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# Transmission and Gear Shift calculation in VECTO

## (European Tool for HDV CO2 testing)

**Stefan Hausberger, Martin Rexeis, Raphael Luz**

**Borlaenge, 21.03.2013**

# Background and Content

**Background:**

**The European Tool for HDV CO2 testing has already a routine to handle different gear boxes in the vehicle simulation.**

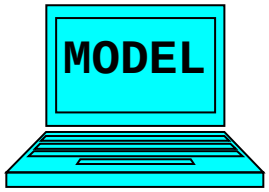
**These routines could be basis for the corresponding routines in the HILS model, since the actual HILS model does not provide gear shift models for complex gear box systems.**

**The approach allows to give any number of gears + transmission ratios as input and provides representative gear shift maneouvres.**

**Content:**

- **Overview European $CO_2$ test method for HDV and VECTO tool**
- **Gear shift rules manual transmission (MT)**
- **Gear shift rules automatized manual transmission**
- **Skip gears in gear shift manoeuvres**
- **Automatic transmission, torque converter**

# Overview test procedure for Heavy Duty vehicles



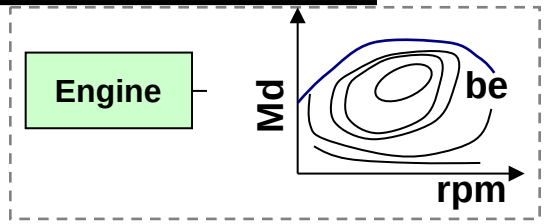

$$Pe = P_{roll.} + P_{air} + P_{acc} + P_{grad} + P_{tr.} + P_{aux} + P_{cons.}$$

$$n = (v \times 60 \times I_{axis} \times I_{gear}) / (d \times \pi)$$

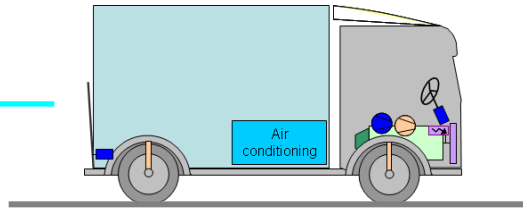
Driver model

**Fuel cons., $CO_2$**

## Component testing:




**Fuel consumption map:**
**steady state + WHTC-correction factors**
map + WHTC test measured on engine test bed




**Air resistance coefficients:**
**constant speed with torque measurement**

**Rolling resistance coefficients: resistance values from tire labeling, EC No 1222/2009**

**Gear box, axis:**
transmission, $\eta$=F(...)

**Transmission ratios, transmission losses**
OEM specific maps and default values

**Auxiliaries**
duty cycle, $\eta$=F(...)

**Power demand at engine from generic $P_{use}$ with generic efficiency maps for the auxiliaries**
OEM specific maps and intelligent controllers under discussion

# Overview VECTO

**Actual model:**

**Backward simulation, adapted for target speed cycles**

**Programming language: Visual Basic.NET**

**Simulation of engine power and engine speed:**

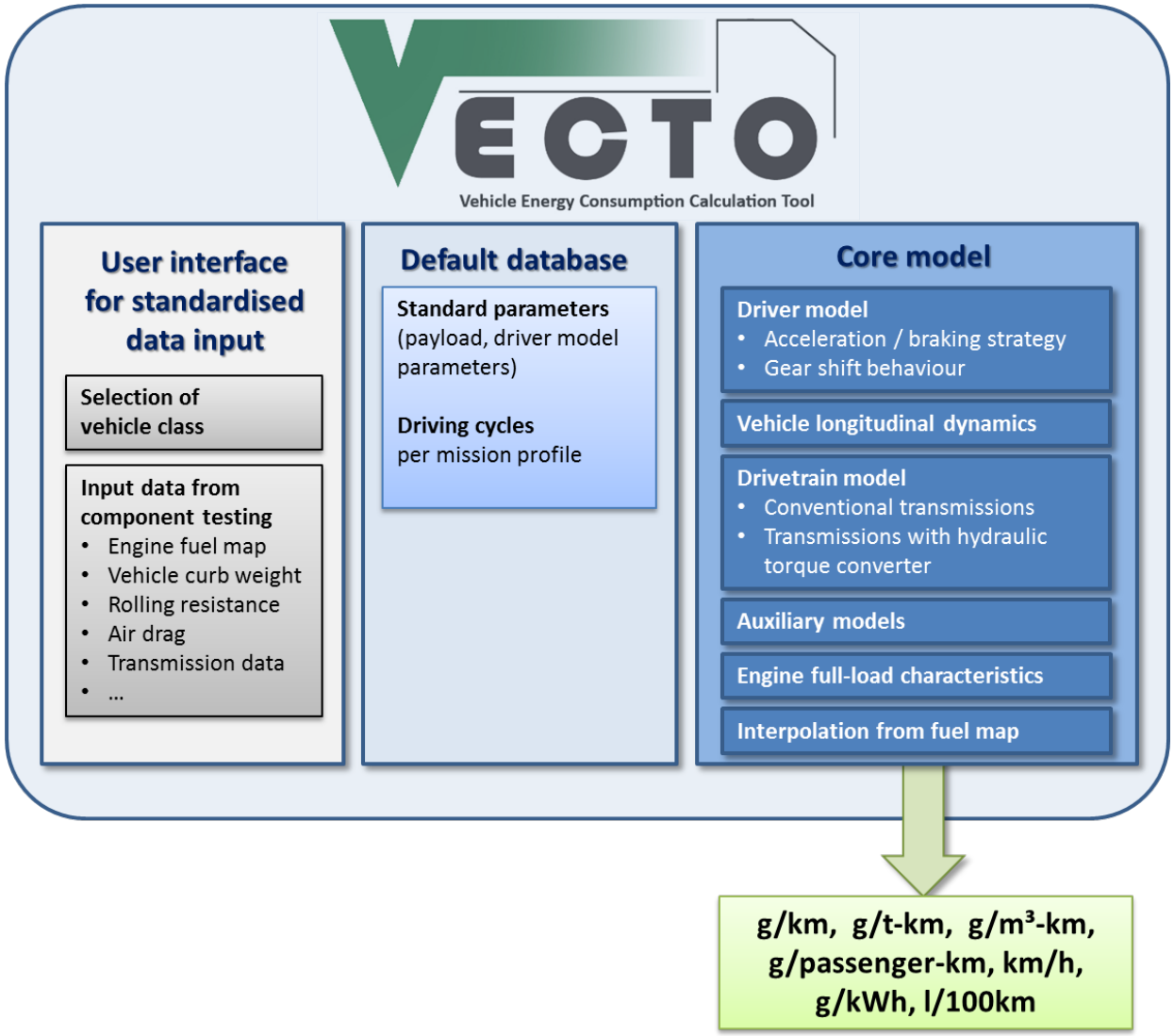
$$Pe = P_{roll.} + P_{air} + P_{acc} + P_{grad} + P_{tr.} + P_{aux} + P_{cons.}$$

$$n = (v \times 60 \times I_{axle} \times I_{gear}) / (d \times \pi)$$

**Interpolation of fuel consumption from engine map**

**Correction of FC for transients and “floating map” effects by "WHTC correction factors" (not yet implemented)**

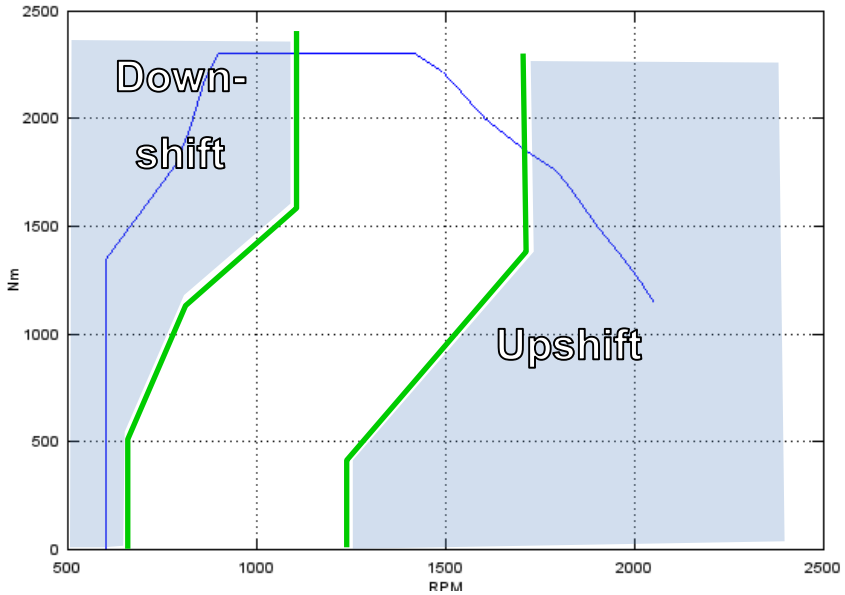
# Overview VECTO



# VECTO Gear Shift Model

## Gear Shift Model (MT, AT, AMT)

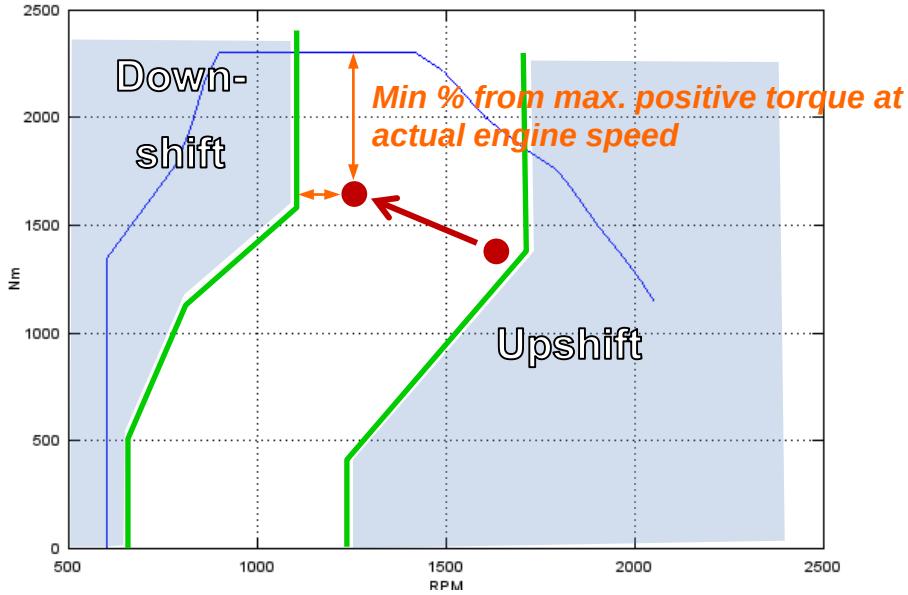
- Up- / Down- Shift based on shift-polygons.
- Polygons are user-defined (during proof of concept phase)
- Final declaration-ready version will calculate polygons based on engine characteristics like full load curve and specific rpm's.



# VECTO Gear Shift Model: Additional Rules (1/2)

## Allow shift-up inside polygons (AMT)

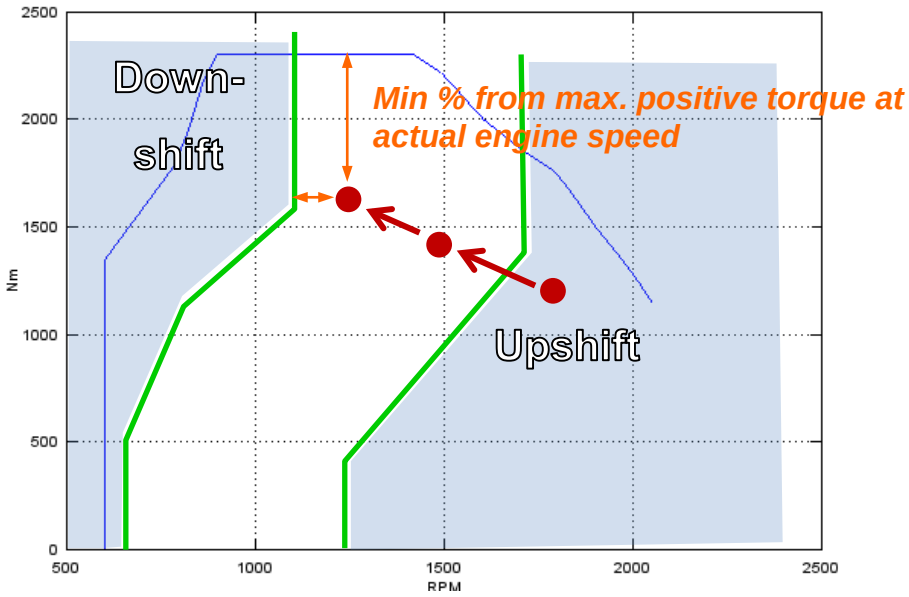
- Only if torque reserve is provided and rpm is still above Down-shift-rpm



# VECTO Gear Shift Model: Additional Rules (2/2)

## Skip gears (AMT, MT)

- Whenever gear shift is initiated (because rpm crosses up- or down- shift polygon) it is possible to skip gears
- Torque reserve must be provided and rpm must remain below Down-shift-rpm



# Driver model: traction interruption during gear shifts

- **Duration of traction interruption is user-defined in seconds**
- **Calculation of coast down deceleration:**
  - Condition: $P_{roll.} + P_{air} + P_{acc} + P_{grad} = 0$
  - $P_{grad} < 0$ may result in $P_{acc} > 0$ (downhill → acceleration), check WHVC gradient effects!
- **Engine power in declutched phases** to compute change of engine speed**:**
  - First time step ("tip out"): $P_e = 25\% * (Pe_{(t-1)} - P_{mot}) + P_{mot}$ $(P_{mot} < 0)$
  - Time steps >1sec: $P_e = P_{mot}$ if $n > n_{idle}$ else $Pe = 0$
- **Engine speed**
  - results from $P_e = I_{eng} * \dot{\omega} * \omega$ -> influence on acceleration characteristic via transient full load

# Automatic Transmission (1/2)

## VECTO method adapted to forward calculation

- Same polygon-based gear shift model
- Settings: sequential gear-shifting, shift-up inside polygons
- Torque Converter (TC):

  - Defined as (virtual) separate gear, i.e. only first gear with TC active
  - While TC active: in forward calculation approach: calculation of torque and speed after TC based on TC characteristic