



Multidisciplinary Design Optimization by modeFRONTIER

An overview on industrial applications

Luka Onesti



modeFRONTIER Users' Meeting 2008

- 45 contributions from modeFRONTIER users
- 3 Plenary sessions
- 3x3 Parallel sessions by application area (Automotive, Aerospace, Electromagnetic, Methodology)
- Closing session by ESTECO staff
- 200 participants



EADS Military Air Systems

- Mission Scenario
- The Parameterized Geometrical Model
- Simulation Model (Wing-Weight, Autopilot, Chimera-Mesh, Loiter-time)
- Optimization Process

modeFRONTIER User Meeting - Trieste - 14-15.09.08



Aerodynamic Optimization of Aircraft Configurations with Multidisciplinary Aspects



**Luca Nardin, Stephan Hitzel,
Kaare Sørensen, Herbert Rieger**

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Aerodynamics & Methods Department
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Explore New Frontiers of Innovation
ESTECO

Integrated Multiphysics Simulation & Design Optimization
Open Industrial Day, Agora Jyväskylä, Finland
March 16, 2009

Optimize for The Mission

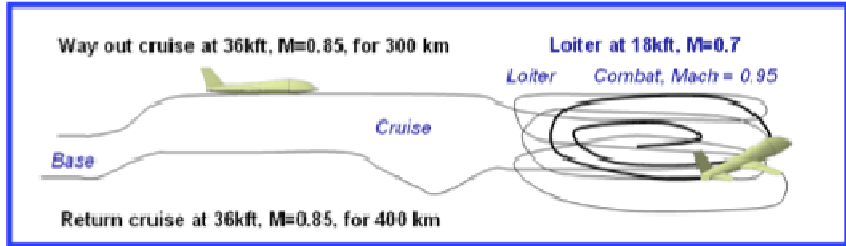
- Gradient and Simplex methods for the wing
- Full aircraft via EA

EADS - Military Air Systems



Mission scenario

- ▶ Fast cruise towards surveillance area
- ▶ Loiter in surveillance area
- ▶ Several high g turns ($N_z = 4.5$)
- ▶ Fast cruise return to base



Way out cruise at 36kft, $M=0.85$, for 300 km

Loiter at 18kft, $M=0.7$

Loiter Combat, Mach = 0.95

Base

Cruise

Return cruise at 36kft, $M=0.85$, for 400 km

Objective: maximize loiter-time

Optimization analysis carried out :

- Full aircraft optimized via Evolutionary Algorithms
- Wing alone optimized via simplex
- Wing alone simulated with adjoint solver and optimized via Gradient Based Algorithms

Aerodynamic Optimization of Aircraft Configurations with Multidisciplinary Aspects modeFRONTIER UM 14-15.10 2008 3



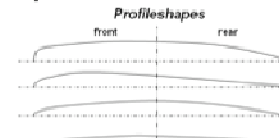
Parameters for Wing, Fuselage, Tail, Engine

EADS - Military Air Systems



Design Parameters for the full aircraft configuration

Profile parameters



parameter

7 Para

Horizontal Tail
Aspect Ratio
Tail Span
Taper
Position
Sweep
Incidence
Profile

15 Para

Fuselage
Length
Cross Sections
Fairing
Length
Shape parameter (3)

4 Para

Engine
Position
Length
Intake Profile

Σ 50 Para

Aircraft Configurations with Multidisciplinary Aspects

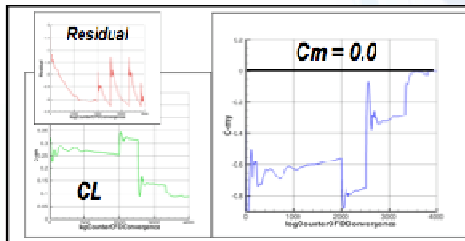
modeFRONTIER UM 14-15.10 2006

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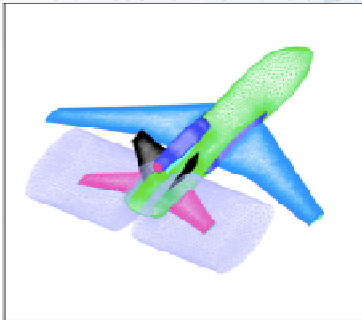
EADS - Military Air Systems

Trimm via Chimera Approach

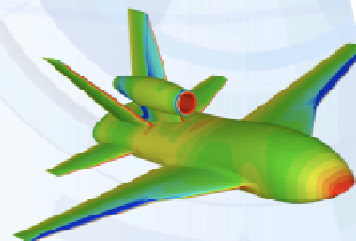
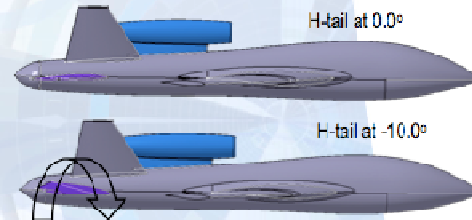
Trimm-History of a complete configuration



Chimera model for H-tail and aircraft



Aerodynamic Optimization of Aircraft Configurations with Multidisciplinary Aspects



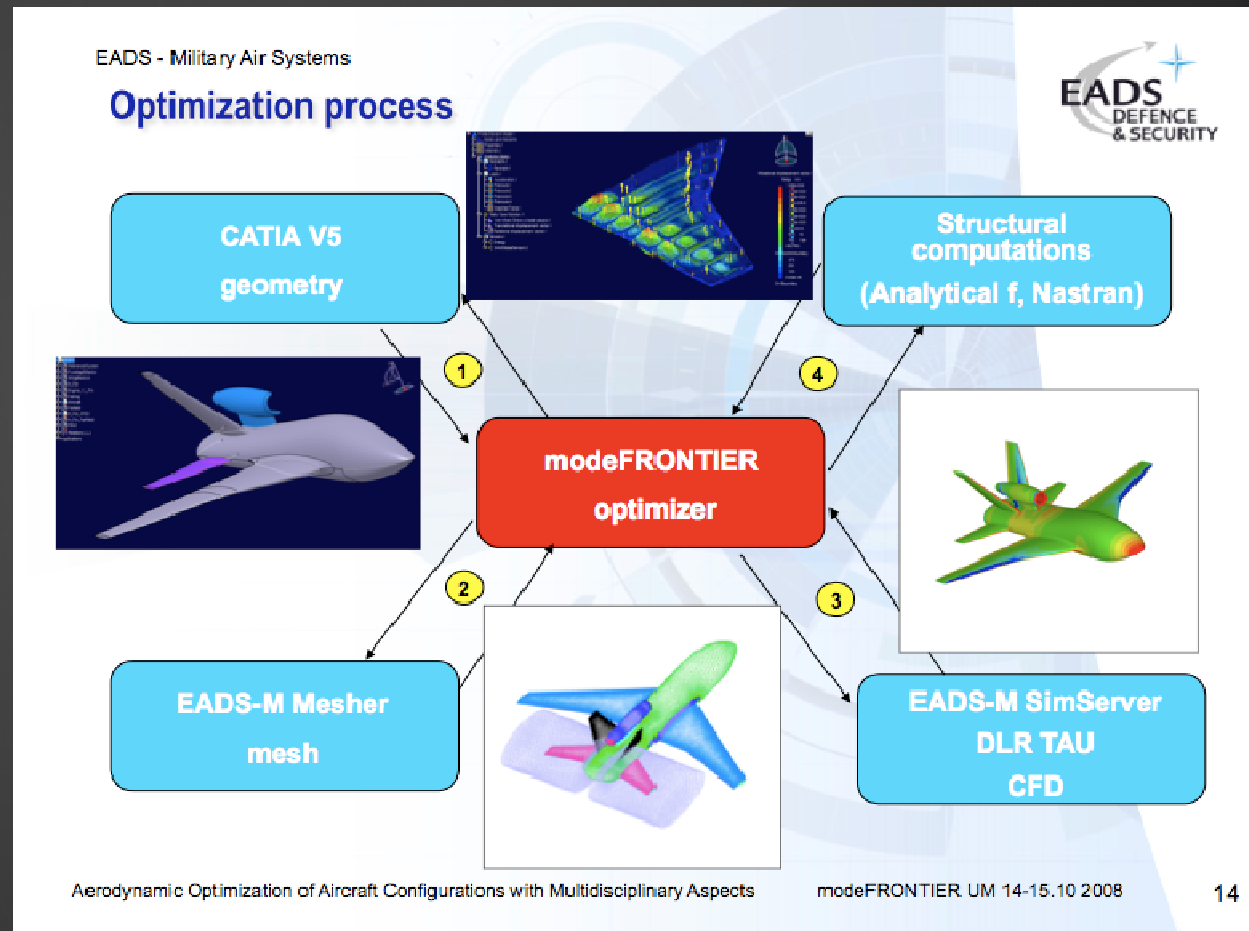
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Simulation Chain & Interaction With The Optimizer

- Several codes are connected:
 - Cad, structure, cfd
 - Pre-Post processing
 - Autopilot

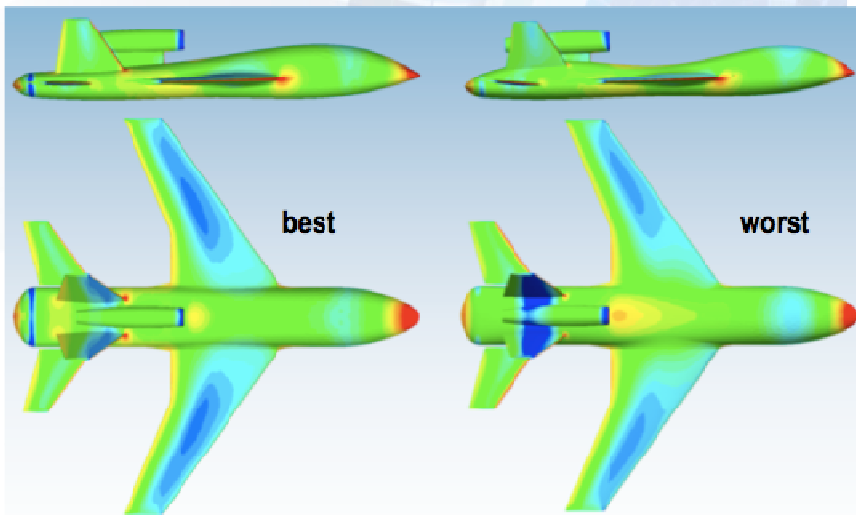


Results

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Aircraft Optimization with Wing Configuration Fixed

- Engine moves forward to alleviate shock and move forward the cg
- Streamlined fuselage reduces recompression effects ahead of the engine



Aerodynamic Optimization of Aircraft Configurations with Multidisciplinary Aspects

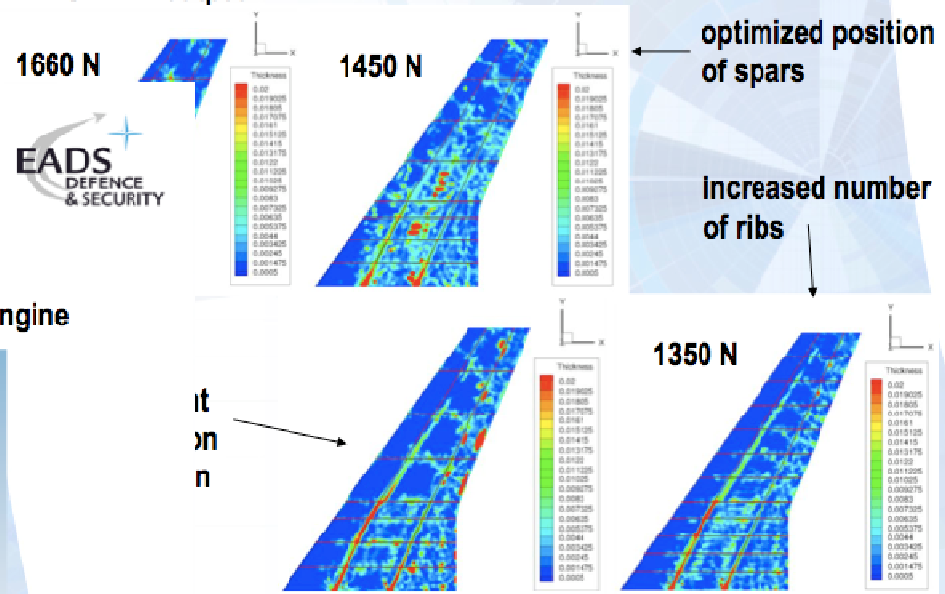
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Structural Optimization of the wing alone

- NASTRAN output:



in of Aircraft Configurations with Multidisciplinary Aspects

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Hydraulic Pump Design

SULZER
Sulzer Pumps

**How to use modeFRONTIER
within the daily hydraulic design process:
Sulzer Pumps' experiences
with automated impeller design**

Susanne Krüger and Wolfgang Maurer

Sulzer Pumps Ltd.
Winterthur, Switzerland

modeFRONTIER user training 14-10-2007 2

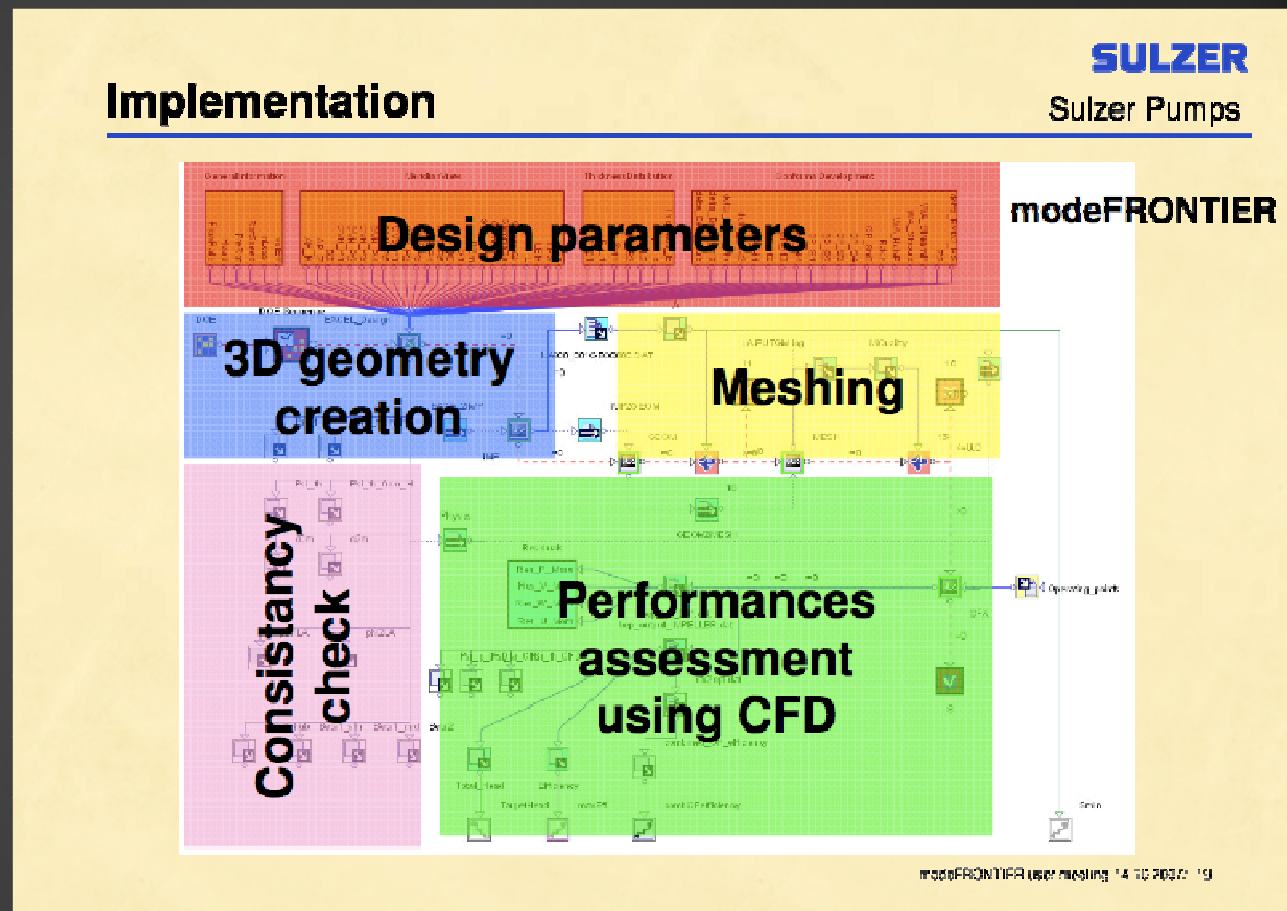


Hydraulic Pump Design

Optimization procedure works very well for serial impellers and suction impellers

Designs obtained with automatic optimization procedure are in excellent agreement with our experience

Design process is significantly reduced in time but quality is obtained



Automotive

BMW Motoren
Giovannini
14.10.2008

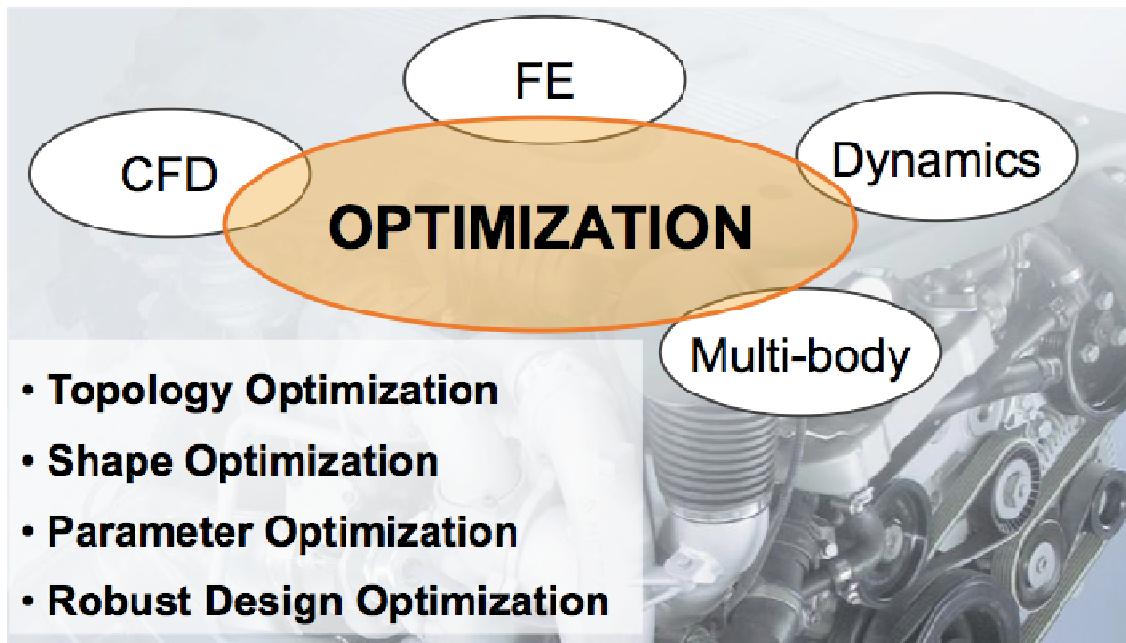
BMW Diesel Engine Development
modeFRONTIER user's meeting 2008



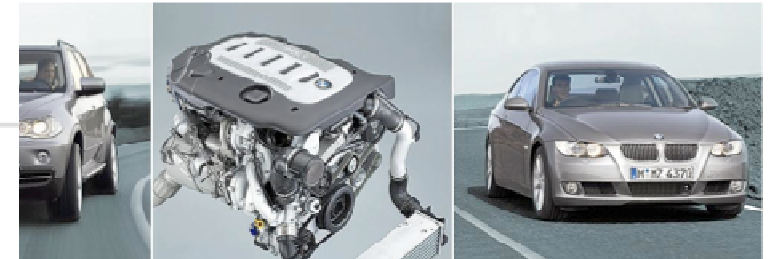
ADVANCED NUMERICAL OPTIMIZATION METHODS IN THE RAPID PRODUCT DEVELOPMENT PROCESS OF DIESEL ENGINES

BMW Motoren
Giovannini
14.10.2008

BMW Diesel Engine Development
Optimization Methods



- Topology Optimization
- Shape Optimization
- Parameter Optimization
- Robust Design Optimization



TIER user's meeting 2008
este - Italy



Giovannini, Dipl.-HTL-Ing. Günther Pessl
ibH Steyr, Austria

Slide Nr. 7

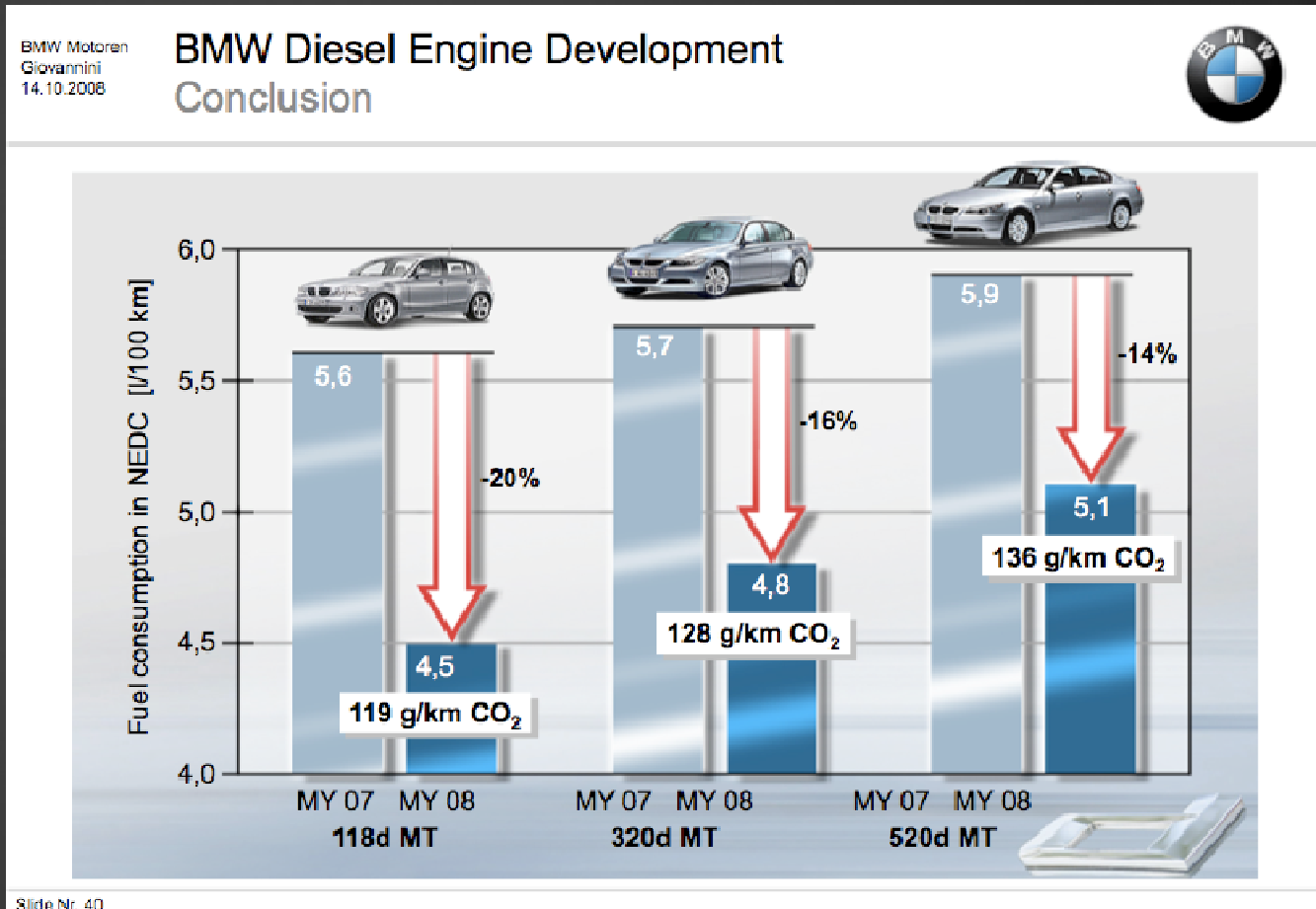


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Integrated Multiphysics Simulation & Design Optimization
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Automotive

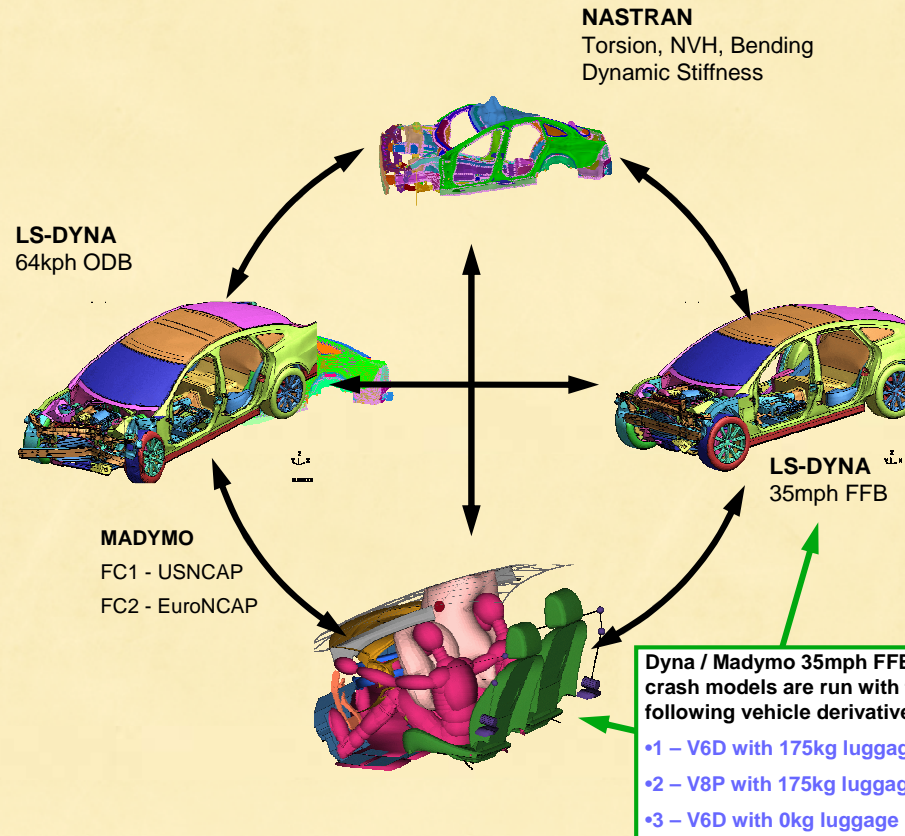
- Numerical methods are an essential part of the product development
- Consistent use of optimization methods help to solve target conflicts



Automotive

CAE Models

Following models are created for each design iteration
Extracted results are constrained or optimised



Design Objectives

- Minimise Mass
- Maximise US/ EuroNCAP star rating

Design Constraints

- Meet all attribute targets and FAC constraints, eg:-
- Vehicle pulse and intrusion
 - Occupant injuries
 - Bending/ torsional stiffness
 - Point dynamic stiffness
 - Body natural frequencies



From 6 weeks
to 2 hours Auto
correlation on
airbags

A Multidisciplinary “High Voltage” Application

A circuit-breaker is:

- Device used to open/close electric circuits
- Complex electro-mechanical thermodynamic device
- Ideal conductor in close position
- Ideal insulator in open position

Why to use a circuit breaker?

- Fault current switching
- Unplanned events initiated by the network’s protection system
- Load current switching
- Planned events initiated by the system operator

Sami Kotilainen,
Per Skarby

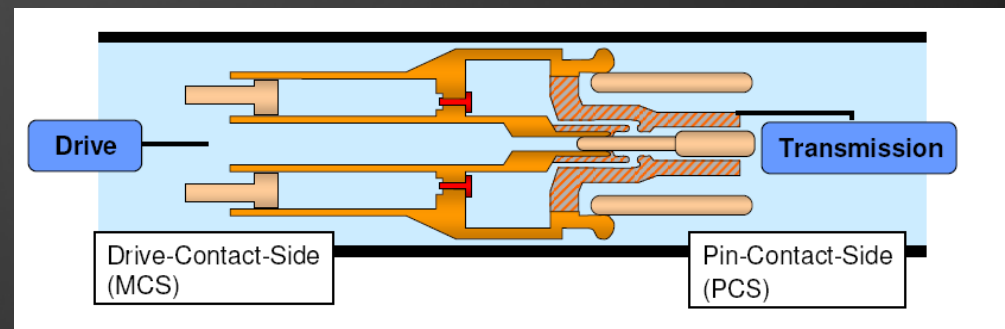
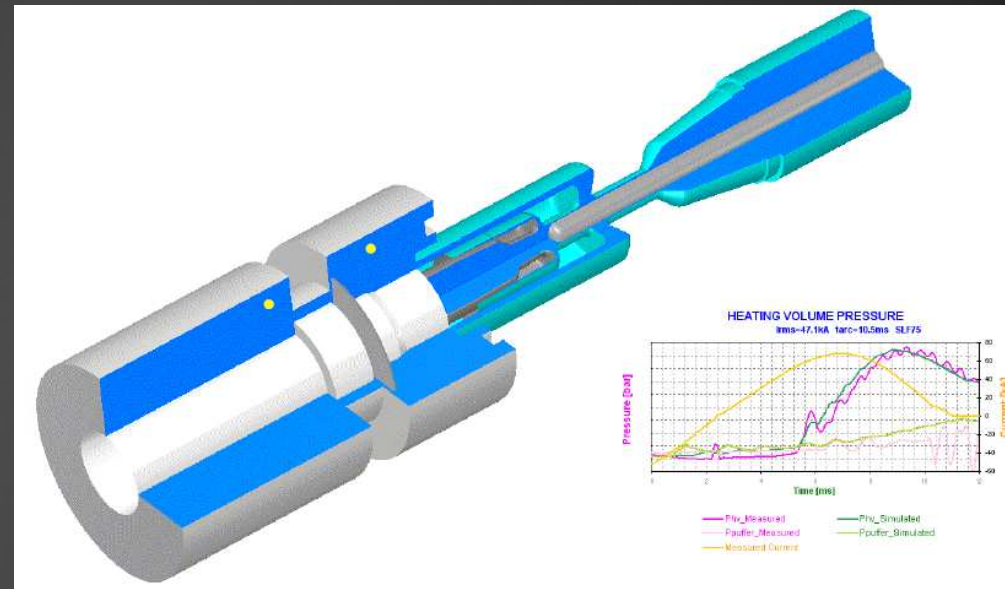
Multi-objective
optimization in High
Voltage Circuit Breaker
Development

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30/09/2008

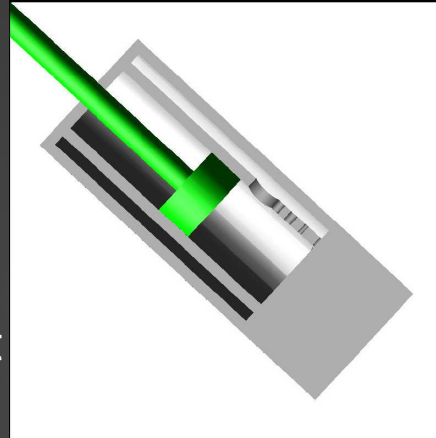


A Multidisciplinary “High Voltage” Application

- Ratings **72-1100kV**, **25-80kA**
- Secure operation over large current range (e.g. **1-63kA**)
- Contact movement **100-200 mm**
- Relative contact velocity **5-15 m/s**
- Operating time **30-50 ms** (accelerations **100-200G**)
- Maximum temperatures **~30000K**
- Maximum Pressures **~100bar**
- Lifetime **~30 years**, **10000 Operations**

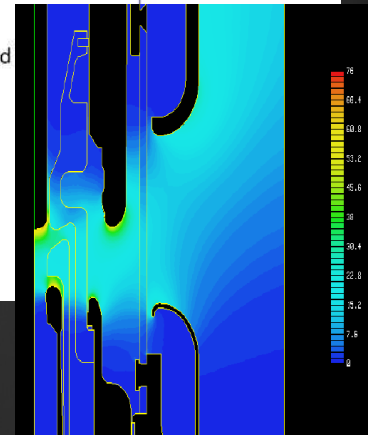
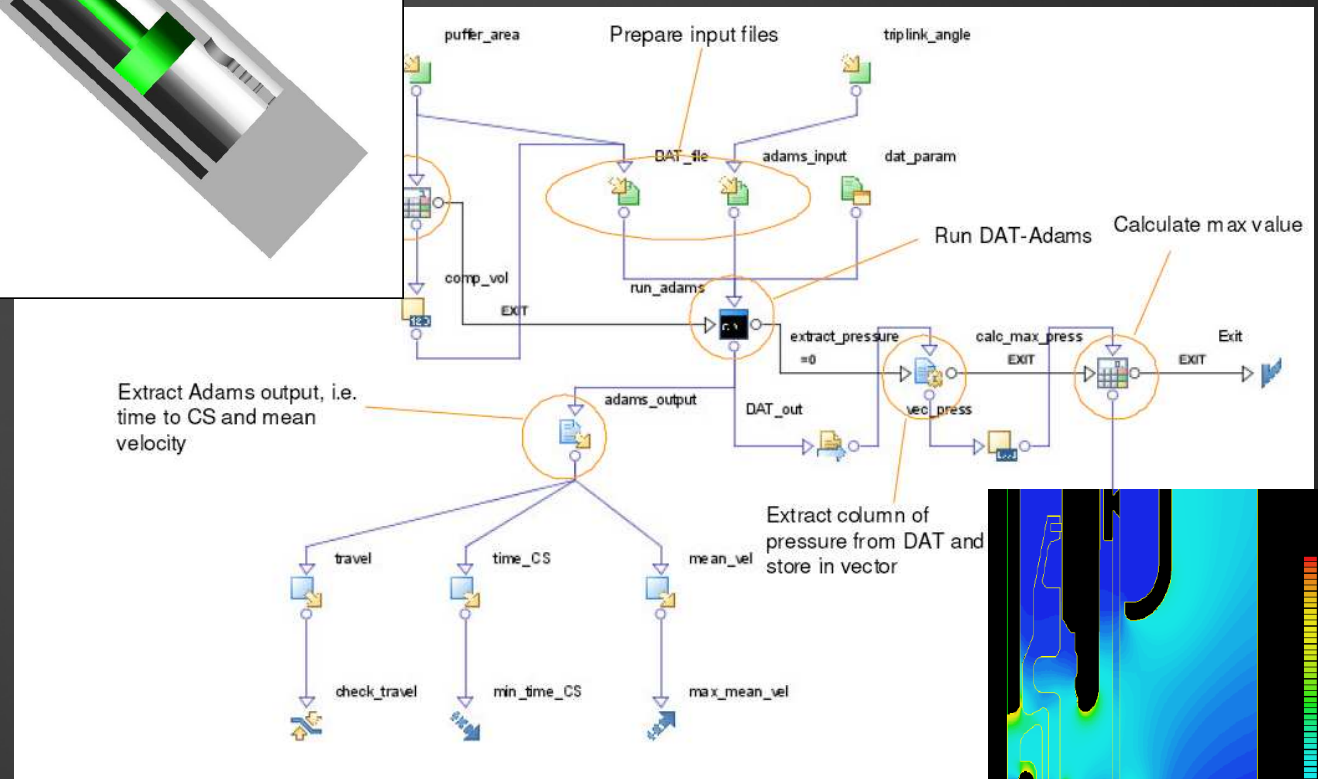


A Multidisciplinary “High Voltage” Application



Model Analysis:

- Preliminary mechanical layout with **Mathcad** model
- Damper model with **ADAMS+ Pressure** build up Simulator
- Coupling with **Electric Field Simulator**



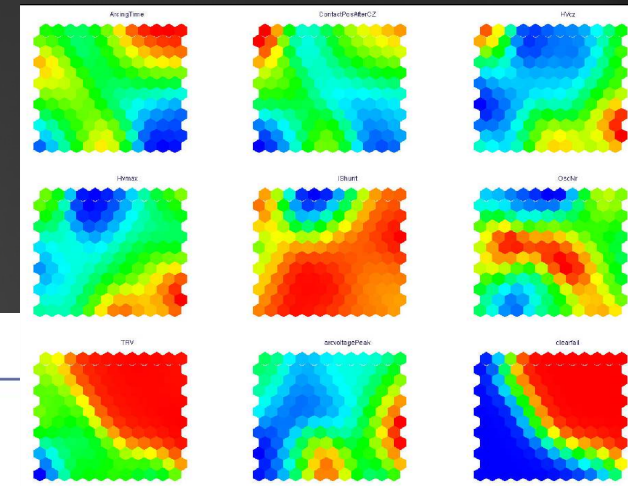
A Multidisciplinary “High Voltage” Application

The Goals:

- Objectives on relative position of contacts:
 - Coordination
 - Capacitive switching 1
 - Capacitive switching 2
 - Reaction time
 - Open gap
- Minimize Force
- Minimize Energy

Optimization Strategy:

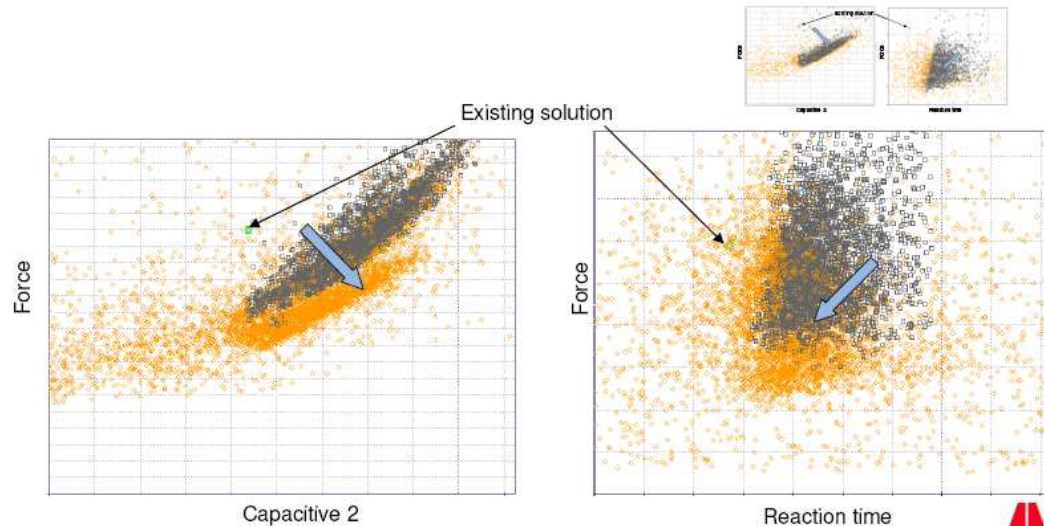
- MOGT (~30min run) initial population
- MOGA (~12h run) improved **BEST solutions by 4-30%**



Optimizing Existing Design

- With size constraints

| | Coordination | Reaction time | Capacitive1 | Capacitive2 | Force | Size |
|-----------------|--------------|---------------|-------------|-------------|-------|------|
| Original design | 0% | 0% | 0% | 0% | 0% | 0% |
| opt10164 | -44% | 4% | 15% | 5% | -53% | 27% |
| opt17113 | -8% | 2% | 39% | 33% | -1% | 27% |



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Supply Chain Optimization

Given an item, **find**:

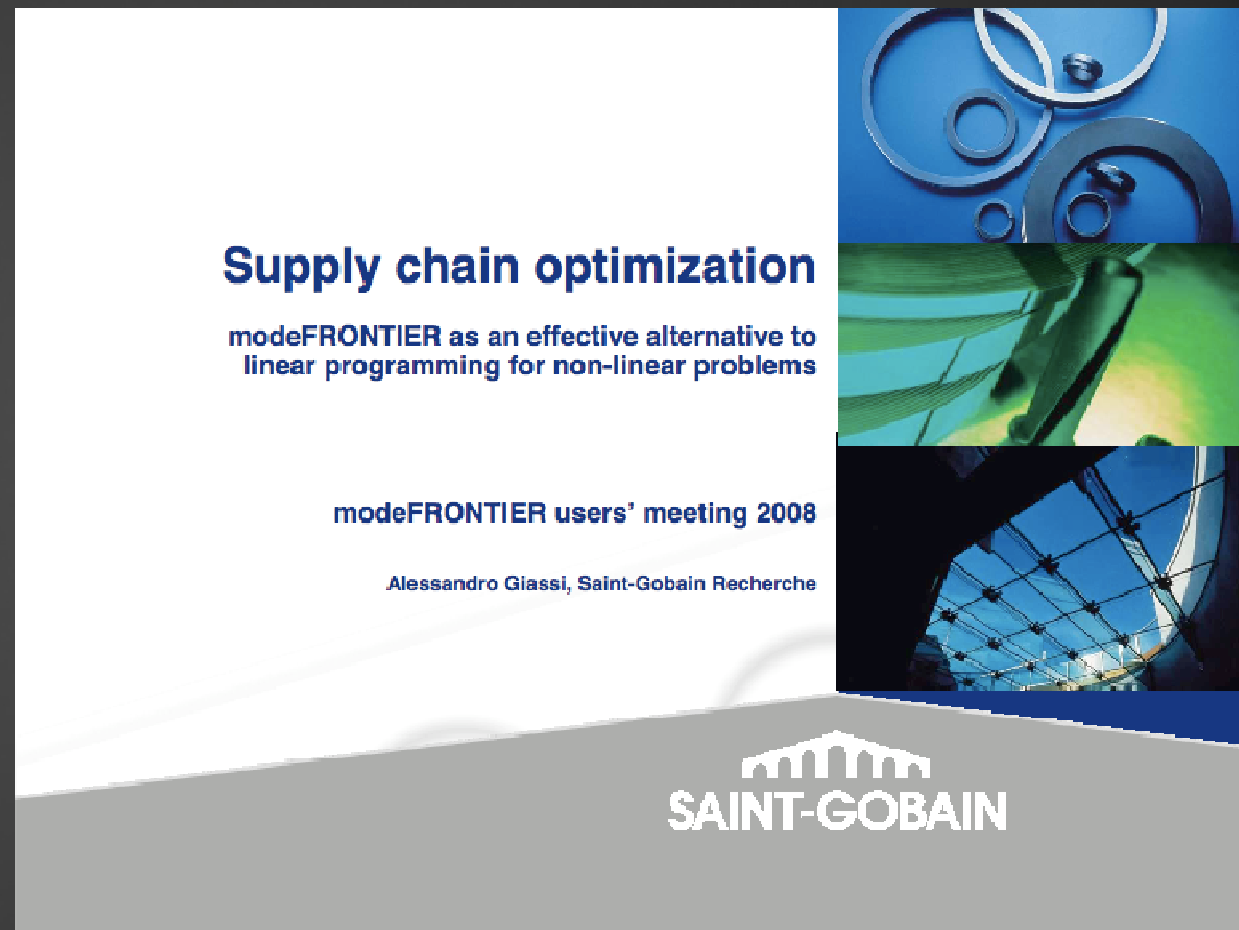
- the plant(s) where it has to be produced
- the satellite stock(s) where it has to be stocked
- the customer catching area of each site

that **minimize** the total logistic cost:

- transport costs (transfer and delivery)
- handling costs
- stock costs

and **respect** the constraints on:


- maximum delivery delay
- stock capacity
- production capacity



Supply chain optimization
modeFRONTIER as an effective alternative to
linear programming for non-linear problems

modeFRONTIER users' meeting 2008

Alessandro Giassi, Saint-Gobain Recherche


SAINT-GOBAIN

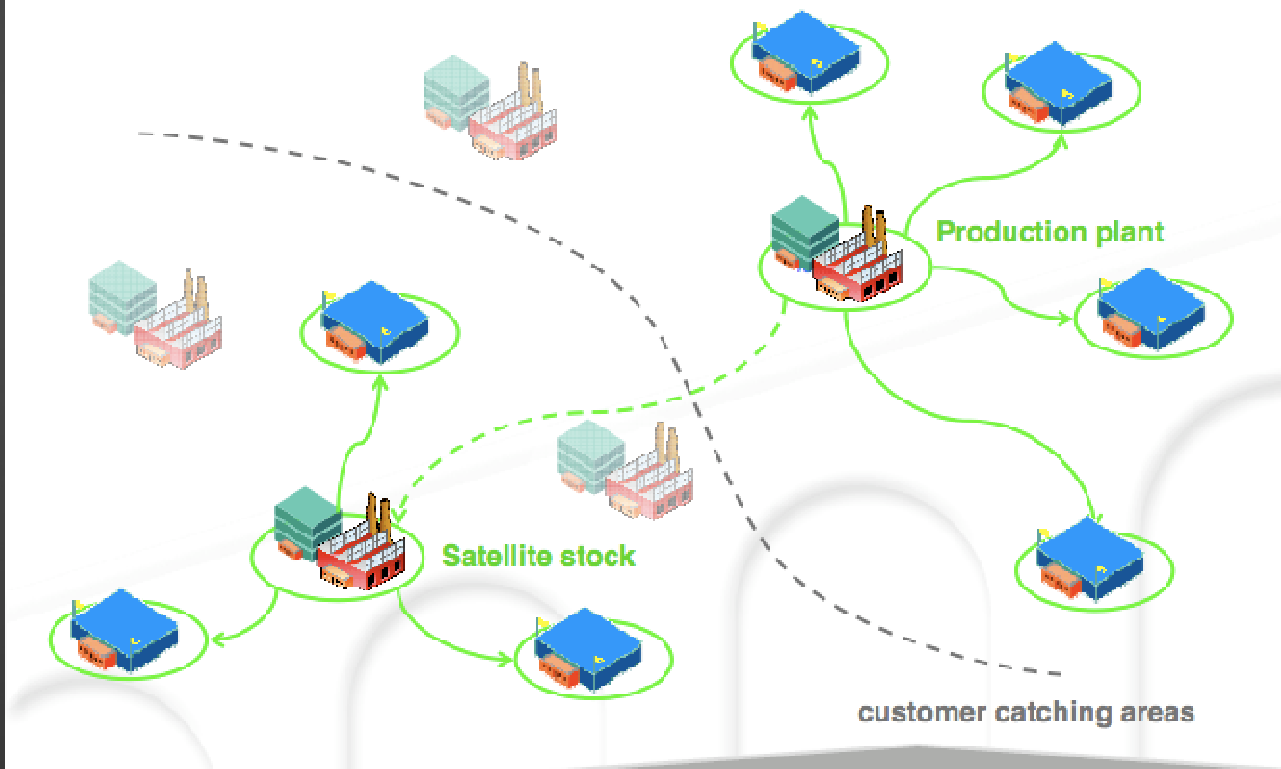


Supply Chain Optimization

Reference solution
Real customer catching
areas of a high added
value item (2007)

Example of supply chain optimization

Customer catching area and replenishment plan



Supply Chain Optimization

Results

The gain of 0.3 M€ (10%) on the delivery cost is not negligible:

At the item scale ...

transport cost savings

0.3 M€ ~ 0.3 M Km

- distance: **7.5** earth's circumferences
- fuel volume: **100.000** liters / year
- CO₂ emission: **600** tons / year

At Saint-Gobain scale ...

transport cost savings

150 M€ ~ 150 M Km

- distance: **1** A.U.
- fuel volume: **50** M liters / year
- CO₂ emission: **300000** tons / year



Real World Accidents Reconstruction

modeFRONTIER has been used to assess the sensitivity of all input factors which would contribute to the accident's unique set of circumstances

Typically when simulation are used to reconstruct accidents, only single iterations are usually developed based on a series of known data and assumptions.



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The application of
modeFRONTIER in real world
collision reconstruction

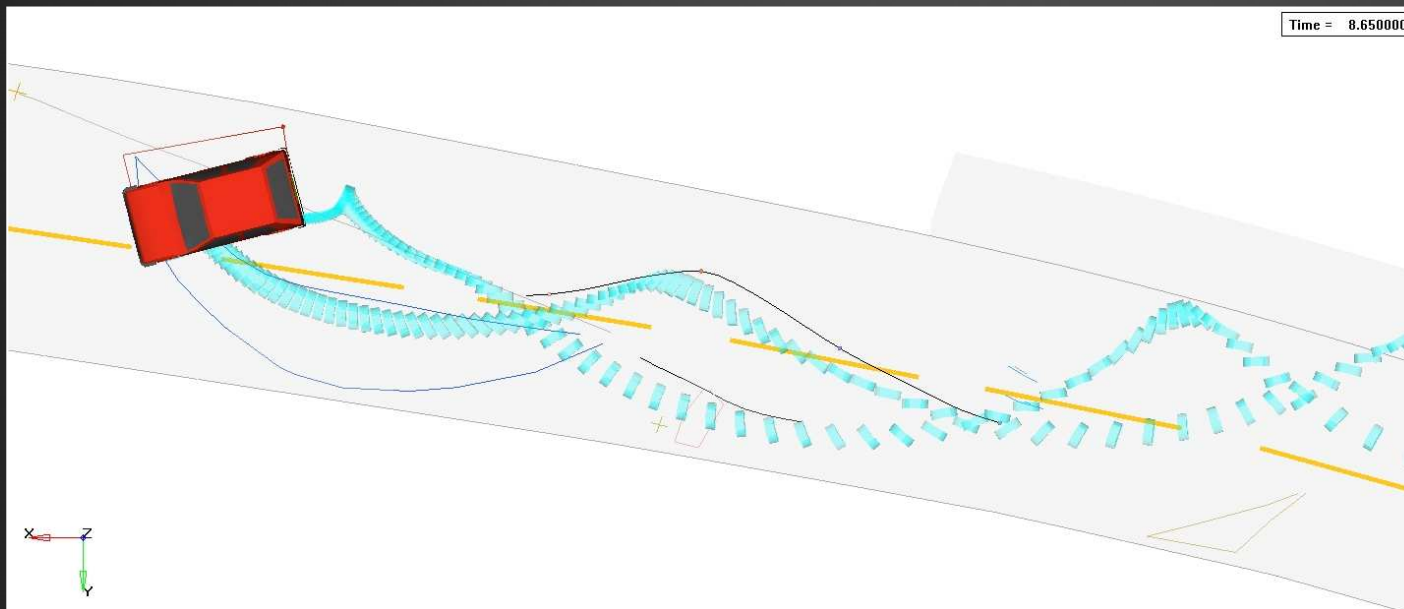
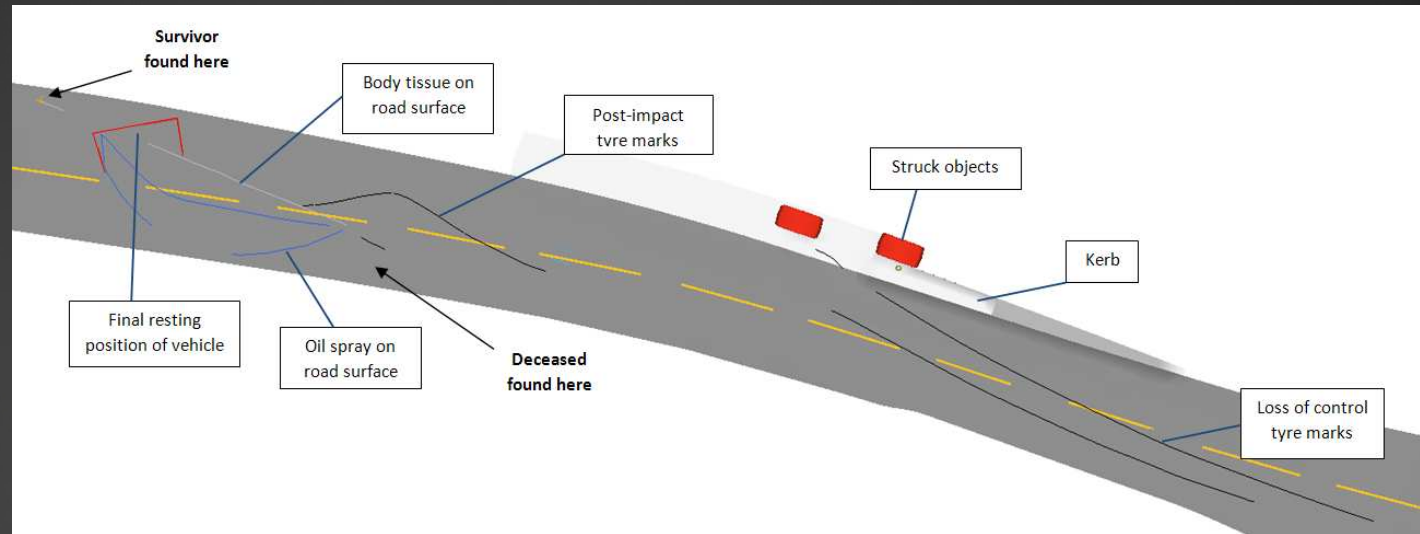
M.Brown



Real World Collision Reconstruction

Very little data is known in this case:

- No initial Speed can be calculated from markings
- Initial position of vehicle is not known
- How did the driver react – i.e. steering & braking



- Approximately 4,000 iterations were carried out
- Loss of Control marks correlated to within one tyre width
- Final positioning matched to within 0.5m



Civil Engineering Applications

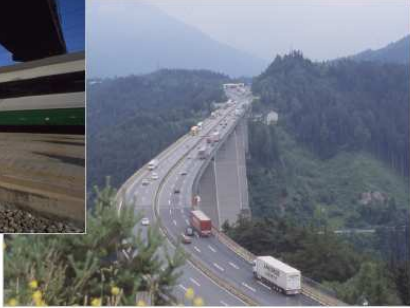


Optimal Road Path



**Multi-objective optimization
in road design**

Eng. Massimo Speziani

SYSTEMA
Autodesk® VAR
www.systemsrl.it



**OPTIMIZATION IN TUNNEL EXCAVATION:
THE BRENNER BASE TUNNEL EXAMPLE**

Trieste - October 15th, 2008

Alessandro Laner – EnginSoft

Cost, Time & Risk Management



modeFRONTIER: a way of thinking

- Look at the global problem
- Analyze the detail to understand its importance
- Improve always whenever possible

