Update 2024

AnalyzerPro 24.0

Manual

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Contents

Preface

Dear accident expert,

I would like to offer my heartfelt welcome to you as a new member of the Analyzer-Pro family. With your decision to use AnalyzerPro you trust in one of the most proven and highly developed accident reconstruction programmes in the world.

The word "family" is not meant as an empty phrase. Software can only develop its full potential if it is tailored to the needs of its every day users. For this reason I would like to invite you to contribute to the further development by letting us know about your specific wishes and requirements.

I am looking forward to your suggestions, criticism, and especially a successful co-operation.

Kind regards,

Matthias Schmidt, MSc

For the team of AnalyzerPro

1 Introduction

When engaging in accident analysis, one of the daily necessities is performing distance-time calculations. This fact has led to the development of a computer programme which enables users to easily calculate a multitude of variants, create distance-time graphs and simulate the kinematics of the vehicles involved (=movie).

On the foundation of experience from working in the field, many standard calculation tools (modules) for a variety of common accident situations were also developed, as well as the collision analysis and driving dynamics tools.

Some important information:

Upgrades

Once a year, usually in December, a new version of AnalyzerPro is being released. With this update, AnalyzerPro is always up-to-date with the latest state of technology. One of the main goals of the updates is to satisfy customer wishes. If you happen to have ideas and suggestions for what you would like to see implemented, please do not hesitate to contact us.

Updates

Any software product as complex as AnalyzerPro can be subject to bugs or might occasionally not work exactly as intended. In this case please send us a mail describing in detail how and when the error occurred. We will try to correct it as soon as possible. From version 22 onwards, the Analyzer carries out an automatic weekly search for new updates. You can also start this search manually under "Links" -> "Update". If you do not have administrator rights on your PC, you can also carry out the installation of an update completely manually: You can download a Zip-file for your specific version for free from our homepage www.analyzer.at via ‘Downloads’. To do this, close AnalyzerPro, unpack the zip file into your AnalyzerPro installation directory and replace the relevant files. If possible, we recommend using the automatic updater.

Seminaries

AnalyzerPro comes with a large number of tools and possibilities, which makes it difficult for self-taught users to use everything to the fullest potential. Therefore, we suggest to every user to visit one of our seminaries. For current seminary dates and further information please visit our homepage, www.analyzer.at, and go to ‘Seminaries’. Unsatisfied with seminary locations or dates? No problem, we might be able to arrange seminaries in your city. Just contact us.

Tutorials

On our homepage www.analyzer.at you will find under the tab "Tutorials" free helpful learning videos for AnalyzerPro.

Questions, Suggestions, Complaints:

Close contact with our customers is very important to us. If you have questions, complaints or suggestions, whatever it is, do not hesitate to contact us via the contact form on our homepage – we try to answer as soon as possible.

1.1 Licence Agreement

1. Validity of these terms and conditions

These terms and conditions apply to any order placed through our website or otherwise. Purchasing conditions of the buyer are excluded for the present legal transaction and the entire business relationship. This also applies in case that the buyer states that he only wishes to contract on his own terms and conditions when placing an order.

1.1 Offer and conclusion of contract

The offer on our website to purchase a license for Analyzer Pro or an update license is without obligation. The purchase contract is only concluded when the order is confirmed by the seller in writing.

1.2 Transfer of business

In case of transfer of the company to another person, the entire contractual relationship is transferred to the successor of the company without notification of the buyer. The buyer's rights of withdrawal and the seller's subsequent liability are excluded in this case.

2. Performance and testing

2.1 The subject of the contract is, against payment of the payment indicated for the respective product:

- the acquisition of rights of use for the software products offered by us

- the purchase of a copy of the software via digital download

- the purchase of an activation key, either in the form of hardware (dongel) or in digital form (license key). The choice of the activation key (hardware or digital) is at the seller's discretion.

- the acquisition of licenses for the use of works,

Not included in the contract is

-the acquisition of further rights of use and exploitation

-the purchase of subsequent software updates and software supplements

-other hardware for using the software.

2.2 Program description

The software Analyzer Pro is used for accident reconstruction by means of electronic data processing by accident experts. The software can be used to create accident simulations, but these always require expert interpretation.

2.3 Notification of Defects

Any defects that may occur, i.e. deviations from the performance specifications agreed in writing in the manual, shall be reported by the buyer to the seller with sufficient documentation, who shall endeavour to remedy the defects as quickly as possible.

3. Dispatch and risk assumption

The dispatch of dongles is at the expense and risk of the buyer. Upon buyer’s request, these will be sent by registered mail at his expense. The digital license key is sent free of shipping costs by e-mail. The seller undertakes to send the physical or digital data carrier within 14 days after receipt of payment, but at the earliest upon confirmation of the order. The purchaser must provide his postal address. Delays in delivery and increases in costs resulting from incorrect, incomplete or subsequently changed data and information or documents provided by the buyer are not the responsibility of the seller and cannot lead to a delay on the part of the seller. Any resulting additional costs shall be borne by the buyer. In case an agreed delivery time is exceeded due to the sole fault or unlawful action of the seller, the buyer shall be entitled to withdraw from the respective order by registered letter if, even after a dunning letter by the buyer within a reasonable period of grace, the agreed performance is not rendered in essential parts and the buyer is not at fault. Force majeure, labour disputes, natural disasters and transport blocks as well as other circumstances beyond the seller's control shall release the seller from the obligation to deliver or allow the seller to redefine the agreed delivery time.

4. Prices, taxes and fees

All prices are in Euro excluding Value Added Tax VAT. The prices quoted are ex the seller's registered office or place of business. The prices only apply to the present order. The costs for the data medium and the dongle or the digital alternatives are included.

For all other services (organizational consulting, programming, training, conversion support, telephone consulting, etc.), the amount of work shall be charged at the rates valid on the day the service is provided. Deviations from an expenditure of time on which the contract price is based, not attributable to the seller, will be charged according to actual effort. The costs for travel, daily and overnight allowances will be charged to the buyer separately according to the rates valid at the time. Travel times shall be deemed to be working time.

5. Payment

5.1 The seller shall submit the invoice in electronic form together with the order confirmation. The invoices issued by the seller, including VAT, shall be payable within 14 days of receipt of the invoice without any deductions and free of charges.

In case of orders comprising several units (e.g. programs and/or trainings, realizations in partial steps), the seller shall be entitled to invoice after delivery of each individual unit or service.

5.2 Adherence to the agreed payment dates is an essential condition for the performance of the delivery or fulfilment of the contract by the seller. Non-compliance with the agreed payment terms shall entitle the seller to withdraw from the contract without granting a grace period. The buyer shall compensate for any damage caused by this, including loss of profit.

In the event of default of payment, interest on arrears will be charged to the statutory extent. In the case of agreed instalment payment, the seller is entitled to declare loss of the payment date ("Terminsverlust") and thus to withdraw from the contract. However, the seller can also insist on payment, which does not require notification.

5.3 The buyer is not entitled to withhold payments due to incomplete total delivery, warranty or guarantee claims or complaints.

6. License scope and use

After payment of the agreed remuneration, the seller grants the buyer a non-exclusive, non-transferable, non-sublicensable and unlimited right to use the software on several workstations simultaneously. All other rights remain with the seller.

Any violation of the seller's copyrights shall result in claims for damages, in which case full compensation shall be paid.

The buyer is not permitted to make copies of the software for archive and data backup purposes.

7. Right of withdrawal

Cancellations of the order by the buyer are only possible with the seller's written consent. If the seller agrees to a cancellation, he has the right to charge a cancellation fee of 30 percent of the purchase price in addition to the services rendered and accrued costs.

8. Warranty, maintenance, changes, leasio enormis (“Verkürzung über die Hälfte” § 934 ABGB)

8.1 The seller warrants that the software can be used with the specified operating system and the specified hardware and other system requirements.

8.2.1 The prerequisite for the elimination of errors in the software or the data carriers is that

- the buyer describes the error sufficiently exactly in an error message and this error can be determined by the seller;

- the buyer provides the seller with all documents (e.g. screenshots) necessary for the elimination of the error;

- the buyer or a third party has not interfered with the software;

- the software is operated under the intended operating conditions in accordance with the documentation.

8.2.2 In case of warranty, improvement and replacement delivery shall have priority over price reduction. A period of one month for remedying defects shall be deemed reasonable. Except in the case of unusability of the software, rescission (“Wandlung § 932 ABGB”) shall be excluded. The seller reserves the right to choose to reduce the price instead of the improvement or replacement delivery.

The presumption of defectiveness according to § 924 ABGB is excluded.

8.2 The seller shall not assume any warranty for errors, malfunctions or damage caused by improper operation, changed operating system components, interfaces and parameters, use of unsuitable organizational resources and data carriers, if such are prescribed, abnormal operating conditions (in particular deviations from the installation and storage conditions) and transport damage.

8.3 In the event of (subsequent) intervention in the software by the buyer's own programmers or third parties, any warranty on the part of the seller shall cease immediately.

Costs for assistance, error diagnosis as well as elimination of errors and malfunctions attributable to the buyer as well as other corrections, changes and additions will be carried out by the seller against payment. This also applies to the elimination of defects if program changes, additions or other interventions have been made by the buyer himself or by third parties.

Furthermore, the seller shall not assume any warranty for errors, malfunctions or damage resulting from improper operation, modified operating system components, interfaces and parameters, use of unsuitable organizational means and data carriers, insofar as such are prescribed, abnormal operating conditions (in particular deviations from the installation and storage conditions) and transport damage.

If the subject of the order is the modification or supplementation of already existing programs, the warranty refers to the modification or supplementation. The warranty for the original program shall not be revived thereby.

8.4 Warranty claims shall become statute-barred six months after delivery.

8.5 The application of § 934 ABGB is excluded.

9. Liability

9.1 The seller shall only be liable to the buyer for damages for which the seller can be proven to be responsible in the event of gross negligence. This applies analogously to damage attributable to third parties called in by the seller. In the case of personal injury for which the seller is responsible, the seller's liability is unlimited.

9.2 Exclusion of liability for incorrect simulation and calculation results

Simulation and calculation errors that are due to programming errors do not entitle the buyer to claim damages from the seller. The final responsibility for the results are with always with the user.

9.3 Liability for indirect damages - such as lost profits, costs associated with business interruption, loss of data or claims by third parties - is expressly excluded.

9.4 Claims for damages shall become statute-barred in accordance with the statutory provisions, but at the latest one year after the damage and the party causing the damage have become known.

9.5 If the seller provides services with the assistance of third parties and if warranty and/or liability claims arise against these third parties in this connection, the seller shall assign these claims to the buyer. In this case, the buyer shall give priority directing the claims to these third parties.

9.6 If data backup has been expressly agreed as a service, liability for the loss of data shall not be excluded in deviation from Section 8.2, but shall be limited to a maximum of EUR 10 % of the order amount per damage event, however, to a maximum of EUR 15,000.00 for the recovery of the data. Any further warranty claims and claims for damages other than those specified in this Agreement - irrespective of the legal grounds - shall be excluded.

10. Miscellaneous

If individual provisions of this contract are or become invalid, this shall not affect the remaining content of this contract. The contractual partners will work together in a spirit of partnership to find a provision that comes as close as possible to the invalid provision.

11. Data protection, secrecy

The seller undertakes to comply with the provisions of §15 of the Data Protection Act.

12. Loyalty

The buyer undertakes to refrain from any enticement and employment, including through third parties, of the seller's employees who have worked on the realization of the orders, for the duration of the contract and 12 months after the termination of the contract. The buyer in breach of this provision is obliged to pay liquidated damages in the amount of one year's salary of the employee.

13. Place of jurisdiction and choice of law

The business relationship between the parties shall be governed exclusively by Austrian law. The application of the UN Convention on the International Sale of Goods is excluded. For any disputes, the local jurisdiction of the competent court for the subject matter for the seller's place of business shall be deemed agreed. For sales to consumers within the meaning of the Consumer Protection Act, the above provisions shall only apply to the extent that the Consumer Protection Act does not necessarily provide for other provisions.

14. Mediation of disputes

The mediation clauses recommended by the Professional Association of Management Consultancy and Information Technology (German: Fachverband Unternehmensberatung und Informationstechnologie) of the Austrian Federal Economic Chamber shall be applicable as a business-friendly means of dispute resolution:

In the event of disputes arising from this contract which cannot be settled by mutual consent, the parties to the contract agree to call in registered mediators (ZivMediatG) with the focus on business mediation from the list of the Ministry of Justice for the out-of-court settlement of the conflict. If no agreement can be reached on the selection of the business mediators or on the content of the mediation, legal action will be taken at the earliest one month after the failure of the negotiations.

In the event that mediation does not take place or is cancelled, Austrian law will apply in any legal proceedings that may be initiated.

All necessary expenses incurred as a result of previous mediation, in particular those for a legal advisor, can be claimed as "pre-litigation costs" in court or arbitration proceedings.

In case of any discrepancy between the German original of these General Terms and Conditions and the English translation in here, the German text shall prevail.

1.2 System requirements

The software has been developed under Microsoft Windows; programming language is Microsoft Visual C++.

The application can only be run from a Windows operating system. We suggest that Apple users run it by installing a virtual machine with a Windows operating system.

We recommend the following system configuration:

- Operating system: Windows 10/11 64 bit or higher (prerequisite!)
- Processor: 2.5 GHz
- RAM: 16 GB
- Graphics card: 8 GB
- Resolution: 1920 x 1080

1.3 Installation

The programme is delivered via a download link. Activation takes place via an online activation key, which must be entered to start the programme.

1.4 Update News

1.4.1 New in Version 19.0

- DXF can be stored in 256 colors
- New module: Grazing Traces Bicycle for plausibility check of scratch traces
- 2D graphic tools: Trees, various obstacles and road elements
- Completely new 3D operation:
  - All objects are now selected in 2D and have their own 3D properties window
  - 3D models are created in real time and can be moved and rotated in real time (no need to close and reopen the 3D anymore)
  - Complete synchronization between 2D and 3D
  - New 3D models (adapt to 2D equivalent): stone wall, garden fence, guardrail, hedge, deciduous tree, conifer, bollard, hat, road block, street lanterns, highway lamps, delineators, etc...
  - Intersection and roundabout now also have a height mesh for center island and sidewalk
- The street can be selected across all elements and can therefore be easily changed later.
- Movable pedestrian models: Woman & Boy
- Restructuring of existing 3D models to make it easier to find them in the database
- The zebra crosswalk can be reset
- Database with location coordinates for sunlight calculation (Germany: 13500 locations, Austria: 2300 locations, Switzerland: 4000 locations, Italy: 8100 locations)
- Agisoft Import:
  - Control of the view with 1,3,7 as in Agisoft
  - Possibility of switching between orthographic and perspective (short key 5)
  - Ortho image with 2048x2048 or 4096x4096 exportable

    - Coordinate cross and tile pattern added to preview for easier orientation
    - System for 3-point alignment of meshes: input of angles and distances precisely aligns the mesh
    - Finer resolution of the bottom gauge for smoother movement over the surface
- Simplified vehicle data: Simplified control through blanking of irrelevant values and insertion of corresponding images
- barrier procedure: Bicycle throwing distance inserted after an investigation by DEKRA
- Tyres: geometry calculator
- Vehicle database extended by more than 1000 vehicles
- Direct synchronization with the Autoview DXF database: When loading vehicle data, the DXF is also loaded if available.
- Revised collision analysis backward: The collision analysis in the pulse backward method is now called up directly from track tracking. Adjustments from track tracking are taken over and calculated directly in the collision analysis. Friction coefficient and k-factor are highlighted in red if the corresponding value is particularly critical.

1.4.2 New in Version 20.0

- Complete revision of the drawing engine
    - Render processes can be processed in a more resource-efficient way
    - Displayed graphics are vector graphics
    - Antialiasing
    - Image processing with alpha channel
- Direct drawing in 3D
    - Lines can be drawn directly
    - Images can be inserted when the 3D view is open
    - Shadow cast revised
- DDD Importer:

- Digital tachograph files can be read in directly and transferred to the distance-time data.
- Readable file types are the C type (social data), M type (1 Hz speed data) and **S type** (encrypted 4 Hz speed data).
- Output of all data in text files possible
- Detailed display for a more accurate representation of the data

- Optimizer for collision analysis: Automatic collision analysis module that outputs possible collision parameters according to start and end positions as well as upper and lower limits.
- Tyre dimensions can be output with decimal numbers.
- The collision analysis now has 3 windows: Small, medium and large.
- New vehicle type: "Animals" - including movable 3D models of dog, cat, horse and deer
- Vehicle database:
  - Expansion by more than 100 vehicles
  - Synchronization with Autoview 19
  - Extension by tyre data of more than 7000 vehicles
  - Over 100 new vehicles

1.4.3 New in Version 21.0

- Calculation and display of curves using Bezier segments
- Complete revision of the driving line
  - Fixation of the start and end point on the driving line
  - Display of phase limits
  - Automatic attachment of further phases
  - Reversing with trailers
  - Multiple changes of direction on a driving line
  - Revised dialogue for resetting
- Import option for Bosch CDR files
  - Reading of pre-collision phases
  - Transfer to kinematics
  - Automatic summary of related recordings

- Barrier procedures
    - Complete revision of the module "Barrier Method"
    - Direct setting of positions in Movieview possible
    - Integrated control calculation by means of throwing distance
    - Direct transfer to the kinematics
- Curved ruler with up to 4 different divisions
- New 3D standard models for the types: car, lorry, lorry train, articulated truck, bicycle, moped, motorbike, bus, tractor, tram, minibus, articulated bus, fork-lift, double articulated bus, double articulated tram
- Tracking: Trailer fields are only displayed if a trailer is present.
- 3D view: middle mouse button to move
- New vehicle types: Scooter & senior citizen mobile
- Updated vehicle database with synchronisation to Autoview 20 and 100 new vehicles
- Vehicle database for trailers with 100 data sets
- DDD Import: User interface revised, specification of the time axis
- "Tree Tool." New elements: Person and bicycle
- Standard vehicle silhouettes: motorbike, moped, bicycle
- Online licence activation via online code
- Protractor with tolerances
- Shortcut "B" for the selection mode for background objects
- Rendering of DXF accelerated
- Measuring stick tool in 2D and 3D
- Module "Pedestrian Accident" graphically revised

1.4.4 New in Version 22.0

- Complete revision of the collision analysis and run-out simulation.
- Extension of the automatic collision analysis:
    - Variation of relative positions
    - EES control computer
    - Display of tracks and stroboscope in the overview window

- Administrator rights are no longer required to use the programme
- Save settings to editable text file
- Import of laser scans in e57 and xyz format
- Extension of the general driving line and GPS import
    - New file types can be imported
    - New diagram for selection
- Extension of DDD import
    - DDD files of the new generation can be imported
    - New diagram for selection
- GPX (bike / sports watch) importer
- Automatic updater
- Synchronisation with Autoview DXF database 2021
- Calculator for solar twilight
- Traffic signs with transparent background
- Module "v = Konst" with extension for multiple vehicles
- New module "Video analysis" to read in surveillance camera video files
- Images can be inserted via drag and drop

1.4.5 New in Version 23.0

- AnalyzerPro is now a 64 bit programme. This means that there are practically no more restrictions on the image and 3D sizes used.
- Image rectification: Rectify and remove barrel or box distortion.
- Create a report: A PDF with exact calculation history is created for better traceability of reports and analyses.
- FIT Reader: The GPX Reader can now also read original FIT files and convert them into a clear format
- ESO Reader: Tables from ESO measuring devices can be loaded and overlaid.
- CDR Steering Angle: The steering wheel angle in the CDR data can now be transferred directly to the driving line.

- Data import: Recording segments are now taken from the end and not from the beginning of the selection range.
- GoPro Reader: Metadata from GoPro cameras can be read out and transferred directly to the kinematic data.
- DWG: Images in DWG format can be read in.
- Shortcuts: Shift + V and Shift + H move graphic elements all the way to the front or all the way to the back.
- The EES value is displayed in the small collision analysis mask.
- Modules with GPS data show them directly on a map.
- Yaw and steering angles are displayed in the coordinates window.
- > 100 new vehicles in the vehicle database, synchronisation with Autoview 2022.
- Graphic module for automatic loading of Google Maps and Openstreetmap maps.
- Position of the toolbar is saved automatically.
- The entries in the vehicle database can be sorted.
- The driving line shows the current phase during mouse-over.
- In the video analysis, frame lengths can be specified manually for calculation.

1.4.6 New in Version 24.0

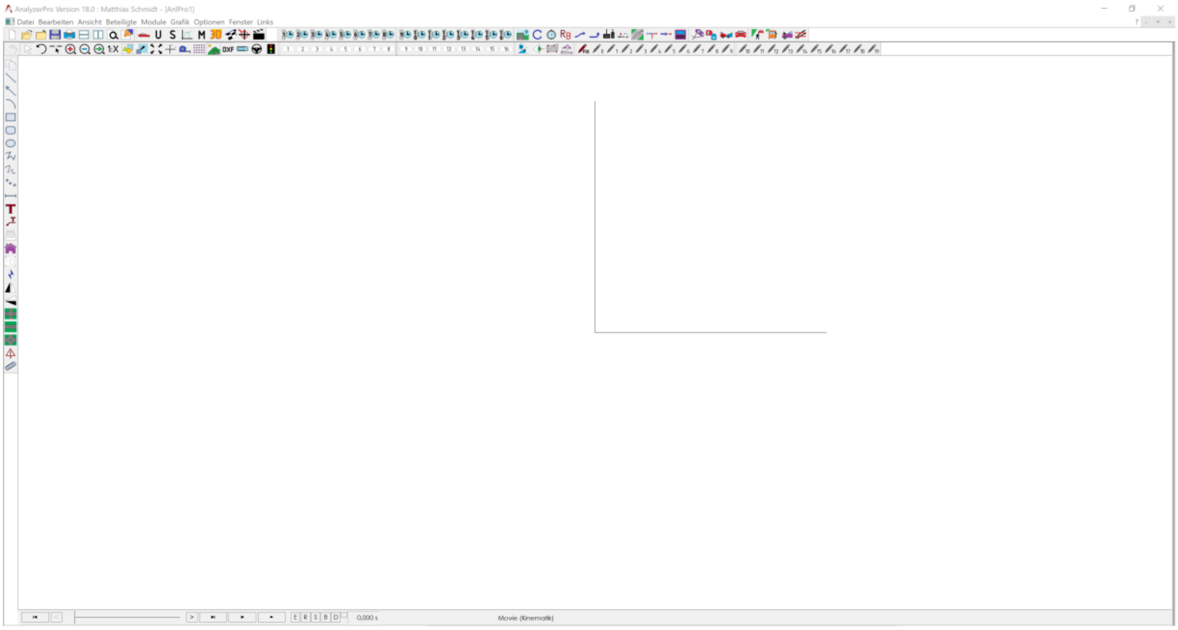
- Automatic Collision Analysis: Impact point height, yaw angle, and yaw rate can now be considered. Additionally, a third vehicle or obstacle can be added.
- New Interface and Chart Enhancements: Charts (e.g., Time-Distance chart) now have a new user interface and many advanced features, such as displaying phases and more.
- Extensive Expansion of the Bosch CDR Import Tool: Charts, tables, data visualization, etc.
- Dashcam Video Analysis Tool: AI analyzes the video stream from dashcam videos and determines the driving speed of the host vehicle.

- Text-Based Video Analysis Tool: For dashcams with written speed text, it can be directly extracted.
- Image Cleanup: Remove distracting objects from images, such as parked cars, with a single click.
- In the collision analysis, both collision partners can now be rotated together, preserving the relative position. Marked graphic objects can also be rotated together.
- Coordinates can be displayed in the print view.
- Vehicles with a trajectory can be rotated directly over the vehicle.
- In the print preview, field sizes can be dynamically adjusted, and a scale can be displayed.
- 3D Models for grass and cornfields, as well as a bus stop.
- Manuals can be accessed directly from the Analyzer.
- A ruler can be placed directly on the trajectory.
- Printing is possible from the 3D view.
- The driver of 3D motorcycles can be turned off.
- Only active phases are visible in the main data mask and can be adjusted.
- The position can be reset and fine-tuned in the "Move Vehicle" feature.
- The Ctrl key restricts movements to the main axis directions.
- Iterating through all movie objects using the "Tab" key only considers currently visible objects.
- Polylines can import and adopt points in various formats (Disto-Files).
- Photogrammetry and laser scan objects are loaded directly after export.
- Groups and DXF files can be scaled like images.
- Phase names can be displayed on the trajectory.
- The Maps graphic tool now supports Google Earth.
- Export data from data analysis modules into a .csv file.
- Fit curves in data analysis tools can assume any polynomial degree.
- "Psychoman" for phase visualization.
- Expansion of the vehicle database by over 100 vehicles, synchronized with Autoview 23.

- Disto Reader for reading measurement points.
- In the main data screen, an unlimited number of phases is now possible.

2 First Steps

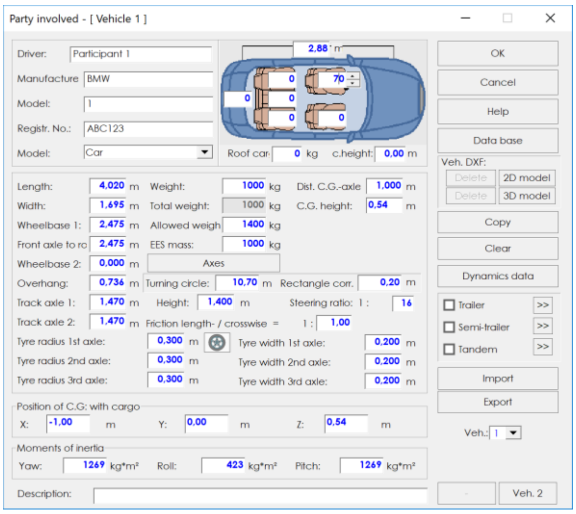
You have successfully installed AnalyzerPro on your computer and activated the programme. You run AnalyzerPro and after a few seconds you will see this picture:

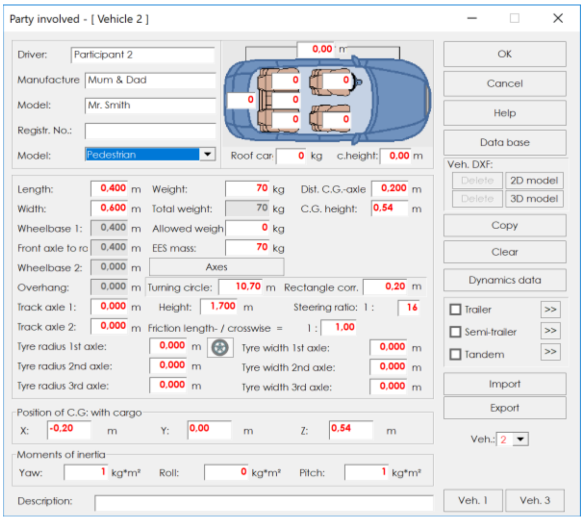


You can now start working on your report.

As a short exercise, we shall now look at this accident between a pedestrian and a car.

1. Define a vehicle:

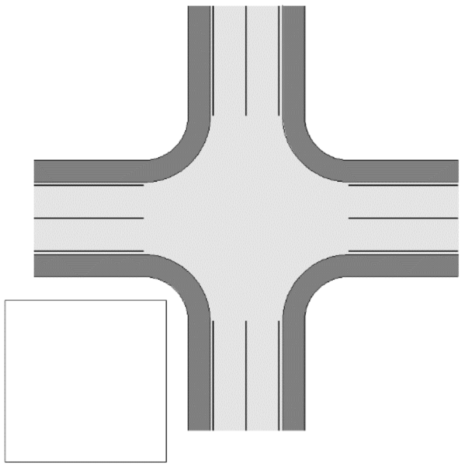




First, the parties involved in the accident have to be defined. Click the icon to call vehicle data options ( ). Define the vehicle type as passenger car (Car). Next, you press the button “Veh. 2” on the bottom right side of the window. Set the vehicle type of vehicle 2 to “Pedestrian”.

2. Create a sketch:

With AnalyzerPro you can both load images and draw your own sketches. In this example, we will draw an intersection using the intersection drawing tool ( ). First click the icon and then click the spot where you would like to place the intersection. For this exercise, we will use the default values and not change any input. Additionally, we draw a rectangle at the bottom left corner which will simulate a house.



3. Create a driving sequence:

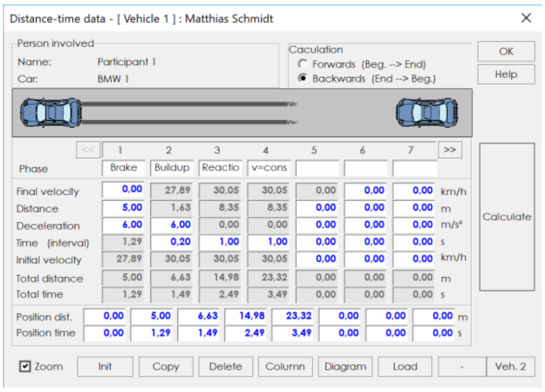
Next, we will create driving sequences. For this we open the main data mask for vehicle 1 ( ). First, we have to choose if we want to calculate forwards or backwards. This has nothing to do with the driving direction! “Forwards“ means: We know the initial conditions and parameters and we would like to calculate the ending conditions. “Backwards“ means we know the conditions at the end and we would like to calculate the conditions at the start.

Let’s assume the following scenario: The car is coming from the left driving with constant velocity, the driver sees the pedestrian and brakes with full power so that the vehicle comes to a halt shortly before hitting the pedestrian. We see skid marks measuring 5 m in length. This is what we do:

We select the calculation mode “Backwards“ because we know the end conditions (Standstill next to the pedestrian). We call a single part of a driving sequence a “phase”. Per phase, we need to enter 3 input values to calculate the unknown ones.

As our first phase, we select “Braking”. Final velocity is 0, die braking deceleration can be estimated to be 6 m/s² because there are skid marks. Braking distance has can be entered as 5m because that is the length of the skid marks. We press “Calculate” to get our first interim result.

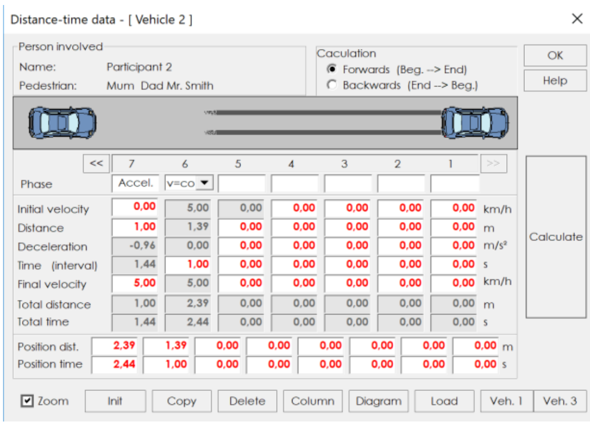
For our second phase we select “Buildup“ in order to factor the time it takes for the brakes to develop their full braking power. Final velocity and deceleration will be taken from the previous phase automatically. By default, the time (interval) for a buildup phase will be 0.2s. Again we click ‘Calculate’.



Before the buildup phase we need a reaction phase, so we select “Reaction” for our 3rd phase. The final velocity will be taken over again, braking deceleration is 0 and the time (interval) is by default 1 s.

As 4th phase we choose driving with constant velocity (v = const.) with a duration of 2 seconds, which is chosen arbitrarily.

The calculation shows us that the car had been driving with a constant velocity of 30.05 km/h in the beginning. We have successfully taken final conditions and calculated a simple initial condition using backwards calculation.



As next step we want to calculate the pedestrian’s distance-time data. The pedestrian claims to have rapidly walked towards the road. We open the main data mask for vehicle 2 (the pedestrian). This time we choose the calculation variant ‘forwards’.

We choose ‘acceleration’ as first phase for our pedestrian. Let us assume that the pedestrian started to walk with one single fast step. We choose initial velocity as 0 km/h, distance of 1 m and final velocity of 5 km/h.

In our second phase we let the pedestrian walk with constant velocity for 1 s.

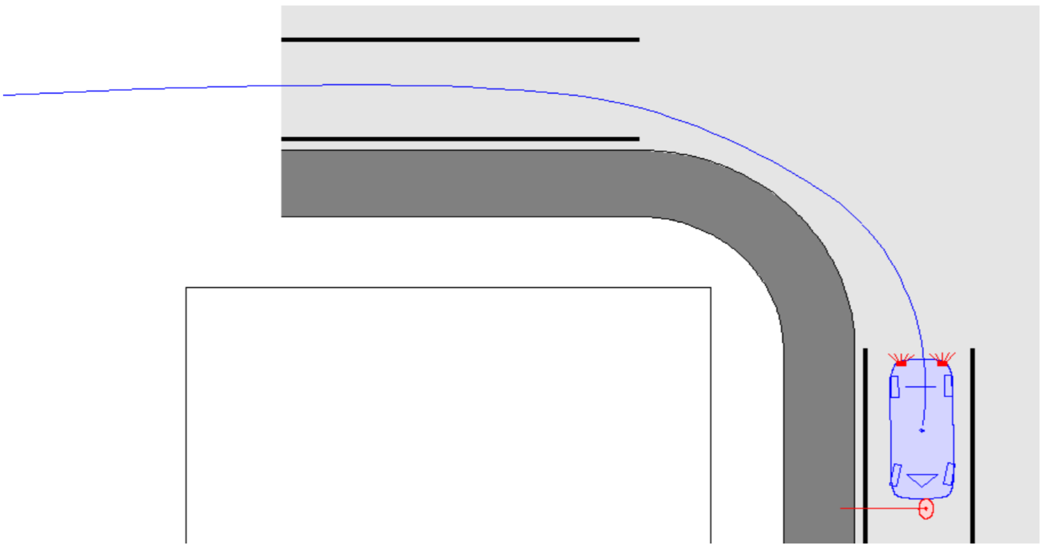
4. Adjust the driving line:

After creating the driving sequences, AnalyzerPro will automatically create the vehicles with a straight driving line.

The vehicles now have to be adjusted to fit the actual scenario. Let us assume that the pedestrian crossed the road just next to the house. Therefore, we drag into the position that is depicted in the image below. When needed, we might want to rotate him or her. The button  can be used to rotate objects. Please keep in mind that vehicles (that includes the pedestrian) are always rotated by rotating their driving line.

Next, we want to adjust the position of the car. For this we have to curve the driving line. To curve the line, we insert an additional point into the line. This can be done by selecting the line with a left click and then right-clicking it and choosing 'Add point'. Alternatively, you can hover your mouse cursor over the line and press F9.

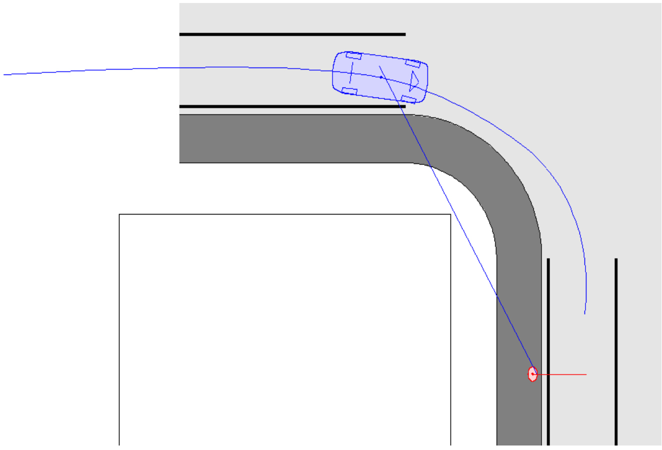
If everything has been adjusted and you are satisfied with the scenario, you can press the 'Play' button on the bottom side of the screen. The road users should now move accordingly.



4. Results:

It could be interesting to know when exactly the driver could have seen the pedestrian, since the view is obstructed by the house in the beginning. We open the window 'Visual ray' ( ) and tick 'from veh. 1 to veh. 2'. A line of sight from the driving cabin to the pedestrian will be automatically drawn.

If we press the button "R", which is located in the lower area of the monitor, and choose "Veh. 1" next, the car is automatically set to the beginning of the reaction phase. Now we can determine that the driver of the vehicle has reacted immediately to the appearance of the pedestrian behind the house.



3 Program Description

3.1 Shortcuts

Esc	Termination of a submenu, return to the superordinated menu. However, it is impossible to close windows this way.
Cursor Up / Down	In a selection box: Marks a menu item with the light bar (but no execution is initiated yet). In an edit field: Increases respectively decreases the input value by the last decimal point with calculation, if a calculation has already been executed previously. If the Ctrl-Button is pressed simultaneously, the changeable value will be increased by factor 10. If the shift button is pressed simultaneously, the changeable value will be increased by factor 100. Without selection: If no object is selected, only the mouse pointer will be moved.
Shift + Move Cursor	Shifts the selected object.
Return/ Enter	In a dialog box: Confirmation of selection respectively input. With a selected object: The property window of the selected object is opened.
Tab	In a dialog box: Leap to the next field. Without selection: Cyclically selects the existing objects that are currently visible in the view, such as vehicles, associated splines, and user-defined splines.
Image ↑	Zoom function: Scale up
Image ↓	Zoom function: Scale down
Ctrl + Draw	Orthomode, which means that only horizontal or vertical lines are drawn.
Ctrl + O	Open file.
Ctrl + S	Save file.
Ctrl + X	Cut.
Ctrl + C	Copy to clipboard.
Ctrl + V	Insert from clipboard.
Ctrl + D	Opens the diagram options menu.
Ctrl + T	Time adjustment.
Ctrl + W	Close file.

F1	Support regarding the topic.
F2	Executes the calculation.
F3	Creates a copy of all depicted vehicles at a particular point in time.
F4	Collision box respectively serial collision box switches between big and small depiction.
Alt + F4	Exit program.
Ctrl + F4	Close active window (is not valid for the dialog box).
F5	Open module „Constant velocity“.
Ctrl + F5	Open module „Reaction - Brake“.
F6	Open module „Calculate Distance – Time“.
Alt + F6	Open module „Calculate Distance – Time“ (Partial braking areas).
Ctrl + F6	Switch to next window.
Ctrl + Shift + F6	Switch to previous window.
F7	Calculator.
F8	Open Distance – Time - Diagram.
F9	Place a point on a selected line (defining) respectively delete a point.
F10	Open box for colour adjustment.
F11	Switch between straight and curved sections of a spline.
F12	Duplicate object.
Alt + Back	Undo.
Alt + Shift + Back	Rerun undone action.
Print	Copies box to clipboard.
Alt + Print	Copies the present box to clipboard.
Z	Function „Zoom“.
X	Play / Stop
F	Catch: Selects the next object and moves the cursor to the appropriate position.
S	Starts the mode „Stretch“ / „Compress“ respectively „Shift“.
E	Starts the mode „Edit“.
R	Starts the mode „Rotate“ / „Shift“.
V	Brings an object one level forward (Sequence).
Shift + V	Move object to the top (Sequence).
H	Sends an object one level backward (Sequence).
Shift + H	Move object to the bottom (Sequence).

P	New vehicle position in tracking.
B	De/activate selection mode for background objects

3.2 The Mouse

Left mouse button: Normal function analogous to other Windows programs: Draw, Drag, Rotate, Select, etc.

Right mouse button: Opens the menu „Properties“, dependent on the current selection.

Mouse wheel: The function of the mouse wheel can be assigned at Options / Properties.

If „0“ is selected,

- Turning the wheel forward/backward → Zoom (forward: maximize, backward: minimize)
- Shift + Turning the wheel forward/backward → Shifts a sketch to the left/right
- Ctrl + Turning the wheel forward/backward → Shifts a sketch upward/downward

Middle mouse button (= pressing the mouse wheel): Shifts the image section.

3.3 File

3.3.1 New

(Icon:) When choosing „New“, an empty report with standard values (mostly 0) is loaded. Subsequently you can determine a name for the new report with „Save as...“.

3.3.2 Re-Open File

A file with the name „New.anl“ will open.

The user can now create an individualized file „new.anl“. This way, personal preferences can be set as standard for upcoming reports. First, you have to select “New” in the menu and specify the desired properties. As a second step, you can load various objects, which you repeatedly need, and adjust the line properties etc. Afterwards, please save the file as “New”.

The next time „Re-Open File“ is selected, this file will be loaded; in order to avoid unintentional changes to the standard report, the window “Save as…” will open as well. Here you can determine the final file name.

3.3.3 Open...

(Icon:) With this icon, you can open already created and saved Analyzer documents.

3.3.4 Close

(Icon:) Selecting this icon will close the current Analyzer document.

3.3.5 Save

(Icon:) Your calculations will be saved under the current name and in the folder from where the file has originally been retrieved.

If no name has been selected yet, for example after „New“, the program will prompt you to insert a name. In case no other particular folder is chosen, the report will automatically be saved in the folder that is set for report files under the menu item „Options“.

The ending of Analyzer documents is *.anl. In case you do not insert an ending, *.anl will automatically be used.

The attached DXF, images and other files are also copied to the destination and stored in the folders "DXF" or "Maps". If the .anl is to be transferred from one PC to another, these folders must be taken along.

3.3.6 Save as...

If you would like to save the calculations under a different file name, please choose this menu item. It will prompt you to insert a name then.

The attached DXF, images and other files are also copied to the destination and stored in the folders "DXF" or "Maps". If the .anl is to be transferred from one PC to another, these folders must be taken along.

3.3.7 Create backup copy

Creates a backup of the current file called " AnlPro_Date.anl ". You can find this file in your installation folder under the subfolder "Temp". Up to 5 backup copies are stored in parallel.

3.3.8 Open graphic

(Icon: ) Files in bmp, jpg, jpeg, gif or dxf format can be used for graphical depictions (Movie and diagrams). The files can be loaded as background images and as normal objects.

If bmp or dxf is selected, the program will automatically show the folder which is set for this type of files under *Options/Settings/Directories*.

Dxf-Files are loaded as a group; you can choose if the grouping shall be loaded in blocks (Layers), labelling of objects or in an ungrouped manner.

If a Dxf is loaded in an ungrouped way, it is only one object and all lines have the same characteristics, f.e. the same colour. If the Dxf is loaded as a group, each line is a separate object with own characteristics.

Images and DXF can also be dragged and dropped from Windows Explorer into the programme.

3.3.9 Copy graphic in clipboard

The content of the diagrams and the movie can be copied in the clipboard as a Bitmap and is then available for other applications.

In order to make a printout of your report in a word processor, you can insert separate parts from the copy in the clipboard to your text.

The current window respectively the current dialog box is copied in the clipboard.

For copying a graphic in the clipboard you can either select the menu item or click on the right mouse button. There you can also choose Copy → Clipboard.

Input windows within the accident modules will be copied in the clipboard without any disturbing operating buttons or switches. The background is white.

This way, only the relevant parts of the modules are copied in the clipboard; operating buttons etc. are not copied and the background remains white.

Operating principle of the “Print” key

Instead of using the right mouse button and selecting the appropriate point, you can also copy dialog boxes, f.e. calculation masks, with the key „Print“ on your keyboard.

If you would like to copy the entire mask (including the background colour) in the clipboard, use „ALT“ + „Print“.

In case the entire screen content should be copied, no input window shall be active prior to using the „Print“ key.

3.3.10 Save graphic as Bitmap

The content of the diagrams and the movie can be copied as a Bitmap and is then available for other applications. The target directory is set in the Bitmap directory.

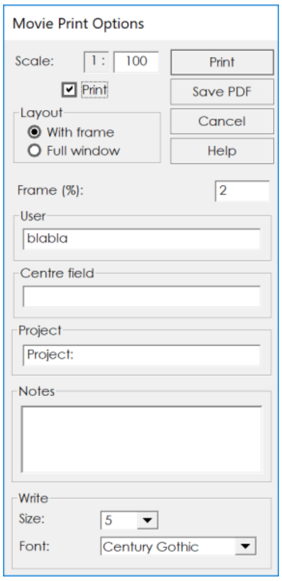
3.3.11 Save graphic as DXF

The prepared drawing of diagrams and of the Movie can be saved as a dxf-file and are available for other applications then. Line properties are considered. For saving, all required elements need to be marked.

3.3.12 Open graphics utilities

(Icon:) The file „Windrose“ is opened. In this file, you can find several useful drawing items which you can copy (Ctrl+C) and insert (Ctrl+V) in your current report file. You can expand this file with further useful elements yourself. The file to be opened as a Utility-file can be determined under Options/Settings/Directories.

3.3.13 Print



(Icon:) The page view allows you to view the printout in advance. You can shift the printable section using the arrow buttons. The view can also be moved with the left mouse button hold down. The view can be zoomed with the mouse wheel.

It is possible to assign a person responsible for the file. The name will be printed on the left below the licence name. Furthermore, the name of the person is saved in the Registry and read by the program when opening it.

Middle Field: In the header of the printout, it is possible to insert a text in the middle. You can choose to create a printout with framing (double line) or as fullscreen without framing. The entire content of the Movie window (without toolbar etc.) is printed.

The frame width is adjustable. If 1 is chosen, only one frame line with the smallest possible frame width is used. The greater the number, the bigger the unprinted frame will become. You can click and drag with the left mouse button to move some of the subdivision lines within a certain range. This setting will be saved.

In the upper right corner, it states: Report: File name

You can change the text in the text box „Report“. The text stays the same within a document unless it is changed again. If the file is saved with a new name or if a new file is opened, the default text “Report: File name” is displayed again.

Under “Comments” further information can be added. The font size, type and colour can also be selected.

If you print from the movie view while having the coordinate display open, it will also be shown in the print preview and can be freely adjusted there.

“Save PDF”: You can save the file directly as PDF. This is based on “Microsoft print to PDF” which is available per default in Windows 10.

"S": Perform a search for network printers. If network printers are found, they will be added to the printer selection drop-down.

Option "Vector Printing": This is the default selection. With this option, all graphic elements are transmitted to the printer or PDF as vector graphics. This means that the resolution in the printout may be better than in the print preview at screen resolution. If you do not choose this option, at the moment of printing, the print preview image is rasterized at the selected DPI density, creating an image that the printer then uses. The advantage of this approach can be that the printer may need to perform fewer potentially resource-intensive operations than with vector printing, which can help avoid issues with certain printers and highly complex sketches. This can also reduce the file size of PDFs.

<u>Tip 1:</u> In case the desired scale does not fit on one page, please create two printouts, with a scroll of the screen in between. In order to ensure a horizontal or vertical scroll, it is recommendable to use the keyboard: Cursor keys on the keypad.

Afterwards, stick the pages together. For a precise juncture, position a small line object on the appropriate border on both sides.

Tip 2: All calculation masks and dialog boxes can be directly printed. For this purpose, perform a right-hand click in an empty area of the calculation mask or dialog box and select “Print directly” in the appearing menu.

3.3.14 Setup printer...

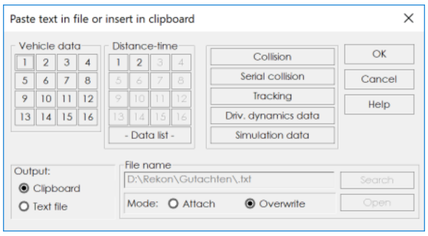
With this icon, you can setup your printer. In case several printers are connected, the right device can be chosen here (see Windows – Support). It is also possible to choose the landscape format in this menu item.

Attention: If you change the printer setup (for example the print format), the scale of the Movie will change as well. The choice of printer is saved and re-selected for the next time, given that the printer is available upon starting the program.

3.3.15 Export data

Input data and calculation data can be saved in the clipboard or in a text file. You can choose between substituting the existing content and adding to the existing content.

The data on parties involved („Vehicle data“), data on „Distance – Time“, the „Serial collision“ as well as stress on the passengers, „Tracking“, „Driving dynamics data“, „Simulation data“ and the collision analysis can be issued as a text here.



If “Output: Clipboard” is chosen, the selected elements can be inserted to a data file using “CTRL+V”.

If „Output: Text file“ is selected, a file is created simultaneously to choosing one of the buttons in the selection box. As a default, this file is given the same name as the report file, but with the ending „.txt“. Of course, you can change the name or select an existing file. With the button “Open”, the file is loaded with the Editor pre-determined in the default settings. If no file with the same name exists, a new one is created.

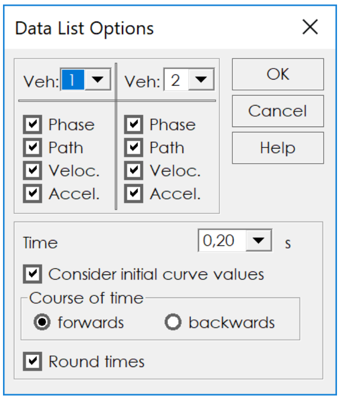
Tip: After you have opened a text file, you may select further data to be inserted to the text file by pressing the selection buttons. However, the Editor cannot “refresh” automatically, hence, the effects are not visible. You need to close the file without saving and re-open it. Use the clipboard to import data in the open text file.

Data of the main data set (Distance – Time data) up to 7 sections is delivered in a way that the sections are arranged in columns. For more than 7 sections space would not suffice, hence, the table is mirrored and sections are delivered line by line.

"Mode: Attach" – The selected text blocks are attached to each other in the arranged order and inserted as one entire block.

"Mode: Overwrite" – Only the last selected element is inserted.

3.3.15.1 Data list



You can issue a data list for one or two vehicles next to each other. Tick the appropriate boxes to determine which values shall be shown. With “Time increment” you can adjust the output frequency.

Furthermore, you can decide if the initial values of the curve shall be considered or not. This means, if the initial values of the curve are not considered, the time and distance of every vehicle starts with 0. The output of time states the duration until the vehicle movement ends, the distance the route until the end. Thus, the output is not synchronous to the other vehicle.

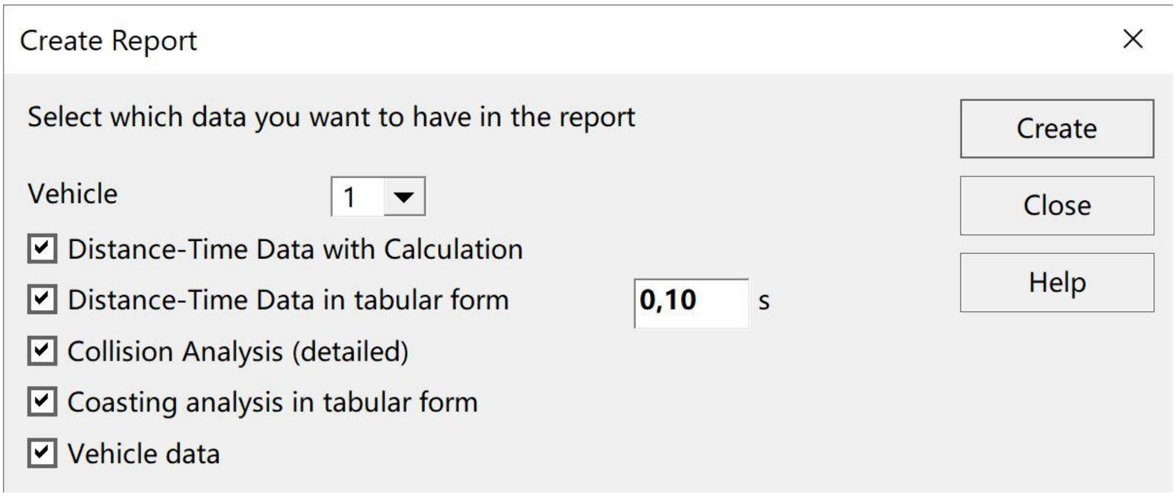
Conversely, if the initial values of the curve are considered, time starts with the last occurring point in time and the distance represents the position of the vehicle now.

The value of the distance is calculated as the sum of the distance to the end plus the initial value of the curve. In this case, vehicles are synchronous.

Moreover, you can determine if the data list shall be issued forward or backward time-wise. Points in time can be rounded. In any case, the phase boundaries between the rounded times are stated. At the beginning of a new phase, a paragraph is inserted. If more than 7 columns are available in the main data mask, the section output will be arranged one below the other, otherwise like in the mask itself next to each other.

3.3.16 Create report

This module is used to create a PDF file to increase the comprehensibility of the calculations for third parties.



Depending on the selection of the different options, different text elements are inserted into the PDF that mathematically explain the previously performed calculations.

3.3.17 Send mail

This menu item opens a new mail in Microsoft Outlook and inserts the current Analyzer file in the attachment.

3.3.18 List of documents

The recently opened Analyzer files are quoted here.

3.3.19 Load backup file

If the setting "Create backup copy" has been made, then a backup copy is created in the set interval in the installation folder under the subdirectory "Temp". Up to 5 different backup files can be created in parallel. If the user has now made changes in the original file after creating a backup file, but then wants to return to the previous status, it is possible to call up the backup file here.

3.3.20 Exit

The program can be closed either with the menu item „Exit“, the „X“ Button in the upper right corner or with „ALT + F4”.

Your last settings (like window size and position) are saved in the Windows-Registry. They are at your disposal as a default option for the next program start.

3.4 Edit

3.4.1 Undo

(Icon: ) Many of the last actions can be undone with this command, for example the editing of lines in the Movie, shifting of curves or similar. Numeric input or the press of keys (f.e. calculation key) cannot be reversed.

3.4.2 Redo

In contrast to „Undo“, this command allows you to redo an action you have previously undone.

3.4.3 Cut

The menu item „Cut“ removes marked text or graphic objects and copies them to the clipboard.

3.4.4 Copy

When using „Copy“, marked text respectively graphic objects are copied to the clipboard without removing them from the document.

3.4.5 Paste

The command „Paste“ inserts marked text from the clipboard in the current text box respectively places graphic objects on the current cursor position.

3.4.6 Copy and paste

(Icon: ) Serves the duplication of the current line object in the Movie window. The copy will be positioned a little bit to the right and below the original object.

If the duplicated object is subsequently shifted, the relative coordinates to the original position are displayed in the lower edge of the screen.

3.5 View

3.5.1 Tool bars

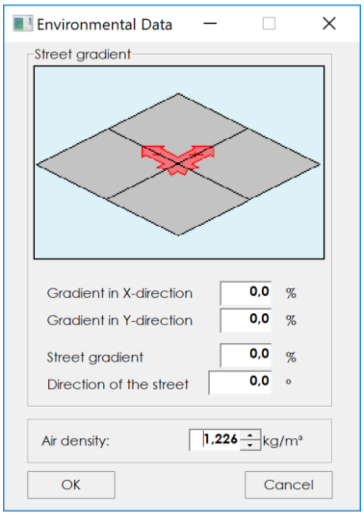
You can select the tool bars to be shown here.

3.5.2 Status bar

Enables the status bar in the lower area of the screen.

3.6 Involved

3.6.1 Environmental data



(Icon: U) With this menu item, the road's gradient can be set. You can adjust it either by entering the gradient in the direction of the x axis and y axis or by stating the street gradient and the direction in the coordinate system. Use positive values for an inclining and negative values for a declining slope.

The street gradient is only taken into account for tracking (Coasting analysis backwards) and driving dynamics respectively a coasting analysis forwards, but not for kinematics. Where applicable, you can also adjust the air density required for calculating the air friction here.

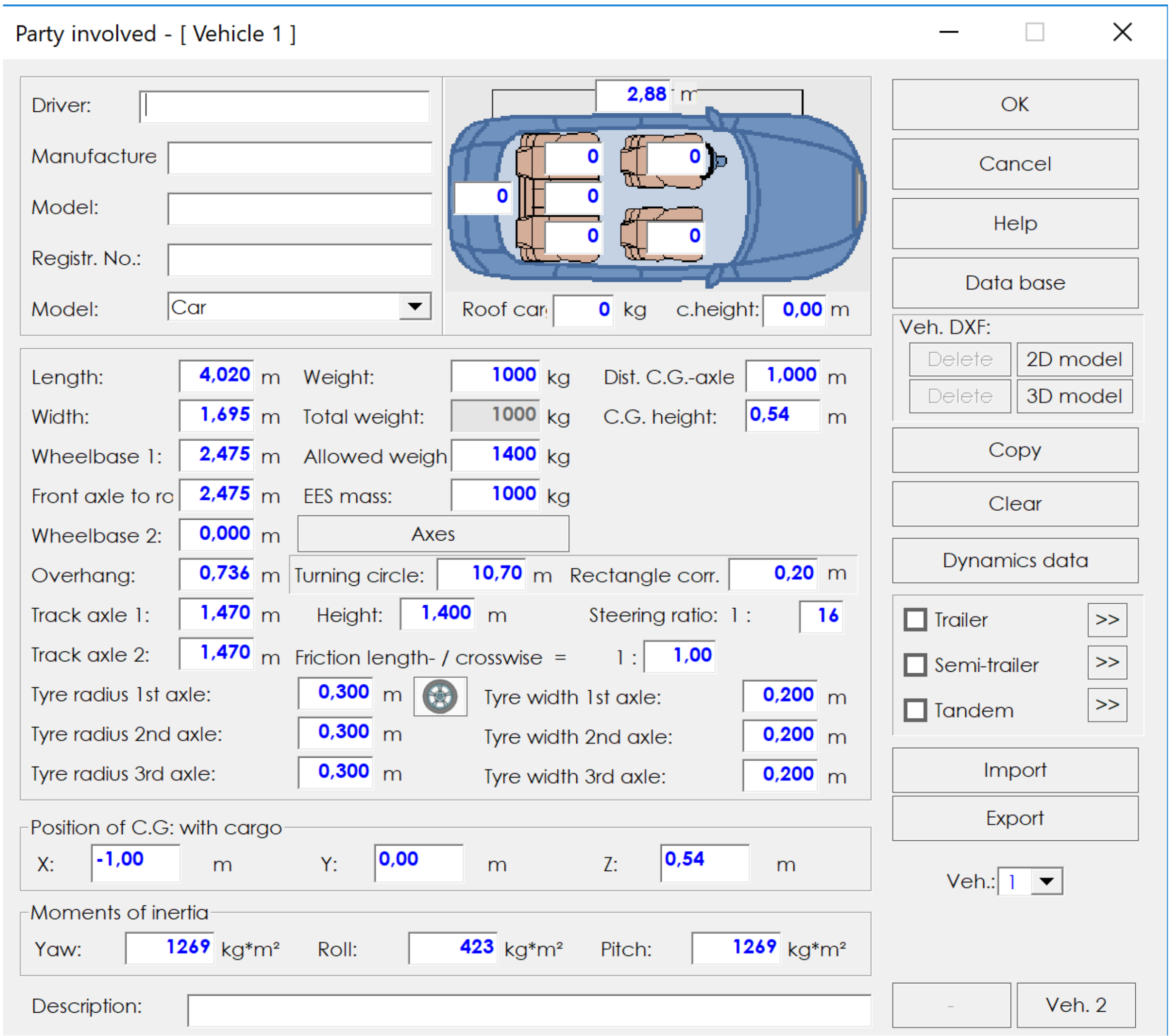
3.6.2 Vehicle data

(Icon:) Up to 16 accident participants can be defined in the input mask. Each participant respectively each vehicle is coded. The current code is recorded in the title bar. In the upper left area you can insert name, manufacturer, model and registration number. At the dropdown menu "Model" you can choose between the following vehicle types:

- Car
- Truck
- Truck trailer
- Semitrailer
- Motor-assisted bike
- Bicycle
- Motorbike
- Pedestrian
- Bus
- Tractor
- Commercial vehicle
- Special vehicle
- Tram
- Minivan
- Obstruction
- Vehicle
- Articulated bus
- Tree
- Forklift truck
- Guardrail
- Double-articulated bus
- Double-articulated tram

- Animal
- Senior citizen mobile
- Scooter

Special case forklift truck: In order to depict the back wheel control in an appropriate way, distance, velocity and acceleration need to be inserted in the Distance – Time data with reversed signs: negative velocity – the forklift truck with back wheel control moves forward.



If a new vehicle model is selected, the default data on file is automatically loaded. The program reads the default values from the files "_PKW.dat", "_LKW.dat", etc. The directory is the same as the one set for the motor vehicle database. You can adjust the values according to your wishes in these files.

In the middle part of the window, you can view and adjust geometrical data to your vehicle.

For vehicles with three axes, it is necessary to insert the „Wheelbase 2“; it represents the distance between the first and second rear axle. If the value equals 0, the vehicle remains biaxial.

With "Front axle to ro." you can adjust the position of the current rotation centre of the vehicle. If the value corresponds with the wheelbase (standard value), the pivot is positioned in perfect prolongation of the second axis. For a biaxial vehicle, the condition laid down by Ackermann are fulfilled.

If simple outlines are used as a vehicle depiction (not for depictions in dxf), a line across the vehicle is drawn at the position. For vehicles with three axes, the value needs to be increased if the third axis is not steered.

Information regarding the weights are required for the serial collision and collision analysis:

Passenger weight and loading: You can insert the mass of passengers and loading into the boxes of the vehicle depiction in the upper area of the window. These values are automatically added to the empty weight of the vehicle and depicted in the box „Total weight“. The value inserted as passenger weight is used for the calculation of passenger acceleration caused by collision.

"Weight": Weight of the empty vehicle.

"EES mass": Value of the mass to which the EES value is referring. At least the empty weight needs to be inserted. In case comparable photos are available, the test mass can be entered here, and the conversion can be skipped.

"Dist. C.G.-axle" (Distance centre of gravity – axle in the empty car): Distance from centre of gravity to the front axle without consideration of the loading. If passengers or a loading is specified, the actual distance from the centre of gravity to the front axle is calculated. The centre of gravity is depicted as a little square in the simple vehicle presentation. The distance from the centre of gravity is required for the collision analysis. The vehicle is connected to the centre of the tyre contact points of the first two axes with a driving line.

If the value of the centre of gravity to the front axle does not amount to half the wheelbase, then a difference in rotation movements arises between the velocity of the centre of gravity and the velocity of the vehicle centre (kinematic velocity).

"C.G. height": Distance of the centre of gravity from the ground in unloaded condition.

"Turning circle": Smallest turning circle diameter. With this value, the smallest possible radius for the module “Turning procedure” is calculated.

"Steering ratio": This value is needed for the module „Turning procedure“ and for driving dynamics.

"Rectangle corr." (Correcting value): Distance of the exterior front vehicle corner to the corner point of the described rectangle. (The turning circle relating to the described rectangle would be greater than the actual turning circle by twice the correcting value.)

"Friction length-/ crosswise": This figure is required for tracking (coasting analysis). It allows to adjust the difference between the frictions of a blocked wheel lengthwise respectively crosswise. For many wheels, the maximum shear force amounts to 85 to 90% of the longitudinal force only; in this case, 0.85 respectively 0.9 has to be entered.

"Tyre radius and tyre width": The tyres in the Movie are depicted on the basis of these values. If the tyres shall not be depicted, either change the colour to background colour or set the values to 0.

"Position of C.G.: with cargo":

X...Distance from the front axle in longitudinal direction,

Y...Distance from the centre in transverse direction, left side: positive,

Z...Distance from ground

"Moments of inertia":

Is calculated automatically, but can also be done manually. For a manual input, the length, wheelbase and masses have to be entered first, as amendments in this field lead to a recalculation of the value.

Yaw: Rotation about the vertical axis (Z axis)

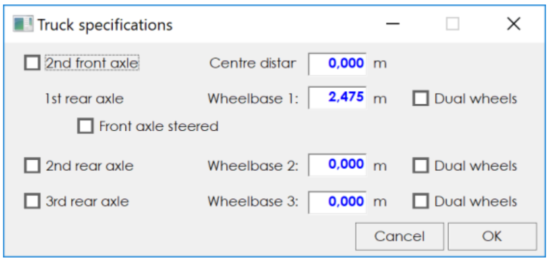
Roll: Rotation about the longitudinal axis (X axis)

Pitch: Rotation about the transverse axis (Y Axis)

3.6.2.1 Axes

If more than three axles are present, they can be adjusted at „Axles“.

You can activate a second front axle as well as a second and third rear axle. Furthermore, it is possible to depict the rear wheels as dual wheel.



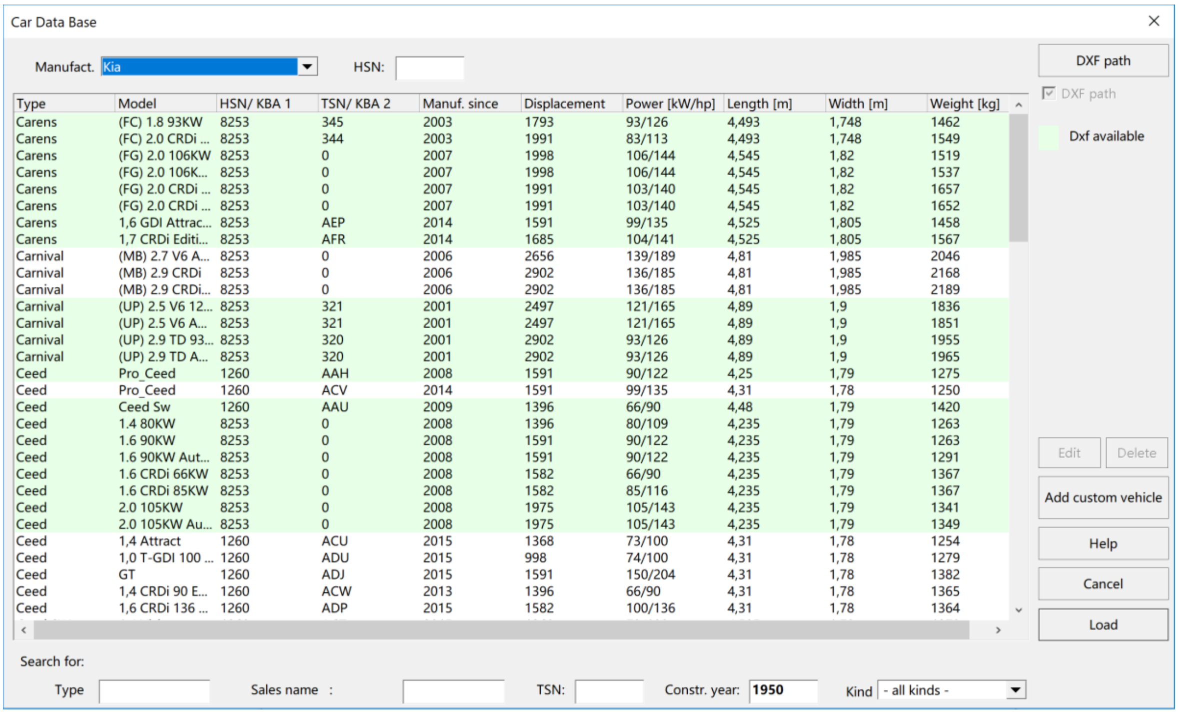
The value "Centre Distance" describes the distance between the first and the second front axle. „Wheelbase 1“ states the distance between the first front axle and the first rear axle, „Wheelbase 2“ is the distance between the first and second rear axle, „Wheelbase 3“ is the distance between the second and third rear axle. The axes are only depicted if the axial distance respectively the wheelbases 2 or 3 are greater than 0. Moreover, you can specify that the first rear axle is steered by the front axle.

3.6.2.2 Calculate Tyres

(Icon: ) The tyre sizes entered here are used for calculating the tyre radius and tyre width.

3.6.2.3 Data base

You can load vehicle data from the data base here. This can be done with the drop-down menu or via the HSN search field. Click on „Data base“ and select the vehicle via a left click and the button „Load“.



By clicking on the designation list in the upper area, the content can be sorted according to the selected value.

Filter: Insert your search parameters in one or several of the boxes. All data sets not complying with your requirements will be concealed. Upper and lower case are not relevant for the search. The sales name does not have to include the entire word. Hence, "*Aston Martin V8 Vantage S*" can be found with the letter „S“.

Type: You can choose if all vehicles of a manufacturer shall be displayed or only for example cars.

DXF path: If you have the Autoview DXF database, you can synchronize it directly with the Analyzer database. Select the path to your DXF database. If the process was successful, a check mark for confirmation is displayed. If a DXF has now been found for vehicle data, the corresponding line is highlighted in red. When the vehicle is loaded, the DXF is automatically loaded, scaled and the contour adjusted.

If the 3D model database has been activated, the existing vehicles are highlighted in blue. The 3D models are then loaded automatically.

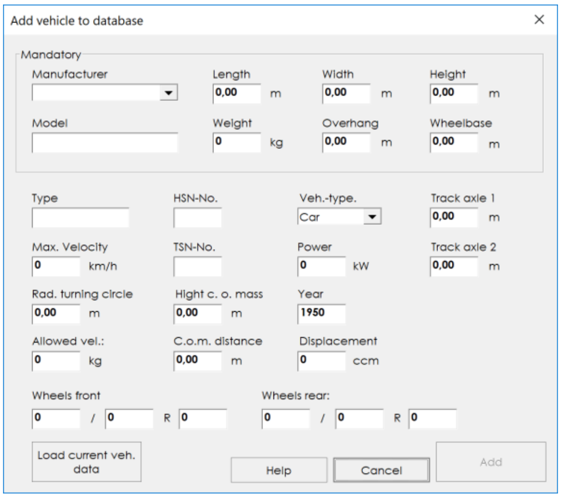
If DXF and 3D models are available, the entry is highlighted in violet.

The database only contains geometrical vehicle data but not vehicle dynamics data. Standard tyres are stored for all vehicles.

3.6.2.4 Add custom vehicle

This menu item offers you the possibility to add own vehicles to the database. Please note that the values required in „Mandatory fields“ have to be specified.

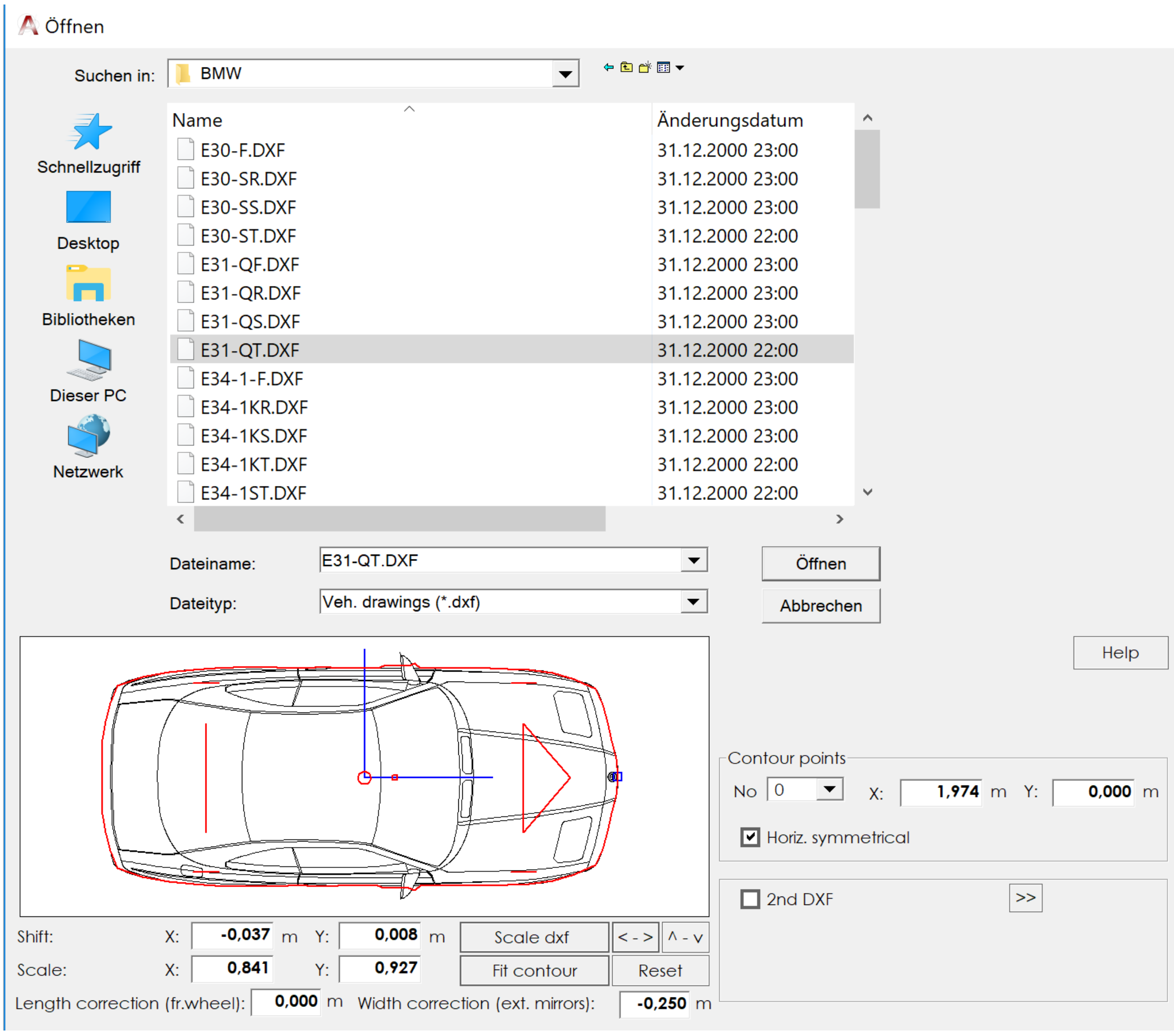
If you have already inserted vehicle data in the respective menu, you can import them via “Load actual vehicle data”.



The database is saved in your installation folder under the name „ExtraVeh.csv“. If you update to a higher version of AnalyzerPro, you can copy the file to the respective installation directory and continue with using the database you have created.

3.6.2.5 2D Model (DXF)

With DXF files, simple outlines in the Movie and the simulation can be substituted with detailed vehicle depictions.



"Open": Selected DXF file is loaded

"Cancel": Selected DXF file is discarded

"Scale DXF": Adjusts the DXF size to the vehicle length and width and centres it.

"< - >": Mirroring DXF

"Fit contour": Length and width of the vehicle are adapted for the DXF, which means that the values are changed according to the DXF and the contour is approximated to the DXF.

"Reset": The default setting of the contour is restored.

"Contour points" – For manual adjustments of the contour:

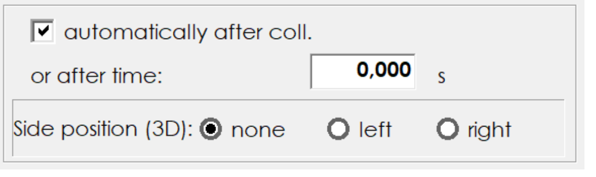
"No": Point number (0 – 47), the blue square marks the selected point

"X": X coordinate (longitudinal direction)

"Y": Y coordinate (transverse direction)

"Horiz. symmetrical": Changes in the upper/lower half of the vehicle are performed identically on the opposite side.

"2nd DXF": It is possible to show a second DXF in the Movie sequence, for example a motorbike can be presented in side view after a fall. In order to select a second DXF, open the dialog box with the button . You can decide to switch the DXF after a collision (phase "KOLLISION" or "DELTA-V") or at a predetermined point in time. Furthermore, you can specify if and in which direction a potential 3D model shall fall.



3.6.2.6 3D-Model

You can load a 3D model for a 3D illustration of a vehicle here. Without selection, a default model according to the vehicle type is loaded. The appropriate models can be found in the folder of the 3D models (PKW.murlpkg, LKW. murlpkg etc.).

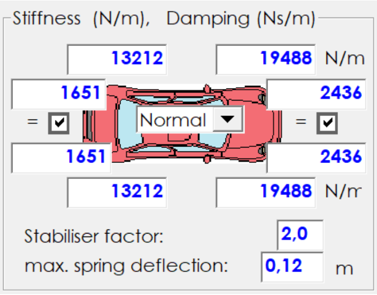
3.6.2.7 Copy

It is advisable to place alternative variants of calculation, for example an avoidance calculation, on another code.

You can copy the data of a party involved in an accident from one code to another.

3.6.2.8 Dynamics data

Dynamics data are used for the coasting analysis with forward calculation as well as the general examinations relevant for driving dynamics. In this mask, you can enter time-independent values. Time-dependent values (like steering, braking, etc.) are keyed into the „Simulation data“.



"Ratio of friction – Slid./static friction": Ratio of the tyre friction from sliding to non-sliding.

"Stiffness, Damping": Stiffness values of the wheels [N/m].

Default values are calculated in a way that the entire spring rate, i.e. the sum of all four wheels, corresponds to the 20/3-fold of the weight / m. Hence, for a vehicle with a mass of 1000 kg it is 65400 N/m. This value will be distributed among the wheels in proportion to the wheel load of the empty vehicle.

In the situation of a retrodisplacement of the centre of gravity, which would equal half the wheelbase, i.e. a wheel load distribution of 50 : 50, the spring stiffness for every wheel would amount to 65400 / 4 = 16350 N/m.

These values need to be decreased respectively increased for softer respectively stiffer spring-loaded vehicles.

In the dropdown menu, the setting can be changed from „Normal“ to „Soft“ – from 20/3 to the five-fold of the weight - for soft spring-loaded vehicles and to „Stiff“ – to the ten-fold – for stiff spring-loaded vehicles.

"Stabilizer factor": This factor indicates by how much the actual suspension roll stiffness of the axes is greater than the one computable with the spring stiffness. Hence, the stiffness of rolling motions is greater than the one of pitching motions by this factor.

"Load capacity": Load capacity of the tires. If the wheel load exceeds this value, the force, which the tire can transfer, cannot increase anymore. Based on a default value, the value is automatically adapted if a new vehicle is loaded. The formula applied is Allowed Weight * 3. This is equivalent to a 20% higher value than a quarter of the maximum allowable weight, respectively if the value of the allowed weight is 0, then Weight * 3,75. Hence, the value exceeds one quarter of the weight force of an empty vehicle by 50%. The calculated value needs to be adjusted for the specific situation. Defective wheels or partially vented wheels can be taken into account here (time-independent) or in the mask for simulation data “Tyre-condition factor” (time-dependent).

"LI" (Load index): Load capacity can also be calculated with the load index. It can be read on the tyre.

"Skew angle maximum": Specifies the limit up to which the cornering force increases with the slip angle of the wheel.

"Wheel positions": A shift of the wheel (potentially caused by collision) can be entered here.

dx : Shift in longitudinal direction

dy : Shift in transversal direction

"Engine – drive train": You can choose between front, rear and 4WD drive train.

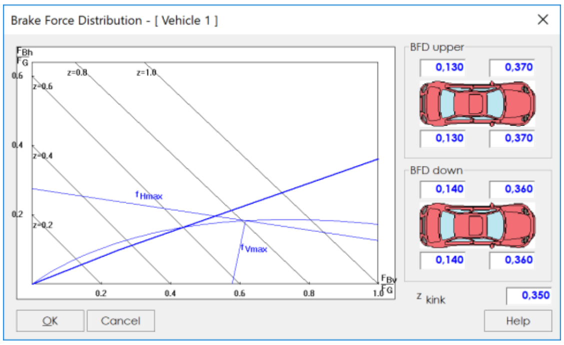
"Engine power": Is required for the acceleration calculation in the calculations section concerning the driving dynamics.

"Motor braking factor": Multiplied with the engine power, this number serves to calculate the motor delay without accelerating. Motor delay ends under 10 km/h. Set this value to 0, if the engine brake shall not be considered.

"Brake": Choose between Normal and ABS.

"Brake force distribution": Distributes the brake force among front and rear axle. The four boxes need to add up to 1 and distribution needs to be equal on both side. The calculation is then automatically updated. The distribution for two sections can be set. Consequently, a break in the brake force distribution is created. The position of the break can be defined with "z_{break}".

"Diagram": With this button, the brake force distribution diagram is loaded, with which the brake force distribution can be adjusted for the vehicle in question. The same distribution is given to the left and to the right, hence, it does not matter if the values are inserted on the left or right side.



The sum of all 4 values equals 1 (100%). The parable complies with the perfect brake force distribution and depends on the retrodisplacement of the vehicle's centre of gravity.

"Data for air- and rolling resistance": Here you can insert values for calculating the air and rolling resistance.

"Draw traces":

"Show traces": With this selection, the wheels draw traces for which the defined criteria are met. The traces are only calculated and depicted in the dynamics view.

"Show trajectories": illustrates the wheel trajectories.

"Criteria for tracing": Traces are shown if:

The "Slip Limit" is undercut or the „Skew Angle Factor" is exceeded, as well as if the ratio "Wheel load/static wheel load" is smaller than the indicated value.

"Sensor position relative to C.G.": You can define a point of the vehicle for which you would like to show various values in the driving dynamics.

"Impact point – Structural stiffness": The calculation of the impact point is based on the ratio of the prescribed structural stiffness of the vehicles.

3.6.2.9 Trailer, Semi-trailer, Tandem

It is possible to assign a trailer, a semi-trailer or a tandem to the vehicle. In the Movie, the driving line is then depicted in accordance with a tractrix curve. No assessment is conducted if this driving line is possible in terms of stability! The rear axle is not steered! However, by indicating the pivot, an adequate effect can be created.

In the kinematics, the actual driving line of the truck trailer respectively semi-trailer will only correspond with the calculated ones in situations with low speed respectively small lateral accelerations. The default data of the trailer has been predicated on the vehicle type (car or truck).

Geometric data can be entered in the depicted sketch which features the trailer in black and the towing vehicle in blue.

For the module „Serial collision“, the vehicle mass stated in the box „Trailer mass included“ will be used as mass for further calculations. In the case of a serial collision, this will certainly be correct.

A general collision analysis considering the trailer is currently only possible in the procedure „Momentum backwards”. For the other methods, the mass of “Trailer mass included“ is used as vehicle mass.

If the push propulsion occurs in parallel to the vehicle, no relative movement takes place between the towing vehicle and the trailer, hence, the general collision analysis can also be applied in other procedures, given that the effective trailer mass is inserted by the user.

Furthermore, you can also determine if the trailer has one or two axes or if the semi-trailer is equipped with three axes. If the semi-trailer has three axes, the driving line will be calculated in a way that the middle axis points to the centre of the curve.

"C.O. mass res.": Distance of the centre of mass from the geometrical centre of the trailer respectively the semi-trailer in longitudinal direction. Positive value: Shift backwards towards the rear. Negative value: Shift to the front.

"Pivot res.": Distance between the front side of the trailer and the point the vehicle rotates about according to the Ackermann theorem.

In case the rear axle is steered, the pivot can be brought forward accordingly.

If two axes are activated, the pivot is assumed to be in the middle by default. Twin tyres can be activated by ticking the appropriate box.

It is possible to add a second trailer to the existing one. For this purpose, check the box in the mask and continue with ”>>” to further define the second trailer.

You can load a DXF as well as a 3D model for all types of trailer.

Under the button "Database" you can find an integrated trailer database.

3.6.2.10 Import & Export

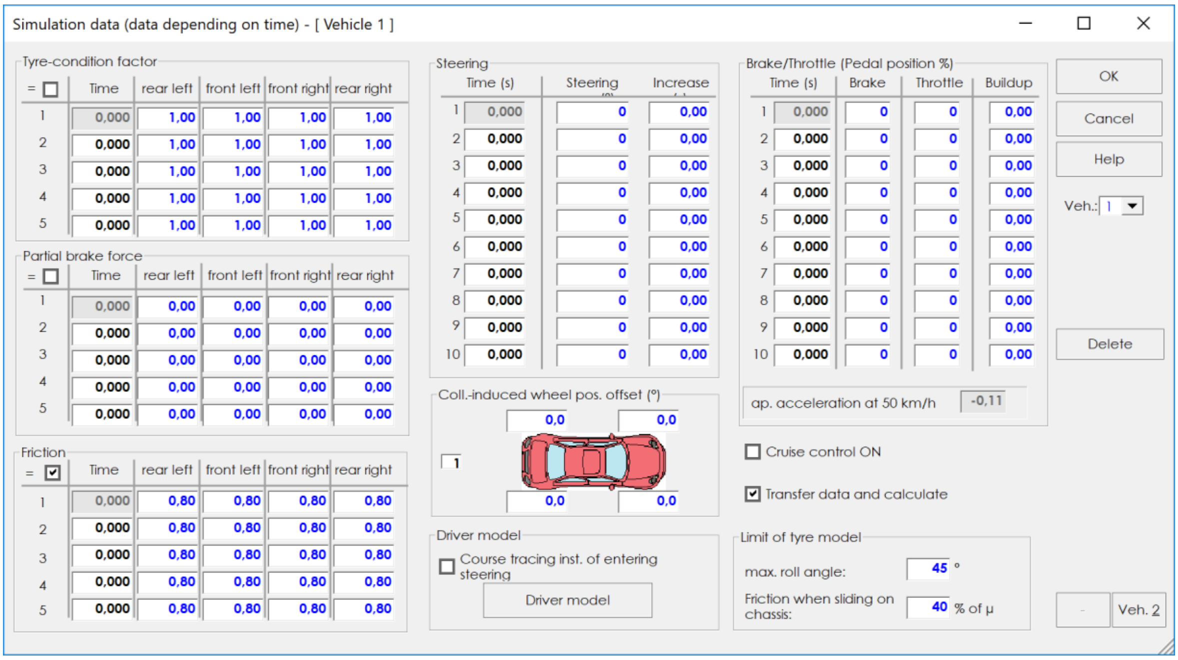
"Export": With this button, all parameters of the current vehicle are transferred to a text file and can be saved.

"Import": Here you can import the text files again.

3.6.3 Simulation data

(Icon: S) Simulation data is used for the coasting analysis in forward calculation as well as for general examinations with regards to driving dynamics. This window allows you to specify time-dependent values. For time-independent values (like stiffness, load capacity of the tires, etc.) use the mask „Driving Dynamics“ which you can enter via the input window for geometrical data.

In general, the first column indicates the time from which the values next to it shall be valid. The first-time input is 0 and cannot be changed so that the starting conditions respectively the initial values are specified. Only if a time different to 0 is stated in the subsequent row, the values next to it will be used from the specified time on.



"Tire-condition factor": Carrying capacity is multiplied with this factor. The possible value can range between 0 and 1. 0: No forces can be transmissed. 1: maximum force transmission.

"Partial brake force": This value allows to brake single wheels. The possible value can range between 0 and 1. 0: Wheel can roll freely. 1: Wheel is blocked.

"Friction": Friction between wheel and road. This value is widely applicable, except for a defined friction surface. In order to define a friction surface, a closed spine needs to be drawn in the Movie monitor. Next, open its properties with a right-click and define a friction surface that is particularly valid for this area.

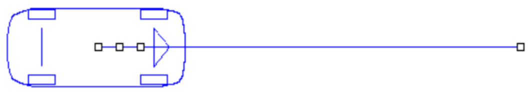
"Steering": You need to insert the steering angle. Based on this input, the angle of the front wheels are calculated by using the steering value. The result is then added to wheel angle entered in this interval. With the time value “Increase”, you can determine after how much time the stated steering angle shall be reached. The maximum steering angle amounts to 900°, the maximum steering angle velocity is set at 400°/s. Except of the beginning (Time 0), the steering angle velocity is limited by this value, even if calculations would result in higher values. Except of the first row, a value for the increase in steering shall be stated. The increase is linear.

"Coll.-induced wheel pos. Offset (°)": Torsion of a wheel caused by collision. On the left side of the four input fields, you can find a number ranging between 1 and 10. This number indicates the according interval. You can determine the interval by inserting time specifications in the section “Steering”. For example, if you click on the third row in the section “Steering”, the interval of the wheel angle will switch to 3.

"Brake / Throttle“: Braking or Throttling can be indicated by defining the respective pedal actuation in %. 0% means no actuation, 100% represents maximum actuation. The brake buildup time can be stated as well; braking will start at the stated point of time then. At the end of the buildup time, the defined percentage of pedal actuation is reached. The increase occurs linearly.

"Ap. Acceleration at 50 km/h": For this box, an approximate value of acceleration is calculated from the positions of the brake pedal and accelerator in in consideration of the partial brake factor, air friction and rolling friction. A precise calculation cannot be carried out directly, but in the section „Driving Dynamics“.

"Course tracing inst. of entering steering": Instead of entering steering angle, you can also specify a course. If this option is selected, a line leading away from the vehicle's centre of gravity will be displayed in the simulation window. This line can be edited analogously to the driving line (Spline). In the beginning, the spline should preferably be directed to the vehicle, otherwise the vehicle would already start off the movement with a side slip angle. Because of this reason, two further points are set already shortly after the start of the course.

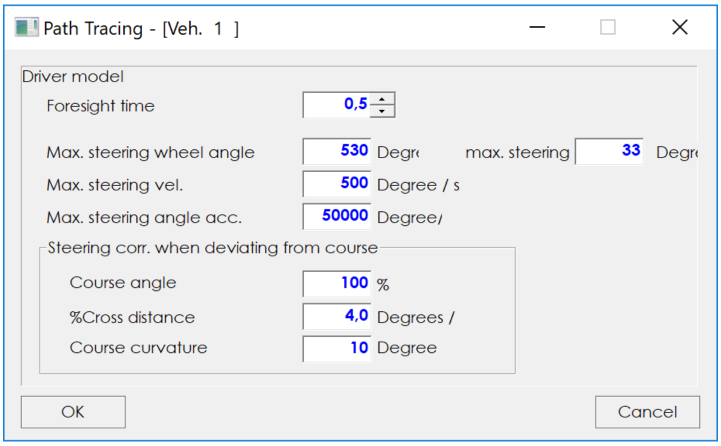


In the module „Driving Dynamics“, it is also possible to import the spline of the course tracing from the driving line of the kinematics. In order to do so, perform a right-hand click on the vehicle or on the course and select "Import driving line" from the pop-up menu. With "Reset driving line", the default course (straight line from the centre of gravity) can be reloaded.

The vehicle tries to follow the spline now by calculating the required steering angles. The calculation method can be set via the driver's module.

"Driver model": Different methods are applied here, whereby certain limits may not be exceeded.

"Max. Steering wheel angle": The angle up to the steering stop. Alternatively, the "Max. steering degree" of the front wheel can be inserted. The suggested value is calculated based on the minimal turning circle diameter.



"Max. Steering vel.": Analogous to the previous point, you can also adjust the „Maximum steering wheel angular speed“, with which the steering wheel can be turned, as well as its alteration, the „Maximum steering wheel angular acceleration“.

"Steering corr. When deviating from course“: Are required if the actual state deviates from the target state, if a distance in cross direction exists and if the current curvature deviates from the target curvature. The values are calculated as a forecast based on the prediction time and considered accordingly.

<u>Tip:</u> It would be generally possible to calculate the course correction with each of these three controls. However, it is preferable to combine all of them and keep the steering correction within the individual requirements small.

"Course angle": Steering wheel correction in % from the course angle deviation. In case the course angle deviates by 1°, the new steering angle will be changed by ...%.

"Cross distance": Per cm deviation in cross direction to the course, the steering angle will change by the specified amount.

"Course curvature": Per 1 m/s² deviation of the lateral acceleration, the steering angle will change by the specified amount.

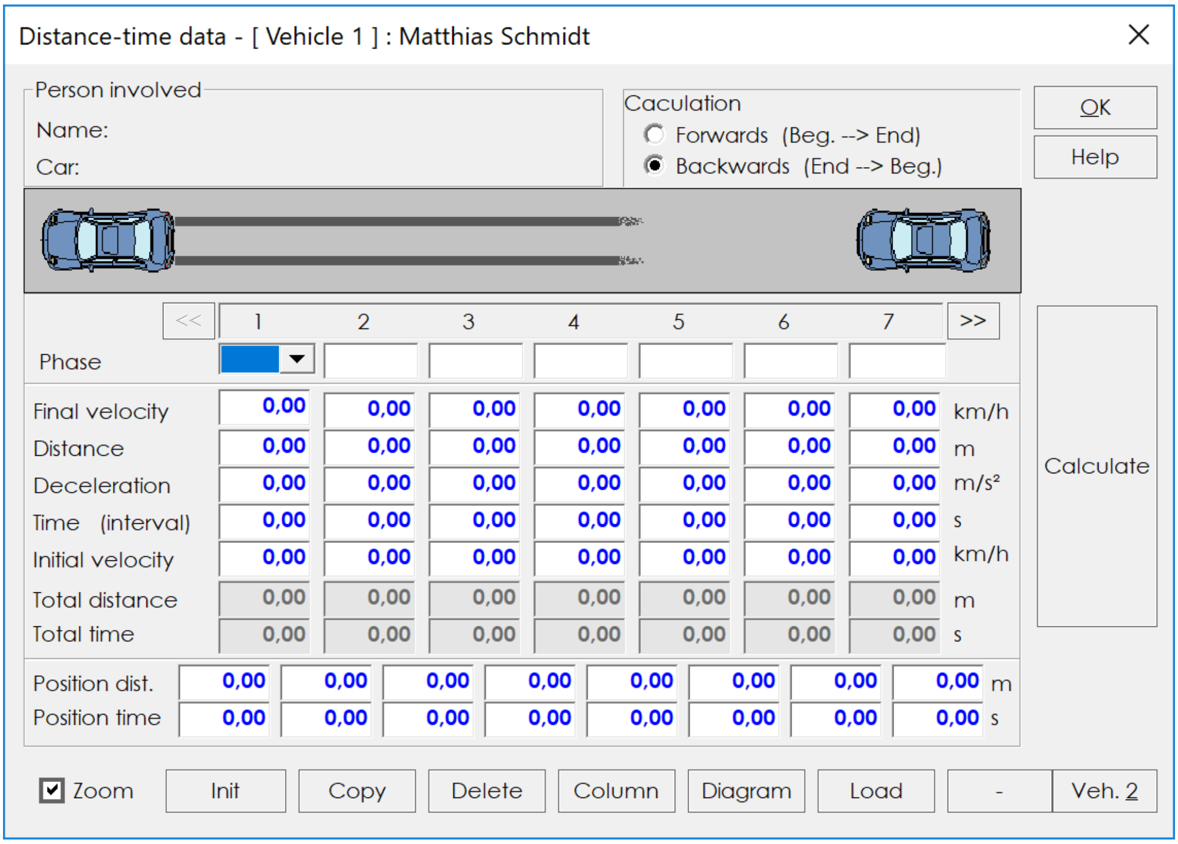
<u>Tip:</u> In order to verify if a course can be driven with a certain velocity, it is necessary to change the 3 values and check which combination offers the best results.

"Cruise control ON": By using this function, the vehicle moves with the velocity specified in the Simulation data. This means, the roll resistance etc. is automatically corrected by accelerating slightly.

"Limit of tire model": This input determines in which situation the tyre model is not valid anymore, thus, when the tyre forces cannot be transferred anymore, for example because the vehicle falls over. The movement of falling over depends on the specified “Max. Roll angle“. If this value is exceeded, the vehicle slides over the chassis and a friction value in percentage in comparison with the friction value of the tyres is given.

3.6.4 Distance – time data

This module represents the central input and calculation section for kinematics.



The mask is intended for allocating the covered distance in movement phases. A separate column is provided for each phase. The calculation is ALWAYS carried out from left to right.

You can scroll horizontally by clicking the boxes << and >>; each click the monitor proceeds by one phase. Ctrl + Click jumps 7 phases forward, Shift + Click jumps 20 phases forward, and Ctrl + Shift + Click jumps to the end or the beginning of the phases.

3.6.4.1 Calculation forwards / backwards

In the upper right corner of the window, you can choose between a “forwards” and a “backwards” calculation. This selection has NOTHING to do with the driving direction; in fact, it deals with the question whether it is a problem of begin or end values.

"Forwards": Initial conditions are known, end conditions are to be investigated.

"Backwards": End conditions are known, initial conditions are to be investigated.

When switching between “Forwards” and “Backwards” you will realize that the input fields of the movement phases will change too. At the same time, the values „Initial velocity“ and „Final velocity“ shift their positions. Current blockings of fields remain applied.

3.6.4.2 Input of phases

Every phase is described with the following values: „Final velocity“ (Velocity at the end of an phase, v_E), "Distance" (s), "Deceleration" (Acceleration, a), "Time (interval)" (t), "Initial velocity" (Velocity at the start of the, v_A). The final velocity and initial velocity of subsequent phases always stays the same and is automatically equated by the program.

Furthermore, the rows „Total distance“ and „Total time“ display the partial sums accordingly. The respective position can be changed in the relevant field, hence, the position of the entire Time – distance curve is changed as well as all other positions consequently.

Out of the 5 values v_E, s, a, t, v_A, 3 values need to be specified for braking and accelerating, and 2 values for a constant velocity. Initially, only values different from 0 are accepted. Without phase input, the program attempts to analyse and conduct an appropriate calculation based on the values given.

If only 2 are different from 0 and v_E is one of them, a uniform movement is assumed, given that a = 0; otherwise, an accelerated movement is assumed. If a <>0, a uniform movement cannot be forced with the input v=konst. If a is different from 0 and a braking manouevre (a>0) is given, the final velocity is used as 0. If a is different from 0 and an acceleration manouevre (a<0) is given, the initial velocity is used as 0.

Except from the first movement phase, v_E is taken over from v_A of the previous movement phase and, therefore, always given. v_E can only be calculated in the very left movement phase or if no data is available in the previous one.

You can name the movement phase in the row „Phase“. You can choose from:

Phase	Description	Effect on calculations?
' '	No phase selected	-
'Collision'	Collision phase	-
'Brake'	Braking phase	✓
'Accel.'	Acceleration phase	✓
'Buildup'	Buildup phase	✓
'Reaction'	Reaction phase	-
'Recog.'	Recognition phase (between seeing and reacting)	-
'v = const'	Phase with constant velocity	✓
'Missing'	Missing brake or vacate distance	-
'Standstill'	Phase with stillstand	-
'Change'	Reeving and pulling out	-
'Coast'	Coasting phase (after a collision)	-
'Delta-V'	Change of velocity without time need	✓
'Turn-in'	Process of turning in	-
'Skid'	Skidding phase	-
'Decel'	Deceleration phase	✓

The input of descriptions primarily serves the printout. Certainly no calculations will be based on it. However, under certain circumstances the selection can influence the type of calculations. Given that the numerical input is adequate, the selection of “v = const.”, „Brake“, „Accel.“ and „Buildup“ is taken into consideration. If considered necessary, the adjustment of a phase leads to an initialization of the respective column.

If a phase is specified as „Brake“, skid marks and braking lights can be illustrated, for „Decel.“ the activation of skid marks and braking lights is ineffective.

If you do not select a phase, i.e. leave the „Phase“ fields empty, the program examines autonomously if a braking, acceleration, buildup, collision, v=const., stillstand or Delta-V phase can be identified. As the remaining phases cannot be identified by the program, you need to adjust them yourself; the selection of the others can be left to the program. For example, if a turn-in manoeuvre or a lane change is calculated with the respective module, the phase is automatically labelled with „Turn-in“ or „Skid”. The selection of a certain phase is amended by the program if this particular phase cannot be present based on the existing numbers.

If “v=const.” is selected, deceleration is set to 0 and the field is blocked. At the same time, velocity is take over from the previous field. If “Buildup” is chosen, the buildup time predetermined in the Settings is inserted as time. The value can be changed of course. At the same time, brake deceleration is taken over from the previous phase if the deceleration there is stated to be <> 0.

The adjustment of the buildup phase has a special effect on calculations. With its choice, the movement phase is mandatorily calculated as buildup phase and the deceleration value of the previous phase (the neighbouring one with the next phase number; chronologically before) is changed to Buildup. In case this phase is a collision or Delta-V phase, it will be skipped and the acceleration value of the phase before is accepted. If the initial velocity of the phase is 0, the buildup of the acceleration value starts with 0. If the initial velocity is 0, there must have been a deceleration before and an acceleration must follow. If the buildup would not start with 0, the vehicle would drive backwards because of the braking before and would continue this movement until the deceleration has decreased to 0. As such a behaviour is obviously not desirable, it is automatically inhibited. The selection of a buildup phase only influences the calculation result, if the values of acceleration differ between the current and the previous column.

If another phase is selected, f.e. a braking phase, a buildup phase is certainly not calculated; depending on the numerical input, either an acceleration or a brake or a uniform movement is computed, whereas the choice of phases is corrected accordingly.

If the phase is empty, the program takes into consideration the differing deceleration value of the chronologically previous phase in order to determine whether a buildup phase is induced and subsequently calculates it with the available data. If the chronologically previous phase is a collision or Delta-V phase, it is skipped. This is to ensure that an average value of deceleration (acceleration) can be stated for the collision phase without the need to join up a buildup phase in circuit.

A collision phase is assumed if the deceleration respectively acceleration is greater than 12 m/s², a Delta-V phase is assumed if the velocities differ and all other values are greater than 0.

The phases „Change“ and „Turn-in“ are created in the modules „Lane change“, „Overtaking“ and „Turning procedure“, where the calculations necessary for the Movie are carried out as well. If you label a phase as „Change“ without having done the appropriate calculations in the Module „Lane Change“, the phase selection has no influence on the driving line in the Movie and the driving line needs to be edited separately. For example, if you have calculated a lane change, the respective phase section will be labelled accordingly. However, you cannot name another phase without such calculations in the same way. The phase “Skid” is used for the export of a tracking in kinematics.

Tip 1: The specified (resp. Calculated) value of brake deceleration relates to the value of brake deceleration at the end of the buildup phase. Therefore, please do not state the average value in time, but its end value!

Tip 2: For the first input, set all values which have to be calculated to 0. These values are seen as non-existent. Overdetermined values are calculated and overdetermined as well. An overdetermination of equation systems is avoided. The following hierarchy is applied: 1. Deceleration, 2. Distance, 3. Initial velocity, 4. Time.

Tip 3: The fields with the values which are to be calculated are blocked after the calculation. This way, a great variety of calculations can be carried out in short time. After having used the „Calculate“ button, incrementation will lead to an immediate recalculation.

3.6.4.3 Calculate

You can either calculate every movement section separately or the entire input at the end by clicking at the button “Calculate”. If no calculations succeed the edit of a field, they can be done by exiting the input mask and clicking on OK or by choosing “Diagram” in the mask, but not if the diagram is chosen via the symbols.

3.6.4.4 Init

If you wish to start a new entry with another input scheme, the column respectively all columns can be newly initialised. This means, the blocking of fields is reversed and you can insert a new data set. It is advisable to set all values which are to be calculated to 0 afterwards.

3.6.4.5 Further hints

Because of their frequent usage, deceleration values are inserted as positive numbers. Thus, acceleration is entered with negative signs.

It is possible to select values based on the suggestions of the selection box. However, please note that these values require an expert examination and could be subject to amendments.

3.6.4.6 Driving direction forwards / backwards

You can change the driving direction to backwards. In this case, the signs of the velocities and the distance are negative. Deceleration values as well as acceleration values need to be entered with reverse signs compared to a forward driving direction. Hence, all distance-dependent values receive a reverse sign.

	Headway	Backway
Deceleration	Positive	Negative
Acceleration	negative	Positive

3.6.4.7 Transfer to the main data set

The program module „Time-Distance Data“ is the centre of the program.

All the data that is stated here at the initial call or after the calculation is also recorded in the main data set, which represents the central data management in the background. In order to ensure that the data here actually reflects the data from the main data set, you need to either calculate or exit the mask with OK.

Therefore, the button „Cancel“ is deliberately renounced in the program. The option for an emergency exit is always given by closing the window with the button “X” on the upper right corner.

If you select „Transfer data“, i.e. tick the box (✓), all data is transferred to the main data set after calculations.

3.6.4.8 Further operations

Copy	Copies a data set including the data of the person involved in an accident from one code to another.
Delete	Deletes data, i.e. all values are set to 0. Either the current column or all columns are erasable. If “All” is selected, the driving line is reset as well.
Column	Undertake column operations: "Remove column": Removes the current column in which the cursor is placed. "Insert column": Inserts an empty movement section in front of the current one.

3.7 Modules

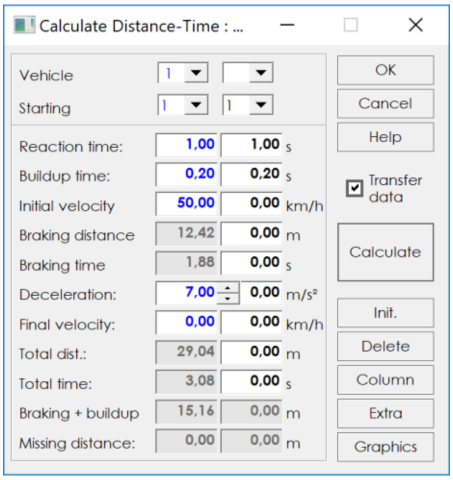
You can transfer results from every module into the main input mask of the parties involved in the accident. If necessary, you can also specify a movement section from which on the values shall be inserted.

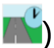
<u>Tip:</u> The data transfer into the time-distance data only works if a party involved in the accident is defined and „Transfer data“ is selected.

A party is classified as defined, if you enter a corresponding code. If you do not want to transfer all parties, insert a blank space instead of a vehicle number and the data transfer will be omitted.

Only data recorded in the distance-time data - and, hence, also in the main data set - can be saved, printed, illustrated with a graphic or used in the Movie.

3.7.1 Calc. Path – time



(Icon: ) In many cases, too few data is available within one movement section. As a result, the braking process has to be calculated as a composed movement. This is for example the case if the total distance (f.e. sight), the reaction time, the deceleration and the final velocity (f.e. collision velocity) are given.

This program part is now the right choice for you. Moreover, it is also intended to help you with cases where you have to switch between the different vehicles a lot and wish to make some adjustments (f.e. of the reaction time or of the sum of distances to the sight); or, for example, when you would like to calculate the stopping distance. The three separate movement sections “Reaction phase – Buildup phase – Braking phase” are combined into one in this case.

After the input of the data, the unknown values are determined and allocated to the separate movement sections. 4 out of 8 values v_E, v_A, a, t_R, t_B, s_B, t_{ges} und s_{ges} have to be available.

Values set to 0 are considered and calculated as non-existent. Overdetermined values are calculated as well in order to avoid an overdetermination of the equation system.

The selection is similar to the Distance-Time Data, whereas the sequence is presented in order of highest priority to lowest: t_R, a, v_A, v_E, s_B, t_R, s_{ges}, t_{ges}. Apart from the missing data, the program also calculates the missing distance, which represents the distance that is missing to the vehicle's total standstill.

The scheme of the first entry is recorded for each column separately so that the values to be calculated do not have to be set to 0 if one input value is amended. This way, a great amount of versions can be calculated in short time. Additionally to the already mentioned values, the sum of braking distance and brake buildup distance (brake distance + buildup distance) and the missing distance is calculated.

"Init": If you wish to start a new entry with a new input scheme, click „Init“ to initialise the respective column. For new calculations, the program will then determine anew which values are given.

"Extra": Position the cursor in a velocity field to calculate the threshold speed of curves. If the cursor is located in an acceleration field, the acceleration can be calculated depending on the road's gradient. By calculating values, they will automatically be transferred to the according field. The transfer into the respective field takes place with the calculation.

"Column": Adjust the number of calculation columns, i.e. simultaneously depicted vehicles, here. The maximum number is 4.

3.7.2 React – Brake

(Icon: RB) In this module, partial braking distances can be calculated. Moreover, it is possible to take a deceleration or acceleration during the reaction phase into account. You can choose between 5 different calculation versions, however, either the initial or the final velocity needs to be available in any case.

The following calculations can be conducted (available, calculated):

Version	Initial velocity	Final velocity	Total distance	Braking distance
1	-	v_E	s_{Ges}	-
2	v_A	-	s_{Ges}	-
3	v_A	v_E	-	-
4	v_A	-	-	s_B
5	-	v_E	-	s_B

3.7.3 Drive off – Brake

(Icon: ) These driving manoeuvres are composed of up to 5 different movement sections: Buildup phase – Acceleration – Constant velocity – Buildup phase – Braking phase

In this module you can calculate the following points:

1.) How much time is needed to accelerate from a specified initial velocity on a specified distance first and slow down to a specified final velocity next, whereby the point of reaction is calculated?

2.) Which distance is required for a specified point of reaction?

You can choose between the driving direction forwards and backwards. If backwards is chosen, the algebraic signs are reversed during the data transfer.

---Example---

A car passes the stop line with 5 km/h and accelerates with approximately 2 m/s². Due to an emerging hazard (f.e. cross traffic coming from the left), the driver reacts with an emergency braking (7 m/s²). Nevertheless, the car collides 12 m after the stop line with a collision velocity of 15 km/h.

Question: How long did it take the car to drive the 12 m, which velocity was achieved? Where and when did the driver react respectively should he have reacted to stop in time?

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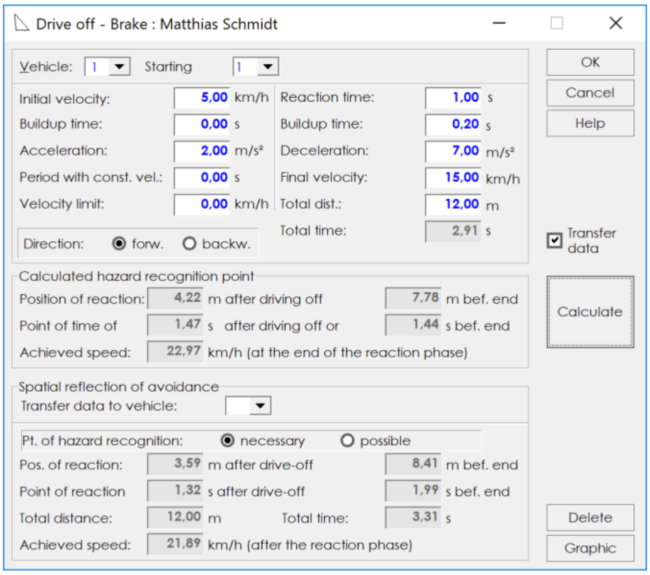

Solution: Based on the initial velocity, final velocity, acceleration, deceleration, total distance and time period of constant velocity, the time needed for the distance of 12 m is calculated to be 2,91 seconds. Hence, a phase with constant velocity is not given.

Independent of the extent to which a phase with constant velocity is entered, the beginning of the reaction time, in any case the reaction period, takes place before the beginning of the buildup phase. For example, if the time period of constant velocity is smaller than the reaction period, then the beginning still occurs within the acceleration phase, otherwise within the phase of the constant velocity.

Tip: Perhaps the reaction point takes place during the buildup phase. This causes the problem that a phase can only be calculated as a buildup phase if it is declared as such. Hence, the part of the buildup phase overlapping with the reaction point cannot be identified as reaction phase. As a consequence, the period called reaction phase is reduced by the section that is located within the buildup phase. As the
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buildup phase is very short anyway, the division into two sections appears unnecessary and was, therefore, not conducted. In case it should be necessary, the division can be done afterwards in the distance – time data mask by hand.

"Spatial reflection of avoidance":

"Possible point of hazard recognition": The point in which the hazard could have been recognized. The distance needed for stillstand is calculated, if the driver would have reacted at this point. If 0 is inserted as “Possible point of hazard recognition”, the buildup time is not considered in the beginning, but a reaction is assumed immediately at this point.

"Necessary point of hazard recognition": Calculates the point in which the driver should have reacted at the latest to ensure a standstill at the end of the specified distance.

Tip: The necessary point of reaction could precede the beginning of the distance. In this case, the following alert appears: „Necessary point of hazard recognition would be too early. Distance till sandstill will be calculated

If the point of hazard recognition is set to „Possible“, the input fields of the reaction point become accessible. Then the distance up to the vehicle’s standstill is calculated in forward calculation, using the point of reaction, the initial velocity, the acceleration, the duration of the reaction and the buildup time.

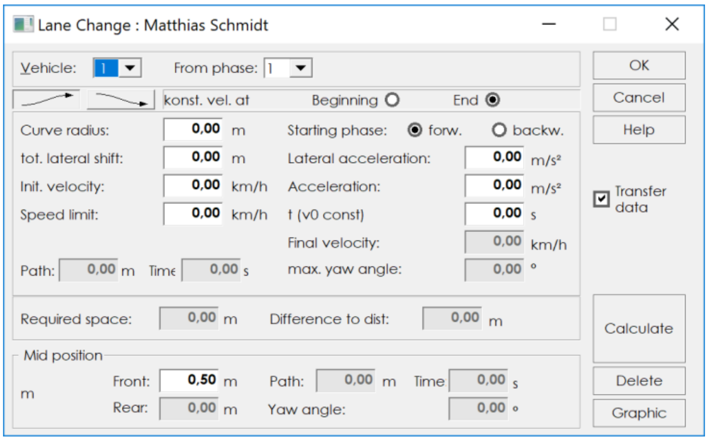
You can also use the module „Drive off – brake“ to calculate the distance (stopping distance) with acceleration or braking during the reaction phase. For this purpose, enter 0 as a „Total Distance“. The beginning of the reaction phase is then transferred to the starting point of the distance. The buildup phase is set to 0 at the beginning.

In the respective section of the hazard point, braking continues until the vehicle’s standstill, thus, the difference in distance is equivalent to the missing distance.

If the cursor is positioned in the input section of the „Spatial reflection of avoidance“, the deleting function only applies for this part. In all other areas, it will extensively erase the input.

3.7.4 Lane change

(Icon: ) Calculates the distance and time necessary for a lane change. An oblique sinus line serves as a model, hence, the vehicle's centre drives along a sinus curve which is rotated in a way that the tangents at the beginning and the end are horizontal and have a distance equal to the specified side distance. The middle between the wheelbase and the width serves as a vehicle centre.



: With this switch you can adjust the driving line for the Movie to a lane change to the left or to the right.

Tip: Only the sections beginning with the one you have specified are transferred into this module, the others are deleted. Therefore, it might be necessary to match the initial and final velocity of neighbouring sections with each other. An appropriate calculation can be carried out in the main data mask. In case the program deems this procedure necessary, a notification will be displayed.

Two calculation versions are possible: You can either set a velocity limit for the initial velocity or for the final velocity.

"Beginning": If the final velocity is stated, the initial velocity will be calculated. If a velocity limit different from 0 is entered, it will result in an acceleration (respectively breaking) with this velocity, given that the calculated initial velocity exceeds the velocity limit. The vehicle drives with constant velocity first (value equal to the velocity limit) and accelerates resp. brakes then until the specified final velocity at the end of the lane change is reached.

"End": If the initial velocity is given, the final velocity is calculated. If the specified velocity limit differs from 0, the vehicle will accelerate (resp. brake) until this velocity is reached. Afterwards, the vehicle continues driving with constant velocity until the end of the lane change.

It would constitute a problem, if a vehicle comes to a standstill during braking, although the lane change is not completed yet. In this case, a message informs you that the missing distance is added at the beginning. The distance is covered with constant velocity (initial velocity).

"Curve radius": For straight road courses, i.e. with parallel driving lines before and after the lane change, the curve radius is set to 0, otherwise the curve radius of the original driving line is entered. The lane change is then approximatively calculated. However, the driving line in the Movie is drawn without a curve and has to be corrected manually.

"Total sideways offset": Offset the vehicle shall perform during the lane change.

"Lateral acceleration": Maximum cross acceleration of the vehicle's centre during the lane change. The higher this value, the faster the lane change is performed. The maximum is reached at the point of the sinus curve at which the radius of curvature is the smallest, i.e. after ¼ or ¾ of the total distance. During accelerations, the maximum is achieved after ¾ otherwise after ¼. Only for a punctiform vehicle the value would be exactly correct. For real vehicles, the actual value is a little bit smaller.

"Initial velocity": Velocity at the beginning of the lane change.

"Acceleration": Accelerations have to be entered with positive signs, decelerations with negative signs.

"Final velocity": Velocity at the end of the lane change.

"Dist.": covered distance.

"Time": required time.

"Max. Yaw angle": Maximum position of vehicle incline.

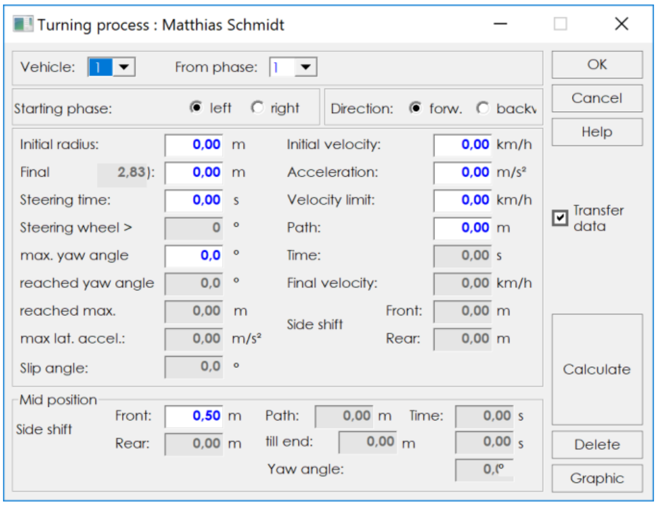
"Space required": Horizontal projection of the distance.

"Diff. To distance": Difference between the covered distance and the space required.

"Mid position": Calculates when and after which distance the front of the vehicle has reached a certain offset. The default setting is 0.5 m. With this, you can, for example, calculate the time of distinctiveness. It needs to be considered that the sinus curve as well as its intersection with the parallel line of the original driving line are very flat. Even light deviations change the result significantly. Hence, it is recommendable to indicate a solution range instead of one single value.

3.7.5 Turning procedure

(Icon:) With this module, you can calculate the distance and time needed to reach a certain yaw angle or you can determine the yaw angle if the distance is given.



"Turn: left / right": Serves the calculation of the driving line in the Movie. Depending on your choice, the driving line curves to the left or to the right.

"Starting radius": Radius at the beginning of a turning procedure. Set the value to 0, if the turning procedure is initiated from a straight driving line. The radius relates to the inner rear wheel, respectively the vehicle's exterior on a level with the rear axle.

"Fin. radius [ ]": Desired final radius. The value in brackets indicates the minimum value, which is calculated based on the diameter of the turning circle. If the initial radius is set to be smaller than the final radius, the steering is turned back during the process. You can install several steering operations after each other. The driving line is calculated automatically. Take care that possible driving conditions like the rotation speed of the steering wheel or the lateral acceleration are not exceeded. Radii refer to the inner rear wheel!

"Steering time": Time required for steering.

"Steering angle": Angle the steering wheel has to be rotated about. The calculated value refers to the steering ratio specified in the geometrical data.

"Max. angle": Yaw angle to be reached at the end of the turning procedure. If the specified value is different from 0, the distance needed to reach this angle is calculated. Alternatively to the yaw angle, you can also enter the distance. In this case, the yaw angle reached at the end of the distance is calculated. In either case, the field of the calculated value is blocked. Insert 0 to release the alternative field again.

"Reached angle": Actually reached value. Under certain conditions the distance might be too small to reach the desired values. Next to time and final velocity, the total sideways offset of front and rear are calculated as well.

"Max. Lateral acceleration": Maximum lateral acceleration reached. The calculated value of the lateral acceleration refers to the vehicle's centre (to the midst of the wheelbase, precisely). The lateral acceleration on the wheels deviates a little bit from this value.

"Slip angle": Slip angle at the end of the turning procedure. The value is transferred to the collision analysis when opening the mask.

"Initial velocity": If the initial velocity and the acceleration are set to 0, the value of the final velocity is copied to the initial velocity.

"Mid position": You can examine when and after which distance the vehicle has reached a certain sideways offset. The default setting is 0.5 m.

Only the sections beginning with the one you have specified are transferred into this module, the others are deleted. Therefore, it might be necessary to match the initial and final velocity of neighbouring sections with each other. An appropriate calculation can be carried out in the main data mask. In case the program deems this procedure necessary, a notification will be displayed.

In case the turning procedure is calculated as the phase before the collision (transferred to section 4, if the collision shall take place in section 3) and the collision analysis is loaded afterwards, the slip angle and the yaw speed are automatically accepted.

If the vehicle grinds to a halt before the yaw angle is reached, you can add a phase of constant velocity in front.

If the vehicle already moves straight ahead before the yaw angle is reached, you can add a phase of constant steering angle in front (initial radius).

A turning procedure in reverse driving with a subsequent movement forward is possible.

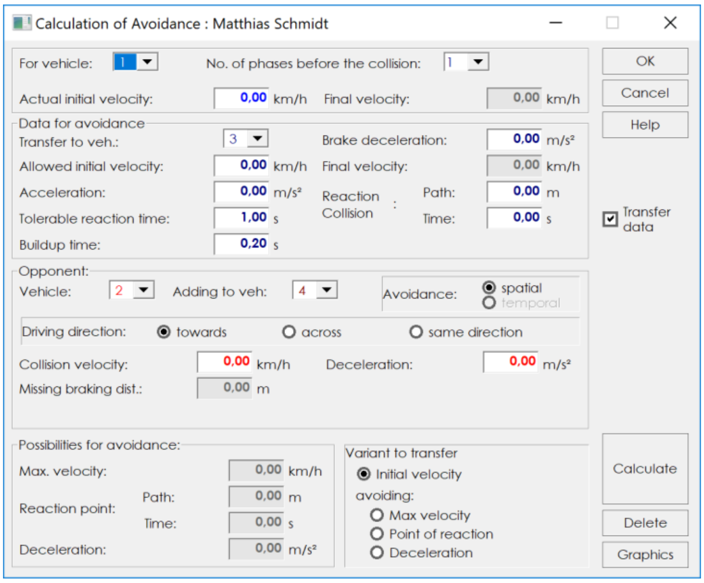
Turning into a collision: The driving line is directed to the collision point. Velocity, slip angle and yaw angle are automatically imported to calculate the collision including the simulation.

3.7.6 Avoidance

(Icon: ) This module conducts calculations of avoidance. Subsequent to a calculation in another module, you can examine the avoidance of an accident here.

The first field „For vehicle“ specifies for which vehicle an avoidance calculation shall be conducted (default setting 1), i.e. the data of which vehicle shall be transferred into the mask.

In „No. Of phases before the collision“, insert the amount of phases before the collision in which the position is located at the time of the beginning of the reaction. The resultant distance and time are inserted in the fields „Reaction – Collision“: „Dist.“ And „Time“.



When you open the module or initialise a vehicle, the program automatically searches for a collision phase (if not existent after a Delta-V phase) and a reaction phase. The number of sections prior to the collision corresponds with the difference of the respective columns. For example, column 2 is the collision phase, column 3 is the braking phase, column 4 is the buildup phase and column 5 is the reaction phase. Hence, the number of sections prior to the collision is 5 – 2 = 3.

If no collision phase or Delta-V phase is labelled, the selection of the „Avoidance“ module prompts a popup window, asking if you want zero as point of collision or if you want to use the end of the curve in the Distance – Time diagram. If you choose zero as point of collision, the coordinates from the zero point from the Distance – Time diagram are used as a reaction point. They are the same values which you can also find in the main data set as “Position Distance and Time” for the reaction point. The meaning of the number of sections corresponds with the section number then. In order to conduct a valid avoidance calculation, the collision point must be located in the zero point, i.e. the Distance – Time curve must cross the zero point.

If no reaction phase is defined, the number of sections before the collision is predetermined to 3. The reaction point is calculated from the distance the time needed during these sections.

"Transfer to veh.": Choose the code of the party involved to which the data of the avoidance calculation shall be transferred.

"Acceleration": If a value different from 0 is entered, the algebraic sign determines whether an acceleration (positive value) or a deceleration (negative value) takes place during the reaction.

"Other party involved in the accident": Enter the code of the other party involved here.

"Adding to veh.": Enter the code of the party involved to which you would like to copy the data set without collision, but with coasting phase. Given that the collision speed of the other party involved in the accident is different from 0, the vehicle would move beyond the collision point in case of an avoided collision (Missing distance or clearing distance). If this distance shall be illustrated, the data of the other party before the collision is transferred to a separate vehicle number and supplemented by a missing distance respectively clearing distance.

Tip: When opening the “Avoidance” module, default data is loaded. A further data transfer is only triggered if the analysed vehicle is changed. This mechanism inhibits that accidentally moving into the fields overwrites the manually inserted data.

"Actual initial and final velocity": Are related to the vehicle for which the avoidance calculations are conducted. If no data is imported from the first field (i.e. no data is available there), you can also conduct a calculation for vehicle 1 simultaneously with the avoidance calculation. The initial velocity can be specified, further data (reaction period, buildup period and deceleration) is used from vehicle 3, plus, the distance reaction and collision is applied.

In case the data is only transferred from the first field (or in case data is already available after a calculation), the field “Initial velocity” in the second row is blocked and a change of data only affects vehicle 3; the data of vehicle 1 remains unchanged.

If no data was transferred and no calculations were conducted, no data is available in vehicle 1. In this case, a composite movement is assumed, i.e. the reaction distance is covered first, followed by the buildup distance and the braking distance, provided that the information given allows these assumptions. In case the stated distance or time is too big, an early standstill (i.e. collision speed decreases to 0) is the result. Thus, the input is automatically adjusted to the greatest possible value. If no data in vehicle 1 is available yet, the reaction place and time for vehicle 1 is calculated first, using a composite movement. After the first calculations, when there is data of vehicle 1 available for sure, the input is only valid for vehicle 3 and can, for example, be used to examine which effects the shift of the reaction place has.

"Reaction – Collision: Distance, Time": Here you can change transferred data. “Distance” and “Time” are related to the collision point. If the distance is amended, the corresponding time is calculated in the other field (and vice versa). If the distance exceeds the one prior to the collision which can be found in the Distance – Time diagram (i.e. the point is located before the beginning of the curve), its coordinates are calculated from the curve’s elongation in backwards direction. A potentially given deceleration or acceleration at the beginning of the curve is taken into consideration during calculations.

Simultaneously to calculations, the driving line of vehicle 1 is copied and used for vehicle 3. If the beginning of the curve of vehicle 1 starts earlier than the one of vehicle 3, a phase with constant velocity is positioned before. This phase is exactly as long as the one of vehicle 1, which is a necessary condition for synchronizing the driving line.

You can select between three types of traffic: „Towards“, „Across“ and in the „Same direction“ as the collision partner.

"Towards": This option takes into consideration that for a collision avoidance the end positions are reached at a later point in time, hence, because of the approaching of the collision partner, the distance is shortened by this partner’s missing distance.

"Across": You can choose whether the calculation shall be conducted for a spatial or temporal avoidance. Obviously, this choice is only available for crossing situations.

"Same Direction": The available distance is elongated.

"Missing braking distance": States the distance vehicle 2 would have to cover to get out of vehicle 1’s driving channel. The missing braking distance is needed for the temporal analysis of collision avoidance. For the spatial collision avoidance and the traffic direction „Across“, the program examines if a time-based collision avoidance would have occurred in the case of the permissible maximum speed (Transfer option: Initial velocity). It is possible that the vehicle driving with the permissible maximum speed could not stop until the collision point, but the other vehicle would have been able to get out of vehicle 1’s driving channel in the meanwhile due to its later arrival.

"Point of disappearance": Indicates where vehicle 2 gets out of vehicle 1’s driving channel. A positive input means that vehicle 1 has more distance available, a negative value means proportionally less distance. The “Point of disappearance” represents the lateral deviation of the clearing distance, i.e. the component of the clearing distance that is parallel to vehicle 1’s driving channel.

Vehicles driving across each other’s or in the same direction can decelerate or accelerate. If they drive across each other, the missing clearing distance may not be smaller than the missing braking distances in case of a temporal avoidance.

Tip: When analysing „temporal avoidance“, you could face the problem that the last point of vehicle 2 leaving vehicle 1’s driving channel is located on the averted side. This could be the case if vehicle 2 aims to leave the driving channel diagonally to the right and vehicle 1 crashes against the right side of vehicle 2. The last point leaving vehicle 1’s driving channel would have been the left rear corner. If the point of disappearance and missing clearing distance shall now be determined, vehicle 1 would reach the point of disappearance at a time when vehicle 2 would have already left it, but before that vehicle 1 would penetrate vehicle 2; i.e. a collision would take place. The mathematical effect could be avoided by neglecting the vehicle’s width. The solution is to assume a smaller point of disappearance. It is advisable to use the point of disappearance of the vehicle’s centre or, even better, of the right rear corner; however, the missing clearing distance must relate to the left rear corner.

If movement sections before the reaction point are available for vehicle 1, a movement section with the same duration before the reaction is positioned for vehicle 3 (which receives the data of the avoidance) as well. A movement section with constant velocity is assumed so that vehicle 3 drives off at the same time as vehicle 1. If this assumption is not desired, you can either delete or adjust the section.

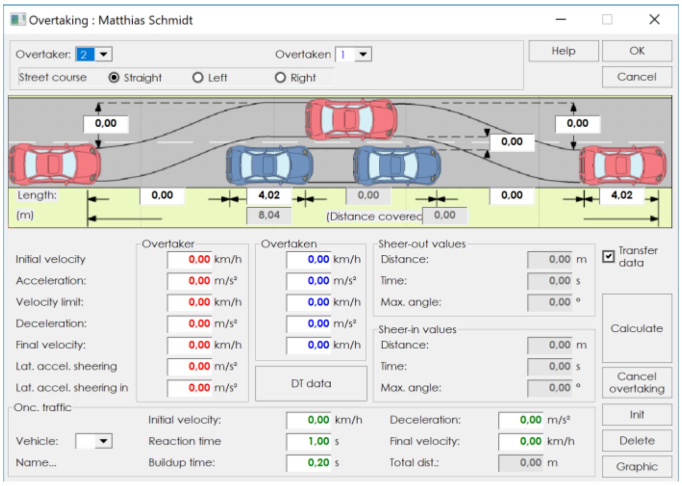
Based on the initial velocity, the (spatial or temporal) point of reaction, the reaction time, the buildup time and the potential deceleration, the values for the accident avoidance are computed:

The initial velocity with the permissible „Initial velocity“, the „avoiding max velocity“, the „avoiding point of reaction“ (at which a reaction would have been essential to avoid a collision) and the „avoiding deceleration“. You can choose the various options one after the other and analyse them in the diagrams and the Movie afterwards.

3.7.7 Overtaking

(Icon: ) This module allows you to calculate the process of overtaking. As indicated on the sketch, the distances and lengths of the vehicles have to be inserted.

In order to consider the „Street course“, choose between „Straight“, curve to the „Left“ and curve to the „Right“, whereas a curve radius has to be specified for the two latter options. The calculation is then approximated in a way that the distance of the vehicle that is being overtaken changes according to the different arc length.



Each of the two vehicles can accelerate from a specified initial velocity to a specified velocity limit and brake down to another specified velocity again. In case the stated velocity limit is not achieved, it is ignored.

The final velocity can only be entered if a deceleration different from 0 is given (negative value means acceleration), the velocity limit can only be entered if an acceleration different from 0 is given (negative value means deceleration). The calculation is conducted in a way that the final velocity is just reached at the end of the overtaking process.

Conversely, the braking can only be stated in combination with a final velocity. However, you can let the vehicle brake without stating a final velocity, if you insert a negative value as acceleration. In this case the vehicle brakes immediately and until the overtaking process is finished. If you let the vehicle brake using the field „Deceleration“, the vehicle moves with the value stated for acceleration (no matter if equal 0 or unequal 0) and starts braking on time, so that the final velocity is reached at the end of the braking process. In order to find a clear solution, the final velocity has to be stated.

Calculation variants:

ve 2	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
vo 2	+	+	+	+	-	-	-	-	+	+	+	+	-	-	-	-
ve 1	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-

vo 12	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-

The variants are read in columns.

ve2 Final velocity of the party overtaking the other

vo2 Velocity limit of the party overtaking the other

ve1 Final velocity of the party overtaken

vo12 Velocity limit of the party overtaken

\+ Value is given

\- Value is not given

The velocity limit is only assumed as given, if the acceleration is available as well. The initial velocity has to be stated for both vehicles. If a velocity limit or final velocity shall not be considered, their values have to be set to 0. As usual, the program will assume that the values are not given.

The program automatically checks if the initial and final distance are big enough. In case a too small value is entered, it is increased to the minimum value. The control mechanism only works if the lateral accelerations for the sheer-out and sheer-in process as well as the respective sideways offset and the lateral distance of the vehicles during overtaking are stated. At the same time, the route is corrected, i.e. the route of the vehicle overtaking the other runs in an arched shape during the sheer-out and sheer-in process and is projected on the street course. The sheer-in and sheer-out process is computed along a diagonal sinus-line. The specified lateral accelerations are related to the smallest driven curve radius. The current velocity at this time is calculated and taken into consideration as well.

Additionally, you can also examine potential oncoming traffic. The oncoming traffic does not influence the calculations of the overtaking distance, it only computes the distance covered by the oncoming traffic in the period of overtaking, except if the vehicle grinds to a halt earlier. If this is the case, you are prompted to decide whether you would like to insert a distance with constant velocity at the beginning or a stand-still at the end of the process. For both variants, the total time of the oncoming traffic is equal to the one of the other two vehicles. However, you can also choose no insert no additional phase at all.

In the event of a collision, it is recommendable to shift the curve of the oncoming traffic so that the current velocities corresponds with the collision velocities in the curve’s intersection with vehicle 2. Then you can immediately recognize when the reaction took place with regards to the overtaking manoeuvre and how big the distance to the oncoming traffic was at the starting point of the overtaking manoeuvre.

In the basic setting of the Time – Distance diagram, the end point of the curve is located within the coordinate origin. If the curve is shifted, the program will ask you in the next calculations if the curve shall be shifted to zero; if this is affirmed, the basic setting is restored; if it is denied, the end point of the curve remains and if at all, a phase is inserted at the beginning.

Generally, the acceleration in the acceleration field has to be entered with positive signs, and the deceleration in the deceleration field as well.

"DT-Data": The Distance – Time Data „Acceleration distance“ (Distance with constant velocity and the braking distance respectively the analogous times) can be viewed when pressing the button „DT-Data“.

"Cancel overtaking": Opens the input mask to calculate the cancellation of an overtaking process.

3.7.7.1 Cancel of overtaking

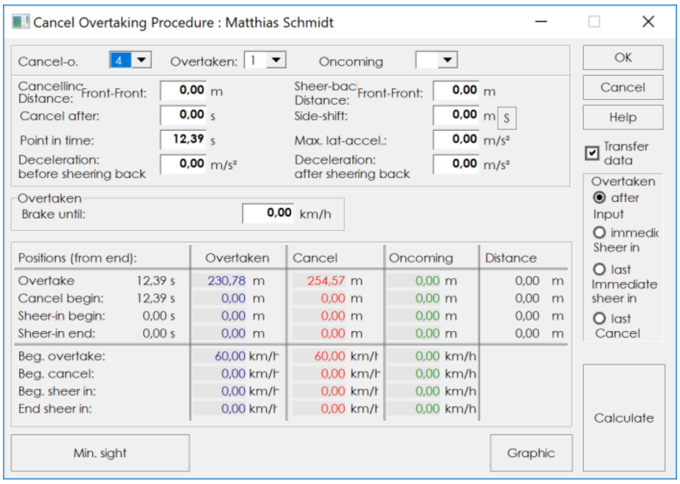
With this module you can examine if the cancellation of an overtaking procedure would have been possible in time. Furthermore, you can determine the minimum sight dependent on the time.

The time of cancellation has to be defined, using one of the following options:

"Cancelling distance: front - front": Distance between the overtaking party and the overtaken party.

"Cancel after": States the time period from the beginning of the overtaking until the beginning of the cancellation.

"Point in time": Corresponds with the elapsed time in the Movie.



The beginning of the cancellation is defined as the point in time from which on the vehicle brakes and/or is steered back. The reaction time takes place before the defined beginning of the cancellation. It is not necessary to mathematically capture the reaction phase, as the original action, i.e. the process of overtaking, is continued in the same way. Only after the reaction time, the behaviour changes, hence, the calculation reinstates at this time.

"Deceleration before sheering back": Starting with the beginning of the cancellation, the vehicle decelerates by the specified value until the point at which the phase of sheering back starts. From now on you can continue calculating with another deceleration (also with an acceleration). If the deceleration is 0 before sheering back, the process of sheering back starts simultaneously with the cancellation. In case the distance during sheering back is different from the distance at the cancellation beginning, the value is automatically amended. The program automatically controls if sheering back is feasible, also if deceleration is 0. However, a correction to the minimal distance cannot be conducted. To be on the safe side, it is recommendable to insert a deceleration before the process of sheering back, even if sheering back and the cancellation of overtaking shall occur simultaneously.

"Sheer back distance: Front - front": The time at which the vehicle starts to sheer back is specified by the value between the vehicles.

Possible situations:

<u>The distance at the time of sheering back is greater than at the beginning of the cancellation:</u> The vehicles brakes with the deceleration at the beginning of the cancellation, until the distance at the time of sheering back is reached. Due to the velocity surplus of the overtaking vehicle, the distance between the vehicles decreases

until the velocity of the vehicle overtaking is smaller than the one of the vehicle being overtaken. Only now the distance between the vehicles can increase to the specified value again.

The distance at the time of sheering back is equal with the distance at the beginning of the cancellation: The program examines if an immediate sheering back manoeuvre is possible without collision. If yes, the manoeuvre is conducted; if no, the vehicle brakes first, the distance between the vehicles initially decreases and then increases to the original value again. Afterwards the process of sheering back begins.

The distance at the time of sheering back is smaller than the distance at the beginning of the cancellation: The vehicle breaks with the deceleration at the beginning of the cancellation until the distance at the time of sheering back is reached. Next, the program examines if an immediate sheering back manoeuvre is possible without collision. If yes, the manoeuvre is conducted; if no, the vehicle continues braking, the distance between the vehicles initially decreases and then increases to the specified value again, followed by the process of sheering back. The program automatically checks if a contactless sheering back is possible with the distance given. If necessary, the value is increased to the required minimum (after an appropriate warning). However, the distance can only be corrected if a deceleration before sheering back was stated as well. The distance between the vehicles at the time of sheering back can also be enlarged if this value is not reached at all, because the velocity of the vehicle overtaking becomes equal to the one being overtaken, and the vehicle overtaking already reverts. Possibly, the sheering back process can also begin at a point at which the overtaking vehicle is positioned before the rear of the vehicle overtaken, i.e. at a point at which the distance is smaller than the vehicle length.

Summary: If the distance at the time of the cancellation of the overtaking manoeuvre is smaller than or equal to the distance at the time of sheering back (steering back), the process of sheering back is mathematically attempted immediately at the point of sheering back. If it is possible without a collision, the vehicle brakes first, i.e. the vehicle overtaking moves beyond the point of sheering back with the brakes applied and further along the vehicle being overtaken. Afterwards, the vehicle reverts and reaches the specified point of sheering back for a second time. This time, the process of sheering back is attempted. If it is again not possible without collision, the specified distance between the vehicles is increased until it becomes possible. Then the user needs to assess the real-life feasibility of such a manoeuvre and to further enlarge the distance if necessary. The distance between the vehicles is only enlarged if still necessary after reverting. The possibility of a collision-free sheering back process is automatically controlled until its completion. In cases with an early cancellation of overtaking, the process of sheering back can be completed early and the velocity of the vehicle overtaking can still be larger than the one of the vehicle being overtaken. Maintaining the same deceleration as during the sheering back process could possibly cause a rear-end collision. As it is possible that the vehicle brakes more intensively after sheering back respectively towards the end, when the lateral acceleration is already 0 or small, an examination cannot be conducted automatically, but has to be performed by the user manually.

"Side-shift": Insert the sideways offset while sheering in here.

Cancellation and sheering back during sheering out: If the overtaking manoeuvre is already cancelled before the process of sheering out is completed and the diagonal sinus line is only partially passed through, the sinus line of the sheering back process is not entirely passed through as well, but only ¾ of it. In the meantime, the driving line is adapted to the curve radius and the yaw angle which is given at the beginning of the second quarter of the sinus line. At this point the smallest curve radius is given, depending on the specified lateral acceleration and the velocity. The value inserted as side-shift is used for the calculation of the entire diagonal sinus line, which in this case is, as already previously mentioned, not entirely passed through. During this section of the driving line you can observe a small „overswing“, however, the missing part of the side-shift is usually not reached. It is advisable to control the calculation in the Movie and correct the side-shift if necessary.

"S": This button initiates an automatic calculation of the side-shift in dependence to the time of cancellation. The calculation is approximate, based on the side-shift of sheering out, and can also be found for the determination of minimum visual ranges.

"Max. Lat.-accel.": Lateral acceleration during sheering back.

"Deceleration after sheering back": Starting with the process of sheering back, a different deceleration can be used for calculations. If necessary, you can also insert accelerations (negative algebraic signs).

The calculations comprehend the positions of the vehicle overtaking, the vehicle being overtaken and, if present, the oncoming traffic at the following times: “Beginning overtaking“, „Beginning cancellation“, „Beginning sheer back“, „End sheer back“ as well as the velocities and distances between oncoming traffic and the vehicle cancelling the overtaking process.

Tip: The data from the overtaking manoeuvre has to be transferred first in order to be able to calculate its cancellation in a second step (Click on „Transfer data“ in the „Overtaking“ mask). In the selection box of the vehicle being overtaken, the same vehicle number as in the overtaking process is set as a default. However, it is also possible to calculate the cancellation with an alternative driving manoeuvre of the vehicle being overtaken. For this purpose, choose another vehicle number. As a precondition, suitable data needs to be available for this number. Due to a lack of space, the data cannot be entered here, but in the main data mask. There you can choose an appropriate vehicle number, copy the original data from the vehicle being overtaken and modify it if necessary.

A similar logic applies to the oncoming traffic. The same vehicle number as in the overtaking manoeuvre is pre-set; another number can be inserted to calculate a variant. If the end of the cancelled overtaking manoeuvre takes place after the overtaking process, the driving line of the vehicle being overtaken is automatically added. At the end, a movement section is appended. For new calculations of the overtaking process, the supplement is deleted again.

Calculation variants:

"After input": The calculation is based on the distance between the vehicles at the time of cancellation and at the time of sheering back.

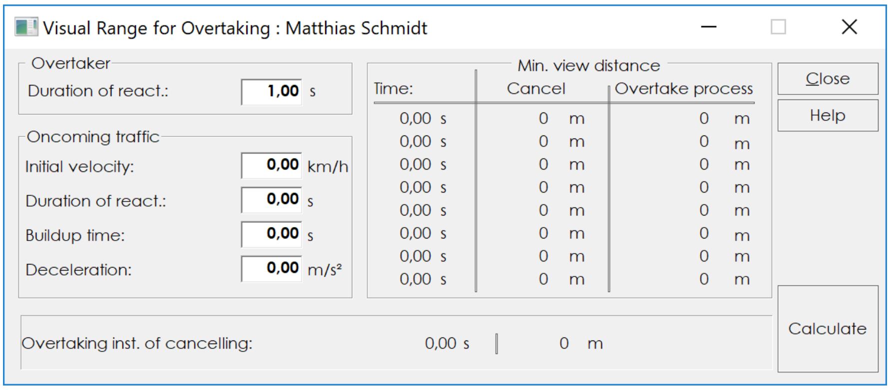
"Immediately sheer back": Mathematically attempts to start the process of sheering back at the same time as the cancellation. If this is impossible, the earliest possible process of sheering back is determined; however, the calculation variant is amended to “After input”.

"Last immediate sheer back": Determines the last time at which the process of sheering back can start immediately at the beginning of cancellation. For this option, the automatic calculation of side-shift is activated.

"Last cancel overtaking": Calculates the ultimate possibility for cancellation. As the result depends on the oncoming traffic, an amendment of oncoming traffic necessitates a new calculation. Before the calculation, the starting point of the curve in the distance – time graphic has to be stated. A shift of the time-distance curve has a significant influence on the calculation result, hence, it is absolutely necessary to conduct the calculation anew. For this variant, the automatic side-shift is activated.

3.7.7.2 Min. sight

In many analyses of overtaking manoeuvres, the calculation of the minimum sight needed to overtake constitutes a great challenge. In consideration of the fact that an overtaking process can also be cancelled, it would be too simple to calculate the minimum sight as the sum of the required distance for overtaking and the distance covered by the oncoming traffic during this time (with maximum permissible speed). Hence, AnalyzerPro calculates the minimum sight dependent on the reaction time in relation to the cancellation. The technical minimum sight is the sum of reaction distance of the overtaking vehicle, the distance during the cancellation process and the distance of the oncoming traffic in the same time.



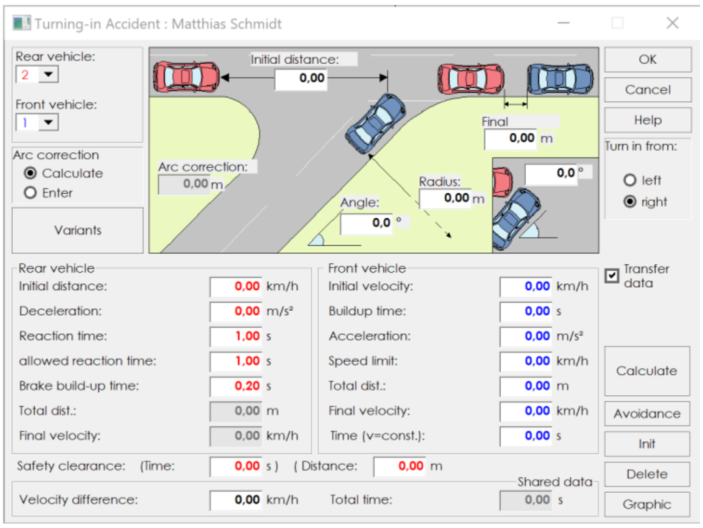
The distance the oncoming traffic covers is calculated based on the values entered for the calculation of visual ranges. When you choose the module, the values from the overtaking manoeuvre are transferred and have to be adjusted according to legal considerations. The program calculates the latest possible cancellation time first, then the time up to this moment is separated into 8 time intervals and minimum sights are calculated for each of the sections. The side-shift for each cancellation is automatically (approximatively) calculated with the overtaking time and the side-shift during sheering out. As long as possible, the calculations for the cancellation process are based on the variant “Immediately sheer in“.

Starting with the last possible moment for cancellation, the minimum sights must equal the rest of the overtaking distance plus the distance possible for the party overtaking during this time.

In addition, the minimum distance for finishing the overtaking process is given.

3.7.8 Turning-in Crash

(Icon:) For turning-in crashes (potentially after turning in) only few results can be achieved if the values of the vehicles are analysed in combination. Based on the given data from both vehicles, this module calculates the missing ones. For common rear-end collisions both vehicles slow down, whereas for turning-in crashes the front vehicle is accelerating. Both types of accidents can be calculated in this module, only the respective value of acceleration has to be stated for the front vehicle. However, for simple rear-end crashes, the easiest option is to use the module solely dedicated to this type of accident. You can adjust if the vehicle turns in from the “left” side or from the “right” side. The main calculations in both cases is the same, however, driving lines are computed differently.



ATTENTION:

Front vehicle: Acceleration positive – Deceleration negative

Rear vehicle: only deceleration possible (insert with positive signs)!

"Arc correction": Differences in length between the arc-shaped drive while turning in and the projection on the driving direction of the vehicle going straight on. For rectangular turning-in procedures the initial distance between the vehicle going straight on and the vehicle turning in equals the distance: Front – closest front corner (f.e. left front corner for turning-in procedures to the right). After turning in, the distance is front – rear. Hence, the final distance needs to be additionally corrected by the value of the rear overhang – ½ vehicle width. The inner curve radius, the curve angle, the collision angle of the vehicle width, the vehicle length and the rear overhang are taken into consideration. If the vehicle moves along a circular arc, you can choose to let the program calculate the „Arc correction“ (“Calculate”) or to enter a value yourself (“Enter”).

"Final distance": Distance from the rear of the front vehicle to the front of the vehicle catching up after the turning-in procedure. For diagonal collisions, enter the distance with negative signs and use the rear corner of the front vehicle along the longitudinal direction of the road that is further behind.

"Initial distance": Distance between the front and the rear vehicle (closer front corner) in longitudinal direction of the street, at the beginning of the prompt for reaction. For calculating, the arc correction is subtracted from the initial distance. As the arc correction also considers the vehicle length, the distance is used in the end for calculations. If a large curve radius and a small curve angle (f.e. 1000m and 0°) is entered for the calculation of the arc correction, it will equal the vehicle length. As the information on distances is usually related to the closer front corner of the vehicle turning in during a turning-in crash, the input form is displayed accordingly. In case a value different from 0 is chosen as a curve radius, the collision angle is calculated.

"Radius" (Curve radius): The curve radius relates to the radius the rear wheel on the inner curve side is performing. If a value different from 0 is entered as curve radius, the collision angle is calculated and does not need to be entered; the arc correction, which has only been calculated for a complete turning-in procedure before, is automatically adjusted with iterative calculations.

"Angle" (Curve angle): Angle between the two roads, i.e. the angle that the vehicle turning in needs to turn around.

"Collision angle": Angle between the vehicles at the time of collision. If 0 is inserted as collision angle, the arc correction at the end of the arc-shaped drive is calculated. If the collision angle is different from 0 in fact, the arc correction is automatically adjusted during the calculation. If the collision angle is known, it is used to compute the distance up to the collision, the total time and the collision velocity of the front vehicle. If a value different from 0 is entered as a collision angle (angle between the longitudinal axes of the vehicles), the total distance and the collision velocity of vehicle 1 is computed. Now the program is also enabled to calculate the arc correction at the time of the collision, i.e. the time at which the defined collision angle is achieved.

Both the possibility that the velocity limit of the front vehicle is prematurely achieved and the possibility that the total time < reaction time plus buildup time or total time < reaction time are factored in.

In case the velocity of the vehicles is equal before the entered end distance is achieved, the end distance at this point in time is calculated and the entered value is corrected. If the collision takes place before the reaction time respectively the buildup time has passed, it is considered in the calculations as well, as you can see in the computed total time.

"Reaction time": Time taken for a reaction, i.e. the period between the realization of a hazard and the beginning of the buildup phase. However, it can also represent the pre-braking time, for example if the front vehicle starts from standstill.

"Acceptable reaction time": The avoidance calculations for the rear vehicle are conducted with the value of the acceptable reaction time and are independent from the entered or calculated value of the used reaction time (which may contain a delay in reaction). Hence, you may, for example, derive at the following conclusion: For a differential speed of 20 km/h a reaction time of 1.4 s is calculated, if the front vehicle accelerates with 2 m/s^2; at the same time, you calculate in the avoidance calculations that a collision could have already been avoided if the acceleration would have been 1.6 m/s^2 only. This is no contradiction, but points to the fact that the collision could have been avoided if the driver of the rear vehicle would have only needed the acceptable reaction time of 1 s, even if the front vehicle would have had accelerated with 1.6 m/s^2 only.

If the calculation variant is not chosen via „Variants“, the program calculates the entered values (only) prior to the first calculation. Afterwards the same input scheme is used for calculations, even if new values are entered. You can observe the difference by checking the blocked respectively unblocked fields.

"Total distance": If the value entered in „Total distance (of the vehicle turning in)“ is different from 0, the resulting final velocity is calculated (under consideration of a possible velocity limit and a time with constant velocity).

"Final velocity": Vice versa, the input of a final velocity is used to calculate the total distance.

"Velocity limit": Velocity with which the vehicle drives after the acceleration respective deceleration (f.e. velocity limit). If a positive value is entered as acceleration, the default setting is 100 km/h; otherwise it is 0 km/h.

"Time (v=const)": After the velocity limit is reached, the rest of the distance is covered with constant velocity. If needed, the time driven with constant velocity respectively the time in standstill is calculated and can also be entered. If the acceleration or velocity limit is amended afterwards, the previously calculated value (distance or final velocity) is computed anew.

"Safety distance": By entering a value into this field, you can adjust the final distance for the avoidance calculations to the safety distance related to the final velocity. Enter the respective time value here (f.e. One-second-distance).

The value entered as „Initial distance“ is only used for the avoidance calculations if the value is bigger than 0.

If the „Initial distance“ is calculated anew during the computations, the entered value is used for the avoidance calculations and also kept for succeeding calculations. If this is not desirable, enter the old value again.

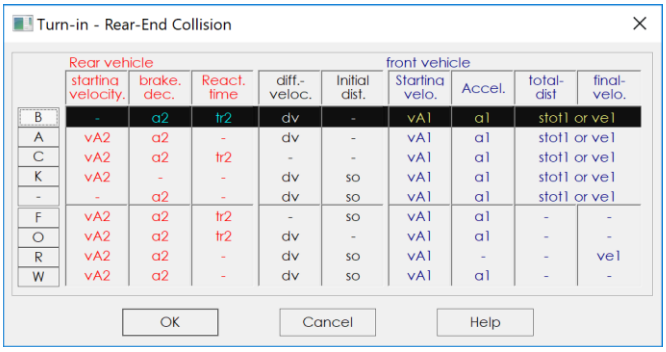
<u>Attention:</u> For drives in curve shape (turning-in crashes), the differences between the displayed distances are not equal to the distances (curve correction!). The deviations are usually rather small, however, it might, for example, be necessary at the end of avoidance curves to marginally enlarge the collision angle, so that vehicle 1 fits between the curves. As the distance is set as length cos (collision angle) at the time of collision and the collision angle at the end of the curve is inevitably different, the distance there cannot match the differences in distance.

3.7.8.1 Variants

Variants: You can choose between 9 calculation options: „BACK“ – is the symbol for backwards, „FORW“ for forwards. The initial velocity for vehicle 1 has to be given in any case. In case of acceleration, it can be 0.

"Forward calculation": The initial velocity of the vehicle catching up is known.

"Backward calculation": The total distance or the final velocity of the front vehicle is known.



Given that the acceleration of the front vehicle is known, the final velocity is calculated when the distance is stated and vice versa. The specified velocity limit is taken into consideration.

The variables are:

vA1... Initial velocity of the front vehicle

a1...... Acceleration (deceleration) of the front vehicle

vE1.... Final velocity of the front vehicle dv...... Differential speed in the end

so...... Initial distance (Depth of distance)

vA2.... Initial velocity of the rear vehicle

a2...... Delay of the rear vehicle

tr2... Reaction time of the rear vehicle

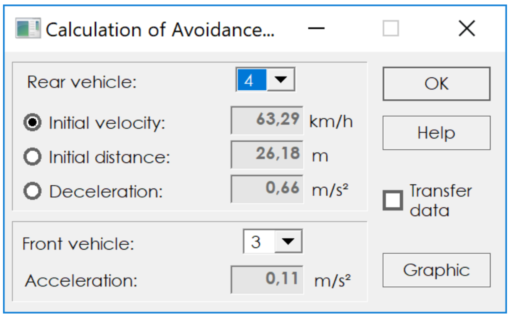
After the choice of variables, the input fields of the items to be calculated are blocked and the specified calculation option is conducted. Alternatively, you can also choose to insert the values as usual, then the program selects the appropriate calculation option based on the stated items (i.e. items different from 0). Fields marked with “-“ are calculated, the others have to be stated.

3.7.8.2 Avoidance

The module „Turning-in Accident“ also comprises an option for avoidance calculations – if possible, the following items are calculated:

"Front vehicle": The avoiding „Acceleration“ (resp. Deceleration)

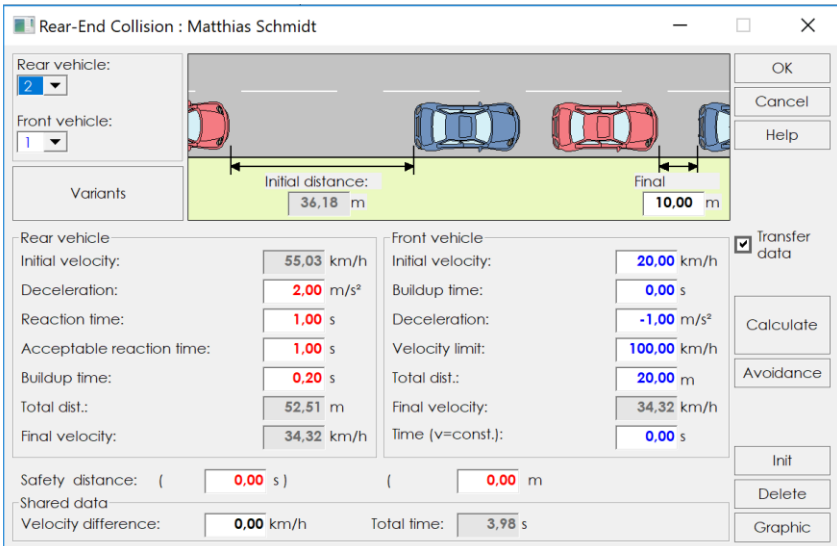
"Rear vehicle": The avoiding „Deceleration“, the avoiding „Initial distance“, or the avoiding „Initial velocity“.



The box asks for the item values which would have been needed to avoid the accident. For avoidance calculations, the arch correction is adapted to the newly emerging collision angle. Values that lead to the same final velocities are calculated.

3.7.9 Rear-End Collision

(Symbol:) The handling is similar to the one of “Turning-in crash”, only the input of curve radius, collision angle and arch correction is not necessary. For turning-in crashes, the front vehicle is expected to accelerate and a positive value has to be inserted (strictly speaking; a negative value would be interpreted as braking), whereas for rear-end crashes the front vehicle is expected to brake and the deceleration should be positive. In this case, the initial distance is the depth distance between the two vehicles (see graphic depiction). The calculations for rear-end collisions and turning-in collisions is the same.



Please note that the calculation of depth distance does not lead to one clear solution, but two: One solution during the reaction phase or buildup phase of the rear vehicle, the other one during the brake phase. You can choose with which option you would like to continue.

At a certain reaction time, the differential speed reaches a maximum. If the indicated differential speed is too large, it is necessary to increase the reaction time to derive at a solution. The program automatically adjusts the item and notifies the user of the change.

The buildup phase of the front vehicle is considered in calculations, however, not the collisions during the front vehicle's buildup phase. Collisions during the buildup phase of the front vehicle are only possible if the distances are extremely small – a condition that is not met in the forensic practice. Hence, the previously described situation is not considered in the program.

3.7.10 Bike braking

The extent of brake delay strongly depends on the driver of the bike. Contrary to cars, the brakes of the front wheel and rear wheel can be controlled separately with hand brake and foot brake. Moreover, motorcyclists need to avoid an overbraking of the wheels if possible, because this status of wheel blocking increases the risk of falling. In general, a blocking of the rear wheel is the less critical scenario, as the bike can potentially still be balanced with weight transfers of the driver.

Only if the front wheel is also blocking after a few moments, a fall cannot be prevented anymore. Hence, whereas a car driver can thoughtlessly conduct an emergency braking, a biker is usually advised to limit the braking to smaller doses.

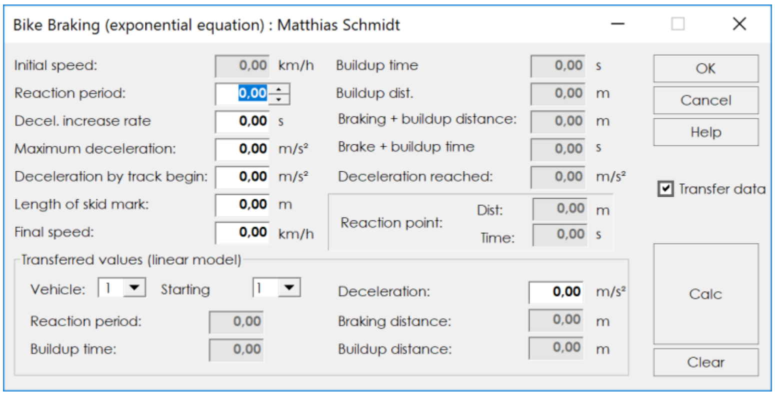
As comprehensive tests by Weber and Hugemann confirm, the control tasks conducted by motorcyclists normally lead to slightly increased rise times until the total deceleration is achieved. "Total deceleration" in this context describes the maximum deceleration value a motorcyclist with driving experience can achieve. The maximum reachable deceleration a typically increases proportionally to the driving experience of the motorcyclist. At the same time, experienced drivers reach this maximum deceleration value faster. In order to describe the motorcyclist's behaviour realistically, a so-called „Exponential equation" for mathematical calculations has been developed. It takes into consideration the longer buildup phase as well as the achievable total deceleration dependent on the driving experience (more information on this topic: Weber/Hugemann, "Der Verkehrsunfall" 28, 1990, S. 832–835).

Contrary to car drivers, the effective brake delays during braking strongly depend on the driving experience of the motorcyclist and on the total time available for the braking manoeuvre. If a rather long wheel track of a motorcycle is given, it usually originates from the rear wheel. At almost all motorcycles, the rear wheel brake is controlled by a pedal that does not allow a precise dosage of braking power. Therefore, it is most often the rear wheel that is blocked during emergency brakes to prevent a collision.

According to some accident analysists, it cannot necessarily be assumed that the front wheel brake was activated as well. Based on the wheel tracks, you can only assume the usage of the front wheel brake if a track of a blocked front wheel is present or if the rear wheel track is relatively weak, because the front wheel break must have considerably supported the rear wheel brake during the braking manoeuvre.

In all other cases, the activation of the front wheel brake cannot be clearly determined. However, comprehensive examinations have shown that motorcyclists permanently exercise the simultaneous activation of the front wheel brake and are also able to activate it more or less precisely in stressful situations (Schmedding/Weber, “Der Verkehrsunfall” 28 (1990), S. 320–322). Every motorcyclist is aware that the sole usage of the rear wheel brake results in a rather small deceleration of the motorcycle. The achievable deceleration level of 3 m/s^2 is less than half of the deceleration possible for a car. The brake distances are more than twice as long compared to a simultaneous activation of the front wheel brake. In many accidents with motorcycles involved, the record of wheel tracks shows both wheels, which means that the blocking of the front wheel brake can directly be concluded. However, the wheel track often extends over a few meters only, followed by a fall of the motorcyclist with the aim to avoid a collision.

During standard braking, the motorcyclists strives for a trackless manoeuvre in order to keep the balance of the motorcycle, which is based on the gyroscopic forces of the turning wheels. Contrary to the simplicity of braking a car, the motorcyclists need to accomplish a complex control task that might overexert them in hazardous situations. In this difficult situation, at least the rear wheel is usually overbraked and creates the first part of the track record before a collision.



The loss of stability through the blocking of the rear wheel can often be compensated by weight transfers of the driver. The blocking of the front wheel almost always leads to a fall, as the gyroscopic forces of the rear wheel, without additional steering corrections on the front wheel, are usually not sufficient to keep the balance. Hence, the blocking of the front wheel has to be prevented in any case and even during the accident development. Unfortunately, this Golden Rule is often not kept in the stressful last phase before the collision: The front wheel blocks. As a result, you can often observe a record of one wheel track in the beginning, accompanied by a second one just before the collision. Due to the motorcycle's incline, often caused by the rear wheel slipping away, the two wheel tracks can present themselves in a lateral shift to each other.

"Exponential equation":

The "Exponential equation" can be used to describe the actual braking manoeuvre:

$$a(t) = a_0 \ (1 - e^{\frac{-t}{T}})$$

a_0 ... asymptotically approximate deceleration (stationary value). The range defined by Weber and Hugemann on the basis of experiments with dry streets are 6,8 m/s² to 10 m/s².

T ... Rise. This item describes the process of rising deceleration and mainly depends on the driving experience of the motorcyclists. According to Weber and Hugemann this value can be found between 0,32 (sharp rise) and 0,6 (flat rise).

The equation integrated once indicates the velocity, integrated twice, we derive at the distance as a function of time. The creation of wheel tracks can start anytime during the braking. In case it is possible to estimate the deceleration at which the tracks started, the initial velocity of braking can be calculated. The time from the beginning of braking until the creation of tracks is called buildup phase.

Based on the final velocity (= collision velocity), the asymptotic approximate deceleration (total brake delay), the deceleration at the beginning of tracks, the rise and the length of the braking track, the initial velocity of braking can be calculated with a mathematical approximation method.

In order to continue using the data in the main data record, it must be converted into the linear model of the main data record, which means that the total distance the total time, the initial velocity and the final velocity are equal. Now it is possible to specify the deceleration. Depending on the value chosen for this item, the phase of constant deceleration and the buildup phase (linear rise of deceleration) are allocated. The reaction phase has to be little bit smaller in the linear model and the buildup phase a little bit bigger so that all necessary conditions remain fulfilled.

The values converted into the linear model are purely fictitious, nonetheless they can easily be used for avoidance calculations. The Distance-Time diagram and the movie, however, are solely based on the linear model and will, therefore, slightly deviate from the exponential model.

3.7.11 Evasion of a motorbike

This modules serves to calculate evasion manoeuvres of motorcycles and to illustrate the required space.

Simplified theory: If the driver of a two-wheeled vehicle decides to swing out to the left, the momentum has to be shifted to the steering wheel in the right direction first. Afterwards, the motorcycle tilts to the left and drives in this direction. The time needed to shift the momentum has to be specified with “Time delay” in this module. The value is taken as a basis for the “Preparation distance”, the distance in which the two-wheeled vehicle continues to drive straight ahead.

Two sinusoids are used to approach the driving line, whereby the maximum radius depends on the maximum velocity during the entire driving manoeuvre.

“Total side offset”: The total side offset covered by the motorcycle.

“Lateral acceleration”: The maximum lateral acceleration affecting the two-wheeled vehicle. The value is used to determine the steepness of the curve.

„Initial velocity“: Velocity at the beginning of the evasion manoeuvre.

“Deceleration”: Positive value – braking, negative value - acceleration.

“Time delay”: Time needed to shift the momentum to the steering wheel.

“Final velocity”: Velocity after the end of the evasion manoeuvre.

“Maximum yaw angle”: Indicates the yaw angle at which the vehicle swings in from the first to the second partial curve.

„Shear rate“: Velocity up to the time of reeving

“Maximum roll angle”: Indicates the maximum roll angle for both parts of the curve.

“Required space (inclination)”: Indicates the maximum space required in direction of the incline for both parts of the curve.

“Preparation distance”: Distance covered during the preparation time.

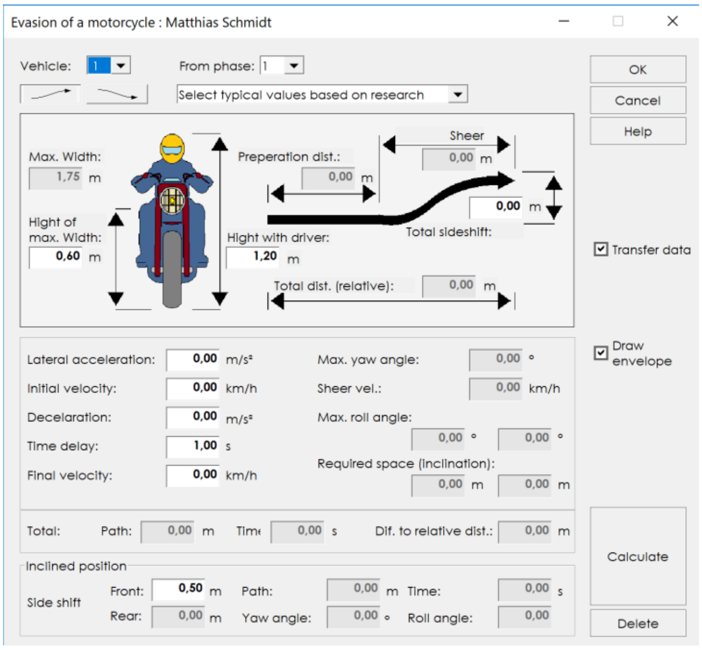
“Sheer distance”: Distance covered during the actual process of shearing

„Total distance (relative)“: Total distance covered, including a projection to the original driving direction.

“Total distance”: Total distance covered.

“Total time”: Total duration of the manoeuvre.

“Difference to relative distance”: Difference between “Total distance” and “Total length (relative)”.



„Draw envelope“: Due to the incline of the motorcycle, it might require more space depending on its geometric data. Hence, the motorcycle is depicted with a cover that illustrates the real space required. The form of the motorcycle is approached with a trapezium.

“Maximum width”: Width of the motorcycle, assumed from vehicle data.

“Height of maximum width”: Indicates how high above the floor the motorcycle has its widest part. This is important for the space required.

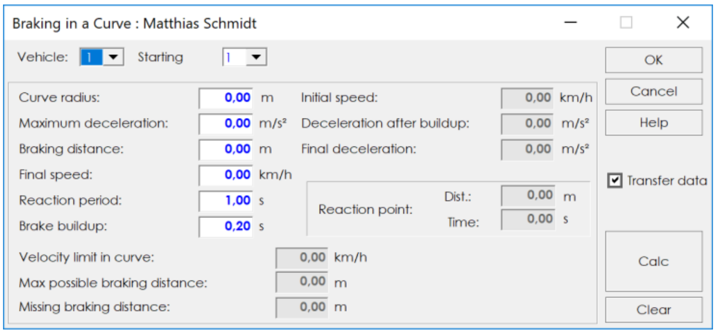
“Height with driver”: Indicates the maximum height including the driver. This is important for the space required.

Mid position:

„Front“: Specify the width of the front’s side offset here. All additional values are issued.

3.7.12 Braking in a Curve

For emergency brakes within a curve, the maximum available tire force has to be partly used for the cornering force. In curves with constant radius, a stronger cornering force is used at the beginning of the braking due to the higher velocity; the possible deceleration is smaller than at the end of braking.

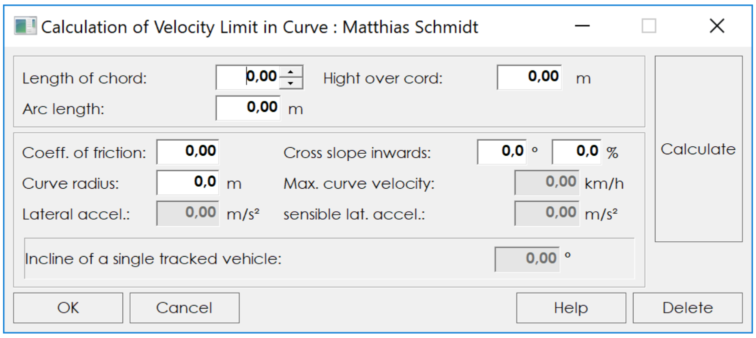


Based on the length of the brake distance and the final velocity, you can calculate the initial braking velocity in this module. The maximum deceleration describes the deceleration that would have been possible without the curve. Next to the initial velocity, the deceleration at the beginning and at the end of the braking distance is calculated as well.

The program transfers the following four phases: reaction phase, buildup phase and two phases of curve braking. As the deceleration is not constant during the curve braking, two buildup phases are transferred. The deceleration at the end of this phase corresponds exactly with the calculated value at the end of the curve braking. The braking distance is divided into two parts.

The program determines the velocity and acceleration in the middle as well as the time periods. The time of the curve braking in the main data set slightly deviates from the calculation model of braking in a curve, because the deceleration does not change linearly with time in the curve braking model, but depends on the instantaneous velocity.

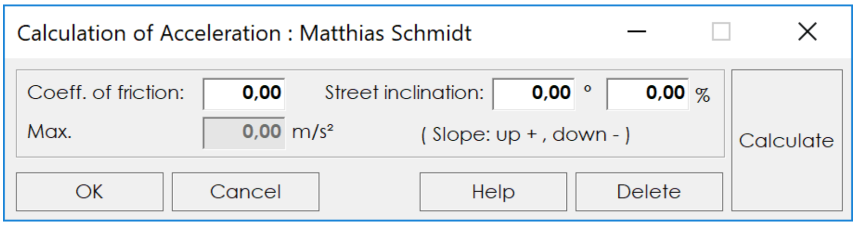
3.7.13 Velocity limit in curve



The maximum velocity is calculated with the coefficient of friction of the street's transverse gradient and the curve radius, whereby the coefficient of friction is defined as the utilized value. The coefficient of friction multiplied with 9.81 results in the lateral acceleration on a horizontal street. If necessary, a street's transverse gradient can be defined in degree or %. A positive value indicates a transverse gradient inwards, a negative value a transverse gradient outwards. The program also calculates the inclined position (deviation from the vertical) a single-lane vehicle would have to drive.

3.7.14 Acceleration (slope)

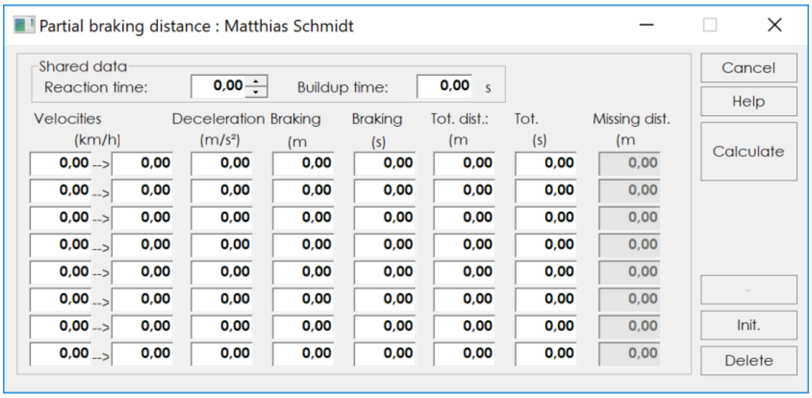
With this module, you can calculate the maximum possible acceleration respectively deceleration as a function of the coefficient of friction and the street gradient. The street gradient may be entered in degree in the first field or in %. A positive value indicates an ascent, a negative value a descent.



3.7.15 Calculator

(Icon: C) On request of several colleagues, this module was implemented to provide the user with a slightly simplified version of the module Distance-Time-Calculations. Partial braking distances can be depicted in list format, f.e. which distances are needed to decelerate from 60 to 20, from 55 to 20, or from 50 to 20 km/h.

Each row represents a separate input, the reaction time and buildup time specified in the upper part of the input box are valid for all rows. If neither a reaction time nor a buildup time is stated, only a braking phase is assumed, and the meaning of distance and time relates to the braking time and braking distance. Otherwise, all three phases of reaction, buildup and braking phase are assumed and distance and time can be interpreted as total distance and total time.

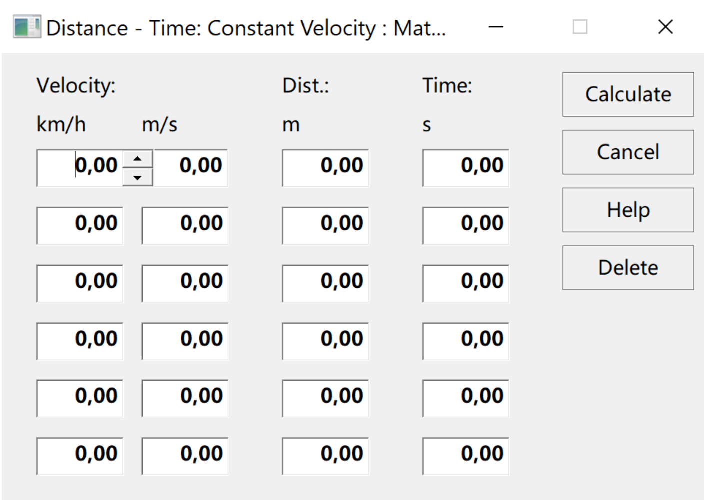


Given that three values are available in a row, the calculations are conducted one after the other. It is not possible to calculate the reaction time in this module.

The data is not transferred to the main data set, but the calculations are saved.

3.7.16 V = const.

(Icon: ⏱) With this little support module, movement sections with constant velocity can be calculated. At least two out of the three sizes distance, time and velocity have to be stated, whereby the latter one can be specified either in km/h or m/s.



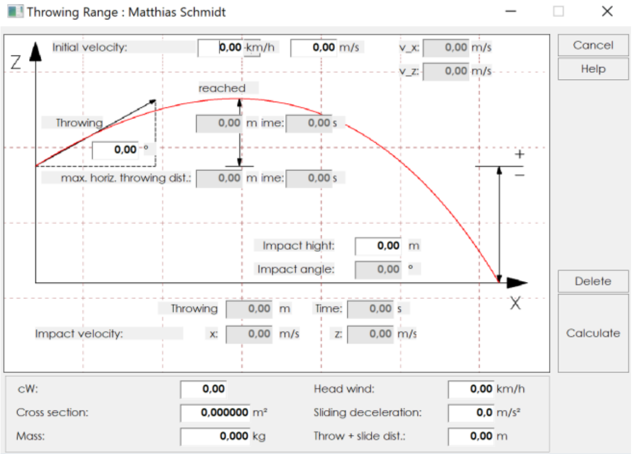
Several calculations can be carried out in parallel. Data is not transferred to the main data set.

3.7.17 Casting distance

Calculates the casting distance in consideration of air friction.

Please insert: "Initial velocity" (Departure velocity in km/h OR m/s), "Throwing" (Departure angle), "Impact" (Height of the point of impact at which the flying object shall land). A negative “Impact” value indicates that the landing point is located below the departure point, which is always characterized by a height of 0.

Furthermore: "cW" (drag coefficient), "Cross section" and "Mass" of the flying object. If a cross section is stated, the mass of a dice with the density of water is proposed as reference value for the mass.

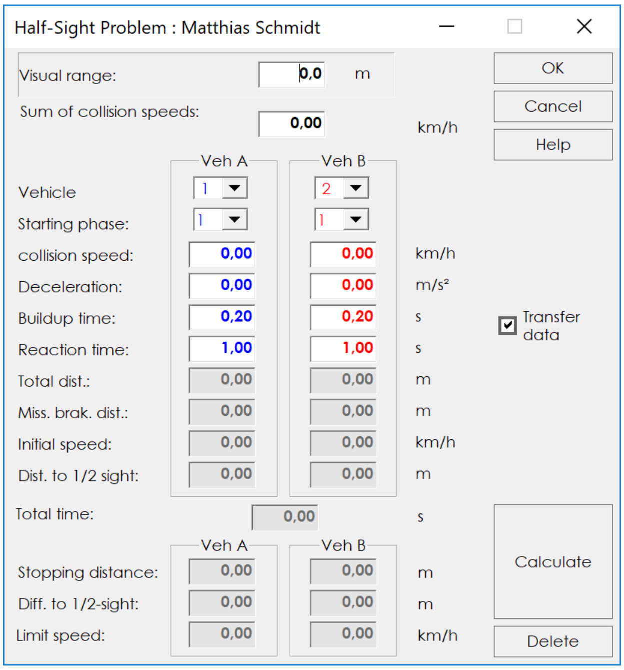


The following values are calculated: The "throwing height" (and the "Time" distance from the point of throwing), the "maximum horizontal throwing" (Height = 0) and the respective point in "Time", die "Throwing" (throw distance) for the specified height and the total "Throwing and sliding distance".

In case a „sliding deceleration“ is stated, the total distance comprises the throw phase and the sliding phase. If a „throwing and sliding distance“ is determined, the „initial velocity“ (departure velocity) is calculated thereof.

Moreover, the x and z component of the departure velocity ("v_x", "v_z") and the impact velocity in x and z direction are calculated.

3.7.18 Half-Sight Problem



With this module, accidents with a restricted view can be examined.

The following sizes have to be stated: „Visual range“, „Sum of collision speeds“, „Deceleration“ and „Reaction time“. Based on these values, initial brake velocities and distances are calculated.

The sum of covered distances results in the visual range. The distances are covered within the same time (total time).

Different view conditions, f.e. because of a curve, can be adapted with different reaction times.

If the collision velocities sum up to 0, collision velocities can be stated for both vehicles separately. If not, only one velocity can be specified and the second one is automatically calculated of the sum. The respective stopping distance for a theoretical standstill is calculated in the lower part of the input box.

"Diff. to ½ sight" calculates the distance that the vehicle would have covered from the collision to half the sight distance (positive value) respectively the distance that the vehicle has covered beyond the point of collision (negative value).

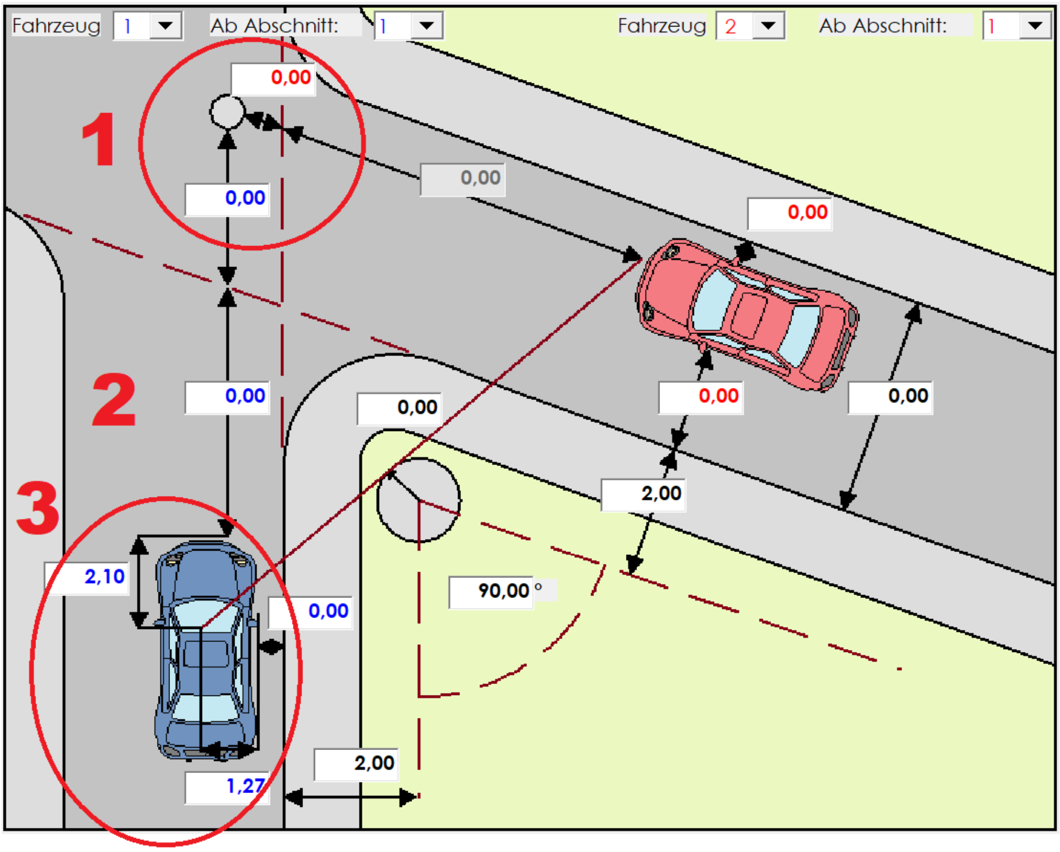
"Limit speed" indicates the maximum speed that would have been needed to stop on half the sight distance.

3.7.19 Right of way problem

Calculates the visual range to the right. The module is based on the following scenario: On unregulated crossings with a right-over-left priority rule, vehicle A must give way to vehicle B approaching from the left. However, vehicle B also needs to consider the possibility of a third car coming from its right and has to adapt the velocity accordingly.

The starting point for the analysis is the position of collision. For both parties, the distance that the vehicles' fronts have moved beyond the line of sight ("1") have to be stated. Furthermore, the distance of vehicle A up to the line of sight of the intersecting road needs to be specified ("2").

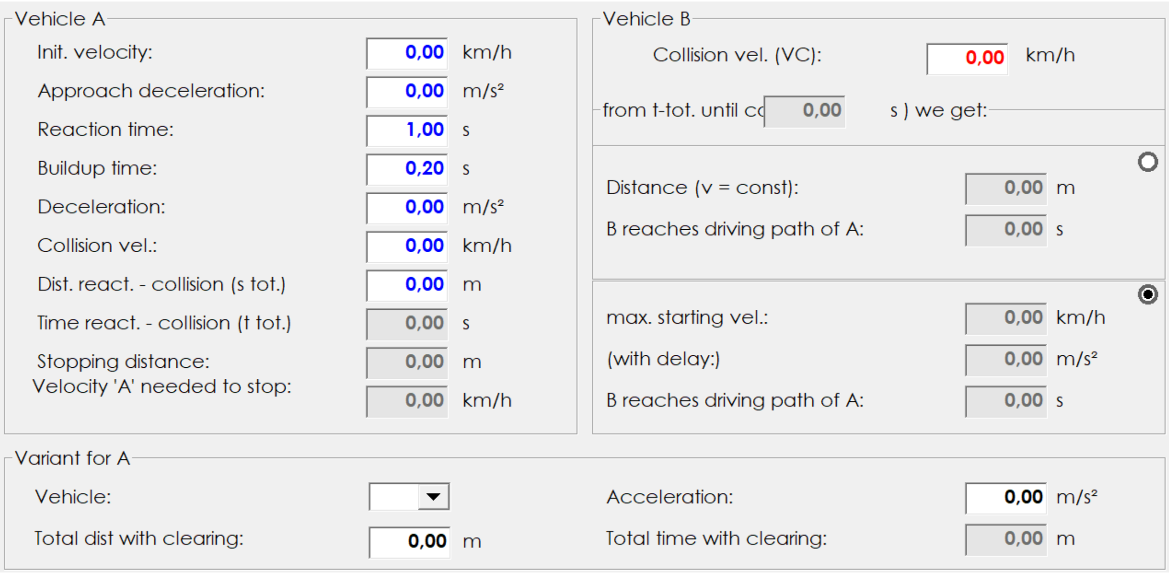
If you enter the „Collision velocity" of vehicle A, the „Initial velocity" is automatically calculated, and vice versa.



It is possible to enter a deceleration during the approximation („Approach Deceleration ") which is then also applied to the reaction. After the reaction phase and the buildup phase, the vehicle slows down with the value indicated as "Deceleration" until the point of collision.

The sight obstruction is depicted as a circle between the two roads. You can specify the radius and the distance to the roadsides to position the obstacle.

The position of the eye is generally pre-defined, but can also be amended here („3"). Based on this information, the visual range to the right (= the distance from the middle front of vehicle B to the line of sight) is calculated.



Moreover, AnalyzerPro calculates the position vehicle B would have had, had it moved with constant velocity, i.e. the collision velocity. In case this value is smaller than the visual range, the vehicle was already visible at the time of reaction and vehicle B could have decelerated during the process of approximation. The velocity at the time of reaction and the deceleration are calculated in the fields below (maximum initial velocity with deceleration).

In case the value is greater than the visual range, the vehicle was not visible yet. In further consequence, the velocity of vehicle B must have increased, and at the time the driver of vehicle A reacted, vehicle B was slower than at the point of collision. Deceleration shows a negative value in this case.

It is also possible to calculate an alternative analysis for vehicle A in which the vehicle accelerates until the end of the clearing distance instead of braking.

3.7.20 Pedestrian Accident

3.7.20.1 Pedestrian Accident

(Icon: ) You can examine accidents with crossing pedestrians in this module.

The module is able to handle distance-based as well time-based methods of calculation.

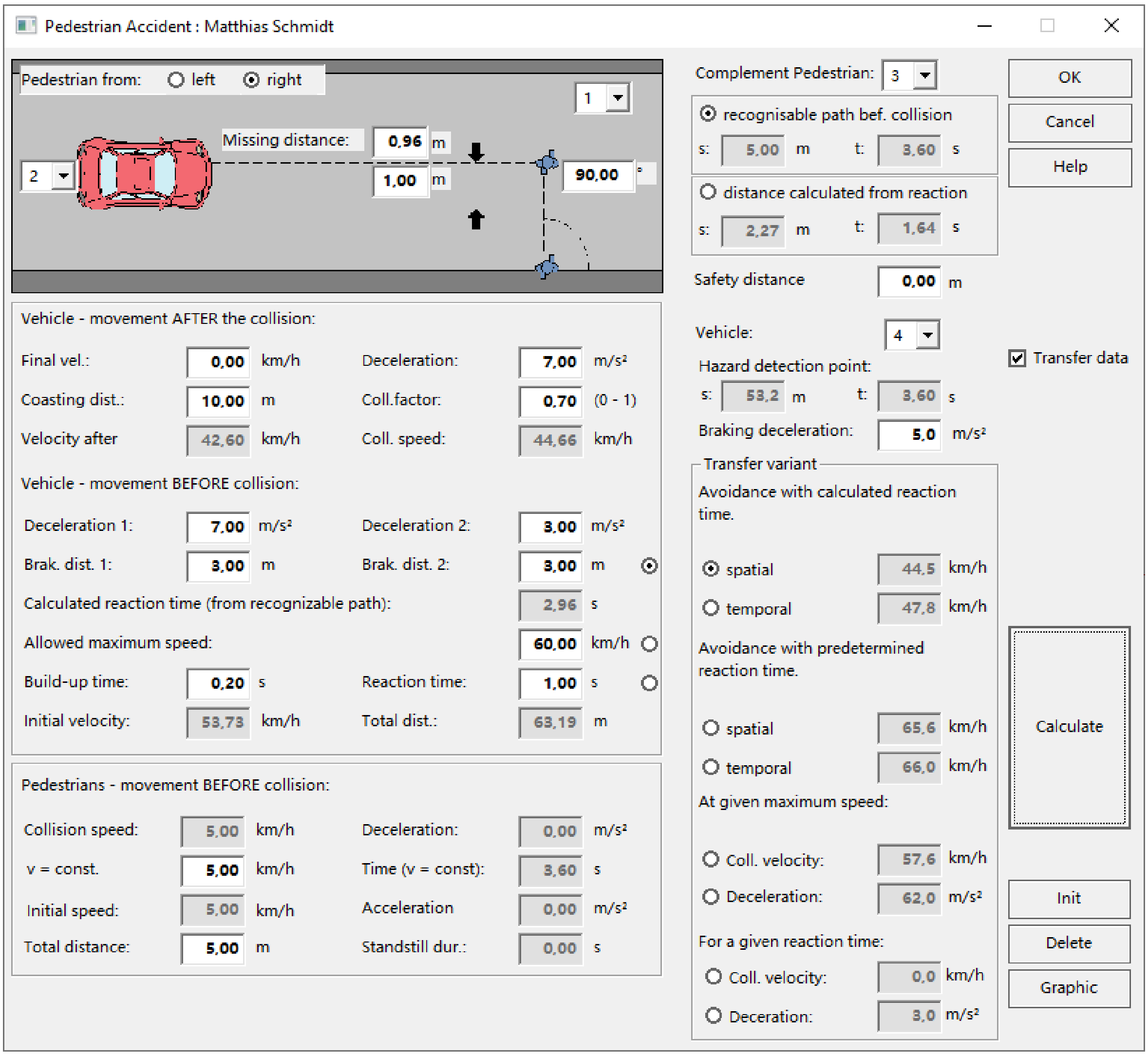
- For distance-based calculations we need to consider the *objective* reaction point of the car's driver. Usually, this is the spot we get if we take the standard reaction time and calculate backwards from the beginning of the visible skid marks.
- Time-based calculation methods on the other hand take the pedestrian's movement into consideration at a defined point of danger recognition, i.e. the point at which the car's driver should have reacted.

The module is divided into various parts. The left half is used to define geometric data and the actual / probable movement of the car and pedestrian. The right half is used to calculate and transfer avoidance calculations, depending on the pedestrian's movement. The calculations on the left side influence the data on the right side, but the calculations on the right side do not influence the left side.

- Top left area: Geometric data of the accident site.
- Centre left area: vehicle driving data.
- Bottom left area: Pedestrian movement data.
- Right side: Avoidance calculations.

<u>Geometric data, top left:</u>

"Pedestrian from left/right": Adjust the moving direction of the pedestrian here. Your choice does not influence the calculation mode, but only determines the depiction in the movie.



<u>Vehicle data, centre left:</u>

"Final velocity": The value is usually 0, except if the vehicle has run into an obstacle (another vehicle, etc.), then the collision velocity has to be stated here.

"Coasting distance": Brake distance after the collision. Based on the specified “Deceleration”, the coasting velocity (= velocity after the collision) is computed.

"Coll(ision) factor": Due to the weight difference between the pedestrian and the vehicle, the velocity of the vehicle changes only slightly in many cases. Assuming that it was a straight and central collision, the velocity immediately afterwards can be calculated as follows:

$$v_k = v_k' * \left(1 + \frac{IF}{100} \frac{m_{Ped}}{m_{Veh}}\right)$$

However, this formula cannot be applied to all types of collisions (dependent on the vehicle type). The shock transmission is incomplete in most cases and can be taken into consideration by amending the impact factor:

"Collision factor " = 0: The vehicle does not loose velocity at all (brushing).

"Collision factor " = 1: Maximum velocity loss according to the above-mentioned formula.

Real accidents usually score in between. A common value is 0,8 (pre-set value).

"Collision speed": Is calculated from the mass ratio vehicle – pedestrian and the „Collision factor“.

<u>Calculating the vehicle approach velocity:</u>

The vehicle approach velocity is calculated by considering:

- Coasting distance
- Velocity change during the collision
- Braking that occurred before the collision

Calculation options:

The initial vehicle speed can be calculated via three different methods, which can be selected by ticking one of the round boxes in the centre of the dialog.

- 1: Distance-based calculation by taking the user-defined braking distances. There might be a discrepancy between the objective and subjective reaction points.
- 2: Time-based calculation by taking the remaining braking time after subtracting the user-defined reaction time. This takes the time of the pedestrian becoming recognisable as potential danger as the base line.
- 3: Use the defined maximum speed.

1: The braking distance before the collision is entered. The braking distance can be split up if different decelerations have to be considered. If a braking distance is given, the initial velocity can be calculated. Based on the prompt for reaction, a potential delay of reaction can be computed: First of all, the pedestrian's distance from the position of the prompt for reaction to the collision has to be investigated (discernible distance to the collision, from which the reaction time is calculated). The difference between the computed and the permissible reaction time is the reaction delay. Different decelerations make it sometimes necessary to split up the brake distance. Two parts are provided for this purpose.

2. In many cases, no track record is available and the initial speed can only be assumed indirectly by combining the permissible reaction time with the discernible distance of the pedestrian. The calculated reaction time complies with the permissible one in this case.

3. As an alternative, the reaction time can be calculated from the permissible velocity.

"Mean deceleration for avoidance": The calculation of avoidance can only be conducted with a uniform deceleration that has to be indicated by the user. If no value is entered and the input stays at 0, the average value weighted by the respective brake distance is calculated.

Pedestrian data, bottom left

The pedestrian could have covered his or her distance in 4 different ways:

With constant velocity: Only one out of three velocity fields has to be specified.

With acceleration or deceleration: As the program assumes that the pedestrian accelerates at the beginning and decelerates in the end, both values are expected to be positive. The program calculates with the right algebraic signs internally. If the pedestrian accelerates in the end against common expectations, the respective value has to be entered with negative algebraic signs.

Depending on the problem, the term „Recognizable distance before impact“ can be defined differently, for example as the distance of the pedestrian from the roadside to the point of collision or from a position within the roadway (like a position 0,5 m away from the roadside or at the middle line marking). From this “Recognizable distance before impact“, the time the pedestrian needs for this distance is calculated, the position of the vehicle at this time and finally the discernible hazard recognition point for the driver of the vehicle. Based on this knowledge, experts could conclude that the driver could or should have reacted in this moment and the required reaction time can be computed. If the discernible distance is specified from the location of the first sight, one has to reconsider what to include in the term “reaction time” (the time needed to direct one’s view, etc.). The difference between the time the pedestrian needs and the time necessary for the build-up and brake phase until the collision yields the calculated reaction time.

Note: As soon as the program detects that the user has entered the minimum number of variables for pedestrian movement and calculated once, the internal calculation method will be locked in. From then on, the result fields will be grey and the user will no longer be able to access to them. In order to reset the pedestrian movement method, the user has to click the “Init” button!

Calculation of avoidance, right side:

Avoidance calculations are only done for the vehicle and not for the pedestrian. The selected pedestrian on the right side is only a complement for the avoiding vehicle in the movie.

On the top there are two options with which the user selects the point of danger recognition that the avoidance calculations are going to use.

- The first option is a time-based method that uses the entered path of the pedestrian from first becoming a potential danger to the impact. This is the objectively required reaction time.
- The second option is distance-based. It uses the estimated reaction time of the driver.

If there is a difference between the calculated reaction time (calculated from the pedestrian movement) and the user-entered reaction time on the left side, we need to consider the possibility of a late reaction of alternatively a longer braking distance before the collision (even without tyre marks).

The *safety distance* is:

- The distance between the stop position of the vehicle and the pedestrian when using spatial avoidance.
- The distance between the movement line of the pedestrian and the vehicle at the moment at which the pedestrian leaves the path of the vehicle.

Avoidance vehicle:

The bottom right side of the module contains 8 different calculations for avoidance for the vehicle, using varying assumptions. If the avoiding speed is greater than the maximum speed, the collision would have been avoidable (using those same criteria).

The 8 options in this area do not influence the avoidance calculations, the buttons only determine which method to transfer to the movie.

Usually, the temporal avoidance speed is greater than the spatial one when dealing with short pedestrian missing distances (for leaving the path of the vehicle). Spatial avoidance encompasses temporal avoidance and therefore the temporal avoidance velocity cannot be lower than the spatial one. If both values are lower than the maximum speed, the crash could have been avoided by braking harder. The necessary decelerations will be calculated.

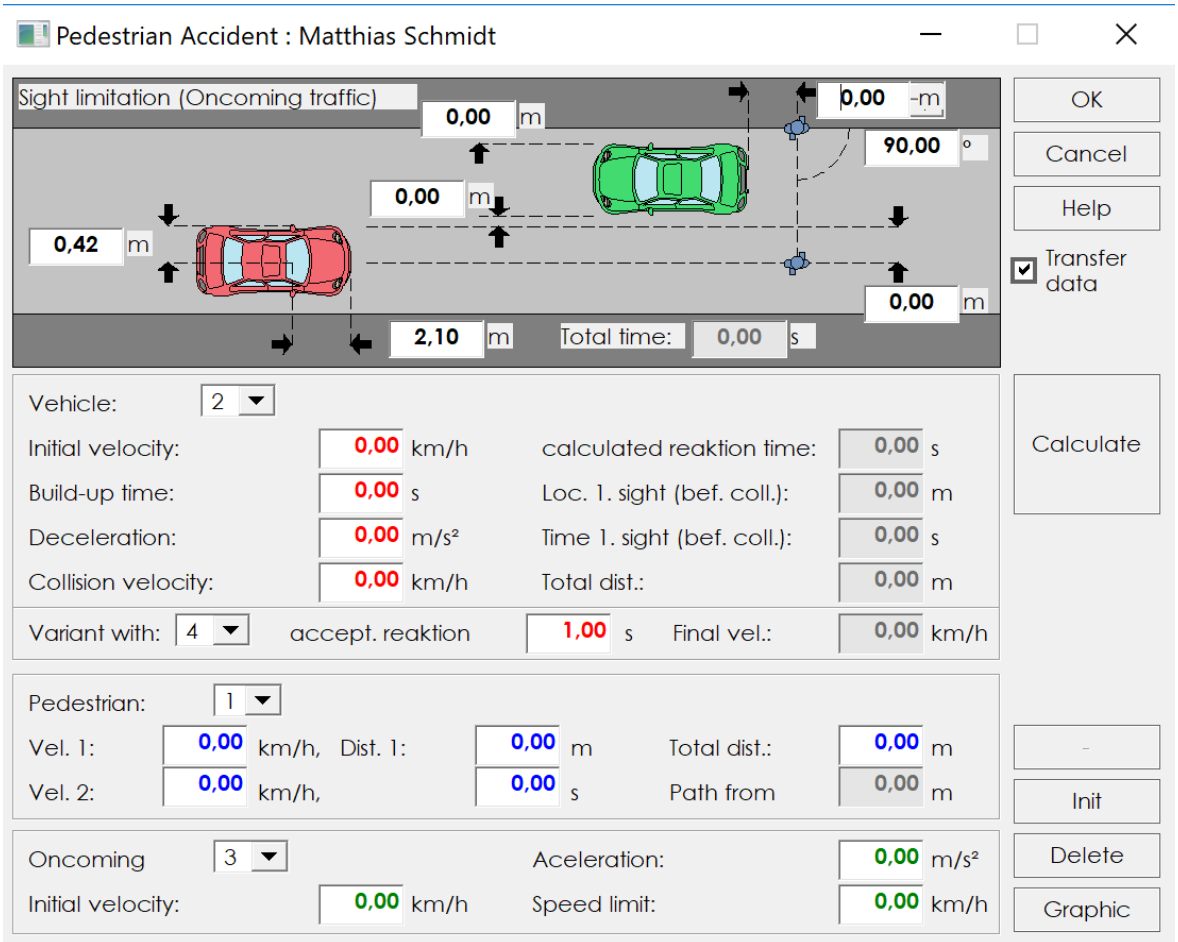
If the calculated reaction time is longer than the predetermined one, we should consider a late reaction and not use the (longer) calculated reaction time. The first variants are for those considerations, giving both temporal and spatial avoidance for both reaction times.

The bottom 4 variants consider accidents that are not avoidable using the defined assumptions. In those cases, we can at least calculate the lowest possible collision speeds. This can be useful when considering potentially less severe injuries. The program also calculates the avoiding decelerations - it is up to the user to judge if those are realistically applicable and would therefore avoid the accident.

3.7.20.2 Involving Oncoming Traffic

(Icon: ) Accidents with pedestrians are often caused by sight obstruction. The reasons for the late recognizability can be static objects like trees, newsstands, etc. or dynamic objects like a vehicle passing by. In many cases, the pedestrian enters the road behind a passing vehicle or public transport service at a bus station. In these cases, the objective visual range onto the pedestrian strongly depends on the current constellation of place and time. Given that the relevant parameters are known, the case can be solved mathematically. This module deals with a situation in which the pedestrian enters the road from the left side and is hidden behind oncoming traffic.

You can either calculate the „Reaction time“ the driver has actually needed or assume the permissible reaction time and compute the „Initial“ and „Final velocity“ („Velocity before impact“). Two out of these three values have to be given.



The reaction time starts with the beginning of the first sight and comprises the time needed to direct one's view and the time until the movement of the pedestrian becomes obvious.

Vehicle:

At least the „Deceleration“ has to be specified for the vehicle involved in the accident as an average value of the entire braking process. Besides of the actually used “Reaction time”, the position of the vehicle is calculated (i.e. the distance from the place of collision) and the “Time 1st sight” as well as the “Total distance” the vehicle covers from the moment the pedestrian enters the road until the collision. The “1st sight” is given if the visual radius from the defined sitting position (distance from the left side and from the front) to the middle of the pedestrian just passes by the rear of the oncoming vehicle. It is assumed that the vehicle has a rectangular shape. Necessary modifications can be made via the value “Distance pedestrian – rear of the passing vehicle“. Only the distance of the pedestrian from the object causing the sight obstruction is essential in this case.

Pedestrian:

The pedestrian's velocity as well as the direction of movement have to be stated. The direction of movement is inserted as an angle to the longitudinal axis of the driving lane. Two different velocities may be specified.

"Velocity 1": Velocity of the pedestrian when starting off and covering „Distance 1“.

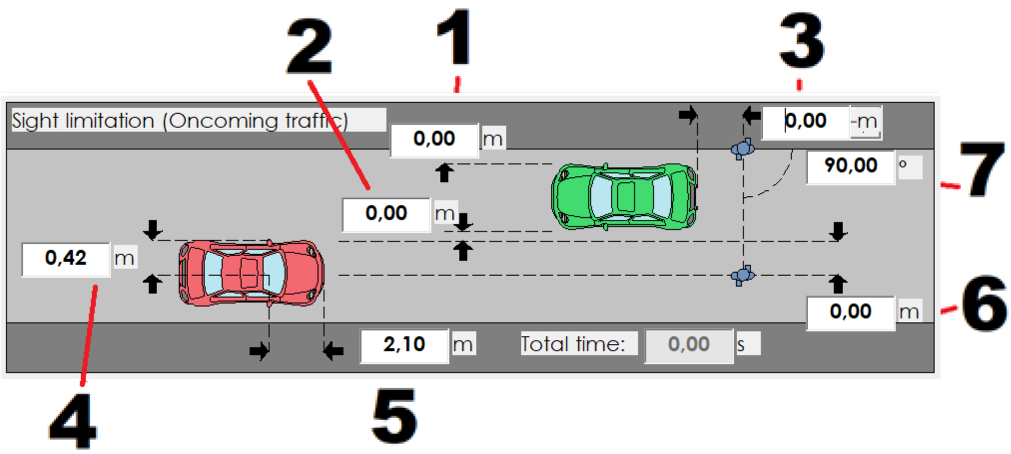
"Velocity 2": Velocity of the pedestrian after „Distance 1“ up to standstill at the end of the total distance respectively up to collision.

The velocity is changed in steps.

If the velocity remains unchanged, the value can either inserted as „Velocity 1“ or „Velocity 2“ and the „Distance 1“ remains 0.

If a „Side distance between the vehicles“ is stated, the „Total distance“ is calculated and vice versa. The “Total distance” of the pedestrian is the result of the side distance of the oncoming traffic to the roadside + the width of the oncoming traffic + the side distance between the vehicles + the distance between the collision point and the left side of the vehicle involved in the accident, adjusted by the angle of the pedestrian's movement direction (divided by the cosine of the angle).

In a possible moment of standstill, the pedestrian could also attempt to turn back. In this case, the time needed for this forward and backward movement is simply stated as standstill period. From a mathematical point of view, the pedestrian is seen as a point; hence, the visual radius should be positioned in the middle of the left side of the body in the Movie. During the initialization of the vehicle, the program scans all phases for the collision phase (if not existent after a Delta-V phase). In case no collision or Delta-V phase is marked, the collision point of the first column is assumed.



1... Distance to the passing vehicle

2... Side distance between the vehicles

3... Distance pedestrian – rear of the passing vehicle

4... Distance seat position – left side of the vehicle

5... Distance seat position - front

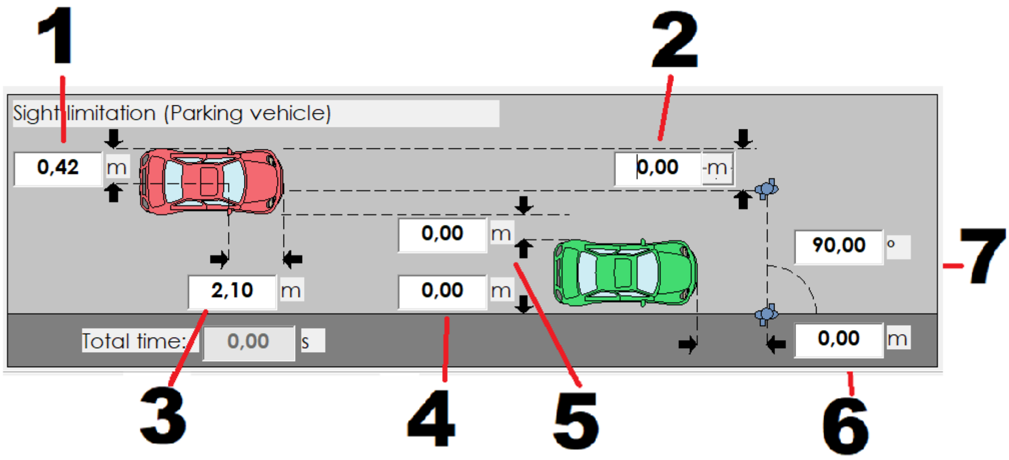
6... Distance collision point – left side

7... Direction (angle relative to street axis)

The sketch shows the oncoming traffic as green (upper) vehicle and the vehicle involved in the accident as red (lower) vehicle. The pedestrian is shown twice, one time behind the oncoming traffic when entering the road (upper position) and one time at the collision point (lower position). The oncoming traffic can move with or without acceleration (resp. braking). The initial velocity relates to the time when the pedestrian enters the road. If a velocity limit is specified, the vehicle accelerates (resp. decelerates) up to this value and keeps driving with constant velocity. The velocity of the oncoming traffic can also be 0 (parking vehicle at the left roadside)The width of the oncoming traffic has to be given, otherwise it is set to 1,65 m.

3.7.20.3 Involving parking vehicle

(Icon: ) The calculations are analogous to the sight obstruction through oncoming traffic. Instead of the side distance and the width of the oncoming traffic, the spatial measures of the parking vehicle (green lower vehicle) have to be stated.



1... Distance seat position – left side of the vehicle

2... Distance collision point – left side of the vehicle

3... Distance seat position - front

4... Distance to the passing vehicle

5... Side distance between the vehicles

6... Distance pedestrian – rear of the passing vehicle

7... Direction (angle relative to street axis)

3.7.20.4 Barrier method

(Icon:) The greatest challenge in pedestrian accidents is the localization of the collision point. Kühnel has developed a method to narrow down the potential collision area based on the traces of the accident as well as testimonies.

For the barrier method, all traces and testimonies shall be considered that limit the collision velocity, collision location or both. Due to the various types of limitations, the terms Distance barriers, Velocity barriers and Distance-velocity barriers are used. The method is based on the idea that the limitations of the various traces of the accident have to be fulfilled, hence, all existent barriers narrow down a certain section in a distance-velocity diagram. The most commonly used barriers are:

- The throwing distance of the pedestrian or biker
- The braking parable of the vehicle
- The position of the first and last glass splinters

So-called additive barriers can emerge from testimonies, local pre-conditions as well as the type and intensity of vehicle damages respectively the pedestrian's injuries. Based on the scale depiction of the accident, the distance-velocity curves for all noted traces of the accident are marked. The curve shape can be determined with the help of a curve regression from previously discussed diagrams.

When all curves are drawn and no contradictory statements have been made, you derive at a solution area in which the collision must have taken place. You always need to check if the premises for each and every barrier are adhered to, otherwise, the indicated solution area could be wrong or too narrow. Moreover, the curved cuts are often too flat, thus, already small shifts of the curve cause strong amendments of the curve position. These factors have to be taken into consideration when interpreting the result.

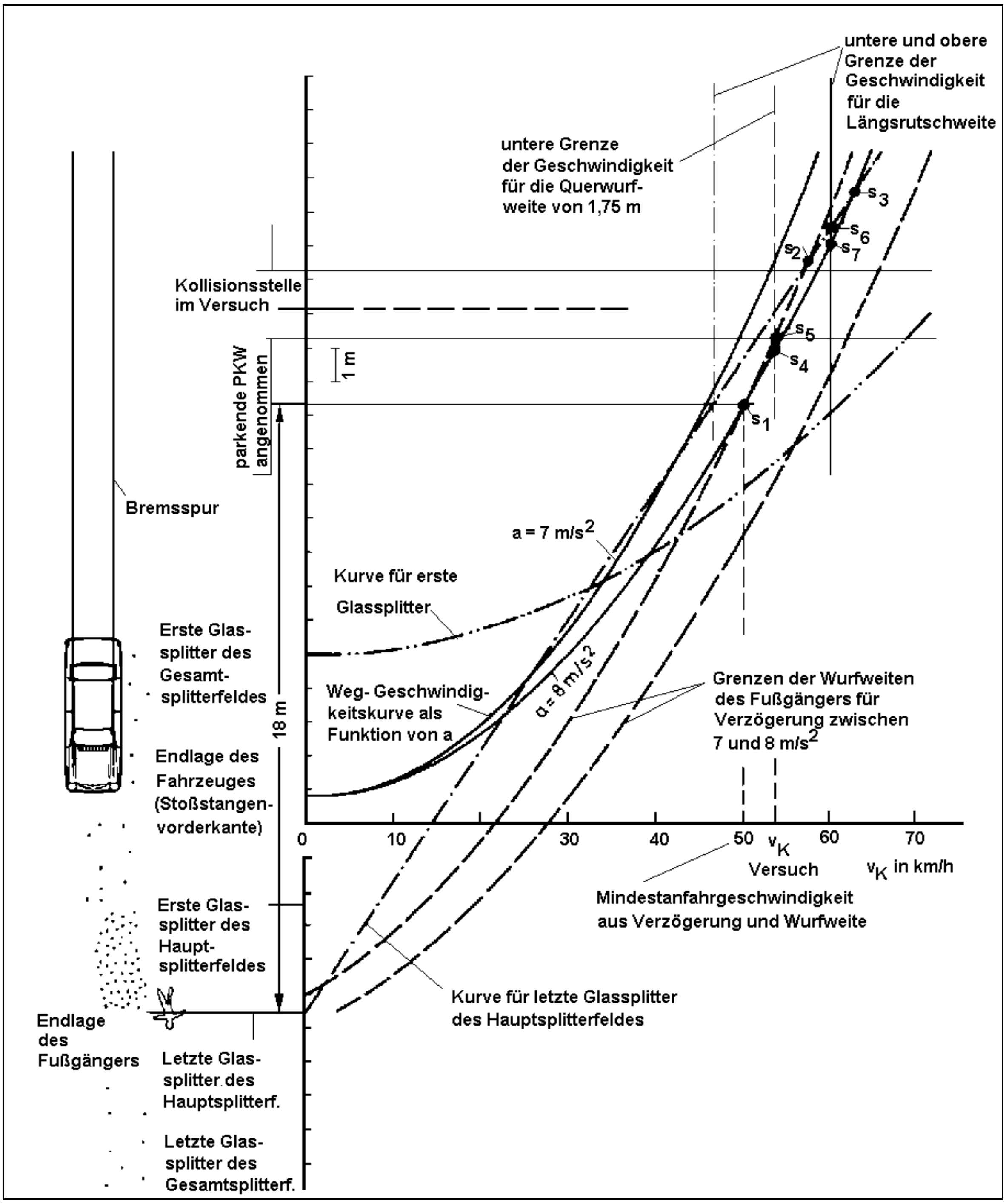
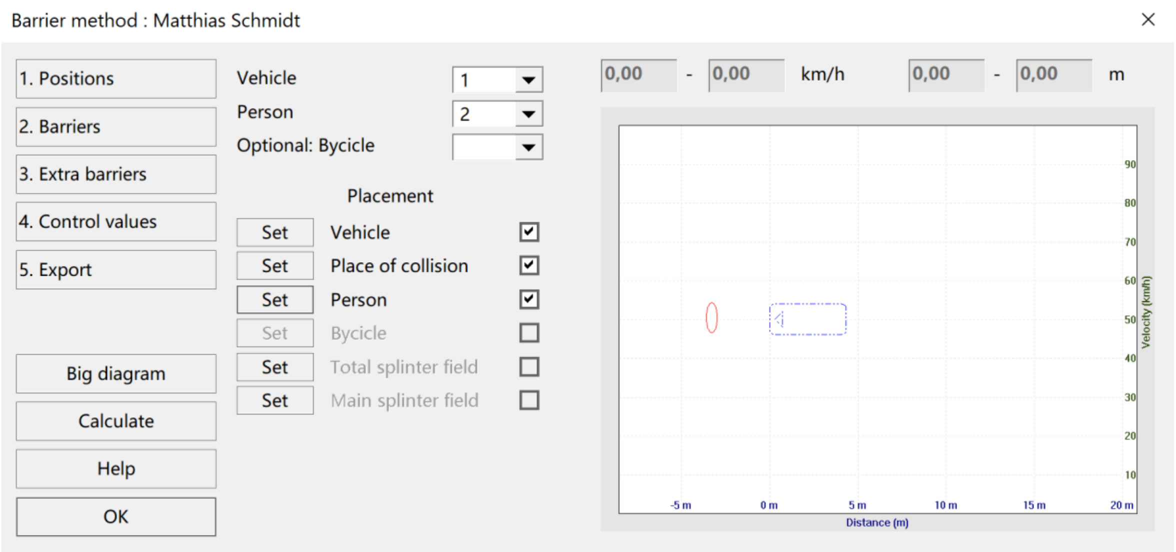


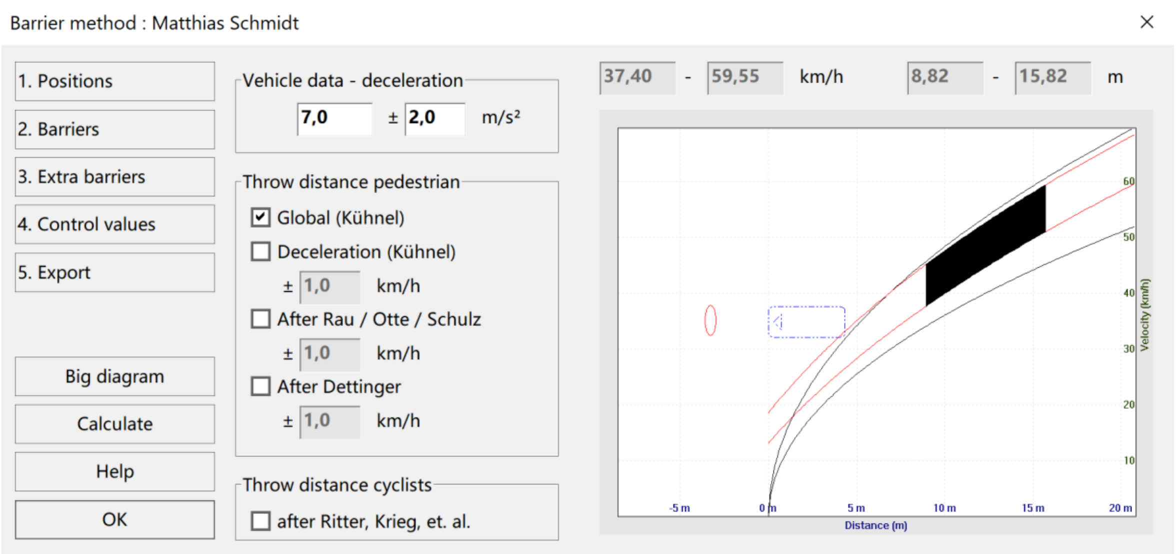
Figure: The principle of the Barrier Method [Kühnel]

The module must be worked through in points 1-5.



"1. Positioning":

First select the vehicles concerned using the dropdown menu. Do not forget to load the corresponding vehicle data in the vehicle data menu. With the button "Set" a silhouette appears in the drawing window, which you can set to the desired position. You must at least set the vehicle, person and collision location.

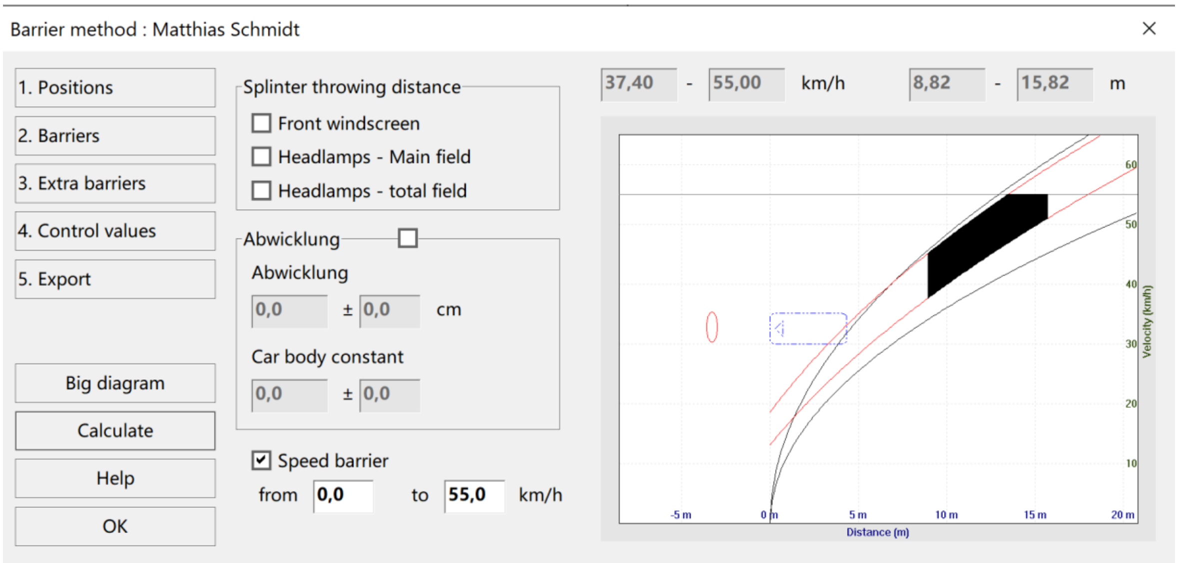


"2. Calculation":

„Deceleration“ and „Tolerance“ of the vehicle have to be indicated. Furthermore, at least one theory of restriction must be chosen. Details of the theories can be found in the technical manual.

"3. Additional barriers":

Additional barriers, e.g. through splitters, can be taken into account here. If applicable, a method called „Abwicklung“ can be used. An adequately large tolerance is recommended. A speed barrier can also be specified.



"4. Control":

Here a control calculation can be carried out by means of a throwing distance calculation. Please note that this is an approximation. The calculation is only for personal control and will not be transferred.

“5. Export”:

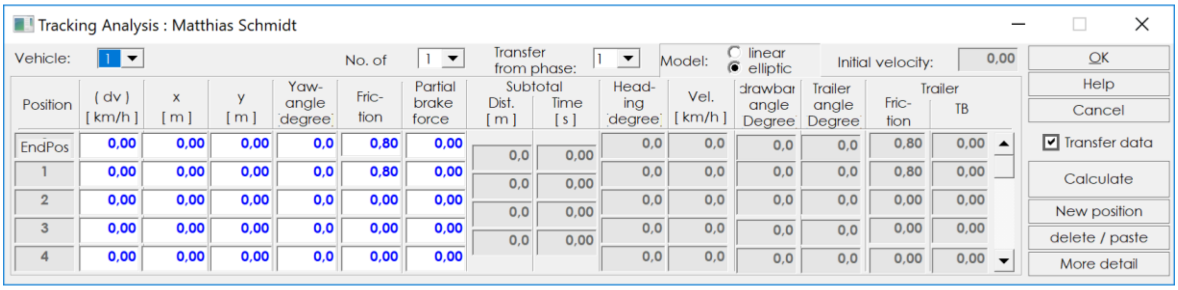
Here you can select the desired minimum, medium or maximum variant for export. In addition, it must be selected whether the pedestrian came from the left or right of the vehicle direction before the collision. This is important because the direction is needed for future pre-collision phases. With the impact factor the deceleration of the vehicle due to the collision is calculated.

$$v_k = v_k' * \left(1 + \frac{IF}{100}\,\frac{m_{Ped}}{m_{Veh}}\right)$$

"Large diagram": Here the diagram can be displayed in a larger version. You can move the frame to make the diagram larger or smaller.

3.7.21 Tracking analysis (backward collision analysis)

(Icon:) The tracking analysis respectively coasting analysis helps to determine the deceleration during skidding, f.e. after a collision, in an easy and fast way.



When opening the coasting analysis, two positions of the predetermined vehicle are placed at the zero point in the Movie. These positions have to be adjusted to the concrete situation either with the mouse or via entering the correct numbers. Position 0 has to be the final position, position 1 the second last, etc... The button "New Positions" places additional positions at the zero point. Alternatively, new positions can be created by moving the mouse to the desired place and pressing the key "p" or "P".

Theory: The method is based on a unicycle model. The thinking behind is that the distance of the focal point is divided into small partial distances (intervals), whereby each interval point is defined by its X- and Y-coordinates in a Cartesian coordinate system. A line (spline) is then positioned along the defined points. The distance results from the numerical integration over this distance. The course angle is calculated in each point with the angular symmetrical line between the directions of the two neighbouring points (= direction of the spline's tangent). For the first and last point, no angular symmetrical line can be calculated because only one neighbouring point is existent in this case. Hence, the same angular deviation between the angular symmetrical line and direction between the neighbouring points is used. The deceleration in every curve point is calculated with the side slip angle. The change of velocity and the time needed for each interval are determined based on the formulas of a buildup phase. It is not absolutely necessary to fix the passage of the side slip angle through 0°, 90°, 180° and 270° with a curve angle. The program takes this passage into consideration by mathematically dividing the interval in two sections.

For example: If the side slip angle of an interval increases from 80 to 100°, the same deceleration can be expected for both 80 and 100°. However, the deceleration reaches a maximum value of 90° in-between and decreases afterwards. Hence, a buildup phase from 80 to 90° and afterwards from 90 to 100° have to be calculated. The program automatically computes approximate values for the user, whereby accuracy increases if a position close to the passage is chosen.

The minimum value mathematically used for deceleration is 0.01 m/s². Data of tracking analysis is saved in a separate data set. The calculation results can be transferred to the main data set. The movement sections are not defined for each interval, but are independent from the number of intervals. In order to ensure that the final velocity, the initial velocity, the total distance and the total time are transferred correctly, only two sections are established. It is not possible to insert too much input data. The total distance is separated into two parts of equal size, then the average deceleration and the velocity in the middle of the distance are calculated for each half. As a next step, the results are transferred to the two chosen sections.

Description of input fields:

"No. of":	Calculation number of tracking analysis. For each vehicle, up to 16 different calculations can be conducted and saved.
"Model":	Selection of calculation model: Elliptical or linear.
"Position":	Interval number. The input is expected to start from the end; hence, the number 0 indicates the end of the movement.
"dv":	Speed level at the end of the interval, if existent. For example, the vehicle could touch the pavement and loose velocity thereof.
"x" & "y":	Cartesian coordinates
"Yaw angle":	Yaw angle of the vehicle at the end of the interval
"Friction (µ)":	Friction (coefficient of friction) in the interval. µ multiplied with g (9,81 m/s²) results in the maximum deceleration in longitudinal direction. The size is used for the deceleration that results from the partial brake force. The transverse deceleration is calculated by multiplying the value with the ratio friction transverse : longitudinal. This ratio is editable at the geometrical data.

	Based on the friction, the partial brake force and a possible ascent or descent, the deceleration is computed. If the value remains 0, the value of the previous interval is assumed.
"Partial brake force":	Proportion of the deceleration compared to a block deceleration, when the side slip angle equals 0 degrees.
"Distance":	Subtotal of distance = distance to the end
"Time":	Subtotal of time = time to the end
"Heading":	Calculated angle at the respective point
"Vel.":	Velocity at the beginning of the respective interval
"Drawbar angle":	Angle between the towing vehicle and the drawbar (only for trailers)
"Trailer angle":	Angle between the trailer and the drawbar resp. The angle between the towing vehicle and the semitrailer
"Friction":	Friction of the trailer (semitrailer)
"TB":	Partial brake force of the trailer (semitrailer)

As illustrated above, the tracking analysis can also be conducted for vehicles with trailers. In order to do so, the partial brake force and the friction have to be defined for the trailer as well. The positioning has to be done graphically. The influence of the trailer is only taken into consideration in the longitudinal direction of movement.

Examples for the partial brake force (reference values):

State of wheels	Partial brake force
Wheels rolling freely	0,01 - 0,1
1 vacuum wheel	0,15
1 wheel jammed	0,25
2 vacuum wheels	0,3
Partial braking on 2 wheels, or 2 wheels jammed on the same side	up 0,5
Both front wheels jammed	0,5 –0,6
4 wheels blocked	1,0

<u>Procedure:</u> With your mouse, catch the vehicle at the coordinate origin and shift it to the final position. Switch to rotation mode. Catch the vehicle on a corner and rotate it to the desired position. In case the pivot is not positioned correctly, you can shift it. Afterwards, the position can be fine-tuned in the respective input field. Now

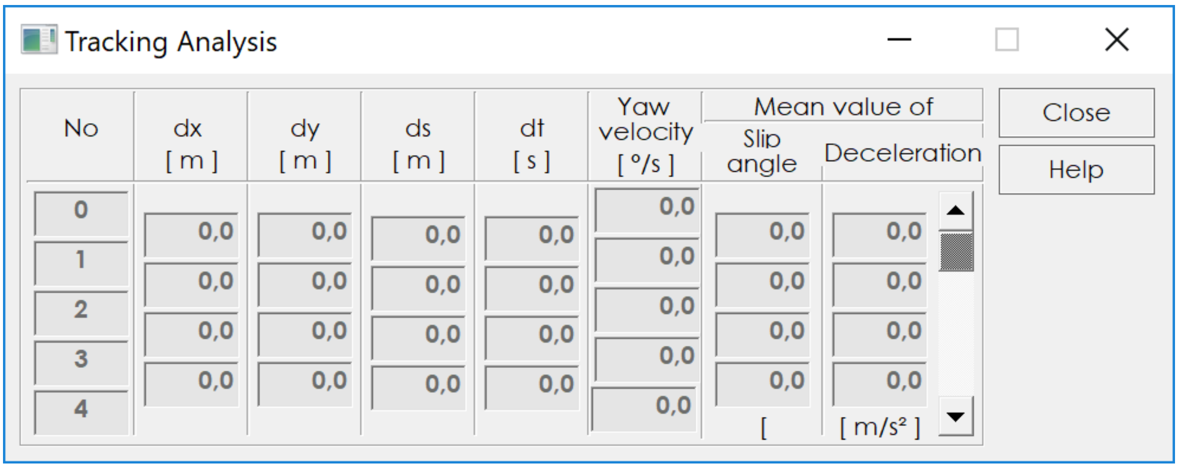
shift the second vehicle to the desired position and rotate it. Further positions are added with the button “New position”.

If all desired positions have been defined one after the other, the friction values and the partial brake force have to be added for the intervals. As a default value of friction, the pre-set value defined under “Options/Settings/General“ is assumed.

Push the „Calculate“ button to start computations. As a first step, distances, velocities, etc. as well as the track of the centre of gravity and the course of the yaw angle are stated. The vehicle’s skid can be viewed in the Movie. If a correction is necessary, you can either change the input in the row relating to this position or you select the vehicle in the desired position in the Movie and correct the position with the mouse or cursor button.

"More detail": Further results can be investigated here.

No	Interval number
dx	X- component of the interval
dy	Y- component of the interval
ds	Length of the interval
Yaw velocity	Yaw velocity at the respective point
Side slip angle	Average side slip angle in the interval
Deceleration	Average deceleration in the interval



Attention: The results have to be examined critically, as deviations of several km/h are possible depending on the velocity range. The precision of calculations depends on the correct estimation of the friction value and the partial brake force.

A partial brake force has to be set for vacuum wheels, whereby the cornering force in the friction value has to be taken into consideration. If a vehicle loses its ground contact temporarily, it has to be taken into account for the friction value as well. For a vehicle sliding along its roof, it is recommendable to set the partial brake force to 1 and to adapt the friction value according to the friction between roof and road.

Tip: Rolling vehicle: If a vehicle with smashed wheels moves into its final position, consider that the arched movement might cause a side slip angle with a mathematical deceleration that is probably too big. Compensate this error by adding a low friction value. The average friction value in the respective interval serves as a good reference point and control mechanism ("more details").

Partial brake force – Example: Area 1 is characterized by a friction value of 0,8, area 2 has a friction value of 0,2. A new position has to be defined both at the position at which the vehicle leaves area 1 as well as at the position in area 2 at which the vehicle has reached the low friction value. Between these two positions, the deceleration can decrease then.

If a backward analysis is conducted, the tracking analysis for two vehicles can be opened simultaneously. This allows you to adjust the collision positions of the vehicles more precisely.

After finishing the tracking analysis, the collision analysis can be opened next. The question whether the tracking shall be imported needs to be answered with "Yes". Before starting with the calculations, the tangent has to be adjusted and possibly a deformation has to be set.

If a value is changed in the tracking analysis while the collision analysis is open, the calculation in the collision analysis is automatically updated.

3.7.22 Collision analysis backwards

You can directly call up the collision analysis backwards from track tracking. Here you can choose between the EES backward and the impulse backward method.

"Momentum backwards": After the coasting coasting analysis (tracking analysis), the results are transferred to the impact analysis and the program automatically switches to „Momentum backwards“. This means that the solution is primarily investigated by applying the principle of linear momentum.

"EES backwards": Analogously to the procedure of „Momentum backwards“, this option is used if the direction of the initial momentum is substituted by the equation defining the law of conservation of energy. With this calculation option, the course angle of one vehicle before the collision is required.

Comparison of the required input parameters Momentum/EES backwards:

	Momentum backw.	EES backwards
Vehicle 1		
Direction momentum after collision	+	+
Absolute value momentum after collision	+	+
Direction momentum before collision	+	
Absolute value momentum before collision		
Spin after collision	+	+
Spin before collision	+	+
EES-value		+*
Vehicle 2		
Direction momentum after collision	+	+
Absolute value momentum after collision	+	+
Direction momentum before collision	+	+
Absolute value momentum before collision		
Spin after collision	+	+**
Spin before collision	+	+
EES-value		+

* . . . . can also be calculated with the structural formula

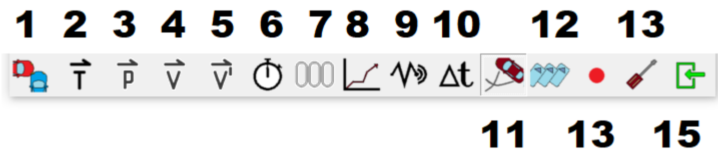
** . . . can be calculated iteratively from the calculated pre-impact data.

Since the track tracing positions have a large influence on the calculation result in a backward analysis, the track tracing remains open during the calculation process. If tracking positions are changed, the result is calculated directly into the collision analysis mask and the result of the total calculation is displayed.

In the backward analysis, the k-factor and the coefficient of friction are calculation results and therefore serve as control parameters. If the values have an untypical behavior, they are highlighted in red in the mask. This is intended as an aid, but does not necessarily mean that the calculation is wrong just because a value is highlighted in red.

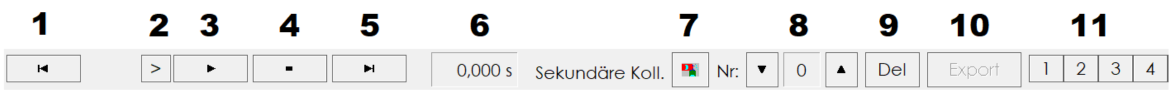
3.7.23 Kinematic data

(Icon: ) The described possibilities of the backward analysis are still limited, as they depend on the availability of tracks. In contrast, the forward analysis with its mathematical model offers a universal procedure. Various driving and skidding movements of quadricycles (f.e. skidding and coasting, acceleration and braking, steady-state circular tests, braking in curves, etc.) can be calculated. The validity of these computations depends on the mathematical method applied to the analysis. Procedure: The mathematical model is started at an arbitrary position of a fixed coordinate system with pre-set base values. It moves in defined time intervals under consideration of external forces (wheel forces, wind, incline). The wheel forces and the underlying wheel characteristics are most important in this procedure. Mathematical substitute models can be found in large numbers and with varying level of detailedness. The complete simulation of a driving manoeuvre requires many input sizes which all have to be determined correctly before the start. In order not to overexert the user, certain compromises have to be found. Hence, parameters with only a limited impact on the movement are more or less neglected. Based on these simplifications, an expert can decide whether the model is applicable to a certain situation or not.



1. Open the mask for collision analysis
2. Contact area
3. Movement vector
4. Velocity vector before impact
5. Velocity vector after impact
6. Basic data
7. Show coordinates during the simulation
8. Show diagrams
9. Show sensor signals
10. Show Delta – t position
11. Show skid marks
12. Stroboscopic depiction
13. Recording function
14. Movie Options
15. Cancel

<u>Attention:</u> The window of kinematic data cannot be cancelled during a sequence. Hence, the button is not active during that time. Please do not try to close the window during a sequence with the X button on the right upper corner, as this would provoke a program crash.

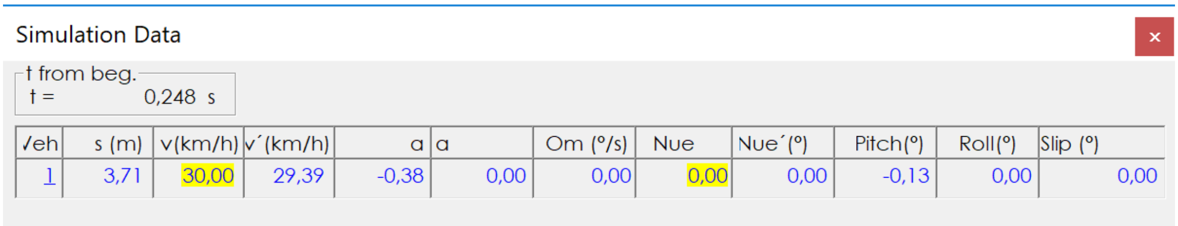


1. Positions the vehicle at the beginning
2. Slider (after pressing „Record") and positions the vehicle 1 ms further
3. Start Movie
4. Stop Movie
5. Positions the vehicle at the end of the sequence
6. Shows the simulation time starting with the begin of the sequence
7. Calculation a secondary collision

8. Selection of a secondary collision
9. Deletion of a chosen secondary collision
10. Export into the kinematics (after pressing “Record”)
11. Activating/Deactivating vehicles

"Basic data": The start values for the simulation are entered here. If the vehicle is rotated in the graphics, the course angle rotates in a parallel way as well. In case this is not intended, the desired value can be inserted at the basic data.

"Coordinate data": When turned ON, a window with the values of the activated vehicles is displayed.


Simulation Data

t from beg.
t = 0,248 s

Veh	s (m)	v(km/h)	v´(km/h)	a	a	Om (°/s)	Nue	Nue´(°)	Pitch(°)	Roll(°)	Slip (°)
1	3,71	30,00	29,39	-0,38	0,00	0,00	0,00	0,00	-0,13	0,00	0,00

s	Covered distance	aq	Lateral acceleration
v	Initial velocity	Om	Yaw velocity
v'	Current velocity	Nue	Initial yaw angle
a	Total acceleration	Nue'	Current yaw angle
Nick	Pitch angle	Wank	Roll angle

"Diagrams": The curves can be turned on and off separately or in blocks of velocity, acceleration, angle, etc.

"Curve selection": The diagrams of only one vehicle can be shown at a time. The selection is divided into blocks. If a certain button is selected, f.e. the one next to velocity, all diagrams except the ones of the three velocities are deactivated and only these three displayed.

"Total" indicates the velocity of the centre of gravity.

"Longitudinal" indicates the velocity in longitudinal direction of the vehicle.

"Lateral" indicates the velocity in lateral direction

You can create various combinations of diagrams by clicking on the respective boxes on the left. Use the button “+Koll”, if you would like to view the acceleration caused by collision. The change of selection will come into effect when you close the diagrams and open it the next time.

Ruler ON/OFF

"Close"

"Sensor data": Shows the measured data of the sensor.

"dt – Position": Displays the position of all activated vehicles at a point in time that has to be defined under „Settings“. If the time is greater than the total sequence, the end position is depicted. The data is automatically updated when values of the vehicles are changed.

"Skid marks": Activate/Deactivate the display of skid marks here.

"Stroboscopic depiction": Separate sequence positions from all activated vehicles in the predetermined time interval („Interval for intermediate position”) are depicted. The stroboscope can be switched on or off for single vehicles in the settings of the respective vehicle.

"Record": After the calculations for the collision analysis are completed, the results can be exported to the cinematics section. Having pressed the button, the slider appearing to the left of the “Play” button may be used to control the temporal position of the depiction. Furthermore, the “Export” button is enabled and allows to export the data to the cinematics section.

"Movie options": A precise description can be found in the chapter „Impact analysis“.

"Cancel".

3.7.24 Collision analysis forward

(Icon: ) The collision analysis in the momentum forward method is used to calculate collisions by varying the input parameters. You can choose between three options of the dialogue window. The large window contains all relevant variables, the middle one was reduced by the structural data and control parameters. However, additional data can be displayed via the newly implemented dialogue box "Parameters". The small mask contains only the most important collision data.

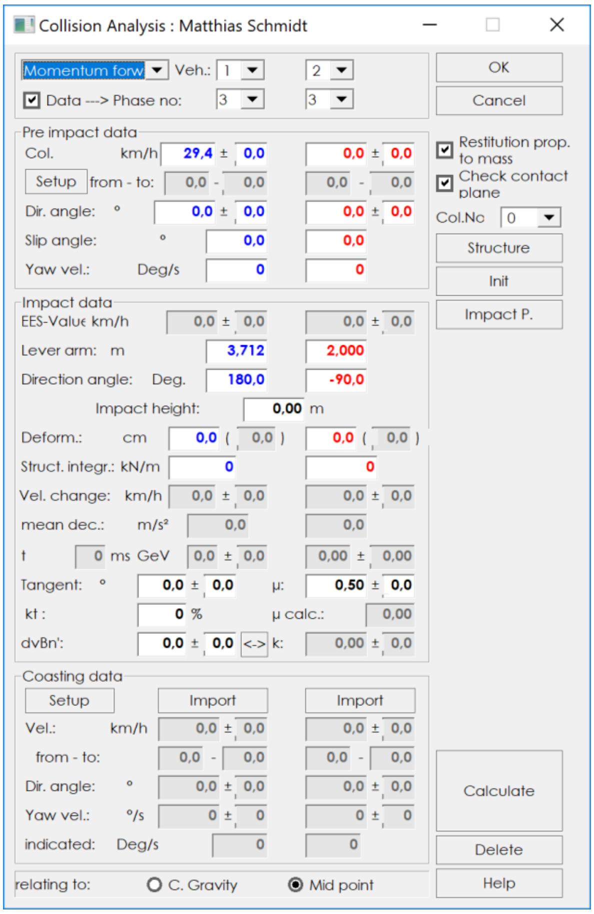
A drop-down menu in the module allows you to choose between the 3 types. The default dialogue can be defined under "Options" → "Settings" → "Collision".

As a basic setting, section number 3 is suggested, which would make it possible to define a coasting in sections 1 and 2, for example via an export to tracking analysis. During the export, the program checks whether the section number is big enough and automatically corrects it if necessary. If secondary collisions with other vehicles take place during coasting, further collisions have to be transferred to the main data set and in each case two sections need to be available in-between for tracking analysis.

"Momentum forwards": The coefficient of friction required for a stictional vibration is calculated. If this value is smaller than the input value, a stictional vibration is computed, otherwise an impact with slipping off is assumed. A stictional vibration is defined as an impact for which the components of the contact point velocities parallel to the tangent are of equal size after the impact. As a precondition, no restitution in the direction of the tangent may take place. Hence, the tangent has to orientate itself in a way that the deformation points to the direction of the normal of the impact. In case a restitution has taken place in the direction of the tangent as well, it can be considered with the size “kt”. “Kt” is expressed as a percentage; 0% indicates no restitution in the direction of the tangent, 100% indicates a restitution of equal size in both the direction of the tangent and the normal.

3.7.24.1 Small dialogue

The small dialogue mask comprises the most essential parameters for impact analysis. Control parameter can be viewed under „Parameter“. There are no mathematical differences between the calculations in the small and large dialogue mask.



3.7.24.2 Large dialogue

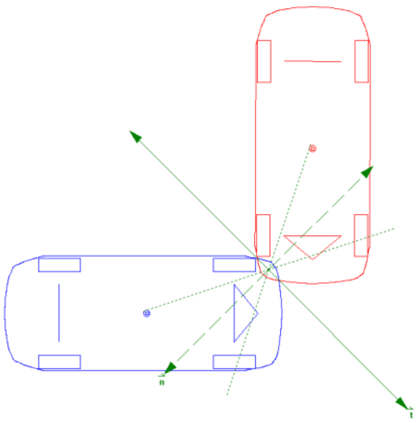
"Restitution proportional to mass": For the structural calculations, you can switch between a restitution proportional or non-proportional to mass:

"Restitution proportional to mass": 3 out of the 6 values (2 EES values, 2 deformations and 2 structural stiffness values, subsequently called “structure items”) have to be given. For the calculation of the principle of linear momentum (forward and backward) the sum of the deformation energy is calculated and the EES values are allocated based on the structural formula. Consequently, deformation energy is classified as a given value and only two further values are required.

"Structure": This button loads a mask for the definition of structure.

"Init": Initialize the structural calculations.

"Imp. P.": The position of the impact point and the tangent can be calculated here. For these calculations, the tangent is positioned parallel to the points of intersections of the chassis. The ratio between the stiffness levels indicated in the kinematic data section is taken into consideration, The impact point can be found in the middle of the enclosed area for vehicles with an equal level of stiffness, otherwise it is shifted to the softer vehicle.



Attention: The calculation is only possible in the sketch depiction, but not in the DXF depiction. The DXF depiction needs to be deactivated for the determination of the impact point and the automatic calculation of secondary collisions.

It is advisable to consider the calculation as a suggestion subject to verification and possibly correction. You can select to depict the vehicles with deformations after the collision. The vehicles are deformed along the contact tangent. Note that this option is only available in sketch mode, but not in DXF depiction. The advantage of deformation is the determination of the impact point for subsequent collisions.

The second block is dedicated to pre-impact data. The field in which you enter data first functions as an input field, the other one as a calculation field. Pressing the button “Init” releases the blocked calculation fields and makes a new input possible.

"Coll. speed": Collision speed with regard to the middle of the vehicle. The conversion to the centre of gravity is done automatically.

"Direction": Direction of the vector of the collision velocity

"Slip angle": Deviation of the direction of the vehicle’s longitudinal axis (yaw angle) from the course angle.

"Omega": Yaw angle, indicates the angular velocity of a potential vehicle rotation.

If the course angle or the slip angle is changed, the yaw angle changes as well. The resulting rotation of the vehicle is done around the impact point in order to preserve the lever arm and the direction angle. The position of the centre of gravity changes.

In the input mask for basic data you can add the values for the collision velocity, the course angle, the yaw angle as well as the coordinates of the centre of gravity. All values relate to the centre of gravity here. If the course angle or the yaw angle is changed, the vehicle needs to rotate around the centre of gravity. In this case, a correction of the impact point might be necessary.

The third block serves the input of „Impact data“ as well as the depiction of control parameters.

"EES value": Energy Equivalent Speed.

"Lever arm“: Distance between the defined impact point and the centre of gravity.

"Angle": Angle between the vector from the centre of gravity to the impact point and the direction of the vehicle’s longitudinal axis (yaw angle). The front centre is positioned at 0°. Points to the left are positive, points to the right are negative.

"Contact height": Height of the impact point above the ground. If the value is 0, the impact is calculated 2-dimensional and the contact height remains unconsidered.

"Deform.": Permanent deformation equivalent to energy speed. The dynamic deformation is stated in brackets.

"Stiffness": Average value of structural stiffness of the deformed area. From a mathematical point of view, it is the slope of the approximate line in the force-distance-curve.

"delta v": The absolute value of the change of the velocity vector before – after the impact. This item does not have to be equal to the difference between collision velocity and coasting velocity.

"Mean dec.": Mean deceleration caused by collision

"t (coll)": Duration of the collision in milliseconds. The impact duration is not transferred for secondary collisions.

"GeV": This control parameter provides information on the type of impact. Central impacts without slipping are usually characterized by a value between 0.75 and 1.2. Impacts with slipping usually show a value below 0.75.

"Tangent": Direction of the defined contact plane at the impact point.

"kt": k-factor in the tangent direction. The value is indicated as a % of the k-factor (0 – 100%). 0% means that no restitution takes place in the direction of the tangent, 100% implies a restitution to the same extent as in the direction of the normal.

"µ": Limit to the coefficient of friction (= tangent of the maximum allowable angle between impact normal and impact drive).

"µ calc.": Actual (calculated) coefficient of friction (= tangent of the actual angle between impact normal and impact drive). "µ calculated" is always smaller or equal to the limit to the coefficient of friction.

"dvBn'": This abbreviation stands for the difference of the velocities of the impact plane in direction of the impact normal. Usual values range between 5 ± 3 km/h. The values previously observed for passenger cars/passenger car collisions range between 0 and 12 km/h.

"k.": The k-factor („impact figure") provides information on the degree of deformation recovery and has to range between 0 and 1. Among other factors, it depends on the value of dvBn'.

Tip: Either k or dvBn' can be inserted for the calculation mode „Momentum forwards".

The fourth block is dedicated to coasting data, i.e. post-impact data.

"Import": A click on these two buttons imports data of tracking analysis (coasting analysis) for the respective vehicle.

"Velocity": Velocity immediately after the collision (middle points of the vertical wheel force) = Point linked to the driving line. This value is also imported for the tracking analysis.)

"Direction": Direction of the vector of velocity (centre)

"Yaw velocity": Angular velocity (value from tracking analysis)

"Induced": Induced (calculated) angular velocity "referring to: C.G. (= centre of gravity)": Displays the velocities and directions of the centre of gravity, i.e. the values referring to the centre of gravity.

"referring to: midpoint": Displays the velocities and directions of the vehicle’s midpoint. This is because the velocity of the midpoint is needed for kinematics. The value can be determined with tracking analysis, whereas for the collision analysis the velocity of the centre of gravity is required. The calculations in the collision analysis are always conducted with the values referring to the centre of gravity. Whether the values referring to the centre of gravity or to the midpoint are displayed is saved in the Registry as a default setting for new reports.

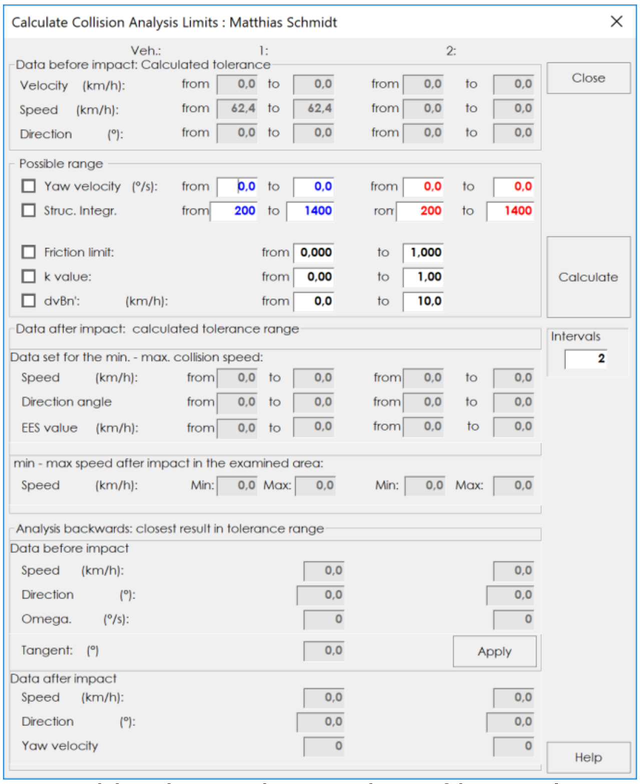
You can specify a band width for several input fields. For calculations, the input value is impinged with the band width positively as well as negatively. Then, all possible combinations are computed. After each calculation, the program checks whether the k value can be found within the valid area (0<k<1) and if the coefficient of friction is physically possible. If not, the result is ignored.

After a coasting analysis (tracking analysis) has been conducted, the results are transferred to collision analysis and the calculation mode is automatically set to „Momentum backwards“. In case you want to work with „EES backwards“, you have to switch to it manually. As the yaw angles of the vehicles are known from tracking analysis and can, hence, be assumed as determined, the items course angle and side slip angle before the collision depend on each other:

Yaw angle = course angle + side slip angle

If one of the two items course angle or side slip angle is amended, the other automatically changes as well to keep the yaw angle constant. This correction only takes place if the data have been imported from tracking analysis.

3.7.24.3 Setup



In the „Setup“ menu you can determine an allowable range for the EES values, the coefficient of friction and the k value. Based on these values, a tolerance zone for the pre-impact data (for backward calculations) resp. coasting data (for forward calculations) is computed. At the same time, a possible area for the input data is created: This calculation, which is quite useful for the adaption to control parameters, divides the tolerance areas defined in the collision analysis mask in intervals and conducts a variation of all possible input combinations. The number of intervals can be defined by the user. The higher the number of intervals, the more calculations are carried out.

Tip: In case you find no solution and initiate a high number of variations, AnalyzerPro might need some minutes for calculating! You can cancel the calculations anytime with the “Esc” button.

Under the section Coasting analysis in the collision analysis window, you specify the area in which solutions shall be searched for; the setup window shows the area that fulfils all conditions.

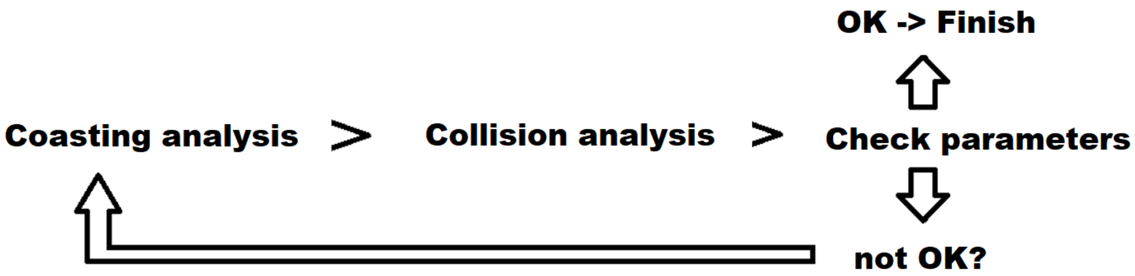
"Data after impact: calculated tolerance range": Two velocity ranges are displayed for coasting. The first row in this section, “Speed from – to“, states the values of the coasting movement which lead to the smallest resp. largest calculated collision velocity. The section „min – max speed after impact in the examined area“ shows the smallest resp. largest possible values within the specified tolerance area with all fulfilled conditions. The input of these values for the collision analysis does not necessarily result in the smallest resp. largest possible value of collision speed.

"Analysis backwards: closest result in tolerance range“: Deals with impact optimization. The program calculates the values for the pre-impact and post-impact data which are within the band width, fulfil all conditions and are closest to the input data. Subsequently, you may calculate the post-impact data within the possible band width in the tracking analysis anew and import them into the collision analysis.

The input values can be transferred to the collision analysis with the button „Apply“. In case a tracking analysis was conducted previously, the actual correction of coasting data has to be done there to ensure that data of the tracking analysis and of the collision analysis harmonize with each other.

3.7.24.4 Flowchart and problem-solving

Basically, no coasting analysis can be conducted with 100% precision. Therefore, various control parameters of the collision analysis are needed to detect the need for possible amendments in the coasting analysis. All amendments have to align with the track record and possible coefficients of friction.



Frequent error messages:

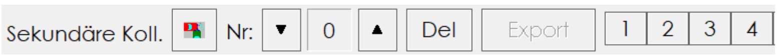
k value too big:	
v_{bn1}' too big	v_{bn2}' too small
Possible solutions:	
Reduce v_1' (if EES value too high)	Increase v_2' (if EES value too small)
Coasting direction 2 flatter	Coasting direction 2 flatter
Reduce yaw velocity 1	Increase yaw velocity 2

k value too small: reverse process

µ value too big	
v_{bt1}' too big	v_{bt2}' too small
Possible solutions	
Reduce v_1' (if EES value too high)	Increase v_2' (if EES value too small)
Coasting direction 1 steeper	Coasting direction 2 flatter
Reduce yaw velocity 1	Increase yaw velocity 2
Rotate tangent	Rotate tangent

<u>Tip:</u> If you want to receive an amendment proposal, switch to forward calculation, insert the target figures for the k factor and the coefficient of friction there and conduct a calculation with this value. The results of the coasting analysis give you a hint on what to change.

3.7.24.5 Secondary collision



"Secondary collision" (): If you stop the sequence at the moment of a secondary collision, you can initialize a second collision by clicking on this button. Given that the same vehicles are involved, only the contact point the tangent, the coefficient of friction and the k value have to be defined. As collision velocities and directions are assumed from the sequence, the respective fields remain blocked. If a third vehicle is involved in the secondary collision, the respective vehicle number has to be set and the collision number needs to be increased. Otherwise, existing data in the main data set is overwritten with secondary collision data.

: You can switch between the secondary collisions with this button.

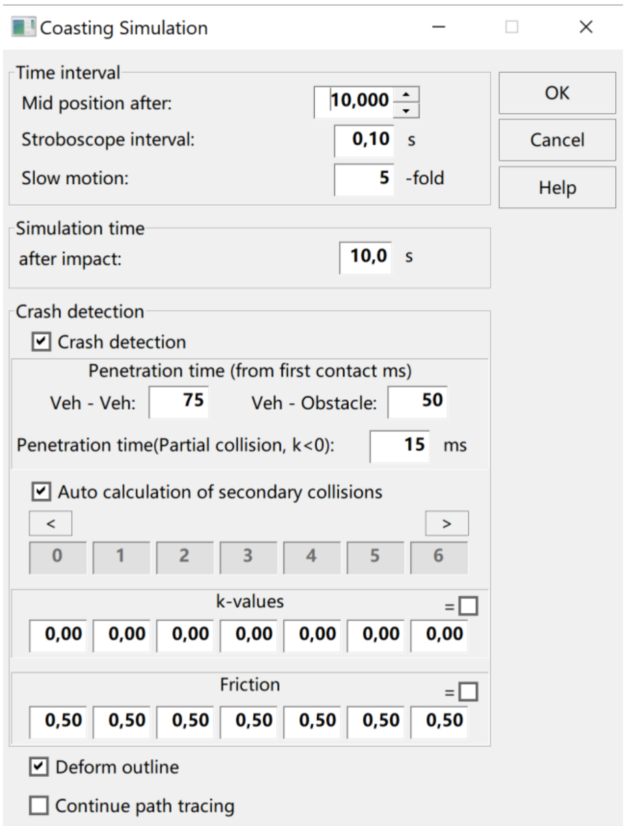
"Delete" (

): Deletes secondary collisions. Activate resp. deactivate vehicles with the numbers bar next to it.

"Export": Export the simulation to kinematics and transfer the data to the main data set. The section numbers for the main data set are automatically allocated by AnalyzerPro; kinematic data of the coasting movement and the collision is loaded accordingly.

Attention: As the data of tracking analysis in the main data set cannot be calculated with a constant deceleration, two sections have to be transferred. A full consistency with the simulation is impossible, however, the movement itself as well as the average deceleration calculated from the simulation are loaded. Even for collision analysis, data can be exported into tracking analysis in backwards calculation. If data from tracking analysis is existent, the program overwrites it – of course after having asked for permission.

3.7.24.6 Coasting simulation



"Mid position after": Calculated position of the vehicle after the defined time. If the value is big enough, the final position is displayed.

"Stroboscope interval": Interval for the stroboscopic depiction.

"Slow motion": Value range from 1 (fast) to 100 (slow).

"Simulation time after impact": Duration of sequence. If the value is big enough, the final position is depicted.

"Crash detection": Activates the automatic crash detection.

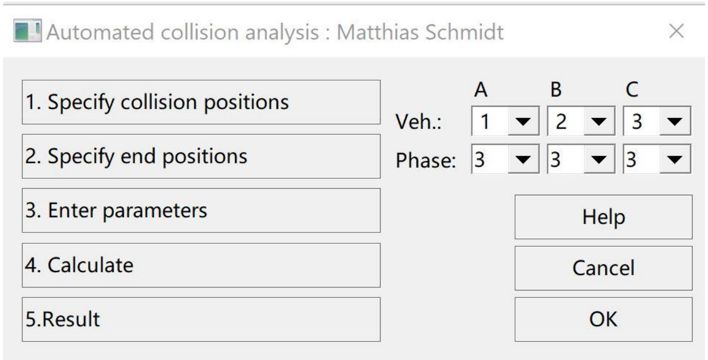
"Penetration depth (first contact ms)": Time frame from the first contact to the defined collision time (which should be the time of maximum impact force). The value is used if “crash detection” finds a new vehicle resp. obstacle and switches to a different vehicle and collision number.

"Penetration time (Partial collision, k<0): Time frame from the first contact to the defined collision point for secondary collisions. The time frame may be shorter if the collision is divided into partial collisions, then the sequence of the k factors has to be defined accordingly. At the beginning of the collision, the k factor should be negative so that the vehicles can penetrate each other further; towards the end of the collision, the value must become positive again.

"Auto calculation of secondary collisions": Calculates possible secondary collisions simultaneously to the simulation sequence. During the sequence of the simulation, the program also investigates whether the respective vehicle overlaps with other vehicles. If yes, it examines after the sequence of the defined penetration time whether the vehicles penetrate each other further, and if this is again the case, a collision is calculated. The position of the impact point and the orientation of the tangent is then calculated. The subsequent collision analysis takes into consideration the k factor defined for the respective secondary collision as well as the coefficient of friction.

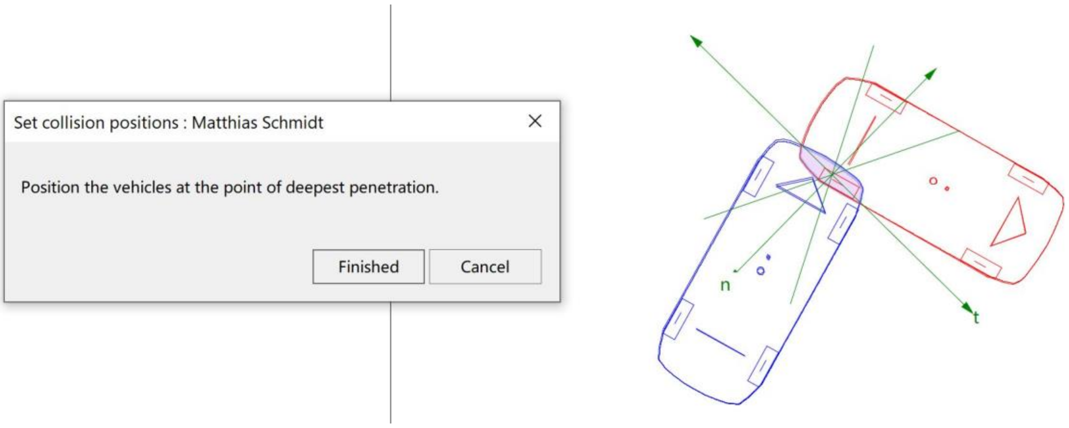
3.7.25 Automatic Collision Analysis

(Icon:) This module performs the collision analysis in forward direction automatically. The task of the user is to define the framework conditions, the underlying algorithm then outputs the optimal solutions for the given problem. Menu items 1 - 3 define the framework conditions for the optimization process, item 4 starts the calculation process and under item 5 the results can be viewed and transferred. The third vehicle can be selected as a stationary obstacle.



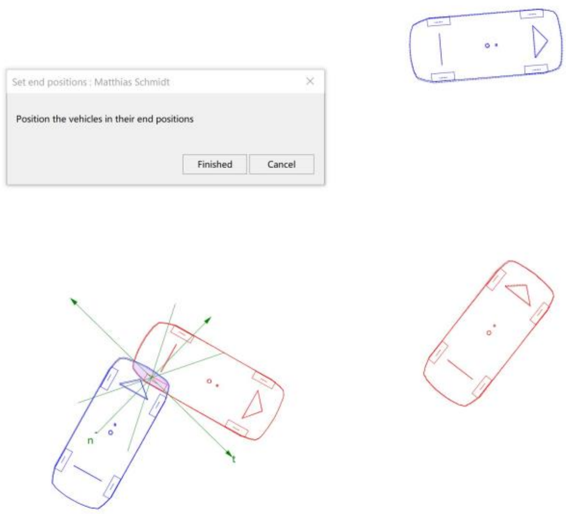
1. Specify collision positions

If you click on this submenu, 2 (resp. 3) vehicles and the impact tangent appear. The vehicles must now be moved to the corresponding collision position at the time of force transfer. The overlapping area is highlighted in blue and the impact tangent is automatically positioned in the middle of the overlap. If available, the stationary obstacle must also be moved to its position.



2. Specify end positions

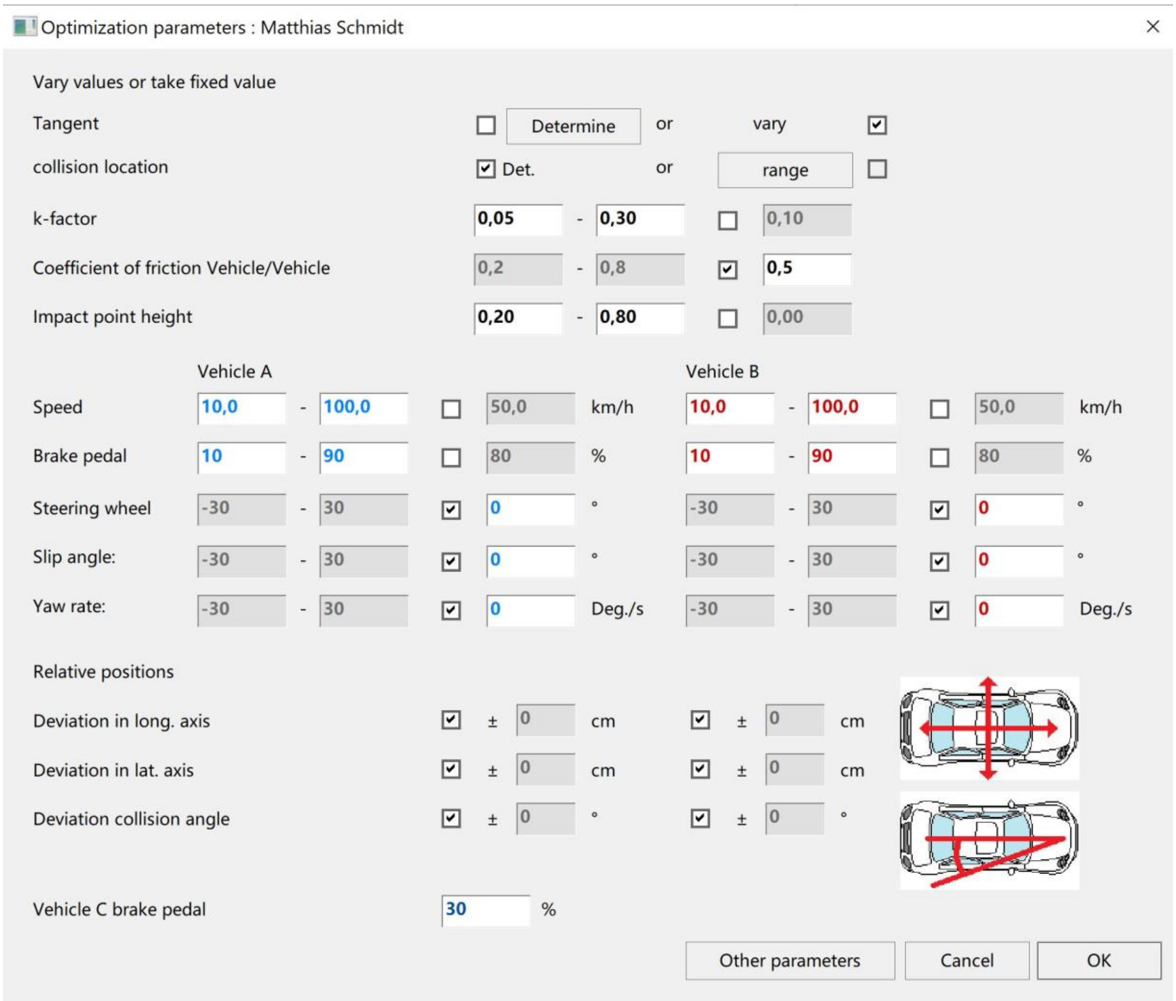
Here, the appearing vehicle silhouettes must be moved to the end positions.



3. Enter parameters

In this menu, parameters can be set or defined as variable. You can either select fixed values or specify ranges, within which variation is required. If the impact point is varied, this is always done within the overlap specified at the beginning. Furthermore, it is possible to define an area for the collision if the exact collision location is not known. The relative positions of the vehicles to each other can be varied via the relative positions.

Under "Other parameters", time-dependent parameters can be defined and the coefficient of friction and k-factor for secondary collisions can be varied.

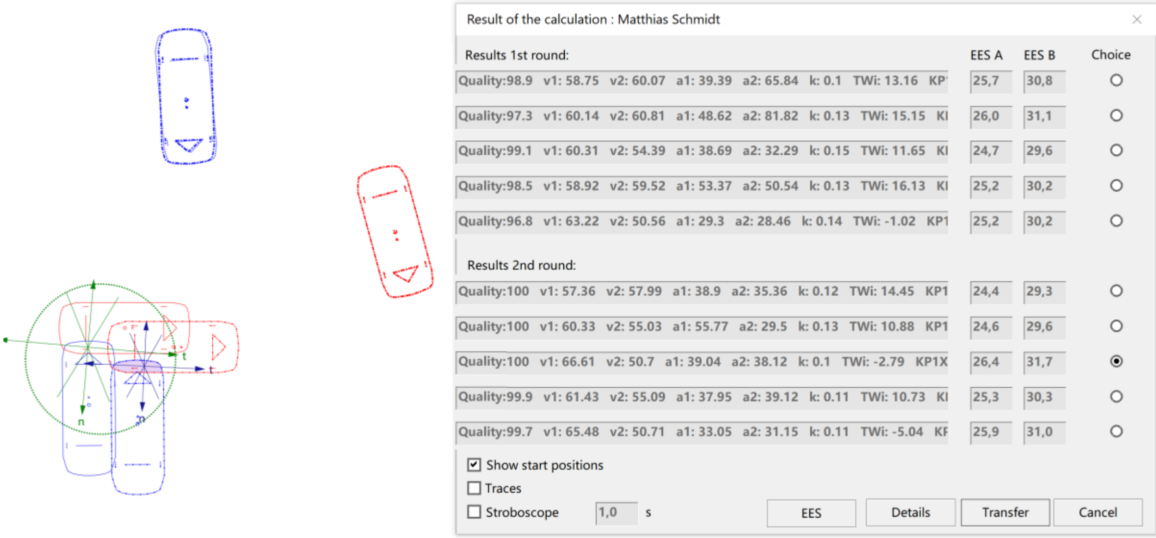


4. Calculate

As soon as this button is pressed, the calculation process starts. The results are indicated with their corresponding qualities. The best possible quality for a calculation is 100. In range 1 the calculation is aborted prematurely if at least a quality of 80 has been reached, in range 2 if a quality of 99 has been reached. Depending on the number of parameters to be varied and the computing power of the computer, the computing time may vary. The calculation can be aborted at any time whereby results that have already been determined can then be used immediately. When all 10 calculations have been performed, window 5 appears automatically.

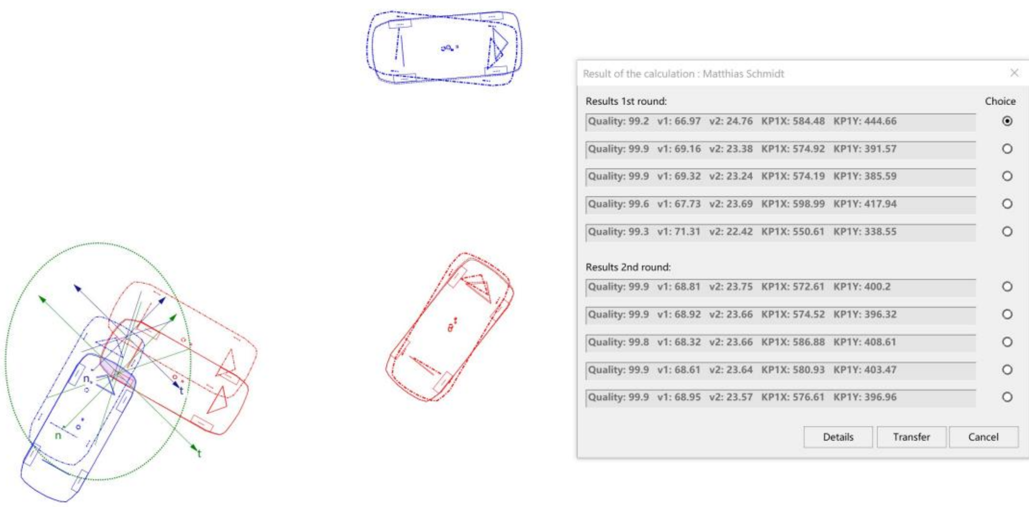
5. Result

Here all determined results are output with the respective quality. If the respective result is selected, the determined end position (and if necessary the collision position) appears in Movie View. By clicking on "Transfer" the calculation is transferred to the collision analysis and the main data mask.



3.7.26 Rear-end impact

(Icon: ) This module deals with collisions (calculation of differential speed, etc.) with negligible rotation, as it is often the case for rear-end collisions. For vehicles with a trailer, the trailer mass is added to the vehicle mass. The same holds true for EES masses.



3.7.26.1 2 Vehicles

The module „Rear-end impact – 2 vehicles“ differentiates itself from the analogue module „Rear-end impact – serial collisions“ only by its more easily comprehensible interface.

3.7.26.2 Serial collisions

Serial collisions can only be conducted after the input of vehicle data. The sequence of vehicles and their allocation to numbers can be specified.

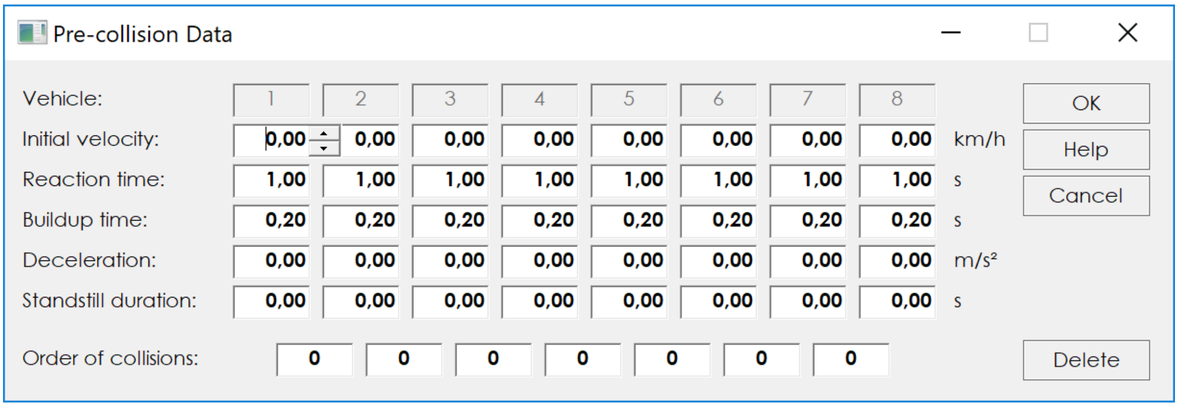
"Restitution proportionally to mass - yes: ☐ no: ☐ ": This field only serves explanatory purposes. Whether the restitution for a certain collision is in proportion to mass or not can be defined in a field that is positioned exactly between the involved vehicles. The restitution with no proportion to mass can be used with and without defined structure. As soon as a structure has been defined and the restitution proportionally to mass is deactivated (no tick between the vehicles), the defined structure is applied.

Serial collision with up to 8 vehicles can be calculated. Up to 4 vehicles can be displayed at a time. You can shift the display of vehicles with the scroll box (

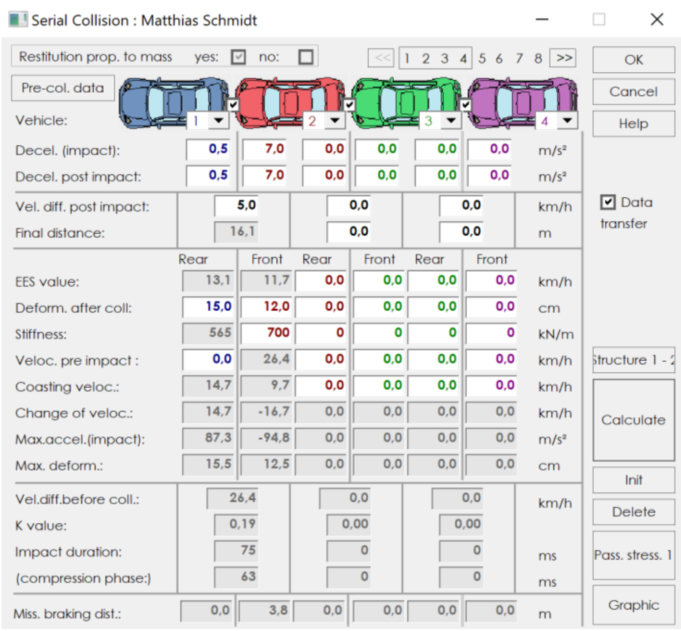

). The calculation of differential speed is only conducted for the two vehicles for which data characterizing the damages are available. In accordance with the input mask, the calculation is conducted from left to right.

Description of input fields: The schematic depiction shows 4 vehicles in order and with different colours. In each vehicle you can find an input field for the vehicle number. Allocating vehicle numbers different from the natural sequence may be useful if, for example, the police protocol already contains a different sequence (f.e. last vehicle as no. 1) or if a vehicle in the middle was able to avoid collision with a pullout-manoeuvre. Each column below belongs to one vehicle and shall contain data on the respective vehicle only. For the ease of use, the values inserted in the fields have the same colour as the vehicle to which they belong to (adjustable). For collisions with only two vehicles, insert data in the first two columns only and ignore the other vehicles.

"Pre-collision Data": In order to define 3 (with standstill 4) movement sections before the collision, open the „Pre-collision Data“ menu and insert the respective values for initial velocity, reaction time, buildup time and deceleration. If you insert 0, the distance-time graphic will draw the curves from the beginning of collision only. It is also possible to specify a time of standstill. In case the calculation shows that standstill at the time of collision is not possible for the respective car, an error message will inform you about it.



"Order of collisions": Specify the order of collisions by allocating numbers from 1 to 7 to the respective columns. If the velocities of each column do not match and make the proposed sequence impossible, the program informs you about it and changes the order automatically. The order has no effects on the calculation value in the module but on the temporal sequence. Hence, consequences can be seen in the diagrams and in the Movie. If you do not specify an order, the program automatically searches for a plausible solution. Please bear in mind that sometimes several solutions are possible.



"Deceleration (Impact)": Specify this value to consider tire friction during the collision.

"Deceleration post": The definition of this value is obligatory for the creation of a distance-time graphic or the depiction of a Movie sequence. Furthermore, it is advisable to state the pre-collision data as well. For calculations of differential speed, the specification is not necessary.

"Velocity difference post impact": Velocity difference immediately after the solving of the two vehicles. The elastic – plastic behaviour is adjustable with this item.

"Final distance": Distance of the vehicles in their final position. A negative final distance indicates that a secondary collision has occurred, but was not considered in the calculation.

Tip: If none of the four velocities (velocity pre-impact and coasting velocity of both cars) is available, the final position provides an additional equation with which the velocities can be calculated. The input item “Final distance” then refers to the value that both vehicles have if no second collision takes place. On the contrary, the calculated value refers to the actual value of the final distance, whereby a second collision caused by a third vehicle is taken into consideration. A potential secondary collision of the same two vehicles cannot be considered. In case of a secondary collision, f.e. if a second collision between the second car and the third car leads to a secondary crash between the first and the second car (the second car crashes into the first car a second time), the ignorance of secondary collisions might lead to a negative final distance. In this case, set the conditions for the secondary collision in the graphic or in the Movie and add an additional collision phase in both vehicles with the help of the main data set. The values can be calculated in the module “Serial collisions” using unoccupied vehicle numbers.

Subsequently, you find 4 columns again. Each middle column features 2 input fields that relate to the „Front“ (left field in each column) respectively „Rear“ (right field in each column) of the vehicle.

"EES value": Equivalent energy speed.

"Deform. After coll.“: Permanent depth of the deformation in impact direction. But be careful: If f.e. a vehicle’s body panel recoils like an outer skin of the bumper without considerable force transmission and the actual vehicle damages, which have also evoked a force transmission, lie behind, the outer skin of bumper needs to be completely neglected and only the deformed parts with regards to the deformation depth as well as the structural stiffness have to be considered. Keep in mind that the permanent deformation is specified in impact direction. If f.e. the vehicle's hood with its incline downwards is extensively dented, not the extension of damage in the vehicle's longitudinal direction has to be considered, but the value about which the entire deformed area has shifted. In some cases, this value might be considerably smaller.

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"Stiffness": Average value of stiffness in the deformed area, i.e. the slope of the approximate line in the force-distance curve.

A calculation is conducted if enough data is available for two vehicles in a row. Collision data between two vehicles is calculated independently from the one of two other vehicles. For the calculation of differential speed at the time of collision you need the following information:

1. Differential speed of the vehicles after the collision; a value of 0 indicates a completely plastic collision.
2. At least one value of the three items EES value, vehicle deformation and structural stiffness per vehicle has to be known. Of both vehicles together, you need three or four items (depending on "deformation proportional or non-proportional to mass"), as the items are interdependent.

If too few information is available, but the structural stiffness of the front vehicle is given, the deformation depth is assumed to be 0.0001 m. With this value, even practically elastic collisions can be calculated; only the two values for structural stiffness have to be defined. The velocity difference before the collision is then solely defined by the velocity difference after the collision, the values are the same (generally not more than 5 to 7 km/h). This calculation can become necessary if the acceleration of passengers respectively its upper limit shall be computed subsequently (f.e. in the case of alleged cervical traumata without vehicle damages). Surplus values are calculated after notification by the program. If you set the EES value and the deformation of a vehicle to 0, AnalyzerPro assumes an elastic deformation (i.e. complete restitution). In order to enable a calculation, at least the structural stiffness in the deformed area of the vehicle have to be specified. Please keep in mind that the elastic restitution causes a relatively high differential speed after the collision; the smaller the structural stiffness of the vehicle with the elastic behaviour, the higher the differential speed. Instead of an elastic restitution, it is recommendable to assume a minor permanent deformation. The EES value can be estimated based on well-known criteria.

It is possible to conduct an equalization calculus in the first input field (upper left corner), which enables you to insert more data than necessary. The EES values and the deformation depth are then adapted in a way that they satisfy required mathematical conditions. The differential speed before the collision is calculated from the EES values and the differential speed after the collision. The collision velocities can only be determined if you either state the pre-impact velocity or the coasting velocity of a vehicle or the final distance of the vehicles. The calculation of collision velocities based on the final distance should only be done if the final distance is more or less precisely known and the coasting decelerations of both vehicles are objectified, because the resulting value is relatively sensitive to amendments of this items. If you neither insert a pre-impact velocity nor the coasting velocity, a front vehicle at the time of collision is assumed.

During the calculations, the program investigates which items are known, selects the according calculation scheme and records it. The fields of the calculated items are blocked. You can now change your input values and conduct a new calculation with the original input scheme without being forced to set all calculated values to 0 again. If you prefer to select a different input variant, click on “Init” to initialize the mask. All fields are unblocked again and the program examines anew which items are given and which calculation scheme is appropriate.

Moreover, the program calculates the velocity change caused by collision and the acceleration respectively deceleration of the vehicles as well as the collision factor (k value). In the case of serial collisions, the order of collisions is often unknown, therefore, the first step is to assume a standstill of the front vehicle at the time of collision. Based on the coasting velocities resulting from this calculation, you can easily verify the possibility that a standing vehicle with an impact on its rear end was pushed against the front vehicle. If the coasting velocity resulting from the rear-end impact of the standing vehicle is smaller than the necessary collision velocity of the front collision, this option can easily be precluded.

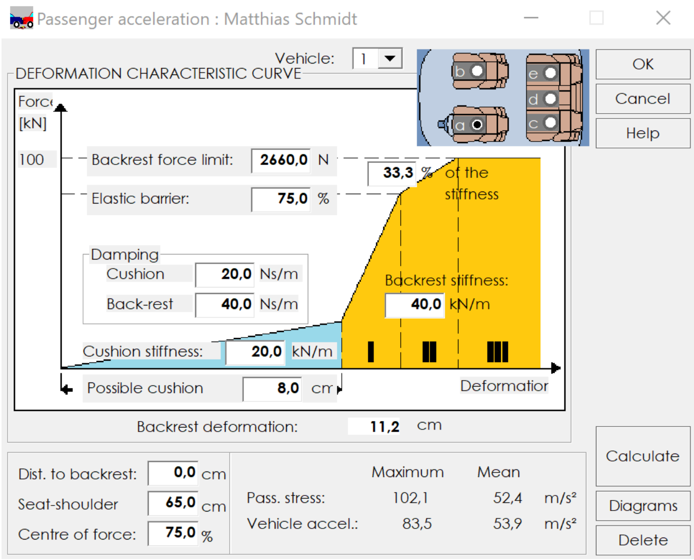
With the specification of f.e. coasting velocities, you can indirectly influence the collision order: If the coasting velocity after the rearward collision is smaller than the front collision velocity, the front velocity is assumed to be earlier, otherwise vice versa. You should avoid to set a value for the coasting velocity that ranges between the pre-impact velocity and the coasting velocity of the front collision, as both collisions would temporally overlap in this case. The issue deriving from this constellation is not dealt with for the time being. If necessary, you can insert a standstill time for a standing vehicle at the time of collision. Moreover, a collision order is proposed. Data can be inserted in the input mask “Pre-col. Data”. If the proposed order is impossible, the program notifies you about an automatic change.

<u>Tip:</u> After the calculation of differential speed you can continue with the analysis of passenger stress by clicking on the respective button. The calculation relates to the vehicle in which input fields you are and which is also mentioned on the „Passenger stress button“.

Do not leave blank spaces in the collisions, as a data transfer and the determination of collision order is only possible with complete information! If a collision took place between vehicle 1 and 2 and between vehicle 3 and 4, but no collision between vehicle 2 and 3, the program has no indication that the collisions are connected. Calculate the collision between vehicle 1 and 2 first, change the vehicle numbers of the two front vehicles to 3 and 4 (formerly 1 and 2) and calculate the collision for these vehicles next. After that, position the vehicles temporally and spatially in the distance-time graphic. A vehicle with a completely elastic behaviour is characterized by a high amount of energy flowing back during restitution. Hence, the differential speed after the collision must amount to a certain minimum value. A control mechanism automatically adjusts the value to its minimum. The other vehicle shows a completely plastic behaviour then. Calculations are based on formulas developed for the restitution non-proportional to mass. If the calculated minimum value is increased, the other vehicle behaves in a partly elastic way.

3.7.26.3 Passenger stress

Click the button „Passenger stress X“ in the main input and calculation mask to open the window for passenger stress calculations in rear-end collisions. The calculation



refers to the vehicle in which input field the cursor is located and which number is also displayed on the button. You can also choose the vehicle number in the module. As a precondition for passenger stress calculations, the calculation of the respective collision has to be completed and the mass of the vehicle driver, for which the passenger stress shall be calculated, needs to be defined. You can select the passenger by clicking on the respective sitting position in the upper right part of the input window.

In the main calculation mask, the vehicle acceleration caused by collision is calculated from the differential speed of the vehicles at the time of collision, the deformation and the tire friction. Based on this value and the structural stiffness of the vehicle, the program calculates the velocity that would result in the same vehicle acceleration and deformation for a rear-end collision through a rigid barrier. Thus, the basic values are the structural stiffness of the vehicle and the maximum vehicle acceleration. The calculation of passenger stress is done with a simulation of a comparable rear-end collision through a rigid barrier. The rear is considered as partly elastic spring that deforms during the collision according to its predefined structural stiffness. Along small time intervals during the simulation (pre-setting: 0.0001 s), the deformation, the current velocity and the vehicle acceleration are calculated and analogously complemented in the next time interval. You can change the pre-setting in the menu “Options/Settings”. As the maximum value of time intervals with still reliable results is 0.0001 s, values higher than that are error-prone and subsequently ignored. In cases with extremely high values of structural stiffness and very small collision times, a small time interval of 0.0001 s is recommendable, otherwise, larger values can be chosen as well.

"Mass of passenger": The mass of passenger has to be adjusted in the menu „Vehicle data“. As only a part of the mass interacts with the backrest, a partial value is taken into consideration for the calculation of backrest deformation and the acceleration connected with it. The pre-set value is 1/3 („Torso mass fraction“, can be changed in the menu Options/Settings/Passenger stress).

"Distance to backrest": Takes into consideration an inclined body posture. Insert the distance between body and backrest at the height of the centre of force.

"Seat-shoulder": Based on this value, the lever arm to which force is applied is calculated, which is in turn used for the determination of the torque deforming the backrest.

"Centre of force": The centre of force transmission is indicated as % of the distance “seat-shoulder”. The resulting value (plus 15 cm distance sitting surface – torque of backrest) is used as lever arm to which force is applied.

"Stiffness cushion and backrest": Function like two springs connected in series. As long as the cushion can be compressed, the characteristic curve is relatively flat. Afterwards, the backrest frame with its greater structural stiffness is bent. You need to specify the structural stiffness and the damping of both parts. The pre-setting of the backrest’s structural stiffness and the force limit correspond with the characteristics of a Mercedes seat.

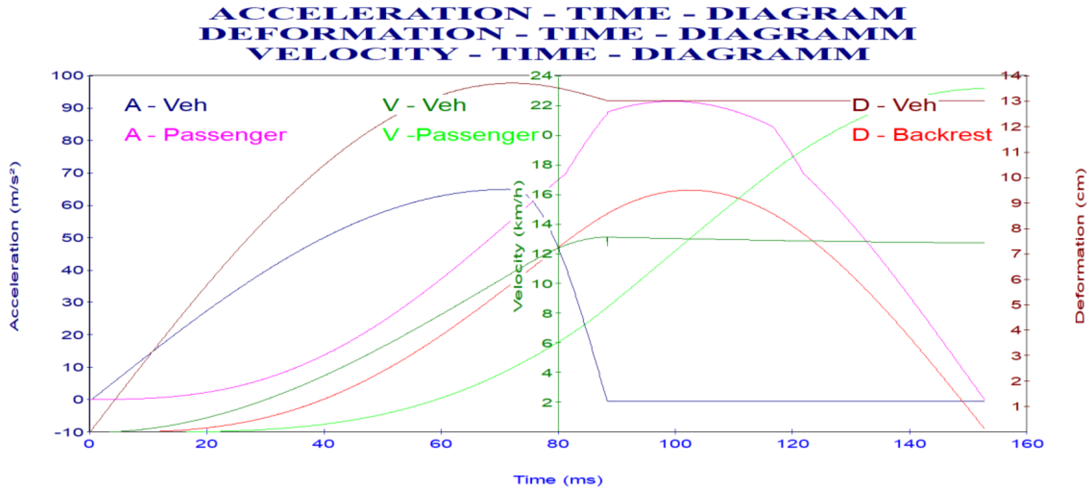
"Possible cushion deformation": Defines for how long the flat part of the characteristic curve is in use.

"Elastic barrier“ and „Backrest force limit“: Up to the „Elastic barrier“ of about 75% of the „Backrest force limit“ the force increases with the stated structural stiffness, afterwards the characteristic line is flatter. The degree of flatness can be adjusted with a statement in %. After having reached the defined force limit, the force remains constant irrespective of the backrest’s ongoing deformation. The described curve shape is caused by the mechanic characteristics of the backrest material and the backrest construction.

"Damping": Indicates the friction caused by velocity during the deformation. Without damping, the cushion and backrest, physically seen as springs, would never stop swinging. The pre-set value significantly reduces the oscillation amplitude after a few oscillations already. The damping is in proportion to the velocity of the deformation and works similar to a shock absorber. The reasons for damping are the inner friction of the material as well as the necessity to compress air within the cushion and to squeeze it out of it.

<u>Calculation result:</u> Comprises the maximum backrest deformation, the maximum acceleration of passengers and the vehicle as well as the temporal midpoint of passenger and vehicle acceleration. The midpoint is calculated with a numeric integration. The average value of vehicle resp. passenger acceleration is based on the process from the beginning of collision to the end of acceleration, however, the program considers that the acceleration for a backrest distance different from 0 is still 0. The duration of the phase is ignored, as it would lead to a wrong reduction of the average value. Hence, the mean value only bases on the duration in which the acceleration is different from 0. Furthermore, the chronological sequence of the acceleration and the velocity for both vehicle and passengers as well as of the vehicle and backrest deformation is calculated.

3.7.26.4 Diagrams for passenger stress



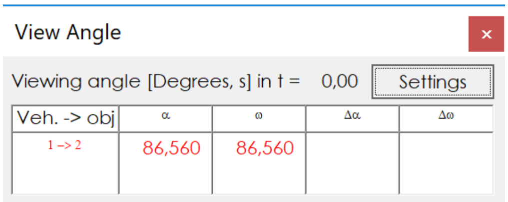
The speed curves in the v – t diagrams start in the lower left corner. The curve for the respective passenger starts to rise later than the one of the vehicle and surpasses it in further consequence. This is because the upper body of the person is pushed forward through the elasticity of the backrest during the backrest's spring-back and is accelerated to a velocity that exceeds the vehicle's one. Depending on the coasting deceleration, the vehicle velocity drops off from its highest point linearly, the curve of passenger velocity ends in the upper right corner. The deformation curves also start in the lower left corner, reach their highest points and arch downwards again. After having reached the point of permanent deformation, the deformation curve continues in horizontal direction.

After their maximum point, acceleration curves characteristically drop down to 0 again. If a deceleration is existent, the zero line is shifted upwards by 10 m/s². Depending on the deceleration, the vehicle acceleration does not immediately start with t = 0, because it is only utilized if the applied force is greater than friction. The curves of passenger acceleration, passenger speed and backrest deformation rise later than the ones of the analogue vehicle data and arch to the left at the beginning.

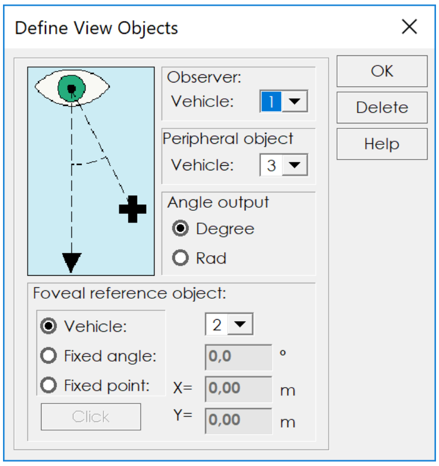
The left bar features an icon for curve selection as well as an „Exit“ button to close the diagram module again.

3.7.27 Angle of sight

(Icon: )



In this modules, you can calculate the angle of sight and its angular speed between a defined viewing direction during the Movie sequence and a vehicle in a peripheral visual area that might become a hazard. All relevant points can be defined under “Settings”.



Determine the „Observer“ first, then the „Peripheral object“ and finally the „Foveal reference object“, the object determining the viewing direction and located in the foveal field of vision (within about 1,5° of the direct viewing direction). It can be another or the same vehicle (f.e. oncoming traffic or a person on the roadside or another point on the vehicle) or a certain viewing direction (f.e. straight ahead) or a fixed point (f.e. an immobile object on the roadside). The “fixed angle” relates to the longitudinal vehicle axis and is used for fixations of far off objects. If you wish to specify a “fixed point”, either indicate the respective coordinates or use the “Click” button to select a point in the Movie, i.e. to position your cursor on the desired point and press the left mouse button.

If you want to adapt the angle of sight after a change of distance to the front vehicle, you can select the same vehicle number for the foveal object and for the peripheral object. Two visual radii will then connect the observer with the vehicle. The front centre is the end point of both visual radii in the default setting. The end of the normal visual radius is marked with a little square as usual, the end of the foveal visual radius is marked with a little cross. Usually the target of the visual radii needs to be positioned at the desired point. Move the cursor to the front centre of the target vehicle. At some point the cursor changes to a cross – an indication that the end of the visual radius is captured. Select and shift the end point as usual. Your settings are saved in the report.

"Angle output": You can adjust the angular unit in degrees (°) or radian measure (radiant).

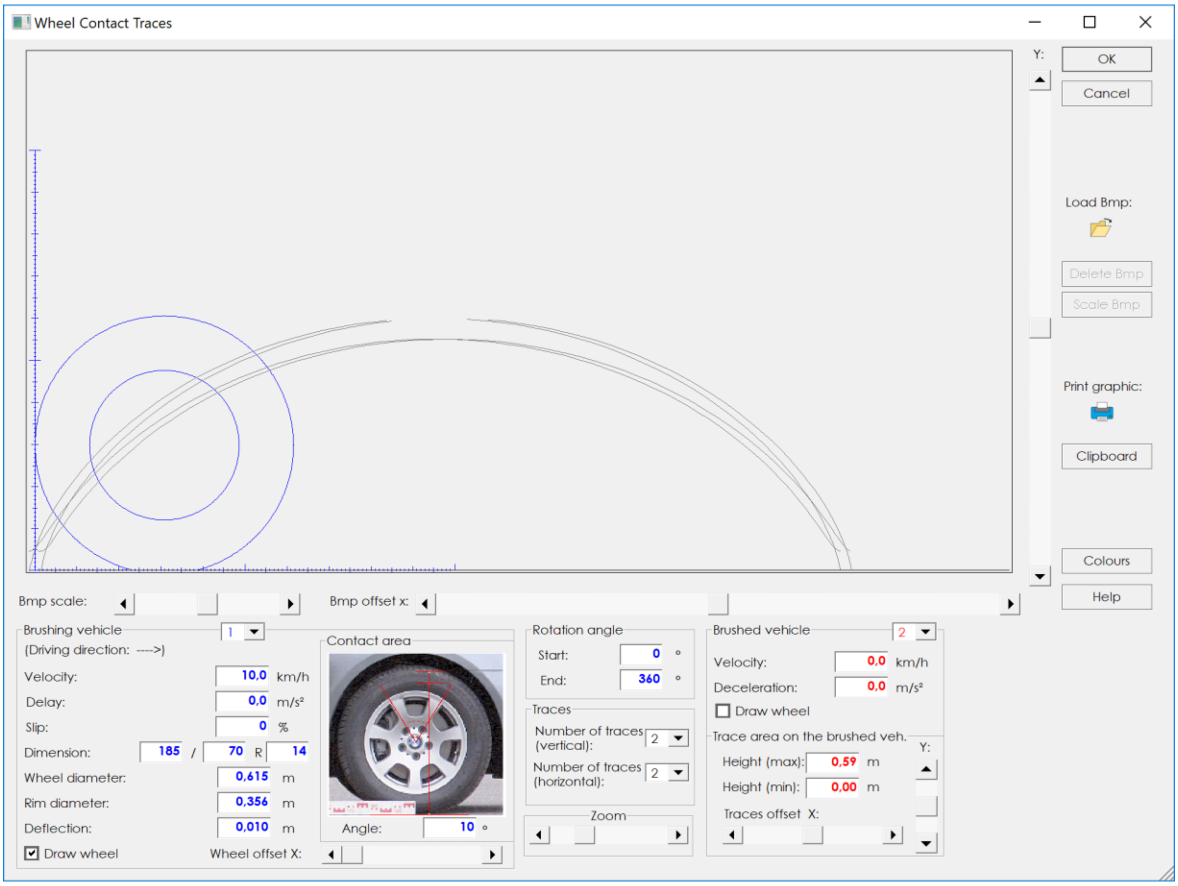
The threshold range of abnormality for angular speed ranges between 3 - 10 * 10^{-4} Rad/s in the literature. This value might occasionally appear to be too low and can be adjusted with a praxis factor. The actual threshold value depends on several factors and has to be examined closely. Among other factors, the observation time should commonly last at least 0.4 s. The threshold range of abnormality (upper and lower limit) and the praxis factor can be adjusted in the menu “Settings/Viewing angle”. The main module window displays the current status of abnormality:

------------	Below the threshold range of abnormality
???????	Close to the threshold range of abnormality
!!!!!!!!!!!!!	Above the threshold value of abnormality

3.7.28 Rim contact traces

In brush collisions, the turning wheel of the brushing vehicle might come in contact with the chassis of the brushed wheel. If the angle between the turning wheel and the chassis of the brushed wheel is very small, contact traces with the shape of a Cycloid might emerge. The exact form of these Cycloids depends on the differential speed, the rotation speed of the brushing wheel and diverse geometric data like wheel diameter and position of contact area on the turning wheel. Hence, the velocity and the deceleration (positive value) or acceleration (negative value) have to be stated. Additionally, the wheel diameter, rim diameter, deflection and slip of the brushing vehicle have to be defined.

The contact area is built upon the height extension (distance to the floor, in the graphic 0.51 – 0.61) and the angle (here 120°). This area can be divided into a varying amount of points in horizontal = tangential and vertical = radial direction. The depiction below shows 3 vertical traces and 4 horizontal traces, which means that Cycloides are drawn from 12 points (= 3 x 4).



The picture used for this module should be in a rectangular position to the vehicle, with the smallest possible perspective distortion. It needs to be loaded first and can be positioned and maximized/minimized with the scrollbar to the right and below the picture.

Afterwards, the track records needs to be positioned true to scale. The depicted wheel and a vertical ruler help to scale it precisely. With the scrollbar “Wheel offset X”, you can shift the wheel and the ruler and position it in the best case on a scale included on the picture. Then you can tailor the size of the wheel/ruler to the one of the scale with the scrollbar „Traces scale”.

The „Rotation angle“ defines which part of the cycloid shall be drawn. At 0° - 360° a full rotation starting and ending at the bottom is drawn. 0°-180° covers the ascending part, 180° - 360° the descending one. Moreover, the displayed area relating to the height above the ground can be narrowed down. As a basic setting, the wheel and ruler are shown in the colour of the brushing vehicle, but can be changed like the colour of the traces in the menu “Colour”.

The following task order is recommended:

1. Load the picture, shift it to the desired position and scale it to the desired size. A scale should be visible on the picture.
2. Shift the depicted wheel and the scale to the position of the ground (wheel contact surface) of the vehicle visible on the picture (Offset Y).
3. Shift the wheel and the scale to the position of the scale included on the picture (Offset X) and scale it afterwards.
4. Determine the rotation angle.
5. Limit the height above the ground where trace records are visible.
6. Determine the contact area of the wheel producing the traces.
7. Insert the velocities of the vehicles.

3.7.29 Cargo securing

Calculation module for cargo securing:

"Maximum payload": Calculated from the permissible total weight minus own weight.

"Load": Load to be secured.

"Cargo area friction": Friction between the floor and the cargo. The value can be entered directly or selected from a range of values.

"Lashing point strength": Strength of the lashing point.

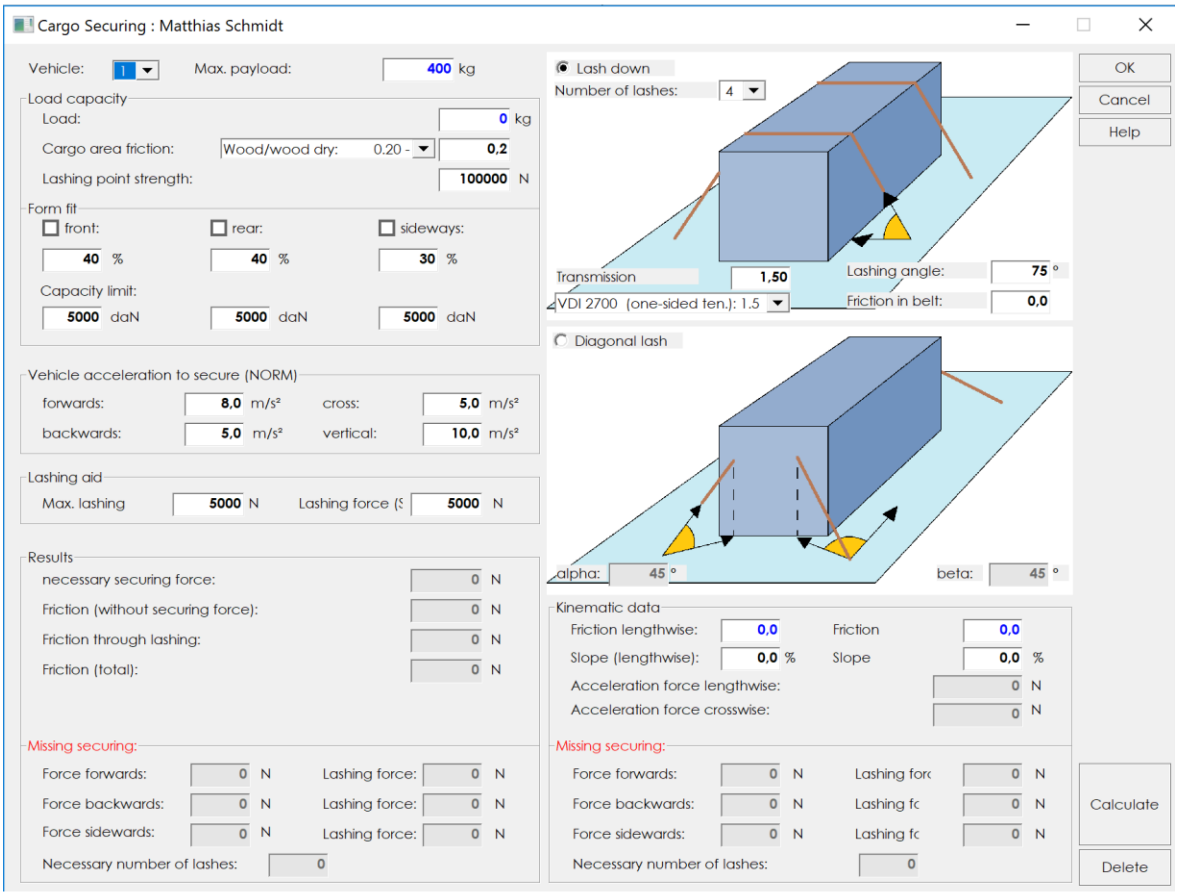
"Form fit": support against the walls. The force is calculated from the maximum payload.

"Capacity limit": Maximum force of support.

"Vehicle acceleration to secure (NORM)": Accelerations the lashing capacity must withstand according to regulations.

"Max. Lashing force (LC) - Lashing Capacity ": Capacity of the lashing strap.

"Lashing force (STF) - Standard Tension Force": Lashing force created with a ratchet.



"Lashing angle": Angle between the loading area and the lashing strap.

Transmission coefficient (drop down menu to the left of “lashing angle”: If both sides are lashed down with a ratchet, the value is 2; otherwise, you need to consider that the lashing capacity on the side without ratchet is smaller because of the friction at the deflection etc. Most often, the value is only 50% then, the transmission coefficient amounts to 1,5.

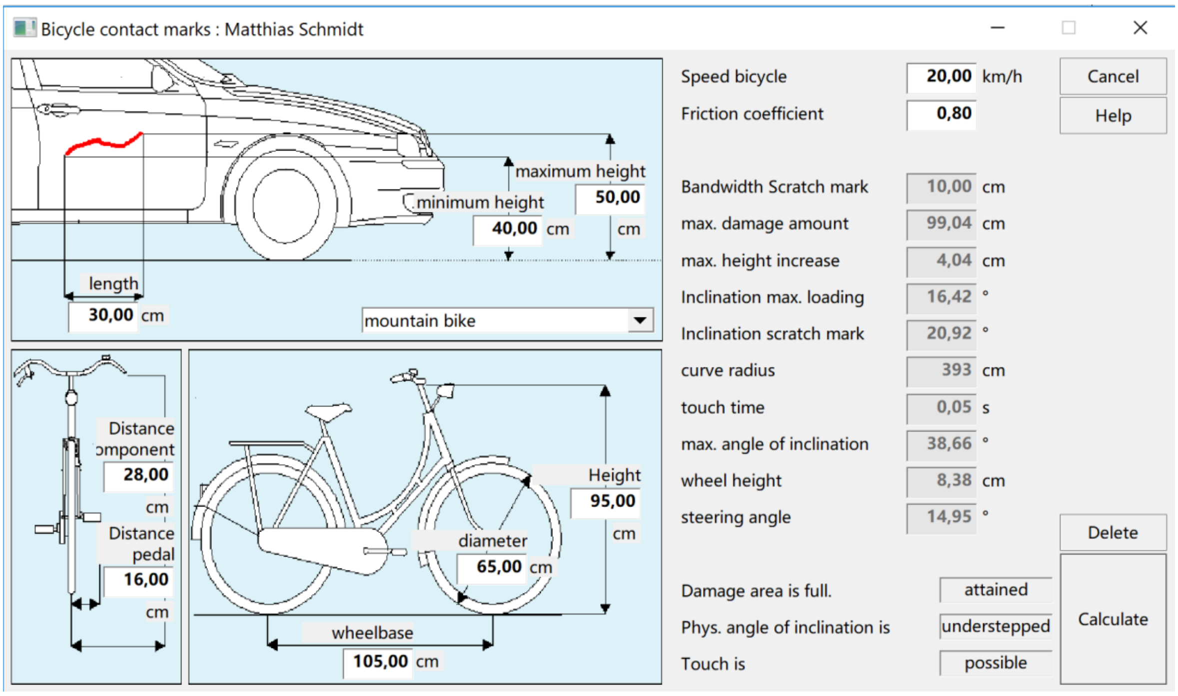
"Friction in belt": The friction between belt and cargo creates a retention force.

"Necessary securing force": Securing force theoretically needed for normal acceleration.

"Friction (without securing force)": Friction solely caused by cargo weight.

"Friction through lashing": Friction solely caused by cargo lashing.

3.7.30 Bicycle contact marks



This module is used to check the plausibility of scratch marks that may be caused by passing bicycles.

In the first step the minimum and maximum height as well as the length of the scratch must be entered (left upper window).

Second, geometric data of bicycles are entered. There are already preselected default values for this in the drop-down menu in the middle of the screen.

In the last step, an assumed speed and a coefficient of friction between the wheel tyres and the ground must be specified in the upper right area of the window.

This results in the results shown.

Scratch mark by a circular movement:

In order to fulfil the equilibrium condition, a counterforce must act. This also happens during driving when the front wheel or handlebars come into contact with a fixed obstacle. In the short period of time between the initial contact of the bicycle and the obstacle, a lateral deflection of the dynamic body occurs. This lateral deflection leads to an arc ride leading away from the back.

Scratch mark due to a change in height:

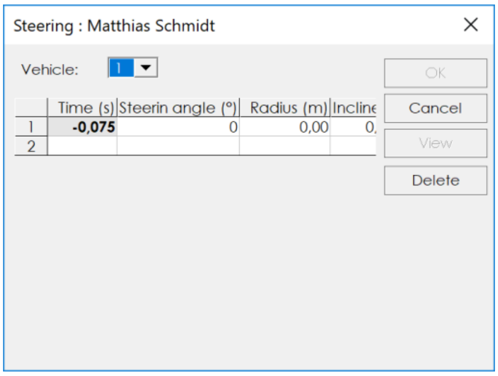
A further assumption is that with a dynamic motion sequence, the bicycle begins to oscillate immediately after initial contact. This is how a possible height difference can be explained. A change in height must be taken into account in the calculation or plausibility check. On the basis of the geometric quantities, a maximum possible angle of inclination can be determined, which is necessary for the scratch track generation.

It is checked whether the scratch mark found on the vehicle lies within this tolerance field. Furthermore, the angle of inclination determined for the track generation is compared with the maximum possible angle of inclination (depending on the road condition). A further boundary condition indicates whether the pedal width is covered by the steering angle of the front wheel. If all the results obtained are summarised, a relatively quick plausibility check can be carried out on compliance with the physical laws.

3.7.31 Steering

(Icon:) Independent of the number of movement sections and the defined phases, the driving line of the vehicle can be calculated kinematically with the entered steering manoeuvres.

Enter the respective vehicle number first and add the steering manoeuvre for certain points in time. You can either specify the „steering angle“ or the „curve radius“ of the back wheel of the inner curve side. The results are automatically converted under consideration of the steering ratio.



Positive value: Steering to the left,

negative value: Steering to the right,

Straight ahead: Steering angle and radius = 0;

"Ascent (s)": Time needed to steer from the old to the new curve radius. The old curve radius is assumed from the previous row.

If the vehicle should drive with smashed wheels right from the beginning, insert Ascent = 0 in the first row and enter the same time in the first two rows. If the ascent > 0 in the first row, then the vehicles steers in from driving straight ahead. The total time of the driving manoeuvre is assumed from the main data set and transferred to the time of the first row.

If the steering angle, the radius and the ascent are 0 in a row, the radius of the previous row is used to proceed. If the total time of the driving manoeuvre changes, you need to open up the „Steering“ menu anew to ensure that the steering movements definitely start at the right moment.

3.7.32 Video Analysis

The video analysis module is used to determine velocity from video recordings with a static camera (e.g. surveillance camera).

A video file can be loaded with the file browser in the upper left area of the image. An algorithm automatically recognises the contours of moving objects such as vehicles.

"Video settings": In this area, you can define the size of objects to be recognised. Areas "smaller than" or "larger than" X pixels are ignored during the analysis. In order to see in which size range your relevant areas move, the setting "Show area" can be activated.

"Distortion Correction": In order to calculate the velocities, the video must be rectified. In the first step, the corners of the red rectangle in the upper video are dragged to known positions with the left mouse button pressed. The real distance between the points can then be entered in the "Distortion Correction" area. The different shapes of the square serve to indicate which values are known.

"Correct lens distortion" automatically determines the camera parameters and can thus rectify barrel distortion, for example.

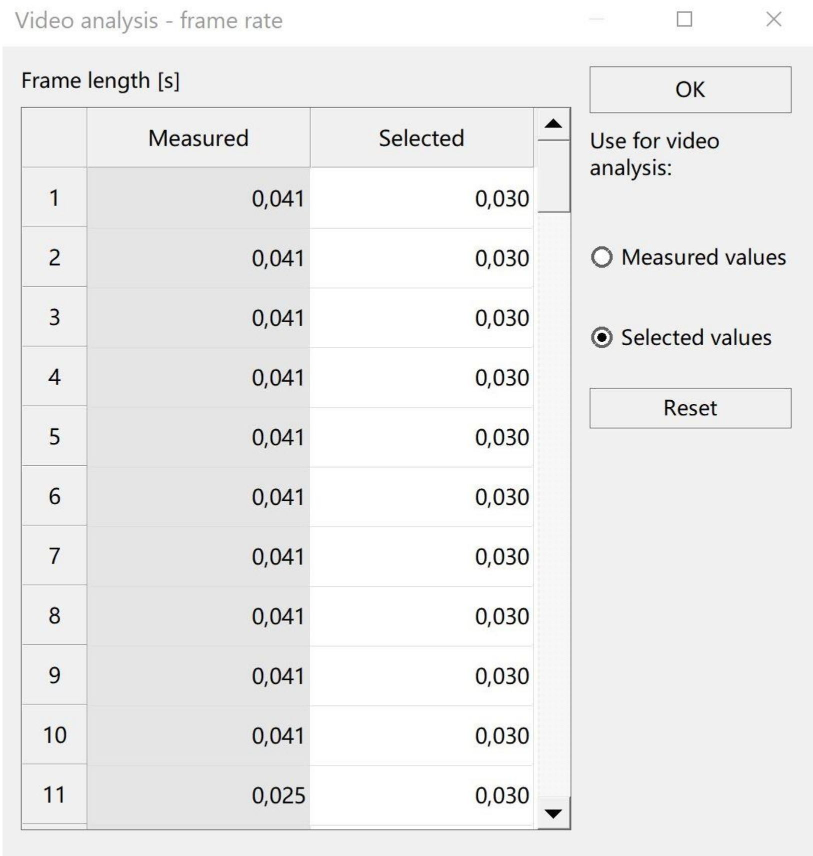
"Play", "<" and ">": This starts the video or jumps one frame forward or backward. The "Number of objects" indicates the total number of objects recognised in the video. The "Video velocity" indicates how fast or slow the video should run.

With "+" and "-" or with the mouse wheel you can zoom in the video below. The video can be moved by holding down the left mouse button.

"Reset" resets the entire analysis.

"Full Analysis" analyses the entire video and saves all velocity data.

Moving objects are assigned an ID in the video. Selecting "ID from video" displays the velocity data in red in the diagram. A fit curve is automatically inserted as a 4th degree polynomial in blue. The data of this fit curve can be transferred to the main data mask. The selection of the desired driving sequence is done directly in the diagram and can be found in chapter “Module Diagram control”.

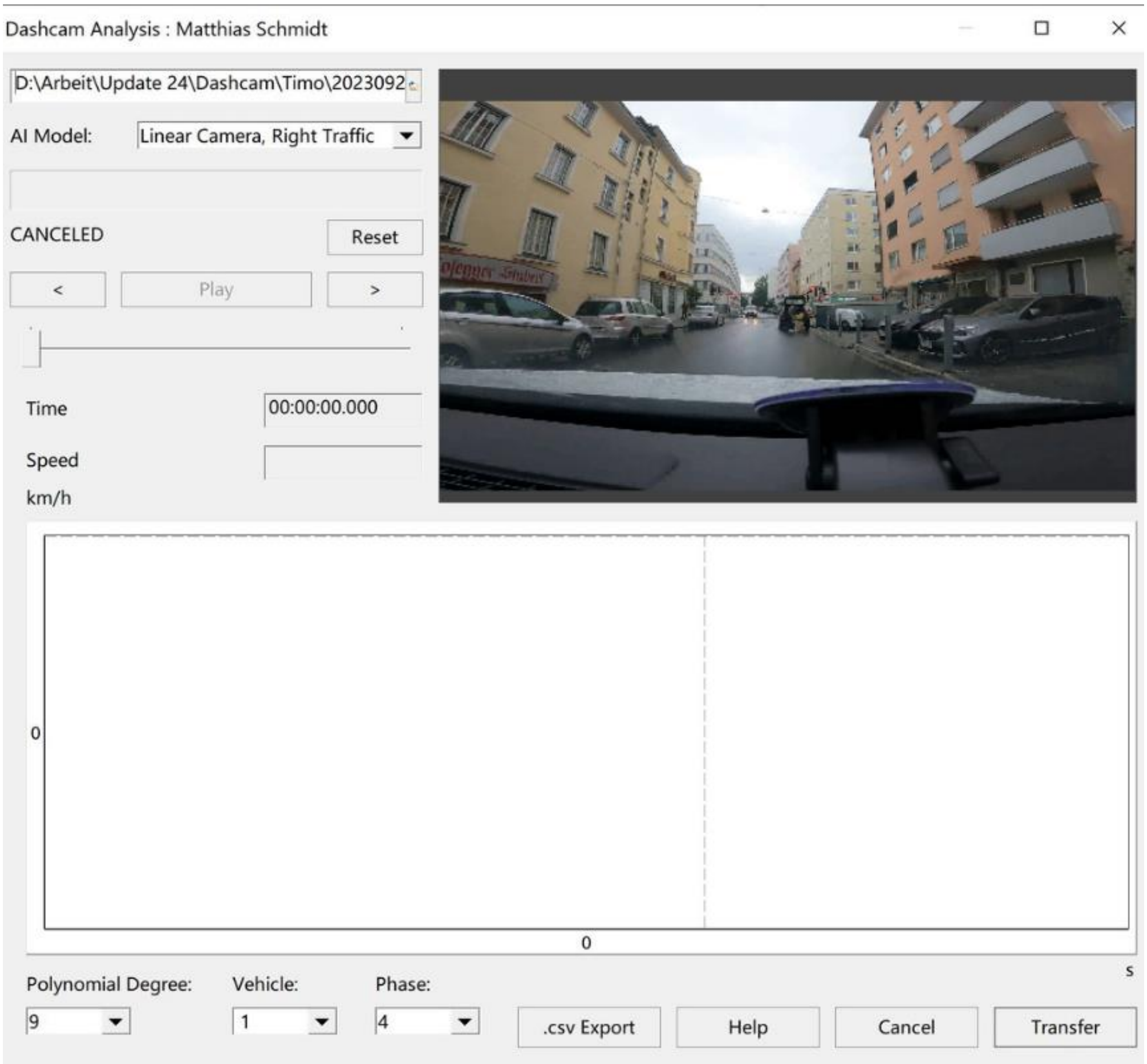


"Frames": Here, instead of the automatically determined frame lengths, time durations can be specified, which are then used for the calculation.

"Reset" resets the selected values to the measured values.

3.7.33 Dashcam video analysis

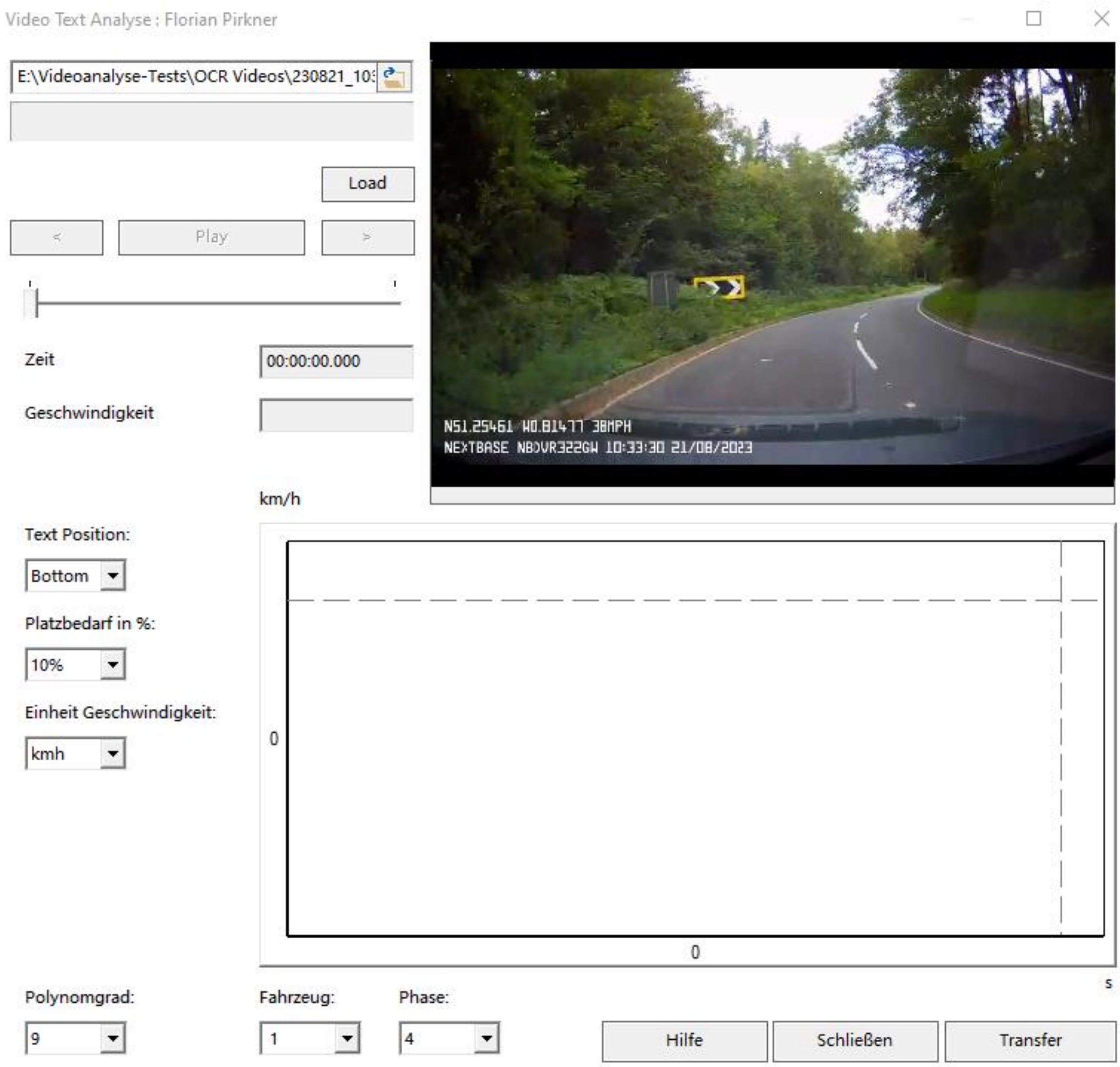
This module allows determining the speed at which the vehicle is traveling from dashcam videos by analyzing the optical flow of pixels between video frames. The conversion between pixel flow and the driven speed is carried out by a neural network specifically trained for this task. Following the analysis, it is possible to transfer the speed data into time-distance data. - Attention: This module is NOT used to determine relative speeds to other road users. Furthermore, only time-distance data is transmitted. A driving path cannot be calculated and must be adjusted by the user afterwards.



First, you need to select a dashcam video that you want to analyze. Since the AI models used have been trained on 10-hertz videos, the video you want to analyze should also have that frame rate. Most of the time, after loading a video, you will be prompted to automatically convert it to 10 Hz and save it. Confirming a location for saving creates a 10 Hz version of the original video, which is automatically used afterward. Next, you need to select an AI model for analysis. There are four models to choose from, each trained for either right-hand or left-hand traffic, and for both linear and wide-angle/fisheye cameras. Select the model that best describes your video. Once a usable video file and a model are selected, the analysis begins automatically. The analysis considers the previous 10 frames as a context for the current frame, during which the pixel flow is analyzed, and the associated speed for the current frame is determined. The progress of the analysis is displayed. At the end, you will receive a speed-time profile for the entire video, which can be fitted with a curve, exported to a CSV file, and transferred to a selected vehicle.

3.7.34 Video analysis for text / OCR

This module enables the text analysis of dashcam videos using an AI model trained for character recognition. "OCR" stands for "Optical Character Recognition," which is the process of recognizing written characters. If you want to analyze a video that displays measured speeds during the drive as text within the video, you can use this module to extract a speed-time profile from it and transfer it to the time-distance data of a vehicle.



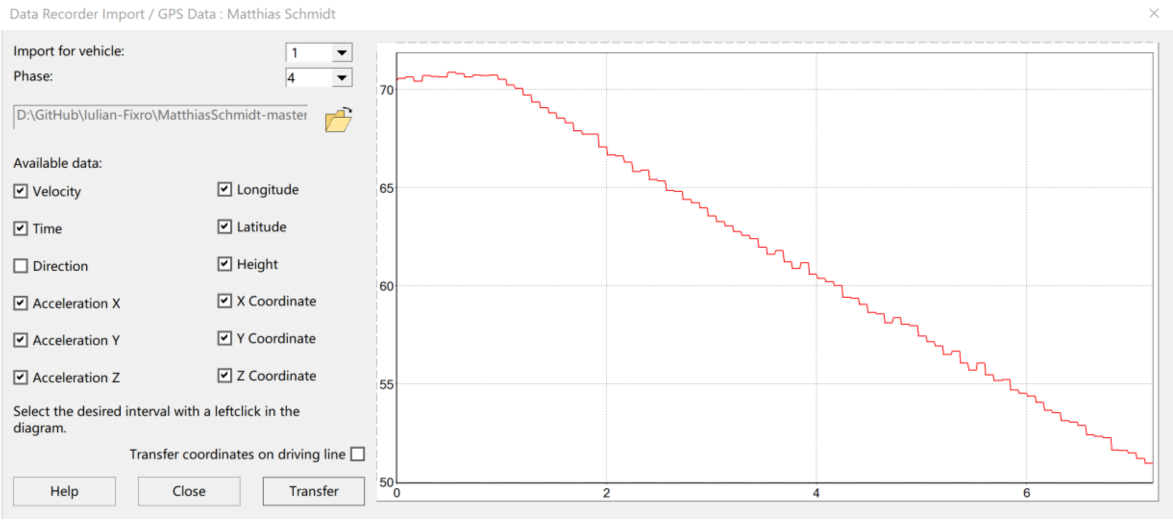
To begin, select the video you want to analyze. Afterward, you can define the area where the text appears in the video and specify its dimensions to increase the analysis speed. In the speed unit selection box, choose the unit that appears in the video. Next, perform the video analysis by clicking "Load." Once the analysis is complete, the speed-time data will appear in the chart below. A fitting curve is generated to smooth the data. As usual, you can then select a range by clicking twice on it, and with a click on "Transfer," you can transfer the data to a vehicle. The data from the fitting curve is used for this transfer.

3.7.35 General driving data / GPS data

The module „General / GPS“ allows you to load drives saved on a data recorder in AnalyzerPro. When a file is loaded, the program automatically draws a driving line and depicts the drive with up to 40 phases. The file format *.csv is supported. The format of the file should ideally include the identifiers for the various items like velocity, time, x-y coordinates, height, yaw angle or driving direction as of a certain row, followed by a line-by-line information of respective data. The data in the rows should be separated by semicolons or commas.

At least the velocity and time, or GPS data and time respectively, have to be available to load the file in AnalyzerPro. X and Y coordinates or the yaw ratio or the driving direction (heading) have to be known in addition to create a driving line.

To start the import click on the respective file in the file browser, choose the vehicle and the phase for which the drive shall be imported.



In the diagram, the y-axis shows the speed in km/h, the x-axis the travel time in seconds. The left-hand area shows which data is available in the file. With the button "Transfer coordinates to driving line", the curvature of the driving line is transferred instead of pure path-time data.

The selection of the desired driving sequence is done directly in the diagram and can be found in Chapter "Module Diagram control".

"Transfer" confirms the input and writes the data to the main data mask.

3.7.35.1 Module Diagram control

This affects the diagrams in the following modules:

- General / GPS Import
- DDD Import
- GoPro Import
- GPX Import
- Video analysis

The following control applies in general:

1. Selection:
    a. First left click: Start of selection
    b. Second left click: End of selection
    c. Third left click: Delete the selection
2. Zoom:
    a. Turn mouse wheel: Zoom by the pointer position

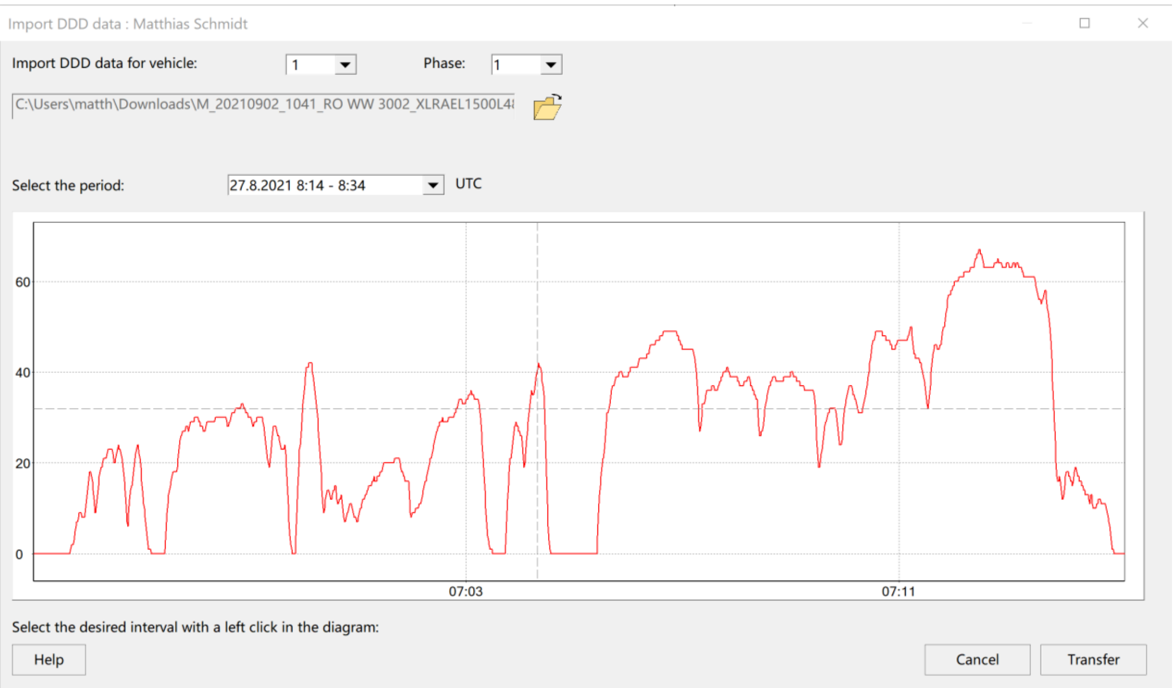
b. Press right mouse button + drag from top left to bottom right: Enlargement of the selected area
c. Press right mouse button + drag from bottom right to top left: Reduction of the selected area

3. Pan:
   a. Hold down the middle mouse button to move the area.

3.7.36 DDD File Import

This module is used to import digital tachographs that are available in the standardized DDD format. These files differ in 3 types, all of which can be read by AnalyzerPro:

- C-type: This type contains social data such as driving times, but no speed data.
- M-type: This type contains average speeds in 1 Hz format.
- S-Type: This type contains encrypted speed data in 4 Hz format.



By selecting the file in the file browser, it is read into the module. You have the possibility to have all read files written into a text file.

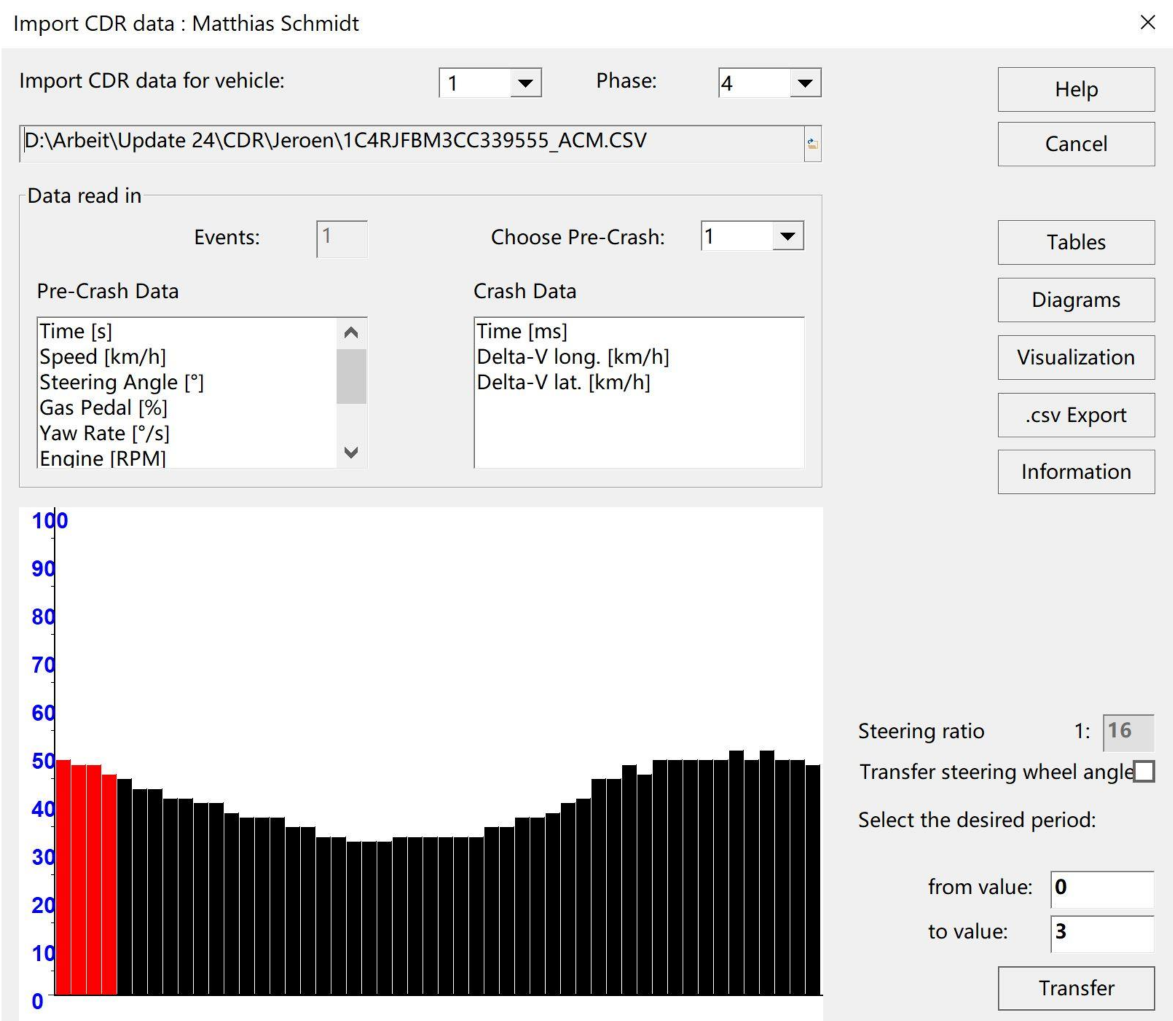
As soon as the data are read in, you can flexibly determine the desired time period under "Select the period"; the corresponding velocity profile is displayed in the window below. In order to transfer the data into the distance-time data, select the desired area as described in chapter Module Diagram control.

The field "Distance transfer" determines what the focus should be on: Exact value transfer from the file or a conversion into a mapping that is as true to the path as possible.

Confirm your selection with “Transfer”.

3.7.37 CDR Data import

This module is used to import .csv files generated with the Bosch CDR tool.



In the first step, you need to select an appropriate .csv file using the file browser and then confirm by clicking "Load." If possible, the file will be read. In the upper half of the dialog, the discovered variables of the pre-crash and crash data will be listed.

"Events": gives information about how many events have been recorded.

For data transfer to a vehicle, only the pre-crash data can be used. Once you select a pre-crash event from the respective selection window, the speed-time profile is displayed in the lower chart.

You can select the desired interval in the lower right corner and insert it into the time-distance data for the chosen vehicle from the selected phase by clicking "Transfer."

If "Transfer steering wheel angle" is selected, the driving line is bent according to the steering wheel angle position and the steering ratio. The steering ratio can be changed in the vehicle data.

On the right side, you will find additional options:

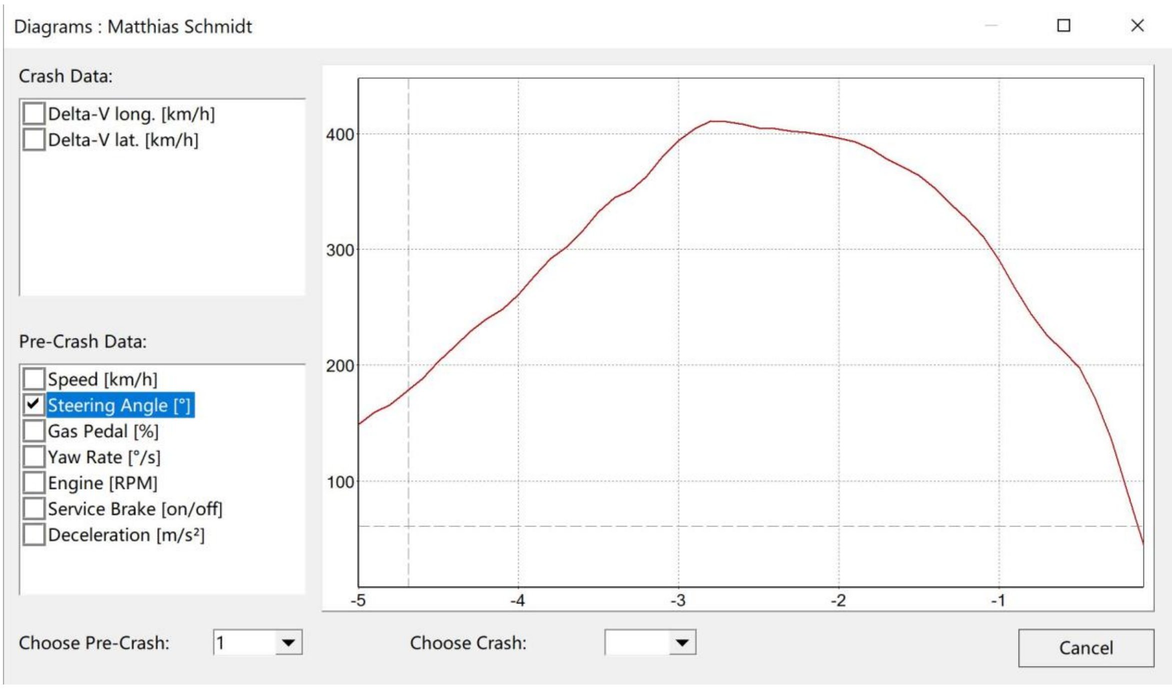
"Tables": Opens a dialog where you can list the time course of various variables in a tabular format for a specific pre-crash event or a specific crash event. Critical values are automatically highlighted in orange. "Critical" might refer to very strong deceleration that might not be achievable through mere braking or active ABS intervention, for example.

Data Tables : Matthias Schmidt

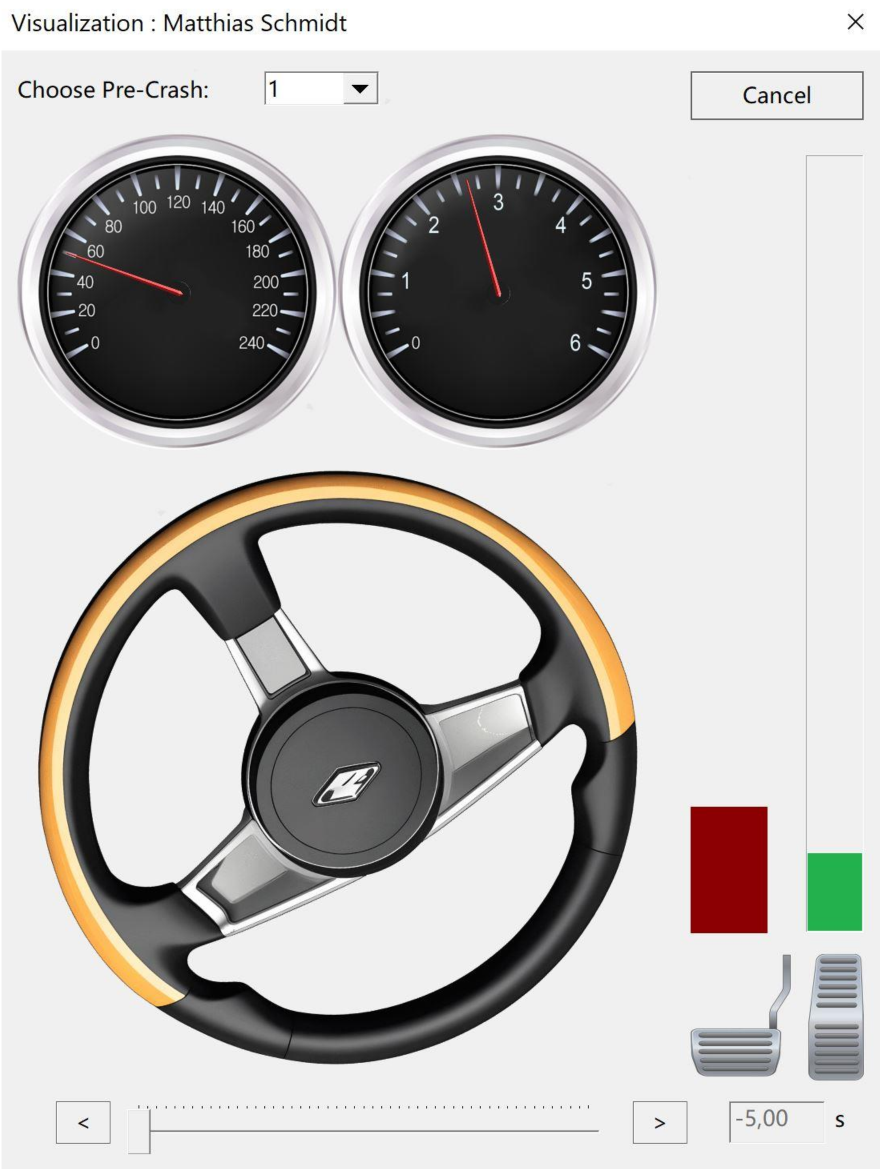
	Time [s]	Speed [km/h]	Steering Angle [°]	Gas Pedal [%]	Yaw Rate [°/s]	Engine [RPM]	ervice Brake [on/of	Deceleration [m/s²]
16	-3,50	35,41	332,00	10,80	42,00	1744,00	0,00	4,47
17	-3,40	35,41	345,00	10,80	43,00	1719,00	0,00	-0,00
18	-3,30	33,80	351,00	10,80	45,00	1700,00	0,00	4,47
19	-3,20	33,80	363,00	10,80	46,00	1694,00	0,00	-0,00
20	-3,10	32,19	380,00	42,80	47,00	1704,00	0,00	4,47
21	-3,00	32,19	394,00	53,10	48,00	1851,00	0,00	-0,00
22	-2,90	32,19	404,00	56,70	49,00	2017,00	0,00	-0,00
23	-2,80	33,80	411,00	59,80	49,00	1917,00	0,00	-4,47
24	-2,70	33,80	410,00	71,60	47,00	1877,00	0,00	-0,00
25	-2,60	33,80	408,00	78,90	45,00	1807,00	0,00	-0,00
26	-2,50	33,80	405,00	80,40	46,00	1793,00	0,00	-0,00
27	-2,40	33,80	404,00	79,90	48,00	1845,00	0,00	-0,00
28	-2,30	33,80	402,00	81,40	48,00	1881,00	0,00	-0,00
29	-2,20	35,41	401,00	98,50	48,00	1891,00	0,00	-4,47
30	-2,10	35,41	399,00	100,00	47,00	1935,00	0,00	-0,00
31	-2,00	37,01	396,00	100,00	46,00	1999,00	0,00	-4,47
32	-1,90	37,01	393,00	100,00	46,00	2059,00	0,00	-0,00
33	-1,80	38,62	387,00	100,00	45,00	2187,00	0,00	-4,47
34	-1,70	40,23	378,00	100,00	45,00	2285,00	0,00	-4,47

Choose Pre-Crash: 1 Choose Crash: Cancel

"Diagrams" opens another dialog that, following the same pattern as "Tables," graphically displays the time course of some interesting variables. First, select a specific pre-crash or crash event, and then on the left, toggle the relevant curves on/off. Note that only one curve per unit type can be displayed at a time.



"Visualization" opens a dialog where various driver actions are presented graphically. For pre-crash events within the time interval available in the file, you can visualize speeds, engine RPM, steering wheel position, as well as gas and brake pedal operation. Below, you can select the point of interest using the slider. The green bar above the gas pedal corresponds to the percentage of gas pedal activation. Brake pedal activation, on the other hand, is a binary "yes/no" state and does not provide information about the strength of the brake application.



".csv Export" allows you to save the data as a CSV file for later use, such as in Excel.

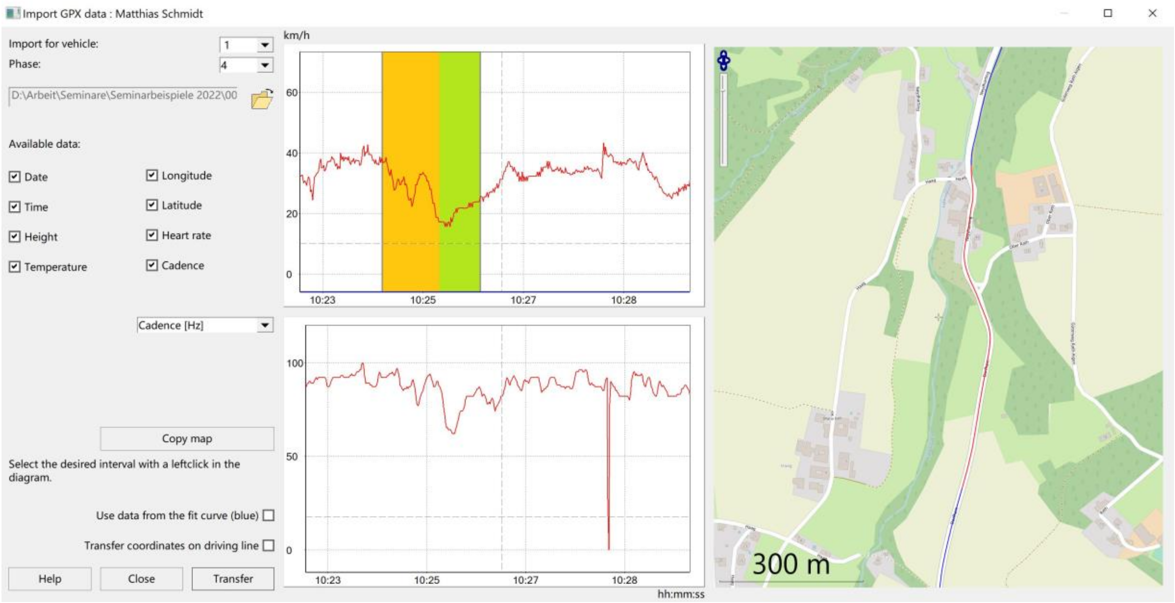
"Information" opens a dialog that emphasizes the need for careful handling when interpreting and using the data obtained through the CDR tool. The data may be error-prone or have a time offset, so it always requires a comprehensive critical review of the entire dataset to identify any unrealistic values as such.

"Manual" allows for manually entering or manually modifying values that have already been read. "Use Manual Data" must be selected to display and transmit these data. To create a new record, choose a desired frequency and click on "Create". If you have already read data, you can copy an existing pre-crash record.

Special thanks at this point go to Mr. Nikolaus Gotthard, who contributed many ideas and expertise to the visualization and processing of CDR data from version 24 onwards. Thank you very much!

3.7.38 GPX Importer

The module "GPX Importer" allows to import data from sports watches in GPX format into Analyzer Pro. Files from the recorders can be imported, whereby the line of travel is drawn and travel is displayed using up to 40 phases. The file formats *.gpx and +.fit are supported. The .fit file is automatically converted into a GPX file in the first step.



The data available is shown on the left-hand side of the screen. In the upper diagram, the velocity is plotted on the y-axis and the time on the x-axis.

The GPS data is displayed in the form of the route on the Open Maps map on the far right of the image by means of the blue line.

If the corresponding data is available in the GPX file, the heart rate, cadence or temperature can be displayed in the lower diagram. The diagrams are synchronised, so a corresponding zoom always affects the diagrams.

"Copy map" copies the displayed map.

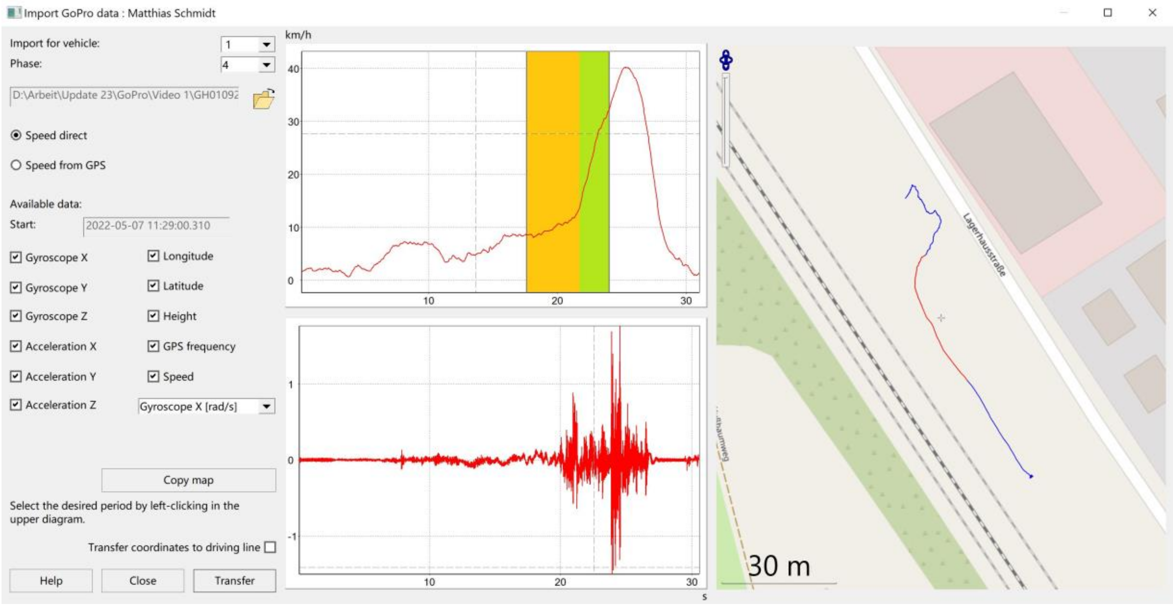
To transfer the data to the distance-time data, select the desired area as described in Chapter “Module Diagram control”.

With the button "Transfer coordinates to driving line" the curvature of the driving line is also transferred instead of pure distance-time data.

Press the "Transfer" button to confirm your selection and write the data into the main data mask.

3.7.39 GoPro Videos

Many videos recorded with the GoPro camera contain meta-data that can be used to calculate speeds. The video can be read in *.mp4 format.



The velocity can be given in two ways: Either from the internal velocity calculation or calculated from the GPS data. The available files are indicated by a marker in the list. The content of the lower diagram can be selected in the drop-down menu. The GPS data is displayed in the form of the route on the Open Maps map in the image on the far right by means of the blue line.

"Copy map" copies the displayed map to the clipboard. With "Ctrl + V" it can be pasted into the report.

To transfer the data to the travel-time data, select the desired area as described in chapter "Modul diagram control".

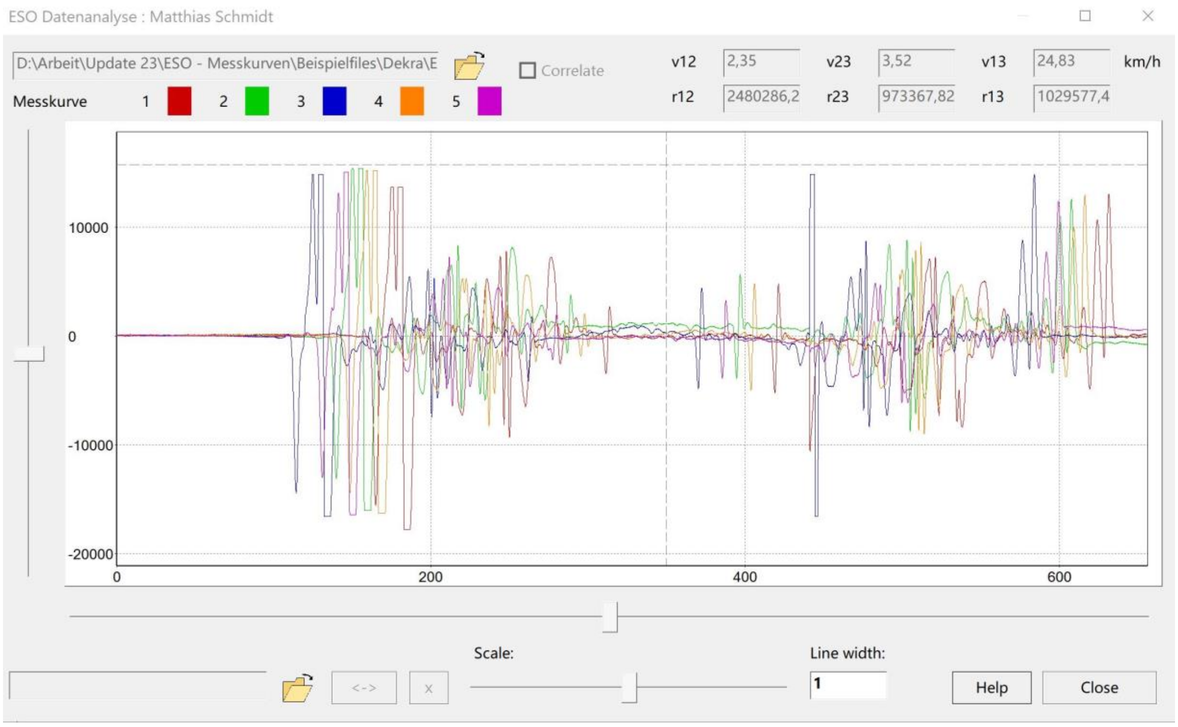
With the "Transfer coordinates to driving line" button, the curvature of the driving line is also transferred instead of pure path-time data.

Press the "Transfer" button to confirm your selection and write the data into the main data mask.

3.7.40 Traffic measurement technology – ESO data

ESO data is used to check whether a type of velocity measuring device is functioning correctly. The data can be output from the associated software in .csv format and then entered into the analyser.

After loading the file, the 5 measurement curves appear in the diagram. If the check mark "Correlate" is set, the curves are shifted over each other so that a deviation of the curves from each other is easily visible.

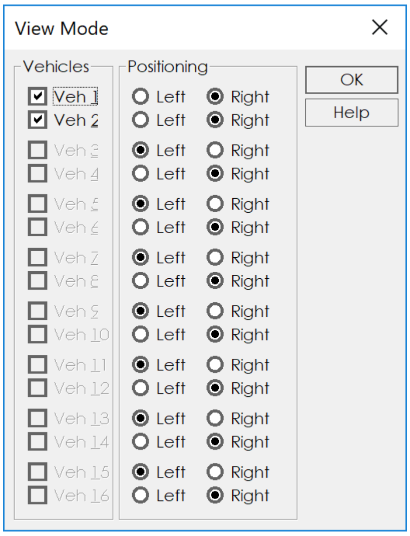


By left-clicking twice in the diagram, an area is marked. Within this area, the velocity "v" and the accuracy "r" between 2 measurement curves are indicated in the upper fields.

The lower loading bar allows loading an image to check the position of the signal-triggering element. The sliders can be used to adjust the position of the image.

3.8 Graphic

3.8.1 Display mode



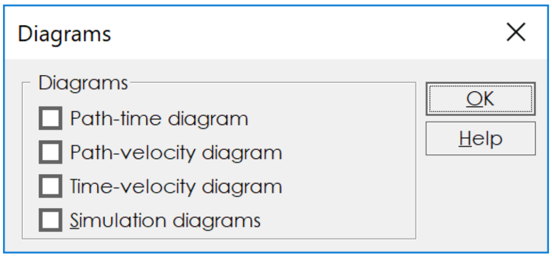
The depiction and positioning of the vehicles can be determined in this window.

"Vehicles“: This column lists the vehicles that are shown in the diagrams and the Movie.

"Positioning": Here you can state from which direction the vehicles should approach and position the respective curve in the diagram.

3.8.2 Diagrams

The following diagrams can be created:



Path-time diagram

Path-velocity diagram

Time-velocity diagram

Simulation diagrams

Only the curves for activated vehicles are displayed. Die phase limit for each curve is marked with symbols.

General phase limit:	small circle
Reaction start:	square
Start of braking:	little filled square
Collision:	filled square

The lower area of the diagrams shows the key to the curves. It contains the vehicle number and the name of the driver. To edit the text, click on the field and use the right mouse button to open the menu for properties and text insertion. The vehicle numbers has to remain unchanged, otherwise standard text is displayed.

After clicking on a curve or using the tab key, you can shift the curve with the cursor keys or your mouse.

On the right, you'll find the chart toolbar, which allows you to quickly manipulate various chart display options.

Using the top 3 buttons, you can switch between time-distance chart (1), speed-time chart (2), and distance-speed chart (3).

4: Opens the axis positioning dialog.

5: Opens the curve positioning dialog.

6: Toggle display of phase names along the curves.

7: Show/hide reference curves for the front and rear of the vehicle. By default, the main curve represents the vehicle's center, and the reference curves' distances correspond to the vehicle's geometry data.

8: Show/hide grid lines at phase boundaries. These lines are parallel to the axes.

9: Add a scaled copy of the chart to the movie. When you click this button, a scaled copy of the chart is added to the movie. The chart copy retains the current chart view. Clicking the button again updates the chart copy.

10: Chart settings: Opens graphic options for displaying the elements of the chart. The settings in this dialog are saved as general properties for all your reports. The inputs are chart-specific, allowing you to assign different layouts, for example, to a time-distance chart compared to a dynamic simulation chart.

11: Exit: Closes the current chart. Any drawing elements created will be retained when the chart is reopened.

3.8.2.1 Path-time diagram

This diagram graphically depicts the relation between path and distance for all activated vehicles. Path is shown on horizontal axis, time on the vertical axis and the respective zero point is positioned in the point of intersection.

Time progresses along the axis from top to bottom. The time distance from zero point indicates the respective time at a certain point. If f.e. the collision is positioned in the zero point, all time values refer to the time before the collision. A position in the upper area of the graphic indicates an early collision point in time and vice versa.

If you shift the path-time curve in vertical direction, the position of the vehicle at a certain time has to change as well. If you shift the curve upwards, the vehicle drives off sooner and the final position is achieved earlier as well. The vehicle's position along the driving line in the Movie changes according to the current point in time.

> Example: The current position of the hairline cross is at two seconds. The program investigates which distance the vehicle has covered up to this moment. We assume that the vehicle has covered 10 m in 2 seconds, hence, it is positioned 10 m after the beginning of the driving line. If you shift the path-time curve upwards, the distance in 2 s has increased and can f.e. amount to 15 m. Therefore, the vehicle is shifted 5 m along the driving line.

A horizontal shift of the path-time diagram changes the displayed coordinates, however, the covered distance as well as the position of the vehicle in the Movie stay the same.

3.8.2.2 Path-velocity diagram

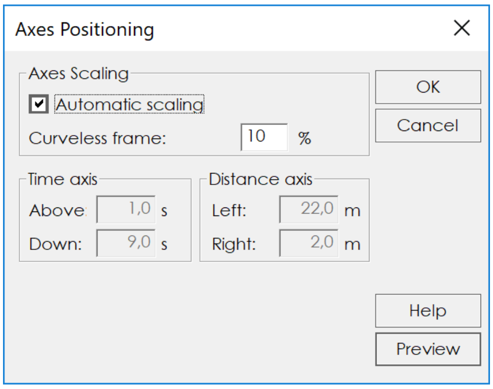
Depicts the relationship between path and velocity graphically. Path is illustrated on the horizontal axis, velocity on the vertical one.

3.8.2.3 Time-velocity diagram

Depicts the relationship between time and velocity graphically. Time is shown on the horizontal axis, velocity on the vertical one.

3.8.3 Positioning of axes

The distance and time axes can be scaled in this window.



"Automatic scaling": If you choose this option, curves are shown in maximum size; otherwise, the length of the time and distance axes can be specified directly. If the „Automatic scaling" is activated, neither the Zooming function nor the shift of axes are possible.

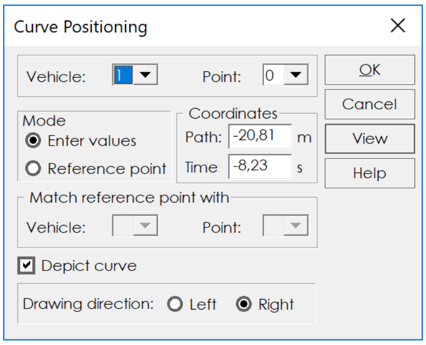
"Curveless frame": The width of the frame can be stated as a percentage.

3.8.4 Positioning of curves

This menu item offers you two different ways to position the curves. Furthermore, you can also insert the position of a phase limit in the main data mask.

"Mode: Enter values": You can directly enter the „coordinates" of a defined point, i.e. the phase limit, here. A positive target value means that the defined point shall be positioned before the zero point, a negative value positions it after the zero point. Analogously, a positive path value indicates a position in before of the zero point, a negative value after the zero point. For a curve that should be drawn on the left side, a positive value indicates a position to the left of the curve; for a curve that should be drawn on the right side, a position to the right of the zero point.

"Mode: Reference point": Insert the points (phase limits) at which the two selected curves should intersect. You can also open this dialogue box with a double click on the respective vehicle, hence, you can directly amend the positioning (either to the left or to the right of the time axis) of the curve. Moreover, you can also shift the curves on the graphic screen.



"Depict curve": Functions similarly to the menu item „Display mode“.

"Drawing direction": You can position a new curve to the left or right side of the time axis. Again, the functionality is similar to the one of “Display mode” and curves can also be shifted on the graphic screen.

Tip: The position of the axes in relation to the curves can be shifted in the „Coordinates“ window.

3.8.5 Movie

A previously calculated driving manoeuvre can be depicted kinematically in the Movie. Each vehicle is illustrated with the vehicle itself, its driving line and the calculated distance-time data set. The driving line is created with the help of a so-called “Spline”, i.e. an editable line.

The vehicle follows the driving line with its centre, i.e. the middle of its wheelbase in this case. The back wheels follow the line in a way that the centre is positioned at the intersection of the prolongation through the rear axle and the curve normal. A side slip angle can be stated for the initial point of the movement. It is further calculated in the sequence.

The program does not verify if the suggested driving line is possible in consideration of lateral acceleration. It is necessary that the track is unequal 0 and the wheel base as well as the overhang are not too small. If you choose a pedestrian as vehicle type, the program automatically loads a suitable set of vehicle data which you should not significantly change. The path proposed in the data file corresponds with the one of the centre. If the spline shows an arched course, a path integral is calculated to ensure that the distance covered on the screen conforms to the one of the data set.

You can view the Movie sequence in real time or in slow-motion. The lower area of the Movie window features a bar to control the temporal sequence.

If you position the mouse on the slider and hold the left mouse button pressed, you can drag the vehicles forwards and backwards. A click to the left or right of the slider shifts the vehicles in middle-sized steps. The time display complies synchronously in the path-time diagram.

E.. Positions the vehicle in the point of recognition (after vehicle selection)

R.. Positions the vehicle in the point of reaction (after vehicle selection)

S.. Positions the vehicle in the point of build-up (after vehicle selection)

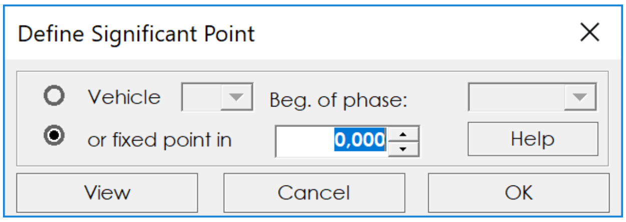
B.. Positions the vehicle in the brake point (after vehicle selection)

D.. Positions the vehicle in a defined point in time (more information see below)

□.. Position the vehicle in t = 0

3.8.5.1 Definable point

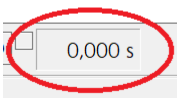
A right-hand click on the button „D“ opens up the menu „Define significant point“.



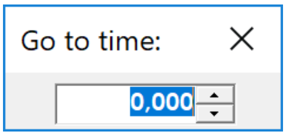
You can either select a fixed point in time or the beginning of a phase for a certain vehicle. Confirm your selection with “Save”. If you now select “D”, the Movie is immediately directed to the defined point in time. If the starting time of the chosen phase changes, the defined point is updated as well. The selected point in time is also saved in your report.

3.8.5.2 Direct time input

Move your cursor to the time display and click on the left mouse button to open up the menu for direct time input.



The Movie jumps to the specified time immediately.

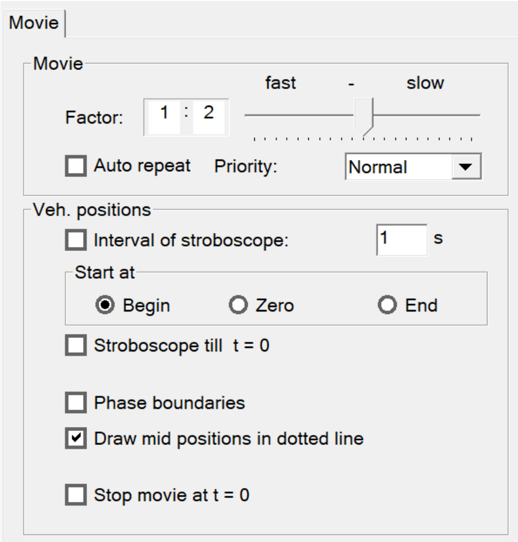


3.8.6 Setup

"Factor": Choose a factor between 16 : 1 (very slow) to 1 : 1 (real time) up to 1 : 16 (very fast) to define the executing speed of the Movie.

"Auto repeat": The sequence is always automatically restarted.

"Priority": Change the processor performance of the Movie here. If you select “Priority: High”, no other program can access the processor resources during the sequence of the Movie and a maximum performance of AnalyzerPro is ensured. However, f.e. if you want to create an avi-file from the Movie, you need to grant the program you use for it a certain part of processor capacity and select “Priority: Normal” or “Low” instead.



"Interval of stroboscope": If this menu item is activated, the positions of the vehicles are drawn in the specified time interval.

"Start at Begin/Zero/End“: Choose the starting point for the first time interval. If “Zero” (zero point) is selected, the activated visual radii are always drawn. Granted that the starting and end point are not at the same time, the visual radii are only drawn if the time increment is equal or a factor of the time difference.

"Stroboscope till t = 0": Only the positions before time = 0 are shown.

"Phase boundaries": If phase boundaries are active, the positions of the vehicles are drawn there.

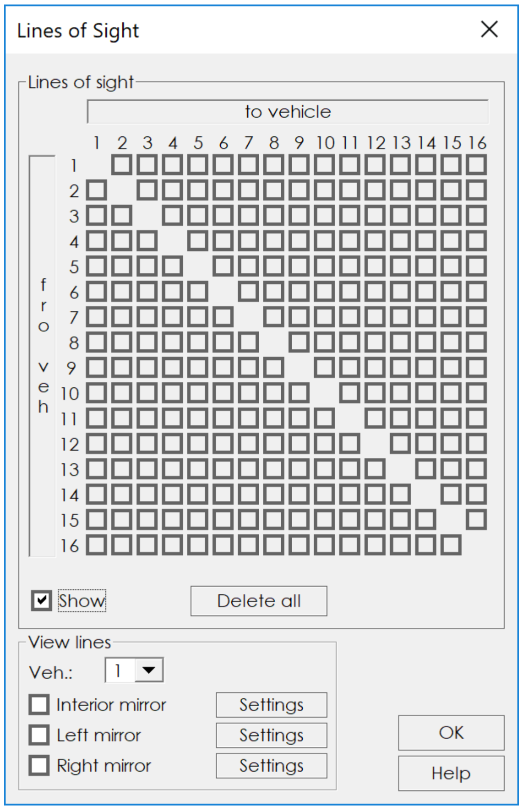
"Draw mid position in dotted line": In order to facilitate the differentiation to Movie positions (dynamic positions, continuous lines), you can draw mid positions (static positions: stroboscopy, phase boundaries, start and end position) with dotted lines.

If both a dynamic and a static position are drawn on the same spot, both lines are normally deleted, however, mid positions with dotted lines remain definitely visible.

"Stop Movie at t = 0": You can choose to stop the Movie at time = 0; the sequence proceeds again with a click on the Play-button.

3.8.7 Lines of visibility

(Icon: ):



Lines of visibility serve the determination of the first sight. You can select various combinations of lines of visibility by clicking on the respective position in the table. The default setting specifies that the starting point of the lines of visibility (eye point) is positioned in the middle of the wheelbase in longitudinal direction and in the point ¼ of vehicle width in transverse direction. The line of visibility ends in the mid front of the other vehicle by default. Both points can be positioned differently by clicking on and shifting them. All settings are saved.

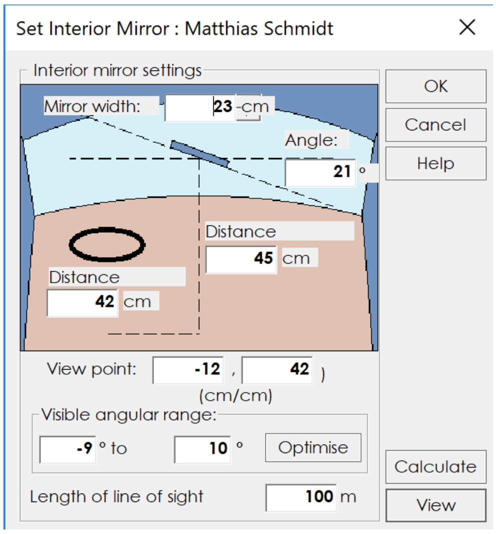
"Delete all": Deletes all input data with one click. Single input values can also be deleted by clicking on them a second time.

"Show": Visualizes the lines of visibility. The entries in the table remain unchanged.

You can decide to show lines of visibility for the interior mirror, the left exterior mirror and the right exterior mirror. Define the mirror width, the position relative to the eye point and the angle relative to the lateral axis in the menu “Settings”. The position of the eye point is the same as the one already stated as starting point for the lines of visibility.

"Distance (lateral)“: Distance between the eye point and the midpoint of the mirror in lateral direction to the vehicle’s longitudinal axis.

"Distance (longitudinal)": Distance in longitudinal direction to the vehicle’s longitudinal axis.



The position of the eye point can also be adjusted. The coordinates relate to the centre of the vehicle (0|0).

You can define the visible angular area numerically, then the angular position is ineffective. Alternatively, you can use „Calculate“ to compute the visible angular area from the angular position and optimise the angular position afterwards.

"Optimise": Calculate the angle for an optimum mirror adjustment. “Optimum” means that the visible angular area is positioned symmetrically to the vehicle, in the case of the exterior mirrors with a line of visibility directed backwards and parallel to the vehicle. If the vehicle falls below the value required by EU regulations, the angle is increased accordingly.

3.8.8 Fix

You can either choose this menu item or click on F3 to create a copy of all visible vehicles including their brake or flashing lights at the respective position. These copies are not linked to a driving line and can be shifted and rotated freely.

3.8.9 Fit time

With this option, you can let all curves in the diagrams as well as the Movie sequences of all vehicles start at the same time. All vehicles for which distance-time data is available are equipped with a phase of constant velocity (resp. standstill) at the beginning. Therefore, the missing time to the curve starting first is determined.

If a phase different from one with constant velocity is desired, you can change it in the distance-time data mask.

3.8.10 Shift curves to zero point

This option shifts all active curves (i.e. of activated vehicles) from their current time to zero.

3.8.11 Show sensor

Displays sensory data in driving dynamics.

3.8.12 Large timer

It might be necessary to show a large timer for presentation purposes. The time available under Graphic → Larger timer can be further enlarged if desired. Move your mouse to the window frame and hold the left mouse button to extend the window. The font size is automatically modified.

3.8.13 Graphics utilities

According to the currently active window (Movie or path-time diagram), the associated utilities are available.

3.8.13.1 Maximize

(Icon: ) Selects the smallest possible scale with which all objects are visible in the window.

3.8.13.2 Grid

(Icon: ) The following types of grids can be chosen for the Movie:

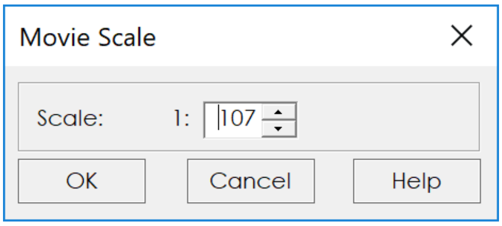
Point: Draw grid points only.

Cross: Mark grid points with crosses.

Line: Draw gridlines.

You can adjust the grid intervals (dx and dy) in x and y direction. The default setting is 5 m each.

3.8.13.3 Movie Scale



(Icon: ) Insert the scale for the Movie display. A print-out then shows the same extraction that is also visible in the window, hence, the picture section changes with the scale. If the scale shall remain unchanged, the picture section should not be zoomed anymore. Therefore, it is advisable to adjust the scale immediately for printing only and shift the section if necessary.

As the page format does normally not comply with the screen format, a space at the top/bottom or on the sides can be left blank at the printout. In order to avoid this, control the section under “File/Print review” before printing.

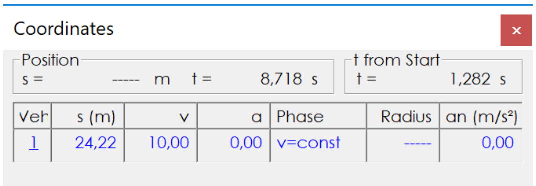
Tip: If it is impossible to show the desire picture on one page with the desired scale, use two printouts with overlapping picture sections instead.

3.8.13.4 Psychoman

This is a visualization tool for the movie that highlights specific body parts of a sample driver in yellow, depending on the current phase of the selected vehicle. The highlighting is intended to illustrate which driver action is particularly relevant or active during the current phase.

3.8.13.5 Coordinates

(Icon: ) Choose this option if you want to display the current Movie coordinates of the vehicles analogously to the Path-time diagram. The position of the displayed coordinates can be changed in the Movie settings.



The distance corresponds with the one in the distance-time diagram at the same time, thus, the start value needs to be considered. Distance has to be viewed as a relative value instead of an absolute value and is measured resp. calculated along the curve. The vehicle arrives at the zero point at the time at which the curve and the time axis intersect in the diagram. If the vehicle drives beyond this point, all values become negative. Usually the collision point corresponds with the zero point in the diagram; then, you can determine the distance to the collision point from the information given on the distance.

The first row show the position of the crosshairs in the distance-time graphic, the time of the Movie from the beginning and from the end and below that the vehicle coordinates. The distance position complies with the distance-time curve at the current point in time. Velocity, acceleration, curve radius (centre of vehicle) and lateral acceleration (= acceleration in transverse direction to the vehicle) are stated at the current point in time as well. Furthermore, the yaw angle and the steering angle are indicated.

Distance-time diagram:

To change the position of the crosshairs which appears with the activation of the coordinates, click on it first; it is now depicted with dotted lines. Next, you can shift it with the cursor keys or with your mouse. For the latter option, position your mouse either within the square or at a line. When the mouse pointer changes its form to a cross or double arrow, hold the left mouse button and shift the crosshairs.

Cursor up / down: Increases / decreases the duration down to zero point. The path position of the vehicles, the current velocities and the accelerations at the moment are displayed. At the same time, the vehicles in the Movie are positioned accordingly.

Cursor left / right: The distance between the crosshairs and the zero point is increased / decreased. Vehicle data is not affected.

3.8.13.6 Pan

(Icon:) Shift the picture section together with the background object (if existent).

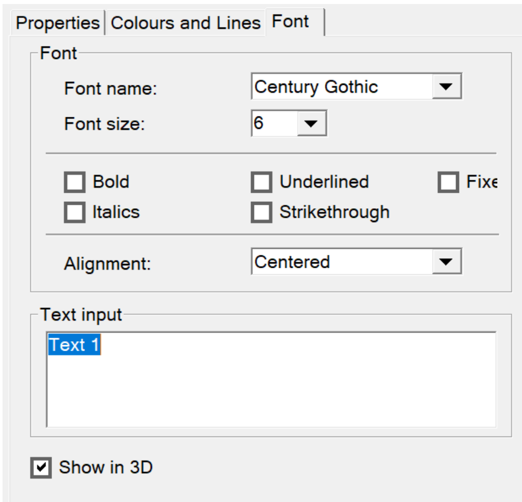
3.8.13.7 Measuring tape

(Icon:) This menu item allows you to measure distances with your mouse. Move the mouse pointer to the starting point, hold the left mouse button and move it along the desired distance. The relative coordinates (distance and time) are displayed in the status bar below. Use the measuring function as long as the button is activated. For the selection of objects, you need to deactivate it again.

3.8.13.8 Label

(Icon:) You can label the Movie as well as the distance-time diagram. The procedure is analogue to the drawing of a rectangle. The size of the created rectangle determines the size of the text window.

"Font name": The selection of fonts depends on your Windows setting.



"Font size": The font size is either indicated as fixed size or in % of the rectangle size (if justification mode is activated).

Depiction: „Bold, Underlined, Italics and Strikethrough are possible.

"Alignment": Aligns the text within the rectangle. If the “Justification” mode is chosen, the font size is automatically adapted to the size of the rectangle, under consideration of the percentage stated previously. The pre-set printing scale affects the text window and consequently the font size.

"Fixed": Choose this option to keep the font size irrespectively of the scale; otherwise the font size changes proportionally to the printing scale.

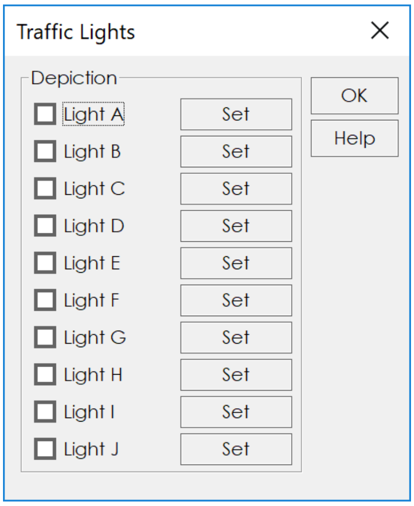
"Text input": You can enter several lines of text. The key combination Ctrl + Enter functions as row separator. Given that the rotation angle is not too big, multiline text can easily be shown in rotated direction.

Like a normal drawing object, you can distort, shift and rotate the text.

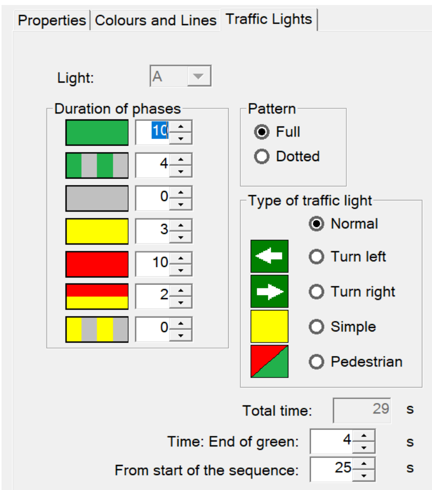
3.8.13.9 Draw line

(Icon:) Draws an arched line object („Spline“).

3.8.13.10 Traffic lights



(Icon:) Up to ten different traffic lights (labels: A, B, ... J) can be created. The labelling of the traffic lights has a meaning for the Movie as well, as the traffic light phases are synchronized based on it. The duration of the phases and the filling pattern of the bars can be adjusted in the respective “Settings” menu or with a double-click on a traffic light phase. Alternatively, you can open the distance-time diagram and load the “Settings” menu via the traffic light button ().



The temporal sequence of the traffic light can be adjusted directly in the distance-time diagram by selecting the respective bar; keep the control key pressed to select multiple bars at one time. Afterwards, move your mouse up or down with pressed left mouse button. The other option is to state the sequence numerically in the settings.

The duration of each traffic light phase can be determined here. The “Total time” shows the time needed for the entire phase cycle.

After defining the traffic light and synchronizing it with the driving processes, you can show the traffic light in the Movie. Press the icon  and select the appropriate traffic light number. The traffic light is automatically depicted in 2D and 3D.

3.8.14 Properties

All vehicles, their lines, line objects and other drawn elements, text and traffic lights are recognized as objects. Their properties, f.e. colour, line thickness, pattern, can be adjusted in this menu. Furthermore you can also change the properties of axes, grid lines and similar objects here. The object properties depend on whether the Movie or the distance-time diagram is activated.

3.8.14.1 Open the Properties window

You can open the Properties window in three ways:

- Open up an options menu with a right-click in the opened Movie window or diagram window.
- Select the object and press the Enter key.
- Double-click on the desired object.

The available menu options depend on the selected object. The left part of the window lists the objects in hierarchical order (analogously to a directory tree). Select your object of choice here. The right part serves the adjustment of the selected option’s properties.

The selected object is immediately selected in the Movie, marked in the directory tree and its name is shown in capital letters: >-- OBJECT NAME.

You can delete objects or change their order and allocation in the Properties window. The directory tree is automatically updated.

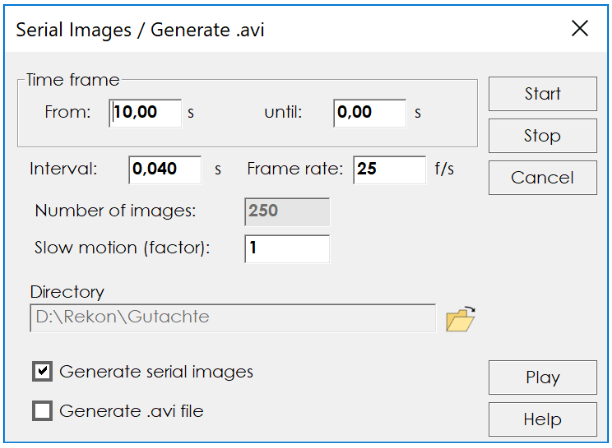
3.8.15 Build BMP sequence / AVI

(Icon: ) You can create bitmaps of the active window (Movie, driving dynamics or coasting analysis) in defined time intervals and save them.

"From": Start time of the first bitmap.

"Until“: End time of the final bitmap.

The time values are transferred from the distance-time data to the Movie and can be changed there. The simulation windows start at time 0 and run through the end of the simulation.



The bitmaps are saved in the same file as the report and receives the same name with a numerical supplement, f.e. the bitmaps referring to a report file called “test.anl” are called “test001.bmp…test999.bmp”. Based on the time frame and the “frame rate” resp. the interval size, the program calculates the number of pictures it has to create. You can also produce a movie file (avi format) with the bitmaps.

"Start": Initiates the creation process of BMP and/or avi files.

"Stop": Cancels the process.

"Slow motion": Decelerates the movie by the stated factor.

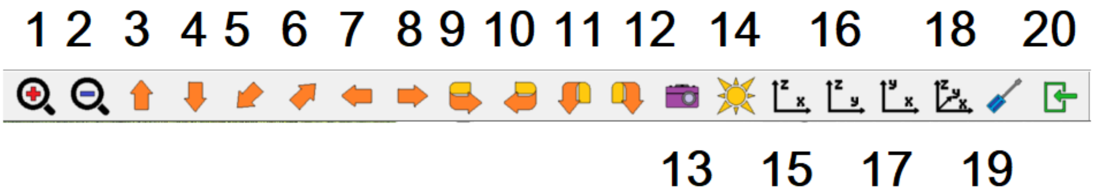
"Play“: Opens the media player pre-set in the Directories.

3.8.16 3D View

(Icon: ) The 3D view can be started from the Movie and the simulation and shows the 3D depiction of the window from which it is called up. You can control the sequence either from the window from which you have opened the view or in the 3D window itself. The Play button in the Movie starts the simultaneous sequence of the

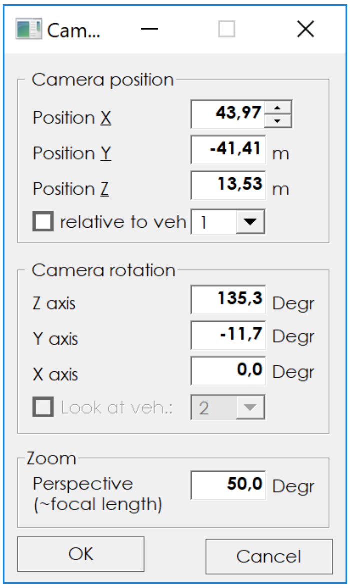
Movie and 3D. Please note that you can open several reports and projects at the same time in AnalyzerPro, but you cannot open several 3D windows simultaneously.

Many 2D objects have a tab with 3D settings under Properties. All settings for the 3D are made there.



1. Zoom in
2. Zoom out
3. Move image upwards
4. Move image downwards
5. Move image to the front
6. Move image to the back
7. Move image to the left
8. Move image to the right
9. Turn to the left
10. Turn to the right
11. Turn to the front
12. Turn to the back
13. Position the camera
14. Position the sun and sources of light
15. Depict the z-x plane (side view)
16. Depict the z-y plane (front view)
17. Depict the x-y plane (aerial view)
18. Depict in x-y-z (diagonally aerial view)
19. Options (settings)
20. Exit: close the 3D window

3.8.16.1 Position the camera



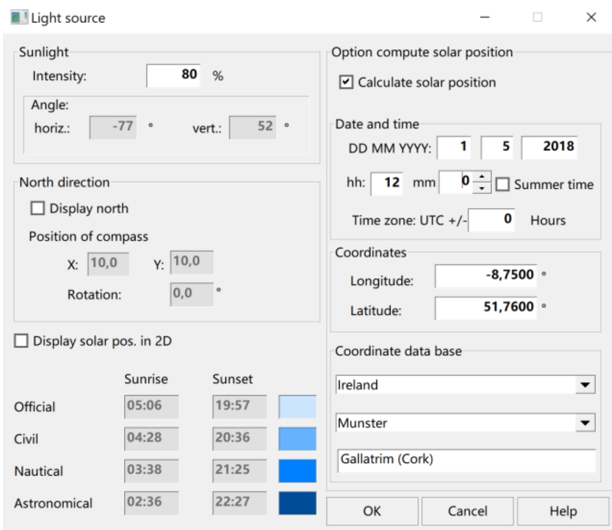
The positive x axis usually points to the right, the y axis to the back and the z axis upwards, hence, the camera (visual focus) is positioned accordingly.

"Relative to veh.": You can position the camera inside a vehicle and occupy its perspective during the sequence.

"Look at veh.": Choose this option to always direct the camera towards the selected vehicle.

"Perspective": Zoom in or out in the 3D view (analogously to the zoom factor of the camera).

3.8.16.2 Source of light and solar position



Adjust and calculate the sunlight in the input box „Source of light".

"Intensity": 0 – 100%.

"Angle horiz./vert.": Position of the sun.

"Option compute solar position": With this option you can calculate the solar position at any time and in any place of the world. The calculation assumes that the Earth is perfectly ball-shaped, therefore, you have to consider if mountains or other surrounding factors might obscure the sun at its solar position. Further limitations could be found with the weather conditions of the respective day, as they might have made the sun irrelevant in certain situation.

To calculate the solar position, insert the longitude and latitude of the accident scene as well as the date and time of the accident.

Hint:

- Make sure that the right time zone is chosen. Central European Time is UTC +1, Eastern European Time is UTC +2, London is UTC +0.
- The option "Summer time" adds one additional hour to calculations.
- Ensure that the coordinates of longitude and latitude are stated as decimals. F.e. a latitude of 45 degrees and 45 minutes is inserted as 45,45°.

The 3D view shows North at top by default, however, you should always adapt the orientation according to your accident situation. The "Compass" that appears when you select the option "Display north" supports you in orientation. Next to the 3D compass, a wind rose in 2D depiction is automatically loaded. You can relocate the wind rose and rotate it afterwards so that it points to the North. The 3D view is then automatically oriented to the North as well and the solar position is updated. Alternatively, you can also use the field "Rotation" in the "Light source" dialogue to change the orientation.

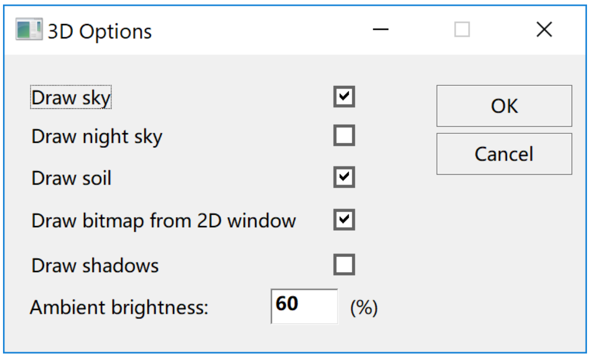
The box "Display solar position in 2D" adds a sun depiction to your 2D window. Like in 3D, the sun depiction is automatically adjusted to the rotation of the wind rose in 2D or 3D.

A coordinate database is stored. First select the country, then the region. Now enter the name of the place. The database makes suggestions for the deposited locations and then automatically enters the coordinates.

The different twilight levels are displayed in the lower left area of the window.

3.8.16.3 3D Options

Change the 3D window's appearance in this menu.



"Draw sky": Draws a blue sky in the background.

"Draw Night Sky: Replaces the sky with daylight with a dark night sky.

"Draw soil": Represents a standard floor.

"Draw bitmap from 2D window": Takes bitmaps from the 2D view.

"Draw Shadow": Shows shadows of 3D objects. Attention: This is relatively calculation-intensive and should only be used with potent computers, because otherwise the program could become very slow.

3.8.17 Show 3D camera

This option activates a camera icon in the 2D window. The position and rotation of the camera in 2D correlates with the ovservation point in 3D.

3.8.18 3D Model Import / Laserscan Import

Choose Graphic -> Import of 3D Models to import vehicles and landscapes in .obj format. As the internal memory is artificially limited by many Windows systems, it might be necessary to minimize the models mathematically. The program will automatically do so in a few minutes.

It is also possible to import files from laser scanners in e57 or xyz format. If you have the choice, however, the .obj format is to be preferred as it can be handled more computationally efficiently.

You can rotate the preview view by holding down the left mouse button. Furthermore, you can rotate the view via the control field or jump into the specified cracks. It is also possible to switch between perspective and orthographic view.

Vehicles:

As a first step, please choose an .obj file via the file browser. The associated .mtl file and .jpg file must be located in the same folder and have the same name. Alternatively, this also works with .e57 or .xyz files.

For example as follows:

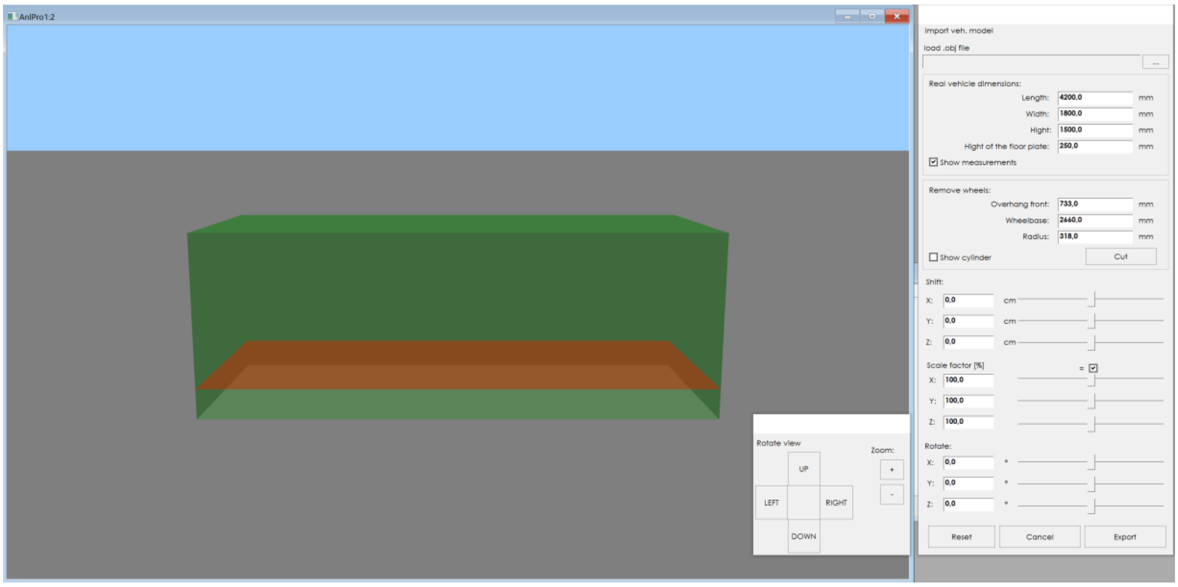
Name	Änderungsdatum	Typ	Größe
straße.jpg	05.07.2017 23:49	JPG-Datei	3 483 KB
straße.mtl	05.07.2017 23:49	MTL-Datei	1 KB
straße.obj	05.07.2017 23:49	Object File	695 113 KB

The vehicle is now loaded and positioned in the middle of the preview screen. Under "Real vehicle dimensions", you can determine the size of the green cube which serves as an adjustment assistance for the 3D model. The red area symbolizes the bottom panel and can be amended under "Height of bottom panel". It determines the vehicle's height above of the ground in its original condition (without additional deflection).

Many vehicle models are drawn with wheels. In contrast to the rotating wheels that are added by Analyzer Pro, fixed wheels might be perceived as disturbing. If you press "Depict cylinder", two blue cylinders appear. You can position them above the wheels with the help of "Overhang in the front", "Wheelbase" and "Radius". The option "Cut" will delete everything located within the cylinders from the models.

The options „Shift", „Scale" and „Rotate" allow you to position the model within the green cube, however, in most cases the scaling factor will be sufficient.

If you have completed the adjustments of your model, click "Export" to save it in .murkpkg format. Afterwards, you can load the new model as 3D model on vehicles as usual (via Vehicle data -> 3D Model).



Landscapes:

Similar to vehicles, the following 3 file types must be available in the same folder: example.obj, example.mtl and example.jpg. If you import data from laser scanners, the data must be in e57 or xyz format.

Use the preview option to view the landscape and position it with “Rotate” and “Shift” according to your wishes.

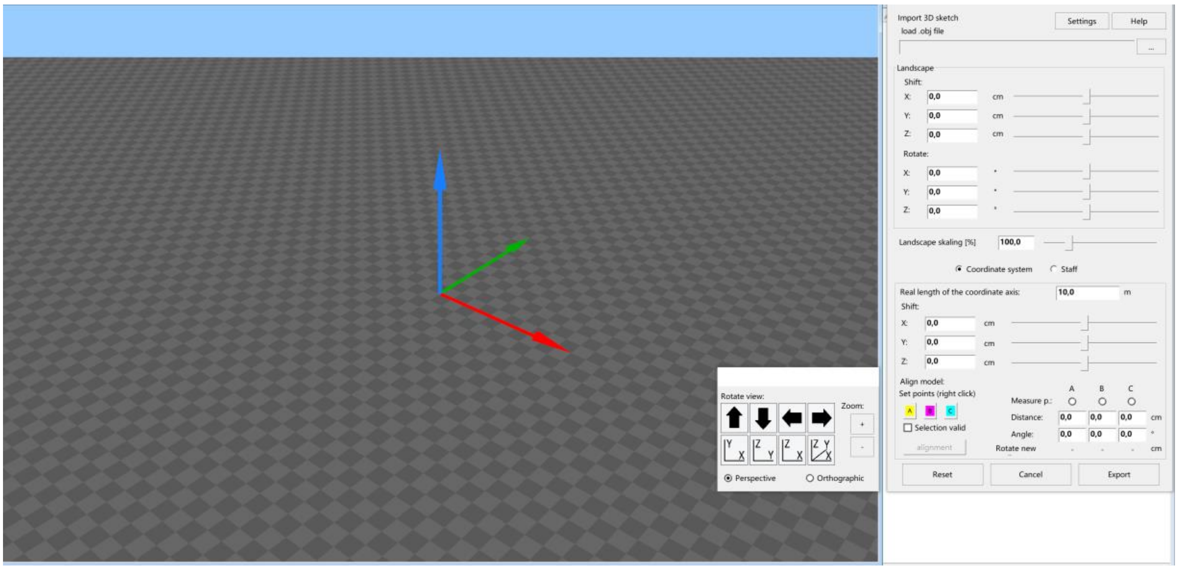
You can scale the landscape in 3 ways. The first option is to drag the stick in red-white-red with the respective sliders to a position of known distance. Then you can enter the real distance as “Real length of yardstick” to scale the landscape accordingly. The second option is to scale the landscape like any other Bitmap after exporting and inserting it into the Movie. The 3D model automatically adapts to the scale.

The third option is via "Align model": To do this, you must know 4 sizes on your model. From one measuring point you measure distance and angle to 2 target points. In the preview, first click on "A" and then right-click on the location in the model where your measurement point A is located. How do you do this for B and C? Then select from which point you have measured. Now enter the distance and angle to the other points. With "Align" your model is aligned and scaled in the plane. A possible error is displayed under "New distance", the model is not distorted, only scaled.

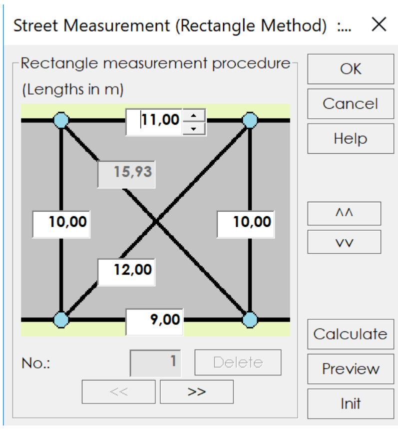
The landscape is saved with the button „Export“. 4 files are created at the target place: example.color.jpg, example.depth.jpg, example.info.txt and example.murl-pkg.

These files may not be renamed and have to stay in the same folder as the report!

If you want to use the landscape, you can either keep the setting "After Export: Load Landscape Directly" or load the file "example.color.jpg" into the movie using "Insert Graphics" and scale it as necessary. Each time the 3D view is opened, it will now automatically load the 3D landscape instead of the 2D Bitmap. The surface was calculated from the model and is perceived from the wheels as such.



3.8.19 Rectangle method (street survey)



(Icon: ) Either the rectangular or triangular method are usually used for street surveys. For the rectangle method, two points on opposing roadsides are marked and connected to a rectangle (mesh). Then the distances of the points in longitudinal direction of the street, their transverse distances and one diagonal are measured. For the calculation of the first mesh, all four sides and one diagonal have to be known, for the subsequent meshes, the left side is already assumed from the previous mesh. The second diagonal is automatically calculated. You can switch from one mesh to the next with the button "<<", ">>", "vv" and "^^". At the same time, the meshes are calculated and drawn in the Movie. The current mesh number and its values are displayed. In the movie, the current mesh is highlighted.

It is possible to draw a smoothed line through the boundary points and activate/deactivate it via the object settings. The same holds true for the depiction of mesh lines.

You can correct the values of all meshes retrospectively or delete the first or last mesh in each case. To re-open the calculation mask, perform a right-click on the graph and choose the menu item “Edit“ in the pop-up menu. You can also call up the „Edit“ window via the Properties window.

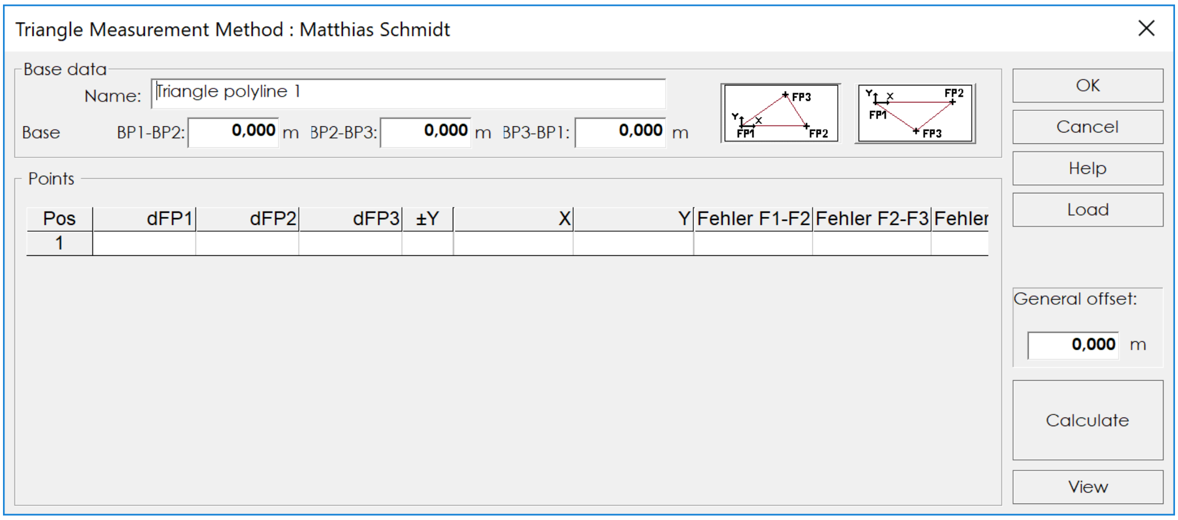
3.8.20 Triangle Measurement Method (street survey)

(Icon:) Two fixed points are needed for this method. The distances of the points to be measured have to be determined, then the relative coordinates of the measured points are calculated with trigonometric formulas. The field "±Y" indicates whether the measurement point is above (“+”) or below (“-“) the distance from FP1 to FP2.

With the definition of a third fixed point and the measurement of the distance to all three fixed points, the location of the point is clearly determined. For each of the value pairs of FP1, FP2 and FP3, the coordinates and thereof the weighted average values are calculated. The flatter the angle, the smaller the weight of the calculated angle.

In order to calculate the distances between the fixed points, you need to specify how the fixed points relate to each other (cyclical or anticyclical).

The three columns „Error F1-F2“ etc. shows the deviation of the calculated mean to the value calculated from FP1 and FP2. If no value is stated in the column, the program was not able to calculate it.



If the distance to the fixed points is measured f.e. with a laser device, the fixed points can be marked with cylindrical pillars. Please consider in this case that the reflection of the laser point around the radius takes place earlier; the radius needs to be added to the result. The program can automatically make this adjustment if you insert a general offset, saying that f.e. an offset value of 0,05 is added to all input values for calculation.

Use the Properties mask to decide on what shall be shown: the fixed point triangle, measuring points, connecting lines between them or a spline through the measuring points.

3.8.20.1 Import of Disto data

Start the import of data from a Disto device via the button „Load“. The importable data can be a simple text file (in text format *.txt) or an Excel file (in format *.csv). It is important that each row ends with the unit “m”, as the number in front of the “m” is imported. The character count in each row may not exceed 25.

Example:

Time	Position	Measured value	Unit
20:31:16	10001	29,075	m
20:33:39	10002	1,775	m
20:33:39	10003	22,16	m
20:33:39	10004	23,914	m
20:33:39	10005	15,538	m

Before the import, the program asks you if 2 or 3 fixed points are used and if the distances of the fixed points should be transferred. If you confirm the latter question, the first values are used for it.

The numbers are transferred one after the other in the first row under dFP1, then dFP2 and, if 3 fixed points are used, in dFP3. Afterwards, the process continues in the next row.

In order to avoid mix-ups, you also need to transfer numbers for points for which a measurement to a fixed point was impossible. Thus, it is advisable to conduct a survey with a reproached object with a distance of 0. After the import of data, you can search for the point again and delete the value: Click on the respective field, press the Return key and then the Delete key.

Import from a table

The second possibility is the import from a table.

f.e.:

	F1 – F2	F2 - F3	F3 - F1
	5,632	6,871	
P	P - F1	P - F2	P - F3
1	6,871	5,32	
2	7,8	8,96	
3	5,67	12,8	

The numbers to be transferred should contain a point or comma and at least one decimal. The table can be created with Word, Excel or any other editor, however, saving is only possible as a txt or csv file. Hence, simple formatting signs are allowed between the numbers. For a measurement with only two fixed points, the first two columns are filled with data; the third column (under F3-F1) has to remain empty.

If three fixed points are used, all three columns have to be filled with numbers. Complete blank cells with a value of 0,0 if a measurement is not possible (f.e. because a fixed point was covered). The number can be manually deleted after the import again.

3.8.21 Draw

Important: The program saves all objects that are imported in the Movie or drawn and imports them to the other windows (driving dynamics and collision coasting), but not vice versa. F.e. if you draw objects in the module of driving dynamics, it is only available there. Hence, we recommend to do most of the drawings and definition work (f.e. for a friction surface) in the Movie.

The drawing tools can be found in the left monitor area by default and can be shifted according to your preferences.

All drawn graphic objects can be re-edited with a right-hand click and the choice of the Properties menu.

Many 2D objects have a tab with 3D settings under Properties. All settings for the 3D are made there.

3.8.21.1 Duplicate

(Icon:) Duplicates a selected graphical object; you can also copy it with Ctrl + C and paste with Ctrl + V.

3.8.21.2 Straight line

(Icon:) Choose the icon, move the cursor to the desired spot for the first point, click with the left mouse button and keep it pushed while moving the cursor to the desired end point.

In 3D the straight line can become a wall, a hedge, a guardrail, a garden fence or a street dividing wall.

3.8.21.3 Arrow

(Icon:) Among other things, you can use the arrow for dimensioning. Change the form of the arrow in the Properties menu: Both for the starting and end point, you can choose between None, Arrow, Circle, Straight. Each option except of "None" can be further amended in terms of length and height. Moreover, you can choose the automatic dimensioning and the depiction of the dimensioning in the menu.

Closed objects

All closed objects can be created in the same way: Click on the left mouse button and pull out the object along a fictional diagonal with the mouse button pressed. The length of the diagonal determines the object size. As the object is drawn with the same size in x and y direction, either a square or circle is created. If you push the

Alt key simultaneously to the pull-out of the object, the length and direction of the diagonal determines the size and form of the object.

3.8.21.4 Circular arc

(Icon: ) Between two radii composing a right angle, an object is created. As each of the radii can be rotated, you can adjust the opening angle as you wish. If you activate the dimensioning function, the angle is displayed and the radii are drawn.

3.8.21.5 Rectangle

(Icon: ) If you specify a height for a rectangle drawn in the 2D window, it is automatically displayed as house in the 3D window.

General 3D objects and cuboids can also be loaded under the settings.

3.8.21.6 Oval

(Icon: ) The depiction of the oval consists of the boundary points and a point in the middle, which you can shift to determine the form of the oval.

3.8.21.7 Ellipse (Circle)

(Icon: ) Create a circle resp. ellipse with this button.

In 3D, a cylinder can be created here.

3.8.21.8 Line objects

You can choose between straight line objects (Icon: ) and spline curve line objects (Icon: ).

Create a line object by moving the cursor to the desired starting point and click on the left mouse button. Move further to the next point and click on the left mouse button again. When you have drawn all necessary points, perform a double-click or press the right mouse button and the Esc key.

You can edit each point by selecting the object and moving the cursor to the respective point. When the cursor changes to an arrow, keep the left mouse button pushed to shift the point with your mouse.

Driving lines of vehicles are also line objects and can be edited in the same way.

If you move the mouse on a line object, a window stating the length of the line appears. You can adjust a permanent display of the length via the setting „Dimension".

Insert / delete a defined point: Move the mouse pointer to the desired spot and press F9. Allocate the defined points more or less evenly with same distances. Curves are adapted in a way that the tangent in the defined point shows in the direction of the angular symmetrical line of the tendons between the two neighbouring points. A too high number of points can be avoided by skillfully allocating the available ones.

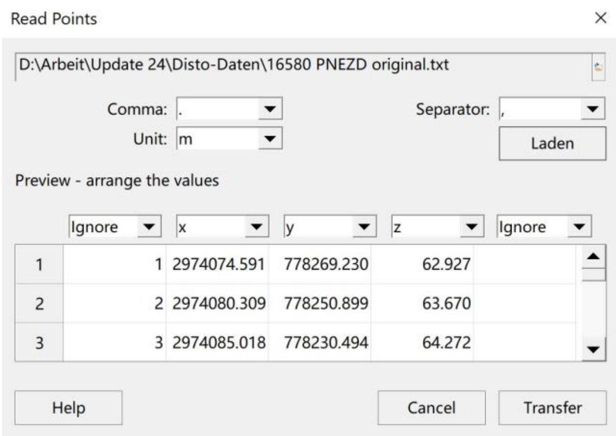
Switch between straight / arched line sections: The curve mode allows you to create straight line sections already while setting the points, if you push the key F11 before placing the second point. You can also switch between straight and arched sections for already created splines: Move the cursor to the respective section and press the key F11.

Switch between open / closed line objects: In order to change a line object from open to close and vice versa, click on the right mouse button and select the desired setting in the pop-up menu. You can view the surface area of a closed line object by moving the mouse on the line.

Connect polylines: Connects two line objects of the same type with each other. Choose the two objects you would like to merge after each other; the cursor changes its appearance when it has recognized a suitable line in the surrounding area. The program connects the line objects at the ends which are the closest to the click points. The connection is not reversible afterwards.

3D Depiction: If the z coordinate in the geometry properties is stated as greater than 0, the line object is illustrated 3-dimensional in the 3D window, whereby the depiction depends on the following choices:

- Terrain: The terrain is lifted within the polyline resp. spline. The height is defined as the average value of the z coordinates, unless you choose “Absolute” as a height; then it is automatically changed to the absolute value you have defined.
- Prism: The polyline resp. spline is changed to a 3D object with the form of a prism. If the outline is not convex, you need to ensure that the external point distance is greater than internal to depict the deck area correctly. It might be necessary to draw an additional point inside.
- Torus: Choose this option to create a torus based on the form of the polyline. The width corresponds with the line width, the height is determined by the z coordinate of the respective point.



Load (coordinates): Loading (of Coordinates): The coordinates of the reference points of a polyline (including a route) as well as the points can be imported from a text or .csv file. After selecting the file, both the comma symbol and the character separating the values must be specified. Clicking 'Load' will display the preview. Finally, it must be indicated which values represent the coordinates. The input is confirmed with 'Transfer'.

3.8.21.9 Points (Crosses)

(Icon:) Places marking points with continuous numbers. The depiction of the points can be changed in the Properties menu.

3.8.21.10 Curved ruler

(Icon:) The procedure for drawing a curved ruler is the same as for curved line objects. In the settings, you can specify the units in which the line is to be divided.

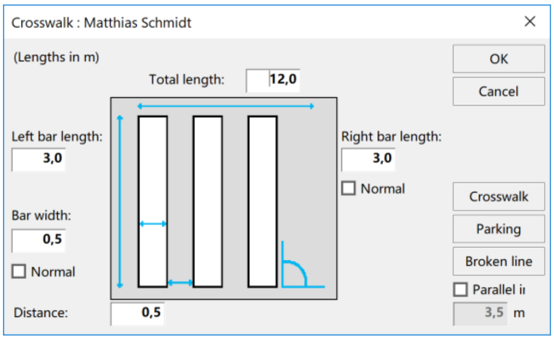
3.8.21.11 Insert text

(Icon: T) Creates a text field. More information is available in chapter 3.8.13.8.

3.8.21.12 Label

(Icon:) Creates an arrow with inscribable end. Insert the label in the respective text field.

3.8.21.13 Crosswalk



(Icon:) Add a crosswalk to your accident sketch. The procedure is similar to the creation of straight lines, only that a field of rectangles is drawn instead of a line. When you release the left mouse button, the Crosswalk menu opens up. You can adjust the left and right bar length, the bar width and the distance between the bars. If the left and right bar lengths do not match, the length of the bars changes from left to right and a trapezoidal crosswalk is created.

"Parking", "Broken line" and "Crosswalk": Click on these buttons to automatically insert the values of a parking space, a broken line or a crosswalk.

"Parallel in … m": Positions a copy of the crosswalk in parallel with the defined distance.

"Normal": The given length is used in a 90 degree angle.

3.8.21.14 Insert graphic object

(Icon:) More information on the insertion of graphic objects can be found in chapter 3.3.8.

3.8.21.15 Group selection

(Icon:) Combine several selected graphic objects with this button. You can shift and rotate them as a group, as well as export them together as DXF files.

3.8.21.16 Utilities

(Icon:) Opens up a utility file that features commonly used graphic objects for copying.

3.8.21.17 Flip objects

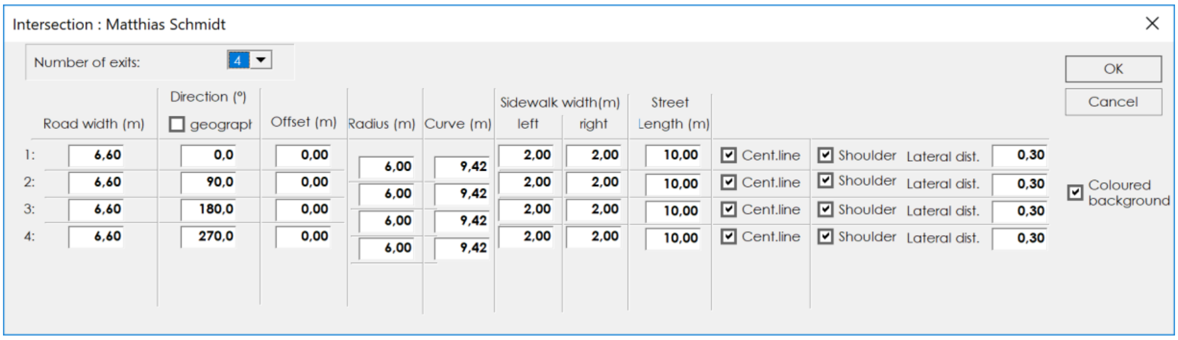
(Icons: (vertical) - (horizontal)) Flip line objects by clicking on one of the icons and inserting a negative scaling factor in the Properties menu:

Scaling factor X = -1, Y = 1 => Flip around the horizontal axis.

Scaling factor X = 1, Y = -1 => Flip around the vertical axis.

3.8.21.18 Intersection

(Icon:) Select the icon and click on the desired position in the Movie. The program opens the Intersection menu and simultaneously draws a default intersection.



"Number of exits": Define how many streets flow into the intersection; the number has to range between 3 and 6. The exits are numbered counterclockwise from mathematical point of view.

"geograph.": The direction can either be in line with the mathematical angular orientation (right = 0°, top = 90°, ...) or with geographical one (North = 0°, East = 90°, ...).

"Road width (m) ": Defines the width of the respective road.

"Offset (m)": The distance that the extension of the middle of the road goes beyond the centre of the intersection. Positive value: From a centre point of view, the extension passes by on the left side; negative value: From a centre point of view, the extension passes by one the right side.

"Radius (m) / Curve (m)": Specifies the curves between the exits. One of the values has to be stated, the other one is automatically complemented.

"Sidewalk width (m) left / right": States the sidewalk width to the left and right of the street. The direction left resp. right relates to the viewing direction away from centre.

"Street length (m)": Defines the length of the straight street away from intersection.

"Central line / Shoulder": Decide whether you want to draw a central line or border line (shoulder) for the respective exit.

"Lateral distance": States the distance from the border line of the roadside.

"Coloured background": You can choose between a depiction with coloured backgrounds and one only showing the intersection lines.

The pavement height can be specified in 3D.

3.8.21.19 Street

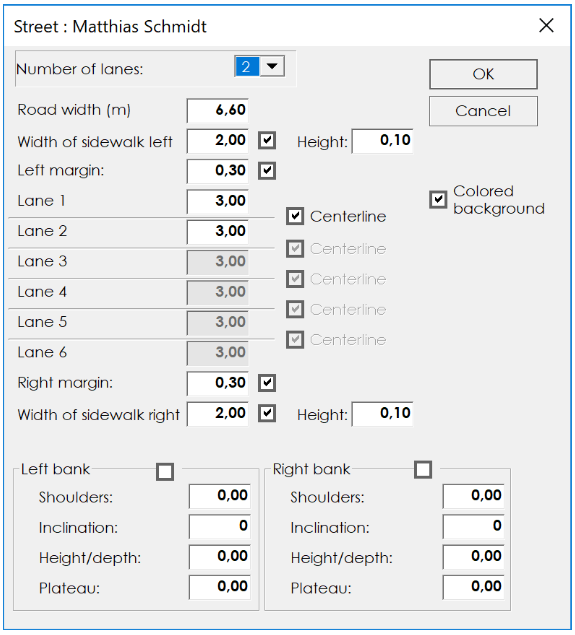
(Icon: ) Drawing a street works like drawing a spline: Select the icon, define the street midpoints with mouse clicks on the desired positions and perform a right mouse click to finish the process and open the input mask.

Tip: The position of the defined points can be changed manually. Click on the middle of the road and shift, add or delete points as you like. Sometimes the street's middle is covered by the centreline and cannot be selected. In this case you have to shift the centreline and select it again. The correct position of the centreline is automatically restored with editing. .

"Number of lanes": States the amount of street lanes.

"Road width (m)": States the width of the entire street without sidewalk.

"Width of sidewalk left / right": States the sidewalk width. You can untick the box next to it if no sidewalk should be drawn at all.



"Left margin": States the distance of the border line from the roadside here. Untick the box next to it if no border line should be drawn at all.

"Lane 1 - 6": Specify the width of each lane.

"Centreline": Decide whether a centreline shall be drawn.

"Coloured background": Decide whether you want to depict a coloured background.

You can decide which type of street limits you want to use for the 3D depiction. Next to a sidewalk with editable height, you can also choose to depict banks and shoulders.

"Height": Defines the sidewalk height.

"Left / right bank": Decide whether banks shall be drawn.

"Shoulders": Insert the width of the shoulders.

"Inclination": Draw a slope with a negative value and an inclination with a positive value.

"Height/depth": Refers to the difference in height compared to the bank.

"Plateau": If you insert a value > 0, a stripe with the defined width is added to one of the banks resp. slopes.

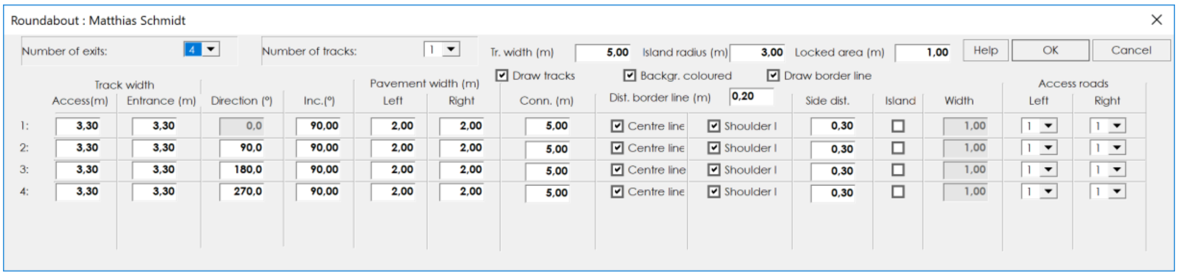
<u>Tip:</u> You can also draw streets with a transverse gradient. Define an appropriate z coordinate for the street border lines to the left and the right, f.e. -0.2 on the left and

+0.2 on the right. Starting from the middle of the street, the street is then linearly lifted by 0.2 and linearly lowered by 0.2 to the left.

It is important to schedule the numerical input and the amendment of single line courses only after the drawing of the street is completed. It the street or the street lines are edited afterwards, all manual changes are deleted and the street is newly built.

3.8.21.20 Roundabout:

(Icon:) Select the icon „Insert Roundabout“ and move your cursor to the position where you would like to insert the roundabout. A click with the left mouse button draws a default roundabout and opens up the menu for further adjustments.



"Number of exits": Select how many streets shall flow into the roundabout; the number can range between 3 and 6.

"Number of tracks": Define how many tracks the roundabout should have. The total radius of the tracks is composed of the number of tracks multiplied with the track width.

"Draw tracks": Determines whether lines shall separate the tracks in the roundabout.

"Background coloured": Choose between the coloured depiction and the one with lines only.

"Draw border line": Choose whether you want to show external border lines.

"Track width": Insert the width of the tracks in the roundabout.

"Island radius": Adjust the radius of the island in the middle of the roundabout.

"Locked area": You can create an additional locked area with a specified width around the island. If this is not needed, insert a value of “0”.

"Track width Access / Entrance": Specifies the width of the roads entering the roundabout at their starting and end points.

"Direction": States the direction in which the exits shall leave the roundabout. The numbering starts with the axis on the right (0°).

"Inc.": Enter the degree of street inclination if applicable.

"Pavement width left / right": States the width of the pavement on the right and left roadside. An average value of both is calculated for the transition area.

"Connection": States the length of the access road.

"Centre line": Activate/deactivate the centre line for each access road.

"Shoulder line": Activate/deactivate the border lines for each access road.

"Side distance": States how far the border lines shall be depicted from the roadside.

"Island": A tick on this box replaces the centre line with separating island. The length of the island corresponds with the length of the access road.

"Width": Modify the width of the separating island here.

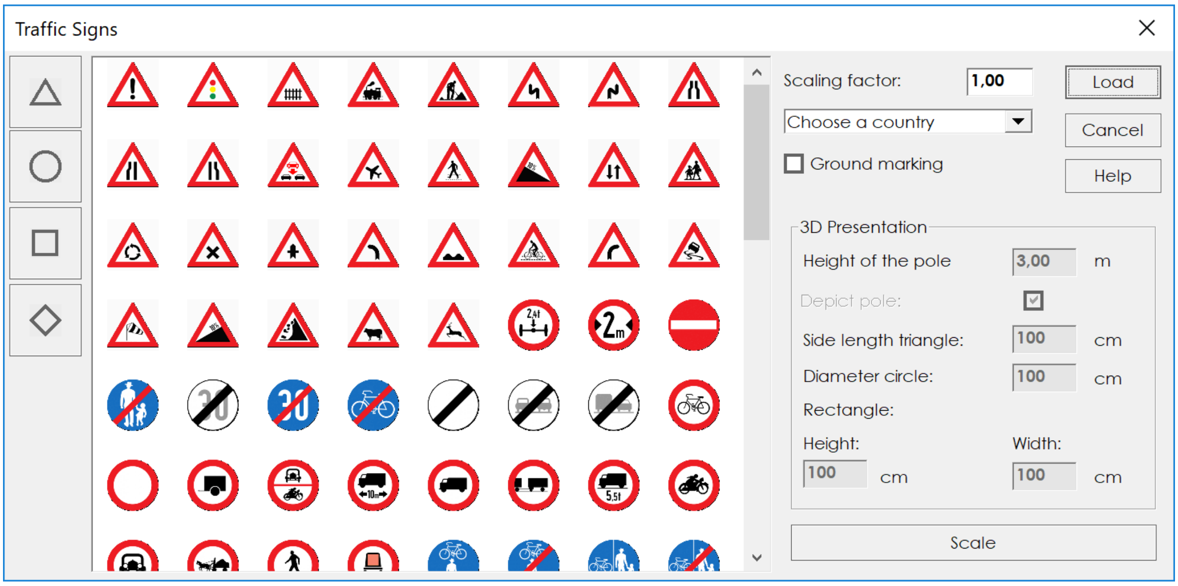
"Acess roads left / right": state the number of access roads to each exit.

Island height and pavement height can be specified in 3D.

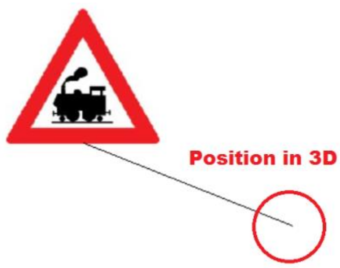
3.8.21.21 Traffic sign

(Icon:) A click on the button „Insert traffic sign“ changes the appearance of your cursor. Click on the position where you would like to add a traffic sign. The Traffic Sign menu opens up automatically.

Choose the traffic sign you want to use first. You can navigate through the selection either with the slider on the right side or with the outline types depicted on the left side of the window. The rhombus type directs you to all signs which cannot generally be allocated to one specific type (f.e. St. Andrew’s cross). When you choose a traffic sign with the left mouse button, the appropriate windows are unlocked in the right area. You can decide if the traffic sign shall be positioned on a pole in the 3D depiction and adjust the height of the traffic sign. To change the size of the traffic sign, either choose one of the standardized sizes of various countries, which are listed in the dropdown menu, or enter the dimensions directly. In any case, you either need to press the “Scale” button to add the stated size as a scale factor in the upper right area of the monitor or enter it directly in the input field. If you tick the box for “Ground marking”, the 3D traffic signs is positioned on the ground. A click on the button “Load” inserts the chosen traffic sign in 2D and 3D.

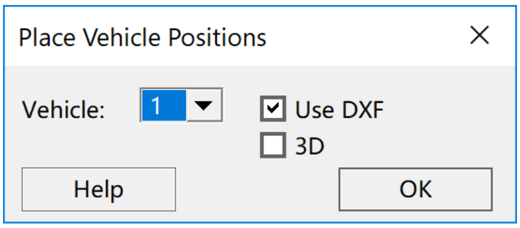


If you shift the sign in the 2D depiction, a line is drawn from the original to the new position. In the 3D view, the traffic sign is always shown at the position at which the line ends. If you delete the line, the 3D traffic sign is drawn in the centre of its 2D equivalent.



3.8.21.22 Sample

(Icon: ) Select the vehicle you want to copy in the dropdown menu. The program automatically uses the vehicle type you have set for the respective vehicle in the vehicle



data menu. With a tick on the box „Use DXF“ you can load a potentially available DXF instead of the standard form. Select the “OK” button or perform a right-hand click to close the menu again. If "3D" is checked, a 3D model will also be loaded at this point.

3.8.21.23 General graphic objects

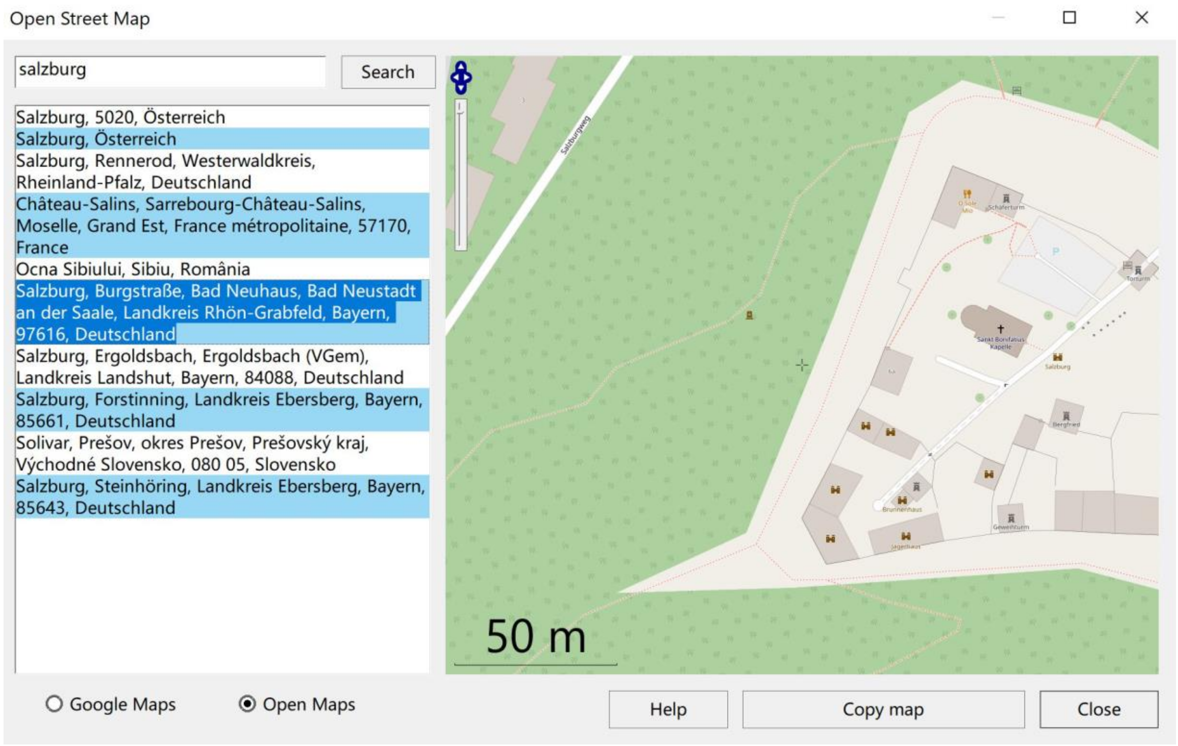
(Icon:) You can use the dropdown menu to select an object. Use the left mouse button to move the object to the desired position. In 2D and 3D, the corresponding object is now loaded.

3.8.21.24 Measuring bar

(Icon:) By keeping the left mouse button pressed, you can draw a measuring bar that also appears in 3D view. In the “Properties” menu you can set up the measuring stick in 3D.

3.8.22 Map import

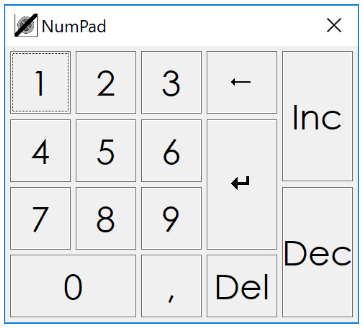
(Icon:) With this module you can search for places in Google Maps or Open Street Maps and insert them into the report.



"Copy map" inserts the current map section into the expert opinion in a scaled format.

3.9 Options

3.9.1 NumPad ON



The NumPad was programmed to enable you to work with AnalyzerPro on touchscreen devices without keyboard.

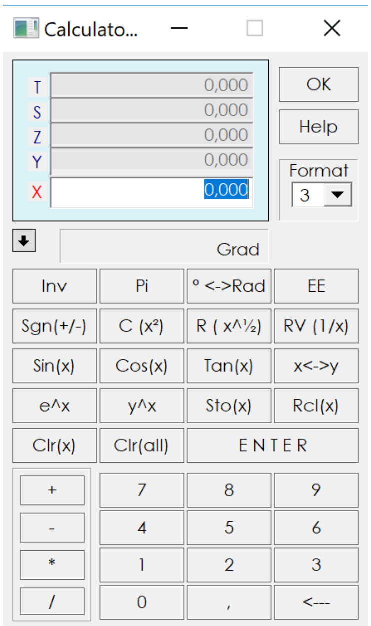
"Inc": Increment.

"Dec": Decrement.

3.9.2 Reset working time WT to 0

The time display in the lower right corner of the monitor indicates how long you have already worked on the report. If you want to reset it to zero, press the button “Reset working time WT to 0”.

3.9.3 Calculator



(Icon: ) The calculator function in UPN mode and is equipped with 5 stack register. After each numerical input finished with the Return key (= Enter), the previous numbers are shifted to a higher stack.

The ultimately entered number is placed in the lowest stack = „x register“, the penultimately entered number in the “y register”, the number entered before that in the “z register” etc.

You can interchange the content of the stack register cyclically resp. anticyclically with the up and down cursor keys.

If you use an operational key, f.e. „+“, the calculation is conducted (y + x) which means that the content of the x and y stack registers are added. The result is displayed in the x register. The values above the y register are moved one stack lower then. The lastly entered number does not have to be finished with the Return key.

The function keys (f.e. „sin“) use the last number entered as an argument (f.e. sin(x)).

You can use the inverse function of each operation by clicking on the „Inv“ key immediately before the respective function key.

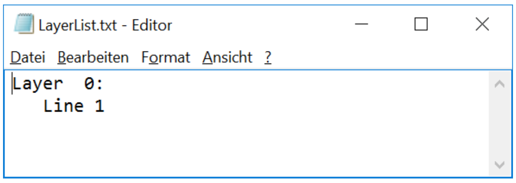
"EE": Switch to exponential representation.

3.9.4 Editor

Opens up the pre-set editor. If a text file with the name of the report is not available yet, you are asked if a new file with the name shall be created. If so, the program additionally creates headings for all vehicles with data available. You can insert comments or other kinds of labels to each vehicle in a later step.

3.9.5 Layer list

The editor (note pad) shows a list featuring the objects in each layer.



3.9.6 Settings

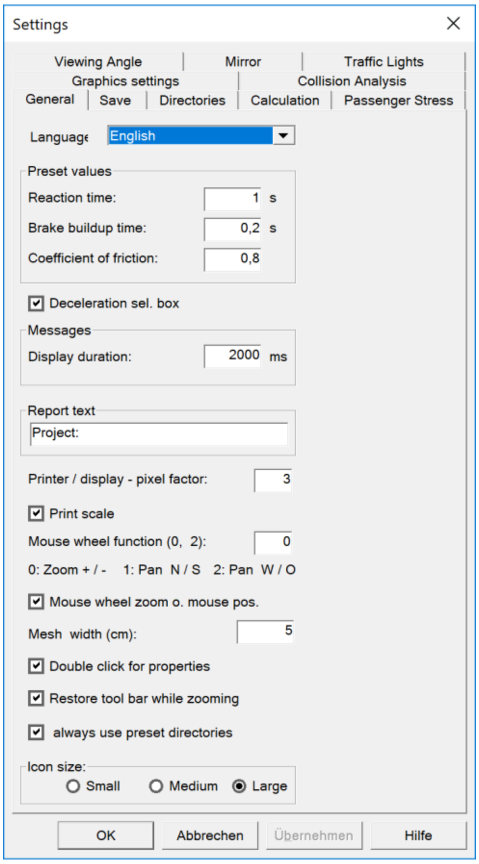
Adjust general settings here.

3.9.6.1 Overview

"Language“: Choose AnalyzerPro’s language from the dropdown menu.

"Pre-set values": Insert the values you want to use as default values here. You can specify Reaction time, brake buildup time and coefficient of friction.

"Deceleration selection box": You can decide whether the selection box for suggestions regarding deceleration and acceleration values shall be displayed.



"Messages – Display duration": You can adjust for how long you want to see messages that close without confirmation of the user.

"Report text": Change the text in the printout here. “Project” is the default setting.

"Printer / display – pixel factor": The pixel number used for the depiction on the screen is often perceived as too small for the printer. You can adjust about which factor the pixel number shall be increased for the printer.

"Print scale": A tick on this box automatically ads a scale to each report printout.

"Mouse wheel function": The three options 0, 1 and 2 are at your disposal; their functions are further described below the input box.

"Mouse wheel zoom on mouse position": You can choose if a zoom with the mouse wheel shall relate to the current mouse position or to the centre of the screen.

"Mesh width (cm)": Specify the distances of the grid points to determine the coefficient of friction and the vertical coordinate. The smaller the value, the more precise – but the required storage space increases as well.

"Double click for properties": Decide if the Properties menu shall be opened with double-click.

"Restore toolbar while zooming": If this option is activated, the toolbar is automatically re-shifted to its pre-set position when you enlarge the window.

"Always use pre-set directories": Determines if all directories saved in the register „Directories“ shall be used.

3.9.6.2 Save

"Save every .... min": Automatically saves the data in a backup file in the specified interval. The backup file has a neutral name so that the current file is not overwritten. If the program is stopped on an unusual way (program crash, power failure etc.), it automatically opens up the backup file the next time. If you have exited the program on a usual way, the backup file is deleted.

"Recovery file (*.bak)": If you want to save a file, but another one with the same name already exists, a backup file is created in the file with the same name and the ending *.bak. The recovery file is not deleted after the program exit, but can be loaded at any time.

"Load last file when the program starts": Automatically opens up the file you have worked on most recently.

3.9.6.3 Directories

Insert the full path to the listed file. The button next to the input field () opens up a browser to search for the directory.

"Calculator EXE file (alternative)": Adjust the path to the directory including an EXE-file of the desired calculator. Leave the field empty if you want to use the Analyz-erPro calculator with UPN mode. The Windows calculator is called “CALC.EXE” and can be found in the Windows directory.

3.9.6.4 Calculation

"Colour selection for edit fields": For the ease of use, the graphic is shown with red and blue cars in some modules. Tick this box to further facilitate the handling of the program by showing the content of the input fields of a certain vehicle in the same colour.

"Print results bold": Determines if the report shall be printed with bold results and a description text.

"Decimal separator": You can decide between point and comma to separate decimals.

3.9.6.5 Passenger stress

"Torso mass fraction": Effective fraction of the passenger's body mass in %.

"Distance seat – rotation point": Indicates the distance between the rotation point of the backrest and the seating surface in cm.

"Integration step (dt)": Time interval for the simulation calculation in seconds. The greatest permissible value is 0.001 s, smaller values increase the level of precision but also the time needed for calculations. Very intense and short impacts usually require a small value.

"Show results running": Tick this box to show the currently achieved acceleration during the calculation of passenger stress.

3.9.6.6 Viewing angle

"Threshold range of angular speed":

"Upper limit": Upper limit of abnormality in rad/s.

"Lower limit": Lower limit of abnormality in rad/s.

"Praxis factor": The praxis factor helps to adapt the upper and lower limit applicable for test conditions (lab conditions) to real-world conditions.

Use this value with caution and consider that it might deviate significantly in certain situations!

3.9.6.7 Mirror

"Width interior mirror": Width of the interior mirror in cm.

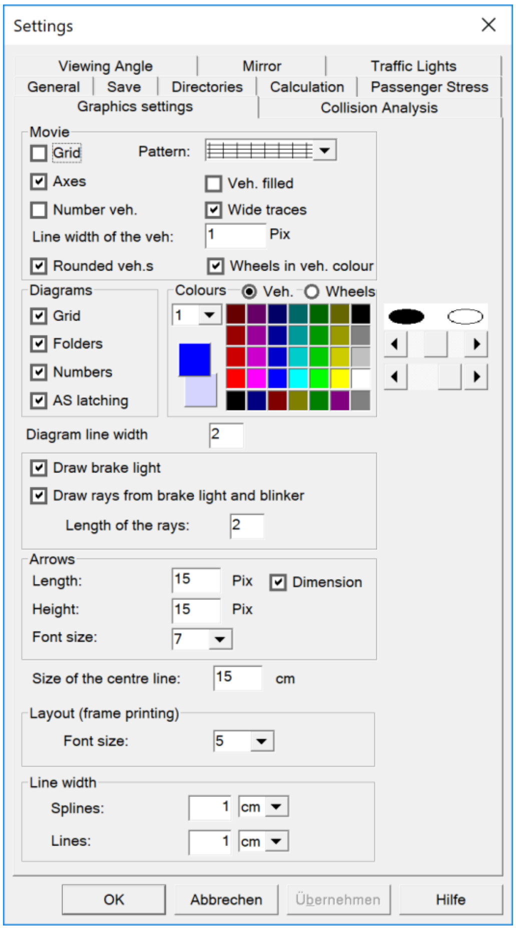
"Distance interior mirror": Distance between the eye and the interior mirror in cm.

The values for the exterior mirror are entered analogously.

3.9.6.8 Traffic lights

Pre-set the phases of the traffic light, f.e. according to country-specific characteristics.

3.9.6.9 Graphics settings



"Grid": Draws a grid (raster).

"Pattern": Choose the desired pattern from the dropdown menu.

"Axes": Draws a coordinate axes to the origin of coordinates.

"Veh. filled": Determine a default setting for the colouring of the vehicles.

"Number veh.": Allocate numerical values to the vehicles based on numbering.

"Wide traces": Skid marks are shown as thin line or in tyre width.

"Line width of the veh.": Indicates the line width in the vehicle depiction.

"Rounded vehicle shape": Decide if the vehicle is depicted as spline (rounded) or polygon.

"Wheels in veh. colour": States if the wheels and the vehicle are shown in the same colour.

"Draw brake lights": Decide if you want to show brake lights during braking.

"Draw rays from brake light and blinker": If you want to show rays from the brake lights and blinkers you can specify their length in the input field below.

"Arrows": This block serves the setting of arrow dimensions.

"Size of the centre": Insert the width of the centre line for all street-related drawing tools.

"Layout (frame printing)": Decide on the font size of the movie frame in the printout.

"Line width": Determine the splines and lines of line width.

"Antialiasing": Should the graphics card use antialiasing in 2D? This setting attempts to blur the "pixelation" of lines. The side effect may be that lines are perceived as slightly less color-consistent.

"Resize Images": If this is selected, all images with more than 8192 pixels in one of the two main axes will be scaled down to this maximum value. This can be useful for less powerful graphics cards.

"High 3D Import Quality": If selected, 3D photogrammetric imports are exported with higher detail. This results in more detailed files but may be more demanding for some graphics cards to handle.

"Left-Hand Traffic": When this option is chosen, 3D models are mirrored along their longitudinal axis, causing the driver to appear on the side typical for left-hand traffic.

3.9.6.10 Collision analysis

"Intrusion duration veh-veh": Duration from the first contact of two vehicles (passenger cars) to the point in time at which the impact point shall be positioned.

"Intrusion duration obstacle": Duration from the first contact of the vehicle and the obstacle to the point in time at which the impact point shall be positioned. The impact duration and consequently the penetration duration have to be shorter for solid obstacles. The value has to be further decreased for collisions with high velocity.

"Spring strength": Factor by which the spring strength increases in fully deflected position.

"Damping strength": Factor by which the spring damping increases in fully deflected position.

"Centre coordinates": You can choose if the values in the collision analysis shall relate to the centre of the vehicle or on the vehicle's centre of gravity.

"Extended collision analysis – open interface": Decide which mask is opened with a click on the respective icon. You can switch between the masks with the function key F4.

3.9.7 Colour

Opens the colour table from which you can choose the colour of selected object.

3.9.8 3D Settings

Further information is provided in the chapter „3D Options".

3.9.9 Select and edit objects

To select an object, move the mouse pointer close the object. When the mouse changes it appearance, you know that a certain object is active and can click on it with the left mouse button. The defined points of the active object are surrounded by a square now.

If an object is positioned behind another one, you cannot select it with the left mouse button. Either change the object order with the right mouse button or select the front object first and pass on the selection to the object behind with the tab key. You can also use the settings definition: Select the desired object in the tree directory (left side of the window) of the Properties menu (right mouse button/Properties) and exit the window with OK. The object is selected now.

The appearance and form of line objects can be changed retrospectively with your mouse or keyboard. Another option is to change them in the Properties menu, f.e. by numerically entering the position of points for a spline or the length and width of a rectangle.

3.9.9.1 Selection modi

Distortion and shift mode: A total of 8 points appear in distortion and shift mode: The 4 corners of the rectangle and the midpoint of each side. Dragging a corner point enlarges the object in x and y direction with constant proportions, dragging a mid-point only enlarges the object in one direction. If you drag a corner point and push the Alt key simultaneously, you can also enlarge the object in only one direction. Dragging any point except of corners and midpoints shifts the object.

Editing mode: In editing mode, the curve end points appear instead of the points described above. You can edit them by moving the cursor to the desired point and shift if with the left mouse button pushed. If you drag no specific point but one in the middle, the two neighbouring points are shifted in parallel.

Attention: Vehicles can only be shifted, not edited.

Rotation and shift mode: The rotation and shift mode is characterized by 4 outline corners and the centre of rotation marked with a cross and a circle. You can shift the centre of rotation to any point and let the object rotate around it by clicking on one of the outline corners. If you click on any other point than the outline corners, the object is shifted instead of rotated. Keep the left mouse button pressed to rotate the line around the centre of rotation. You can rotate all drawn and imported objects except of EMF and WMF files. Multiple selected objects can be rotated around a common pivot point simultaneously. To make this work, all the selected objects must be "rotatable."

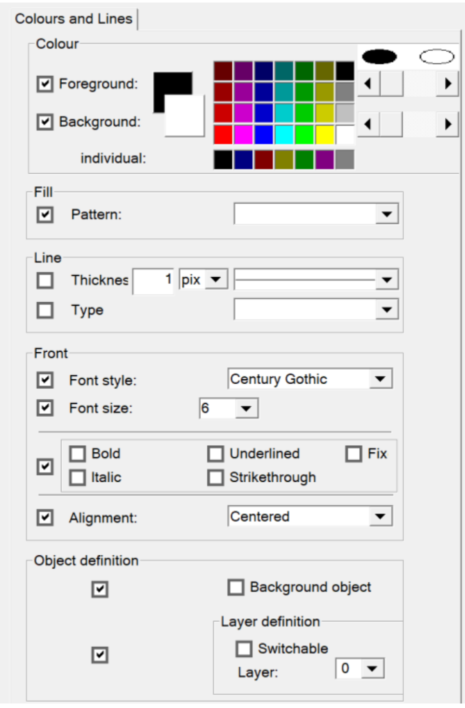
3.9.9.2 Measuring and Shifting

When an object is selected, the program automatically defines a starting point and sets the display of dx and dy in the lower left monitor area to 0. All object shifts are now measured from the new starting point. The values dx and dy are also set to 0 when the left mouse button or the shift key are pressed.

3.9.9.3 Multiple selection

Select multiple objects at a time by keeping the left mouse button pressed and creating a rectangle that covers all desired objects. If you pull out the rectangle from the upper left to the lower right, the program selects all partly or fully covered objects. If you pull out the rectangle from the lower right to the upper left, only the fully covered objects are selected. Alternatively, you can also keep the Ctrl key pressed and select the desired objects one after the other.

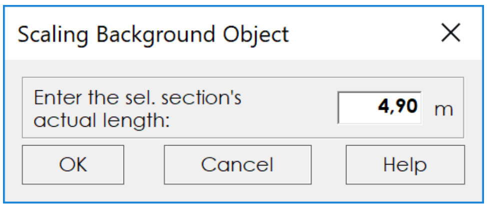
3.9.9.4 Changing the properties of several objects



You can change the properties of several objects at one time. Perform a multiple selection as described above and press the right mouse button or the Enter key to open the Properties menu. Tick the boxes of the properties you want to change. The program has already ticked the boxes of properties that are already the same. Changes to the properties are only applied to the marked objects if the respective boxes are ticked.

Due to space constraints, the properties “Bold”, “Underlined”, “Fixed”, “Italic” and “Strikethrough” can only be selected as a group with a tick on the respective box.

3.9.9.5 Scaling of graphical objects



Scale the objects to adapt them to the screen scale. After the loading of the graphic object, select it, open the Properties menu with the right mouse button and choose the point “Scale”.

You are prompted to mark a known distance on the Bitmap. Position the cursor on the starting point of the distance and keep the left mouse button pressed while moving the cursor to the end of the distance. When you release the button, a pop-up dialog box asks you to insert the true length of the distance. After you have confirmed the inserted value with “OK”, the object is depicted in the right monitor scale.

3.9.9.6 Order

Move an object one layer forwards with the key V and one layer backwards with the key H. You can also change the order of objects in the Properties menu.

3.9.9.7 Driving lines

The editing of driving lines works analogously to the one of normal lines. The driving line should not be shorter than the distance to cover, otherwise the vehicle moves further along the tangent of the last point. A too long driving line is no problem, as the vehicle automatically stops at the end of the calculated distance.

In the modules, an appropriate driving line is calculated as a default value for the first calculation.

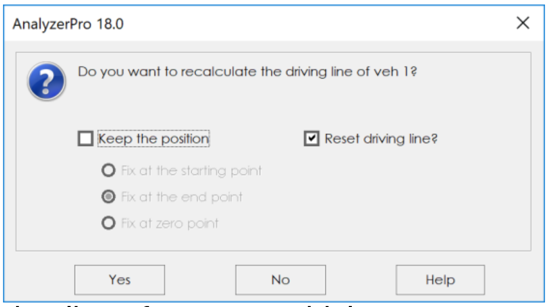
When you have edited a driving line and open the Movie, the program asks you if the driving line shall be calculated anew. If you want to continue using your edited driving line, press “No”. If a new driving line is calculated, you can determine if the position shall be remained. This means that the program either keeps the user’s shift and rotation of the driving line or applies the default settings. In case you use modules, in which the driving lines of several vehicles and their relative position to each other is calculated, it is recommendable not to remain positions, as the user would have to adapt the relative positions of the driving line manually. The new calculation comprises the driving line’s length as well as its course f.e. during lane changes.

Without re-calculation, the driving line can be too short or too long. To adapt its length, select the driving line, click on its first or last point and drag it in the desired direction. You are not asked again for further calculations. If you want to conduct a new calculation, select the driving line or the vehicle, open the pop-up menu with a click on the right mouse button and choose “Recalculate driving lines”. You have two options now: “Form Reset” and “Keep the position”.

"Form Reset": Resets the driving line to the basic setting. Choose this option f.e. if you have distorted the driving line erroneously.

"Keep the position": Keeps the position of the driving line respectively the vehicle. You can choose to keep the position at the starting point, the end point or at the zero point.

You can combine several driving manoeuvres like skidding, changing lanes or turning for the calculation of driving lines. The program concatenates the driving lines with each other and also calculates the necessary rotation for steady and smooth transitions.



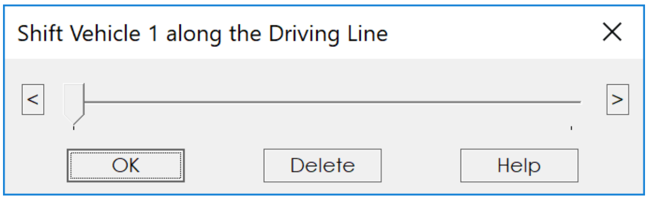
For complex driving lines like f.e. a combination of driving manoeuvres forwards and backwards, it is advisable to combine the driving lines from two vehicles.

Avoid too small values for the wheelbase and the overhang, as this would weaken the mathematical model and could result in movements similar to skidding.

3.9.9.8 Shift vehicles

The starting point of the vehicle’s movement is usually identical with the starting point of the driving line. However, you can shift a vehicle along its driving line, hence, the starting point of the vehicle’s movement is shifted along the driving line.

Select the driving line or vehicle, click on the right mouse button and open the menu option „Move vehicle“. The dialog box now offers you the possibility to roughly shift the vehicle with the slider and fine-tune the position on the driving line with the buttons to the left and right of the slider.



The shift of the vehicle along the driving line is not related to the time offset, but only the vehicle’s starting point relative to the starting point of the driving line is changed. This can be useful if you want to shift the vehicle in the collision position without shifting the already adapted driving line. You can alternatively change the starting point, however, the collision position is often hardly recognizable in big-scale depictions. If you then show a window area of the collision position, the starting point often does not fit on the picture.

3.9.9.9 Driving line in 3D

If the defined points of the driving line are entered with a z coordinate unequal to zero, a 3D spline is positioned along the points the vehicle moves along a 3D curve, which is of course only visible in the 3D window. The calculation of the distance is also 3-dimensional then.

If you have drawn a street and shift the points of the driving line onto it, the height of the street level at the respective point is calculated and assumed as z coordinate of the driving line. We therefore recommend to either draw a lot of points in the driving line or to position the points close to the defined points of the street.

3.9.9.10 Assignments

It is possible to assign all objects to already existing ones. Determine assignments in the Properties menu under „Properties“. The assigned object “Son” can be shifted in relation to his “Father”. If the “Father” object is moved, distorted or rotated, the “Son” object moves accordingly. You can use assignments f.e. to accompany a vehicle with a drawn light beam or to allocate a text to a diagram curve (f.e. Reaction point).

3.9.9.11 Selection mode for background objects

(Icon: ) Graphic objects can be defined as „Background objects“. If an object is classified as background, you can deactivate the selection mode for this particular object. Hence, you can avoid to unintentionally select and change the background with this setting.

3.9.9.12 DXF Depiction

(Icon: DXF) This button activates resp. deactivates the depiction of loaded DXF pictures on vehicles.

3.9.9.13 Colour fill vehicles

(Icon:) You can turn on or off the colouring of vehicles here.

3.9.10 Properties

3.9.10.1 Colour and lines

"Foreground": Use the left mouse button to select a colour field. The foreground colour is used for the object resp. border line.

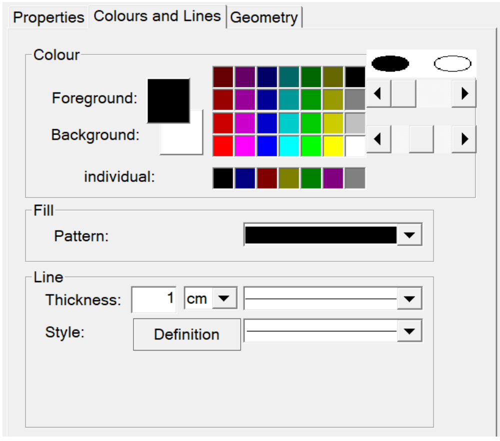
"Background": Use the left mouse button to select a colour field on the right side. It is used as a filling colour of objects.

Double-click on a colour field to choose the colour of the selection field, either from the available basic colour or select a user-defined one. The choice of background colour is only effective for closed line objects.

More colour are available and can be defined. The colour chosen here is transferred to the colour field on which you have double-clicked and is at your disposal until you close the program.

The first 27 colour fields are initialised during each program restart, the chosen colour of the last 7 colour fields (own colour) are saved in the Registry and are available even after the program restart.

"Pattern": Closed objects can be filled with a pattern. The pattern is shown in the foreground colour, the inner area in background colour.



"Thickness": Adjust the line width here. You can either insert the width numerically or choose it in the dropdown menu. The unit is either cm or Pixel. The graphical selection box only offers 14 options, but the numerical insertion can exceed this number.

"Style": Use one of the predefined line styles. The first 6 patterns are in accordance with Windows standards. If you choose the sixth and blank option, no line is drawn. Use this option if you do not want to depict the edge of closed lines. Starting from style number 7, you can define styles in the file Lines.ini (Analyzer – Registry).

As the dots of the dotted lines are shown in foreground colour and the gaps in-between in background colour, the chosen colour have to be different from each other.

"Definition": You can define line elements and save them in the report. The defined line elements can be written into the file Lines.ini.

3.9.10.2 Geometry

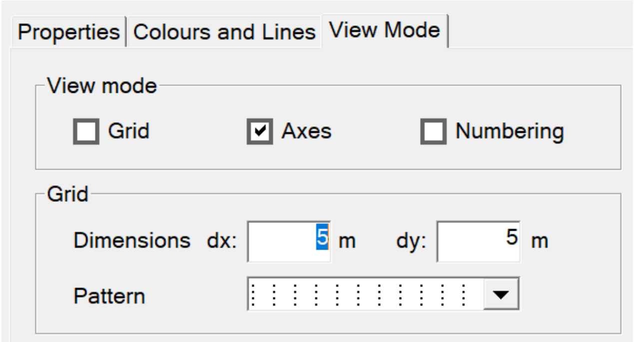
Insert the data of graphical objects here. The values for position relate to the starting point of the object. The coordinates are stated in meter.

Use the scaling factor to distort objects. The specified coordinates are impinged with the scaling factor. Further inputs like height and width vary between open and closed objects.

For line objects, the coordinates of all points can be entered relative to the starting point. If you wish to work with absolute coordinates, the coordinates of the starting point have to be 0 / 0. At the end of the list, you can switch to a new row with the tab key and add a new point by specifying coordinates.

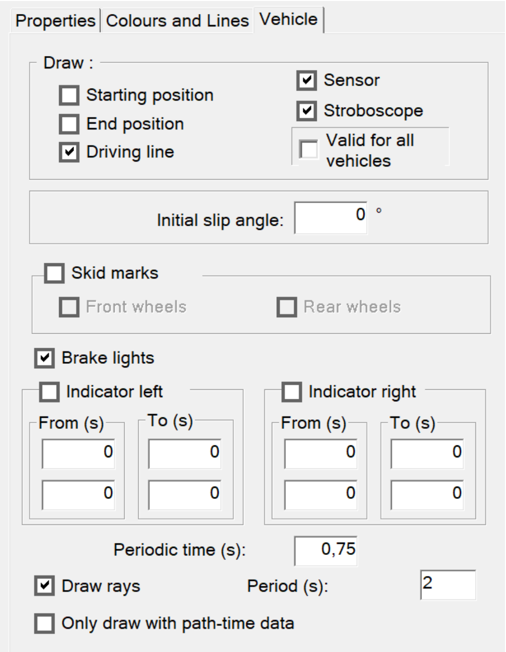
3.9.10.3 Background

Open the properties menu of the background with a right-hand click and choose the tab "View Mode". You can either select a grid or axes to depict the coordinate origin. Furthermore, you can automatically number the used vehicles with a tick on the "Numbering" box. Insert the distance of the grid at "Dimensions" and decide on an appropriate pattern below.



3.9.10.4 Vehicle

You can draw the starting position, end position and driving line for the vehicle you have opened the Properties menu for. Moreover, the depiction of a sensor as well as the stroboscopic depiction can be switched on or off.



The option „Valid for all vehicles" determines if the changes shall only be valid for the selected vehicle or for all. If the tick in the box is greyed, it means that not all vehicles have the same setting at the moment.

A vehicle is drawn with dotted line in a static position (starting, middle or end position) and with normal lines in the dynamic Movie position. If the vehicle is on a static position with its Movie position, it is shown with dotted lines.

If the driving line of a vehicle is already curved at the beginning, you need to specify a „Starting slip angle". This slip angle is calculated in the modules Turning procedure and Turning-in crash. The slip angle can only be inserted for the beginning of the driving line. The further positions of the slip angle are calculated from the driving line (Ackermann condition).

The rotation of the vehicle can be done using either the driving path or the vehicle itself.

You can decide to draw skid marks of the front wheels and/or rear wheels.

"Brake lights": Activates the depiction of brake lights as red rectangles.

"Indicator left / right": Two intervals can be defined, whereby the time relates to the time positions in the distance-time diagram.

"Period (s)": Duration of one indicator interval.

You can draw rays in addition to brake lights and define their length.

"Only draw with path-time data": You can decide to only show the vehicle in the Movie if data is available in the respective time section. This option allows you to allocate the movement of a vehicle on several vehicle numbers. As you can only switch the driving direction (forward or backward) once for each vehicle number, you might f.e. need it to show a vehicle reversing several times.

3.9.10.5 Friction surface

A closed spline can be defined as friction surface. In case this property is defined, another friction value can be defined for this area. If a wheel comes in contact with this area in calculations concerned with driving dynamics, the friction value defined here is used for the calculation of frictional force. Special frictional characteristics can then be defined for certain areas (f.e. icy spots, oil stains, etc.).

3.9.10.6 Image editing

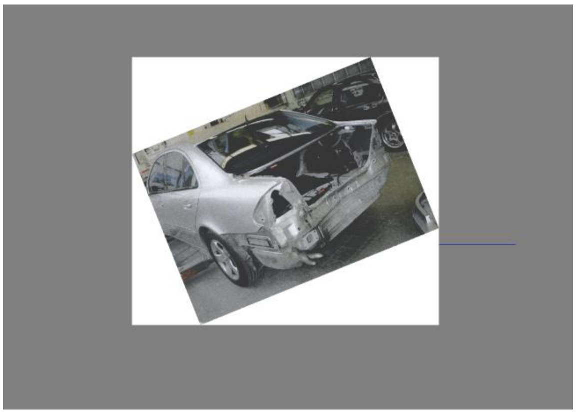
Images used and edited in AnalyzerPro are not changed in their original form, hence, allegations of manipulation are fruitless. Edited pictures can be saved and printed separately.

Transparency:

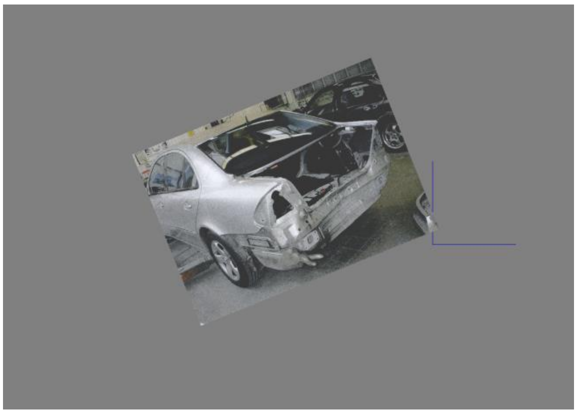
"Degree": The degree of transparency can range between 0 = non-transparent and 100 = completely transparent. The default setting is 50%. The Bitmap is then displayed according to its transparency and can be placed in front of other objects. If you want to put one picture in top of another, make the brighter one transparent.

Transparency for colour:

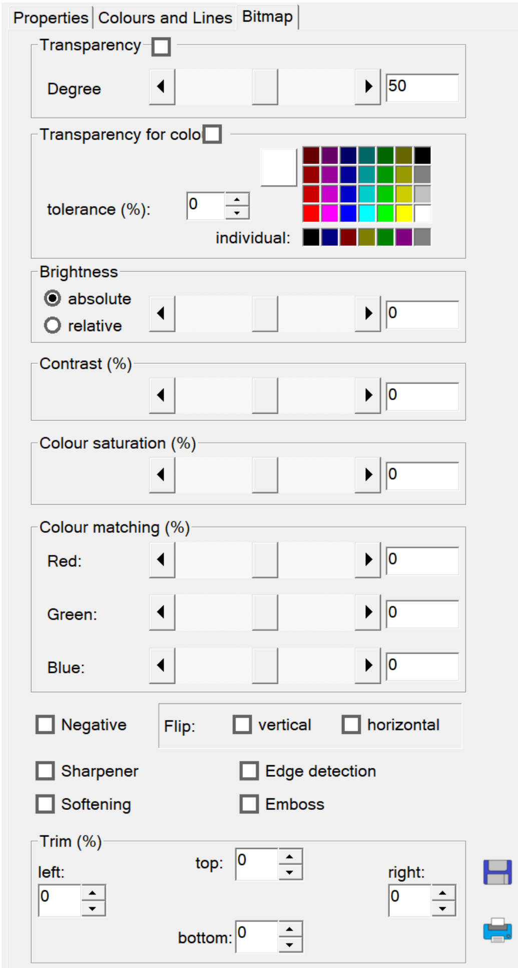
With this option, you can make certain colour transparent. You can f.e. make the background colour white transparent, then the usually white contouring rectangle of a rotated image is not visible:



Without transparent colour



White as transparent colour



"Tolerance": Insert a tolerance between 0 and 100 for the colour you want to make transparent. F.e. If you insert a tolerance for a grey colour (128,128,128), all colour between (118,118,118) and (138,138,138) are made transparent as well. The values of the number tripe are the colour values RGB for Red Green Blue. With all three values being 0, the point in the image is black; with all three values being 225, the point in the image is white. (255,0,0) is Red, (0,255,0) Green and (0,0,255) Blue.

Brightness:

The level can either be changed in „absolute“ or „relative“ terms.

"Absolute": Each image point is brightened to the same extent, i.e. the values of RGB increase or decrease by the same value.

"Relative": Darker image points are brightened more, or brighter image points are darkened more.

Contrast:

Brighter image points become brighter and darker image points become darker.

Colour Saturation:

Colour are intensified or weakened, i.e. the difference to the gray value increases or decreases.

Colour Matching:

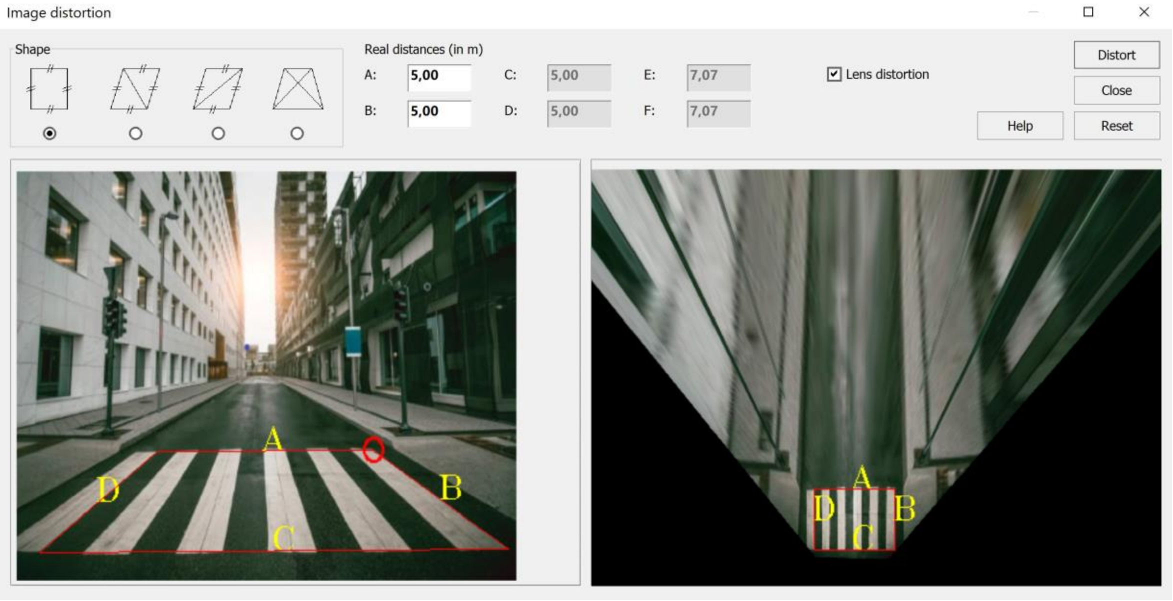
The R, G or B value of all image points is increased or decreased by the specified value.

"Negative": All colour values are inverted.

"Flip": Mirrors the image.

3.9.11 Distort image

When a picture is selected, the option "Distort image" can be selected by right-clicking on it.

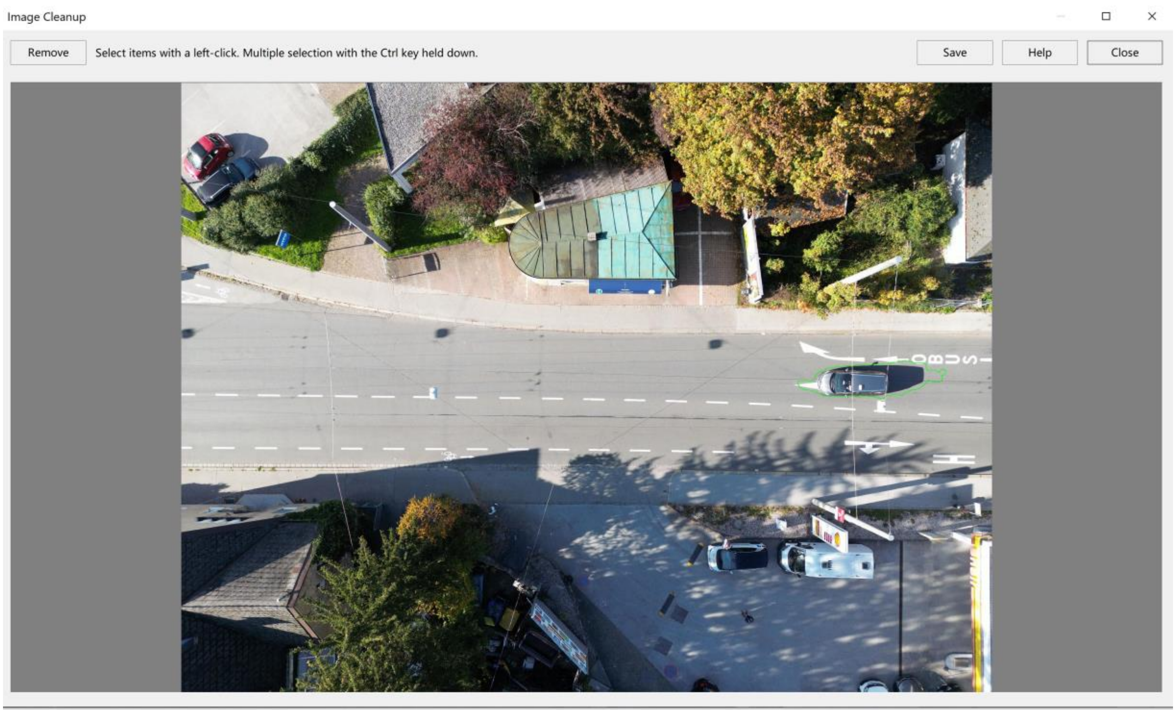


Depending on which shape is selected in the left area, the corresponding dimensions must be entered in the middle area. The right image is distorted accordingly.

"Lens distortion" automatically determines the camera parameters and can thus rectify barrel distortion, for example.

"Distort" loads the right image into the expert opinion.

3.9.12 Cleanup image



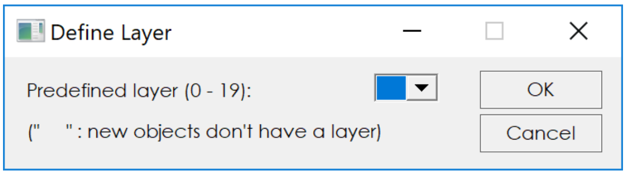
When you have chosen an image, you can select the "Cleanup image" option by right-clicking. A dialog with the loaded image will open. You can click on a region in the image using the left-click. Depending on the contrast, an outline will then be drawn around the part of the image recognized as a connected region. You can then click "Remove", which replaces the region with a computationally "likely" background. This can be used, for example, to remove parked vehicles from an aerial image and ideally replace them with a background in the surrounding road color. Clicking "Save" will save the modified image, replacing the previously loaded image.

3.9.13 Switchable line objects (Layers)

Each line object can be defined as switchable line object, hence, lines can be switched on and off easily for these objects. A total of 20 layers (levels) are available. Layers with objects in it have a coloured background.

3.9.13.1 Fix

(Icon: ) With the option „Fix“, you can determine to position all subsequently drawn line objects in the defined layer.



3.10 Windows

This menu organises the depiction of windows.

3.10.1 Overlapping cascade

Choose „Overlapping cascade“ to stagger all opened windows on your Desktop. All overlapping windows have the same size and are partly covered by the windows in the foreground.

3.10.2 Next to one another

Choose „Next to one another“ to show all opened windows next to each other. The windows fill the entire desktop without overlapping each other.

3.10.3 Vertical

Choose „Vertical“ to show all opened windows below each other. Up to 3 windows can be placed in a vertical row, 4 windows are organized in a square. The windows fill the entire desktop without overlapping each other.

3.10.4 Arrange icons

This option rearranges the icons on your desktop. Newly arranged icons are positioned evenly on the lower left corner of the desktop. The opened files have to be minimized to an icon, otherwise the order is ineffective.

3.10.5 Opened windows

All windows of all opened reports are listed here and can be placed in the foreground with a click.

3.11 Links

3.11.1 Update

This starts the automatic updater. Please confirm the administrator rights and follow the instructions given.

3.11.2 Homepage

Link to the homepage www.analyzer.at.

3.11.3 Manual

Opens a dialogue from which you can open either the manual, the short manual or the technical manual.

3.11.4 Crashservice

Link to the crashtest service of Schimmelpfennig & Becke.

3.11.5 EES catalogue

If available, a deposited EES catalogue is opened here.

3.11.6 Activate licence online

This opens a dialog where you can enter your license key to activate your license online. From now on, you no longer need a hardware dongle to use the software, but you do require internet access at least once within 30 days to verify your license. If you don't have internet access, it is possible to request an offline license.

3.11.7 Deactivate licence

Deactivates your online licence. You can then reactivate the licence on another PC if it is still valid.

3.11.8 Downgrade to Analyzer Version …

Allows downgrading to a previous version of AnalyzerPro.