dynardo
dynamic software & engineering

optiSLang & digital twins

Calibration of measured data

WOST2017

Daniel Arnold

David Schneider

optiSLang & digital twins

Calibration of measured data

Outline

1. Define the Calibration Task

2. Digital Twin
   – get in touch real-world and simulation –

3. Operation
   – speed up simulation –

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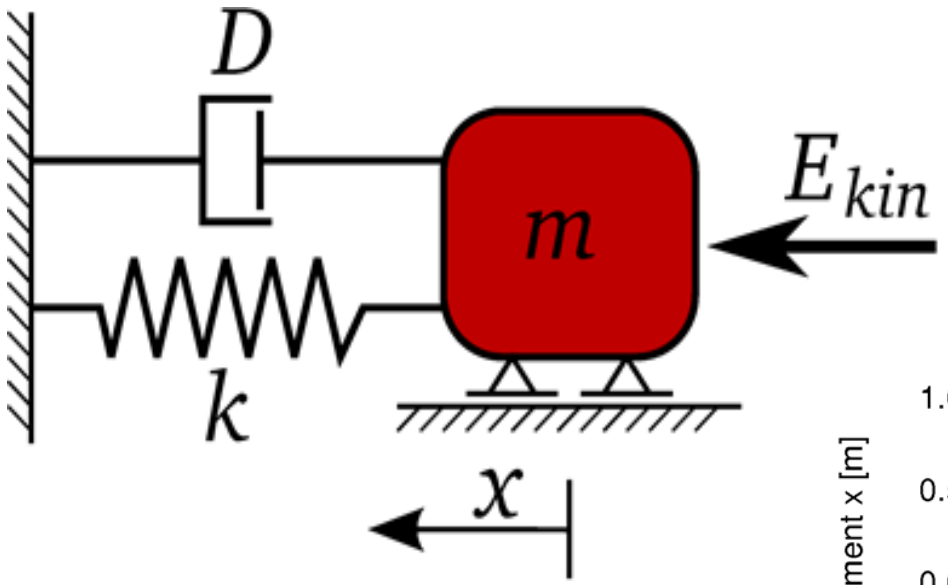
Task

System calibration of a rotating machine

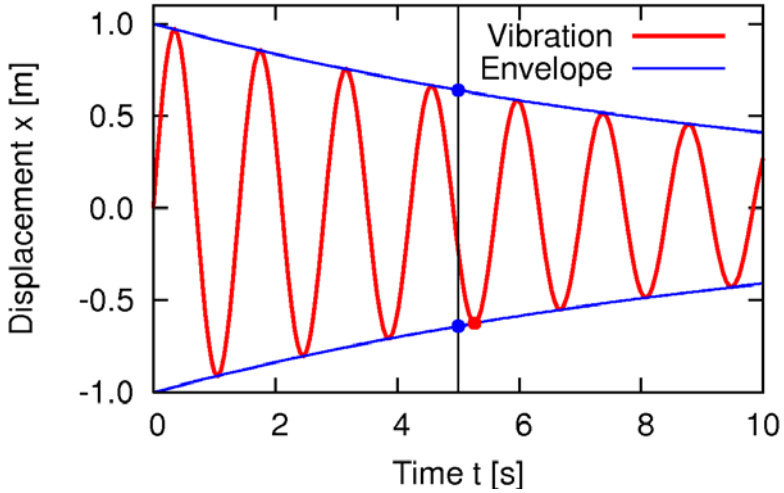
Example: Oscillator should be illustrate a simple rotating machine

- Parametric simulation model



$$m \in [0.1;\ 5.0\ \text{kg}]$$
$$k \in [10;\ 50\ \text{N/m}]$$
$$D \in [0.01;\ 0.05]$$
$$E_{kin} \in [10;\ 100\ \text{Nm}]$$

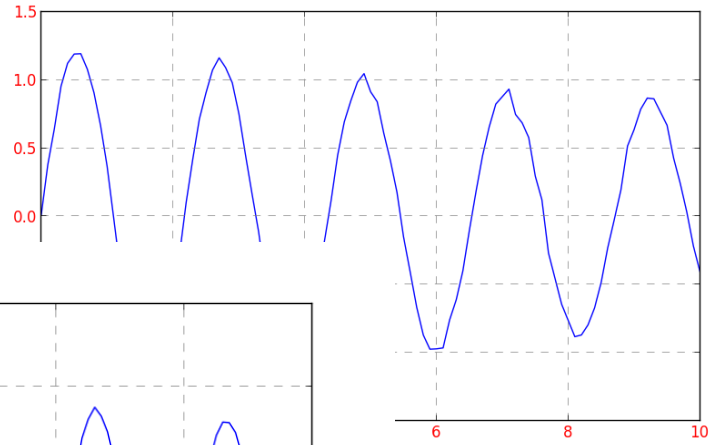
- "machine" response

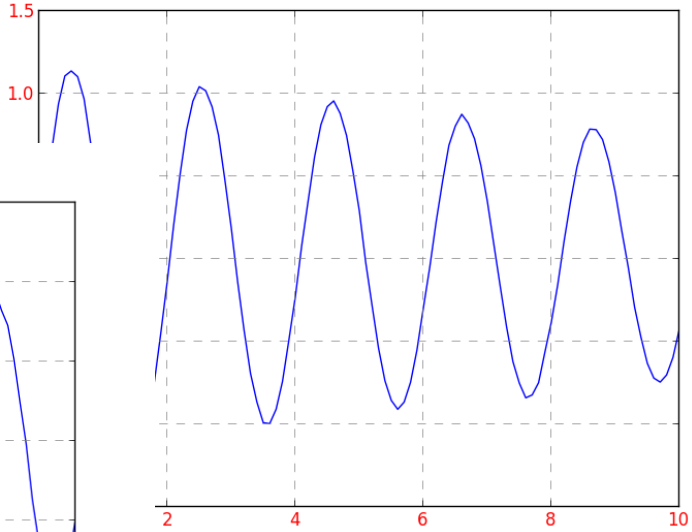


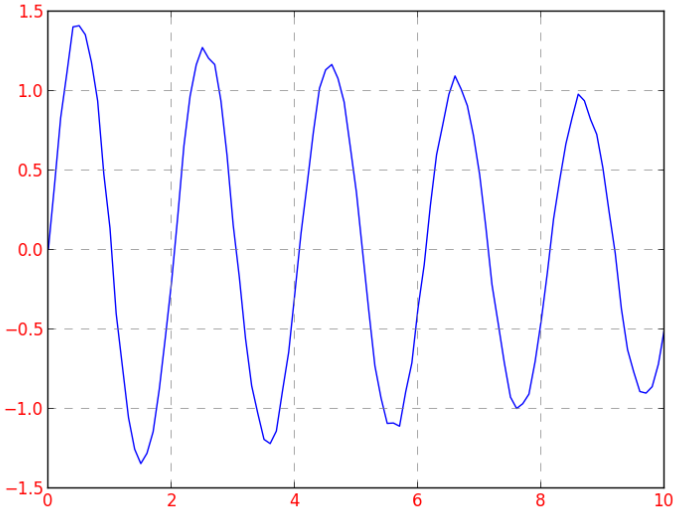
Example: Sensor data

- Illustration different machine conditions:

  measurement of a time-dependent oscillation







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Simplified machine conditions

→ Energy

→ Mass

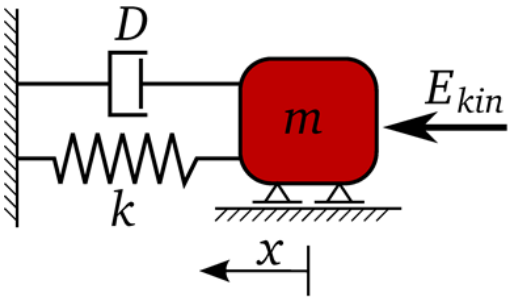
→ Stiffness

→ Damping

} machine condition needs to be controlled for maintenance

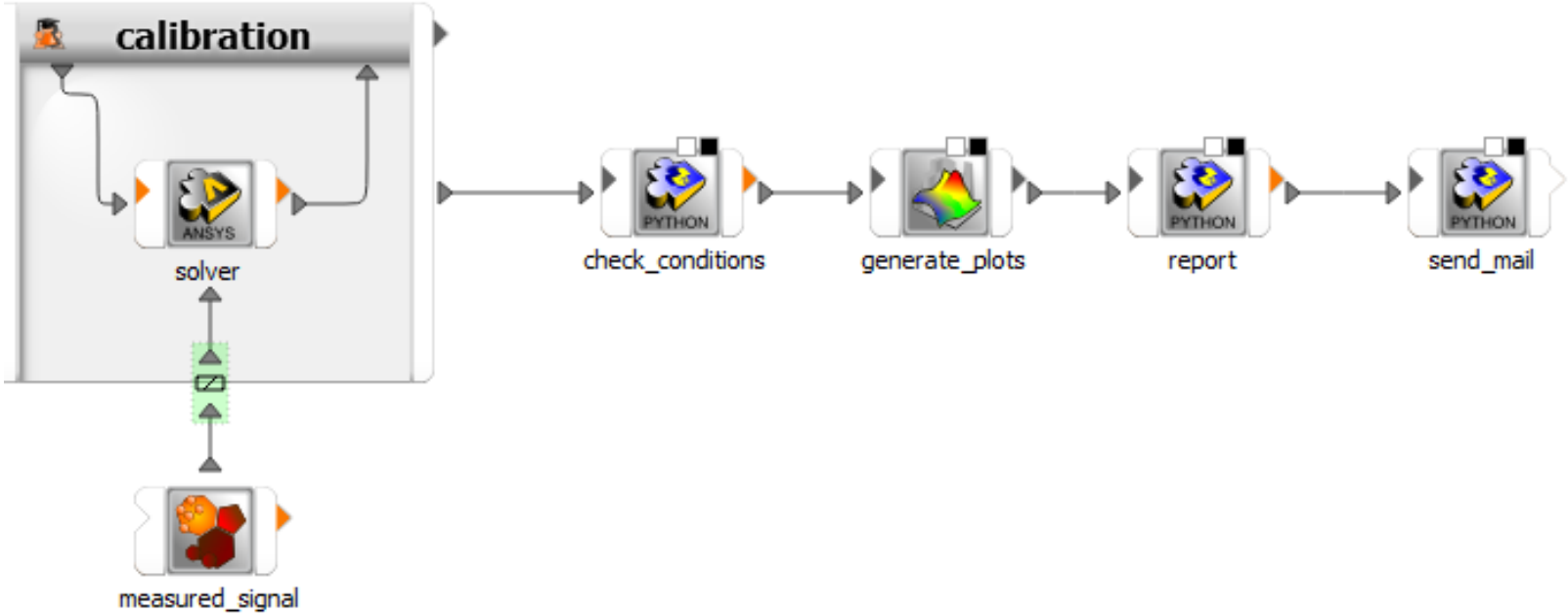
Loading

➔ Identify the parameters based on digital twin simulation



Machine condition calibration flow

- Generate an identification flow in optiSLang



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Digital Twin

“combine sensor data with detailed product simulation”

ANSYS EKM

Process Execution & Data Management

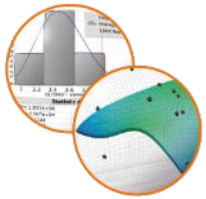
EKM interfacing layer

optiSLang

Simulation Workflows

CAx Automation

Robust Design Optimization



Data Analysis & ROM

ANSYS Simulation Plattform

Fluids

Structures

Electronics

Semiconductors

Systems

Embedded Software

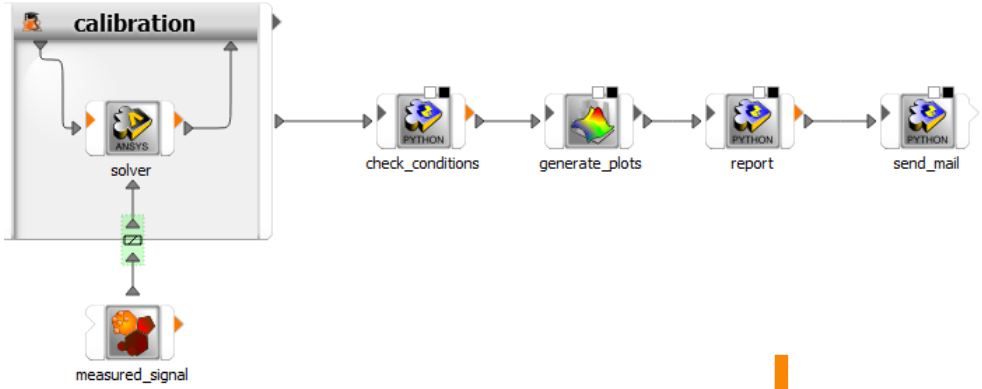
Multiphysics

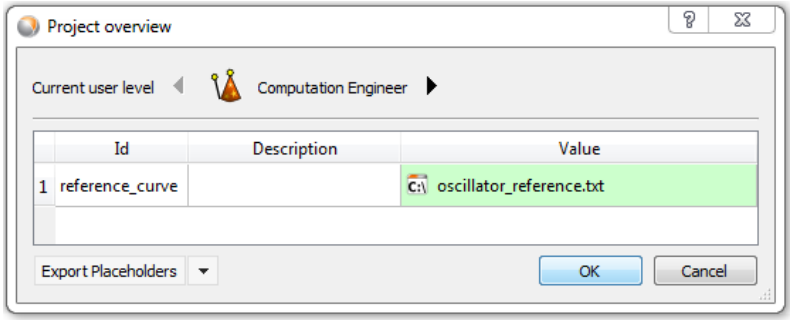
Platform

Workflow engineer

➔ builds and maintains workflow

➔ Build the machine data calibration workflow





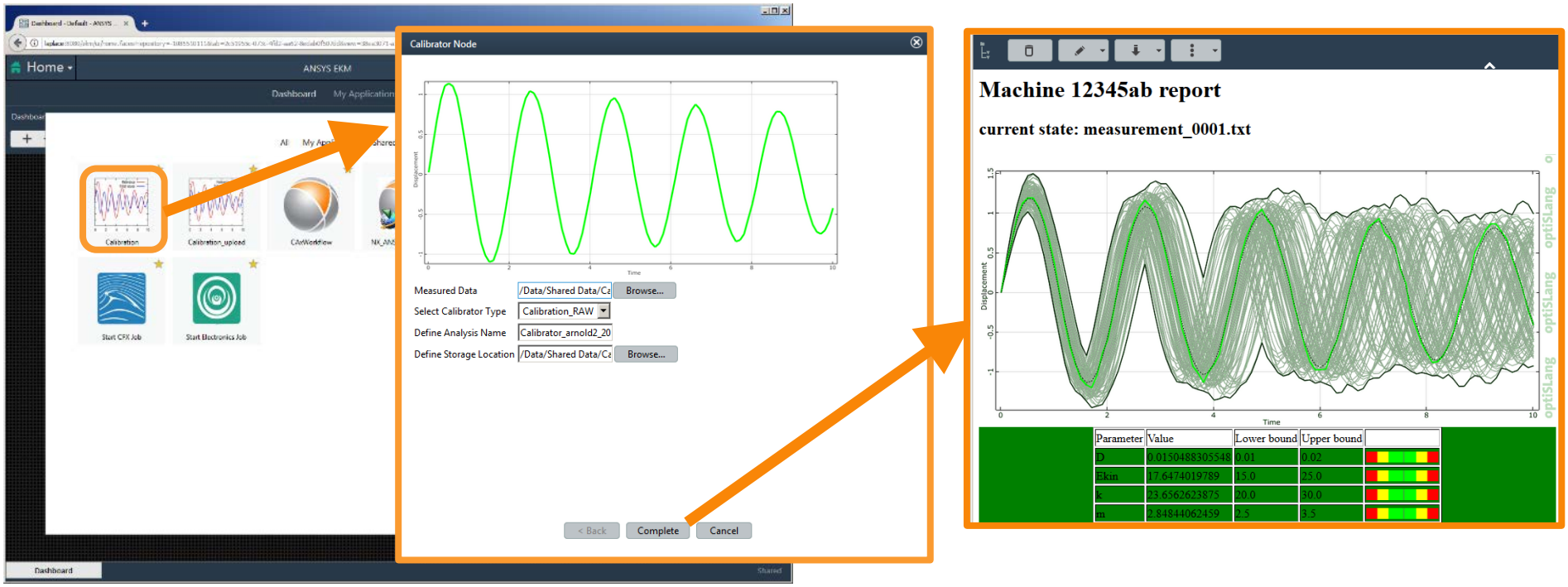
publish workflow

ANSYS EKM

Process Execution & Data Management

“in-field” engineer

- ➔ Start EKM in web browser
- ➔ Connect measurement curve to Calibration flow (to identify machine status)
- ➔ Wait for results (because of real CAE solver runs)
- ➔ Identifies machine parameter within minutes/hours/days

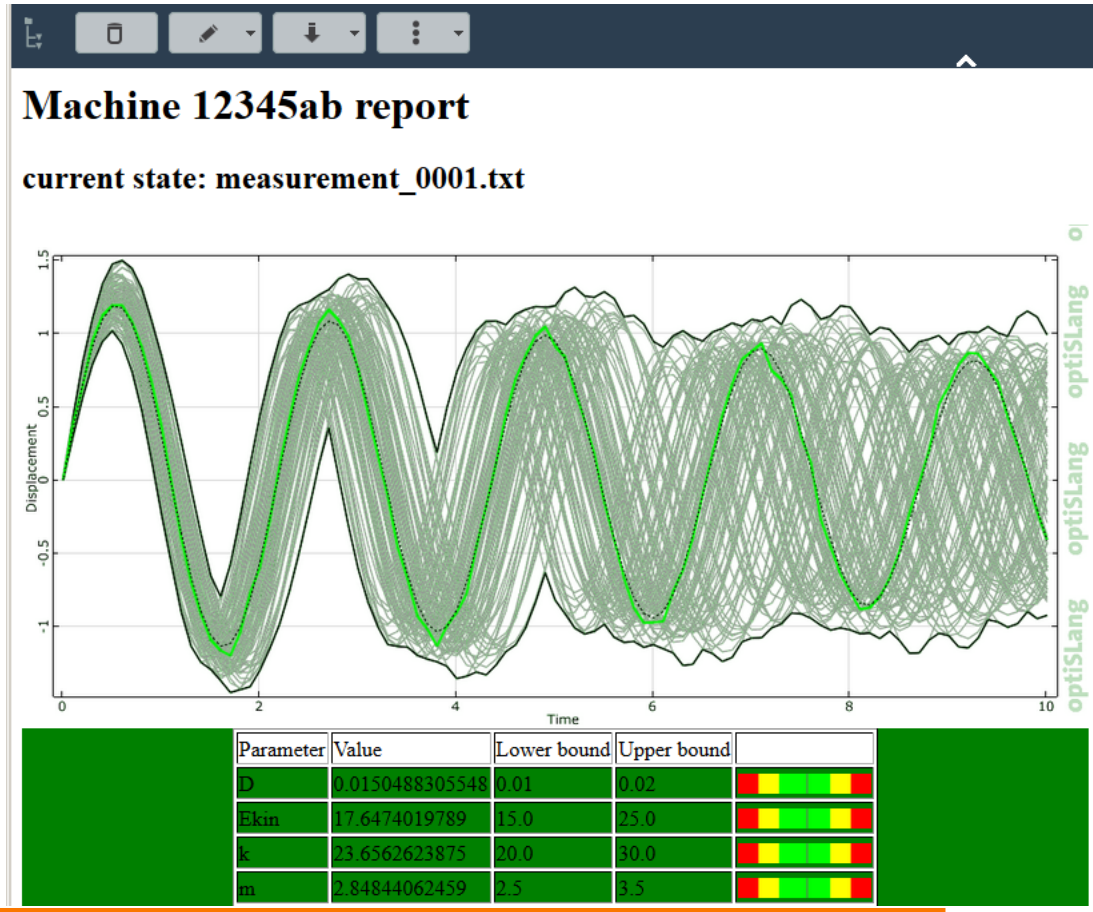


Results

➔ Identified conditions and values as html report.

➔ *.csv file extraction

➔ Send report as email



Parameter	Value	Lower bound	Upper bound	
D	0.0150488305548	0.01	0.02	
Ekin	17.6474019789	15.0	25.0	
k	23.6562623875	20.0	30.0	
m	2.84844062459	2.5	3.5	

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Operation

"We need operating parameters immediately"

Operation

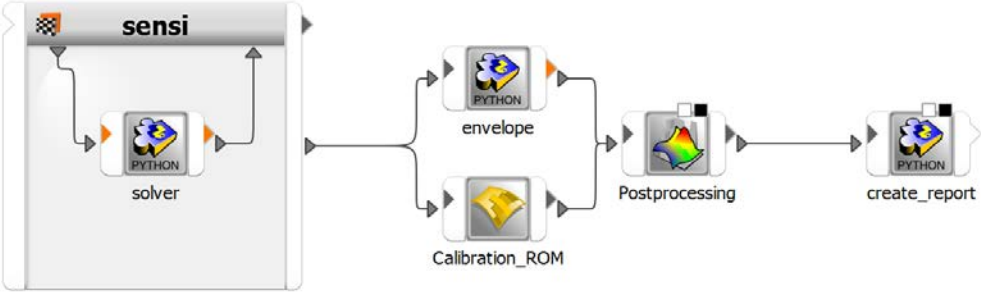
“Digital twins need operating parameters very fast (in time … real time)”

optiSLang
hosts calibration workflows and generates data-based ROMS

Calibration – based on MOP

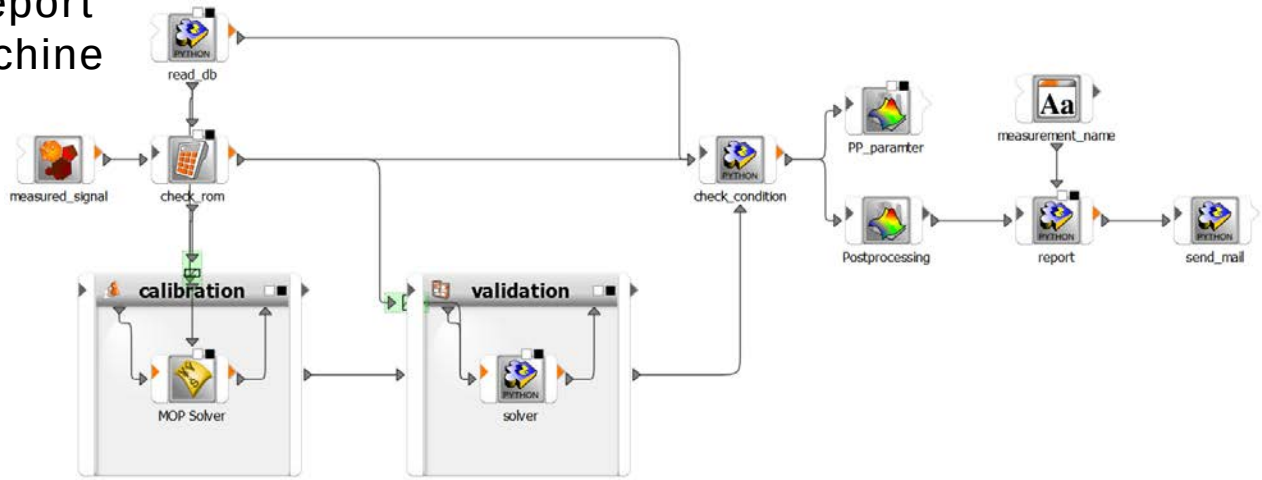
Generate MOP based ROM

→ Define valid parameter range
→ Build up ROM based on MOP



Calibration on MOP based ROM

→ Pre-Test if measured signal might be in pre-simulated parameter space
→ Use MOP Solver as ROM simulation
→ Check system condition based on defined reliable parameter space
→ Update the history report of the monitored machine



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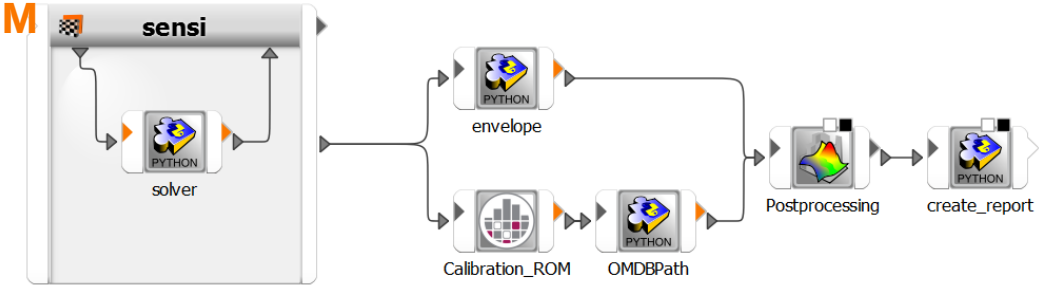
Calibration – based on Statistics on Structures

Generate SignalMOP based ROM



→ Define valid parameter range

→ Build up SignalMOP using optiSLang's SoS integration

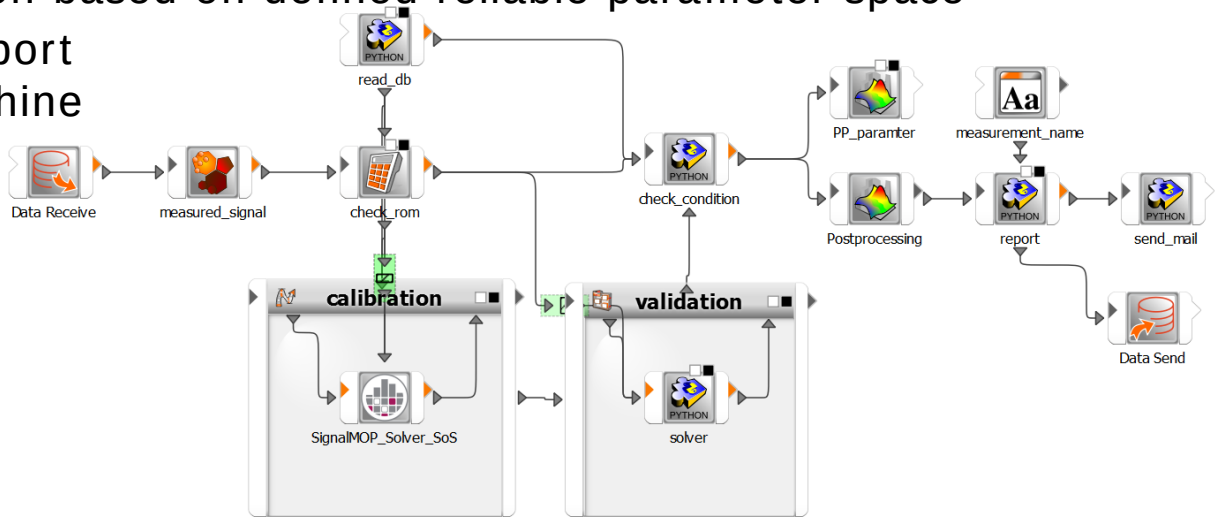
Calibration on SignalMOP based ROM

→ Pre-Test if measured signal might be in pre-simulated parameter space

→ Use SignalMOP Solver (SoS) as ROM simulation

→ Check system condition based on defined reliable parameter space

→ Update the history report of the monitored machine



Operation

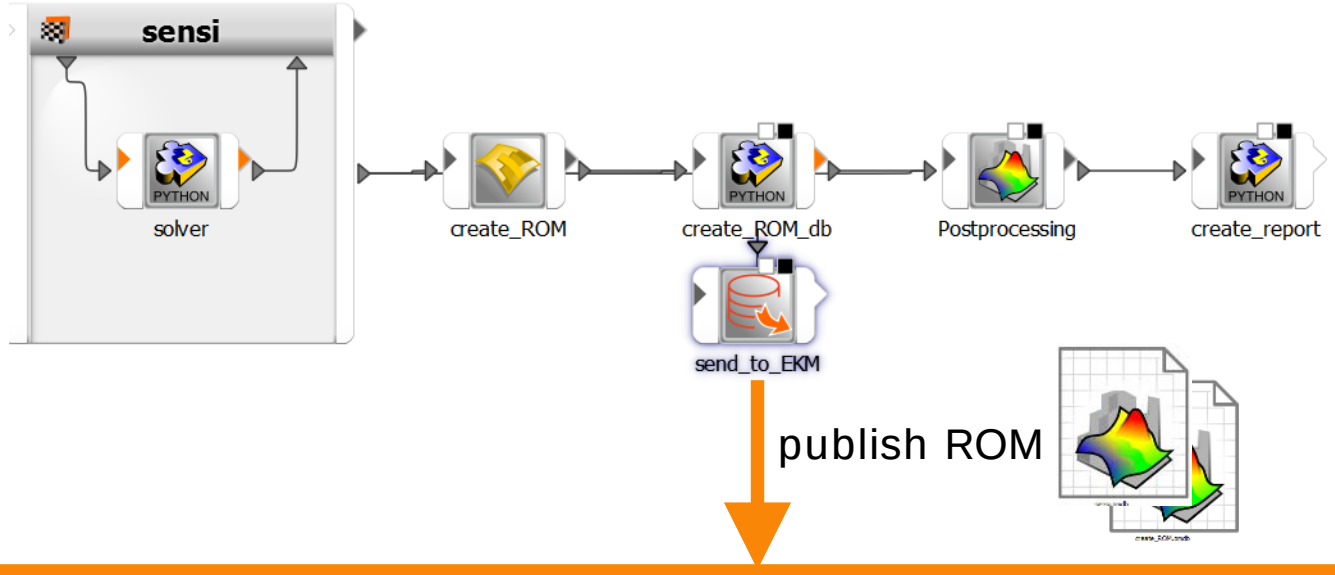
“Digital twins need operating parameters very fast (in time … real time)”

EKM
is the ANSYS gateway to digital twins

Workflow engineer: Workflow "Generate ROM"

Generate and publish the data-based ROM

➔ Creates fully automatic the data-based ROM (MOP) based on up-front simulations within a predefined variation space



ANSYS EKM

Process Execution & Data Management

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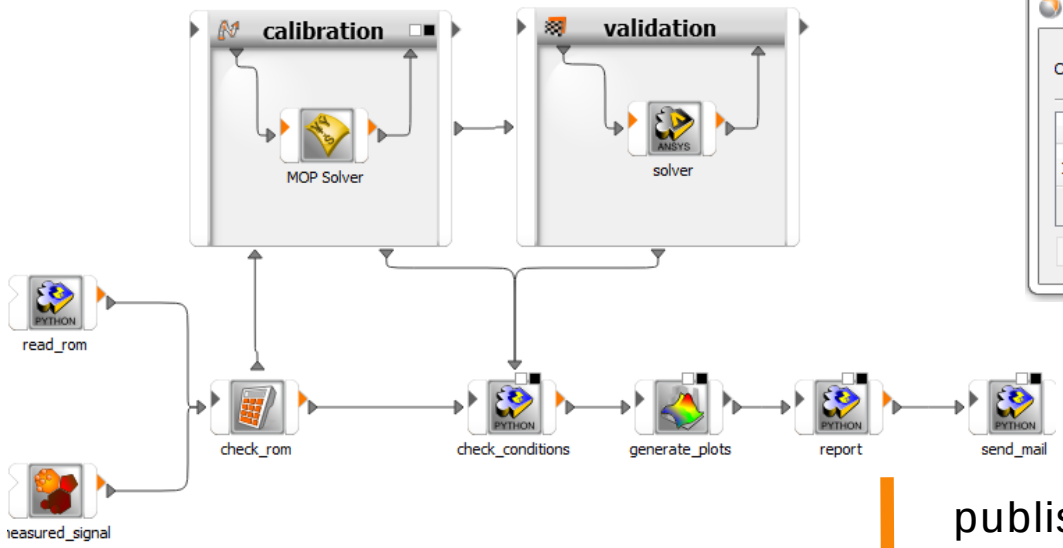
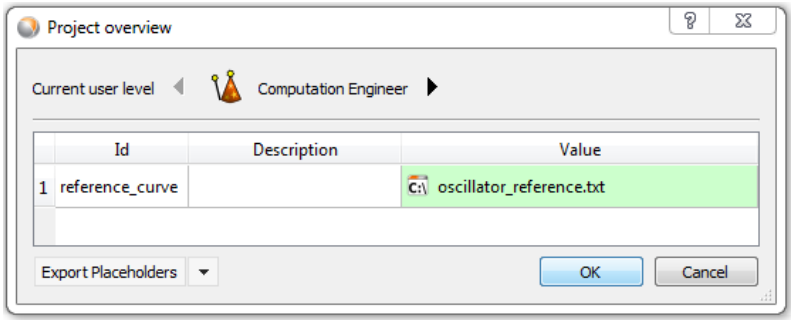
Workflow engineer: Workflow “Calibrate on ROM”

Using data-based ROM for machine data calibration workflow

➔ Calibration workflow in optiSLang including MOP algorithm





publish ROM based calibration workflow

ANSYS EKM

Process Execution & Data Management

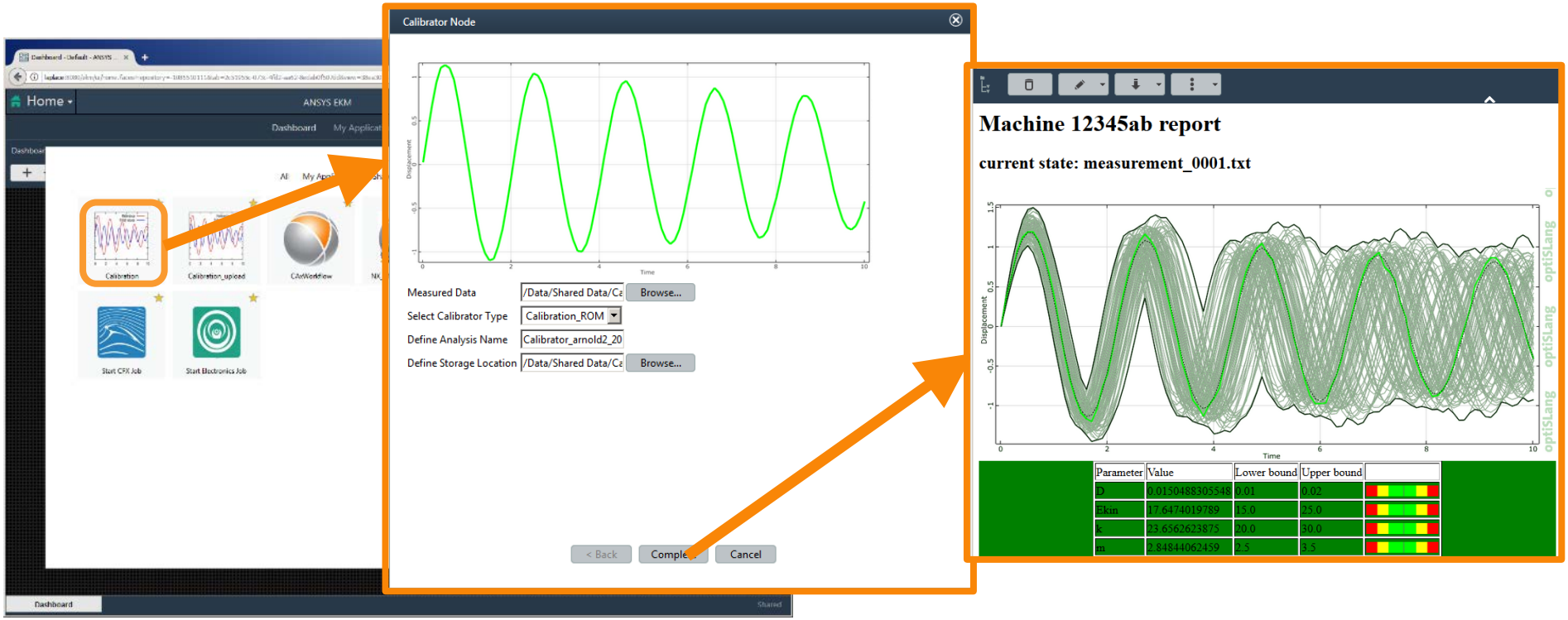
“in-field” engineer: Calibrate measured signal

Using ROM-based calibration workflow as black-box

➔ Start EKM in web browser

➔ Connect Measurement curve to Identification flow

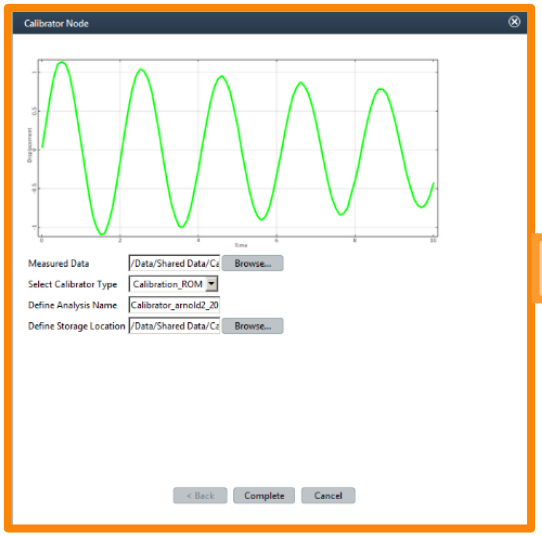
➔ Identified parameters within seconds using the data-based ROM



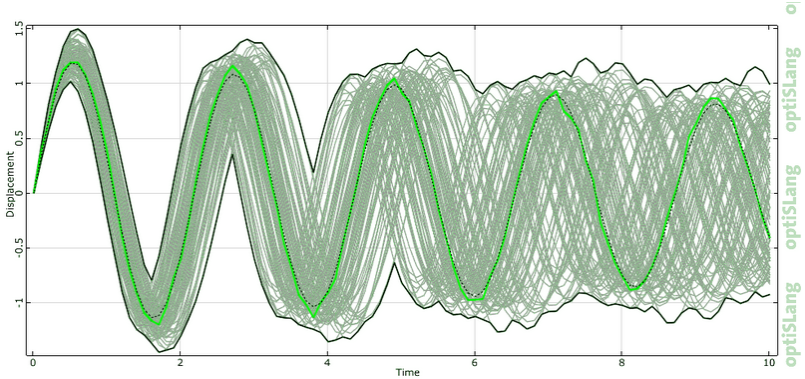
data-based ROM shows a green flag

➔ “green state”

➔underlaying ROM covers the machine signal with pre-investigated variation window and can identified system parameters



current state: measurement_0001.txt

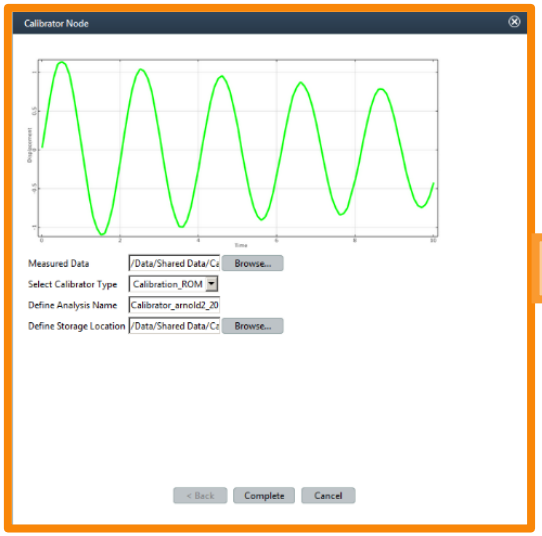


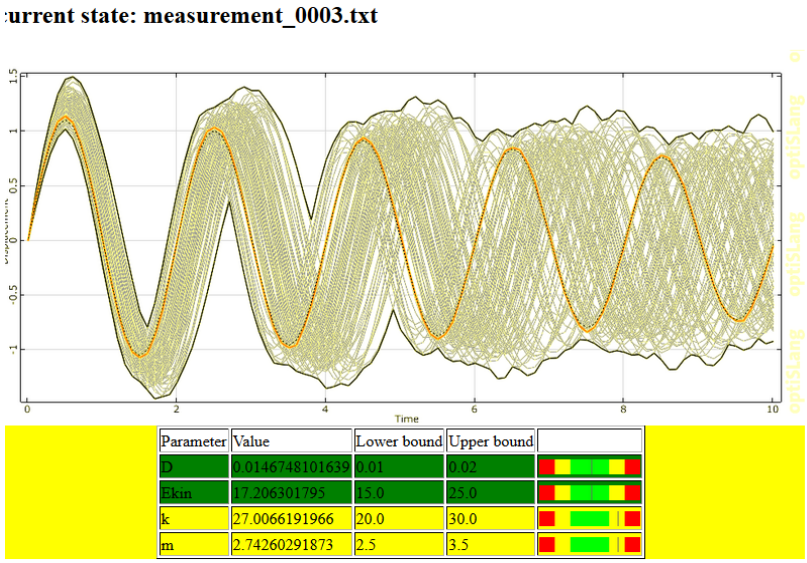
Parameter	Value	Lower bound	Upper bound	
D	0.0150488305548	0.01	0.02	
Ekin	17.6474019789	15.0	25.0	
k	23.6562623875	20.0	30.0	
m	2.84844062459	2.5	3.5	

data-based ROM shows a yellow flag

➔ “yellow state”

➔The signal scratch the pre-investigated variation window of the underlaying ROM or the identified parameter reach bounds

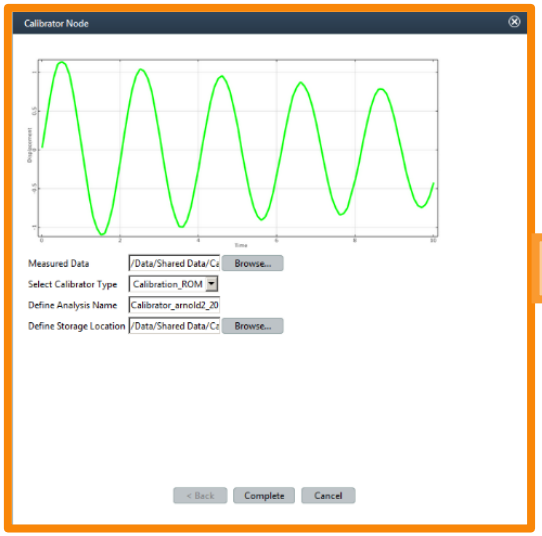


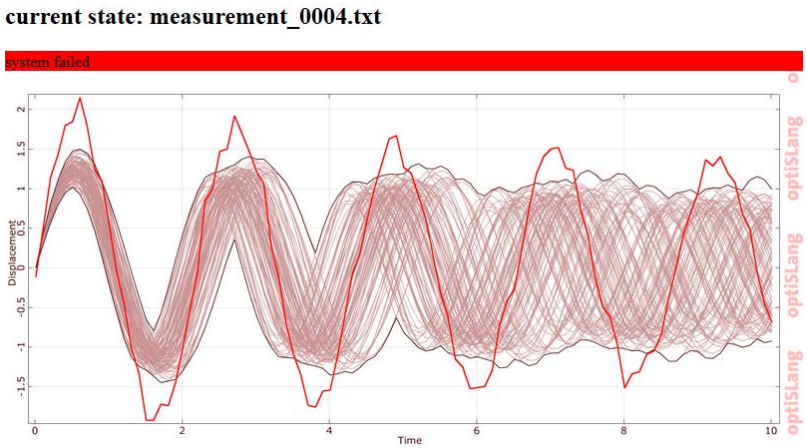


data-based ROM shows a red flag

➔ “red state”

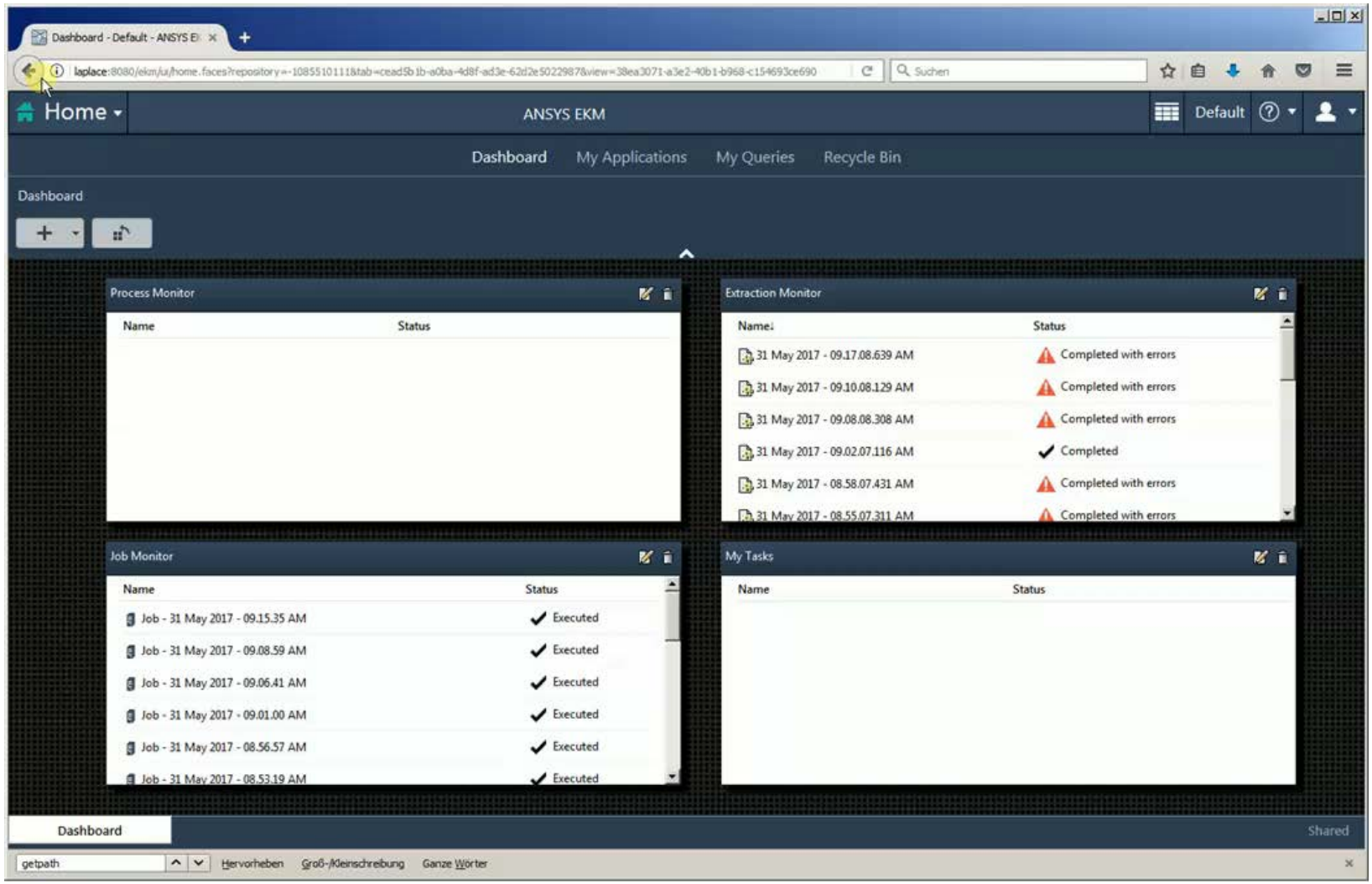
➔The signal is outside the pre-investigated variation window of the underlaying ROM or the identified parameter are our of bounds (ROM extrapolation mode will be necessary)





➔The data-based ROM need an update

Look & Feel

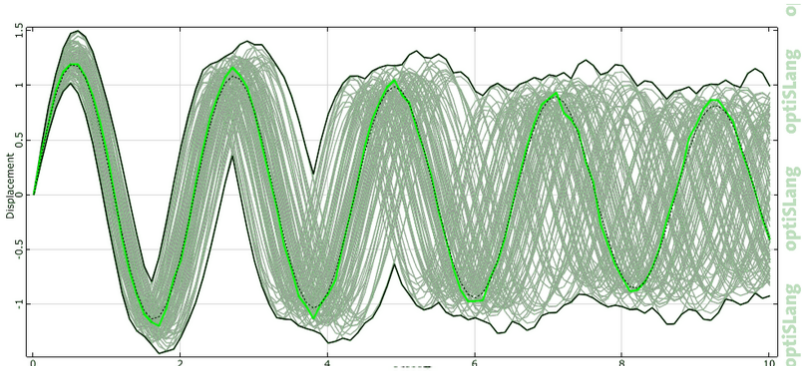

Dashboard - Default - ANSYS E
laplace:8080/ekm/ui/home.faces?repository=-1085510111&tab=cead5b1b-a0ba-4d8f-ad3e-62d2e5022987&view=38ea3071-a3e2-40b1-b968-c154693ce690
Suchen
Home
ANSYS EKM
Default
Dashboard
My Applications
My Queries
Recycle Bin
Dashboard
Process Monitor
Name
Status
Extraction Monitor
Name
Status
31 May 2017 - 09.17.08.639 AM
Completed with errors
31 May 2017 - 09.10.08.129 AM
Completed with errors
31 May 2017 - 09.08.08.308 AM
Completed with errors
31 May 2017 - 09.02.07.116 AM
Completed
31 May 2017 - 08.58.07.431 AM
Completed with errors
31 May 2017 - 08.55.07.311 AM
Completed with errors
Job Monitor
Name
Status
Job - 31 May 2017 - 09.15.35 AM
Executed
Job - 31 May 2017 - 09.08.59 AM
Executed
Job - 31 May 2017 - 09.06.41 AM
Executed
Job - 31 May 2017 - 09.01.00 AM
Executed
Job - 31 May 2017 - 08.56.57 AM
Executed
Job - 31 May 2017 - 08.53.19 AM
Executed
My Tasks
Name
Status
Dashboard
Shared
getpath
Hervorheben
Groß-/Kleinschreibung
Ganze Wörter

Digital twin results

➔ See results in EKM – report

➔ Archived for traceability

current state: measurement_0001.txt

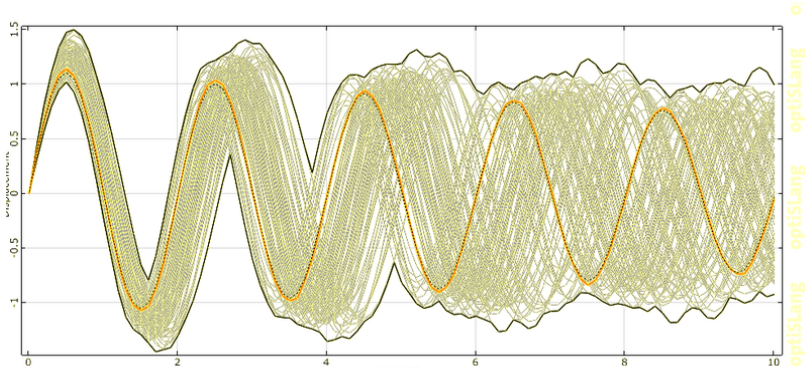


Parameter	Value	Lower bound	Upper bound	
D	0.0151504200557	0.01	0.02	
Ekin	17.2913530143	15.0	25.0	
k	26.5128429852	20.0	30.0	
m	2.75584511941	2.5	3.5	

➔ All machine parameter green

➔ No maintenance necessary

current state: measurement_0003.txt



Parameter	Value	Lower bound	Upper bound	
D	0.0146748101639	0.01	0.02	
Ekin	17.206301795	15.0	25.0	
k	27.0066191966	20.0	30.0	
m	2.74260291873	2.5	3.5	

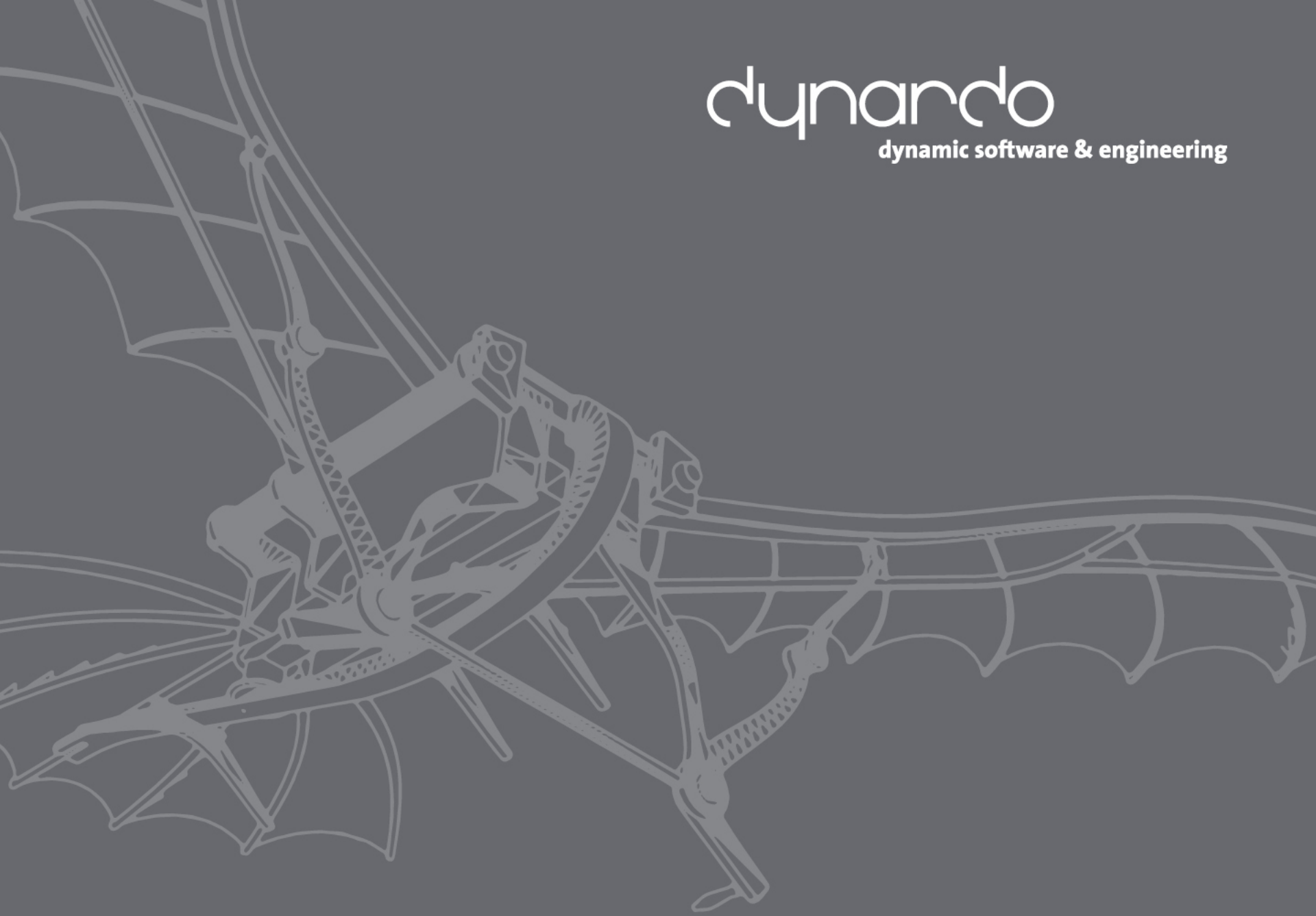
➔ Some machine parameter yellow

➔ maintenance needs to be scheduled

ANSYS optiSLang + EKM

If you have any questions belonging the presentation do not hesitate to contact

johannes.will@dynardo.de (CEO Dynardo)
david.schneider@dynardo.de (product manager optiSLang)



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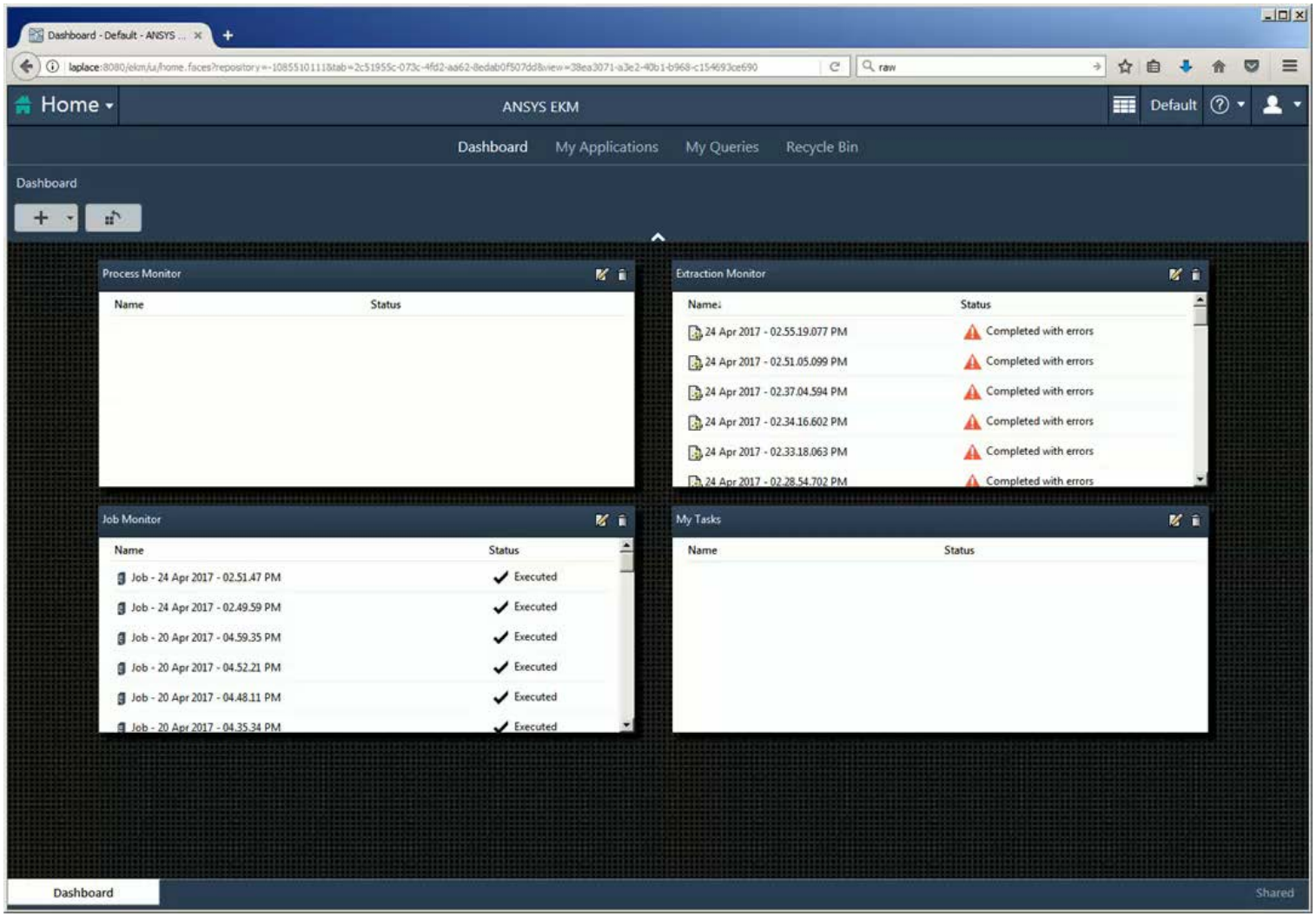
dynamic software & engineering

Further Slides

"Do we have further some questions to discuss?"

Look & Feel


Dashboard - Default - ANSYS ...
Home
ANSYS EKM
Default
Dashboard
My Applications
My Queries
Recycle Bin
Dashboard
Process Monitor
Name
Status
Extraction Monitor
Name
Status
24 Apr 2017 - 02.55.19.077 PM
Completed with errors
24 Apr 2017 - 02.51.05.099 PM
Completed with errors
24 Apr 2017 - 02.37.04.594 PM
Completed with errors
24 Apr 2017 - 02.34.16.602 PM
Completed with errors
24 Apr 2017 - 02.33.18.063 PM
Completed with errors
24 Apr 2017 - 02.28.54.702 PM
Completed with errors
Job Monitor
Name
Status
Job - 24 Apr 2017 - 02.51.47 PM
Executed
Job - 24 Apr 2017 - 02.49.59 PM
Executed
Job - 20 Apr 2017 - 04.59.35 PM
Executed
Job - 20 Apr 2017 - 04.52.21 PM
Executed
Job - 20 Apr 2017 - 04.48.11 PM
Executed
Job - 20 Apr 2017 - 04.35.34 PM
Executed
My Tasks
Name
Status
Dashboard
Shared

Operation

“Digital twins need operating parameters very fast (in time … real time)”

optiSLang
hosts calibration workflows and generates data-based ROMS

EKM is the ANSYS gateway to digital twins

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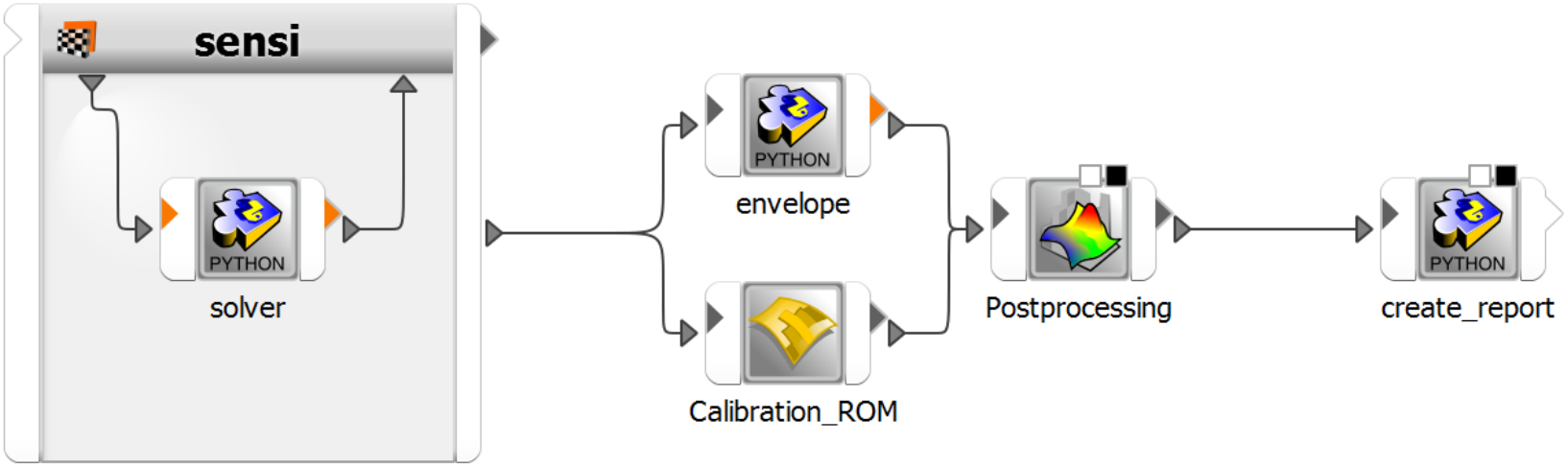
Calibration – based on MOP

Generate MOP based ROM

→ Define valid parameter range

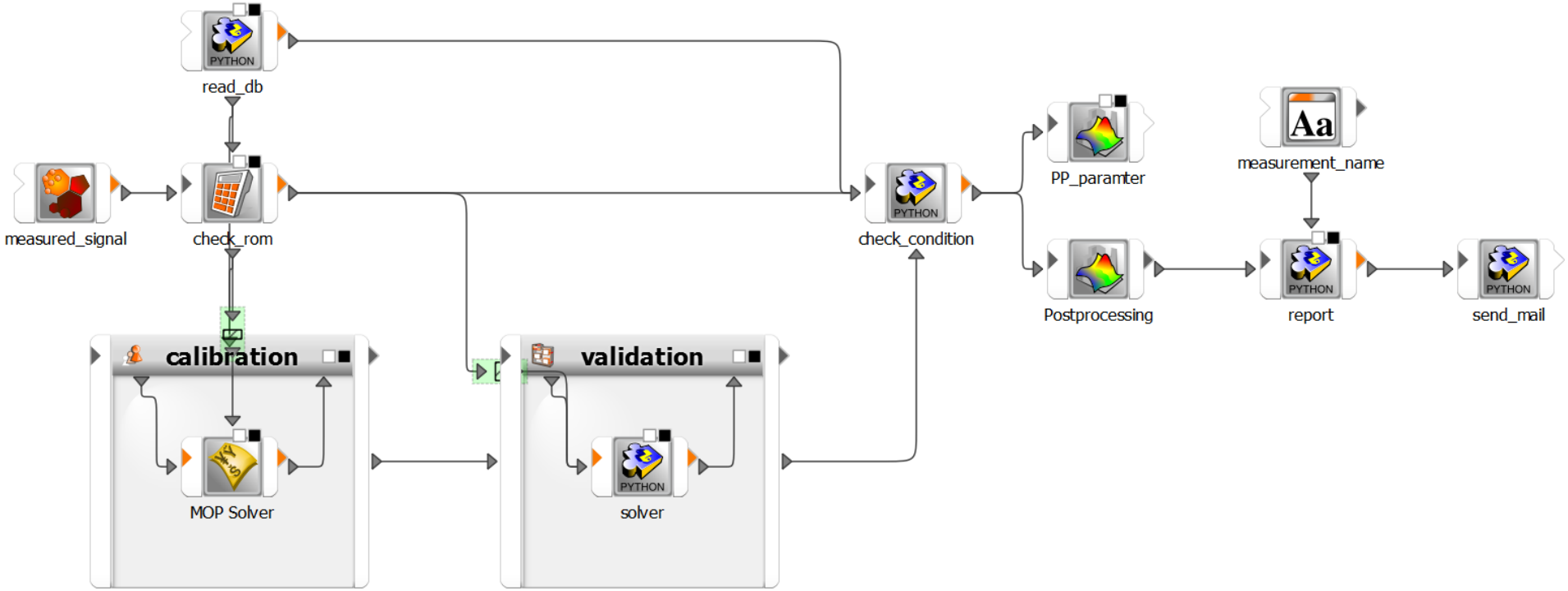
→ Build up ROM based on MOP



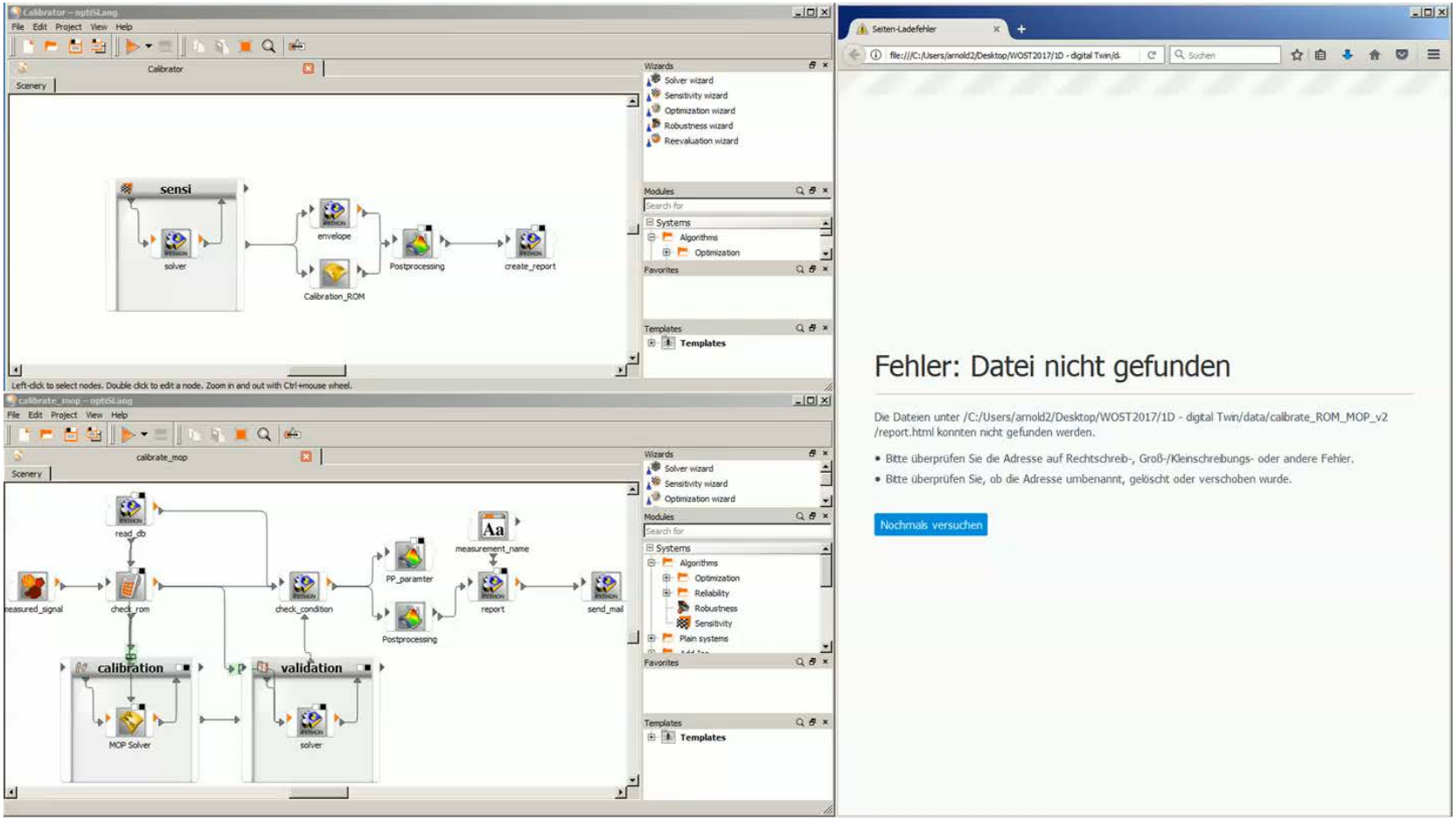
Calibration – based on MOP

Calibration on MOP based ROM

→ Pre-Test if measured signal might be in pre-simulated parameter space
→ Use MOP Solver as ROM simulation
→ Check system condition based on defined reliable parameter space
→ Update the history report of the monitored machine



Calibration – based on MOP

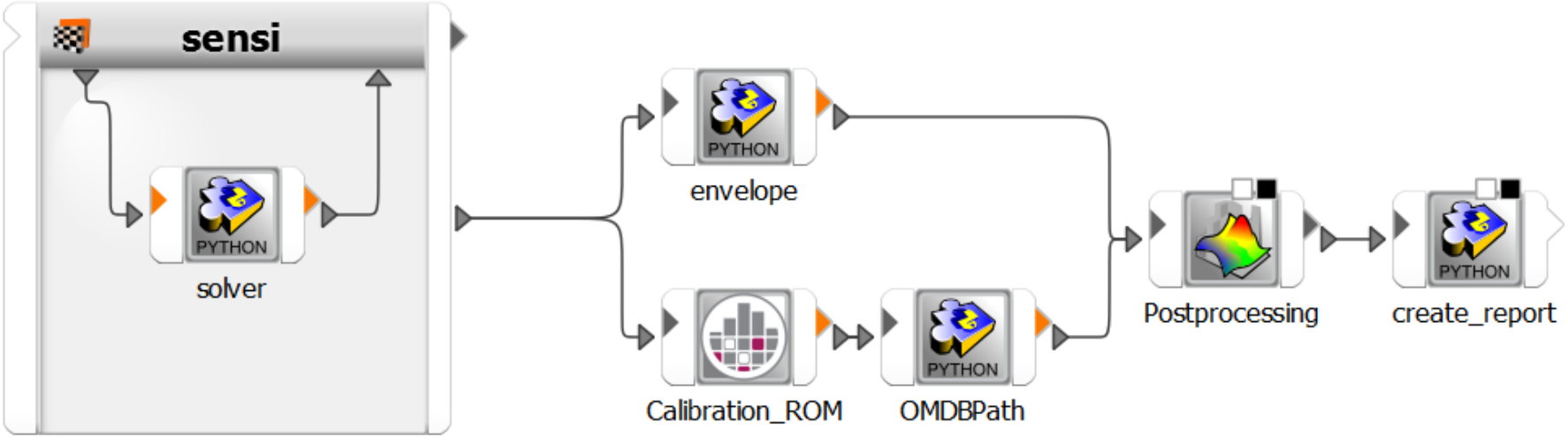


Calibration – based on Statistics on Structures

Generate SignalMOP based ROM

→ Define valid parameter range

→ Build up SignalMOP using optiSLang's SoS integration



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Calibration – based on Statistics on Structures

Calibration on SignalMOP based ROM

→ Pre-Test if measured signal might be in pre-simulated parameter space
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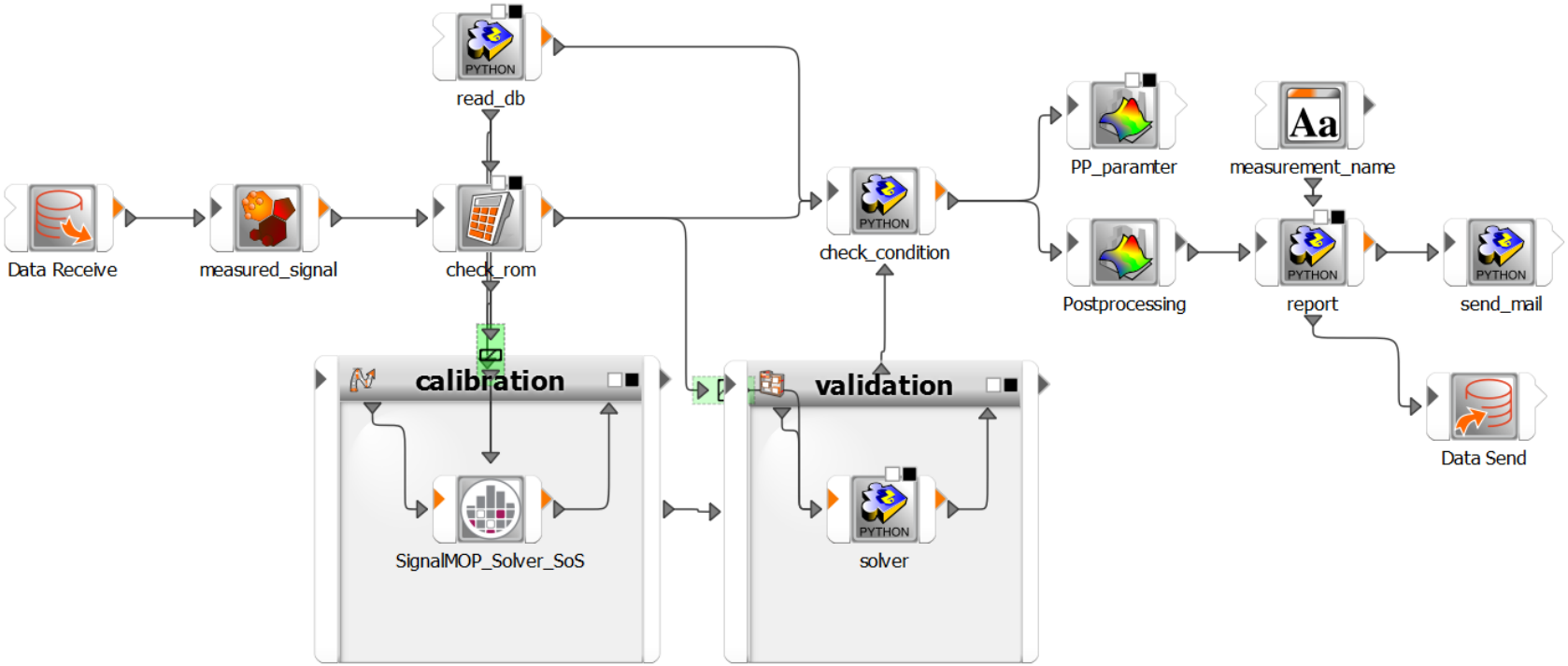
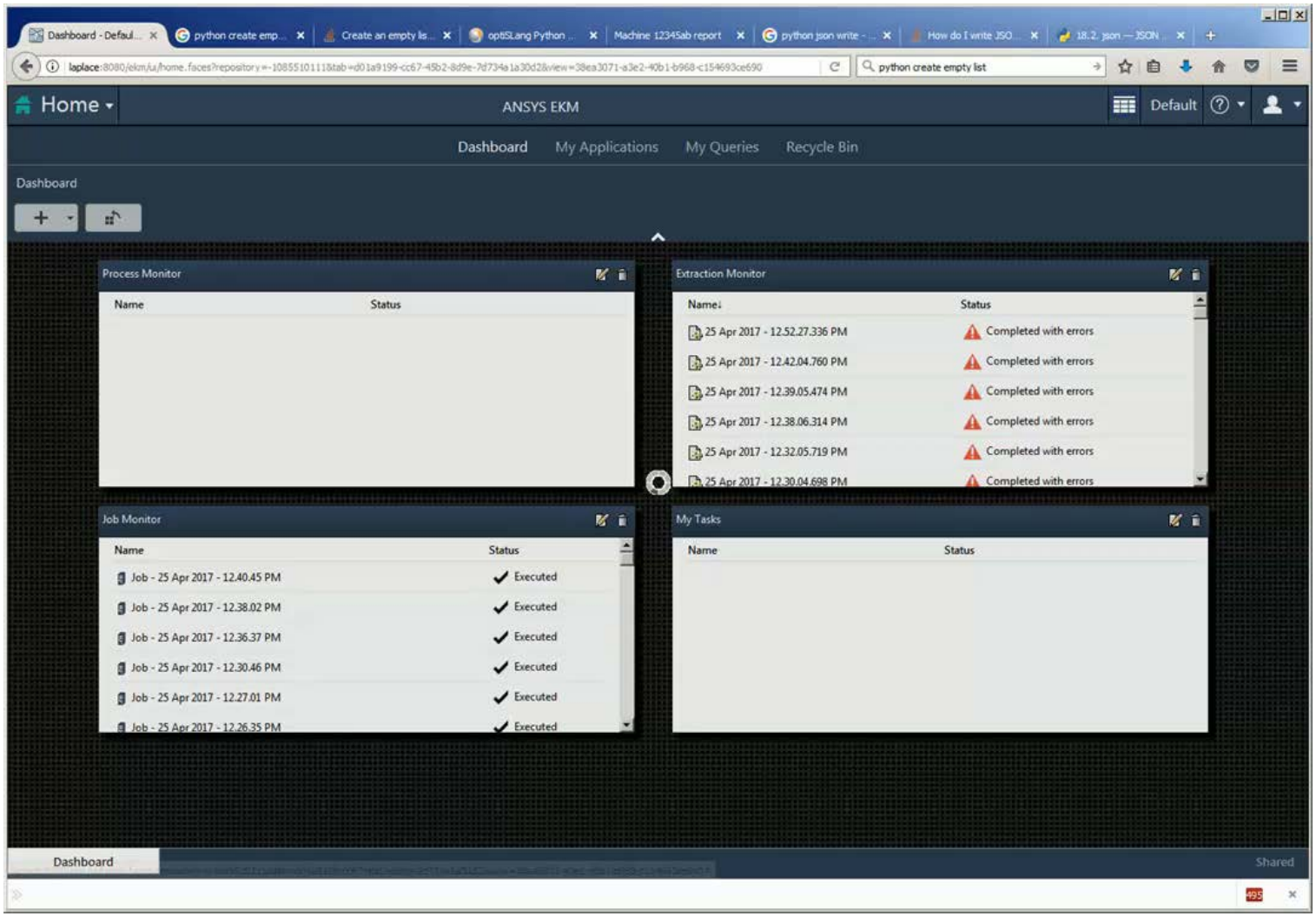


Look & Feel – v1


Home
ANSYS EKM
Default
Dashboard
My Applications
My Queries
Recycle Bin
Dashboard
Process Monitor
Name
Status
Extraction Monitor
Name
Status
25 Apr 2017 - 12.52.27.336 PM
Completed with errors
25 Apr 2017 - 12.42.04.760 PM
Completed with errors
25 Apr 2017 - 12.39.05.474 PM
Completed with errors
25 Apr 2017 - 12.38.06.314 PM
Completed with errors
25 Apr 2017 - 12.32.05.719 PM
Completed with errors
25 Apr 2017 - 12.30.04.698 PM
Completed with errors
Job Monitor
Name
Status
Job - 25 Apr 2017 - 12.40.45 PM
Executed
Job - 25 Apr 2017 - 12.38.02 PM
Executed
Job - 25 Apr 2017 - 12.36.37 PM
Executed
Job - 25 Apr 2017 - 12.30.46 PM
Executed
Job - 25 Apr 2017 - 12.27.01 PM
Executed
Job - 25 Apr 2017 - 12.26.35 PM
Executed
My Tasks
Name
Status
Dashboard
Shared