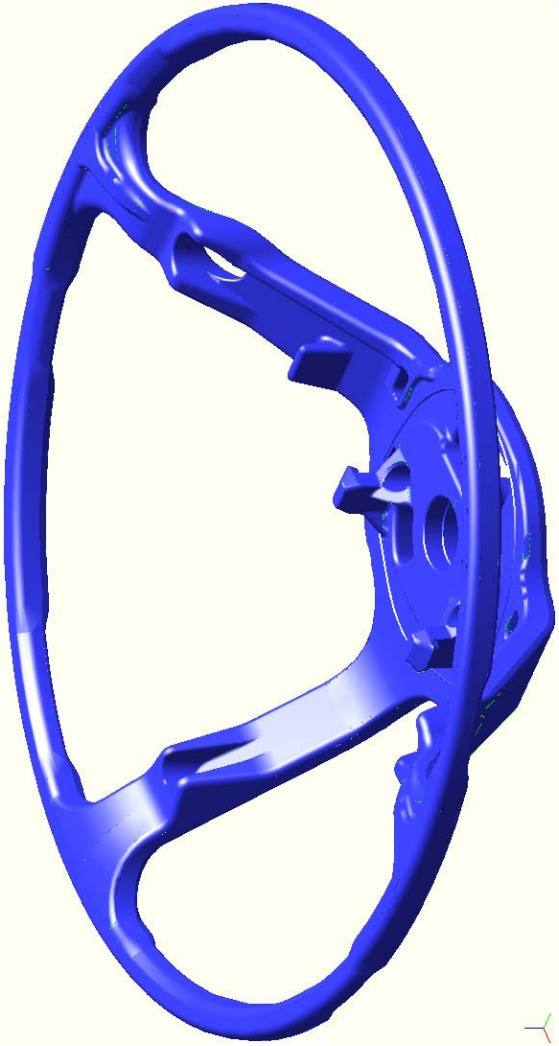
The Quality Of 3D Models

Problems and Solutions for Applications Post-Design

Fathi El-Yafi
Senior Product Engineer
Product Department of EXA Corporation

Quality Of 3D Models : Overview

- **Status**
  - Problems Identified
  - Defect Sources
- **Objectives**
- **Quality Approach**
  - Intermediate Model
  - Pre-Process Steps
- **Triangulation**
  - STL
  - FEM Mesh
- **Interactivity Aspects**



Quality Of 3D Models : Status

Modeling History

- 1980 Geometry & Drawing
- 1990 Parameterize Model
- 1995 Digital Mock-Up
- 2000 ?? Quality of the Model ??

Problems Survey

- From CAD Model → Numerical Model
- Increasingly Complex Models
- Many Anomalies in the CAD Model
- Too Much Time Consuming
- Interactive CAD Fixing
- Interactive Simulation Model Fixing

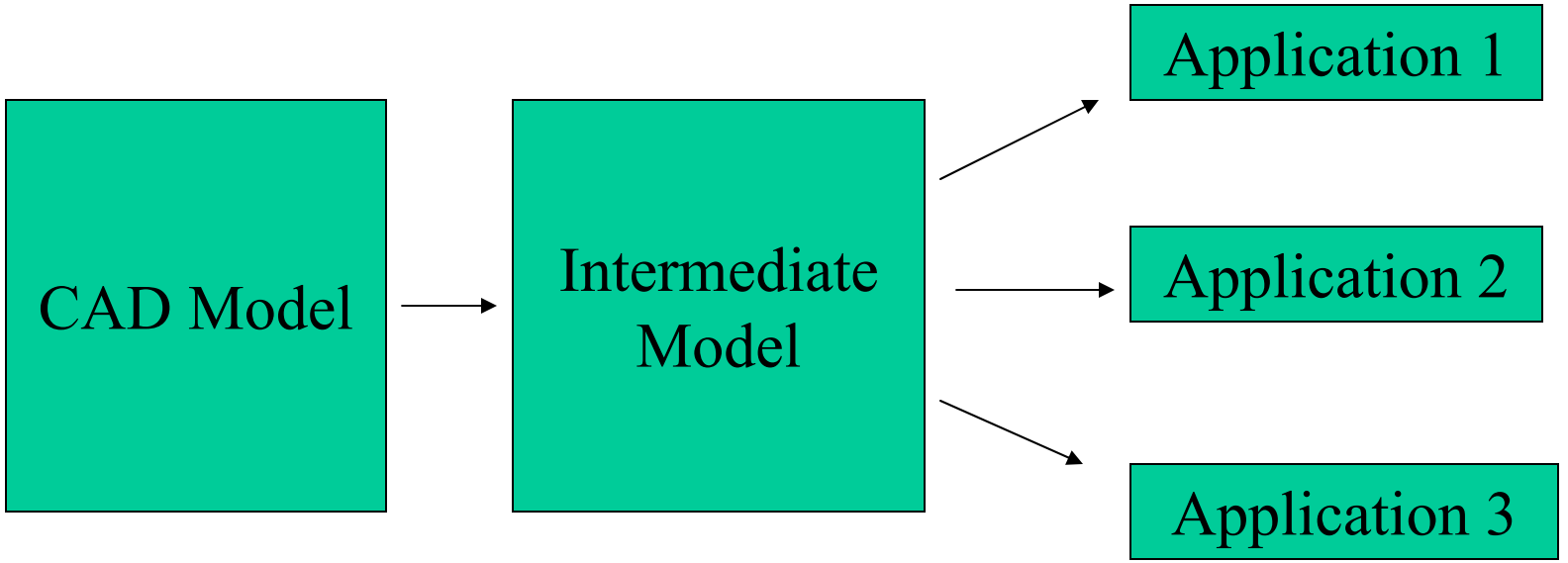
Defect Sources

- Defects While Export (IGES, STEP, Native, Etc.)
- Defects While Import (IGES, STEP, Native, Etc.)
- Interpretation of the Standard Data Exchange
- Errors & Defects in the CAD Original Model
- Differences in Internal Data Representation
- Ignorance of User Requirements
- User Errors
- Internal Company Rules

Objectives

- Reduce Simulation Time Modeling
- Tolerance with “very small defects” (Auto Fixing)
- Highlighting the Major Defects

Approach



Regular CAD Model → Qualified intermediate Model

Intermediate Model

- Adapted to a Specific Application
- Simplicity → Reliability, Efficiency
- Coherent Triangulation, Water-tight (no gaps, no overlapping)
- Guarantee of the Geometry Accuracy (triangulation ←→ CAD model)

Pre-Process Steps

- Creation of a Discrete Geometry
- Cleaning of Each Elementary Face
- Connexity Analysis, Topology Creation
- Building the First Triangulation Level

Quality Of 3D Models

Discrete Geometry

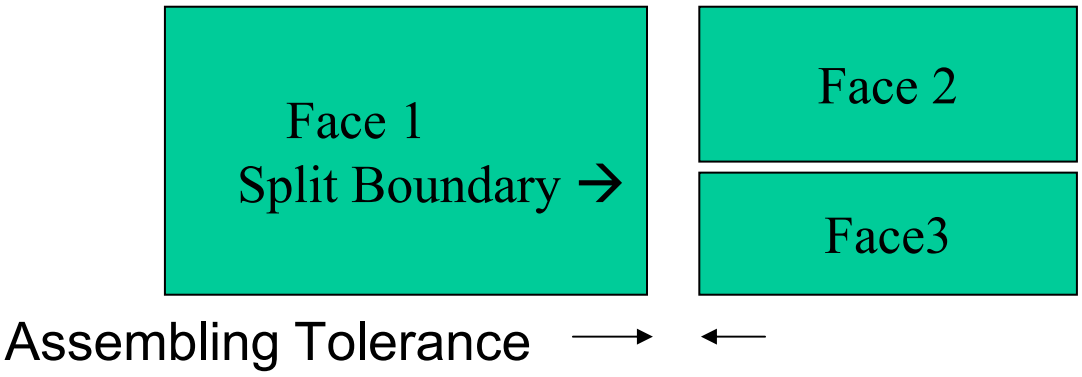
- Isolation of the CAD Model From it's Environment
- Data Structure Organization (Efficiency)
- Surface → Grid of Points (u, v, x, y, z)
- Bounding Curves → Line of Points (u, v, x, y, z)

Fixing Discrete Geometry

- Put in Order the Boundary Curves
- Removal of Very Small Faces
- Removal of Lap Back Points
- Concatenation of Very Small Curves
- Re-Arrange Curve & Surface Parameters

Connexity Analysis

- Creation of Adjacency Relations
- Detection of the Free Edges
- Detection of Multiple Adjacencies
- Detection of Feature Lines
- Domains / Volume Skins



Quality Of 3D Models

Tessellation / STL Triangulation

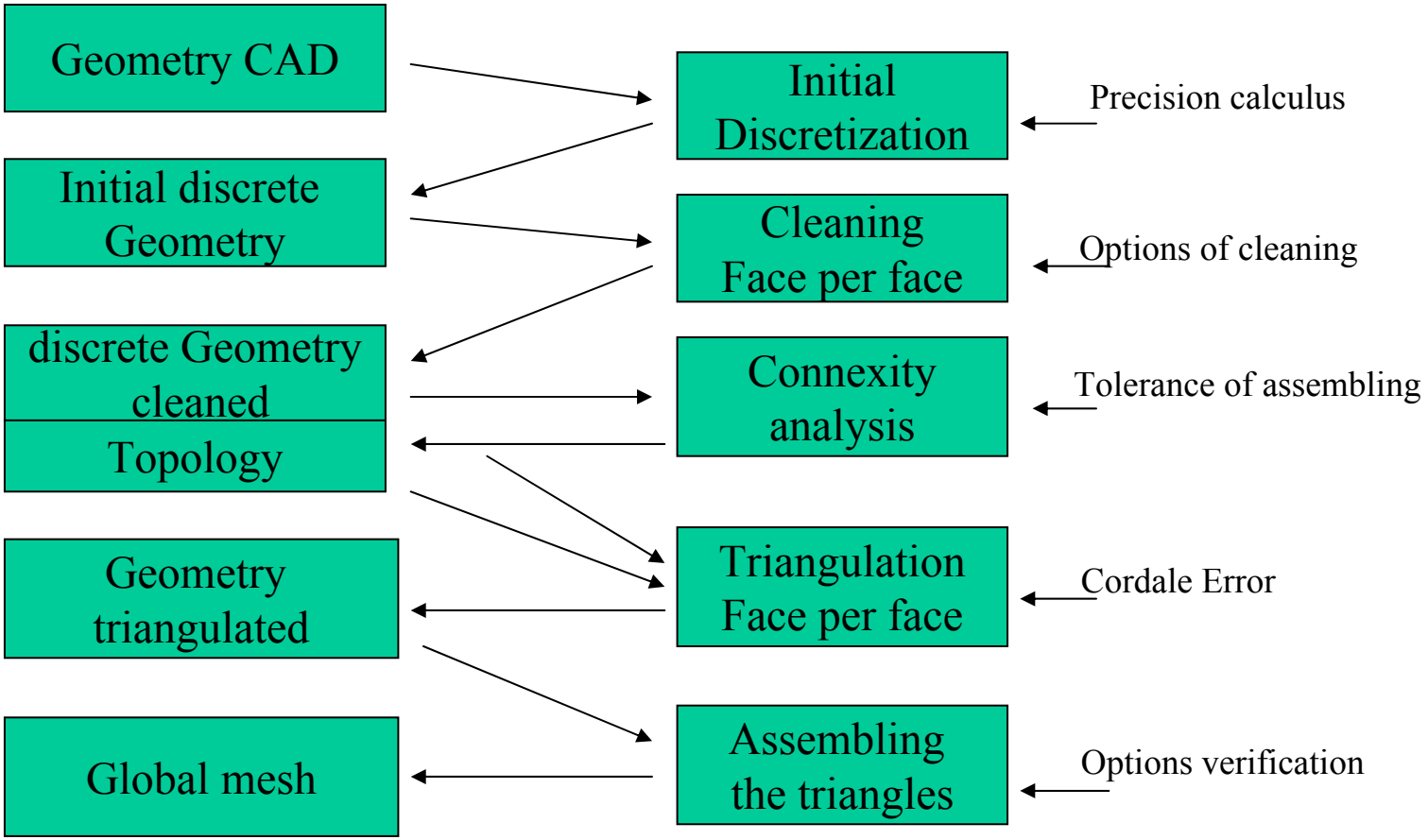
- Face By Face
- In the Parametric Space
- Evaluation of Density of Points (In / Out)
(with respect to the prescribed accuracy)
- Delaunay Incremental Method (u, v)
- Use of Connexity Relations
- Creation of STL File (attributes ← → Face)

Quality Of 3D Models

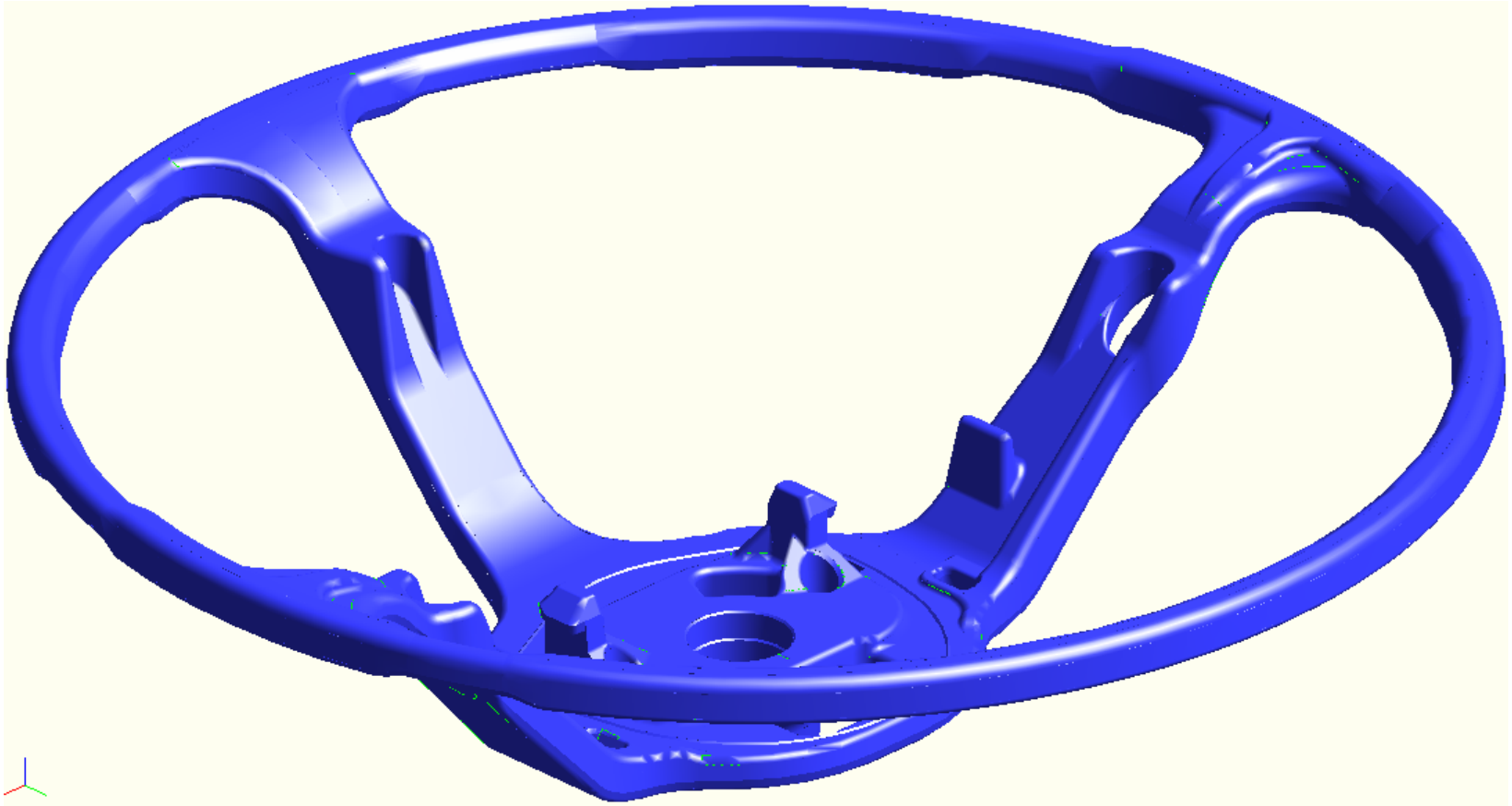
Global STL Triangulation

- Assembling the Triangles → Mesh
- Detection of the Free & Multiple Edges
- Fusion of Too Close Points
- Verification of Overlapped Triangles
- Vertex Normal Evaluation
- Export the Other Applications

Sketch of the Process Steps



Steering Wheel



2028 Faces

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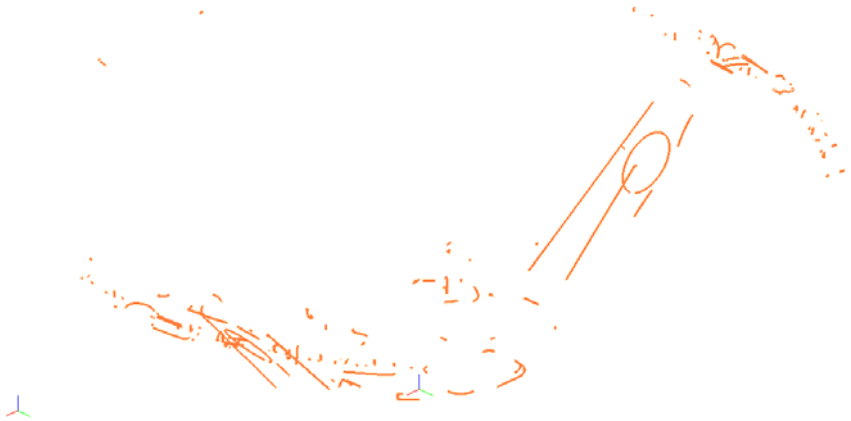
Steering Wheel



Stitching Tolerance 0.1 → 150 defects



Stitching Tolerance 0.2 → 72 defects



Stitching Tolerance 0.3 → 28 defects

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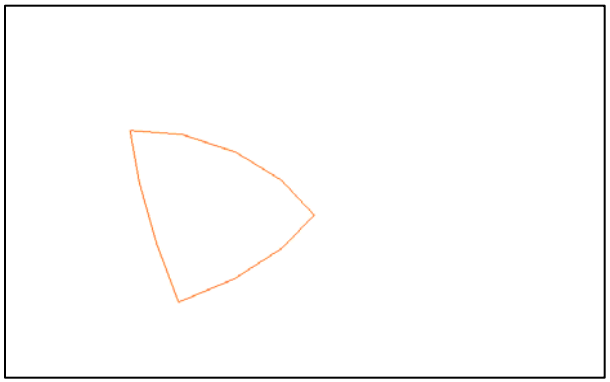

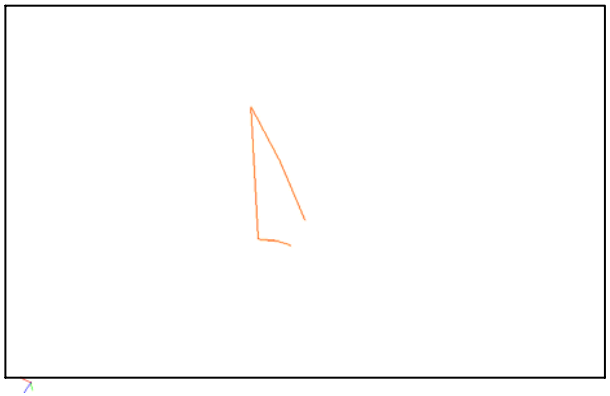

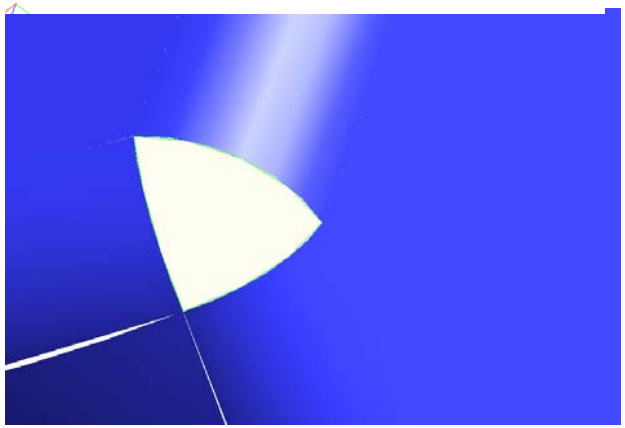

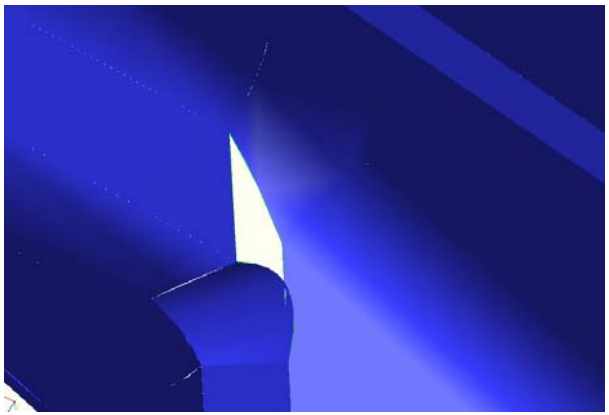

Defects > 0.6 ZOOM

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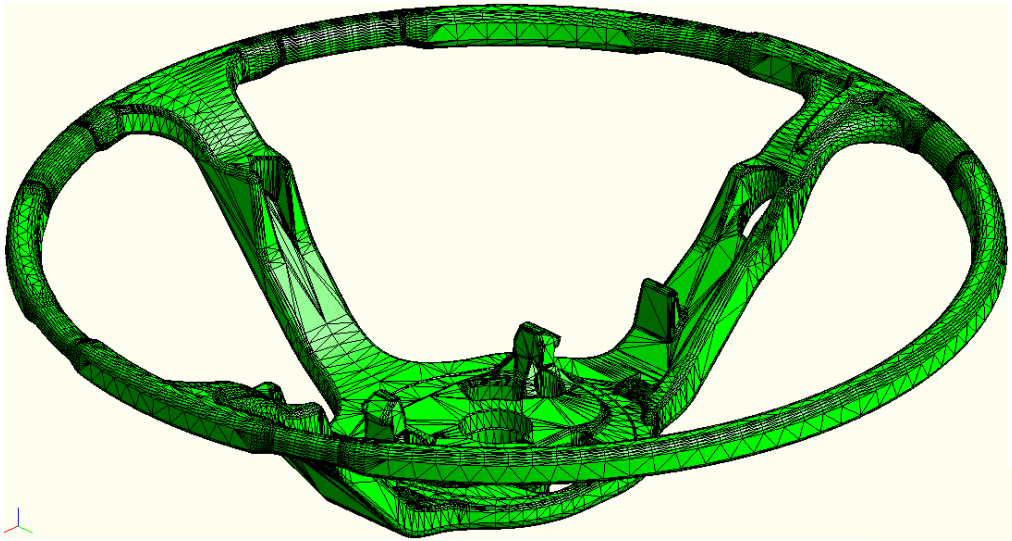
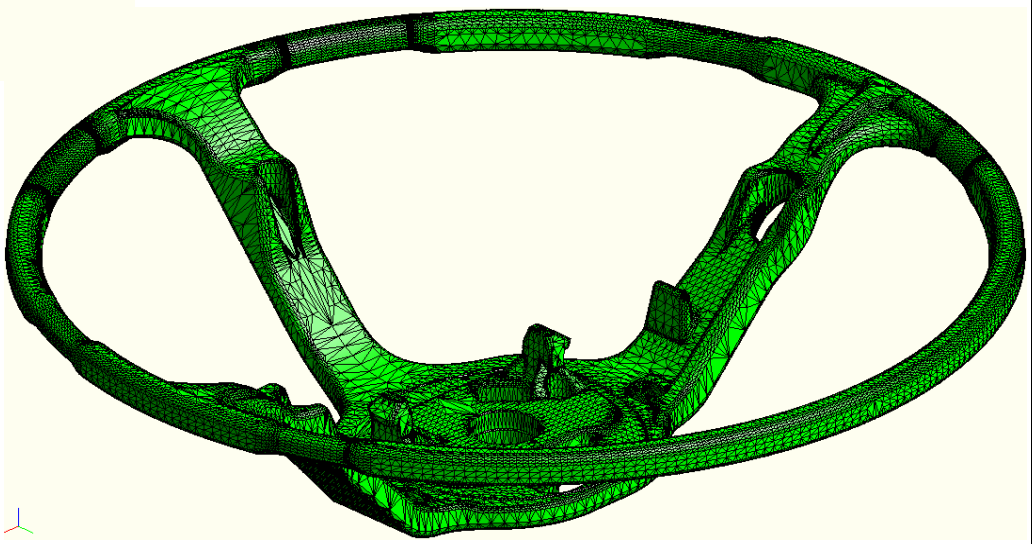
Steering Wheel



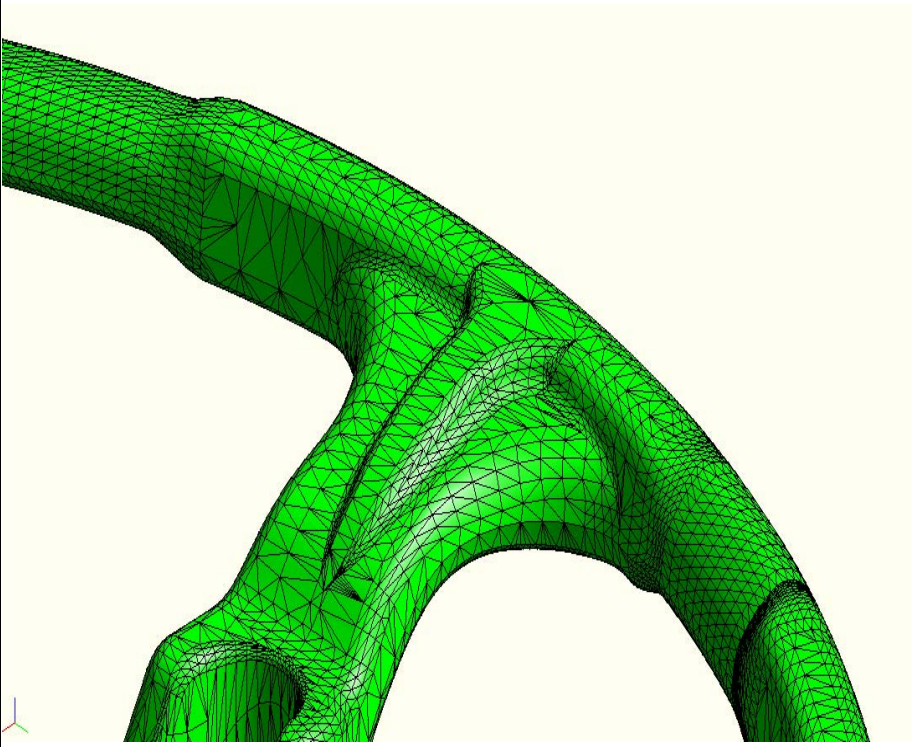
Mesh 1 precision 0.1
46 032 triangles

Mesh 1 + Constraints
Max. Size 50 mm
Max. Ratio 3
128 000 triangles

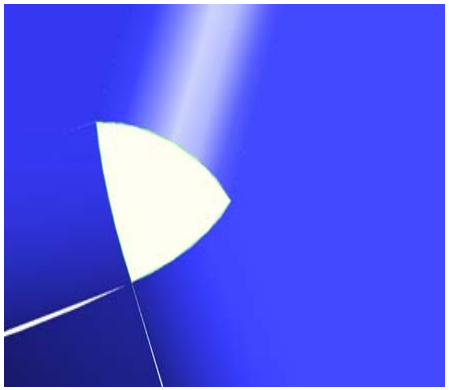


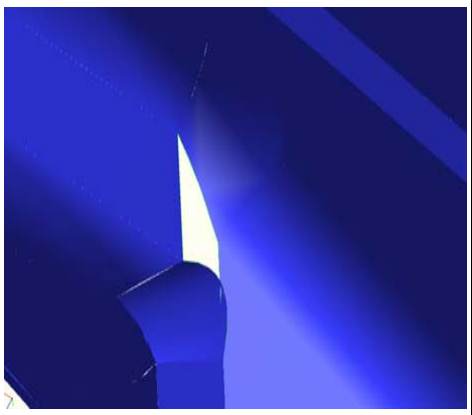
Quality Of 3D Models

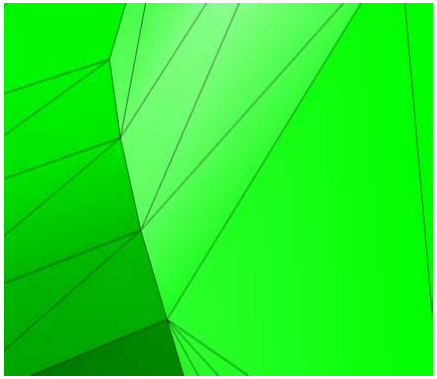
Steering Wheel

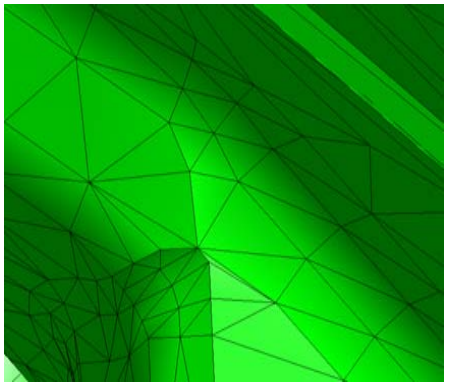


Mesh Detail



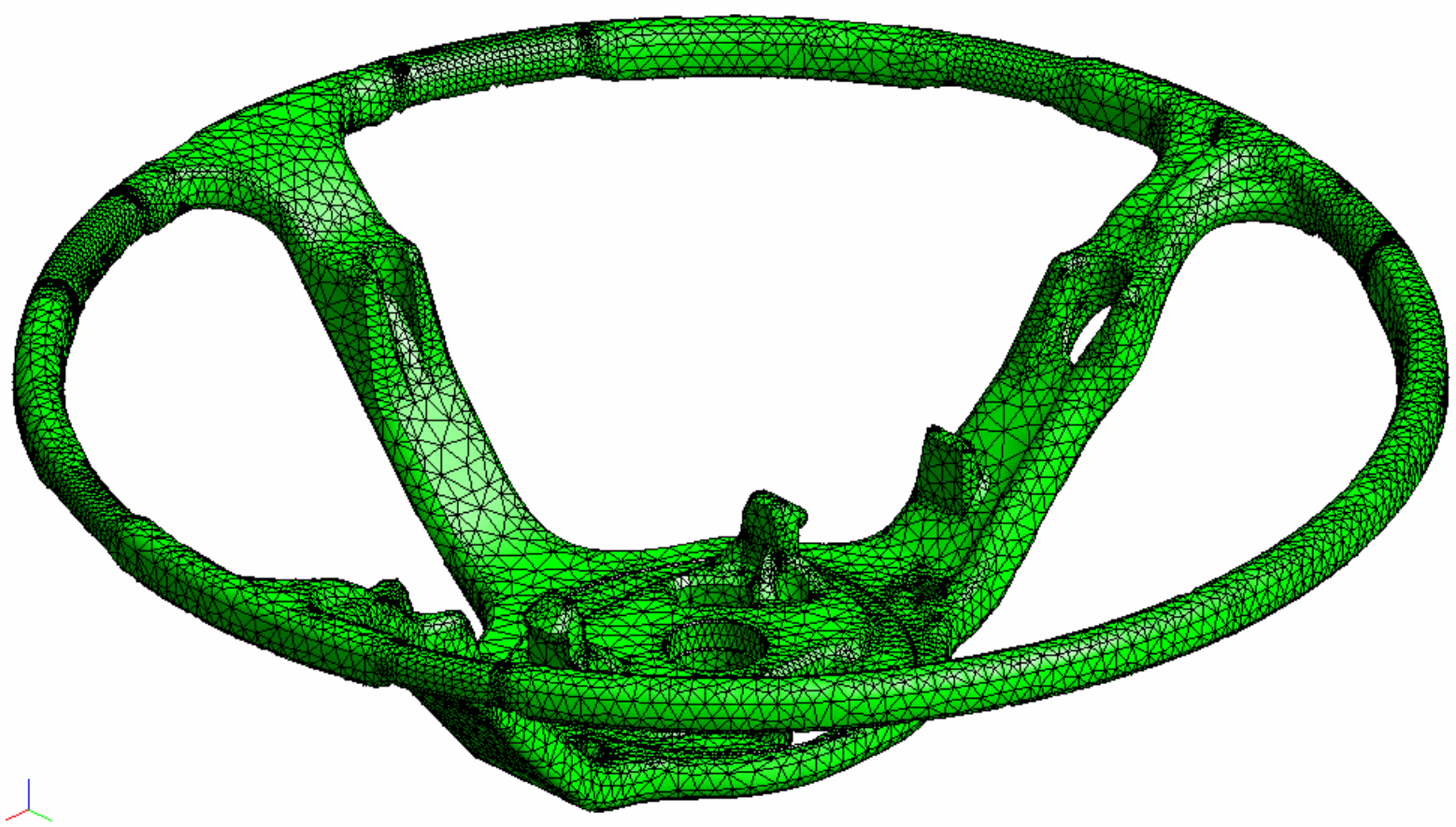






Defect Mesh > 0.6

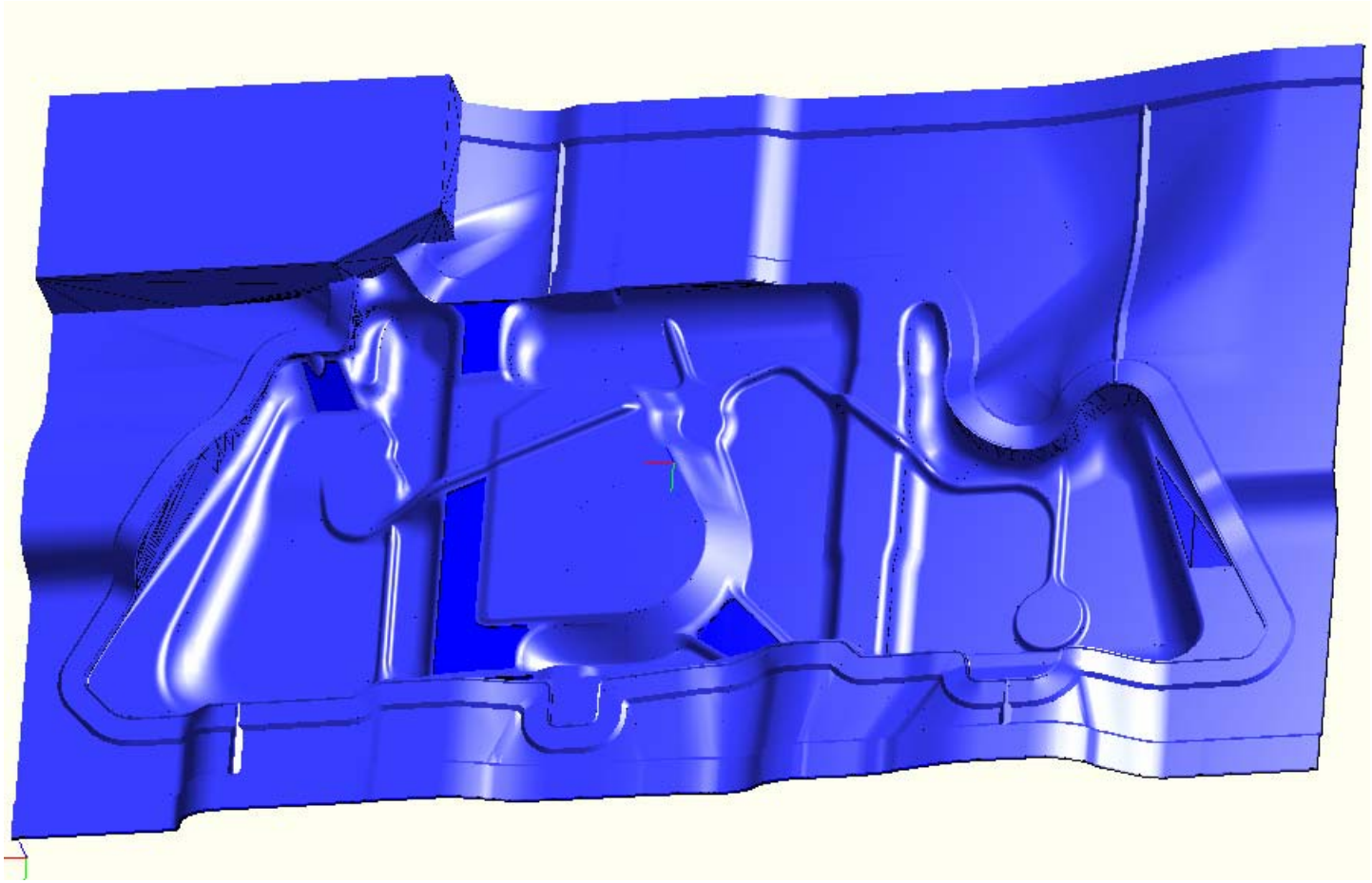
Steering Wheel



FEM Mesh 48 000 Triangles

Quality Of 3D Models

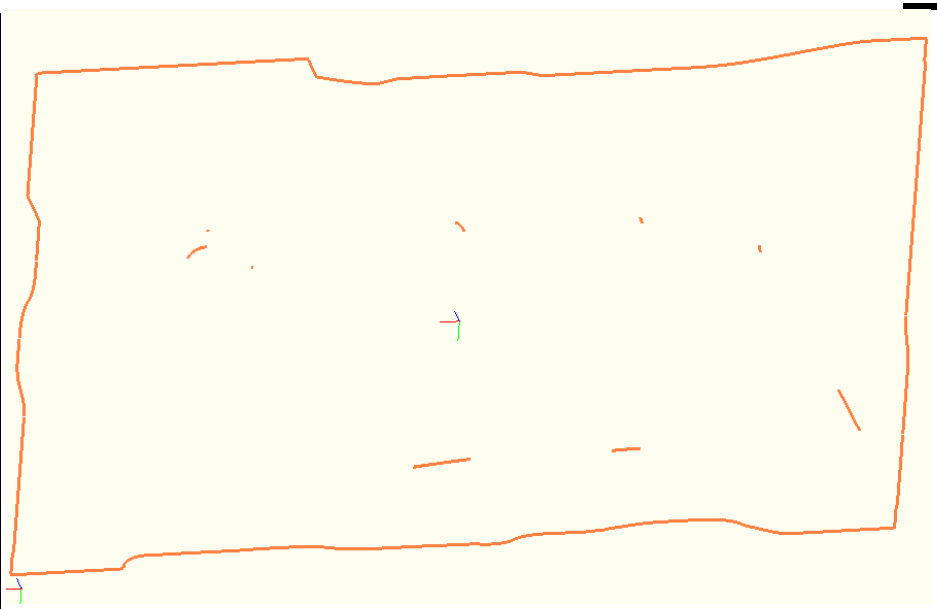
Plate



1415 faces

Quality Of 3D Models

Plate



Stitching Tolerance 0.1 mm

Stitching Tolerance 0.3 mm

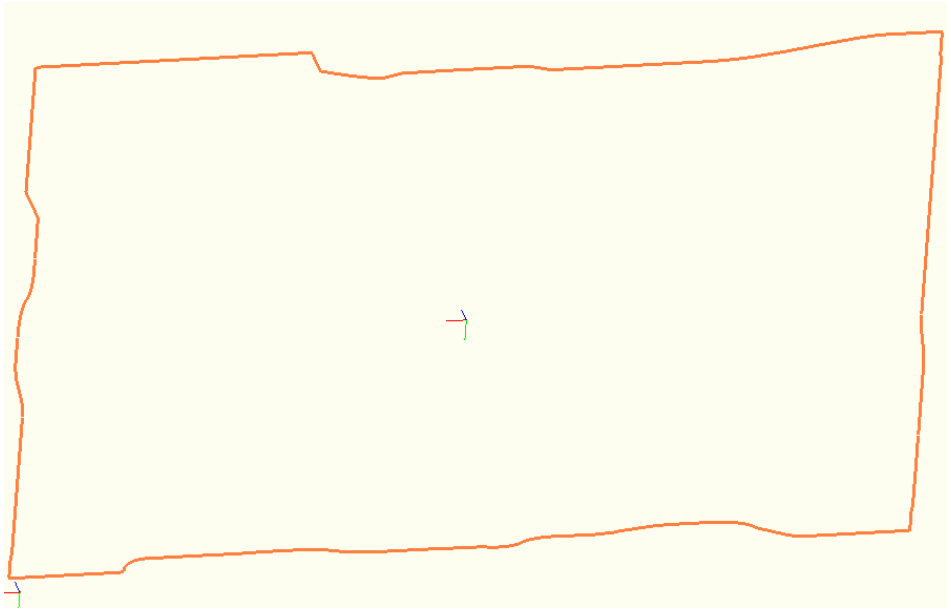


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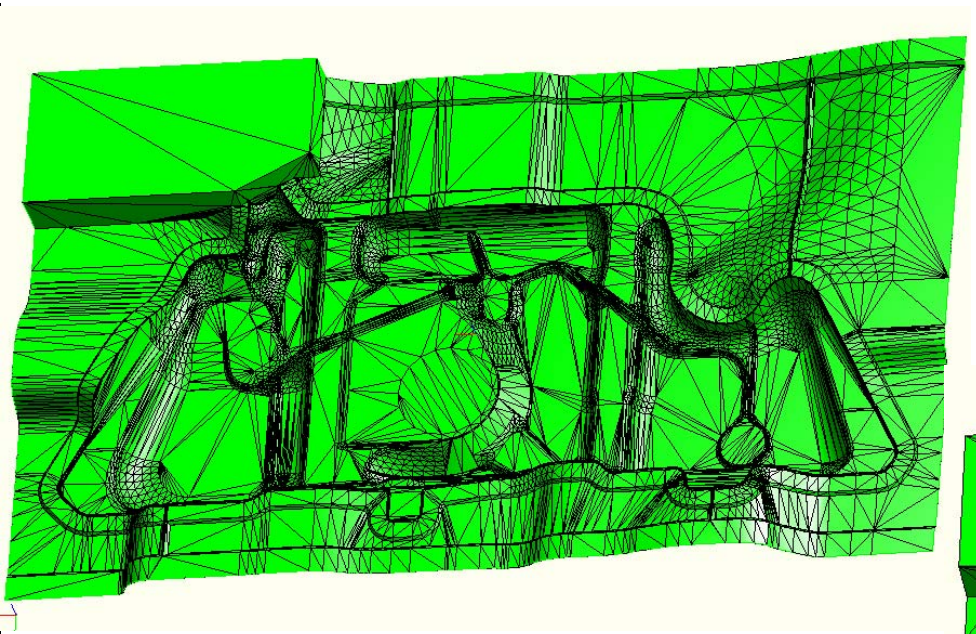
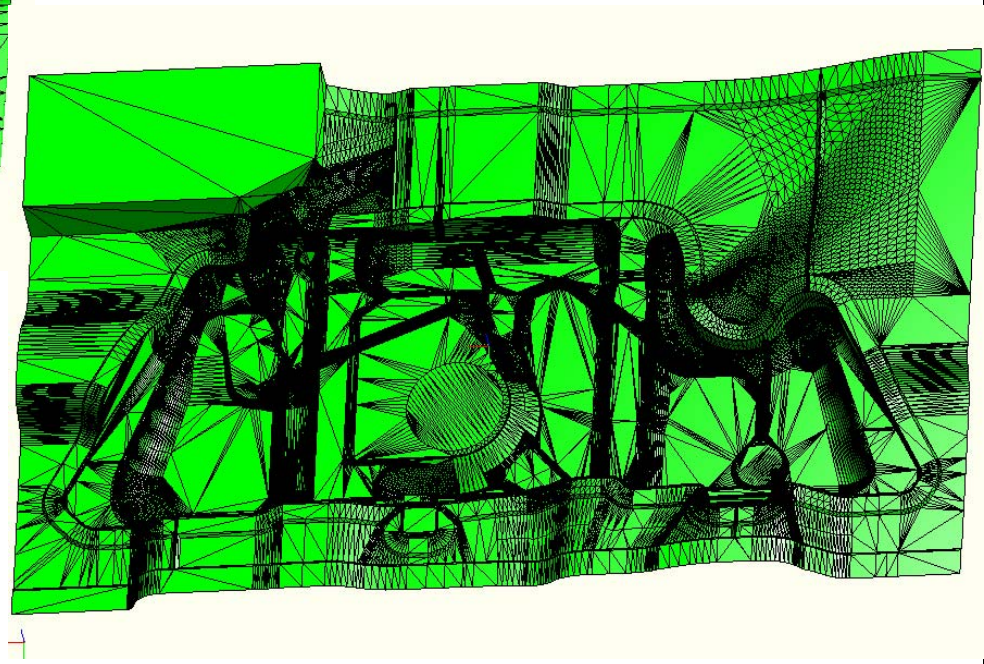
Plate



Mesh Precision 1.0 mm
12574 Triangles



Mesh Precision 0.1 mm
61527 Triangles

Conclusion

- CAD Model → Quality Triangulation
- Better Quality of Visualization
- Prototyping (export STL Format)
- CAM ???
- A Great Benefit for FEM Models