VECTO: FREQUENTLY ASKED QUESTIONS (FAQ)

1. **What is the VECTO software and VECTO software platform?**
   The Vehicle Energy Consumption calculation TOol (VECTO) is a software developed by the European Commission for determining CO_2 emissions and fuel consumption from the whole vehicle. VECTO has been introduced in the European vehicle type-approval regulation in May 2017, as the official tool used in Europe to certify and monitor the fuel consumption and CO_2 emissions from HDV. VECTO software platform consists of VECTO software and a series of other software tools developed for the needs of the HDV certification procedure. Those include VECTO-Engine, VECTO-AirDrag and VECTO-hash&sign tools, which are used at various points during the certification process.

2. **What is the relation between VECTO and official CO_2 certification methodology for HDVs?**
   VECTO is a key component of the European Heavy Duty Vehicle CO_2 and fuel consumption certification methodology. The CO_2 certification methodology is based on the measurement of the performance of different vehicle components contributing to the vehicle energy consumption (aerodynamic drag, torque losses in the drivetrain, fuel map of the engine, power demand of auxiliaries, tyre-rolling resistance etc.). The results of these measurements are then used as input in VECTO in order to simulate vehicle operation over different driving conditions. A series of official driving cycles have been developed for the purpose.

3. **How can I access to the VECTO tool?**
   For the time being, VECTO is hosted in the CITnet platform: https://webgate.ec.europa.eu/CITnet/confluence/display/VECTO/VECTO+Home

   In order to obtain access rights to enter the VECTO project, you need to contact the VECTO functional Mailbox (FMB) that JRC is responsible for: JRC-VECTO@ec.europa.eu

   For new VECTO users, we ask for some basic information before we proceed with the registration:
   - Name;
   - Surname;
   - E-mail;
   - Organization/ Company;
   - Position;
   - Country;
   - Number of people in the organization.

   VECTO can be also found on DG CLIMA's website where the user can easily download the tool (downloadable executable file).

4. **How VECTO has been developed?**
   VECTO and the respective certification methodology were developed under a series of contracts launched by DG CLIMA. A summary of the main ones can be found here. The

Commission's JRC acts as scientific co-ordinator of the VECTO development and has performed a series of independent validations, the main results of which can be found here.

Several stakeholders have contributed significantly in the development process by providing data, feedback, insight and by validating extensively VECTO and its sub-routines; those include heavy duty vehicle manufacturers, transmission manufacturers, tyre manufacturers, vehicle component suppliers, heavy duty vehicle body-builders and other industrial stakeholders. In addition, a series of non-industrial organizations have supported the development with feedback and validation exercises including European member states, research bodies and other organizations.

5. **What are the IT requirements in order to install VECTO?**
   Ensure that you the system where you plan to install VECTO meets the following Requirements:
   a. Operating system: Windows
   b. At least 40MB free storage space on the Disk you plan to install it.
   c. Has installed .NET Framework: >= version 4

   The size of the extracted folders of the latest versions of the 3 tools are:

   a. AirDrag_3.1.7: 63 MB
   b. VECTO-3.3.0.1250: 30 MB
   c. VECTO-Engine 1.4.3.1355: 1.3 MB
   d. VECTO Hashing Tool: 189 KB

6. **How I can get started with VECTO tool?**
   All the VECTO platform components, VECTO, VECTO-Air Drag, VECTO-Engine, VECTO-hash&sign contain demo files in order to start a simulation and see how the software operates. In addition, the softwares include User-Manuals that will help you understand the workflow for a successful VECTO simulation.
   The DG CLIMA webpage includes additional support material comprising demo videos for each software tool and a comprehensive set of slides on each topic related to VECTO.

7. **What programming language is used, what operating system is necessary to run VECTO?**
   The VECTO-platform components are written in C# and delivered as executable files. The tools are portable applications, i.e. it is not necessary to run a setup procedure for installation. The executable file can be run from any place on a computer or in a network (Windows environment only).

8. **What is the licensing scheme of VECTO?**
   VECTO is an open source software. All components of the VECTO platform are licensed under the EUPL v1.2.

9. **Can we use VECTO platform components for commercial purposes and real tests with our customers?**

The VECTO tool is free to be used by anyone. Commercial companies or other organizations are free to use VECTO in their projects, including for commercial use. However according to the EUPL if VECTO, or parts of it, are embedded into a commercial application, this application has to be open-sourced as well (EUPL) and the application's sources have to be provided together with the executable file.

10. **Makros & ActiveX, which are necessary to run the program, excel somehow crashes immediately.**
    You have to check the version of Microsoft Office. This has been reported Microsoft Excel 2007. Updating to a newer version (2010), solved the problem.

11. **What are the main inputs for running a VECTO simulation?**
    The main vehicle characteristics in order to run a VECTO simulation are:
    a. Vehicle category (rigid truck, tractor);
    b. Axles configuration (i.e. 4x2, 4x4, 6x2 etc.);
    c. Gross vehicle mass rating (w/o trailer) [kg];
    d. Vehicle curb mass [kg];
    e. C_d x A [m²]
    f. Tyre characteristics (rolling resistance coefficient [-], wheel dimensions etc.)
    g. Engine characteristics (full load curve, drag curve, fuel map, displacement etc.)
    h. Gearbox & Final Drive characteristics;
    i. Auxiliary specifications (selection from a list of technologies);

12. **What input data is needed to run the VECTO-Engine tool?**
    VECTO Engine needs 4 separate input files (determined according to the current version of the technical annex):
    a. Fuel consumption map of CO_2-parent engine;
    b. Full-load curve of CO_2-parent engine;
    c. Full-load curve of engine to be certified;
    d. Motoring curve of CO_2-parent engine.

13. **What inputs are needed to run the VECTO-AirDrag tool?**
    Here is an overview of the input files:
    a. Vehicle: contains relevant information on the tested vehicle configuration (e.g. vehicle test mass, anemometer height)
    b. Ambient conditions: contains ambient conditions as measured by the stationary weather station
    c. Configuration file for measurement sections: contains the configuration of the measurement sections (coordinates, driving directions etc.) on the test track. The measurement sections can be configured for the calibration run and the measurement runs separately.
    d. Measurement data: contains the measurement data recorded at the vehicle consolidated in 100 Hz.
    e. Altitude profile (optional): contains the altitude profile on the measurement sections. This data is used for the correction of traction force for gradient influence in the evaluation if the related feature is activated in the VECTO-AirDrag GUI.

f. Job: contains all information for a test evaluation (evaluation settings, paths to input data). The job file is automatically created if VECTO-AirDrag is operated via the user interface but can also be generated or edited e.g. by means of a text editor. After a successful calculation VECTO-AirDrag also writes the main evaluation results into the job-file.
g. Criteria (optional): can be used to save or import a set of evaluation parameters (e.g. validity criteria or settings for correction functions). For reasons of traceability for each calculation the used parameters are in any case also stored in the Job-file.

14. **How I can get access to the code?**
The code of VECTO is placed in CITnet Bitbucket. For now, we provide access only after requesting it, and only in one member per company/Authority, since CITnet has limited capacity. In the future, the VECTO project will be transferred in another development platform where there will be more capabilities and more rights for the users. The idea is to make VECTO code available for all the users. Until then, you can contact the Administrators in the VECTO FMB (JRC-VECTO@ec.europa.eu), and they will grant you access to the source code.

15. **What is included inside the VECTO repository in CITnet?**
Every VECTO user has access in the spaces:
a. **Confluence**: There, the user will find the basic material in order to start with VECTO. Installation instructions, all the releases for VECTO, VECTO-Air Drag and VECTO Engine Releases. In addition, a list with all the Companies/ Authorities that use the tool.
b. **Private group**: Every company/ Authority has a private page that only its members and the page administrators have access. There, the administrators place the licenses, so the user will be able to run the VECTO softwares. In addition, there is a dialog box, so the user can communicate with the Administrators.
c. **JIRA**: It is a project that provides bug tracking, issue tracking, and project management functions. There, the user can address a question to the developers of VECTO, provide feedback, report bugs. Besides this, every user is automatically signed in a particular thread for announcements regarding VECTO (new releases and important bug-fixes).

16. **What is the difference between declaration mode and engineering mode?**
The declaration mode is the official simulation mode for declaring CO_2 emissions of a vehicle. In declaration mode, several model parameters such as the payload, gearshift parameters, simulated mission profiles, etc. are generic. Moreover, in declaration mode the loss-maps and fuel-consumption maps as provided in the input data are not extrapolated. In the engineering mode, VECTO can be operated like any other vehicle simulation tool. All simulation parameters can be set and/or edited by the user.

17. **Which vehicles are currently supported in declaration mode?**
Currently only rigid trucks and tractors are supported in declaration mode. According to the upcoming Commission Regulation on the determination of CO_2 emissions and fuel consumption of HDVs, Annex I, Table 1 vehicles are allocated to certain groups according to

gross vehicle mass rated, axle configuration, and vehicle type (tractor, rigid truck). Supported vehicle groups actually are 1, 2, 3, 4, 5, 9, 10, 11, 12, and 16. All-wheel drive vehicles (4x4, 6x6, and 8x8) are excluded from CO_2 declaration at the moment.

18. **Why are vehicles simulated on different cycles? What are the criteria for selecting the cycles?**
    Depending on the vehicle group, a vehicle is typically used for certain purposes and the cycles ("mission profiles") also represent different usage profiles. Thus, the vehicle group determines which cycles are simulated. The allocation of vehicle groups to mission profiles is defined in the upcoming Commission Regulation on the determination of CO_2 emissions and fuel consumption of HDVs Annex I, Table 1. Certain vehicle groups may be used also in EMS vehicle configurations (European Modular System, gross combination mass of 60.000 kg and a maximum length of 25.25 m) if the engine power is sufficient. In this case the long-haul and the regional delivery mission are simulated with an additional trailer.

19. **What is the vehicle's total mass for the simulation?**
    The vehicle's total mass for the simulation is the sum of 'corrected actual curb mass', 'body mass', mass of the trailer(s), and 'payload'. In the VECTO declaration mode all of those parameters, except the 'corrected actual curb mass' are generic (depending on the vehicle group). The definition of 'corrected actual curb mass' is specified in Annex III of the upcoming Commission Regulation on the determination of CO_2 emissions and fuel consumption of HDVs.

20. **Why is the fuel consumption for group 2 vehicles on the long-haul cycle significantly higher than on the other cycles?**
    Group 2 vehicles are simulated on the long-haul driving cycle with an additional trailer which increases the fuel consumption significantly.

21. **What is the meaning of the VECTO messages "FC-Map too small" or "Loss-map too small"?**
    In declaration mode, VECTO does not extrapolate the fuel consumption map, transmission or axle loss map as provided in the input data. If an error occurs, indicating that a loss-map is too small, either the component data does not contain the full map, or the gearbox/axle gear does not match the engine's maximum torque (positive torque range) and engines' drag torque (negative torque range).

22. **Why are the cycles defined as target speed over distance instead of actual speed over time?**
    Driving behaviour of HDV to a very large extend is determined by the power to mass ratio of the vehicle. This parameter varies significantly between different vehicles and is additionally highly dependent on the payload conditions. Hence, a general valid definition of typical HDV driving behaviour is not possible via vehicle speed over time cycles.

    In VECTO driving cycles are defined as target speed over distance. The VECTO model operates the vehicle according to its full-load capabilities applying a driver model with underlying definitions for maximum desired acceleration, vehicle coasting and decelerations

during braking events. This approach provides a good representation of typical driving behaviour for all HDV types in all loading conditions.

23. **The component tools (VECTO Engine, VECTO Air Drag) produce an XML file that cannot be used in the VECTO Graphical User Interface (GUI). Why?**
    The VECTO process as foreseen in the official certification for HDV is based on handling and compiling of data in XML structure. This process is actually not supported via the VECTO GUI. For a VECTO simulation in using the XML files from VECTO Engine, VECTO Air Drag a job file needs to be compiled that contains data on all vehicle components. For this purpose the 'Engine', or 'Airdrag' XML block need to be copied to the correct position in the job file describing the complete vehicle. This XML file than can be loaded to the VECTO GUI job list and the simulation can be started.

24. **Why is the fuel consumption simulated in version x different from version y?**
    Although VECTO is already quite mature, it is still under development. Models may be refined, strategies may be adjusted, etc. Some of those changes have no (or a negligible) impact on the fuel consumption, other changes might have more effect. In any case the changes are typically due to a more accurate simulation. Other cases are that certain generic values are adapted in a new version. Details can be found in the VECTO changelog.

25. **The values computed in the .vmod file do not accumulate to the results in the .vsum file.**
    VECTO uses variable time steps in the simulation. In order to calculate the accumulated results for the total cycle the instantaneous data for the single time steps need to be weighted with the simulation interval dt.

26. **What is the impact of the vehicle's 'Gross Vehicle Mass Rated'?**
    In the declaration mode the vehicle's 'gross vehicle mass rated' is used for selecting the according vehicle group to allocate the generic model parameters. The 'gross vehicle mass rated' is furthermore used to limit the payload such that the simulated vehicle mass does not exceed the gross vehicle mass rated. For vehicles of type 'tractor' the 'gross vehicle mass rated' model parameter is only the GVMR of the tractor, without the trailer. VECTO adds the GVMR of the trailer internally (and limits the total GVMR to 40t or 60t for EMS configurations)

27. **Why is it required to specify the engine idling speed in the vehicle configuration?**
    According to Annex V of the upcoming Commission Regulation on the determination of CO_2 emissions and fuel consumption of HDVs an engine is certified with the lowest possible idling speed. The vehicle manufacturer, however, can decide that in a particular vehicle configuration the engine idling speed is set to a higher value. After the certification it is not possible to modify the engine component file because this would void the integrity measures. Therefore, the engine idling speed has to be specified additionally in the vehicle input data. This value must not be lower than the idling speed in the engine component (otherwise this input is ignored).

28. **How are the shift polygons computed in declaration mode? What happens if no shift polygons are specified in engineering mode?**

The shift polygons depend on the gear ratios, the wheel dimension, the axle ratio, and the engine full-load curve. Based on all those parameters the shift polygons are computed based on the rules described in the user manual.
Currently an update of the AMT and AT gear shift models is under elaboration which will be based on more complex decision criteria (gear selection mainly driven by optimisation of overall powertrain efficiency).

29. **We tried to reproduce the cross-wind correction in declaration mode. How is the Cd scaling factor computed?**
In declaration mode, an ambient wind of 3m/s in 4m height blowing from uniformly distributed from all directions is assumed. The dependency of C_dxA on the yaw angle is described by a generic 3rd order polynomial depending on the vehicle configuration in the particular mission profile. The final C_dxA scaling factor for a certain vehicle velocity is calculated considering boundary layer effects of the ambient wind speed. The user manual contains the detailed equations and provides an Excel spreadsheet to calculate the C_dxA scaling factor as applied in the declaration mode.

30. **The air-drag losses in the .vmod file do not match the manually re-computed values using the average velocity for a certain time step.**
A basic definition in VECTO is that the acceleration is constant within a simulation time step. Consequently, forces and torques from vehicle inertia are constant and vehicle speed and rotational speeds evolve linear within a certain simulation interval. The air drag resistance, however, depends on the vehicle's velocity squared and hence does not evolve linear within a time step. To consider this influence correctly, for each time step VECTO computes a power-equivalent average air drag resistance force. For a single simulation step, VECTO analytically computes the energy losses due air drag and then computes a constant air drag resistance force that results in the same energy losses. This air resistance force does not match with the value re-computed values using the average velocity for a certain time step if the vehicle speed is not constant.

31. **What are the properties of the trailer used for the simulation (wheels dimension, rolling resistance, wheels inertia, mass, volume, …)?**
Depending on the vehicle group either a T1, T2 or ST1 trailer is used in the simulation. The simulation parameters can be found in the file "Body_Trailer_Weights.csv" in the Declaration folder. The rolling resistance is 5.5 N/kN with an FzISO of 37.5kN for all tires at all trailers.

32. **How is the total rolling resistance coefficient computed?**
The total rolling resistance is the sum of the rolling resistance for every axle (truck and trailer), whereas the tyre's rolling resistance coefficient is scaled according to the actual tyre load. The actual tyre load is the total vehicle mass multiplied by the relative axle load share (generic value) and divided by the number of wheels on the axle.

33. **Does VECTO support any advanced driver assistant systems?**
From the early 2019 version on VECTO will include generic CO2 reduction rates for the ADAS systems:

- Engine stop-start during vehicle stops
- Eco-roll without engine stop-start
- Eco-roll with engine stop-start
- Predictive cruise control (PCC)

in all its reasonable combinations.

34. **How to handle aftersales changes in engine mapping which, for example, are performed for customer specific optimisation of fuel consumption?**
    The "engine system" as defined in the family concept of Annex V of Regulation (EU) 2017/2400 includes the engine control system. Hence, any changes not in agreement with the approval authority are illegal. In general, a new engine certification is needed in such cases.