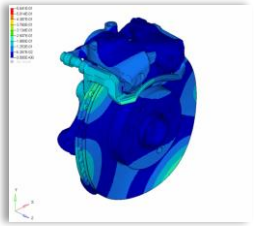
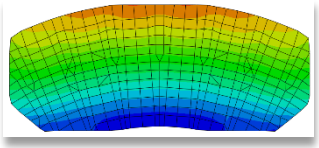
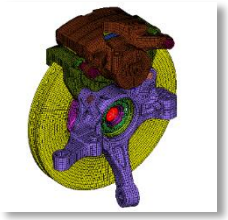




Simulation Productivity Gain through Automated Simulation System for Caliper Brake CAE

* Korea Delphi Automotive System Corp.

* 김 대업

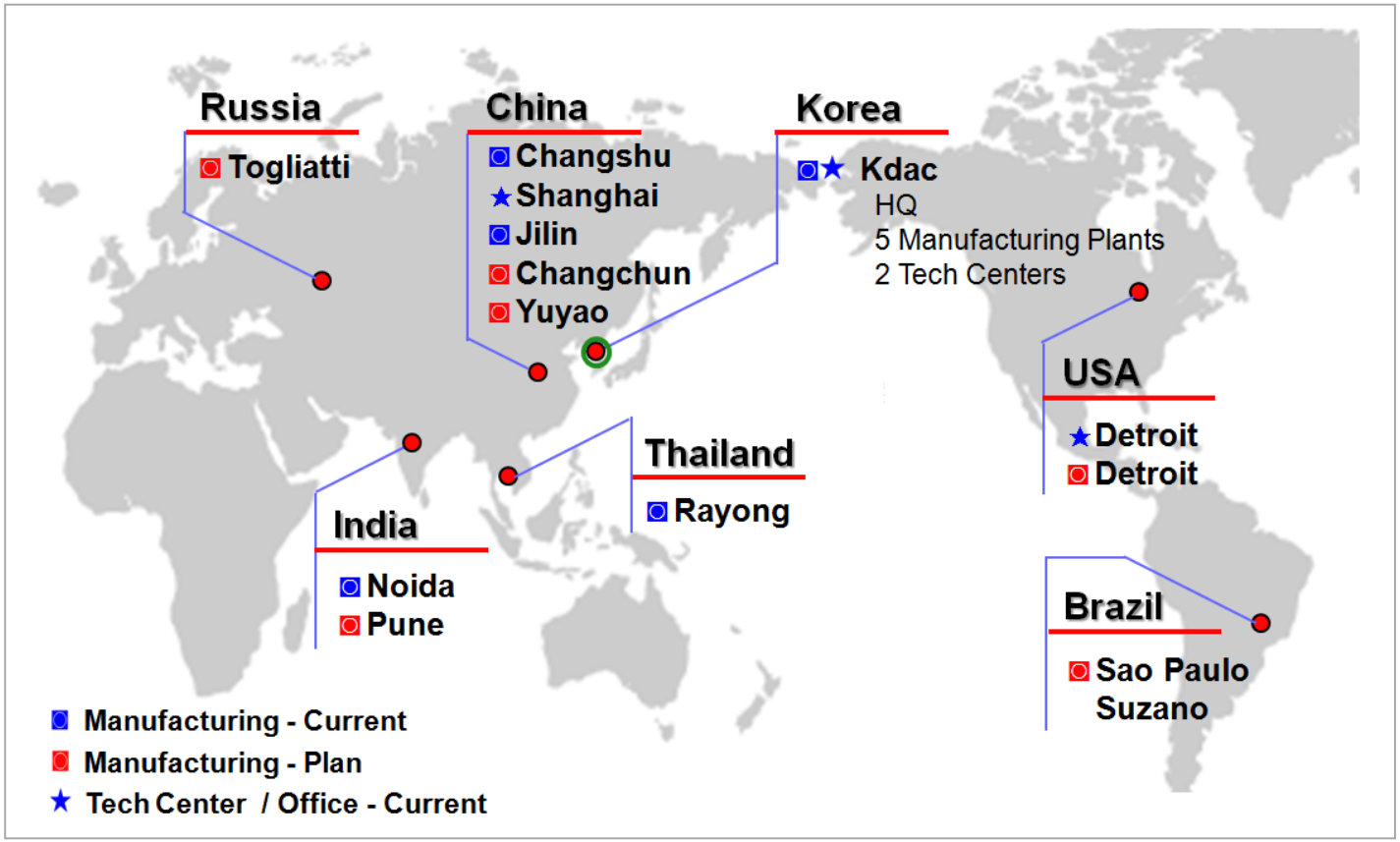
kdac

Agenda

1. Kdac Overview
2. CAE Coverage (Functionality & Product)
3. VPD Vision & Key Success Factor
4. Brake Simulation System

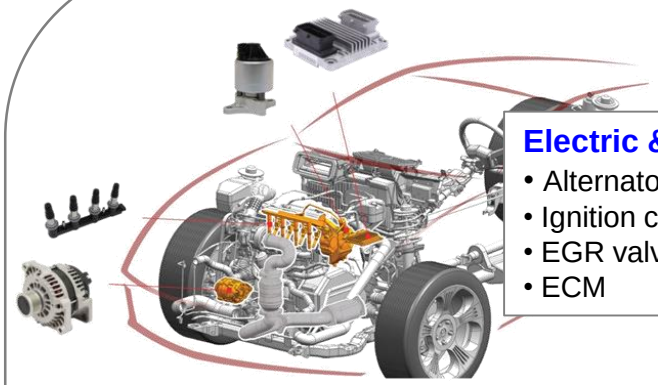
Kdac Overview

- **Year 1984** : Company established
- **Year 2015**
  - 9 Manufacturing plants in 4 countries (Korea, China, Thailand, India), about 2000 employees
  - 5 Manufacturing plants & 2 tech center in Korea

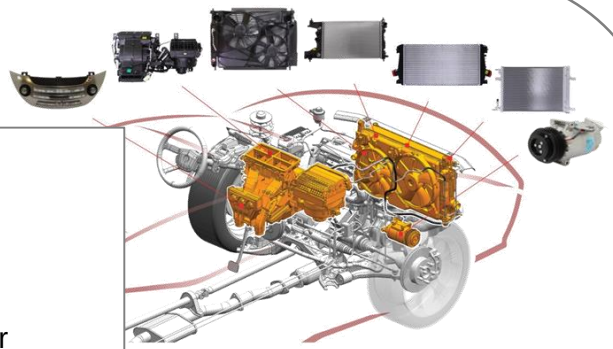


Kdac Overview

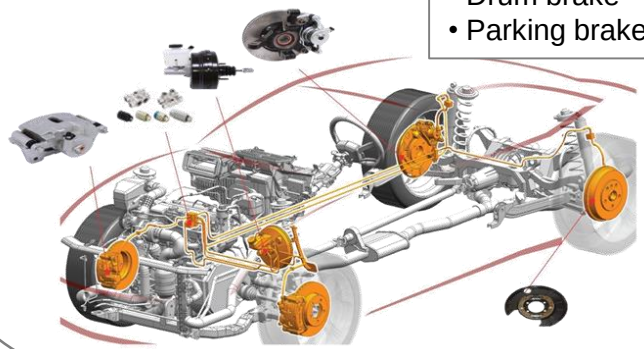
Main products



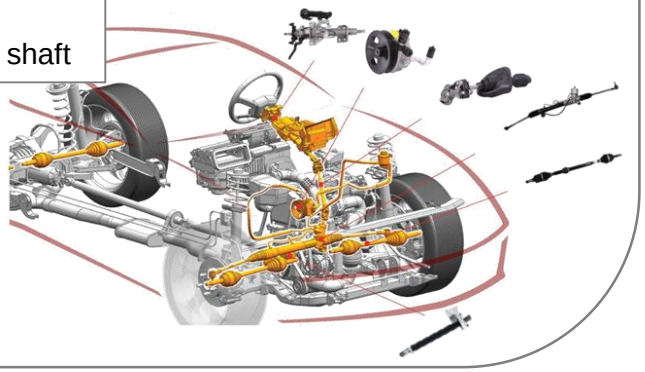
Electric & Electronics
- Alternator
- Ignition coil
- EGR valve
- ECM



Thermal
- HVAC controller
- HVAC module
- Cooling fan
- Radiator
- Charge air cooler
- Condenser
- Compressor

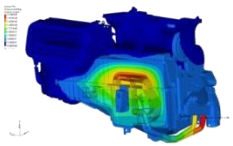
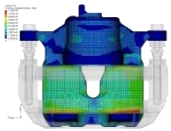
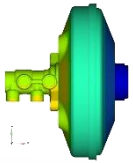
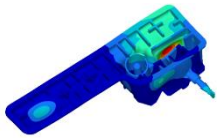
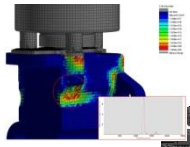
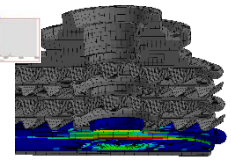


Brake
- Caliper brake
- Proportioning valve
- Power brake
- Drum brake
- Parking brake



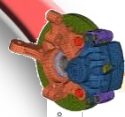
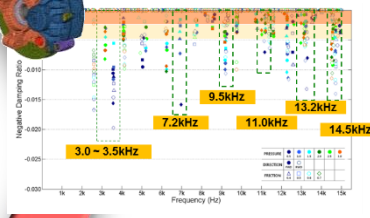
Steering & Drive
- Steering column
- Power steering pump
- Intermediate shaft
- Steering gear
- Halfshaft
- Intermediate drive shaft

CAE Coverage - Functionality

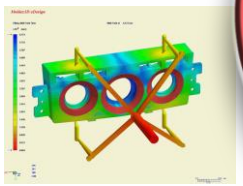







Stiffness / Strength

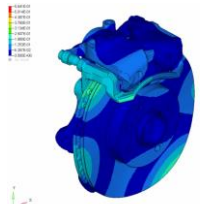
Durability / Fatigue

NVH



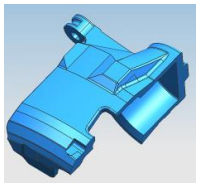
Manufacturing



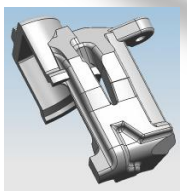
Impact

Optimization

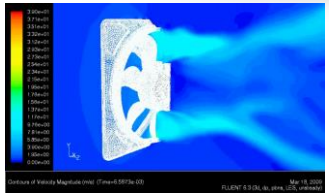
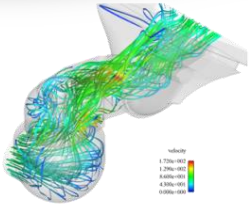
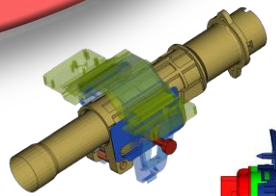
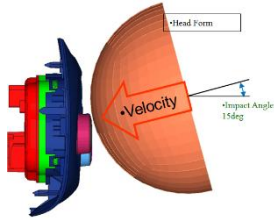
CFD



Original Design



Optimized Design

Available S/W @ Kdac

CFD CD-adapco STAR-CCM+ Flow pattern Flow speed Flow rate Temperature Pressure analysis	**Structrue** Abaqus ANSYS Stress & Deformation Vibration Heat Transfer	**Dynamic** RecurDyn™ MSC ADAMS Motion Analysis Kinematic Analysis System dynamic Analysis Vibration Analysis
Fatigue FE-Fatigue nCode DesignLife™ Fatigue Failure Meantime to Failure	**Crash & Impact** DYNA Stress & Large Deformation Failiure Analysis Crashworthiness Simulation	**Injection molding** moldflow Weldline prediction Warpage prediction Sink mark prediction Fiber orientation analysis
Optimization Altair® HyperWorks® Topology Optimization Morphing for Shape Variables Composite Laminate Optimization Optimization for New Response	**Electro-Magnetic** ANSYS /E-mag Electrostatics Magnetostatic Steady-State Current Conduction	**Post process** CEI En-Sight Advanced Animation Visualization Surface Particle trace Transient Data

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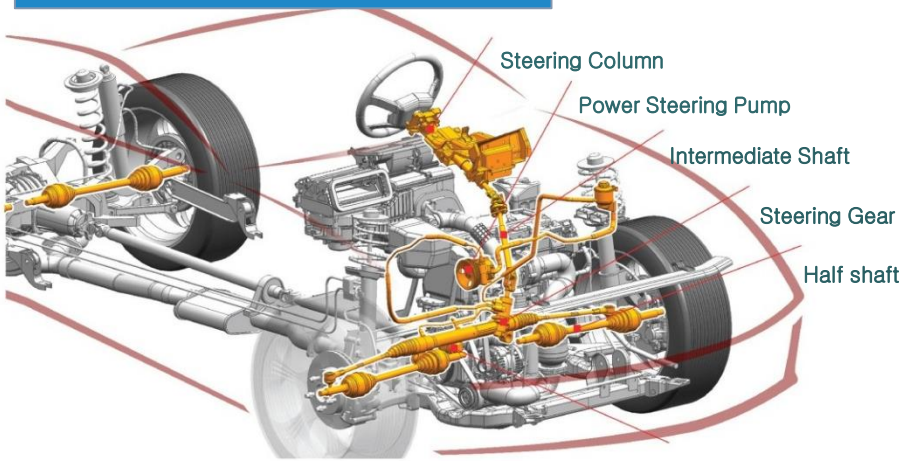
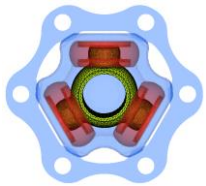
CAE Coverage – Driveline

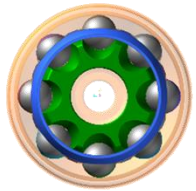
Driveline



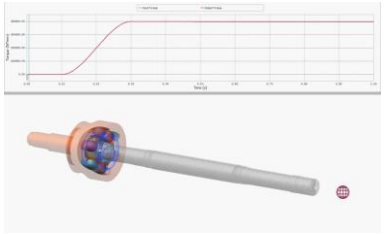
CV Joint Dynamic Efficiency



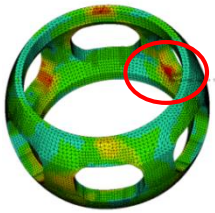
Tripod Joint

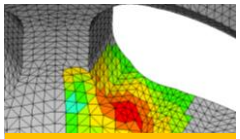


Ball Joint (HERz)

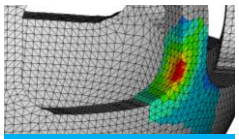


8 Ball – Cage Stress Comparison

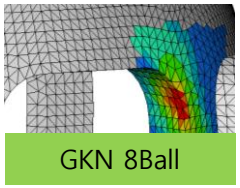




HARz 6Ball

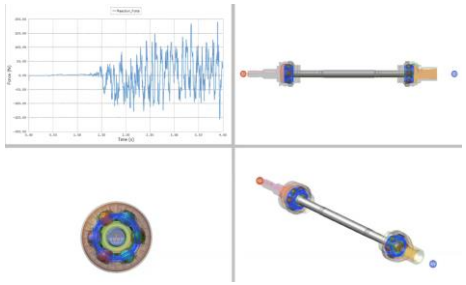


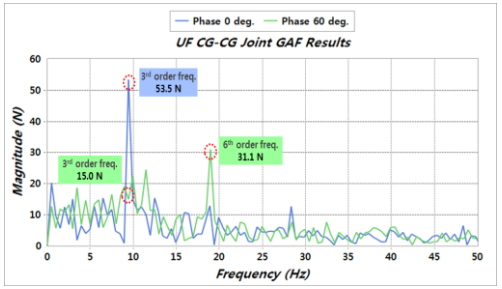
HERz 8Ball



GKN 8Ball

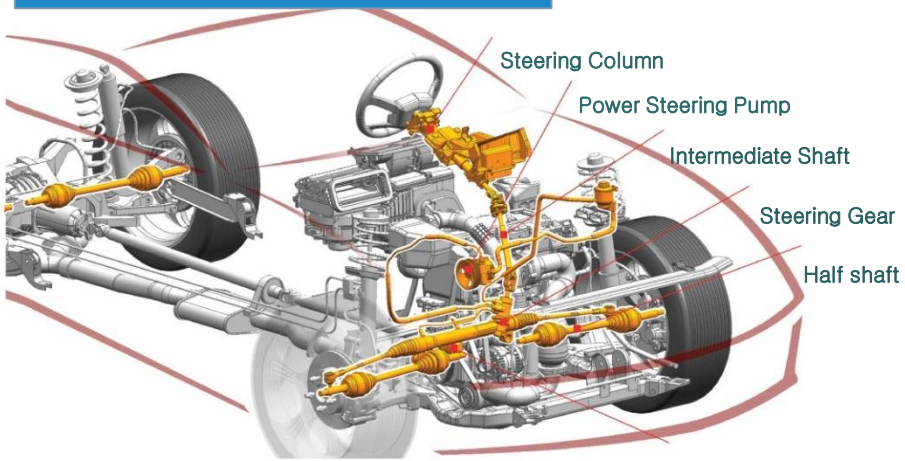
General Axial Force



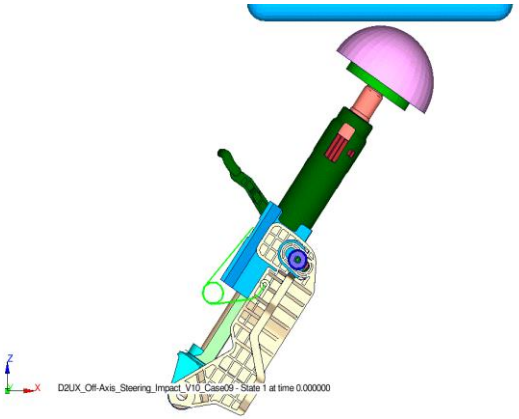


CAE Coverage – Steering Column

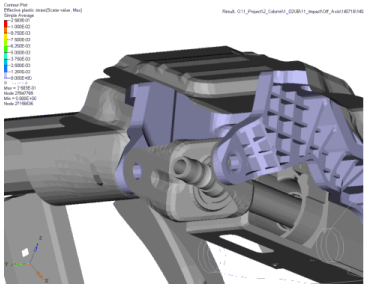
Steering Column / Half Shaft

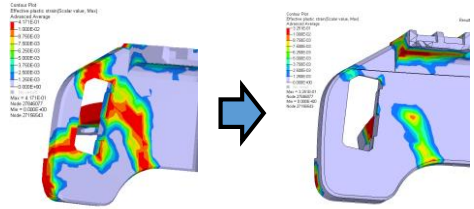


Off-Axis Impact

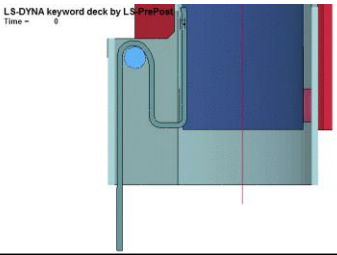


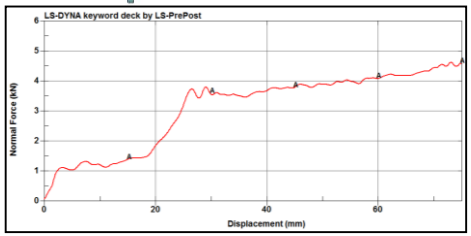
Structural Rigidity Improvement



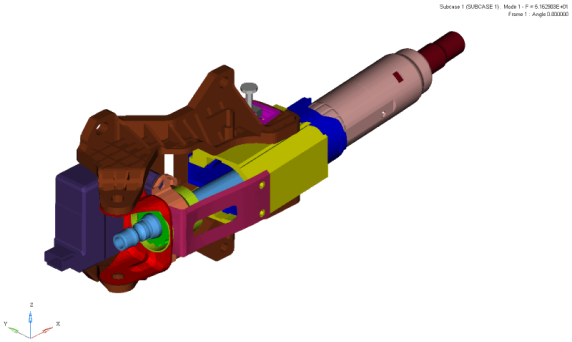


Strap Design Development



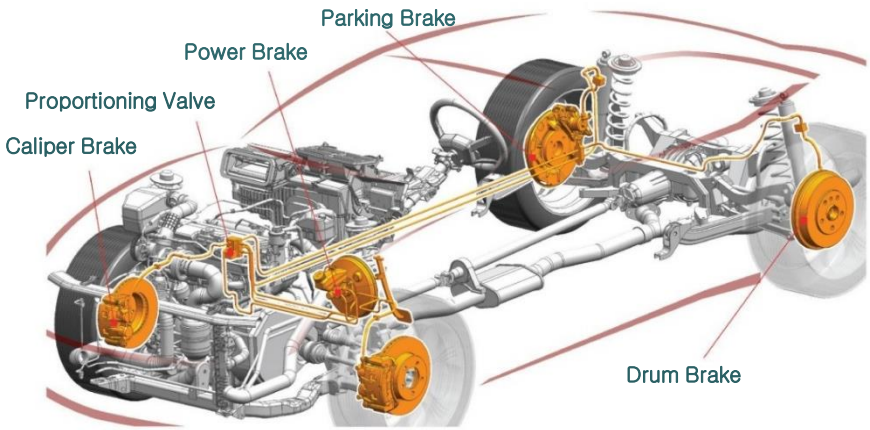


Natural Frequency

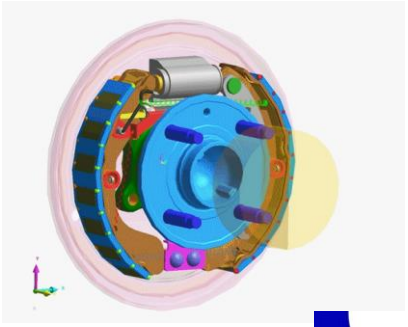


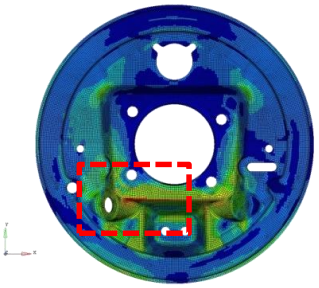
CAE Coverage – Brake System

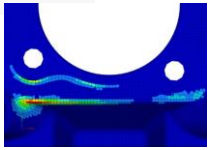
Brake System



Drum Brake

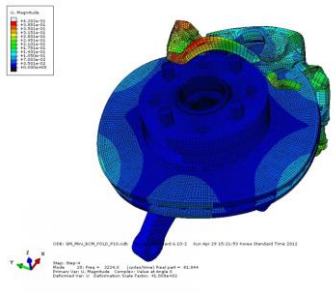


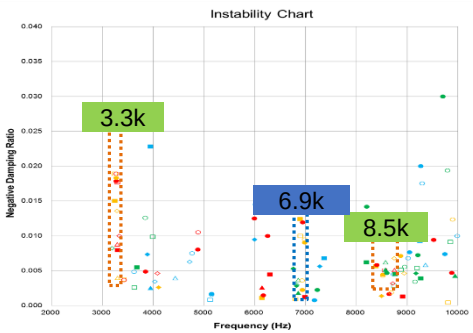




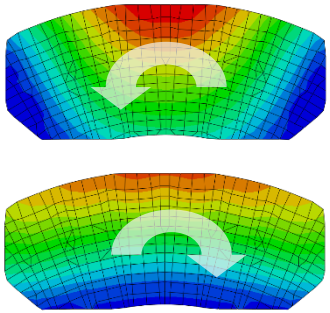
Strength Analysis of Back Plate

Caliper Brake

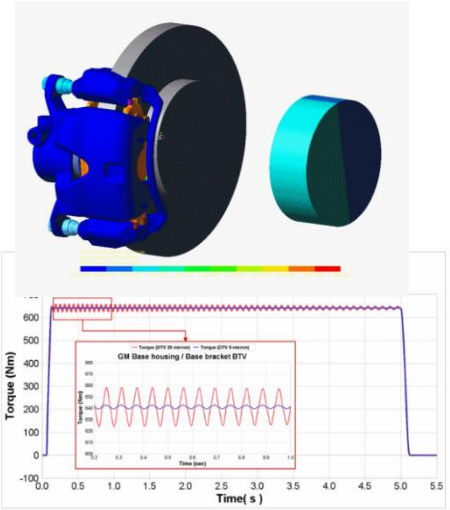




Squeal Noise Analysis (Complex Eigenvalue)



Contact Pressure Distribution (Pad)

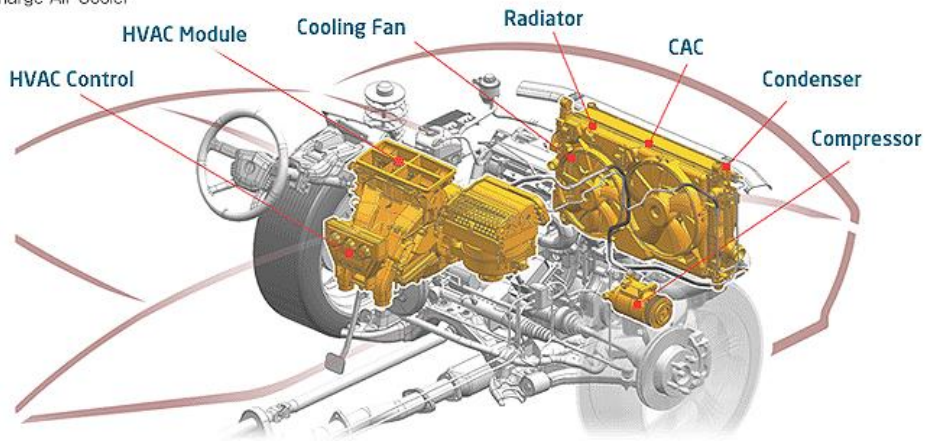


BTV (Brake Torque Variation)

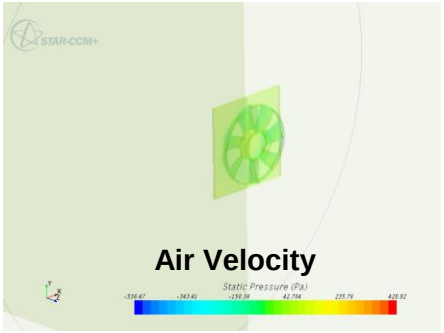
CAE Coverage – HVAC & CRFM

HVAC / CRFM

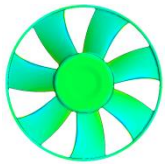
- **HVAC** : Heating, Ventilation and Air Conditioning
- **PTC** : Powertrain Cooling
- **CAC** : Charge Air Cooler

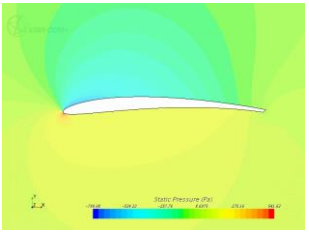


CRFM

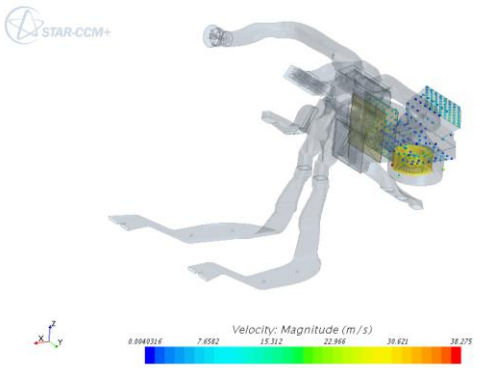


Engine Cooling Fan



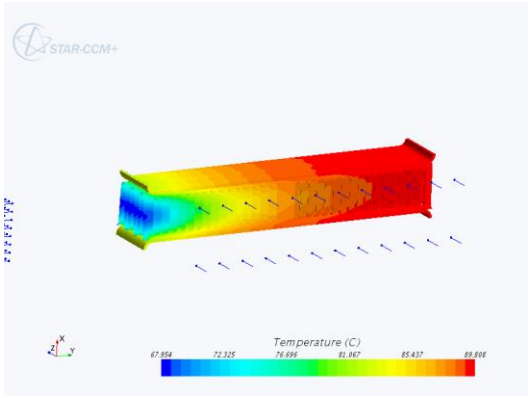


HVAC



Air Velocity

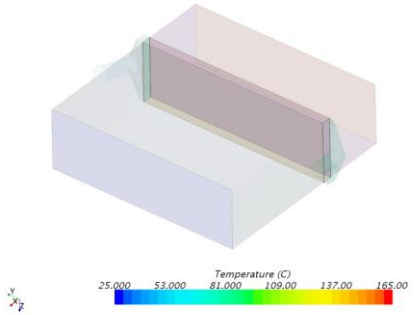
Evaporator



Air Velocity / Fin Temperature

CAC

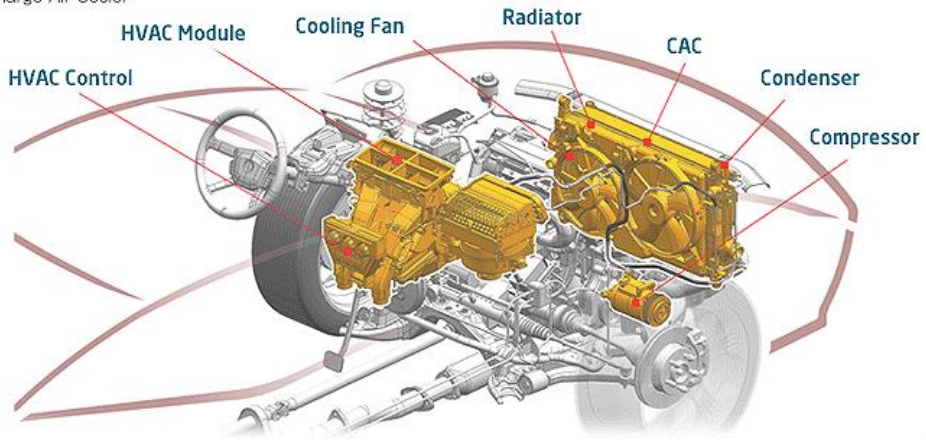
Dual Stream(In/Outside) Velocity



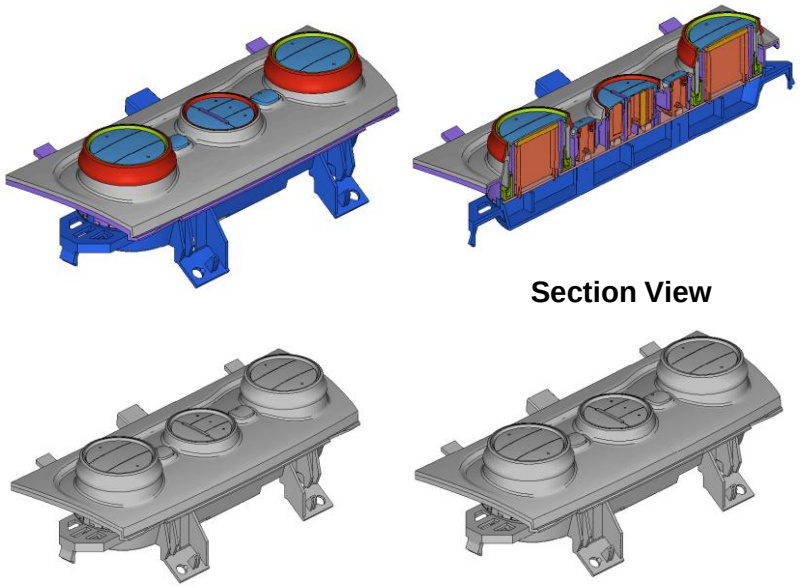
CAE Coverage – HVAC Controller

HVAC Controller

- HVAC : Heating, Ventilation and Air Conditioning
- PTC : Powertrain Cooling
- CAC : Charge Air Cooler



Mechanical Shock Analysis

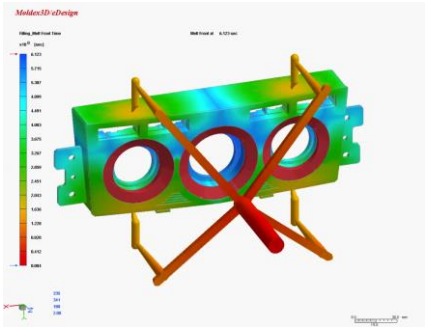


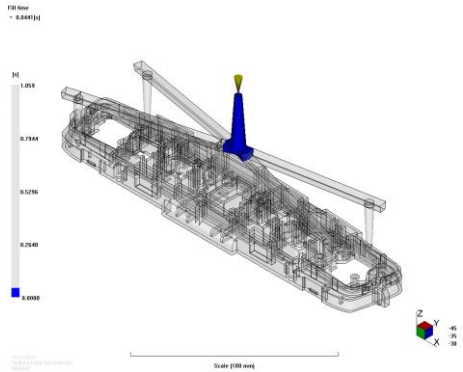
Section View

Displacement

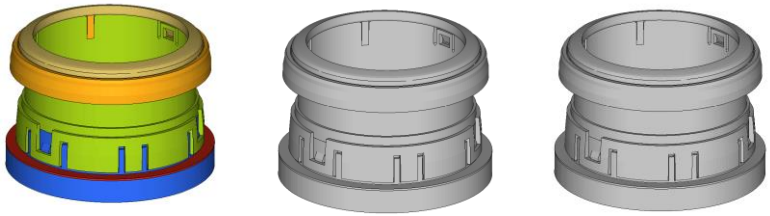
Stress

Mold Flow Analysis





Knob Pull Force Analysis



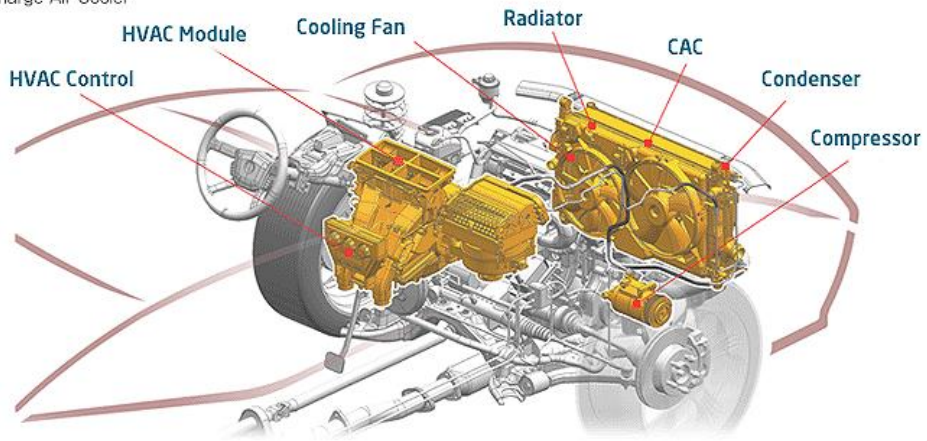
Displacement

Stress

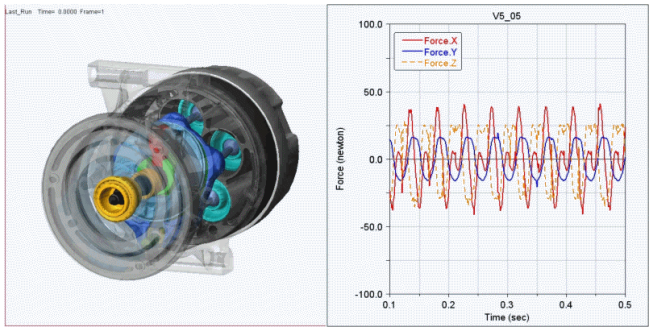
CAE Coverage - Product

Compressor

- HVAC : Heating, Ventilation and Air Conditioning
- PTC : Powertrain Cooling
- CAC : Charge Air Cooler

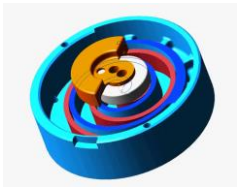


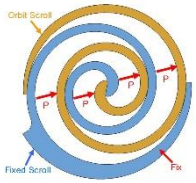
Multi-Body Dynamic Analysis

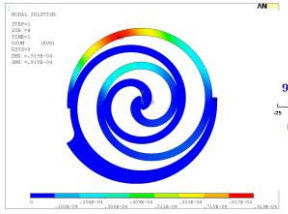


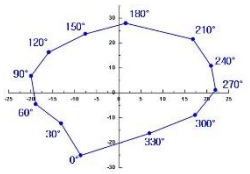
Reaction Force

Scroll Compressor Movement





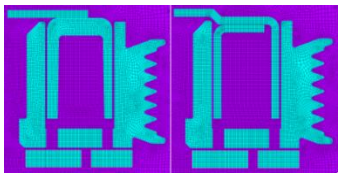


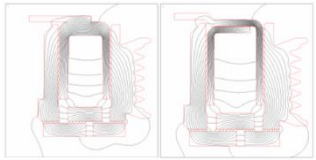


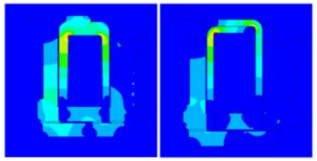
Displace ment

Reaction Force

Clutch Magnetic Field

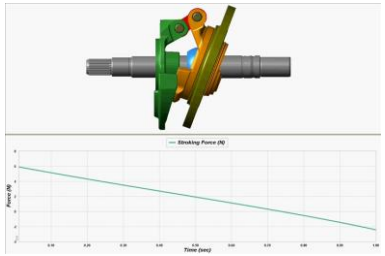


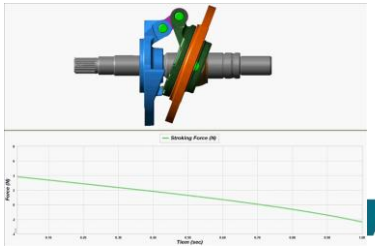




Magnetic Force

CVC Compressor Stroke Force

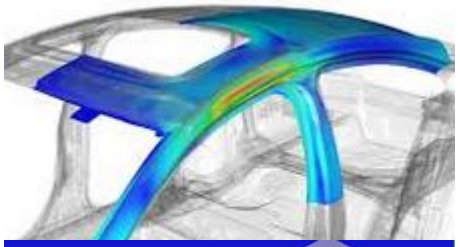




kdac

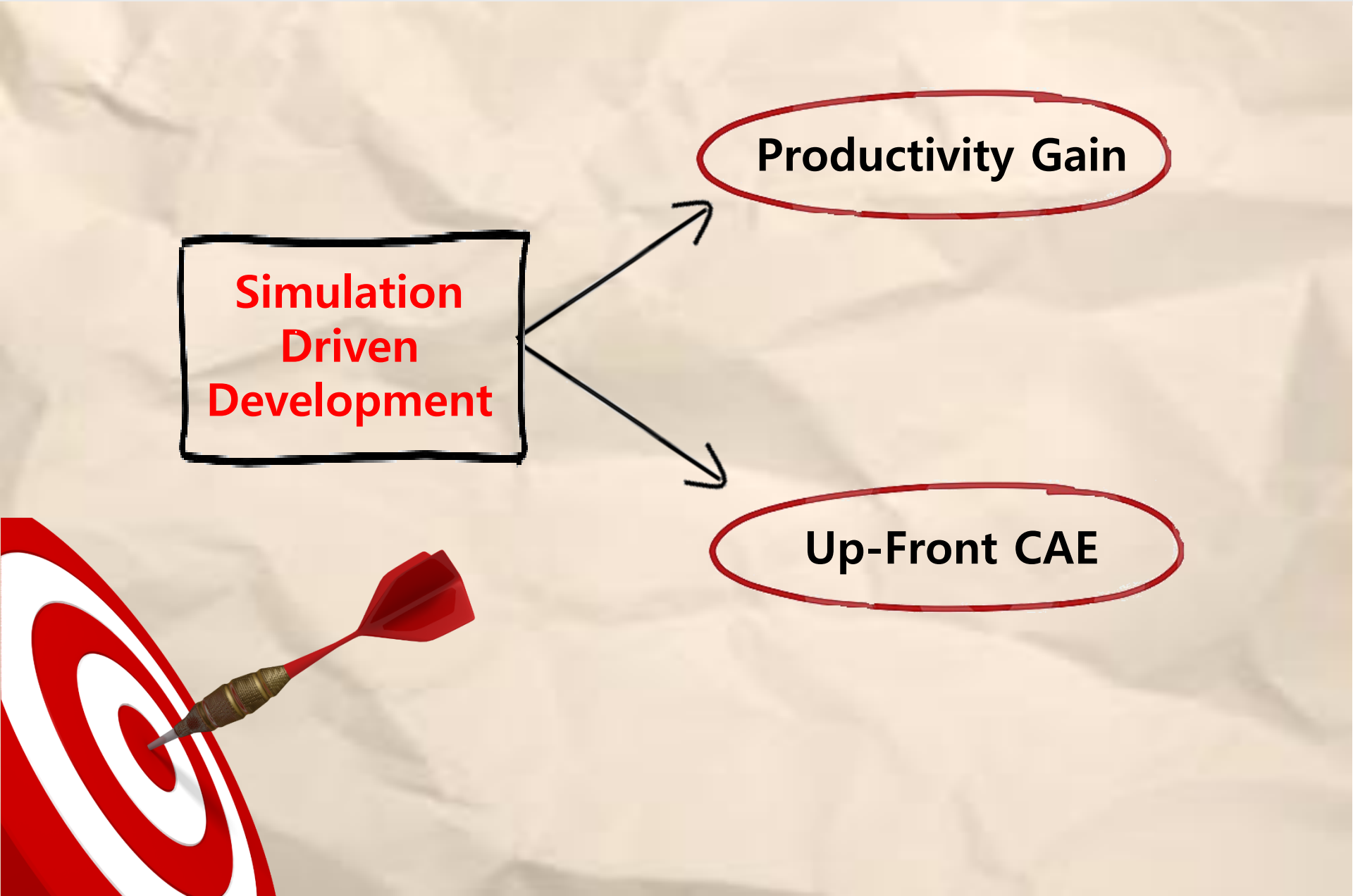
VPD Vision and Key Success Factors

It is apparent that CAE is a vital tool in Product Development.



Methods continuously improving, but CAE Role ?

VPD Vision and Key Success Factors



VPD Vision and Key Success Factors

Repetitive, Tedious, Time-consuming tasks in Pre/Post Processing

Task Automation with Scripts

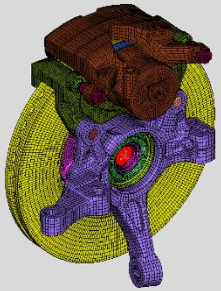
Scripts itself, Not enough

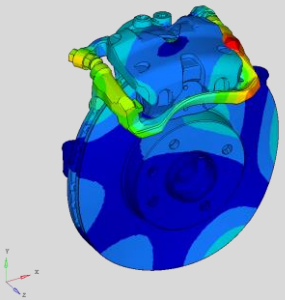
Better be linked

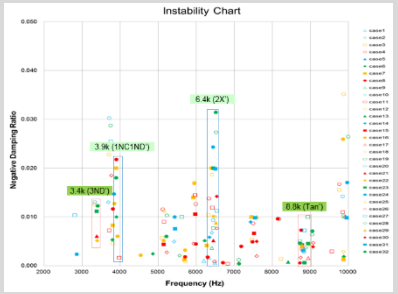
Better be organized and managed within system

Caliper Brake Simulation

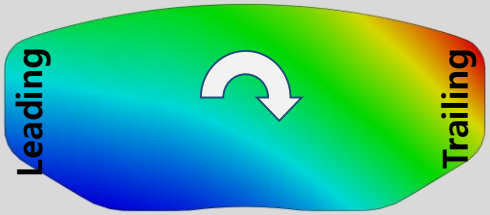
Squeal Noise Analysis

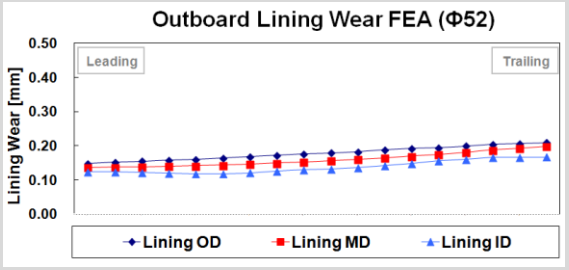


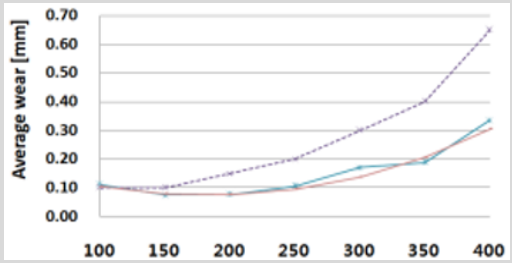




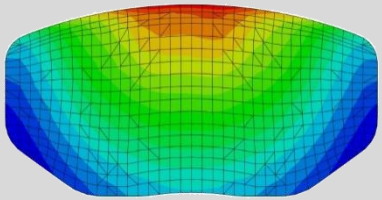
Pad Wear Analysis

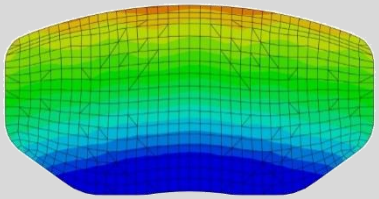






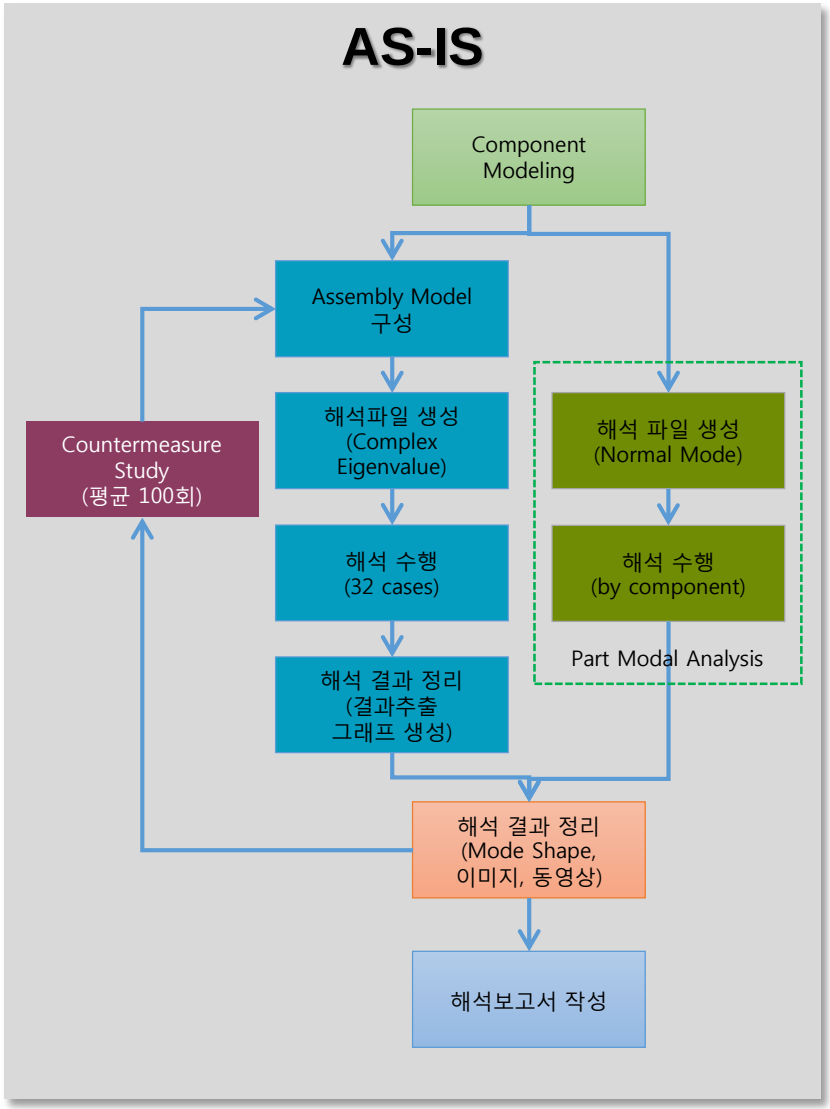
Pad Contact Pressure Analysis

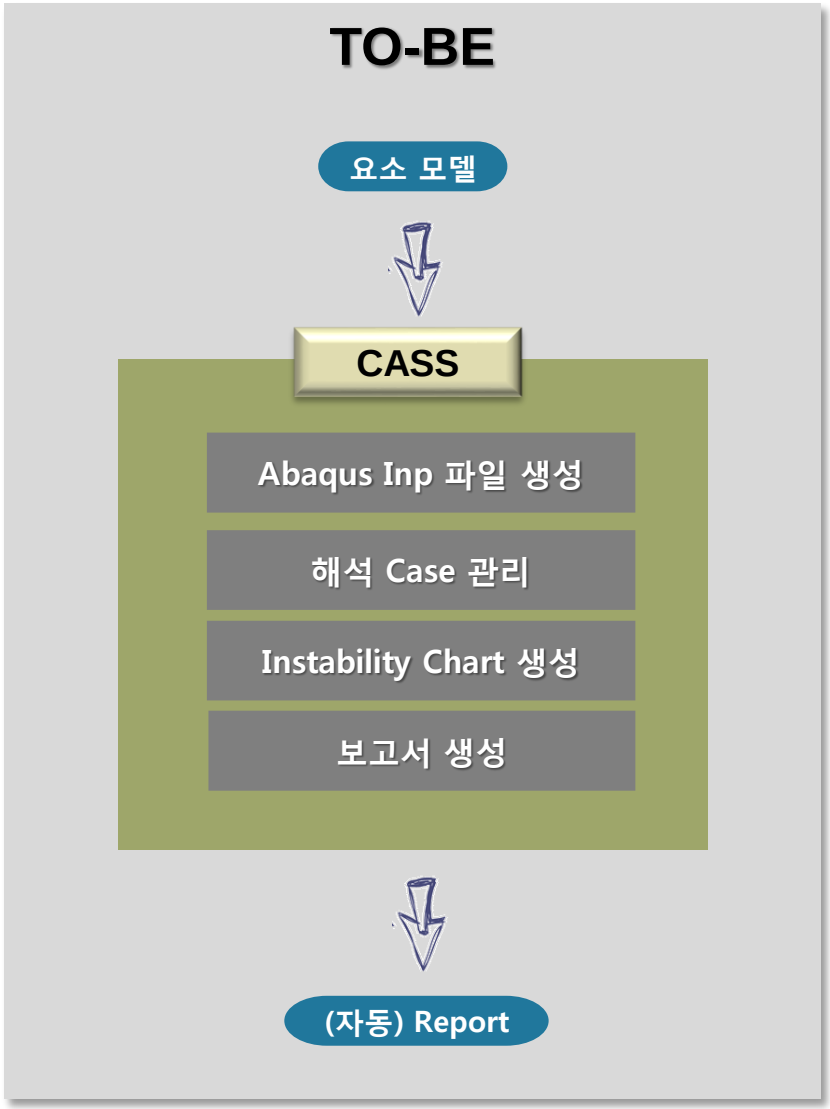




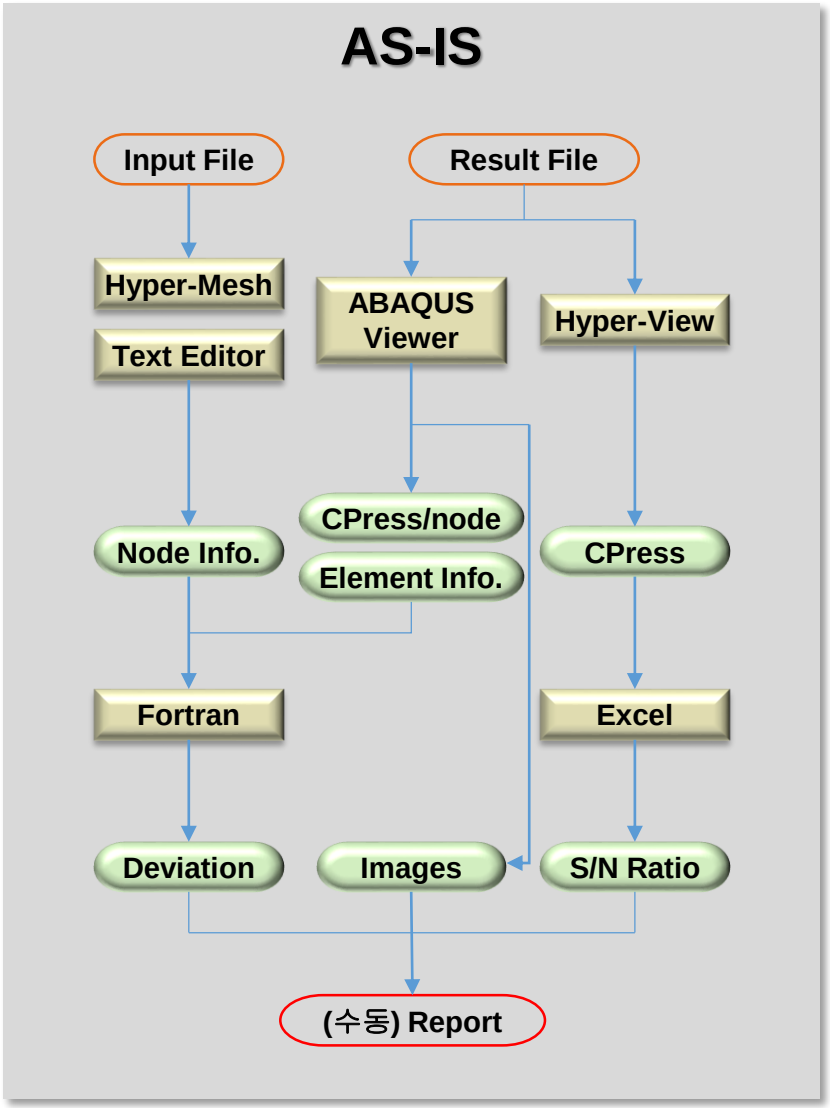
Inboard		Outboard	
Deviation	S/N Ratio	Deviation	S/N Ratio
Value [mm]	Value [dB]	Value [mm]	Value [dB]
1.5	10	2.0	9.0

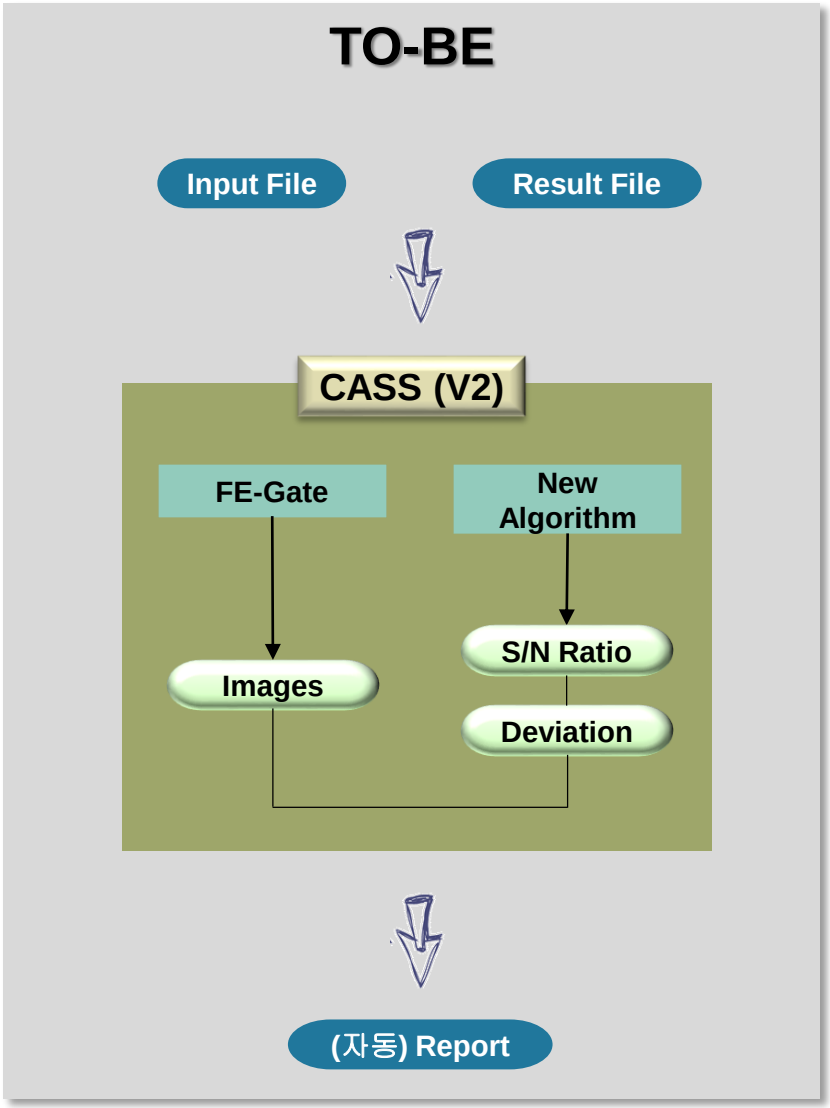
Squeal Noise Analysis



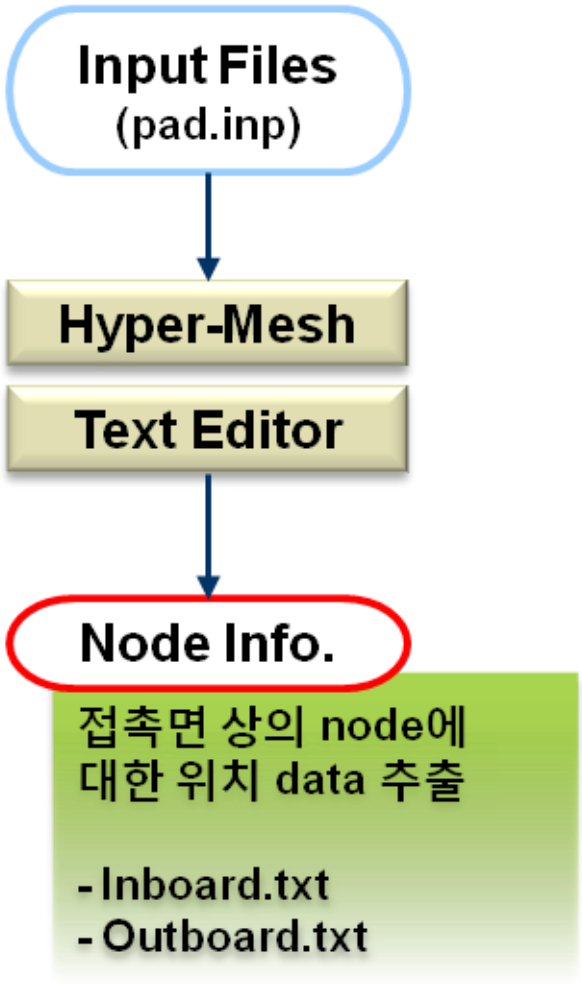


Brake Contact Pressure Analysis

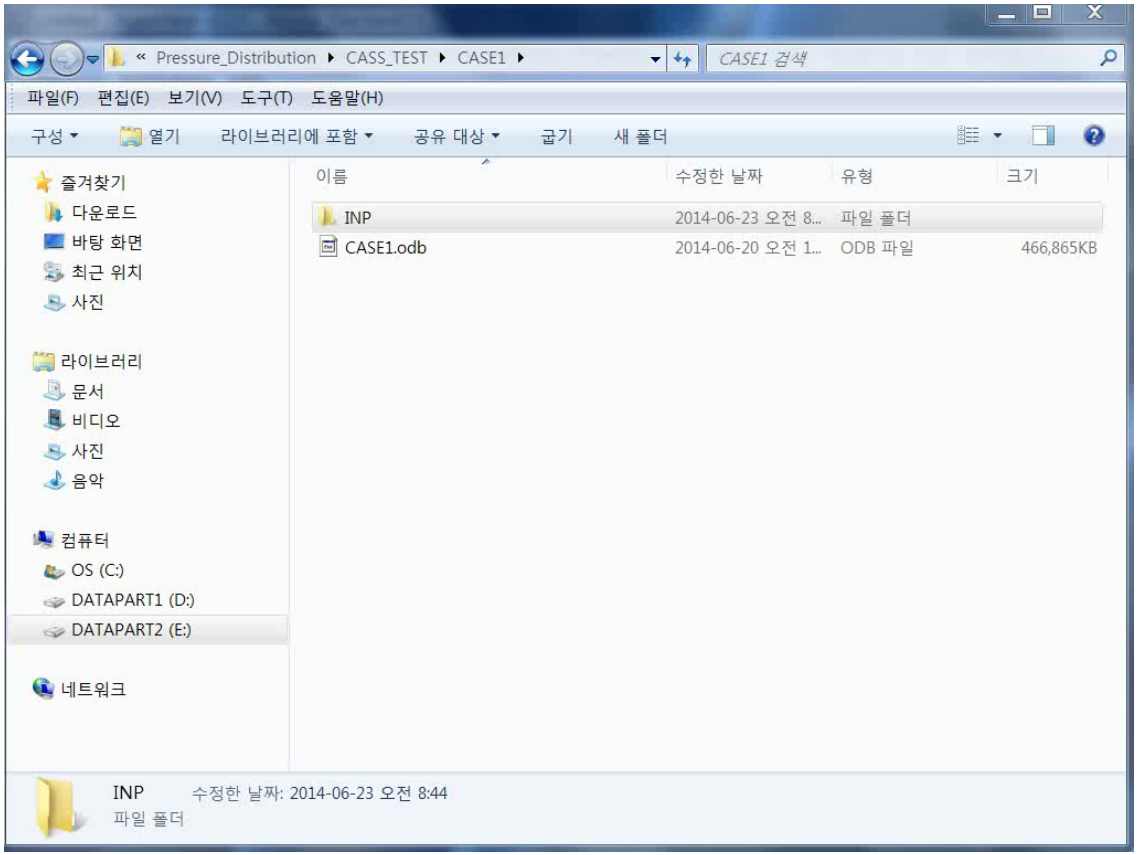




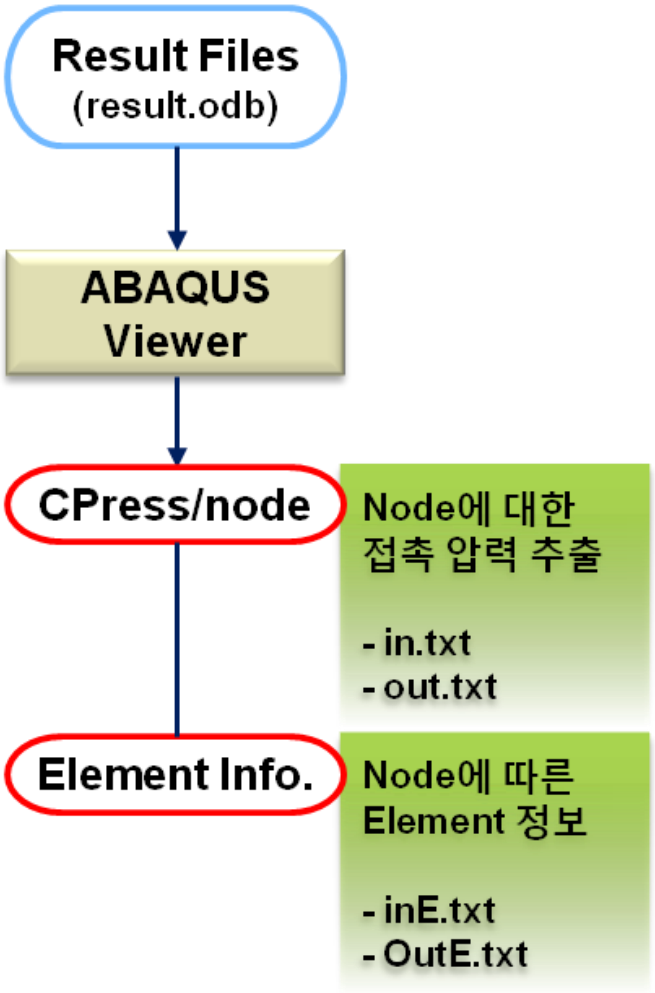
현재의 해석 과정



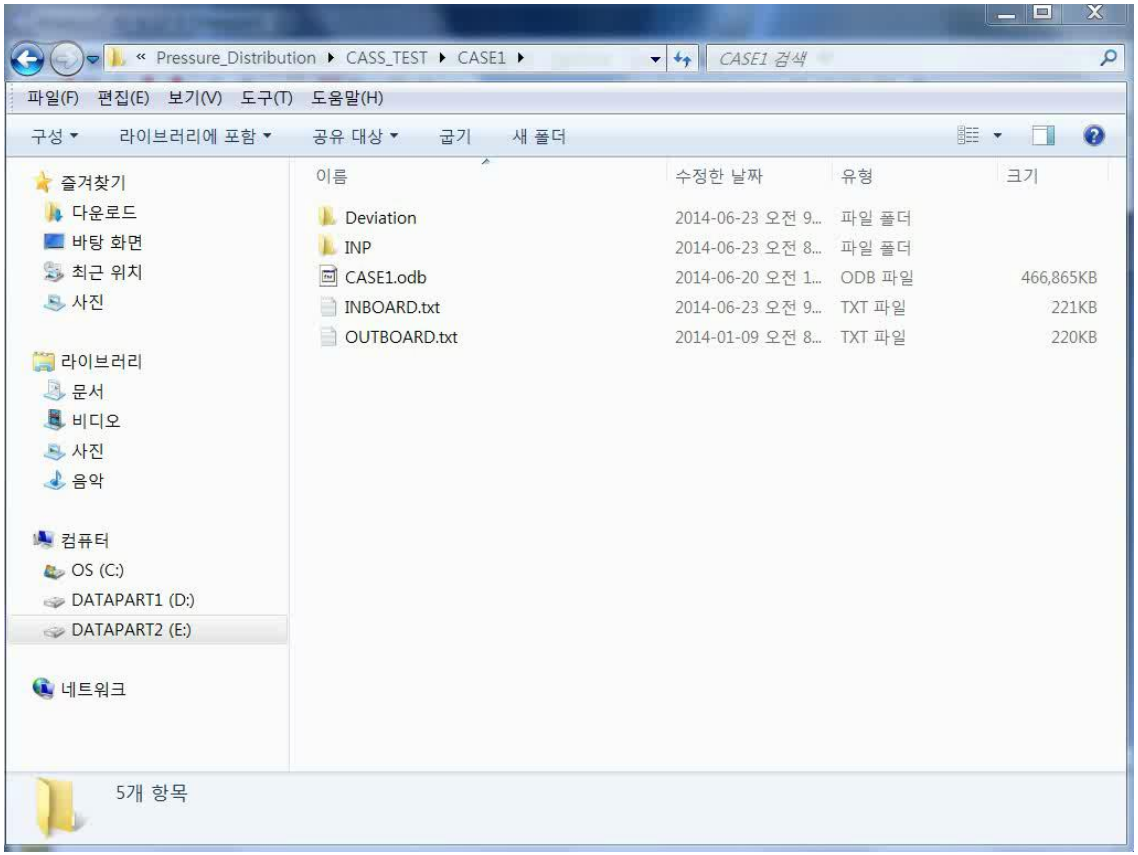
관련 동영상



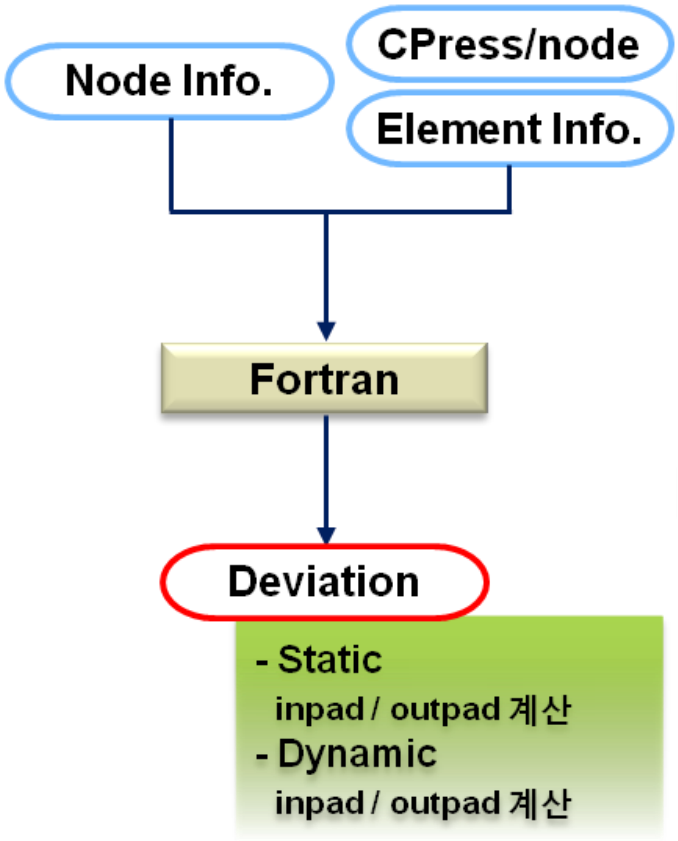
현재의 해석 과정



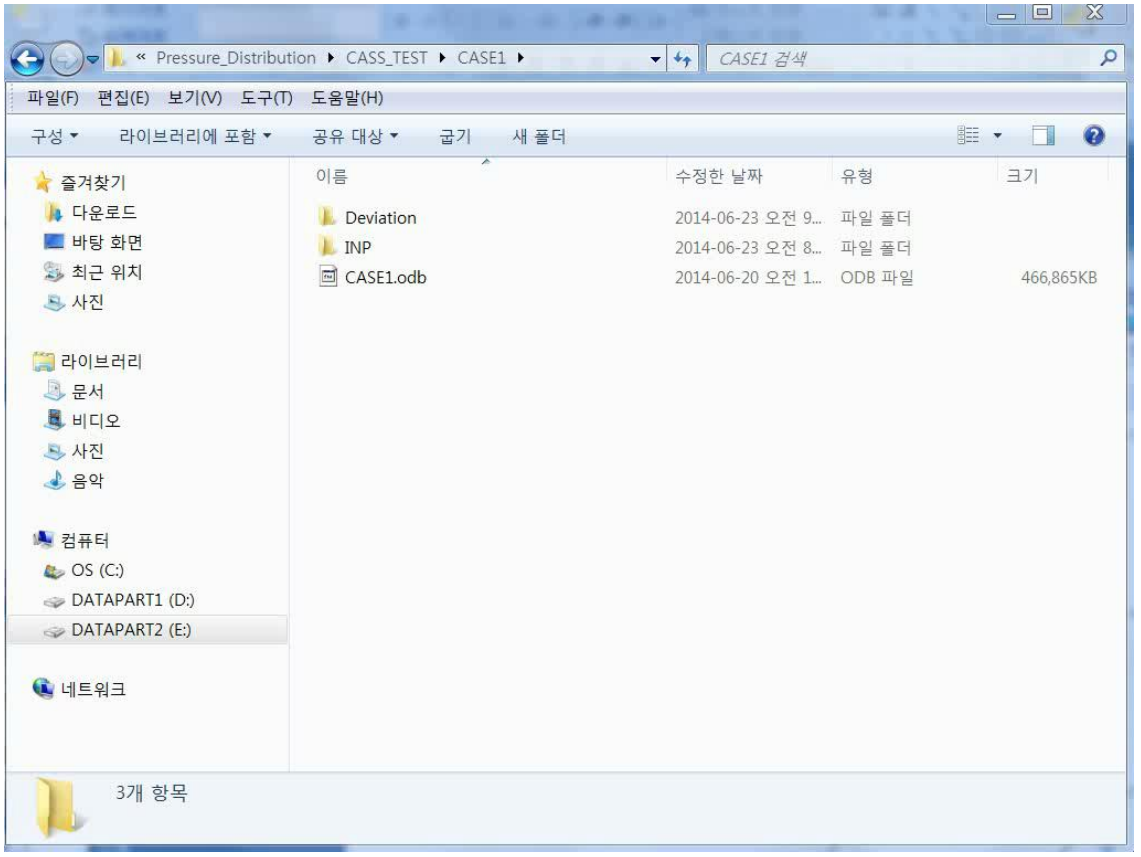
관련 동영상



현재의 해석 과정



관련 동영상



현재의 해석 과정

Result File
(result.odb)

↓

Hyper-View

↓

CPress

↓

Excel

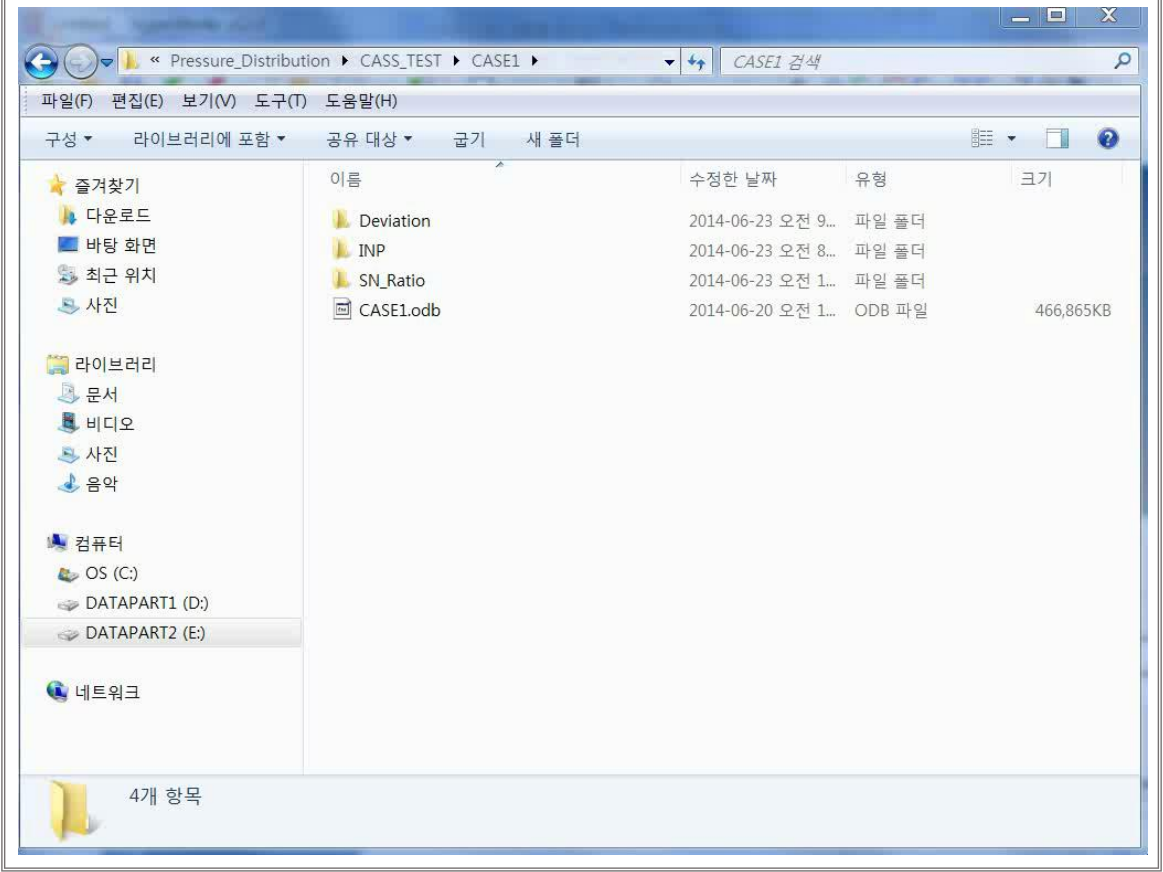
↓

S/N Ratio

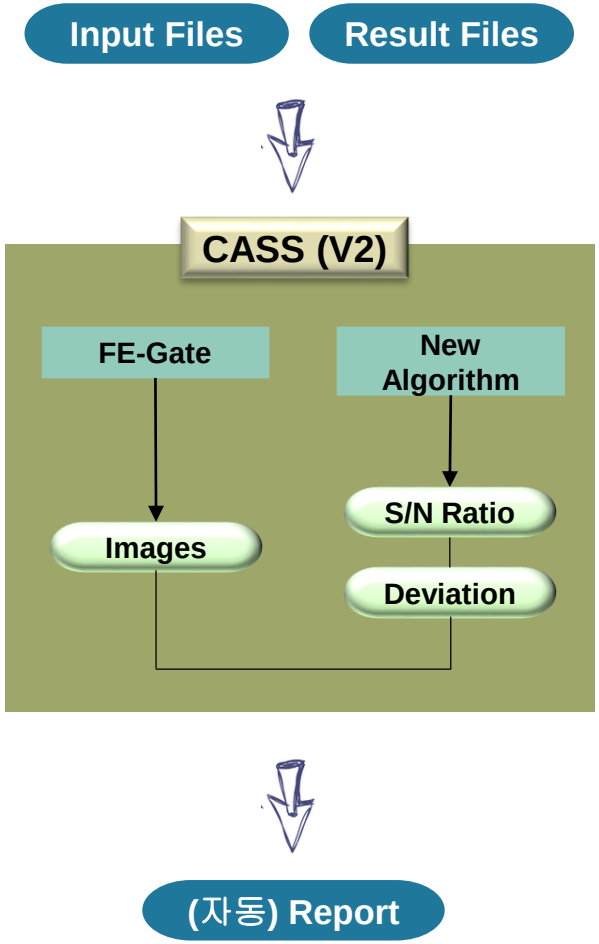
$$S/N = \eta_{dB} = 10 \times \log\left(\frac{\bar{y}^2}{\sigma^2_{n-1}}\right)$$

- Static
  inpad / outpad 계산
- Dynamic
  inpad / outpad 계산

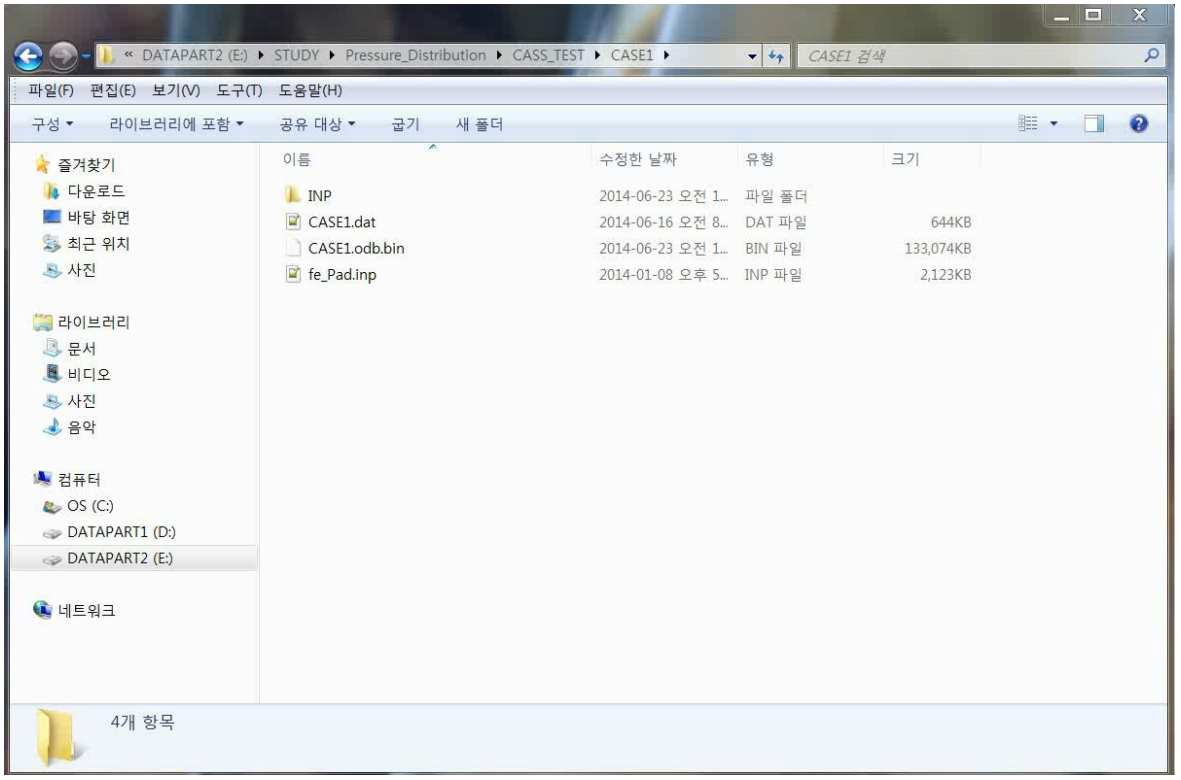
관련 동영상



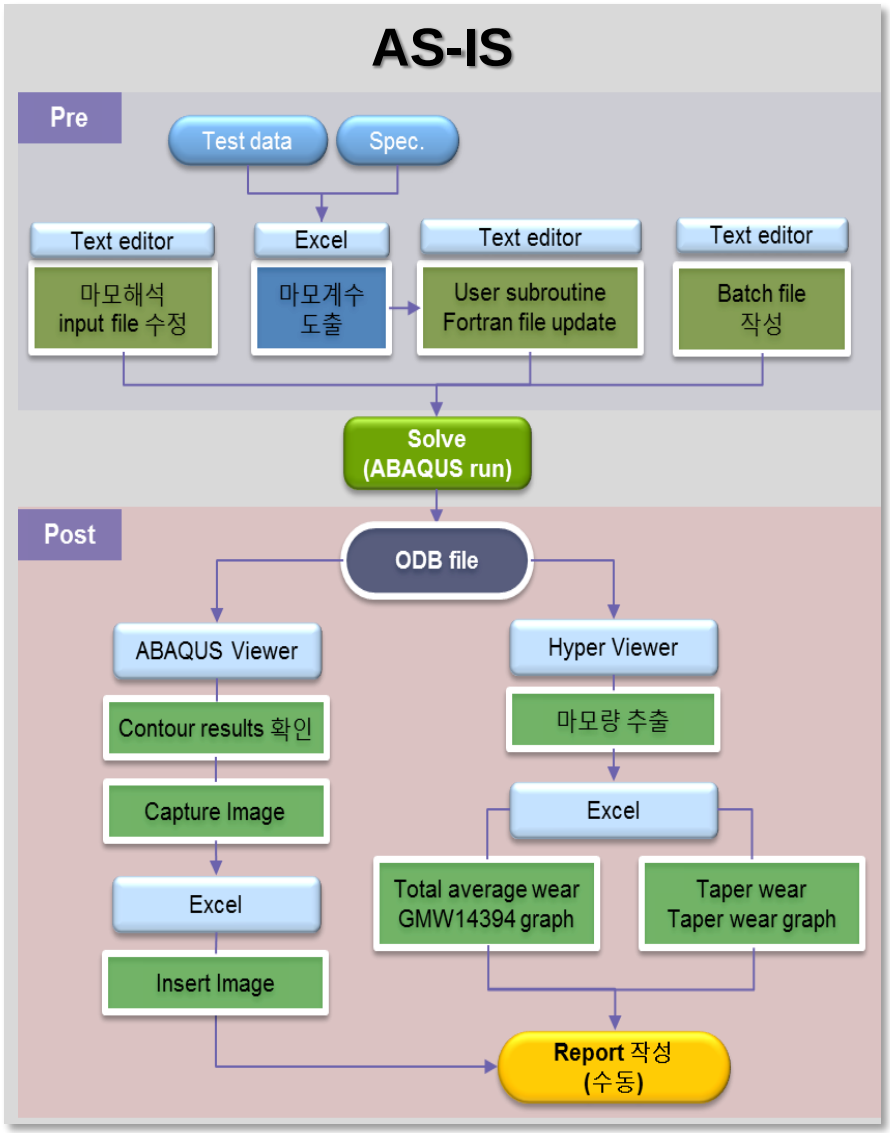
자동화된 해석 과정

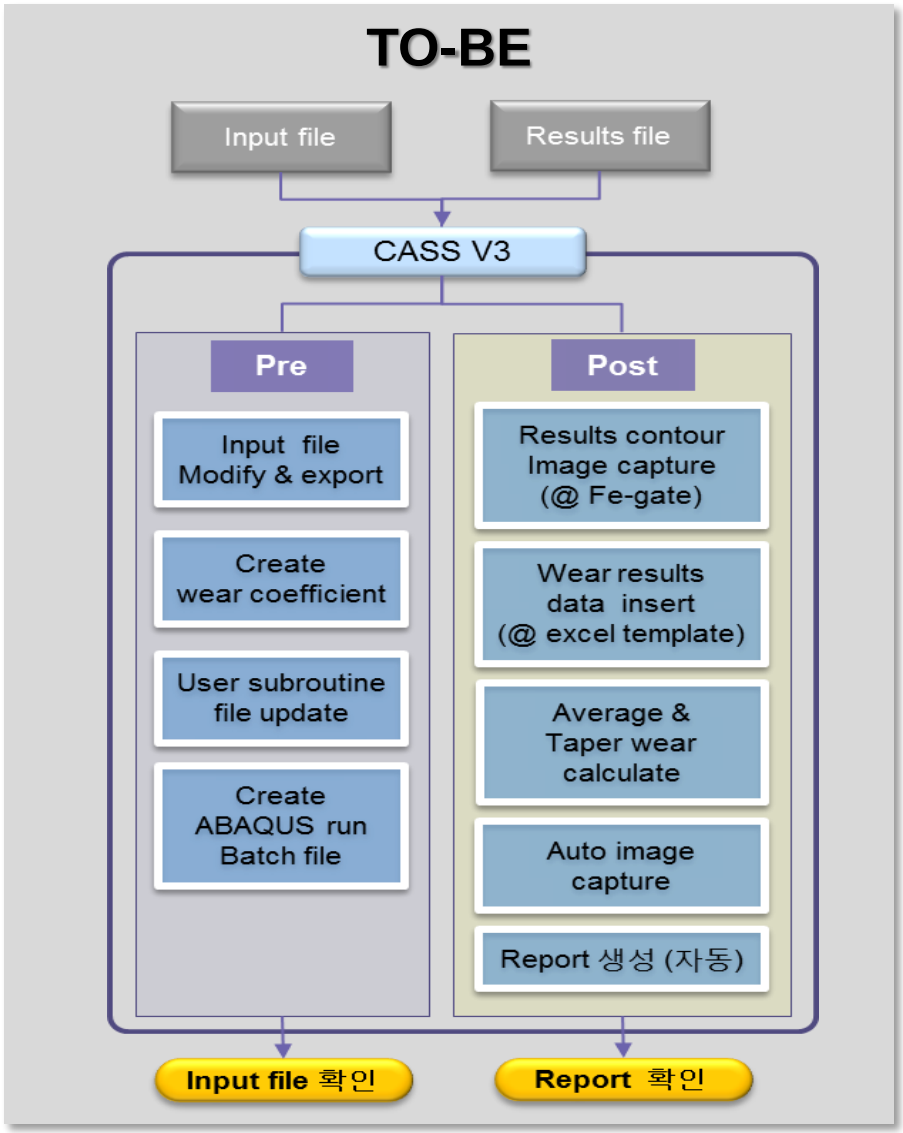


관련 동영상



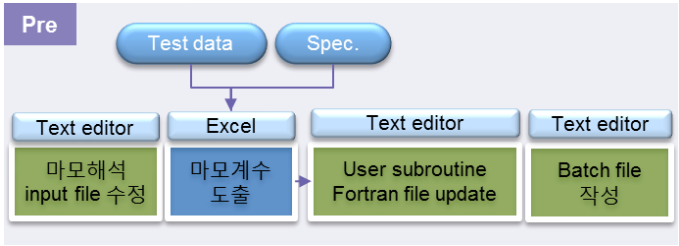
Taper Wear Analysis

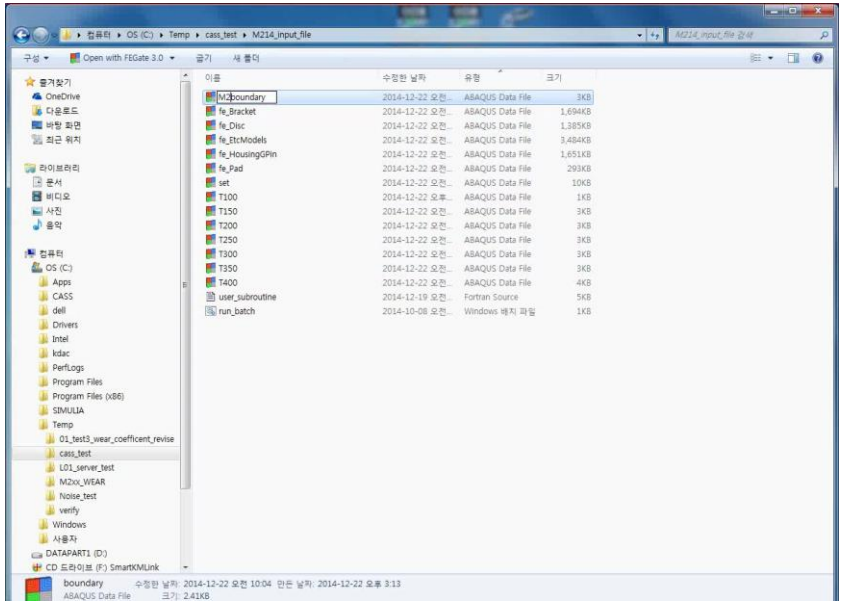




Brake Contact Pressure Analysis

AS-IS (Manual)

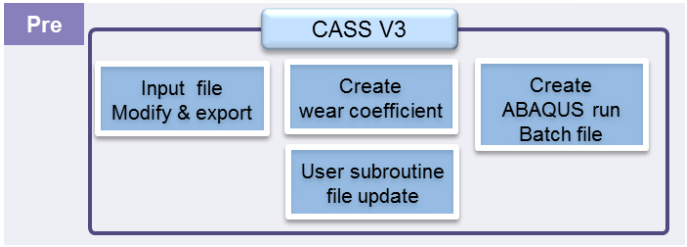


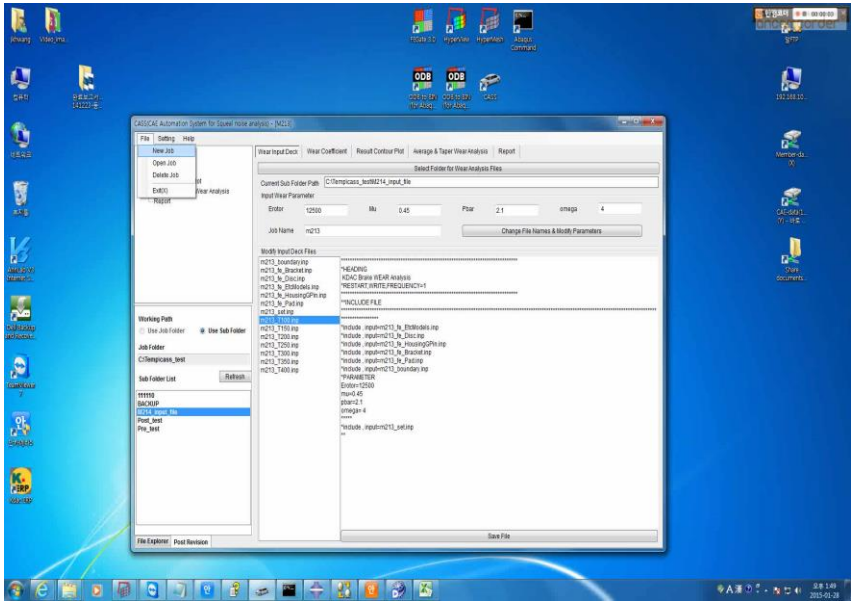


▶ Manual Method를 이용한 Pre-Process 수행 과정

☞ Text editor를 이용하여 수작업으로 input file의 내용 (Include file, parameter등)을 수정함.
☞ 마모시험 data를 이용하여 excel에서 마모계수를 도출하고, text editor를 이용하여 user subroutine file의 내용을 수정함.
☞ Solving을 위한 batch file 수정 작업을 수작업으로 진행.

TO-BE (Automation)



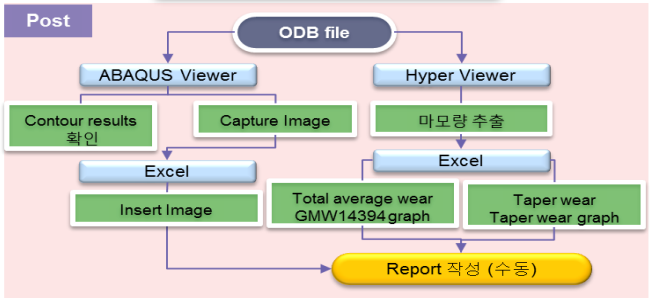


▶ 자동화 프로그램(CASS)를 이용한 Pre-Process 수행 과정

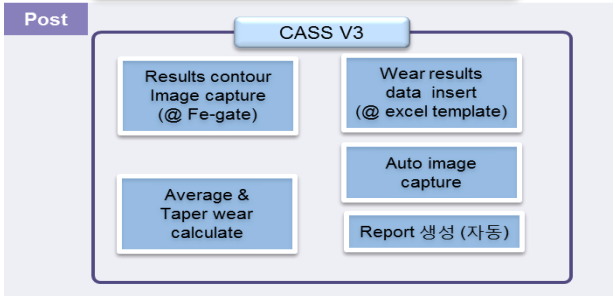
☞ Parameter 값을 user가 입력하면 input file의 내용을 자동으로 수정하고, 마모시험 data를 이용하여 마모계수 도출, user subroutine file, batch file 생성 작업이 자동으로 진행 됨.

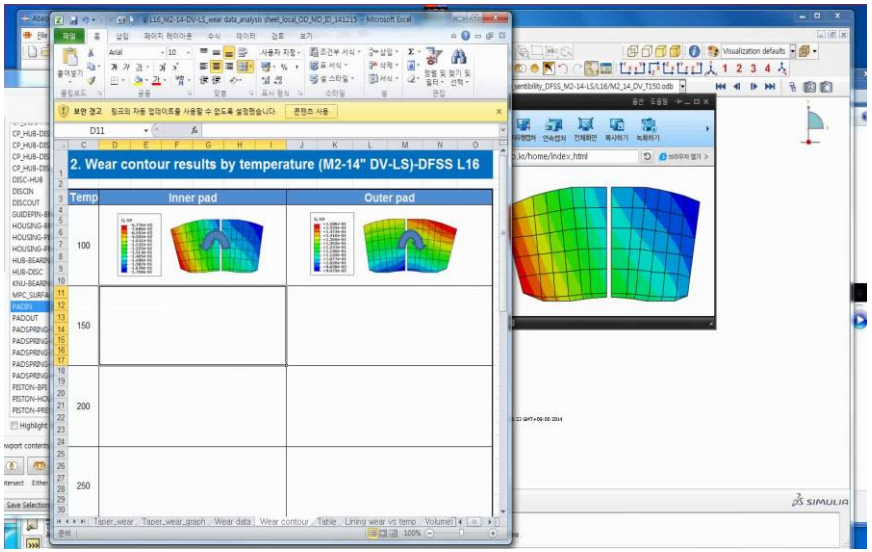
Brake Contact Pressure Analysis

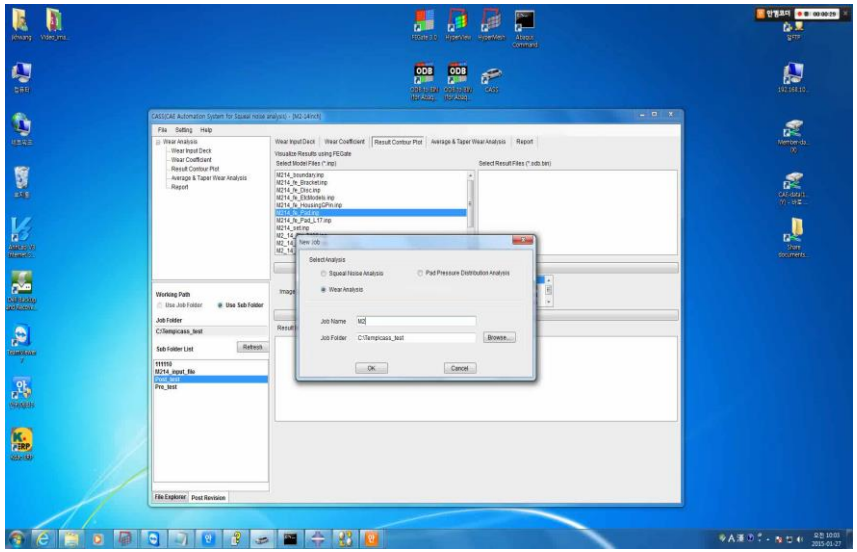
AS-IS (Manual)



TO-BE (Automation)







▶ Manual Method를 이용한 Post Process 수행 과정

☞ 온도별 패드 마모 해석 contour 결과 image를 수작업으로 capture하여 excel template file에 붙여 넣음.
☞ Pad(Inner/outer) node에서의 wear 결과값을 수작업으로 추출하여 taper wear 분석을 위한 excel template file에 붙여 넣음.
☞ Excel template file의 image, graph 및 마모결과 값을 이용하여 수작업으로 report를 작성함.

▶ 자동화 프로그램(CASS)를 이용한 Post Process 수행 과정

☞ 자동으로 pad wear contour 결과 image capture, wear data 추출하여 average wear 와 taper wear 결과 도출을 위한 excel template file과 PPT report를 생성함.

Benefit from Brake Simulation System

Squeal Noise Analysis

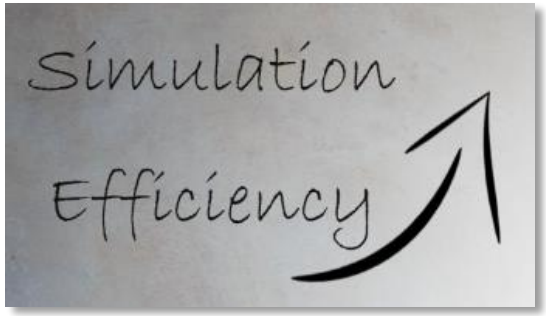
연간 절감 효과
450 hrs
(50 working days)

Pad Contact Pressure Analysis

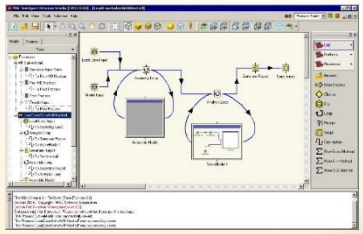
연간 절감 효과
300 hrs
(33 working days)

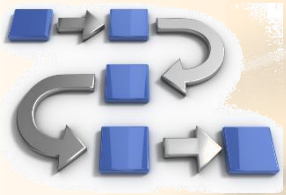
Benefit from Brake Simulation System

- Improved engineering reusability
  - Data management standardized
  - Full pedigree of data managed
- Increased engineering throughput
  - Reduce simulation turn-around time
  - More engineering cycles to do more complex tasks
  - Increase simulation throughput
- Protect and retain corporate IP (Knowledge, Methods, Data, Etc)



Path to Future State of Kdac CAE





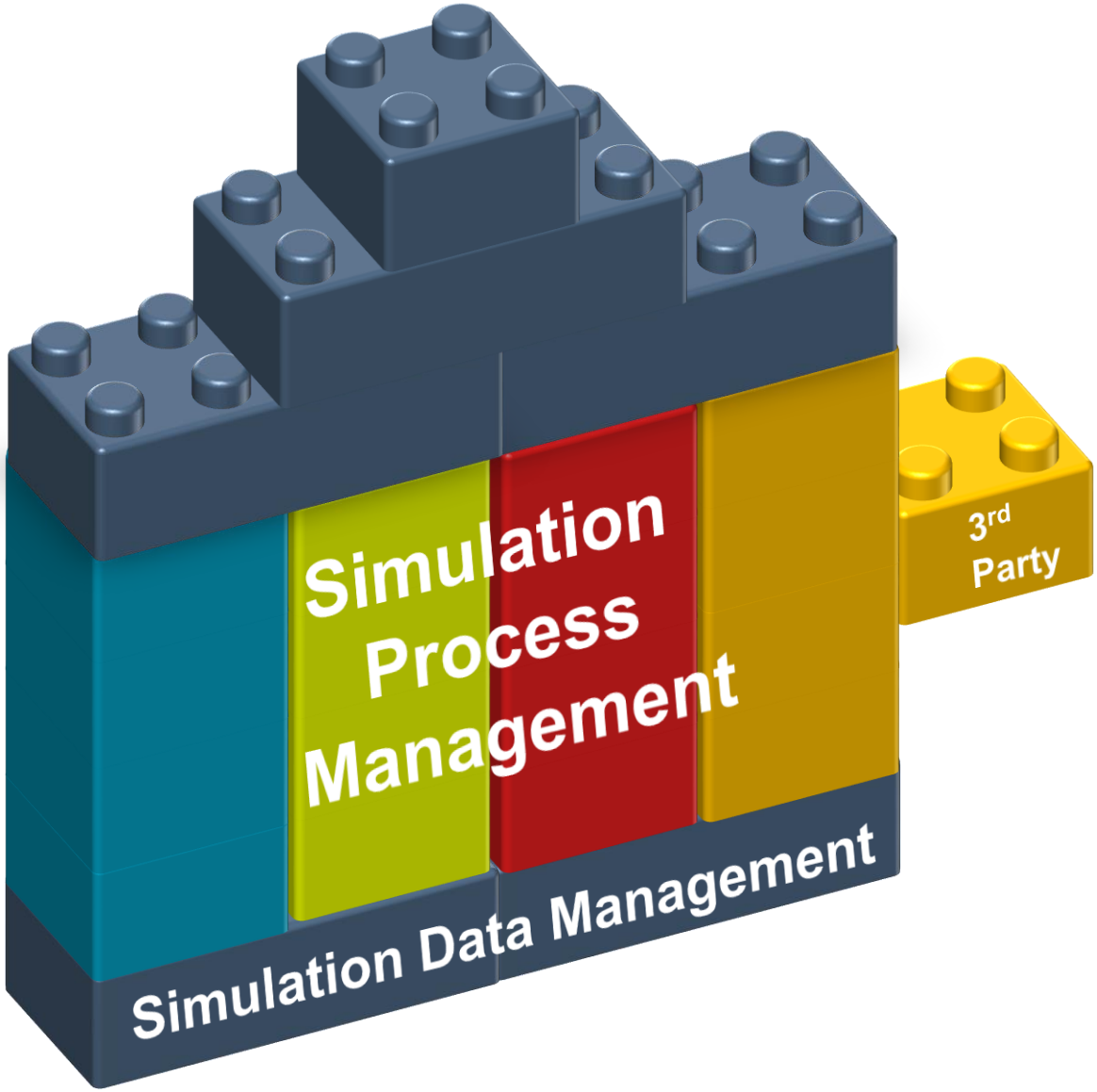
Simulation
Process
Data
Management

Task Automation

Standardization

Best Practice

Future State of Kdac CAE



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