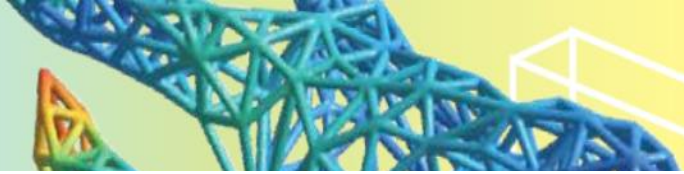


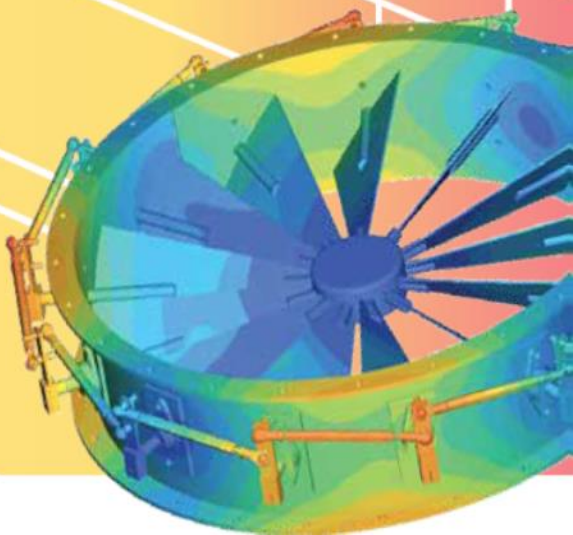
제품 개발 프로세스 효율화 방안

(Simulation based Design)

건국대학교
다중물리해석 및 최적화 연구실
강병식
bkang@konkuk.ac.kr

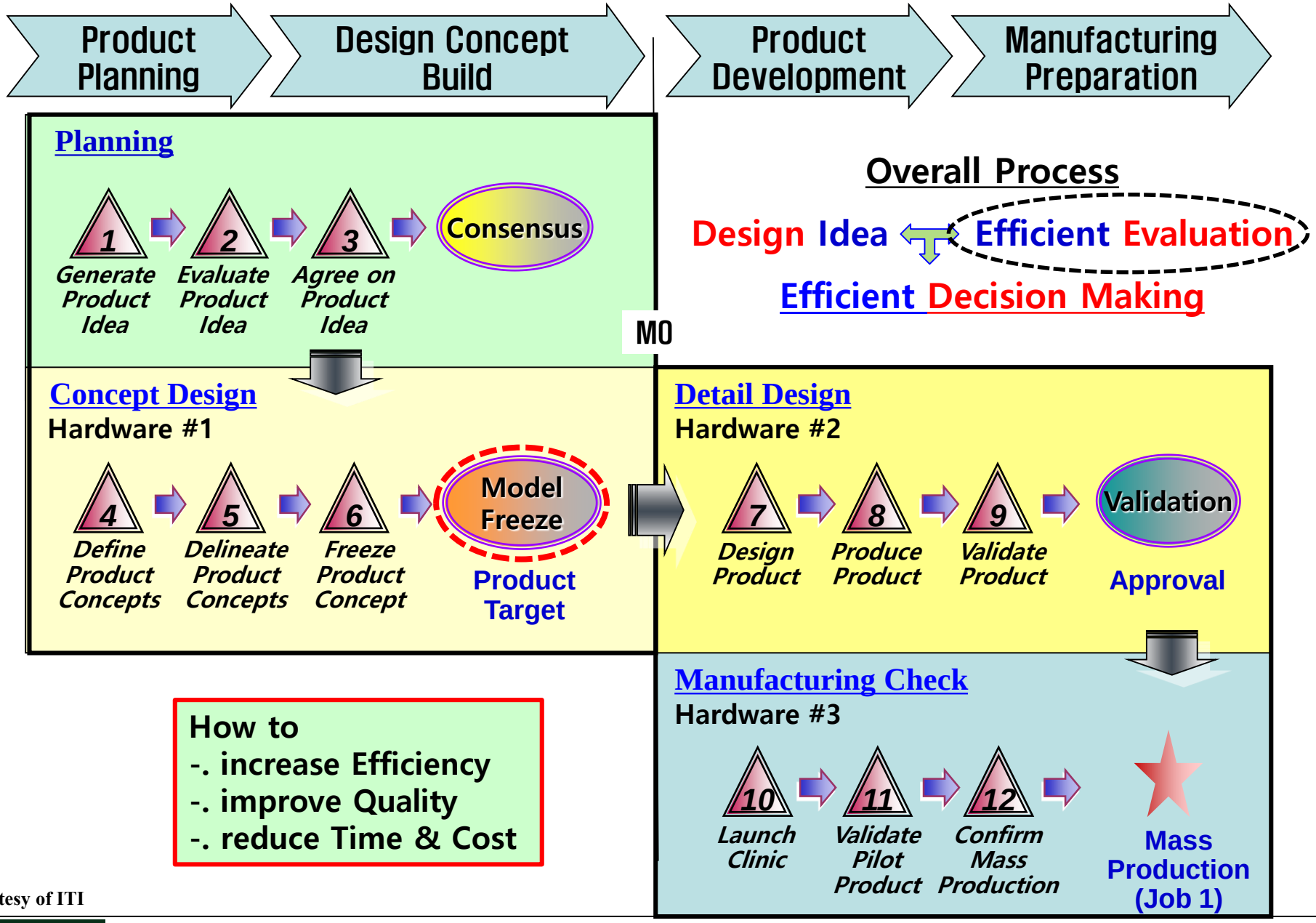
Altair SimSolid™

2018년 12월 11일 오후 1시
스타트업 캠퍼스 1층 컨퍼런스홀



AGENDA

Product Development Process

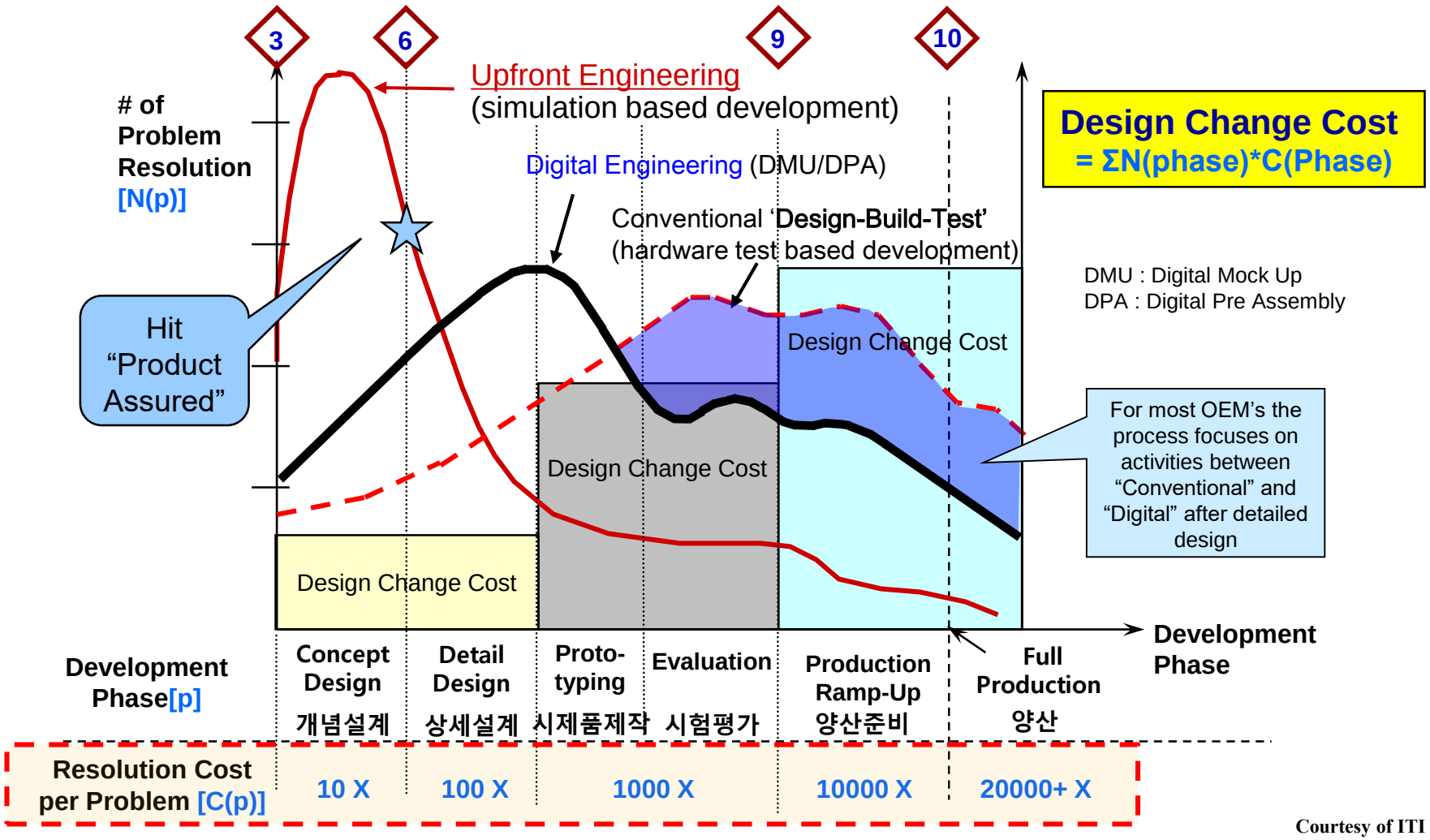


How to
-. increase Efficiency
-. improve Quality
-. reduce Time & Cost

Courtesy of ITI

Strategy for Improving Development Process

Upfront Engineering: **Evaluation in early stage** of Development Process

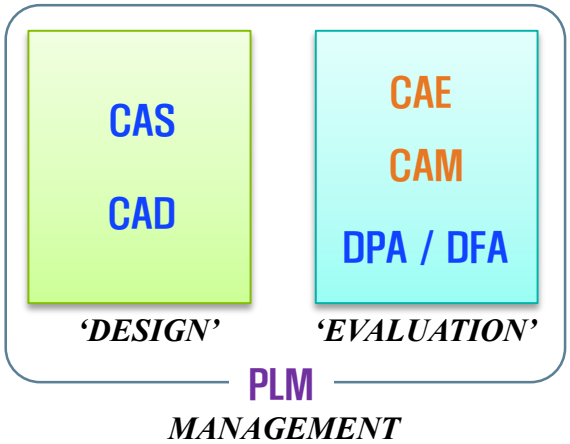


Courtesy of ITI

Minimize Engineering Change … after Start of Detail Design

Digital Development (VPD, Virtual Product Development)

Digital Development Tools
CAx (Computer Aided x)



Practice

Upfront Engineering
&
Concurrent Engineering

Digital Development : Prototyping & Manufacturing

Automotive Development Methodology Shift

M−β — 12~15 — M0 — 12~15 — M+α

상품 제안 | 제품 구상 | 개발 착수 | 패키지 및 개념설계 | 상세설계 | 생기검증 | 양산Pilot | 양산

Platform

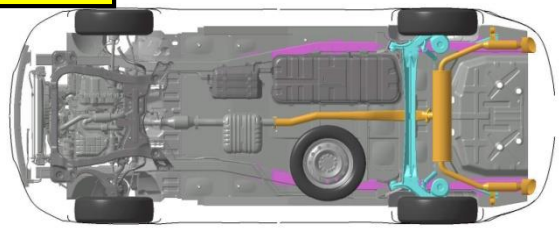
Powertrain

Test Car

Proto Car

Pilot Car

품평 – 승인 – 고정



플랫폼 선정 및 Test Car 개발

Styling 확정

Prototype 제작 및 시험

Hardware based Development

DESIGN → BUILD Prototype → TEST

Trial & Error

시험개발 by *Design-Build-Test* Iterations

Simulation based Development

SIMULATION → OPTIMIZATION

시뮬레이션개발 → 시험확인

- Minimize Design Change
- Less Hardware Stages

Digital Development in Automotive Industry

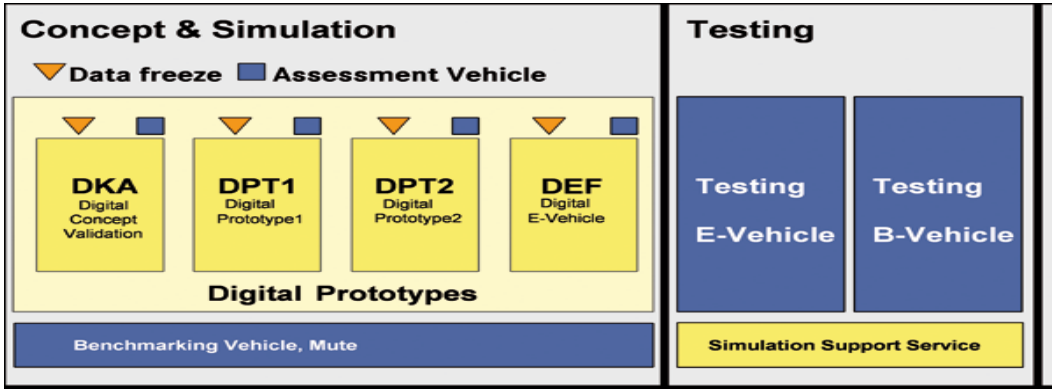
<u>Digital Car Project</u>, 1997 – 50% shorter development cycle (60 → 30 mon.)

-. Increase Parallelization of Design Tasks

-. Elimination of some design iterations

-. Quicker Completion of the remaining design iteration

Mercedes-Benz

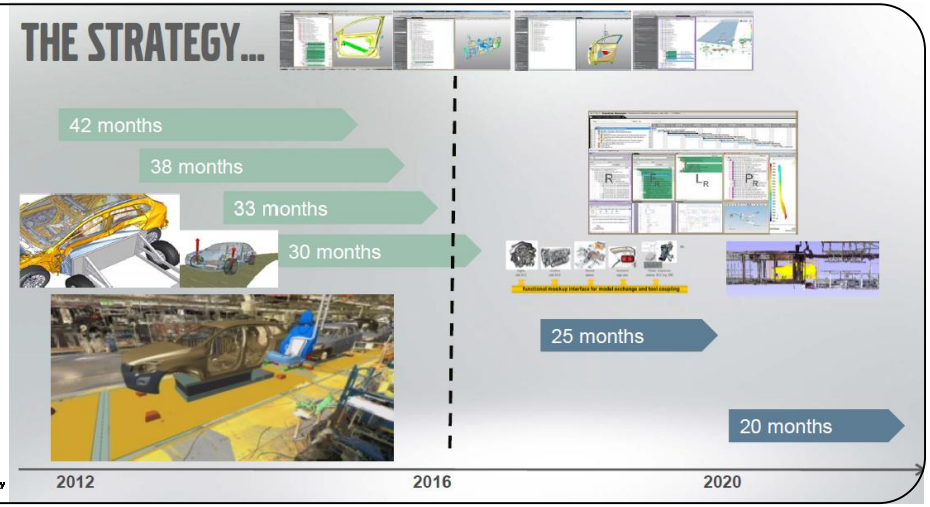


VOLVO

Reduce Development Time (44 → 20 mon.)

by **CAE based development**

& Platform Technology



Platform_Strategy

AGENDA

Role of CAE in Automotive Development

CAE Benefit : Efficiency / Completeness / Easiness
CAE Purpose : Quality Design / Efficient Development

Efficiency

Proto Test

1st Test
~2 Months
₩ 100,000,000

2nd Test
2~3 Weeks
₩ 100,000,000

CAE

1st Simulation
~2 Weeks
₩ 0

2nd Simulation
1~2 Days
₩ 0

* 장비 및 공수 산정 비용 미포함

1day turn around

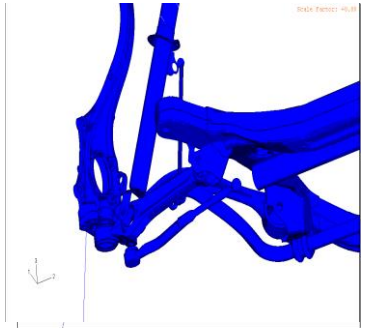
Complete Info

1st Test

2nd Test

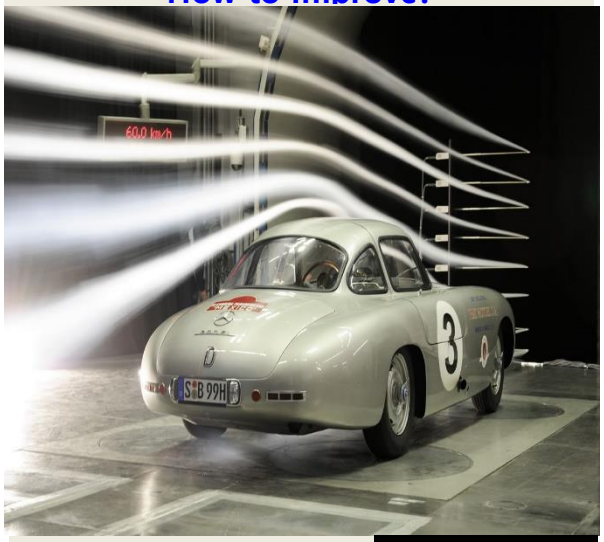
내구해석 결과

모든 취약부위
동시 예측



Easy to Understand

Pass? / Fail?
How to Improve?



Best CAE for communication : 'As it is simulation'

CAE Role Evolution : Evaluation Tool → Design Tool

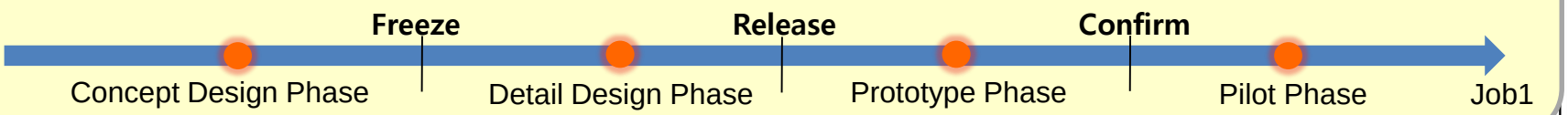
CAE 1st Stage (~ late 90s)
- After Design Release
- Failure Analysis
- Improvement

CAE 2nd Stage (~ late 2000s)
- Before Design Release
- Design Evaluation
- Improvement

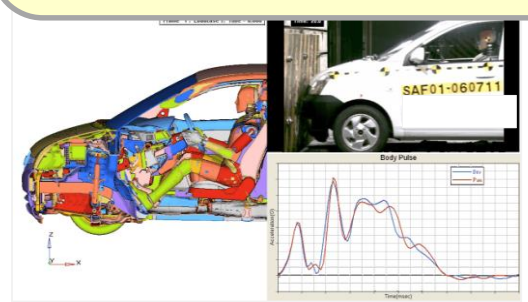
CAE 3rd Stage (mid 2010s ~)
- Before Detail Design
- Concept Evaluation
- Optimization

Role Change : After Design Release → Before Release → Concept Optimization

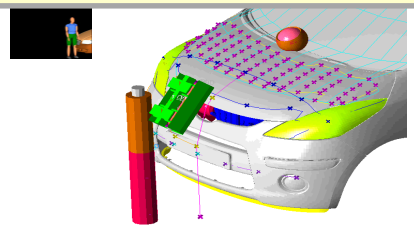
후행평가 기능 선행평가 기능 선행설계 기능



Prototype Evaluation



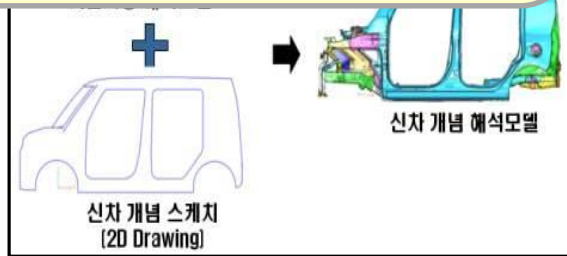
Design Review

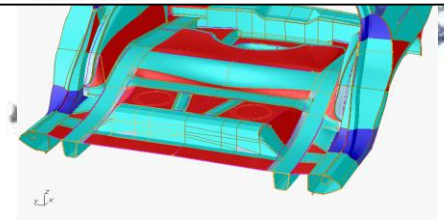


~170 Head Impact Points on Hood & Windshield Glass

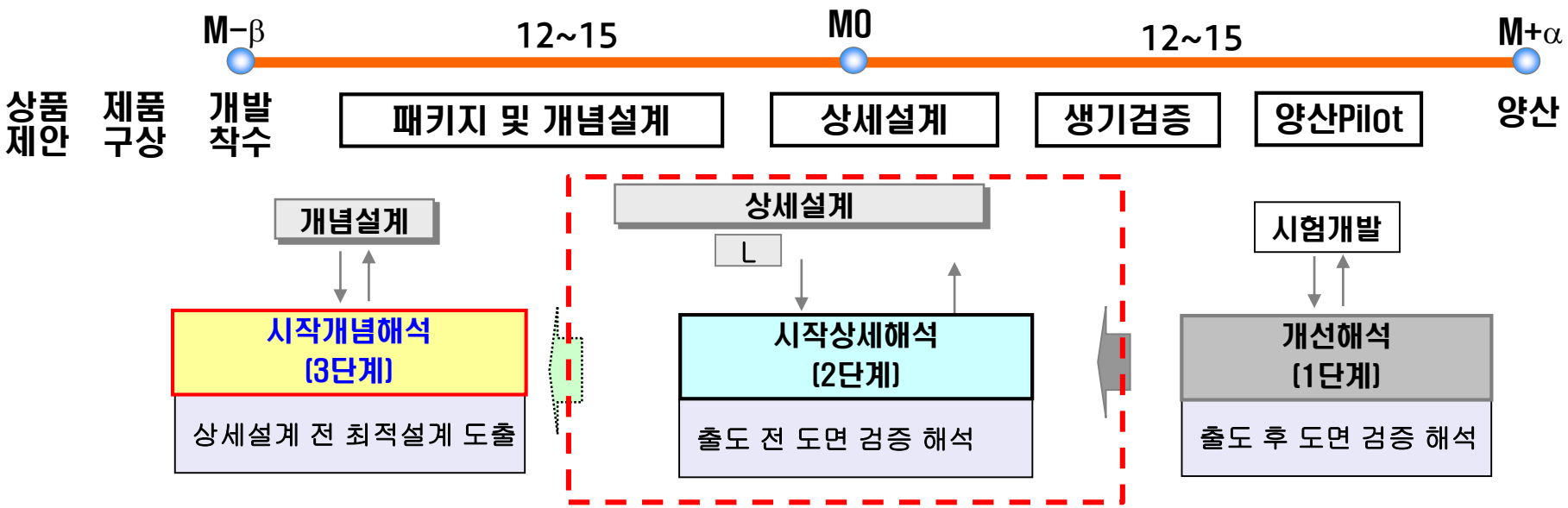
8 weeks → 1.5 weeks

Concept Design





Automotive Development Process Integration



Concept Development *(Test Car Stage)*

Package / Layout	Concept Design	Pre Evaluation (Simulation)	Design Release	Prototype Build	Post Evaluation (Test)

Product (Detail) Development *(Proto Car Stage)*

Detail Design	Pre Evaluation (Simulation)	Design Release	Prototype Build	Post Evaluation (Test)

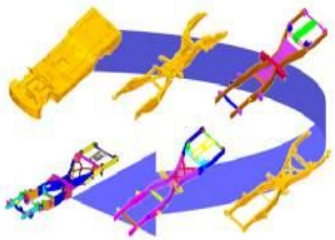
* 각 Hardware 단계에서 '설계-선행평가-설계출도-후행평가 ' 과정 반복

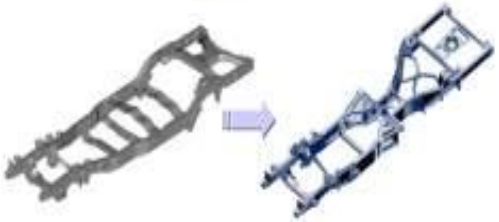
CAE Role in each Stage of Development Process

개념설계 단계

- 시점: 도면 작업 前
- 검증 Tool → 설계 Tool
- 설계 방향 제시

- 위상 최적화 기법 (Topology)
- 형상 모델링 (Morphing)





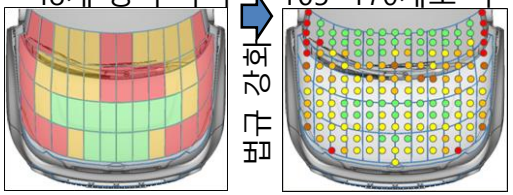
설계검증 단계

- 시점: all도 출도 前
- 설계 협업 기간 확보
- 신속한 검증 및 설계개선

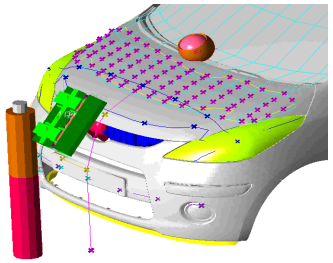
- Routine Job 개발 해석 자동화
- 설계정보입수–모델링- 해석
  (PLM) (자동화)

예) 보행자보호 해석자동화

48개 영역 타격 → 165~170개소 타격



170 개소타격 기준 - 해석기간 : 8주 → 2주

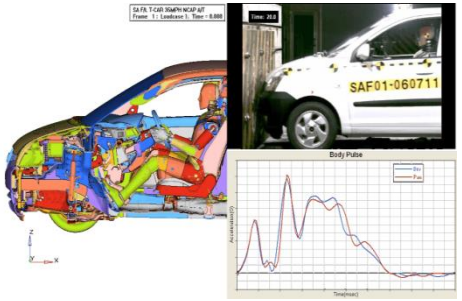


시험검증 단계

- 시점: 실차 제작 이후
- 문제점 검증/효율적 개선
- 해석기반 예측 정확도

- 시험-해석 correlation
- 시험결과 상세분석

예) 충돌 시험-해석 비교

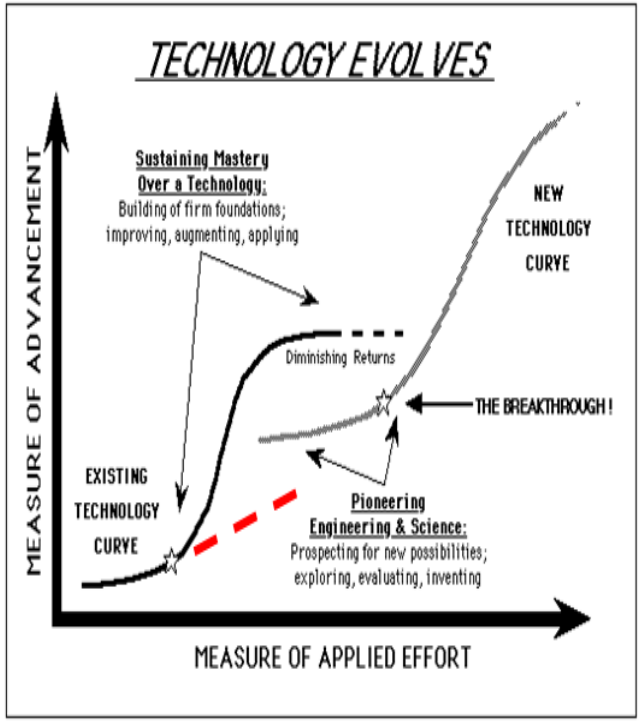


AGENDA

Democratizing CAE

- ✓ Raised issue on rapidly increasing CAE demand at NAFEMS 2013
- ✓ Resource limit to meet demand (not enough CAE engineers)
- ✓ Proposed 'Democratizing CAE' at NAFEMS 2015
- ✓ Allow Design engineers perform CAE evaluation in Design Process

•NAFEMS : National Agency for Finite Element Methods & Standards



NWC 2015 NAFEMS WORLD CONGRESS
21-24 JUNE | SAN DIEGO | CALIFORNIA | USA
A WORLD OF ENGINEERING SIMULATION

Democratizing CAE

Expert Knowledge Capture & Reuse

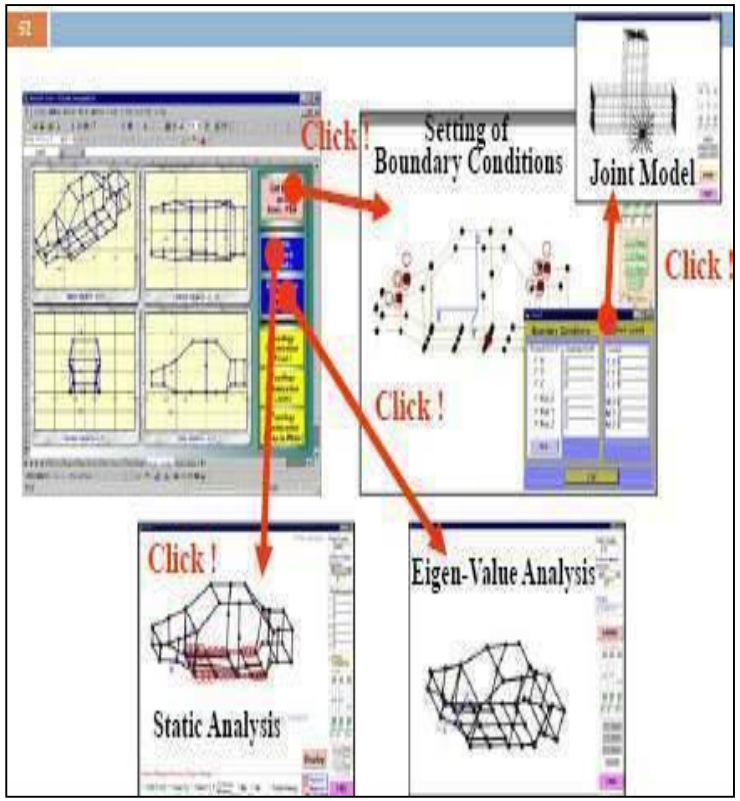
Usability

Accessibility

Democratizing CAE (for Designer)

FOA (First Order Analysis)

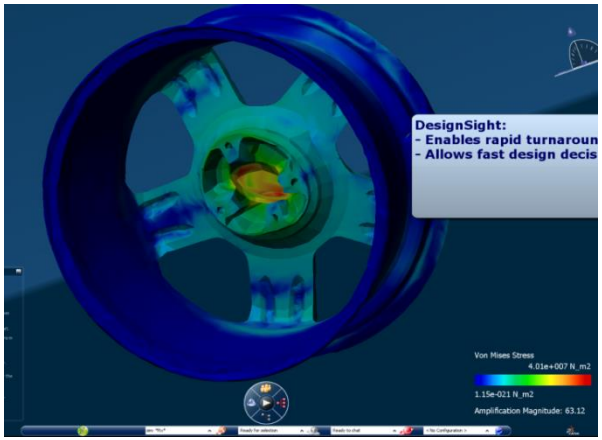
Concept Study: Intuitive 1-D Analysis Tool (Toyota)



Expanding CAE work
Designer perform CAE

CAD Tool base Analysis

Full FEA
Easy to use for Designers w/o CAE skill
Limit: Single Part, Linear Analysis



Currently Available Tools : Inspire / DesignSight

CAE Process

Pre-Processing (Modeling) → **Solving** → **Post-Processing**

Equivalent to Test Car Build

- -. Meshing
- -. Property Assignment
- -. Material Assignment
- -. Assembly
- -. Boundary Condition
- -. Loading Condition

Equivalent to Test

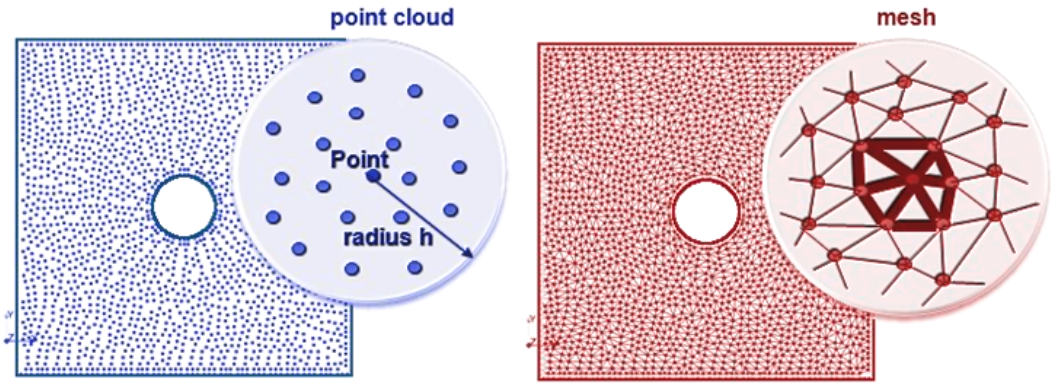
- -. Solver Selection
- -. Parameter Set Up
- -. Output Set Up

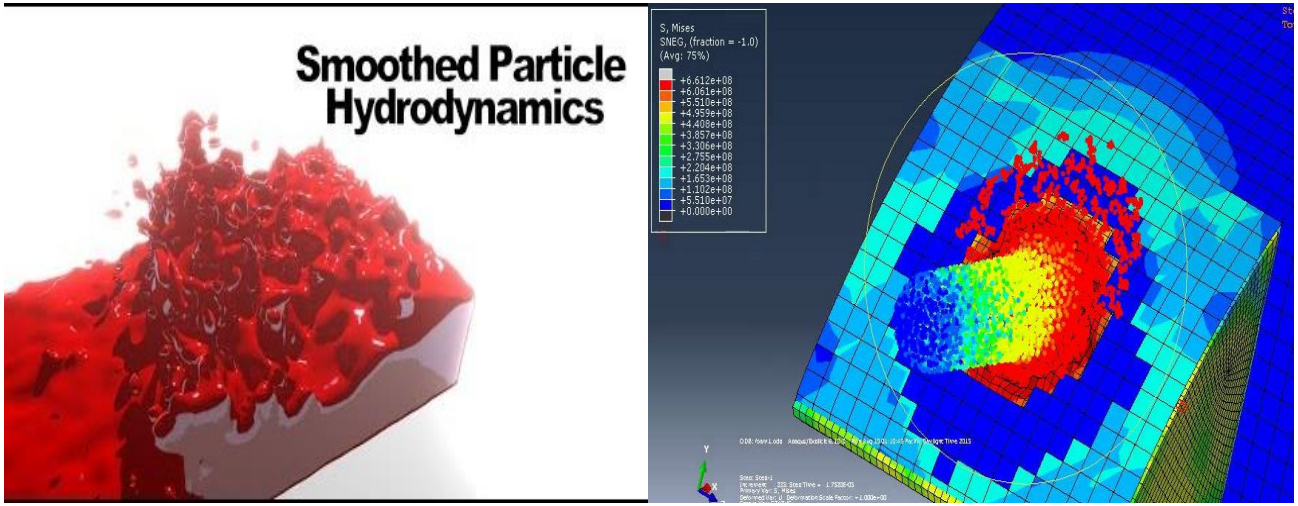
Test / Design Engineer Function

- -. Result Analysis
- -. CAE / Test Correlation
- -. Engineering Judgment
- -. Design Recommendation

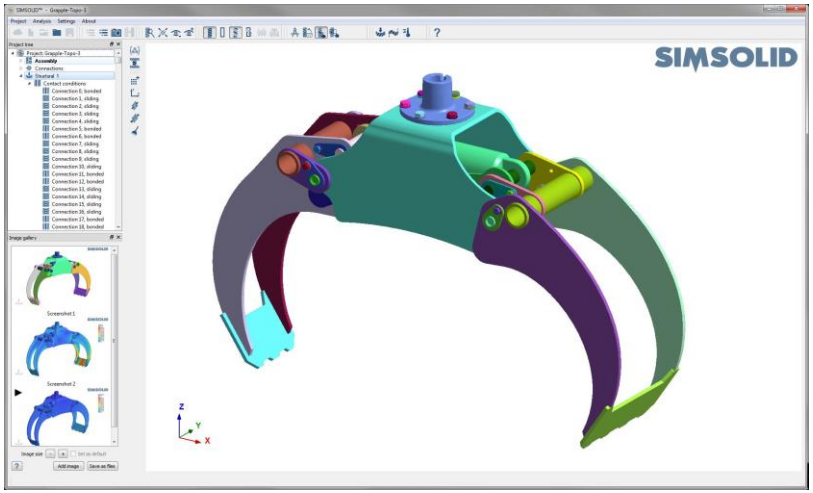
Optimization

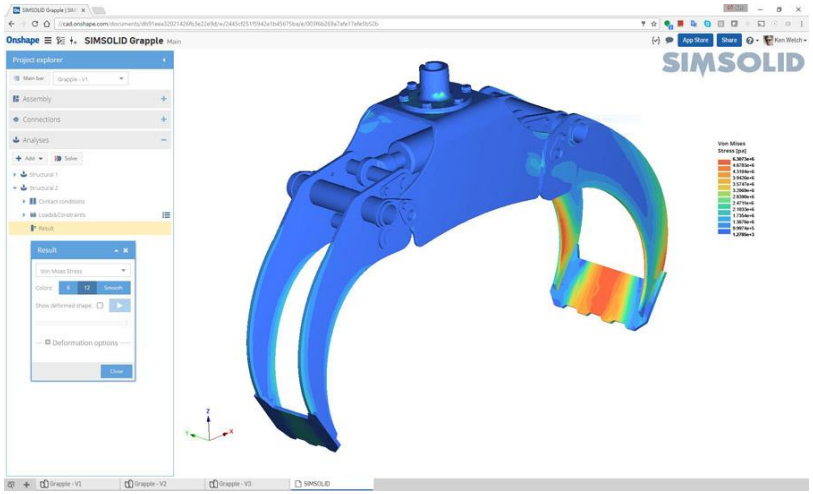
Meshless Methods



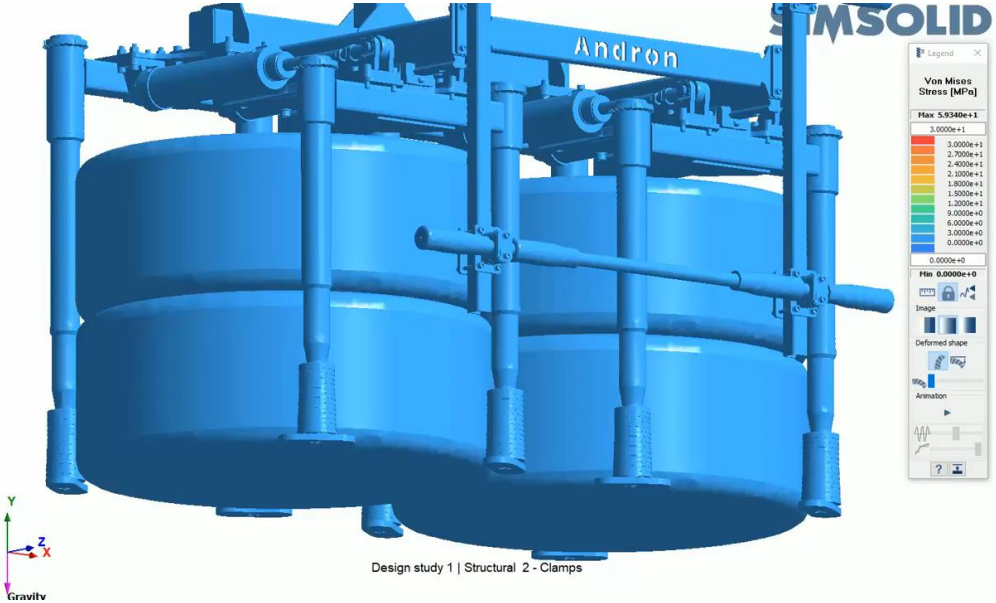


Democratizing CAE (for Designer & CAE Engineer)





Assembly or System level
Nonlinear Analysis



AGENDA

Optimization

"**Optimization is the Design Goal & CAE Purpose**"

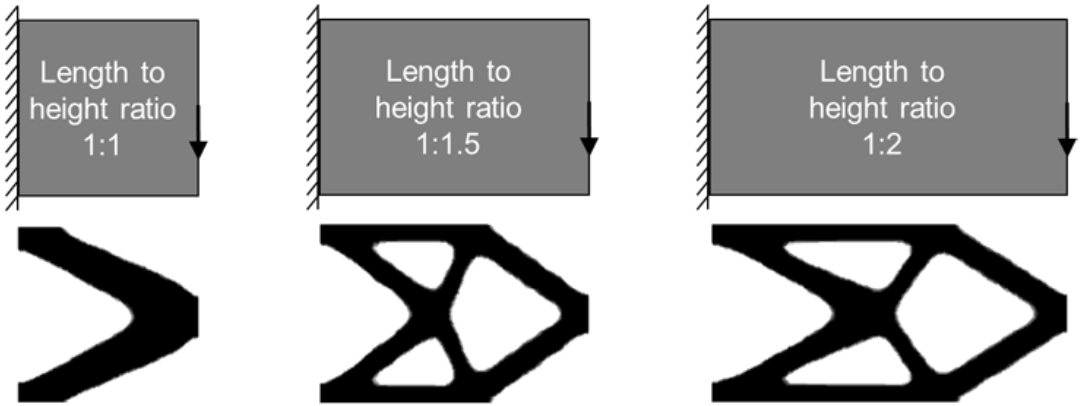
- **Sensitivity**, 민감도 (for Linear Problem)
- **DoE** (Design of Experiment), 실험계획법
- **Shape Optimization**, 형상최적화
- **Topology Optimization**, 위상최적화

- **MDO** (Multi-Disciplinary Optimization), 다 분야 최적설계
- **MOO** (Multi-Objective Optimization), 다 목적함수 최적설계
- **RBDO** (Reliability Based Design Optimization), 신뢰성 기반 최적설계

✓ **PIDO** (Process Integration & Design Optimization)

Topology Optimization

"Easy to use for non expert in optimization"
(somewhat 'As it is' concept)

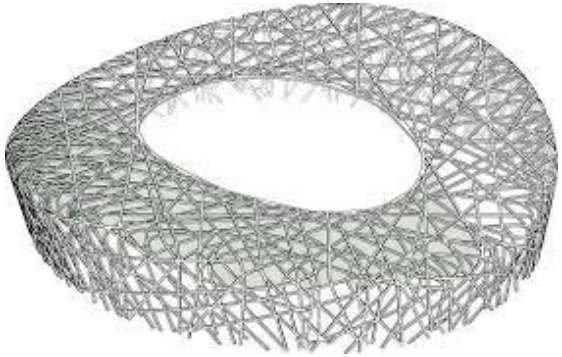


Design variable : Mass or Stiffness of ***Meshed Element***

< Typical Problem >
Objective : Minimize Weight or Maximize Performance
Design Variable : Elements' Mass
Constraints : Design Space

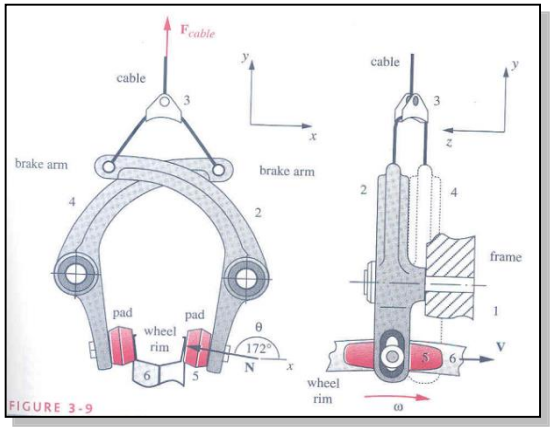
Topology Optimization

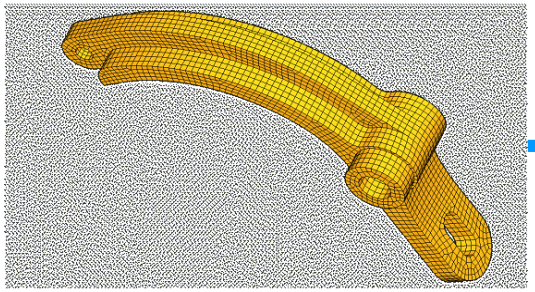
- ✓ **Powerful Tool for Optimal Concept Design**
- ✓ **Easy to use even without CAE or Optimization Expert Knowledge**
- ✓ **Architects can get design concept**



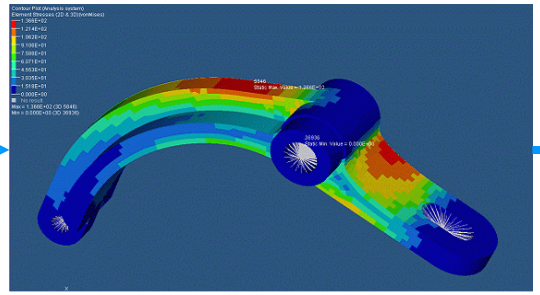
> 대학생 최적화 경진대회 사례 – 자전거 Brake Arm 최적화

AOC_2013





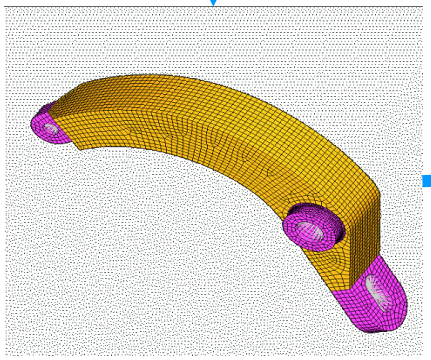
INITIAL DESIGN



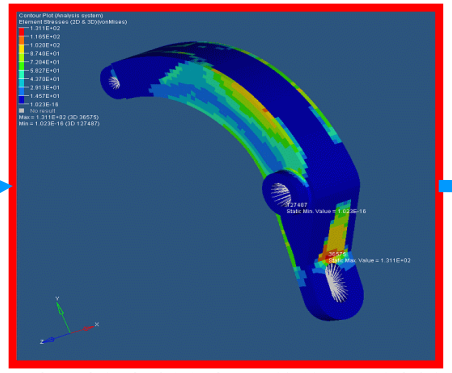
INITIAL DESIGN STRESS

Max. Stress : 136.6 MPa

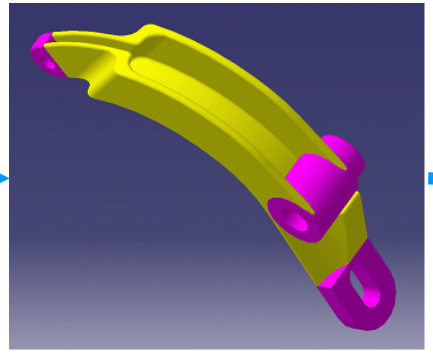
Volume : 39,370 mm³



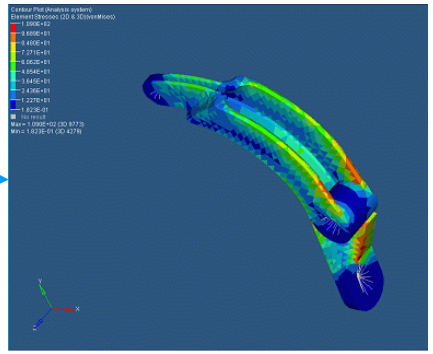
DESIGN DOMAIN



TOPOLOGY OPTIMIZATION



REDESIGN



REDESIGN STRESS

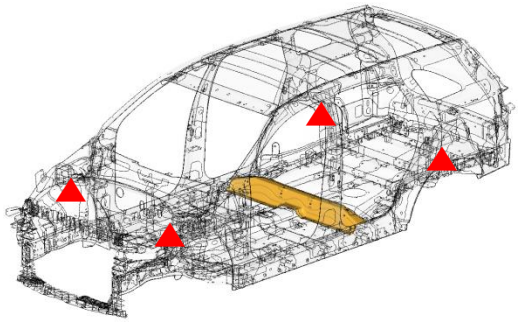
Max. Stress : 109 MPa (20%↓)

Volume : 32,350 mm³ (18%↓)

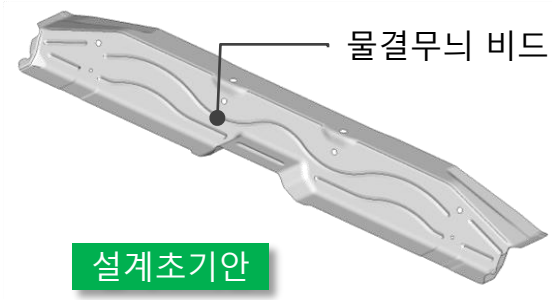
(* '08 알테어 대학생 최적화 경진대회 작품 참조)

❖ Panel Bead Pattern 최적화 (Topology for NVH)

▣ 인텀플로어



▲ 경계조건 : 전후스트럿 고정
■ 하중 : 인텀플로어 압력 부과

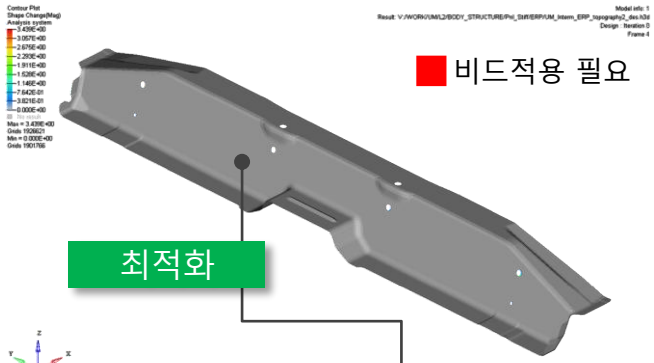


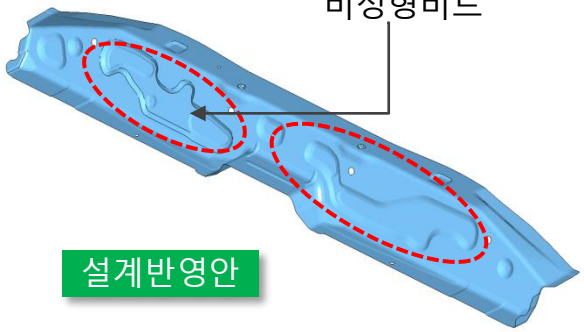
TOPOGRAPHY
(비드패턴최적화)

◈ 목적함수 : 변형에너지 최소

◈ 제한조건 : 판넬 떨림 억제를 위한 판넬강성 확보

◈ 설계변수 : 판넬 비드패턴

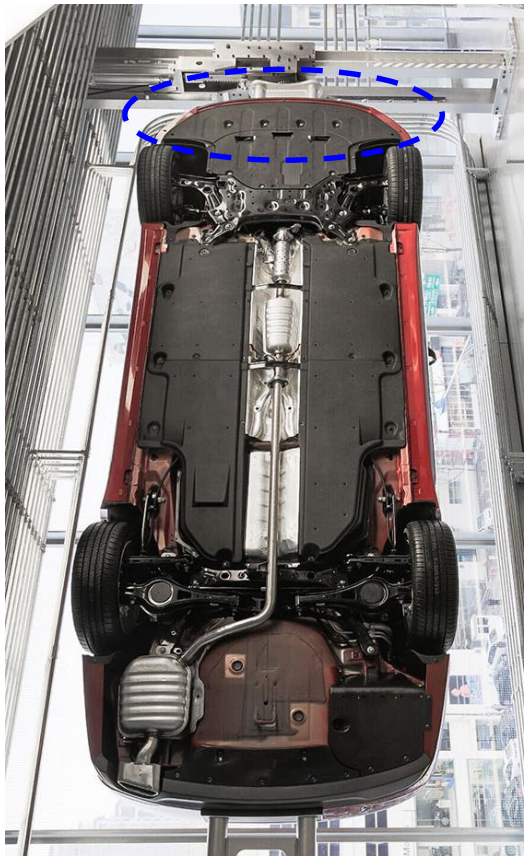


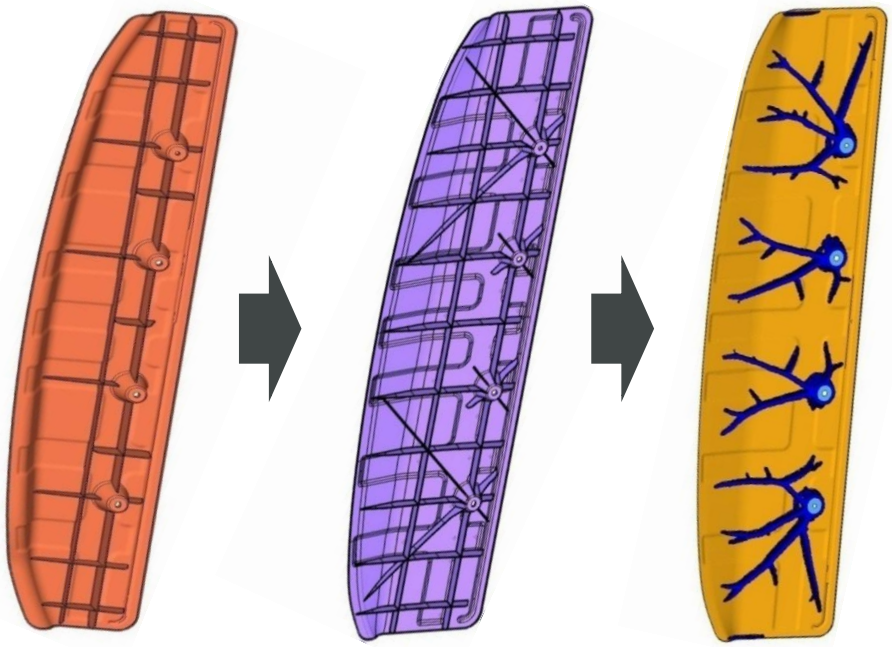


▶ 인텀플로어 판넬강성 190% 향상
: 0.85→1.4t 효과 (1.3Kg 절감효과)

Optimization Case in Automotive Industry – Topology

❖ 위상 최적화 기법을 활용한 전단부 언더커버 리브 형상 최적화





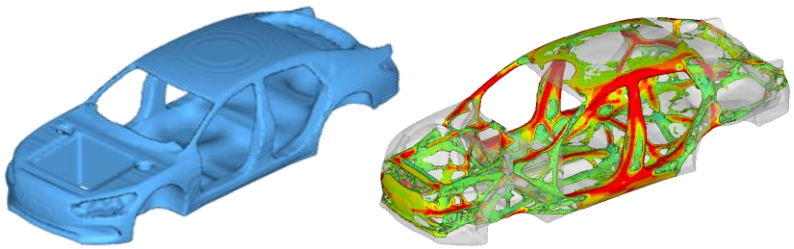
양산 개조 - 초기 개조 - 최적화

✓ Beyond engineer's intuition
✓ Learning from Nature →
Getting close to Nature ?

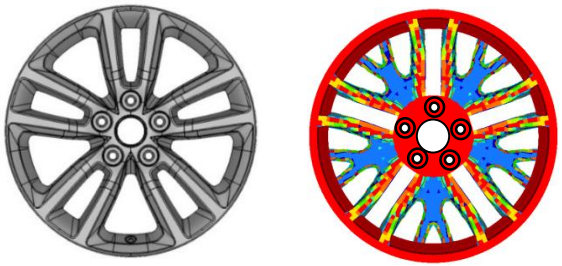
Optimization Case in Automotive Industry – Topology

❖ Topology Optimization (위상최적화)

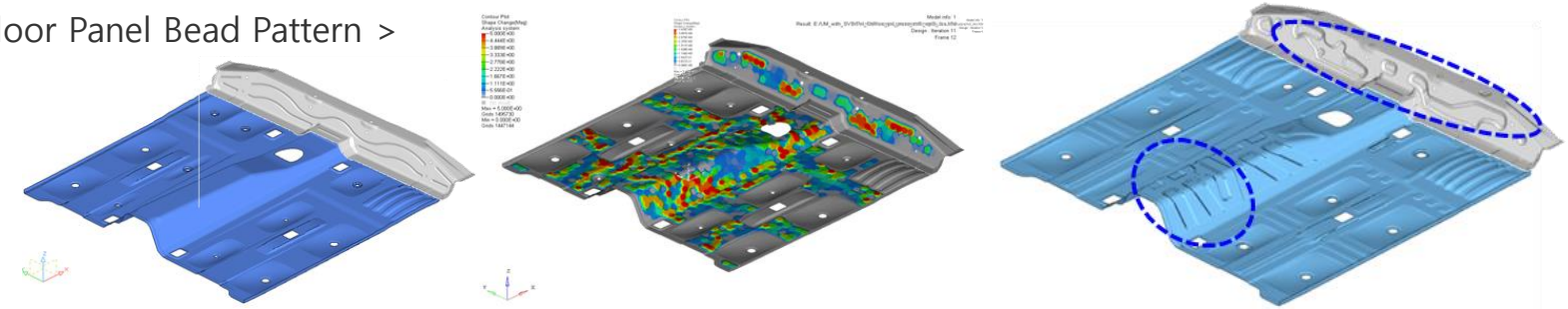
< Body Design Concept >



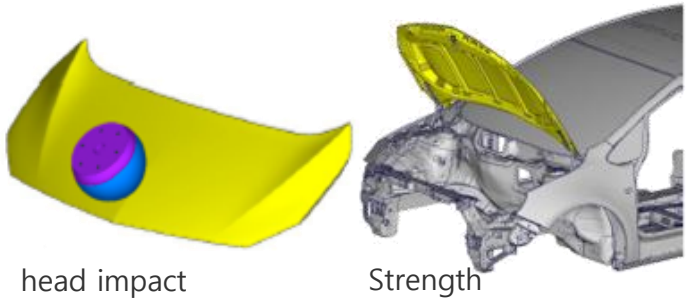
< Wheel Styling Concept >



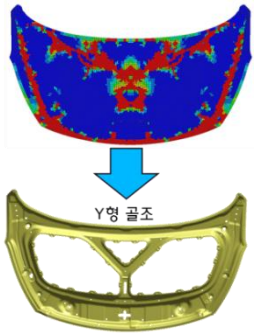
< Floor Panel Bead Pattern >



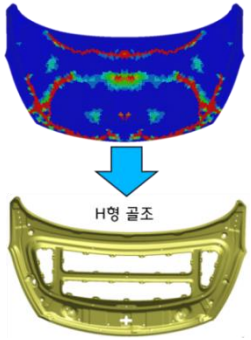
< Hood Inner Structure >



Steel



Aluminum



AGENDA

Summary

✓ **Simulation Based Development**

Hardware based Development

DESIGN → BUILD Prototype → TEST

Trial & Error

시험개발 by *Design-Build-Test* Iterations

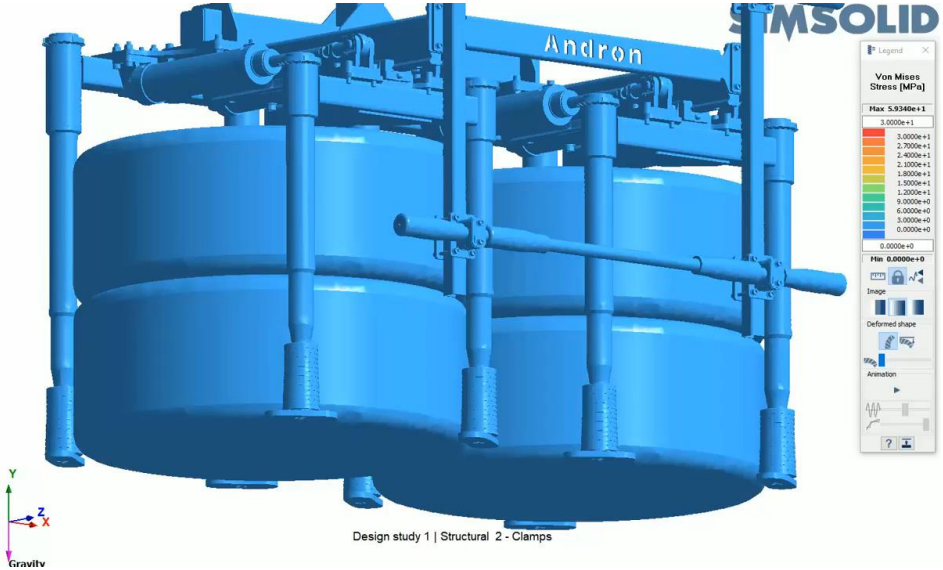
Simulation based Development

SIMULATION → OPTIMIZATION

시뮬레이션개발 → 시험확인

- Minimize Design Change
- Less Hardware Stages

✓ **Democratizing CAE**



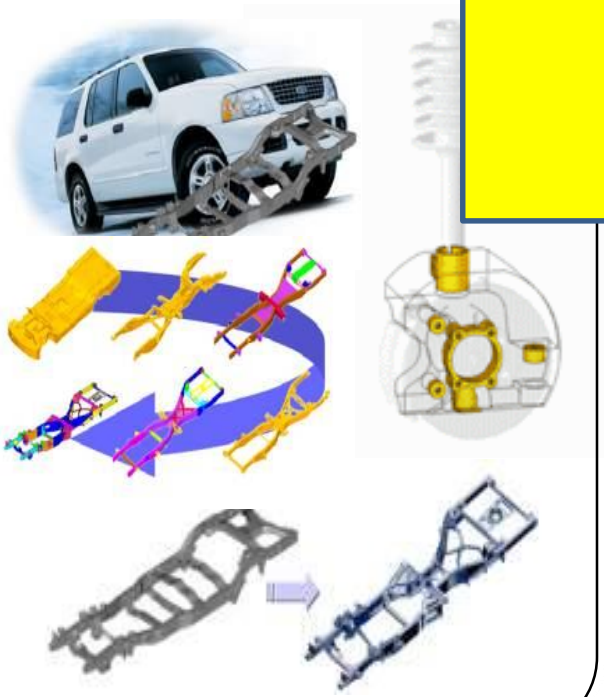
✓ **Topology Optimization**

Simulation based Development Process

- 시점: 도면 작업 前
- 검증 Tool → 설계 Tool
- 설계 방향 제시

개념설계 단계

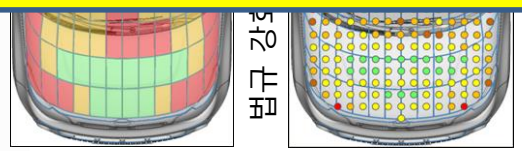
- 위상 최적화 기법 (Topology)
- 형상 모델링 (Morphing)



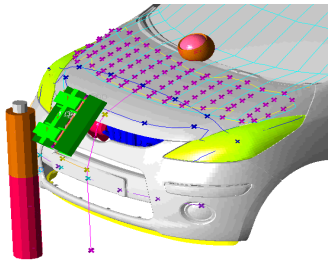
- 시점: all도 출도 前
- 설계 협업 기간 확보
- 신속한 검증 및 설계개선

설계검증 단계

- Routine Job 개발 해석 자동화



170 개소타격 기준 - 해석기간 : 8주 → 2주

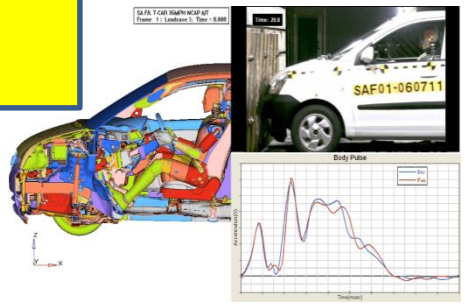


- 시점: 실차 제작 이후
- 문제점 검증/효율적 개선
- 해석기반 예측 정확도

시험검증 단계

- 시험-해석 correlation
- 험결과 상세분석

) 충돌 시험-해석 비교



Minimize Design Change

Less Hardware Test Stage

Improve Quality & Reduce Time

TO GET THROUGH THE HARDEST JOURNEY WE NEED TO TAKE ONLY ONE STEP AT A TIME, BUT WE MUST KEEP ON STEPPING.

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감사합니다

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