A REAL EXAMPLE OF END-TO-END PROCESS IN ADDITIVE MANUFACTURING TO CREATE A BOOGIE FOR ROLLER COASTER'S TRAIN

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Extreme Manufacturing Engineering

EXTREME-3D
MANUFACTURING
ENGINEERING

Introduction

NEW-CO for production of 3D metal printing of

LARGE INDUSTRIAL PARTS

LARGE SCALE PRODUCTION

OUR MISSION:

To overcome the prototypal phase in which AM is currently confined, for serial production of parts even of big dimensions and weights.

Kick-starting the effective additive manufacturing industrial revolution

HYSTORY (2023)

Roadmap&Evolution

Starting point

Taking the decades of experience from

Extreme Analysis Engineering (EAE)

which works in the designing, optimization, simulation and validation mechanical components with high complexity, such as roller coasters, aerospace and racing sectors.

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November 2023
Firstly signed contract for BLT machines starting new euorpean cooperation, at Formnext.

November 2024
Ready to install BLT S450 and BLT S800 to start up production.

January 2025
Planned to raise up a factory plant for 12 more printers and post processing operations.

September 2025
Lead AM to real production for higher quantities and large parts.

We propose to help our customers design and build products with AM technology until we deliver the finished product to them according to their requirements

EME ON THE MAP

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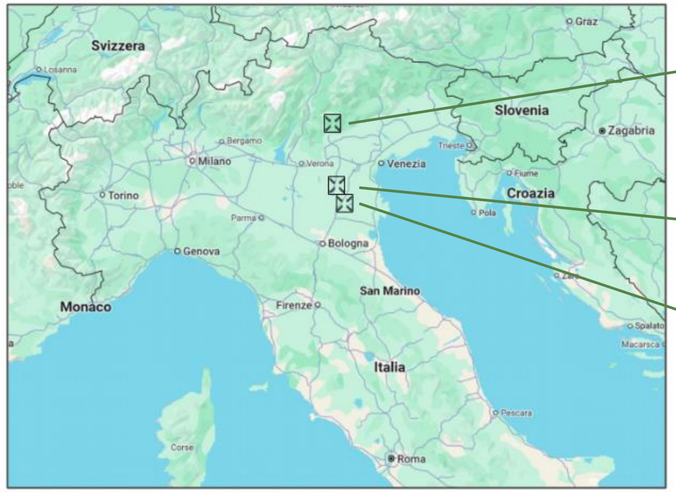
Position of our companies



Rovereto (TN)

EME R&D center in TNsviluppo

Casaleone (VR)

EAE HQ, temporary office for EME

Calto (RO)

EME HQ Factory (under construction)

First 2 installation PBDF Printing Machines in EME

BLT-S800

BLT-S450

Strategic Partnership

Companies

BLT

Partnership with ***BLT*** – world leader for SLM 3D metal large parts printers

POLO MECCATRONICA [Pro]M MECHATRONICS PROTOTYPING FACILITY

Supporting us in R&D and in prototyping to help the companies to learn how to industrialize the AM production

Application of AM in amusement rides

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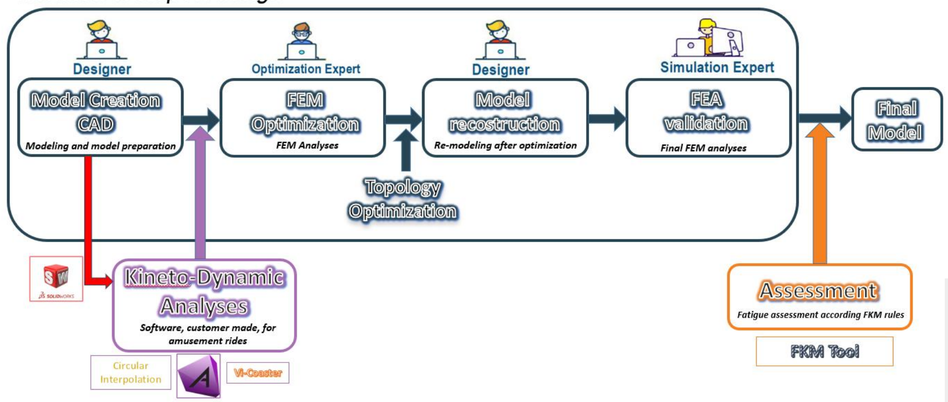
1. What is END-TO-END process in Extreme Engineering

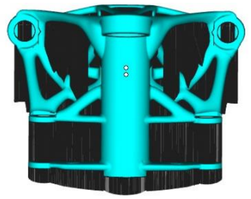
1.1 General Introduction

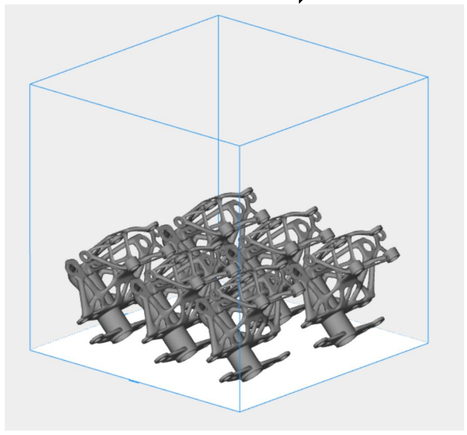
We propose ***End-to-End*** concept of Additive Manufacturing application for each sector where the technology is applicable or makes sense to be applied targeted at industrial design/production

END ***TO*** ***END***

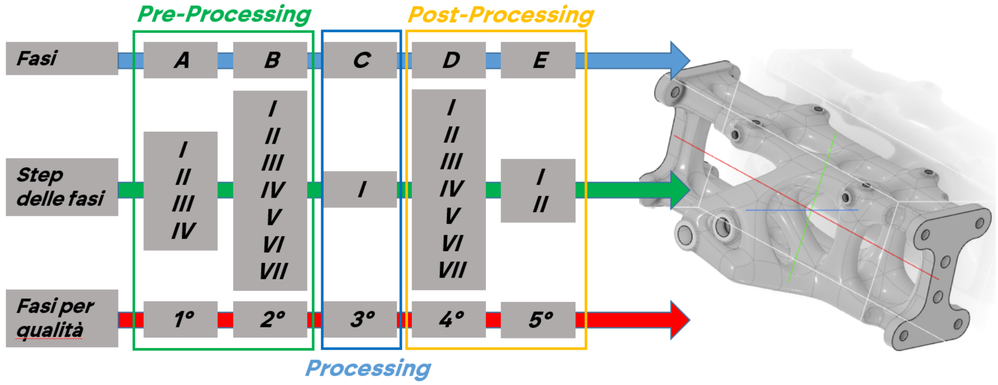
Workflow of step for design







Workflow Manufacturing process



Engineering design based on first patent

«Metodo per la progettazione topologica e la produzione con manifattura additiva o similare processo 3d di elementi meccanici/strutturali di giostre»

Production in quality based on second patent:

«Metodo supervisionato di controllo qualità e gestione della produzione di componenti meccanici con tecnologia additiva nel settore delle giostre»

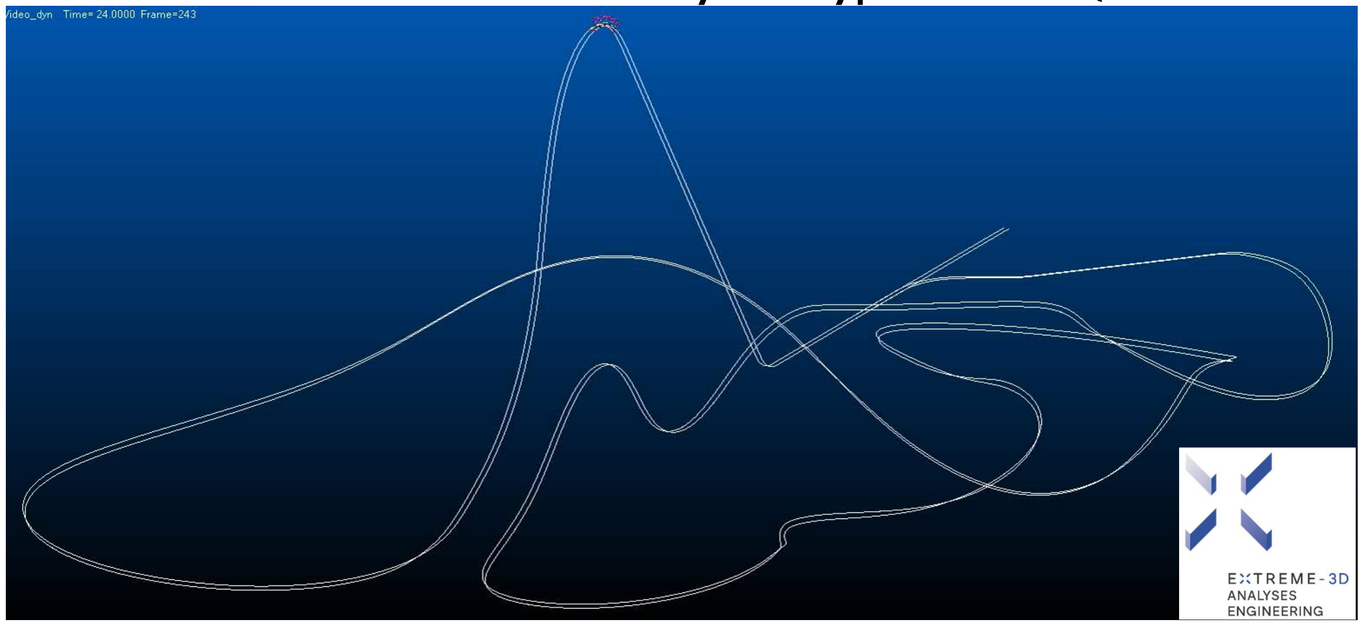
Traceability with Quality SW

CONCEPT PROPOSABLE FOR ANY SECTOR

2. Status of Art for design of roller coaster

2.1 Design of rollercoaster

We have made a technical feasibility of a hyper coaster (STATE OF ART)



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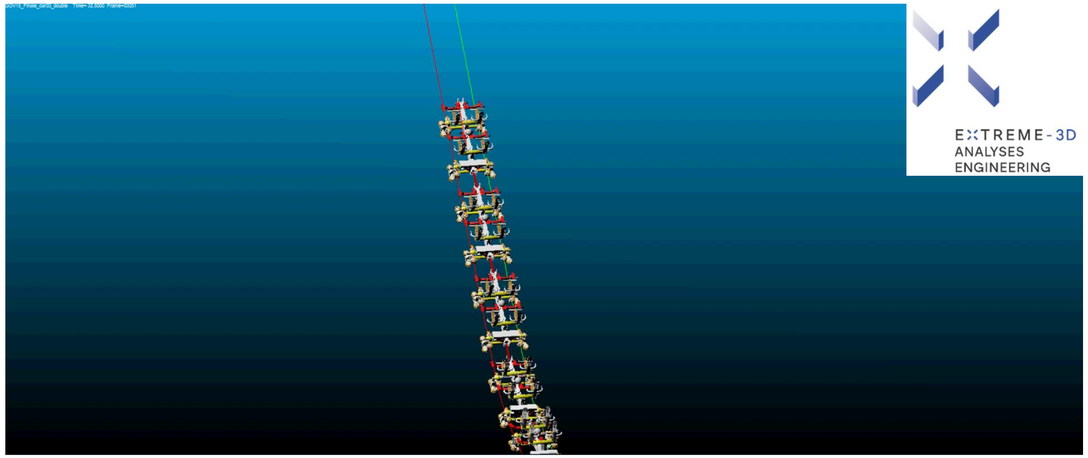
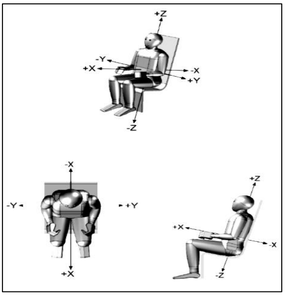
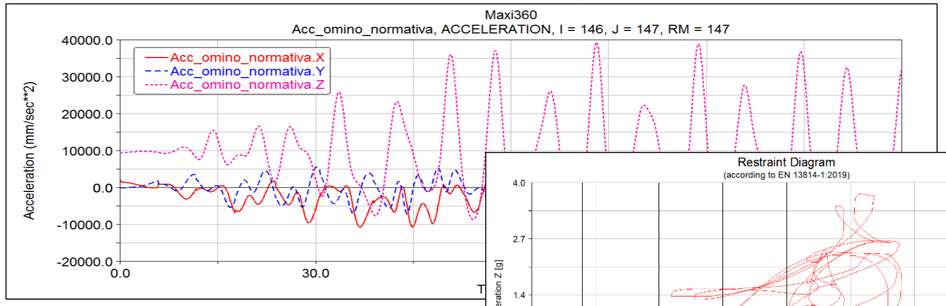
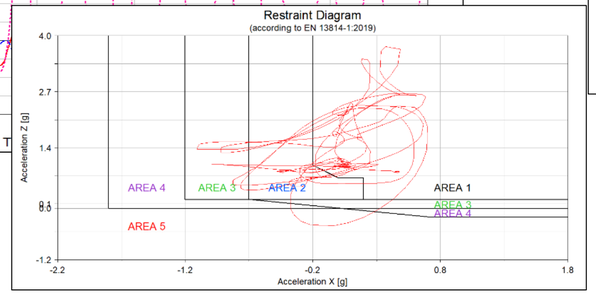


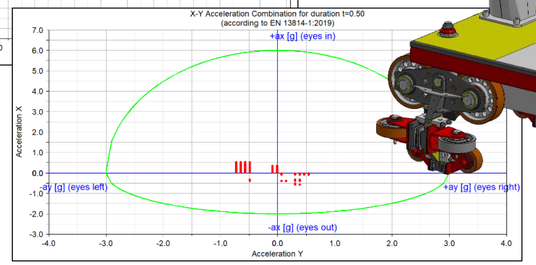
All the acceleration and reaction force to calculate the train arrive from kineto-dynamic Analyses

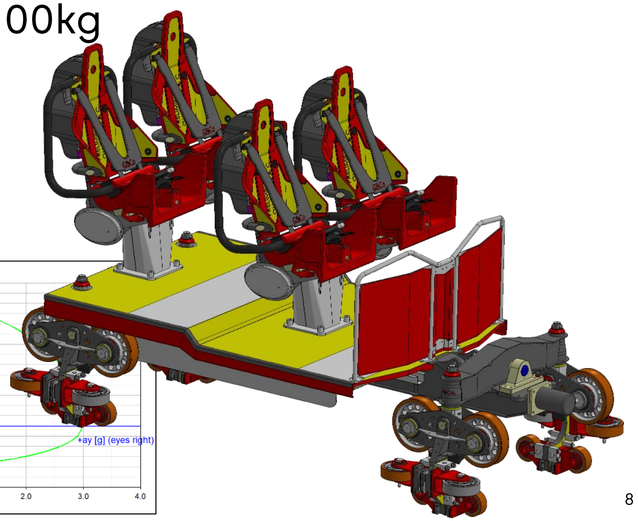
As Example a typical train vehicle is a classical risciò model and the structural parts weight is 1100kg





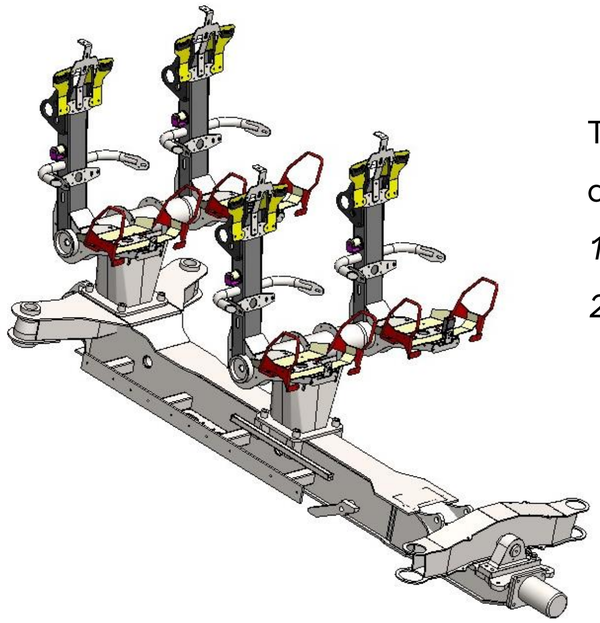






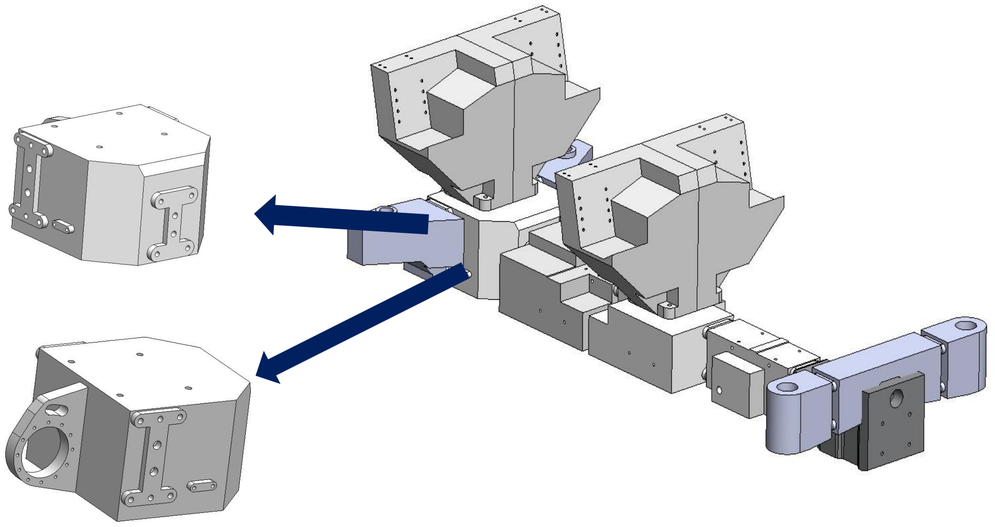
2. Status of Art for design of roller coaster

2.2 Actually design & application of DfAM



The study of the original model allows the designer to understand the two main types of constraints during the construction phase of the Design Space o DfAM.

1. *Geometric constraints:* not all parts of the model can be changed, frozen zones are thus defined
2. *Overall dimension constraints:* in this case obtaining a wrong shape could lead to problems related to the functionality of the piece.



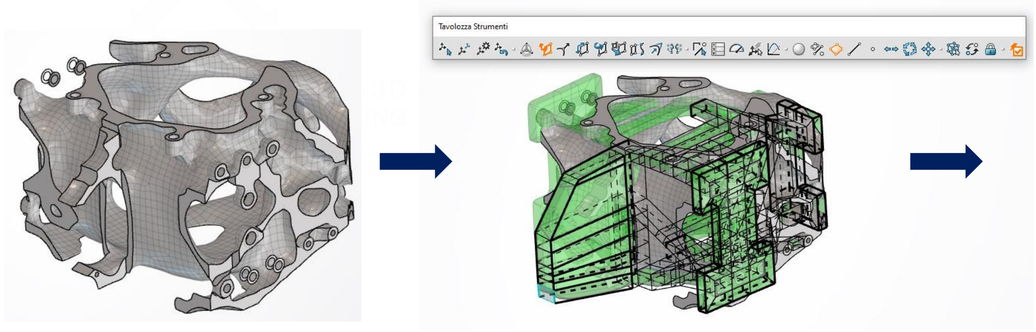
The creation of the design space must be carried out taking into consideration the constraints described above and trying to attribute the maximum possible volume to the piece intended for the optimization.
A larger volume allows two very important things:

1. Greater freedom in the reconstruction phase of the piece, in fact everything created outside the design space will be removed by the optimizer software.
2. Greater availability of deformation and distribution of the material in the computing phase, this allows to avoid stiffness nodes or mass concentrations that are not required and difficult to modify.

3. How the Additive manufacturing was integer in a design of roller coaster

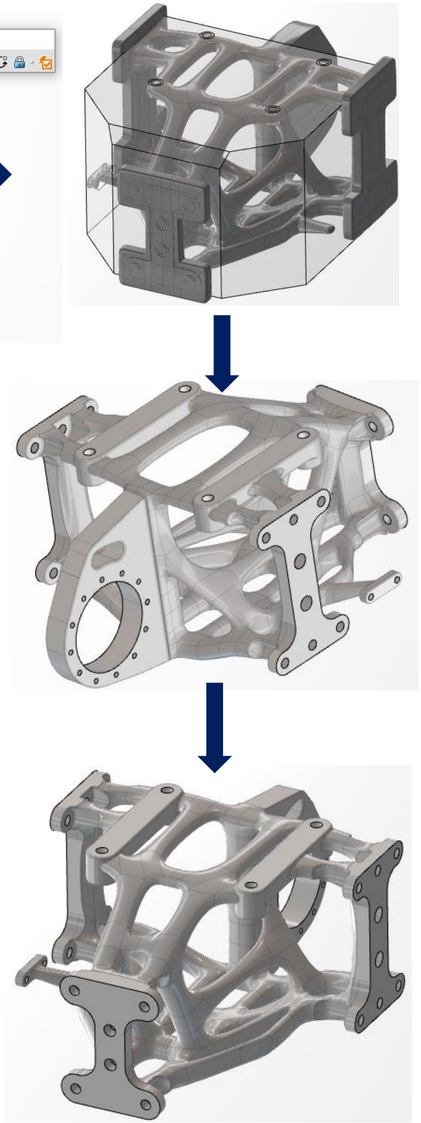
3.1 Fatigue Assessment and results

TOPOLOGY OPTIMIZATION



Next are the reconstruction phases using CAD tools and NURBS management of the concept shape obtained.

1. Modelling of NURBS in order to obtain an acceptable shape with the parametric modification tools of the surfaces (Green).
2. Application of the «Design Space» to the NURBS model. The Design Space will apply all the geometric limits defined in the preparation phase. At the same time, the frozen zones defined during the preparation of the FEM model are applied.
3. Finishing through hybrid CAD and NURBS management tools after applying the Design Space.



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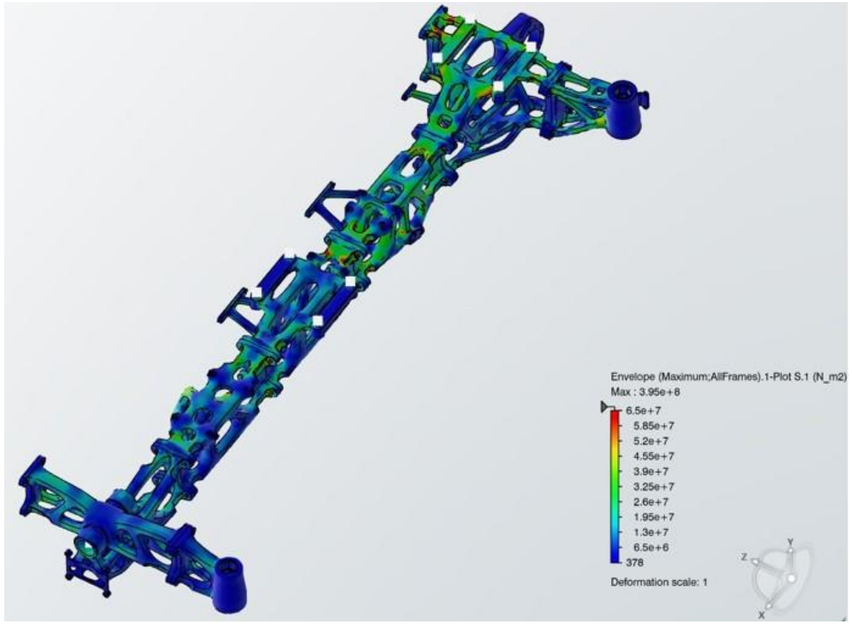
The validation phase takes place in two separate moments.

The first involves internal validation of the optimization platform by exploiting the present CAE.

Once this preliminary validation is done, a validation is passed on an external CAE as in this case ABAQUS with the FKM plug in for the fatigue assessment.

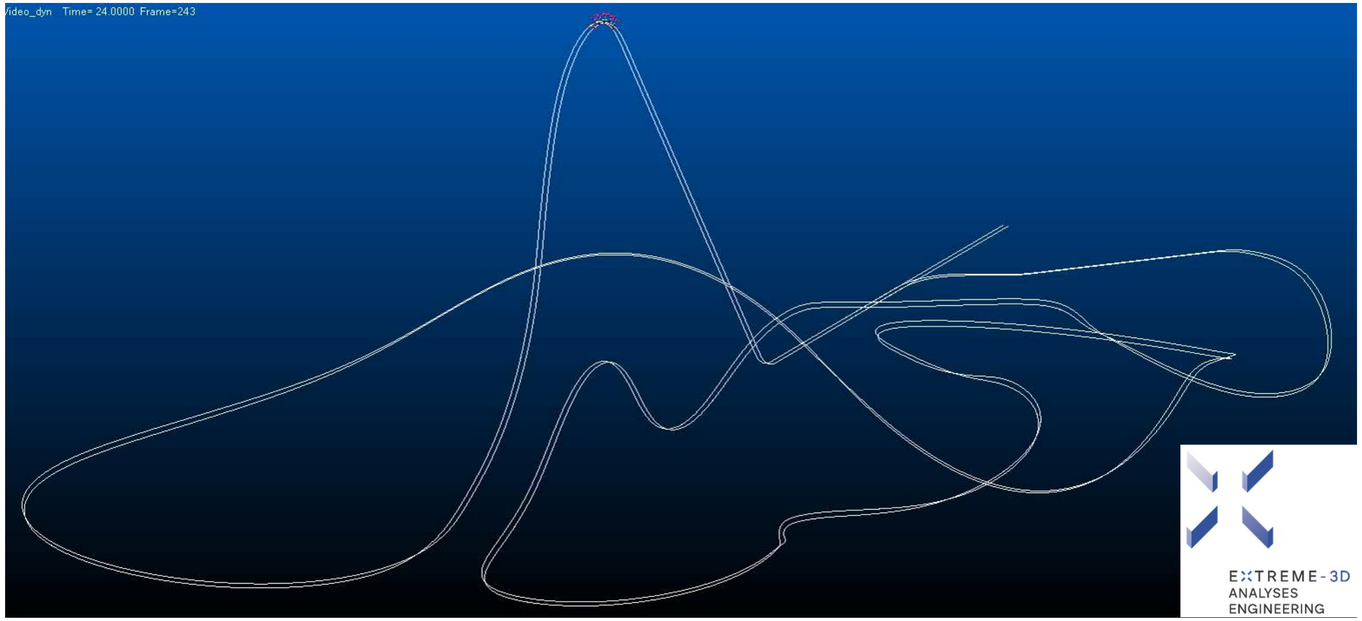
In case static and fatigue validation is passed even here the model can be considered suitable for the following phases, on the contrary it will be necessary to return to the CAD environment inside the platform to proceed with a correction or modification of the problematic areas.



3. How the Additive manufacturing was integer in a design of roller coaster

3.2 Final reconstruction

We have made a new technical feasibility of the hyper coaster (new car structure)



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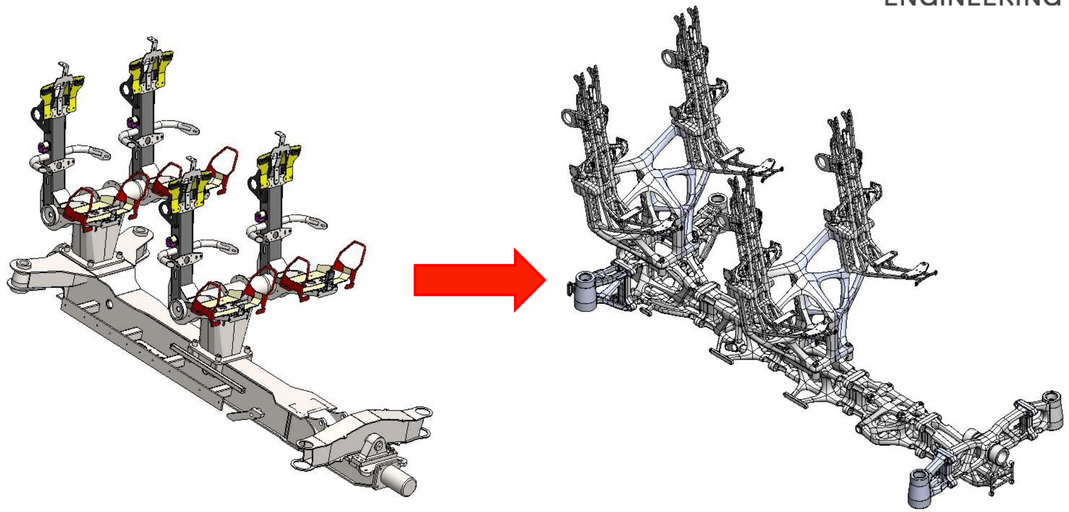
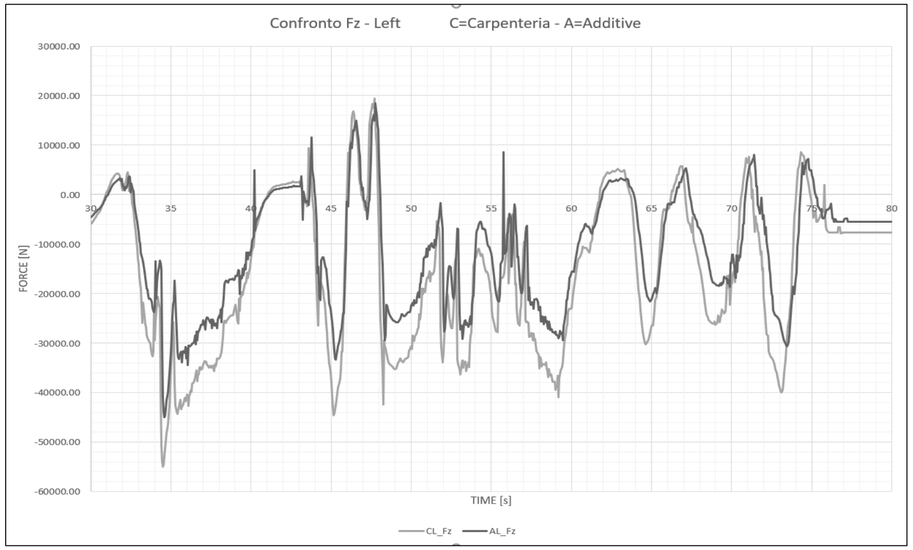


The weight of car is now ***350kg.*** The acceleration remain the same, but what happen at reaction force on Rail and entire structure of coaster?

65% Reduction of moving mass on the main structure of train

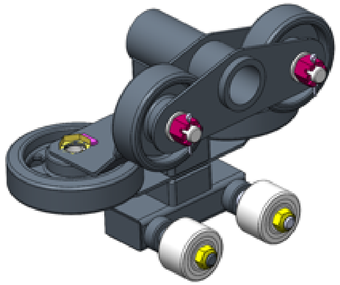
30% reduction of the supporting structure
(rails and colonnade/sub structure)



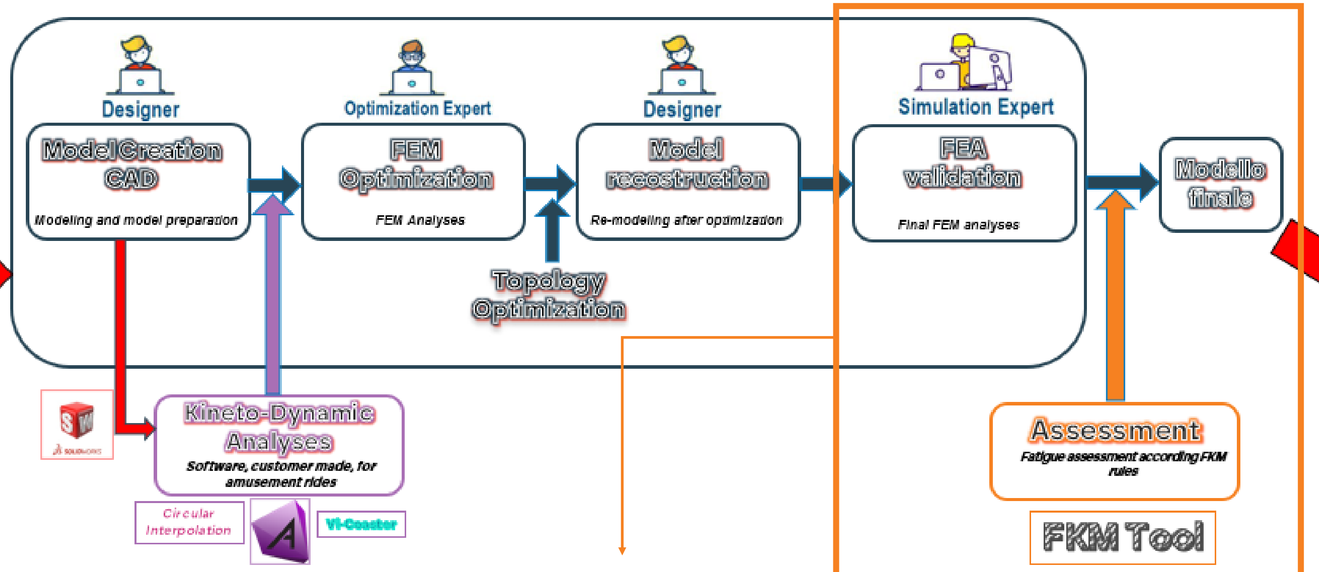
4. Example of printed Boogies

4.1 How END-TO-END was applied: First END

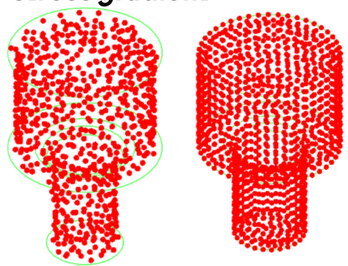
This design method, examples of which will follow, is a patent in EAE for an integrated design with fatigue validity of structural calculations for additive manufacturing

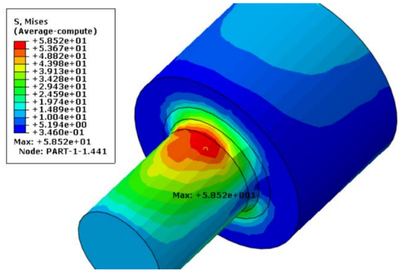


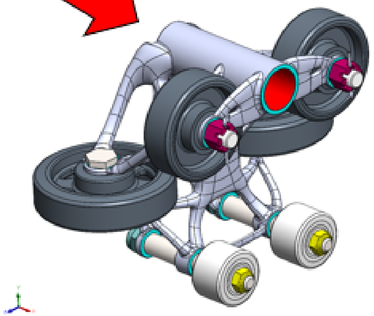
Original part &Starting 3D model:
Data:
Weight 25kg
13 Parts welded
Must be painted and protect against the corrosion



The procedure identifies nodes on the outer and adjacent surfaces below the surface and calculates the stress gradient





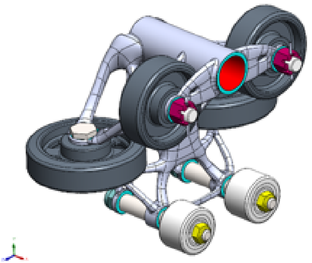


Final 3D model:
Dati:
Weight 10 kg
Only 1 part printed
No protection against the corrosion

4. Example of printed Boogies

4.2 How END-TO-END was applied: Second END

The 3D model studied in EAE arrives at EME to be 3D printed



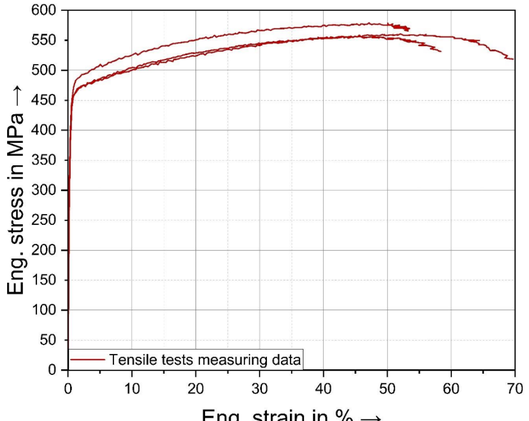
Traceability with Quality SW

Pre-Processing

Post-Processing

Phases	A	B	C	D	E
Step of Phases	I II III IV	I II III IV V VI VII	I	I II III IV V VI VII	I II
Quality phases	1°	2°	3°	4°	5°

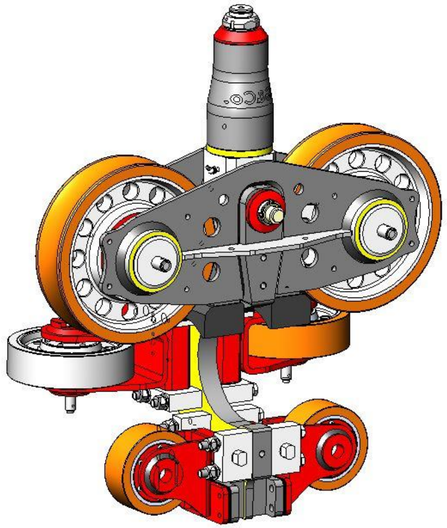
Processing

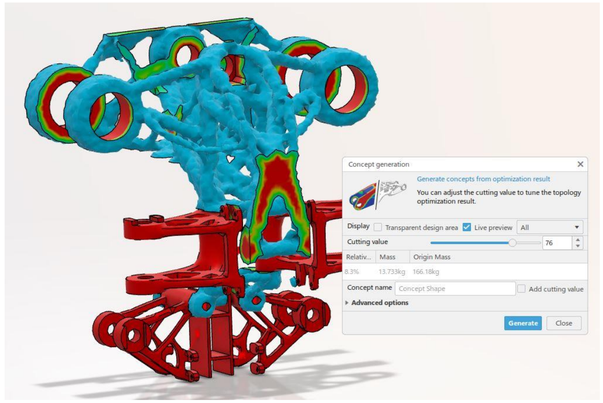


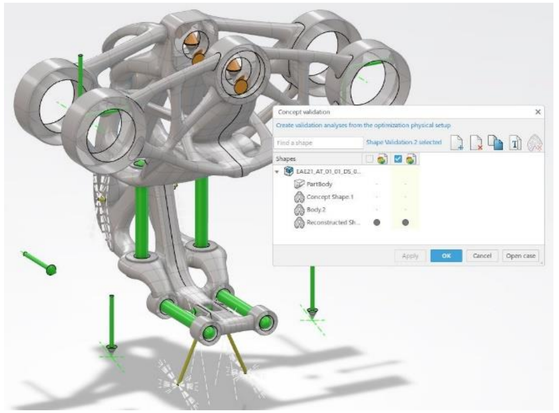
4. Example of printed Boogies

4.3 Results from applied method

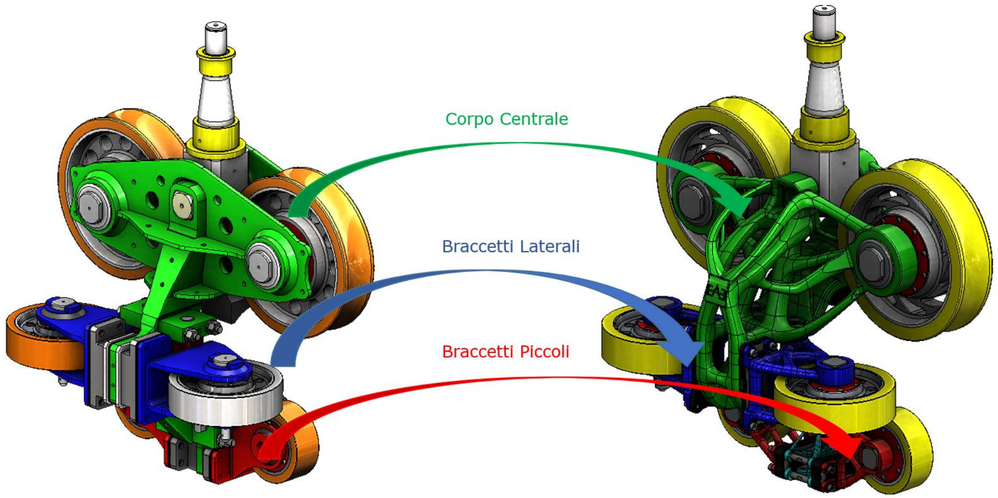
Phases to recreate the boogie

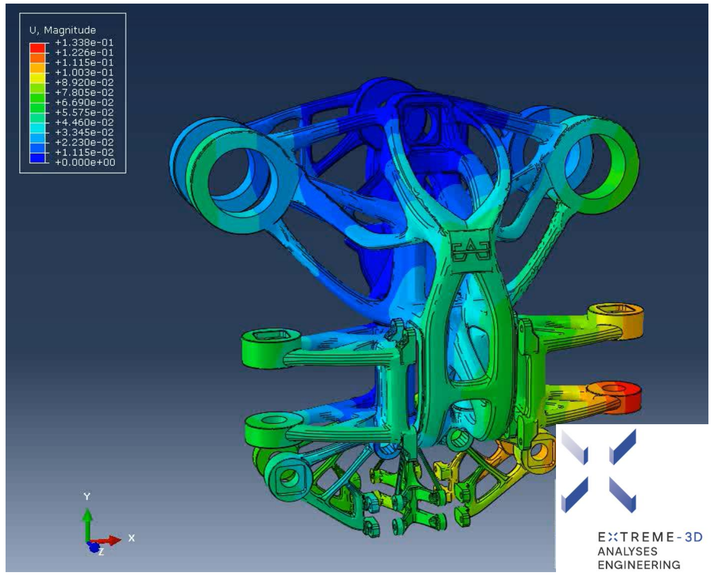






With reaction force from kinetodynamic analyses we create a new model of boogie with a reduction weight of ***65%***





Bilanciere realizzato in carpenteria	Bilanciere realizzato con AM
Materiale: Acciaio	Materiale: Lega Alluminio
Numero di componenti: 36	Numero di componenti: 6
Peso totale (Corpo Centrale, Braccetti Laterali, Braccetti Piccoli) : 95.7 Kg	Peso totale (Corpo Centrale, Braccetti Laterali, Braccetti Piccoli, Lamina): 24.3 Kg

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5. Benefit of AM in Amusement rides sector

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Conclusion

➢Reduced construction and operating costs for example roller coasters:

- weight reduction of moving parts (60-70%)
- weight reduction of the structure (30-40%).

➢Reduced component production time.

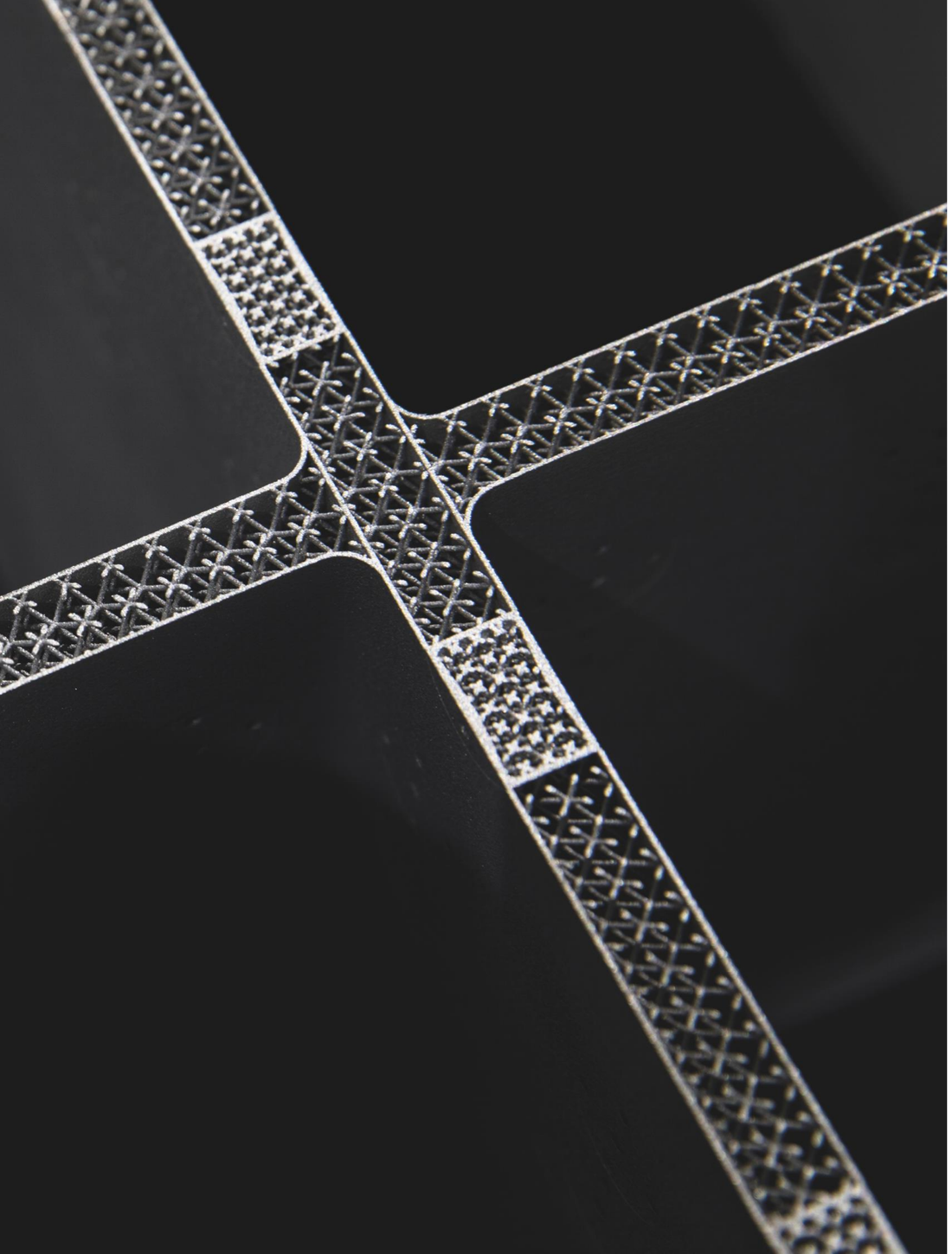
➢User benefits:

- energy saving (20-30%)
- Reduction of maintenance cost
- Reduced wear of operating components (Wheels, bearings, etc.)

➢Rapid transition from ideation-design-component construction, continuous and integrated design between the different phases.

➢Possibility of realizing complex structures impossible with other methods of construction / production with safety guarantees required by standards.

➢Construction safety: complete integration and guarantee of coherence between the projected model and the realization of the artifact.



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Thanks for your attention

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