

# VIRTUAL ECU

ANSYS BEST PRACTICE SESSION:  
„SIMULATION DRIVEN PRODUCT DEVELOPMENT FOR EVERYONE“

DANIEL KRÄTSCHMER  
FRIEDERIKE LOERKE

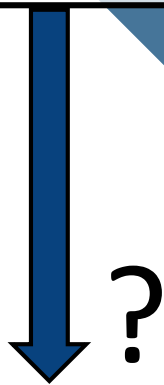
CASCON 2019



# Simulation Process Management: Virtual ECU

## Motivation

Load derivation from a system perspective



Cut out design element  
for product integration

load / load  
capacity level

Reliability Assessments

geometry-independent  
design rule, e.g.  $\sigma \leq \sigma_{max}$

stress / strength  
level

Level 0



System:  
Vehicle

Level 1



Sub-System:  
RB system  
(e.g. injection  
system)

Level 2



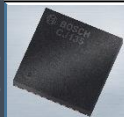
Manufactured  
Item:  
ECU

Level 3



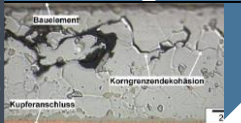
Assembly

Level 4



Component

Level 5



Material,  
Interface

How to establish a robust data / information exchange between product-independent design element assessments & product-specific load derivation and load path design?

### Motivation

- ▶ Only with standardized load path methods transparent requirements for design elements can be derived
- ▶ Standardized load path methods as enabler for tool based, automatized evaluation of design elements in mechanical architectures

# Simulation Process Management: Virtual ECU

## Motivation

Load derivation from a system perspective

Automated setup of ECU models to feed reliability models with needed information

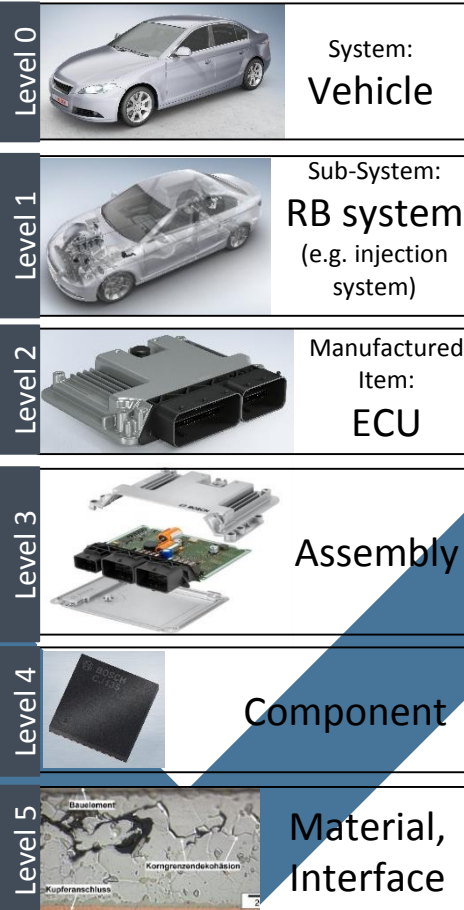
Cut out design element for product integration

load / load capacity level

Hosting of detailed reliability models

geometry-independent design rule, e.g.  $\sigma \leq \sigma_{max}$

stress / strength level



- Democratization in CAE-based product development means to empower non-experts to take advantage from simulation technology
- CAE experts could put the power of simulation safely into non-experts hands to overcome the general lack of CAE engineers

## Democratization ?

# Simulation Process Management: Virtual ECU Outline

- ▶ Motivation
- ▶ Our journey to Simulation Process Management (SPM)
  - ▶ Drive ANSYS via Microsoft Excel / GUI
  - ▶ Process Automation & ANSYS WB Scripting by ACT
- ▶ Simulation Process Management
  - ▶ SPM Framework “Concert Hall” by Dynardo GmbH
- ▶ Virtual (Assembly of) ECU as automated solution for load derivation
  - ▶ “Deep-Dive” in customized workflow
- ▶ Outlook and Summary

# Simulation Process Management: Virtual ECU

## Our journey to Simulation Process Management



### Drive ANSYS via Excel / GUI

- ▶ APDL Scripting
  - Excel-Front-End
  - MATLAB & python GUI

2012

# Simulation Process Management: Virtual ECU Drive ANSYS via Microsoft Excel: smart-TC

APDL-Driven ANSYS Backend



VBA-Driven MS Excel-Frontend

**BOSCH**

Project: Test Run

smart-TC

[Back] [Cancel] [OK] [Print] [Help]

Options

Sensitivity Study

? Confirmation state

Import COES model

No co-simulation with

Layer	Material	Length L [mm]	Width W [mm]	Height H [μm]	Thermal conductivity κ [W/m.K]	Heat capacity c [J/kg.K]	Density ρ [g/cm³]	Position x [mm]	Position y [mm]	Power loss Pw [W]
Layer 1	Silicium	4.5	4.5	175	100	795	2.33	210.2	101.3	8.7
Layer 2	LowDielectricSi	10	10	100	30	1000	1	207.8	99	
Layer 3	Cu (DBCL)	10	10	300	395	1000	1	207.8	99	
Layer 4	AlN33 gasperized	10	10	300	22	1000	1	207.8	99	
Layer 5	Cu (DBCL)	10	10	300	395	1000	1	207.8	99	
Layer 6	WLM Shuntum	10	10	100	2.5	1000	2.85	207.8	99	
Layer 7										
Layer 8										

Layer	Material	Length L [mm]	Width W [mm]	Height H [μm]	Thermal conductivity κ [W/m.K]	Heat capacity c [J/kg.K]	Density ρ [g/cm³]	Position x [mm]	Position y [mm]	Power loss Pw [W]
Layer 1	Silicium	4.5	4.5	175	100	795	2.33	224.2	101.2	8.7
Layer 2	LowDielectricSi	10	10	100	30	1000	1	220.8	99	
Layer 3	Cu (DBCL)	10	10	300	395	1000	1	220.8	99	
Layer 4	AlN33 gasperized	10	10	300	22	1000	1	220.8	99	
Layer 5	Cu (DBCL)	10	10	300	395	1000	1	220.8	99	
Layer 6	WLM Shuntum	10	10	100	2.5	1000	2.85	220.8	99	
Layer 7										
Layer 8										

Layer	Material	Length L [mm]	Width W [mm]	Height H [μm]	Thermal conductivity κ [W/m.K]	Heat capacity c [J/kg.K]	Density ρ [g/cm³]	Position x [mm]	Position y [mm]	Power loss Pw [W]
Layer 1	Silicium	4.5	4.5	175	100	795	2.33	224.2	101.8	8.7
Layer 2	LowDielectricSi	10	10	100	30	1000	1	220.8	106.6	
Layer 3	Cu (DBCL)	10	10	300	395	1000	1	220.8	106.6	
Layer 4	AlN33 gasperized	10	10	300	22	1000	1	220.8	106.6	
Layer 5	Cu (DBCL)	10	10	300	395	1000	1	220.8	106.6	
Layer 6	WLM Shuntum	10	10	100	2.5	1000	2.85	220.8	106.6	
Layer 7										
Layer 8										

Layer	Material	Length L [mm]	Width W [mm]	Height H [μm]	Thermal conductivity κ [W/m.K]	Heat capacity c [J/kg.K]	Density ρ [g/cm³]	Position x [mm]	Position y [mm]	Power loss Pw [W]
Layer 1	Silicium	6.5	6.5	175	100	795	2.33	210.2	101.8	16.36
Layer 2	LowDielectricSi	10	10	100	30	1000	1	207.8	109.3	
Layer 3	Cu (DBCL)	10	10	300	395	1000	1	207.8	109.3	
Layer 4	AlN33 gasperized	10	10	300	22	1000	1	207.8	109.3	
Layer 5	Cu (DBCL)	10	10	300	395	1000	1	207.8	109.3	
Layer 6	WLM Shuntum	10	10	100	2.5	1000	2.85	207.8	109.3	
Layer 7										
Layer 8										

Layer	Material	Length L [mm]	Width W [mm]	Height H [μm]	Thermal conductivity κ [W/m.K]	Heat capacity c [J/kg.K]	Density ρ [g/cm³]	Position x [mm]	Position y [mm]	Power loss Pw [W]
Layer 1	Silicium	6.5	6.5	175	100	795	2.33	210.2	101.8	16.36
Layer 2	LowDielectricSi	10	10	100	30	1000	1	207.8	109.3	
Layer 3	Cu (DBCL)	10	10	300	395	1000	1	207.8	109.3	
Layer 4	AlN33 gasperized	10	10	300	22	1000	1	207.8	109.3	
Layer 5	Cu (DBCL)	10	10	300	395	1000	1	207.8	109.3	
Layer 6	WLM Shuntum	10	10	100	2.5	1000	2.85	207.8	109.3	
Layer 7										
Layer 8										

Layer	Material	Length L [mm]	Width W [mm]	Height H [μm]	Thermal conductivity κ [W/m.K]	Heat capacity c [J/kg.K]	Density ρ [g/cm³]	Position x [mm]	Position y [mm]
Layer 1	Al (DBA)	50	50	6.00E+02	210	896	2.7	195	90
Layer 2									
Layer 3									
Layer 4									
Layer 5									
Layer 6									
Layer 7									
Layer 8									

TIC1

a [μm²/s]

Convection at highest area / top side

0

0

Convection at inner surface

0

0

Convection at sides of last linear area

0

0

Convection at bottom of heat sink

20

10000

Heat flux

1

Time / sec

1

At all x steps

Save as Template

Select a template from the dropdown

Co-Modelation

Basic

Material: AI (DBA)

Length L [mm]: 50

Width W [mm]: 50

Height H [μm]: 6.00E+02

Thermal conductivity κ [W/m.K]: 240

Heat capacity c [J/kg.K]: 896

Density ρ [g/cm³]: 2.7

Position x [mm]: 195

Position y [mm]: 90

Convection at highest area top side: 0

Convection at lowest area bottom side: 0

Convection at sides of last layer heat sink: 0

Convection at bottom of heat sink: 20

Heat factor: 1

Time / sec: 10000

7" after a slope

Save as Template

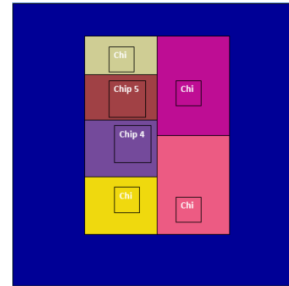
Download a template from the application

Go to Simulation

Preview Layout

Run Simulation

2th Simulation



```

*dim,n_s,array,n_c
*dim,n_1,array,n_c
*dim,a_s,array,n_c,num_comen_ctot
*dim,b_s,array,n_c,num_comen_ctot
*dim,d_s,array,n_c,num_comen_ctot
*dim,d_tot,array,n_c
*dim,nc,array,n_c
*dim,dtot,array,n_c

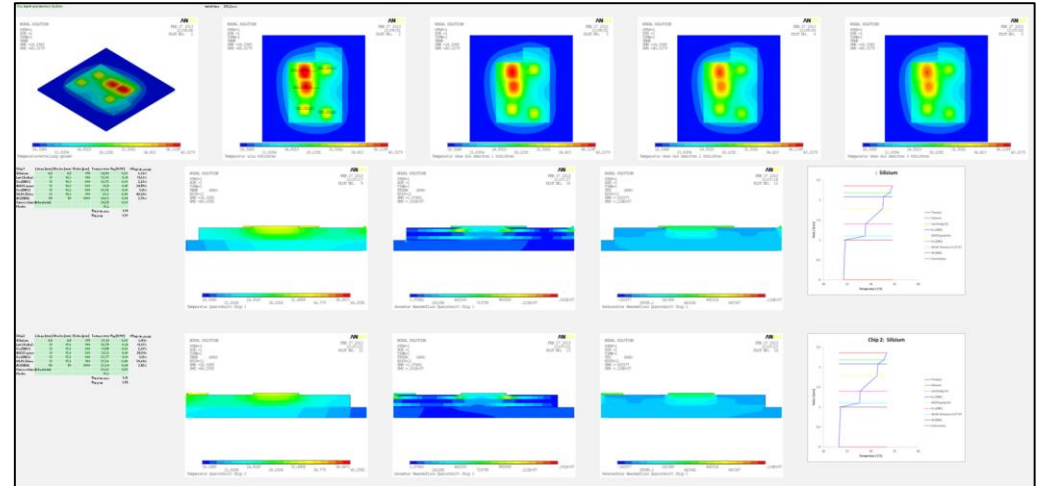
*dim,mpformtr,array,n_c,n_ctot
*dim,rtt,array,1,1
n_num=0

*do,1,1,n_c
start=startrt
if,Cylindr_start,eq,1,then
p_wq(1)=1e6*max(Kkstart,1e-20)/(3.141592654*0.25*Ckstart*Ckstart)
else
p_wq(1)=1e6*max(Kkstart,1e-20)/(Ckstart*Dkstart)
endif

p_min(1)=1e6*1e-16/(Ckstart*Dkstart)*(1+1e-8)
nc(1)=n_cnk
start=startrt+n_cnk-1
*do,k,1,n_cnk
if,n_cnk,gt,k,then
if,Kkstart,gt,0,then
*if,Cylindr_start,eq,1,then
p_wq(1)=1e6*max(Kkstart,1e-20)/(3.141592654*0.25*Ckstart*Ckstart)
else
p_wq(1)=1e6*max(Kkstart,1e-20)/(Ckstart*Dkstart)
endif
nc_h(1)=k
endif
endif
*endif

```

User Input defines APDL Code definition



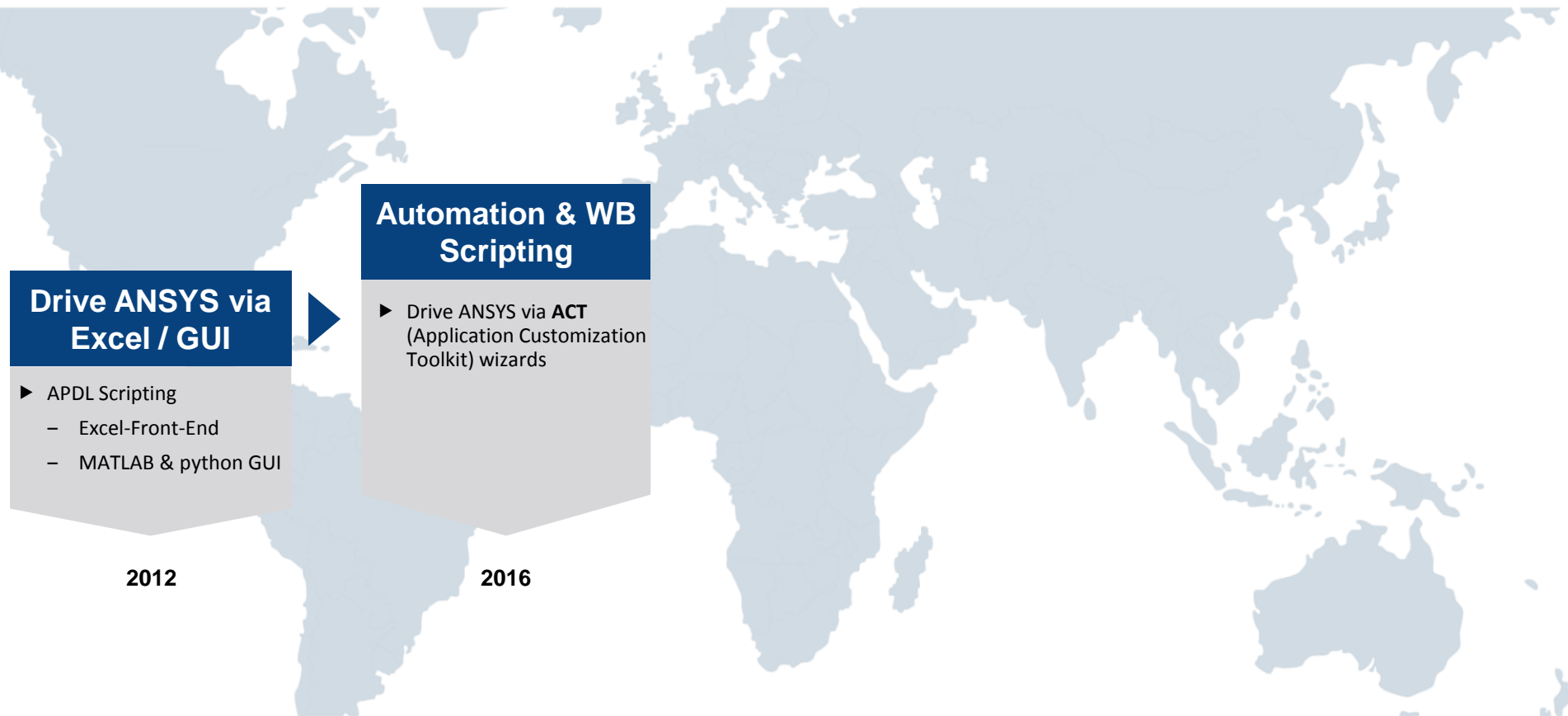
Excel-based user interface

Post processed Results visualized in Excel



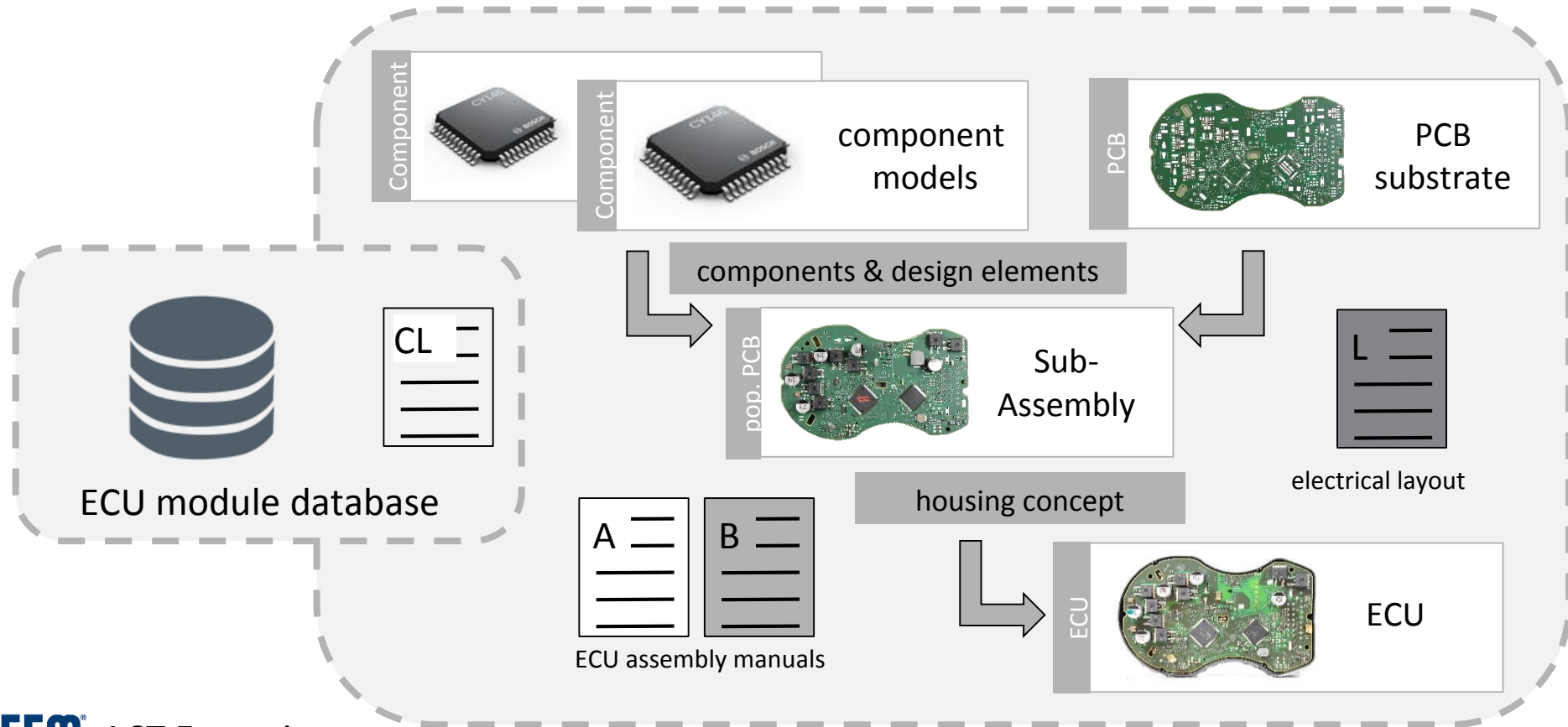
# Simulation Process Management: Virtual ECU

## Our journey to Simulation Process Management



# Simulation Process Management: Virtual ECU

## Virtual Assembly of PCB/ECU



**CADFE<sup>®</sup>** ACT Extension



# Simulation Process Management: Virtual ECU Virtual Assembly of PCBs / ECUs-ACT

CADFEM



ACT-Driven ANSYS-Frontend

ACT Wizard Programmierung: XML + Python + HTML

- **XML**: Konfiguration + GUI-Definition
- **Python**: Implementierung
- **HTML (optional)**: Benutzerhilfe

```
# step 1

def oninit(step):
    global _controller
    if _controller == None:
        _controller = controller.Controller(ExtAPI, step, globals())

def save_project_to(step):
    return _controller.save_project_to(step)

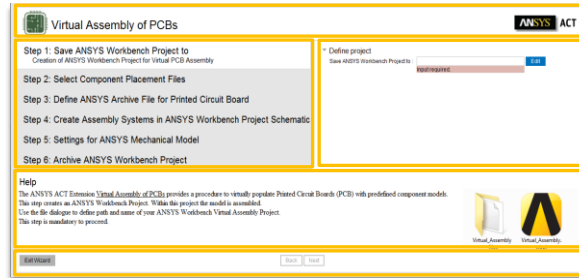
def reset_step1(step):
    return _controller.reset_step1(step)
```

```
<?xml version="1.0" context="Project" icon="wizard_icon">
<description>Project schematic wizard for virtual assembly of PCBs.</description>

<!-- step 1 -->
<step name="WorkbenchProjectCreation" caption="Step 1: Save ANSYS Workbench Project to" context="Project" version="1" HelpFile="help/project_save_as.html">
<description>Creation of ANSYS Workbench Project for Virtual PCB Assembly</description>

<callbacks>
  <oninit>oninit</oninit>
  <onupdate>save_project_to</onupdate>
  <onreset>reset_step1</onreset>
</callbacks>

<propertygroup name="step_1" display="caption" caption="Define project">
  <property name="save_project_to" caption="Save ANSYS Workbench Project to :*" control="custom" class="src.templates.file.FileSaveObj">
    <attributes filters="Workbench Project Files (*.wbproj);*.wbproj" buttonLabel="Browse"/>
  </property>
</propertygroup>
</step>
```



Virtual Assembly of PCBs

Step 1: Save ANSYS Workbench Project to

Step 2: Select Component Placement Files

Step 3: Define ANSYS Archive File for Printed Circuit Board  
Select the archive file for Printed Circuit Board (PCB)

Step 4: Create Assembly Systems in ANSYS Workbench  
Project Schematic

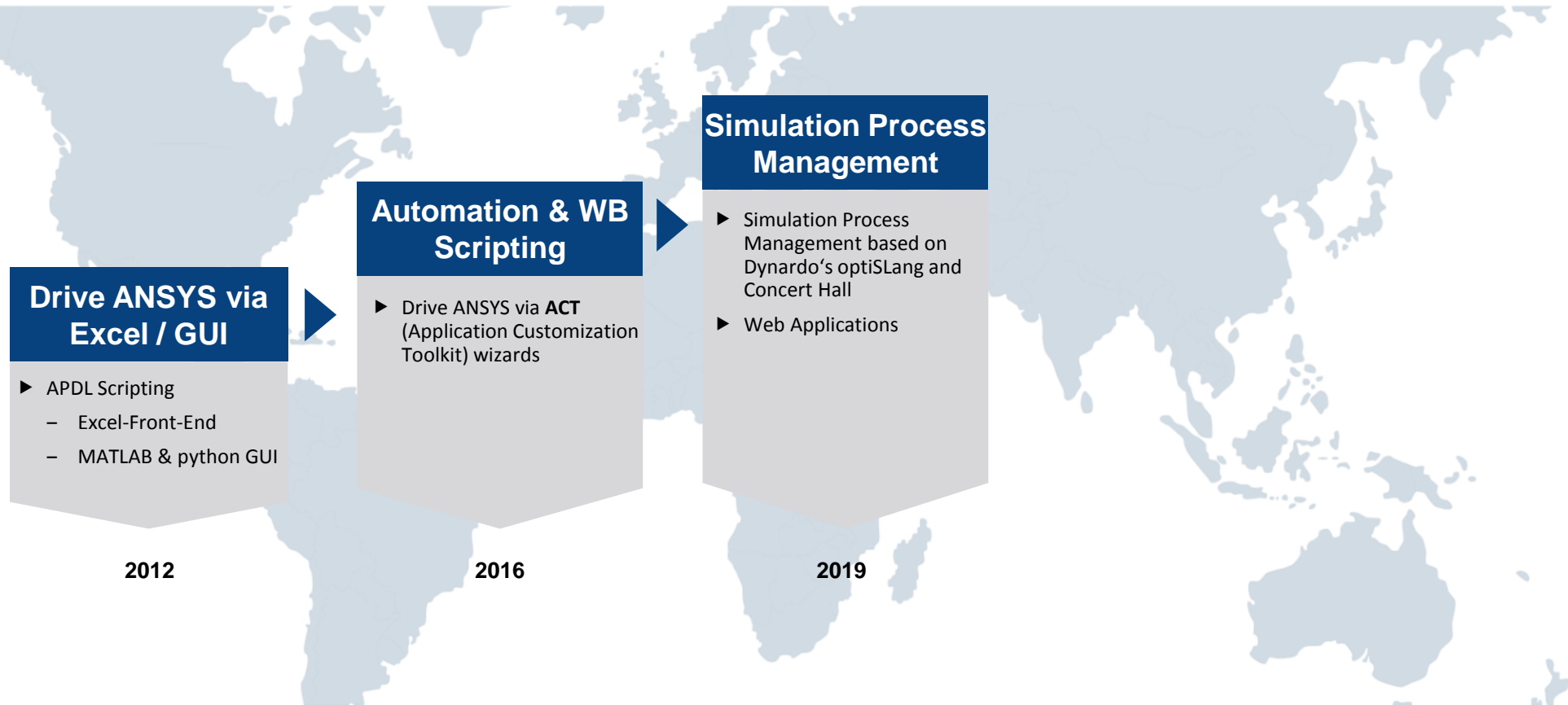
Step 5: Settings for ANSYS Mechanical Model

Step 6: Archive ANSYS Workbench Project

Krätschmer, D., Zhang, Y.: “Automatisierter Workflow zur modellbasierten Bauelementbestückung von Leiterplatten elektronischer Steuergeräte”,  
CADFEM ANSYS Simulation Conference 2017

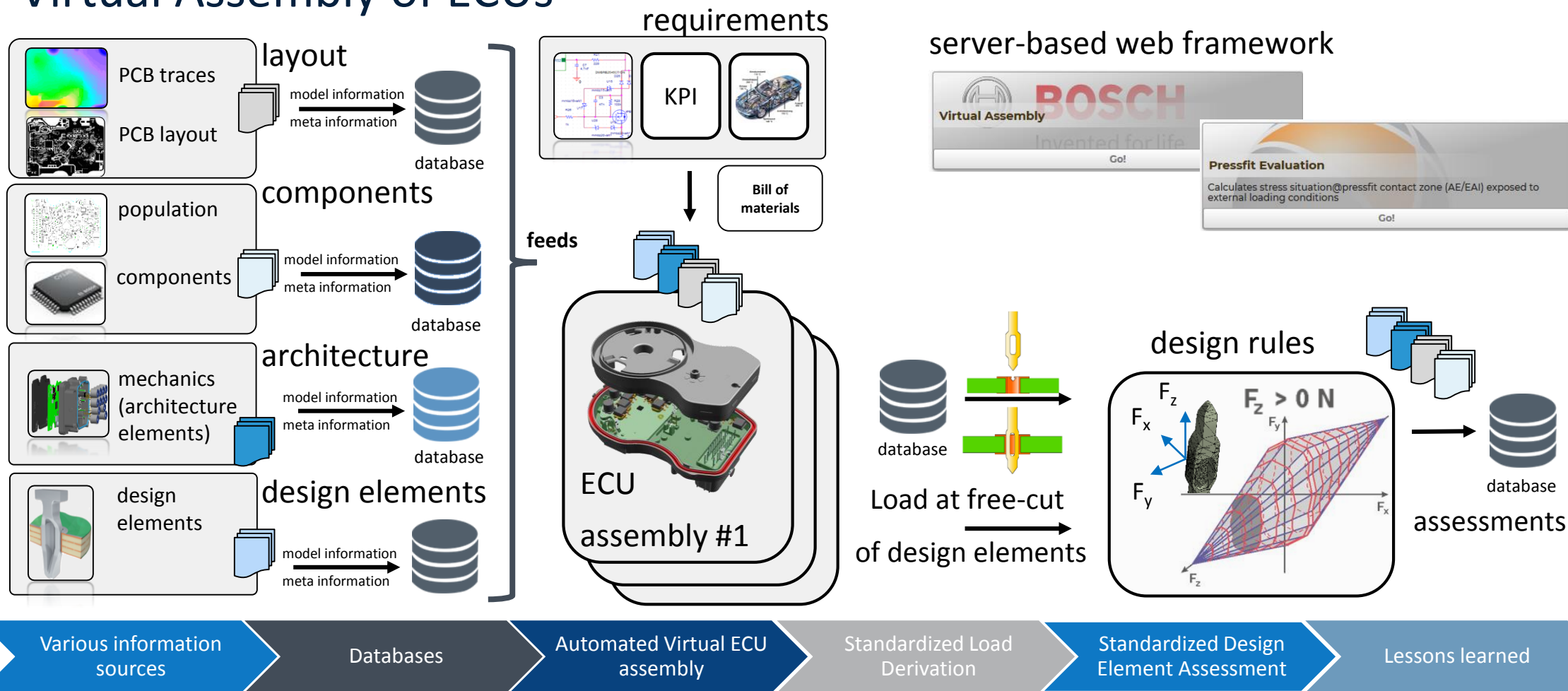
# Simulation Process Management: Virtual ECU

## Our journey to Simulation Process Management



# Simulation Process Management: Virtual ECU

## Virtual Assembly of ECUs



# Simulation Process Management: Virtual ECU SPM Framework



dynardo  
dynamic software & engineering

admin  
Logout



## RC-Network (Cauer Regression)

Provides Cauer-based RC-chain elements based on thermal behaviour

Go!

## Component Model Updating

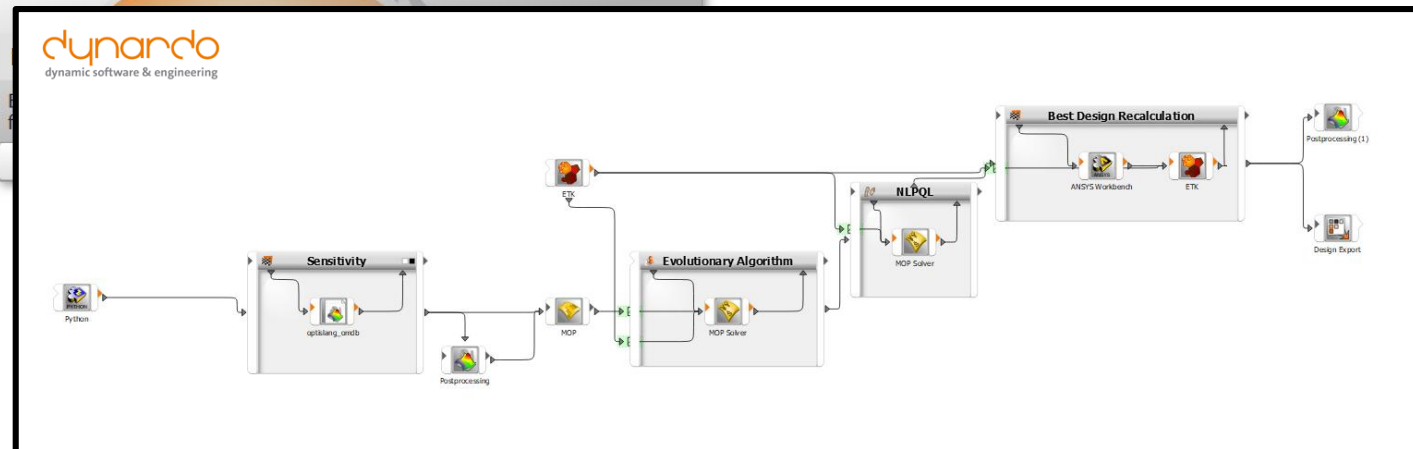
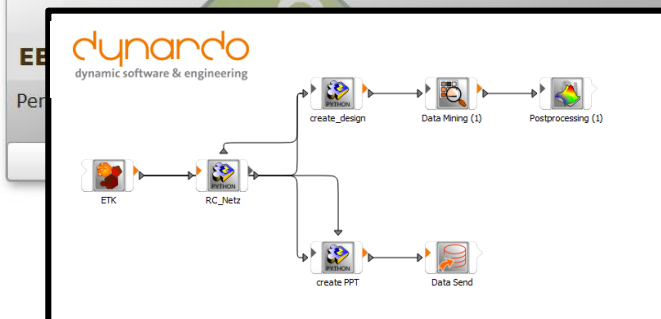
Performs Model Updating of electrical components

Go!

## EBS Thermal Assessment

Performs standardized Thermal Assessment for ESP Gen9.x & ESP Gen10

Go!



Dynardo's web framework hosts optiSLang projects offering user input and upload opportunities

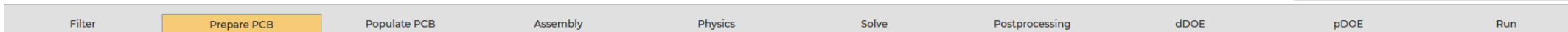
# Simulation Process Management: Virtual ECU

## Embedding and extension of ACT solution

Web-based provision of “Virtual Assembly of ECUs”



Step by step approach



Prepare PCB

Substrate

ESP\_Gen9\_3\_EV7I40\_C1  
pcb - ESP\_Gen9\_3\_46pol\_16HC1221C00000005  
ecad - 16HC1221C00000005\_1030L06568\_v01  
cpreport - CPR\_1030L06568\_v01

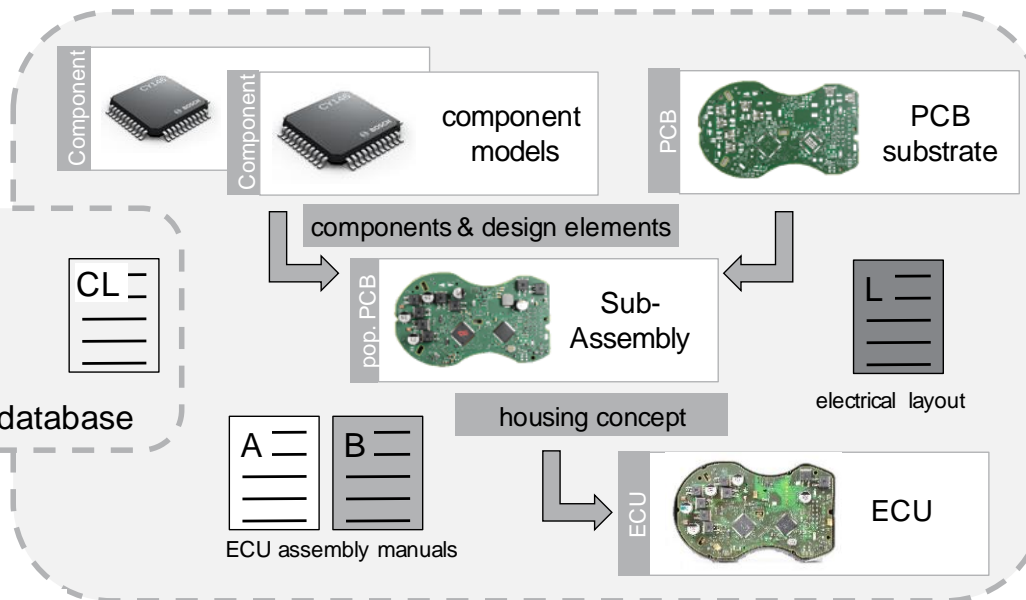
choose substrate

Components

ESP\_Gen9\_Gen10\_Components  
components - Thermal\_270248002  
components - Thermal\_270248006  
components - Thermal\_0272240286AA  
components - Thermal\_2261098422T  
components - Thermal\_2261098423T  
components - Thermal\_2261098507T  
components - Thermal\_8909002288  
components - Thermal\_8909003608  
components - Thermal\_8909003680  
components - Thermal\_8909003704  
components - Thermal\_8909004443  
components - Thermal\_8909004600  
components - Thermal\_8909005344  
components - Thermal\_8909006289  
components - Thermal\_8909008656  
components - Thermal\_126737518  
components - Thermal\_126737519  
components - Thermal\_8909004442  
components - Thermal\_1267375251  
components - Thermal\_8909005638  
components - Thermal\_8909006290  
components - Thermal\_8909003190  
components - Thermal\_8909B01907  
components - Thermal\_1270E3546601T  
components - Thermal\_1270E3546501  
components - Thermal\_1270E3558301T  
components - Thermal\_8909006510

ready to use for  
**everyone**

choose components



knowledge provided by  
**experts**

Prepare PCB

Populate PCB

Assembly

Load Case

Solve

Post-processing

Mission: CAE workflows are fully covered by SPM based on standardized database-hosted modules

# Simulation Process Management: Virtual ECU

**CADFEM**<sup>®</sup>

**dynardo**  
dynamic software & engineering

**ANSYS**<sup>®</sup>

Automotive Electronics | AE/EBS | 2019-08-07

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# Simulation Process Management: Virtual ECU

## Embedding and extension of ACT solution

Web-based provision of “Virtual Assembly of ECUs”



admin  
Logout ⓘ ?



Prepare PCB

Substrate

ESP\_Gen9\_3\_EV7I40\_C1

pcb - ESP\_Gen9\_3\_46pol\_16HC1221C00000005  
ecad - 16HC1221C000000005\_1030L06568\_v01  
cpreport - CPR\_1030L06568\_v01



Components

ESP\_Gen9\_Gen10\_Components

components - Thermal\_270248002  
components - Thermal\_270248006  
components - Thermal\_0272240286AA  
components - Thermal\_2261098422T  
components - Thermal\_2261098423T  
components - Thermal\_2261098507T  
components - Thermal\_8909002288  
components - Thermal\_8909003608  
components - Thermal\_8909003680  
components - Thermal\_8909003704  
components - Thermal\_8909004443  
components - Thermal\_8909004600  
components - Thermal\_8909005344  
components - Thermal\_8909006289  
components - Thermal\_8909008656  
components - Thermal\_126737518  
components - Thermal\_126737519  
components - Thermal\_8909004442  
components - Thermal\_1267375251  
components - Thermal\_8909005638  
components - Thermal\_8909006290  
components - Thermal\_8909003190  
components - Thermal\_8909007907  
components - Thermal\_1270E3546601T  
components - Thermal\_1270E3546501  
components - Thermal\_1270E3558301T  
components - Thermal\_8909006510



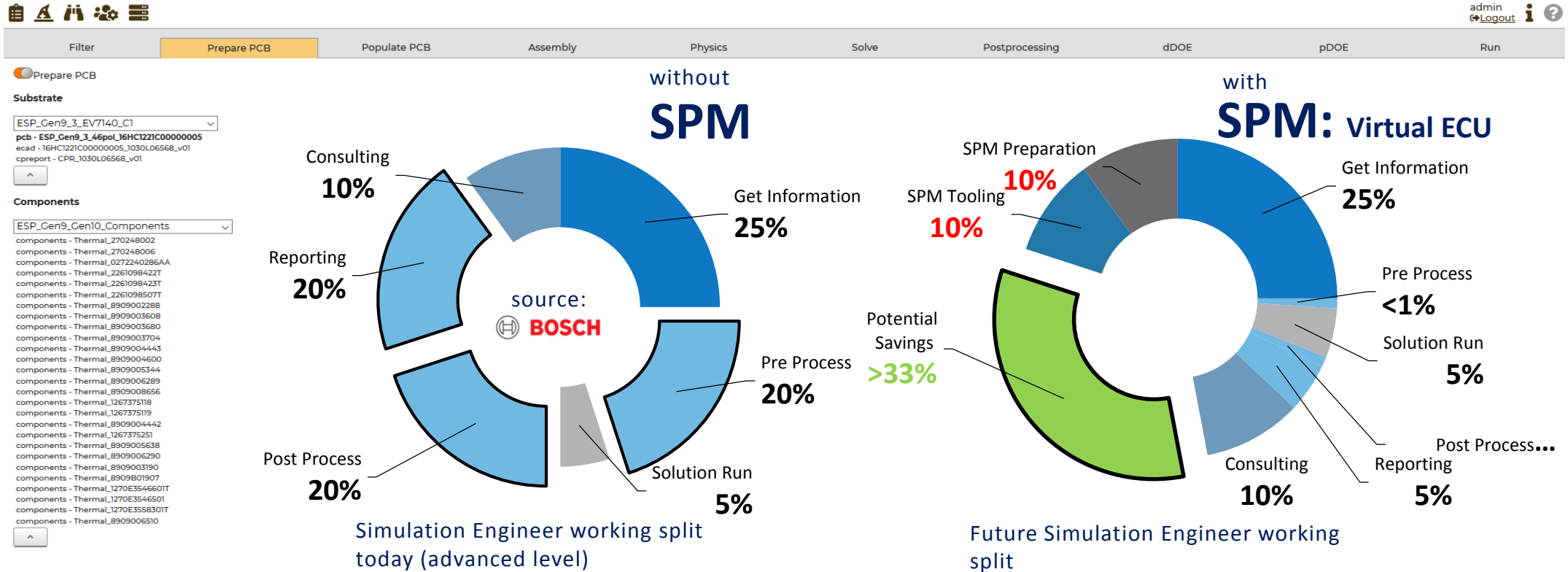
- ▶ Approach to host CAE engineering workflows by central web-service ready to use for AE associates
- ▶ CAE Apps serve as baseline for highly standardized design element reliability assessments in ECU architectures
- ▶ CADFEM-provided CAE workflow for general ECU-related simulations embedded in Simulation Process Management (SPM)-Framework
- ▶ ACT-programming as a software project (architecture, documentation, testing,...)
- ▶ Scalable framework solution ready to be extended by additional ANSYS modules

Relevant CAE workflows are fully covered by SPM based on standardized database-hosted modules

# Simulation Process Management: Virtual ECU

## Effect of Digital Transformation in CAE Engineering

Web-based provision of CAE Engineering workflows



Automation of time-consuming tedious tasks promises efficiency gains of 33% (mid-term perspective)

# Simulation Process Management: Virtual ECU

## Outlook

Load derivation from a system perspective

Automated setup of ECU models to feed reliability models with needed information

Cut out design element for product integration

load / load capacity level

Hosting of detailed reliability models

geometry-independent design rule, e.g.  $\sigma \leq \sigma_{max}$

stress / strength level

Level 0



System:  
Vehicle

Level 1



Sub-System:  
RB system  
(e.g. injection system)

Level 2



Manufactured Item:  
ECU

Level 3



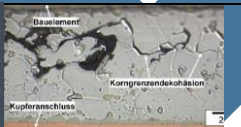
Assembly

Level 4



Component

Level 5



Material,  
Interface

- Democratization in CAE-based product development means to empower non-experts to take advantage from simulation technology
- CAE experts could put the power of simulation safely into non-experts hands to overcome the general lack of CAE engineers

Democratization !

# Simulation Process Management: Virtual ECU Outlook & Summary



Any Questions?

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