HIGH LEVEL GEOMETRY RESTORATION FOR CFD PURPOSES IN ANSA

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KEYWORDS – Automotive CFD, Vehicle Safety, Le Mans

ABSTRACT – In the 1955 Le Mans race, the worst crash in motor racing history occurred. This accident would change the face of motor racing for decades. Numerous investigations has been carried out on this disaster, however still today a number of key questions remain unsolved; and one open area is the influence of aerodynamics on the scenario, since the Mercedes-Benz 300 SLR involved in the crash was equipped with an air-brake and its influence on the accident is basically unknown.

In a first attempt to establish CFD as a tool to aid in resolving aerodynamic aspects in motor sport accidents, a research project was started where CFD is used to investigate the aerodynamics of this vehicle and potentially uncover the aerodynamic aspect of this accident.

To generate a representative base model of this vehicle, suitable for CFD-simulations, the project borrowed a 1.24 die-cast collector's item of the Fangio/Moss vehicle. This model was then laser-scanned, however since it had metallic coating the scanner had severe issues with reflections and the resulting geometry was bad.

Although looking really bad, with the FE-tools in ANSA this model was salvaged and a clean surface was recreated of the input data. With this data the project carried on, and first step of results was published on SAE Motorsports Engineering Conference in the autumn of 2008, the second step of the project was published on European Automotive Simulation Conference EASC, Munich 2009.

TECHNICAL PAPER -

1. INTRODUCTION

The 1955 Le Mans 24 hour race changed the world of motor sport entirely. Many persons have the opinion that this accident moved the sport from innocence to moderny. After roughly two and a half hours of race the largest accident in motor racing history occurred when two cars crashed into each other just outside the former pilots and motor dealers stands.

The crash was a race incidence, one of the reasons being the combination of fast and slow cars competing on the same track and moving in and out of the pit lane. What happen was that a fast Jaguar D-type driven by the Englishman Mike Hawthorn went for pit stop and braked heavily in front of a slower Austin Healy 100. The Austin Healy, driven by the Englishman Lance Macklin, performed and evasive manoeuvre to avoid collision with the Jaguar, but instead was the Austin Healy clipped in the rear by a fast Mercedes-Benz 300 SLR driven by a Frenchmen, Pierre Bouillon (raced under the name of Pierre Levegh). Lance Macklin could stay on the track, unfortunately the Mercedes-Benz went up in the air and at the end of its flight path it hit a concrete tunnel, and spitted in parts which killed more than 80 people.

Over the years has this tragic and fatal accident been much discussed, analyzed and investigated. A few recent publications to mention are Bonte (2005) [5] and Hilton (2005) [4]. There are many interesting aspects of this accident, one being political; one must remember that this accident involved Frenchmen, Englishmen and Germans just ten years after the end of the Second World War. Other significant issues and more relevant to this project are the large number of technical questions and unclear statements which still remain unsolved.

The objective of the project, which this paper presents results from, are to elucidate some unclear questions of the accident scenario in the 1955 Le Mans race, the major one addressed in this project being that; even though a heavy vehicle like the Mercedes-Benz 300 SLR creates a substantial momentum, it is still difficult to explain how it could fly such a long distance as it did before it hit the concrete barrier. What has been investigated here is the influence of aerodynamics on the flight length of this particular vehicle.

2. METHODOLOGY

Generation of Surface Geometry

To get a representative geometry of the Mercedes Benz 300 SLR involved in the accident, a 1:24 die-cast model car of Fangio / Moss, from the model maker Pauls Model Art, was borrowed. The Fangio / Moss car was one of the competing cars 1955, identical to Levegh's.

Figure 1 – 1:24 Model of the Fangio/Moss Mercedes-Benz 300 SLR

This model car was laser scanned with and without the air brake in operation. The resulting STL data is seen in figure 2.

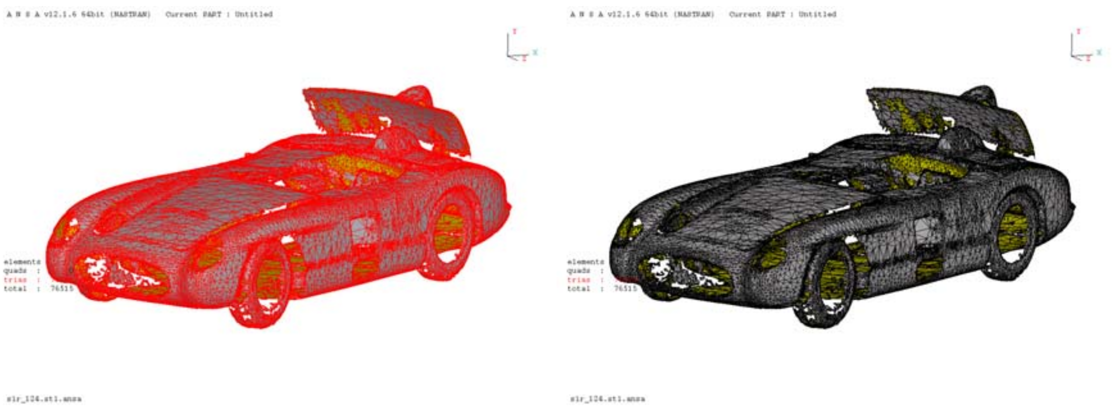

Figure 2 – Resulting geometry after scan, left highlighting unconnected STL geometry, right showing the how severely bad the scanned result was.

Due to the fact that the vehicle had a silver coated surface, the laser scanner had severe problems with reflections. Furthermore, due to the collector value of this model we were not allowed to repaint the car in a matt black color and have it rescanned. Hence, available geometry was what can be seen in figure 2.

At a point of make or break the project decided to take the long road and repair the heavily damaged surface. Together with an advanced course in ANSA and much needed guidance from Vangelis Skaperdas at BETA CAE Systems the surface was repaired and cleaned in ANSA 12.1.3, newly released at this point in time. The resulting geometry is displayed in figure 3. Most of the FE-tools in the Mesh menu were at some stage used in the project. To mention the most frequent tools used to salvage this geometry: FILL GAP [FREE/COONS], UTIL [FILL HOLE], RECONS, RESHAPE and FEMTOPO. These tools were used together with a couple of hotpoints / weldpoints and assisting construction curves.

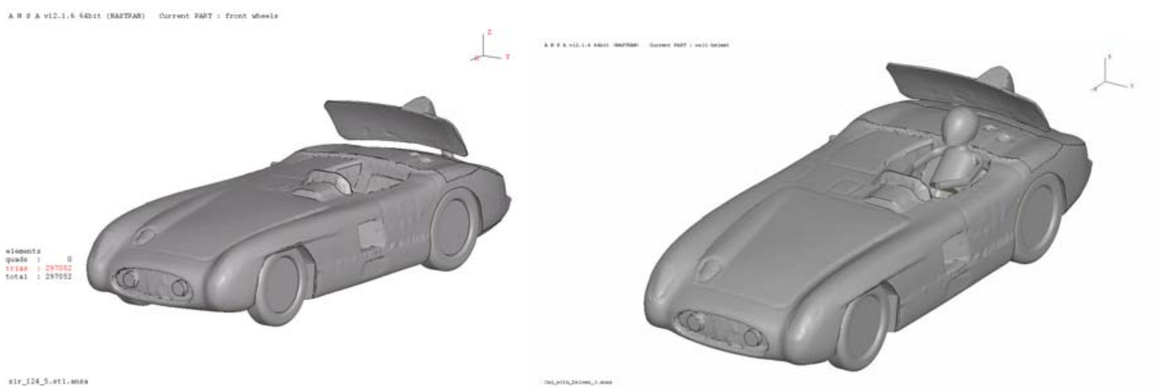

Figure 3 – Repaired and cleaned geometry to the left. To the right with a driver model added.

<u>Generation of CFD Model</u>

To generate a CFD model, the surface geometry in figure 3 was imported into Harpoon version 3.1. In Harpoon a hex-dominated volume mesh was created around the vehicle. Some details on the windtunnel settings can be found in [1] and [2]. A magnified image of the resulting volume mesh is seen in figure 4. The resulting meshes contained between 11 and 16 million cells.

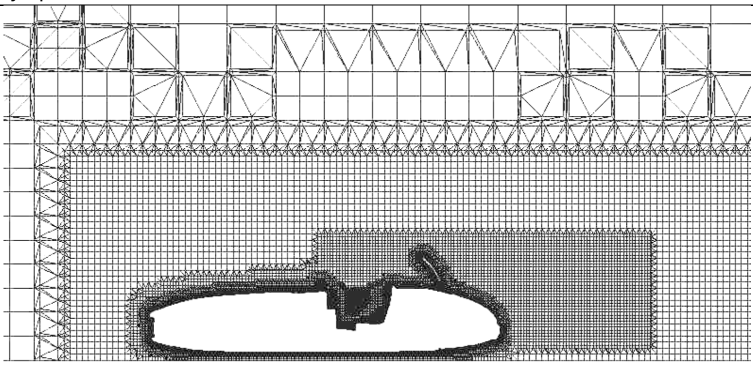

Figure 4 – Resulting volume mesh

This mesh was then imported into Fluent version 6.3.26 were the cases were set up and solved for.

Simulated Cases

With this geometry, figure 3, a couple of different things were studied. In the first paper, [1], the general aerodynamics of the vehicle and the function of the airbrake were studied. This was done for four cases, cases with and without the airbrake in operation together with the vehicle in close proximity to the ground or in the free stream, table 1 summarizes this.

Case #	Ground status	Airbrake status
1	Vehicle in close proximity of ground	In operation
2	Vehicle in close proximity of ground	Not in operation
3	Vehicle in free stream	In operation
4	Vehicle in free stream	Not in operation

Table 1 – Cases studied in paper [1]

In the second paper, [2], the above presented geometry and methodology was used to simulate the aerodynamic influence of the vehicle to different pitch angles. In [2] pitch angles between -60 and +60 were simulated for. Furthermore, in [2] a mechanical model was derived to calculate the path of flight of the vehicle with and without the action of aerodynamics on the vehicle, enabling to investigate the influence of aerodynamics on the length of flight.

3. RESULTS

General Aerodynamics

In the first study, [1], aiming to study and quantify the general aerodynamics of the vehicle, the following results were obtained, see table 2 and figure 5-7.

Case #	Drag Coefficient	Lift Coefficient	Pitch Coefficient
1	0,615	-0,013	-0,234
2	0,295	0,337	-0,073
3	0,611	-0,211	-0,044
4	0,278	0,085	0,049

Table 2 – Aerodynamic Coefficient for first study, pitch axis definition is shown in figure 5

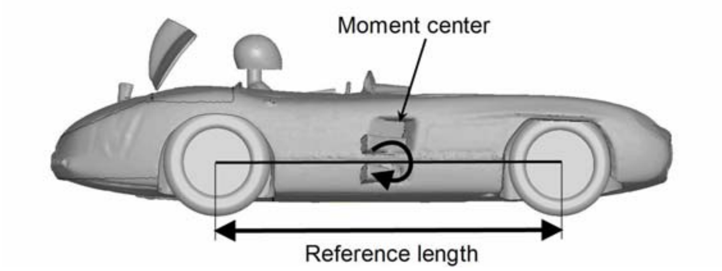

Figure 5 – Pitch axis definition

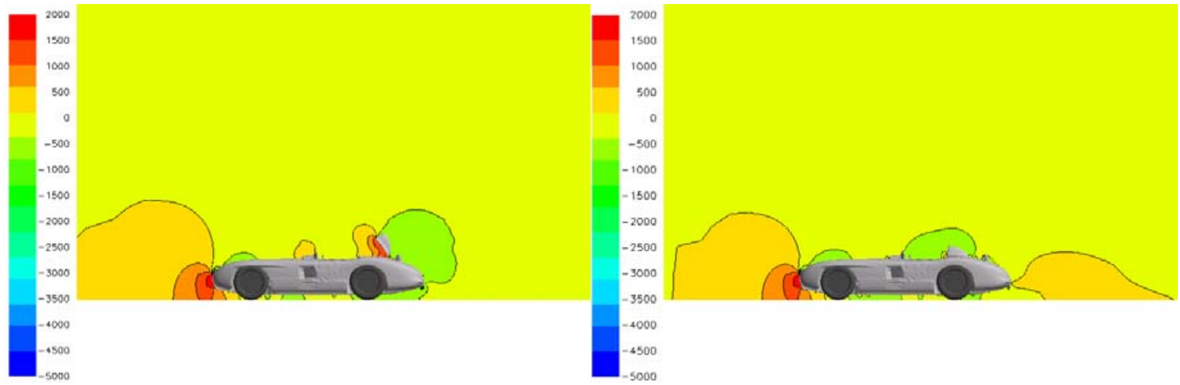

Figure 6 – Static pressure contours of the vehicle in close proximity to ground with (left) and without (right) the airbrake in operation.

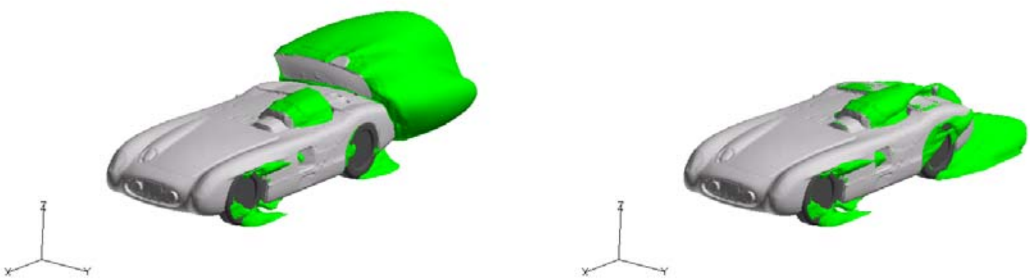

Figure 7 – Total pressure = 0 isosurfaces of the vehicle in close proximity to ground with (left) and without (right) the airbrake in operation

Pitch Influence and Flight Length

In the second study, [2], aiming to simulate enough data to calculate a flight path of the vehicle with and without aerodynamic effects acting on the vehicle, the results according to figure 8 were obtained.

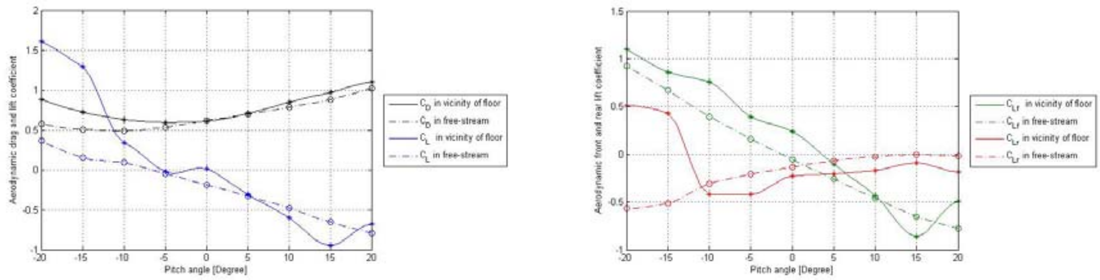

Figure 8 – Aerodynamic coefficients of the vehicle plotted as dependent upon vehicle pitch angle. To the left is in close proximity to ground, to the right for free stream conditions

After this the length of flight was computed with and without aerodynamic effects. See figure 9 for one example.

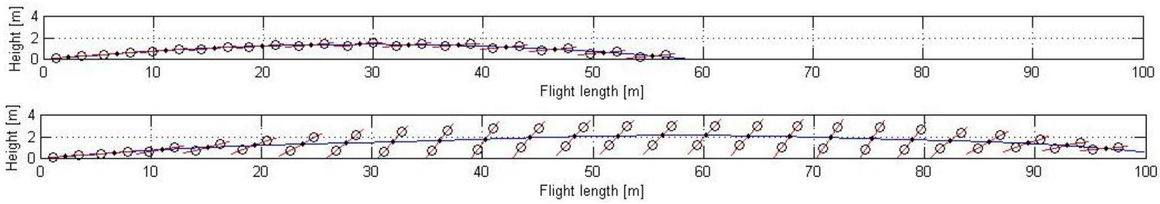

Figure 9 – Example showing a calculation with and without aerodynamic effects, the upper figure shows without the action of aerodynamics on the airborne vehicle, the lower shows with the action of aerodynamics.

In the second study, [2], two assumptions had to be made, one regarding the moment of inertia of the vehicle and one regarding the severity of the crash. The influence on the results of the initial assumptions were also investigated and published in [2].

4. DISCUSSION

Regarding the aerodynamic investigation of this vehicle some interesting things were found. First of all was the function of the airbrake confirmed; aerodynamic drag more then doubled with the airbrake in operation, see table 2. This action has also been confirmed in wind tunnel testing published in [3], and can quite easily be understood by looking either in figure 6 or 7. In figure 6 one can see the heavily increased static pressure in front of the airbrake when this is raised. This increase of pressure results in an increase in drag. In figure 7, for the iso-surfaces of total pressure one can verify the increased volume of low total pressure behind the airbrake. This corresponds to areas of high energy losses in the flow, hence an increase in aerodynamic drag.

When it comes to the downforce this study found a positive effect of the airbrake on downforce. With the airbrake in operation downforce actually increased, this would actually improve corner handling of this vehicle in a race situation.

The two effects of the airbrake, increased drag and increased downforce has actually been documented by the drivers of that time in the classical literature. Mike Hawthorn wrote in [7] that "…he (Juan Manuel Fangio) could leave his braking (on the Mercedes) just about as late as I could on the disc-braked Jaguar…". Similar statements are found in [6]. Also Juan Manuel Fangio and Stirling Moss were joined in the statement that this version of Mercedes Benz 300 SLR "had a much better cornering with the air-brake in operation", see Moss and Nye [8]

Unfortunately, due to the rearward placement of this device, it creates a resulting off-axis drag; this will cause a significant pitch moment of the vehicle, verified in table 2. In an accident scenario will this pitch moment aid the car to take off, and in the second study was the flight path calculated and the aerodynamics of the vehicle was found to be one major influencer of the length of flight of this particular vehicle design, seen in figure 9. For the settings presented in this paper the length of flight increased with 80% with the action of aerodynamics on the vehicle.

5. CONCLUSIONS

What has been seen in the above work is primarily that aerodynamics had a significant effect on the Mercedes Benz 300 SLR. With basic aerodynamic simulations has the driver perceived behaviour of the vehicle been verified.

Regarding the accident has this work shown that the aerodynamic influence of the vehicle with airbrake in operation is significant. Although the flight path estimations were based on a highly simplified model a clear tendency of a much longer flight path was found when including aerodynamic effects.

Potentially has this work uncovered a major contributor to the severeness of the accident in 1955 Le Mans race and contributed to deeper understanding of the accident scenario.

Furthermore has this project also showcased the strength of the pre-processing facilities of the BETA software ANSA,

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