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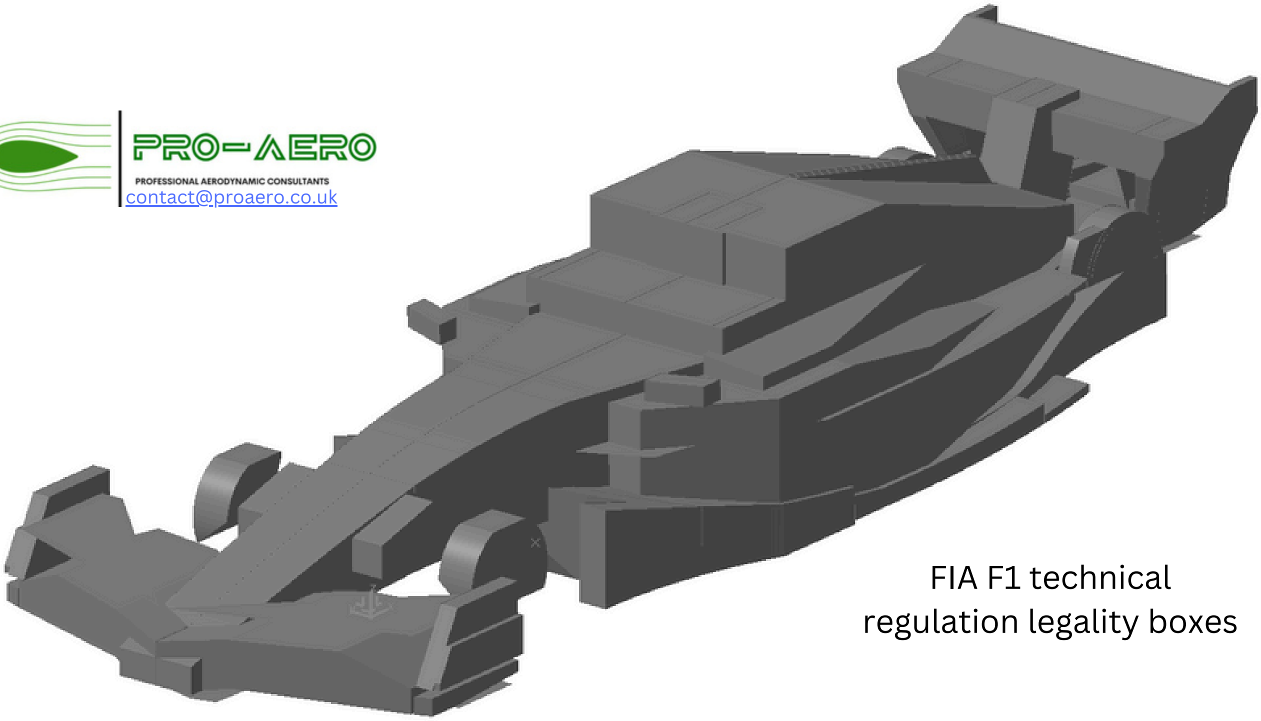


FIA F1 technical regulation legality boxes

1.1 CONSTRAINTS OF AERODYNAMIC DEVELOPMENT IN FORMULA 1

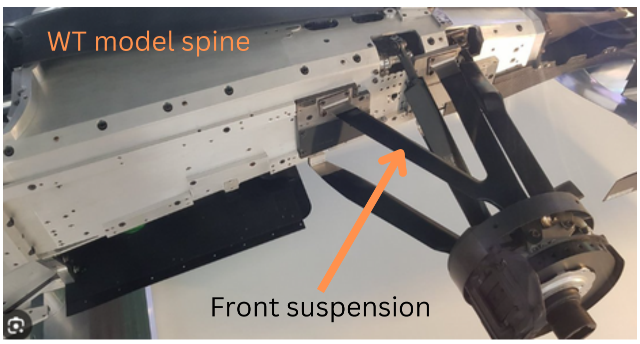
Building on the initiation of a new aerodynamic project as discussed in section 1.0, the subsequent step involves assessing aerodynamic constraints to prevent investing time in geometries that are unfeasible or unsuitable. In this article, we will delve into the following topics:-

1. Legality
2. Packaging
3. Modularity
4. Cooling requirements
5. Structural requirements
6. Weight considerations
7. Budget

1. **Legality** - The regulations governing aerodynamics are stipulated by the Fédération Internationale de l'Automobile (FIA) and can be accessed online at https://www.fia.com. Originating from the 1950s, the FIA's regulations covered engine specifications, safety features, and aerodynamics. These regulations have grown in complexity over the years to enhance safety and foster closely contested racing. The image at the top of the page illustrates the various volumes within which the aerodynamic features are situated.

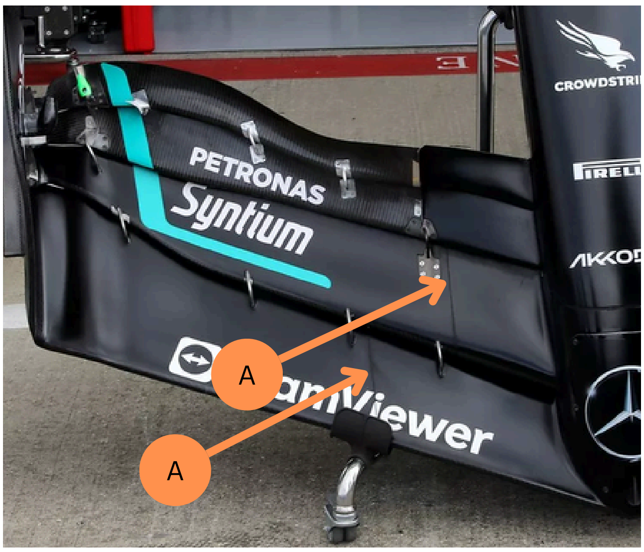
In addition to the volume constraints, there are additional restrictions that dictate allowable curvatures, the number of sections, and so forth, depending on the specific development area. The aerodynamicist in charge of a particular area must comprehend the regulations comprehensively to ensure that only fully compliant geometries are tested in computational fluid dynamics (CFD) or the wind tunnel.

2. **Packaging** - Numerous mechanical and electronic components necessitate careful packaging within both the race car and the wind tunnel development model. The image below illustrates a typical structure of a wind tunnel model, which is then covered with 3D printed materials.



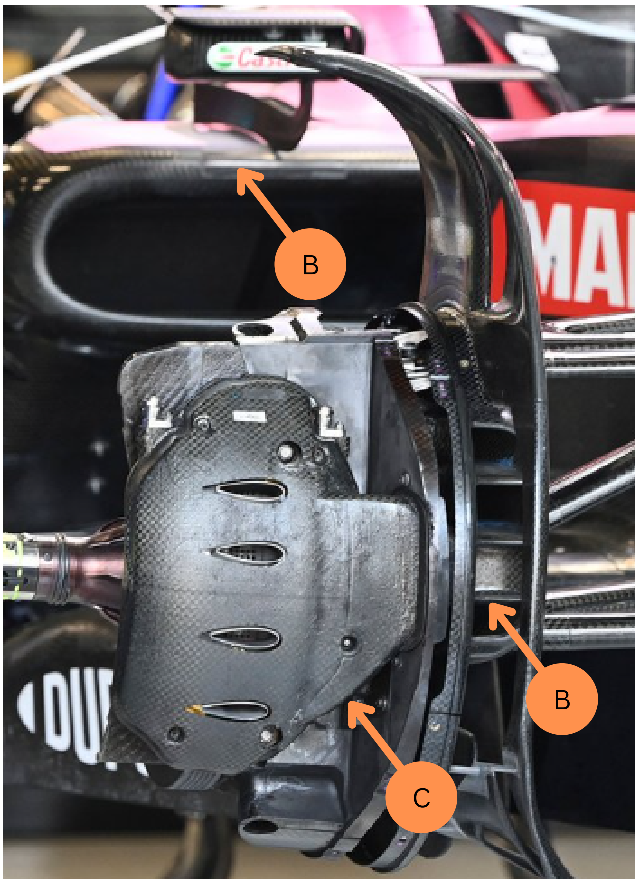
During aerodynamic development, the understanding of aerodynamic sensitivities evolves to identify the optimal placement of the car's architecture in order to enhance aerodynamic performance. Incorporating additional volume at a low height can provide performance benefits by maintaining a low center of gravity. Various factors such as wiring looms, pressure tubes, bolts, etc. need to be considered, and the required clearances depend on manufacturing tolerances, heat of surrounding materials, and adjustments for legal requirements. During the early stages of car development, it is crucial that aerodynamic development is not limited by the car's hardware.

3. **Modularity** - Both the race car and development model is designed with modularity in mind, allowing specific areas to be repaired or updated in a cost-efficient manner. For instance, the Mercedes front wing depicted in the photo below features a split line (A) in the flow direction, which minimises the loss of load in case of any steps in the final surface. By separating the front wing tip, any contact damage during a race can be quickly repaired back at the factory in sections. Additionally, if a new front wing tip geometry is developed, it can be implemented more efficiently and cost-effectively compared to replacing the entire front wing.



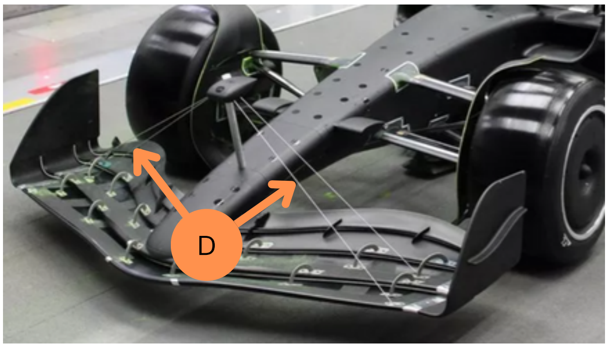
Excessive split lines can lead to increased weight and a poorer quality surface finish resulting reduction in aerodynamic load.
It is important that the 60% scale WT model uses the same split lines at the FS components to ensure updates are compatible.

4. **Cooling requirements** - In order for the car to function, the brakes, engine, gearbox, electronics and intercoolers temperatures have to be controlled specifically for each race. Targets are determined using previous years records and offsets applied for following traffic and change in input load. Cooling rigs are one of the few items that can be tested in isolation without testing restrictions. The aerodynamicist role is to meeting the mass flow targets whilst improve flow surrounding structures to increased load. Attention to detail is required to align splitter LE profiles (B) and design ducts with progressive expansions (C) to maintain flow attachment. This can be very time consuming when considering the car changes steer, yaw and ride height .



5. **Structural requirements** - All aerodynamic features have a load distributed on the surface. An extreme example being the suspension elements which requires collaboration with structural engineers to define minimum sectional area to work with. It is important to quantify the trade-off between aerodynamic sensitivity and structural requirements throughout development.

In the example of the front wing, the loading distribution and the stiffness of the elements can be controlled so the FW elements angle of attack reduces when increasing speed. This is a performance benefit by weakening the tip vortices to delay the front wheel wake being in-washed into the floor LE. The photo below shows a model scale front wing with a tether fitted to control the FW position. There would typically be three setting representing low, medium and high speed corners.



6. **Weight consideration** - For a lap time reduction, it is important to consider how the mass of the car and CoG changes as a consequence of implementing aerodynamic updates. For example, a 'blade' style roll hoop structure (E) compared to a traditional triangle may offer a aerodynamic benefit but at a cost of adding weight at the highest point on the car.

It is generally easier for the full scale designers to make a light weight front wing if the profiles are thicker. This is often an iterative process where a compromise is arrived at.

7. **Budget** - With budget restrictions now in place in F1, it is important to have a strategy that allows good value for money for development. For example, the floor fences and edge details are very sensitive and can offer a significant performance step for a reasonable cost. Where areas suspension and rear wing are high cost items and would need to achieve a significant load gain for it to be an in-season update.

These are the main aspect for consideration when carrying out aerodynamic development. There is also potential of driver or simulator feedback which changes the aerodynamic targets during the season. For example low speed understeer or high speed instabilities.

With the first two steps of the aerodynamic development cycle covered, the next step will look at starting to scheme using CAD.

If your company needs support with aerodynamic projects. Please contact us at contact@proaero.co.uk