CATIA V5 Automotive Extensions Vehicle Architecture — Safety (CA9)

User Guide

BPA Delivery 7 for V5R19 (V5.7)

TRANSCAT

Instruction symbols used in this guide

The following symbols are used in this guide; these should enable you to navigate throughout the text with greater ease:

Warning triangle

The warning triangle refers to *critical circumstances*,
which should be considered imperatively
in order to avoid serious problems in your work..

Hint symbol

The light bulb relates to *hints*,
which provide you with practical examples
to simplify your work.

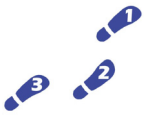
Note symbol

The hand symbol relates to *notes*,
which you should pay attention to in order to assure
that you can *work without problems*.

Information symbol

The information symbol relates to *Information*,
which illustrates a situation.

Work steps symbol



The work steps symbol
relates to a
step-by-step instruction sheet.

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0. CAVA in General

In order to understand the basics of CATIA, please, read first the *General* CAVA User Manual. General information on CAVA is given only in that manual. You will find there also information required for work with CAVA OVA, e. g.:

- How CAVA is started?
- How to create and edit CAVA features?
- How to configure CAVA?
- What is Standard Mode, what is Free Mode?
- Which parameters can be changed in which mode?
- How to export geometries?

1. The Safety Module

Product + Description	Functions	Description see Chapter
SAFETY 		
Pedestrian- and passenger protection (The simulation of a collision is not part of CAVA.) Details see user manual „CAVA SAFETY“.	CAVA PEDESTRIAN PROTECTION	Section 2 since p. 8
	CAVA PEDESTRIAN PROTECTION OFFSET	Section 3 since p. 46
	CAVA HEAD IMPACT	Section 4 since p. 61
	CAVA SAFETY RADIUS	Section 5 since p.79

This group of functions contains applications, which cover the norms and legislation in the field of vehicle safety for passengers as well as pedestrians.

The functions contained are:

- Pedestrian protection
- Pedestrian protection offset
- Head impact (Reference points according to FMVSS 201)
- SAFETY RADIUS (EEC 74 / 483 EWG and ECE-R 26

All functions are saved as new features in the document.

The functions of the *Safety* module generally need vehicle parameters as input values, especially the corresponding loadings as well as more or less detailed geometry of the car front and the passenger compartment respectively.

If a curve or a point could not be calculated, e.g. because the selected car geometry was wrong or incomplete, an error symbol will be displayed in the main dialog of „Pedestrian Protection“ and „Head impact“ instead of the general icon for the respective point or curve (see right side).

For a proper calculation the symbols of the curves or points must not have an error symbol.

If a curve or point is marked with the error symbol please check and adjust the selected geometry. Afterwards recalculate the curves or points, using the „Apply“ button.

The functions of this module define the geometric fields/ curves / points described in the individual standards dependent on the actual geometry.

Collision simulation is not part of CAVA.

2. Pedestrian Protection

Standards for pedestrian protection are still relatively new and have to be considered in future vehicle development.

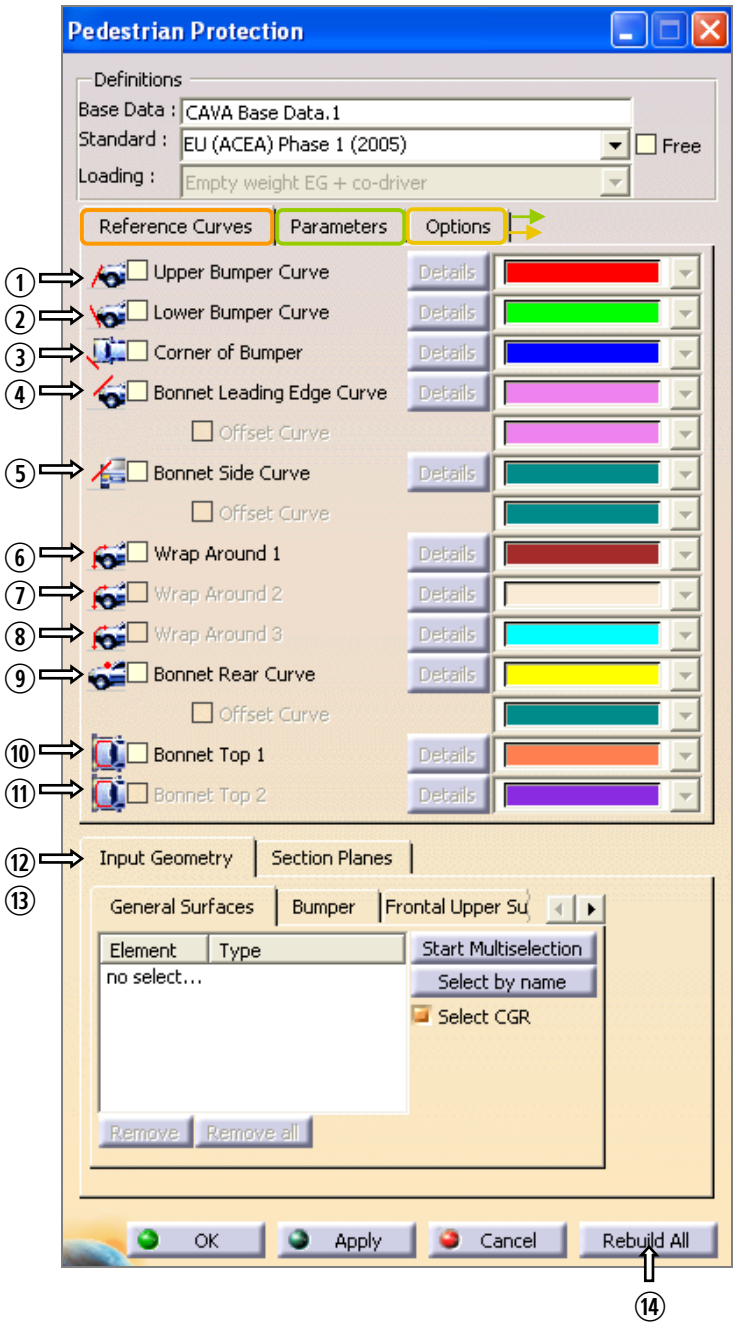
Since 2005 Europe has pertinent legislation for the protection of pedestrians, which is to be implemented in 2 phases.

There is similar legislation for Japan, which will also be put into practice on new vehicles from the end of 2005.

In addition there is the EURO NCAP directive, which while not being binding for homologation still has a very high marketing impact.

Within the individual legislation listed above various ranges and curves are defined, which mean certain requirements for a crash test. The calculation of the various curves is relatively similar. But not all regulations call for all of these curves.

- *Pedestrian Protection* dialog box



Description see chapter:

→ *Parameters* tab card p. 38
→ *Options* tab card p. 40

→ 2.1.1 Upper Bumper Reference Line p. 14
→ 2.1.2 Lower Bumper Reference Line p. 17
→ 2.1.3 Corner of Bumper p. 20
→ 2.1.4 Bonnet Leading Edge p. 23
→ 2.1.5 Bonnet Side Curve p. 27
→ 2.1.6 Wrap-Around Distance (1...3) p. 30
→ 2.1.7 Bonnet-Rear Reference Line p. 32
→ 2.1.8 Bonnet Top 1–2 p. 36

You can specify default values for the colors of the reference lines and points. The definition can be done in the CAVA–settings using the `Tools/Otionen...` menu or directly inside the configuration file for the pedestrian protection.
For detailed information, please refer to the „CAVA–General“ manual.

- ***Reference Curves*** tab card

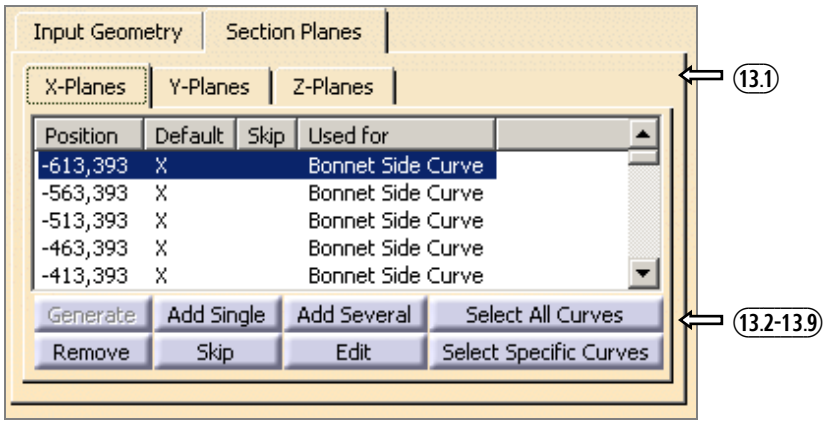
⑫ Tab cards for the geometry selection

Select the corresponding Tab card for the required geometry Bumper, Frontal Upper Surface, Fender, Windshield or Bonnet Rear Extra Elements and add the geometry by selecting from the model.
Input geometry can either appear as V5 surfaces, V5 solids or CGR data.
In the list field of the Tab card „General Surfaces“ all the vehicle geometry elements can be added that are required for the calculation of the curves, points and areas. It is not necessary to define the geometry in the specific tab cards *“Bumper”*, *“Frontal Upper Surface”*, *“Fender”*. Even the geometry for the tab card *„Windshield“* and *„Bonnet Rear Extra Elements“* have to be added to the lists in the corresponding Tab cards.

Advantage:	The user does not have to think about the exact geometry definition e.g. whether the lamps belong to the fender or the frontal upper surface.
Disadvantage:	Longer calculation time.

⑬ Section Planes

Since version 1.8.x it is possible to define the area of section planes more detailed. The default step of e.g. 50 mm for the whole vehicle width can be separated in areas with more section planes so that the curve is more precisely for a specific area of car geometry.



⑬.1 Tab for the section planes x, y and z

Each tab page contains a table with the defined section planes. The column header are briefly described in the following:

- Position: This column contains the coordinate (*x*, *y* or *z*, according to the selected tab page) of the section plane.

- Default: If this column value is set to „*x*“ the section plane is created by the CAVA application according to the used standard. An empty value will indicate that the section plane was added by the user.
- Skip: If this column value is set to „*x*“ the respective section plane will not be taken into account for the calculation. So the user can control the section area and make the calculation more precisely.
- Used for: This column value reports the curve(s) for which the section plane is used for.

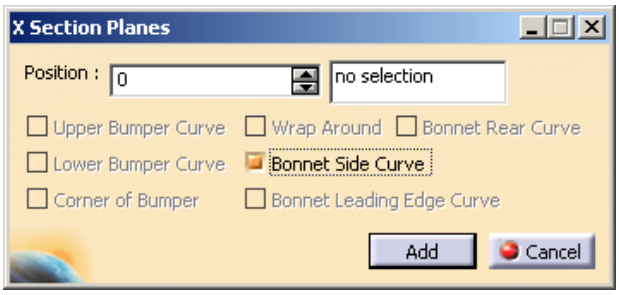
(13.2) to (13.9) Buttons to control the tables for the user defined section planes.

- Generate:

If the input geometry has changed, you have to recalculate the default section planes by pressing the button „Generate“ to obtain correct results.

- Add Single

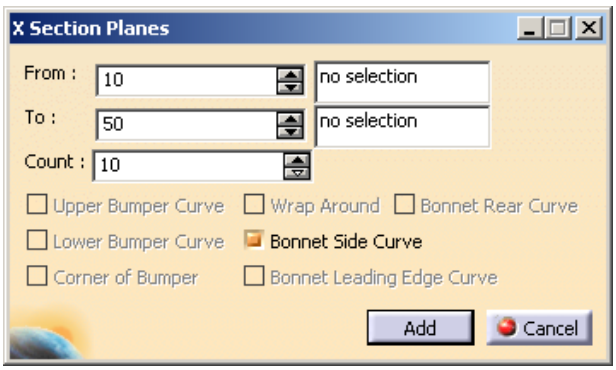
Using this button you can add a single section plane to the list. The following dialog box will open on button click.



In the field „Position“ you have to enter a value for the coordinate at which the section plan should be inserted. Alternatively, you select an existing V5-point as reference in the field beside. Additionally you have to define the curve in which the section plane should be created. Activate the respective check button in front of the curve(s) title.

- Add Several

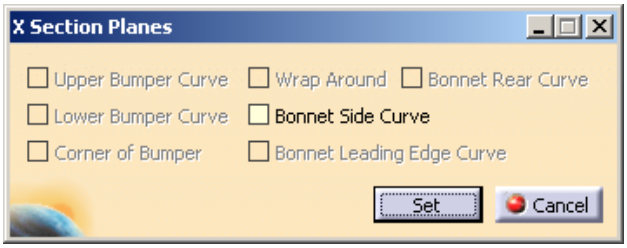
Using this button you can add several section planes to the list. The following dialog box will open on button click.



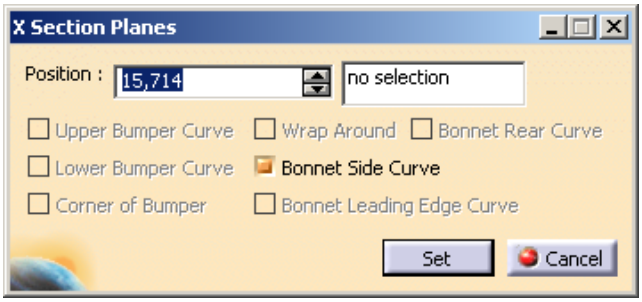
Enter the start and end coordinate in the fields „From“ and „To“.

In the field *Count* you have to define how much section planes should be inserted between the start and end coordinate. Additionally you have to define the curve in which the section plane should be created. Activate the respective check button in front of the curve(s) title.

- Select All Curves
  Select one element from the list. Click on the button „All Curves“. All reference curves will be assigned to the selected elements. This means that the selected section planes will be used for the calculation of each reference curve.
- Select Specific Curves
  Select one element from the list. Click on the button „ Select Specific Curves“. A dialog box will open in which you can assign a specific curve to the selected elements (section planes). This means that the selected section planes are uses for the calculation of the assigned curve.



- Edit
  Select one element from the list and click on the button „Edit“. A dialog box will open in which you can edit the values fort he selected section plane.



- Skip
  Select one or more elements from the list and click on the button „Skip“. The selected elements will be marked with an „x“ in the column titled „Skip“ and will not be taken into account for the calculation.

Since version 1.12.4, the behaviour of default section planes marked to be skipped has changed.
Old behaviour:
In case a default section plane was marked to be skipped, all previous (or next) planes were disabled automatically.
New behaviour:
A default section plane can now be skipped without any impact on the previous (or next) planes.

- Remove
  Select one or more elements from the list and click on the button „Remove“ to delete the values from the list.

⑭ Button „Rebuild All“

Click here to recalculate the complete curves or points.

According to the input data the curves and points mentioned above are created as geometry inside the feature. Additionally, the output parameter for the *Upper Bumper Height,* the *Lower Bumper Height* and the *Bumper Lead* are calculated (minimum / maximum and actual value for a defined *y*-coordinate).

You will receive an error message if only less than 50% of the required points could be calculated for the following curves:

- *Upper bumper curve*
- *Lower bumper curve*
- *Bonnet leading edge*
- *Bonnet side curve*
- *Wrap around curve 123*
- *Bonnet rear curve*.

For a description of the standard buttons please refer to the „CAVA Manual General“—chapter „ Standard buttons in CAVA“.

2.1.1 Upper Bumper Reference Line

Dialog link: ①

The Upper Bumper Reference Line is calculated at the front bumper, by drawing a "line" of 700 mm length at an angle of 20 deg to the road surface to which the geometry is attached. This is done from various points (in the *y* direction), which are at most 100 mm apart from each other. The upper boundary points are considered. The curve formed by these boundary points defines the Upper Bumper Reference Line. It is possible that it shows discontinuities.

Only contact points with the bumper are considered during calculation. In case the line touches other vehicle parts due to its length, it can be shortened by carrying out a practical test.

For an implementation within CAVA the geometry of the bumper, or the relevant parts respectively, as well as specifications about length, angle and spacing of the support points in the y direction are needed. These values are defined in the configuration file (`PedestrianProtection.xml`).

This reference curve is required by all aforementioned standards.

Upper Bumper Height is calculated along with the geometry of the curve and is displayed as an output parameter. It is the minimum and maximum distance of the curve to the road surface.

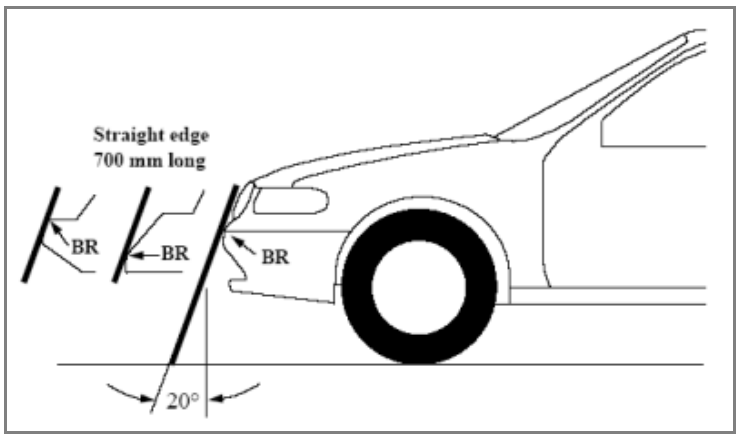
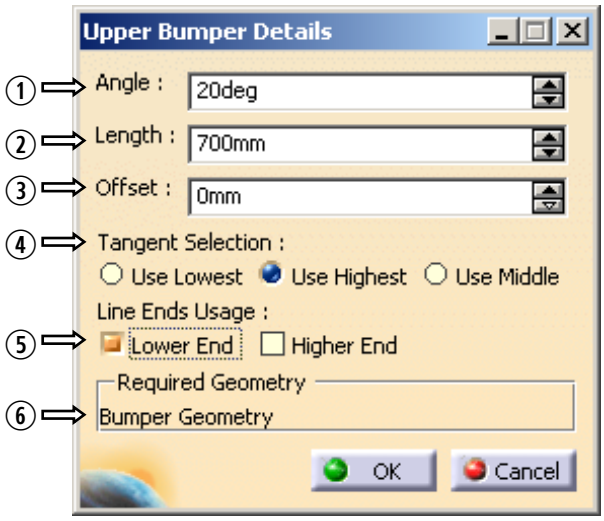


Fig: Determination of the upper bumper curve

If Upper Bumper Curve is selected in the user dialogue, you can retrieve information about the applied values and the geometry to select by clicking on the *Details* button. By selecting the *Free* mode you can define your own setting for specific values.



① Angle

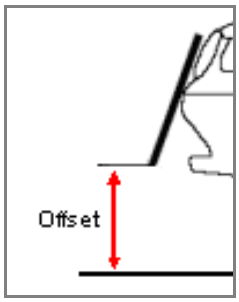
Angle to the road surface at which the line is attached to the geometry.

② Length

Length of the line, which is attached to the geometry at the angle defined in ①. If the line touches other vehicle parts due to its length, a smaller value can be defined.

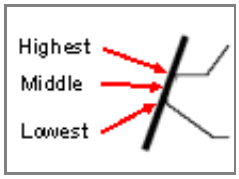
③ Offset

Offset of the starting point of the line if it is not located on the road surface.



Tangent Selection —Use Lowest / Middle/ Highest

In case the reference line has a number of tangential boundary points with the vehicle geometry, the user can determine which point is to be used.

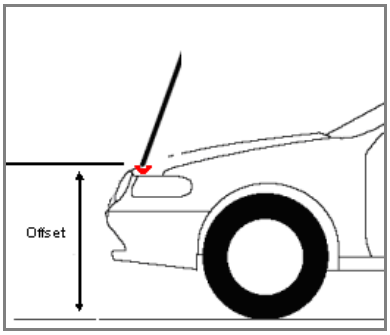


⑤ Line Ends Usage —Lower End / Higher End

In case the reference line has no tangential boundary point with the vehicle geometry, the user can determine that the lowest or highest point of the line is nevertheless included in the calculation by selecting Lower End or Higher End, respectively.

Example:

With very low cars (e.g. sports cars) and a defined offset it is possible that the reference line intersects with the vehicle geometry (see picture). In such a case the user must select Lower End from the Option *Line Ends Usage* in order to include the boundary point into the calculation.



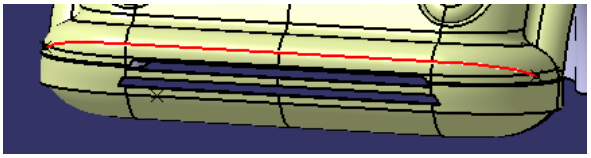
⑥ Required Geometry

List of the required geometry, which has to be selected for calculation. This information assists the user with the selection.

For determination of the *Upper Bumper Reference Line* the following geometry is required:

- Bumper geometry

The result is shown as a line in the model *Upper Bumper Reference Line* in the color chosen by you.



An entry with the values used for the Upper Bumper Reference Line is created in the specification tree. The feature can be edited at any time by doubleclicking on the tree entry.

2.1.2 Lower Bumper Reference Line

Dialog link: ②

The Lower Bumper Reference Line is determined by attaching a 700 mm long line from the lower rear to the bumper at an angle of 25 deg to the road surface. The lowest boundary points found are considered. Again the points found at certain intervals (<100 mm) are connected by a curve.

Implementation within CAVA happens analogous to the Upper Reference Line but with a different angle value.

This curve is also required by all mentioned standards.

Along with the geometry of the curve, Lower Bumper Height is calculated as well and displayed as an output parameter. It is the minimum and maximum distance of the curve to the road surface.

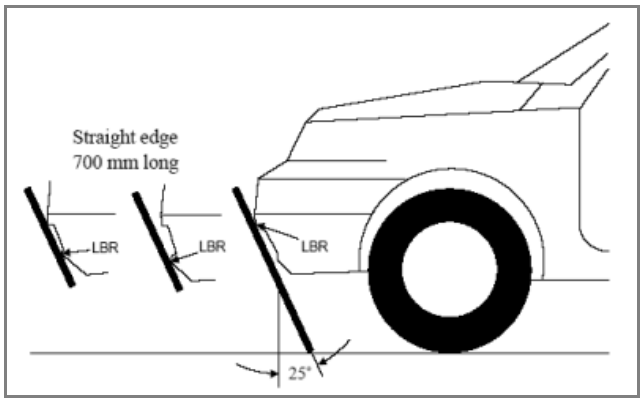
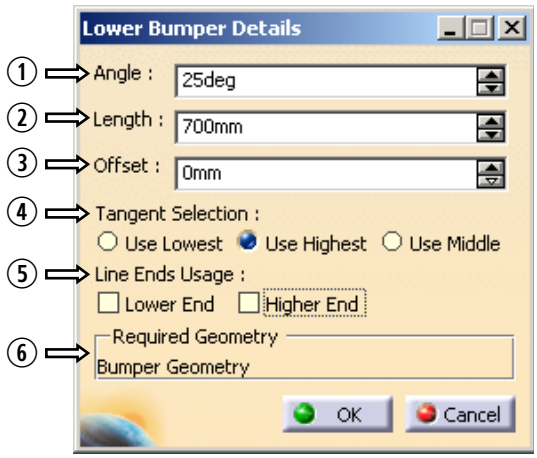


Fig.: Determination of the lower bumper curve

If *Lower Bumper Curve* is selected in the user dialogue, you can retrieve information about the applied values and the geometry to select by clicking on the *Details* button. By selecting the *Free* mode you can define your own setting for specific values.



① Angle

Angle to the road surface at which the line is attached to the geometry.

② Length

Length of the line, which is attached to the geometry at the angle defined in ①. If the line touches other vehicle parts due to its length, a smaller value can be defined.

③ Offset

Offset of the starting point of the line if it is not located on the road surface.

(Cp. Upper Bumper Reference Line)

④ Tangent Selection—Use Lowest / Middle/ Highest

In case the reference line has a number of tangential boundary points with the vehicle geometry, the user can determine which point is to be used.

(Cp. Upper Bumper Reference Line)

⑤ Line Ends Usage—Lower End / Higher End

In case the reference line has no *tangential* boundary point with the vehicle geometry, the user can determine that the lowest or highest point of the line is nevertheless included in the calculation by selecting Lower End or Higher End, respectively.

(Cp. Upper Bumper Reference Line)

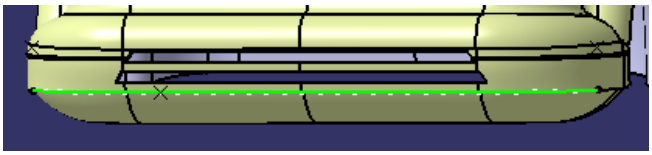
⑥ Required Geometry

List of the required geometry, which has to be selected for calculation. This information assists the user with the selection.

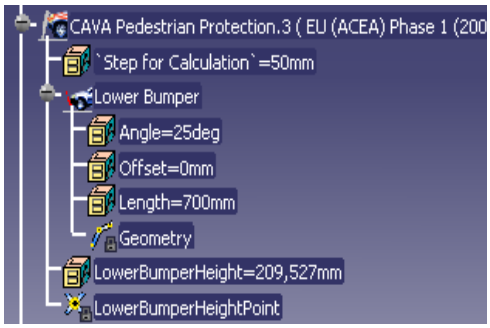
For determination of the *Lower Bumper Reference Line* the following geometry is required:

- Bumper geometry

The result is shown as a line in the model *Lower Bumper Reference Line* in the color chosen by you.



An entry with the values used for the Lower Bumper Referenc Line is created in the specification tree. The feature can be edited at any time by doubleclicking on the tree entry.



2.1.3 Corner of Bumper

Dialog link: ③

The Corner of Bumper point is determined by attaching a vertical plane at an angle of 60 deg to the vehicle centerline and tangentially to the outer points of the front bumper. This is repeated for both sides of the vehicle. If more than one boundary point is present the one farthest outside (*y* direction) is selected.

For implementation in CAVA the bumper geometry is required and the angle must be defined (configurable). The result is a V5 point within the Pedestrian protection feature.

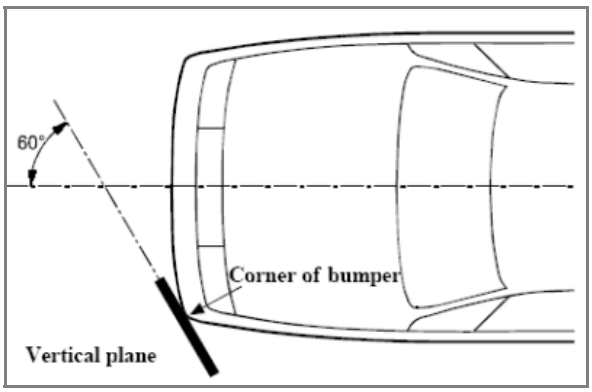


Fig.: Determination of the bumper curve

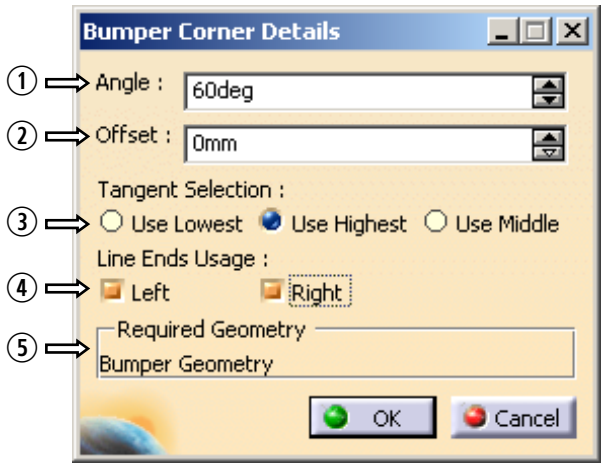
Note:

Since version 1.12.4 the algorithm that calculates the bumper corner points has been changed from a section-based calculation to a distance measurement method.

In previous versions, the 'Bumper Corner' points have been created by using section planes with discrete steps. So it was not inevitably sure that the correct point was determined. Now the calculation is similar to the one used in the 'Bumper Pendulum' feature (without cutting steps).

As CATIA does not allow to create a topological assembly of multiple points, the result for CGR elements shows only the nearest point.

If *Bumper Corner* is selected in the user dialogue, you can retrieve information about the applied values and the geometry to select by clicking on the *Details* button. By selecting the *Free* mode you can define your own setting for specific values.



① Angle

Angle at which a vertical plane to the vehicle centerline is attached tangentially to the outer points of the front bumper.

② Offset

Not applicable.

③ Tangent Selection—Use Lowest / Middle/ Highest

In case the reference line has a number of tangential boundary points with the vehicle geometry, the user can determine which point is to be used.

(Cp. Upper Bumper Reference Line)

④ Line Ends Usage—Left/ Right

In case the reference line has no *tangential* boundary point with the vehicle geometry, the user can determine that the lowest or highest point of the line is nevertheless included in the calculation by selecting Left or Right, respectively.

(Cp. Upper Bumper Reference Line)

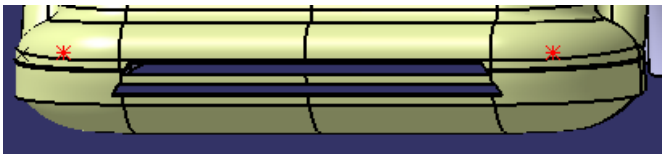
⑤ Required Geometry

List of the required geometry, which has to be selected for calculation. This information assists the user with the selection.

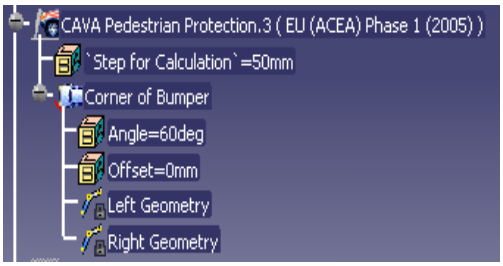
For determination of the *Bumper Corner* the following geometry is required:

- Bumper geometry

The result is shown as points in the model *Corner of Bumper* in the color chosen by you.



An entry with the values used for the *Corner of Bumper* is created in the specification tree. The feature can be edited at any time by doubleclicking on the tree entry.



2.1.4 Bonnet Leading Edge

Dialog link: ④

The curve Bonnet Leading Edge Reference Line is determined by boundary points, which are generated if a 1000 mm long line is drawn in the *x* direction at an angle of 50 deg to the road surface over the geometry of the car front. The lowest point of the line is located 600 mm above the road surface. The boundary points found at defined intervals (<100 mm) are connected analog to the above mentioned curves to form a curve, which can be erratic.

If the distance between the curve and the 1000 mm long Wrap Around Line defined below, is smaller than the defined head diameter, a warning will appear. In such a case the "BLE" is to be used for calculation of the head impact area.

Within CAVA this curve is defined similar to the other curves, i.e. the necessary specifications about length, angle and height are configurable and the geometry can be selected by the user.

This curve is used to limit the Bonnet Top area in the front, which is significant with regard to the impact on the bonnet.

Along with the geometry of the curve, the Bonnet Leading Edge Height is calculated and displayed as an output parameter. It is the minimum and maximum distance of the curve to the road surface.

Along with the Upper Bumper Reference Line, the minimum and maximum horizontal distance between the curves, called Bumper Lead, is calculated and displayed. V5 points are generated at the corresponding locations within the feature.

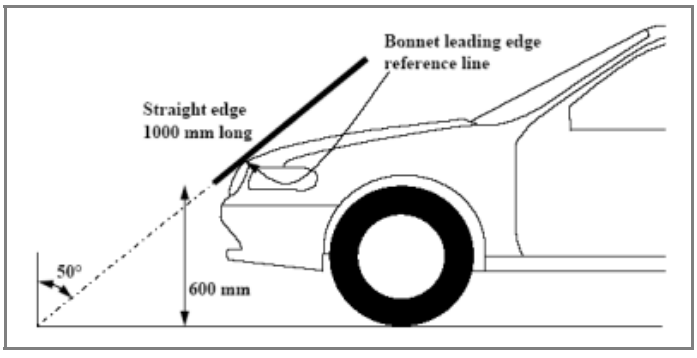
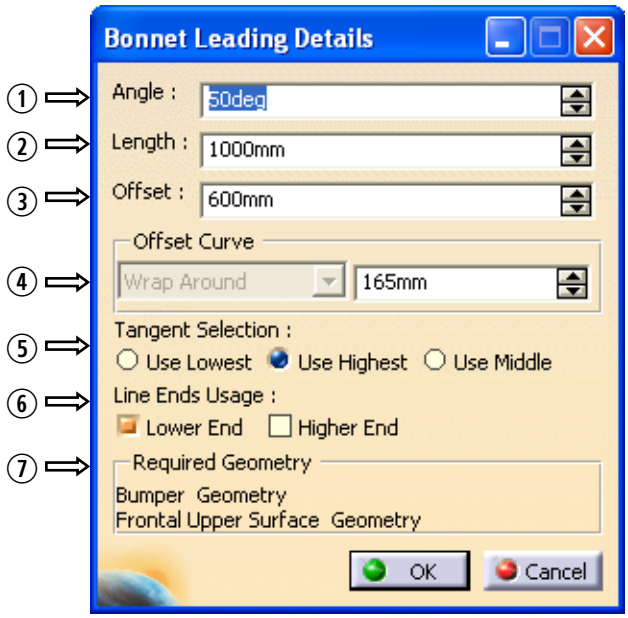


Fig.: Determination of the bonnet leading edge reference line

If Bonnet Leading Edge Curve is selected in the user dialogue, you can retrieve information about the applied values and the geometry to select by clicking on the *Details* button. By selecting the *Free* mode you can define your own setting for specific values.



① Angle

Angle to the road surface at which the line is attached to the geometry. (Default value is 50 deg).

② Length

Length of the line, which is drawn over the geometry of the car front with the angle defined in ①.

③ Offset

Not applicable.

④ Offset-Curve

It is possible to create offset lines of the front and side curves without the need to calculate the whole bonnet top.

Starting from the *Bonnet Leading Edge* a second curve with a defined offset can be created. Do the following to accomplish:

(1) Activate the Free mode in the main dialogue.

(2) Open the dialogue „Details“.

(3) In the frame „Offset Curve“ enter a value greater than zero.

(4) Close the dialogue „Details“.

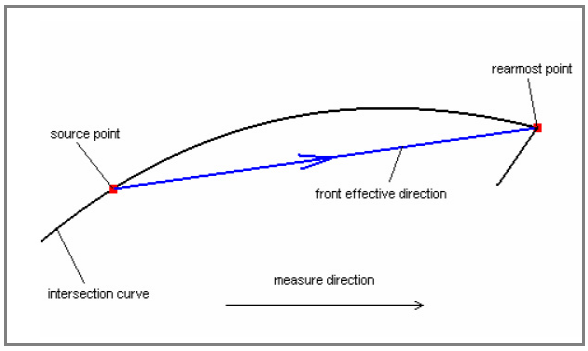
(5) Now you are able to activate the option “Offset Curve” in the main dialogue. Select this option.

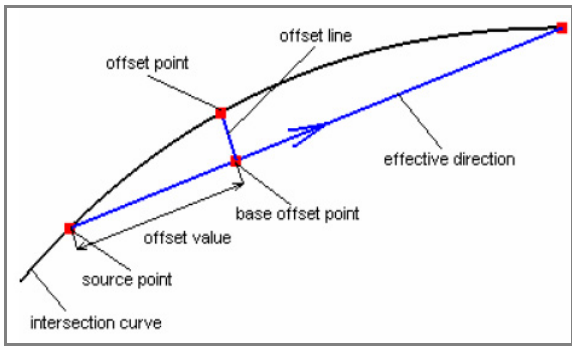
(6) Reopen the dialogue „Details“.

(7) Now select a type for the „Offset Curve“ and click OK.

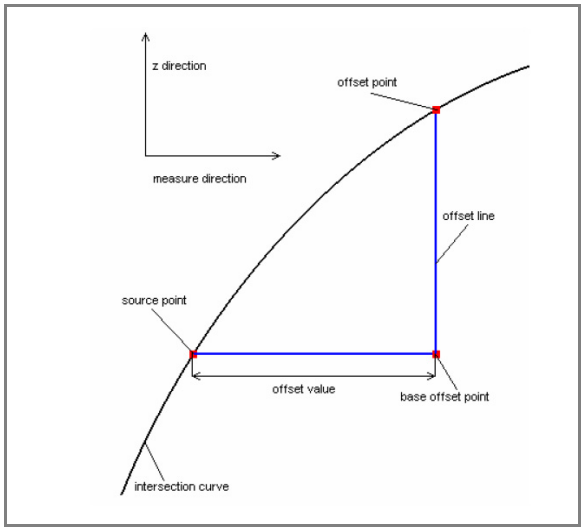
Offset types

- *Type: Effective Direction*

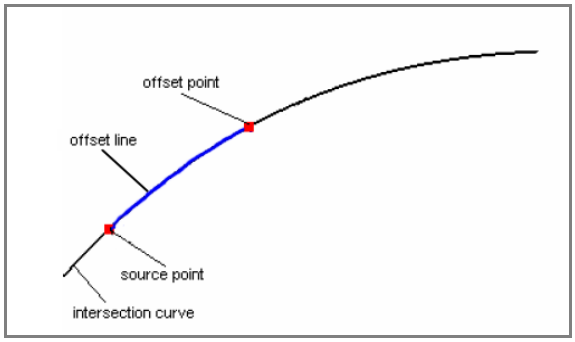




- Type: *Axis Direction*



- Type: *Wrap Around*



④.1 Spinner „Offset Curve“

Offset to the *Bonnet Leading Edge* in positive *x* direction related to the road level.

Click *Apply* or *OK* in the main dialogue to calculate the curve.

⑤ Tangent Selection—Use Lowest / Middle/ Highest

In case the reference line has a number of tangential boundary points with the vehicle geometry, the user can determine which point is to be used.

(Cp. Upper Bumper Reference Line)

⑥ Line Ends Usage—Lower End/ Higher End

If the bonnet is so low, that the line does not meet tangentially but the lower edge of the line meets the bonnet (at 600 mm) these boundary points are the ones to be considered (Lower End). The same applies analogously if the upper edge of the line meets the geometry first because the bonnet is respectively higher (Higher End).

(Cp. Upper Bumper Reference Line)

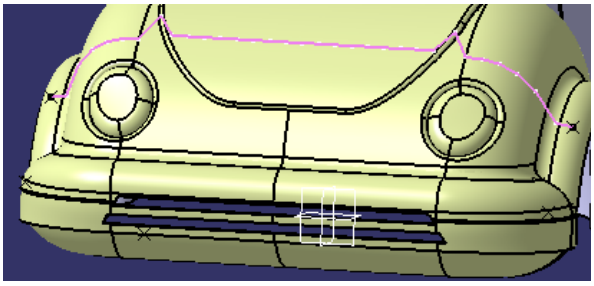
⑦ Required Geometry

List of the required geometry, which has to be selected for calculation. This information assists the user with selection.

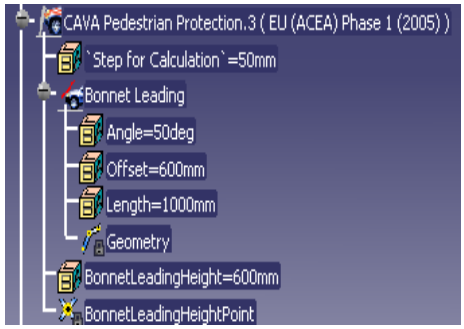
For determination of the *Bonnet Leading Edge Reference Line* the following geometry is required:

- Bumper geometry
- Frontal Upper Surface Geometry

As a result the *Bonnet Leading Edge Reference Line* is displayed in the model in the color chosen by you.



An entry with the values used for the *Bonnet Leading Edge Referenc Line* is created in the specification tree. The feature can be edited at any time by doubleclicking on the tree entry.



2.1.5 Bonnet Side Curve

Dialog link: ⑤

The lateral reference curve on the fender / bonnet is determined by attaching a 700 mm line from the side, at an angle of 45 deg to the road surface, to the vehicle geometry. The uppermost boundary points are considered. Like before the points found at certain intervals (< 100 mm) are connected by a curve.

Implementation within CAVA is carried out analogous to the other reference curves determined in the same way.

This curve is used to limit the Bonnet Top area laterally, which is significant with regard to the impact on the bonnet.

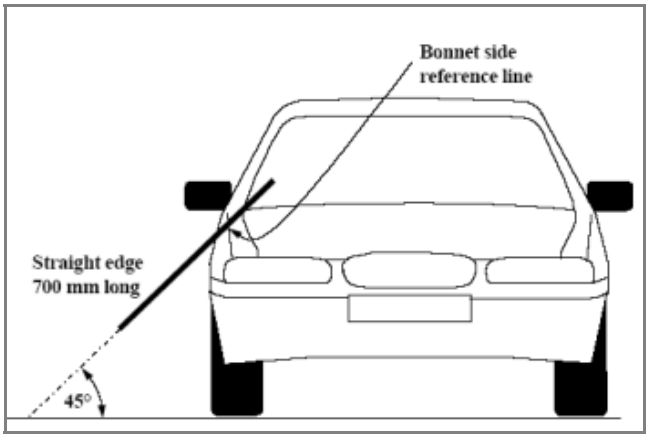
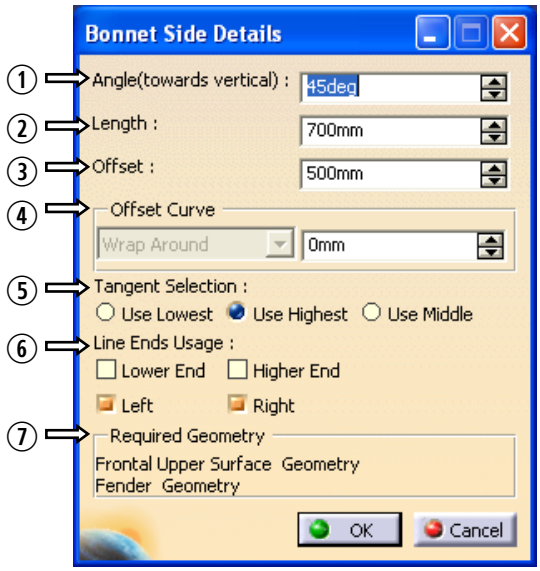


Fig.: Determination of the bonnet side curve

If *Bonnet Side Curve* is selected in the user dialogue, you can retrieve information about the applied values and the geometry to select by clicking on the *Details* button. By selecting the *Free* mode you can define your own setting for specific values.



① Angle

Angle to the road surface at which the line is attached to the geometry. (Default value is 45 deg).

According to the standard the angle for the bonnet side curve is officially measured to the horizontal. In CAVA the angle of the tangent curve is also measured to the vertical as it is done for the frontal reference curves.

② Length

Length of the line, which is drawn over the geometry of the car front at the angle defined in ① (Default value is 3000 mm)

③ Offset

Offset of the starting point of the line if it is not located on the road surface.

(Cp. Upper Bumper Reference Line)

④ List field with spinner "Offset-Curve"

It is possible to create offset lines of the front and side curves without the need to calculate the whole bonnet top

Starting from the *Bonnet Side Curve* a second curve with a defined offset can be created.

You can use the types *Wrap Around* and *Axis Direction.* For definition and procedure refer to page 24 point ④ Offset-Curve.

⑤ Tangent Selection—Use Lowest / Middle/ Highest

In case the reference line has a number of tangential boundary points with the vehicle geometry, the user can determine which point is to be used.

(Cp. Upper Bumper Reference Line)

⑥ Line Ends Usage—Lower End / Higher End

If the bonnet is so low, that the line does not meet it tangentially but the lower edge of the line meets the bonnet, these boundary points are the ones to be considered (Lower End). The same applies if the upper edge of the line meets the geometry first because the bonnet is respectively higher (Higher End).

(Cp. Upper Bumper Reference Line)

Right / Left

Since the curve is generated for the driver side (Right) as well as fort the passenger side (Left), the user can choose whether it should be calculated only for the left, the right or both sides.

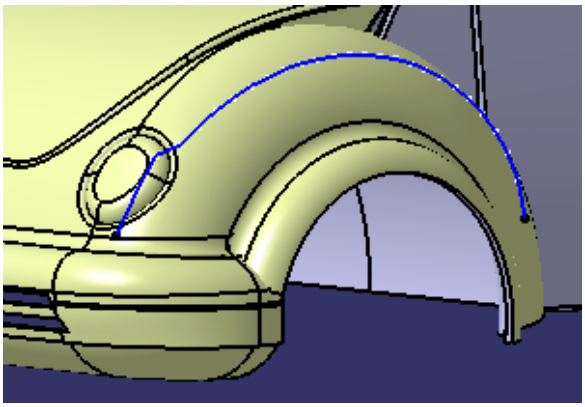
⑦ Required Geometry

List of the required geometry, which has to be selected for calculation. This information assists the user with the selection.

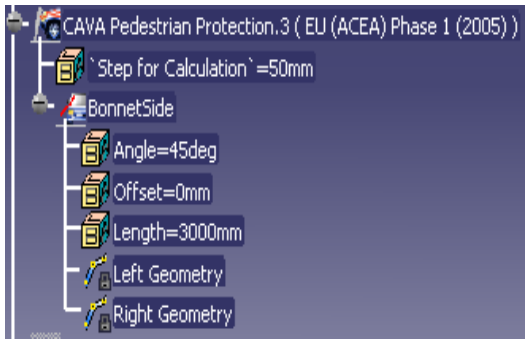
For determination of the *Bonnet Side Reference Line* the following geometry is required:

- Frontal Upper Surface Geometry
- Fender Geometry

As a result the *Bonnet Side Reference Line* is displayed in the model in the color chosen by you.



An entry with the values used for the *Bonnet Side Referenc Line* is created in the specification tree. The feature can be edited at any time by double clicking on the tree entry.



2.1.6 Wrap-Around Distance (1...3)

Dialog links: ⑥, ⑦, ⑧

The Wrap-around distance is determined by fixing flexible bands of a defined length (usually 1000 mm, 1500 mm and 2100 mm) at certain *y* intersections (intervals < 100 mm) with one end on the road surface and with the other end on the bonnet. The fixing point on the road surface is thereby defined by the smallest *x* value of the vehicle geometry at the given *y* value.

These curves are required by all standards. Within in CAVA you are free to configure the length of the band as well as the number of curves (max. 3 per feature).

The standards vary with regard to limitation at the rear. EURO NCAP considers the whole wrap-around distance, even if the curve lies on the windscreen. In addition the area defined by the wrap-around distance lines is divided into sixths (see next chapter).

The ACEA standards (European) wrap-around distance is limited by the Bonnet-Rear Reference Line, described later in this section.

The required input data are:

- Bumper geometry (is selected separately, but is normally already defined for the Bumper Reference curves). It can consist of a number of planes / elements.
- Frontal Upper Surface geometry, i.e. bonnet etc.

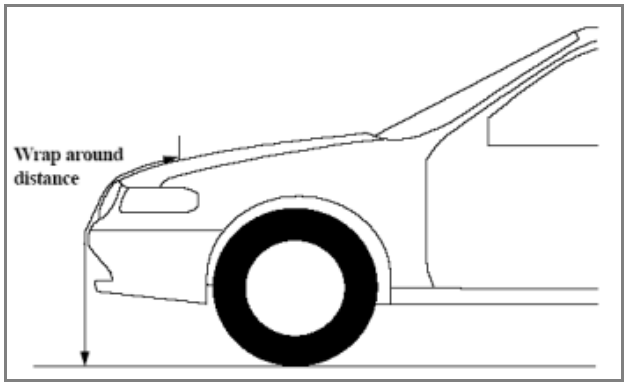
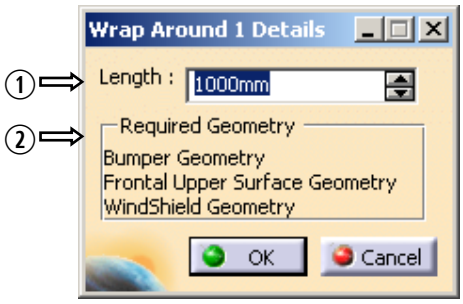


Fig.: Determination of wrap-around distances

If *Wrap Around* is selected in the user dialogue, you can retrieve information about the applied values and the geometry to select by clicking on the *Details* button. By selecting the *Free* mode you can define your own setting for specific values.



① Length

Length of the flexible band fixed at certain *y* intersections (intervals < 100 mm) with one end on the road surface and with the other one on the bonnet.

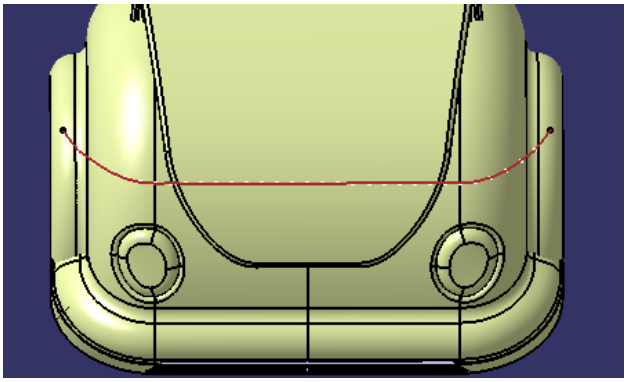
② Required Geometry

List of the required geometry, which has to be selected for calculation. This information assists the user with the selection.

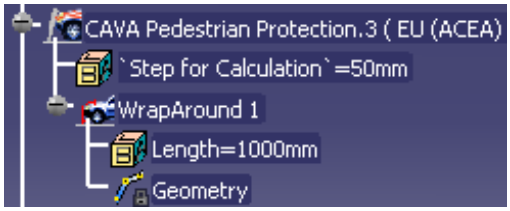
For determination of the *Wrap Around Line* the following geometry is required:

- Bumper Geometry
- Frontal Upper Surface Geometry
- Windshield Geometry

As a result the *Bonnet Wrap-Around Distance* is displayed in the model in the color chosen by you.



An entry with the values used for the *Wrap-Around Distance* is created in the specification tree. The feature can be edited at any time by double-clicking on the tree entry.



2.1.7 Bonnet-Rear Reference Line

Dialog link: ⑨

This reference curve describes the rear limitation of the Bonnet Top area. Calculation is carried out with the help of a sphere with a defined radius, which is rolled down between the windscreen and the surrounding parts, which touch the sphere (on the glass). The surrounding parts are the Frontal Upper Surface but also mounted parts such as wiper casing, wiper axis, water tank casing etc. The elements to be considered along with the bonnet have to be selected by the user in advance. The rearmost contact points (i.e. highest *x* value) of the sphere with the planes define the Bonnet-Rear Reference Line.

The radius of the sphere can be dependent on the Wrap-around distance at the beginning of the windscreen.

The required input is the windscreen as V5 plane. Bonnet geometry has already been specified for the other reference curves.

If this curve is to be generated, the radius to be used for the sphere is configurable and therefore defined by the selected standard.

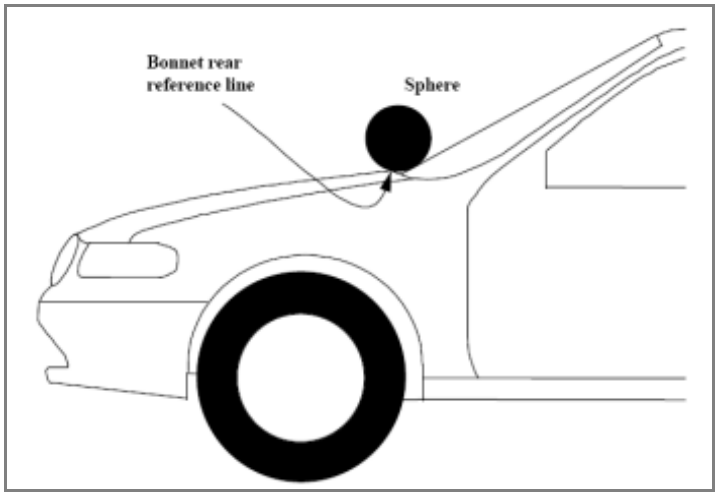
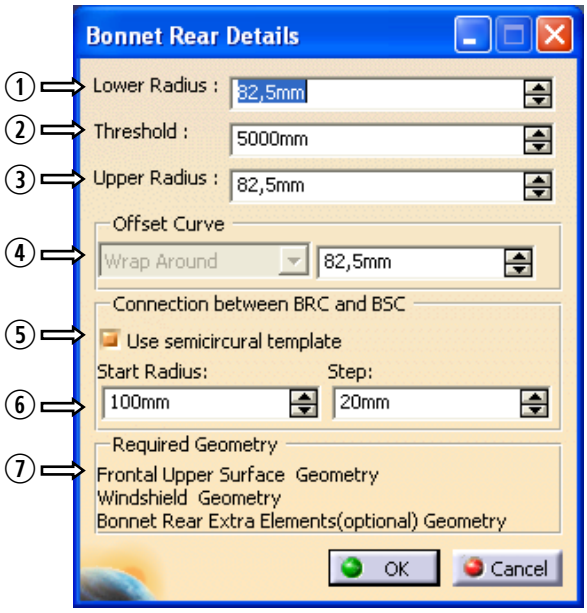


Fig.: Determination of the Bonnet-Rear Reference Line

If Bonnet Rear Curve is selected in the user dialogue, you can retrieve information about the applied values and the geometry to select by clicking on the *Details* button. By selecting the *Free* mode you can define your own setting for specific values.



① Lower Radius

Radius of the sphere rolled down between the windscreen and the surrounding parts.

② Threshold

Defines the threshold value for the length of the Wrap Around, from where the Upper Radius is used instead of the Lower Radius.

③ Upper Radius

Radius of the sphere rolled down between the windscreen and the surrounding parts, when the Wrap Around exceeds the value defined in Threshold.

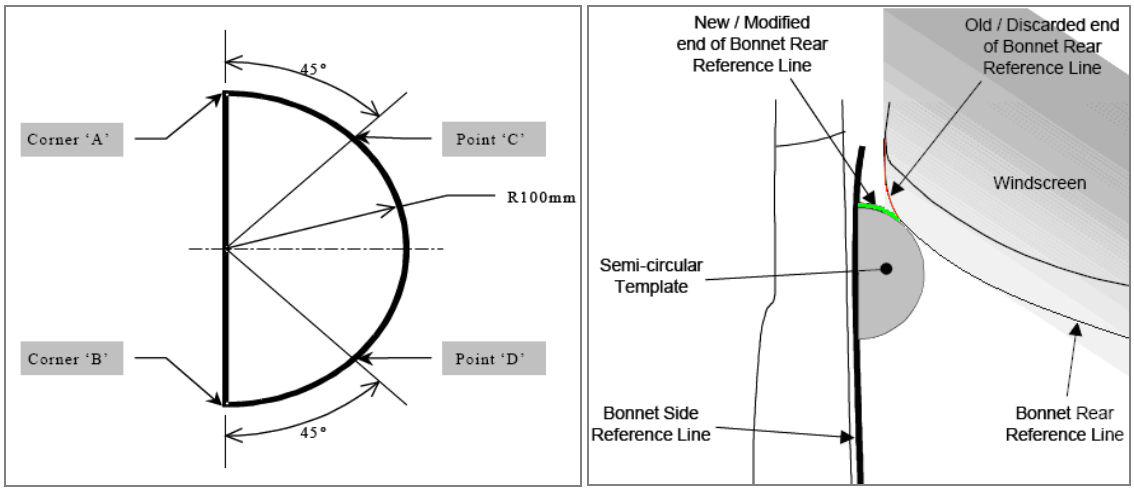
④ List field *Offset Curve* and Spinner

It is possible to create offset lines of the front and side curves without the need to calculate the whole bonnet top.

Starting from the calculated *Bonnet Rear Curve* a second curve with a defined offset can be created in negative *x* direction related to the road level. For definition and procedure please refer to page 24 point ④ Offset-Curve

⑤ *Use semicircular template* check box

If the Bonnet Rear Reference Line and the Bonnet Side Reference Line do not intersect, the Bonnet Rear Reference Line should be extended or modified by using a semicircular template with a radius of 100 mm (figure below).



This template is placed on the vehicle geometry with point A and B coincident to the Bonnet Side Reference Line and slipped rearwards until the arc of the template is in contact to the Bonnet Rear Reference Line. During this process the template is curved to follow the outer contour of the vehicle's Bonnet Top. If the contact between the template and Bonnet Rear Reference Line is tangential and the point of tangency is outside of the arc defined by point C and D, then the Bonnet Rear Reference Line is extended and/or modified to follow the circumferential arc of the template to meet the Bonnet Side Reference Line.

⑥ Slider Start Radius and *Step* Slider

Radius of the template for the first check. If there was no intersection found between the Bonnet Rear Reference Line and the Bonnet Side Reference Line, the radius will be increased by the value defined in the *"Step"* field (default is 20 mm). The check will be repeated until the intersection will be found.

If the semicircular template cannot be placed on the Bonnet Side curve, the Bonnet Rear curve is extended and intersected with the Bonnet Side curve.

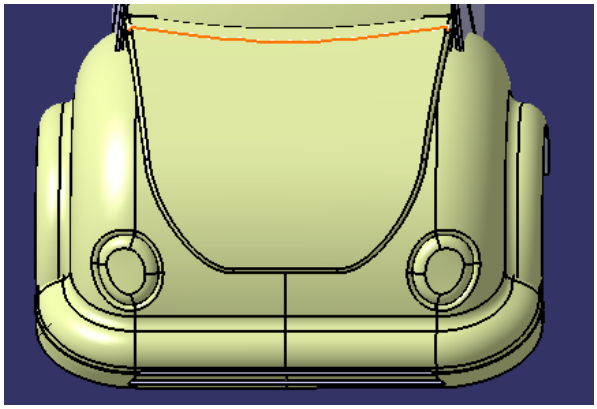
⑦ Required Geometry

List of the required geometry, which has to be selected for calculation. This information assists the user with the selection.

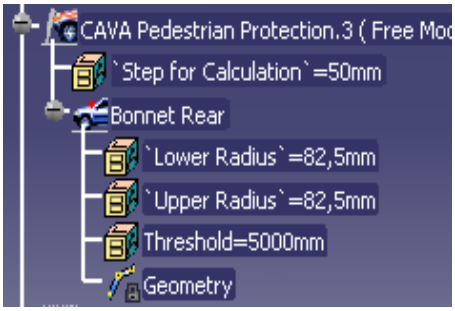
For determination of the *Bonnet-Rear Reference Line* the following geometry is required:

- Frontal Upper Surface Geometry
- Windshield Geometry
- Bonnet Rear Extra Elements Geometry (optional)

The result is shown as a line in the model *Bonnet-Rear Reference Line* in the color chosen by you.



An entry with the values used for *Bonnet-Rear Reference Line* is created in the specification tree. The feature can be edited at any time by doubleclicking on the tree entry.

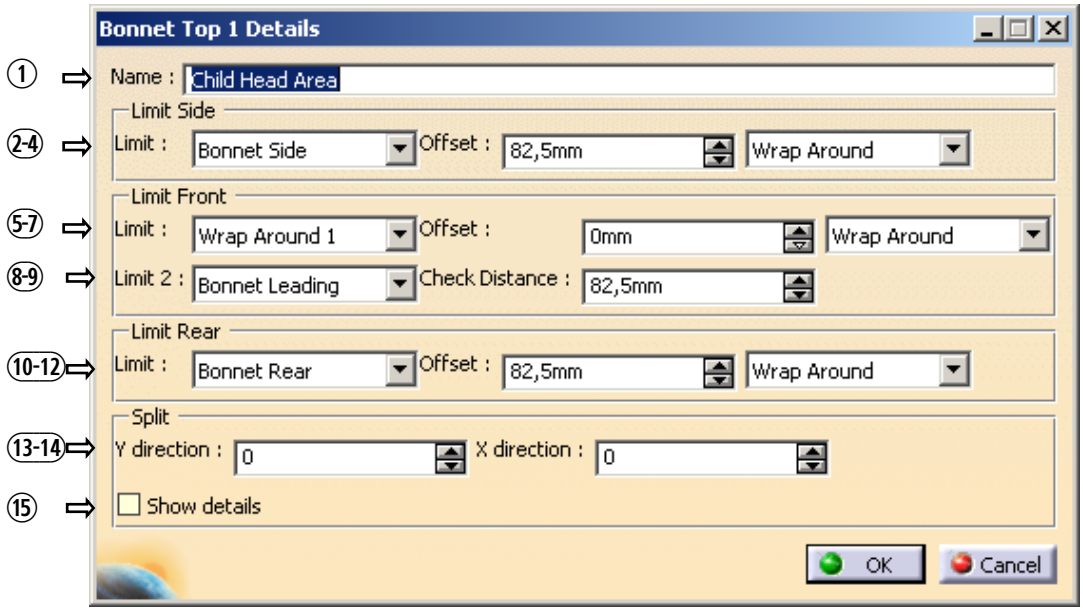


2.1.8 Bonnet Top 1–2

Dialog link: ⑩, ⑪

For calculating the Bonnet Top all necessary boundaries (Bonnet Side, Bonnet Leading Edge, Bonnet Rear and Wrap Around) have to be defined in advance. Ensure that these curves are selected in the dialogue and have no error symbol (⚠) attached to them.

If Bonnet Top is selected in the user dialogue, you can retrieve information about the applied values and the geometry to select by clicking on the *Details* button. By selecting the *Free* mode you can define your own setting for specific values.



① Text field „Name“

Since the Bonnet Top area is usually defined for two sizes of pedestrians (child and adult) this field defines the size on which the calculation is based. The name is lodged in the configuration file.

②⑤ ⑧⑩ List fields „Limit“

In the list fields you can define lateral, front and back limitation of the Bonnet Top area. Usually one of the Wrap Around Curves is chosen as Front Limit.

③⑥ ⑪ Spinner „Offset“

Defines an offset of the lateral limitation towards the vehicle center. The value of 82.5 mm corresponds to the radius of a child's head.

④⑦ ⑫ List fields for the offset type

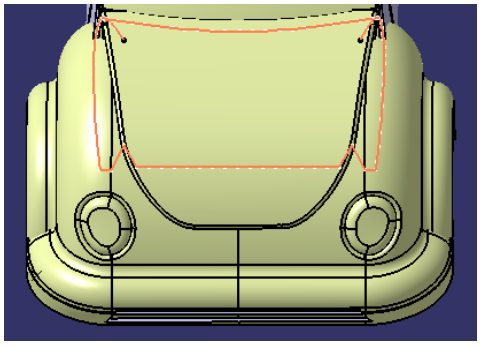
Here you can define which type of offset you want to use for the calculation of the bonnet top area. (For description refer to side 25).

⑤ ⑧ ⑨ List fields „Limit“ and „Limit 2“ and Spinner „Check Distance“— context

If the list field “Check Distance“ contains a value greater than zero (> 0), the list field „Limit 2“ will be activated. If the offset between the curves specified in the fields *Limit* and *Limit2* is smaller than the *check distance,* the curve defined in field *Limit2* will be taken for the boundary of the bonnet top.

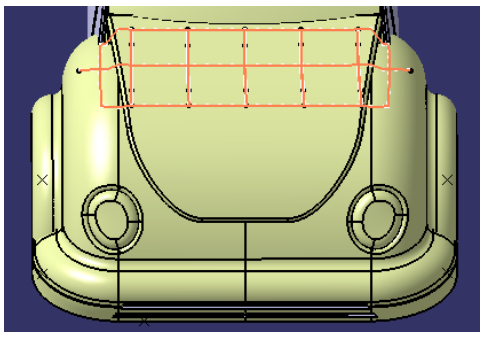
If the offset between the curves specified in the fields */imit* and */imit2* is larger than the check distance, the curve from Limit will be taken for the bonnet top boundary.

If all curves for the *Bonnet Top Area* are calculated, the user has the option to display only this area, i.e. the four boundary curves are trimmed together.



Optionally, a segmentation of the Bonnet *Top Area* can be activated. That enables you to split the area into six parts, as defined in the EURO NCAP.

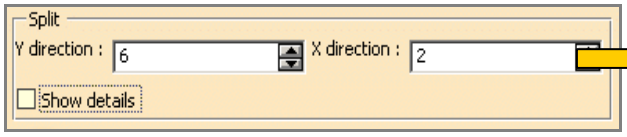
The kind of segmentation is defined in the configuration file.

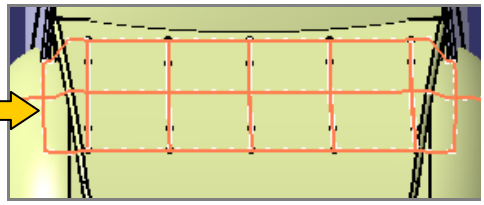


⑬-⑭ Split *y* direction/*x* direction

Definition of the segmentation of the *Bonnet Top Area* in *yz* or. *xz* plane.

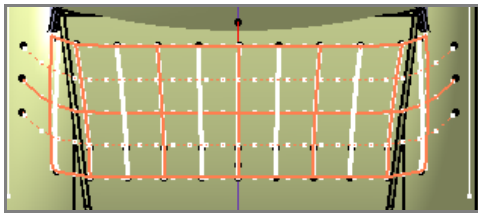
Example:





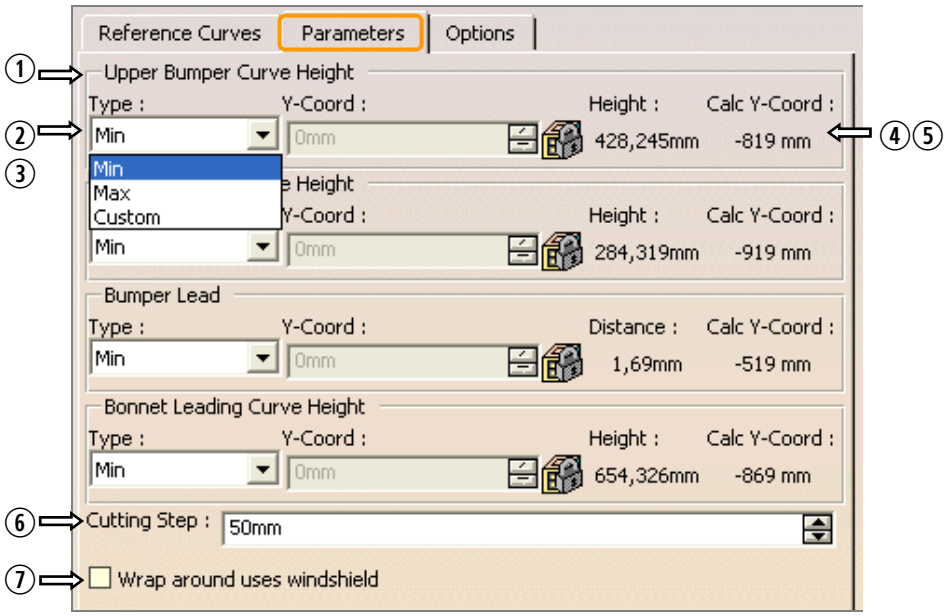
⑮ Show details

If this option is activated, the segments are quartered once more.



- ***Parameters*** **tab card**

The minimum and maximum values of *Upper Bumper Height*, *Lower Bumper Height* and *Bumper Lead* are shown as output parameters. In addition there is the possibility to enter a specific *y* coordinate, for which these parameters are calculated. This means that within the CAVA feature the user can display for example the *Bumper Lead* value for a specific *y* coordinate.



⑮ Fields for additionally calculated parameters

For each curve some parameters have to be defined. They are described in the following.

① Name of the parameters

Each frame title describes the name of the parameter.

② List field „Type“

Here you can define whether the maximum, the minimum or a user defined height *(custom)* should be calculated. If you have selected the option „custom“ you will have to insert a value in field „Y-Coord.“ for the *y* coordinate at which the height should be calculated.

③ Spinner „Y-Coord.“

If the type *custom* is selected in field ② here you will have to define the *y* coordinate at which the calculation should be done.
This field is deactivated for the types *Min* and *Max.*

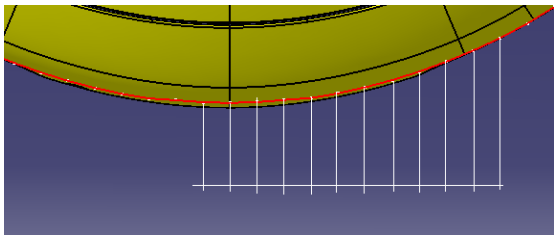
④ Height/Distance

For the users information the value of the maximum or minimum height is displayed here. The height is measured perpendicular to the appropriate road level.

⑤ Info field „Calc Y Coord“

For the users information the *y* coordinate for the maximum or minimum measured height is displayed here.

⑥ Spinner „Cutting Step“



Cutting Step defines the interval (increment) between the points set for drawing the lines. The intervals are measured at a straight line and then projected onto the vehicle geometry

The increment is normally 50 mm. By selecting *Free* Mode you can set a different value (< 100 mm).

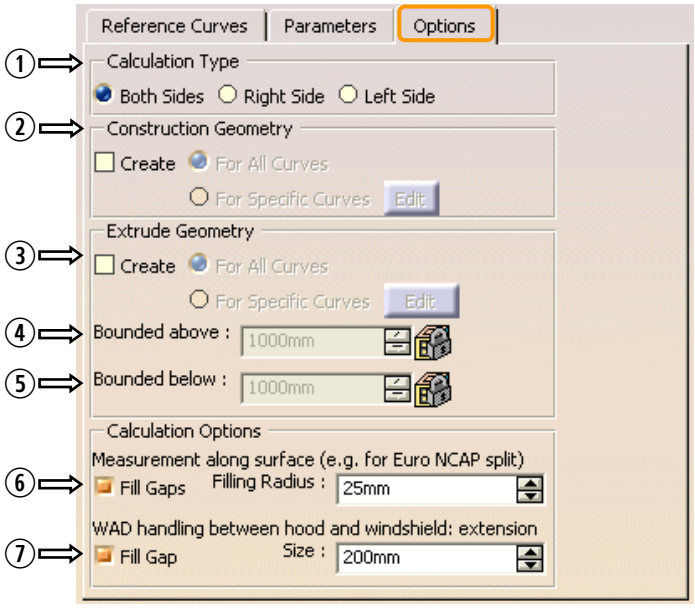
⑦ Check box “Wrap Around Uses Windshield“

If a Wrap Around curve lies on the windshield it is normally shortened to the length of the Bonnet Rear.
With the Wrap Around Uses Windshield option it is defined explicitly that the curve can lie on the windshield and is not to be shortened.

The provided configuration file `PedestrianProtection.xml` covers the standards (within the parameters mentioned above) for JAPAN, ACEA 1 and 2 and as well the EURO NCAP. The configuration can be extended arbitrarily.

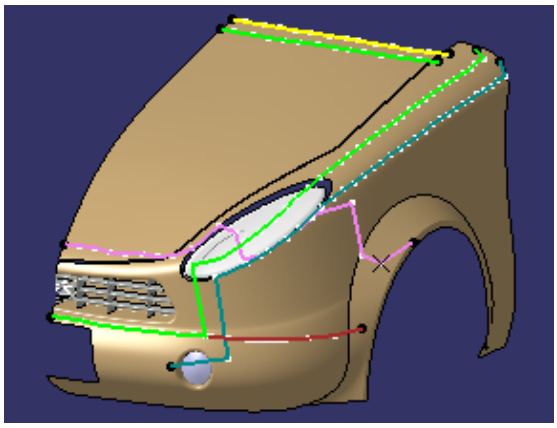
• *Options* tab card

The Option tab card offers several settings for the calculation and visualization of the resulting and construction geometry.



① Calculation Type

During the design process you often may have available only one side of the car instead of the complete vehicle geometry. This option enables you to calculate the reference curves for either the left or the right side.



② Construction Geometry

Activate the *Create* checkbox to visualize the intermediate geometry (section planes, intersection with geometry, tangent lines and (circles for bonnet rear))

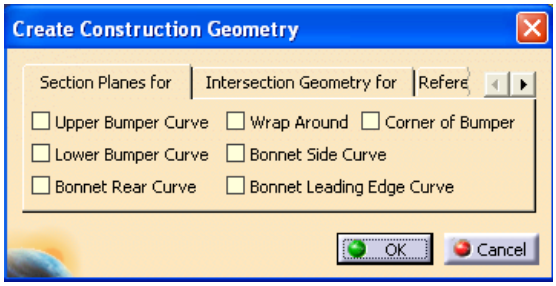
The construction geometry will be created at each reference point on the curve and is done only for existing and calculated reference curves. The number and position of the reference points is dependent from the Cutting Step that is defined on the *Parameters* tab card.

• *For All Curves*: (Available only if *Create* is selected)

Creates the construction geometry for all existing reference curves.

• *For Specific Curves*: (Available only if *Create* and *For specific curves* is selected)
Creates the construction geometry only for a subset of existing reference curves. Use the *Edit* button to define the subset of curves.

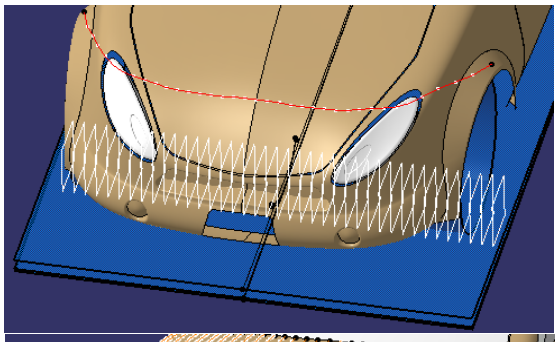
• *Edit*: (Available only if *Create* is selected)
Select the check boxes of the reference curves you want to create. The dialog contains three tab cards, each providing the reference curves for activation.



Make your selection and click *OK* to close the dialog. Then click *Apply* in the *Pedestrian Protection* dialog box to refresh the visualization in the workspace.

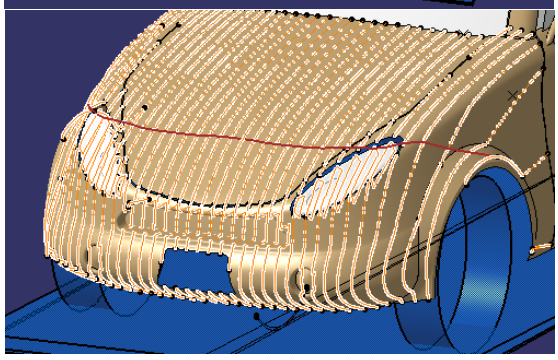
Section Planes

On this tab card you can activate the creation of section planes for each reference curve (see example for the *Wrap Around* below).



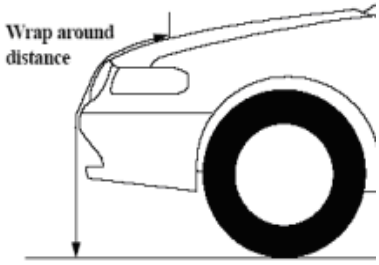
Intersection

On this tab card you can activate the creation of intersections for each reference curve. The output is the visualization of intersections through the selected vehicle geometry (see example for the *Wrap Around* below).

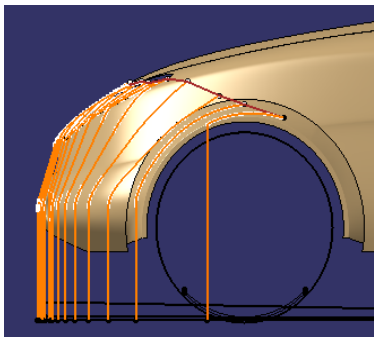


Reference Geometry

On this tab card you can activate the creation of the reference geometry for each reference curve. As Result you will get the geometry as it is described in the standard definition (see example for the *Wrap Around* below).



Schematical draft for the standard definition



Output geometry created by the CAVA application

③ Extrude Geometry

To get an extruded surface of the reference curves, activate the *Create* check box and click *Apply*. The extrusion geometry will be created only for existing and calculated reference curves.

The extrusion is always created in negative and/or positive *z* direction (CAD system).

- *For All Curves*: (Available only if *Create* is selected)

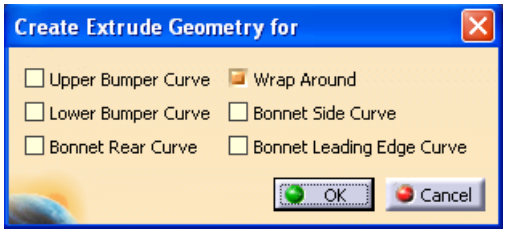
Creates the extruded surfaces for all existing reference curves.

- *For Specific Curves:* (Available only if *Create* is selected)

Creates the extruded surfaces only for a subset of existing reference curves. Define the subset using the *Edit* button.

- *Edit*: (Available only if *Create* is selected)

Click on the button to select the reference curves for which you want to create the extrusion.



④ Bounded above

Specify the upper limit of the extrusion. The value has to be a positive number greater than zero and is measured from the corresponding reference line in positive *z*-direction.
(In the picture to the right it is the green marked area.)

⑤ Bounded below

Specify the lower limit of the extrusion. The value has to be a positive number greater than zero and is measured from the corresponding reference line in negative *z*-direction.
(In the picture on the right it is the yellow marked area.)

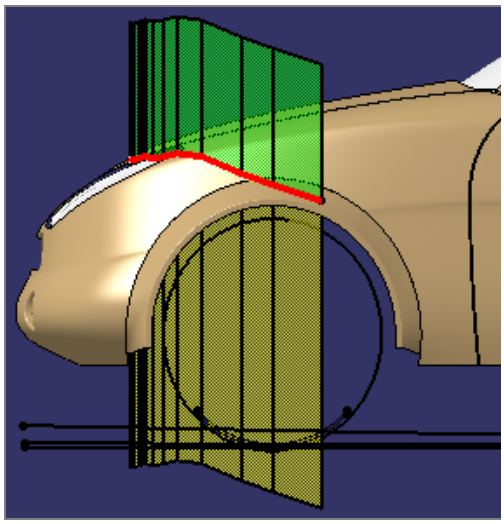
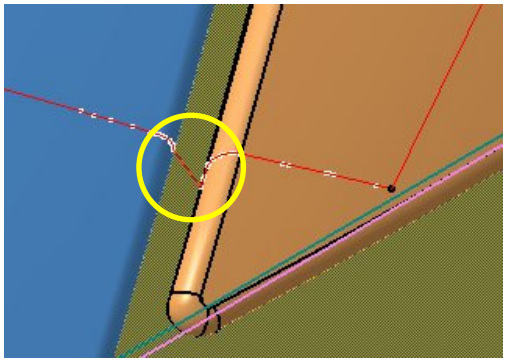


Fig.: Example for *Wrap Around* Curve:

- Bounded above: 400 mm (green)
- Bounded below: 900 mm (yellow)

⑥ Measurement along surface

If the measurement is done along the surface and the and there is a gap (e. g. between fender and hood) that will not be closed by some upper line connection, the measurement will lead to a bigger distance (see figure to the right)



If the *Fill gaps* option is enabled, all gaps smaller than a given measure (value defined in field *Filling Radius*) will be closed.

Filling Radius defines the radius of a circle rolling over the upper line curve. If the circle diameter is less than the length of the gap, the gap will be closed.

⑦ WAD handling between hood and windshield

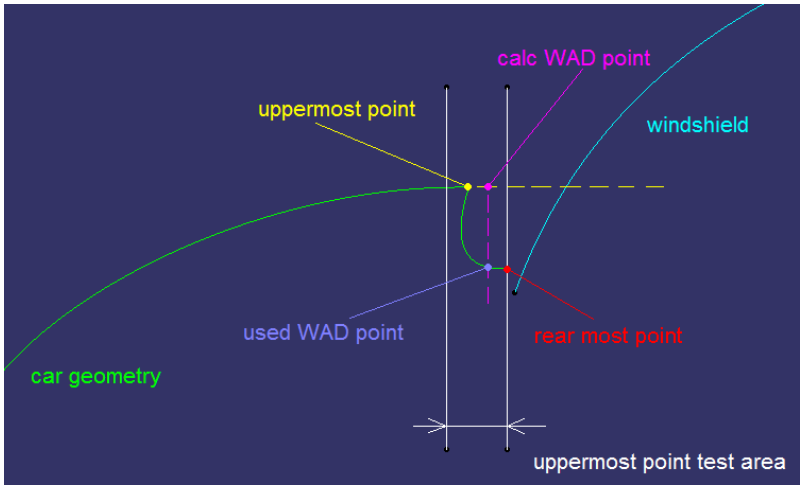
Prereq.: Windshield is selected as separate selection.

In case the end of the flexible tape is between the engine hood and the windshield, the tape should not be wrapped around the wiper or other geometry but extended in x direction (horizontally) towards the windshield. The end point will then be projected onto the geometry and the WAD curve will be positioned there.

If the projection of the point fails due to missing geometry a point on the virtual horizontal connection between hood and windshield is used instead.

Procedure:

- Get the rearmost point of the section curve of the engine hood (general selection)
- This point is projected onto the shield
- As this point is not necessarily the best point, a straight horizontal line is used with a length (defined in the *Size* field) between the rearmost point and the windshield
- Move this line from the windshield top downwards until it touches the engine hood
- The WAD is calculated along this virtual conncetion
- Only in case the limit is on that part, the projection is done.



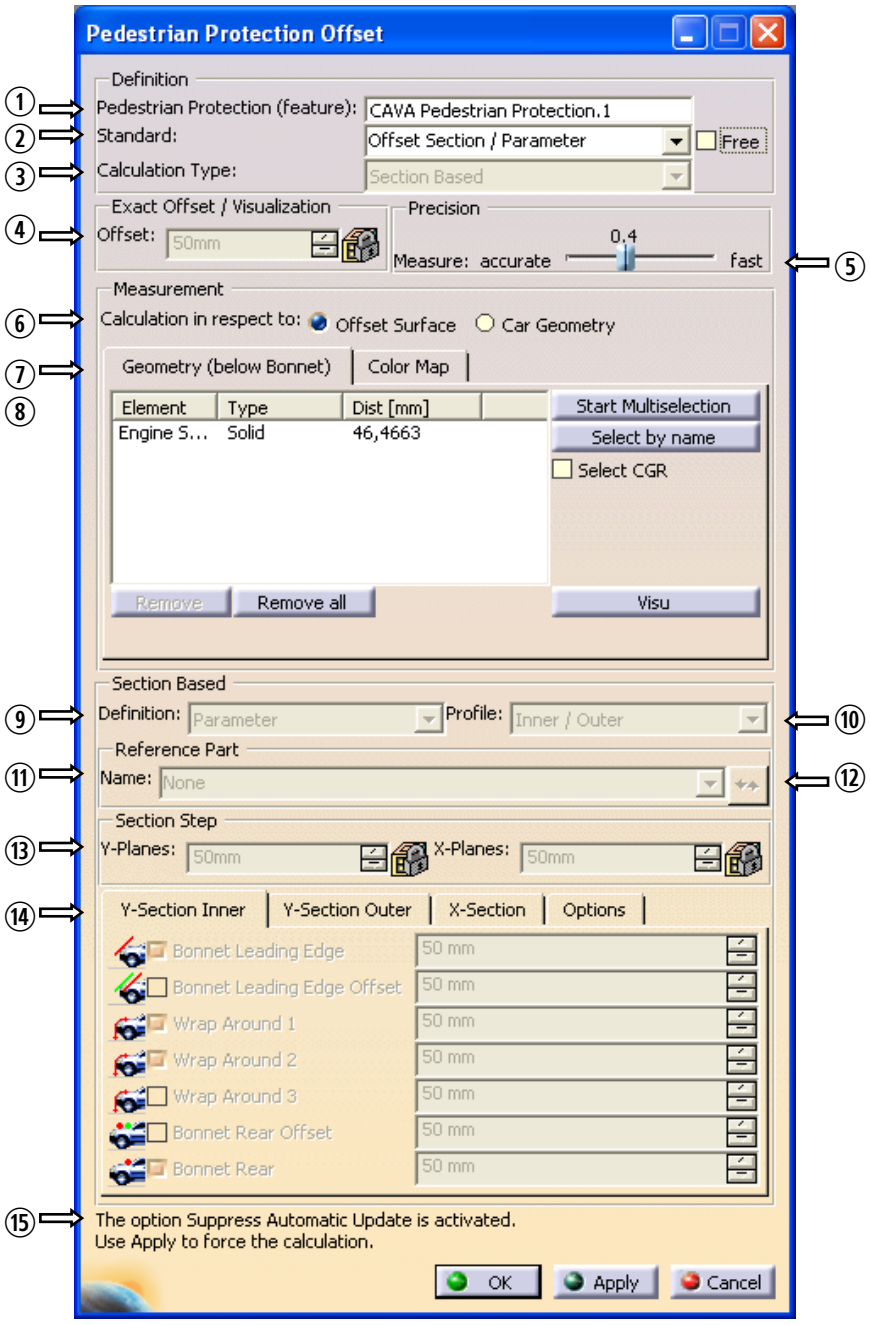
The configuration file `PedestrianProtection.xml`, which is delivered with CAVA, covers the norms for JAPAN, ACEA 1 and 2 as well as EURO NCAP (within the the parameters described above). The file can be supplemented according to the user's needs.

3. Pedestrian Protection Offset

This CAVA feature creates an offset surface of the bounding geometry from an existing CAVA PEDESTRIAN PROTECTION feature.

After the feature has created the offset surfaces, the user can imagine where to position the engine and other parts inside the vehicle's front end and specify some limits for them.

This feature provides different methods for the creation of the offset surfaces that are implemented as predefined (non official) standards.



① Pedestrian Protection (Feature)

In this field you have to reference an existing CAVA PEDESTRIAN PROTECTION feature that is used as input for the measurements and offset surface creation. The required reference curves and vehicle geometry are also taken from this referenced CAVA PEDESTRIAN PROTECTION *feature*. If a parameter needed for the calculation (e. g. *Wrap-Around* curve) is missing, you have to modify the respective CAVA PEDESTRIAN PROTECTION feature first before you can proceed to work on the CAVA PEDESTRIAN PROTECTION OFFSET feature.

② Standard

The implemented standards are no official norms or rules. They use different methods to calculate the distance or to create the offset surface. You can find a detailed description of the calculation methods in ③ (Calculation type).

- *Measurement without Offset*
  This standard uses the "*Measurement only"* calculation type.
- *Visualization Type* (50 mm)

This standard uses the "*Visualization"* calculation type. The created offset curve has a predefined offset of 50 mm.

- *Offset Section/Parameter*

This standard uses the *"Section Based Offset"* calculation type. The distance of the offset curve is defined by a length parameter.

- *Offset Section/Sketch*

This standard uses the "*Section Based Offset"* calculation type. The geometry of the offset curve is defined by a sketch taken from a reference part.

③ Calculation Type

The calculation type defines the way the offset surface is created. The content of this list field is given by the selected standard and can be changed only in "Free" mode.

Besides the individual functionality of each calculation type, the common functionality of all types is that they measure the distance between the vehicle geometry or the offset surface that is defined in the referenced CAVA PEDESTRIAN PROTECTION feature, and the geometry elements from the geometry selection list (⑦).

(As an exception, this has no effect on the *"Measurement only"* calculation type as no offset surface is used.)

Optionally you can display the measured result as color map (see ⑧).

- *Visualization:*

The offset surface is created by using an internal tessellation of the vehicle geometry of the referenced CAVA PEDESTRIAN PROTECTION feature.

The result geometry is pure CAVA visualization geometry. This means you cannot use it for ongoing CATIA V5 actions (e. g. measurements, intersections, etc.).
As reference geometry for the CAVA measurement functionality you can use CGR data and V5 surfaces.

- *Exact Offset:*

The offset surface is created as an exact offset of a V5 surface.
Therefore you can use only V5 surfaces as referenced geometry.

- *Section Based Offset*

The created offset is based on parametric values that define a distance to the intersection points of certain reference curves of the referenced CAVA PEDESTRIAN PROTECTION feature with the *y* plane, or it is based on a sketch of a reference part (For de-

tailed description please refer to point ⑪.)

• *Measurement only:*

No offset surface is created. This calculation method measures only the distance between the vehicle geometry of the referenced CAVA PEDESTRIAN PROTECTION feature and the geometry elements of the geometry selection list (⑦).

④ Offset

Defines the distance of the generated offset surface to the selected reference geometry (see ⑥). This field is available for the calculation types *Exact Offset* and *Visualization*.

⑤ Precision

Use this slider to control the accuracy of the internal tessellation of the geometry and consequently the calculation time. If the selected geometry in list ⑦ is homogenous, you can decrease the accuracy in order to reduce the calculation time. On the other hand, if the geometry is very complex and unsteady (many small raises), you should set the slider to high accuracy so that for the CAVA measurement all raises will be taken in consideration.

⑥ Calculation

The distance measurement can be started from two different reference geometries:

• Offset Surface

The distance is measured between the geometry selected in list ⑦ *(Below Bonnet)* and an offset surface that has been created with a defined offset to the vehicle geometry of the referenced CAVA PEDESTRIAN PROTECTION feature.

• Car Geometry

The distance is measured between the geometry selected in list ⑦ *(Below Bonnet)* and the vehicle geometry of the referenced CAVA PEDESTRIAN PROTECTION feature.

⑦ Geometry (below bonnet)

Add all geometry elements to this list that reside below the bonnet and that should be included in the distance measurement.

⑧ Color Map

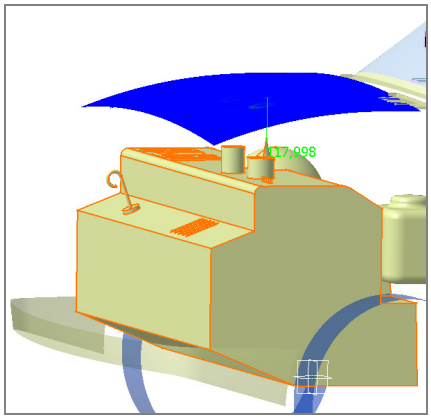
This tab card contains optional settings for displaying the measured results.

In the table you can define different colors for how to represent value sets of the measurement results.

Additional options:

- Create Color Map

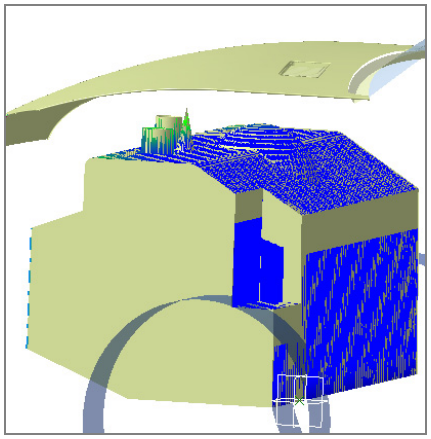
A colored surface is generated according to the settings in the color range definition table.



The colored surface represents the result of the distance measurement between the vehicle geometry of the referenced CAVA PEDESTRIAN PROTECTION feature or an offset surface (depending on the calculation type and options selected) and the geometry elements selected in list ⑦.

• On Geometry (below bonnet)

If this option is active, the colors surface will be created directly on the geometry that has been selected in list ⑦.



• *Use Interpolation*

The measured values that lie between the upper and the lower boundary of a color range are visualized in graduated color steps.

The topics described below are only available for the “Section based Offset” calculation type (③).

Section Based Offset

⑨ Definition

This field defines the way the offset surface will be created.

• Parameter:

The distance between the offset surface and the reference curve is defined by the length parameters specified on the *Y-Section Inner* or *Y Section Outer* tab card. An offset curve with the specified distance will be created for all activated reference curves (see ⑭). These offset curves finally will be connected to one offset surface.

• Sketch

The offset surface geometry is defined by a sketch in a reference part in relation to the reference curve. For detailed description of this procedure refer to point ⑪.

⑩ *Profile*

There are several ways to define the profile of the generated offset surface:

- One Profile

The offset surface is one single surface with a continuous course.

- Inner/Outer

The resulting offset surface is split into different sub-profiles,

  - one inner Area and
  - one outer area at the left and one on the right boundary of the vehicle bonnet geometry.

These areas are generated for each *x* section according to a certain formula.

You can find a detailed description of these areas below in the description of the *x* sections (⑭).

⑪ *Reference Part*

If you have selected the *„Sketch"* option in ⑨, you have to select one reference part from this list that contains the sketch to create the surface geometry from.

This list contains all reference parts that reside in the reference parts folder (specified in the CAVA settings in *Tools* > *Options* > *Infrastructure* > *CAVA Vehicle Architecture* on the *„Administration"* tab card).

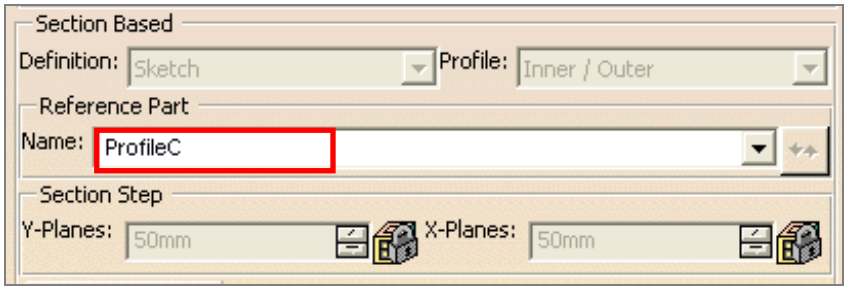
There are some conventions for the design and naming of the reference parts.

The file name has to correspond to the following convention:

- Prefix: `CAVAPPOffset` (name must not be changed by the user)
- Profile name: `ProfileC` (name can be changed by the user)
- File name extension: `.CATPart`

Example: `C:\References\`**`Safety`**`\CAVAPPOffsetProfileC.CATPart`

The selection list in the user dialog will then contain name **ProfileC.**



The profile of the offset surface is defined by two sketches. The sketch for the inner part of the offset surface must have the name `CAVAPedOffset_Inner` and the sketch for the outer part `CAVAPedOffset_Outer`.

If this naming convention is not respected, the first found sketch will be used for the

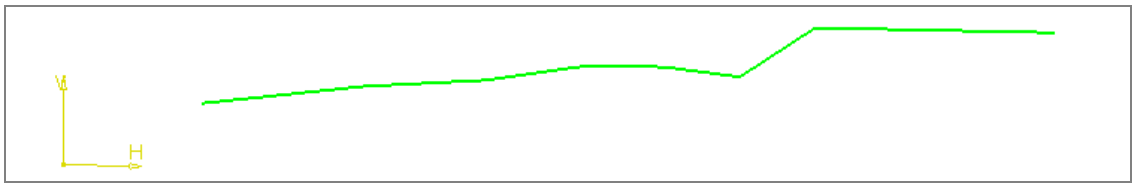
inner part and the second one for the outer part of the offset surface.

If only one sketch exists, it will be used for the inner and the outer part of the offset surface.

The sketch that is used for the profile definition has to correspond to the following conventions:

Sketch creation

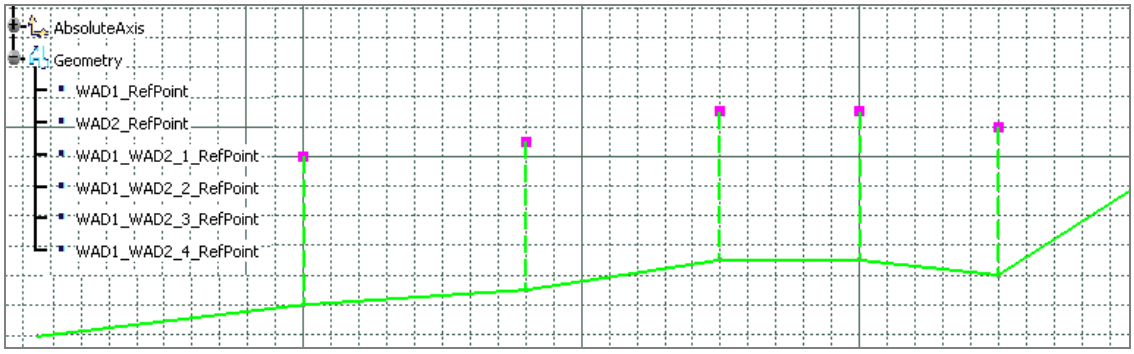
• Step 1:
As starting geometry you have to create one single curve. This geometry is finally used to generate the outline of the offset surface.



• Step 2:
Insert control points to the sketch. These control points afterwards will be positioned by CAVA so that they coincide with the respective reference curve of the referenced CAVA PEDESTRIAN PROTECTION feature.

The control points are defined by specific names:

• BLE_RefPoint – Bonnet Leading Edge curve
• BLEO_RefPoint – Bonnet Leading Edge Offset curve
• WAD1_RefPoint – Wrap Around 1 curve
• WAD2_RefPoint – Wrap Around 2 curve
• WAD3_RefPoint – Wrap Around 3 curve
• BRO_RefPoint – Bonnet Rear Offset curve
• BR_RefPoint – Bonnet Rear curve



• Step 3:
Create constraints between the starting geometry and the control points (e.g. length, angle, ...)

Each control point must have a constraint as fix point, and must be declared to be part of the construction geometry.

All other geometry except the starting geometry also must be declared to be part of the construction geometry.

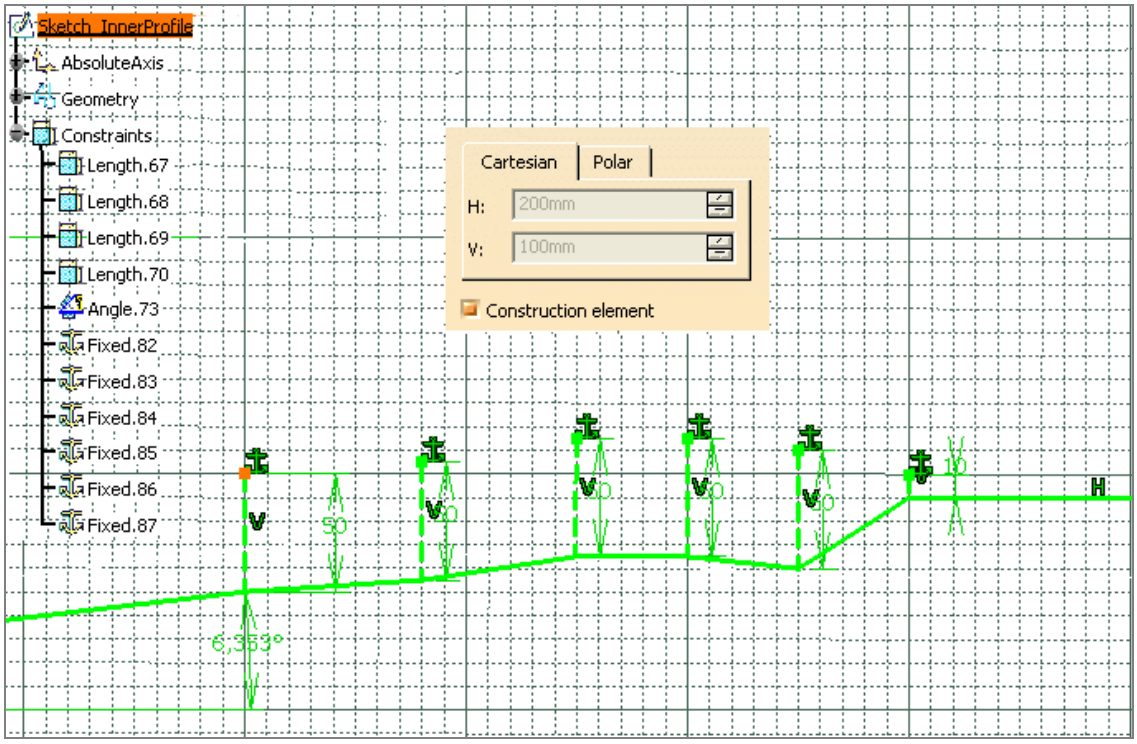
You can also add several “internal” control points between two “reference” control points. For these points use the following naming convention .

`First_Curve_Name, Second_Curve_Name, **Index**, RefPoint`

Example:

`WAD1_WAD2_1_RefPoint, WAD1_WAD2_2_RefPoint, …`

The index determines the order of the points (ascending order).



Now, the sketch is completed and can be saved, taking in account the above mentioned naming convention.

Since version 1.12.2 you can also define control curves inside the sketch.

Control curves are spline-curves constrained by a fix start -and end point.

Control curves do not need constrained definitions to any other constraints. The naming convention (identifier – see below) is type of constraint to the Pedestrian Protection-Offset feature.

The Orientation of the spline curve must be from front to rear part of engine hood. (see Fig. 1).

The following types of control curves, that are defined by a specific identifier, are available:

- SectionCurve – Section curve (*)
- SectionCurve_*NNN* – Section curve with an offset of *NNN* mm (*)
- *RP1_RP2_NNN*_SectionCurveSegmentOffset – Segment of a section curve from point *RP1 to point RP2* with a translation of *NNN* mm in direction to the inner part of the engine compartment (A positive value for NNN leads to a translation in negative z-direction - Currently a negative value for NNN is not allowed).
  The points *RP1 a*nd *RP2* have to be one of the following:
  [BLE, BLEO, WAD1, WAD2, WAD3, BR, BRO]

The reference points used for RP1 and RP2 have to exist in the sketch, even if they are not used explicitly in any other way. For example, if you define a SectionCurveSegmentOffset using the points WAD1 and BRO (e.g. *WAD1_BRO_52*_SectionCurveSegmentOffset) and WAD1 and/or BRO is not inside the sketch, the creation of the sectionCurveSegmentOffset fails.

- WindShieldSectionCurve – Section curve of the windshield (*)

(*) A section curve is a representation of the outer vehicle geometry in a particular y-section plane.

For the calculation of *section curve*, *section curve offset* as well as *translation curve for a given area*, the upper curve method is used, therefore only upper geometry is "sent to sketch". For example, the windshield geometry that resides beyond the bonnet hood geometry is not considered for offset creation

Spline curves are modified during PEDESTRIAN PROTECTION-OFFSET feature's build to represent requested curve in section, therefore in the sketch it is possible to define distances related to given curve and/or other different constraints.

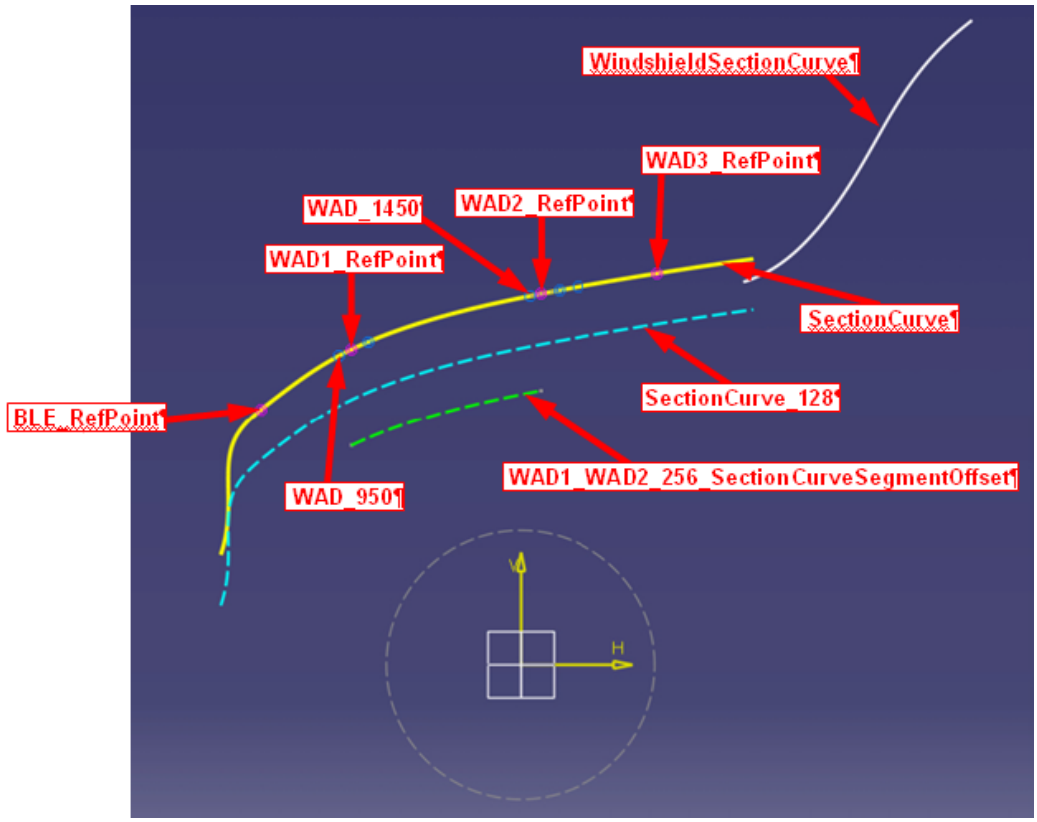


Fig. 1 Re*ference points- and curves*

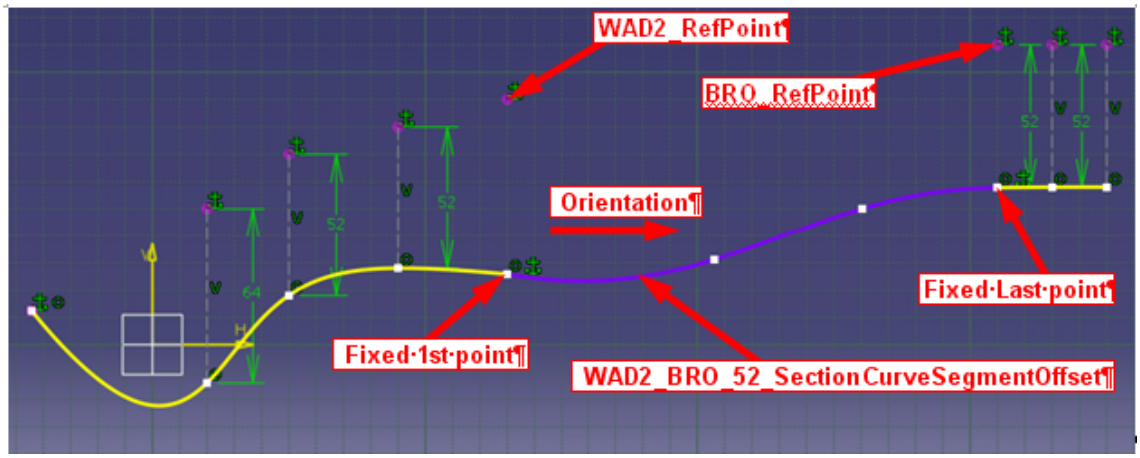


Fig. 2 Section curve-segment-Offset

Fig. 1 shows how to define SectionCurveSegmentOffset - segment of a section curve from WAD2 to BRO translated by 52mm. WAD2_RefPoint and BRO_RefPoint must be explicitly defined, although they are not used in any other geometry.
(NOTE: The yellow curves are no SectionCurveSegmentOffset!)

In case of a faulty definition of the sketch, the PEDESTRIAN PROTECTION OFFSET Feature cannot report a detailed description of the reason that is causing the error.

If you create or modify a sketch, proceed step by step to isolate faulty definitions of geometry and constraints.

Offset surface creation

During calculation, intersections between trace curves and a section plane are calculated. Coordinates of control points and shape of control curves in the sketch are modified and the sketch is updated. The result geometry of the sketch is extracted and used as a profile curve of the Offset surface in place of the section plane.

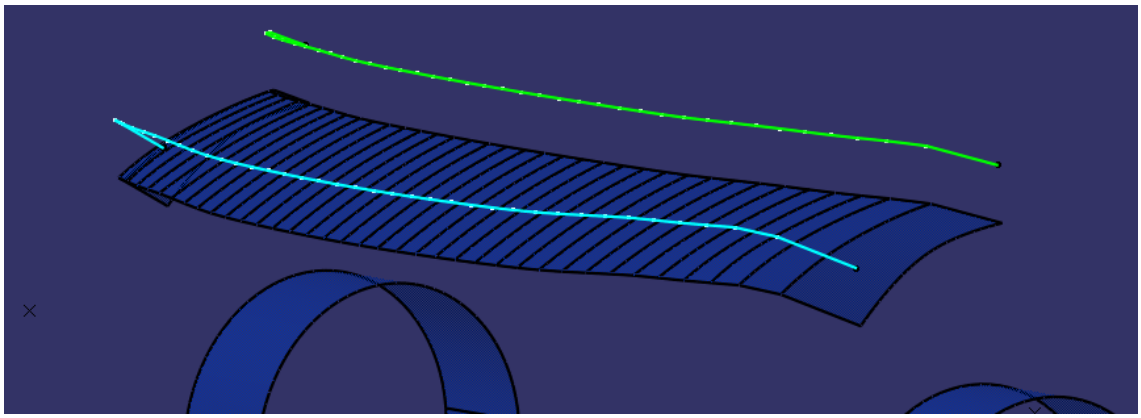


Fig. 2 *Offset-surface created from a sketch with internal points*

Limitations on CATIA *V5R16:*

- Constraint definitions in the sketch are handled correctly only if they use the start or end point of the curve.
- In V5R16 it is not possible to use constraints of type “coincident” with section curves, section curve offset, section curve segment offset or windshield section curve. Therefore you cannot define constraints like 50 mm in front of WAD1 along the curve. Such a constraint leads to time-consuming calculations with doubtful results. (Since V5 R18 this kind of constraint definition is possible.)

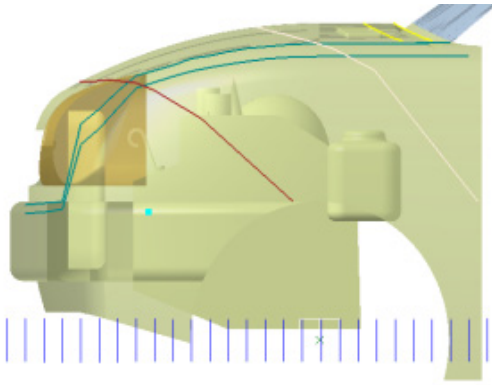
⑫ *Refresh List*

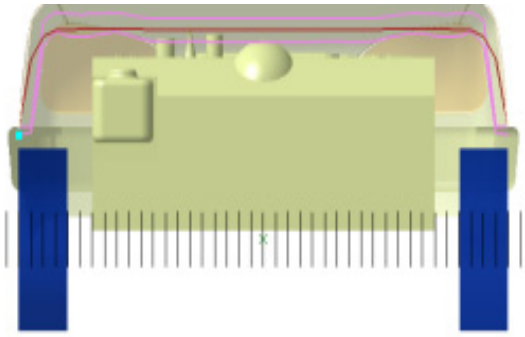
If the sketch in the referenced part has been edited since the latest calculation of the CAVA-PEDESTRIAN PROTECTION OFFSET feature, you can refresh the feature's input to be on the current state.

⑬ *Section Step*

Definition of the distance between two section planes along the *x* and *y direction*.

- *x* sections
- *y* sections





⑭ Definition of the section

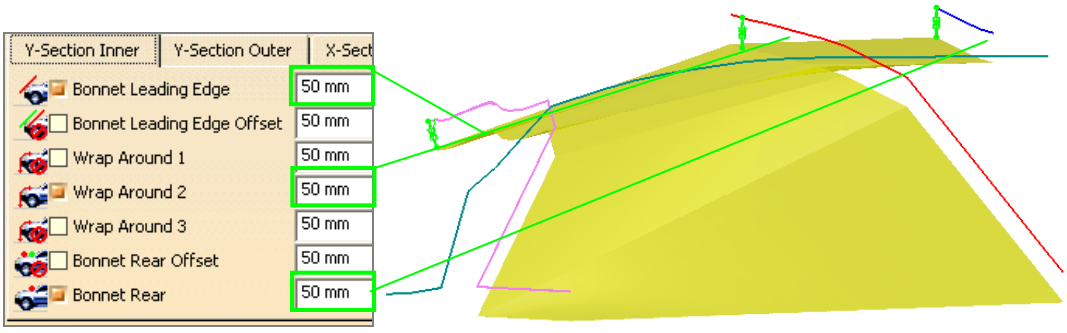
Tab card to define the sections in the respective planes.

The set of options available on this tab card depends on the selected standard ② or calculation type ③, as well as on the definition ⑨ and the selected profile ⑩.

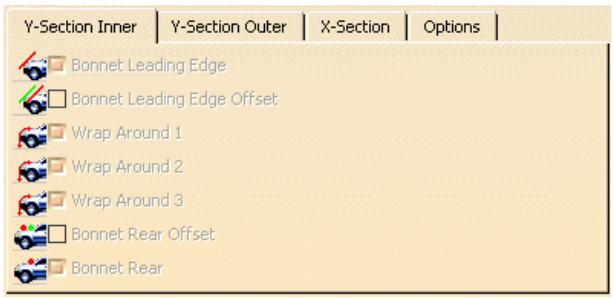
- *Y*-Section Inner:

When using the option "Parameter" in field ⑨:

The distance between the offset surface and the reference curve is defined by a value (length parameter). The offset surface is created from the offset curves of each section plane.



When using the option „Sketch“ in field ⑨:



The distance between the offset surface and the reference curve is defined by a predefined sketch. For each selected reference curve (see figure) an offset to the sketch geometry is created in each *y* section. The needed reference curves are given by the configuration. If one curve was not generated in the referenced CAVA PEDESTRIAN PROTECTION feature, the offset surface cannot be created. In this case, a warning message will be displayed.

The sketch itself is described above in ⑪.

The offset surface is built from the separate offset curves.

In order to create the offset surface, on the tab card there must be at least two curves selected.

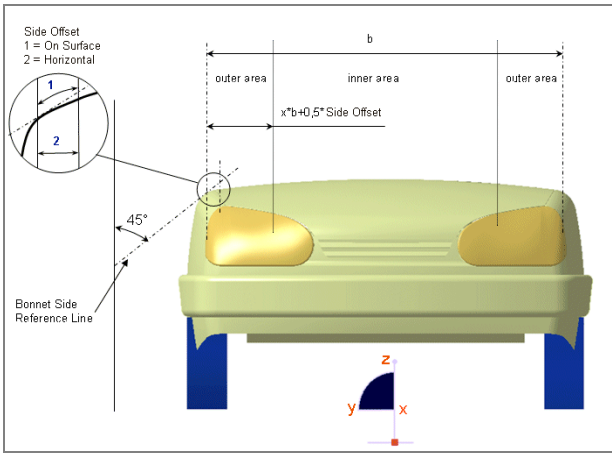
Reference curves that not have been generated in the referenced CAVA PEDESTRIAN PROTECTION feature ① can not be selected here. These curves are marked with the ⊘ symbol.

X Section

On this tab card you can define the parameter used to calculate the inner area and the outer areas for the respective section in the *x* plane (see figure).

The outer area is calculated according to the following formula:

```
x * b + side offset
```



- *x*

  Coefficient used in the formula. This value is given by the standard or the configuration file.

- *b*

  Distance between the contact points of the bonnet side curve (left and right) and the vehicle geometry

- Additional fields on *X-Section* tab card

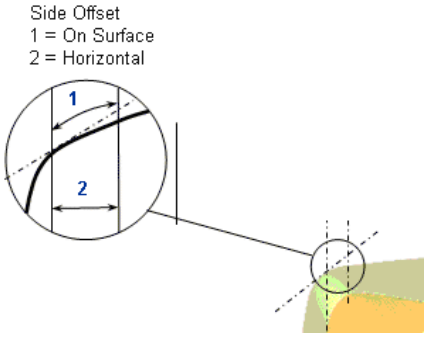
  Measurement

  - On Surface

    The value specified in the "*Side Offset*" field is measured along the vehicle geometry—see figure to the right (1).

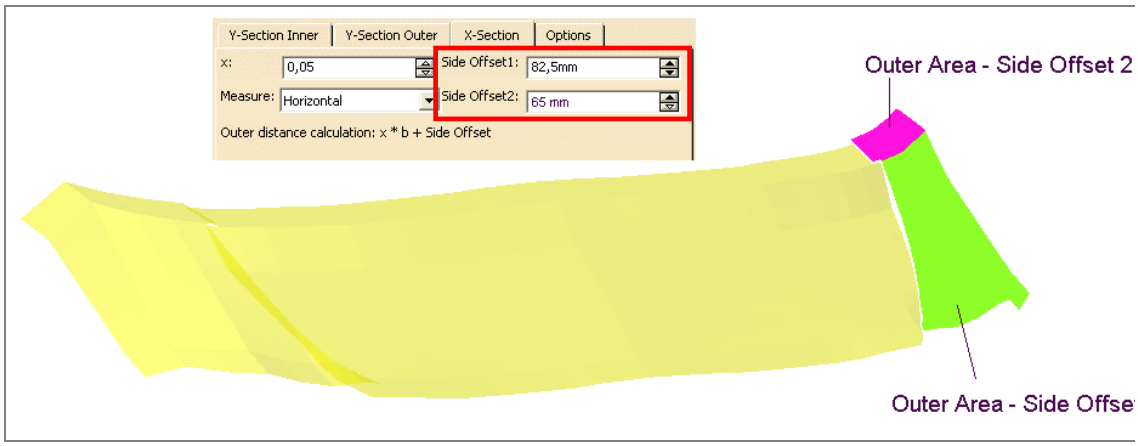
  - Horizontal

    The value specified in the "*Side Offset*" field is measured horizontally in *y direction*—see figure to the right (2).



  Side Offset1/ Side Offset2

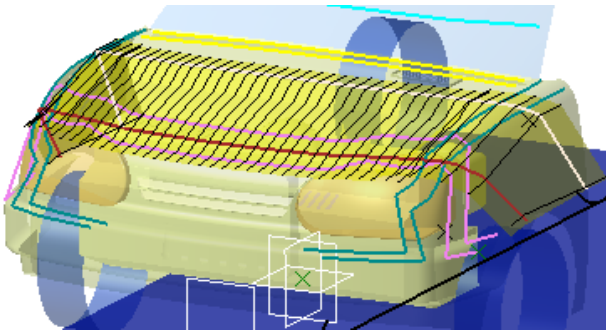
  The side offset that is used to calculate the inner and outer area, can be separated in two segments that have a different distance to the *Bonnet Side Curve*.



- *Options* tab card

  Create Construction Geometry

  By activating this option you can visualize the geometry that was used for creation of the offset surface. In the figure you can see the separate curves in the *y* sections from which the surface will be generated.



  Cut by Car Geometry

  If you use a reference part for the offset surface creation, it could happen that the profile curve of the sketch protrudes over the vehicle geometry. This option trims the created offset surface at the outline of the vehicle geometry.

⑮ Text hint for update

This message will be shown if you have selected in the CAVA Settings for the CAVA feature „Pedestrian Protection Offset" the suppress-automatic-update option. (*Tools* >*Options* > *Infrastructure* > *CAVA Vehicle Architecture* > *'Defaults'* tab card).

4. Head Impact according to FMVSS (Target points)

The FMVSS 201 standard describes a series of reference points (target points) within the interior of the vehicle, which have to be checked for the event of a head crash. These points are dependent on vehicle data especially on vehicle interior geometry. The CAVA Head Crash function generates these points within the V5 parts.

The various target points are listed below along with a short description each.

The standard further defines "valid targets", which means that there is a check for the individual points, whether or not the passenger's forehead could hit it at a certain angle. If that is not possible the point is shifted. This functionality is not integrated in the current step within CAVA.

To ease the geometry selection that is partly a little bit sophisticated (e. g. internal dependence of points, complex input geometry, etc.) the user is guided by a geometry selection agent.

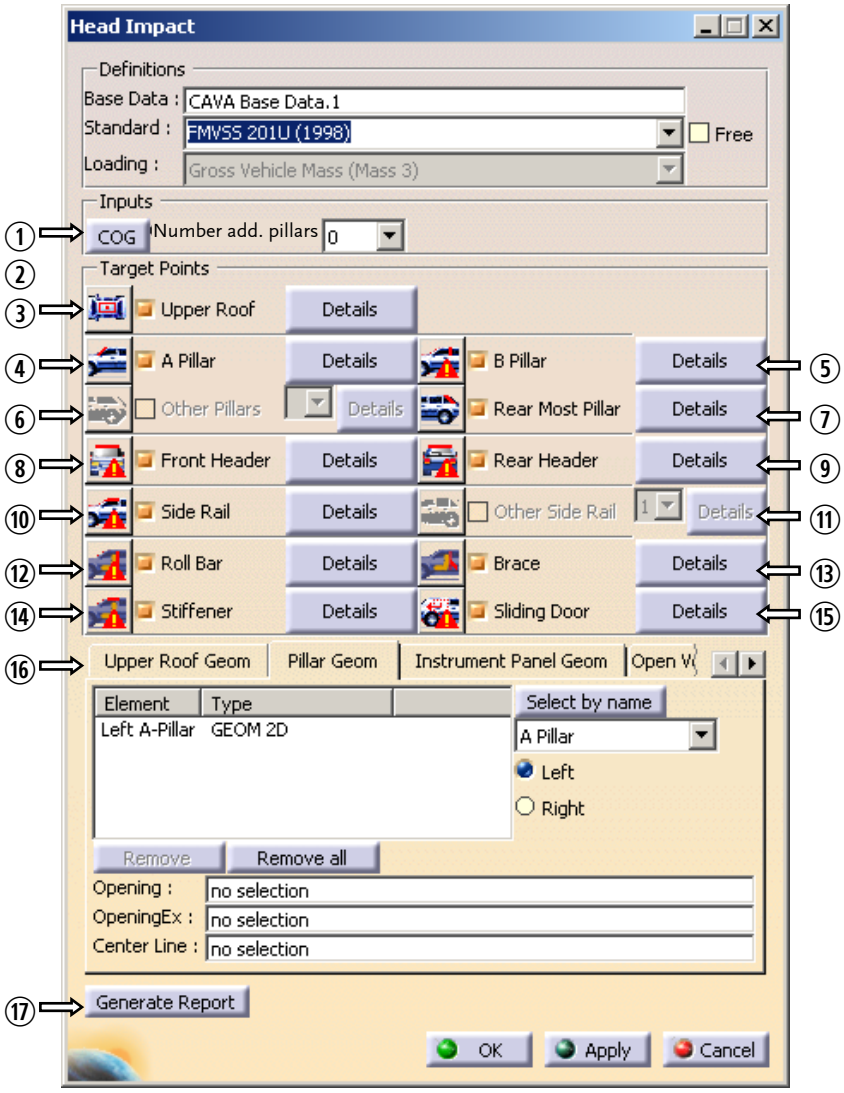
The points are created in a specific order since they are partly interdependent, e. g. the point RH can only be calculated if the target point for the *Upper Roof* was defined before. If one point cannot be determined, the following points built on it will also be marked as invalid or their creation is hidden in the user dialogue.

For some points Wrap-around distances (e.g. on the roof) are necessary. In this case it is important that the complete geometry is available. At an early stage this is not always possible. Therefore the program fills larger gaps with a defined radius. In part the calculation of normals in points is important in order to arrive from the outer side of the roof to the inner side. If the geometry is unfavorable this can result in nonsensical values which in turn lead to incorrect target points. In the case of such nonsensical values the program shows an error message and the user has the possibility to replace the relevant plane (by a smoother one).

In principle for some points a highest, lowest ... (etc.) point on certain geometry is expected as input. In such a case the user either selects the point directly or the geometry from which the point is calculated.

If another target point is required as input, it will be automatically entered if it has been calculated (i.e. Upper Roof Area). A similar thing is true for the input geometry; however separate elements can be selected for individual points.

When defining the geometric input it is the user's responsibility to choose correctly, especially if the standard allows different alternative possibilities.



① Button „COG"

If you click on the button a dialog box appears, containing the defined values for the *x* and the *z* coordinate of the center of gravity, relative to the SgRP. The Center of Gravity (COG) points are calculated for each defined sitting position. They depend on the SRP and for the front sitting positions on the H-Pnt-Travel.

CG-F1 = Center of gravity of the head for the forward front seat position.

CG-F2 = Center of gravity of the head for the aft front seat position.

CG-R = Center of gravity of the head for rear seat position.

② Number of additional pillars

If the vehicle has more than the usual A-, B- and C-pillars, the number of additional pillars can be entered here. They can then be specified further with the target points.

③-⑮ *Target*-Points

By activating the check boxes the target areas can be selected on which the target points are calculated. Some of the target areas can only be selected after the required input values have been defined.

After the activation of the check boxes the geometry selection wizard starts. The user is guided to select the required geometry that is necessary to calculate the target points. The agent also gives information about the required geometry. You can find a detailed description in chapter 4.1.1 *Geometry Selection Wizard* on page 66.

Already created target points are automatically taken over for the points to be generated.

The target areas with their target points are explained below starting from chapter 4.1.2.

For each target area there is a button named „Details“. If you click on this button you will get a dialog containing the detailed data and geometry definition for the respective target area.

If problems occur during the calculation of individual points, a message indicates these problems, so that the user can modify the input geometry accordingly. If problems occur during the update of the feature, without it being actually edited, a detailed error message appears as soon as the feature is edited again (Update errors are displayed as well).

In order to allow for calculation of the following points in case of an error or to define a target point in certain cases, in the Free Mode every individual point can be defined via selection by the user.

Optionally the program can generate the construction geometry that is necessary for the creation of the individual points for you. In this case the names from the standard text (numbered planes and points) are used. In the same way the resulting geometry is given corresponding names (APR, ...) in order to be easily identified in the specification tree.

For every individual target point there is a node in the specification tree under which the output geometry and potentially the construction geometry is displayed.

Points and lines are V5 elements, so that they can be used for measurements or as reference for other V5 features.

The target points are generated as geometry with corresponding names within the CAVA feature.

The description of each point is done in the chapters labeled right beside the figure below.

⑯ Geometry selection

This section of the user dialogue contains a number of selection lists for geometry selection in various tabs. The elements can either be interactively added to or removed from the list by the user or they are automatically added to the respective lists by the *Selection Wizard*.

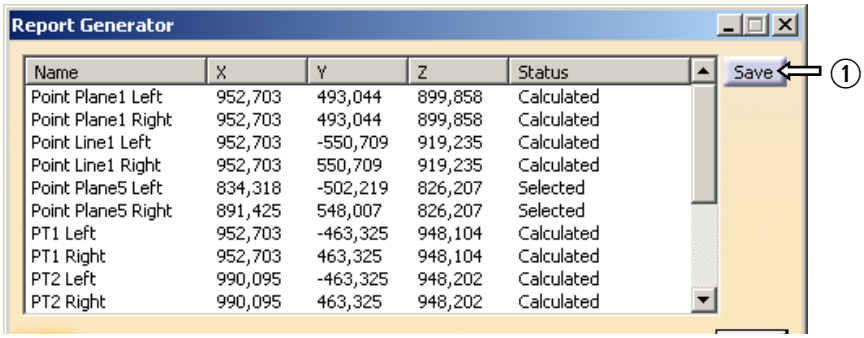
It depends on the individual target point, which kind of geometry (points, curves, planes or solids) can be selected. In part there are alternative selection possibilities, i.e. the user can e.g. define the curve of a door opening or directly specify the highest point of the opening.

The Geometry Selection Wizard will be introduced later with the example of A-pillar points (p. 66).

V5 geometry that has already been defined for a calculated point will be taken over, provided that it corresponds to the same standard. An example would be "day light opening", which is needed for a number of points. However, it is still possible to define this geometry individually for each target point.

⑰ Button „Generate Report“

This button generates a report of all calculated and selected points with their coordinates. It also contains information about the entered input, e.g. the equipment features.



⇦ ②

① Button „Save“

By clicking on the *Save* button, the table can be saved as Report File in text format (`.txt`).

② Button „OK“

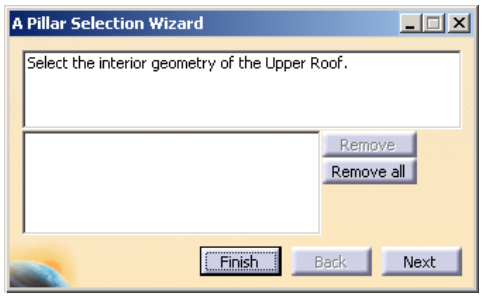
By clicking on the *OK* button the dialog will be closed.

4.1.1 Geometry Selection Wizard

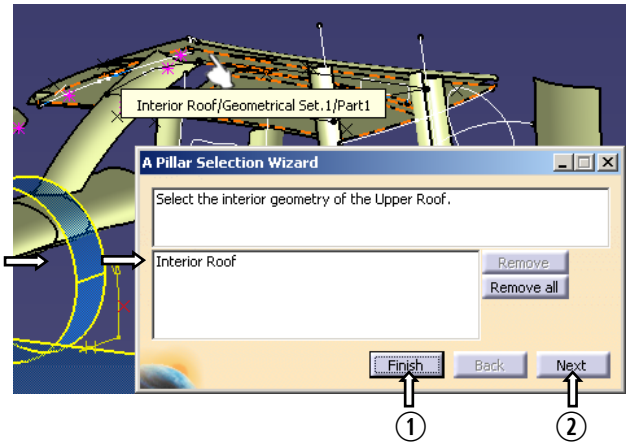
If you activate the check box of the target area for the *„A-Pillar“*, the geometry selection wizard starts to guide you through the geometry selection process. The selected geometry is automatically inserted in the element list on the respective Tab cards. The procedure is described in the following for the A-pillar.

(1) Activate the respective option (here: „A-pillar“)

The geometry selection wizard opens and prompts for the selection of the interior geometry of the upper roof.
Beside the selection demand in some cases the wizard gives additional information about the geometry.



(2) Select the geometry in the model or in the structure tree.



① Button „Finish“

You can stop the geometry selection wizard at any time with the „Finish“ button. An error message will prompt you that the selection is not complete.

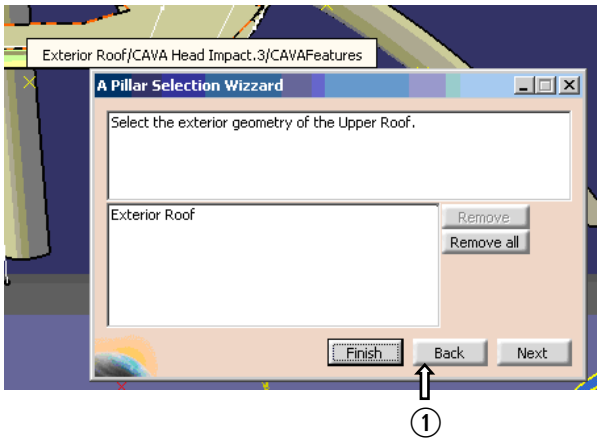
② Button „Next“

By clicking the „Next“ button the current selection step will be finished and the next selection step will be activated. The selection process is complete when the “Next” button is deactivated.

If you have selected the wrong element by accident, simply continue by selecting the correct element. The accidentally selected element can later be removed from the list with the help of the user dialogue.

(3) Click on „Next“.

(4) Select the exterior roof geometry or the upper roof.



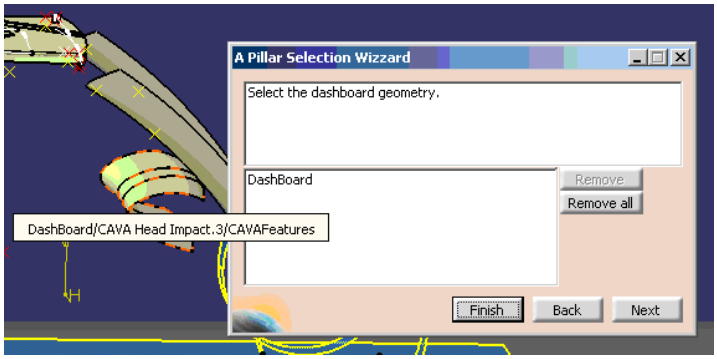
① Button „Back“

In case you forgot to select an element during the previous step, you can return to the previous selection list by clicking on *Back*.

You can stop the geometry selection wizard at any time with the „Finish“ button. An error message will prompt you that the selection is not complete.

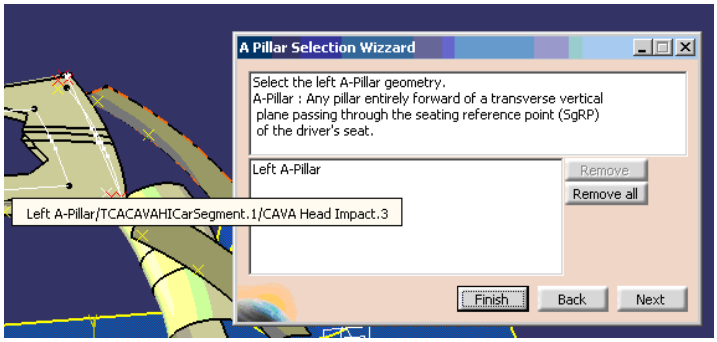
(5) Click on „Next“..

(6) Select the *Dashboard* geometry.



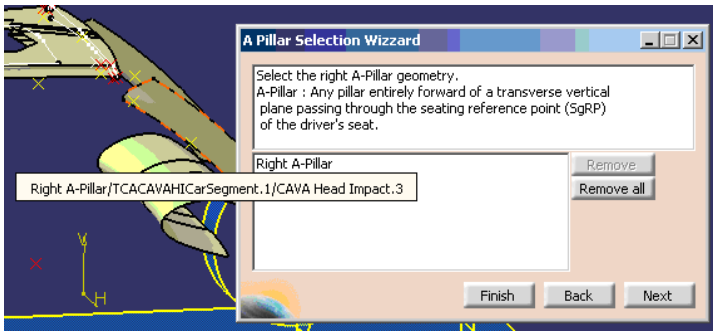
(7) Click on “Next”.

(8) Select the interior geometry of the left A-pillar.



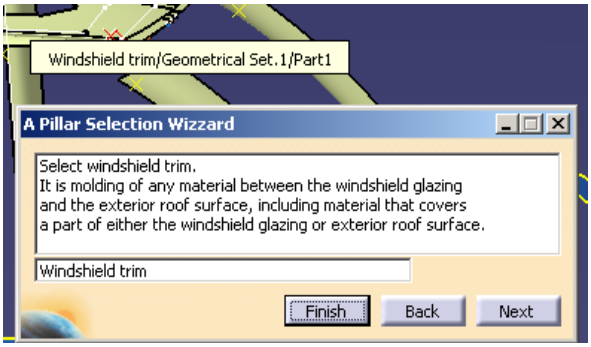
(9) Click on “Next“.

(10) Select the interior geometry of the right A-pillar.



(11) Click on “Next”.

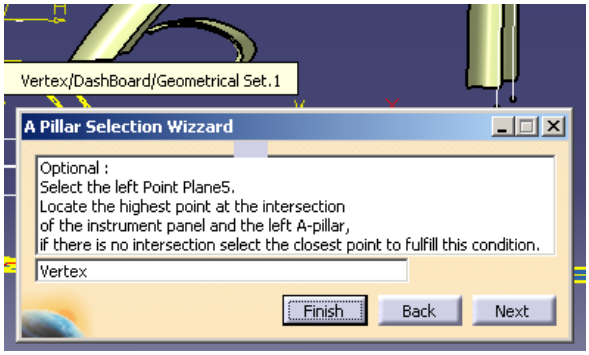
(12) Select the windshield trim geometry.



(13) Click on “Next”.

(14) Select the left point plane5. You can either select the intersection point between the left A-pillar and the dash-board yourself or the program can calculate it for you. In this example the point is selected by the user.

If you want the program to determine the intersection point, click on *“Next”* without selecting an element.

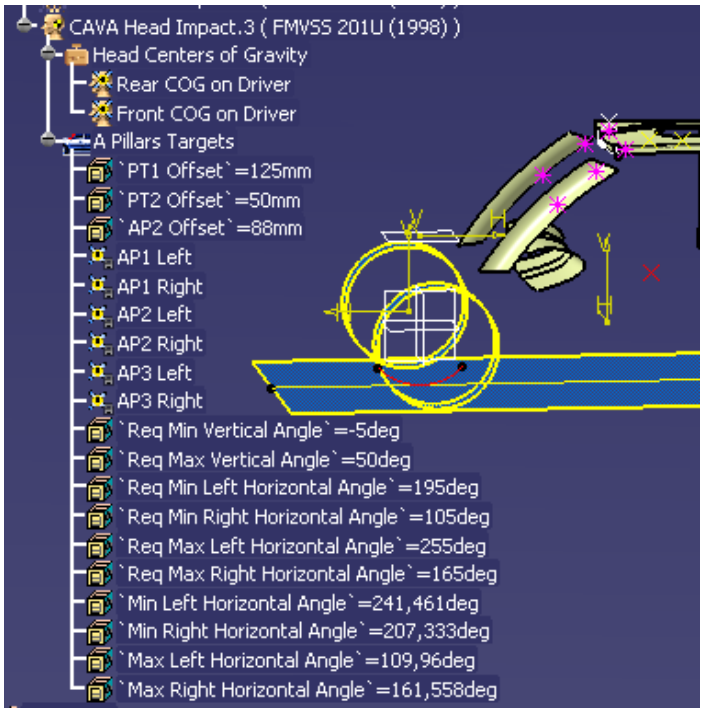


(15) Click on „Next“.

(16) Select the right point plane5. In order to select the intersection point between the right A-pillar and the dashboard, proceed as in the proceeding step.

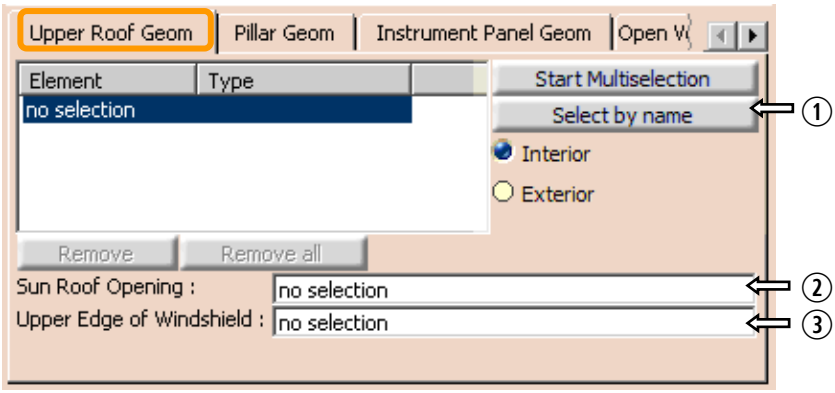
(17) Click on the *Finish button*, in order to finish your selection. The Wizard is closed and you will return to the user dialogue.

(18) A-pillar points for both sides are generated in the model (see magenta points in the fig. below).



After the wizard is terminated, all selected geometries can be found in the selection lists in the respective Tab cards (see the following figures).

- Tab card „*Upper Roof Geometry*“



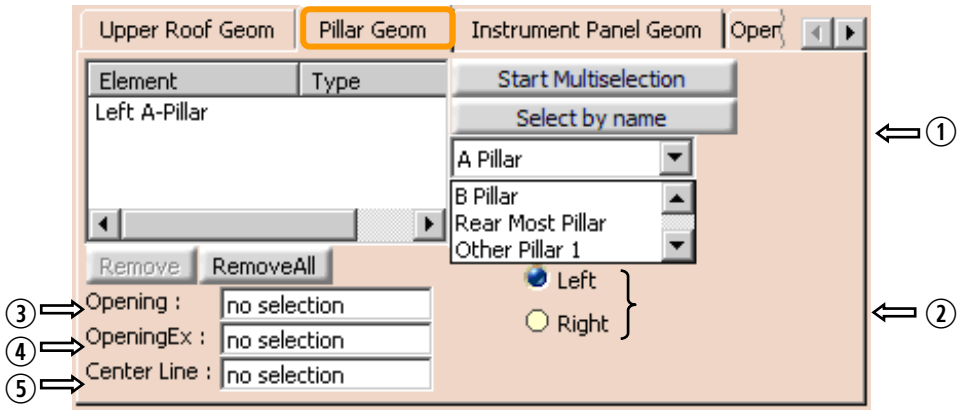
① Use the options button in order to display the selected *Interior* or *Exterior* Upper Roof Geometry.

② The *Sun Roof Opening* geometry and the Upper Edge of Windshield is shown in a ③ separate field.

If you would like to remove an element from the list, select it and click on *Remove*. The *RemoveAll* button deletes all elements from the list.

If you would like to choose the geometry for this field, first select the respective field and then the geometry within the model

- **Tab card „Pillar Geometry“**



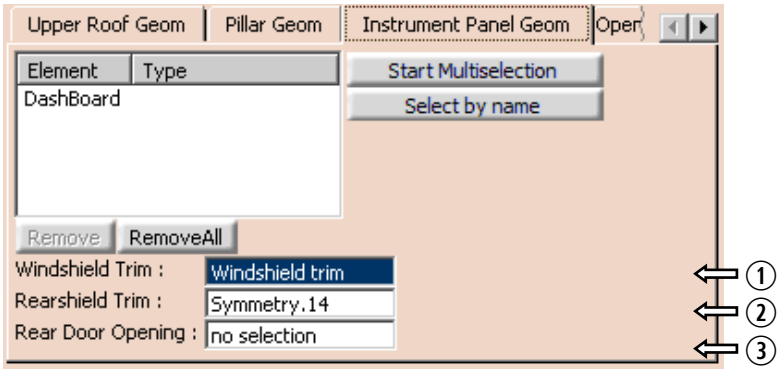
① In the selection field to the right of the list you can define which geometry list field will be shown. The A- and B-pillar and the rearmost pillar are contained by default. Other pillars can be listed in addition, if you have defined them in the *Number of additional Pillars* field.

② Use the options button in order to display either the *Left* or *Right* pillar geometry.

③ The *Opening*, *OpeningEx* and *Center Line* geometries are displayed in a separate field.
④
⑤

If you wish to select the geometry for one of these fields, first select the respective field and then the geometry within the model.

- **Tab card „Instrument Panel Geom“**

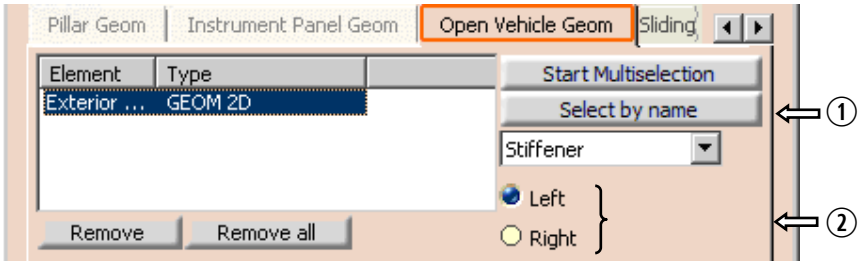


① The *Windshield Trim, Rear shield Trim* and *Rear Door Opening* geometries
② are displayed in a separate field.
③

To remove an element from the list, select it and click *Remove*. The *RemoveAll* button deletes all elements from the list.

If you wish to select the geometry for one of these fields, first select the respective field and then the geometry within the model.

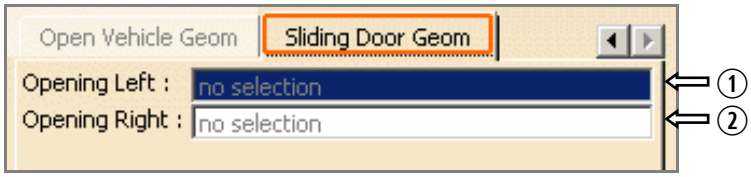
- **Tab card „Open Vehicle Geometry“**



① In the selection field to the right of the list you can chose whether the geometry selection for the *Roll Bar*, a *Stiffener* or a *Brace* will be shown.

② Use the options button in order to display either the Left or Right side geometry.

- **Tab card „Sliding Door Geom“**



①② This tab does not contain any list. The geometries for the *Opening Left* and the *Opening Right* are each shown in separate fields. If you wish to select the geometry for the sliding door, first select the corresponding field and then the geometry within the model.

- **Dialog box „Detail“**

You can retrieve information about the values by clicking on the *Details* button.

By selecting the *Free* mode you can define your own setting for specific values.

After successful creation of the A-pillar points, *Upper Roof Zone* is now activated for selection as well.

4.1.2 Upper Roof Zone—UR

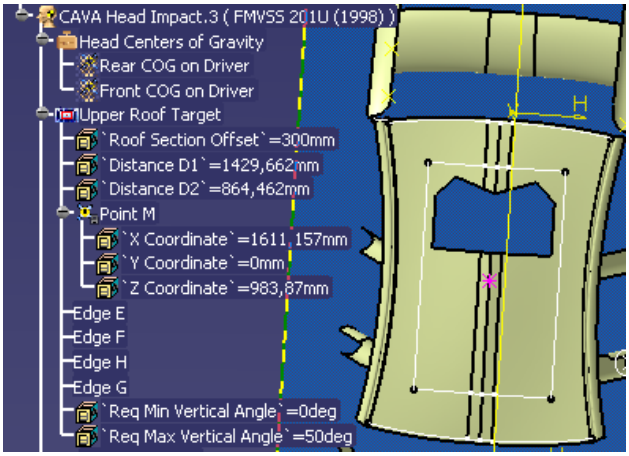
This function calculates a point—Roof center and an area—Upper Roof Zone on the roof.

If you have selected the *Upper* Roof option in the user dialogue, the Selection Wizard prompts you to select the required geometry. It subsequently asks for the geometry of the

- Roof interior, at least the front most and rearmost point as well as the area 300 mm behind the AP1 points. If the area is to be created the whole surface is necessary.
- the geometry of the roof exterior,
- the border strip of the windshield and
- the geometry of the rear window.

If you have already selected geometry within another function, continue to the next selection by clicking *Next*. If all required geometries have been selected, close the Wizard by clicking on the *Finish* button. It is of course possible to add elements to and remove elements from the list at a later stage.

The point is generated as point within the feature and the area is limited by 4 curves at the interior of the roof, if it already exists. The area subsequently becomes an input for other target points.



You can retrieve information about the values by clicking on the *Details* button.

By selecting the *Free* mode you can define your own setting for specific values.

4.1.3 A-Pillar Target Points

This function calculates the points AP1, AP2 and AP3 on the A-pillar.

Required Input:

- Geometry of the windshield, or rear border strip
- Geometry of the roof with the door opened
- Geometry of the roofs interior
- Geometry of the interior of the A-pillar
- Intersection between dashboard and A-pillar. It can either be calculated or directly specified.

For these points Wrap Around lines on the roof are needed and the normal for the roof is calculated at certain points (see notes above).

The points are calculated for both sides of the vehicle.

Along with the information about the position of the target points the allowed angle areas at which the point has to be met is also of interest to the user. They are stated in a table in the standard, but partly (for A- and B-pillars) they are defined by geometric conditions. For the horizontal angles of the A- and B-pillar the actual angle areas are calculated within the program. The geometries of the A- and B-pillars are required.

4.1.4 B-Pillar Target Points

If you have selected the *B-Pillar* option in the user catalogue, the Selection Wizard prompts you to select the required geometry. It subsequently asks for the geometry of the

- Roof interior
- left B-pillars
- right B-pillars
- left B-pillar centerline, or B-pillar geometry (in that case the centerline is calculated automatically)
- right B-pillar centerline, or B-pillar geometry (in that case the centerline is calculated automatically)
- left highest point of the front door opening as V5 point or geometry of the upper door boundary (in this case the point is calculated)

- right highest point of the front door opening as V5 point or geometry of the upper door boundary (in this case the point is calculated)
- lowest left point of the front window (Day-Light-Opening) or geometry of the window (in this case the point is calculated)
- lowest right point of the front window (Day-Light-Opening) or geometry of the window (in this case the point is calculated)
- Optional: left point BP2
- Optional: right point BP2

The point BP2 can be defined freely; it depends on the position of the seat belt bracing. This point is not calculated but can be directly specified by the user.

If you have already selected geometry within another function, continue to the next selection by clicking *Next*. If all required geometries have been selected, close the Wizard by clicking on the *Finish* button. It is of course possible to add elements to and remove elements from the list at a later stage.

The points are created on the B-pillar (driver and passenger side).

You can retrieve information about the values by clicking on the *Details* button.

By selecting the *Free* mode you can define your own setting for specific values.

4.1.5 Additional Pillars

This function calculates the points OP1 and OP2 on the additional pillars (if available).

If you have defined additional pillars in the field *Number of additional Pillars*, these points are generated on each additional pillar. The algorithm and therefore the required geometry is similar to the points on the B-pillar

4.1.6 Rearmost Pillar

This function calculates the points RP1 and RP2 on the rearmost pillar.

If you have selected the *Rearmost Pillar* option in the user dialogue, the Selection Wizard prompts you to select the required geometry. It subsequently asks for the geometry of the

- Upper Roof area (automatically taken over, see above). Interior of the inner roof planes.
- Depending on whether the point RP2 is directly specified (if the seat belt bracing is mounted on the pillar) or not, you need the geometry of the pillar in order to calculate RP2.

The points are calculated for both sides of the vehicle.

4.1.7 Front-Header Target Points / Sun Roof Opening

This function calculates the points FH1 and FH2.

Required input:

- A-pillar points (automatically taken over)
- Rear border strip of the windshield or the windshield respectively Optional: Geometry of the sun roof (interior)

The calculation of the FH2 point varies depending on the positioning of the optional sun roof.

For this points it is partly relevant, how the sun visors are positioned (rear limitation of the pane). This is the responsibility of the user, i.e. the selected geometry is decisive.

4.1.8 Rear-Header Target Points

This function calculates the point RH.

The following input is required:

- Upper Roof area (automatically taken over)
- Upper limitation of the rear door opening or Day Light Opening as geometry.

It the work plane does not intersect with the Day Light Opening, the upper horizontal plane is considered through the nearest window.

Another distinctive fact is that there must be kept a minimum distance to an auxiliary point.

4.1.9 Side-Rail Targets

This function calculates the points SR1 and SR2 on the Side Rails.

The following input is required:

- A-pillar points (automatically taken over)
- Upper limitation of the door opening as geometry
- Upper Roof area (automatically taken over)

4.1.10 Other Side-Rail Targets

This function calculates the point SR3. The position of the point depends on whether a belt bracing or a grab handle is positioned on the Side Rail. In that case the point can be defined relatively freely by the user, i.e. the user directly selects a V5 point as target point. Otherwise the SR3 point will be calculated and needs the following input:

- B-pillar points or other points on other pillars (OPR), depending for whichever area the points are calculated. (automatically taken over)
- Upper Roof Area (automatically taken over)
- Upper limitation of the door opening or Day Light Opening as geometry

These points are created between all pillars, which are located behind the B-pillar and in front of the rearmost pillar.

4.1.11 Roll-Bar Targets

This function calculates the two points RB1 and RB2. They are only determined, if the vehicle has a roll-bar. In case the seat-belt bracing point is located on the roll bar, the points can be placed relatively freely on the bracing, analogous to some other points.

Required input:

- Geometry of the roll-bar as planes or solid.
- CG-F2 or CG-R points are automatically taken over.

4.1.12 Brace Target

This function calculates the point BT that is located on the rear brace of the roll-bar and can be positioned, i.e. selected by the user. The condition is that the point at the specified height is the one closest to the vehicle center.

Input:

- Geometry of the rear brace as V5 plane or solid.

The feature is created within the current open body and can be edited at any time by double clicking on the entry in the specification tree.

4.1.13 Stiffener Targets

This function calculates the points ST1 and ST2 on the stiffener similarly to the points: RB1 and RB2. The input is the geometry of the upper brace between windshield and roll bar.

4.1.14 Sliding-Door Target

The target point SD is only considered if there is a sliding door.

The following input is required:

- Upper Roof area (automatically taken over)
- Boundary of the sliding door opening for determination of the center plane through the opening.

- **Configuration file**

All data relevant for calculation can be read out from the configuration file. Any number of defaults can be defined, which can also depend on their category.

It can be defined for each default which points are included. However it is not possible to add points in addition to the above mentioned ones. Length specifications within a standard are configurable.

Additions to the configuration file can be made at any time.

5. Safety Radius

The European standards EEC 74 / 483 and ECE-R 26 define minimal allowed radii inside the "reachable" areas of the vehicle outer geometry. The "reachability" of the surfaces is checked using a sphere with a defined diameter (100mm). In these areas, the surface must have a radius of curvature that is above a specific limit (e. g. 2,5mm).

The standard also defines special restrictions for the area of air openings (radiator grille, etc.). These restrictions are not handled in the current version of CAVA.

The checks are performed in different regions of the vehicle. An introduction to the definition of these regions and the used test criteria is given below.

5.1 Check regions and test criteria

Check for minimum Radius

The check for minimum radius is accomplished in 2 steps.

In the first step, the program determines the check points on the vehicle geometry that can be used for the test ("reachability"). This is done by using a sphere that is unrolled on the surface. The diameter of the sphere (usually 100mm) is defined by the standards (EEC 74 / 483 and ECE-R 26).

In the second step, the radius of curvature is determined for all points that are reachable by the sphere or optionally for all points above the "floor line" and beneath the 2m limit (see description below).

If the radius of curvature at a specific point is less than the minimal allowed value or if the surface has a sharp edge at this check point, this point is marked as invalid. The definition of a sharp edge is based on a limiting angle (consistency of the surface's normal).

The unrolling of the sphere is done in 3D space.

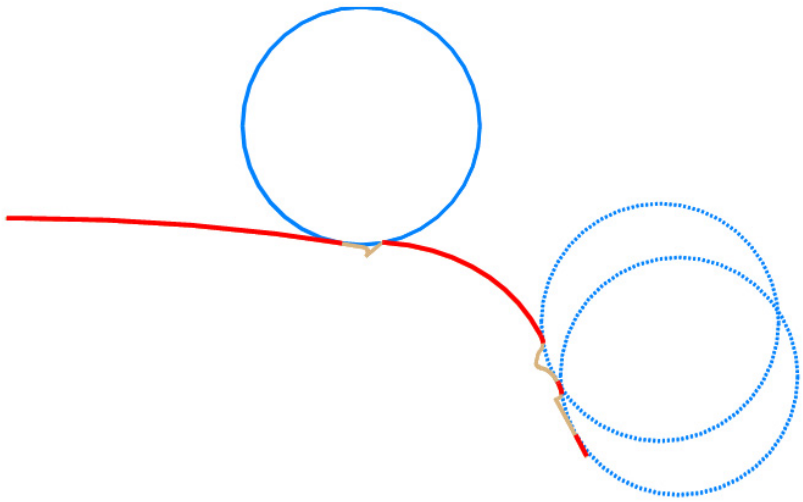


Fig. 1: Example of the check for reachability

Floor line

The check region of the vehicle geometry can be limited at the top and at the bottom. As defined by the standard, the upper limit is 2m above the road plane, whereas the lower limit is defined by a floor line. Vehicle geometry that is outside these limits is not taken into account for the minimal radius check.

The floor line can be used optionally. This means, that you can also check any surface beyond the floor line for minimum radius (by disabling the use of the floor line in the user dialog).

The floor line is created by unrolling a cone with an opening angle of 30 deg as low as possible along the outer vehicle geometry.

In case of multiple contact points, the lowermost one will be taken. All contact points are connected to one line which is called the floor line.

Wheel openings have to be closed before checking the minimal radius (requirement given by the standard). The user can close the opening manually by designing an appropriate surface or he can optionally define the start and end coordinate in x-direction of the wheel opening. This region will be handled by CAVA internally as closed surface.

The current road level is used for the creation of the floor line.

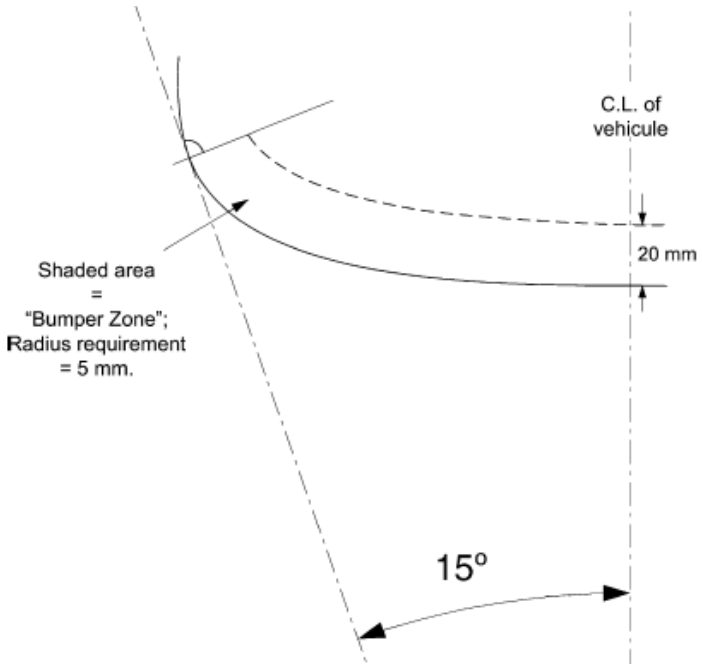
The calculated floor line is visualised as 3D poly line.

Bumper check

The standard defines a special region on the front and rear bumper, for which a radius is allowed which is different from the rest of the bumper geometry.

This region is defined by two planes (one for the left and one for the right side) that are positioned in a 15 degree angle to the vehicle mid plane and put tangent to the bumper geometry. The outer boundary of the bumper geometry is then projected on the road plane and a second curve is created as 20mm offset to the inside from the projection curve (see figure. below).

In this region, called „Bumper Zone“, the required radius of curvature is 5mm.

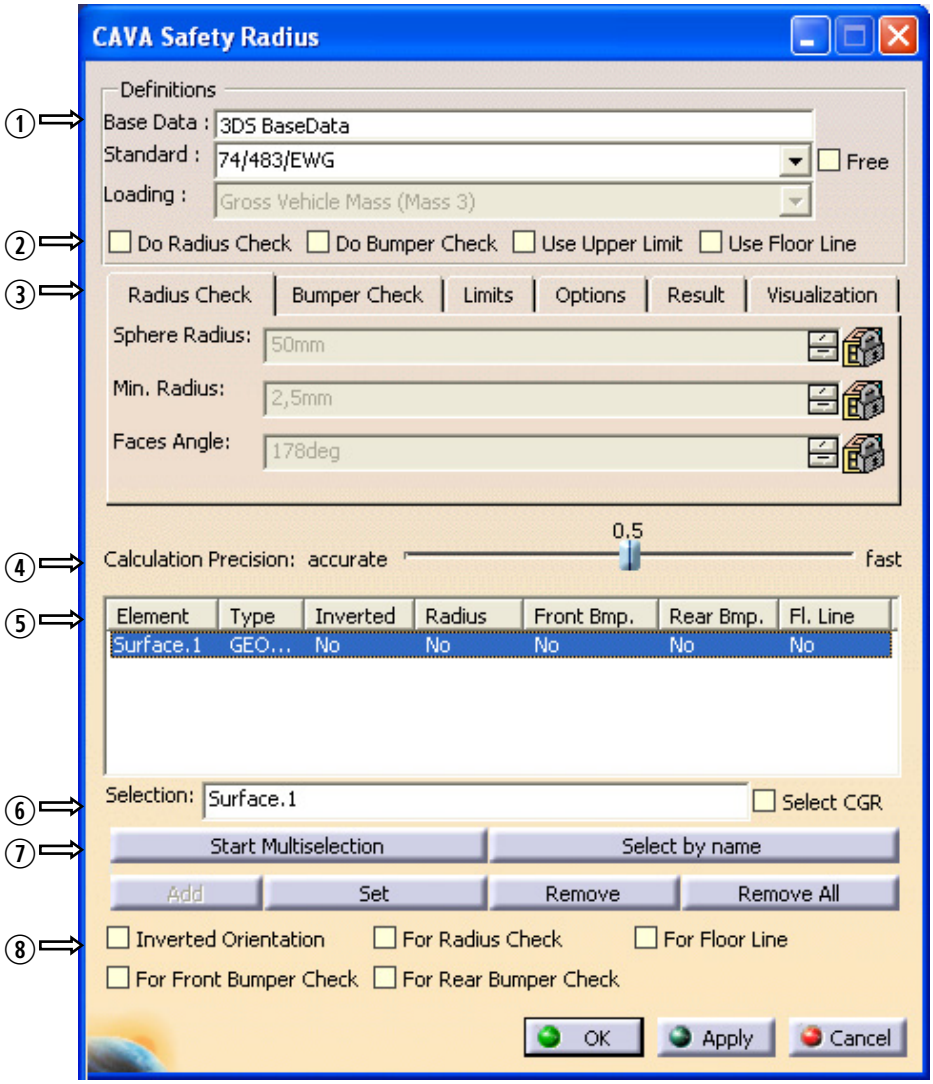


The usage of the bumper check is optional. This means that you can also check any surface for minimum radius (by disabling the use of the bumper check in the user dialog).

The calculation of the minimal radius of curvature and the sharp edges requires V5 surface(s) as selected geometry (no CGR Data). These V5 surfaces (or V4 surfaces when used in product context) are tessellated with an adjustable accuracy.

CGR data can be used if you only want to determine the floor line or if you want to check the reachability. CGR data cannot be checked for minimum radius, but it is possible to consider existing bounding surfaces as CGR (e.g. windscreen, A-pillar), if you want to calculate the Reachability of a surface (e.g. rear bonnet).

5.2 Safety Radius User Dialog



① Base Data

The reference of a Base Data features is required to build the floor line or the 2m line *(Upper Limit)* or the bumper check because this calculation is based on the road level.

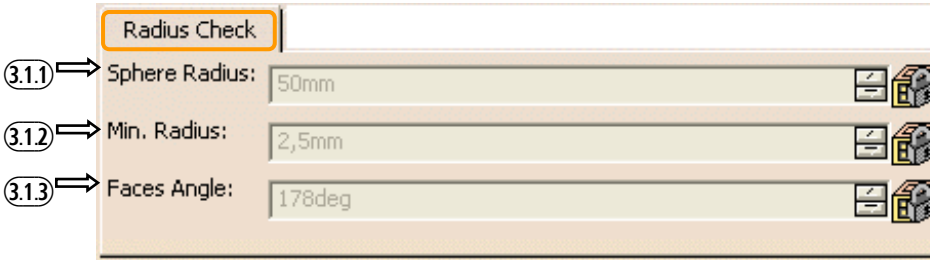
② Buttons for calculation options

Use these check buttons to drive the calculation methods for the selected geometry, described above. Note that the geometrical options (see ⑧) are set according to the selection you made here.

③ Tab cards

In these tab cards you can set different parameters for the respective checks and for the visualization. Most values are given by the selected standard.

Radius Check



3.1.1 Sphere Radius

This value gives the radius of the sphere is that is used for the reachability check. Default value from the standard is 50mm

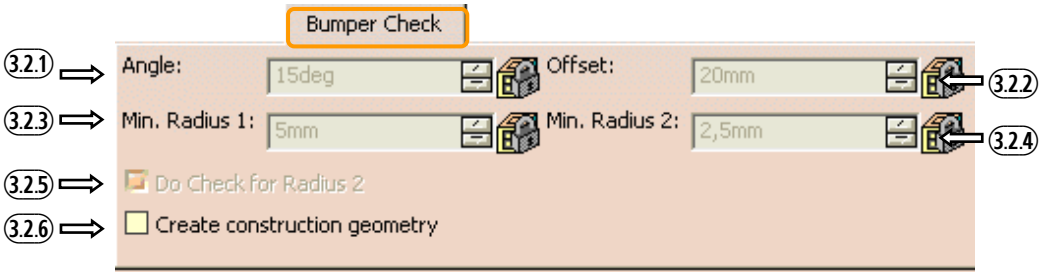
3.1.2 Min. Radius

This value gives the the minimal allowed radius of curvature at a specific check point of the selected geometry.

3.1.3 Faces Angle

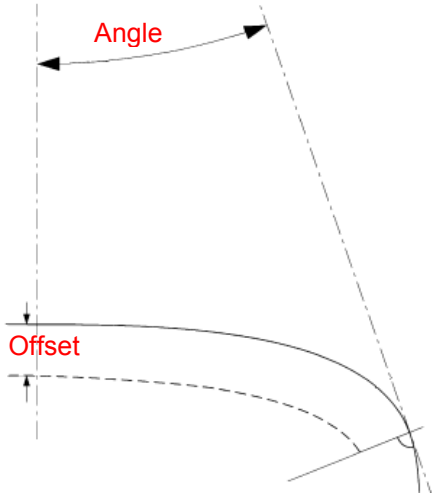
This value gives the angle between two surfaces or the unsteadiness of a single surface describing a sharp edge. All angles smaller than the one mentioned here are indicated as sharp edge.

Bumper Check



③.2.1 Angle

Angle of the plane that is positioned tangential to the bumper geometry (outgoing from the vehicle mid plane).
Default: 15 deg



③.2.2 Offset

Offset of the projected outer bumper geometry to the inside. The area between these two curves is called *Bumper Zone*.
Default: 20 mm

③.2.3 Min. Radius 1

This value defines the minimal allowed radius of curvature for the check *inside* the bumper zone
Default: 5 mm

③.2.4 Min. Radius 2

This value defines the minimal allowed radius of curvature for the check *outside* the bumper zone.
Default: 2,5 mm

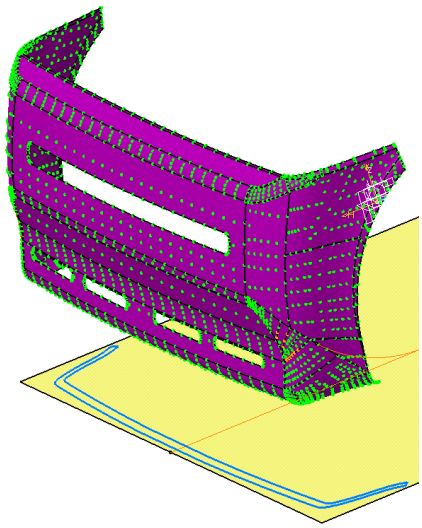
③.2.5 Do Check for Radius 2

Enable this option, if the radius of curvature should also be calculated for the area outside the bumper zone.

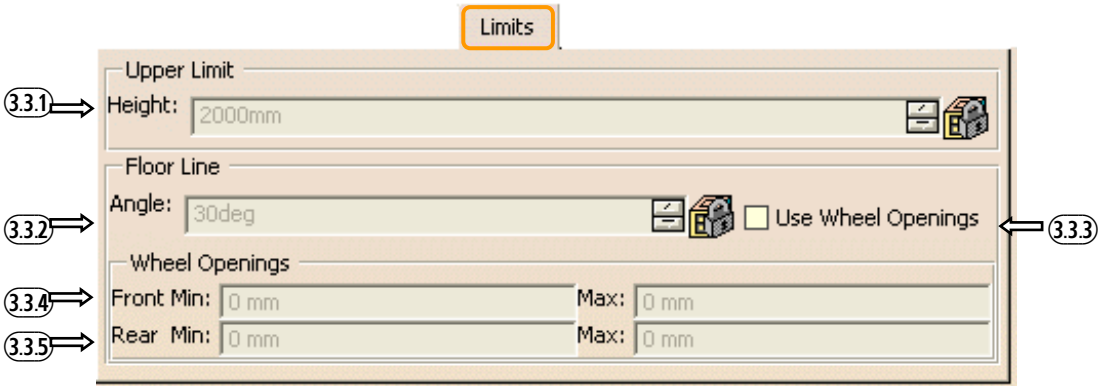
③.2.6 Create construction geometry

Enable this option to visualize the bounding curves of the bumper zone. These curves are generated by the projection of the outer bumper geometry to the road plane, with an offset to the inside defined in ③.5.

This option is only available if the option „*Do Bumper Check* “ in ② is selected.



Limits



3.3.1 Height

You can restrict the check area of the vehicle geometry by defining a lower and an upper limit. The upper limit is defined by the standard (2 meter above the road level).

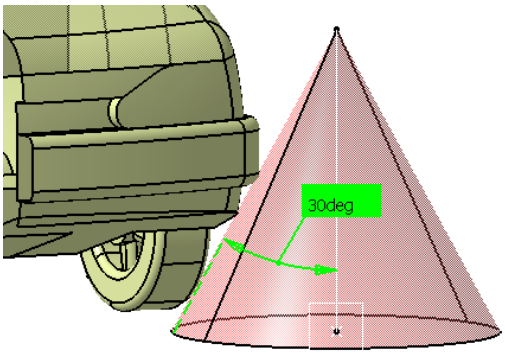
This field defines the value fort he upper limit.

3.3.2 Floor Line Angle

The lower limit (optional) of the check area is defined by the so called 'floor line'. All geometry below this floor line will not be used for calculating the minimum radius.

The floor line is generated by unrolling a cone along the outer shape of the vehicle geometry.

The value defined in this field determines the opening angle of the cone (see figure).



If you want to use the upper limit and/or the floor line for the check, please make sure to have the appropriate options selected in ② and ⑧.

3.3.3 Use Wheel Openings

According to the standard, the wheel openings are considered as a closed area. All input geometry that you have selected is used for the calculation of the check area. Therefore you either have to close the wheel opening manually or you can activate the *Use Wheel Openings* check box. In the latter case, you have to define the start- and end coordinate in x-direction (see 3.13 and 3.14) of the wheel opening. The area between these start and end coordinates is internally handled as closed surface by the CAVA application.

This check box is only enabled, if you have selected the *Use Floor Line* option in ②.

③.③.④ Wheel Openings Front Min/Max

Enter here the start and end coordinate in x-direction of the wheel opening, if you have activated the *Use Wheel Openings* check box.
You can define exact coordinates or indicate a V5 point in the workspace. In this case the x-coordinate is then automatically posted into the field.

③.③.⑤ Wheel Openings Rear Min/Max

See ③.⑬ according to rear wheel opening.

Options

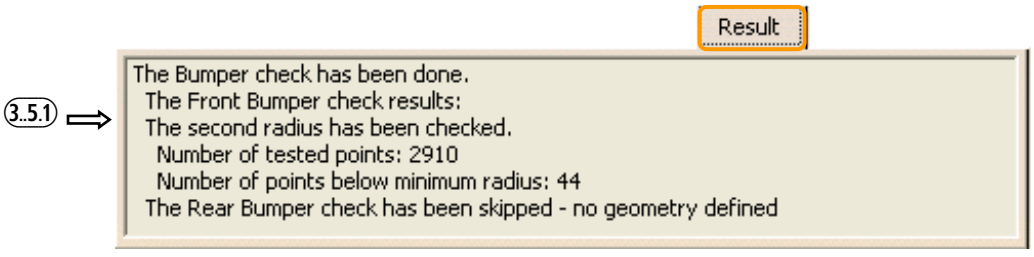
③.④.① ⇨

③.④.① Calculation Type

Here you can select the vehicle side for which the calculation should be done, if you have only one side of the vehicle's geometry available.

Note: Please take in mind to have this option always switched to the correct setting. Otherwise, the calculation will produce strange results.

Result



③.⑤.① ⇨

(3.5.1) Result

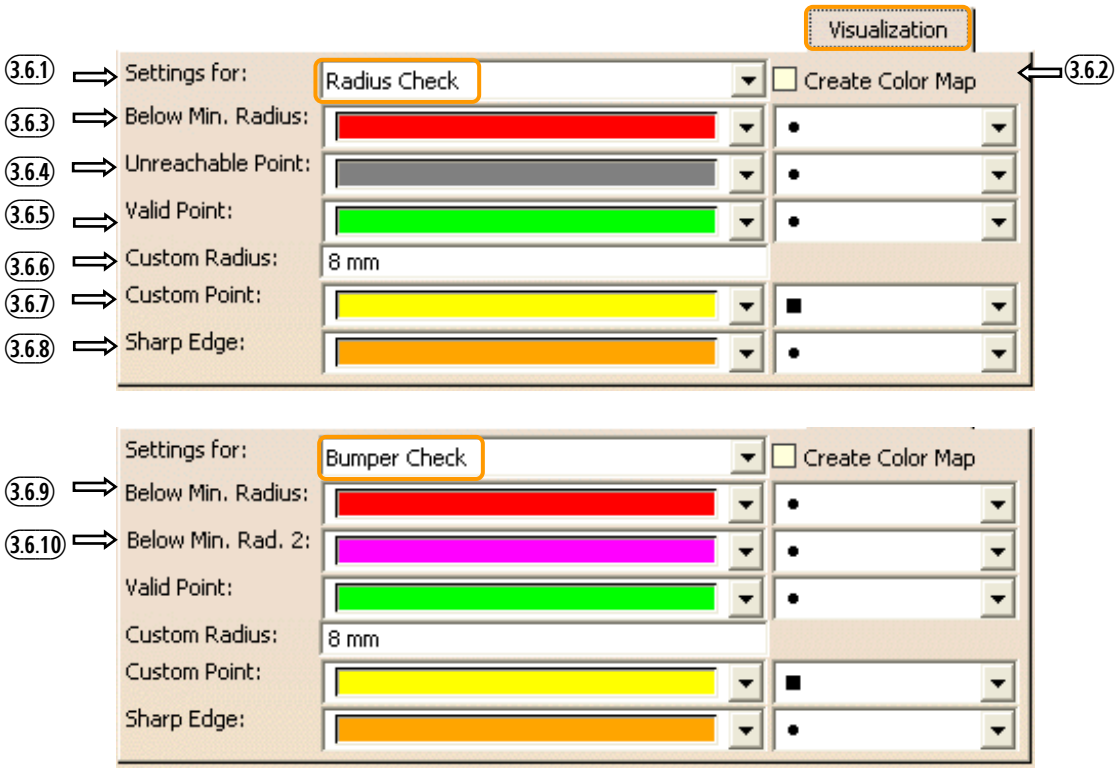
This window displays a message with the check results. You get information on which checks were performed and which have been skipped (e.g. because of missing input geometry) as well as the number of

- checked points
- reachable points
- points that do not match to the minimal allowed radius of curvature
- ...

Visualization

The calculated results are visualized in CATIA V5. For each type of output result you can choose a specific color from the selection list. The coloring is done for each check point on the vehicle's geometry according to the used triangulation.

Due to performance reason the points are only created for visualization. They are not created as CATIA V5 points and therefore cannot be measured with the CATIA V5 measuring tool.



3..6.1 Settings for

Select the type of check from the list for which you want to define the color and point settings.

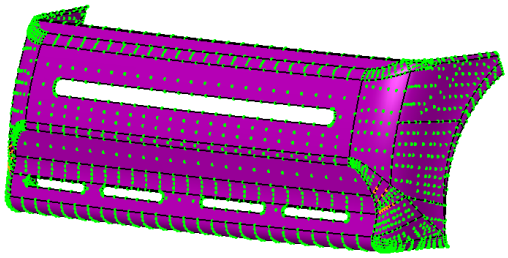
- Radius check
- Bumper check

The available options depend from the selected type of check (e.g. the bumper check has no option for unreachable points).

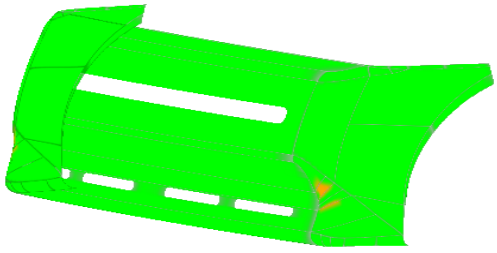
3..6.2 Create Color Map

Enable this option to visualize the check results as colored map (see figure below).

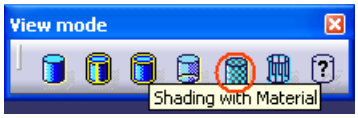
Visualization as points



Visualization as color map



To visualize the *Color Map* you have to activate the view mode 'Shading with Material' in CATIA.



3.6.3 Below min. Radius

or 3.6.9

Define a color and point type that is used to visualize all points at which the radius of curvature is less than the minimal allowed radius.

The minimal allowed value is defined on the respective tab card for the radius or bumper check.

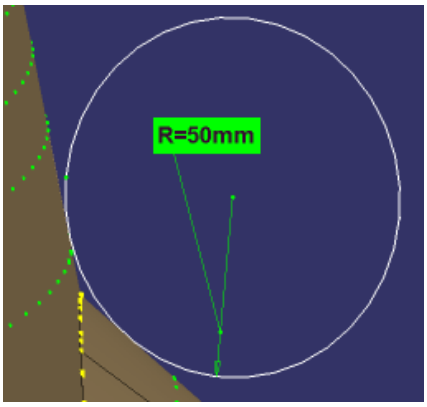
3.6.10 Below min. Rad 2 – only for bumper check

Define a color and point type that is used to visualize all points at which the radius of curvature is less than the minimal allowed radius.

The minimal allowed value is defined on the respective tab card for the radius or bumper check.

3.6.4 Unreachable Point – only for radius check

Unreachable points are points that are not touched by the sphere which is unrolled on the vehicle geometry.



Example:
The yellow points in the figure to the left are not touched by the unrolled sphere.

Define a color and point type that is used to visualize all these points.

3.6.5 Valid Point

Define a color and point type that is used to visualize all (reachable) points, at which the radius of curvature is bigger or equal than the minimal allowed radius.

3.6.6 Custom Radius

Here, you can define a radius that is checked additionally to the one that is given by the standard.

3.6.7 Custom Point

Define a color and point type that is used to visualize all points at which the radius of curvature is bigger or equal than the custom defined radius.

3.6.8 Sharp Edge

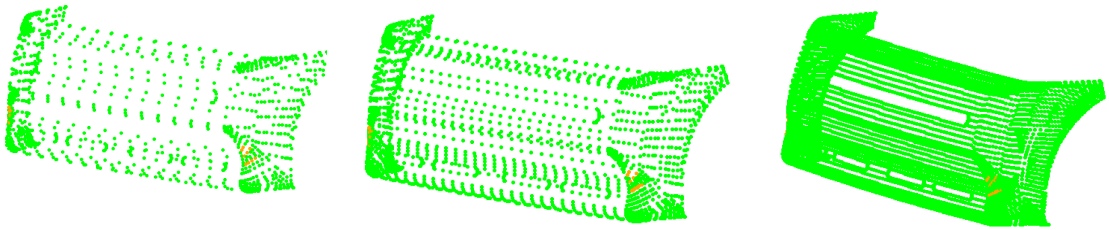
Define a color and point type that is used to visualize all points at which the sharp edge criterion (refer to tab card 'Radius-Check/Face Angle) is satisfied.

4 Calculation Precision

Use this slider to drive the accuracy of the internal triangulation for the selected vehicle geometry. A more detailed triangulation leads to a higher density of check points and therefore to a more accurate result. However, at the same time the computation time increases.

By default, the internal triangulation is more detailed on curved surfaces than on planar surfaces.

Accuracy: 1,0 (fast) Accuracy: 0,5 Accuracy: 0,1 (accurate)



⑤ Element list

This list contains all selected vehicle geometry and their specified parameters (refer to ⑧).

⑥⑦ Geometry selection and list control

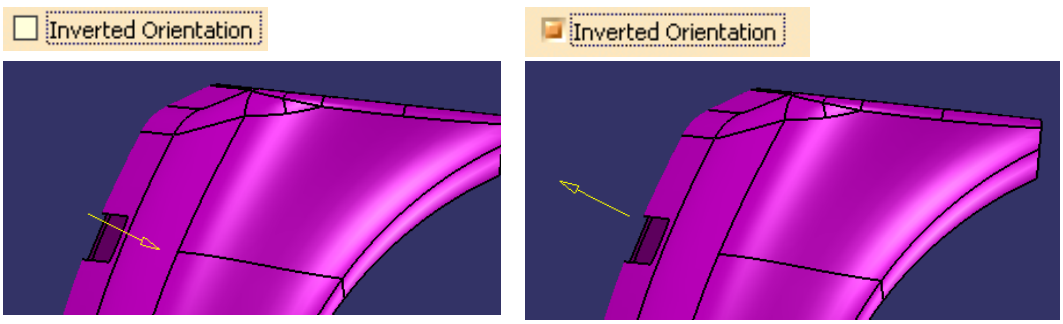
If you want to add new elements to the list, activate this field and select the desired geometry in the model. Use the option buttons to assign the corresponding parameters to the geometry (refer to ⑧) and click the *Add* button to commit the element to the list. Optionally you can also use multiselection *(Start Multselection)* or the select by name *(Select by Name)* tool.

To edit or delete one element from the list, you have to select the item from the list. To edit the element, you can now change the options (⑧) and commit the new settings to the list by pressing the *Set* button. To delete the element just click on the *Remove* button.

⑧ Option settings for geometry elements

Because CAVA can perform different checks which are optional in some cases (e. g. floor line), you have to define the type of check for each selected geometry element.

- Inverted Orientation
  The Orientation of the surface normal is required to perform the check for minimal radius. The topological direction of the surface normal (given by CATIA V5) is visualized for each selected geometry element by an arrow.
  Enable this option to invert the given direction (the geometry of the surface remains unchanged).



Please note that CGR Data has no orientation and therefore cannot be used for all checks.

- For Radius Check
  Enable this option if the selected geometry should be checked for minimal radius of curvature.
- For Floor Line
  Enable this option if the selected geometry should be used to generate the floor line.
- For Front Bumper Check
  Enable this option if the selected geometry belongs to the front bumper.
- For Rear Bumper Check
  Enable this option if the selected geometry belongs to the rear bumper.

Please make sure that all options selected here are corresponding to the selection you have made in ②.

* * *