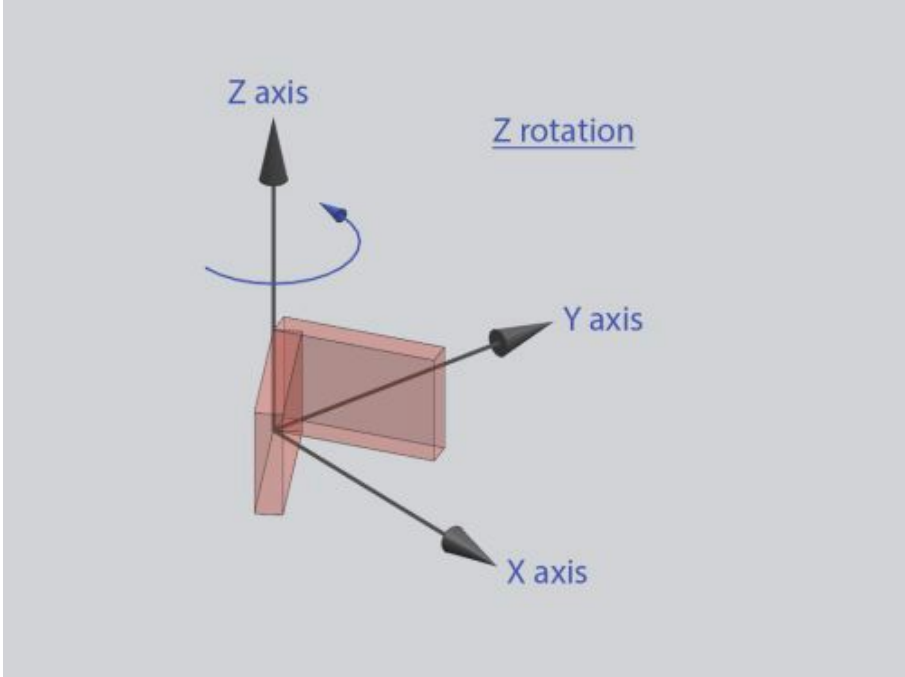
KVRC 2016 Rulebook
Revision 2, 21/4/2016

Lateral/transverse = X axis (+X = towards the right when viewed from the front)
Longitudinal = Y axis (+Y = towards the rear)
Vertical = Z axis (+Z = up)
FWCL = Front wheel centerline, RWCL = Rear wheel centerline

The reference plane is Z=0, which is coincident with the lowest surface of the allowed bodywork volume. The lowest point of the wheels is below the reference plane. The wheelbase of the car is fixed at 3000mm with the FWCL at Y=0 and the RWCL at Y=3000mm.

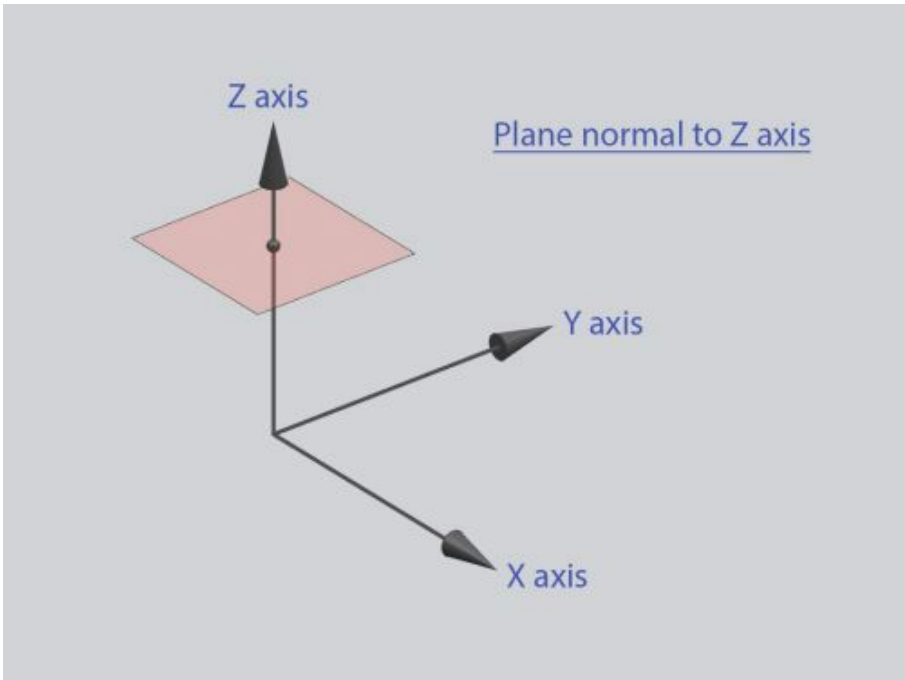
All supplied part files apply to one half of the car (the +X side). The other side of the car must be a symmetric copy of this side. Except where specified otherwise, any dimensions given apply to the entire car, if modelling one half of the car this needs to be taken into account.

For CFD purposes, the center of gravity will be considered to be at 1.65m rearward of the FWCL. The optimum center of pressure will be near this value, depending on track.



Introductory subclass:
A set of parts that comprises all bodywork necessary to form a legal car, with the exception of the front wing, rear wing and floor, is provided on the KVRC website. These parts may be used as part of a KVRC submission by any entrant. However you may choose to compete in the “introductory subclass” using these parts without modification, and limiting your submission to bodywork inside the introductory subclass volumes. These volumes can be found in the rulebook_introductory STL/STEP file (the normal rulebook STL/STEP file should be ignored). The parts you submit will be combined with the supplied bodywork to form the complete car. **Please do not submit the supplied parts. These parts will be added to your submission before running the CFD simulation.**

Participants in the introductory subclass will be ranked alongside full participants, but the introductory subclass champion will be the best-placed introductory subclass entrant. Any introductory subclass entrant is free to become a full participant at any point during the season, keeping the points earned so far, but doing so will mean that the participant is no longer eligible for the introductory subclass championship.



K1.1
All modelled geometry is considered as bodywork unless otherwise specified. No bodywork is allowed outside the bodywork volume unless otherwise specified.

K1.2
No part of the bodywork may be less than 10mm thick. See **appendix 1** for the exceptions to this rule.

K1.3
The **body**, **rear wing**, and **front wing** parts, when joined together, must form closed shell(s) with no holes. No bodywork is permitted which is detached from the body of the car, bodywork must either form one complete closed shell, or multiple intersecting closed shells. Please avoid including internal construction geometry.

Introductory subclass: For this rule, the supplied bodywork is considered part of the body.

K1.4
Full entries should include:

- (K4.2) Engine inlet surfaces, named "**engine-intake**"
- (K4.3) Engine exhaust outlet surfaces, named "**engine-exhaust**"
- (K4.1) Cooling inlet surfaces, named "**cooling-intake**"
- (K4.1) Cooling outlet surfaces, named "**cooling-exhaust**"
- (K4.1) **EITHER** cooling inlet area template, named **"area-template"**
  OR front faces of heat exchangers as a single part named **"hx-front"**, and rear faces as a single part named **"hx-rear"**
- **(optional)** (K3.2) Rear wing, named "**wing-rear**" (a finer mesh resolution will be applied)
- **(optional)** Some or all bodywork forward of the FWCL excluding the front fenders, named "**wing-front**" (a finer mesh resolution will be applied)
- Remaining bodywork, named "**body**"

Introductory subclass entries should include:

- **(optional)** (K3.2) Rear wing, named "**wing-rear**" (a finer mesh resolution will be applied)
- **(optional)** Some or all bodywork forward of the FWCL, named "**wing-front**" (a finer mesh resolution will be applied)
- Remaining bodywork, named "**body**" (Do not include the supplied bodywork)

These parts should be exported as separate STL files with 1 unit = 1m. The unit setting may be verified by opening the STL file in ParaView and checking "bounds".

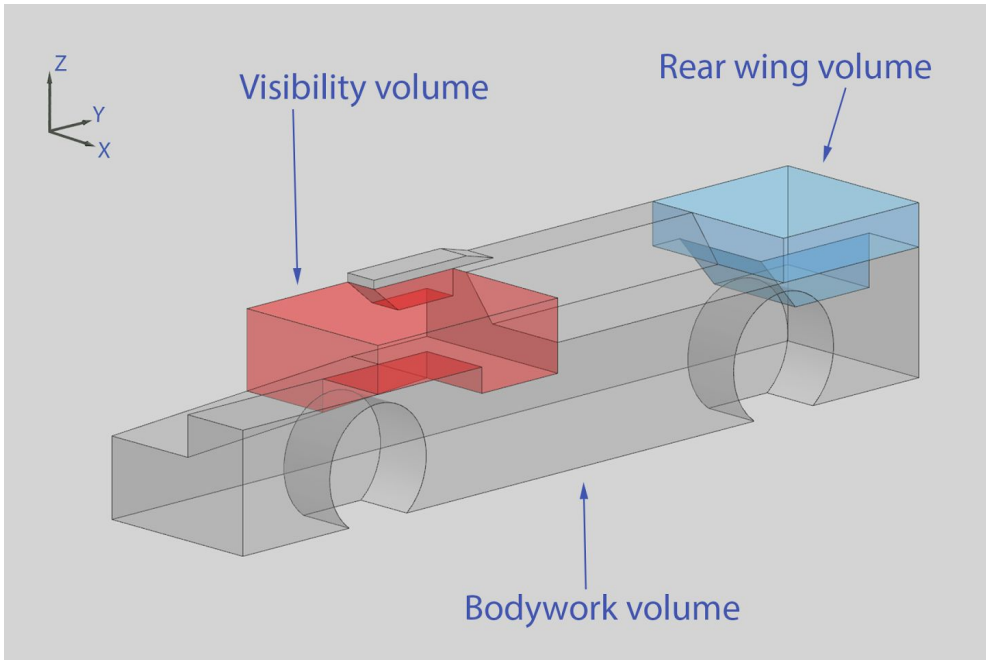
K1.5
A text file must also be submitted to specify the offset in mm for the following parts compared to their position as supplied in the parts file, if they have been moved:

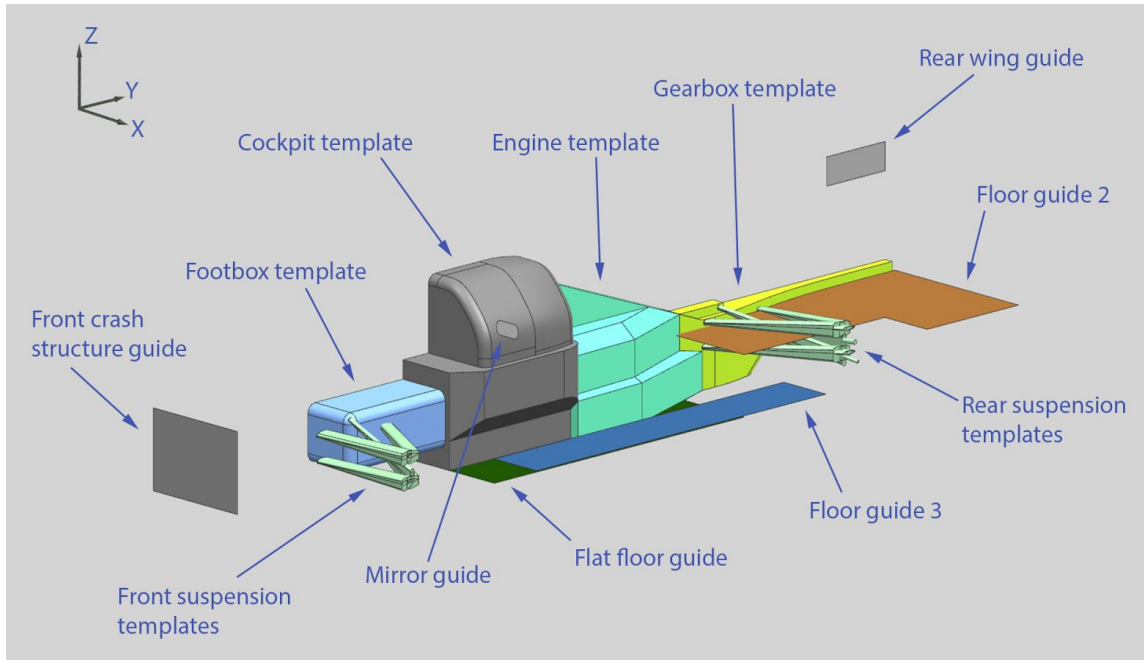
- Front suspension templates Z-offset
- Footbox template Z-offset (only for full entries)

K1.6
Only the parts specified in K1.4 and the text file in K1.5 should be included. No other guide parts should be submitted. Submission should be in the format of a single compressed archive (ZIP etc). Please keep the combined size for the STL files (before compression) below 80mb for ASCII STL, or below 20mb for binary STL.

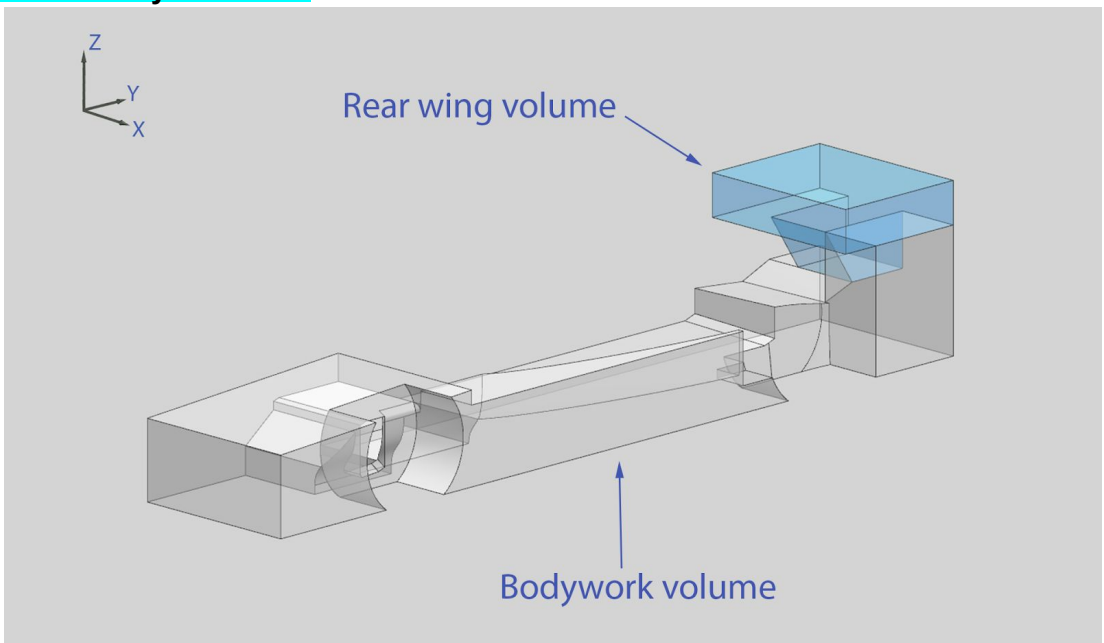
Introductory subclass: 60mb for ASCII STL, 15mb for binary STL

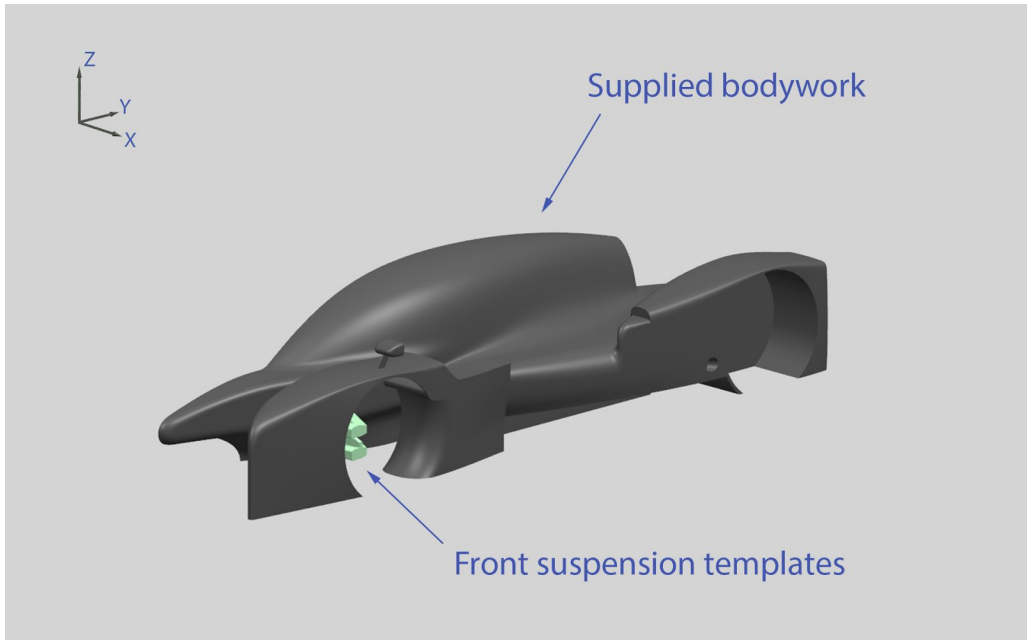
Full entries:





Introductory subclass:





K2.1
All supplied parts must not be moved, rotated or altered, with the following exceptions:
Full entries:

- The footbox template may be moved vertically no more than ±100mm from its supplied position (upwards until the top face is level with the ledge on the cockpit template, or downwards until the bottom face is on the reference plane).
- Supplied **front** suspension templates may be moved (as a group) no more than 100mm upwards or 50mm downwards from their supplied position.

Introductory subclass: front suspension templates only, moved vertically (as a group) no more than ±50mm from the supplied position.

K2.2 (ignored for introductory subclass)
Bodywork must completely enclose these provided parts:

- Cockpit template
- Engine template
- Gearbox template
- Footbox template

K2.3 (ignored for introductory subclass)
No bodywork is permitted inside the visibility volume except the following:

- Surfaces of the cockpit which would form the windows and A-pillars. This area should form a smooth continuous shape, no separate window surfaces.
- Rear view mirrors, their mountings and their fairings. Mountings and fairings which clearly impede cockpit vision, or which are made larger than structurally necessary so as to produce downforce, will be judged to be illegal.

K2.4 (ignored for introductory subclass)
Bodywork covering the wheels:

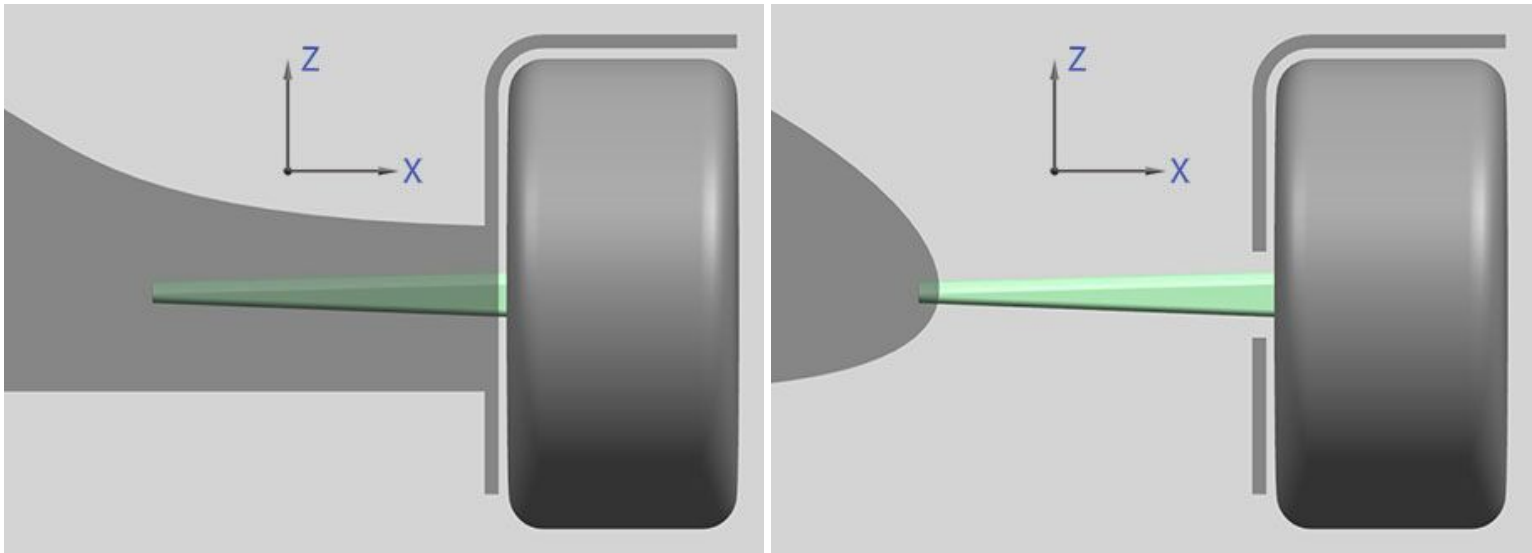
- As viewed from above, no part of any wheel may be visible. This requirement is ignored in areas more than 950mm from the car centerline.
- As viewed from the front, no part of the front wheels may be visible. This requirement is ignored in areas more than 950mm from the centerline of the car or less than 50mm above the reference plane
- For this rule, the phrase ‘wheels’ refers to the entire volume inside the wheel wells of the bodywork volume.

K2.5
Bodywork surrounding suspension parts:

- As viewed from above and from the front, no part of the front suspension templates may be visible.
- As viewed from above, no part of the rear suspension templates may be visible.

K2.6 (ignored for introductory subclass)

- The inner end of each suspension template must lie inside the volume formed by bodywork. Any such bodywork must form a realistic load path to the chassis, being at least 25mm thick.
- There must be only one intersection between each template and the surface of the bodywork:
  - **either** the suspension template must lie fully inside bodywork, except for the outer end which protrudes from the bodywork to meet the wheel,
  - **or**, the inner end of the suspension template must lie inside the central bodywork, with no other bodywork intersecting the suspension template.

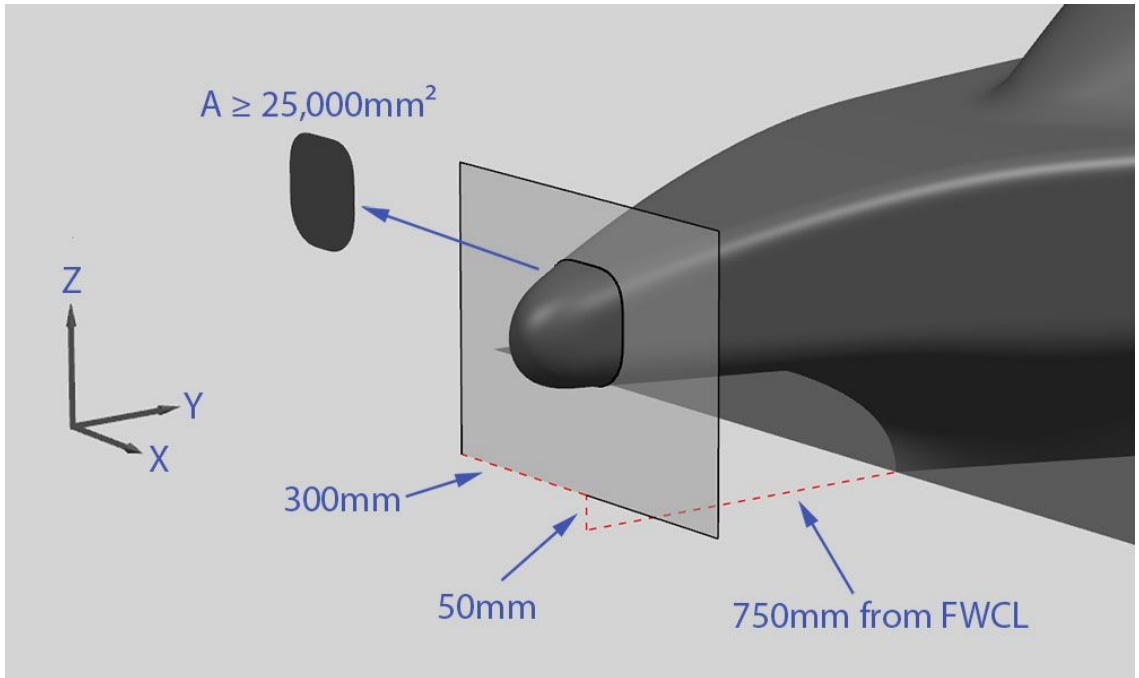


When using K4.1 option 2 (internal duct), the internal walls of the duct (in the region bounded by the cooling inlets and cooling outlets) are ignored for the intersection requirements above. If a suspension template intrudes into the duct, there should not be any holes in the duct allowing the templates to pass through.

K3.1 (ignored for introductory subclass)

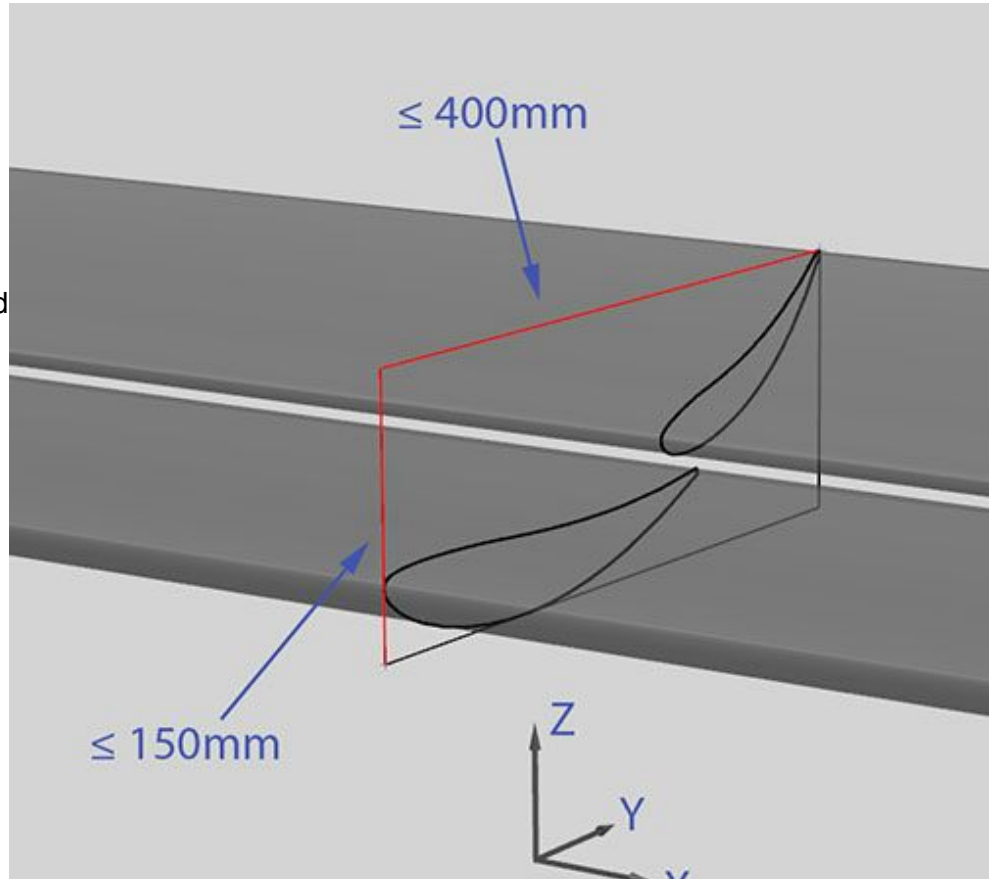
- The front crash structure must be attached to the bodywork covering the cockpit templates to provide a realistic load path.
- The intersection of bodywork with the front crash structure guide (a plane 750mm forward of the FWCL, only considering areas less than 300mm from the car centerline and more than 50mm above the reference plane) forms one or more closed shapes. The shape(s) must be at least 25000mm^2 in total area. The shape(s) must each be at least 100mm high/wide at any point (measuring perpendicular to the boundary).
- As the plane forming this intersection is moved rearwards towards the cockpit, the load-bearing region(s) must not diminish below the 25000mm^2 minimum and must remain at least 75mm high/wide (measuring perpendicular to the boundary).

Structurally unrealistic designs will be judged to be illegal.



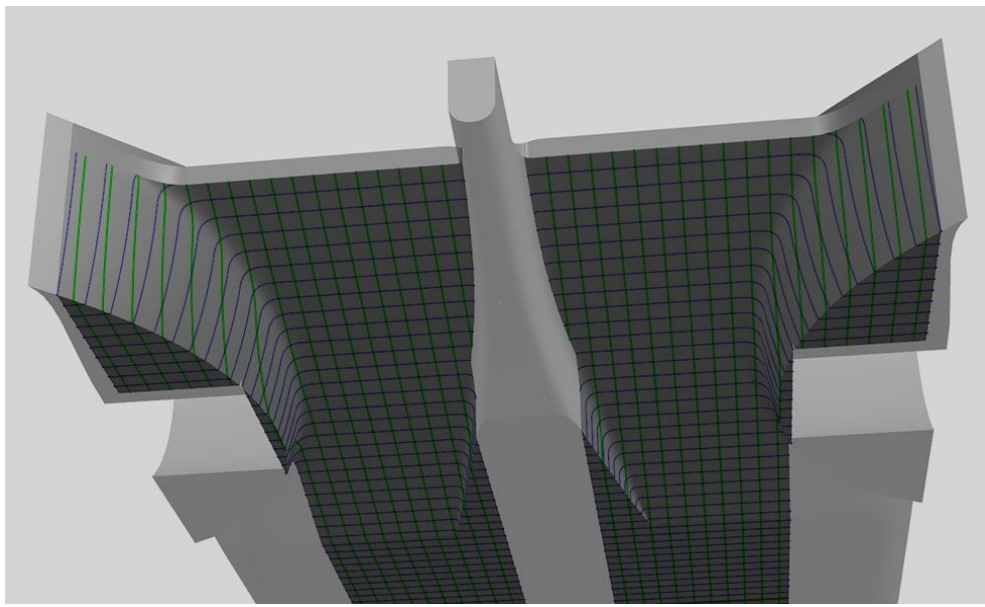
K3.2 - rear wing

- No bodywork is permitted inside the the rear wing volume other than:
    - The rear wing profiles
    - An endplate on each end
    - Up to 2 pieces of bodywork whose sole purpose is to attach the rear wing profiles to the bodywork
- When referred to from elsewhere, “endplate” and “attachments” are defined as bodywork inside the rear wing volume only. The continuation of these parts beyond the rear wing volume is considered as normal bodywork.
- Any intersection of the rear wing profiles with a plane normal to the X-axis must form either 1 or 2 closed sections. The entirety of these sections must fit into a rectangle of 400mm (Y-axis) by 150mm (Z-axis). The included rear wing guide is a rectangle with these dimensions.
- The rear wing must be attached to the bodywork by at least 2 points. Endplates may be used as attachments. The attachments must be separated by at least 350mm in the X-axis, and must provide a realistic load path to the body of the car.
- When viewed from the rear, at any vertical position inside the rear wing volume, each endplate must not span more than 25mm in the X-axis.
- It is permissible to not use any rear wing profiles. In this case, there should be no bodywork inside the rear wing volume.



K3.3 - floor

- Covering the entire area specified by the flat floor guide there must be a flat, unbroken surface lying on the reference plane.
- Any bodywork visible from below, which lies directly above/below floor guide 2, excluding the parts inside the rear wing volume, must be no more than 320mm above the reference plane.
- Any bodywork visible from below, which lies directly above/below floor guide 3, must be no more than 125mm above the reference plane.
- When any bodywork specified in this rule is intersected with any plane normal to the X or Y axes, there must be no gaps in any of the sections formed (considering only one side of the car). Surfaces inside the diffuser which are vertical will be considered to be visible from below. The engine exhaust outlet surfaces are ignored for this requirement. A small tolerance will be allowed in the area surrounding the wheel well.



K3.4
After having met K3.3, thin bodywork elements (turning vanes / fences, no thicker than 25mm) may be added in the regions specified in K3.3, provided that these elements do not extend beyond the trailing edge of the rear diffuser when viewed from below.

K3.5 (ignored for introductory subclass)
One rear view mirror each side is mandatory:

- The reflective surface must be 150mm wide (X-axis) and 75mm high (Z-axis), with a 25mm radius fillet at each corner. A guide is included for this area.
- The reflective surface must be positioned within the visibility volume, and more than 400mm from the car centerline.
- The reflective surface must be planar, facing directly rearward, and must be fully visible from the rear of the car, ignoring the parts in the rear wing volume.

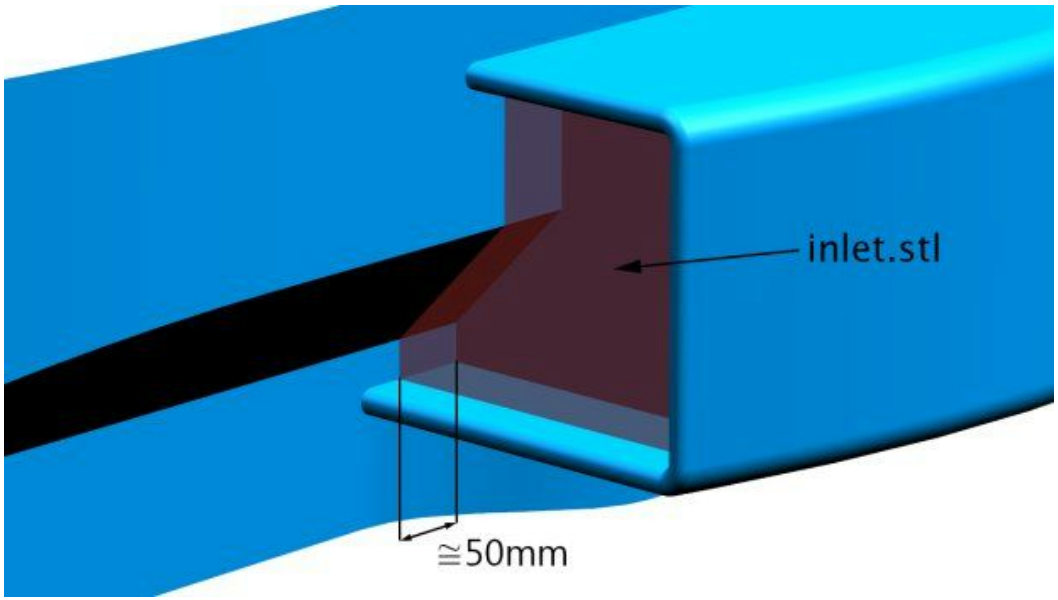
The reflective surface is then considered as bodywork.

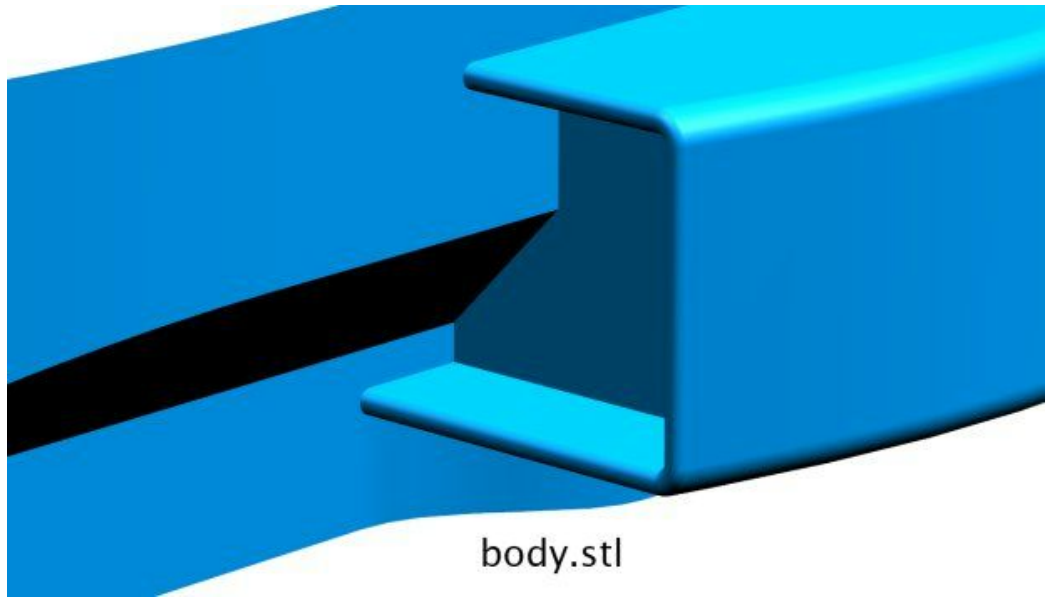
Mandatory inlet/outlet surfaces

The ability to provide adequate airflow for cooling and engine inlets/outlets is calculated from the airflow analysis rather than being enforced in the regulations. Designs unable to meet the nominated airflow requirements will have reduced engine performance. See **appendix 2** for these requirements.

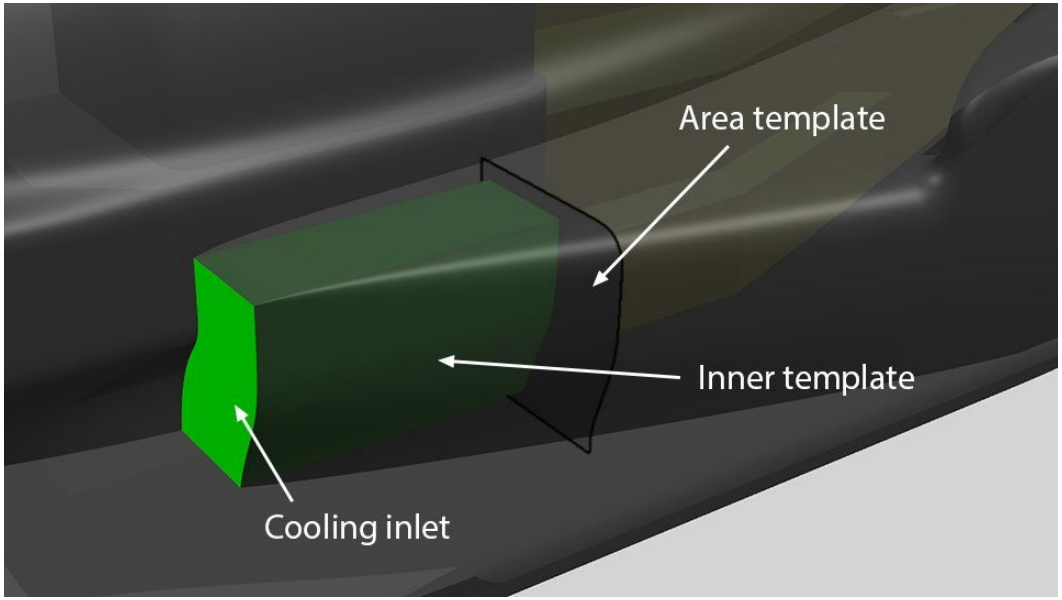
The rest of the rulebook is ignored for the introductory subclass, other than the appendices.

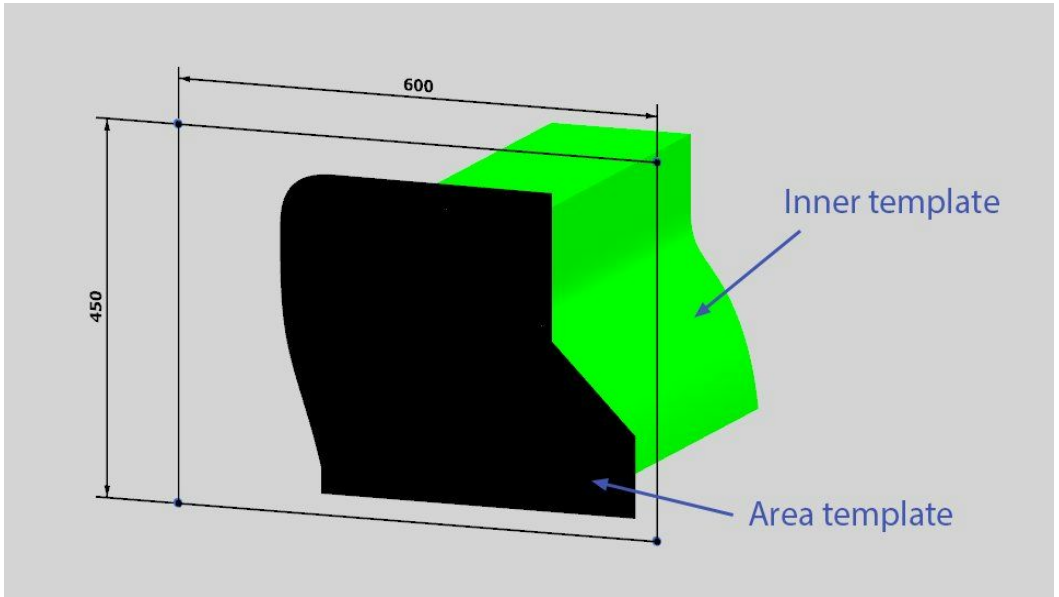
The inlet / outlet / heat exchanger surfaces should each be planar surfaces, not solids. As specified in K1.4, these parts are submitted as separate STL files. The recommended format is as shown below, with the surfaces fitting into recesses in the body. The surfaces should fit within the bodywork so that the outer edges of the surfaces are touching the bodywork without any gap. The faces may extend slightly inside the bodywork, unless the area of the inlet / outlet / duct section is very close to the minimum allowed.





K4.1: option 1





Cooling inlets:

- There must be one cooling inlet surface each side of the car. Each cooling inlet surface must be a planar shape which is at least 50,000mm^2 in area, and no more than 400mm wide (measured in the direction of the X-axis projected onto the plane containing the inlet surface) or high (projection of the Z-axis).
- The cooling inlet surfaces may be rotated from a forward-facing orientation by no more than 30 degrees.
- The *cooling inlet inner template* is an extrusion of each inlet surface rearward **along its normal** for for at least 500mm and no more than 1000mm. These template(s) must be entirely enclosed within the bodywork and must not intersect any other parts or templates.
- There must be an *area template* for each inlet surface. Each area template is a single continuous shape which is coplanar with the rear face of the inner template. The area template must cover the entirety of the rear face of the inner template, must be at least 200,000mm^2 in area, and must be no more than 600mm wide (measured in the direction of the X-axis projected onto the plane containing the template) and no more than 450mm high (projection of the Z-axis). The area template must be entirely enclosed within the bodywork and must not intersect any other parts or templates. As specified in K1.4, the area template must be included with the submission as a separate part.

Cooling outlets:

- There must be a minimum of 1 and maximum of 4 cooling outlet surfaces, with a combined area of at least 75,000mm^2 **(over the entire car)**.
- All outlet surfaces must be planar shapes at least 60mm high/wide at any point (measuring perpendicular to the boundary).
- They must be located within the bodywork volume, with the forward-most point at least 1200mm rearward of the rearward-most point of any cooling inlet surface.
- The surfaces may be rotated from a rearward-facing orientation by no more than 30 degrees.
- The *cooling outlet inner templates* are the volume(s) formed by an extrusion of each outlet surface forwards **along its normal** for 300mm. These templates must be entirely enclosed in bodywork and must not intersect any other parts or templates, with the exception of the **rear** suspension templates.

K4.1: option 2 (intended method - not being used for the first few rounds in 2016)

Cooling inlets:

- There must be one cooling inlet surface each side of the car. Each cooling inlet surface must be a planar shape which is at least 50,000mm^2 in area, and no more than 400mm wide (measured in the direction of the X-axis projected onto the plane containing the inlet surface) or high (projection of the Z-axis).
- The inlet surfaces must be located within the bodywork volume. They may be rotated freely.

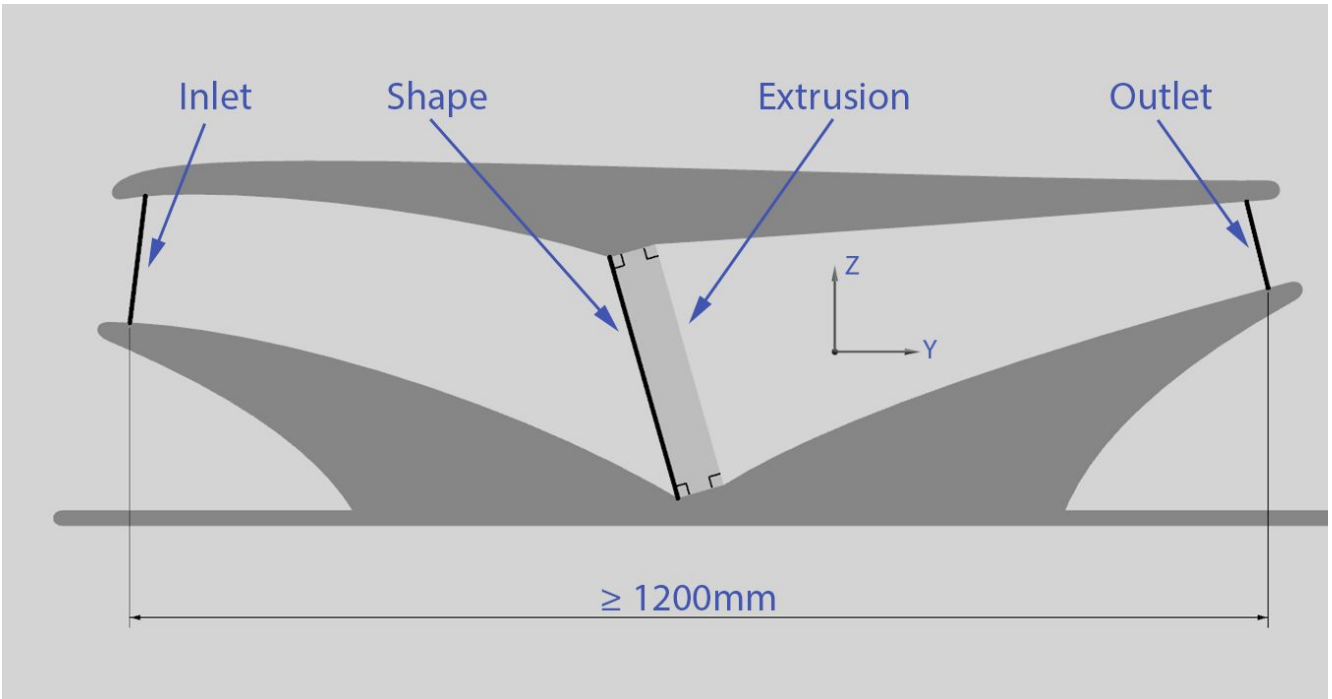
Cooling outlets:

- There must be a minimum of 1 and maximum of 4 cooling outlet surfaces, with a combined area of at least 75,000mm^2 **(over the entire car)**.
- All outlet surfaces must be planar shapes at least 60mm high/wide at any point (measuring perpendicular to the boundary).
- They must be located within the bodywork volume, with the forward-most point at least 1200mm rearward of the rearward-most point of any cooling inlet surface. The outlet surfaces may be rotated freely.

The bodywork must include the full internal ducts running from the cooling intake to the cooling exhaust(s). There may be no openings in the duct other than the inlet and outlet surfaces defined above. No templates may intrude into this region other than the heat exchangers and the front and rear suspension templates. If any suspension template intrudes into a duct, there should not be a hole allowing the template to pass through, the template should intersect the wall of the duct (see K2.6).

There must be one heat exchanger each side of the car:

- Each heat exchanger is made up of a single planar shape extruded rearward **along its normal** by a distance of 100mm.
- Each planar shape must be no more than 600mm wide (measured in the direction of the X-axis projected onto the plane containing the shape) and no more than 450mm high (projection of the Z-axis). Each planar shape must be at least 200,000mm^2 in area.
- The heat exchangers may be rotated from a forward-facing orientation by no more than 30 degrees.
- The heat exchangers must be positioned such that they fit within the internal ducts, with the entirety of the boundary faces of the extrusion touching the inner faces of the duct, without any gap and without the heat exchangers extending beyond the walls of the duct.
- As specified in K1.4, the **planar shapes** must be included with the submission as separate part. **Please do not include the 100mm extrusion.**



K4.1: option 2 (fallback method - used for the first few rounds in 2016)

Cooling inlets:

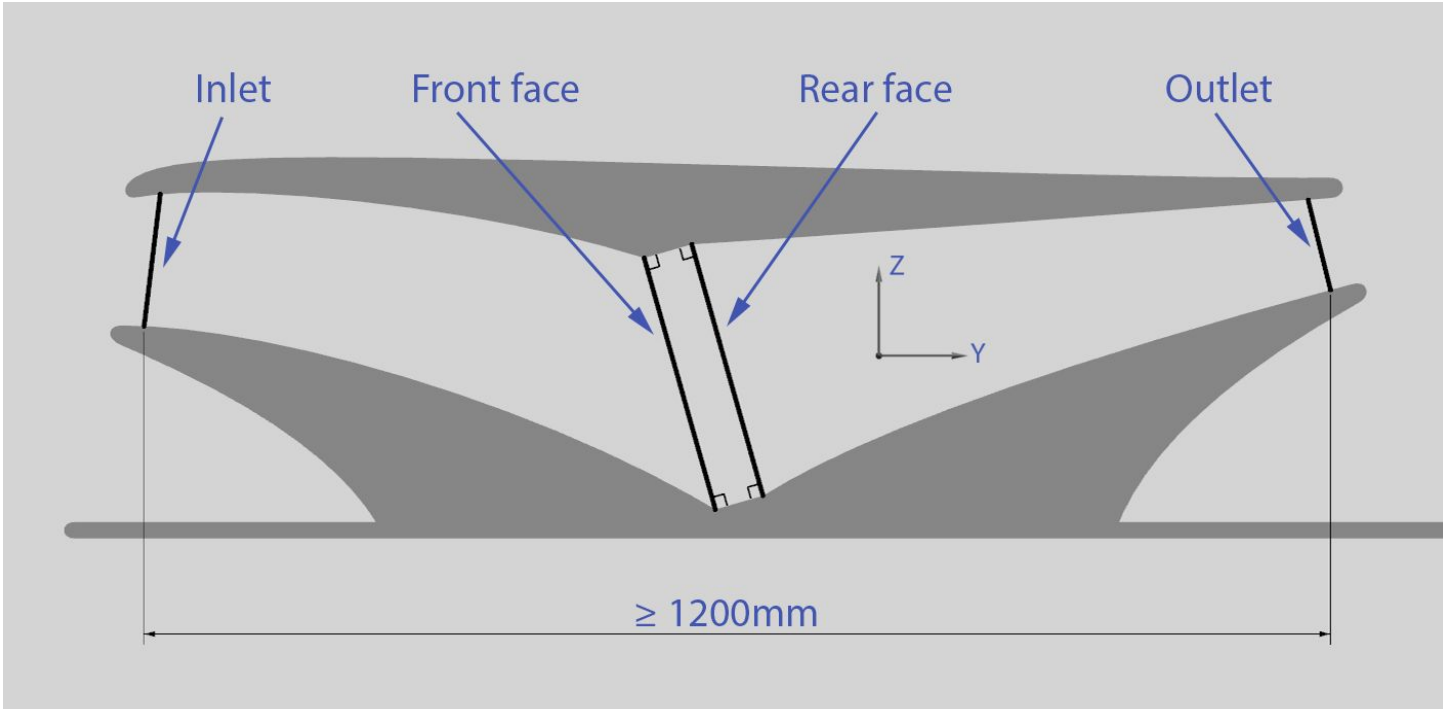
- There must be one cooling inlet surface each side of the car. Each cooling inlet surface must be a planar shape which is at least 50,000mm^2 in area, and no more than 400mm wide (measured in the direction of the X-axis projected onto the plane containing the inlet surface) or high (projection of the Z-axis).
- The inlet surfaces must be located within the bodywork volume. They may be rotated freely.

Cooling outlets:

- There must be a minimum of 1 and maximum of 4 cooling outlet surfaces, with a combined area of at least 75,000mm^2 **(over the entire car)**.
- All outlet surfaces must be planar shapes at least 60mm high/wide at any point (measuring perpendicular to the boundary).
- They must be located within the bodywork volume, with the forward-most point at least 1200mm rearward of the rearward-most point of any cooling inlet surface. The outlet surfaces may be rotated freely.

There must be one heat exchanger each side of the car. Each heat exchanger is made up of a front and a rear face:

- The front face must be a planar shape, at least 200,000mm^2 in area, no more than 600mm wide (measured in the direction of the X-axis projected onto the plane containing the shape) and no more than 450mm high (projection of the Z-axis). It may be rotated from a forward-facing orientation by no more than 30 degrees.
- The rear face is an identical copy of the front face, but translated 100mm rearward **along its normal**.
- The front and rear faces must lie within the bodywork volume.
- As specified in K1.4, each front and rear face must be included with the submission as separate part.



The bodywork must include the full internal ducts running from the cooling intake to the front face of the heat exchanger, and then from the rear face to the cooling exhaust, as shown in the images above. There may be no openings in the ducts other than the inlet and outlet surfaces defined above. No templates may intrude into the ducts, other than the front and rear suspension templates. If any suspension template intrudes into a duct, there should not be a hole allowing the template to pass through, the template should intersect the wall of the duct (see K2.6).

K4.2 - engine inlet

Either 1 or 2 engine inlets surfaces are required **(over the entire car)**, which:

- Must be planar surfaces with a combined area of at least 15,000mm^2.
- Must be at least 50mm high/wide at any point (measuring perpendicular to the boundary).
- Must be located within the bodywork volume, and between a point 875mm rearward of the FWCL and a point 600mm forward of the RWCL.
- May be rotated from a forward-facing orientation by no more than 30 degrees.
- The *engine inlet inner templates* are the volume(s) formed by an extrusion of each inlet surface rearward **along its normal** for a distance of 100mm. These templates must be entirely enclosed in bodywork and must not intersect any other parts or templates.

K4.3 - engine exhaust

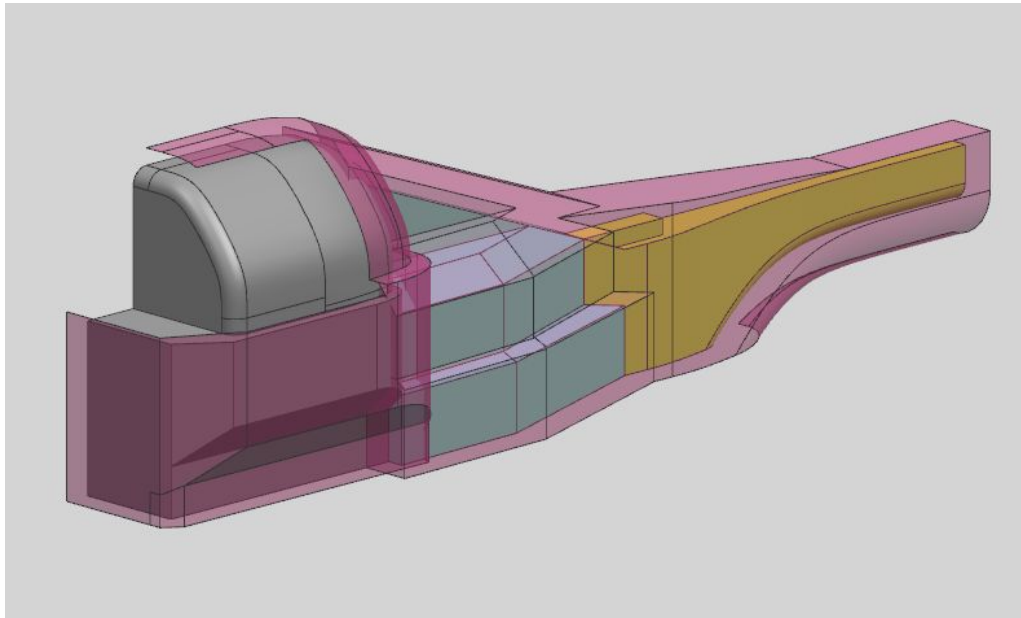
2 exhaust pipe outlet surfaces are required **(over the entire car)**, which;

- Must be circular, planar surfaces, each 5000mm^2 in area.
- Must lie within the bodywork volume, and rearward of a point 1000mm forward of the RWCL.
- May be rotated from a rearward-facing orientation by no more than 30 degrees.
- The *engine exhaust inner templates* are the volumes formed by an extrusion of each exhaust outlet surface forward **along its normal** for a distance of 100mm. These templates must be entirely enclosed in bodywork and must not intersect any other parts or templates.

K4.4

The volume formed by bodywork must allow for realistic paths through which:

- Flow from the engine inlet(s) could reach the engine template (this path may pass through the internal ducts if using K4.1 option 2)
- Flow from the engine template could reach the exhaust outlets (this path may pass between the rear suspension templates, and may pass through the internal ducts if using K4.1 option 2)
- Coolant lines could be run to connect the heat exchanger (or area template) to the engine template
- Flow from the cooling inlet could reach the area template (for K4.1 option 1)
- Flow from the area template could reach the cooling outlets (for K4.1 option 1)



Other than where specified, these paths may not pass through the volume taken up by any of the supplied templates. In cases where the paths specified above would pass through the space between bodywork and the internal templates, bodywork in the relevant area may not be ‘shrink-wrapped’ around the internal templates. The surfaces of the corresponding **offset guide** should be used to judge how much space must be left between the bodywork and the internal template to provide the “realistic path”.

Appendix 1: 10mm thickness

- For front and rear wing parts, each wing element should be at least 10mm thick at some part along its chord (across the entire span). Problems may be encountered at the CFD meshing stage if the thickness remains very low over a long distance at the rear of the chord.
- For thin bodywork elements (plates, strakes / fences), once the 10mm thickness requirement is met, a sharp trailing edge and rounded leading edge (roughly circular in shape) are permitted. The 10mm thickness should be maintained over approximately ⅔ of the length or more.
- For any gurney flap / wickerbill, a triangular section is permitted if the base width is at least 10mm and the height is no more than 50mm.
- Thickness may be checked in Netfabb (free version), by opening an STL file, scaling by 1000, clicking 'new measuring' and using the 'wall thickness' option.

Appendix 2: airflow requirements for inlets and outlets

	KVRC 2016	**Aim for future seasons**
Engine Intake	• Velocity boundary condition will be applied such that the total intake flow rate is **0.3 m^3/s** (whole car) • Total surface integral of pressure must be **>= 0 $Pa.m^2$**	As KVRC 2016
Engine Exhaust	• Velocity boundary condition will be applied such that the total exhaust flow rate is **0.3 m^3/s** (whole car) • Total surface integral of pressure must be **<= 4.5 $Pa.m^2$** (whole car)	As KVRC 2016
Cooling K4.1 option 1	• Velocity boundary condition will be applied such that the total inlet and outlet flow rate is **3 m^3/s** (whole car) • Difference in total surface integral of pressure (inlets - outlets) must be **>= 20 $Pa.m^2$** (whole car)	• Flow rate: 5 m^3/s • Difference in surface integral: 56 $Pa.m^2$
Cooling K4.1 option 2 (intended method)	• Heat exchanger will be given a certain porosity • Combined flow rate through heat exchangers must be **>= 3 m^3/s** (whole car)	• Flow rate: 5 m^3/s
Cooling K4.1 option 2 (fallback method)	• Velocity boundary condition will be applied to the front and rear heat exchanger faces such that the total flow rate is **3 m^3/s** (whole car) • Difference in total surface integral of pressure (inlets - outlets) must be **>= 17 $Pa.m^2$** (whole car)	

Lap Time Prediction

Lap time prediction shall be performed by the Virtual Stopwatch application using the aerodynamic coefficients and characteristics of each car which are calculated by the CFD analysis program OCCFD.

The mechanical parameters of the car in Virtual Stopwatch are fixed throughout the season and summarised below:

Total vehicle mass (including driver): 950kg
Mass Distribution (F:R): 45:55
Track Width: 1.64m
Wheelbase: 3.0m
Tyres: 365-18" Slick, Soft Compound
Engine: 3.0 litre, 540hp @ 12,000 rpm
KERS: 2000kJ storage, 144bhp max output
Gearbox: 8 Speed, Seamless Shift. (fixed ratios between 2:1 and 0.91:1)
Final Drive: 3.2
Suspension: Unequal length, double wishbone, push-rod front and rear.

With the above parameters fixed, and with the baseline aerodynamic coefficients provided below, the performance of the vehicle shall be as per the following table:

	Cd.A = 1.3 Cl.A = 4.5 COP = 1.65m	+20% Drag and Downforce	-20% Drag and Downforce
Nurburgring	386.44s	-3.17s	+3.13s
Monaco	84.31s	-0.75s	+0.75s
Silverstone	104.92s	-1.33s	+1.33s
Sepang	107.53s	+0.5s	-0.55s
Sao Paulo	81.34s	+0.4s	-0.44s

The competitor can test the performance of a car using Virtual Stopwatch throughout the season at any of the tracks listed above using the following link:
http://www.competition-car-engineering.com/VSW_KVtest.htm