Additional information on engine speeds in Annex 10

In order to facilitate the discussion on the “red line” of Annex 10

Prepared by the Netherlands for
ASEP TF Aug 2006 Detroit

Issues

1. Area to cover in Annex 10
    - Maximum engine speed
    - Maximum acceleration
    - Maximum speed

2. How to compare measurements in different gears

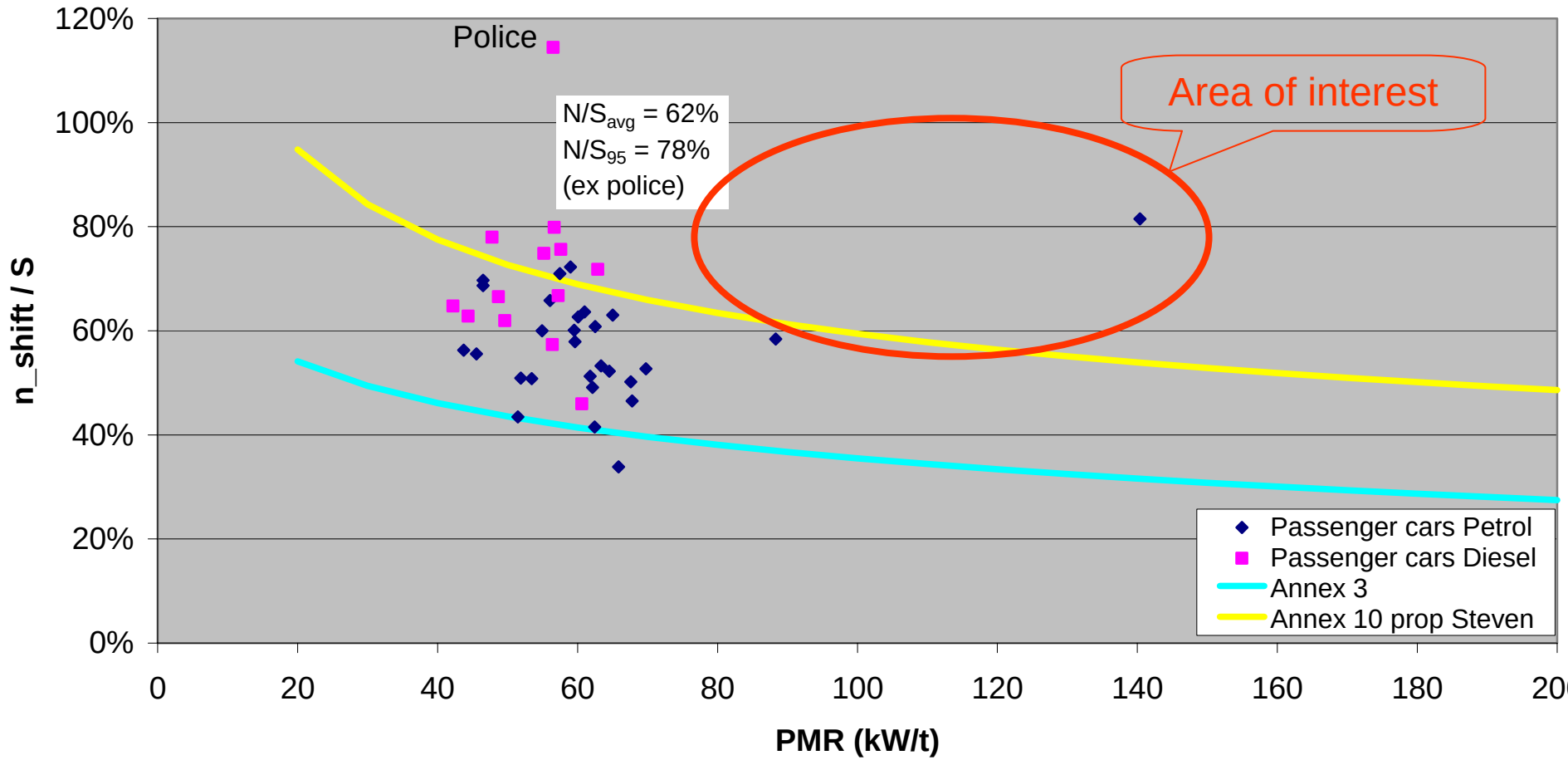
Issue 1: area to cover in Annex 10

- Vehicles of special interest: GTI's
  - Wishes for more sound design/noise exist in the market
    - in OEM as well as in after market
  - Significant market share makes it environmentally important
    - More important compared to (super)sportscars
  - Good regulation of RESS in R59 only possible with good anchor point in R51
  - Still limited information available

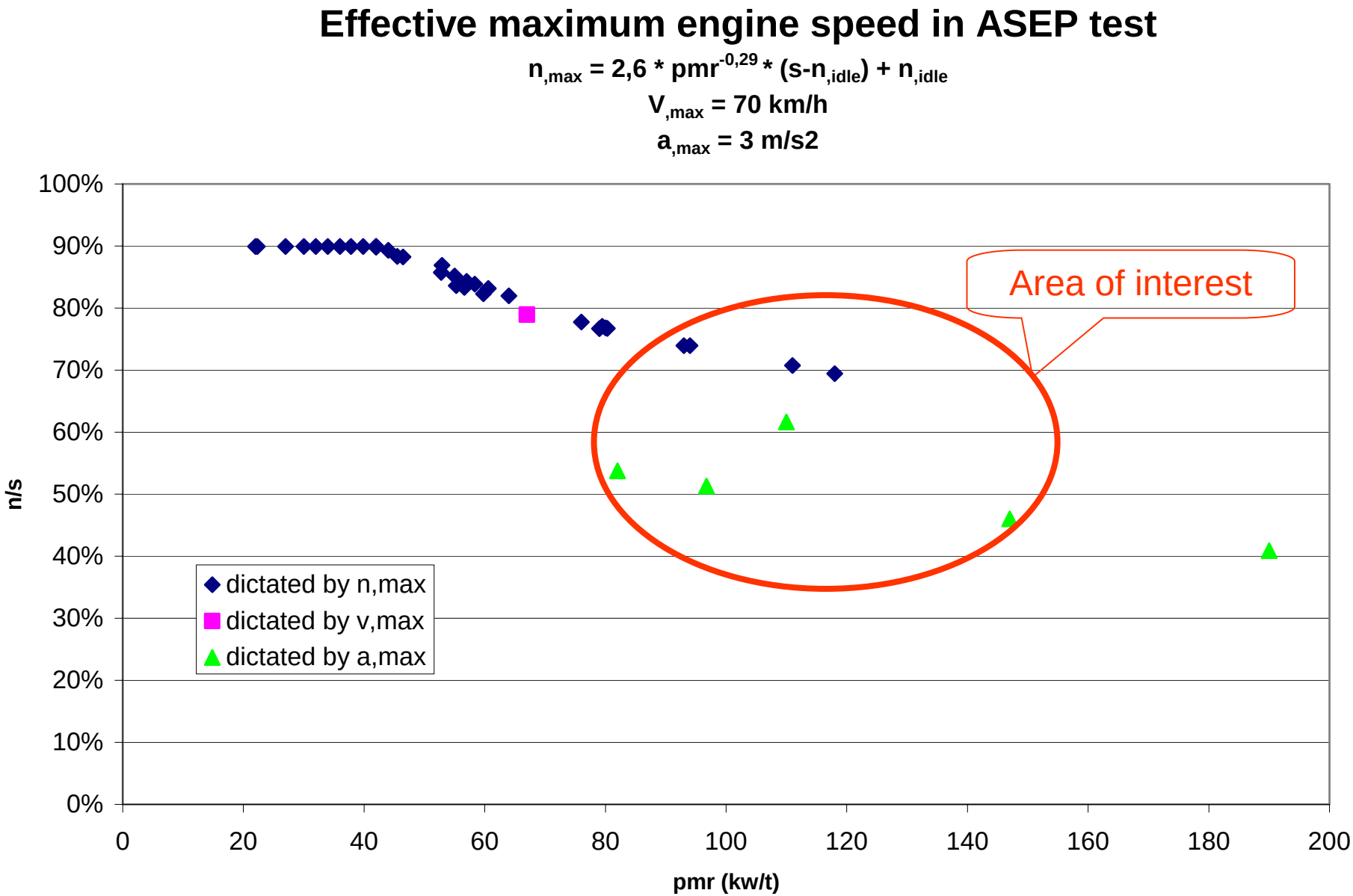
- Rough classification:
  - mass production vehicles 40-80 kW/t:
  - GTI's (ca. 2% of fleet?) 80-120(150) kW/t:
  - sportscars (ca. 0.2% of fleet?) 120(150)-200 kW/t:
  - supersportscars (ca. 0.02% of fleet?) > 200 kW/t

Data from IG ASEP The Hague

Engine speed just before shifting
during acceleration from roundabout (max speed: 100 km/h)
derived from radar and noise measurements along road side



Data from ASEP TF Tokyo



Additional tests to gain more information on this issue

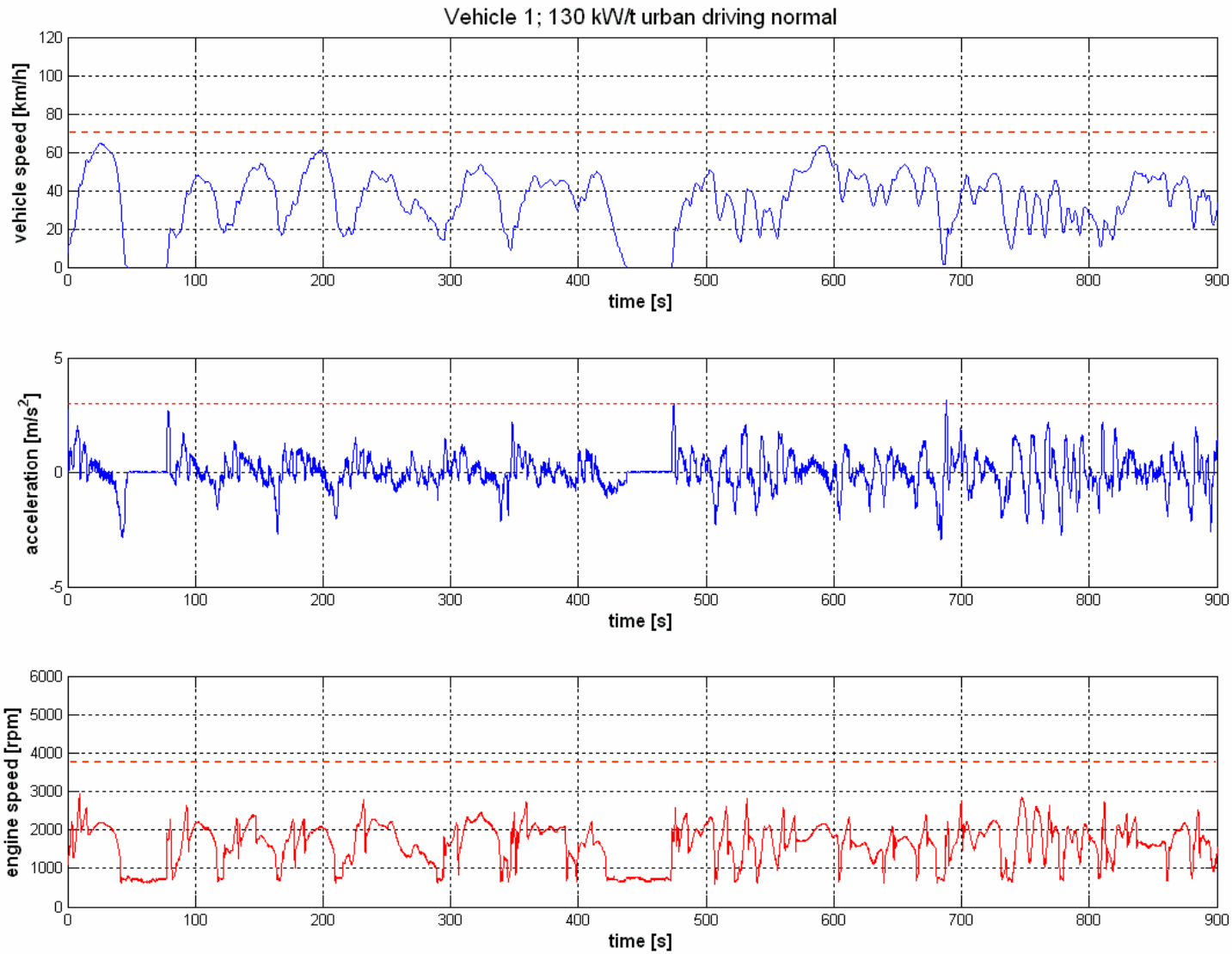
- Two sets of measurements
  - Urban driving (normal and hectic)
  - WOT acceleration in all gears on test track

- Two GTI class vehicles

Vehicle 1	Vehicle 2
130 kW/t	105 kW/t
petrol	petrol
6 speed manual gearbox	6 speed manual gearbox
4 Wheel Drive (permanent)	Front Wheel Drive
Traction control (permanent)	Traction control (switchable)
S= 5600 rpm	S= 5400 rpm
n at Tmax = 4000 rpm	n at Tmax = 4200 rpm
N,max annex 10 proposal = 3821 rpm	N,max annex 10 proposal = 3869 rpm
Acoustic + visual warning at n > 5000rpm	-

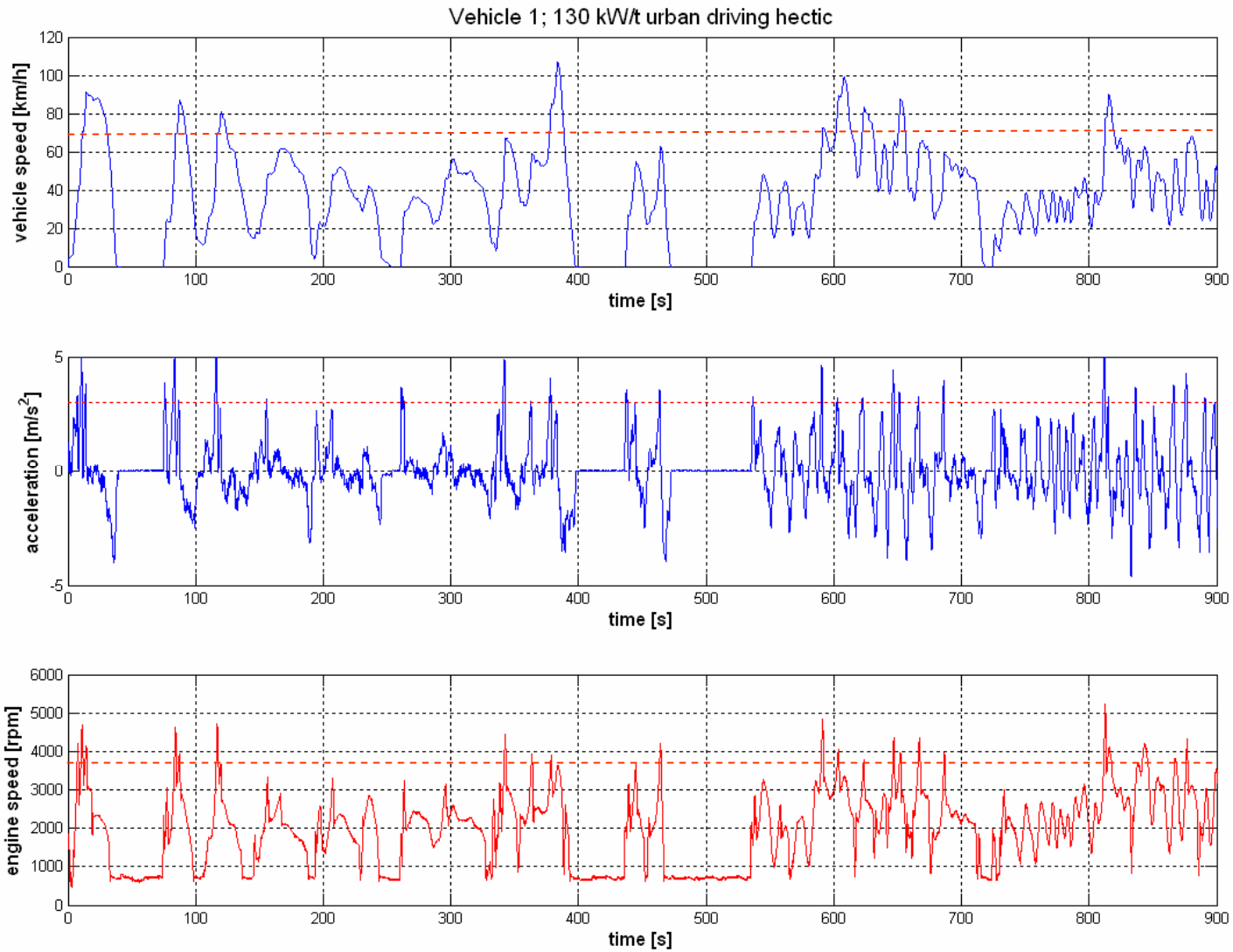
Results of urban driving

- Normal driving remains below annex 10 boundaries (3 m/s^2, 70 km/h and 3821 rpm)



Results of urban driving

- Sporty driving:
  annex 10 boundaries (3 m/s^2, 70 km/h and 3821 rpm) are exceeded many times

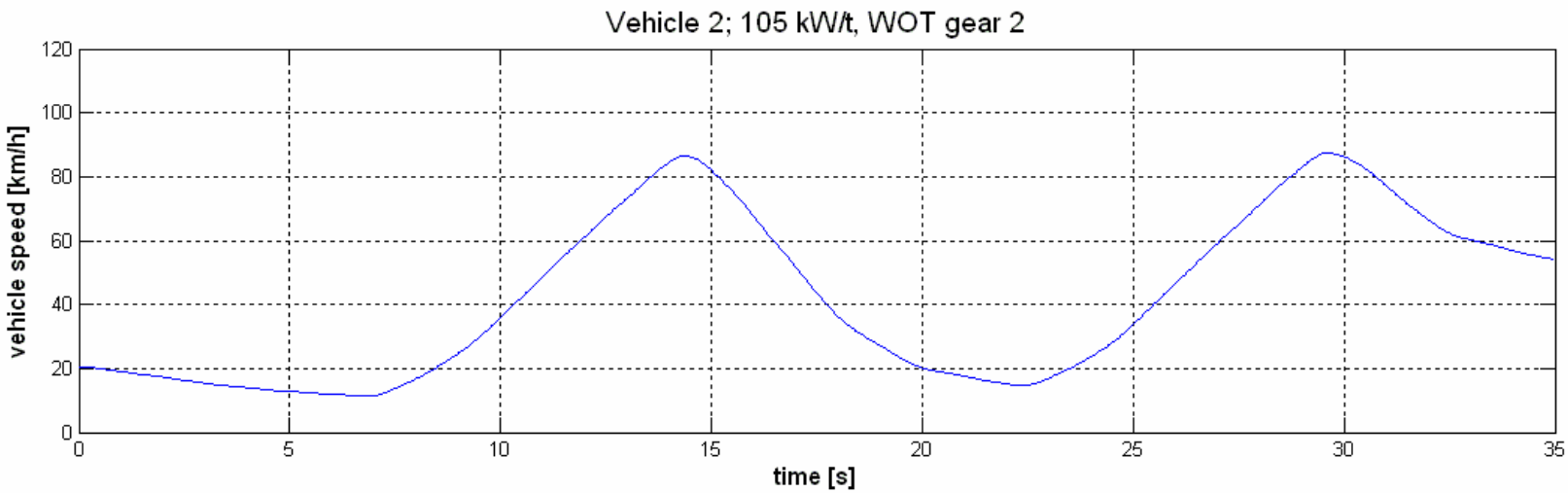


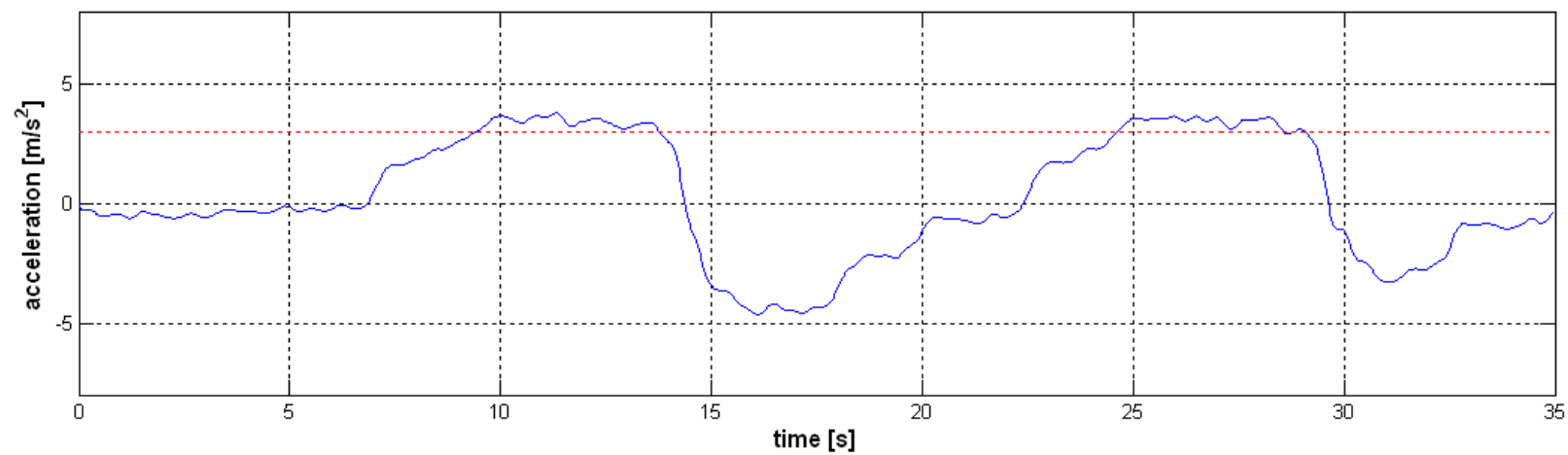
Results of urban driving

Limit exceeded during sporty driving	vehicle	# events per hour driving
a > 3 m/s^2	1	93
	2	56
a > 4 m/s^2	1	40
	2	4
a > 5 m/s^2	1	13
	2	0
n > n,annex 10 prop	1	74
	2	100
n > 0.8*s	1	23
	2	61
n > 0.9*s	1	6
	2	27

Acceleration results on test track

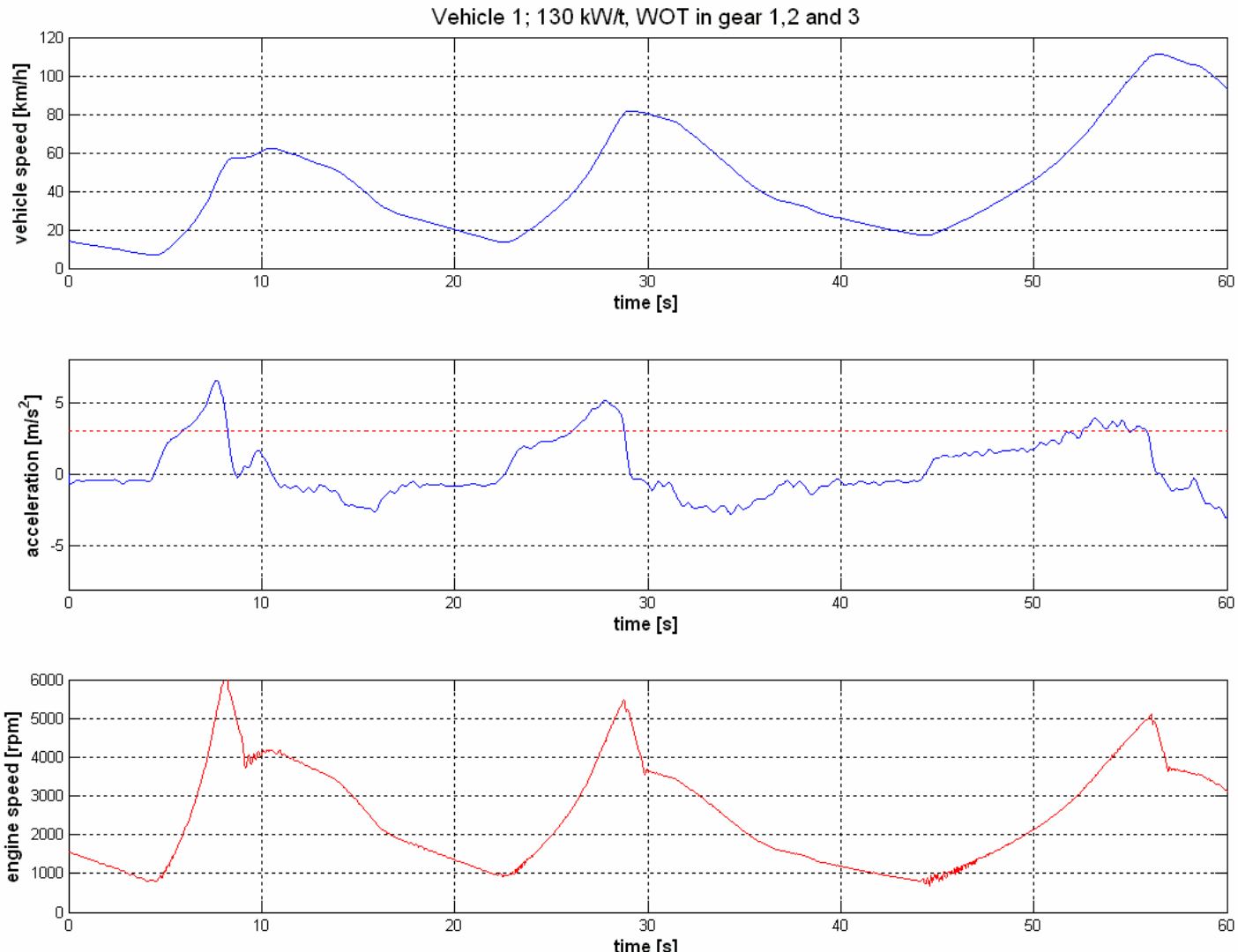
- Vehicle 2, gear 2: acceleration exceeds annex 10 boundary of 3 m/s^2





Acceleration results on test track

- Vehicle 1: acceleration exceeds annex 10 boundary of 3 m/s^2 in gear 1, 2 and 3
- Acceleration very sensitive to rpm (e.g. 2nd gear 2 – 5 m/s^2)



Acceleration results on test track

	Vehicle 1; 130 kW/t				Vehicle 2; 105 kW/t			
gear	1	2	3	4	1	2	3	4
$a_{wot,50\ km/h}$ (m/s^2)	6.1	4.1	2.1	1.4	-	3.8	2.7	1.6
$a_{wot,max}$ (m/s^2)	6.5	5.2	3.8	-	5.1	3.9	2.7	-
$a_{wot,max}$ (rpm/s)	2790	1290	630	-	2520	1060	490	-

Engine speed results on test track

Maximum engine speed limited by:

- 3 m/s^2 and 70 km/h boundaries in Annex 10
- 2 m/s^2 boundary in Annex 3

	Vehicle 1; 130 kW/t				Vehicle 2; 105 kW/t			
gear	1	2	3	4	1	2	3	4
$a_{wot,50\ km/h}$ (m/s2)	6.1	4.1	2.1	1.4	-	3.8	2.7	1.6
$a_{wot,max}$ (m/s2)	6.5	5.2	3.8	-	5.1	3.9	2.7	-
$n_{max,annex3}$ (rpm)	-	-	-	1800	-	-	-	1900
$n_{max,annex10}$ (rpm)	-	2700	3000	2400	-	-	3500	2500

Issue 2: How to compare measurements in different gears

- Extract tyre noise and propulsion noise out of total pass by noise (proposal France);
  - Pro: looks as though it works for most products!!
  - Contra: Large uncertainty when tyre noise close to total noise
  - Contra: sensible to torque induced tyre noise
  - Contra: Analysis as function of engine speed often more logical than as function of vehicle speed

- Present data as function of v*a instead of v or n (proposal Gerhard);
  - Pro: scientific charming alternative for engine speed / vehicle speed dilemma
    - technology neutral
    - Acoustical power vs mechanical power
  - Contra: separation of propulsion noise from total vehicle noise is not solved
  - Contra: sensible to peaks in torque curve (eg turbo engines)
  - Contra: may lead to unintended comparison between vehicles
  - Contra: does not work for low acceleration and/or partial throttle due to residual power consumption

How to compare measurements in different gears

New idea:

1. Accept total noise Lwot as measured in annex 3 in gear i.
2. Determine engine speed in gear i at Lmax ($n_{i,Lmax}$)
3. make new reference measurement at same engine speed ($n_{i,Lmax}$) in any gear of interest
4. Check Lmax,i-x,($n_{i,Lmax}$) < Lmax,i,($n_{i,Lmax}$) and accept this total vehicle noise as reference value for this gear
5. Determine linearity of total vehicle noise from this reference engine ($n_{i,Lmax}$) speed onward for every gear separately.

- Pro: no need to separate tyre noise from total noise
- Contra: assumption that propulsion noise at a given engine speed is independent from gear choice
- Pro/con……. (to be discussed)