



CAXMAN: COMPUTER-AIDED TECHNOLOGIES FOR ADDITIVE MANUFACTURING

Georg Muntingh, SINTEF Digital

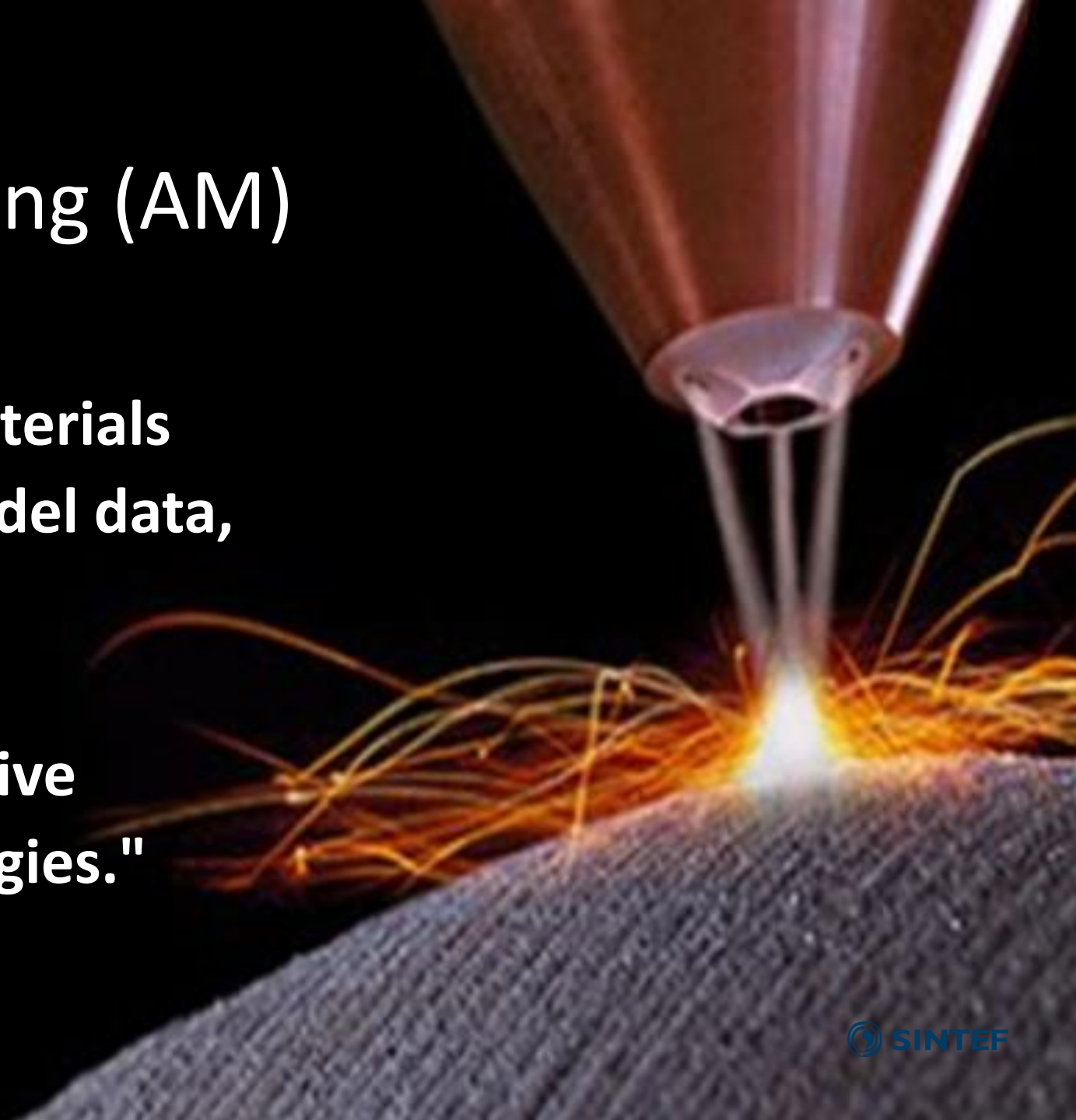


This project has received funding from the European Union's Horizon 2020 research and innovation programme, under grant agreement No. 680448 (CAxMan) www.caxman.eu

Additive manufacturing (AM)

"The process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies."

ISO/ASTM 52900



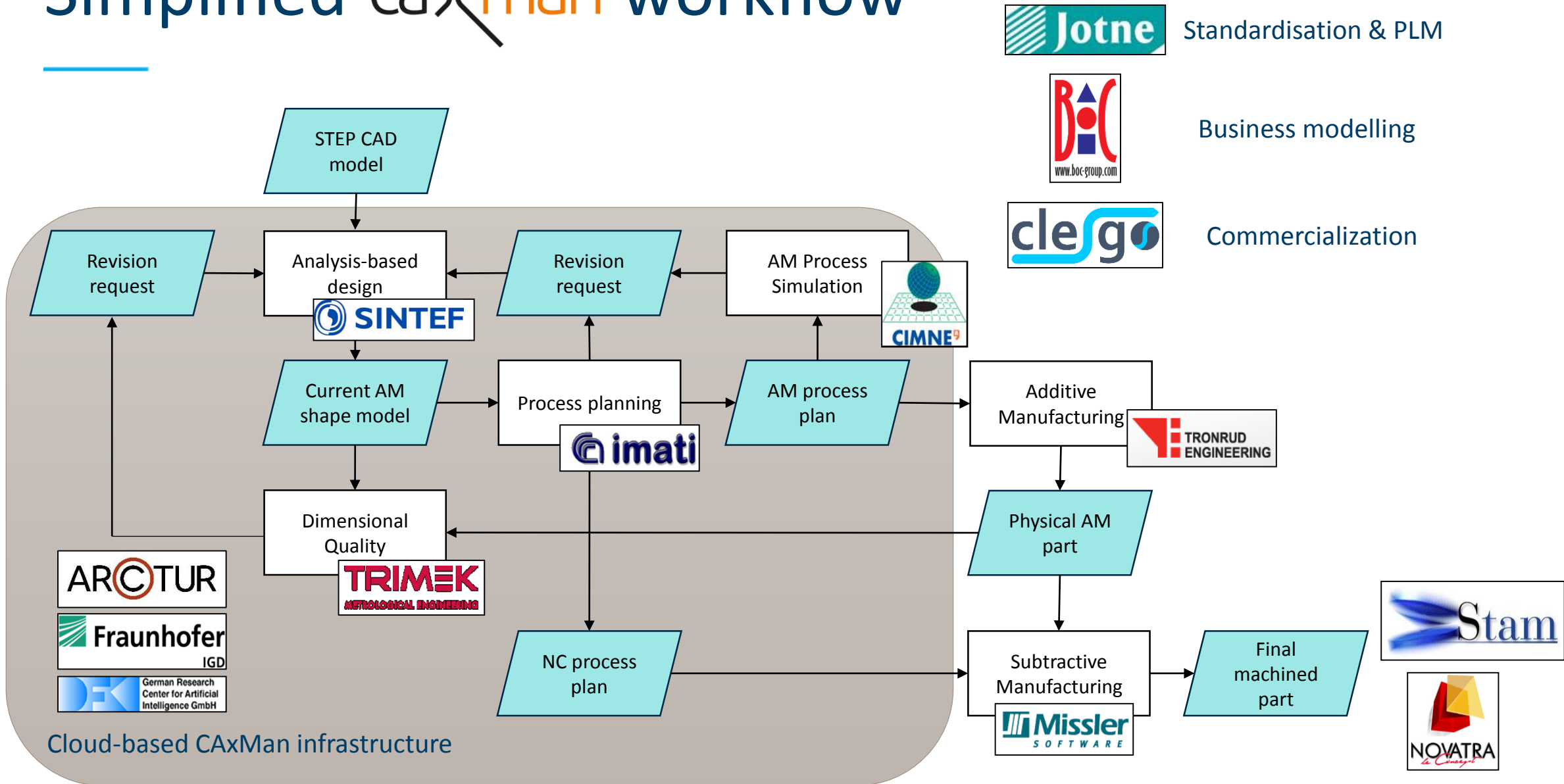


HORIZON 2020

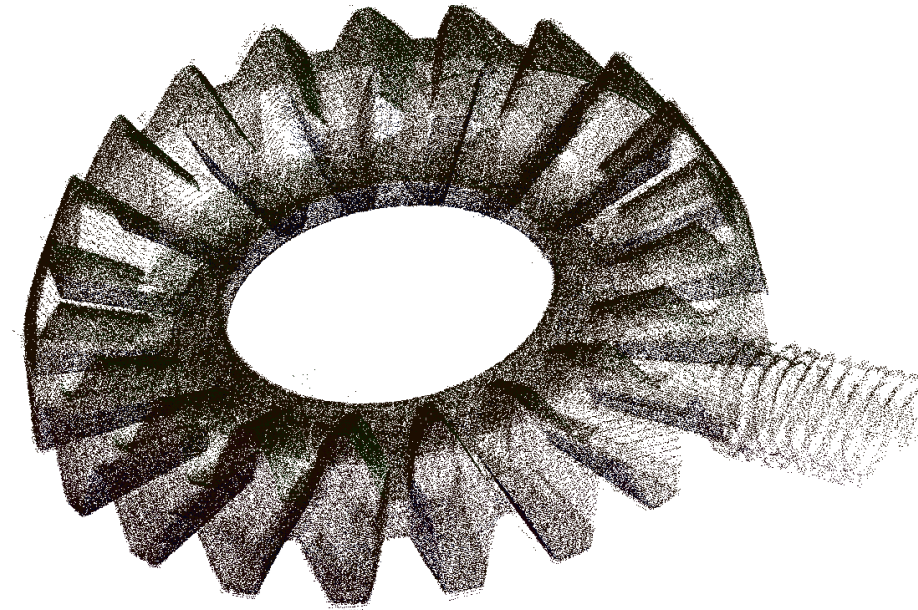
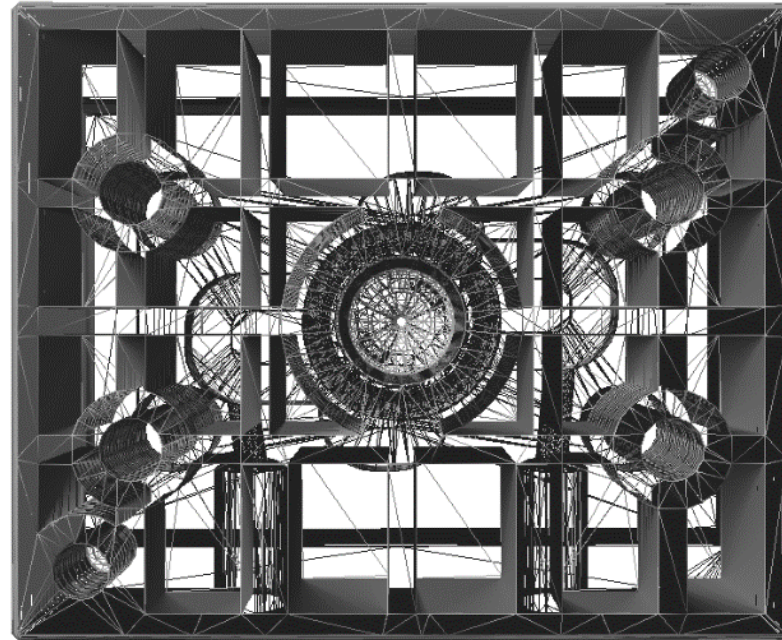
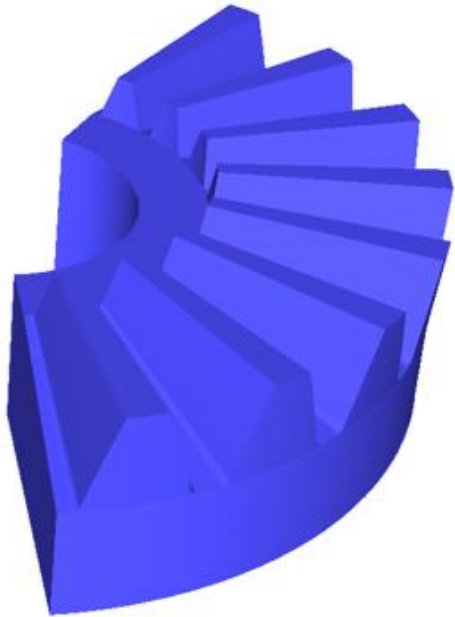
Computer Aided Technologies for Additive Manufacturing (CAxMan)



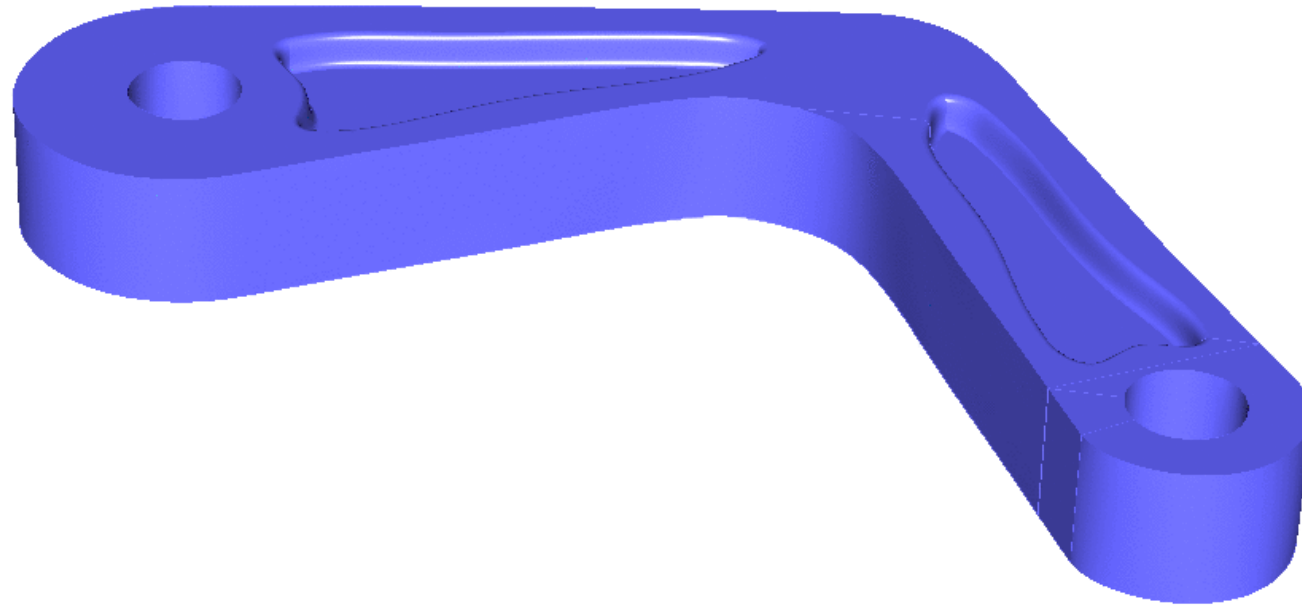
Simplified caXman workflow



Interoperability of digital representations



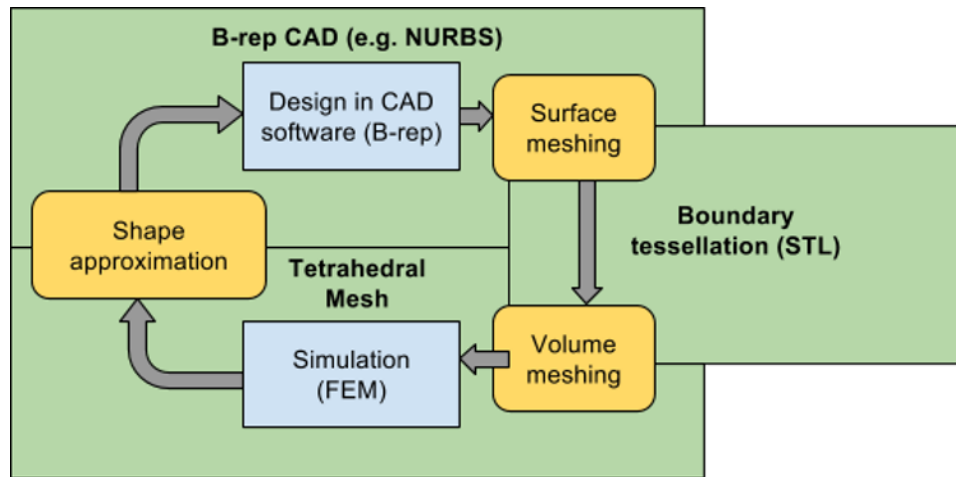
A true volumetric representation



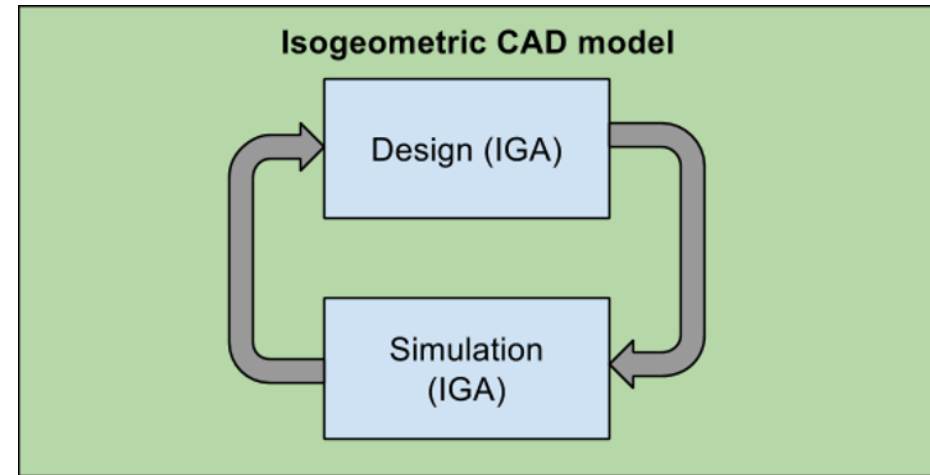
- Can represent every boundary-represented CAD model exactly
- Can describe local material properties, like density, material composition, anisotropy
- Is suitable for isogeometric analysis
- Is standardized in STEP ISO 10303-42

Isogeometric analysis for analysis-based design

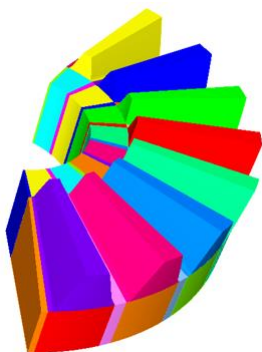
Isogeometric analysis (IGA) provides a robust approach to analysis-based design for AM.



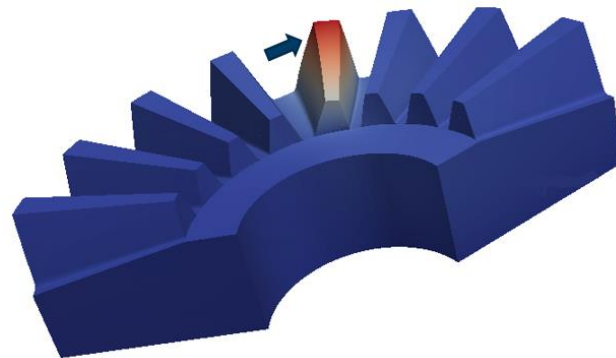
State-of-the-art workflow



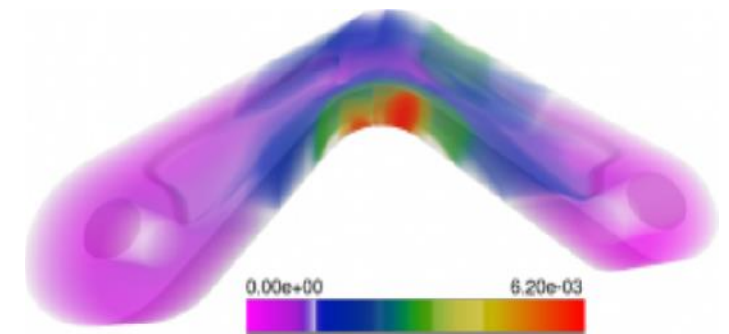
Isogeometric approach



Volumetric design



Direct simulation



Direct visualization

To conclude

- AM involves a wide range of complex technologies
- Robustness in the workflow is demanded in the customized setting of AM
- Interoperability is essential for the future of AM


CAXMan takes the first steps towards achieving this, and towards building future CAD systems that truly represent the complexity of modern product design

Thank you!

For more information, please stop me in the break, and take a look at the poster outside.


CAxMan : Computer-Aided Technologies for Additive Manufacturing

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What is CAxMan?

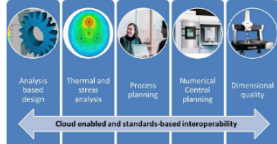
Additive manufacturing (AM) is: "The process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies" — ISO/ASTM 52900



CAxMan is a Research and Innovation action funded by the EU under their Horizon 2020 programme. CAxMan establishes cloud-based toolboxes, workflows and a one-stop-shop for computer-aided technologies supporting the design, simulation, and process planning for additive manufacturing.

The current design and production chain for additive manufacturing is an add-on to the chain for subtractive manufacturing. The state-of-the-art approach is to convert the CAD shapes to the STL format, after which the surface shape is represented without any reference to colour, texture or other common CAD model attributes.

The project establishes novel workflows and services for discrete manufacturing (combinations of additive and subtractive) by allowing the computer-aided technologies as services and workflows in the cloud, from design to production of physical prototypes.




Objectives

CAxMan has the ambition:

- To reduce material usage and increase weight savings, by introducing internal cavities and voids
- To optimize distribution and grading of material for multi-material additive manufacturing processes
- To facilitate the manufacture of components which are currently impossible or very difficult to produce by subtractive processes
- To enhance analysis-based process planning for additive manufacturing including thermal and stress aspects, and their interoperability with the design phase
- To enable the compatibility of additive and subtractive processes in production in order to combine the flexibility of shape in additive manufacturing with the surface finish of subtractive processes

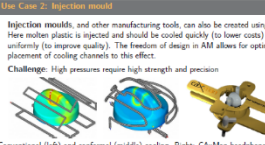
Use Case 1: Advanced gearbox — NUGEAR

The NUGEAR couples bevel gears with the concept of rotation, allowing for speed reduction ratios from 10 to 3,000 and high shock tolerance/reliability. Shape optimization leads to weight reduction, beneficial to aerospace applications.
Challenge: Cost-effective manufacturing



Use Case 2: Injection mould


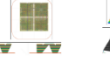



Injection moulds, and other manufacturing tools, can also be created using AM. Here molten plastic is injected and should be cooled quickly (to lower costs) and uniformly (to improve quality). The freedom of design in AM allows for optimal placement of cooling channels to this effect.
Challenge: High pressures require high strength and precision



Conventional (left) and conformal (middle) cooling. Right: CAxMan headphone holder.

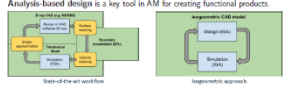
Interoperability of representations

Many different representations are needed in the AM process chain. Interoperability of these representations is essential for the future of AM.

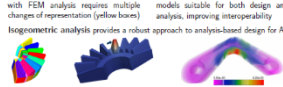
CAD models STEP (ISO 1593)	Slicing formats CLL/SLI (EOS), G-code	Finite Element Models STEP, HDPS
		
Boundary tessellation STL (STereoLithography)		Point cloud data LAS, xyz
		

Threats to isogeometric analysis for analysis-based design

Analysis-based design is a key tool in AM for creating functional products.

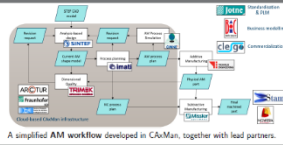


The traditional approach of B-rep CAD requires multiple models suitable for both design and analysis, improving interoperability. Isogeometric analysis provides a robust approach to analysis-based design for AM.



Volumetric design (left), direct simulation (middle) without the need for meshing, and direct visualization (right) of the higher-order geometry and result fields.

Simplified CAxMan workflow




A simplified AM workflow developed in CAxMan, together with lead partners.

Standardization

In CAxMan efforts are made towards standardization in AM. This includes:

- Monitoring of project requirements for standards
- Organizing an interoperability workshop in November 2016 by regular telecons to resolve issues with identified standards (converters and FEM services)
- Resolving interoperability requirements that could not yet be mapped to existing standards, such as workflow feedback annotation information
- Validating ISO 10303-209 (AP299), and agreed issues resolutions with ISO
- Support of standardizing ISO 10303-242 (AP242) edition 2, with focus on the AM module, ISO 10303-1835, "Additive manufacturing part and build information", and on isogeometric analysis
- Monitoring of ISO/TC 261 activities



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