

# VECTO-DEV

14.05.2019



## Gearshift Models

# Gearshift Strategies

- The following gearshift strategies are implemented in this development release
  - **AMT**
    - Classic AMT gearshift strategy (as in the current official VECTO version)
    - ACEA/Scania proposed gearshift strategy
    - TUG proposed gearshift strategy (FC-based)
  - **AT**
    - Classic AT gearshift strategy (as in the current official VECTO version)
    - Voith proposed gearshift strategy
    - TUG proposed gearshift strategy (FC-based)

# Selecting Gearshift Strategy

Engine Only Mode

General Driver Model

Overspeed

☒ Off Max. Overspeed 5 [km/h]

☐ Overspeed Minimum speed 50 [km/h]

Look-Ahead Coasting

Min. Velocity 50 [km/h]

Preview distance factor 10

Decision Factor - Target Speed

Decision Factor - Velocity Drop

DF\_coasting = 2.5 \* 1.5 \* DF\_vTarget \* DF\_vDrop

Max. acceleration and brake curves

Driver Acceleration/Deceleration File (.vacc):

Driver.vacc

Gearshift Strategy

VECTO Job File

Engine Only Mode

General Driver Model

Vehicle CityBus\_AT\_Ser.vveh

Engine Engine\_175kW\_6.8l.veng

Gearshift **gearshift.vgdx**

Shift

- The Job-Window contains two additional input fields
  - Gearshift Strategy on the 'Driver Model' tab allows to select from applicable gearshift strategies (AMT/AT)
  - On the general tab, an additional file needs to be provided with parameters for the selected shift strategy (details see later)
- By default (and in declaration mode) the 'classic' VECTO gearshift strategies are used
  - These do not need an additional file with the shift parameters (shift lines can be defined in engineering mode for every gear in the gearbox window)
- **Note:** the shift parameter file (and all referenced files) can not be edited in the GUI! Please use a text editor (e.g., notepad++ or notepad) to change certain parameters. You can use the provided examples as starting point

# Classic AMT Gearshift Strategy

- Based on upshift and downshift lines which are calculated based on certain parameters of the engine (idling speed, full-load curve)
- For details please see the VECTO user manual

## ACEA/Scania AMT Gearshift Strategy

- The principle is described in '*Scania\_2018-03-29\_Prototype-TCU-VECTO.pdf*' and '*Scania\_2018-06-20\_VECTO--Transmission-Control-Unit.pdf*'
- The documentation of the Matlab implementation is provided in '*Scania\_Transmission Control Unit\_Matlab.pdf*'
- The parameters required for this gearshift strategy are documented in '*Scania\_2018-11-02\_Settings-TCU-VECTO.pdf*'

# ACEA/Scania AMT Gearshift Strategy Parameter

- The following parameters have to be provided in the shift parameter file (see for example "Examples\Class5\_Tractor\_4x2\_AMT\_ACEA\ShiftParameters.vtcu")

- <i>StartSpeed</i>	- <i>P_card_curr_threshold</i>
- <i>StartAcceleration</i>	- <i>Diff_curr_targ_vel</i>
- <i>GearResidenceTime</i>	- <i>EngineSpeedHighDriveOffFactor</i>
- <i>Dn_Tq99L_high_min_1</i>	- <i>Rating_current_gear</i>
- <i>Dn_Tq99L_high_min_2</i>	- <i>AccelerationReserveLookup</i>
- <i>GearRangeUp</i>	- <i>ShareTorque99L</i>
- <i>GearRangeDown</i>	- <i>PredictionDurationLookup</i>
- <i>LookBackDriver</i>	- <i>ShareIdleLow</i>
- <i>DriverAccelerationLookBackInterval</i>	- <i>ShareEngineHigh</i>
- <i>DriverAccelerationThresholdLow</i>	
- <i>P_card_avg_threshold</i>	

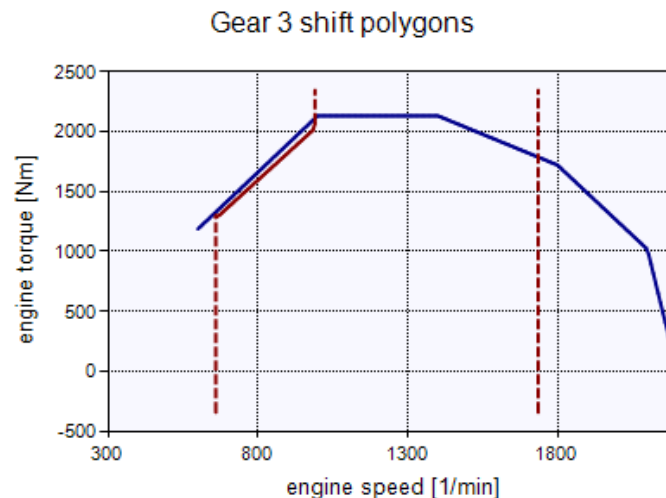
- Some of the parameters are lookup-tables in CSV format

# TUG FC-Based AMT Gearshift Strategy

- The shift strategy is based on gearshift lines for upshift and downshift (similar to the classic VECTO gearshift strategy)
  - Allow early upshifts if the current engine operating point is within the gearshift lines if the following criteria are met:
    - Upshift:  $i_{\text{gear}+1} \leq \text{RatioEarlyUpshiftFC}$  AND
    - $\text{FC}_{\text{gear}+1} < \text{FC}_{\text{gear}} * \text{Rating\_current\_gear}$
  - Allow early downshifts if the current engine operating point is within the gearshift lines if the following criteria are met:
    - Downshift:  $i_{\text{gear}-1} \leq \text{RatioEarlyDownshiftFC}$  AND
    - $\text{FC}_{\text{gear}-1} < \text{FC}_{\text{gear}} * \text{Rating\_current\_gear}$
- Purpose of 'RatioEarlyUpshiftFC' and 'RatioEarlyDownshiftFC': avoid frequent sequential shifts for lower gears (i.e. high gear ratios), FC-based early upshift shall only be possible for higher gears.

# TUG FC-Based AMT Gearshift Strategy

- Definition of gearshift lines
  - Upshift line
    - Vertical line at  $n_{rated}$
  - Downshift line
    - Vertical line at  $1.1 * n_{idle}$  speed up to  $Tq(n_{idle} * 1.1) * 0.98$
    - Engine full-load curve -2% between  $n_{idle}$  and  $n_{tq\_99}$
    - Vertical line at  $n_{tq\_99}$
    - $n_{tq\_99}$ : lowest engine speed where the engine's full-load curve reaches 99% of the max. torque





# TUG FC-Based AMT Gearshift Strategy

- The following parameters have to be provided in the shift parameter file (see for example "Examples\Class5\_Tractor\_4x2\_AMT\_TUG\ShiftParameters.vtcu")
  - *Rating\_current\_gear*
  - *RatioEarlyDownshiftFC*
  - *RatioEarlyUpshiftFC*

# Classic AT Gearshift Strategy

- Based on downshift (pre-shift) and upshift (post-shift) lines
- For details please see the VECTO user manual

cont.

# Voith AT Gearshift Strategy

- The idea is described in '2019\_03\_25\_New\_gear\_shift\_logic\_for\_Vecto.pdf', including documentation of the Matlab model
  - Limitation: not tested for gearboxes with 2 torque converter gears

cont.

# Voith AT Gearshift Strategy

- The following parameters have to be provided in the shift parameter file (see for example "Examples\CityBus\_AT\_GSVoith\ShiftParameters.vtcu")
  - *LoadStageShiftLines*
  - *LoadStageThresholdsUp*
  - *LoadStageThresholdsDown*
- LoadStageShiftLines contains the upshift and downshift lines for all load stages. An example is given "Examples\CityBus\_AT\_GSVoith\GearshiftLines\Voith.vgsv". Details on the LoadStageShiftLines are provided on the next page
- LoadStageThresholdsUp and LoadStageThresholdsDown is a string with the thresholds for determining the individual thresholds, separated by semicolons (;) – see example

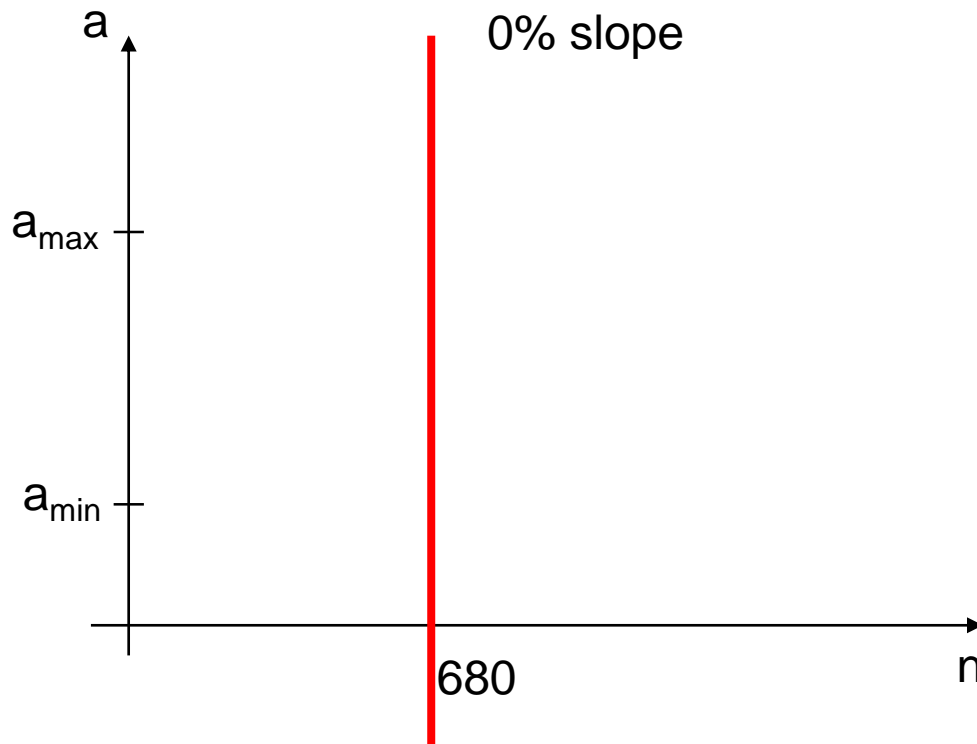
# Voith AT Gearshift Strategy

- LoadStageShiftLines: compared to the documentation provided by Voith, VECTO uses a more general approach for defining the shift lines
  - Shift lines have to be defined for every load stage
  - For every load-stage, an upper and lower shift line is defined for downhill (-5%), level (0%), and uphill (+5%)
    - The shift speed is interpolated between upper and lower bound
    - If no interpolation is intended, set the upper and lower bound shift line to the same values
  - For both, the upper and lower bound shift lines, the shift speed for  $a_{\min}$  and  $a_{\max}$  have to be defined
    - For a vertical shift line, set  $a_{\min}$  and  $a_{\max}$  to the same value
  - In order to simplify the LoadStageShiftLines file, VECTO uses the following rules in case no value is provided in the input file
    - The lower bound shift speeds for  $a_{\max}$  have to be provided in any case (downhill, level, uphill)
    - If the lower bound shift speeds for  $a_{\min}$  are missing, the lower bound shift speeds for  $a_{\max}$  are used
    - If the upper bound shift speeds for  $a_{\max}$  are missing, the values from the lower bound shift lines for  $a_{\max}$  are used
    - If the upper bound shift speeds for  $a_{\min}$  are missing, either  $a_{\max}$  from the upper bound or  $a_{\max}$  from the lower bound is used

# Voith AT Gearshift Strategy

- LoadStageShiftLines: Example upshift 1 -> 2, load stage 1; values for amin

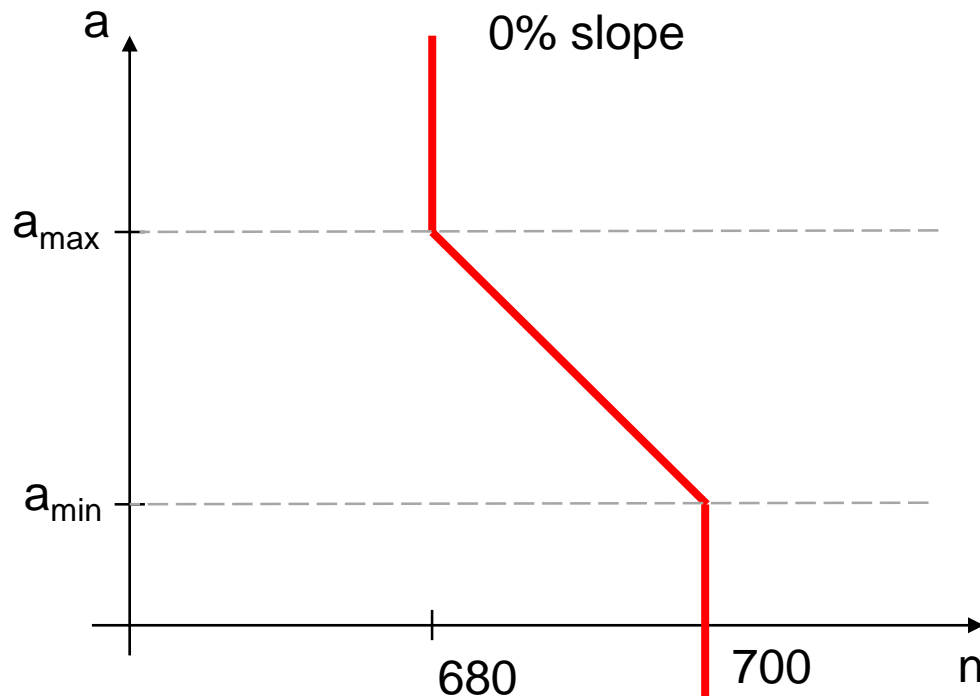
```
shift , LoadStage , n_dh_amax_lower , n_level_amax_lower , n_uh_amax_lower , n_dh_amin_lower , n_level_amin_lower , n_uh_amin_lower , [...]
1-2 , 1 , 650 , 680 , 725 , , , , [...]
```



# Voith AT Gearshift Strategy

- LoadStageShiftLines: Example upshift 1 -> 2, load stage 4

```
shift , LoadStage , n_dh_amax_lower , n_level_amax_lower , n_uh_amax_lower , n_dh_amin_lower , n_level_amin_lower , n_uh_amin_lower ,
n_uh_amin_upper
...
1-2 , 4 , 650 , 680 , 725 , 670 , 700 , 745 ,
...
```



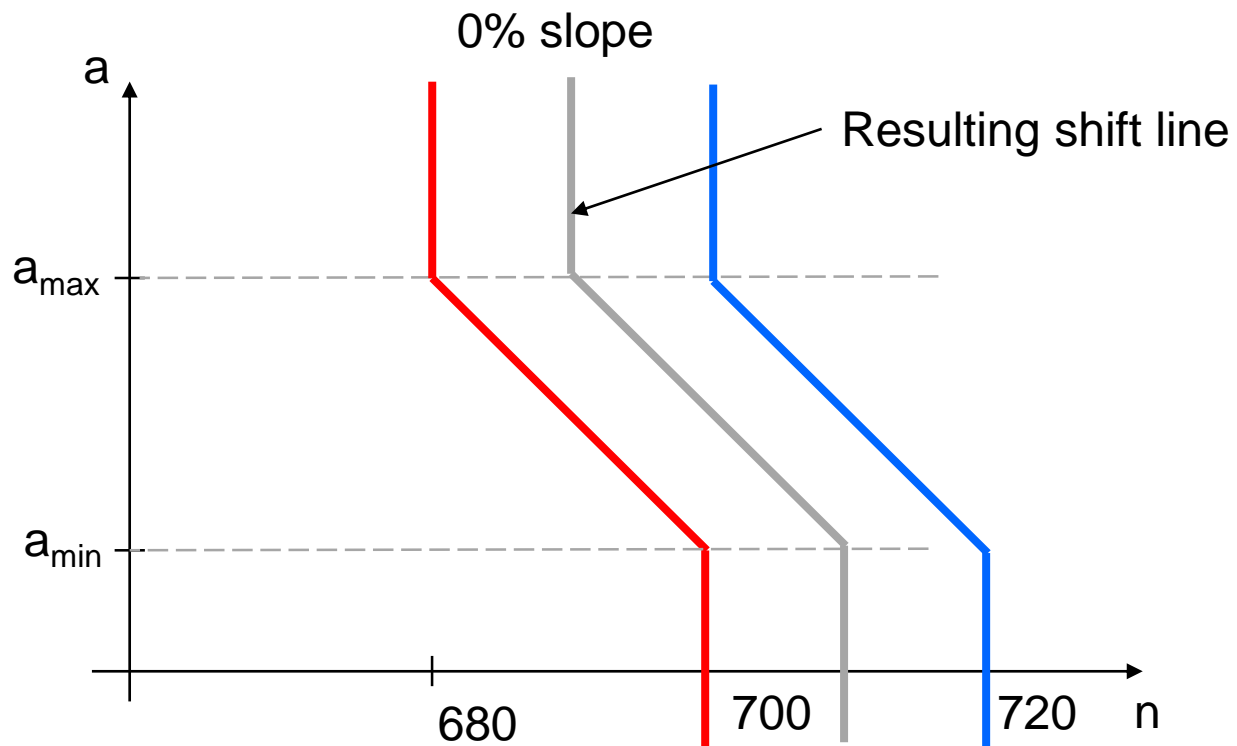
# Voith AT Gearshift Strategy

- LoadStageShiftLines: Example upshift 1 -> 2, load stage 5

```
...shift , LoadStage , [...], n_level_amax_lower , [...], n_level_amin_lower , [...], n_level_amax_upper , [...], n_level_amin_upper , [...]
```

```
1-2 , 5 , [...], 680 , [...], 700 , [...], 700 , [...], 720 , [...]
```

...



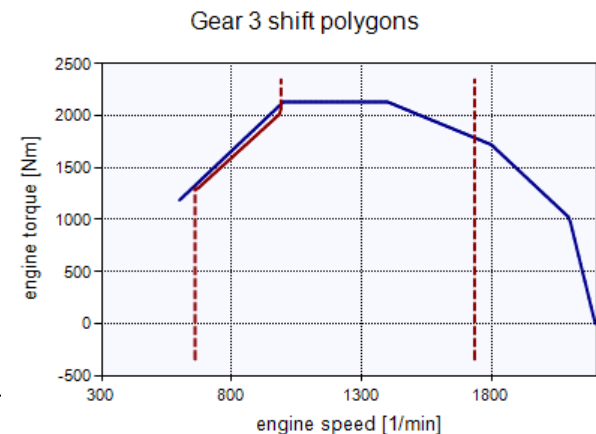


## TUG FC-Based AT Gearshift Strategy

- The shift strategy is based on gearshift lines for upshift and downshift (similar to the classic VECTO gearshift strategy) and uses the same principle as the FC-based AMT gearshift strategy
  - Allow early upshifts if the current engine operating point is within the gearshift lines if the following criteria are met:
    - Upshift:  $i_{\text{gear}+1} \leq \text{RatioEarlyUpshiftFC}$  AND
    - $\text{FC}_{\text{gear}+1} < \text{FC}_{\text{gear}} * \text{Rating\_current\_gear}$
  - Allow early downshifts if the current engine operating point is within the gearshift lines if the following criteria are met:
    - Downshift:  $i_{\text{gear}-1} \leq \text{RatioEarlyDownshiftFC}$  AND
    - $\text{FC}_{\text{gear}-1} < \text{FC}_{\text{gear}} * \text{Rating\_current\_gear}$
- Limitation: not applicable for gearboxes with 2 torque converter gears at the moment

# TUG FC-Based AT Gearshift Strategy

- Gearshift lines can be provided as .vgbs file in the gearbox dialog for every gear
- In case no gearshift lines are provided, the following shift lines are used
  - Upshift line
    - Vertical line at  $n_{rated}$ , converted to post-upshift speed via the transmission ratios
  - Downshift line
    - Vertical line at  $1.1 * n_{idle}$  speed up to  $Tq(n_{idle} * 1.1) * 0.98$
    - Engine full-load curve -2% between  $n_{idle}$  and  $n_{tq\_99}$
    - Vertical line at  $n_{tq\_99}$
    - $n_{tq\_99}$ : lowest engine speed where the engine's full-load curve reaches 99% of the max. torque



## VECTO Outputs

- Depending on the selected gearshift strategy, the .vmod file contains additional columns, e.g., the calculated load stage for the AT-Voith proposal, or several intermediate results for the ACEA/Scania proposal
- The .vsum file contains an additional column indicating the used gearshift strategy