VECTO Trailer Tool

User Manual

DG CLIMA

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References to information in Technical Annexes of the Trailer Regulation

Annex Number	Title	Further Explanation
Annex I	Classification of vehicles in vehicle groups	Required definitions and classification system for trailers covered by the Regulation
Annex II	Requirements and processes for the operation of the simulation tool	Requirements for the process to be able to determine the official values within the framework of trailer regulation by means of the VECTO Trailer Tool
Annex III	Input information about the characteristic of the vehicle	Definitions and precise description of the input parameters into the tool and how to determine them
Annex IV	Template of the Manufacturer‘s Records file and of the Customer Information file	Definition of content and structure of the Manufacturer‘s Records file (MRF) and the Customer Information file (CIF)
Annex V	Vehicle‘s air drag data	Defines the procedures how the features of aerodynamic devices shall be determined, either via virtual testing using CFD or by applying standard reduction rates for aerodyanmic devices fulfilling certain minimum properties

Platform requirements

Hardware Requirements

- Microsoft Windows PC running Microsoft Windows 7 or later

Software Requirements

- Microsoft .NET Framework 4.8

Software Requirements to use the pdf function of the tool

- Microsoft Visual C++ Runtime must be installed. If this is not the case for your computer, it can be downloaded free of charge from the following links:
  - 32 bit: https://aka.ms/vs/17/release/vc_redist.x86.exe
  - 64 bit: https://aka.ms/vs/17/release/vc_redist.x64.exe

Installation Options

VECTO Trailer Tool is distributed as a portable application. This means you can simply unzip the archive and directly execute it. This, however, requires write and execute permission for the VECTO Trailer Tool application directory.

In case you do not have execute permissions, please ask your system administrator to install VECTO Trailer Tool into an appropriate directory (e.g. under `C:\Program Files`). Installing VECTO Trailer Tool requires the following two steps:

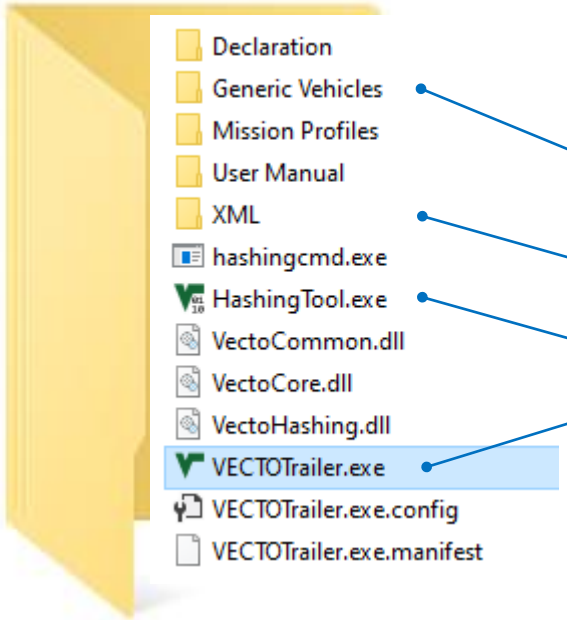
- Copy the VECTO Trailer Tool directory and all its files and subdirectories to the appropriate location where the user has execute permissions
- Edit the file `install.ini` and remove the comment character (#) in the line containing `ExecutionMode = install`

If the ExecutionMode is set to install (this is also possible when running VECTO Trailer Tool from an arbitrary directory), VECTO Trailer Tool does not write its configuration files and log files to the application directory but to the directories `%APPDATA%` and `%LOCALAPPDATA%` (usually `C: \User\<username>\AppData\Roaming` and `C: \User\<username>\AppData\Local`).

Important: If the ExecutionMode is set to install it is necessary that you copy the generic VECTO Trailer Tool models distributed with VECTO Trailer Tool to a location where you have write permissions as VECTO Trailer Tool writes the results to the same directory as the job files

VECTO Trailer Tool – Software package

Content of VECTO Trailer Tool package as downloaded from JRC server
can be copied to any place on a PC/server*



Example files for trailers, tyres, certified aerodynamic devices and XML files of the generic towing vehicles

Example XML files and XSD files

VECTO Hashing Tool

VECTO Trailer Tool Executable, double-click to start

* Snapshot shows only a reduced set of data included in the downloadable package

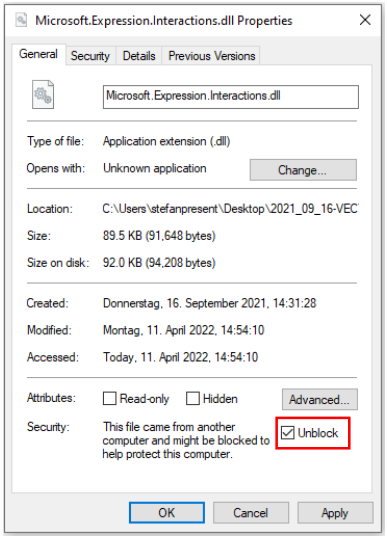
VECTO Trailer Tool – What to do if tool doesn't start

Such a behaviour has been observed in cases where the VECTO Trailer Tool software package was unpacked with the Windows Explorer and marked the executables and dlls as unsafe (because loaded from the internet).

How to fix this?

Option 1:

Check all exe and dlls and mark them as "safe" → explorer → right click properties and then in the lower area tick the box that says "Unblock" (see Snapshot to the right)



Option 2:

Unpack VECTO Trailer Tool with another software ("7zip" for example)

VECTO Trailer Tool – JobFiles GUI

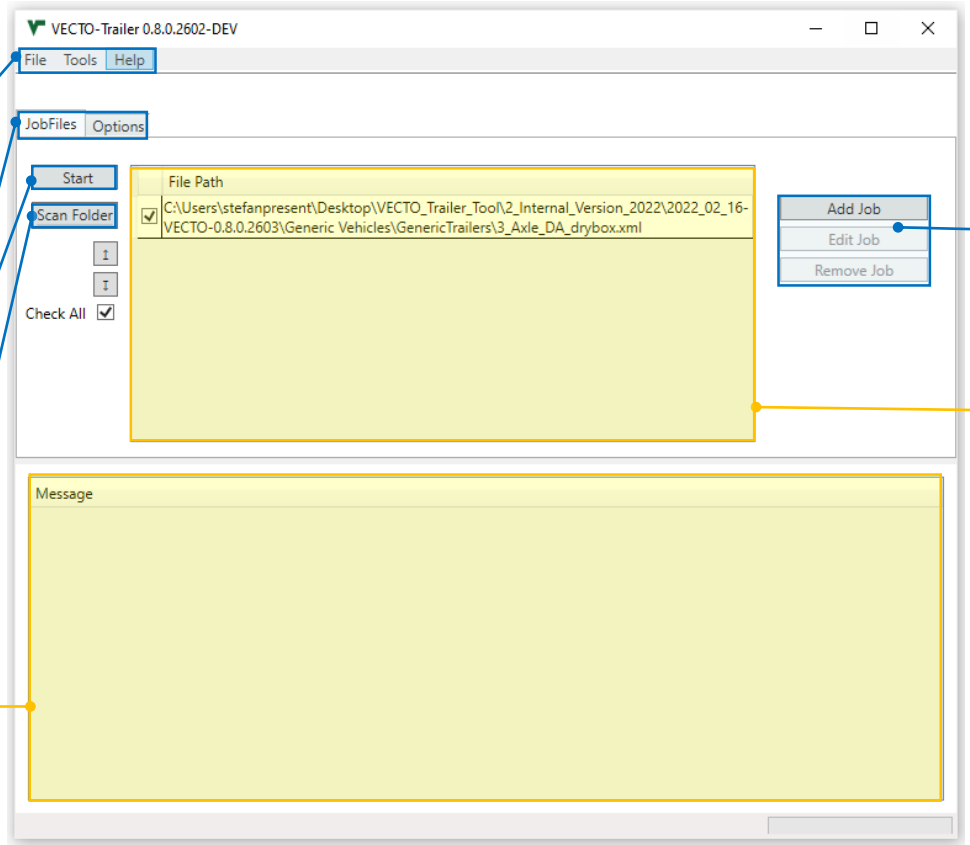
Toolbar with common controls like
- add new Job
- search for Job files
- open User Manual
- etc.

Switch between “Job Files” and “Options” tab

Start button to simulate active Jobs

Button to activate/stop background worker

Message window showing the calculation status



Buttons to handle Job files
- Add new Jobs
- Edit existing Jobs from Job window
- Delete Jobs from Job window

Job window that shows all loaded Job files

VECTO Trailer Tool – Options GUI

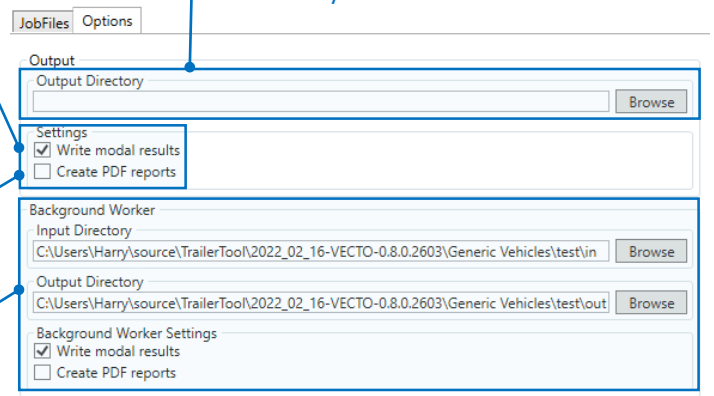
- At first program start it is recommended to define the default output directory and check the settings for writing modal results and creating formatted pdf reports
- Settings only affect the handling of input data or results, but do not influence the official results.

This input can be used to write all simulation result files to a certain directory. This can either be an absolute or a relative path

If selected, the tool writes modal results (.vmod files) for every calculation run. A Summary file (.vsum) is always created

If selected, the tool creates a formatted pdf report for both the CIF and MRF for every simulated job

Input/Output directories for the Background worker as well as options to write modal outputs and pdf reports of the simulation runs



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VECTO Trailer Tool - Background worker

Enables a simple automation of simulation runs

1. The background worker periodically (i.e. every 4 seconds) searches a directory specified by the user for new input XMLs (Input Directory)
2. If a new file is available, a calculation is automatically started in the background
3. After completion, the result files are stored in another directory to be specified by the user (Output Directory)*

- Important boundary conditions / information on using the Background worker
  - Input and Output Directory **must be** different folders
  - In case an erroneous file is read from the Input directory, the tool will display an error message but still simulate the remaining valid Job files

*The background worker has to be initiated for a certain input/output directory by pressing the „Scan Folder“ button under „JobFiles“

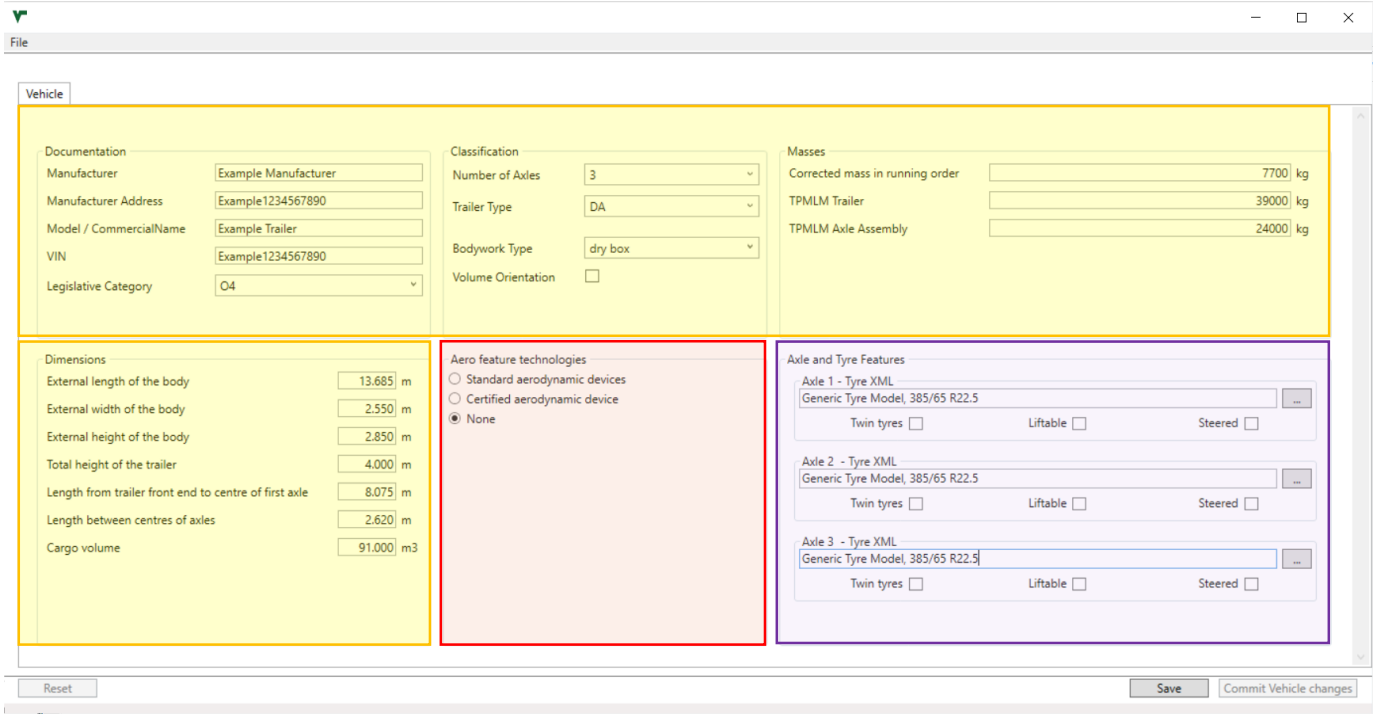
VECTO Trailer Tool – Create or edit trailer job (1/6)

1. Open window via
   - "Edit Job" or
   - Right click on Job window → "Create Trailer Job"

2. Define main trailer specifications

3. Define Aero feature technologies

4. Define Axle and Tyre features



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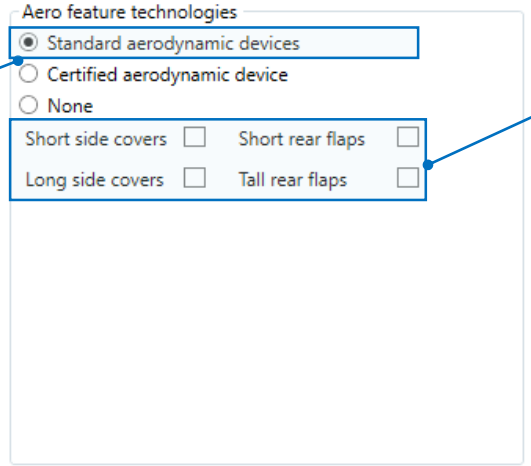
VECTO Trailer Tool – Create or edit trailer job (2/6)

3. Define Aero feature technologies

Select if standard values for reduction rates from aero devices are to be applied

Standard values as automatically allocated by the VECTO Trailer Tool are documented in:

- Masterexcel sheet „Combination Add-ons“ or „Specific Trailer“ column Y to BH
- Specific_trailer.csv in the Declaration folder
- Task 2 report



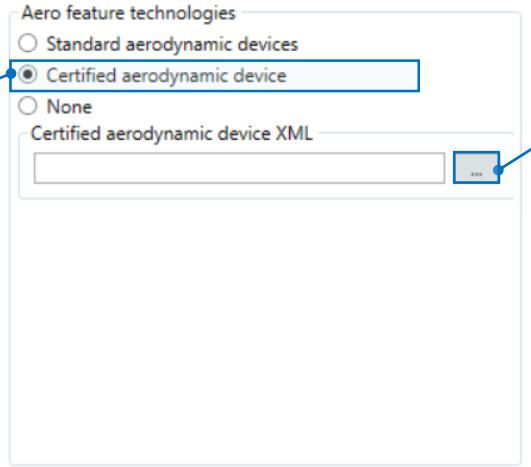
Checkbox to declare applicable standard aerodynamic device(s)
Note that not all combinations are valid → see also:

- Masterexcel sheet „Combination Add-ons“
- Trailer_combination_addon.csv in the Declaration folder
- Task 2 report

VECTO Trailer Tool – Create or edit trailer job (3/6)

3. Define Aero feature technologies

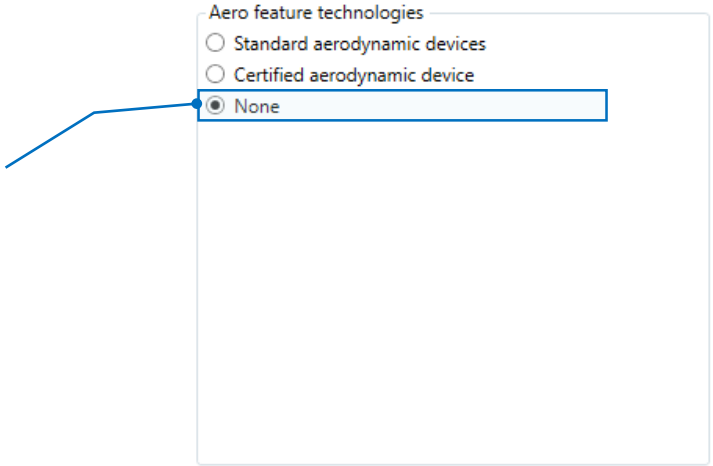
Select if certified reduction rates from aerodynamic devices are to be applied



Brows button to browse for the XML file of the certified aerodynamic device

VECTO Trailer Tool – Create or edit trailer job (4/6)

3. Define Aero feature technologies



Select if the trailer is equipped with no aerodynamic device(s)

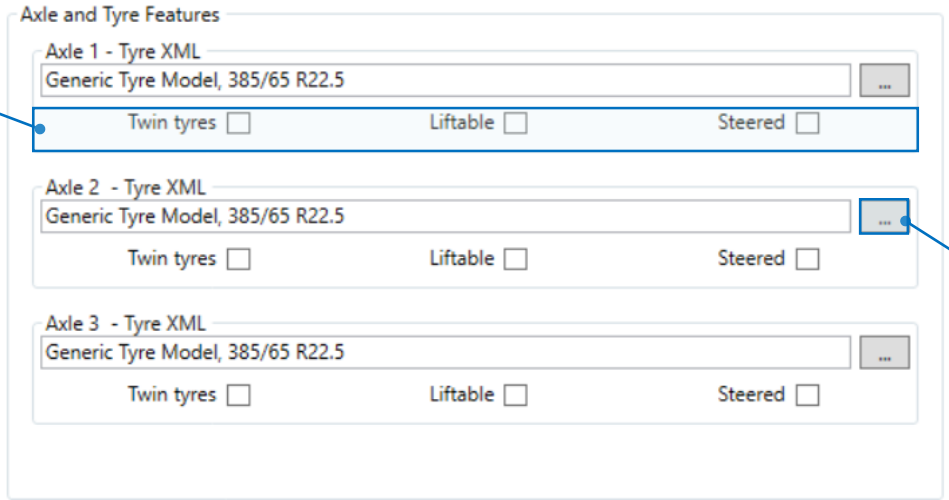
VECTO Trailer Tool – Create or edit trailer job (5/6)

4. Define Axle and Tyre features

Checkbox to declare applicable tyre/axle features

Effects as automatically considered by the VECTO Trailer Tool for liftable/steered axles are documented in:

- Masterexcel
  - sheet „Specific Trailer“ column E to P
- Specific_trailer.csv in the Declaration folder,
- Task 2 report

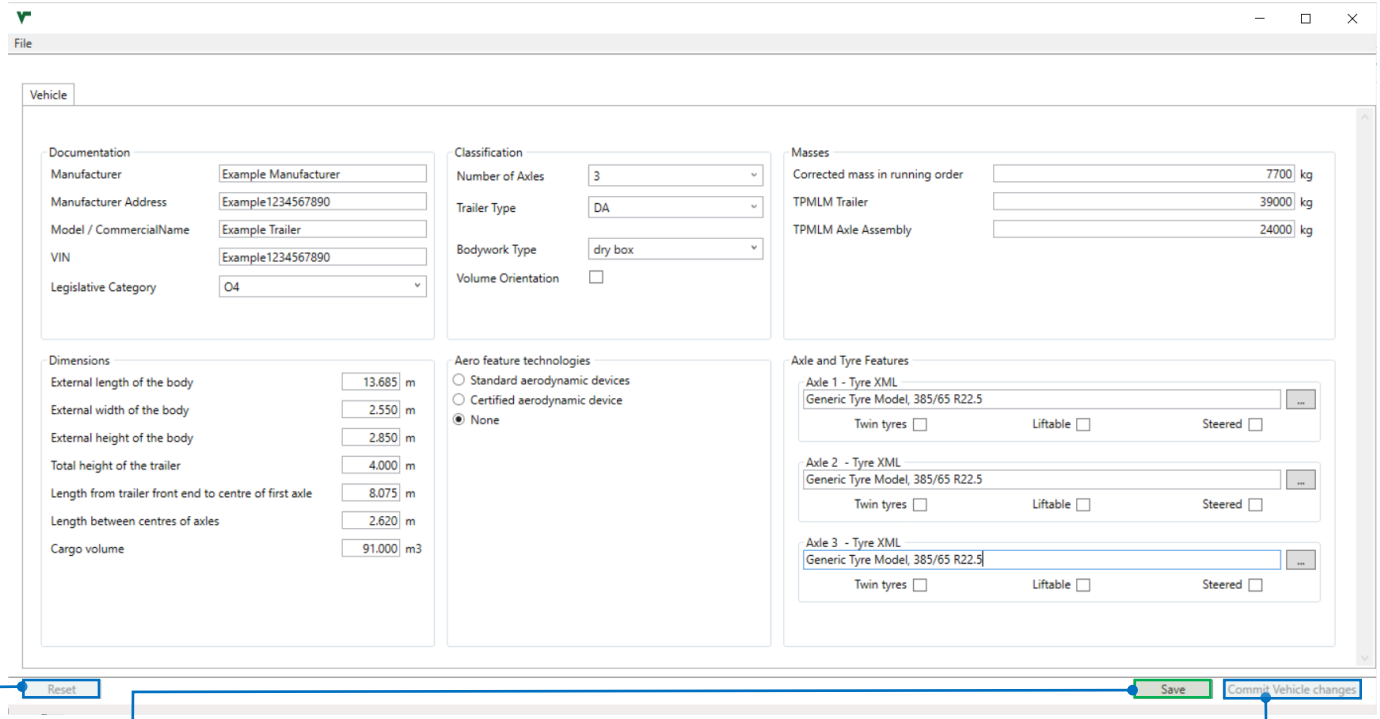


Browse button to search for tyre XMLs

VECTO Trailer Tool – Create or edit trailer job (6/6)

5. Save Job file

6. Press “Start” in Job file editor to start simulation of active Jobs



Button to reset all input fields to the last committed state

When the Job-file is saved, a message window will pop up if any errors are detected in the inputs

Button to commit changes made to the input fields. However, in order to permanently commit the changes it is necessary to save the file (closing the file without saving will reset the changes)

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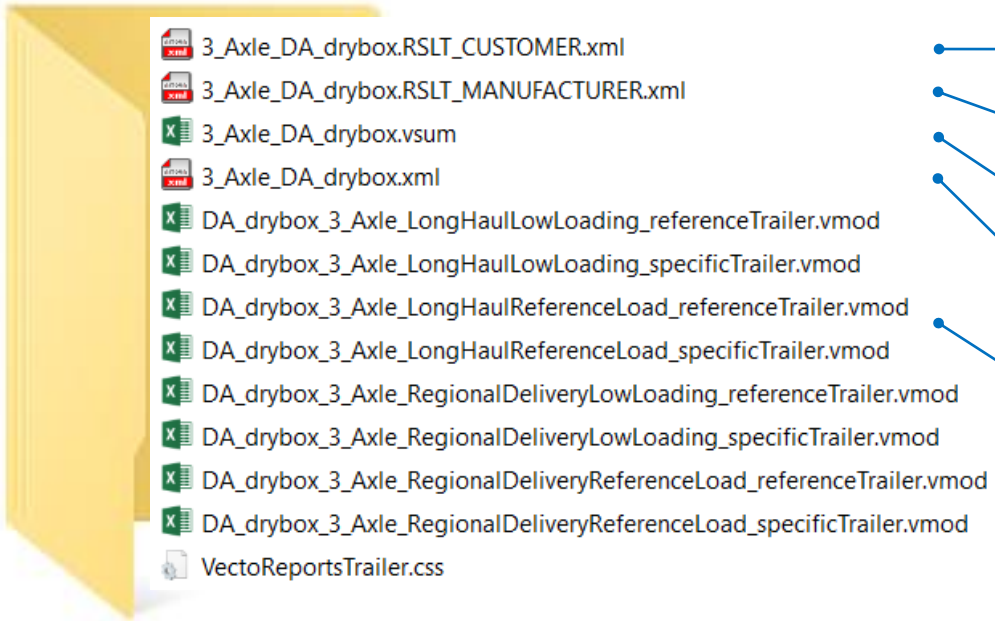
VECTO Trailer Tool – Result files (1/2)

Outputs created by the VECTO Trailer Tool including the corresponding Job file*



* Snapshot doesn't show all .vmod files calculated for this particular trailer configuration

VECTO Trailer Tool – Result files (2/2)

Result file	Description
Manufacturer's Records File (MRF)	**Output for regulatory purpose in XML format** a file produced by the simulation tool which contains manufacturer related information, a documentation of the input data and input information to the simulation tool, and the performance of the vehicle with regard to its influence on the CO2 emissions and fuel consumption of motor vehicles, and which takes the form of the template laid down in Annex IV, Part I
Customer Information file (CIF)	**Output for regulatory purpose in XML format** a file produced by the simulation tool which contains a set of vehicle related information and the performance of the vehicle with regard to its influence on CO2 emissions, fuel consumption, of motor vehicles, and which takes the form of the template laid down in Annex IV, Part II
Pdf-output	Formatted printable output of the customer information file
vsum-file*	Output for engineering purposes in csv-format. Single line of results per each simulated combination of trailer, mission profile and payload with aggregate and or average values
vmod-file*	Output for engineering purposes in csv-format. Single file per each simulated combination of trailer, mission profile and payload with time-resolved simulation results from the VECTO core.

* A documentation of the results contained in the vsum and vmod files can be found in the help file for the VECTO calculation core (help.html), which is also included in the VECTO Trailer Tool release.

What is the "Efficiency Ratio"? (1/2)

The Efficiency Ratio (ER) is a dimensionless characteristic value for the rating of a (semi-)trailer with regard to its influence on CO_2 emissions, fuel emissions and energy consumption of the towing vehicle.

$$\textbf{Efficiency Ratio} = \frac{CO_{2,\,spec(S)T}}{CO_{2,\,ref(S)T}}$$

Where:
$CO_{2,\,spec(S)T}$ ... CO_2 emissions with the generic towing vehicle and the **specific** (semi-)trailer
$CO_{2,\,ref(S)T}$ ... CO_2 emissions with the generic towing vehicle and a **reference** (semi-)trailer

Accordingly, an ER of 0.95 indicates that CO_2 emissions are 5% lower with the specific (semi-)trailer than with the reference trailer.

ERs are provided:

- For CO_2 emissions in the units "grams per km", "grams per ton-km" and "grams per m^3-km"
- For each relevant mission profile and payload combination and for the weighted-mix of mission profiles and payloads

Reference (semi-)trailers are defined for all vehicle groups currently covered by the Regulation and represent typical configurations (mass, dimensions, rolling resistance) as of approx. the year 2020. The specifications of these reference (semi-)trailers are documented in the VECTO Trailer Tool Masterexcel. However, their knowledge is not essential for the interpretation of the ERs.

What is the "Efficiency Ratio"? (2/2)

Further information for individual use of the results from the VECTO Trailer Tool:

- Since fuel consumption and CO_2 emissions correlate linearly, the results as indicated by the ERs also apply to fuel consumption. For energy consumption of fully electric vehicles, at least similar trends apply.
- If (semi-)trailers in different groups are to be compared with each other (e.g. a standard variant with a volume-oriented variant), this cannot be done using the ER, as the reference (semi-)trailers are different. Such a comparison can be made using the results for fuel consumption (lit./100km, g/km) or CO_2 emissions (g/km). For a direct comparison, it must be ensured that the assigned generic towing vehicles are also identical on the basis of Annex I.
- Results for fuel consumption in the units lit./100km, g/km and CO_2 emissions in the unit g/km can be interpolated or extrapolated to other payload conditions in a specific mission profile in a very good approximation via the linear trend established by the results for the two fixed payloads as provided by the VECTO Trailer tool.

What is the “Reference Ratio”? (1/3)

The reference ratio can be used by a vehicle operator to calculate fuel consumption and CO_2 emissions for specific vehicle combinations for which VECTO results for both the towing vehicle and for the (semi-)trailer are available.

$$\text{FC or } CO_2 = \text{FC or } CO_2 \cdot \text{Reference Ratio} \cdot \text{Efficiency Ratio}$$

For the specific vehicle combination	VECTO result for the specific towing vehicle	VECTO Trailer Tool results for the specific (semi-)trailer
Units: lit./100km; g/km	Units: lit./100km; g/km	

The following constraints need to be considered:

- The towing vehicle must be of the same vehicle group as the generic towing vehicle defined in Annex I for the (semi-)trailer.
- The calculation must be carried out separately for each combination of mission profile and paylaod.
- The calculation can only be performed for the units specified above. For the Efficiency Ratio the "kilometre-based" value is to be used.

What is the "Reference Ratio"? (2/3) Application example

- Group 9 lorry with drawbar trailer

			Results motor vehicle VECTO	Results VECTO Trailer Tool		
Mission profile + payload	**Vehicle configuration as in VECTO for motor vehicles**	**Vehicle configuration as in VECTO Trailer Tool**	**FC (l/100km) towing vehicle**	**Reference ratio**	**Efficiency ratio**	**FC (l/100km) specific combination**
Long haul (low/rep.)	**Specific group 9 lorry** + T2 standard trailer (type DC)	Generic group 9 lorry + **specific DB trailer**	26.8	0.929	0.973	24.2
			34.8	0.949	0.965	31.9
Regional delivery (low/rep.)	**Specific lorry as "rigid solo"**	Generic group 9 lorry + **specific DB trailer**	20.1	1.282	0.976	25.1
			23.5	1.368	0.972	31.2

Other mission profiles are not of relevance (urban delivery is not simulated for group 9 vehicles by motor vehicle VECTO, municipal cycle is not relevant for trailers)

What is the "Reference Ratio"? (3/3)
Background information

The reference ratio is calculated by the tool as follows:.

$$\textbf{Reference Ratio} = \frac{\mathbf{CO_{2,\,ref(S)T}}}{\mathbf{CO_{2,\,stand(S)T}}}$$

Where:
$CO_{2,\,ref(S)T}$ ... CO_2 emissions with the generic towing vehicle and the **reference** (semi-)trailer
$CO_{2,\,stand(S)T}$ ... CO_2 emissions with the generic towing vehicle and a **standard** (semi-)trailer

This cuts the reference trailer out of the equation and leaves the ratio between spec and standard trailer, which then multiplied by the VECTO motor vehicle value for standard trailer gives the CO_2 value for the specific trailer.

$$\text{FC or } CO_2 = \text{FC or } CO_2 * \frac{CO_{2,ref(S)T}}{CO_{2,stand(S)T}} * \frac{CO_{2,spec(S)T}}{CO_{2,ref(S)T}}$$

For the specific vehicle combination
Units: lit./100km; g/km

VECTO result for the specific towing vehicle and standard (semi-)trailer
Units: lit./100km; g/km

VECTO Trailer Tool results for the specific (semi-)trailer

Hashing (1/2)

The following hashing functions are integrated into the automated programme sequence of the VECTO Trailer Tool:

- The trailer input XML is hashed before the simulation and the hash is written to the MRF.
- The hash of the trailer MRF is calculated and written to the CIF.
- The hash of the trailer CIF is calculated and written to the CIF.

→ **This means that in the official application of the tool for calculating the "Performance of new vehicles with regard to their influence on CO_2 emissions and fuel consumption“ all steps with regard to hashing are automated. The separate VECTO Hashing Tool is not used.**

Hashing (2/2)

The VECTO Hashing Tool shall be used in the context of certified input XMLs:

- Creation of the component hash
- Verification of the component hash

This process is demonstrated on subsequent slides on the example of certified aerodynamic device input XML.

For tyre input XMLs, the entire process is completely identical to Regulation (EU) 2017/2400.

Plausibility checks for input data

IF	THEN
Number of Axles = 1	No Type DB allowed
Trailer Type = DB + Number of Axles = 2	Axle 1: steered and not liftable Axle 2: not liftable and not steered
Trailer Type = DB + Number of Axles = 3	Axle 1: steered and not liftable Axle 2: not steered Maximum 1 axle is liftable
Trailer Type = DC + Number of Axles = 1	Legislative Category = O3
Trailer Type = DA + Number of Axles = 1	
Trailer Type = DC + Number of Axles = 1	Axle 1: not liftable and not steered
Trailer Type = DC + Number of Axles = 2	Axle 1: not steered
Trailer Type = DC + Number of Axles = 3	Axle 1: not steered Axle 2: not liftable and not steered
Trailer Type = DA + Number of Axles = 1	Axle 1: not liftable
Trailer Type = DA + Number of Axles = 2	Axle 1: not steered
Side covers short	No Side covers long
Side covers long	No Side covers short
Trailer Type = DB	No Side covers long
Trailer Type = DC	No Side covers long
Rear flaps short	No Rear flaps long
Rear flaps long	No Rear flaps short
Trailer Type = DC	TPMLM Axle Assembly ≤ TPMLM Trailer
Trailer Type = DA	TPMLM Axle Assembly < TPMLM Trailer

Parameter	Requirements
VIN	17 characters
Mass in running order, TPMLM Trailer and TPMLM Axle Assembly	>1.000kg
External width of the body	1000 mm< x ≤ 2.600mm
Total Height of the Trailer	1000 mm< x ≤ 4.000mm
External height of the body	< Total height of the Trailer
External length of the body	< Max. length per type: Body DA ≤ 14.000mm Body DC ≤ 12.000mm Body DB ≤ 12.000mm

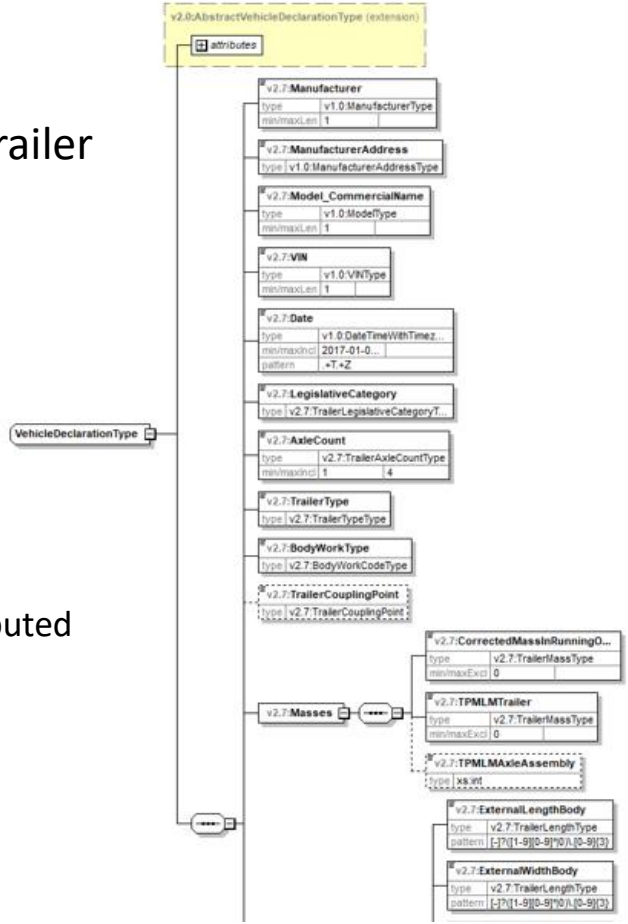
Important note:

The listed checks can only catch gross implausibilities in the inputs to the tool. More subtle errors, e.g. typos in the numbers, in the input will remain undetected. In any case, within the scope of the official application of the tool, the user of the tool must be responsible for the correctness of the entries. Compliance with the corresponding quality standards is the subject of the process certification according to Annex II of the regulation.

Options for automation

The process for generating official results of the VECTO Trailer Tool can also be fully automated.

- Generation of input XMLs
  - E.g. create it out of your product database system
  - XML schema files are distributed with the tools (see snapshot)
- Running the simulation
  - Use the “background worker” feature as shown in the live demonstration and described in the User Manual
  - Use the command-line tool **`vectocmd.exe`** as distributed with the archive.
    → **`vectocmd.exe -q <XML-File>`**
  - Calling VECTO from your own application is also possible.

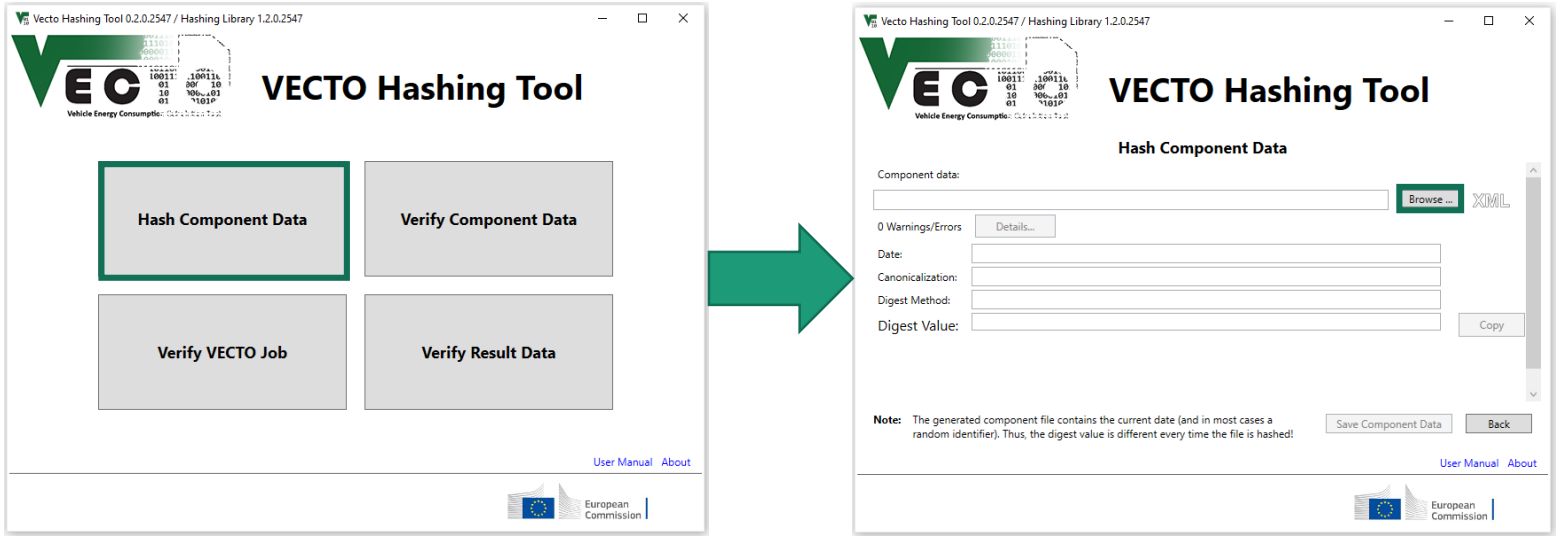


Generation of input XML for a certified aero device (1/4)

- The XML needs to be created by the supplier within a separate certification process
- A template of the XML is located in the downloadable VECTO Trailer Tool package in the “Generic vehicles” folder
- The XSD file is located in the downloadable VECTO Trailer Tool package in the “XML” folder

Generation of input XML for a certified aero device (2/4)

- At the start screen click „Hash Component Data“
  - then click the browse button to search for a non hashed XML → XML will be hashed automatically once loaded to the hashing tool



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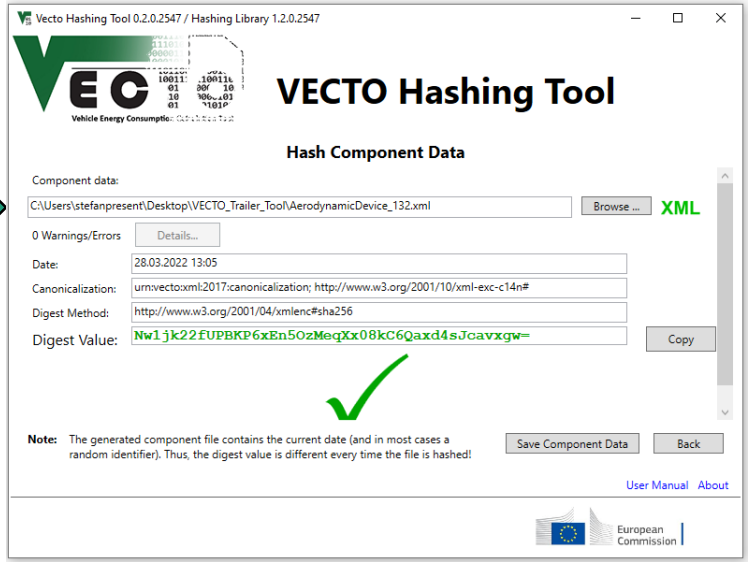
Generation of input XML for a certified aero device (3/4) Hashing example

```
<?xml version="1.0" encoding="UTF-8"?>
<tns:VectoInputDeclaration xmlns="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:DEV:v2.7" xmlns:v2.0="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:v2.0"
xmlns:v2.1="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:v2.1" xmlns:v2.2="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:v2.2"
xmlns:v2.7="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:DEV:v2.7" xmlns:tns="urn:tugraz:ivt:VectoAPI:DeclarationComponent:DEV:v2.7"
 xmlns:di="http://www.w3.org/2000/09/xmldsig#" schemaVersion="2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:schemaLocation="urn:tugraz:ivt:VectoAPI:DeclarationComponent v:\VectoCore\VectoCore\Resources\XSD/VectoDeclarationComponent.xsd">
    <tns:CertifiedAeroReduction >
        <Data xsi:type="CertifiedAeroDataDeclarationType" id="AERO-asdf">
            <Manufacturer>Generic Manufacturer</Manufacturer>
            <Model>Generic Aero Model</Model>
            <CertificationNumber>e12*0815/8051*2017/05T0000*00</CertificationNumber>
            <Date>2022-04-12T11:00:00Z</Date>
            <AeroReductionYawAngle0>1.00</AeroReductionYawAngle0>
            <AeroReductionYawAngle3>2.00</AeroReductionYawAngle3>
            <AeroReductionYawAngle6>3.00</AeroReductionYawAngle6>
            <AeroReductionYawAngle9>4.00</AeroReductionYawAngle9>
            <ApplicableVehicleGroup>132</ApplicableVehicleGroup>
        </Data>
    </tns:CertifiedAeroReduction>
</tns:VectoInputDeclaration>
```



After succesfull hashing of the component XML click „Save Component Data“

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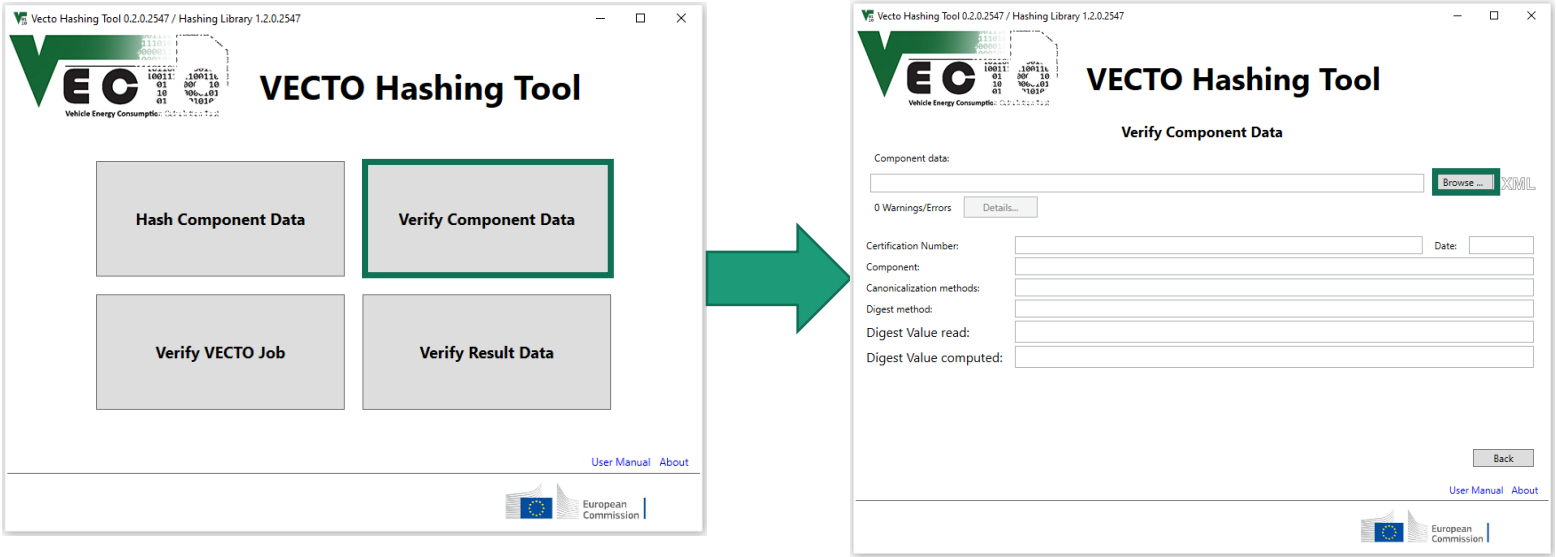
Generation of input XML for a certified aero device (4/4) Hashing example

- Hashed component File

```
<?xml version="1.0" encoding="UTF-8"?>
<tns:VectoInputDeclaration xmlns="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:DEV:v2.7" xmlns:v2.0="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:v2.0"
xmlns:v2.1="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:v2.1" xmlns:v2.2="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:v2.2"
xmlns:v2.7="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:DEV:v2.7" xmlns:tns="urn:tugraz:ivt:VectoAPI:DeclarationComponent:DEV:v2.7"
 xmlns:di="http://www.w3.org/2000/09/xmldsig#" schemaVersion="2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:schemaLocation="urn:tugraz:ivt:VectoAPI:DeclarationComponent v:\VectoCore\VectoCore\Resources\XSD/VectoDeclarationComponent.xsd">
    <tns:CertifiedAeroReduction >
        <Data xsi:type="CertifiedAeroDataDeclarationType" id="AERO-asdf">
            <Manufacturer>Generic Manufacturer</Manufacturer>
            <Model>Generic Aero Model</Model>
            <CertificationNumber>e12*0815/8051*2017/05T0000*00</CertificationNumber>
            <Date>2022-04-12T11:00:00Z</Date>
            <AeroReductionYawAngle0>1.00</AeroReductionYawAngle0>
            <AeroReductionYawAngle3>2.00</AeroReductionYawAngle3>
            <AeroReductionYawAngle6>3.00</AeroReductionYawAngle6>
            <AeroReductionYawAngle9>4.00</AeroReductionYawAngle9>
            <ApplicableVehicleGroup>132</ApplicableVehicleGroup>
        </Data>
        <Signature>
            <di:Reference URI="#AERO-asdf">
                <di:Transforms>
                    <di:Transform Algorithm="urn:vecto:xml:2017:canonicalization"/>
                    <di:Transform Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>
                </di:Transforms>
                <di:DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256"/>
                <di:DigestValue>Nw1jk22fUPBKP6xEn5OzMeqXx08kC6Qaxd4sJcavxgw=</di:DigestValue>
            </di:Reference>
        </Signature>
    </tns:CertifiedAeroReduction>
</tns:VectoInputDeclaration>
```

Verification of component hash for a certified aero device (1/3)

- At the start screen click „Verify Component Data“
  - then click the browse button to search for a hashed XML → Digest values will only match if nothing was changed after hashing



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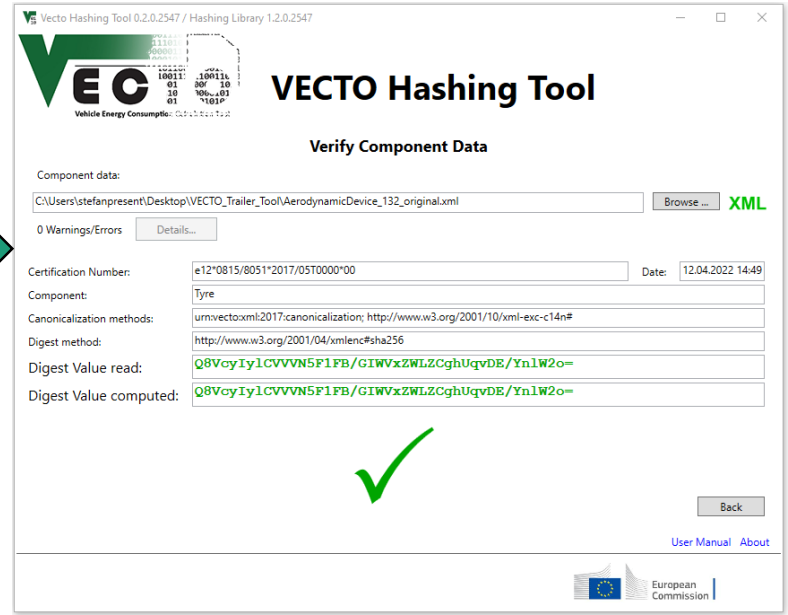
Verification of component hash for a certified aero device (2/3)

- Example verification of an unchanged XML

```
<?xml version="1.0" encoding="utf-8"?>
<tns:VectoInputDeclaration xmlns="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:DEV:v2.7" xmlns:v2.0="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:v2.0"
    <tns:CertifiedAeroDevice>
        <v2.7:Data xsi:type="CertifiedAeroDataDeclarationType" id="AERO-asdf">
            <v2.7:Manufacturer>Generic Manufacturer</v2.7:Manufacturer>
            <v2.7:Model>Generic Aero Device Model</v2.7:Model>
            <v2.7:CertificationNumber>e12*0815/8051*2017/05T0000*00</v2.7:CertificationNumber>
            <v2.7:Date>2022-04-13T11:21:11.8581891Z</v2.7:Date>
            <v2.7:AeroReductionYawAngle0>1.00</v2.7:AeroReductionYawAngle0>
            <v2.7:AeroReductionYawAngle3>2.00</v2.7:AeroReductionYawAngle3>
            <v2.7:AeroReductionYawAngle6>3.00</v2.7:AeroReductionYawAngle6>
            <v2.7:AeroReductionYawAngle9>4.00</v2.7:AeroReductionYawAngle9>
            <v2.7:ApplicableVehicleGroups>
                <v2.7:ApplicableVehicleGroup>422</v2.7:ApplicableVehicleGroup>
                <v2.7:ApplicableVehicleGroup>112</v2.7:ApplicableVehicleGroup>
            </v2.7:ApplicableVehicleGroups>
        </v2.7:Data>
        <v2.7:Signature>
            <di:Reference URI="#AERO-asdf">
                <di:Transforms>
                    <di:Transform Algorithm="urn:vecto:xml:2017:canonicalization" />
                    <di:Transform Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#" />
                </di:Transforms>
                <di:DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256" />
                <di:DigestValue>Q8VcyIylCVVVN5F1FB/GIWVxZWLZCghUqvDE/YnlW2o=</di:DigestValue>
            </di:Reference>
        </v2.7:Signature>
    </tns:CertifiedAeroDevice>
</tns:VectoInputDeclaration>
```



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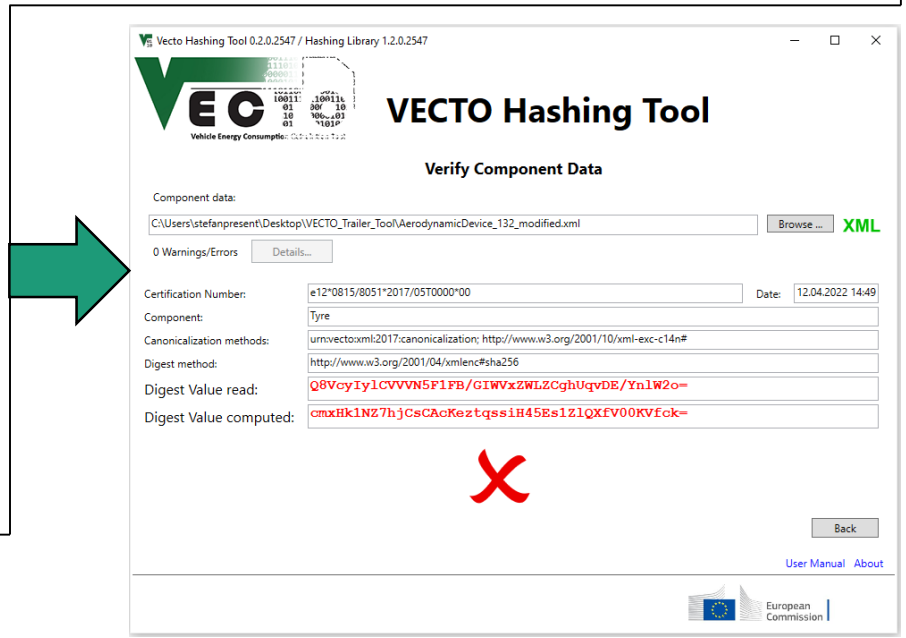
Verification of component hash for a certified aero device (3/3)

- Example verification of a modified XML

```
<?xml version="1.0" encoding="utf-8"?>
<tns:VectoInputDeclaration xmlns="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:DEV:v2.7" xmlns:v2.0="urn:tugraz:ivt:VectoAPI:DeclarationDefinitions:v2.0"
    <tns:CertifiedAeroDevice>
        <v2.7:Data xsi:type="CertifiedAeroDataDeclarationType" id="AERO-asdf">
            <v2.7:Manufacturer>Generic Manufacturer</v2.7:Manufacturer>
            <v2.7:Model>Generic Aero Device Model</v2.7:Model>
            <v2.7:CertificationNumber>e12*0815/8051*2017/05T0000*00</v2.7:CertificationNumber>
            <v2.7:Date>2022-04-13T11:21:11.8581891Z</v2.7:Date>
            <v2.7:AeroReductionYawAngle0>1.10</v2.7:AeroReductionYawAngle0>
            <v2.7:AeroReductionYawAngle3>2.00</v2.7:AeroReductionYawAngle3>
            <v2.7:AeroReductionYawAngle6>3.00</v2.7:AeroReductionYawAngle6>
            <v2.7:AeroReductionYawAngle9>4.00</v2.7:AeroReductionYawAngle9>
            <v2.7:ApplicableVehicleGroups>
                <v2.7:ApplicableVehicleGroup>422</v2.7:ApplicableVehicleGroup>
                <v2.7:ApplicableVehicleGroup>112</v2.7:ApplicableVehicleGroup>
            </v2.7:ApplicableVehicleGroups>
        </v2.7:Data>
        <v2.7:Signature>
            <di:Reference URI="#AERO-asdf">
                <di:Transforms>
                    <di:Transform Algorithm="urn:vecto:xml:2017:canonicalization" />
                    <di:Transform Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#" />
                </di:Transforms>
                <di:DigestMethod Algorithm="http://www.w3.org/2001/04/xmlenc#sha256" />
                <di:DigestValue>Q8VcyIylCVVVN5F1FB/GIWVxZWLZCghUqvDE/YnlW2o=</di:DigestValue>
            </di:Reference>
        </v2.7:Signature>
    </tns:CertifiedAeroDevice>
</tns:VectoInputDeclaration>
```



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Standard aerodynamic devices – for DA trailers

Allowed configurations				
Combination Number	Side cover SHORT	Side cover LONG	Rear flaps SHORT	Rear flaps LONG
0				
1	1			
2		1		
3			1	
4				1
5	1		1	
6	1			1
7		1	1	
8		1		1

ΔCdxA reduction rates [%]			
Yaw 0.0	Yaw 3.0	Yaw 6.0	Yaw 9.0
0.0%	0.0%	0.0%	0.0%
1.4%	2.7%	3.0%	3.7%
4.0%	3.4%	3.5%	4.7%
2.8%	3.2%	3.8%	4.9%
3.9%	4.1%	5.1%	6.0%
3.8%	5.8%	8.3%	8.7%
4.7%	6.8%	9.2%	10.1%
6.5%	6.4%	7.8%	9.4%
7.6%	7.7%	9.2%	10.9%

Standard aerodynamic devices – for DB trailers

Allowed configurations					ΔCdxA reduction rates [%]			
Combination Number	Side cover SHORT	Side cover LONG	Rear flaps SHORT	Rear flaps LONG	Yaw 0.0	Yaw 3.0	Yaw 6.0	Yaw 9.0
0					0.0%	0.0%	0.0%	0.0%
1	1				N/A	N/A	N/A	N/A
3			1		N/A	N/A	N/A	N/A
4				1	3.4%	4.6%	5.0%	3.9%
5	1		1		N/A	N/A	N/A	N/A
6	1			1	N/A	N/A	N/A	N/A

* Missing values to be completed via CFD in second half of 2022

Standard aerodynamic devices – for DC trailers

Allowed configurations					ΔCdxA reduction rates [%]			
Combination Number	Side cover SHORT	Side cover LONG	Rear flaps SHORT	Rear flaps LONG	Yaw 0.0	Yaw 3.0	Yaw 6.0	Yaw 9.0
0					0.0%	0.0%	0.0%	0.0%
1	1				N/A	N/A	N/A	N/A
3			1		N/A	N/A	N/A	N/A
4				1	2.3%	3.7%	5.2%	11.1%
5	1		1		N/A	N/A	N/A	N/A
6	1			1	N/A	N/A	N/A	N/A

* Missing values to be completed via CFD in second half of 2022

Bonus factors for liftable and steered axles - Overview

- In order to model the effect of liftable and/or steered axles on fuel consumption and CO_2 emissions, generic bonus factors are applied in the VECTO Trailer Tool.
- The general formula how to apply these factors ("bf_{lift}", "bf_{steer}"; unit = %, "-" means reduction) is shown below:

$$\mathrm{FC_{corr}}, \mathrm{CO2_{corr}} = \mathrm{FC}, \mathrm{CO2} \cdot \left(1 + \frac{\mathrm{bf_{lift}}}{100}\right) \cdot \left(1 + \frac{\mathrm{bf_{steer}}}{100}\right)$$

- In cases where there is more than one liftable or steered axle on a vehicle, special rules apply.

Bonus factors for liftable axles

Trailer Classification				Liftaxle bonus factor					
				Long Haul		Regional Delivery		Urban Delivery	
Bodywork type	Volume orientation	Trailer type	Number of axles	payload low	payload rep	payload low	payload rep	payload low	payload rep
all	No/Yes	DA	2	-0.8	-0.3	-2.3	-1.6	-3.2	-2.1
			3	-0.6	-0.2	-3.6	-2.4	-5.3	-3.5
		DC	2	-0.6	-0.2	-2.2	-1.5	-3.1	-2.0
		DB	3	-0.6	-0.2	-2.1	-1.4	-3.0	-2.0
		DC	3	-0.6	-0.2	-3.6	-2.4	-5.2	-3.5

Bonus factors for steered axles

Trailer Classification				Steered axle bonus factor					
				Long Haul		Regional Delivery		Urban Delivery	
Bodywork type	Volume orientation	Trailer type	Number of axles	payload low	payload rep	payload low	payload rep	payload low	payload rep
all	No/Yes	DA/DC	1	0.0	0.0	0.0	0.0	0.0	0.0
			2	0.0	0.0	-1.5	-1.5	-2.3	-2.3
		DA/DC	3	0.0	0.0	-3.0	-3.0	-4.5	-4.5
		DB	3	0.0	0.0	-1.5	-1.5	-2.3	-2.3

Bonus factors for liftable and steered axles – Special cases

- **Special case #1:** 1 liftable and 1 steered on different axles

$$\mathrm{FC_{corr}}, \mathrm{CO2_{corr}} = \mathrm{FC}, \mathrm{CO2} \cdot \left(1 + \frac{\mathrm{bf_{lift}}}{100}\right) \cdot \left(1 + 0.5 \cdot \frac{\mathrm{bf_{steer}}}{100}\right)$$

- **Special case #2:** 1 liftable and 1 steered on the same axle

$$\mathrm{FC_{corr}}, \mathrm{CO2_{corr}} = \mathrm{FC}, \mathrm{CO2} \cdot \left(1 + \frac{\max(\mathrm{bf_{lift}}, \mathrm{bf_{steer}})}{100}\right)$$

The generally valid formulas implemented in the code are documented here. For some cycles, some bonus factors are 0.

Bonus factors for liftable and steered axles – Special cases

- **Special case #3:** 2 liftable axles

  Payload “low”: $$\mathrm{FC_{corr}}, \mathrm{CO2_{corr}} = \mathrm{FC}, \mathrm{CO2} \cdot \left(1 + 1.5 \cdot \frac{\mathrm{bf_{lift}}}{100}\right)$$

  Payload “rep:”: $$\mathrm{FC_{corr}}, \mathrm{CO2_{corr}} = \mathrm{FC}, \mathrm{CO2} \cdot \left(1 + \frac{\mathrm{bf_{lift}}}{100}\right)$$

- **Special case #4:** 2 steered axles

$$\mathrm{FC_{corr}}, \mathrm{CO2_{corr}} = \mathrm{FC}, \mathrm{CO2} \cdot \left(1 + 1.2 \cdot \frac{\mathrm{bf_{steer}}}{100}\right)$$

- **Special case #5:** In case more than 2 features are present on the vehicle (could theoretically only be the case for a 3-axle trailer and comprising at least a single steered axle), the rules for special case #1 are applied.

The generally valid formulas implemented in the code are documented here. For some cycles, some bonus factors are 0.

Overview content of Masterexcel (1/4)

The VECTO Trailer Tool Masterexcel is an integral part of the tool documentation and fulfils the following functions:

- Documentation of the classification matrix used internally in the tool, which is more detailed than the classification according to Annex I.
- Documentation of all generic data stored in the tool, e.g.
  - mission profile and payload allocation
  - specifications of reference trailers
  - standard values for reduction rates of aerodynamic devices
  - bonus factors for liftable and steered axles
- Interactive documentation of the formulas for calculating the air drag for the various combinations of generic towing vehicles and trailers

The content of the individual sheets is described in overview on the next slides.

In the context of a normal application of the tool, it is not necessary to engage with the Masterexcel.

Overview content of Masterexcel (2/4)

Excel sheet	Description
Classification	General information stored in the tool for each trailer configuration • Vehicle group acc. to Annex 1 • Information on the allocated generic towing vehicle • Mission allocation + weighting for aggregated results • Payload and axle weight shares per mission
Generic CAD vehicle	Main dimensions and air drag values of the generic CAD models used as a starting point to calculate the air drag of trailers with different dimensions (could be the reference- or the specific trailer)

Reference Trailer	Information on the reference trailers for each trailer configuration
	• Curb mass and cargo volume
	• Tyre specifications
	• Main external dimensions to calculate the air drag
	• Indication on which aero corrections are applied to which trailer configuration
	  • „1“ means aero correction is applied
	  • „0“ means aero correction is not applied

Overview content of Masterexcel (3/4)

Excel sheet	Description
...	...

Specific trailer	Information on technologies that may be present on a specific trailer
	• Bonus factors for liftable and steered axles depending on trailer configuration, mission and payload
	  • These factors are to be understood as reduction factors on overall fuel consumption / CO_2
	• Indication on which aero corrections are applied to which trailer configuration
	  • „1“ means aero correction is applied
	  • „0" means aero correction is not applied
	  The individual aero correction formulas can be viewed in the “Reference/Specific Trailer Aero" sheet and are documented in detail in Task 2 report section 2.4.5.
	• Aero reduction values for standard aerodynamic devices acc. to sheet „Combination Add-ons DX*“

Standard Trailer	Information on the standard trailers also used in Regulation EU 2017/2400 to calculate the reference factors

*DX... Placeholder depending on trailer type
DA... Semi Trailer
DB... Drawbar Trailer
DC... Centre axle Trailer

Overview content of Masterexcel (4/4)

Excel sheet	Description
...	...
Reference (Specific) Trailer Aero	Main dimensions and air drag values of the generic CAD models used as a starting point to calulate the air drag of trailers with different dimensions (Reference/Specific trailer) Step by step calculation process on how to apply the individual aero corrections to get the final air drag values for a reference/specific trailer In the columns AN to AX, the aero-relevant data can be entered for the individual trailer groups. The results for CdxA(0) as well as the polynomial coefficients of the polar can then be found in the columns DT and EB to ED.
Standard aero device DX*	Air drag reduction in % for the specific combination of standard aerodynamic devices (the reduction values can also be found in the sheet „Specific Trailer“
Efficiency Ratios - DA	Example on how the individual and weighted efficiency ratios are calculated based on a DA trailer

*DX... Placeholder depending on trailer type
DA... Semi Trailer
DB... Drawbar Trailer
DC... Centre axle Traielr