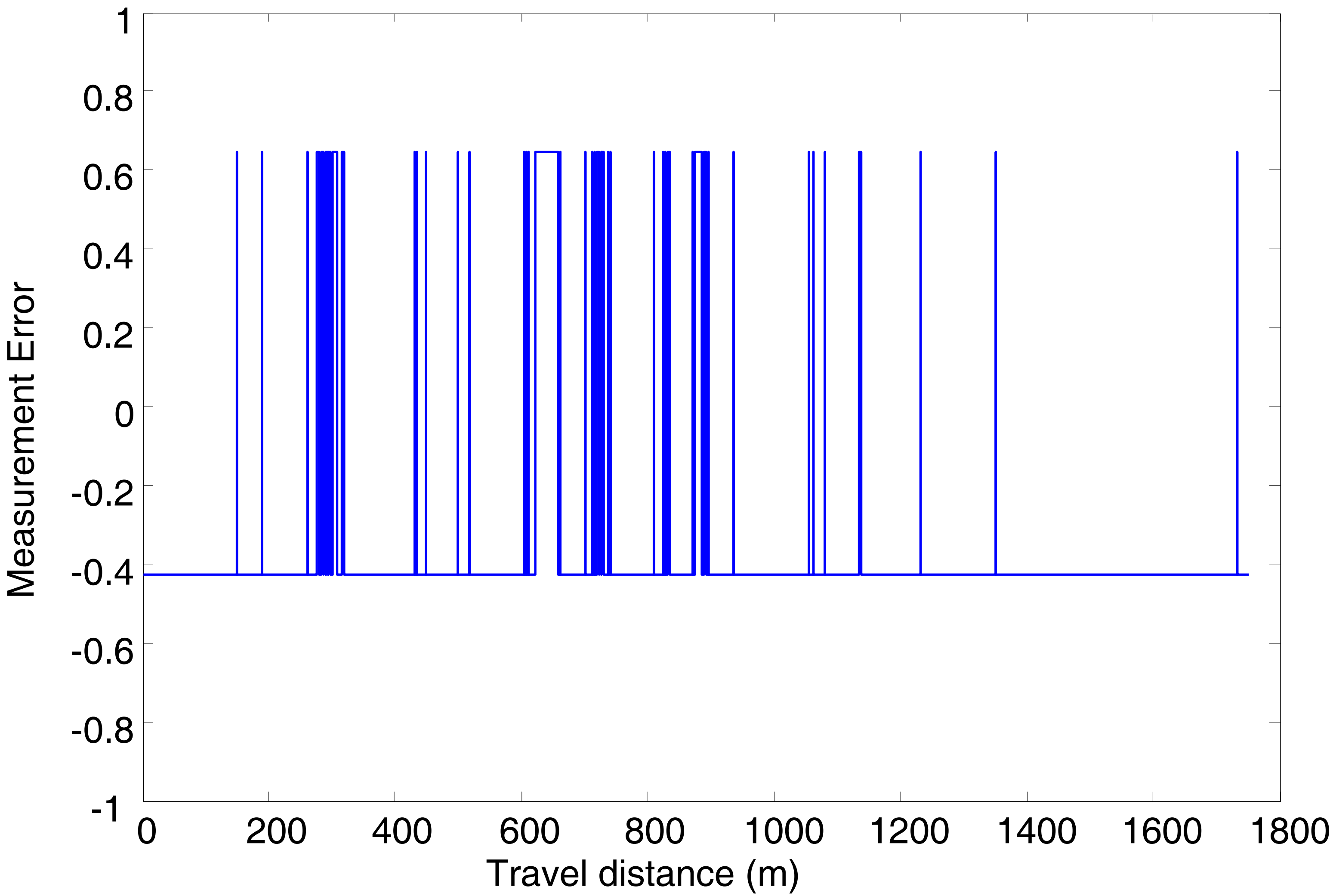


Simulation Results
– consistency/reliability

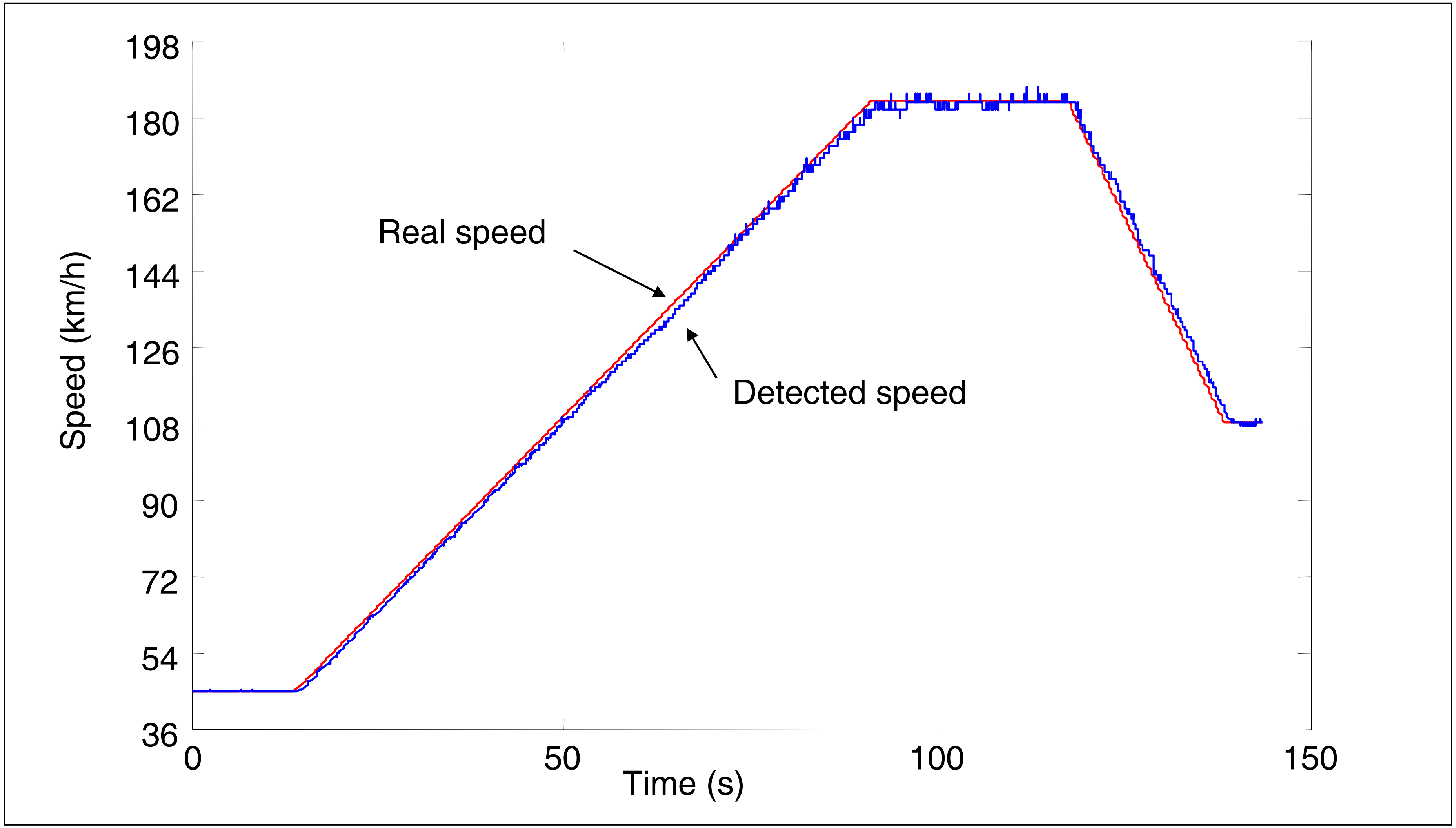


Simulation Results – errors in detail

At V = 100 km/h (or 27.8m/s)



Simulation Results
– acceleration/deceleration



Requirement - UIC standard for wheel slide control (UIC-5014-05)

- **5km/h, if measured speed is above the real speed** – an absolute error no more than 1.39m/s,
- **10 km/h, if the real speed is lower than 200 km/h** – the maximum absolute error of 3.78m/s, relative error of 5% at 200km/h (or more at lower speeds)
- **15 km/h, if v-real is above 200 km/h** – the maximum absolute error of 6.17m/s, relative error of 7.5% (or less at higher speeds)
- **No action from wheel slide protection systems for velocities lower 3km/h (0.83m/s)** – which may be used as a target for the low speed measurement for the proposed technique.

Conclusions

- Accurate measurement across a wide range of vehicle speeds
- Use of simple bogie based inertial sensors
- Realistic data processing requirements
- Applications - for traction/braking control and/or as a calibration tool (for axle based measurement)

- Further work – track testing or real data for offline processing

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