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LCPC Laboratoire Central des Ponts et Chaussées

CETE de Lyon laboratoire régional des ponts et chaussées de Lyon

Final Seminar

DRIVER SUPPORT WARNING
(« Black spots » warning, Rollover)

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HEAVY ROUTE

ROLLOVER RISK APPLICATION

Objectives

- Develop on-board concepts design of systems to increase safety.

- To prevent in real time the rollover risk (Alarm to the driver)

➔ Recommended speed calculation

Use Cases

- Truck driver provides information during tour:

  (the driver is informed about driving relevant status and status changes given by the database..)
- Reliable safety warnings in vehicle
- Give recommended speed to avoid any accident during journey
- …

Methodology

Since we do not have sensors, the following states have been off-line estimated

- Estimation of impact forces,
- Estimation of the Center of gravity height,
- Recommended speed calculation,
- Lateral acceleration ➔ $Acc=V^2/R$.

Rollover risk prediction

The rollover risk is detected when one of the wheels of the same axle leaves the ground

➔ **LTR (Load Transfer Ratio)**

$$LTR = \frac{|F_{zL} - F_{zR}|}{F_{zL} + F_{zR}} = \frac{2m_2}{m \cdot T}\left|(h_0 + h\cos\phi)\frac{a_y}{g} + h\sin\phi\right| < R_{\lim} = 1$$

m: total masse,

m_2 : sprung masse

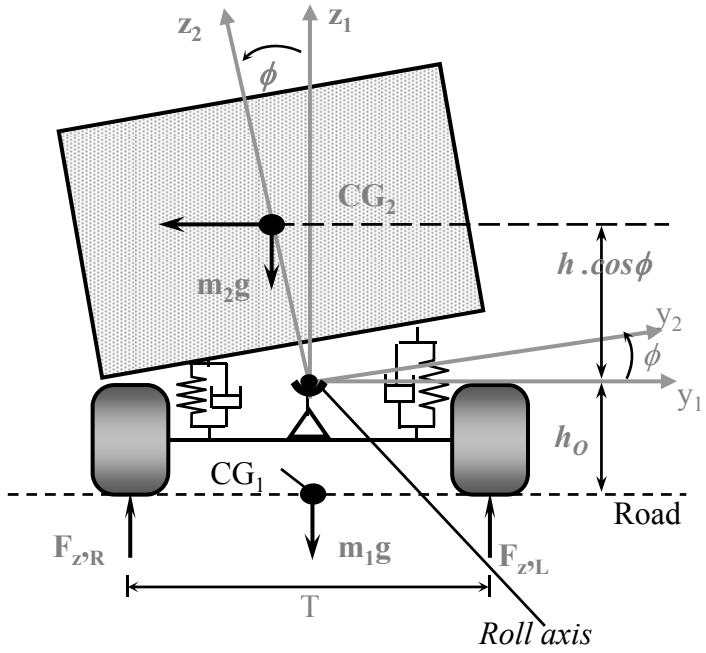
T: distance between Wheels of the axel

ay : lateral acceleration,

ϕ: roll angle

h_0: roll axis height

H= $(h_0+h\cdot\cos\phi)$: center of gravity height



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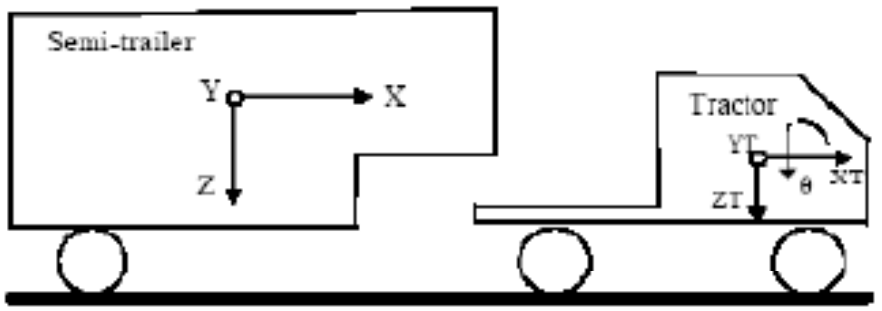
Selected Truck Model

Tractor/Semi-trailer model

Inputs: Road profile, skid resistance, radius of curvature, Longitudinal and transverse slope.

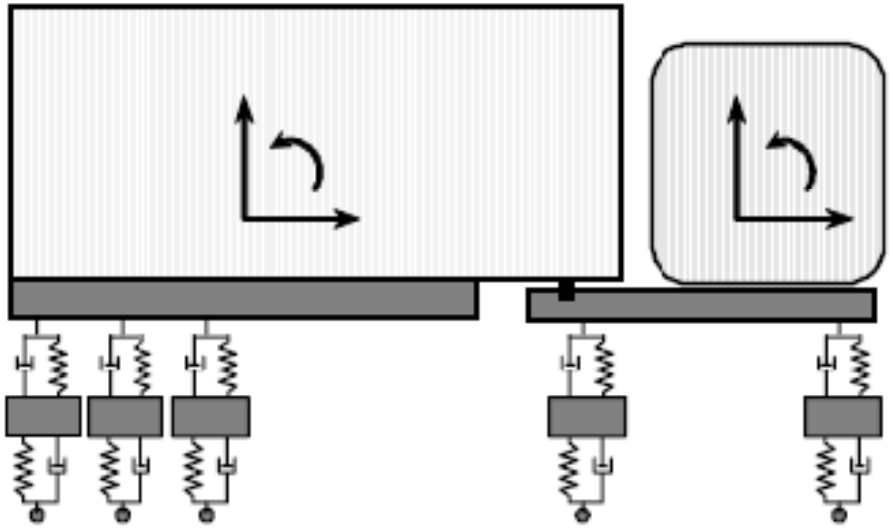
$$M(q)\ddot{q} + C(q,\dot{q})\dot{q} + G(q) = F_g \in \mathrm{R}^{12}$$

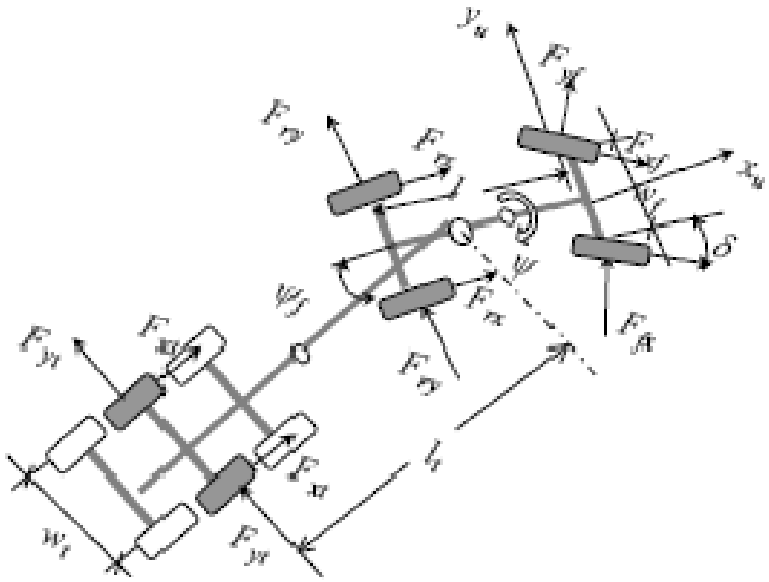
$$q = \left[x, y, z, \phi, \psi, \psi_r, q_1, q_2, q_3, q_4, q_5, q_6\right]^T$$



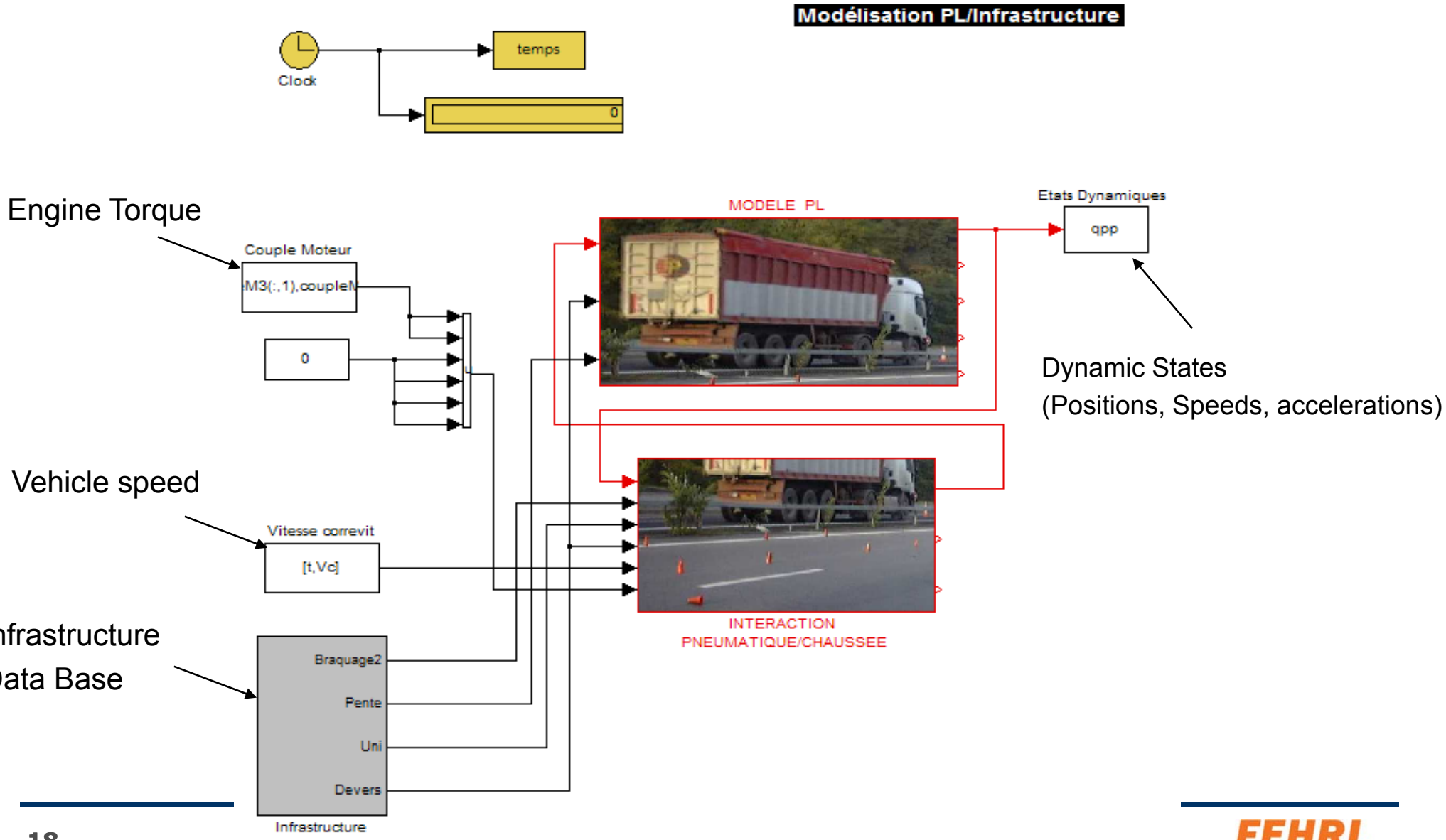
Fg : Forces vector (internal and applied)

- Tyres forces
- Suspensions forces



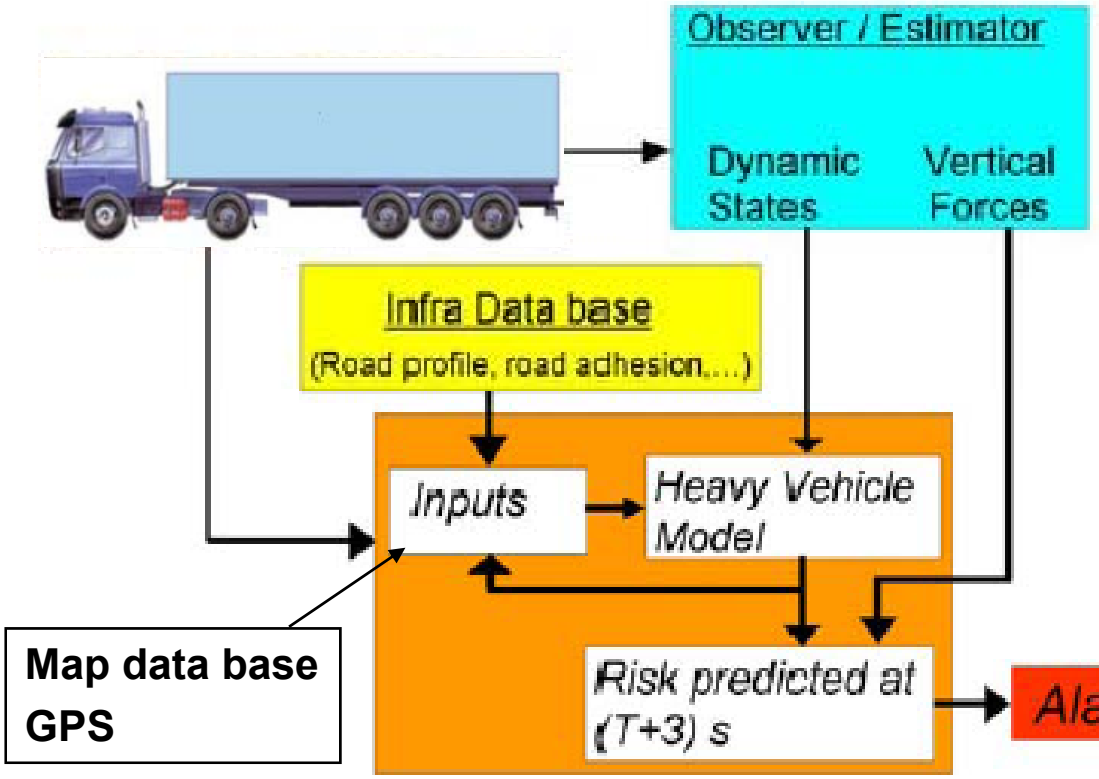


Tractor/Semi-trailer model description



INPUTS	OUTPUTS
Road data : Radius of curvature, Longitudinal and transverse slop, Skid resistance, road profile, GPS	Vehicle positioning (X, Y and Z) Longitudinal, lateral and vertical
Steering angle	Roll, pitch and yaw angle
Engine Torque	Suspension deflections
	Vertical displacements of the wheels
	Impact forces (Fx, Fy and Fz)
	Vehicle speeds (Vx, Vy and Vz)
	Vehicle accelerations (Ax, Ay and Az)

Rollover Risk Predictive System



Rollover predictive system

- Speed reducing
- Route changing

Speed limits
Acceleration limits
Rollover risk

Acceleration limit

$$ay \leq \frac{gmT}{2m_2H} - \frac{gh\sin(\phi)}{H}$$

$$ay = \frac{V^2}{R} \quad \Rightarrow \quad V \leq \sqrt{R\frac{gmT}{2m_2H} - R\frac{gh\sin(\phi)}{H}}$$

Recommended speed

$$V_{\max} = \sqrt{R\frac{gmT}{2m_2H} - R\frac{gh\sin(\phi)}{H}}$$

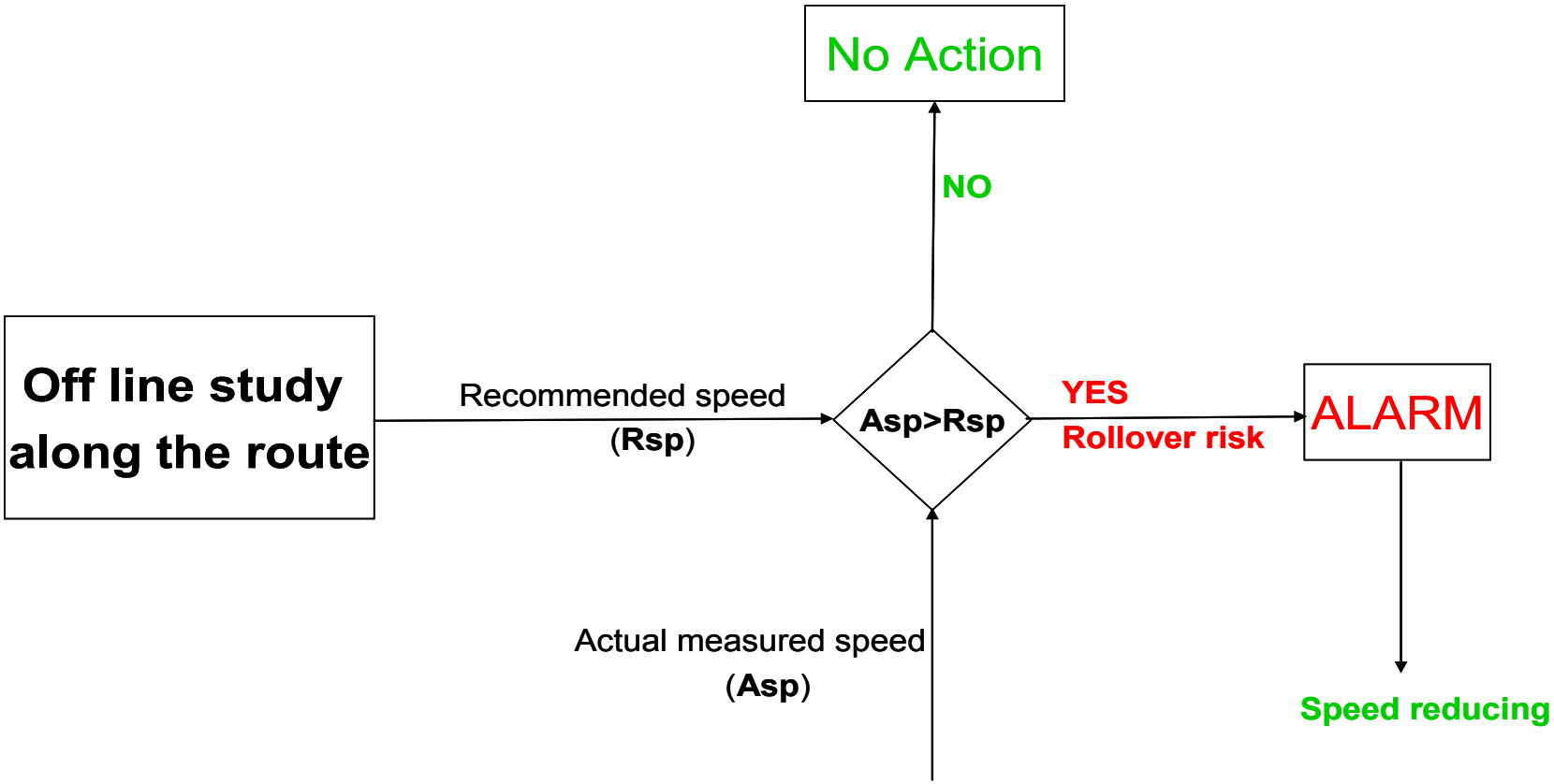
R : Radius of curvature

Rollover warning integration

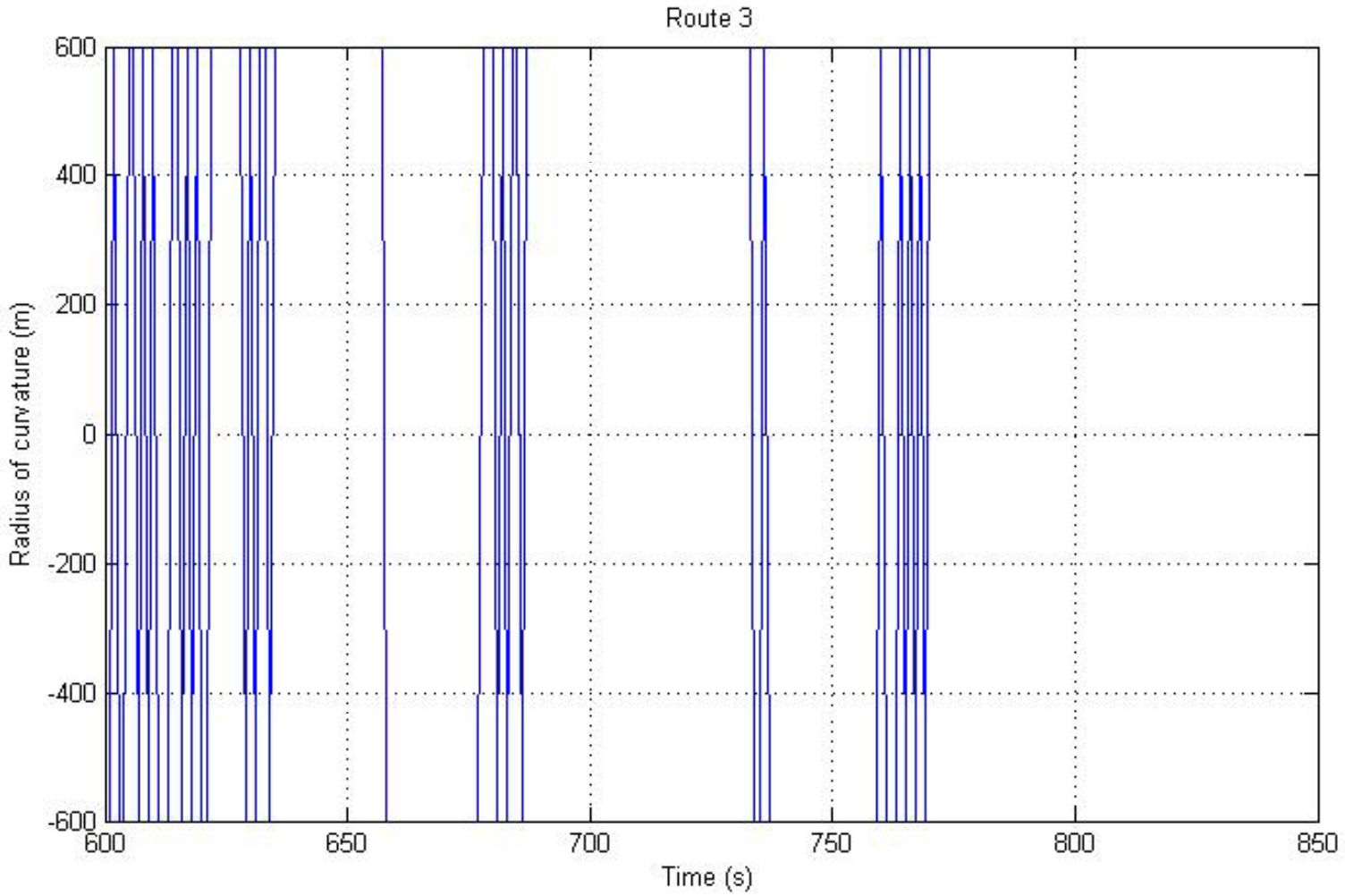
Collected data (from CAN bus):

- *BreakPedalPos - % of fully pressed*
- *CurrentGear - gear nr (maximum 12)*
- *SteeringWheelAngle – radians ➔ Used*
- *VehicleSpeed - km/h ➔ Used*
- *YawRate - rad/s ➔ Used*
- *FuelRate - instant l/h*
- *GPS_Latitude - decimal degrees N*
- *GPS_Longitude - decimal degrees E*
- *GPS_Speed - m/s ➔ Used*
- *GPS_Altitude - m (uncalibrated)*
- *GPS_Time - seconds since 1970*
- *CummulatedFuelRate - fuel used since the logging started observe! Unit in dl*

Rollover warning integration



Experimental results



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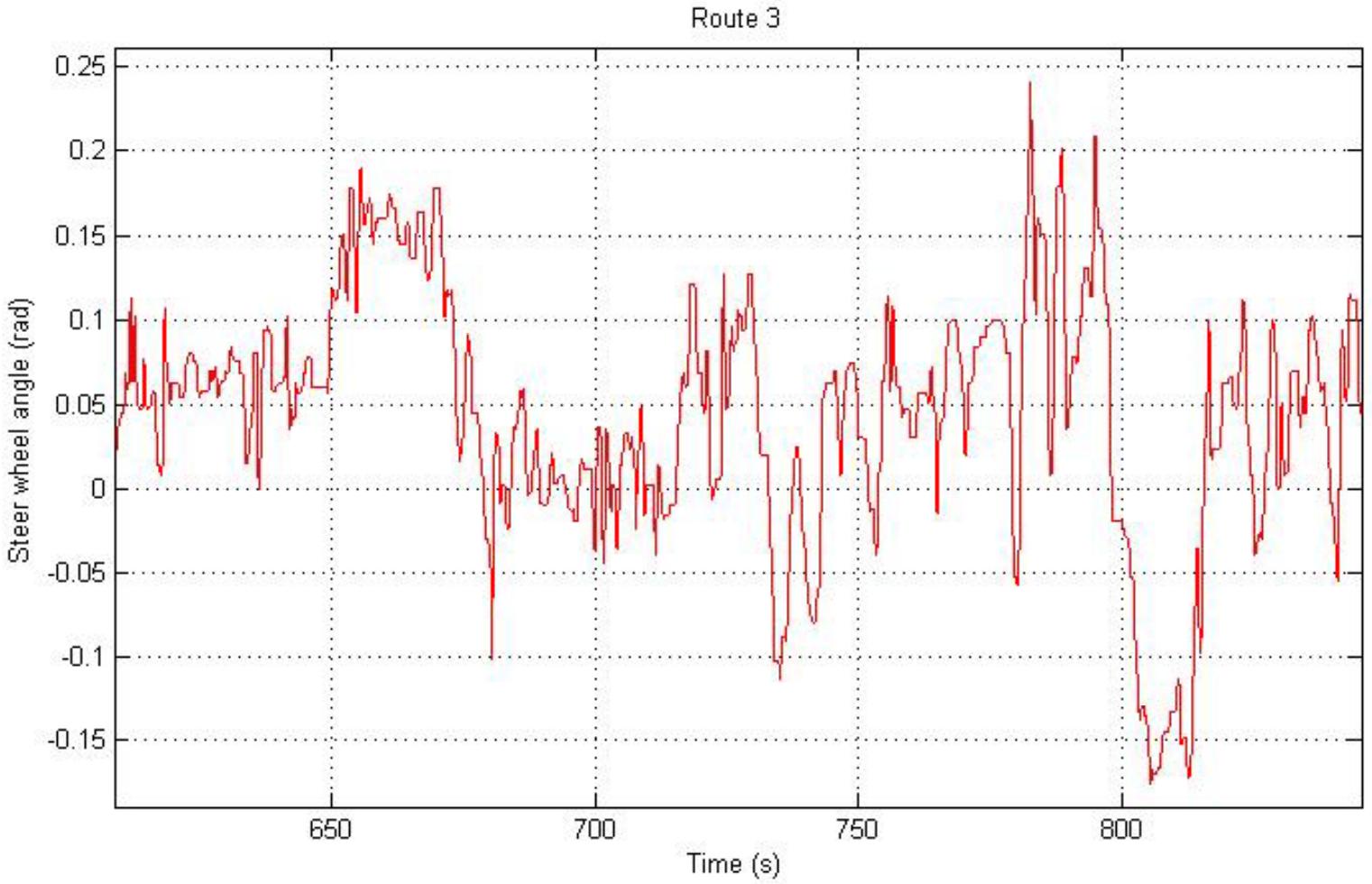

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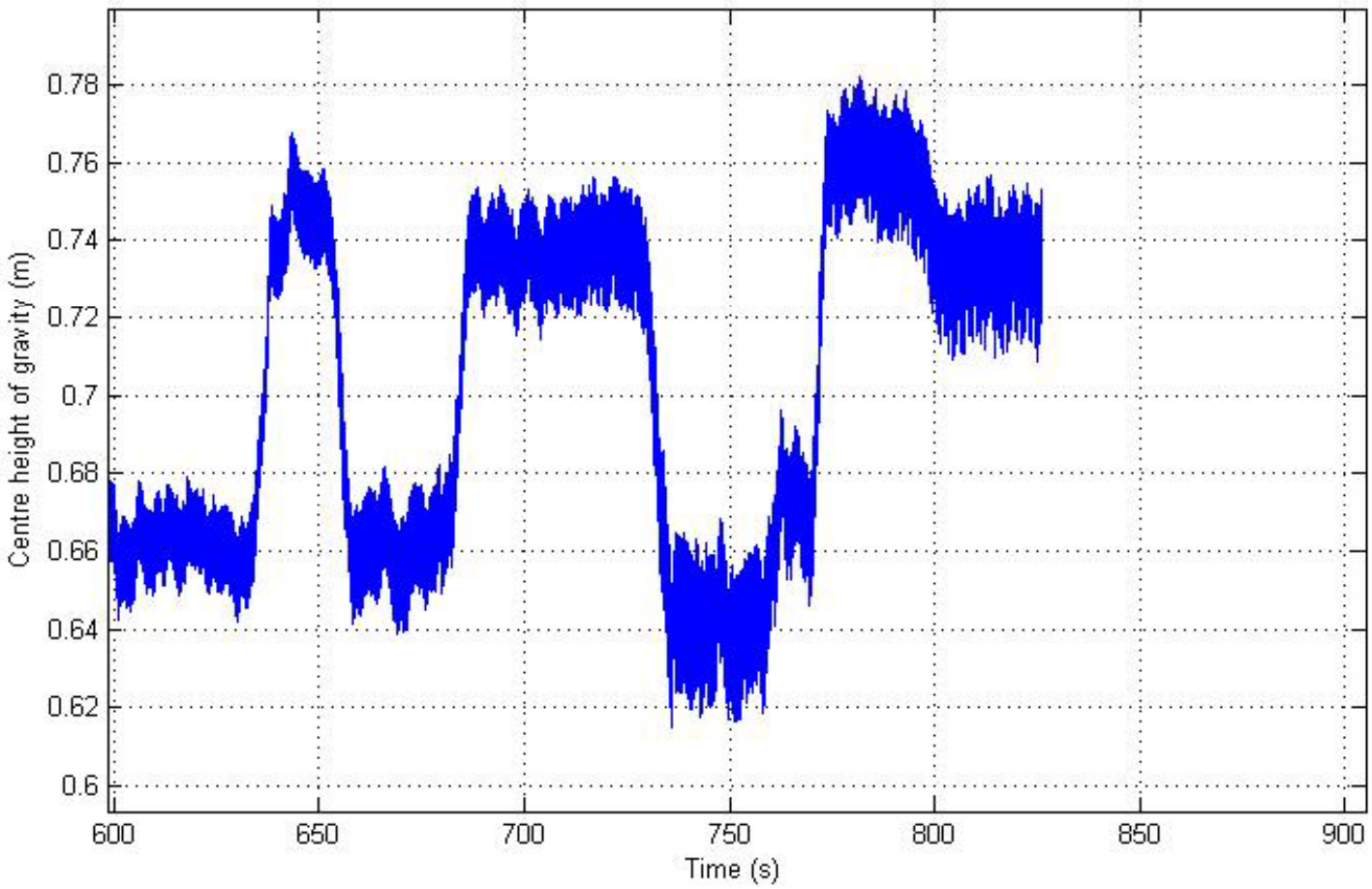

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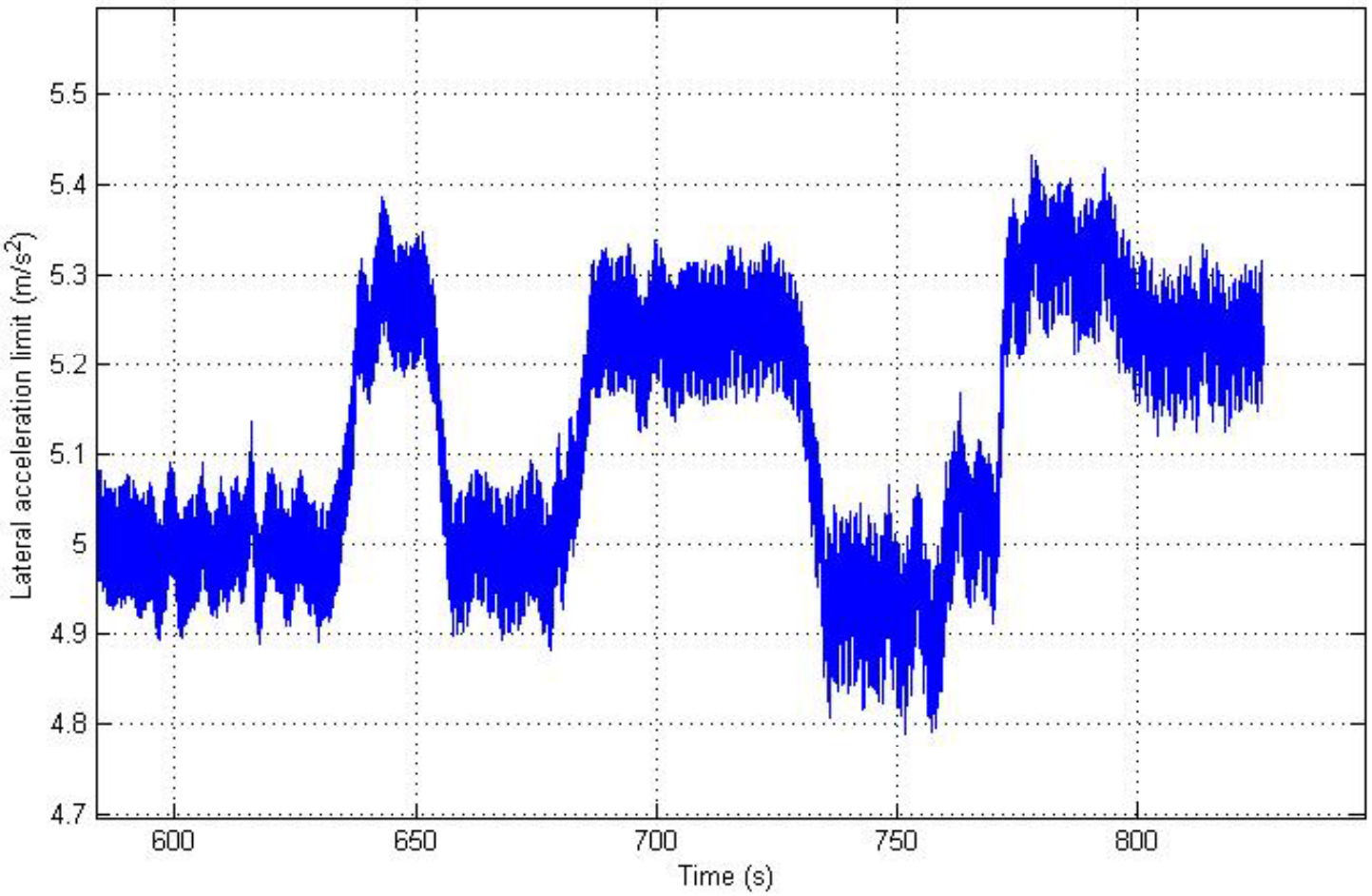

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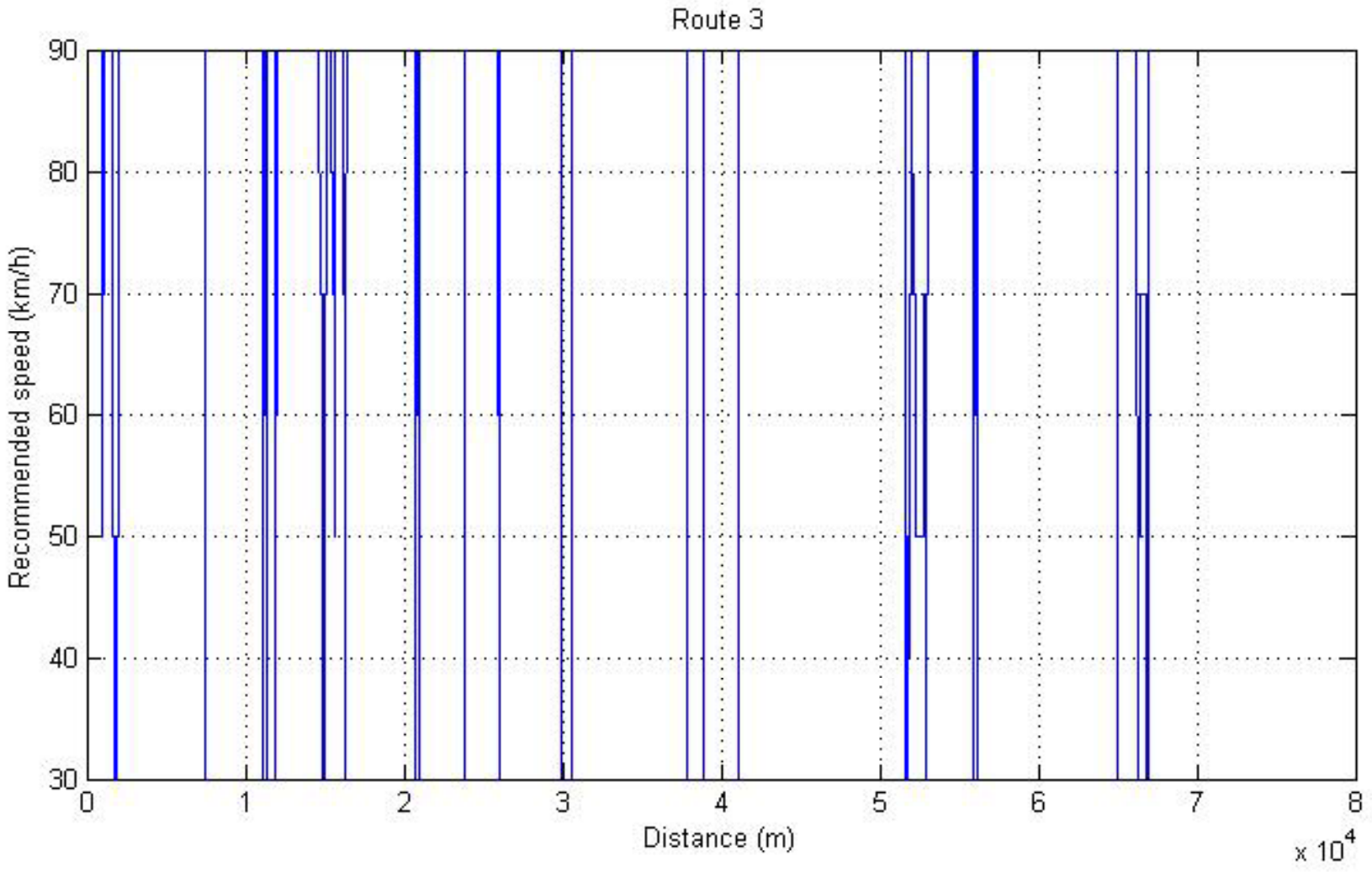

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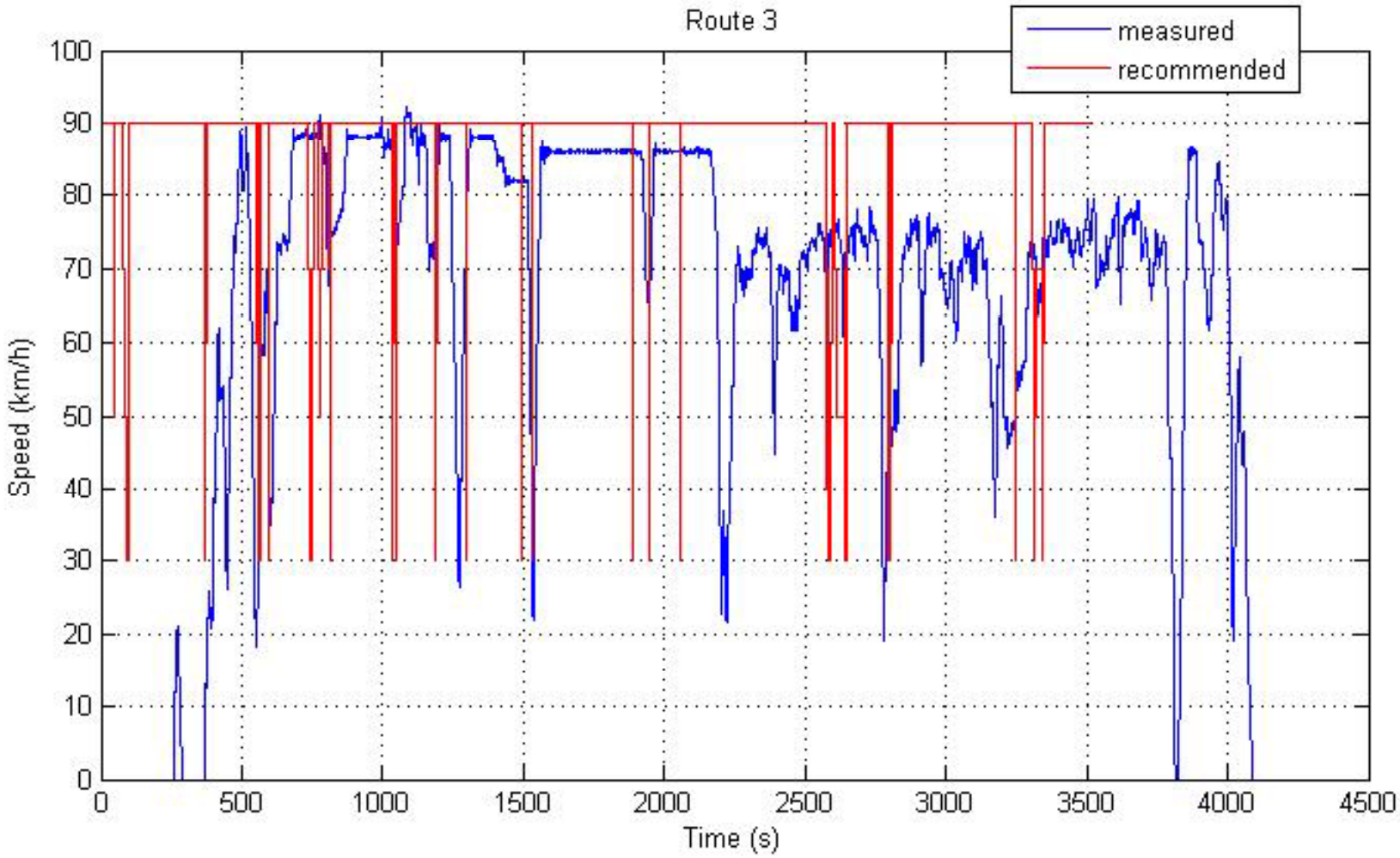

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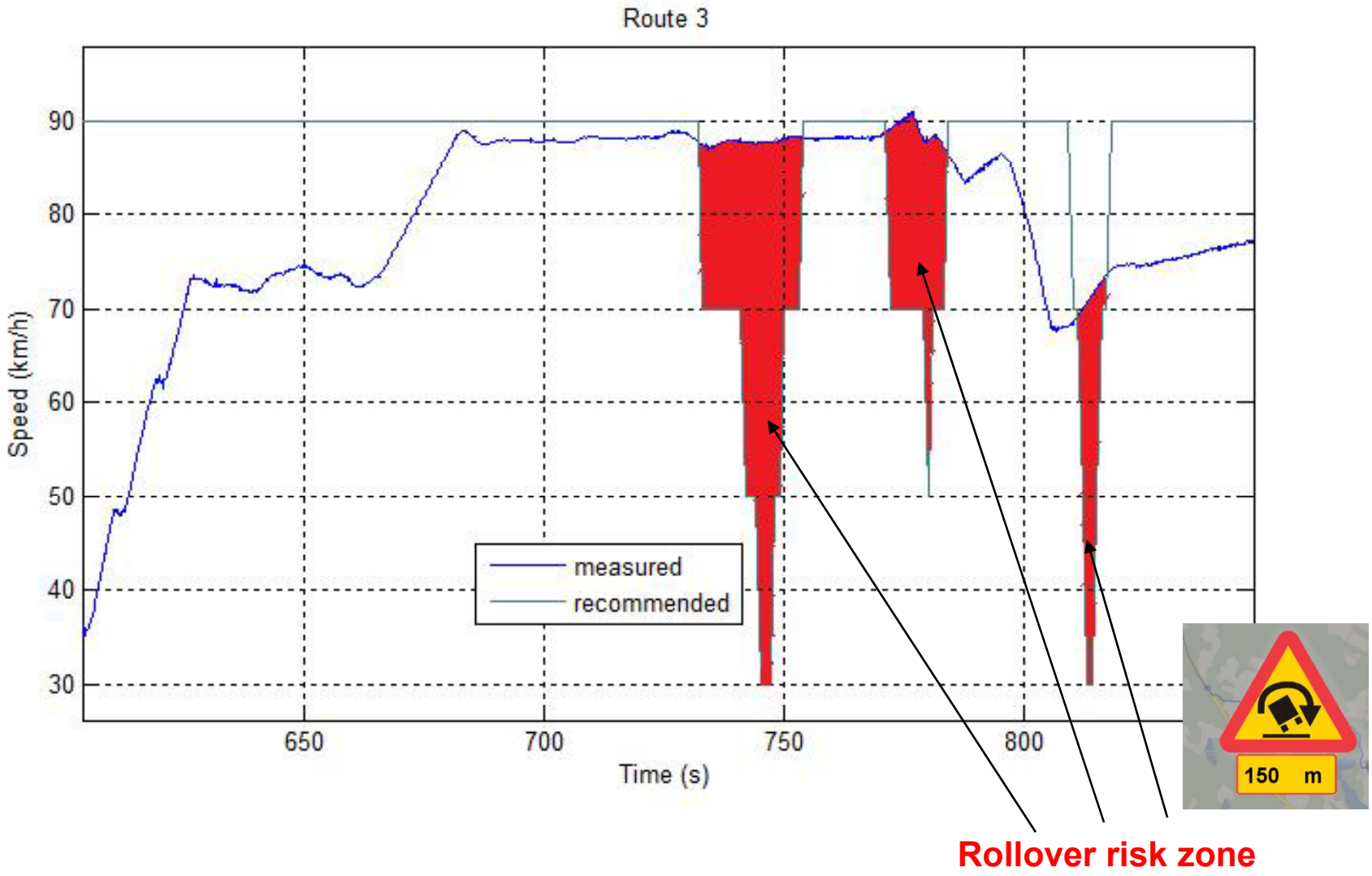

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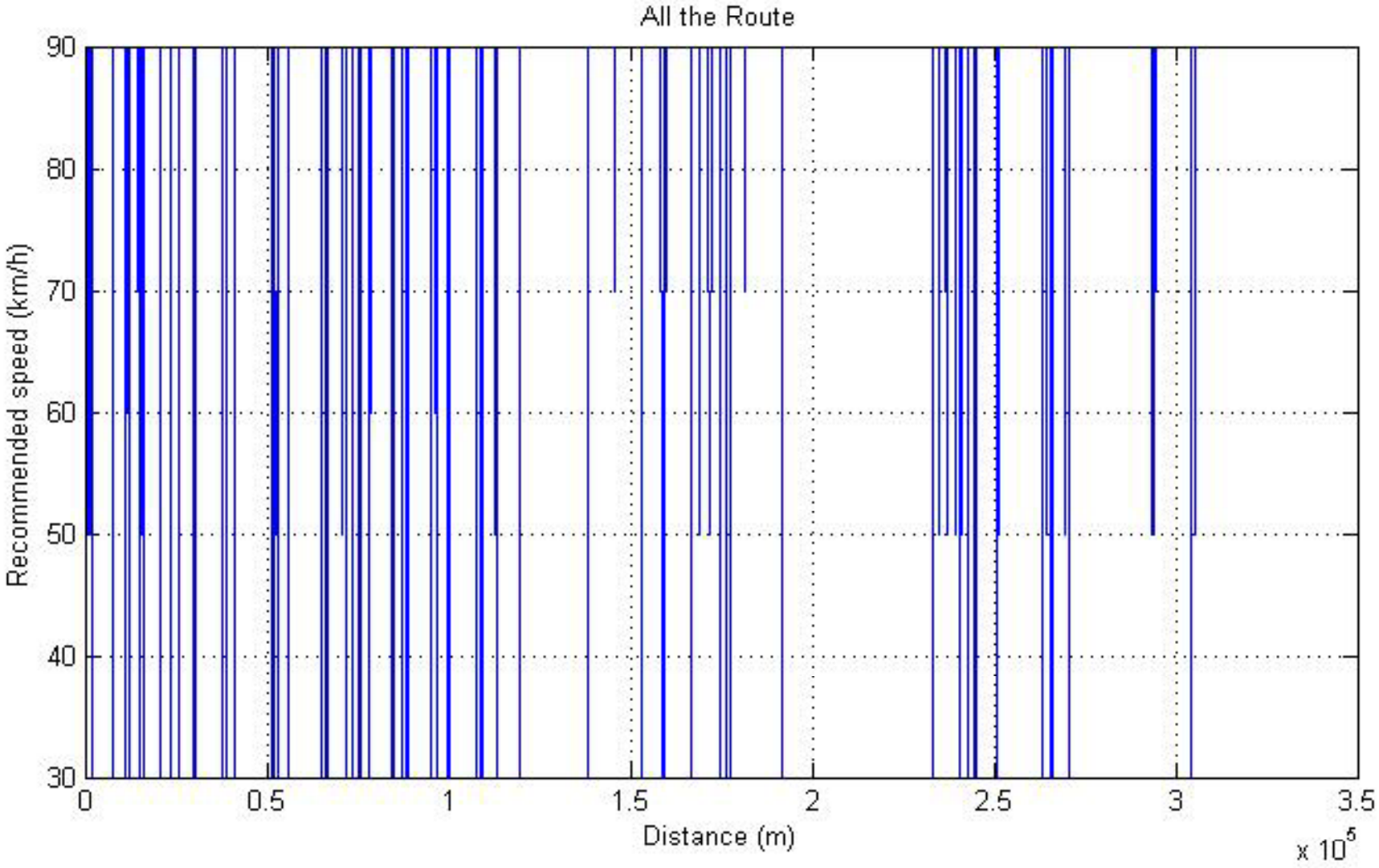

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Conclusion

- *The dynamic states of the vehicle are estimated, the recommended speed is calculated and the alarm is sent to the driver.*

- *Some false alarms are occurs. This is due to the fact that:*
  1- the calculation is done off-line and not in real time
  ➔ The vehicle dynamics can be changed during the trip.
  2- The road data base is incomplete (SFC value)
  3- The vehicle parameters are not known

- *Adding some sensors (measures) are necessary to have robust speed calculation and reducing false alarms.*