MECH 410 and MECH520

Computer-Aided Design

Introduction

Modern CAD/CAE/CAM Tools and Their Applications

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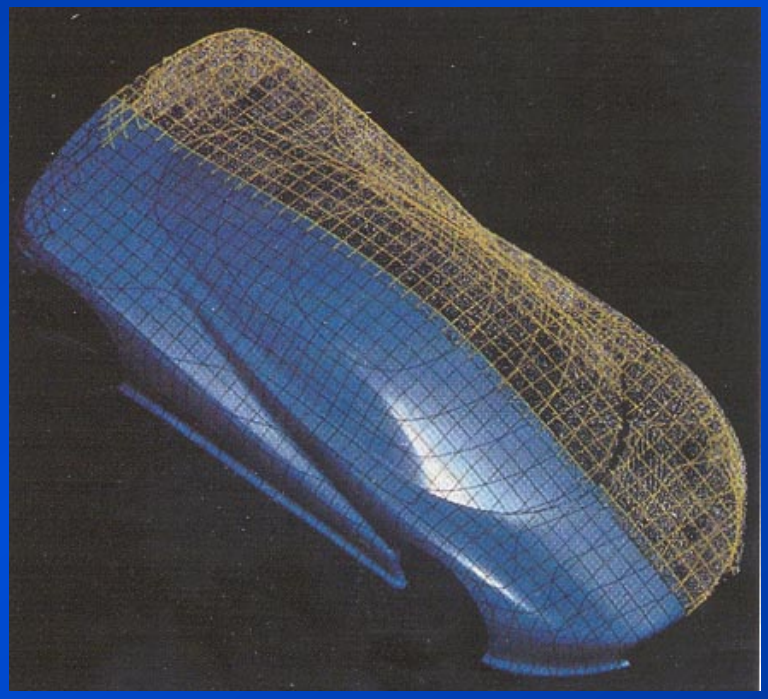
CAD (Mechanical Design Automation)
State of the Art

- **An Essential Tool for Mech. Design and Drafting**
  - Millions of mechanical engineers and designers worldwide use advanced 3-D solid modeling technology
  - Even more are using 2-D mechanical drafting
- **A Key for Improved Productivity**
  - Entire automobiles, airplanes, and jet engines are being designed in an integrated (CAD/CAE/CAM) manner.
  - Internet is being used to exchange design data worldwide.
  - Products that previously took several years to bring to market can be developed in just months.
  - The products are more reliable, meet customer expectations better, and are less costly to manufacture.

Broad Applications, Many Systems and Rapid Advance of Technology

- **Mechanical Design and Visualization**
  - Detailed Design and Electronic Drafting
  - Parametric Modeling
- **Motion Simulation/Animation**
- **Engineering Analysis and Optimization**
  - Pre- and Post- Graphical Processors for *Finite Element Analysis* (Mechanics, Dynamics, Thermo-flow, etc.)
  - Identification of Optimal Design Parameters and Configurations
  - Motion Analysis (Location, Speed, Acceleration and Force)
- **Manufacturing Planning of Simulation**
  - Machining
  - Industrial Robots

Sculptured Surface Design and Modeling



Motion Concept Vehicle, Mississauga, Ontario

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Visual Reality in Architectural Design

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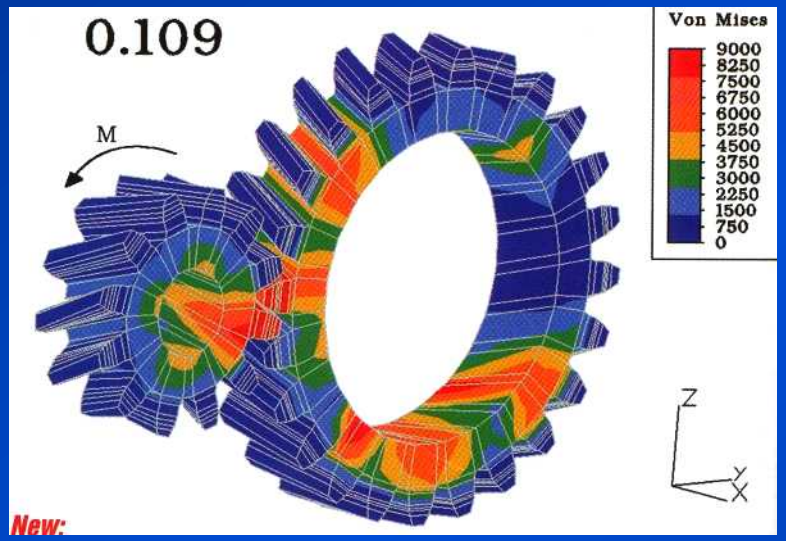
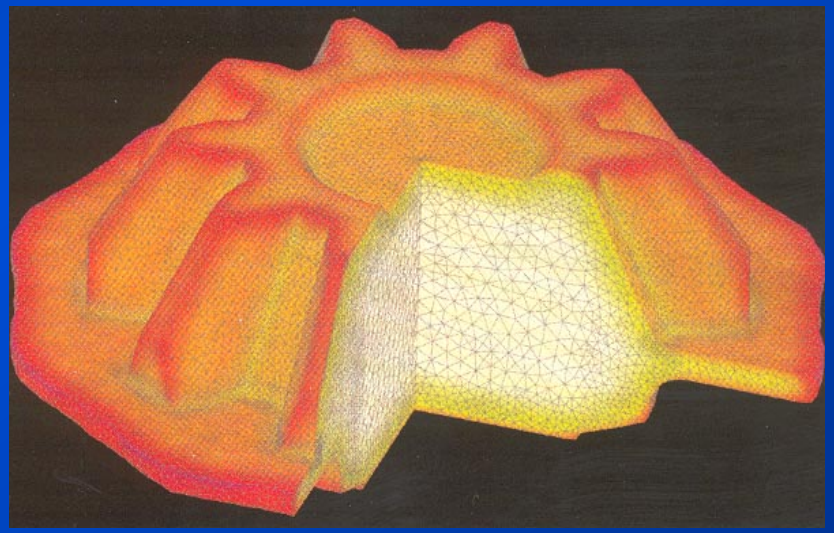
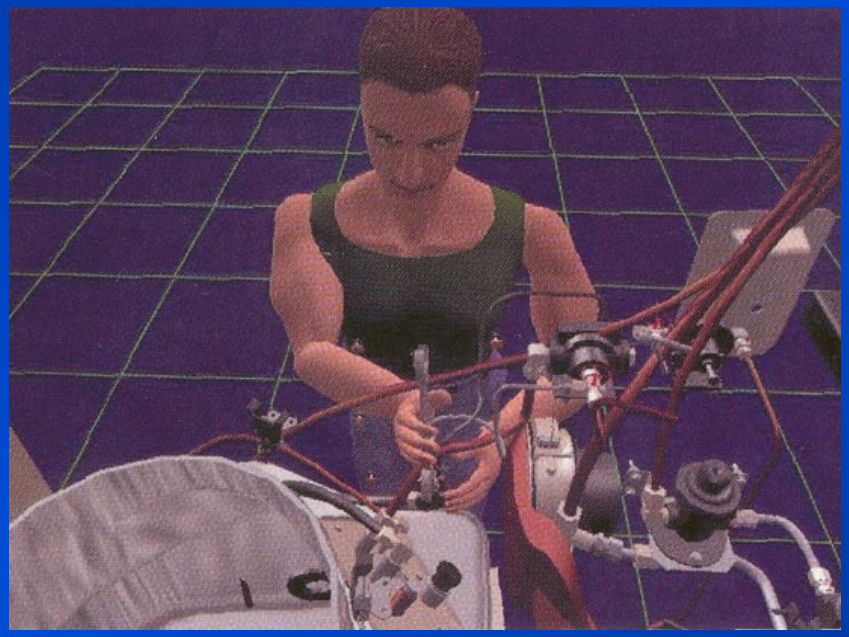
Motion Animation and Simulation
(Tractors)

Applications in Stress Analysis





Workspace and Sequence Simulation

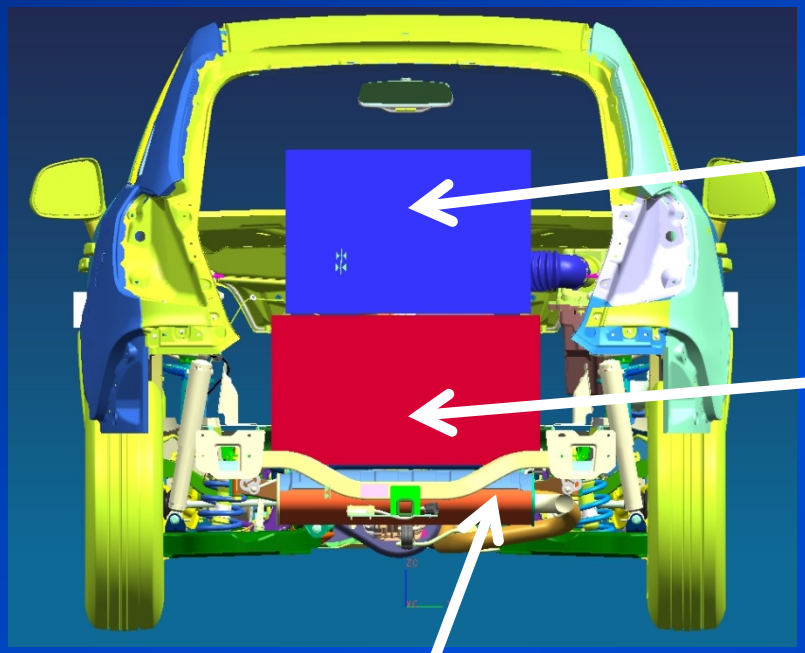


Ergonomics and accessibility test (Jack and Jill)

EcoCAR HEV Design and Analysis Using Unigraphics NX

2-Mode AWD Plug-in Hybrid Vehicle Architecture Design

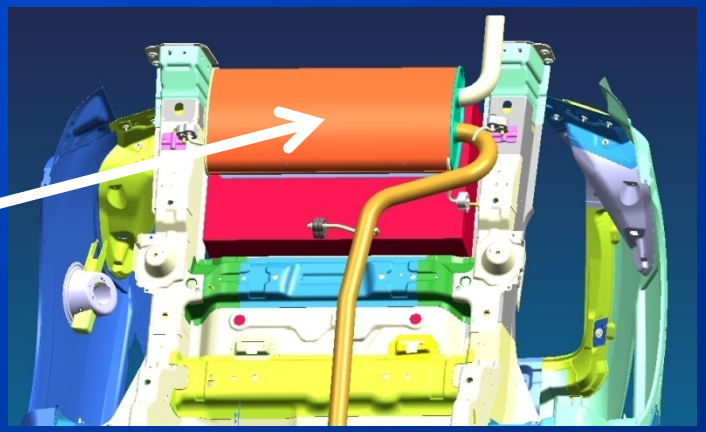
Electrical Team: Jonathan Cronk, Dian Ross, & Mechanical Team: Ian Lougheed



Cargo Envelope (for Emissions measurement equipment)

Battery Envelope .2205 m^3 for 20 kWh

Stock VUE muffler location



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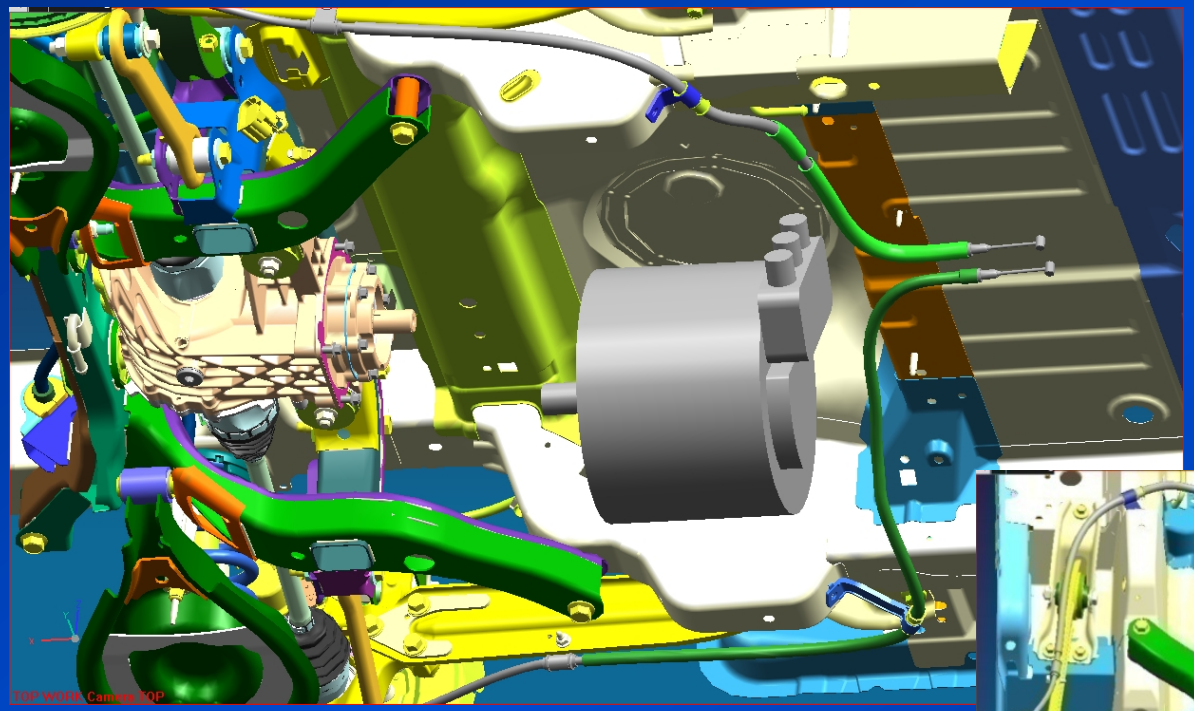
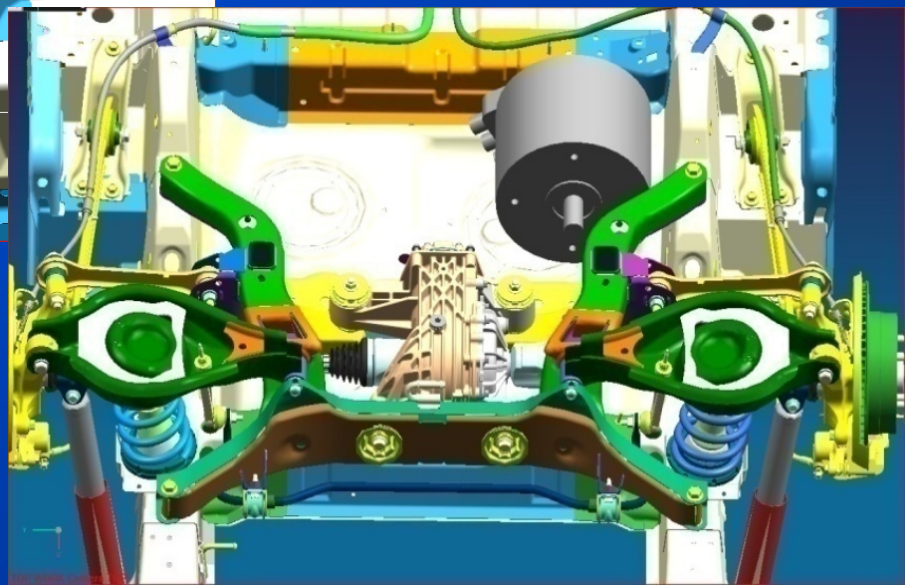
EcoCAR HEV Design and Analysis

Electric Rear Wheel Drive Gearbox

Adam Binley, Jake Soepber, Kyle McWilliam, Bryce Donnelly, Yoshua Ichihashi & Sean Walsh





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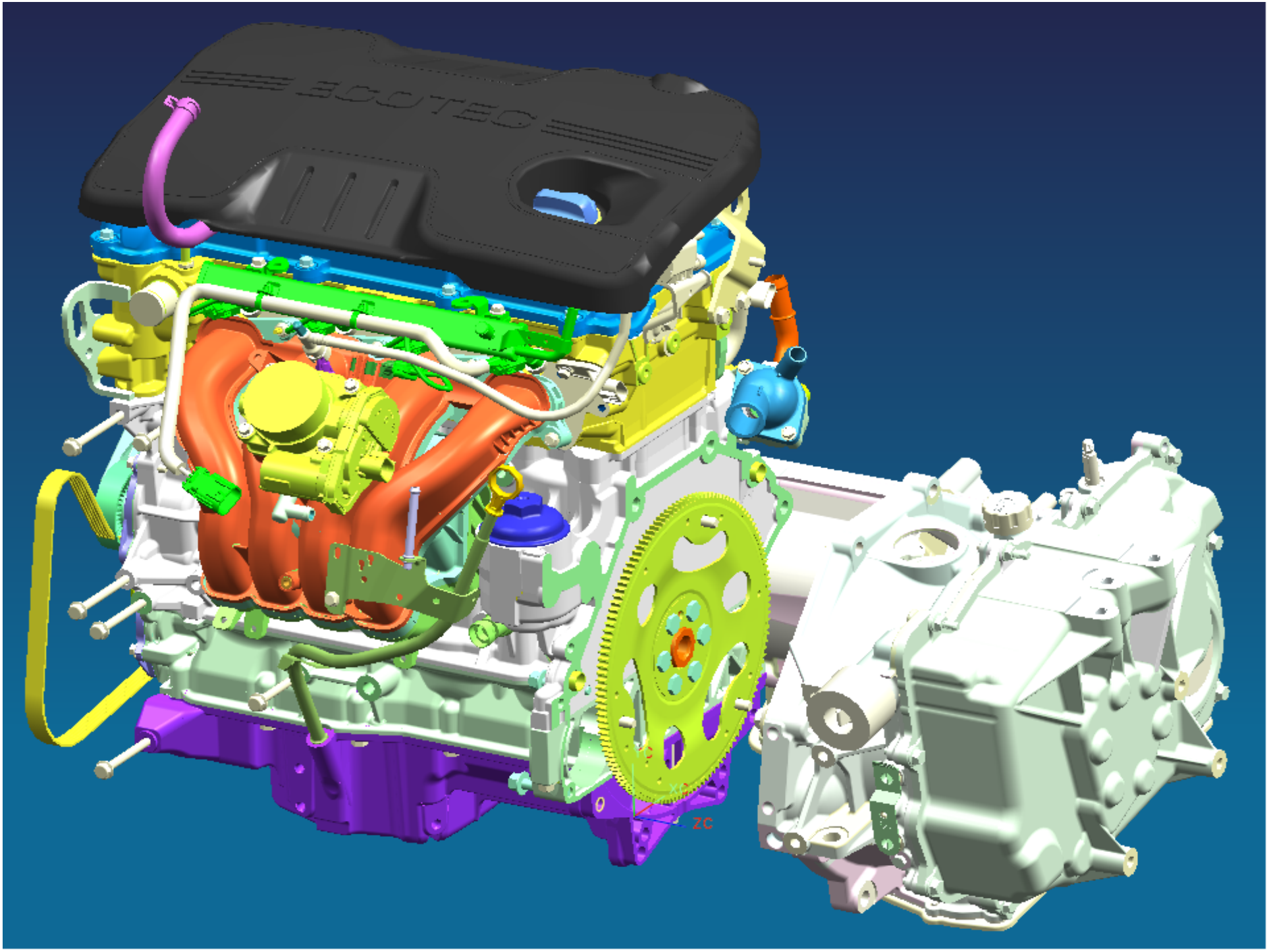

ECOTEC
ZC

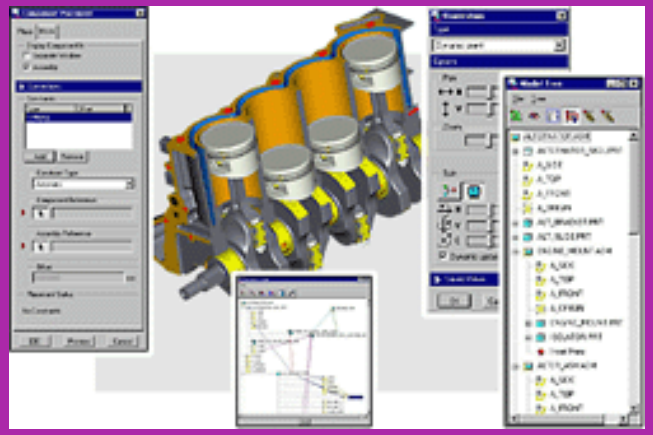
Integrated CAD/CAE/CAM Systems

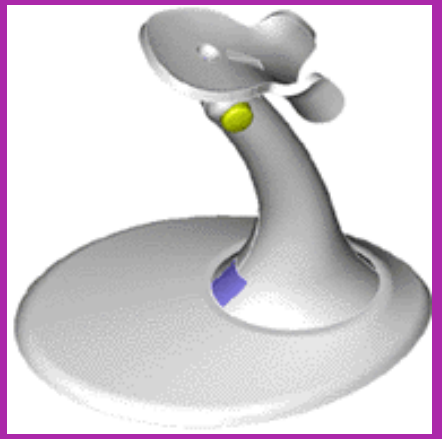
- **Professional CAD/CAE/CAM Tools**
  - CATIA (Dassault Systems - IBM)
  - Unigraphics NX (Electronic Data Systems Corp - EDS)
  - I-DEAS (EDS)
  - Pro/ENGINEER (PTC)
- **Other CAD and Graphics Packages**
  - AutoCAD Mechanical Desktop
  - SolidWorks (CATIA)
  - Solid Edge (EDS)
  - MicroStation
  - Intergraph

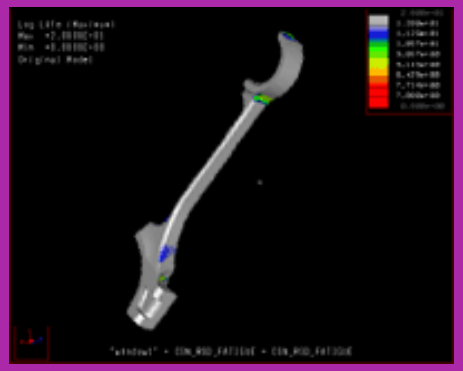
Pro/ENGINEER (now Creo Elements)

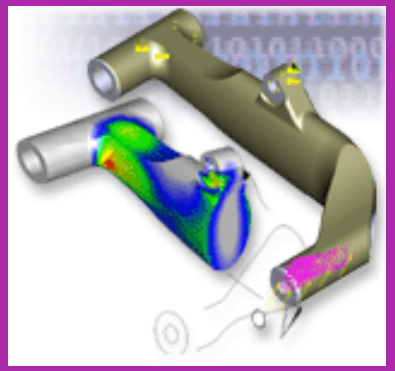
- One of the CAD/CAM/CAE industry's leading suppliers of software tools from Parametric Technology Corp. (PTC)
- A pioneer of the new feature-based, parametrically driven design paradigm in late 1980s, now industrial standard.
- A system used to automate the development of a mechanical product from its conceptual design through production.
- Offering integrated software technologies to reduce time to market, improve engineering process, and optimize product quality.
- One of the fastest growing companies in the mechanical design automation market
- Improved user's interface in recent release.

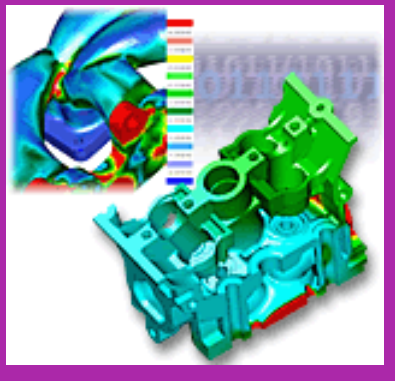
Pro/ENGINEER

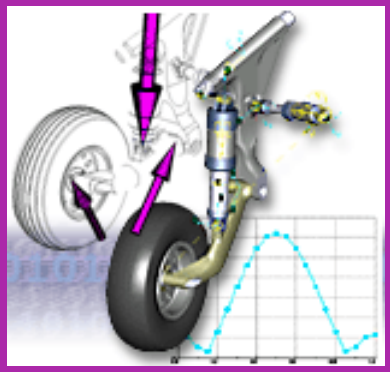


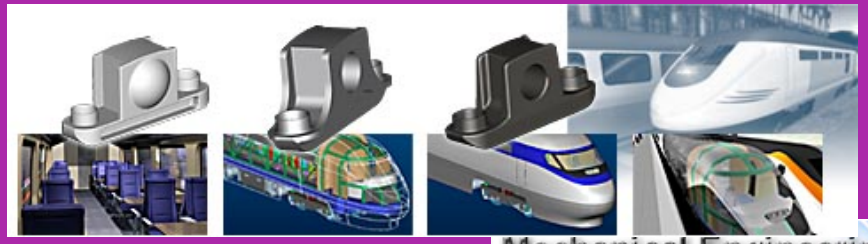












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Unigraphics

- A full spectrum design modeling, analysis, simulation, and manufacturing CAD/CAE/CAM software from Unigraphics Solutions
- One of the older and well-established CAD/CAE system.
- A software of choice for a wide variety of applications, especially in automotive and aerospace product development.

Unigraphics

Automotive & Aerospace Virtual Product Development Process

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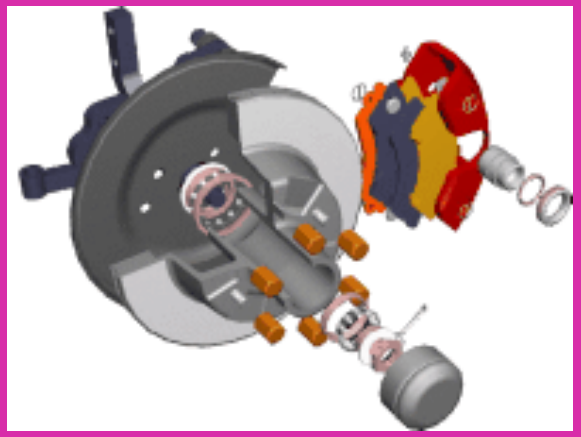
CATIA

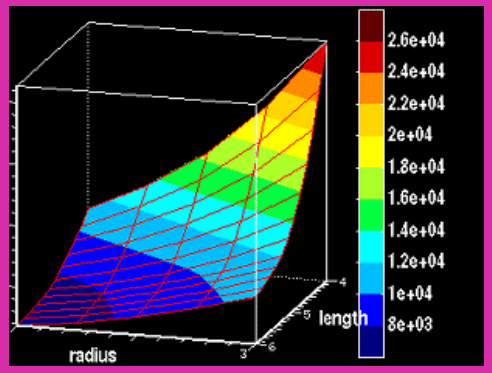
- A process-centric CAD/CAM software solution marketed exclusively by IBM and developed by Dassault Systems
- A system used to design and manufacture many complex 3D products. Today, 7 out of every 10 airplanes and 4 out of every 10 cars are designed using CATIA-CADAM Solutions, making it the de facto standard for these markets.
- A software of choice for a wide variety of applications ranging from consumer goods and machinery to plant design and shipbuilding.
- 300,000 CATIA users worldwide, nearly half in English language markets

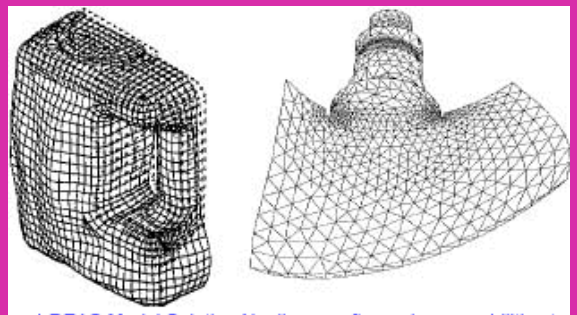
I-DEAS

- A full spectrum design modeling, analysis, simulation, and manufacturing CAD/CAE/CAM software from Structural Dynamics Research Corporation (SDRC)
- One of the older and well-established CAD/CAE system, having a significant market share.
- Having very strong CAE capabilities
- A software of choice for a wide variety of applications ranging from consumer goods and machinery to automotive (Ford Motor Company)

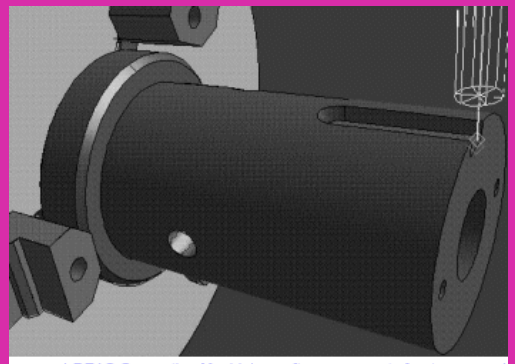
I-DEAS







I-DEAS Model Solution Nonlinear software has capabilities to solve geometric and material nonlinear problems.



I-DEAS Generative Machining software supports front, rear, and dual-turret turning machines.

Solid Edge

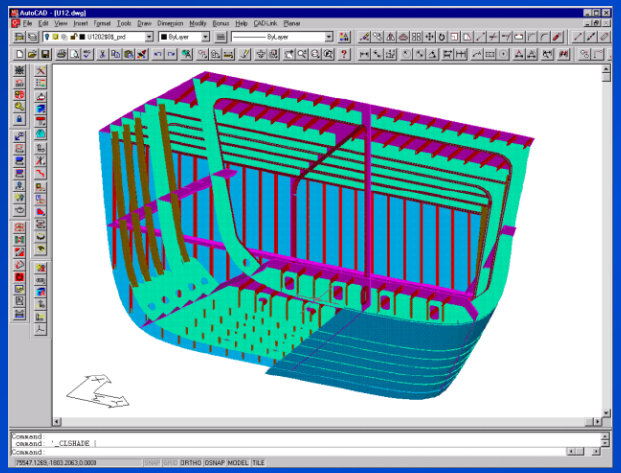
- Powerful modeling tools
- Integrated design management
- Productivity for large assemblies
- Ease of adoption
- Model faster
- Eliminate errors with engineering aids
- Drafting tools
- Unmatched interoperability
- Design-through-manufacturing

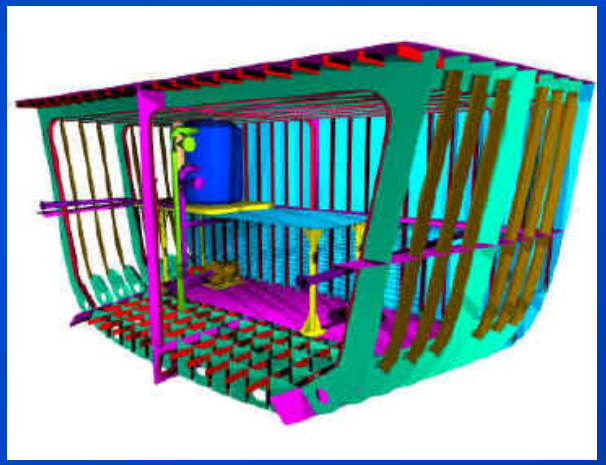
AutoCAD and Mechanical Desktop

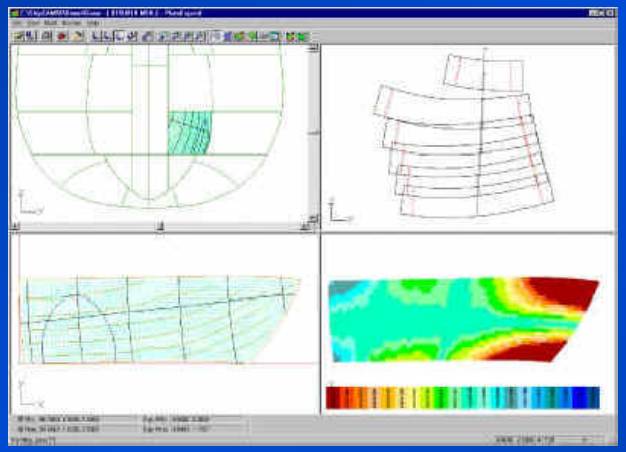
- A world's leading PC-based 2D and 3D mechanical design package, from AutoDesk Inc.
- Used to be the primary PC drafting package (dealer, PC)
- The world's most popular CAD software due to its lower cost and PC platform
- New features (Mechanical Desktop):
  - ACIS 3.0 Advanced Solid Modeling Engine
  - NURBS Surface Modeling
  - Robust Assembly Modeling and Automated Associative Drafting
- Flexible programming tools, AutoLISP, ADS and ARX

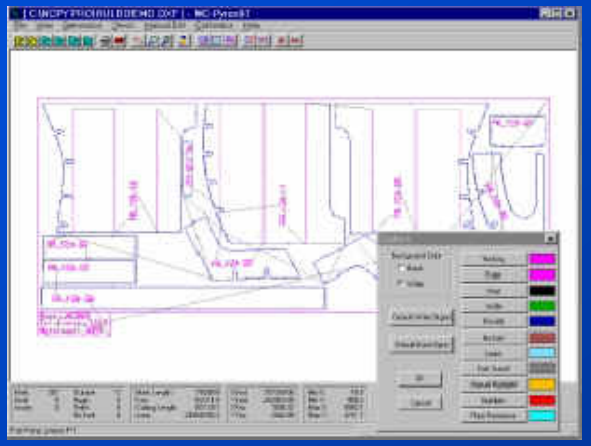
CAD Applications through Programming in AutoCAD

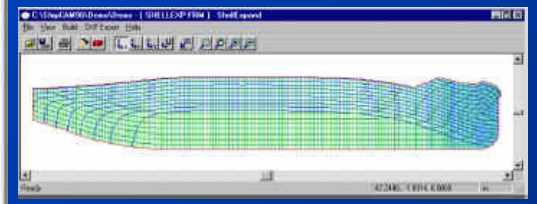
ARL
Ubacore Research Ltd.











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SolidWorks

- 3D Computer-aided Mechanical Design software from SolidWorks Corp. founded in 1993 and acquired be Dassault System in 1997.
- A leader of the group of new lower-priced mechanical design solution companies based upon component software.
- A system used for designing and engineering parts and assemblies in a completed 3D-centric process linked to automated assembly and drafting functions.
- The first solid modeling program to run in native Windows environments, and sells for a fraction of the cost of similar programs

SolidWorks - COSMOS

SolidWorks - a design automation software package used to produce parts, assemblies and drawings

Package fully embedded within SolidWorks software

- **COSMOSXpress** - an easy-to-use stress analysis tool
- **COSMOSWorks** - stress, frequency, buckling, thermal, and optimization analyses
- **COSMOSMotion** - motion simulation and kinematics.
- **COSMOSFloWorks** - fluid flow analysis with robust capabilities normally found in high-end CFD programs.
- **COSMOSEMS** - 3D-field simulator for low frequency electromagnetic and electromechanical applications
- COSMOSDesignSTAR™ is a powerful design analysis program that works with most popular CAD programs.

MicroStation

- A premier CAD software for infrastructure engineering and major architectural and civil engineering from Bentley Systems, Incorporated, the worldwide leader in engineering software products, user services and overall quality.
- The software foundation underlying the engineering of well-known buildings, airports, hospitals, highways, bridges and industrial plants throughout the world, used in over 70% of the largest US engineering firms.
- Bentley System now serves over 250,000 professionals in construction engineering, geo-engineering, and mechanical engineering fields.

Integrated CAD/CAE Tools

- Pro/MECHANICA (integrated with Pro/E)

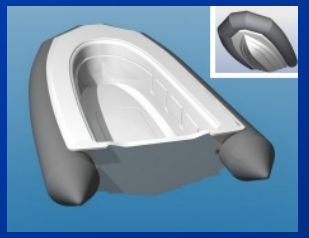
  A system provides an open flexible MCAE environment for multi-disciplinary design analysis, and simulate product performance and manufacturing processes.
- ANSYS (from ANSYS Inc.)
- COMSOL Multiphysics
- NASTRAN (from MacNeal-Schwendler)
  - A powerful structural analysis program for analyzing stress, vibration, dynamic, nonlinear and heat transfer characteristics.
  - PATRAN provides an open flexible MCAE environment for multi-disciplinary design analysis, and simulates product performance and manufacturing processes.

Integrated CAD/CAM Tools

- Mastercam (from CNC Software, Inc.)
  - A system for generating 2- through 5- axis milling, turning, wire EDM, lasers, mold base development and 3D design and drafting.
- Virtual Gibbs (from Gibbs and Associates)
  - A powerful, full featured CAM system for NC programming
- Varimetrix (from Varimetrix Corp.)
  - A system with design modeling, CAM (planning, resource management and CNC programming), and drafting
- Pro/MANUFACTURING (integrated with Pro/E)
  - A system for generating machine code (CNC codes for 3 axis milling, turning and wire EDM) to produce parts.

Integrated CAD/CAM Tools

- SURFCAM (from Surfware Inc. CA)
  - An outgrowth of the Diehl family's machine shop
  - A system for generating 2~5- axis milling, turning, drilling, and wire EDM.
  - Toolpath verification (MachineWorks Ltd.)
- Rhinoceros (NURBS modeling)
  - Industrial, marine, and jewelry designs; cad/cam; rapid prototyping; and reverse engineering

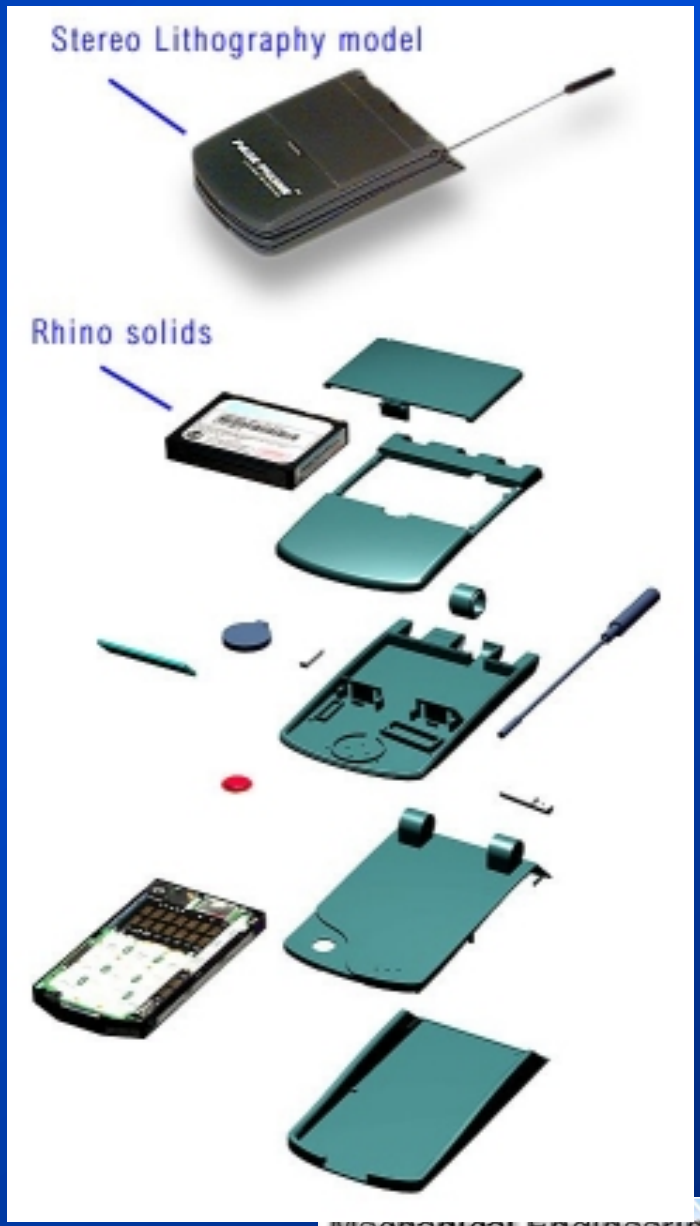


Rapid Prototyping

Solid Freeform Fabrication

Building a solid part directly from a CAD model, layer by layer, by material deposition.

- Sterolithography, SLA
- Selective Laser Sintering, SLS
- Laminated Object Modelling, LOM
- Fusion Deposition Modelling, FDM
- 3-D Printing
- Solid Ground Curing, SGC
- Shape Deposition Manufacturing, SDM



Technology Advance of CAD

In 1960's

- mechanism design satisfying several geometric constraints
- design parameter optimization
- simple 2-D graphics

In 1970's

- wireframe modeling
- free-form surface modeling – *mainframe computers*

Late 1970's

- solid modeling

Early 1980's

- turn-key CAD systems
- CAD/CAM integration
- mechanical feature recognition from a CAD database

Technology Advance of CAD

Middle 1980's

- feature-based CAD system – *mini and micro computers*
- parametric design – *PC's & Turnkey systems*
  (Pro/ENGINEER Products)

Late 1980's

- design for manufacturing
- design for automated assembly

Early 1990's

- concurrent engineering design
- integrated design, analysis and optimization

Present

- integrated design, analysis and optimization
- virtual-prototyping and automated design optimization
- Internet based design automation
- Direct Modeling

Information Embedded in a CAD System

- Graphical Information
  - Part geometry
  - Topological and assembly relations
- Textual Information
  - Dimensions
  - Tolerances (dimensional & geometric)
  - Materials
  - Surface finishes

Data Organization in CAD Systems

- **Past Approach**

  The geographical information is represented using low level graphical elements such as points, lines, arcs, etc. The textual information is represented as texts, notes and symbols attached to a drawing.

- **Ideal/Present Approach – feature-based modeling**

  To represent part geometry using high-level feature primitives such as holes, slots, pockets, etc. (consistent to the engineering practice), and to represent dimensions, tolerances, surface finishes, etc. as meaningful design entities.

Photorealistic Rendering of Concepts or Finished Models