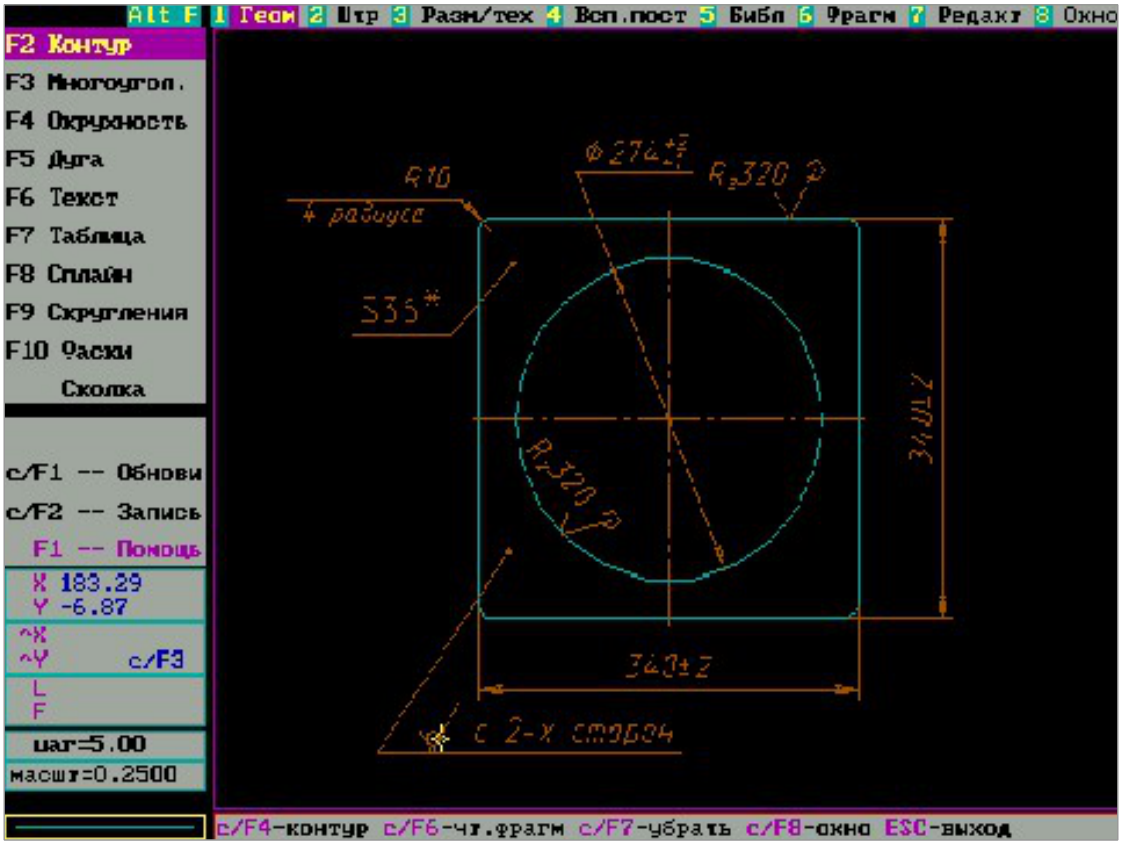
C3D Kernel

Geometric Modeling Toolkit For 2D & 3D Software Developers

C3D History

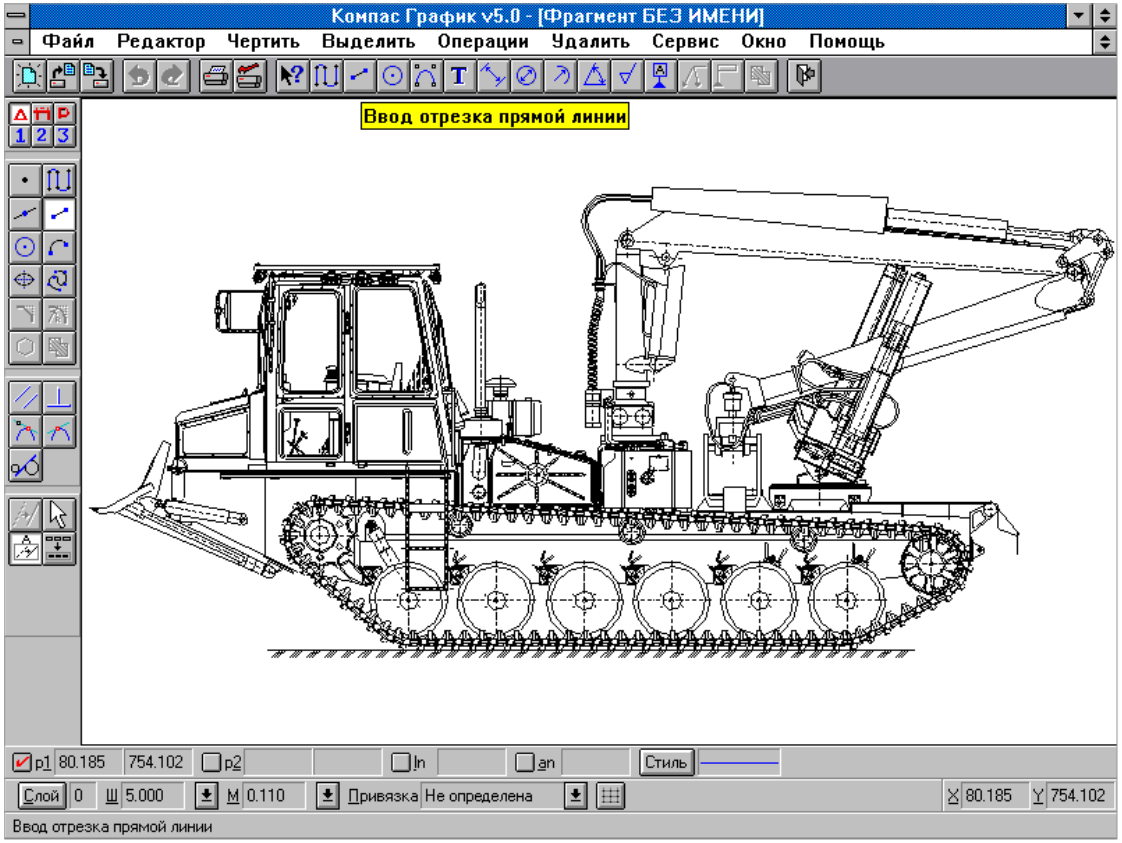
1986, Kolomna Design Bureau

1989, ASCON Company



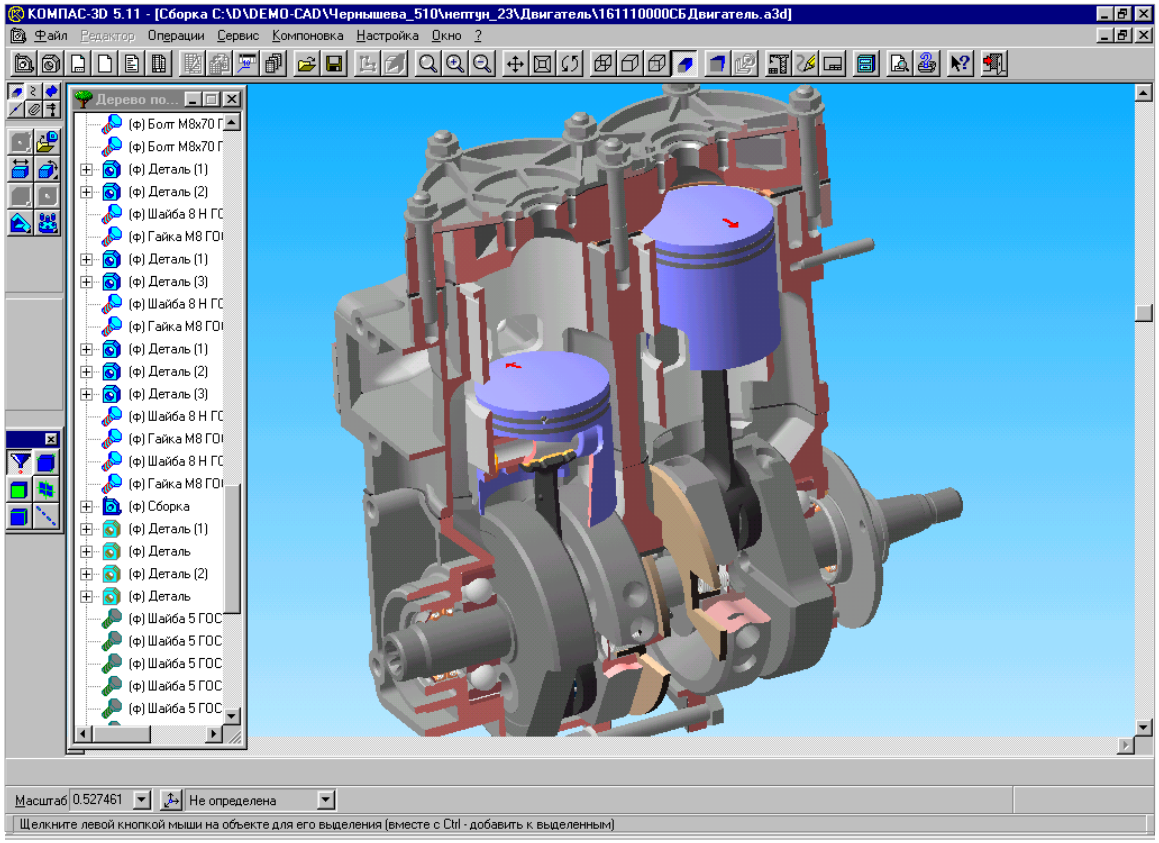
KOMPAS-Graphic for MS-DOS

1995, KOMPAS-Graphic for Windows



Start the C3D Project

2000, KOMPAS-3D



Mechanical CAD

Improvements

2000: 3D solid modeling algorithms

2001: Geometric constraint manager; data converter

2002: Associative views of 3D models

2003: Basic surface modeling features

2004: Sheet metal modeling algorithms

2005: Manifold solid modeling

2007: Wireframe modeling

2008: Kinematic joints implemented for modeling mechanisms

2009: Support for geometric model attributes

2010: Full-fledged surface modeling

2011: Expansion to cross-platform support

2012: Direct modeling elements

2013: English documentation; test applications

2012

KOMPAS-3D — most popular 3D-CAD in Russia

70 000 seats

The mathematical division of ASCON became a separate company **C3D Labs** to develop and promote kernel

ASCON & C3D Labs Today

ASCON Group

Biggest Russian CAD/AEC/PDM developer with

30 offices, **6** developer's centres, **600** stuff on board

9000 enterprise customers

C3D Labs

Sk Resident

Key Industries

Automotive

Heavy Machinery

Aerospace and Defense

Agriculture

Oil Production and Power Generation

Manufacturing and Construction

Electronics and Engineering Industries

Sk Resident

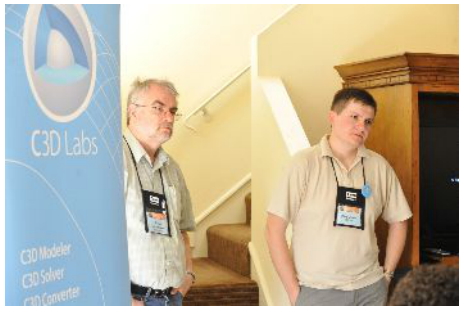
C3D Labs

Many customers worldwide

Development Partners: *ProtoTech Solutions (India), Rubius*

Resellers: *LEDAS, Solar Tech (Korea), intrinSIM (USA)*

Seminars and events are held across the world



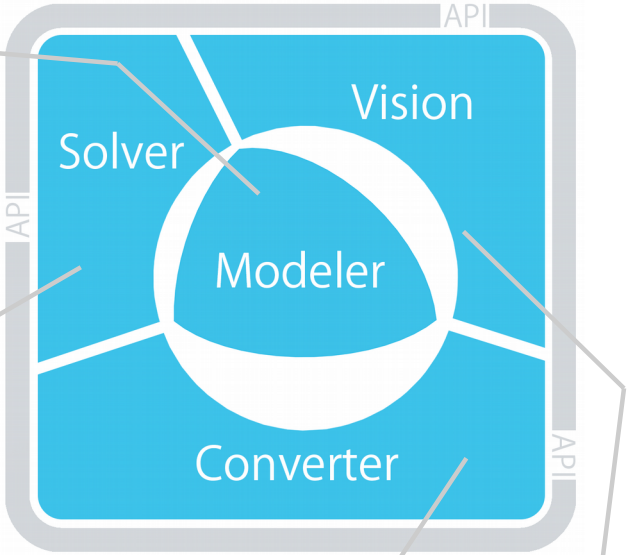
What is C3D?

What is C3D?

C3D Geometric Kernel
It offers functions for 3D solid and hybrid modeling, sketching, and 2D drawing

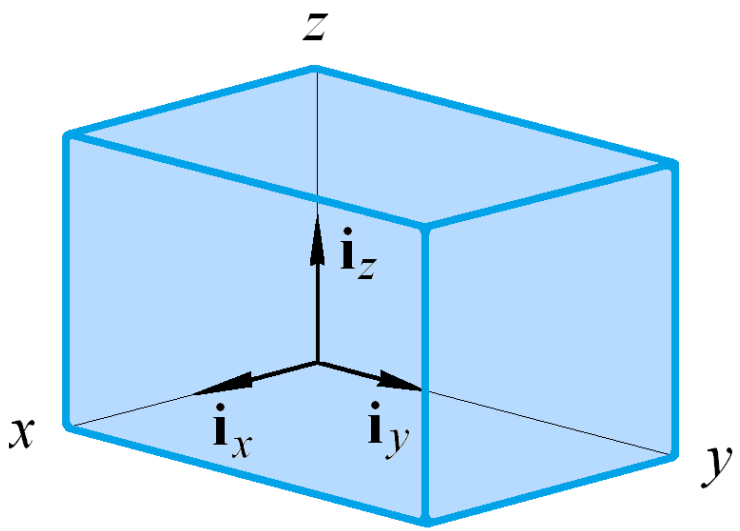
C3D Parametric Kernel
It boasts functions for creating and solving parametric constraints on 2D and 3D geometry

C3D Convertion Module
It reads and writes geometric models in all primary exchange formats



C3D Visualization Module
performs detailed visualization of geometric models and provides interaction with the interface of CAD systems

C3D Kernel

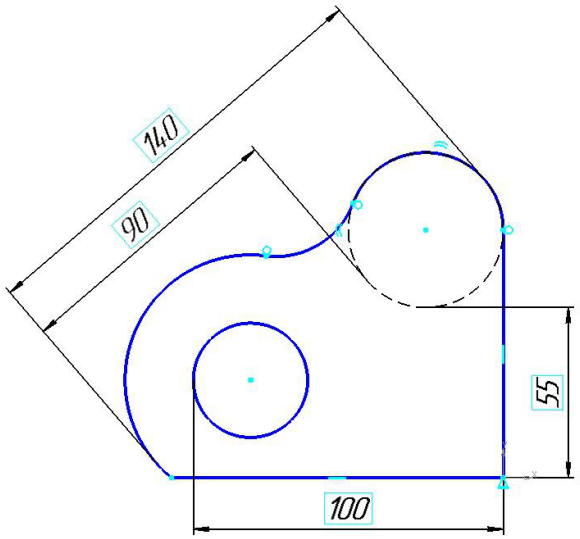


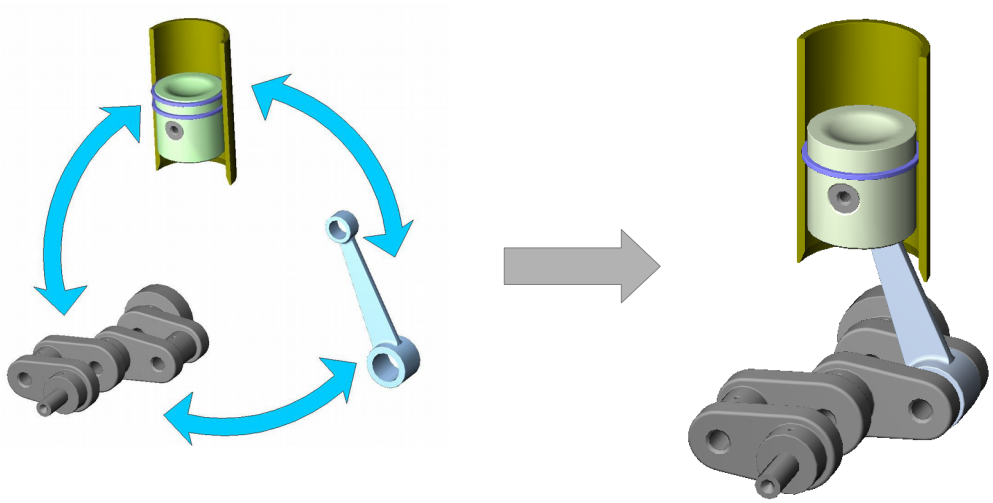
$$\mathbf{r}_1(u_1,v_1) = \mathbf{p} + u_1\mathbf{i}_X + v_1\mathbf{i}_Y;$$
$$\mathbf{r}_2(u_2,v_2) = \mathbf{p} + u_2\mathbf{i}_Y + v_2\mathbf{i}_Z;$$
$$\mathbf{r}_3(u_3,v_3) = \mathbf{p} + u_3\mathbf{i}_X + v_3\mathbf{i}_Z;$$
$$\mathbf{r}_4(u_4,v_4) = \mathbf{p} + u_4\mathbf{i}_X + v_4\mathbf{i}_Y + z\,\mathbf{i}_Z;$$
$$\mathbf{r}_5(u_5,v_5) = \mathbf{p} + u_5\mathbf{i}_Y + v_5\mathbf{i}_Z + x\,\mathbf{i}_X;$$
$$\mathbf{r}_6(u_6,v_6) = \mathbf{p} + u_6\mathbf{i}_X + v_6\mathbf{i}_Z + y\,\mathbf{i}_Y;$$

$$0 \le u_1 \le x, \quad 0 \le v_1 \le y,$$
$$0 \le u_2 \le y, \quad 0 \le v_2 \le z,$$
$$0 \le u_3 \le x, \quad 0 \le v_3 \le z,$$
$$0 \le u_4 \le x, \quad 0 \le v_4 \le y,$$
$$0 \le u_5 \le y, \quad 0 \le v_5 \le z,$$
$$0 \le u_6 \le x, \quad 0 \le v_6 \le z.$$

Used in software products as the component responsible for geometric **model construction** and constructed **model control**

C3D Kernel

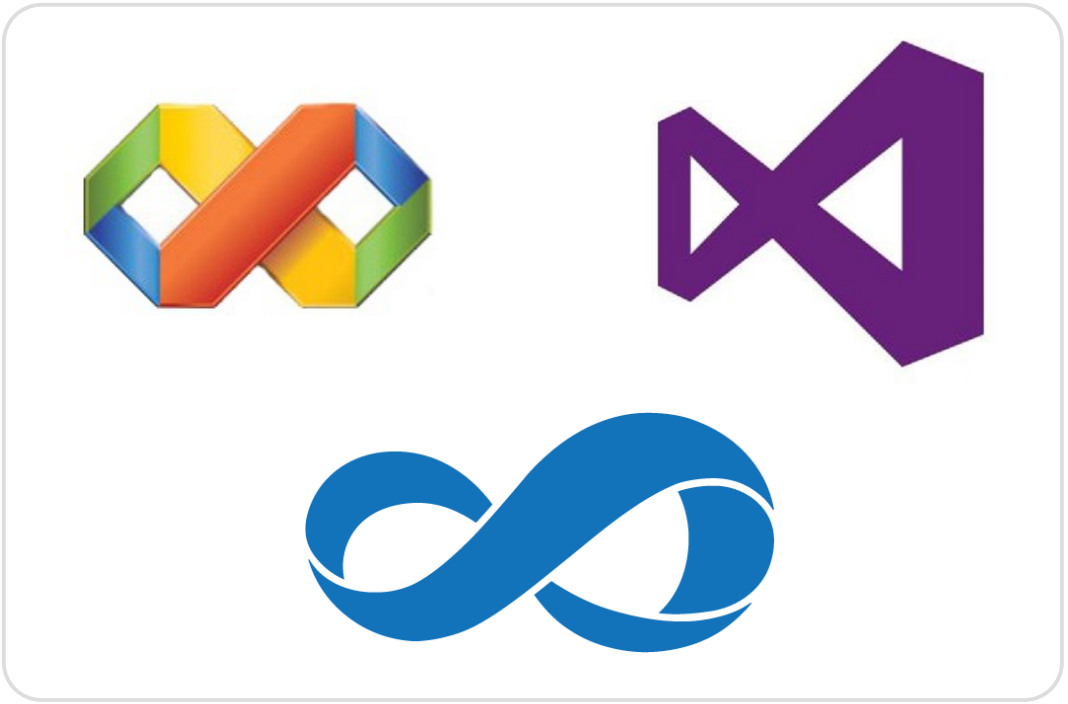




Used in software products as the component responsible for geometric **model construction** and constructed **model control**

C3D Kernel

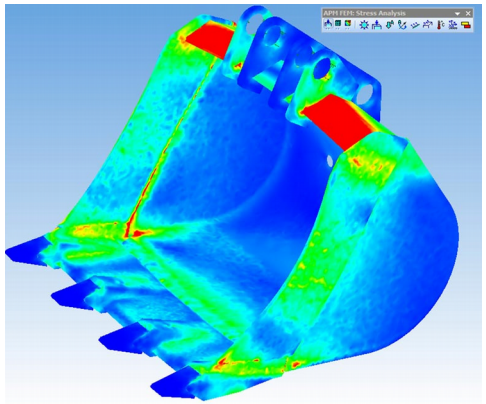
Originally developed by ASCON Group, now by **C3D Labs**, using ***C++*** and written in ***Microsoft Visual Studio***

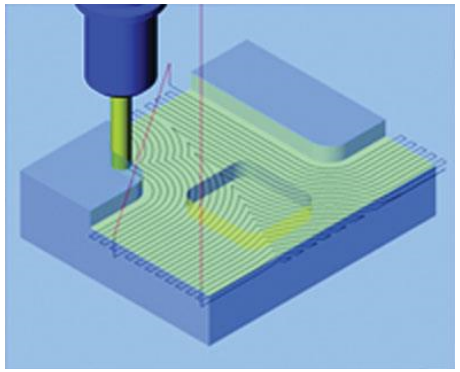


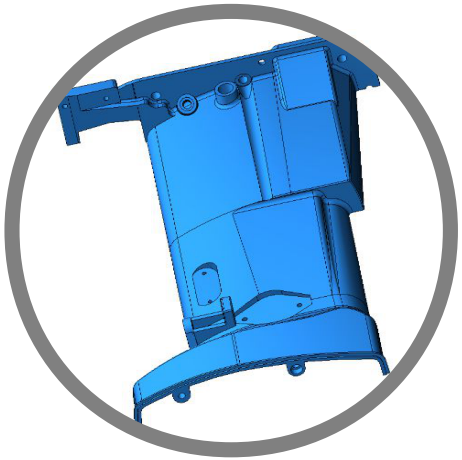
C3D Kernel

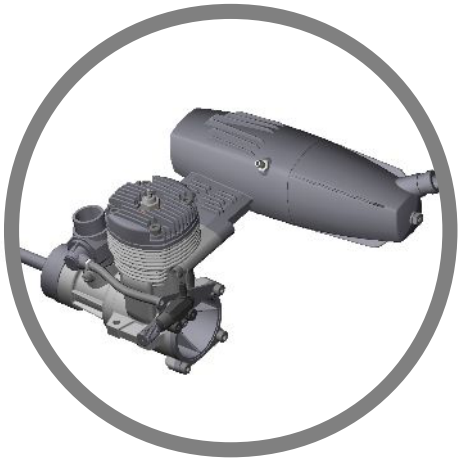
The most known software in which **C3D** is typically used are

- computer aided design (**CAD**) systems
- computer-aided manufacturing (**CAM**) systems
- computer-aided engineering (**CAE**) systems





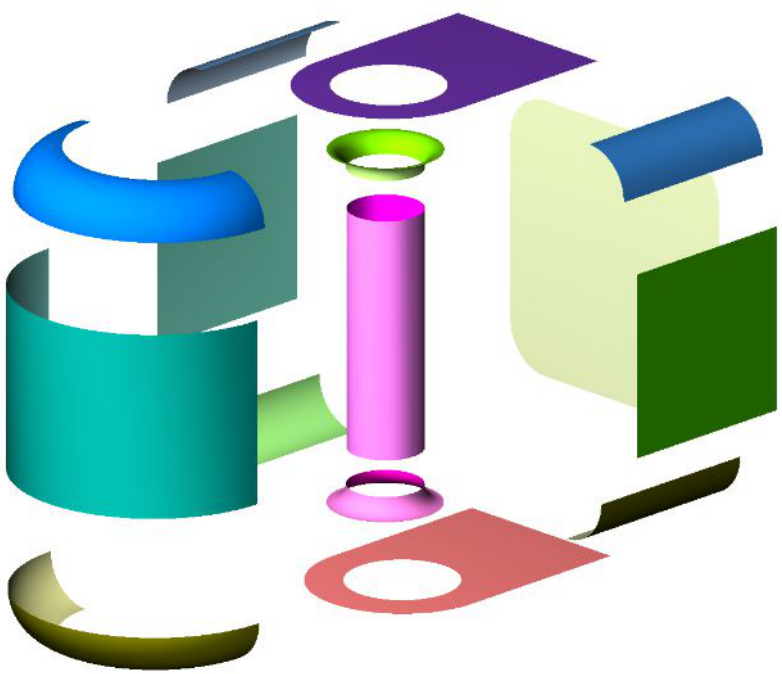


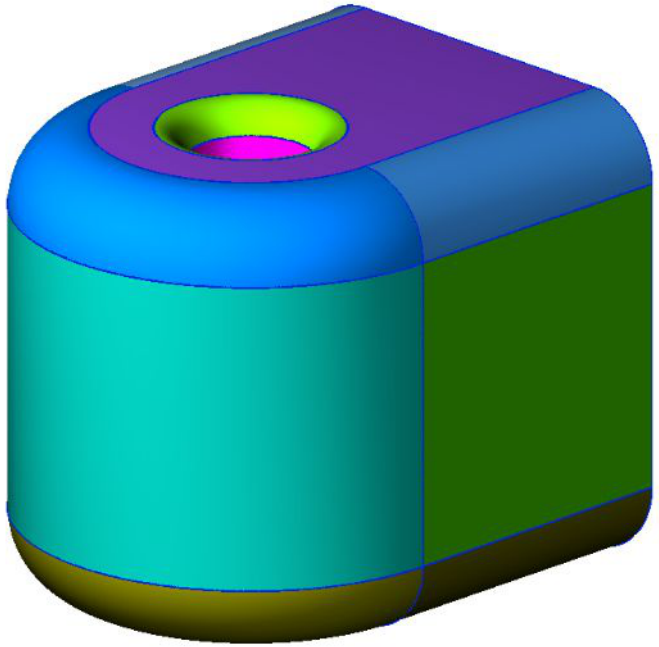


C3D Modeler

Modeling Approach

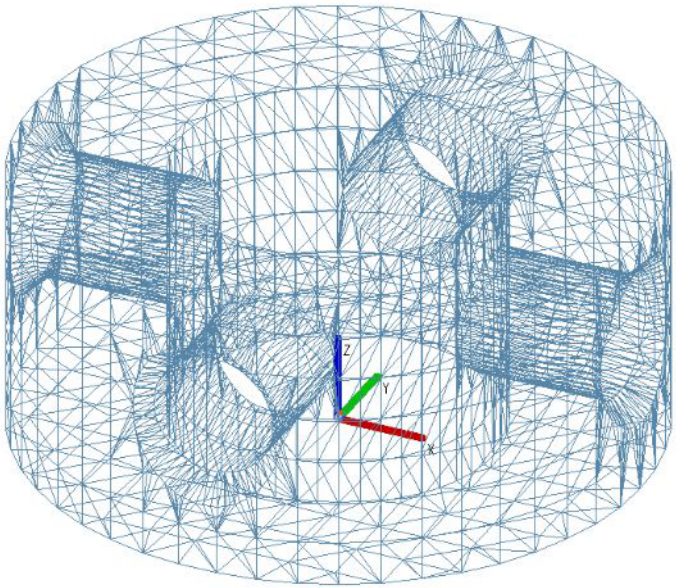
Boundary Representation (B-Rep)

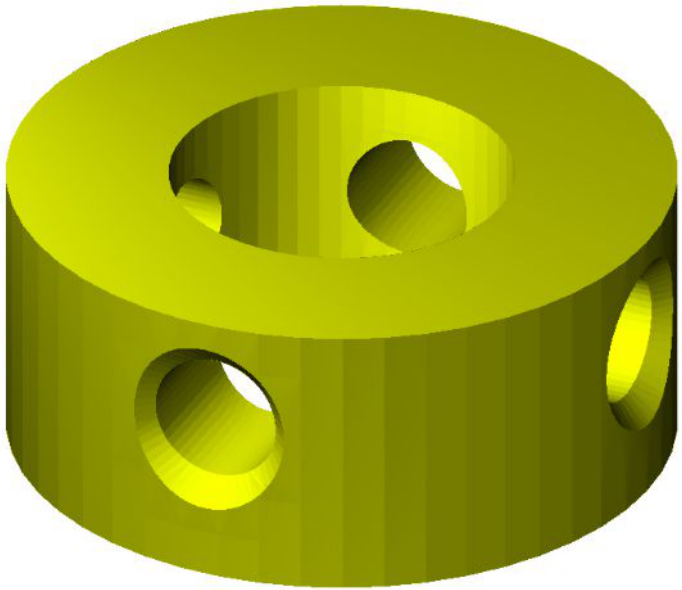




Visualization of Geometric Model

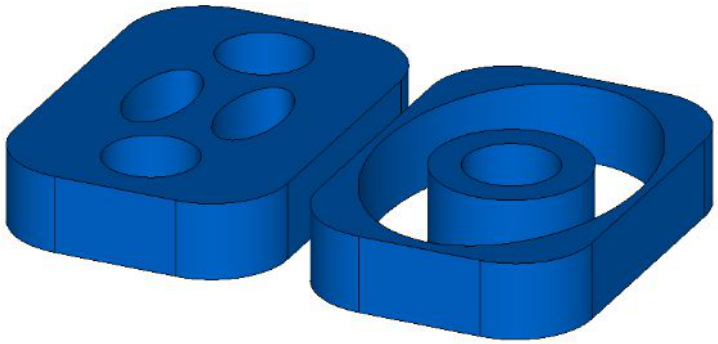
Polygonal Representation

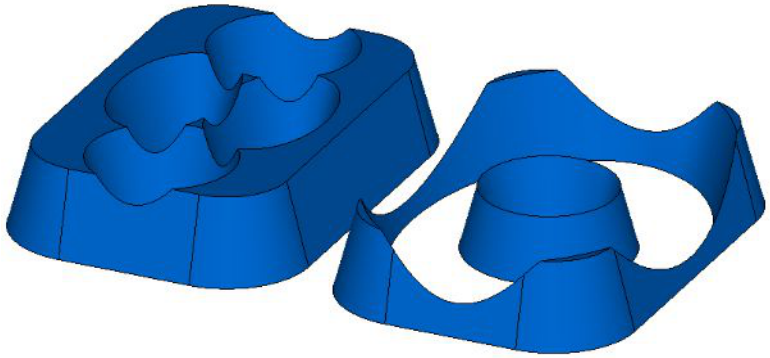


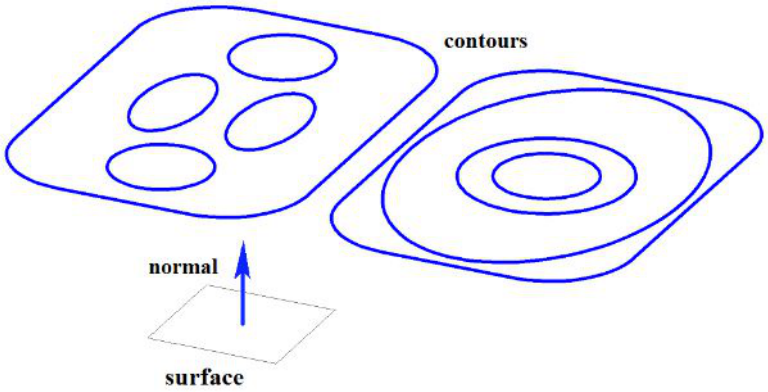


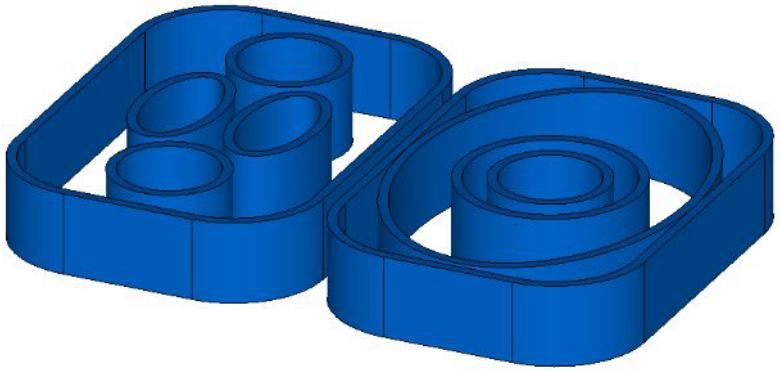
Geometric Modeling

Solid Modeling



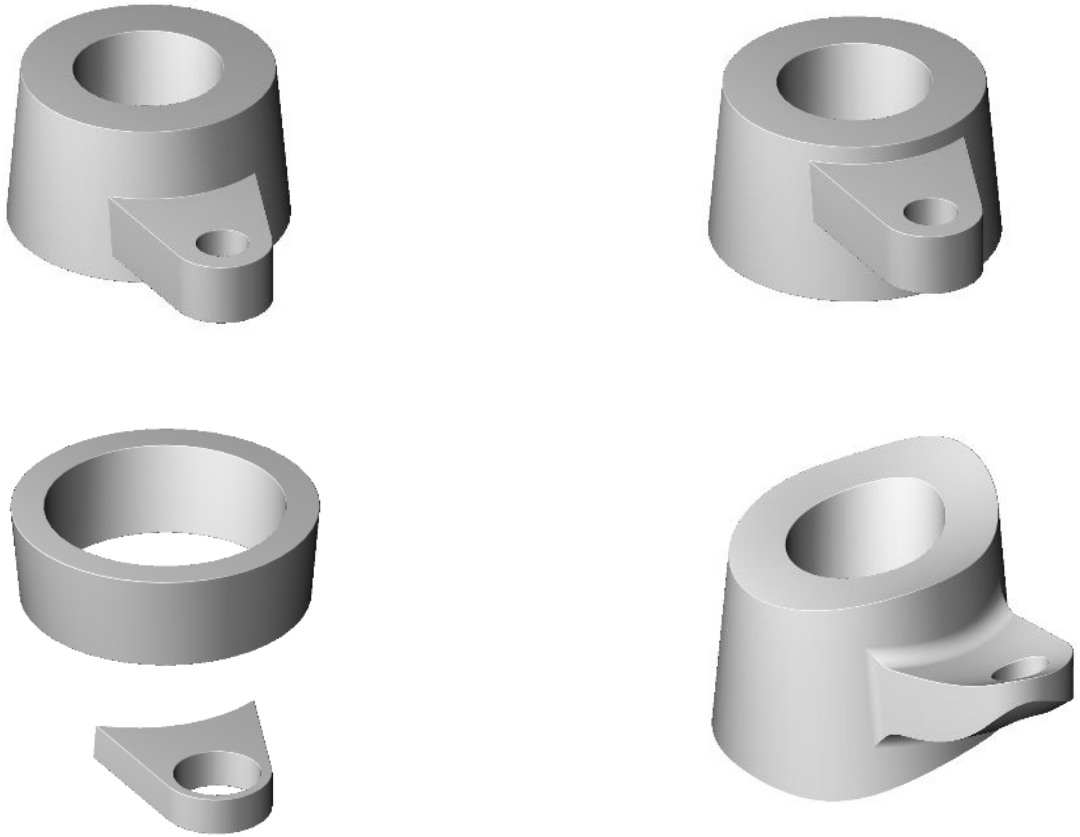






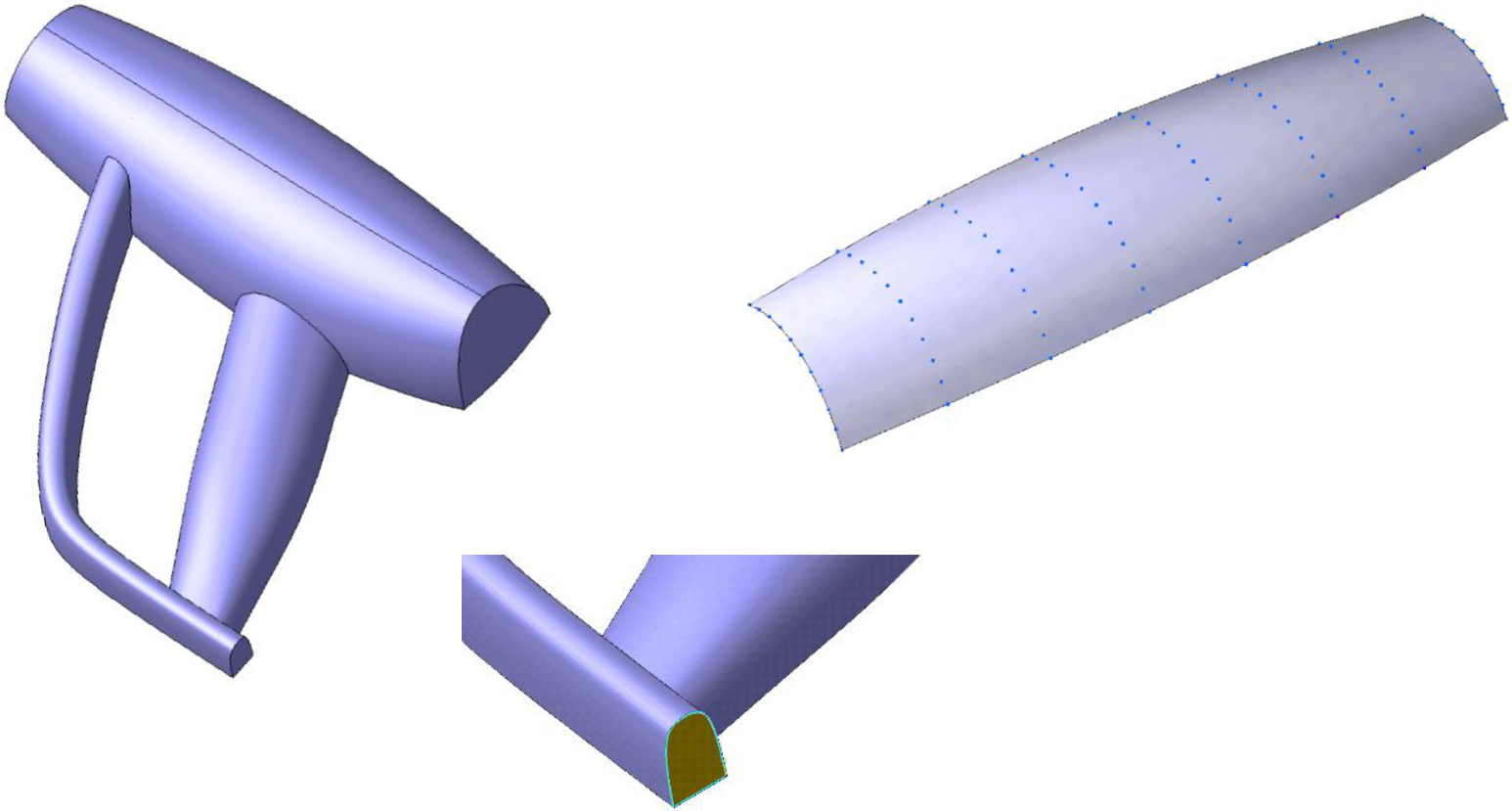
Geometric Modeling

Direct Modeling



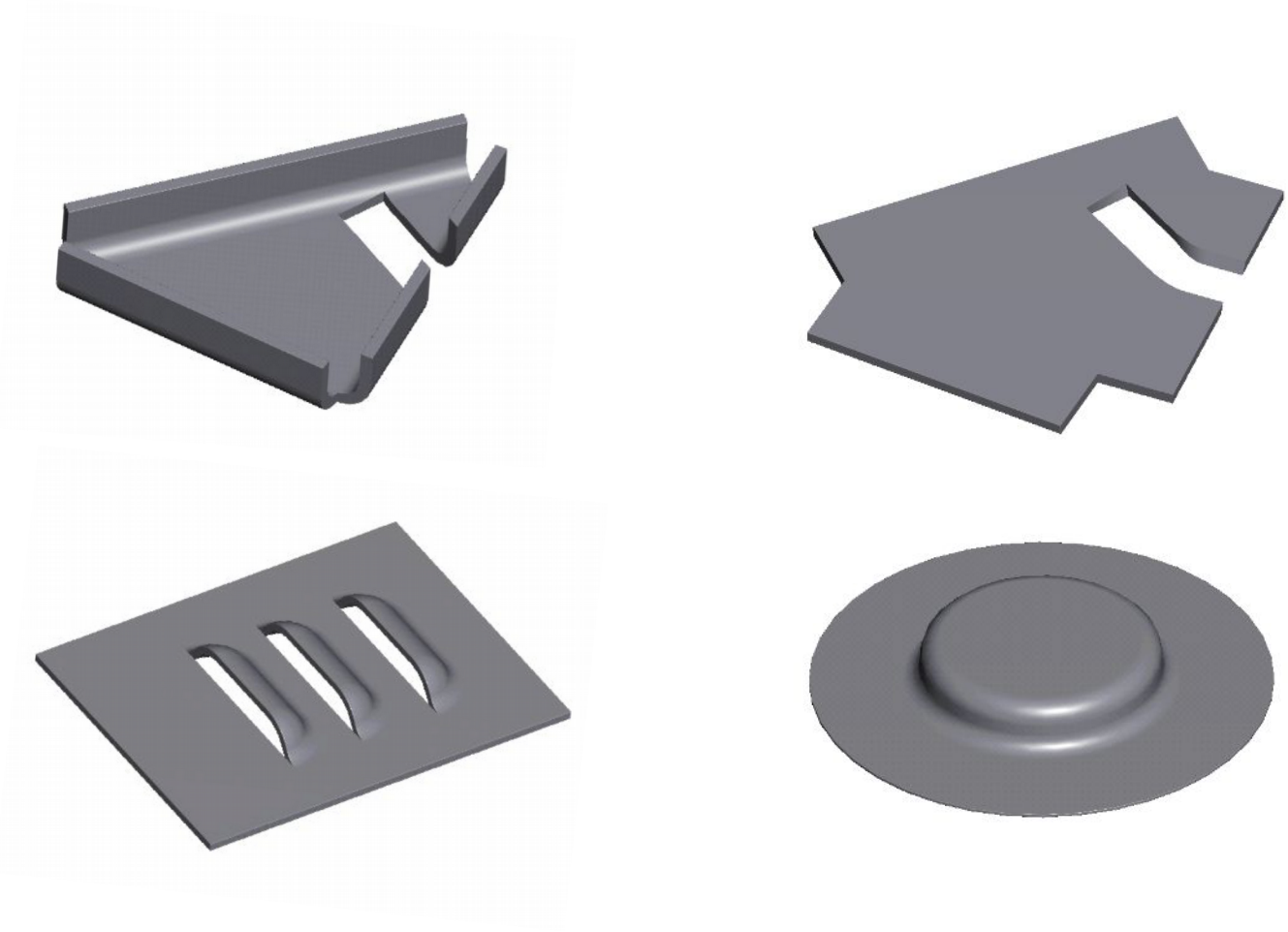
Geometric Modeling

Surface Modeling



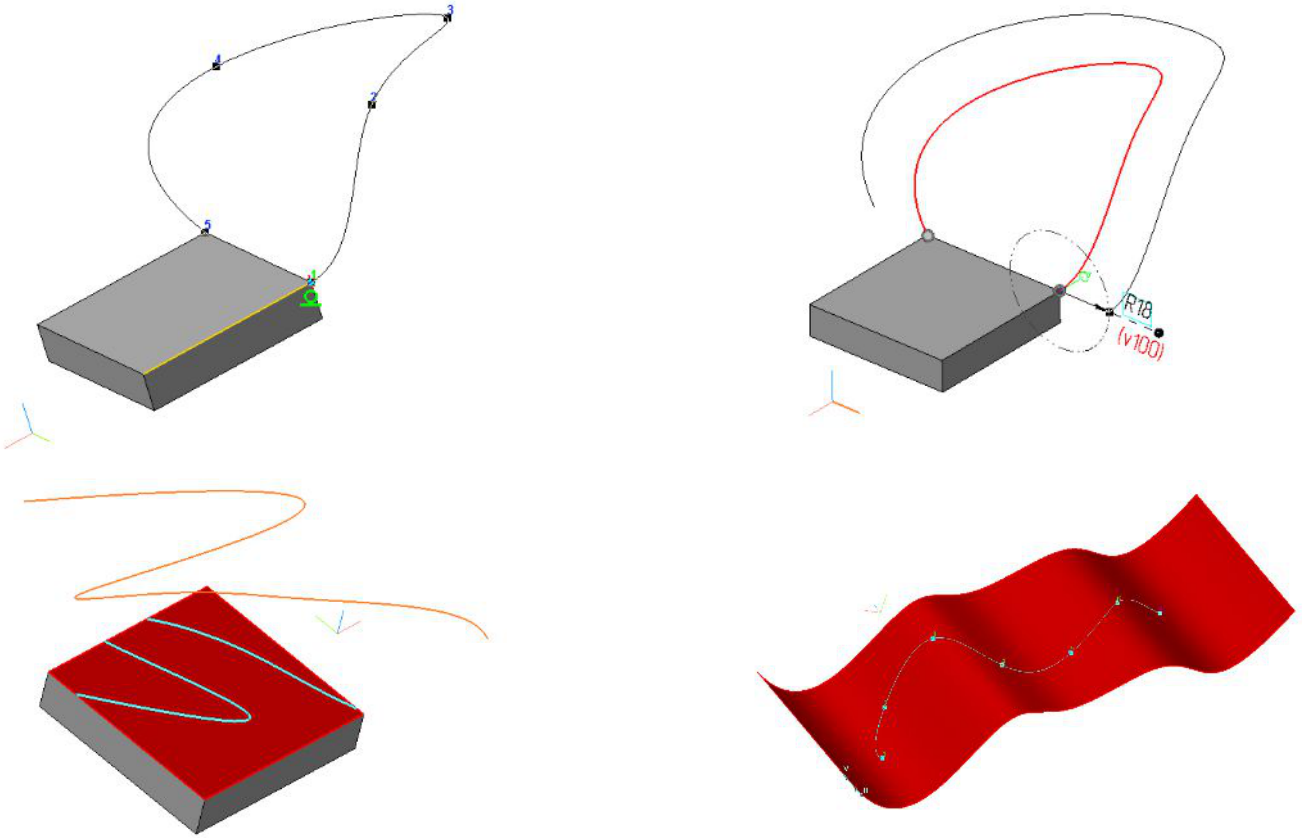
Geometric Modeling

Sheet Metal Modeling



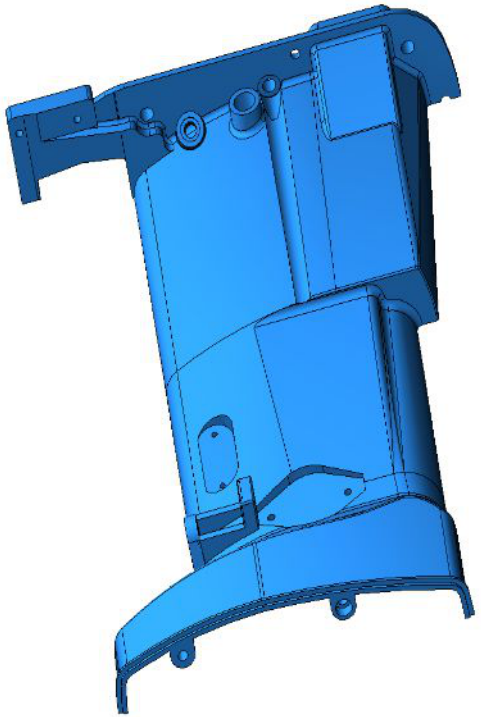
Geometric Modeling

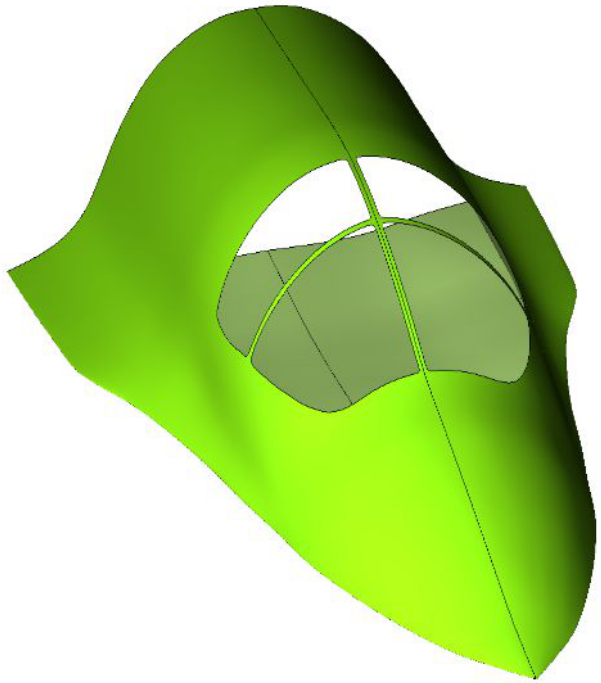
Wire Frame Modeling



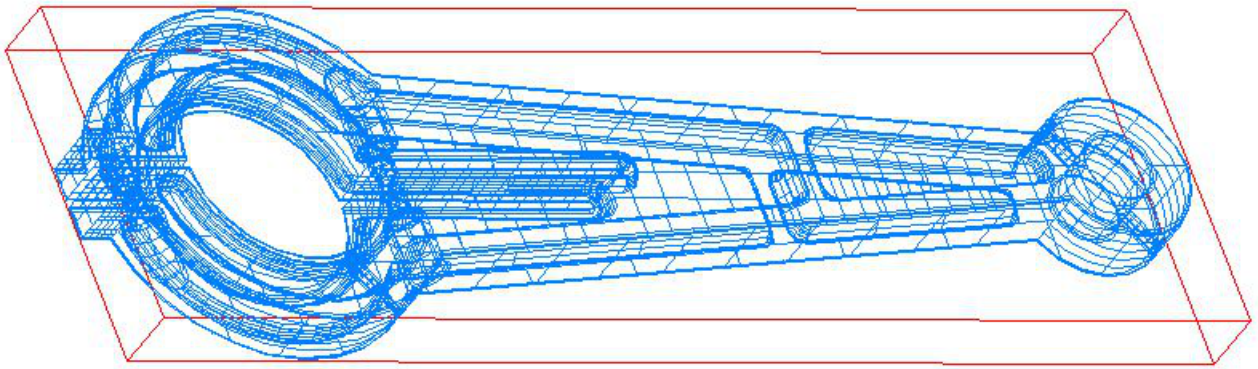
Geometric Modeling

Hybrid Modeling

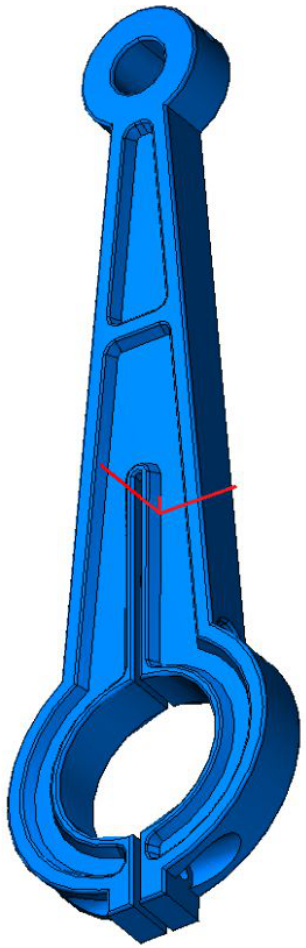


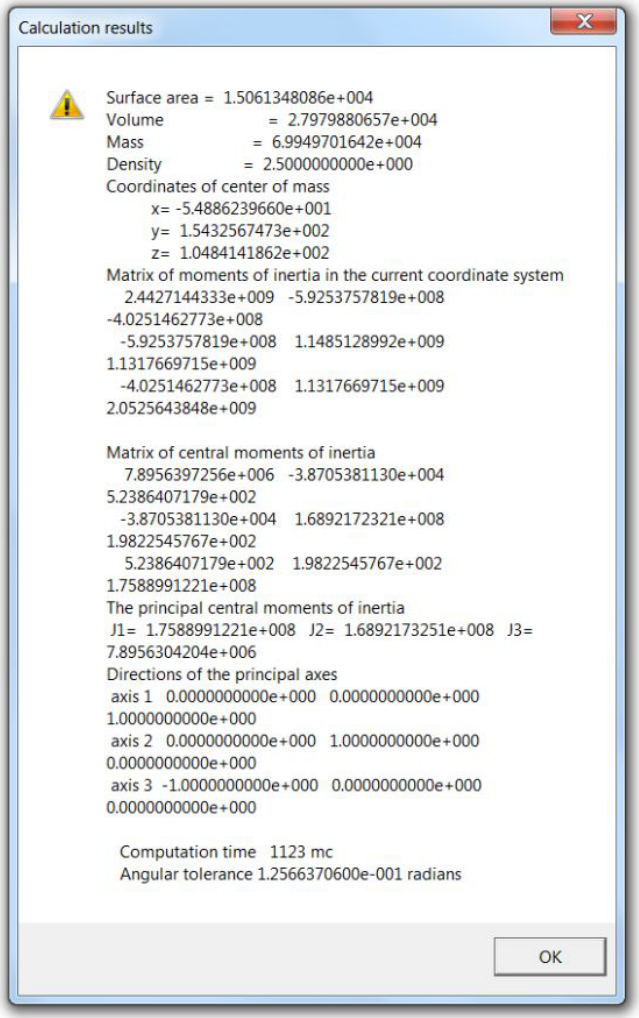


Geometric Calculations

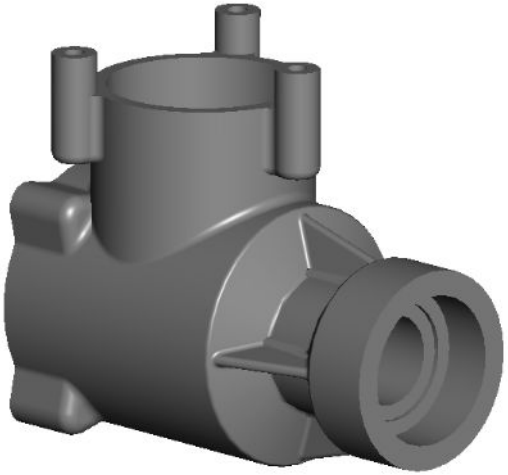


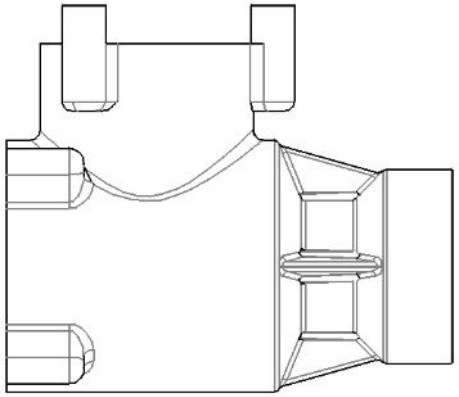
Mass-Inertia Properties

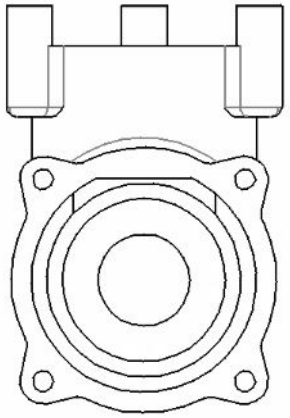


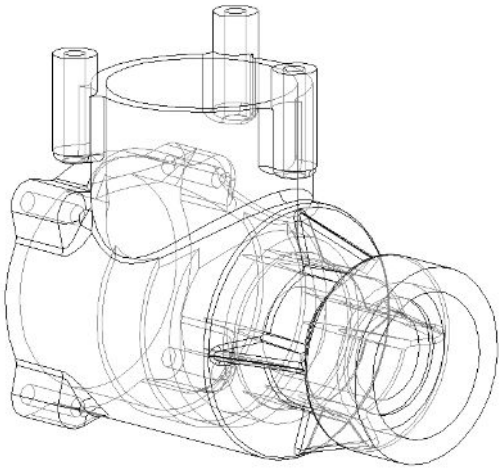


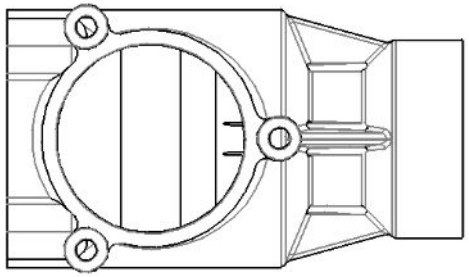
Planar Projections

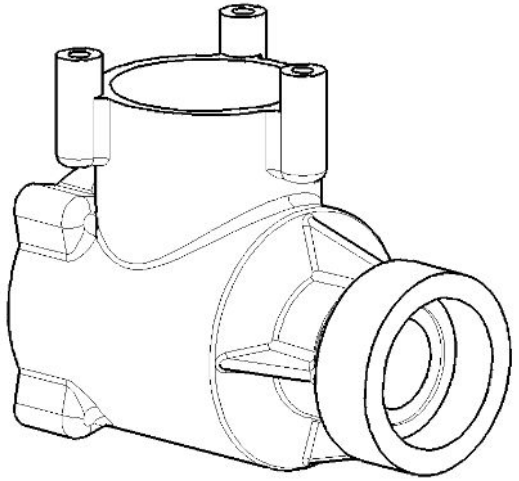


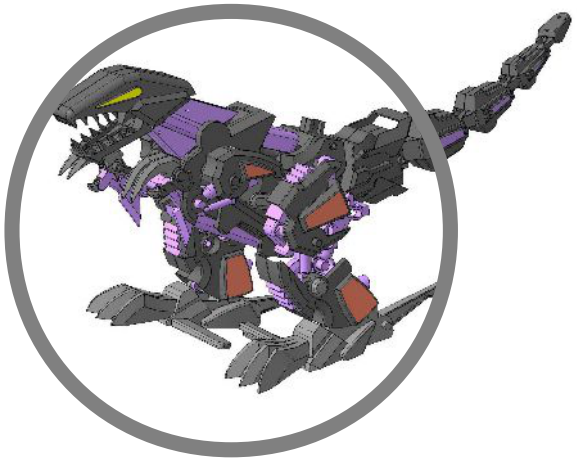


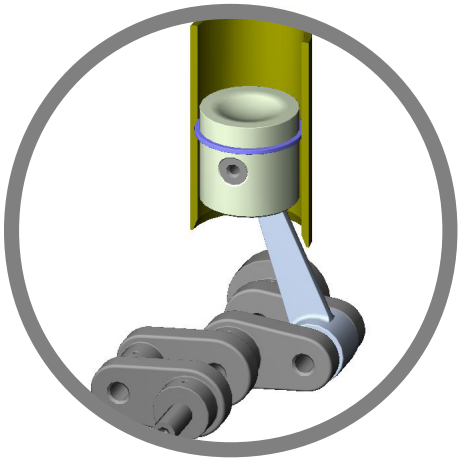


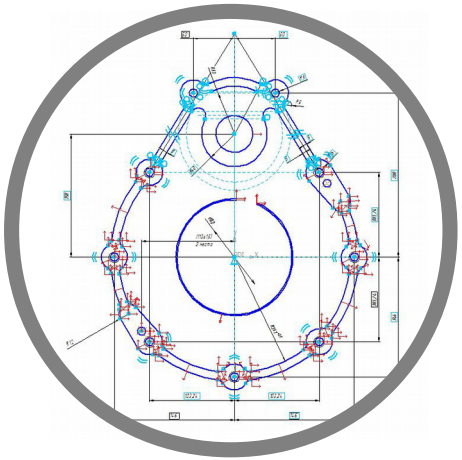












C3D Solver

Modeling with Constraints

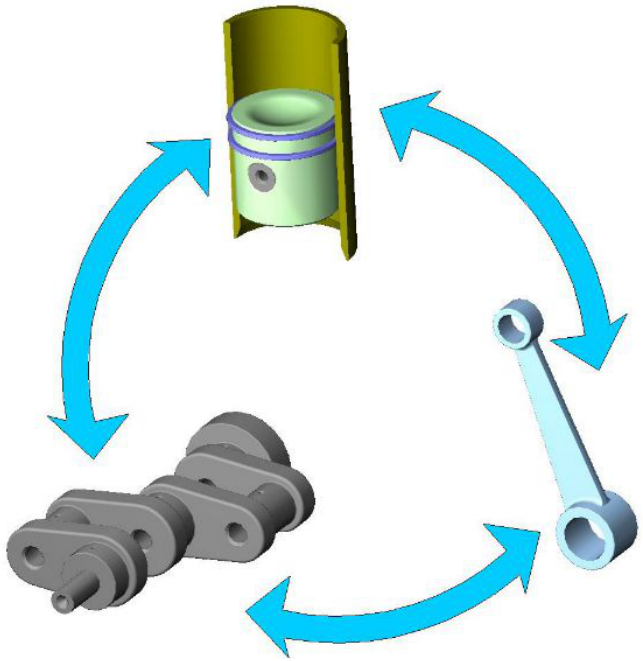
Primary features of C3D's constraint-based modeling:

Relationships between geometric objects **not subject to a strict order**

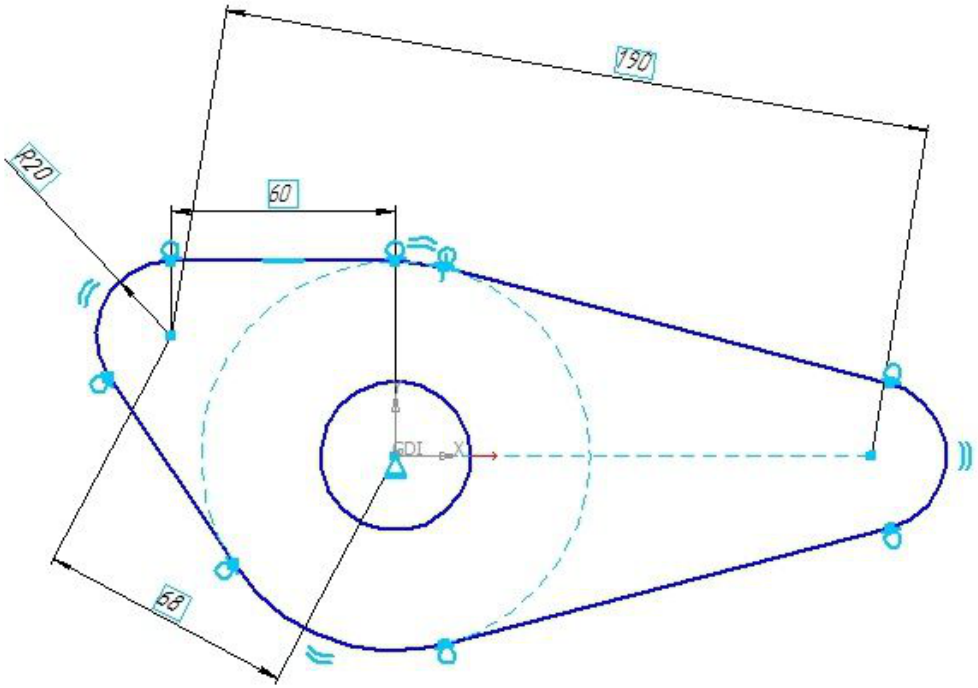
Declarative approach means there is no need to plan model creation steps in advance

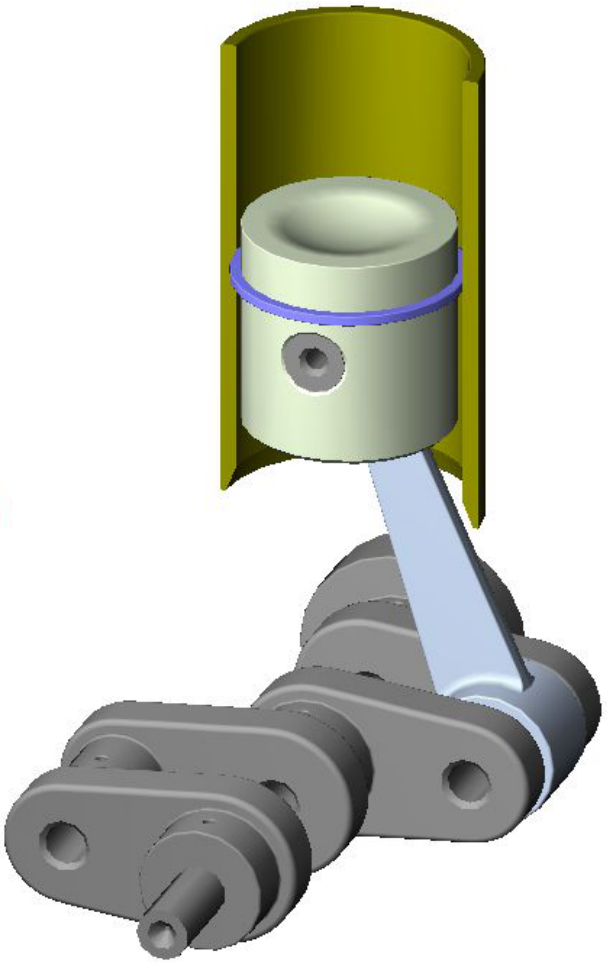
Geometric constraints allow **quick changes** to existing models

Models can be parametric, with driving dimensions assigned in a user-friendly manner

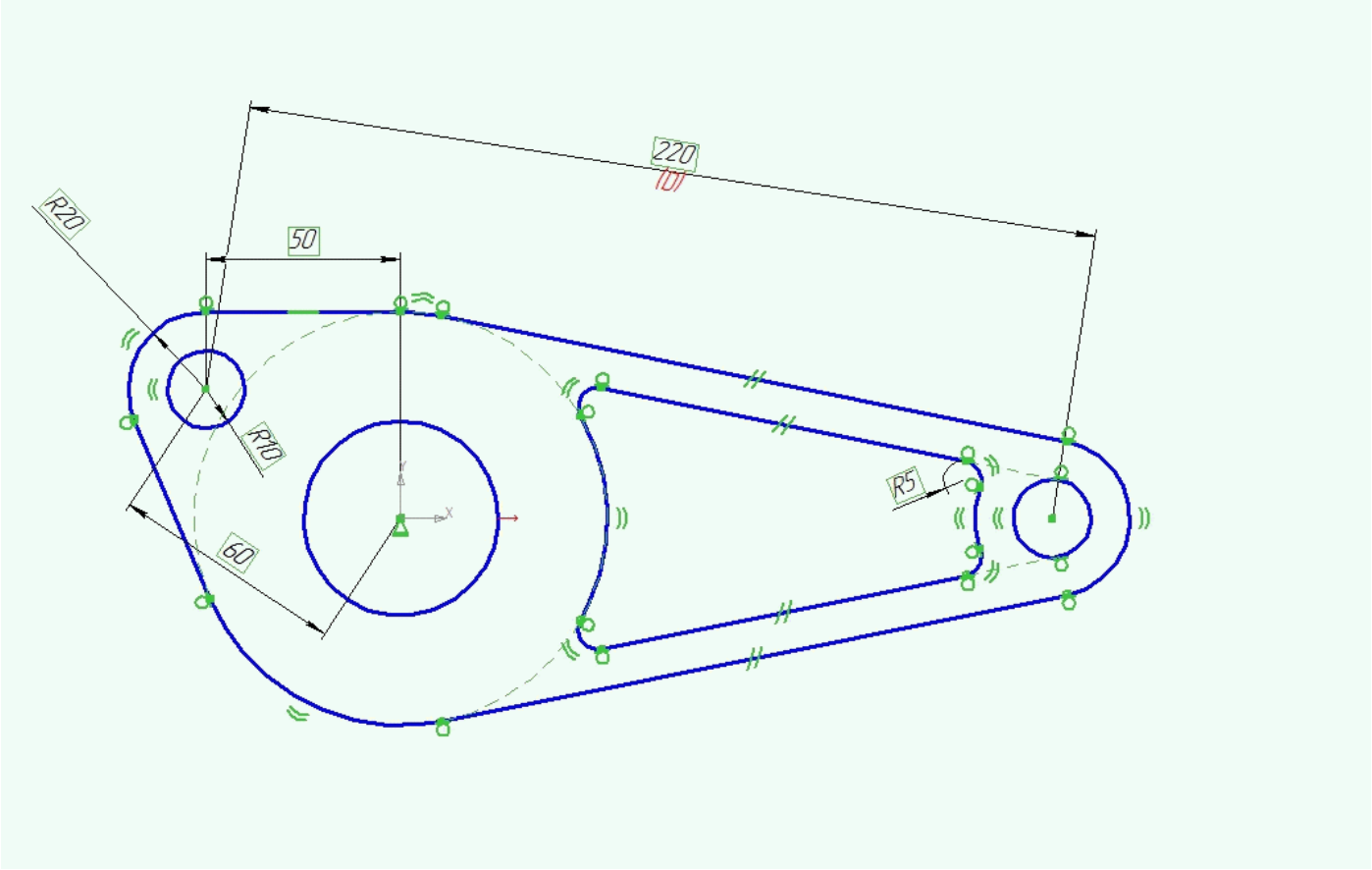


Solving Constraint Satisfaction

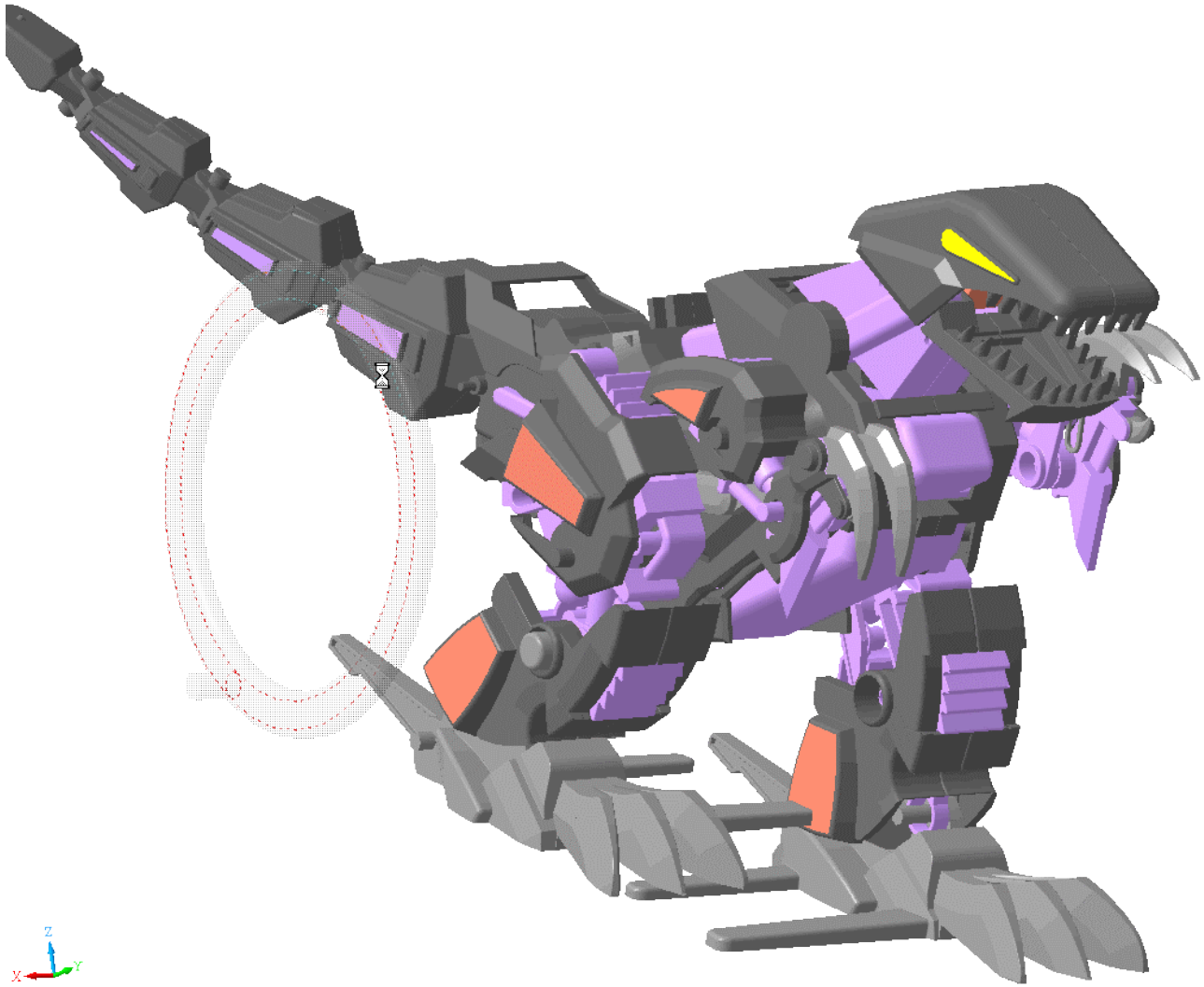




Constraint-Driven Parametric Drawings



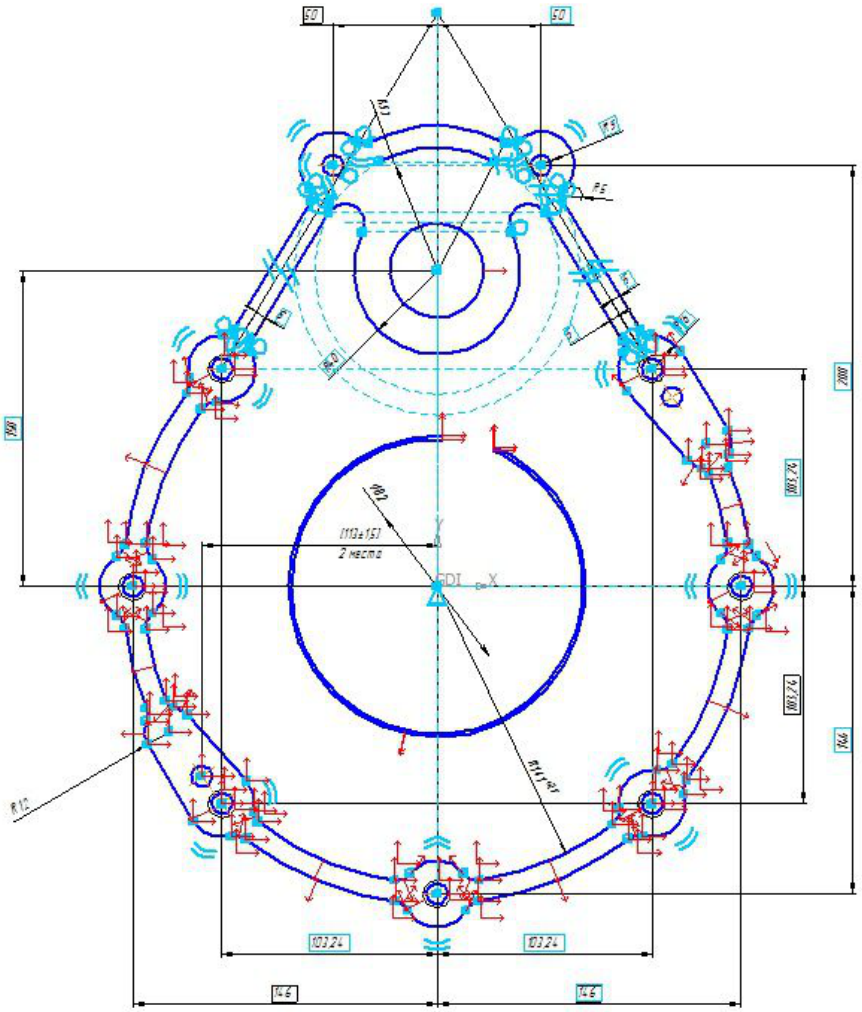
Assembly Modeling and Kinematic Simulation



C3D Labs

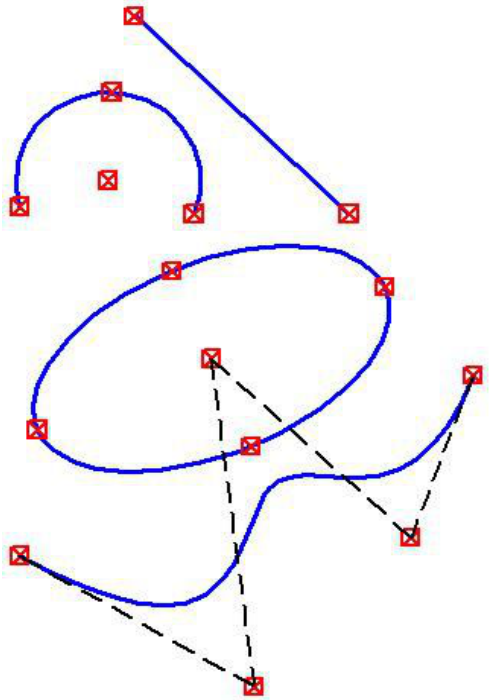
Sk Resident

Evaluating Under-Constrained Geometry and Degree of Freedom Analysis



2D Solver Data Types

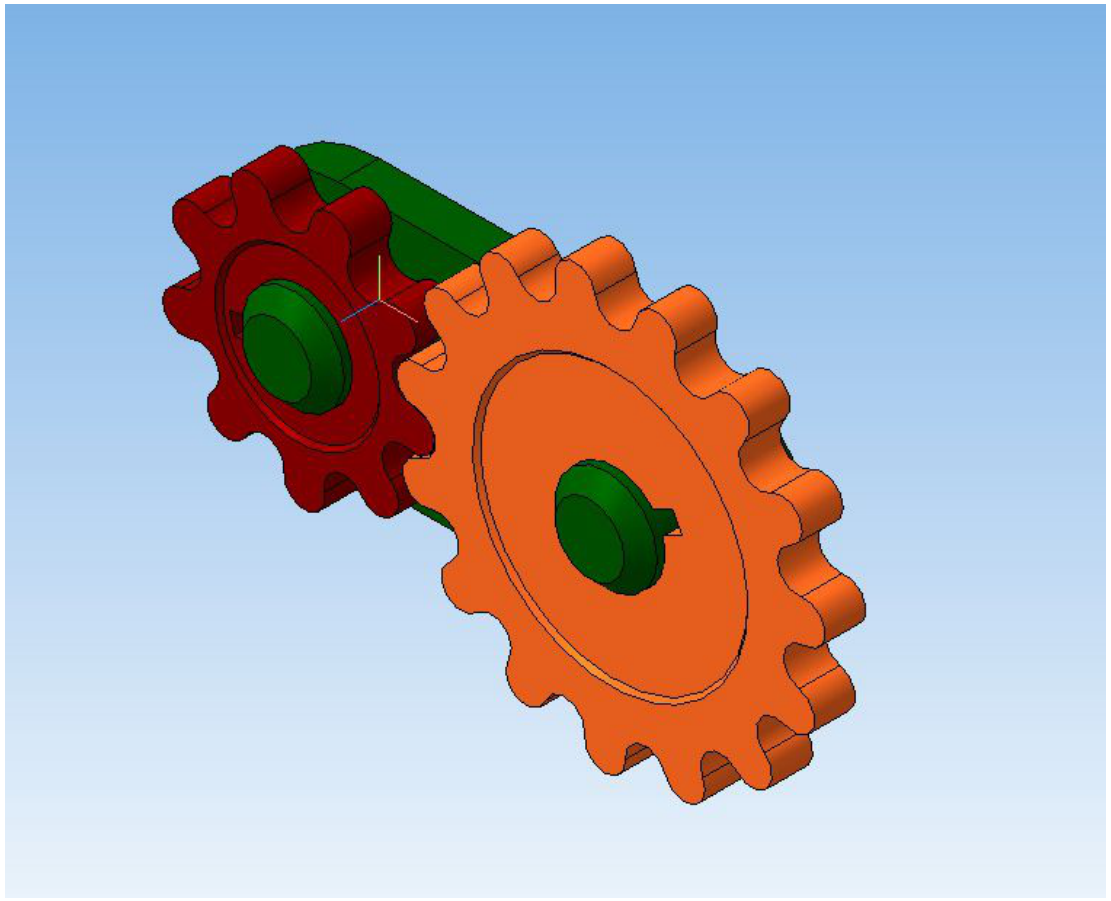
Geometry	Constraints
Points	Coincidence
	Incidence
Lines, line segments	Parallelism
	Perpendicularity
Circles, arcs	Align points
	Tangency
Ellipses	Distance
	Angle
Splines	Radius
	Fix, freeze geometry
Parametric curves	Fix length or direction
	Equal lengths
	Equal radii



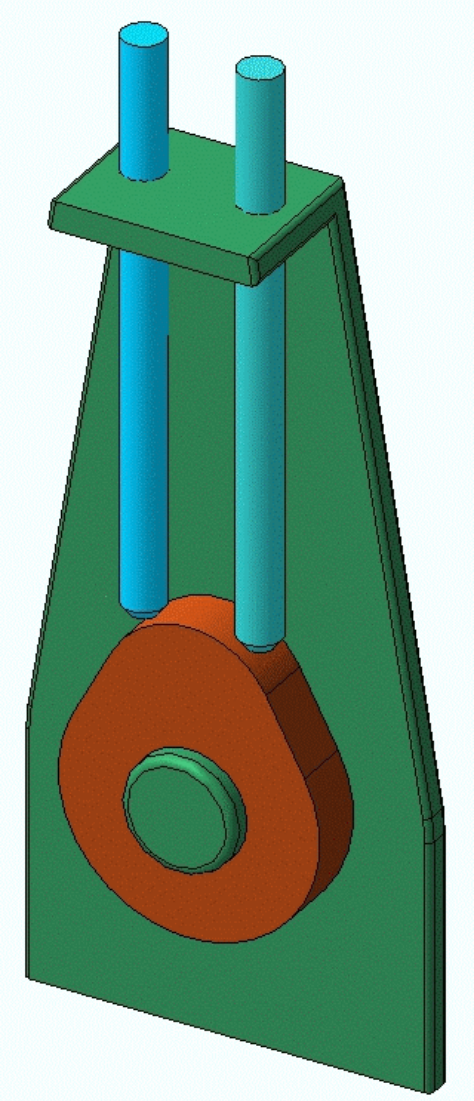
3D Solver Data Types

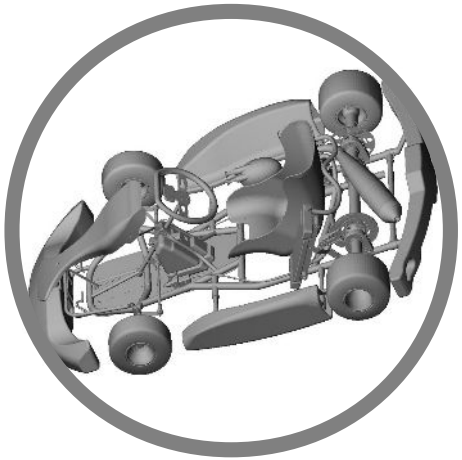
Geometry	Constraints
Points (vertices)	Coincidence
Lines	Coaxiality
Planes	Parallelism
Cones/cylinders	Perpendicularity
Tori	Tangency
Spheres	Distance
Markers	Angle
Rigid bodies	Fix geometry
	Transmissions

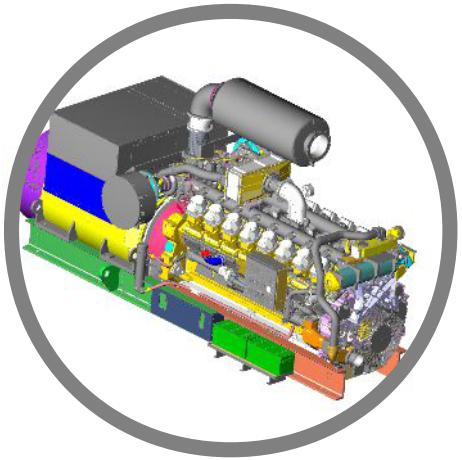
Mechanical Transmissions

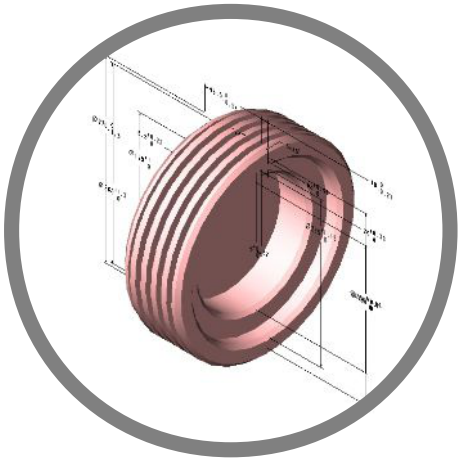


Cam Mechanism









C3D Converter

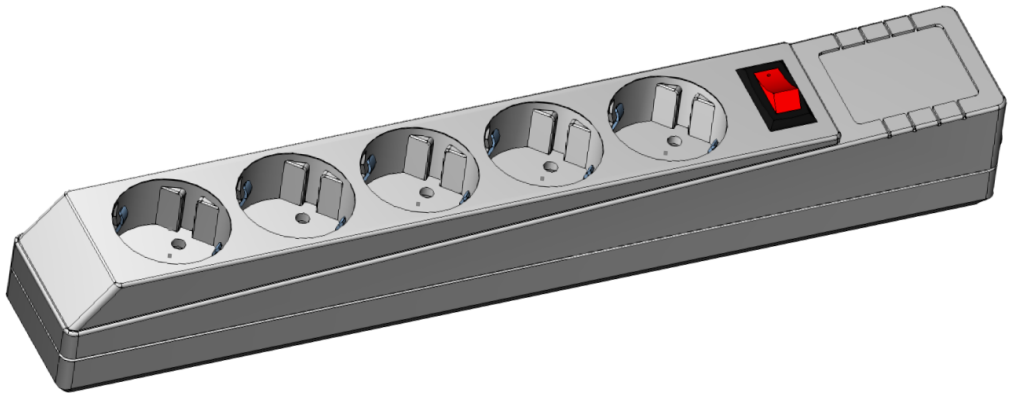
C3D Converter

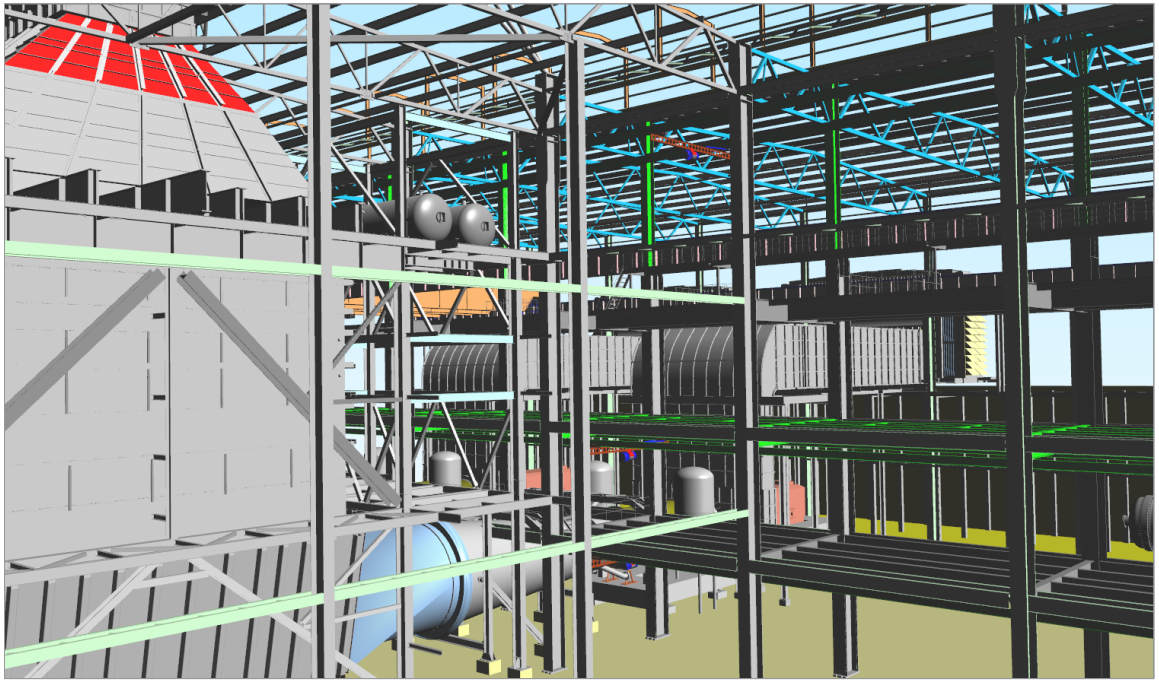
Reads:

STEP AP203, AP214 (with PMI)
IGES v.5.3.
Parasolid X_T, X_B v.25.0
ACIS SAT v.22.0
STL, VRML v.2.0

Writes:

STEP AP203, AP214 (with PMI)
IGES v.5.3.
Parasolid X_T, X_B v.10.0
ACIS SAT v.2.0
STL, VRML v.2.0





C3D Vision

C3D Vision

Visualization module of C3D Kernel

With polygonal representation of 3D objects

Easy to use for C3D customers

Fast, fast, fast! Very fast!

Available features - OpenGL and Levels Of Detail, LOD

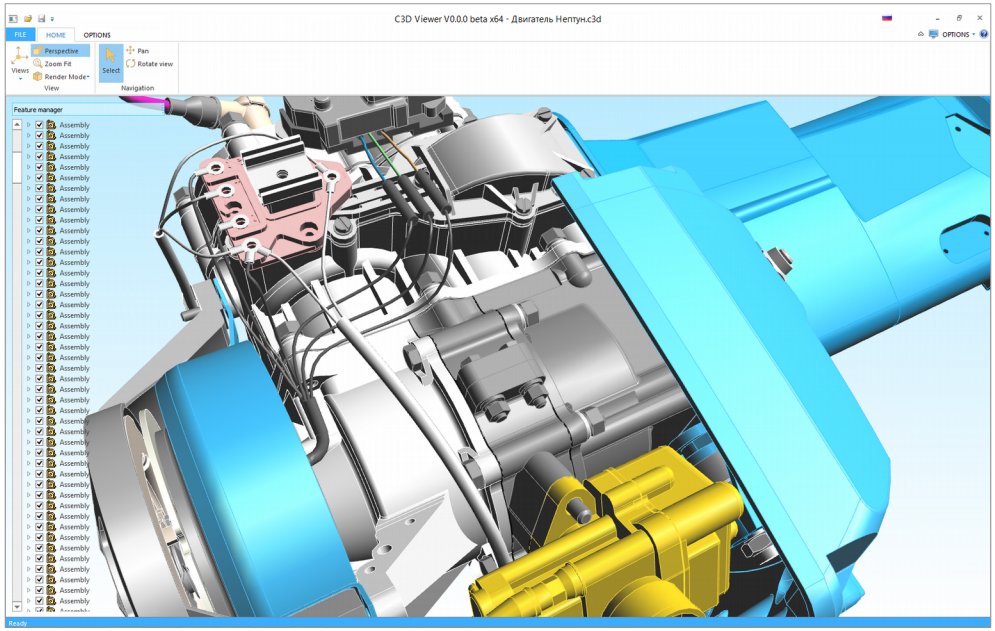
Objects search engine is based on Object Identification

3D Widgets are supported

C3D Viewer

Test application for C3D Vision and C3D Converter

Easy to integrate for developers

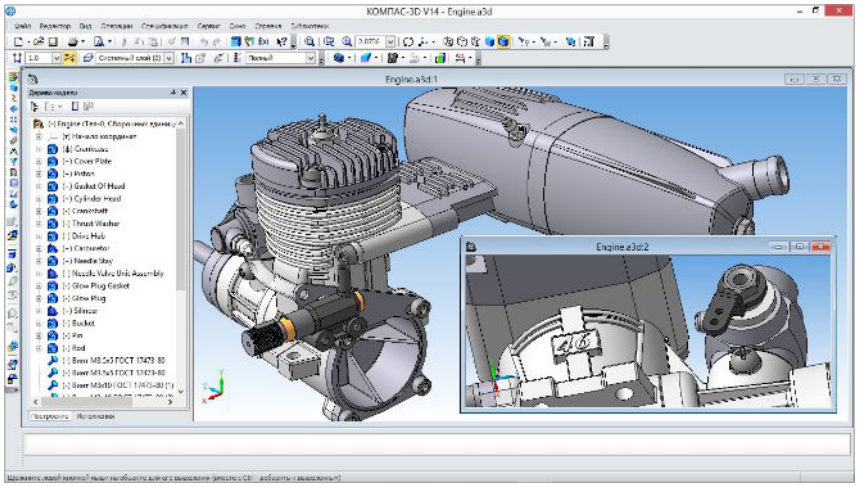


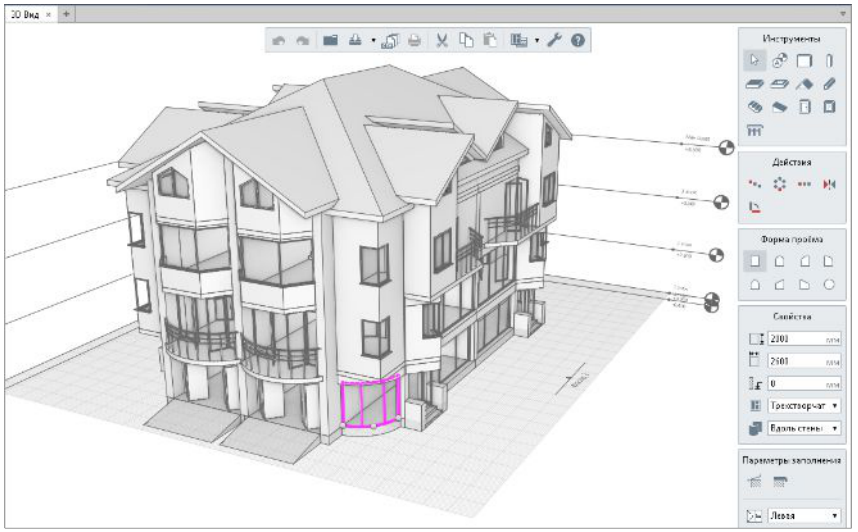
C3D Customers

Our Customers – CAD/CAM/CAE Developers

ASCON

KOMPAS-3D, MCAD
Renga Architecture
KOMPAS:24 for Android

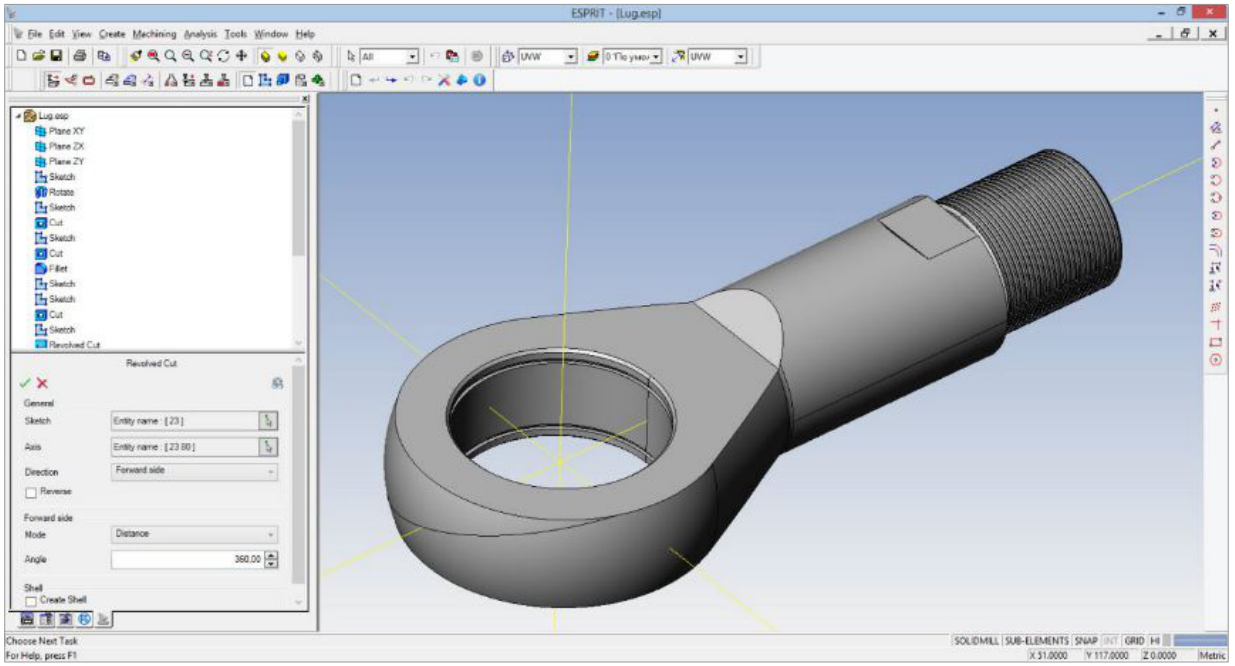




Our Customers – CAD/CAM/CAE Developers

LO CNITI and **Rubius**

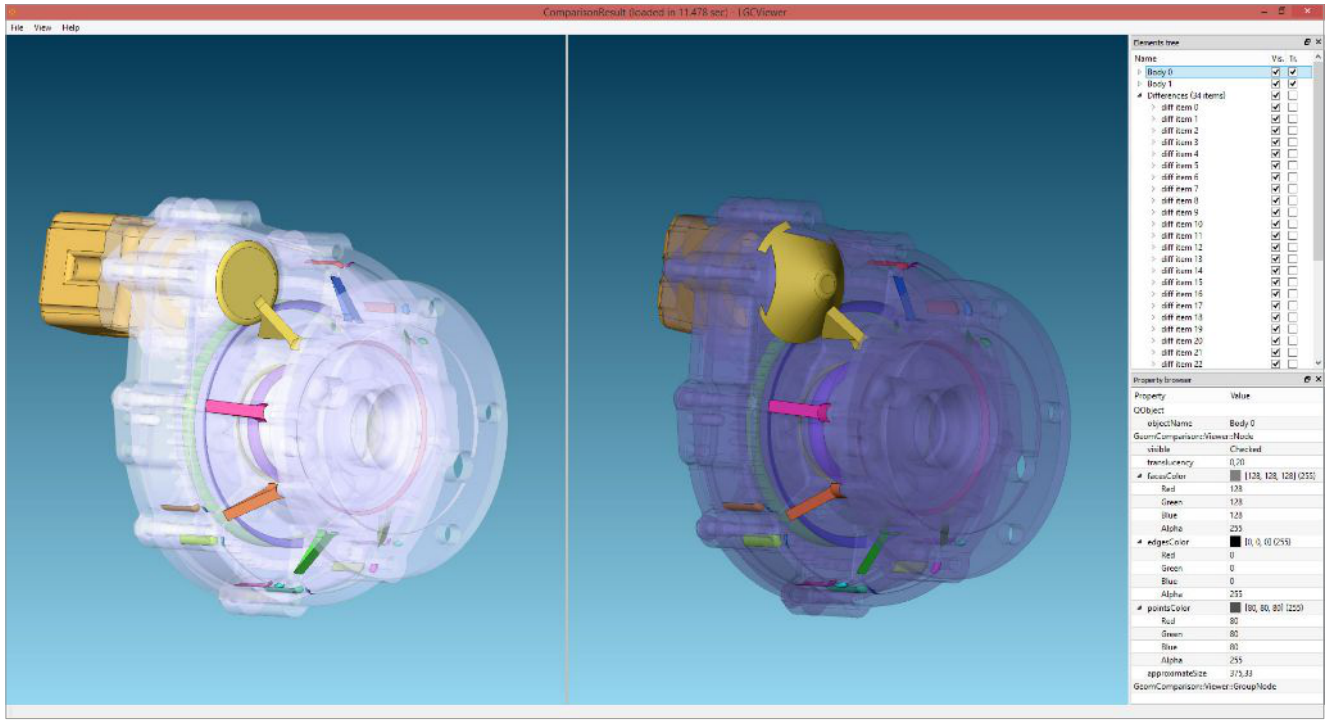
Extra CAD for ESPRIT



Our Customers – CAD/CAM/CAE Developers

LEDAS

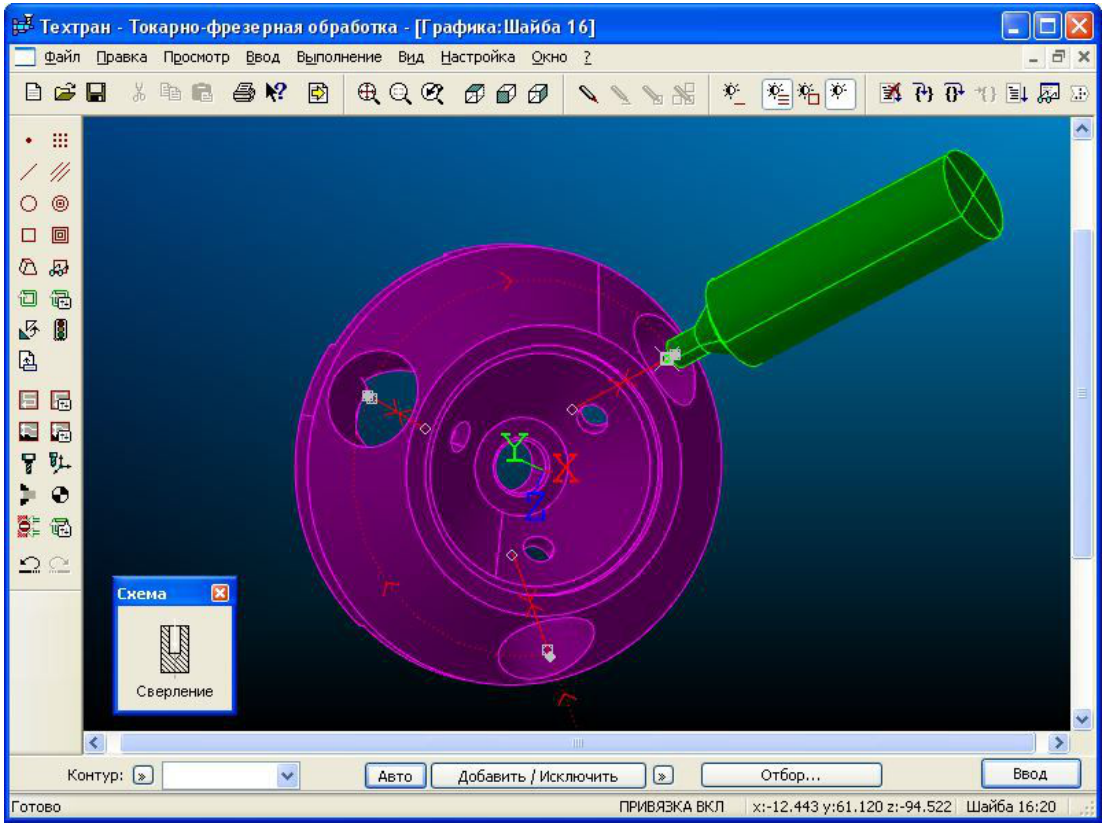
Geometry Comparison (LGC)



Our Customers – CAD/CAM/CAE Developers

NIP Informatica

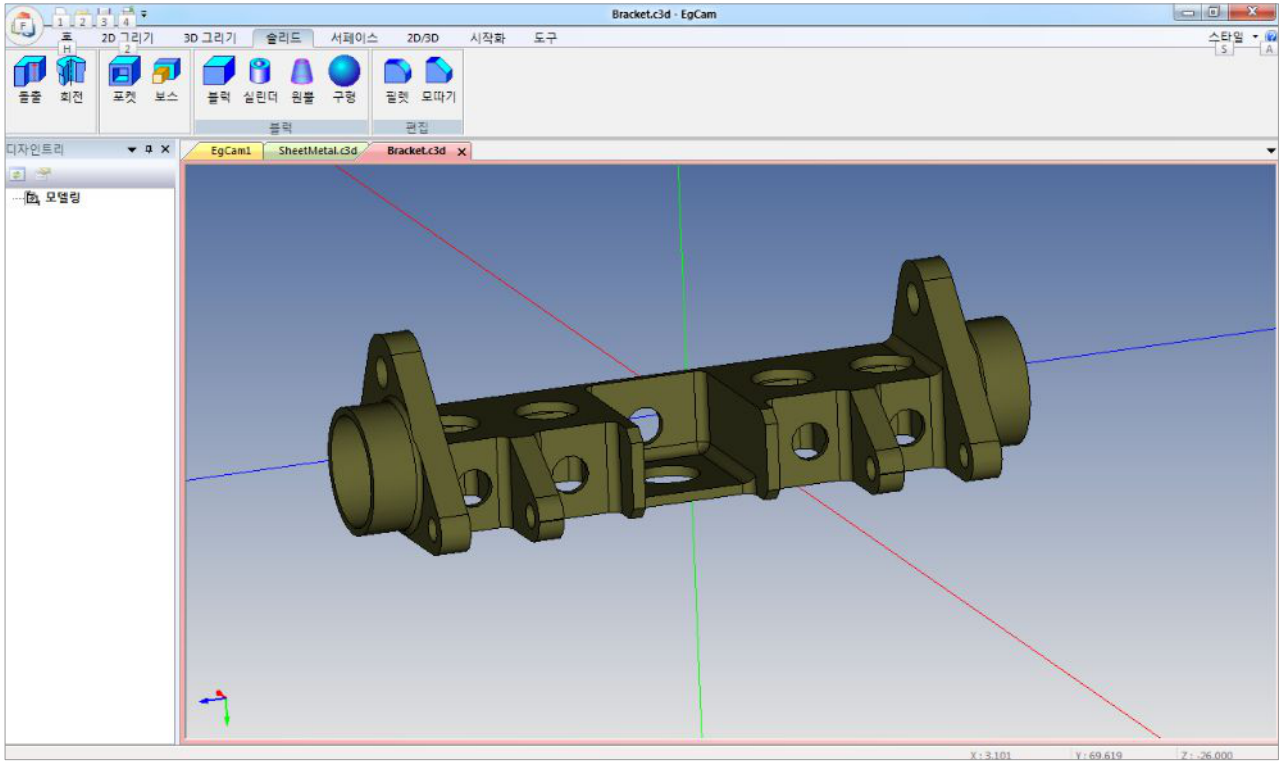
TECHTRAN CAM



Our Customers – CAD/CAM/CAE Developers

Solar Tech (Republic of Korea)

Quick CADCAM



Our Customers – CAD/CAM/CAE Developers

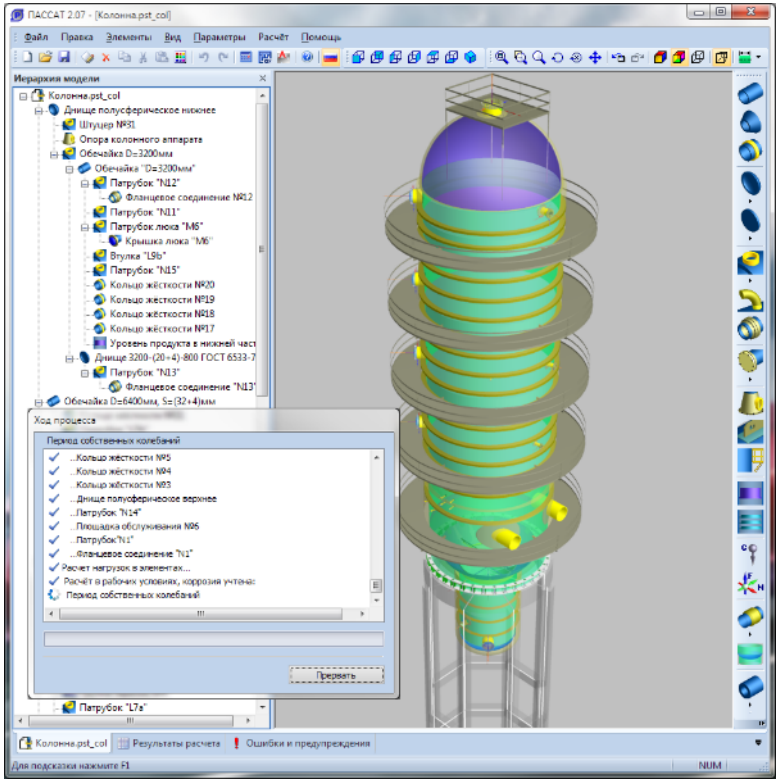
Elecosoft Consultec (Sweden)

Staircon

Our Customers – CAD/CAM/CAE Developers

NTP Truboprovod

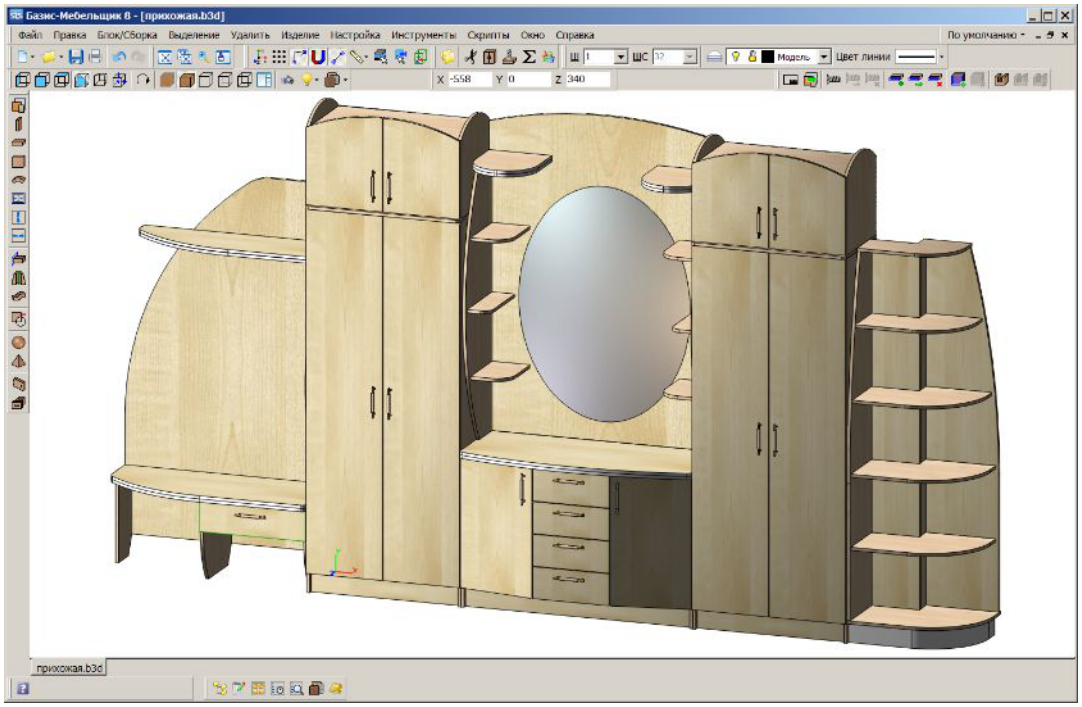
PASSAT (Strength and stability calculation of vessels and apparatuses, CAE)



Our Customers – CAD/CAM/CAE Developers

BAZIS-Center

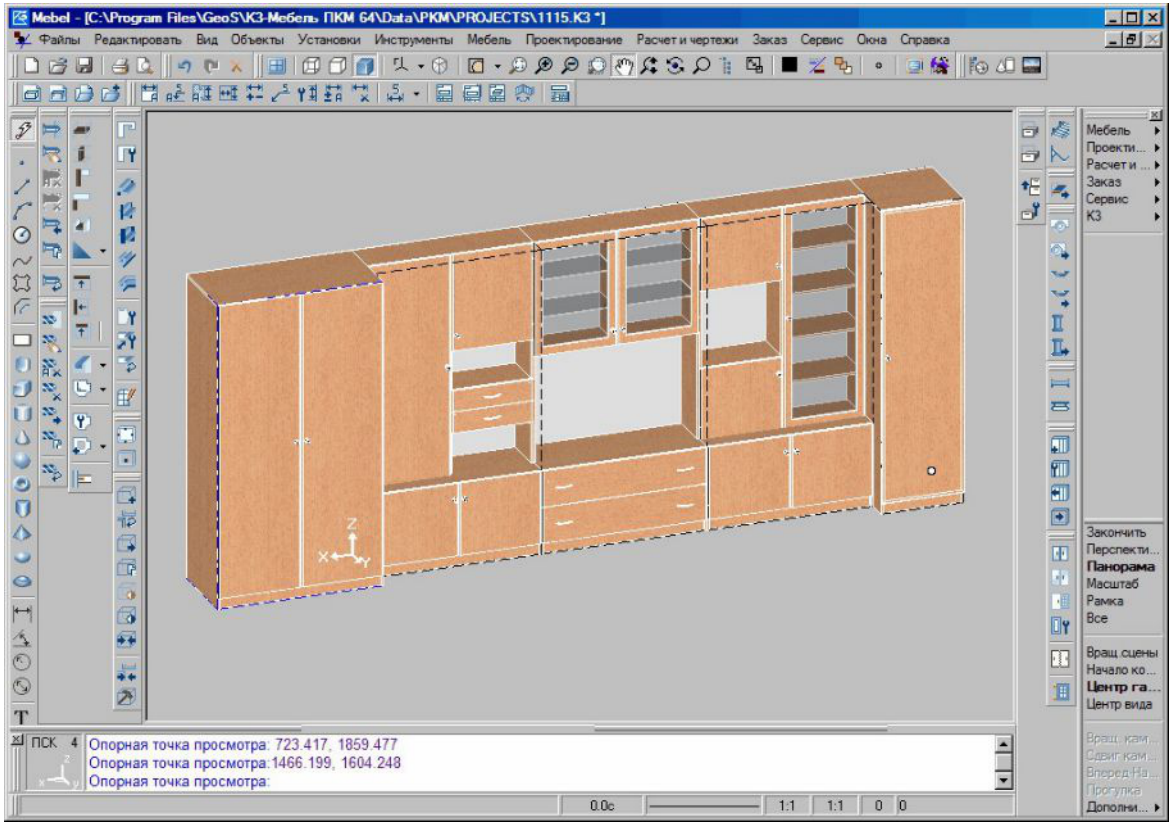
BAZIS



Our Customers – CAD/CAM/CAE Developers

Center GeoS

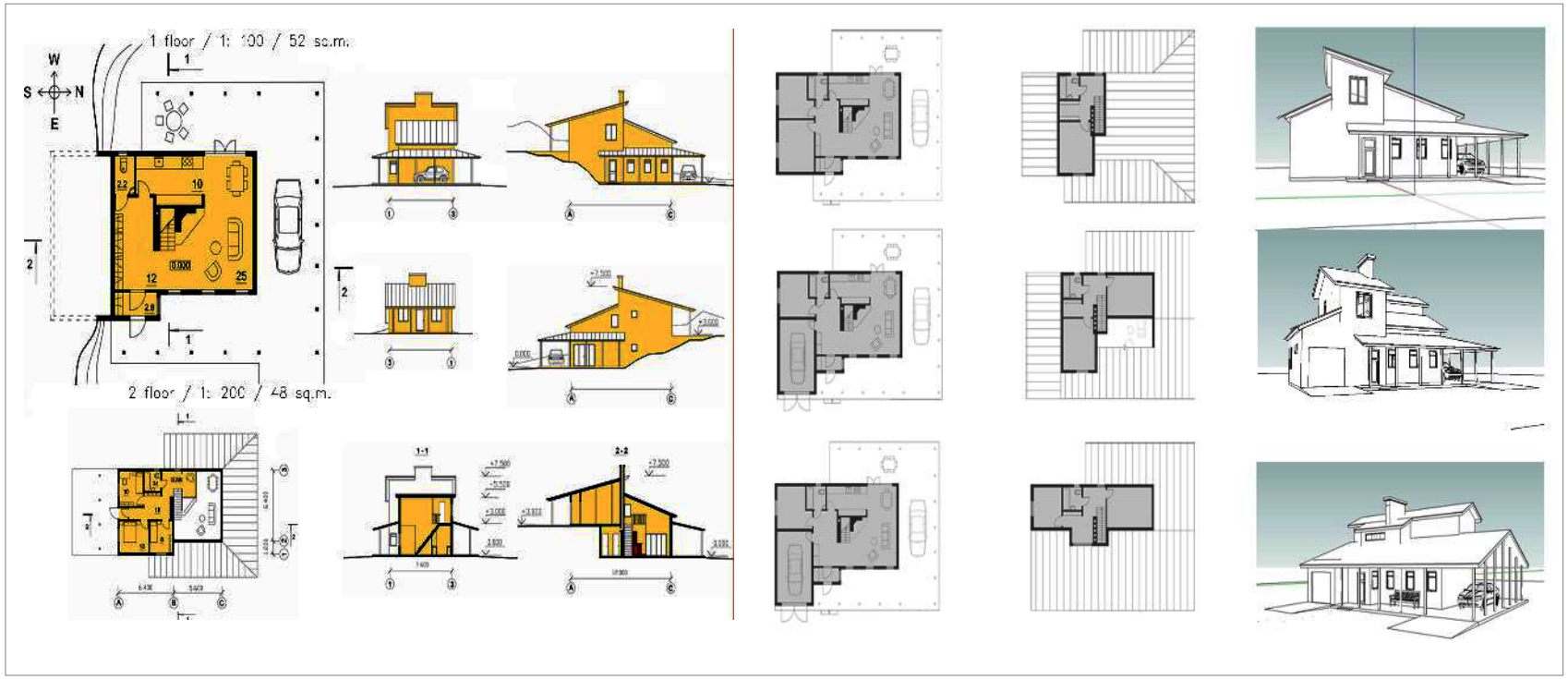
K3-Furniture



Our Customers – CAD/CAM/CAE Developers

BSP

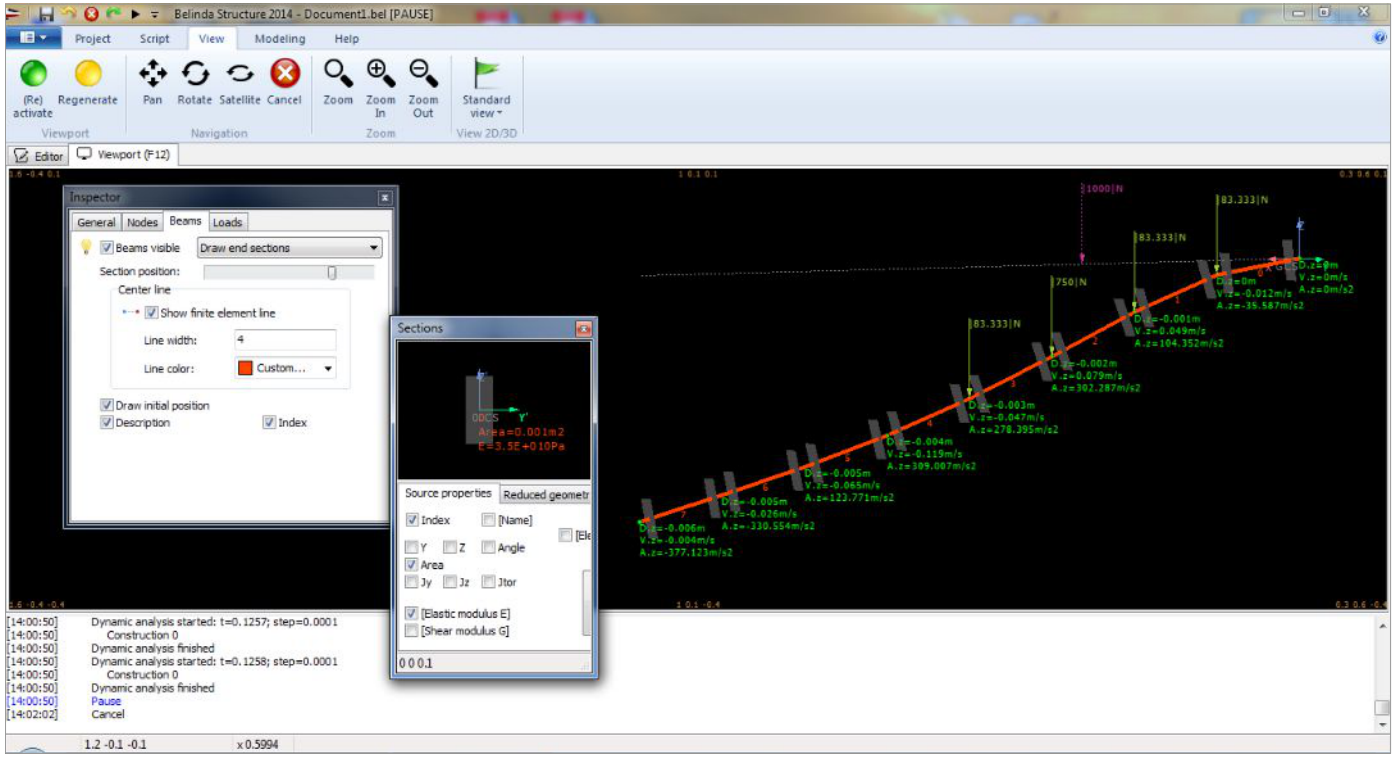
HABITEK (AEC CAD)



Our Customers – CAD/CAM/CAE Developers

Dynamics & Structures, Lab (Ukraine)

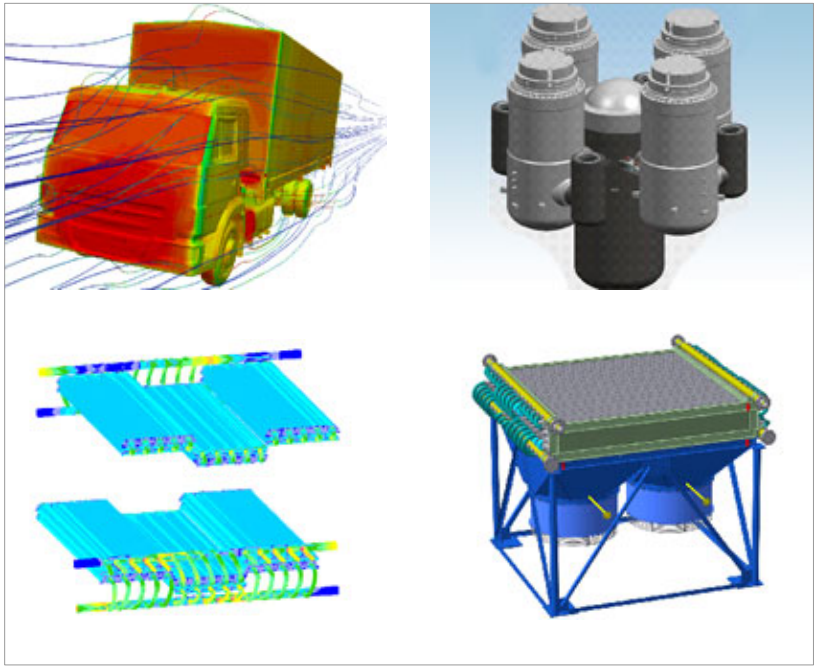
Belinda Structure



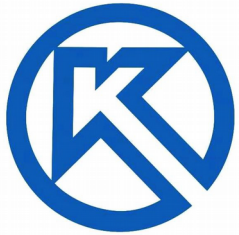
Our Customers – CAD/CAM/CAE Developers

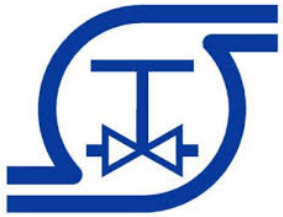
State Atomic Energy Corporation ROSATOM (RFNC — VNIIEF)

LOGOS for computing simulations with supercomputers



Our Customers – CAD/CAM/CAE Developers

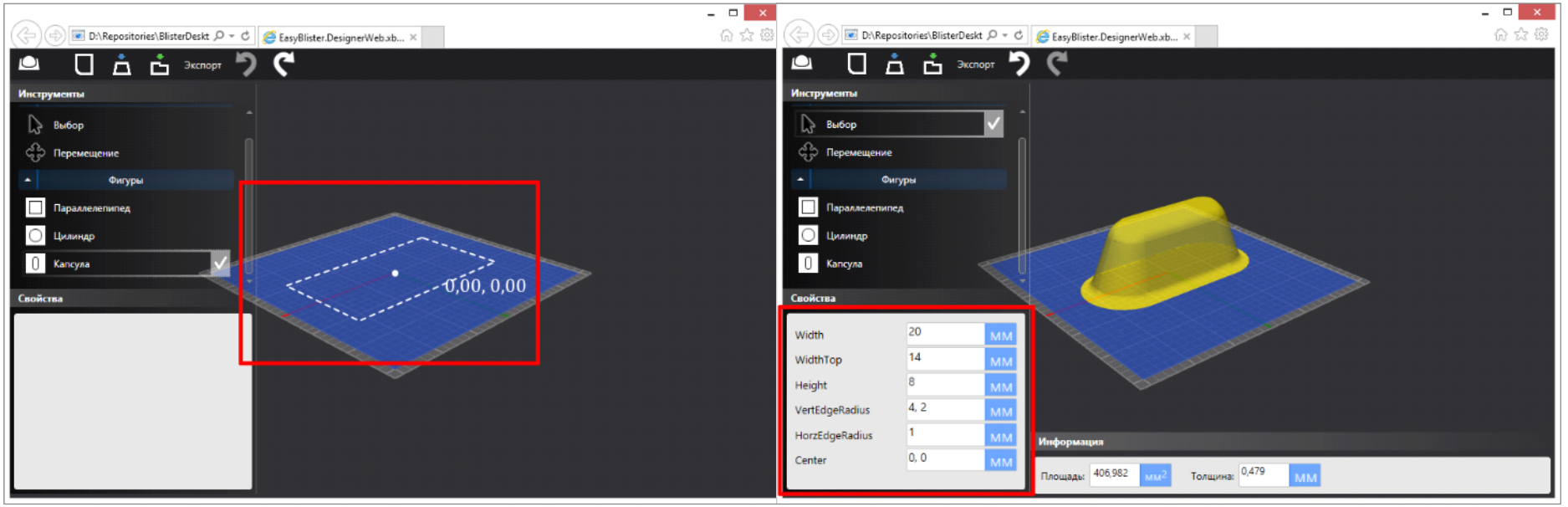




Our Customers in Education

St. Petersburg State Technological Institute

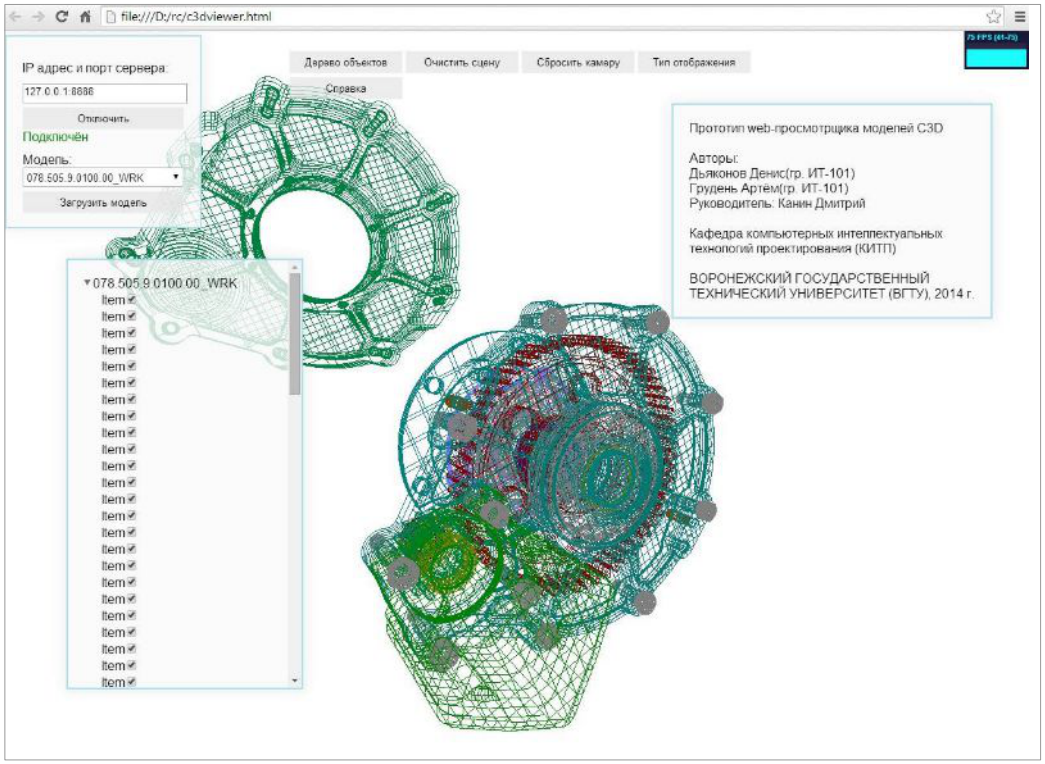
EasyBlister for Klöckner Pentaplast (Germany)



Our Customers in Education

Voronezh State Technical University

Web 3D-Viewer



Our Customers in Education

National Research Ogarev State University of Mordovia

Saint Petersburg State Institute of Technology

Voronezh State Technical University

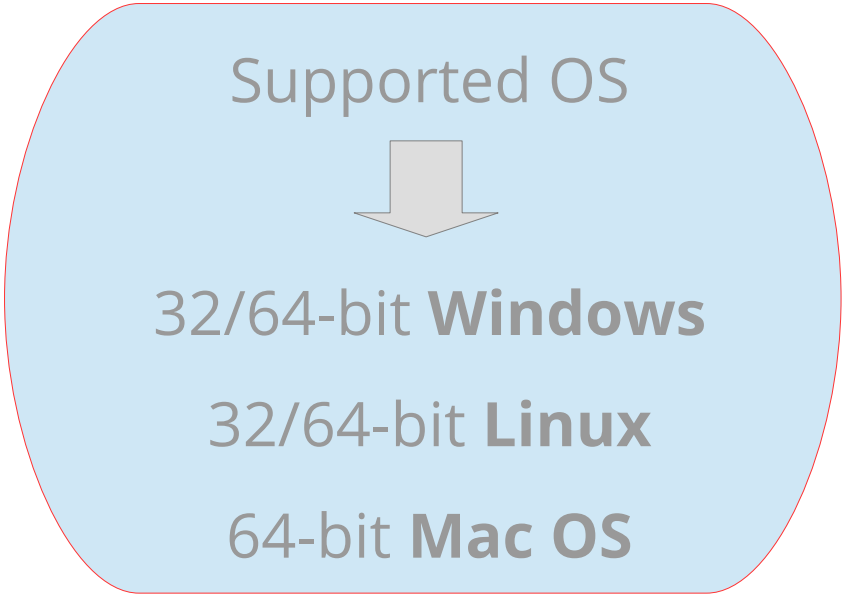
Taras Shevchenko State University of Transnistria

Ulyanovsk State Technical University

National Research Tomsk Polytechnic University

Developer Toolkit

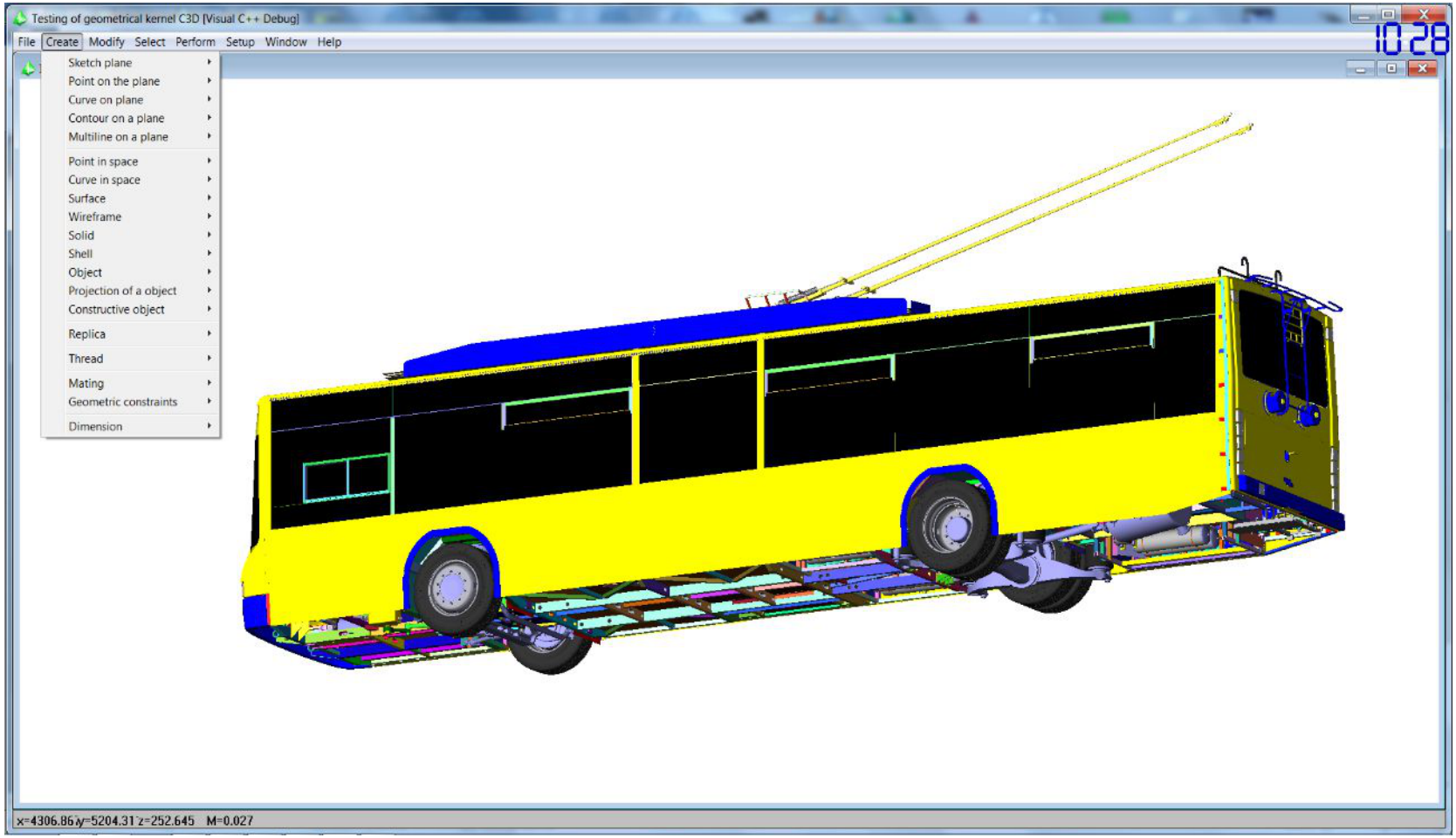
Working Environment



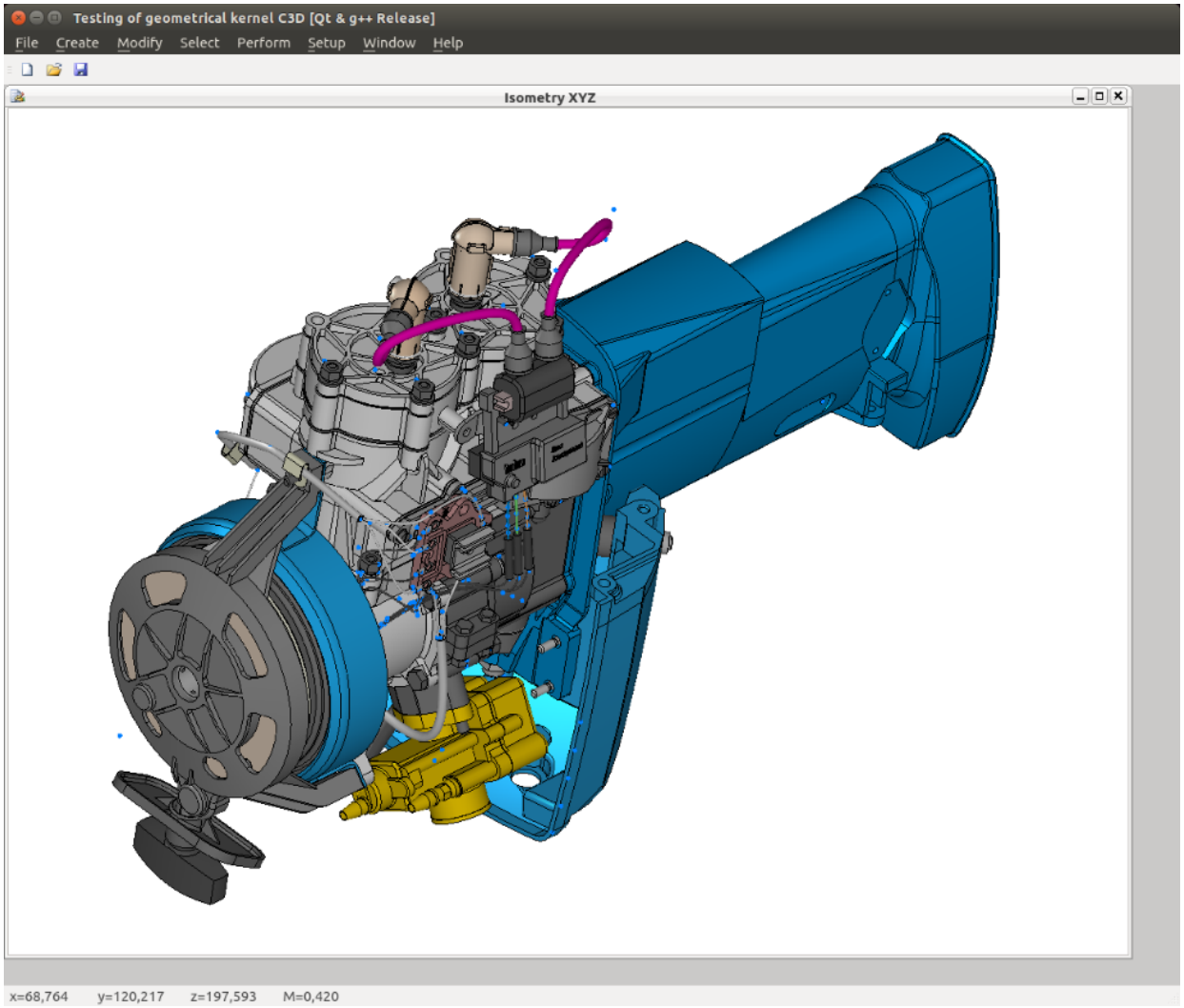
C++, C# wrapper

Working Environment

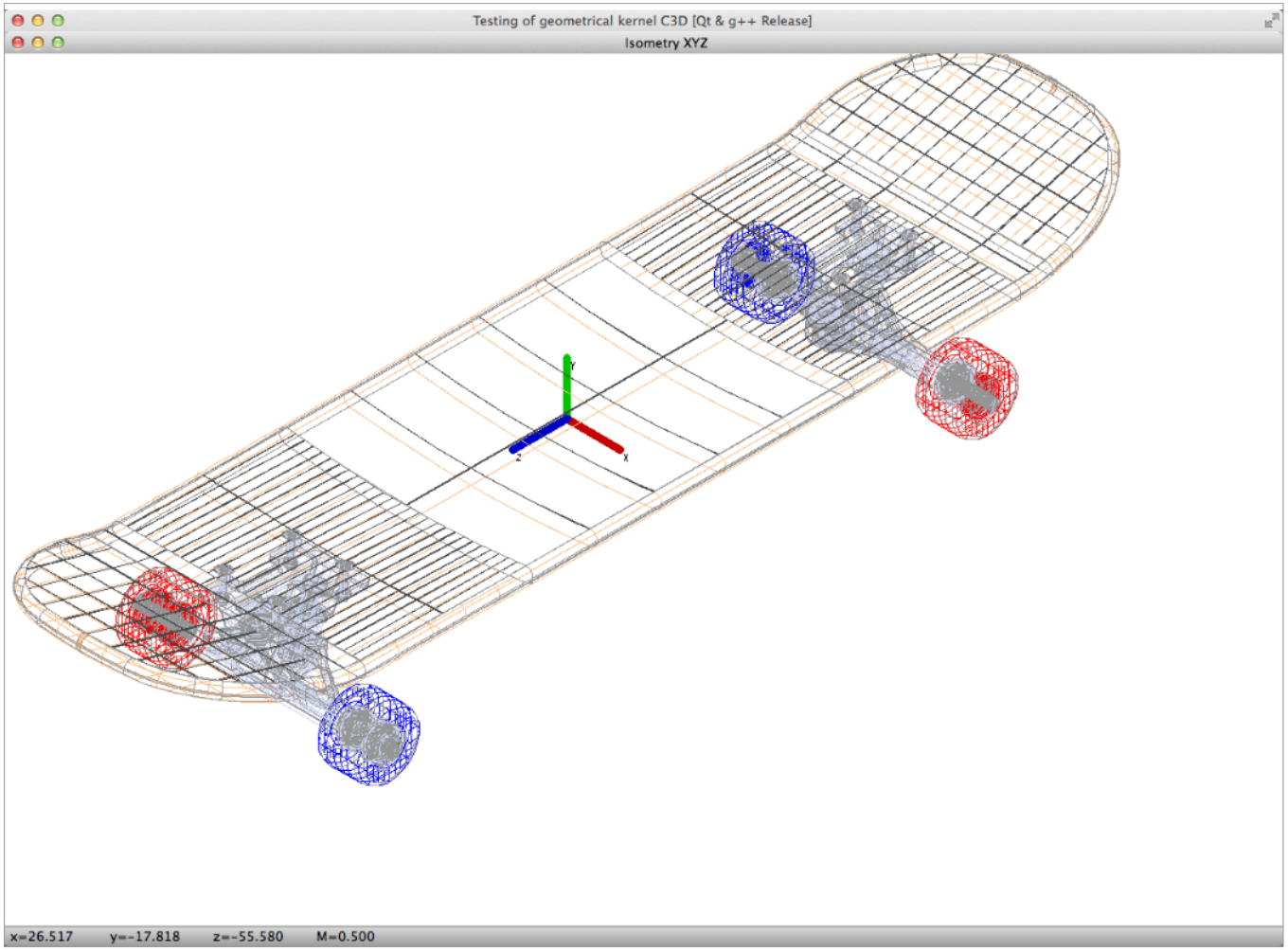
Test Application for Windows



Test Application for Linux



Test Application for Mac OS



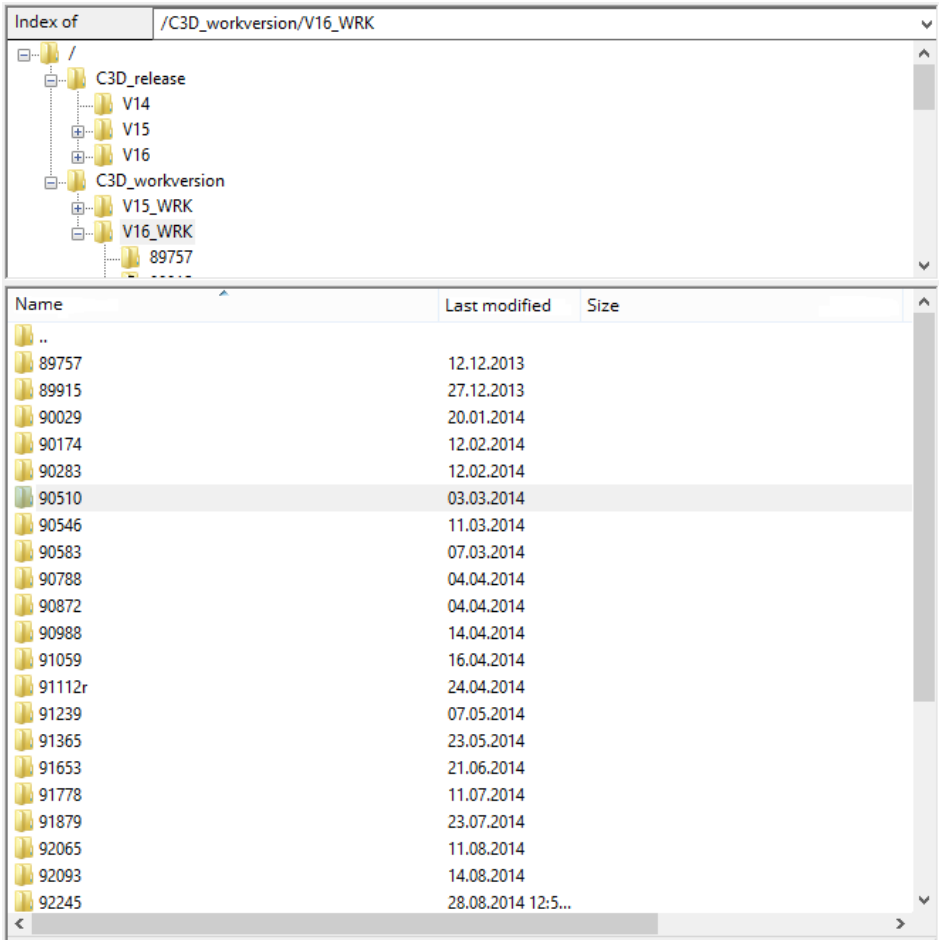
Customer Support

Technical support:
sd.ascon.ru

FTP server:
c3d.sd.ascon.ru

Include:
C3D releases
C3D workversions

New versions
Every 2 weeks!



Automated Testing System

350 000

Control 3D models

1,000,000

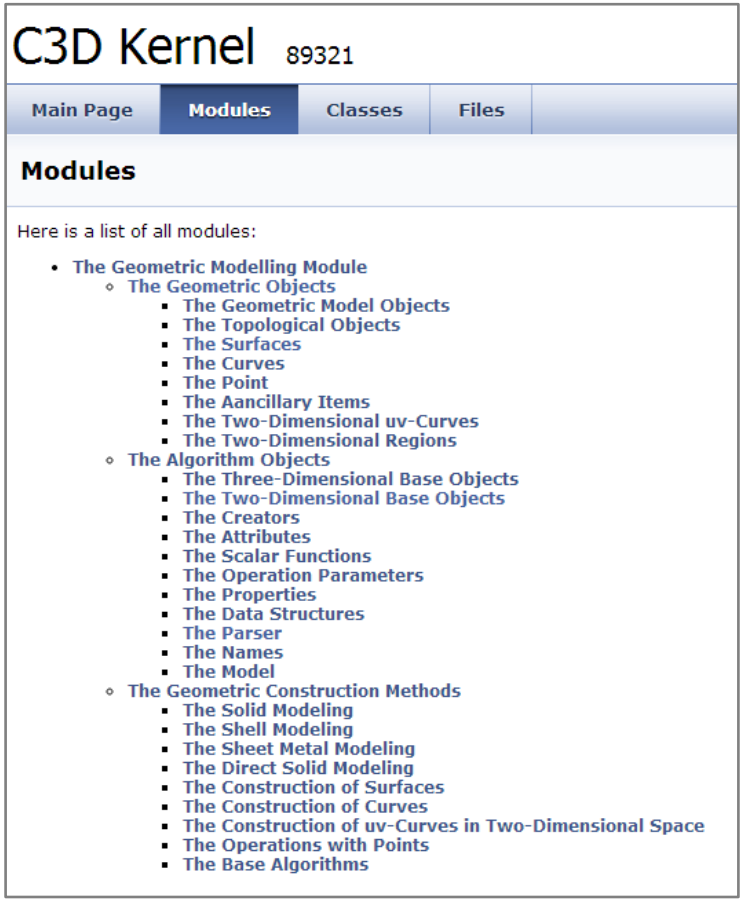
Boolean operations
performed every night!

C3D Labs

Sk Resident

Online Documentation

http://c3d.ascon.net/doc/math/modules.html



C3D Kernel 89321

Main Page | Modules | Classes | Files

Modules

Here is a list of all modules:

- The Geometric Modelling Module
  - The Geometric Objects
    - The Geometric Model Objects
    - The Topological Objects
    - The Surfaces
    - The Curves
    - The Point
    - The Aancillary Items
    - The Two-Dimensional uv-Curves
    - The Two-Dimensional Regions
  - The Algorithm Objects
    - The Three-Dimensional Base Objects
    - The Two-Dimensional Base Objects
    - The Creators
    - The Attributes
    - The Scalar Functions
    - The Operation Parameters
    - The Properties
    - The Data Structures
    - The Parser
    - The Names
    - The Model
  - The Geometric Construction Methods
    - The Solid Modeling
    - The Shell Modeling
    - The Sheet Metal Modeling
    - The Direct Solid Modeling
    - The Construction of Surfaces
    - The Construction of Curves
    - The Construction of uv-Curves in Two-Dimensional Space
    - The Operations with Points
    - The Base Algorithms

New User Manual

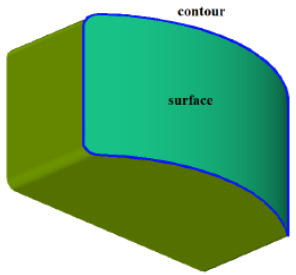


Рис. М.1.4.12.

На рис. М.1.4.13 приведено тело, полученное выдавливанием контура на криволинейной поверхности, приведенного на рис. М.1.4.12.

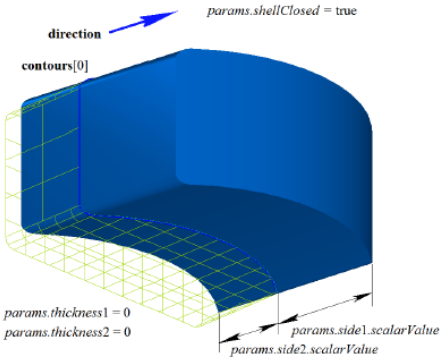


Рис. М.1.4.13.

На рис. М.1.4.14 приведено тонкостенное тело, полученное выдавливанием контура на криволинейной поверхности, приведенного на рис. М.1.4.12.

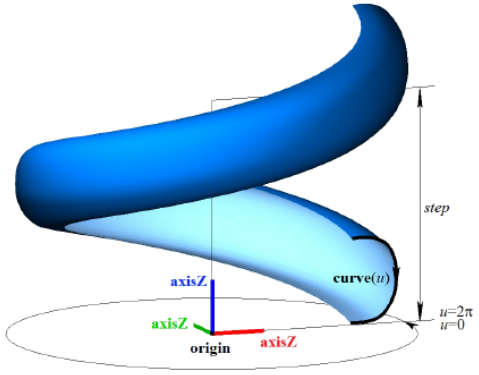


Рис. О.5.10.1.

Для граничных значений второго параметра поверхности должно соблюдаться неравенство: *vmin*<*vmax*.

О.5.11. Кинематическая поверхность MbEvolutionSurface

Класс MbEvolutionSurface объявлен в файле surf_evolution_surface.h.

Кинематическая поверхность MbEvolutionSurface принадлежит к группе поверхностей движения MbSweptSurface. Кинематическая поверхность является общим случаем поверхности движения с произвольной направляющей кривой. Поверхность вращения описывается образующей кривой MbCurve3D* **curve**, направляющим объектом MbCurve3D* **spine**, положением начала направляющей MbCartPoint3D **origin**. У поверхности есть ещё некоторые данные, которые не обязательны и служат для ускорения работы методов поверхности.

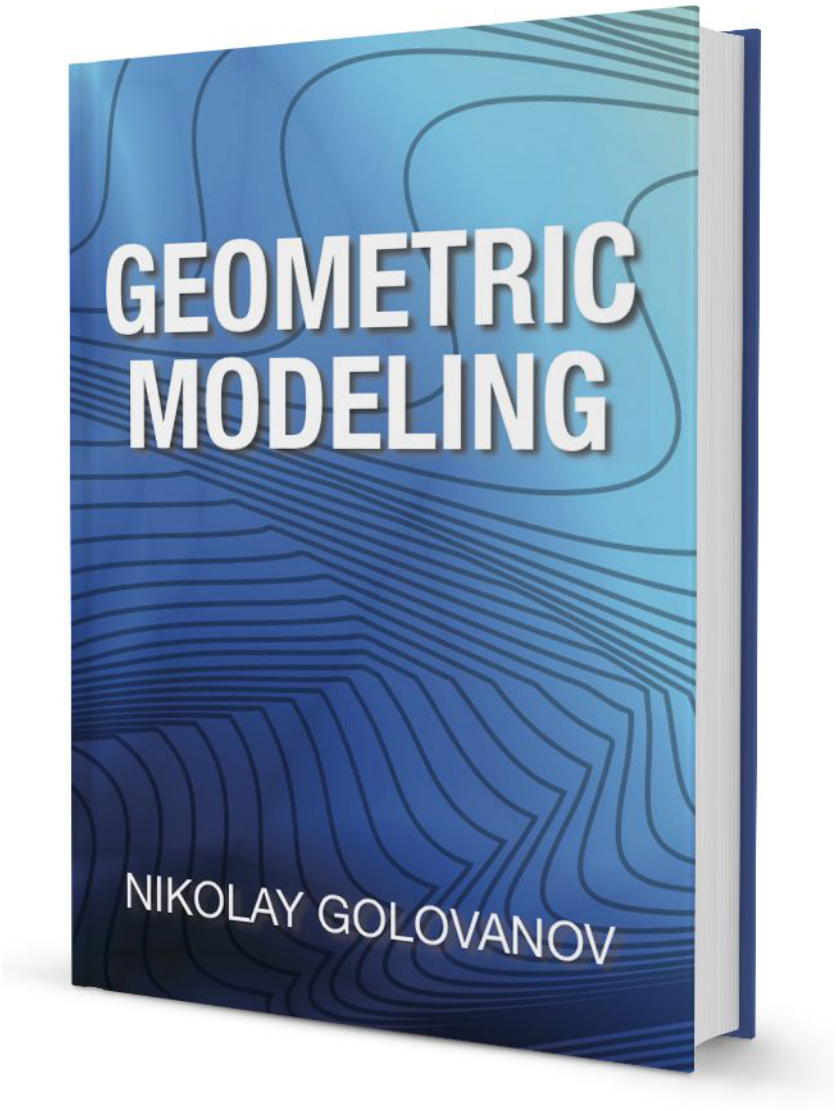
Первый параметр поверхности *u* совпадает с параметром образующей кривой **curve**. Первый параметр поверхности принимает значения на отрезке *umin*≤*u*≤*umax*, который соответствует области определения образующей кривой. Поверхность может быть периодической по первому параметру, если периодической является образующая кривая.

Направляющий объект **spine** заменяет собой направляющую кривую, построен на базе кривой и отличается от последней тем, что может генерировать локальную систему координат, связанную с кривой. Второй параметр поверхности *v* совпадает с параметром кривой направляющего объекта **spine**. Второй параметр поверхности принимает значения на отрезке *vmin*≤*v*≤*vmax*, который соответствует области определения направляющей кривой. Поверхность может быть периодической по второму параметру, если периодической является направляющая кривая.

В методе **PointOn**(double *u*, double *v*, MbCartPoint3D & s) радиус-вектор поверхности s описывается векторной функцией

Geometric Modeling by Nikolay Golovanov

Ph.D. in Mechanical Engineering



"Golovanov has created a text that will enable any serious student of geometric design to grasp the full power and beauty of the mathematics behind this essential set of tools, and put them to work. I am deeply impressed by the logical and methodical presentation, and by the clarity of the teaching. Highly recommended!"

Joel N. Orr, Ph.D.

“Geometric modeling continues to grow in importance... Understanding the constructs that underlie geometric modeling will place students and developers at the forefront of these new advancements. Nikolay Golovanov has paved the way to that understanding with this comprehensive presentation.”

Ken Versprille, Ph.D.

Sk Resident

Business Model

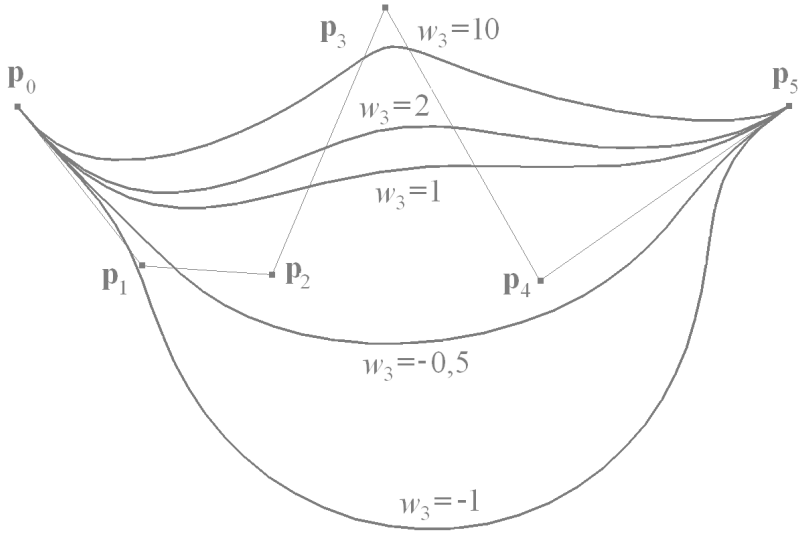
C3D Labs

Sk Resident

Easy to Get

3 month
Free evaluation

Direct support
from developers



C3D Labs

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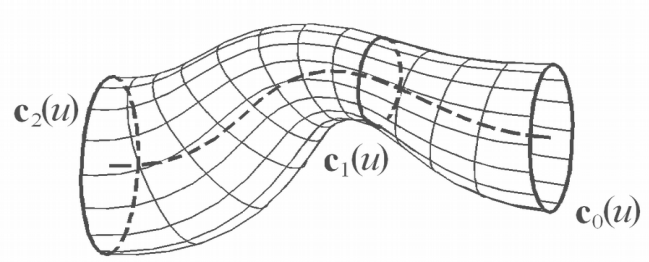
Flexible Licensing Policy

Royalty-free
for free and low-cost products

Special terms for startups

Educational program
for universities



Our Goal

Strong one-on-one **partnerships** with customers

Thank you!

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