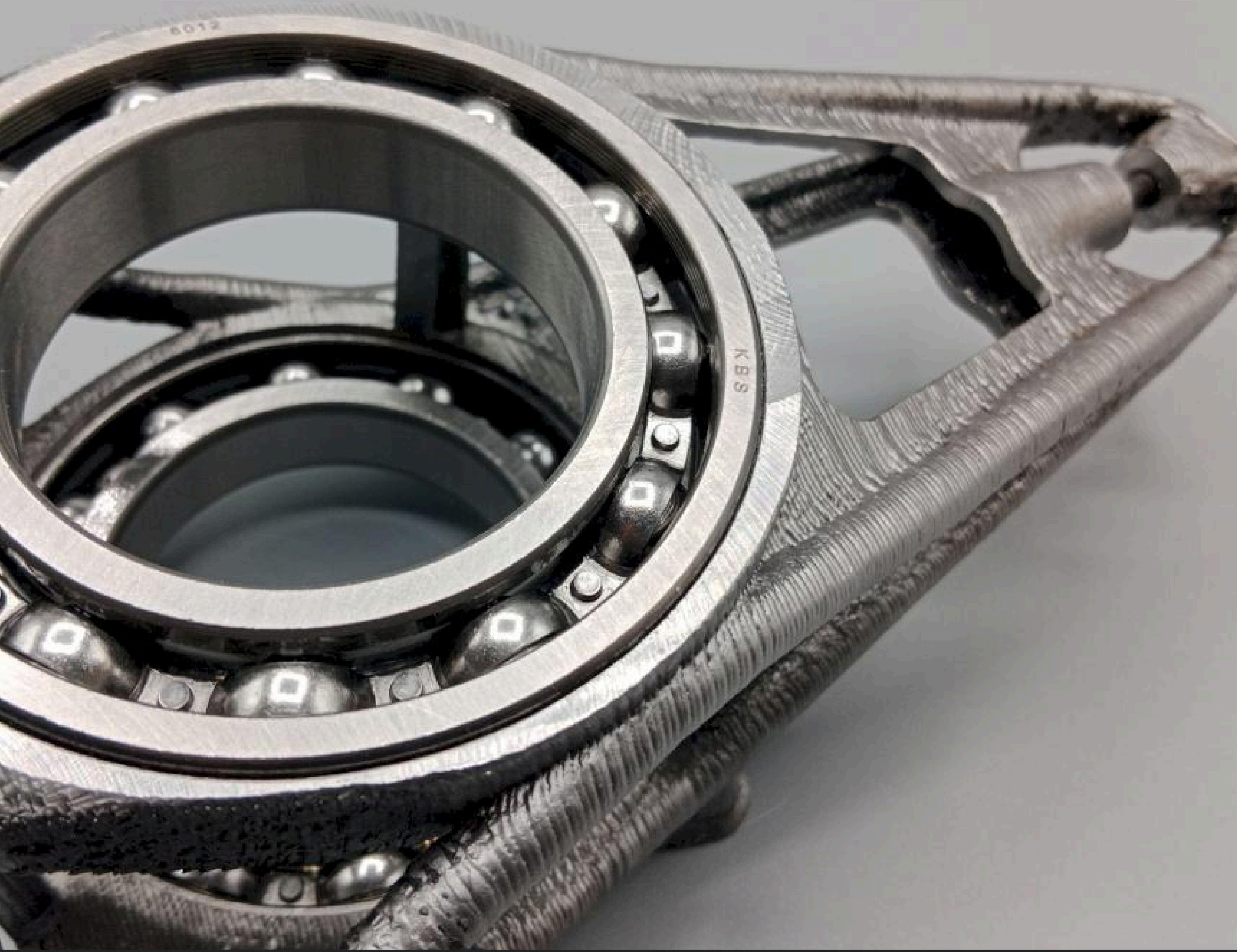
MELTIO

Q1 / 2025



Application Case Study development with Meltio system

Case study developed by Hirudi 3D Intelligence

Meltio M450

Index

Introduction

1.1. Application Industry

You have chosen to compete in the automotive sector. And why?

In this sector, the constant evolution of the systems that make up the vehicle requires production volumes that are usually no more than a single set but require complex, light, and precise parts. In addition, these vehicles are often unique and are redesigned for each new season.

Figure 1: Market trend in the motorsport sector

The demanding characteristics of this sector might lead one to think that technologies such as LMD are out of the question.

However, HIRUDI is convinced that Meltio's LMD technology has a potential that exceeds the range of complexity usually attributed to it. They have chosen this high-requirement sector to demonstrate Meltio's potential. In this way, we could address more sectors that also demand designs with complex geometries, high load capacity, and low numbers of units.

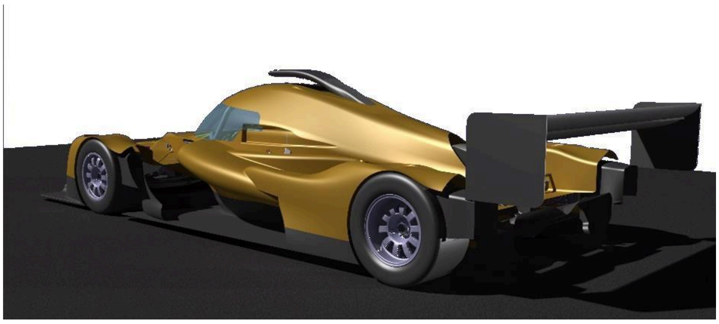


Figure 2: Racing car for mountain climbing

1.2.Application overview

A component of the suspension system of a prototype hillclimb vehicle has been chosen. The component under development, the stub axle, is a mechanically demanding part whose operation is critical to the performance and safety of the vehicle.

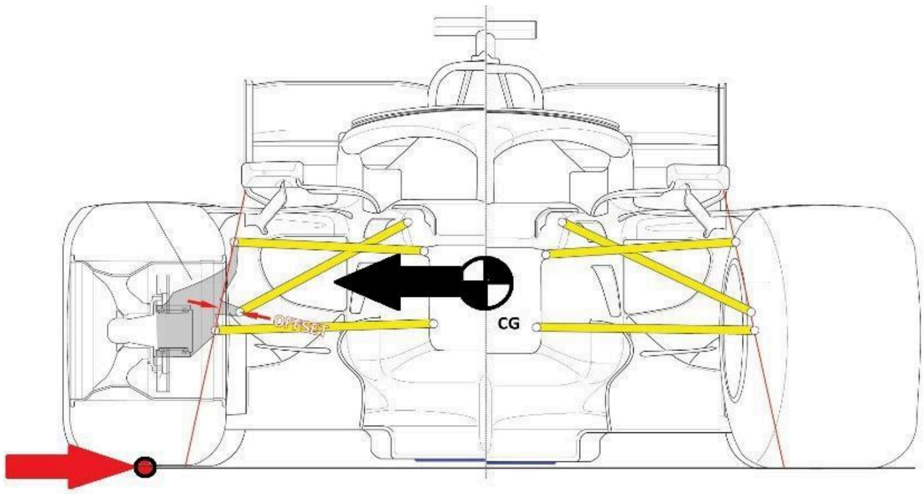


Figure 3: Market trend in the motorsport sector

The stub axle is the element that supports the wheel hub, mounted on one or more bearings. It transmits the forces generated in the contact track between the wheel and the ground to the chassis via the suspension arms.

They control the relative position of the stub axle to the chassis and the relative position of the wheels to the ground.

Their geometry, stiffness, mechanical strength, lightness, versatility and ease of access and maintenance are critical.

1.3. Starting point. Boundary conditions

The design of the stub axle for Hybrid Manufacturing is a further variant in the process of exploring possibilities. Previously, the design had been oriented towards boiler-making processes, with mechanically welded solutions and machining.

These designs exploited the advantages of the manufacturing process for which they were conceived, minimised the impact of their limitations and adopted strategies to limit the cost of manufacture.

The set of geometrical and operational conditions imposed by other vehicle systems, the mechanical strength requirements and the rigidity and lightness objectives were taken as a starting point.

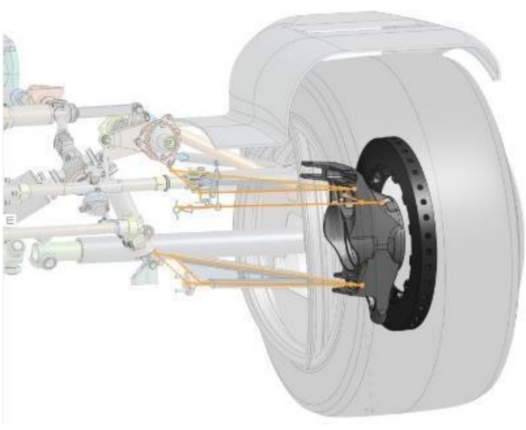


Figure 4: Stub axle sub-assembly

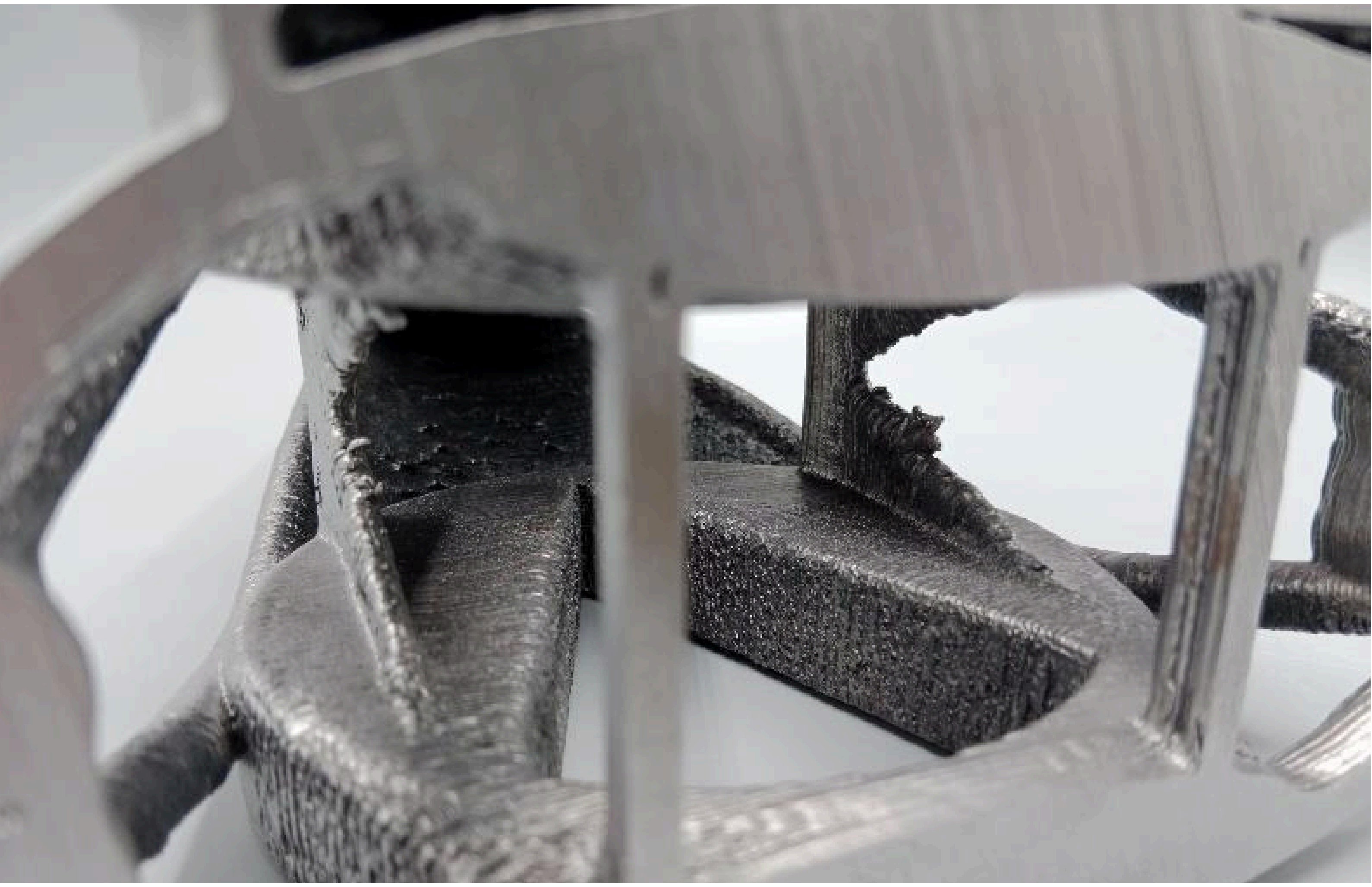
The geometrical and operational conditions define the design volume, and the anchorage points of other elements and impose the need to allow access to certain regions for tools, parts to be installed, etc.

The mechanical requirements involve an iterative process in which compliance with the imposed conditions of strength and stiffness must be verified..

2. Objectives

This project aimed to explore the possibilities of the concept of Hybrid Manufacturing (Additive + Subtractive) for parts with a certain relevance for the industrial fabric. These will be an alternative if the results are positive by pursuing various advantages:

- Exploit the potential of the Meltio system to solve geometric challenges and design a rigid and lightweight part.
- Reduce the cost of this element compared to the SLM alternative by improving metallurgical quality while maintaining a certain geometric complexity.
- Reduce delivery time and costs compared to other manufacturing processes.



3. Stages

3.1. Design adaptation for Meltio process with Wire

The design process begins, after establishing the starting point, with a study of the conditioning factors of the Meltio system manufacturing process and the subsequent machining process.

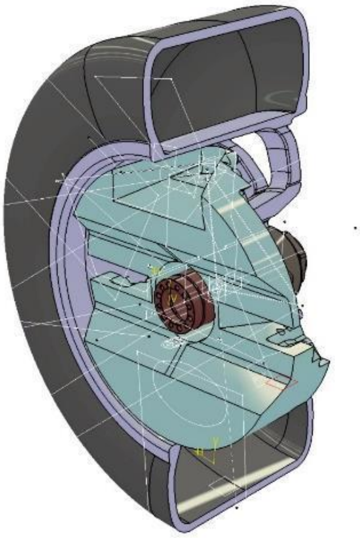
The conditioning factors of the Meltio system, in our case an M450 machine, are diverse. On the one hand, the work volume limits the size of the workpiece. The Meltio M450 system has a volume of 150 × 200 × 450 mm. On the other hand, the design guide describes the recommended values for different geometric elements for optimal printing.

3.2. Part analysis. Design

After a study of all the factors that define the envelope of design possibilities and requirements, a part concept and a design philosophy were defined.

The stub axle was conceived as a series of geometric elements designed to absorb the load of a set of external bodies (bearings, spherical plain bearings, bolted joints...) and another series of geometric elements whose purpose is to transmit the load between the former.

Given the possibilities of the Meltio system, the design of the latter results in very mechanically efficient load-bearing elements, located in the regions where the material will be most in demand.



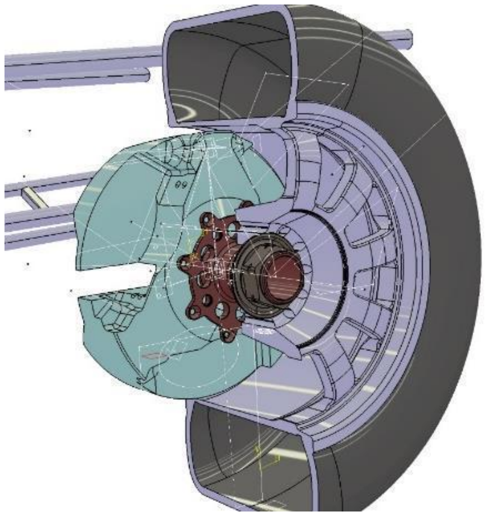
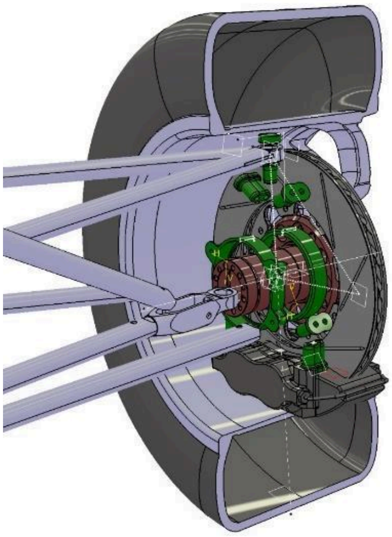


Figure 5: Available volume interior view *Figure 6: Available volume external view*



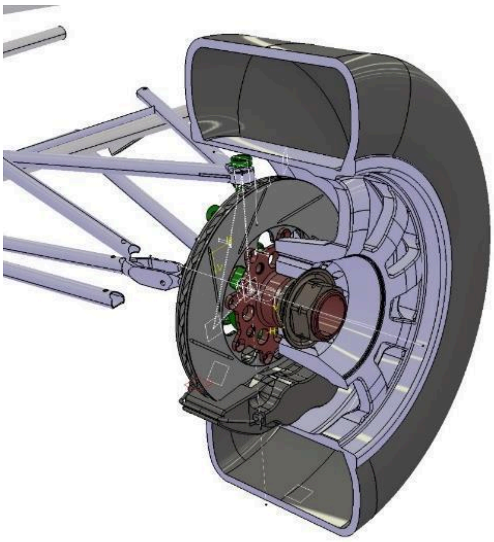


Figure 6: Load-absorbing regions (green, inside view) Figure 7: Load-absorbing regions (green, outside view)

3.3. Design/manufacturing iterations

An iterative design and manufacturing process was started to move forward consolidating all those features of the Meltio system manufacturing process that had been assumed.

Each design iteration worked on increasingly sized fragments of the target part. The CAD design was followed by a verification of the manufacturing conditions (thicknesses, maximum cantilever angles...).

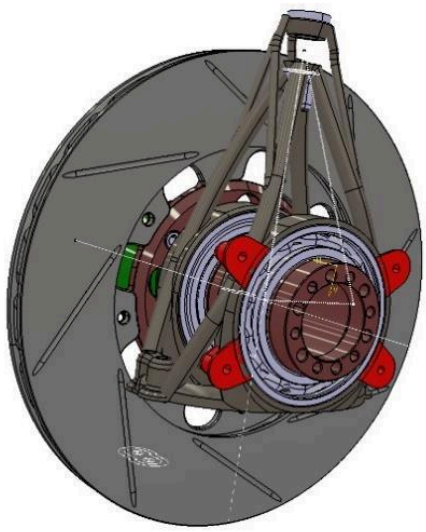


Figure 7: Mechanical design. Iteration

Subsequently, the lamination for the manufacture of the part was carried out and the potential problems or difficulties that could be encountered with the design to be examined were studied.

3.3.1. Auxiliary elements for the correct manufacture

To minimise machining and save material, the supports were designed from the CAD model itself so that the areas of the part that were most difficult to print were self-supporting.

In this way, we avoided the need to allocate large volumes and material supports in the lamination process in Simplify 3D.

An example of this is the housing for the central bearings or the upper part where the ball joint is housed.

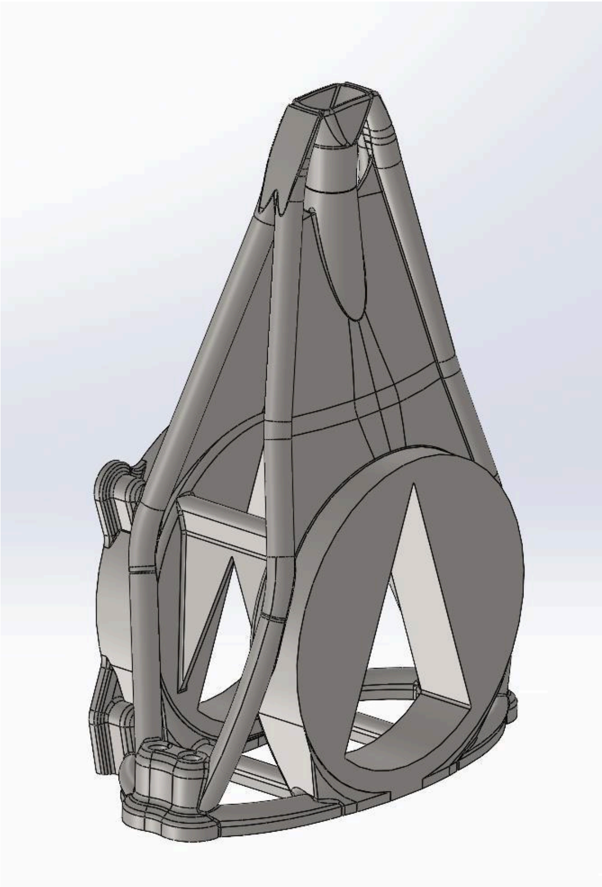


Figure 9: Auxiliary elements for proper manufacturing

3.4. Characterisation of manufacturing

In this phase, the process parameters were iterated by varying them to find the optimum settings that would allow the part to be produced with the fewest possible geometric restrictions.

These iterations were carried out by fragments, giving the greatest relevance to the most requested areas. Each part of the piece corresponds to different lamination processes.

The criteria for separating the part was based on the main geometric characteristics that influence manufacturing:

- Size of the surface area of isolated sections (islands):

This feature is related to the control of the energy and flow deposited on the surface to be worked. By controlling these two parameters, we avoid overheating that may occur during the printing process.

- Overhang angle
- Path overlaps to consolidate the density of the part to be printed.

Each fragment was fabricated after the previous one was consolidated. These fragments were fabricated together with the previously fabricated fragments to see the overlapping behaviour with the pre-existing fragments.

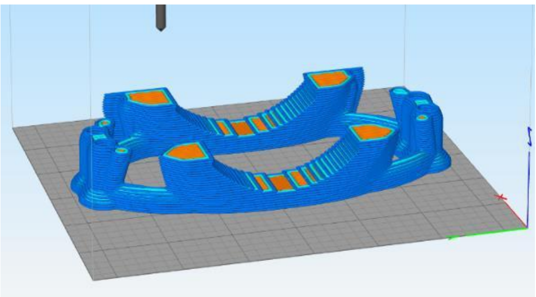


Figure 10: Fragmentation 1

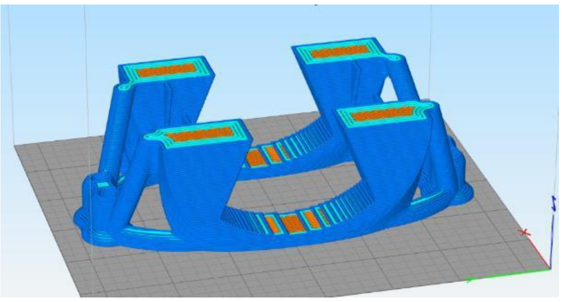


Figure 11: Fragmentation 2

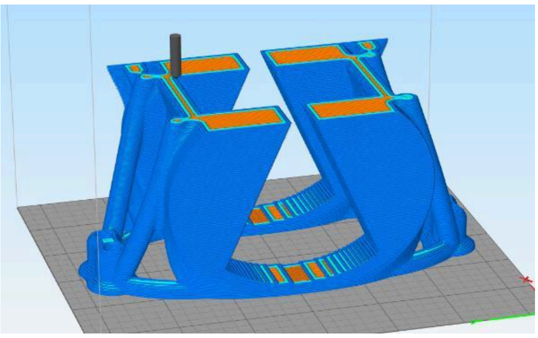


Figure 12: Fragmentation 3

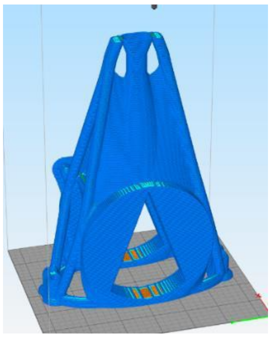


Figure 13: Fragmentation 4

The results of the tests carried out resulted in the following laminate. Each part of the part is a process in which the layer height, number of perimeters, amount of deposited energy and input rate vary.

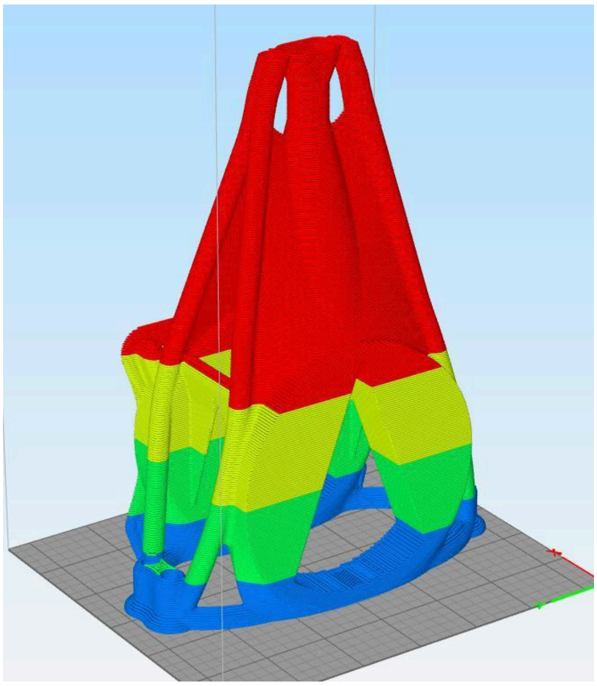


Figure 14 : Complete rolled part in different processes

It was possible to reach the limit of certain variables such as cantilever angles, wall thicknesses or minimum manufacturable cross-section. This made it possible to discover the limits with which the design department had to deal in order to achieve manufacturing success.

Once these limits were known, the relevant design changes were made and the complete manufacturing was carried out based on the empirical findings.

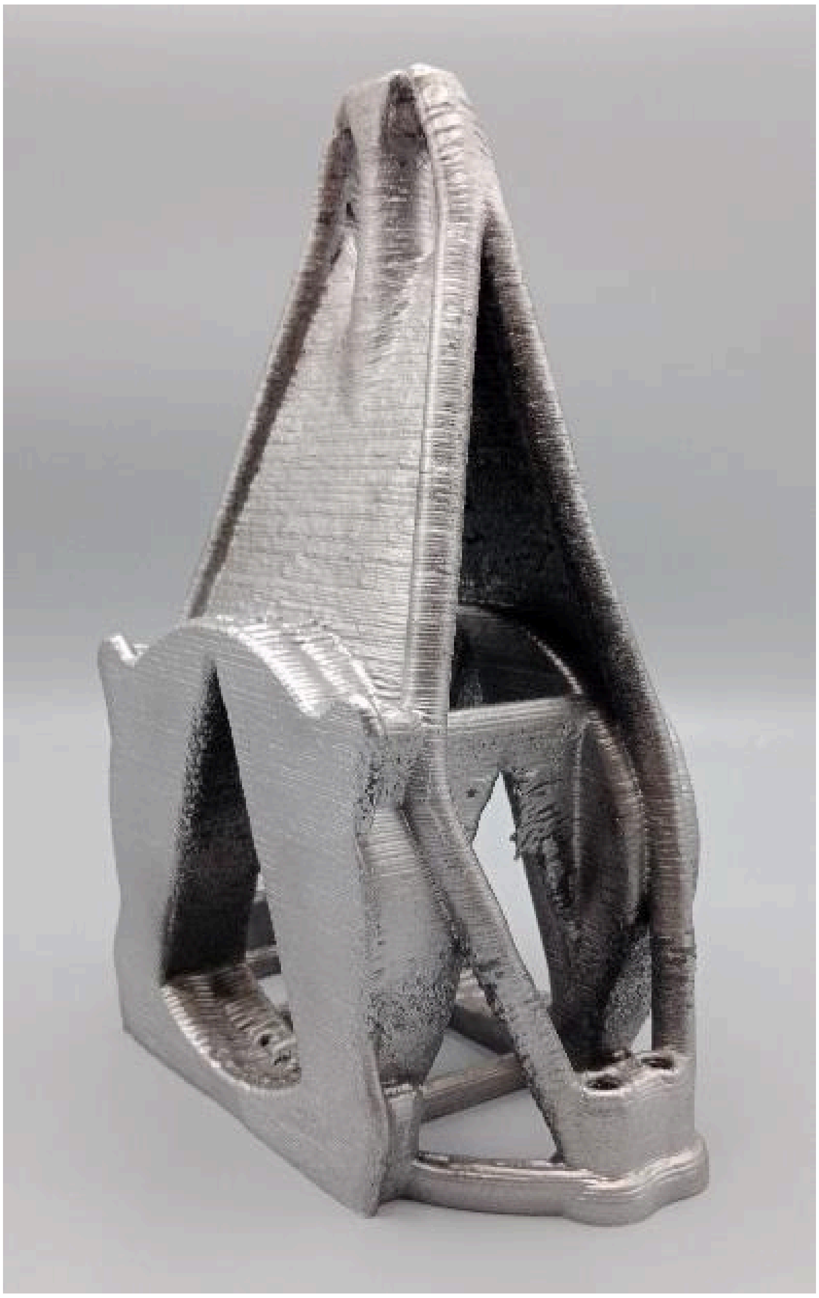


Figure 15: Result of the iterative process

3.5 FEA Simulation of the part

Each iteration cycle was validated with FEA tools before manufacturing. Although the region of interest in each iteration was fragments of the part representing increasing percentages of the total part, the entire part had to be designed (and redesigned) to perform the full FEA analysis.

The main load cases that mechanically require the part are the lateral load and the braking load.

The material used for the manufacture of this part was ER70S6 mild steel, which is highly weldable and easy to machine.

A mesh convergence study was first performed to determine an efficient element size for the case to be analysed to capture the complex geometry of the model.

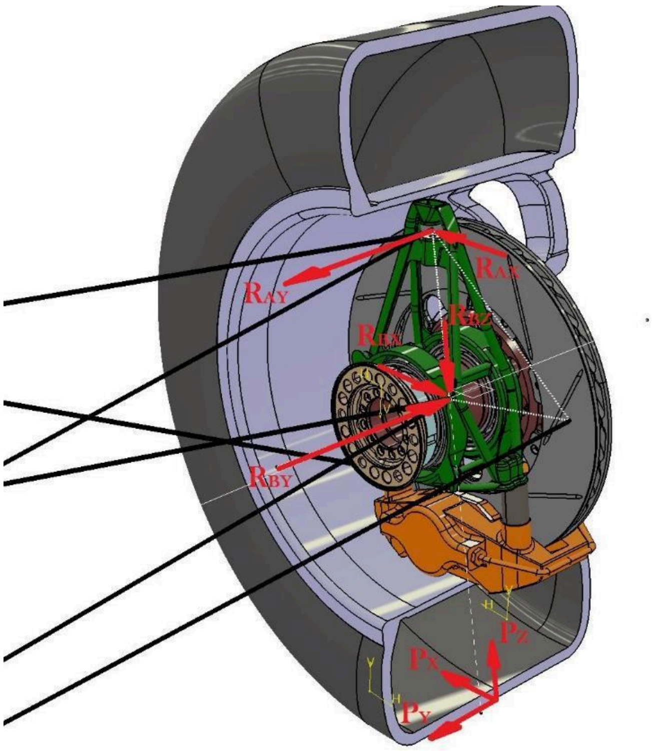


Figure 16: Stub axle loads and reactions

Loading case	Value					
Longitudinal	Fax(N)	Fay(N)	Faz(N)	Fbx(N)	Fby (N)	Fbz (N)
	7000	0	0	10000	0	-4000
Lateral	Fax(N)	Fay(N)	Faz(N)	Fbx(N)	Fby (N)	Fbz (N)
	0	11500	0	16250	0	-3000

Property	Value	
Density	7750	kg/m3
Modulus of elasticity	210 000	Mpa
Poisson's ratio	0,33	-
Yield strength	400	Mpa
Breaking strain	525	Mpa

3.5.1. Lateral load

The lateral load is calculated according to the lateral acceleration target of 2Gs. Associated with this load case are forces acting in combination relative to a vertical load case. Safety coefficients of 2 and 4 are used for horizontal and vertical loads respectively.

The suspension system must be protected from vertical impacts, but the suspension arms must yield above certain load values.

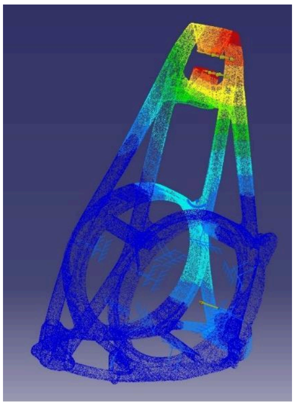
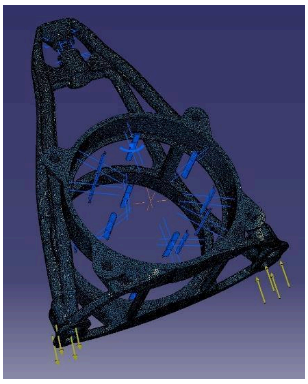
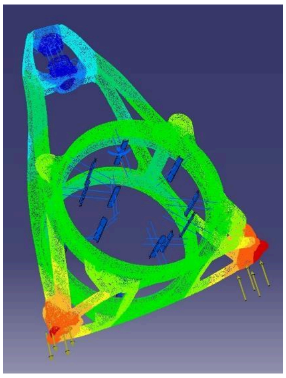


Figure 17: Lateral load case. Mesh size 0.5mm Figure 18: Lateral load stresses Figure 19: Lateral load displacements

3.5.1. Longitudinal brake load

The longitudinal load is calculated according to the braking acceleration target of 2.5Gs. Forces relative to the vertical load also act in combination. Safety coefficients 3 and 4 are used for the horizontal and vertical loads respectively.





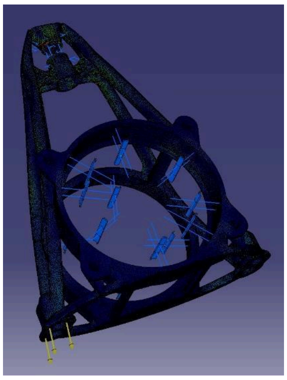


Figure 20: Lateral load case. Mesh size 0.5mm Figure 21: Lateral load stresses Figure 22: Displacements

The following table shows the maximum Von Mises displacement and nodal stress values for the different load cases.

Loading case	Tension Max Mpa	% Elastic limit	Max displacement (mm)
Longitudinal	325	82,48	0,75
Lateral	367	87,61	1,25

On the other hand, this study has not considered the auxiliary elements that will be installed with the part in operation: bearings, spherical plain bearings with their bolts, suspension arm supports, etc., which support the loads at the points where they act and provide added rigidity.

3.6. Machining

As mentioned above, the machining process was always present during the development of the design due to the constraints it imposes.

It was not until this development had been completed that the manufacturing plans were drawn up for machining.

The parts to be machined were limited to the areas where the commercial components were to be assembled, in addition to the areas where supports were incorporated from the design stage.

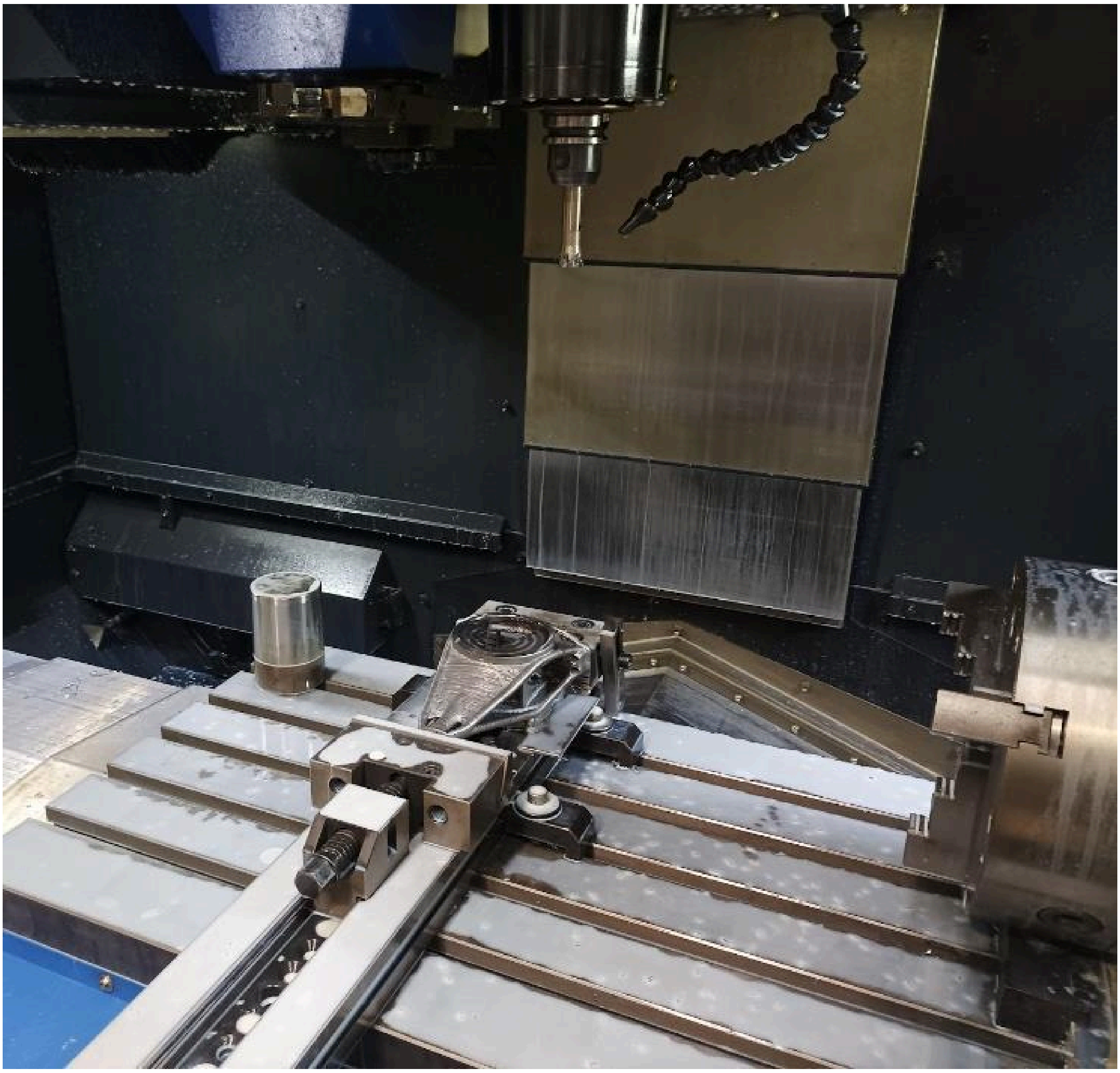


Figure 23: Perform during the machining process

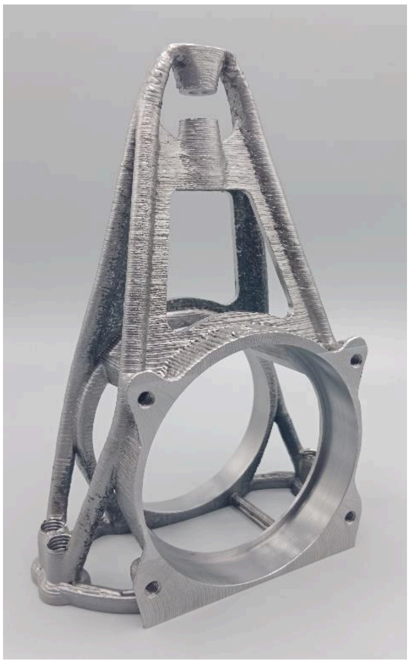


Figure 24: Machined part

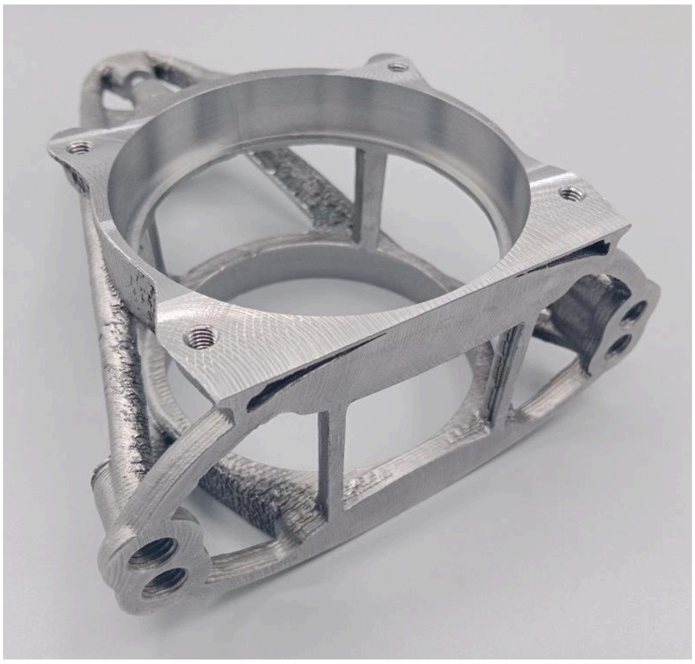
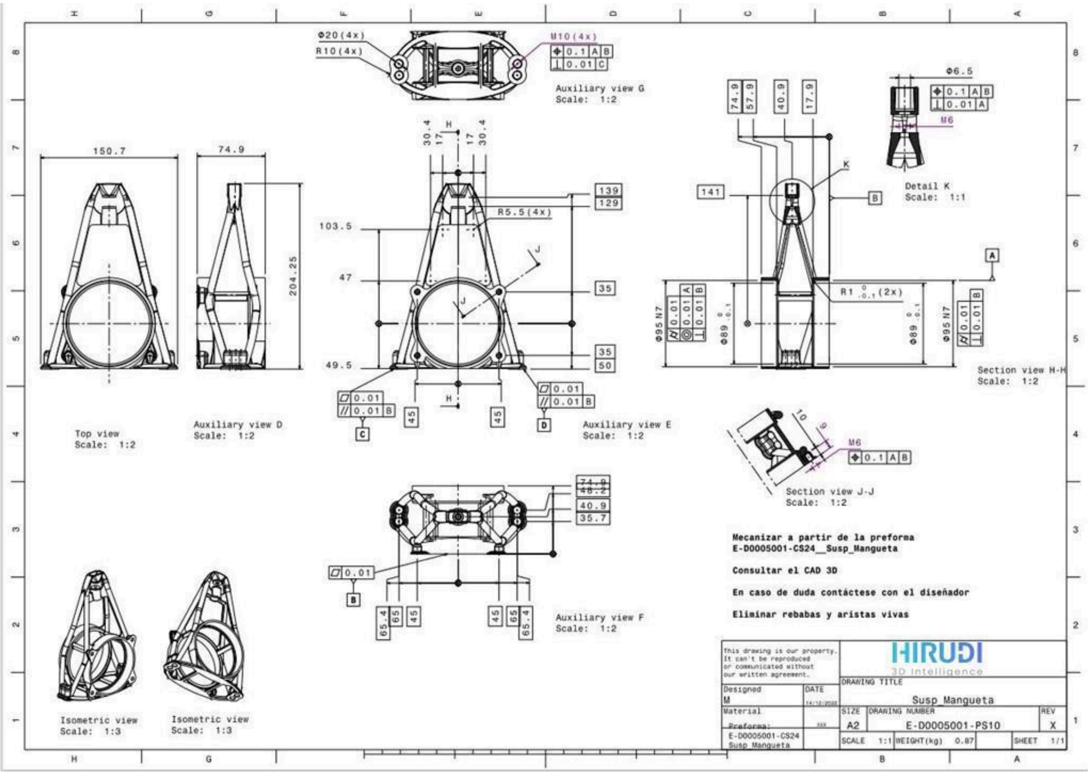


Figure 25: Bottom view. Brake caliper mountings

Figure 26: Machined part with mounted bearings

4. Results



The result of the manufactured part has been satisfactory as it has met the requirements of the company that requested the work.

The mechanical requirements of the part have been maintained, reducing its weight by 62.5% compared to the machined part.

4.1 Conclusions part geometry and metallurgical quality

From the results obtained, we can affirm that the Meltio system is valid for the manufacture of optimised parts with complex geometries.

The ability to manufacture parts with such complexity opens up a range of market possibilities in the racing car sector.

4.2 Time costs and comparison with machining only.

Loading case	Operation raw material cost	Transformation cost	Delivery time	Part weight	Total cost
Machining only	230€	550€	1.5 weeks	1.6 Kg	780€
Machining + LMD	11,54€	490€	1 week	1.0 Kg	501.54€

MELTIO

www.meltio3d.com