



The Frontloading Design Centric Simulation a Myth or Reality?

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We are living in a Digital World

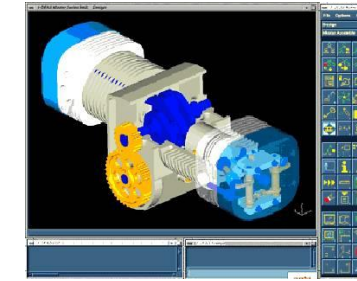
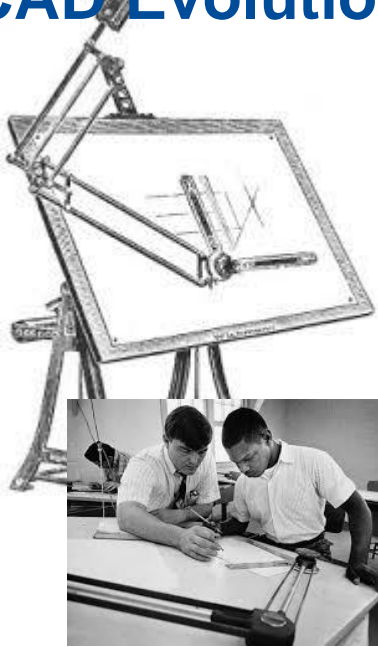
Mobility, Interconnectivity, Green Energy, Big Data

- Electronic
- Electrical or Fuel Cell
- Autonomous Vehicles
- Digitalization
- Big Data and Software

Emails, Socialmedia (Facebook, Twitter, WhatsApp, LinkedIn..)

Speed - Real Time

CAD Evolution since 1970 boosted the 3D Creation by Design Engineers



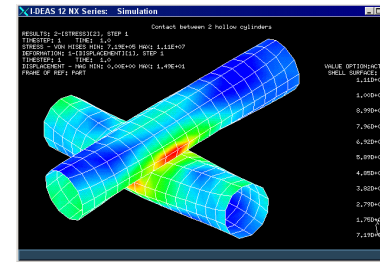
SIEMENS



The Digital Twin
3D Product Creation
Simulation/Test
Mechanical
Electronic



Virtual Reality
Augmented Reality



70

78

82

91

95

97

06

010
-
017

2D Analog

2 ½ CAD/CAM

Simulation based Design

IDEAS Master Series

PLM 1.0

VR-AR

PLM 2.0, 3.0

CADAM
Calma
Computervision
Applicon
McAuto Unigraphics

SDRC CAE
3D NURBS-Solid Modeling
IDEAS - Geomod, Supertab
Model Solution, Systan

Internet

SDRC
Unigraphics
PTC
Dassault
Autodesk

SAP-PL

Siemens PL
Dassault
PTC
Autodesk
Clouds
IoT



Democratization of CAD/CAE driven by Technology changes and visionaries

Economical Pressure

- Traditional Software expensive
- Cost of ownership too high

Software/Hardware Complexity

- No ease of use
- Programmed in Fortran/Assembler
- Limited Graphical UI
- Unix and Inhouse OS
- Inhouse Hardware

Hardware / Software

- **IBM PC**
- New Graphics Standards
- C++ Object Oriented Code
- Windows/Linux

Education of Design Engineers

- FEM Analysis in Study
- CAD in Study

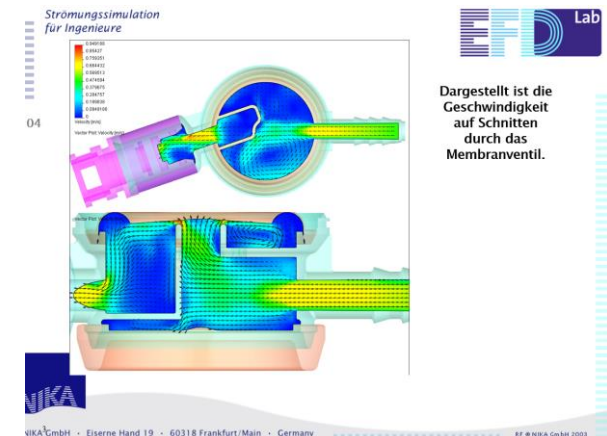
Autodesk
1982

Cosmos
1982

Solidworks
1993

SolidEdge
1993

Nika
1998





New Generation of Design Engineers

- Strong Foundation: Physics and Maths
- Affinity to computers and software
- Have used CAD and CAE while at school
- Have also economical understanding
- Ready for global companies

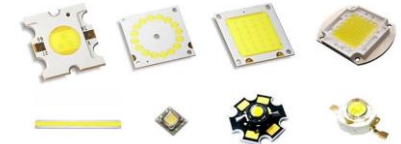
Design Engineers Today





New century – New challenges

- Emerging and Evolving technologies
 - Electrical Hybrid vehicles
 - Autonomous vehicle
 - LED and Laser lights
 - “Smart” products
 - New materials
- Economical factors
 - Costs
 - Reduction of design cycle
 - New competitors
- Safety and Regulations
 - CO₂
 - Cyber security
 - Green power





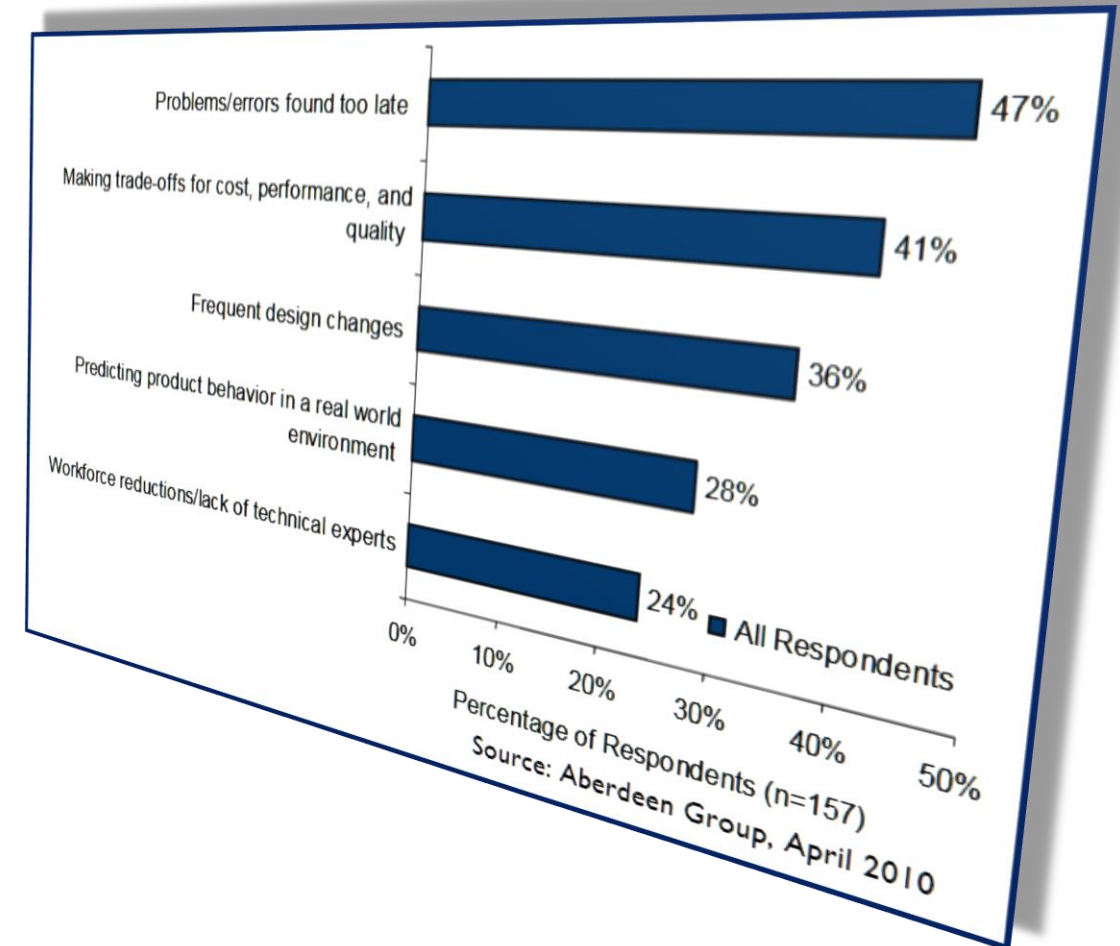
Challenges to be addressed

(by Aberdeen Group's survey of 157 Best-In-Class companies, 2010)

Aberdeen Group
A Harte-Hanks Company

Top 5 Hurdles for Product Design

- Problems found too late
- Trade-off for cost, performance and quality
- Frequent design changes
- Predicting a real world environment
- Lack of technical experts





Obstacles to the Best-In-Class Strategy

Traditional CAE Simulation very Time Consuming

- Complex geometry – Need simplification
 - Takes long, cannot be automated: intense user implication
 - Simplification impacts the real world properties (poor test data correlation)
- Complex geometry – difficult to mesh
 - Takes too long, Special Software needed to manipulate the Geometry for meshing.
- CAE Simulation – Can be done by expert only, because of the legacy tools
 - Analysis team is overloaded: long turn around, Designers need to wait too long
 - Experts must conduct routine work: No Time for innovation
- Different Systems for Analysis and Design
 - Transferring geometry to Simulation and back: long turn around time
 - Hard to design variation: design changes are not synchronized

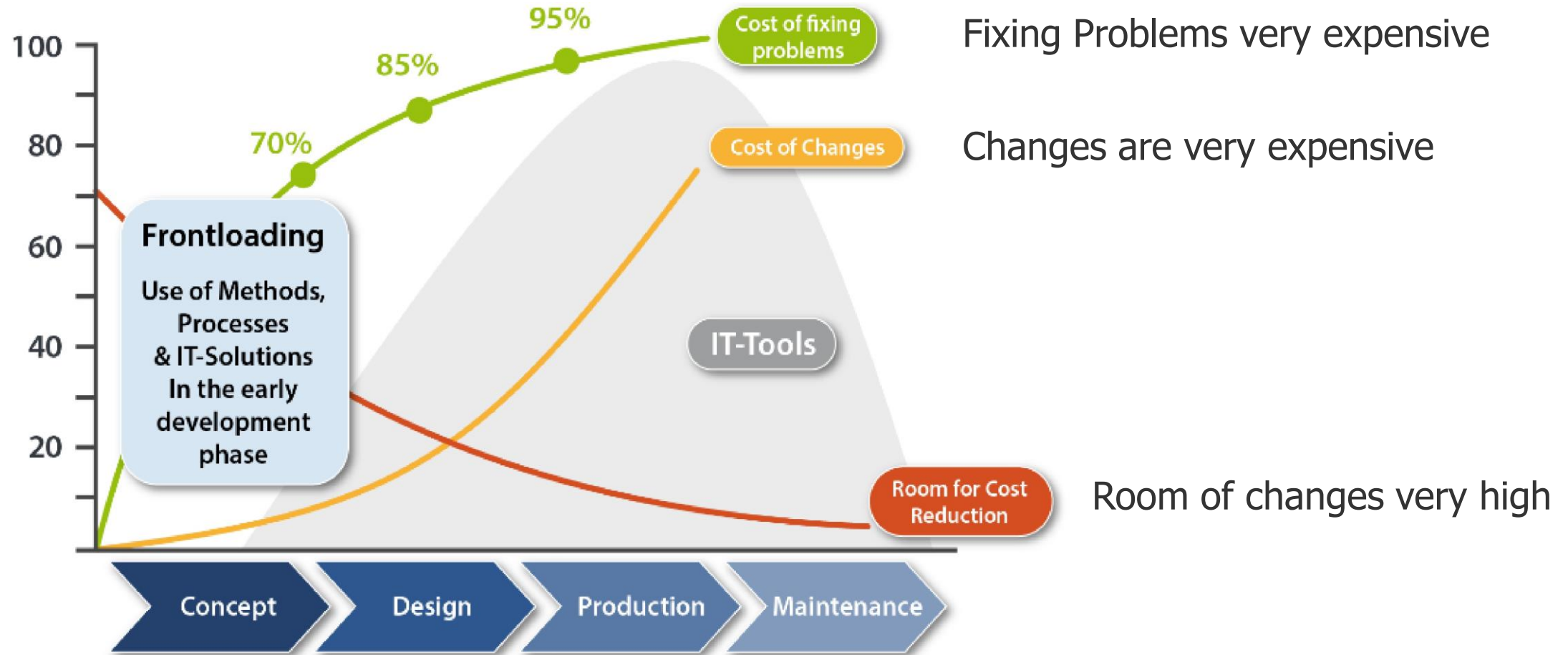


Design Engineers have become mission critical

- Design Engineers are mission critical for the entire product engineering process.
- In fact they are responsible for the product future.
- They take difficult decisions in the early stage of their design.
- Therefore they need the right tools to make upfront those decisions.
- FRONTLOADING oriented tools are essential in the early design process.



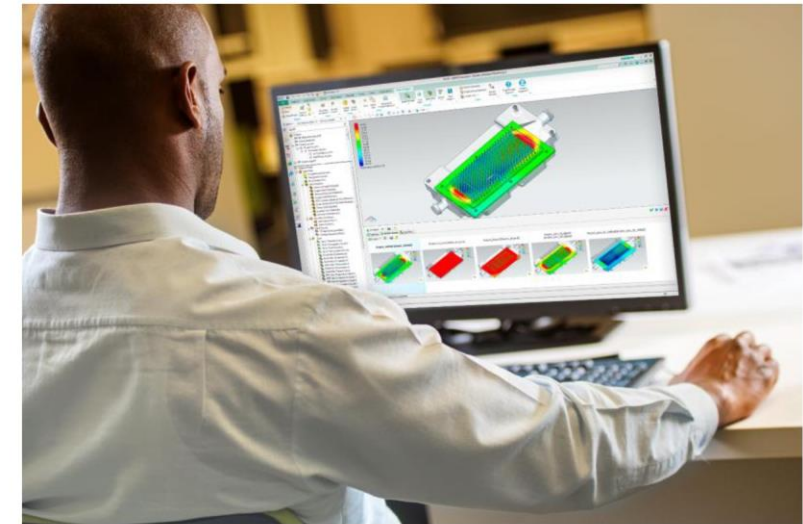
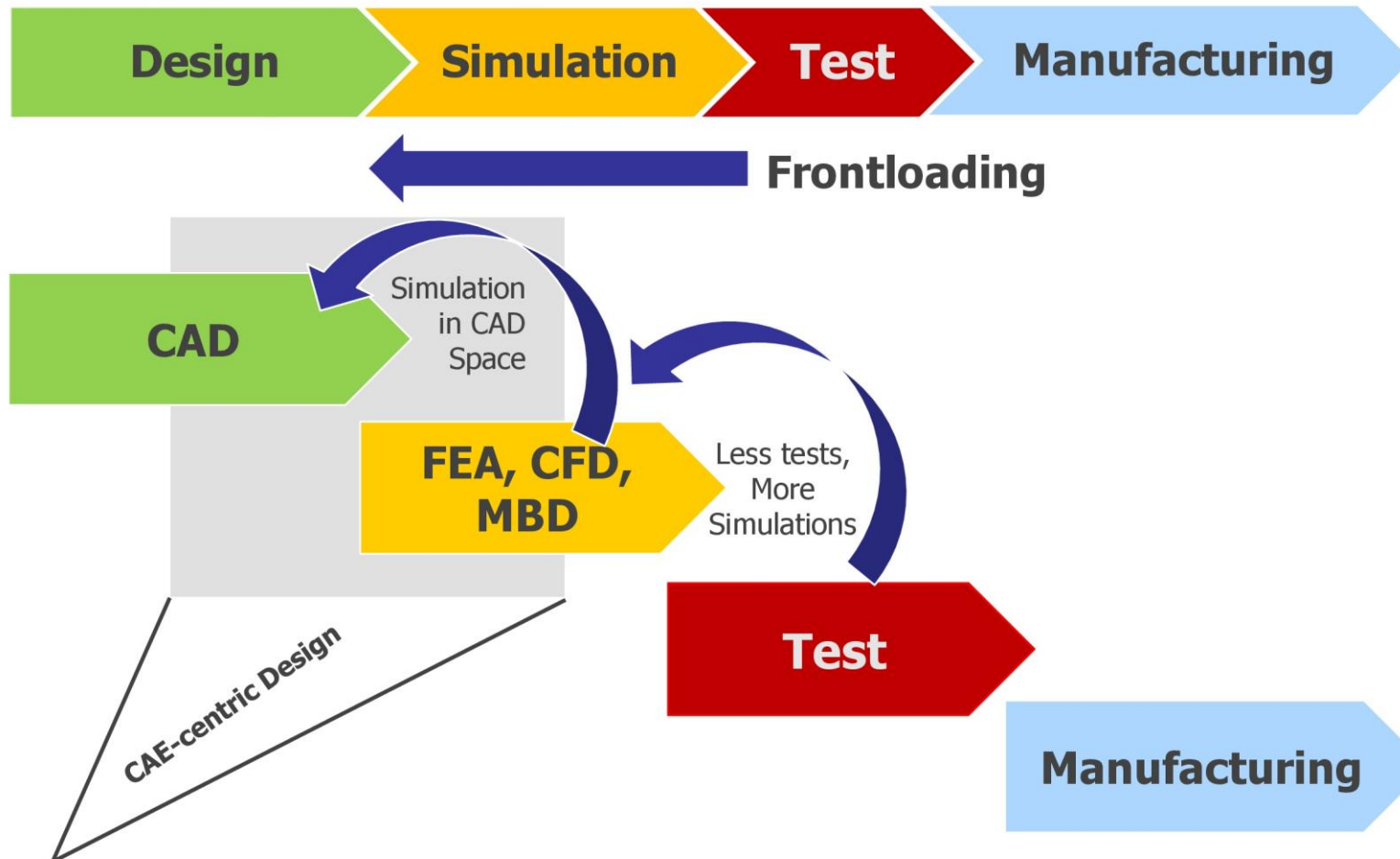
Frontloading economical values



Source: Prof. Dr. Martin Eigner VPE TU Kaiserslautern



Simulation Centric Design ➡ Frontloading



FloEFD for NX CAD-embedded CFD



New challenges requires new workflow: A Paradigm Shift

Challenges

Analyze product behavior earlier

3D CAD to define and create new product concepts

Tear down barriers between Simulation and Design

Simulation has become **mission critical**



Workflow

Integrate Product Concept validation from beginning in the Engineering process
To get it right the first time

Involve design engineers, be CAD centric

Empower Design Engineers to simulate more products variations in the early design
100% cooperation Design/Simulation

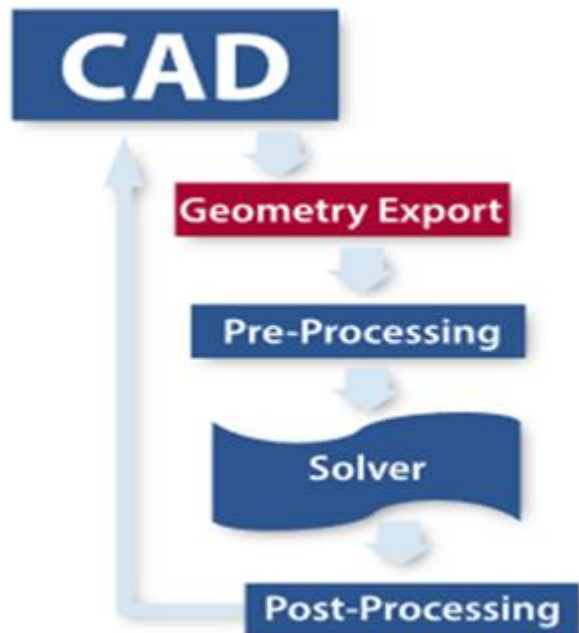
Design Engineers and CAE Experts will then run more simulation jobs and reduce the No. of physical prototypes



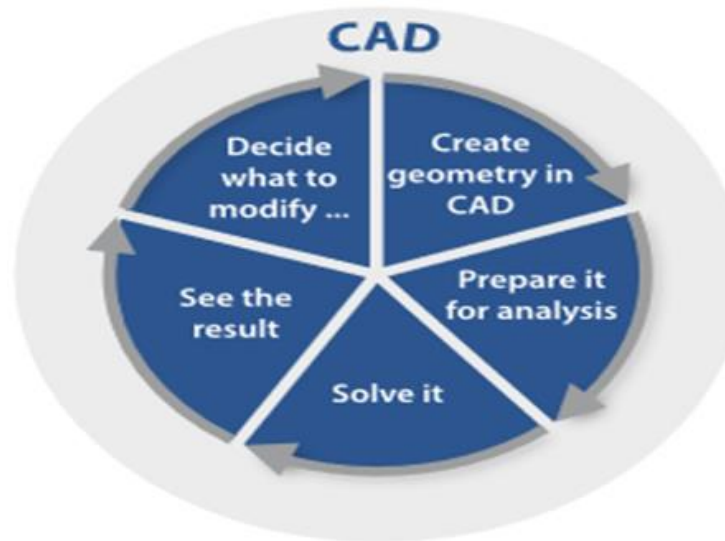
CAE Workflow : Frontloading vs. Traditional



Traditional CAE is a serial Process



CAE Frontloading is CAD Centric



- Frontloading helps to predict failure very early in the design process.
- Frontloading increases the level of reliability for new product concept
- Frontloading gives designers and analysts the ability to validate quickly many product concept variations



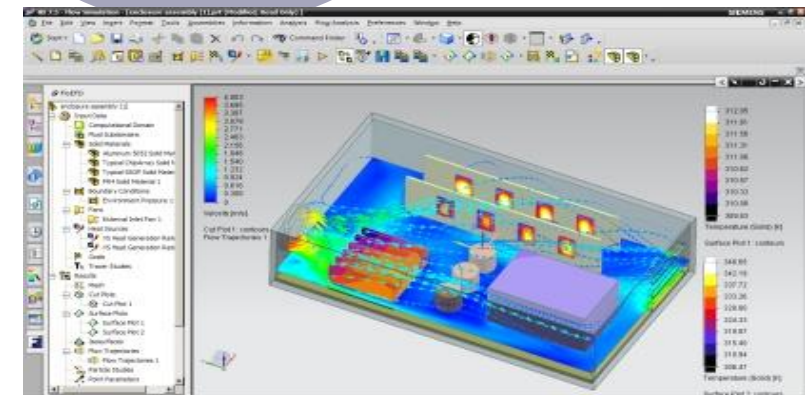
Frontloading CAE Solutions

Can be used by design engineers

- 100% CAD embedded
- Manage Complex Geometry; No Simplification! (Design Engineers use native Geometry as it is)
- Easy-to-use; Easy-to-learn
- No additional scripting or Macros

Enable Simulation at early design stages

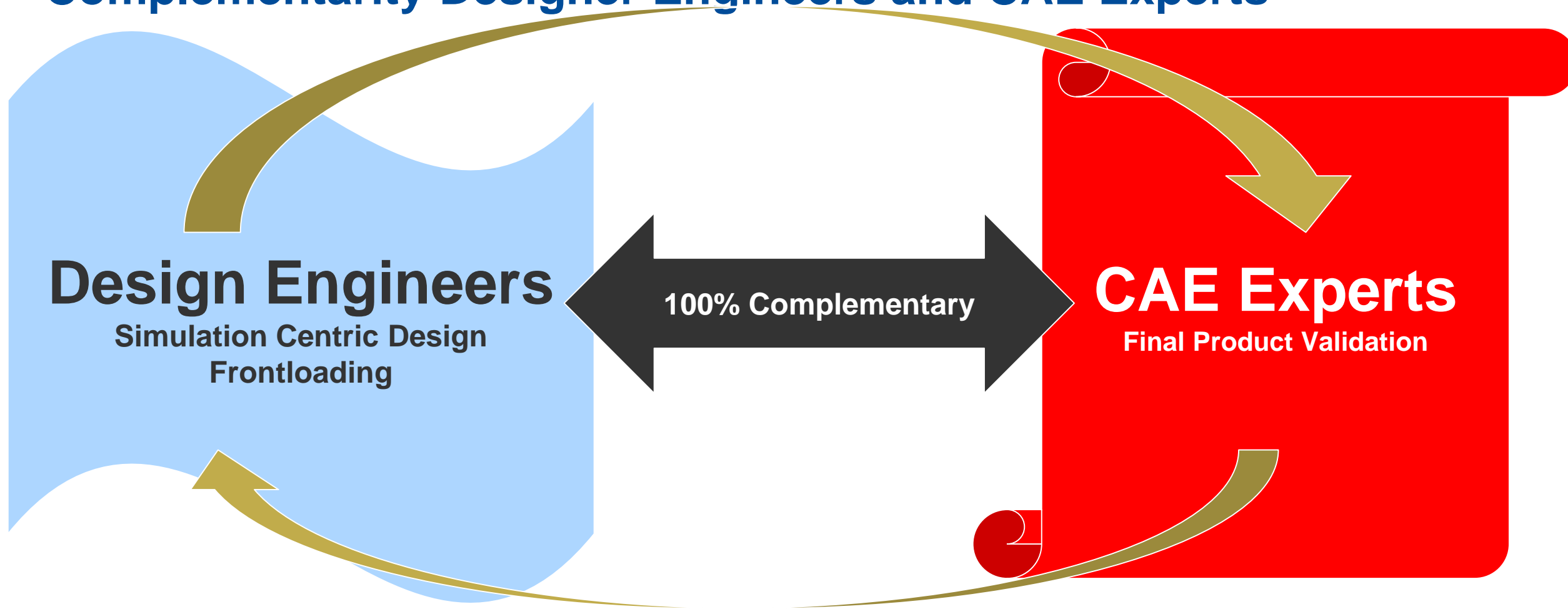
- Minimize time to answer and costs
- Increase productivity
- Focus on Innovation / Creativity



NX **SIEMENS**



Complementarity Designer Engineers and CAE Experts



More simulations to validate more product variations → help innovating



New Simulation Space for Design Engineers has been created

The industry is open/ready for Frontloading:

- a) A new additional Simulation space has been created
- b) Bigger Simulation capacity
- c) Despite many cultural barriers; the adoption is moving forward
- d) Classical CAE Software Vendors are offering now Frontloading solutions in addition to their experts solutions
- e) This trend has increased the level of importance/urgency of **SIMULATION**
- f) **SIMULATION** is therefore mission critical to reduce costs and time to market and help companies to be more competitive.



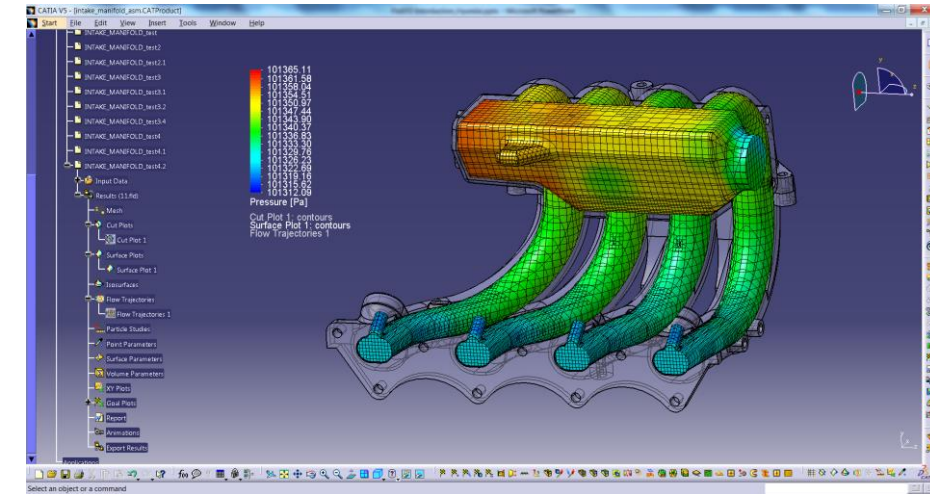
A successful example for CAE Frontloading

FloEFD

FloEFD is made for Design Engineers

Make CFD accessible for Design Engineers

- **CAD Embedded** (in major CAD systems)
 - Run inside the CAD System- is 100% CAD Centric
 - Same User Interface
 - Easy-to-use by design engineers
- Digest and handle very complex native CAD Geometry
- No Need for Simplification
- No Programming needed
- Fast meshing and Solving
 - Minimize user interactions
 - Ensures robust solving and automatic convergence



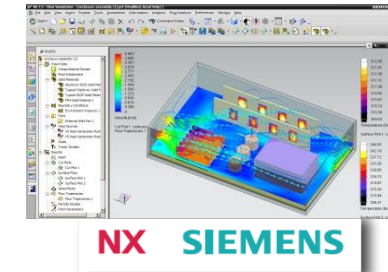


FloEFD is CAD Embedded

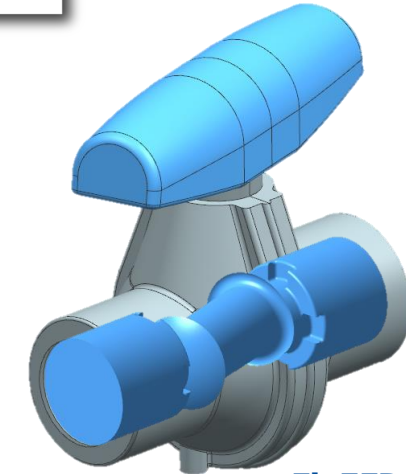
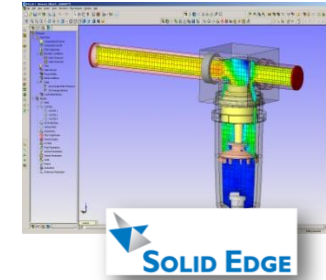
Advantages of being embedded in CAD

- No need to transfer geometry from CAD to CFD
- Geometry changes detection: model and analysis are synchronized
- Automatic fluid volume detection
- Analysis input data (pre-processing) is defined inside CAD
- Results (post-processing) are displayed inside CAD
- Easy to learn
- Leveraging from being embedded in CAD: detailed geometry information is used for effective meshing and solving

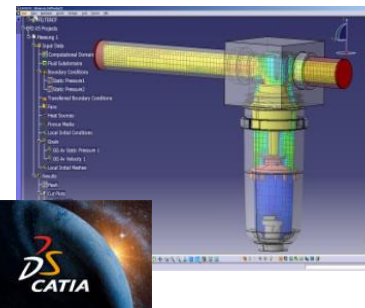
FloEFD for NX



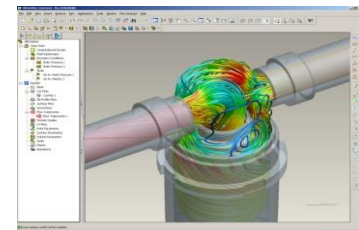
FloEFD for SolidEdge



FloEFD for CATIA V5



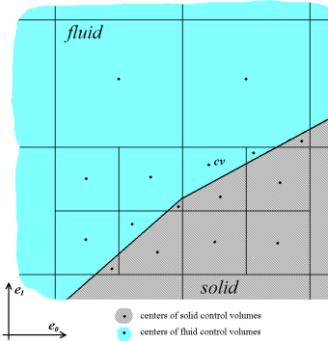
FloEFD for Creo





State of the Art Technology: Numerical-Analytical Combination

Partial Differential Equations



$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x_i}(\rho u_i) = 0$$

$$\frac{\partial \rho u_i}{\partial t} + \frac{\partial}{\partial x_j}(\rho u_i u_j) + \frac{\partial p}{\partial x_i} = \frac{\partial}{\partial x_j}(\tau_{ij} + \tau_{ij}^R) + S_i \quad i = 1, 2, 3$$

$$\frac{\partial \rho H}{\partial t} + \frac{\partial \rho u_i H}{\partial x_i} = \frac{\partial}{\partial x_j}(u_j(\tau_{ij} + \tau_{ij}^R) + q_i) + \frac{\partial p}{\partial t} - \tau_{ij}^R \frac{\partial u_i}{\partial x_j} + \rho \varepsilon + S_i u_i + Q_H,$$

$$H = h + \frac{u^2}{2},$$

Traditional Numerical Approach



Out of the books Algorithms

FloEFD Extension

Analytical Equations

$$\rho c_p \frac{\partial T}{\partial t} - \text{div}(\lambda \text{grad}(T)) = f + q_j$$

FloEFD Extension

Aerospace Test Data



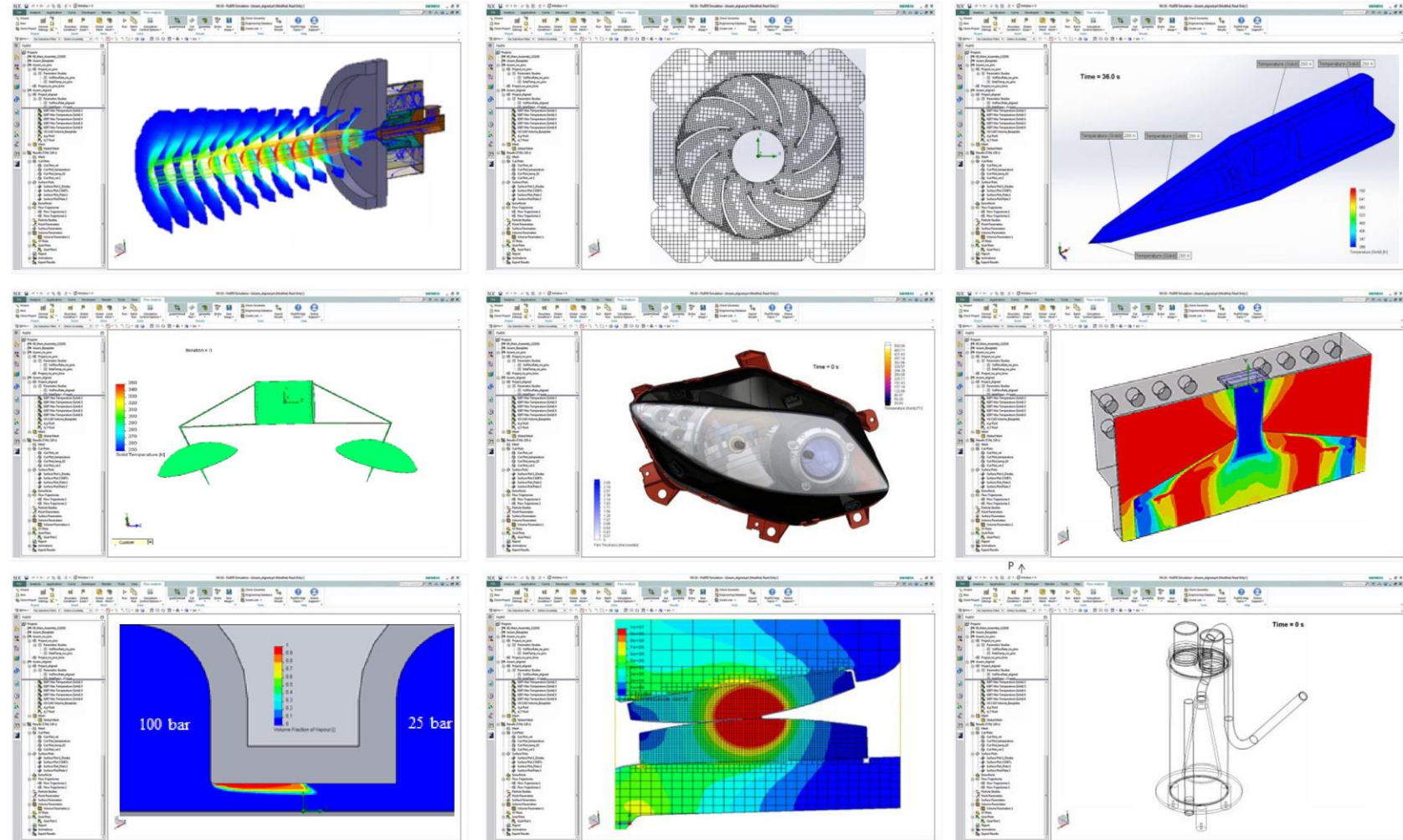
Validated through Tests

FloEFD is based on a unique technology. No other CFD codes use it. It has a robust solver which has been validated and correlated with test data in conjunction with the Russian aerospace program where accurate results were mission critical and mandatory.

With FloEFD a wide range of physics problems can be solved

PHYSICS RANGE

Fluid Flow
Heat Transfer
Real Gas Flows
Non-Newtonian Flows
Aerothermal Flows
Free Surface Flows
Condensation Films
Rotating Flows
Cavitation
Joule Heating
Hypersonics
Liquid Films
Surface Deicing
Equilibrium Combustion
Radiation & Optical Effects

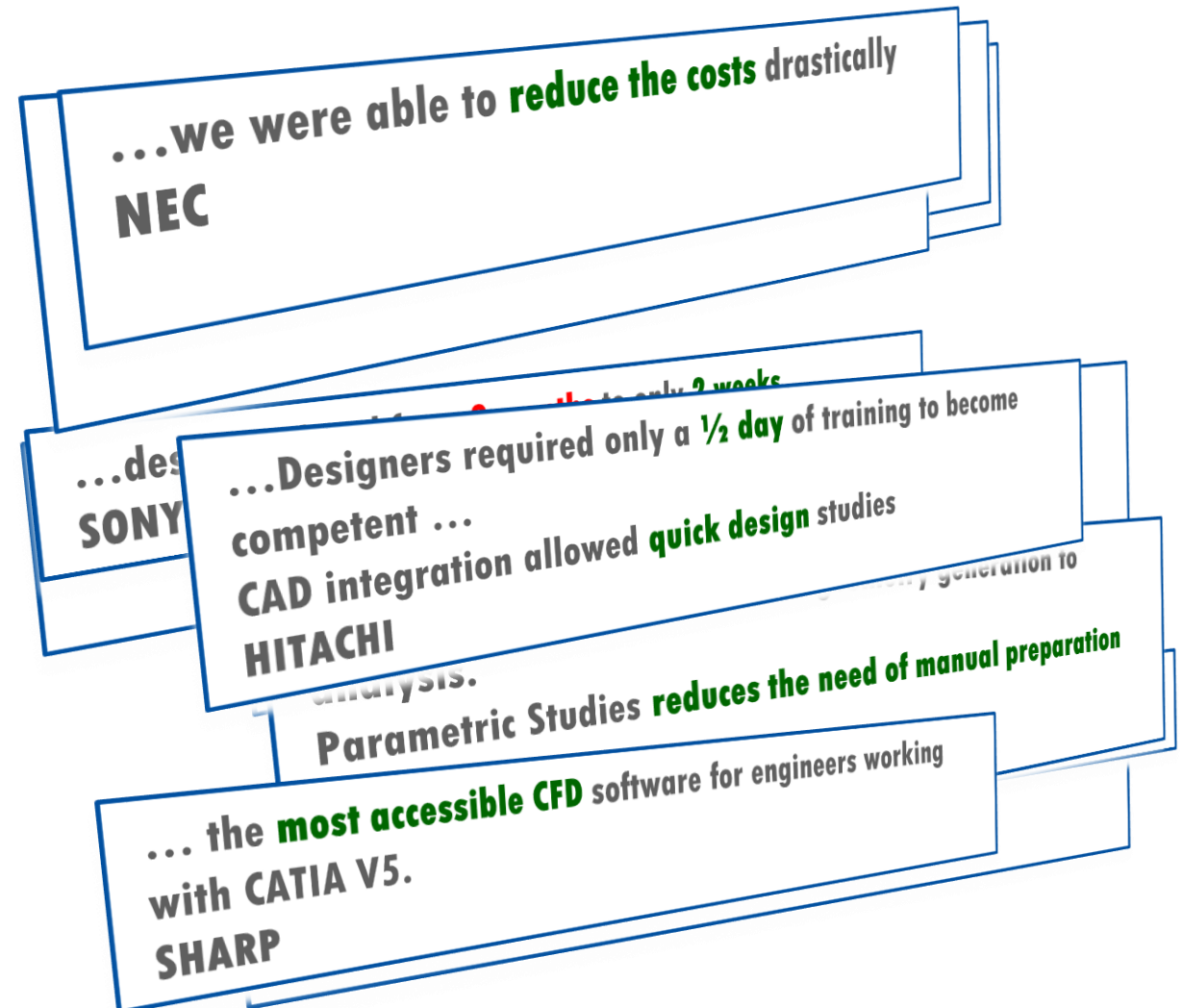




FloEFD is a paradigm shift in CFD - Because it is Frontloading CFD

FloEFD

- Analyze product behavior earlier
- “Get it right the first time”
- More design variations in the concept/design stage
- Collaboration between analysis experts and design engineers
- Fast response time during the Design phase
- CAD embedded facilitates the Integration in the Enterprise PLM Workflow





Frontloading is a Reality; It is not a Myth

Because it is being used successfully in large scale enterprises

- **FloEFD** is a good example for Frontloading
- **CAD** Embedded
- **Easy Adoption** by Design Engineers
- **Increase** Simulation capacity
- **Increase** the relevance of Simulation in general
- **Create** more sophisticated projects for the CAE Experts
- **Strong** Return on Investment



Siemens PL with FloEFD enables Design Engineers to do smarter Analysis



HOEFD

Thank you!

