CAEvolution
GmbH

Engineous software

Multi-objective, Robust Design Optimization using ENGINEOUS Software Package iSIGHT - FD

Agenda:

- About CAEvolution
- About ENGINEOUS
- MDO at Pratt & Whitney

International Conference ERCOFTAC 2006
April 5 – 7, Gran Canaria, Canary Islands, Spain
Dr. H. Sippel

CAEvolution GmbH

About CAEvolution

Engineous software

CAE*volution* & Engineous
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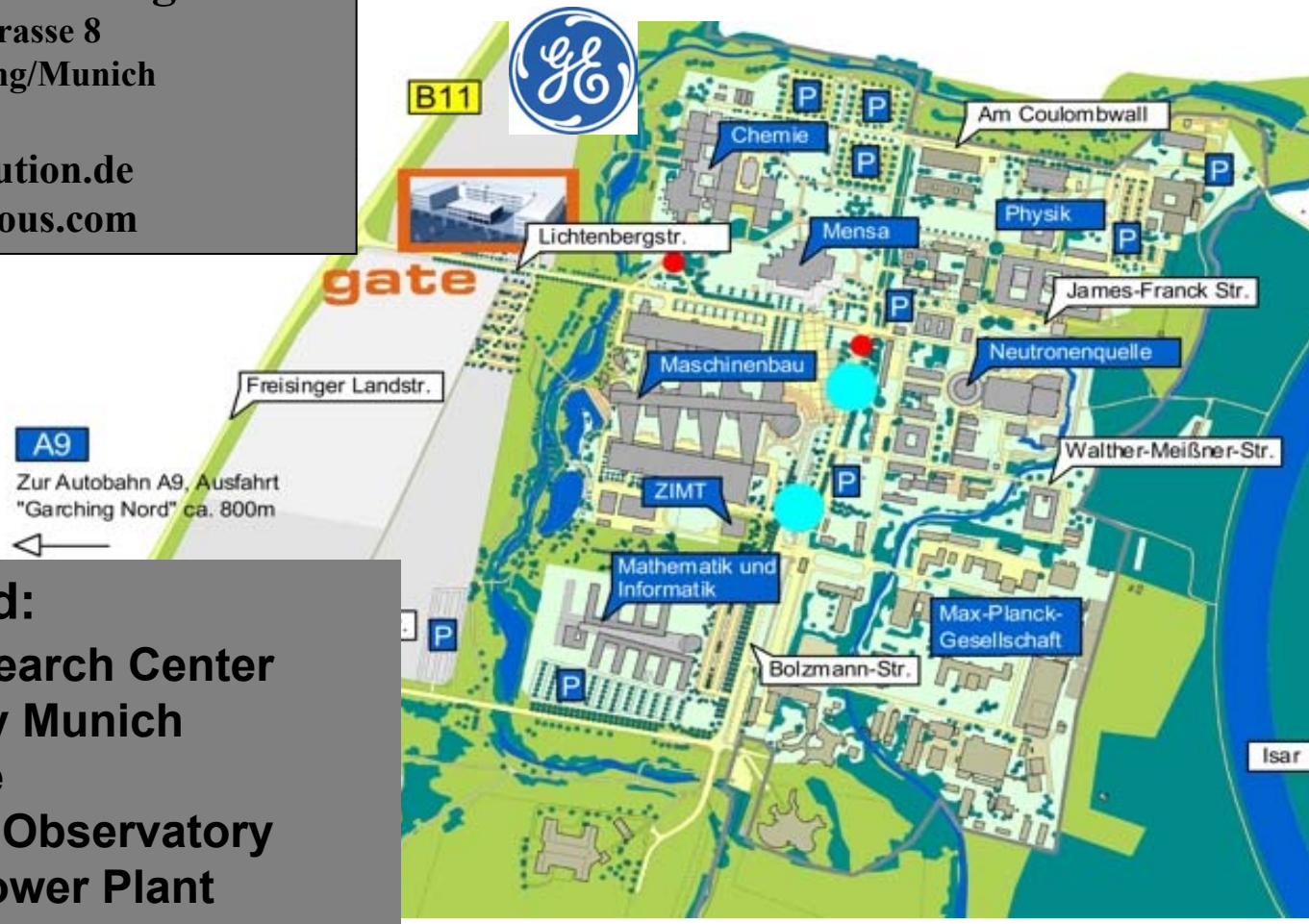
Germany
www.caevolution.de
www.engineous.com



Our Neighbourhood:

- **GE – European Research Center**
- **Technical University Munich**
- **Max Planck Institute**
- **European Southern Observatory**
- **Research Atomic Power Plant**
- **....**

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About CAEvolution

Engineous software

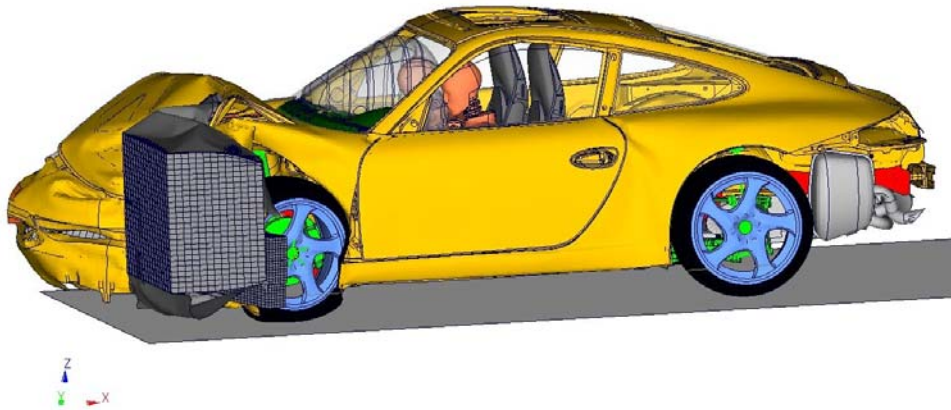
1. Marketing & Sales of CAE – Software

➔ www.caevolution.de

(SFE Concept; iSIGHT FD: Optimization & Process Integration)

2. “Brussels”

- ➔ Evaluator
- ➔ Project Management (AUTOSIM)
- ➔ MDO in FW - 7



3. Business Consulting

- ➔ Market Surveys
- ➔ Technical Management

With courtesy of Dr.Ing.h.c. F.Porsche AG

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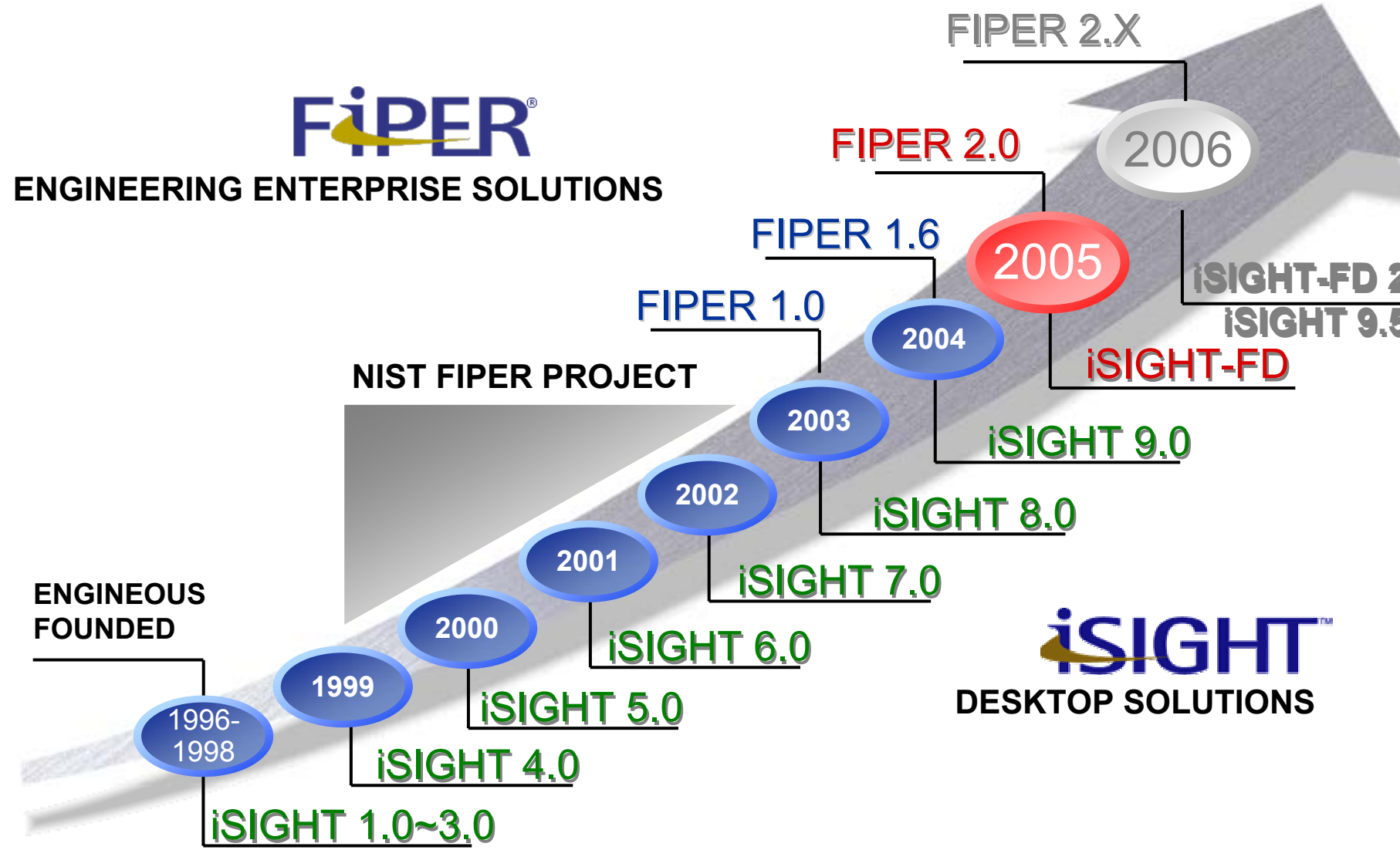


FIPER®

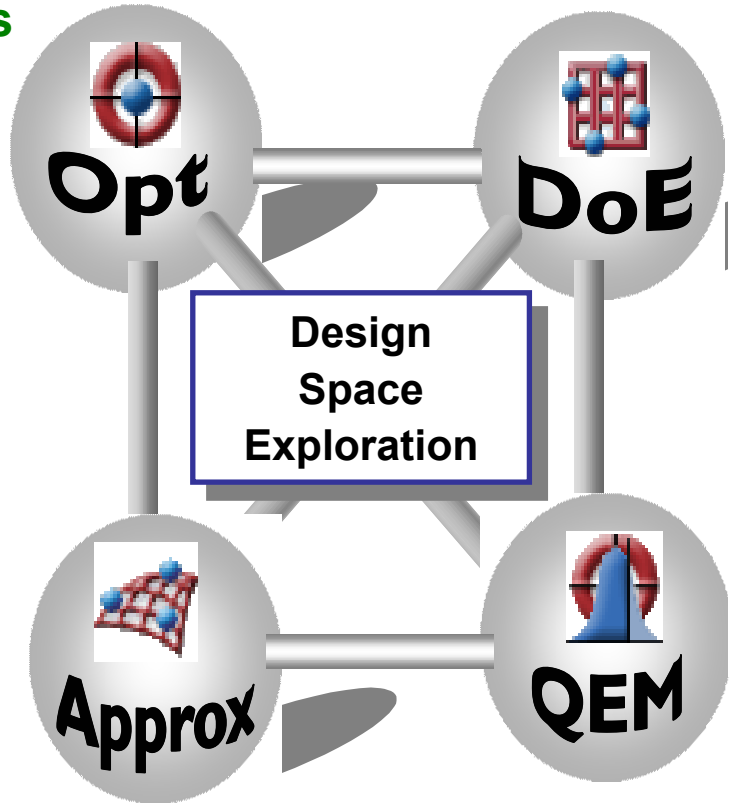
ENGINEERING ENTERPRISE SOLUTIONS

iSIGHT™

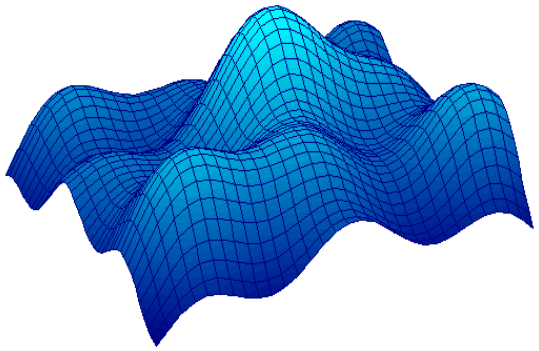
DESKTOP SOLUTIONS

About Engineous

POINTER Algorithm
Exploratory (GA etc)
Gradient based
20 Optimizers



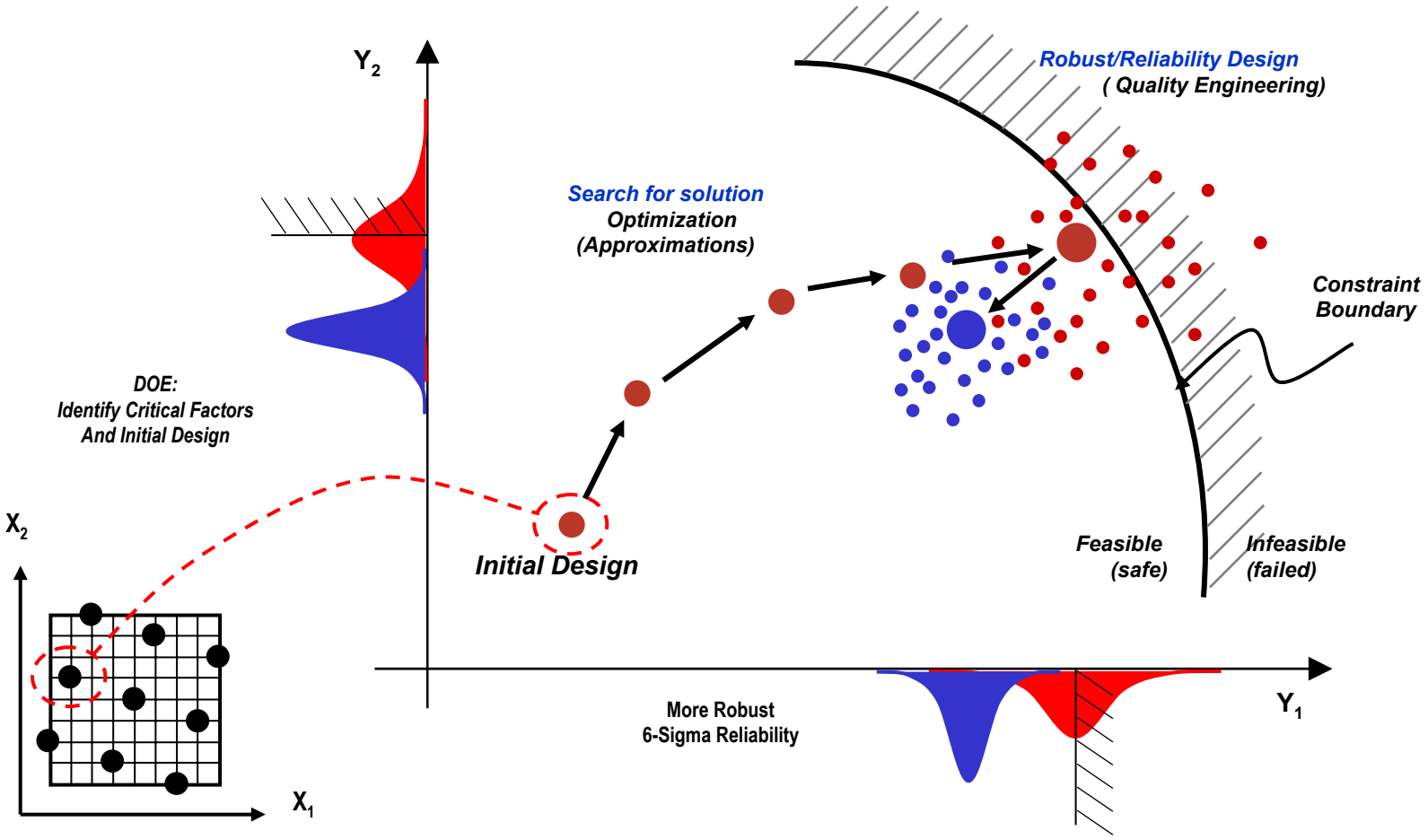
- Central Composite
- Full Factorial
- Orthogonal Array
- Latin Hypercube …



Taylor series
Response Surface
Variable complexity

- Monte Carlo
- Taguchi Robust Design
- Reliability Analysis
- Reliability based Optimization
- 6 Sigma

About Engineous



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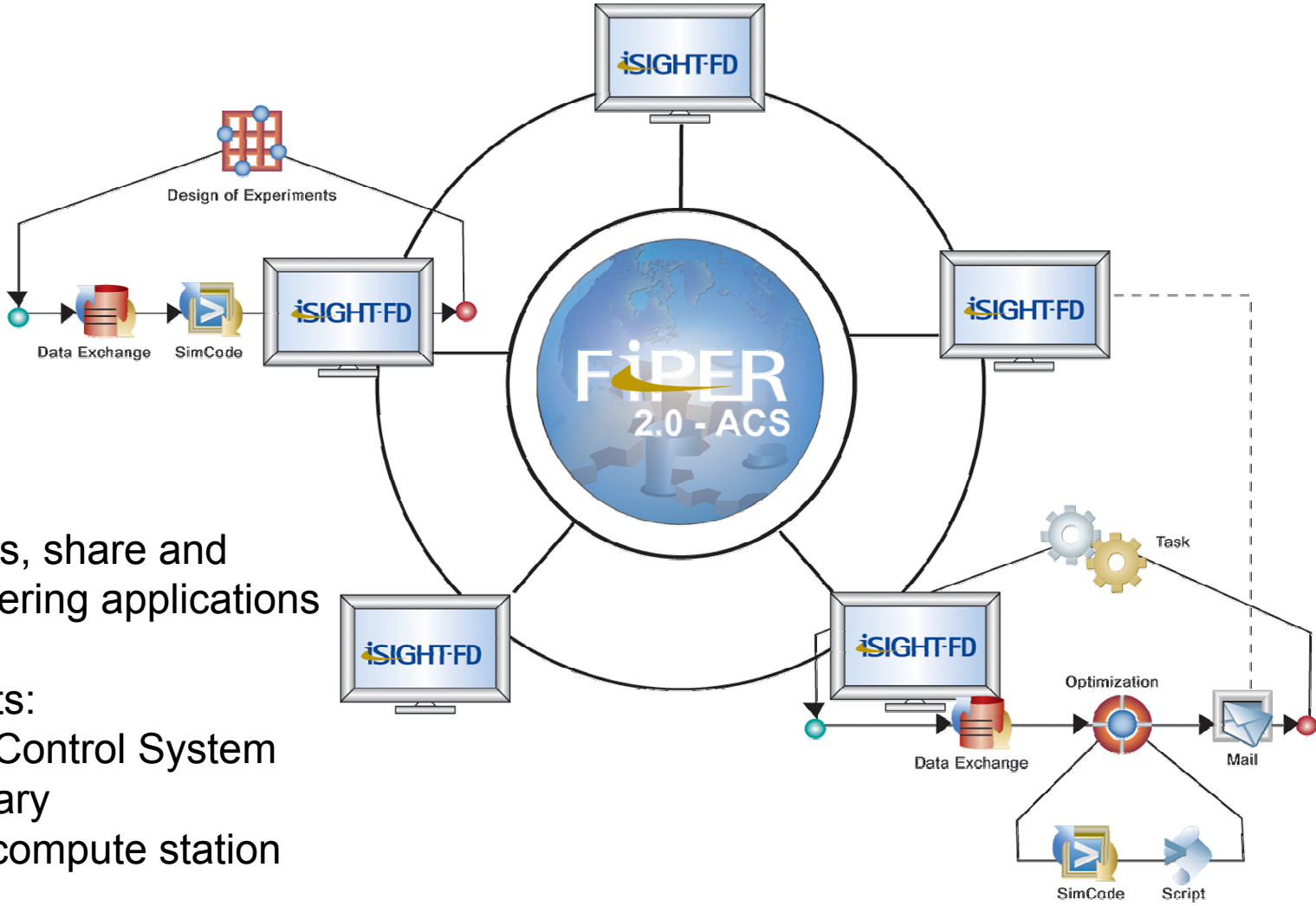
About Engineous

Engineous software



asier to access, share and
xecute engineering applications

ey components:

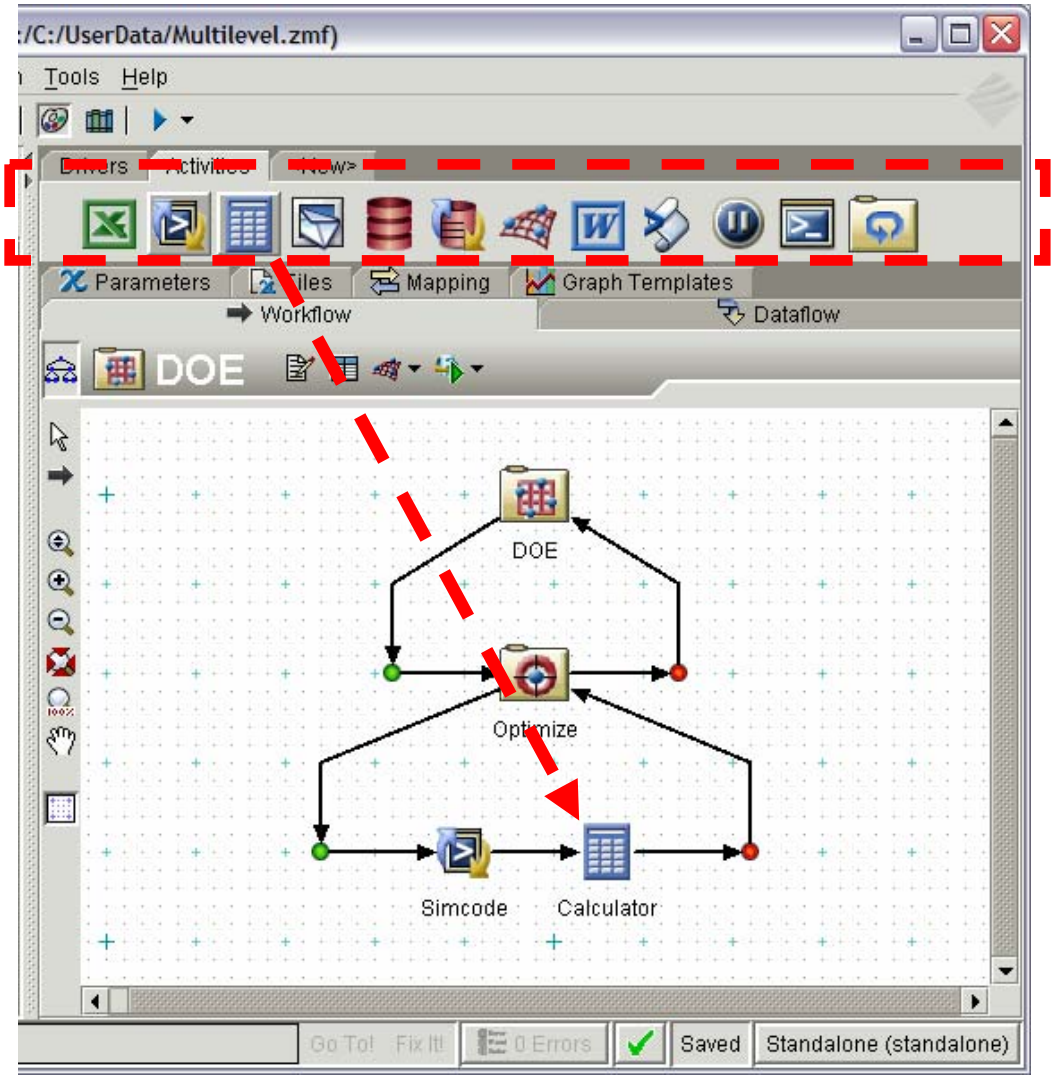
- Application Control System
- Shared Library
- Distributed compute station framework

iSIGHT FD: Create Workflow

Workflow Components

- Drag & Drop from Palette
- Cut & Paste
- Right-click menu
- Multi-Level
- Conditional, Parallel

- **External** Optimizers easy to integrate



iSIGHT FD: Multi-Level Workflow

Supports hierarchical problem formulation:

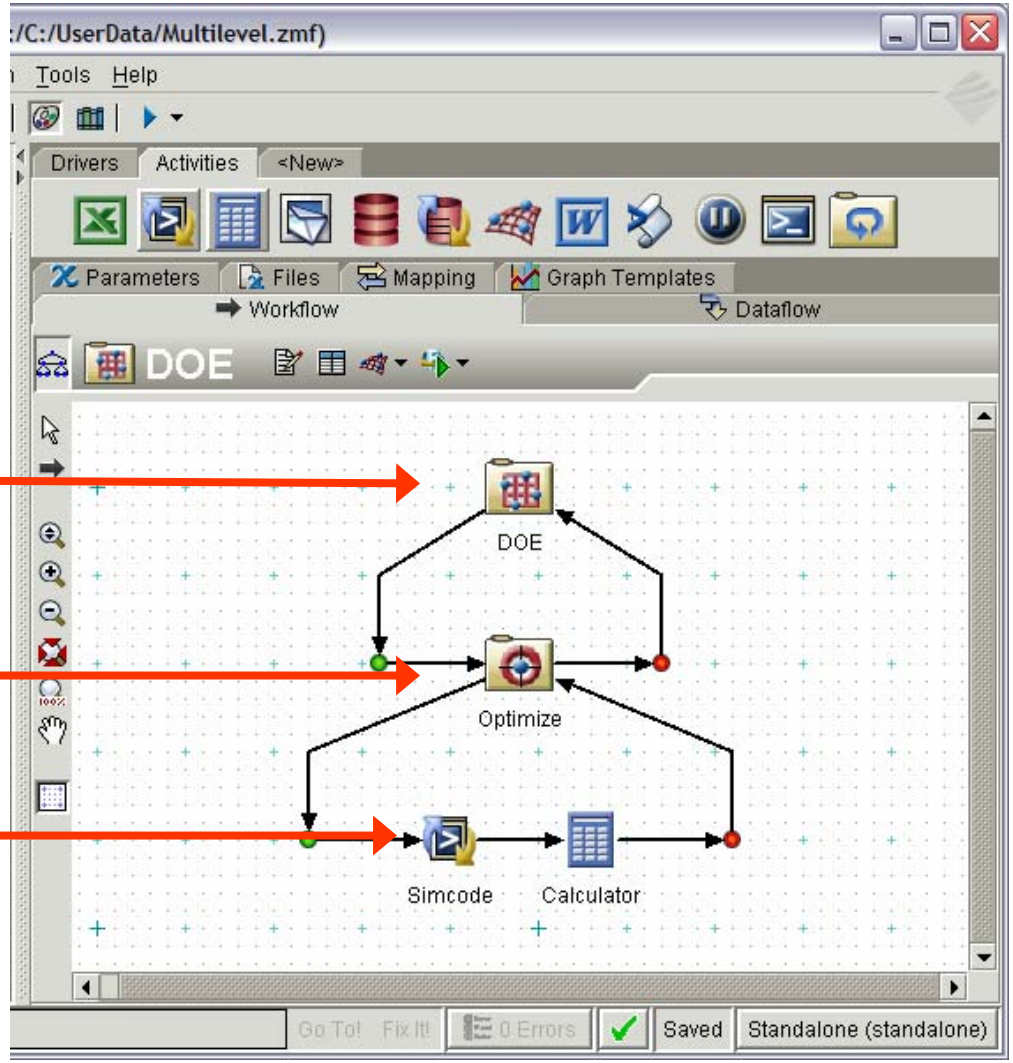
- **Nested design studies**
- **MDO**

Execute a whole model

Execute sub-model

Execute component

SIMCODE is generic (CFX, StarCD, Nastran …)



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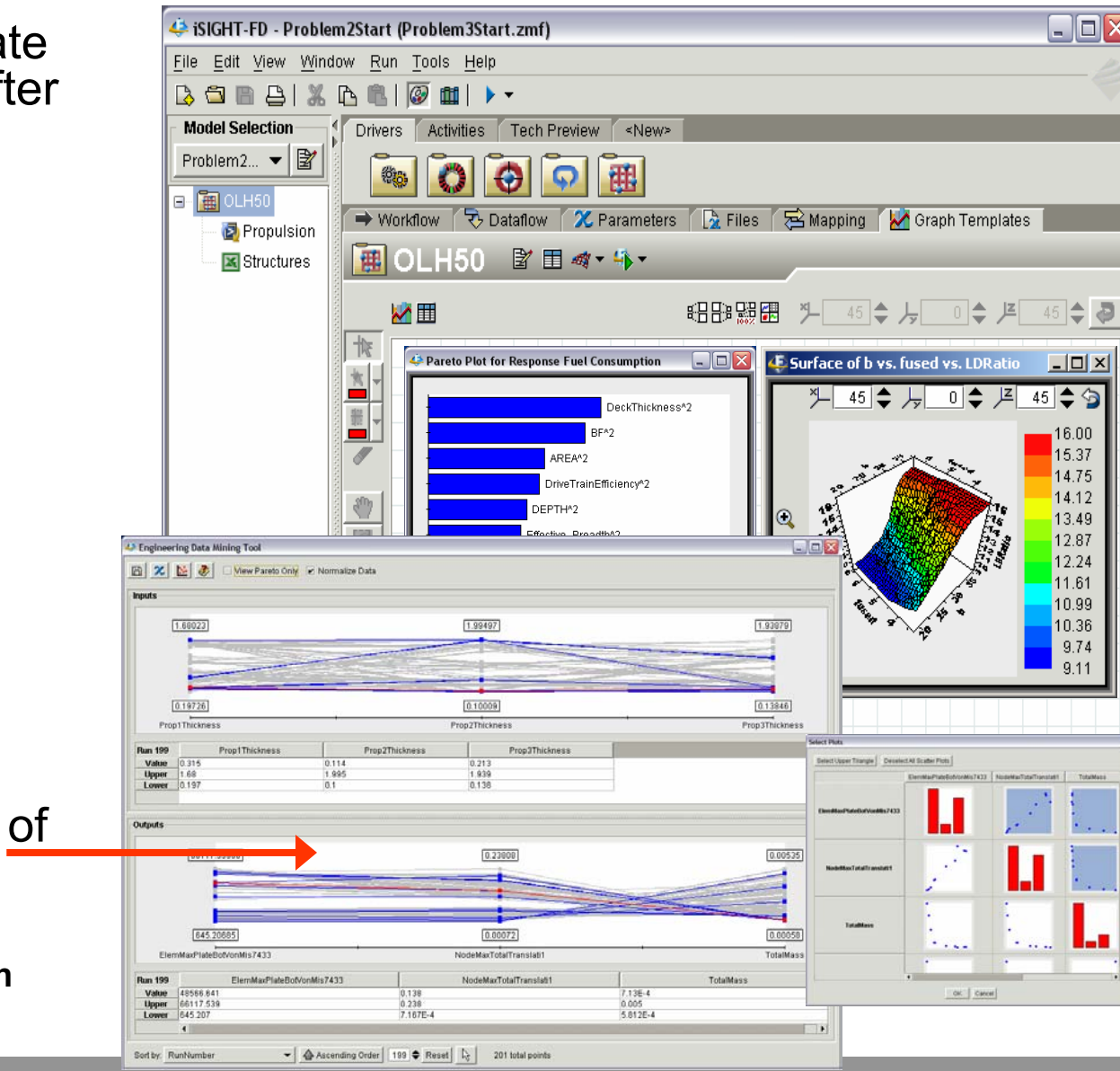
iSIGHT FD: Graphs and Tables

Engineous software

- Create as a template ahead of time or after execution
- Tables, 2D History Plots
- 3D Plots – Scatter, Surface, Contour, mix
- Statistical Plots
- Plots are made available in the context of the type of design driver executed

Pareto Front visualization



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Case Studies
Turbomachinery

Engineous software

Find out how other leading turbomachinery manufacturers are using iSIGHT to stay ahead of the competition. To download any of these materials, click on the title below. You will need Adobe Acrobat Reader to review and print any of the following PDF documents.

Retrieving any of these documents requires a username and password. Fill out this form to have your username and password immediately emailed to you. Note that this is a different username and password than used in the "iSIGHT Users" section of this website.

- A Total Blade Design Framework
- Engineous Technologies Shape New Product Designs
- iSIGHT saves aircraft engine manufacturers millions
- Compressor impeller design cycle time reduction
- Automatic centrifugal compressor design optimization with Concepts NREC software
- Daratech study: iSIGHT creating new levels of efficiency in turbomachinery industry
- Using iSIGHT for Design for Six Sigma (DFSS) at GE Power Systems
- Preliminary system design optimization of GE aircraft engines
- Forging and heat treatment process optimization for GE aircraft engine components
- Aircraft engine design process integration, automation, and optimization at Rolls-Royce
- Reducing design cycle time at York International
- Application Study of Turbomachinery Design Using Inverse Design Method and Optimizing Algorithm
- Gas turbine power generation system configuration study and optimization
- Compressor design cycle time improvement using iSIGHT

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General Electric GE90

Turbofan Redesign Using Engineous – HOW everything started

Engineous software

- **Problem**

  In the final 3 months of a multi-year project, GE discovered their engine design (GE 90) was too heavy

- **Solution**

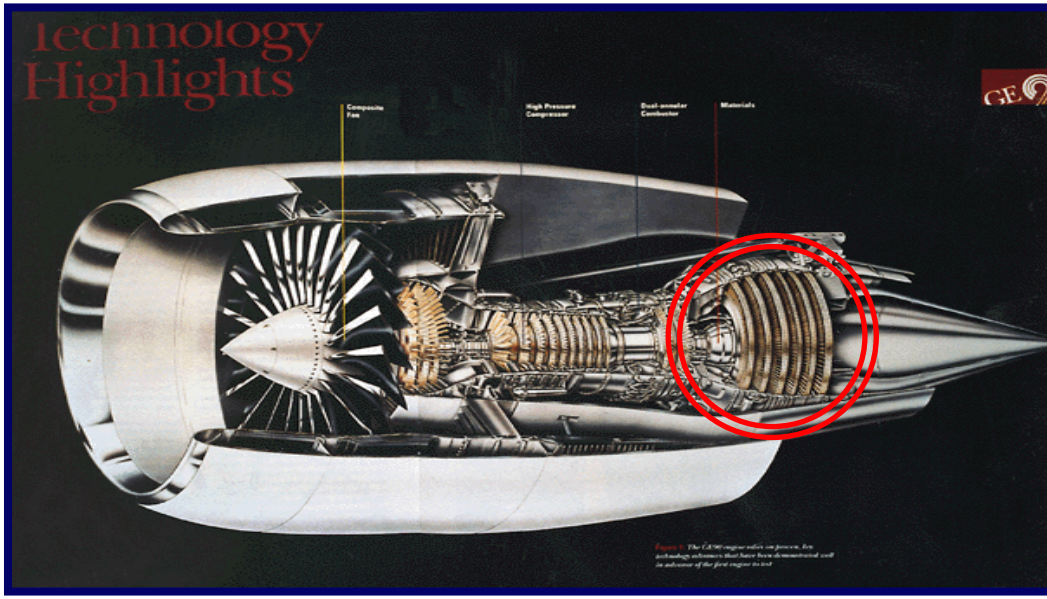
  2 months to develop application, 2 weeks to run

- **Results**

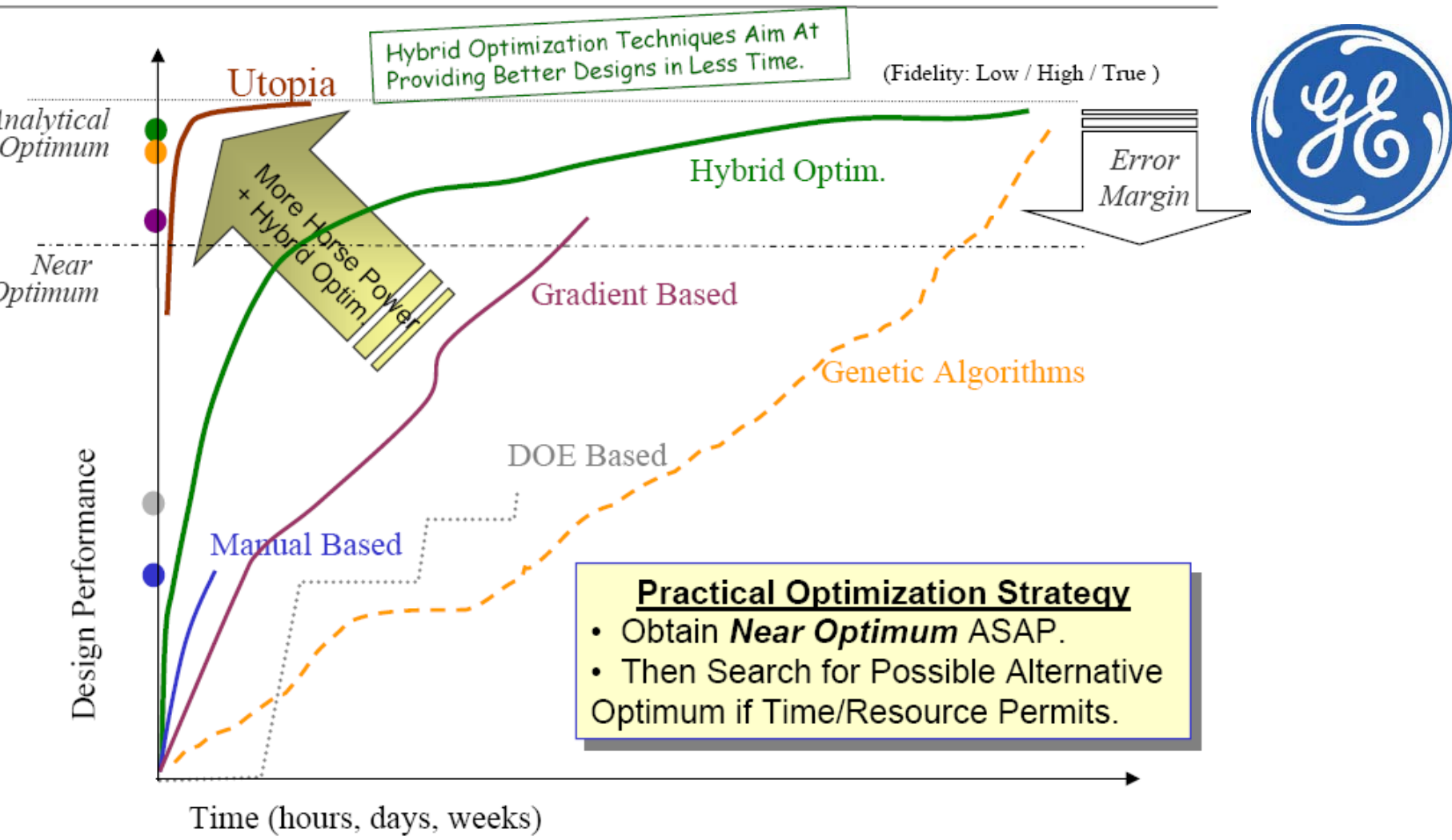
  Saved $250,000 per engine

  Estimate total savings $500M

  200-250 lbs. lighter

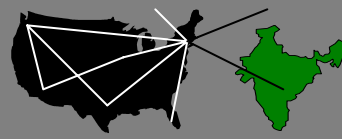


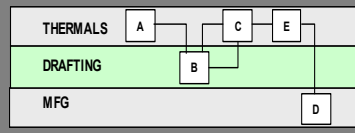
Design Optimization – Practical Strategy



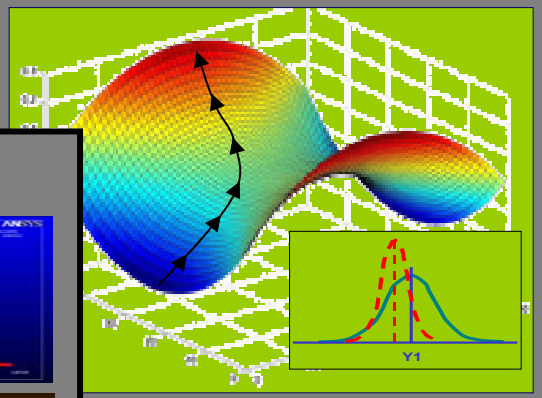
Multidisciplinary Design Optimization, MDO, The Next Jump in CAD/CAE for The Design Of Aircraft Propulsion

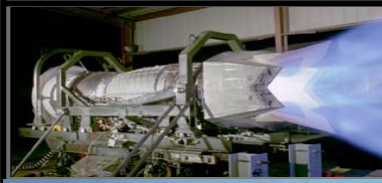
Execution



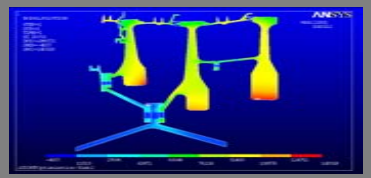


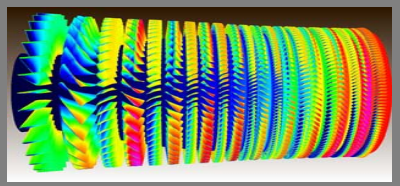
Optimization

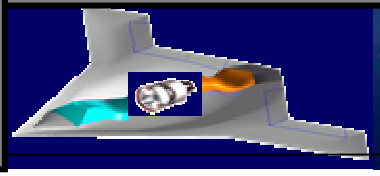




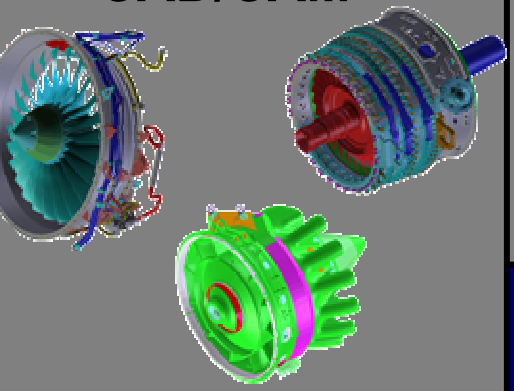
Simulation







CAD/CAM



J. Brent Staubach, Pratt & Whitney, Manager, Systems Optimization

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Computing Power Will Fundamentally Change How We Design Gas Turbines

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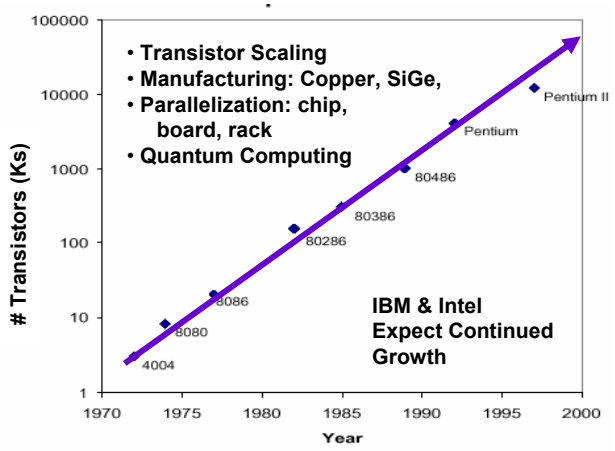
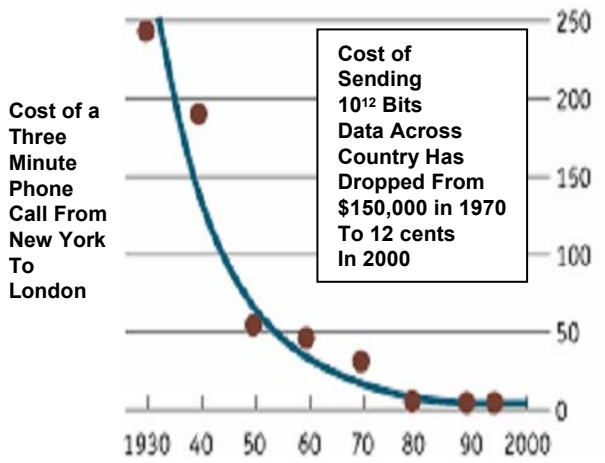
Computer Speed
- 2x Every 18 months -



Network Speed
- 2x Every 9 months -



Tremendous Growth

Billion X Speed
by 2025

Hardware: 100,00X

Massive Parallel Grid Computing, Assume ~10,000X

RELEASE THIS POWER ON DESIGN PROCESSES

- Review Current Manual Design Optimization Practices
- Computer Based Design & Key Enablers
- **Future → *Zero Design Cycle Time***

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Modern Gas Turbine Optimization: An Exercise In Managing Complexity

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50,000 PARTS

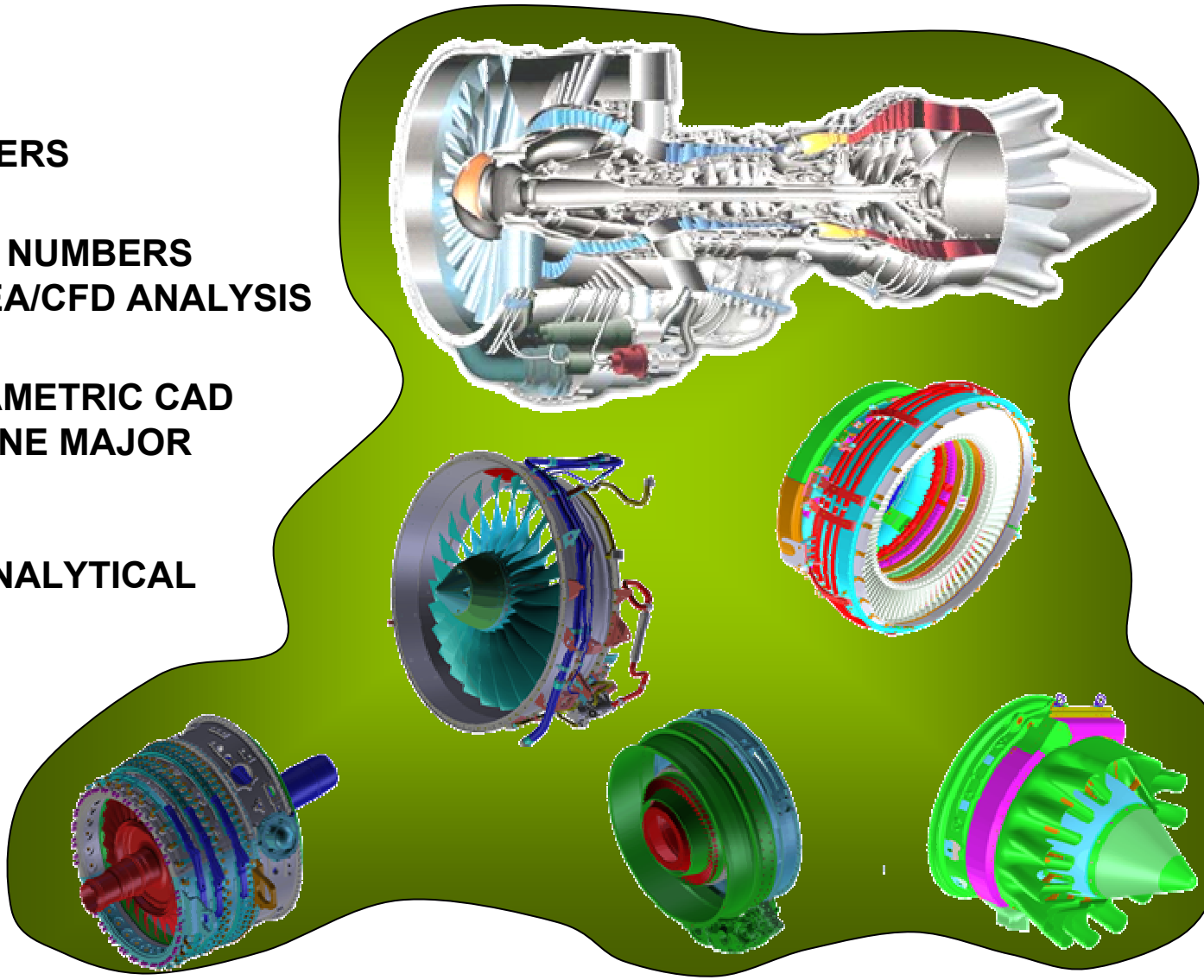
~5000 PART NUMBERS

~ 200 MAJOR PART NUMBERS REQUIRING 3D FEA/CFD ANALYSIS

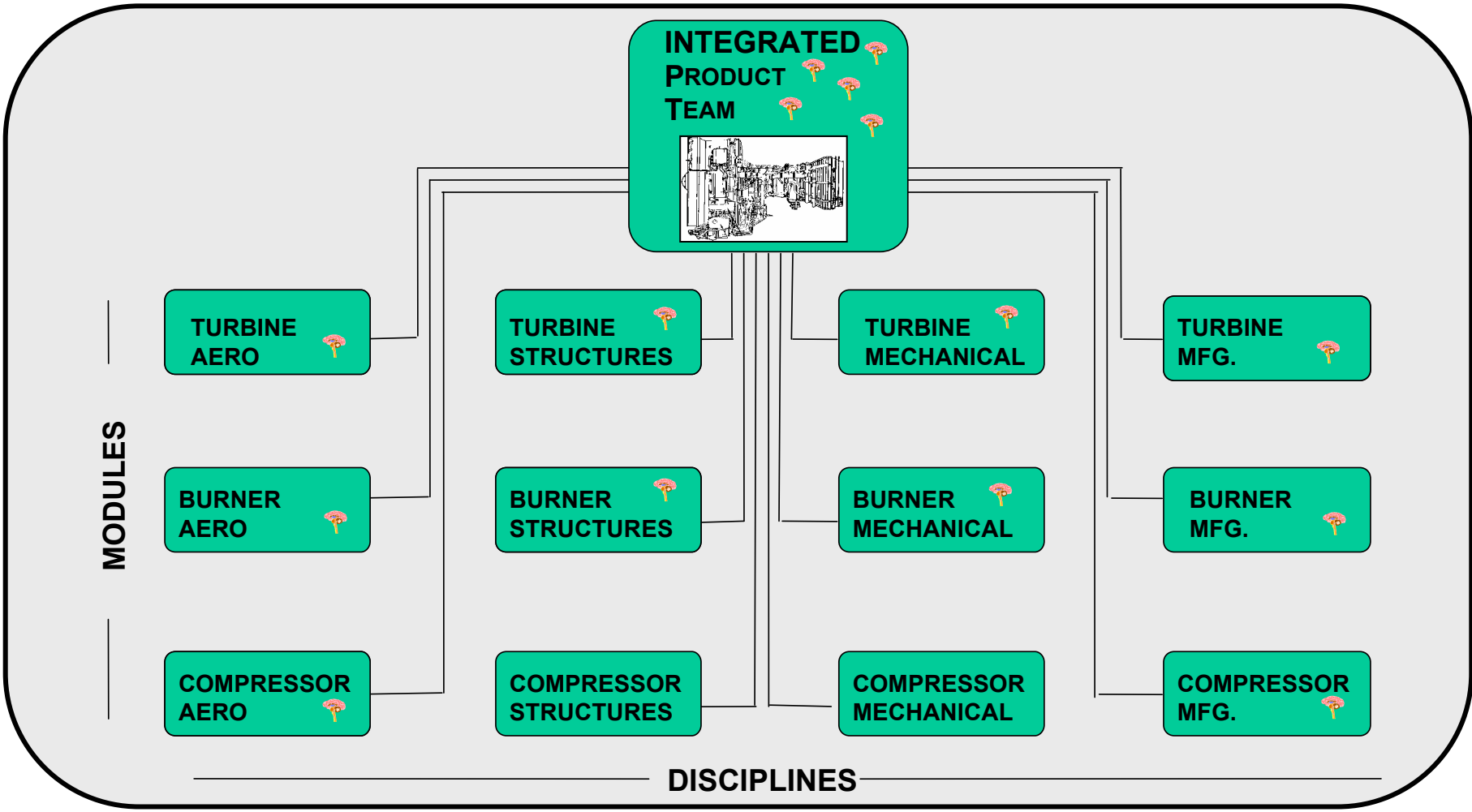
~ 5000-10,000 PARAMETRIC CAD VARIABLES DEFINE MAJOR PART NUMBERS

~ 200 MAN-YEAR ANALYTICAL DESIGN EFFORT

~ 200 MAN-YEARS DRAFTING / ME EFFORT



Complexity Is Managed By Decomposing The Design, Coordinating & Re assembling via The *IPT* Process



IPTs* ARE THE ORGANIZATIONAL MECHANISM THAT ENABLES A BALANCED DESIGN - *MANUAL MULTI-DISCIPLINARY DESIGN OPTIMIZATION

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Complex Designs Are Inherently & Brutally Iterative, Bounded By Best Practice Rules

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CAD MODEL

PHYSICS MODEL

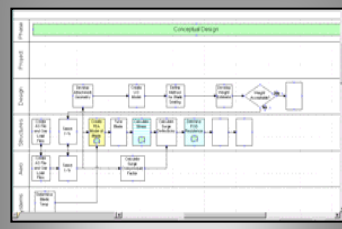
DESIGN SPACE

- NON LINEAR
- MULTI MODAL
- DISCONTINUOUS
- NOISY
- HIGHLY CONSTRAINED

DESIGN

DECISION

STANDARD WORK



WORK INSTRUCTIONS

CRITERIA

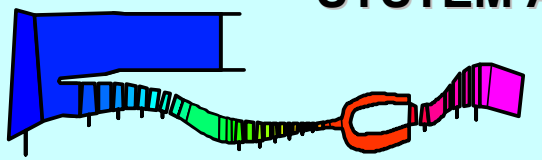
VALIDATED ANALYSIS

PREFERRED CONFIGURATIONS

ENGINEER MAY ITERATE 100s TO 1000s OF TIMES TO GET SATISFACTORY RESULTS -- MANUALLY !

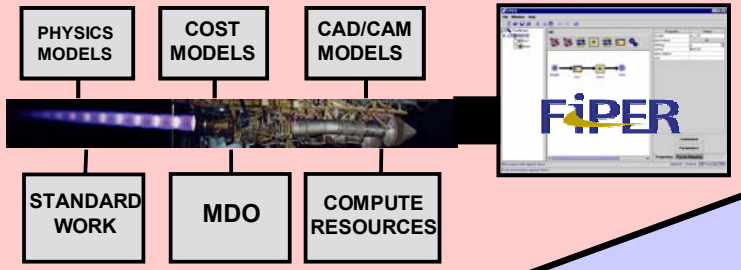
Technologies Are Progressing To Enable Large Scale Computer Based MDO

SYSTEM ANALYSIS



CHALLENGES
- *CYCLE BALANCE*
- *2ND FLOWS*
- *TRANSIENTS*

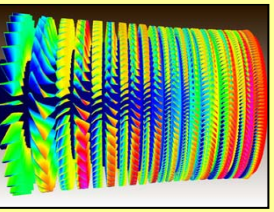
INTEGRATION FRAMEWORKS

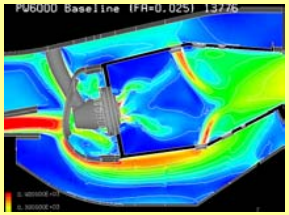


COMPUTER BASED MDO

NAVIGATE THE VIRTUAL DESIGN SPACE

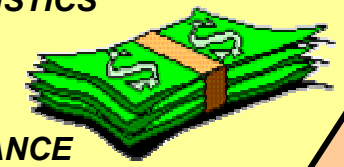
ASSESSMENT MODELING





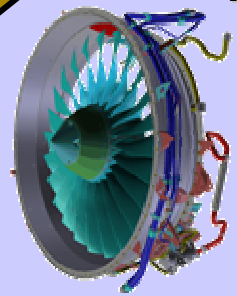
PHYSICS
- *SOLVE TURBULENCE*
- *MULTIDISCIPLINARY ANALYSIS (MDA)*
- *MATERIAL PROPERTIES*
- *PROBABILISTICS*

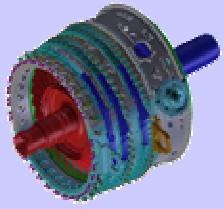
COST

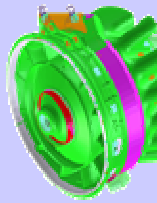


- *MFG*
- *MAINTENANCE*
- *NEGOTIATED*

ROBUST PARAMETRIC MASTER MODEL







CHALLENGES
- *LARGE ASSEMBLIES*
- *TOPOLOGICAL*
- *GENERATIVE*
- *DIRECT MFG*

GRID COMPUTING

CHALLENGES
- *SECURITY*
- *POLITE COEXISTENCE*
- *FAULT TOLERANCE*

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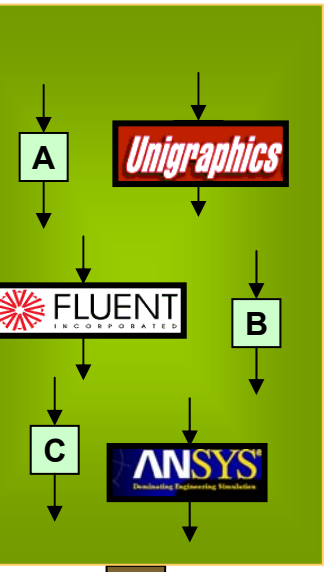
Implementation Path:
Electronic Enterprise Engineering

Engineous software

LIBRARY OF "WRAPPED" TOOLS



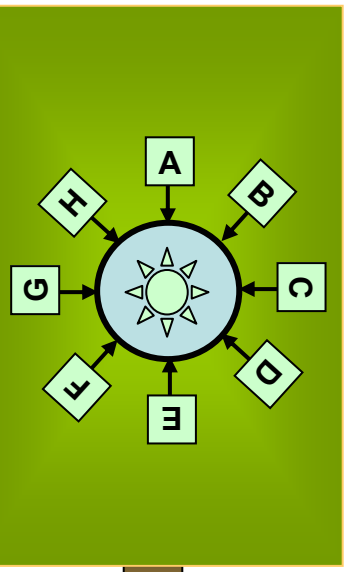
VALIDATED

CERTIFIED

EMBEDDED KNOWLEDGE

CONTROLLED

INTEGRATION FRAMEWORK

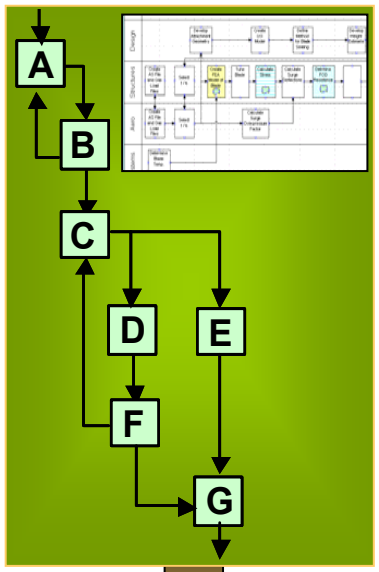


INTEGRATE THIRD PARTY & LEGACY TOOLS

INDUSTRY ACCEPTED

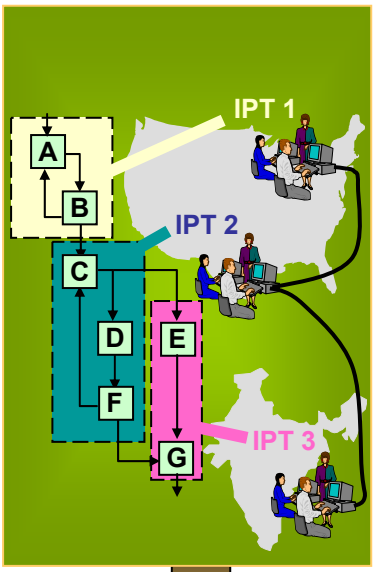
COMMERCIAL

ELECTRONIC PROCESS MAPS



TOOLS INTEGRATED INTO ELECTRONIC PROCESS MAPS & ASSOCIATED WITH WORK INSTRUCTIONS

ELECTRONIC IPT

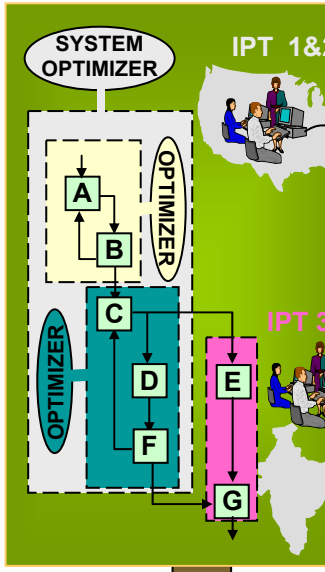


WORK FLOW MANAGEMENT

COLLABORATIVE ENGINEERING

SECURE B2B

COMPUTER BASE OPTIMIZATION



AUTOMATE ITERATION

SATISFY CRITERIA

GRID COMPUTING

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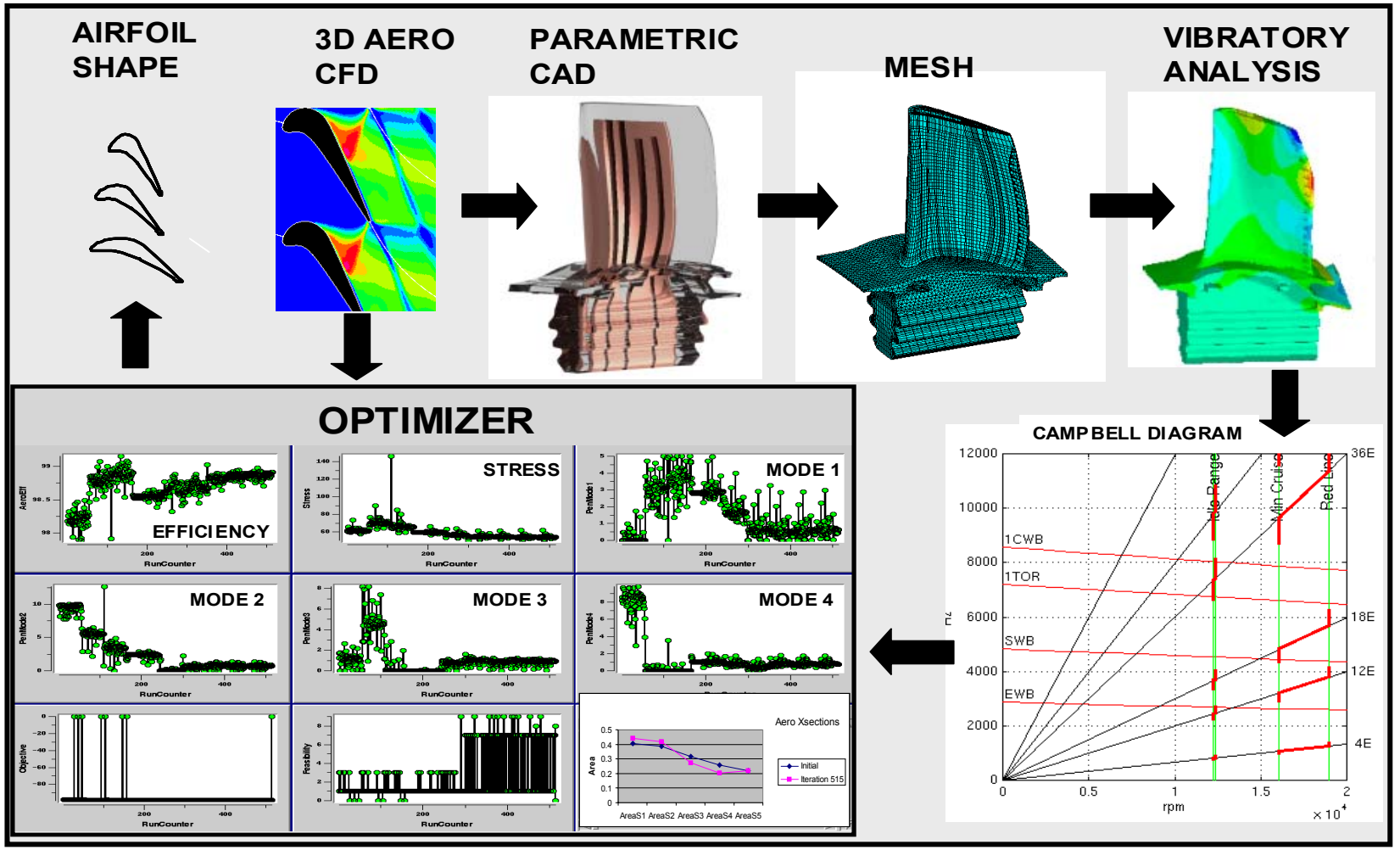
Large Scale Computer Based MDO Is Already Becoming Practical

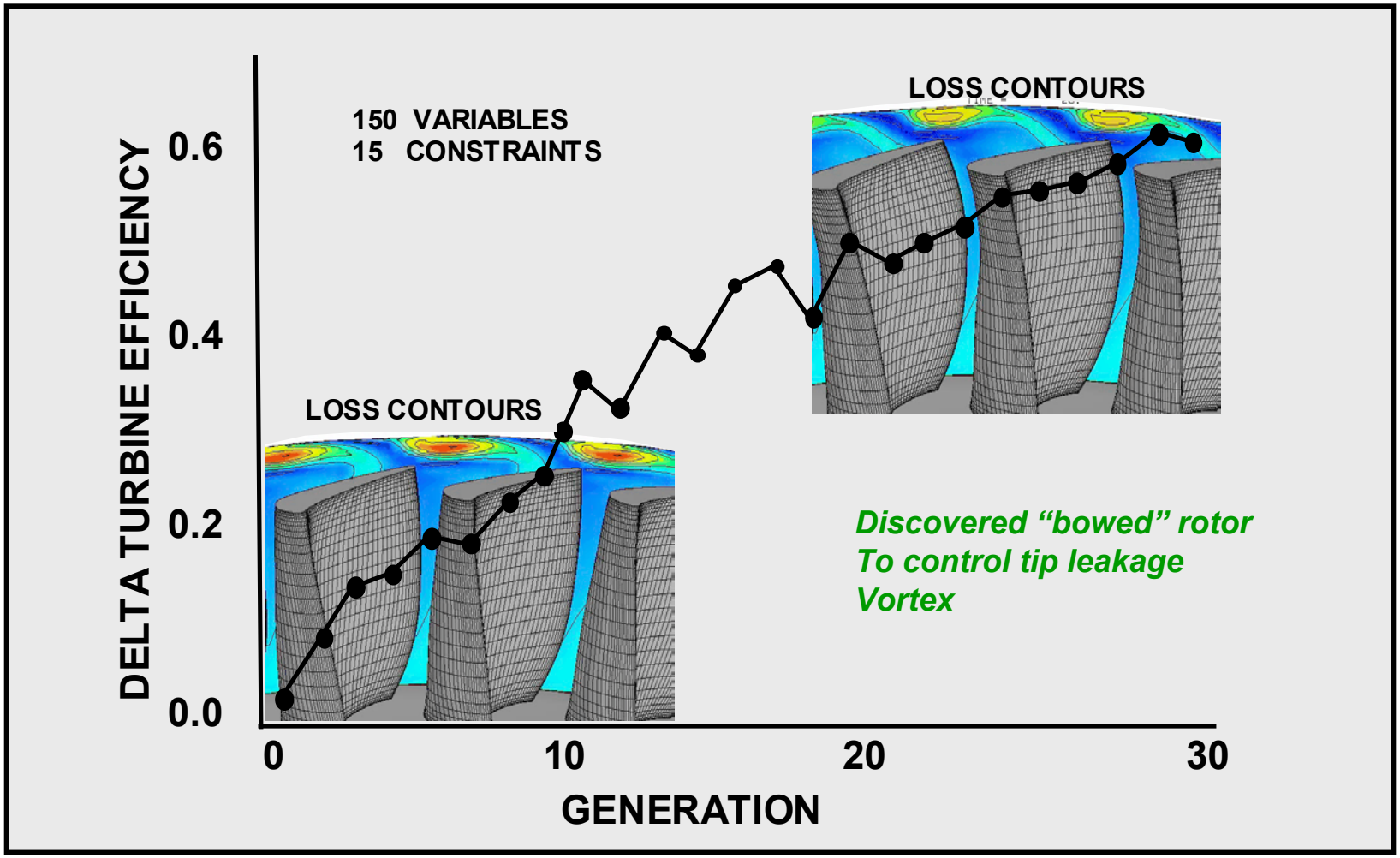
Engineous software

3D Aero-Vibratory Shape Optimization Of A Cooled Turbine Airfoil
(Single Row RANS CFD, Cooled UG Parametric Model, 3D ANSYS Vibes)



Large Scale Computer Based MDO Is Already Becoming Practical

3D Shape Optimization Based On Hybrid Genetic Algorithm & Rule System
(3D RANS Multi Row CFD, Population Size 80, Total Runs 2400, Run Time 48 hrs on 40CPUs)



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Zero Design Cycle Time

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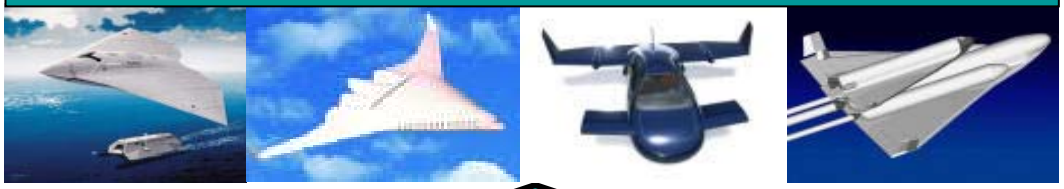
CUSTOMER NEEDS



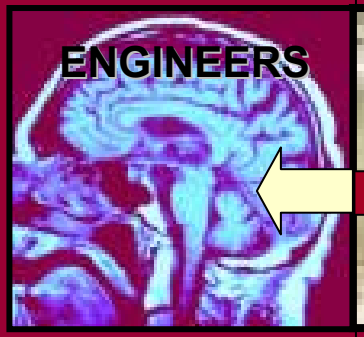
UNDERSTAND THE FUTURE

CREATE TECHNOLOGY

MPROVE MODELS

RE-FORMULATE PROBLEM

UPGRADE COMPUTER BASED DESIGN "MACHINE"

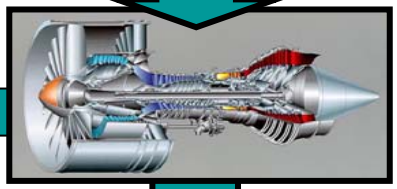


RUN 24/7 365 DAYS A YEAR

CONTINUOUS DETAILED DESIGN

SOLVE ALL POSSIBL APPLICATIONS @ TECHNOLOGY READINESS LEVEL

CUSTOMER REQ. EXCEED TECHNOLOGY



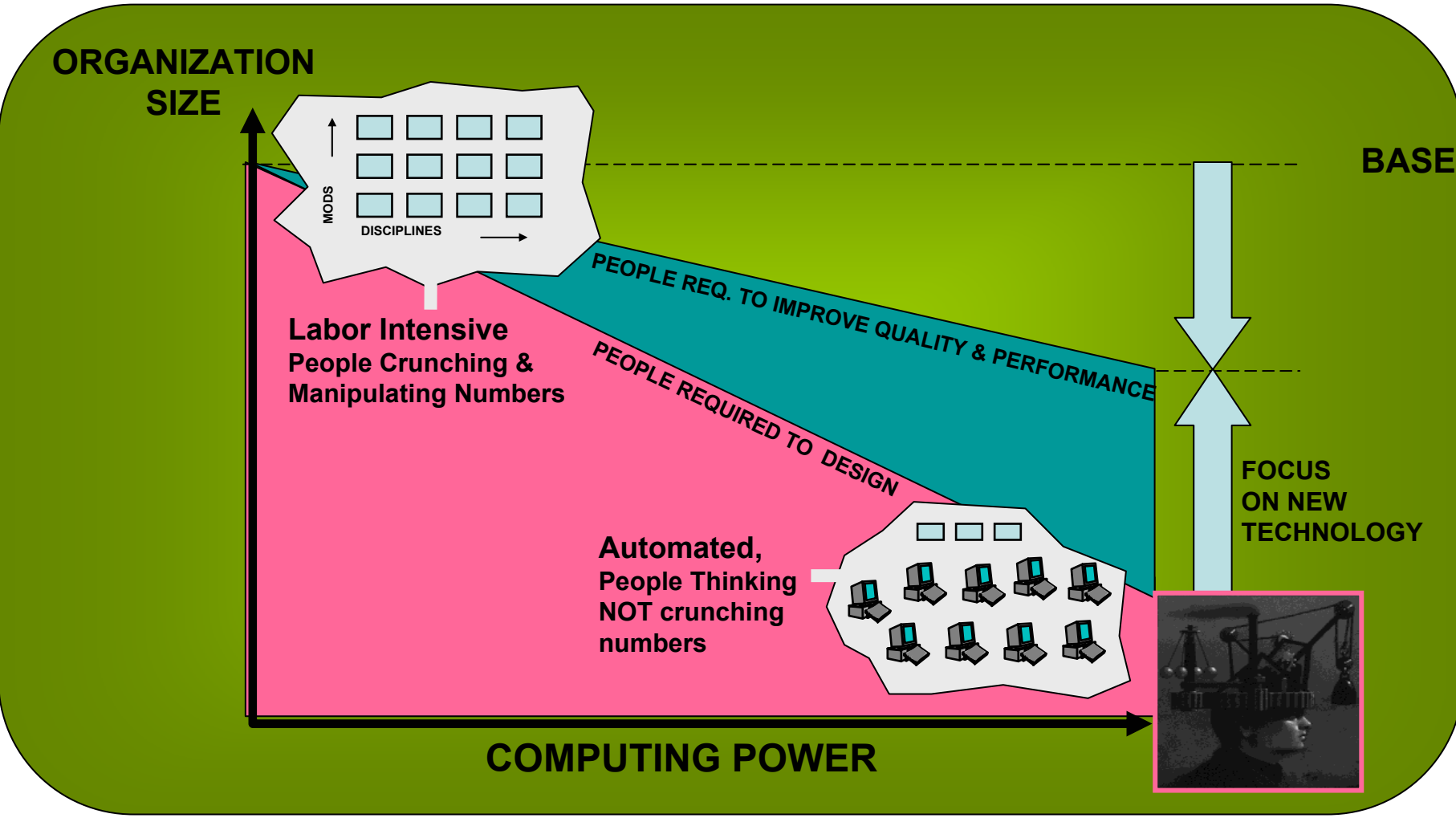
ZERO DESIGN CYCLE TIME

DESIGN IS ALWAYS READY AND WAITING TO "BEST" MEET CUSTOMERS NEEDS

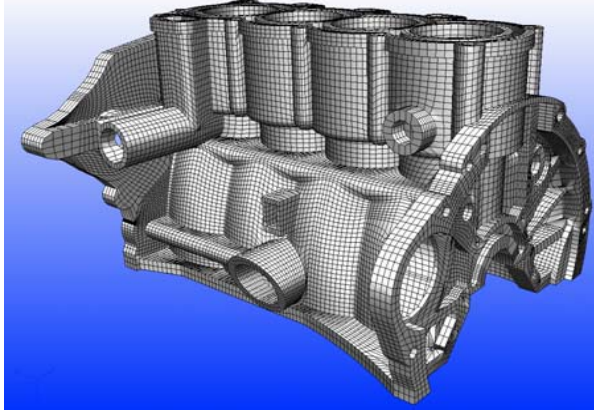
CAEvolution GmbH

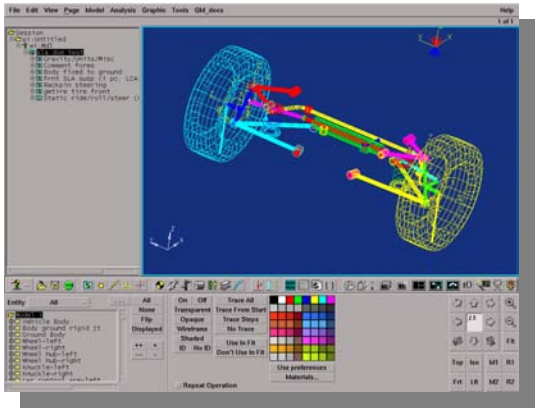
Design Organizations Will Shrink and The Role Of Technology Will Grow

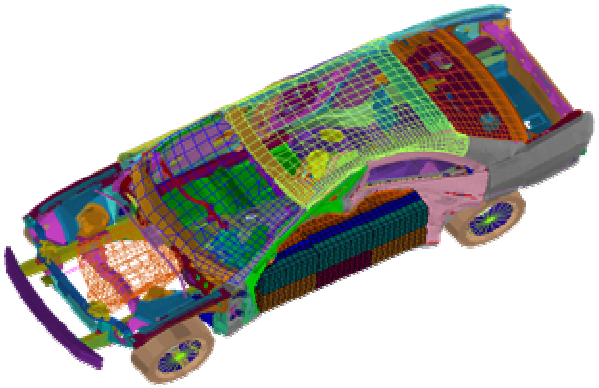
Engineous software

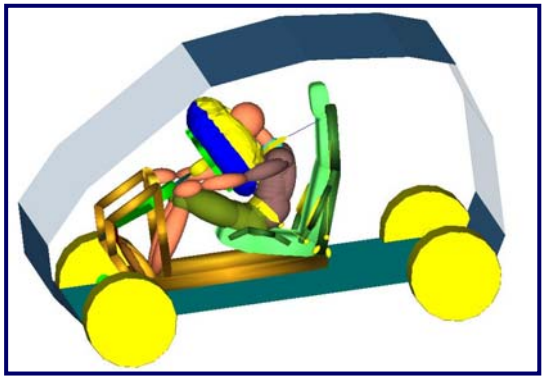


Highly Skilled, Creative, Technology Centric Engineers Will Be Needed









Thanks for your Attention!