

Productivity Increase in Powertrain Calibration

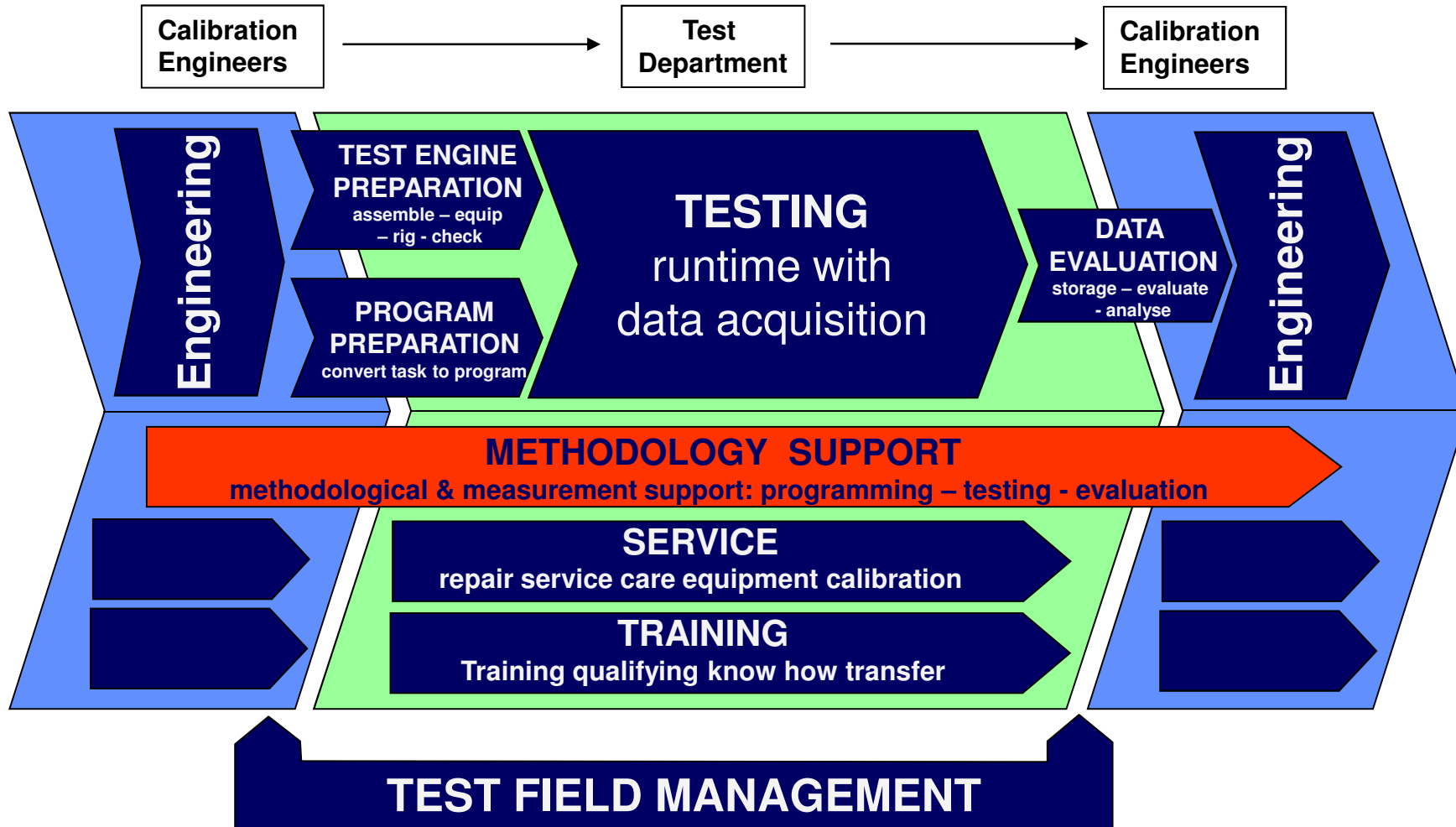
How to get more results out of your measurement campaigns ?

02.06.2010

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Eike Martini
Dr.Sari Abwa



Development Process: Example calibration at engine testbeds





Productivity – Metrics Typical and Possible Values

$$\text{Productivity} = \left(\frac{\text{Results}}{\text{Good Data}} \right) \times \left(\frac{\text{Total Data}}{\text{Run Hour}} \right) \times \text{Run Hours} \times \left(\frac{\text{Good Data}}{\text{Total Data}} \right)$$

$$<10\% = 40\% \times 40\% \times 65\% \times 60\%$$

No DoE
No Reuse
Loss of Data

Average 5 min per
measurement point

5 days a week at 2
shifts of 8 h = 52h

Typical Value at
major OEM

DoE
Reuse

Average 2 min per
measurement point

7 days a week at 3
shifts of 8 h = 130h

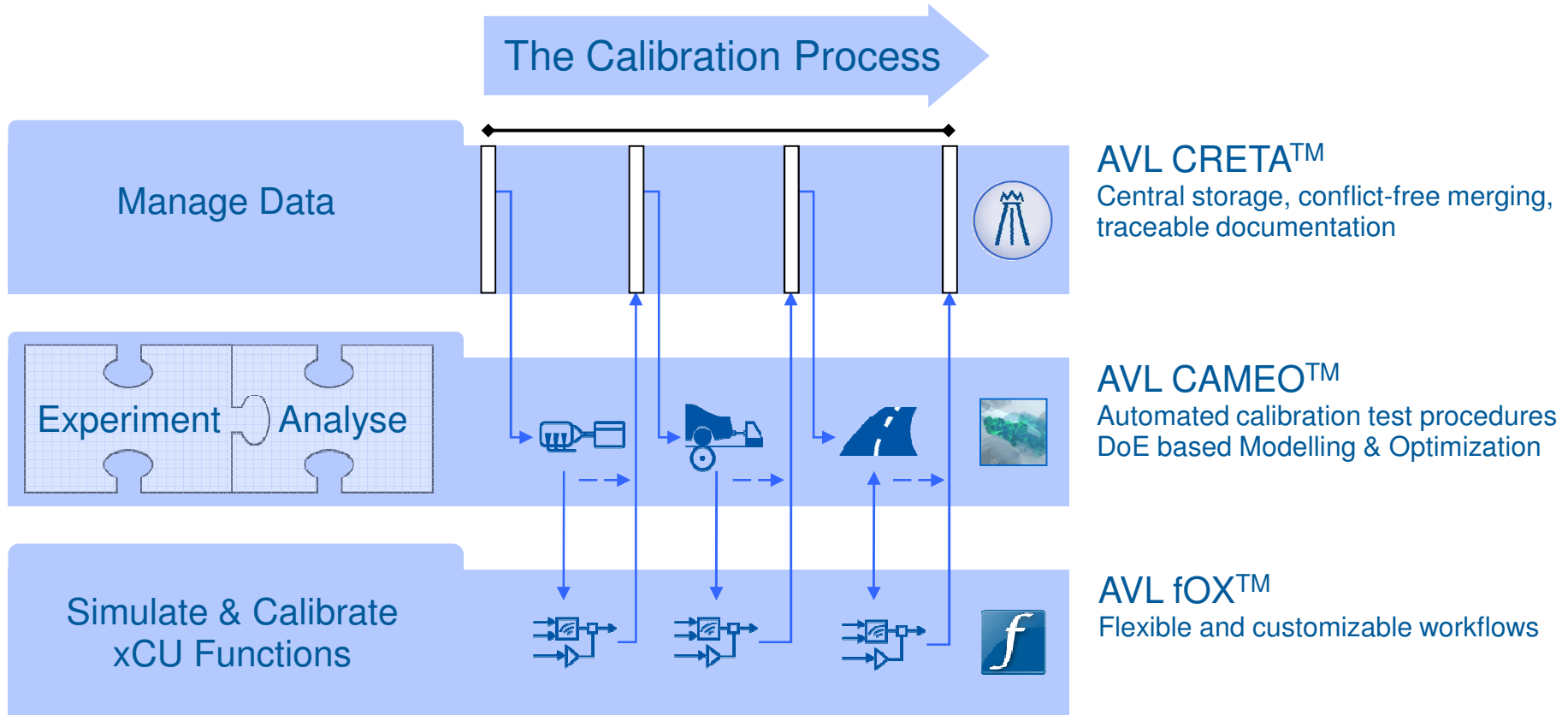
Intelligent
Automation and
Diagnosis

$$79\% = 120\% \times 100\% \times 77\% \times 85\%$$

AVL Calibration Technologies Product Portfolio

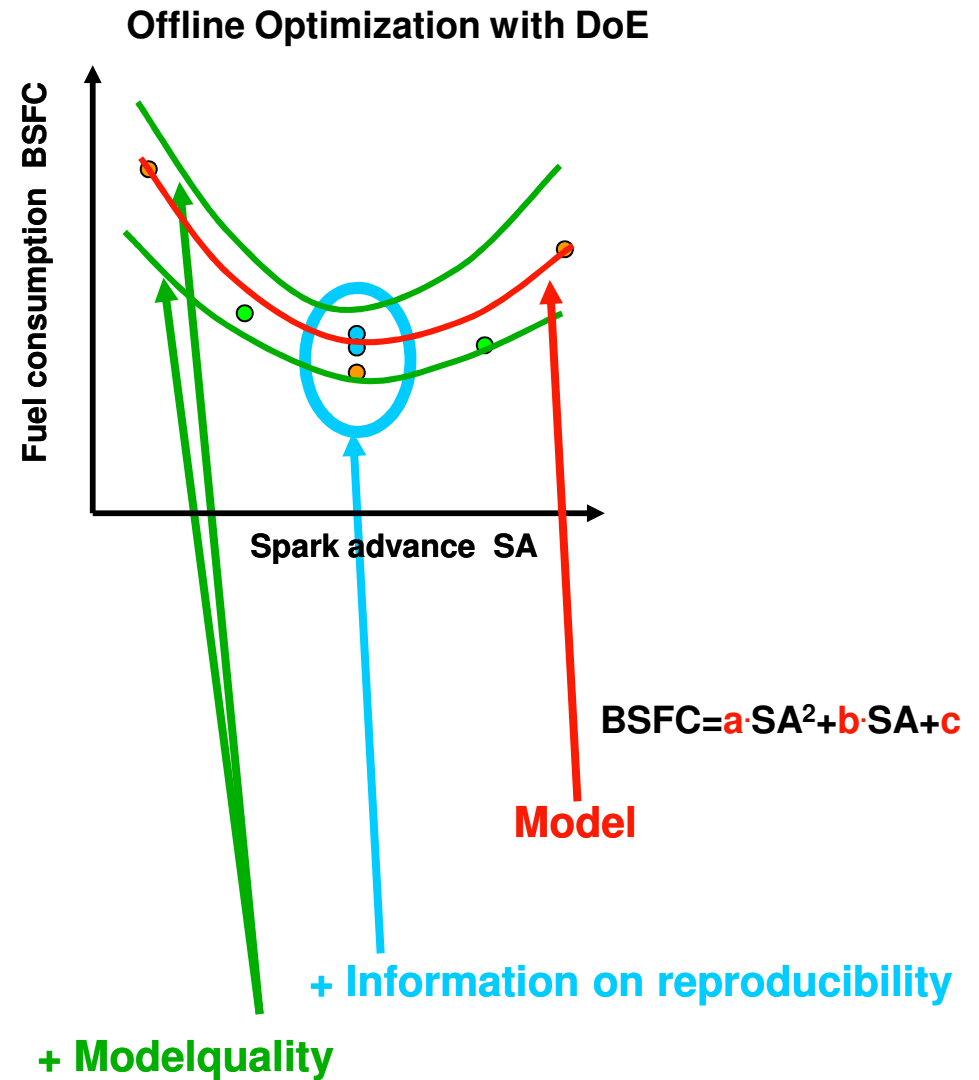
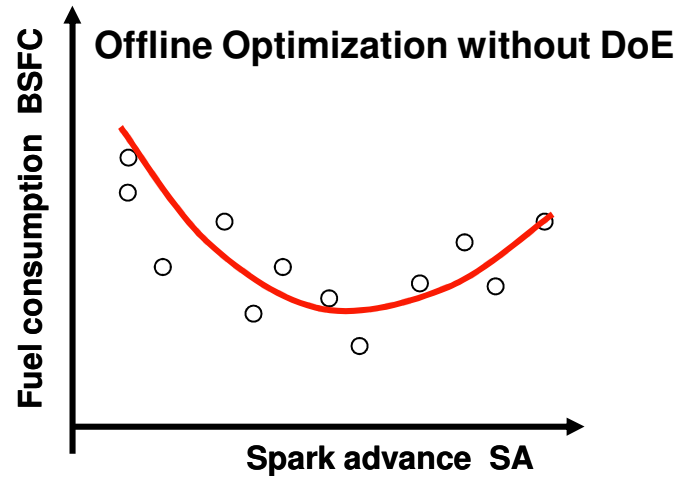
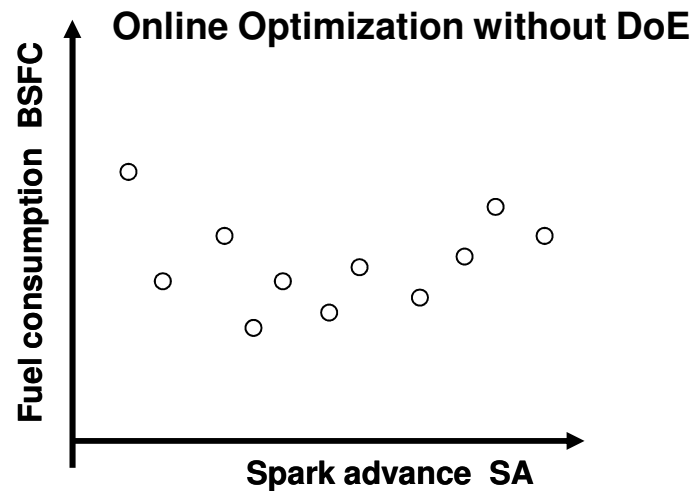


The Calibration Process

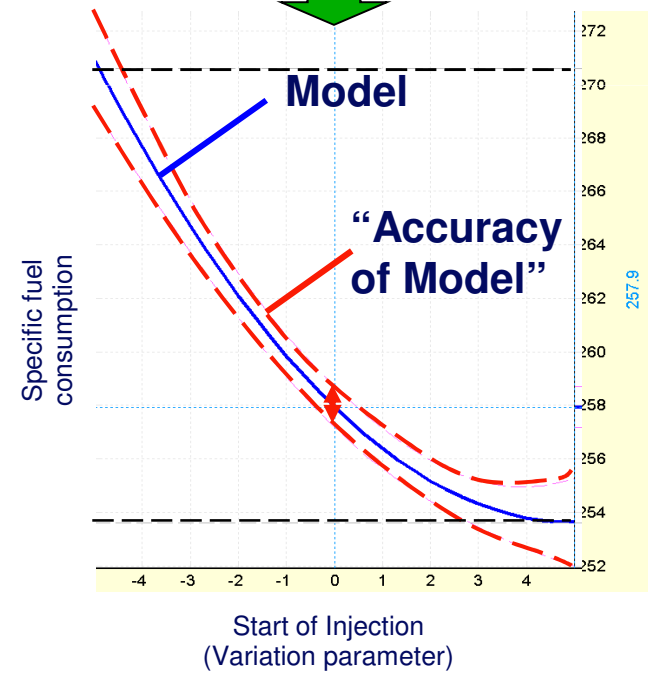
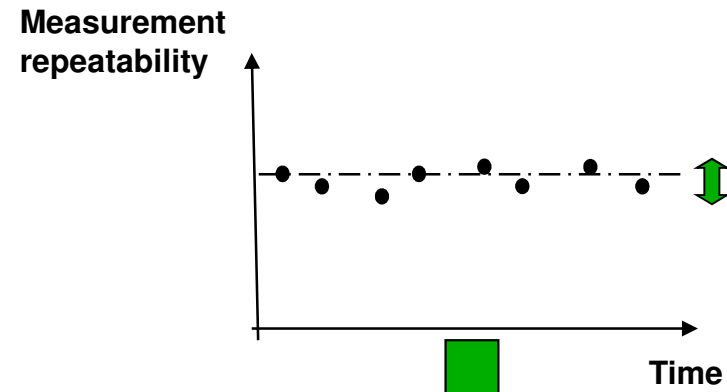
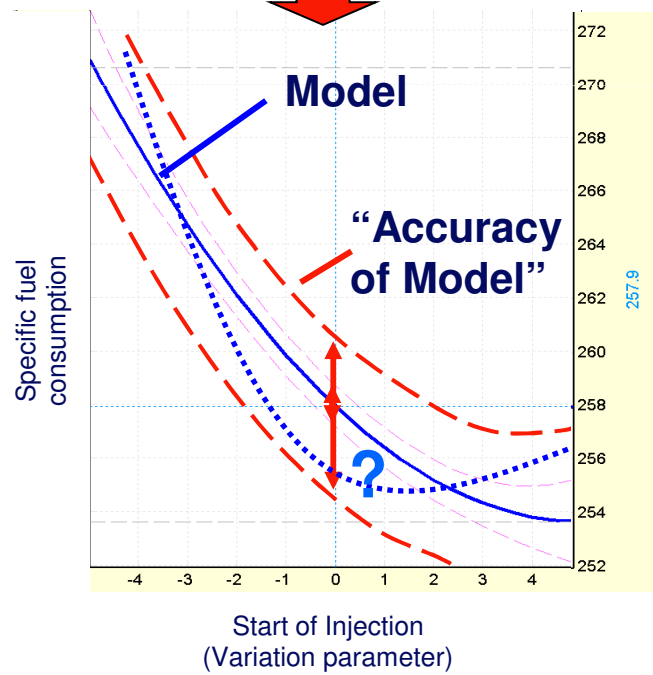
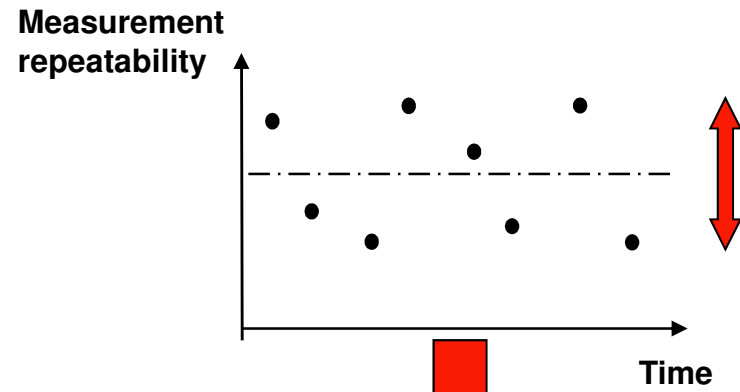


Introduction to DoE

Reduced number of measurements and more results ?



DoE Model Quality - Confidence Interval

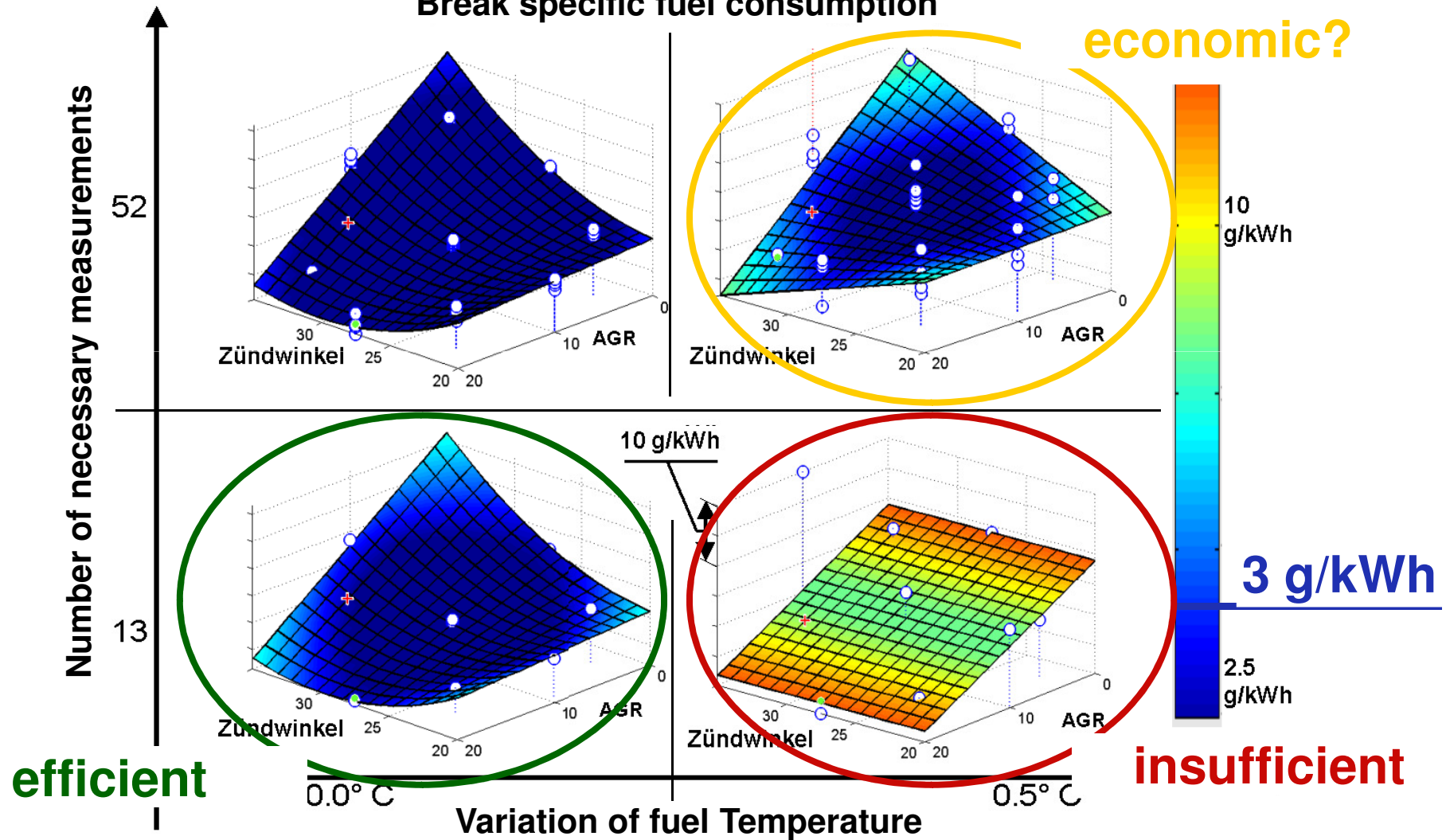


Number of necessary measurements due to bad reproducibility



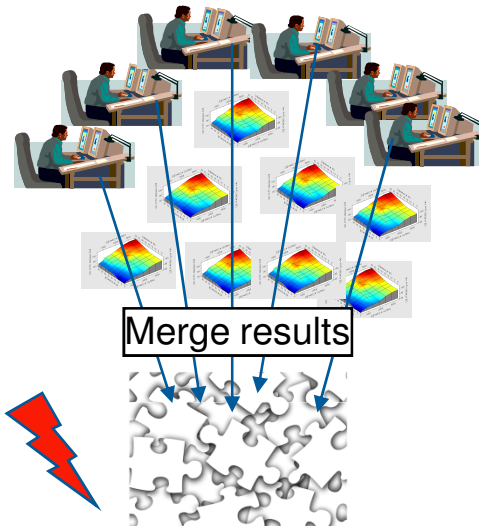
$$be = \frac{\pi}{30000} \cdot \frac{BH(N, MD)}{N \cdot MD} \left[\frac{g}{kWh} \right]$$

Break specific fuel consumption



Major challenges in calibration which CRETA™ can solve

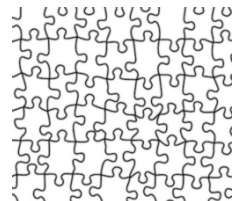
Calibrators produce a flood of calibration results



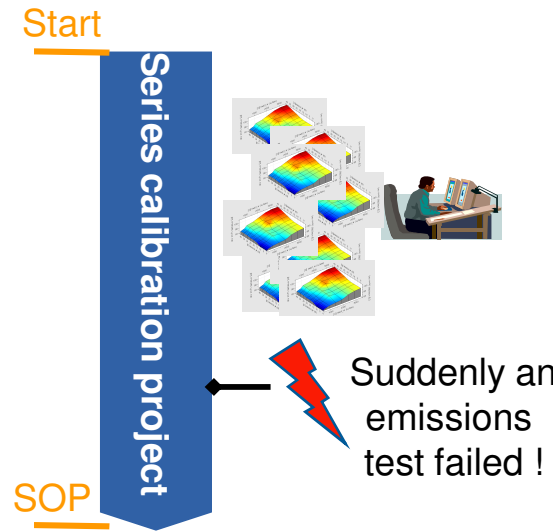
One calibrator overwrites the content of another calibrators result => final generated results are inconsistent!

Well-managed and conflict-free merging of data!

CRETA



Calibrator changes many labels many times



Calibrator cannot find reason for the problem because no reports & old data are available => he starts costly re-testing!

Fully traceable reports of entire history in changes!

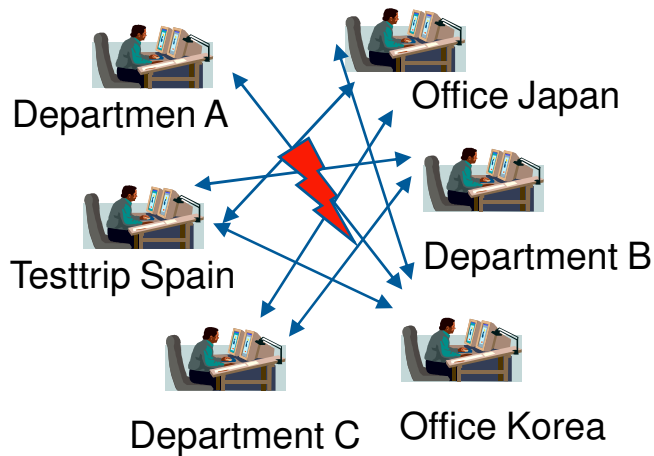
CRETA



CREATED DATE	DATASET	SOFTWARE	COMMENT	OWNER	SCORE	STATE
APR						
11	05.12.2006.08.38.10_7102z01	42TH-DEM0		None	0	OK
13	05.12.2006.08.38.10_7102z01_1	42TH-DEM0		None	25	OK
13	05.12.2006.08.38.10_7102z01_2	42TH-DEM0		None	25	OK
14	05.12.2006.08.38.10_7102z01_3	42TH-DEM0		None	25	OK
15	05.12.2006.08.38.10_7102z01_4	42TH-DEM0	test bad 17	None	90	TEST
MAY						
16	05.12.2006.08.38.10_7102z01	42TH-DEM0		None	0	OK
16	05.12.2006.08.38.10_7102z01_1	42TH-DEM0		None	25	OK
16	05.12.2006.08.38.10_7102z01_2	42TH-DEM0		None	25	OK
21	05.12.2006.08.38.10_7102z01_3	42TH-DEM0	test bad 17	None	90	TEST
JUN						
25	05.12.2006.08.38.10_7102z01	42TH-DEM0		None	0	OK
25	05.12.2006.08.38.10_7102z01_1	42TH-DEM0		None	0	OK
25	05.12.2006.08.38.10_7102z01_2	42TH-DEM0		None	0	OK
28	05.12.2006.08.38.10_7102z01_3	42TH-DEM0		None	0	OK
28	05.12.2006.08.38.10_7102z01_4	42TH-DEM0		None	0	OK
28	05.12.2006.08.38.10_7102z01_5	42TH-DEM0		None	0	OK

Major challenges in calibration which CRETA™ can solve

Calibration teams are distributed at many sites

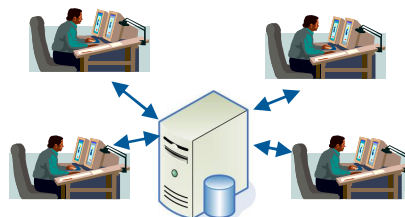


Sharing information very difficult, failure prone and often not safe and very time intensive!

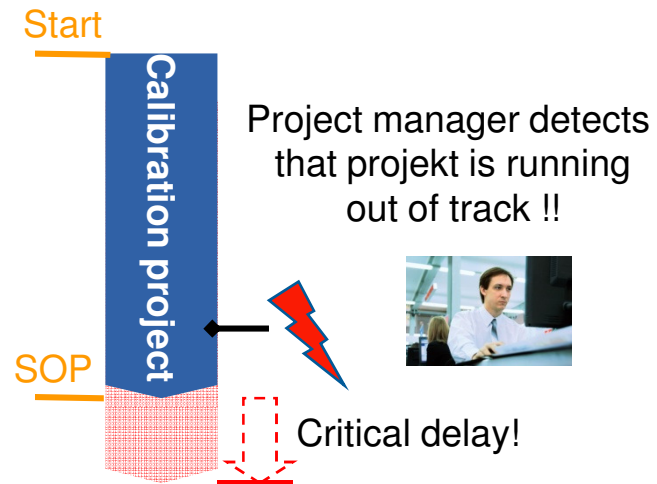


Central administration and data easy worldwide data exchange

CRETA



Many calibrators work on lots of application variants

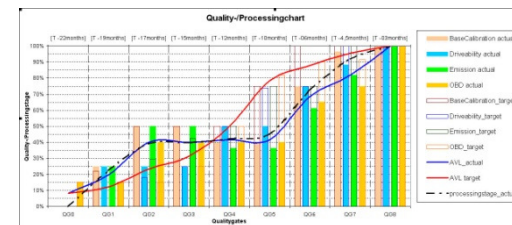


Project progress estimations for complex projects (many cross-influences) very difficult

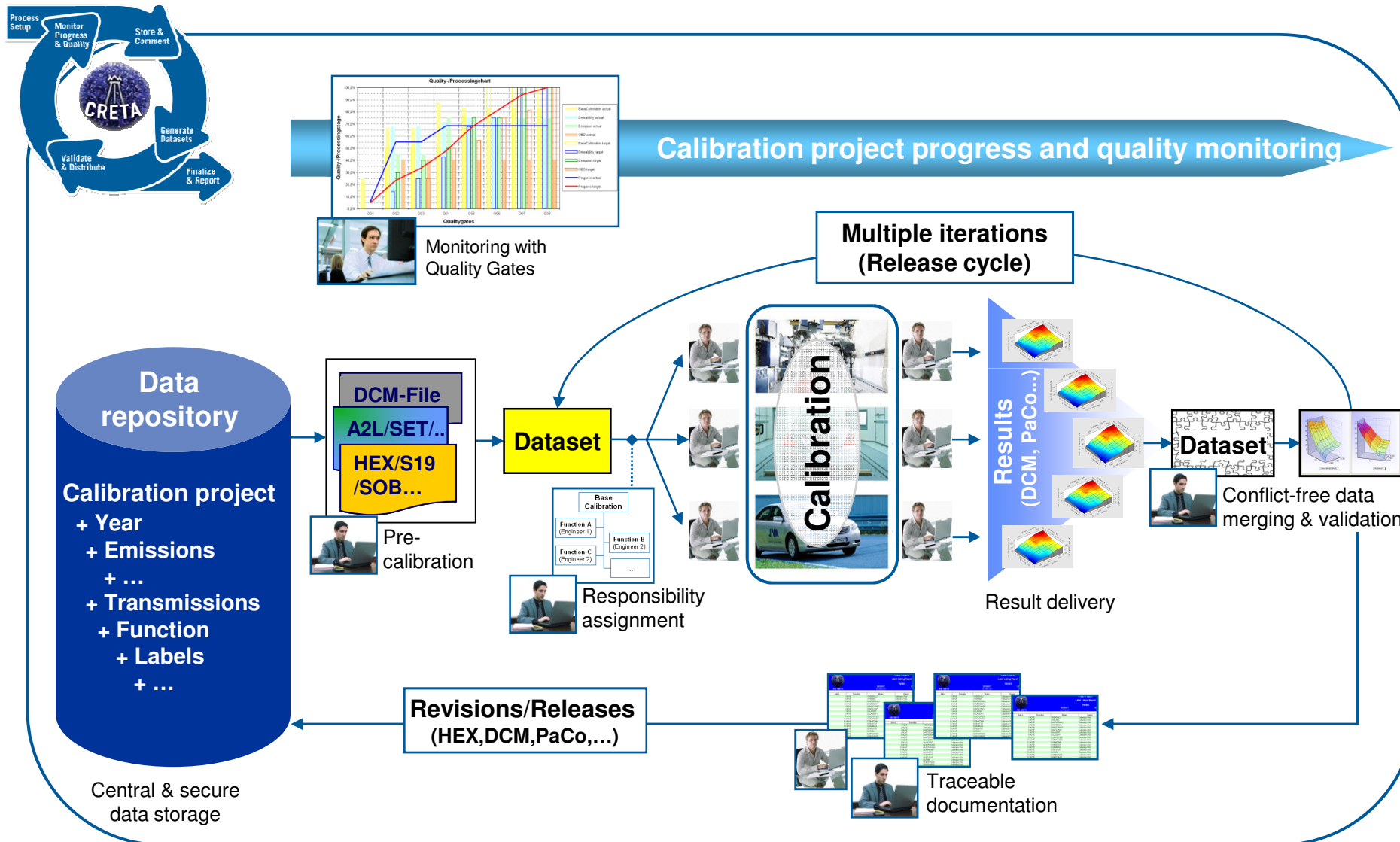


Fully transparent and measurable tracking of calibration progress

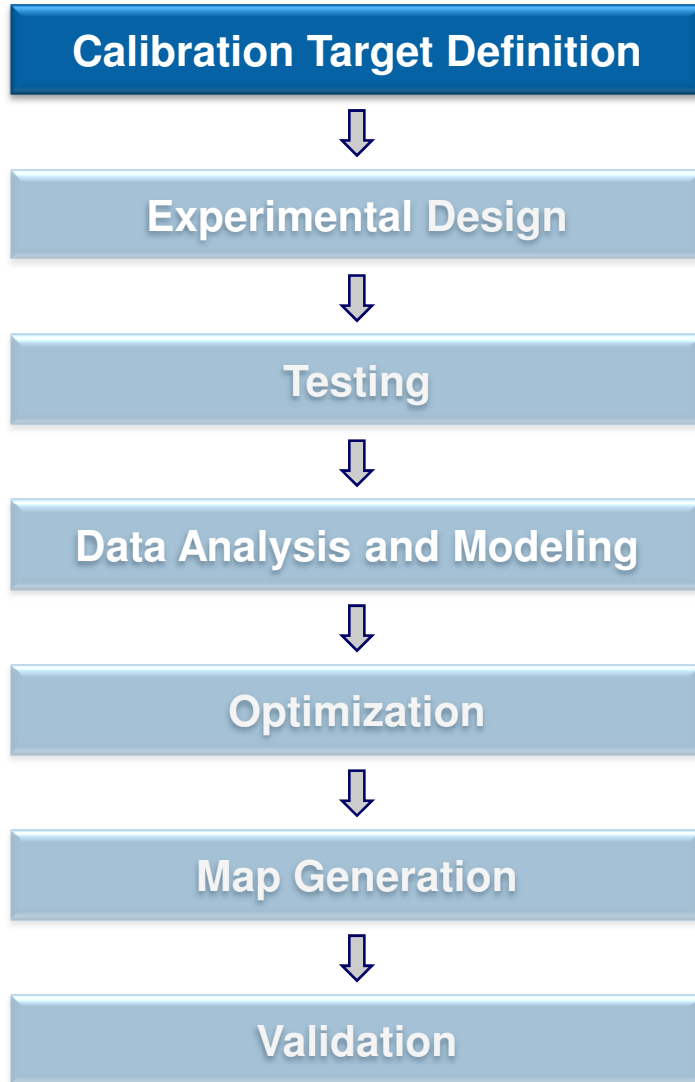
CRETA



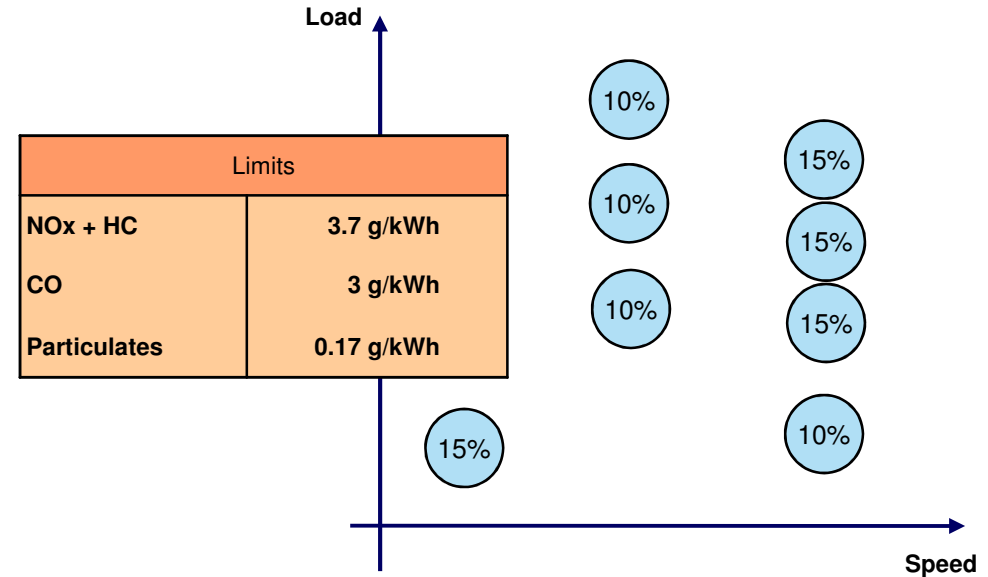
AVL CRETA™ Process overview



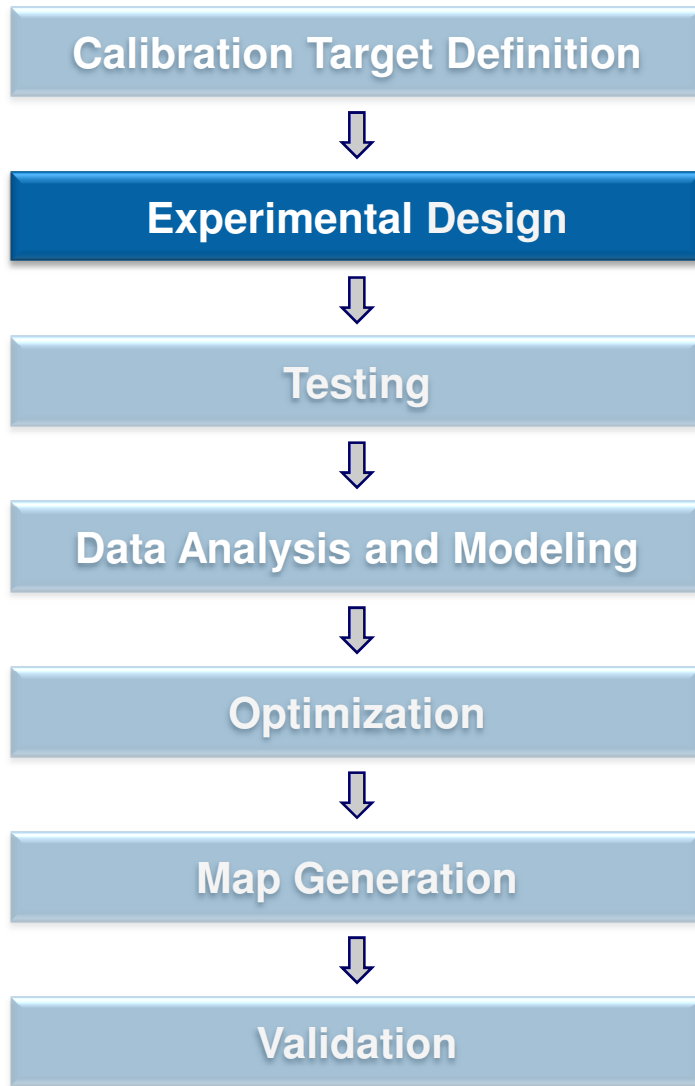
AVL CAMEO™ Calibration Development Stages



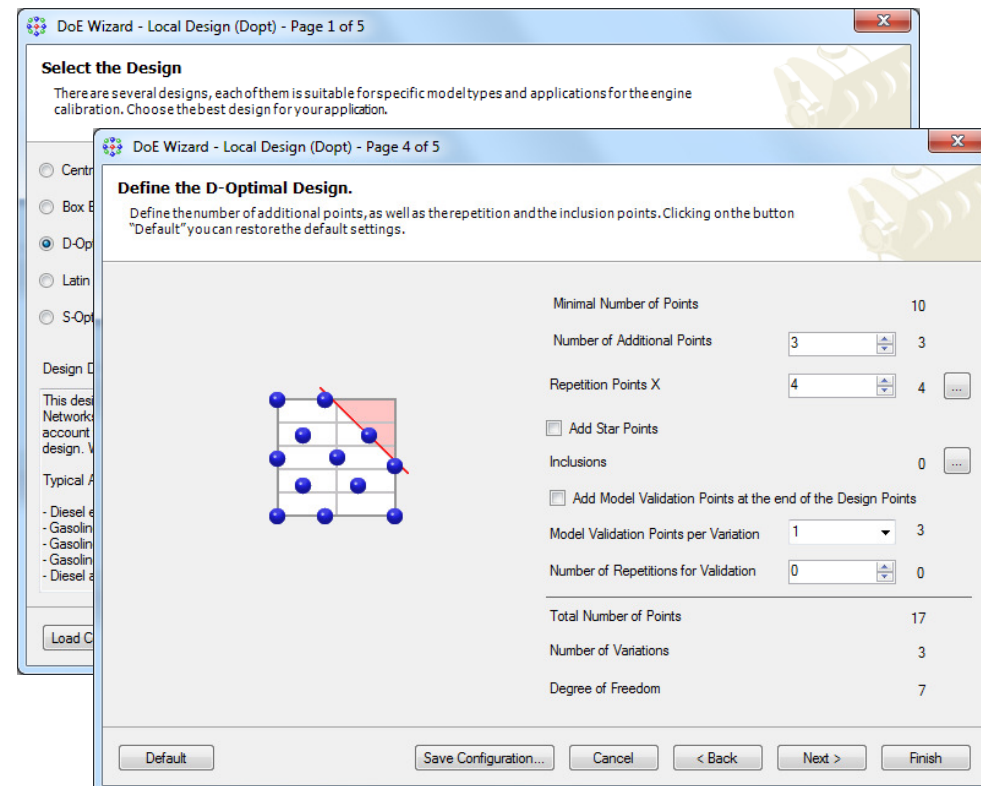
- Definition of the Calibration Task
- Definition of Measurement Channels (Targetfunction)
- Expert knowledge, Experience
- Testcell Environment



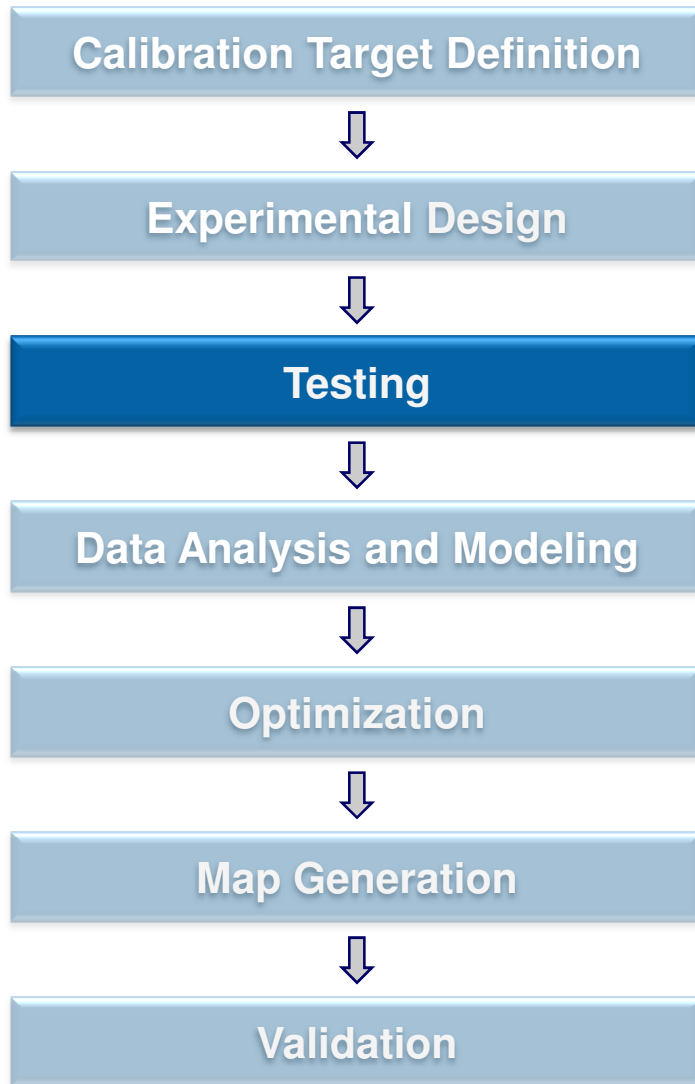
AVL CAMEO™ Calibration Development Stages



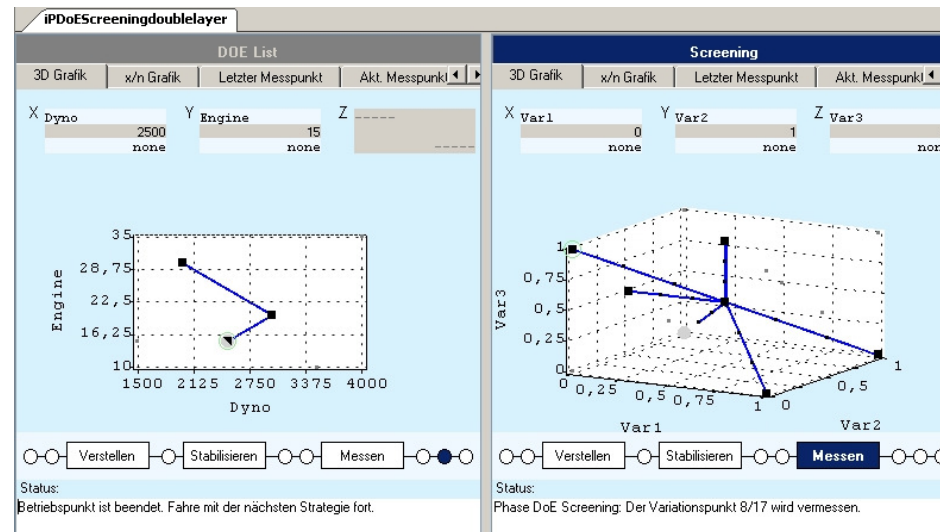
- Definition of relevant Operating Points and Variation Parameters (e.g. 8 mode 6 parameters = 900 points instead of 8000)
- Creation of Testplan (Design of Experiments...) – DoE Wizard in CAMEO
- Definition of Limits



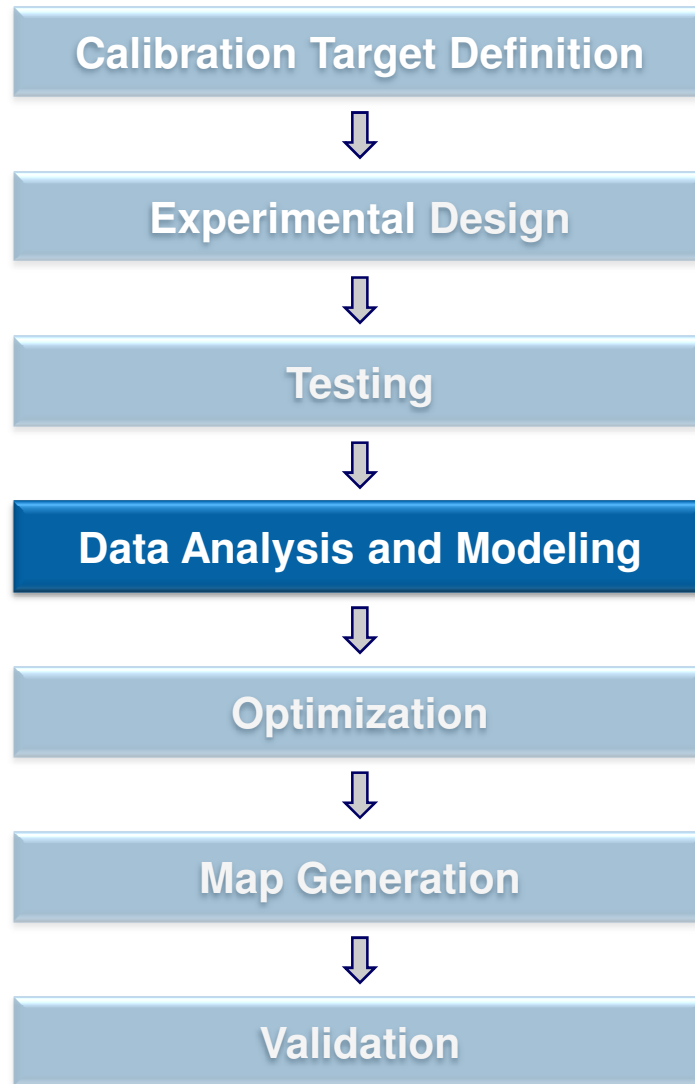
AVL CAMEO™ Calibration Development Stages



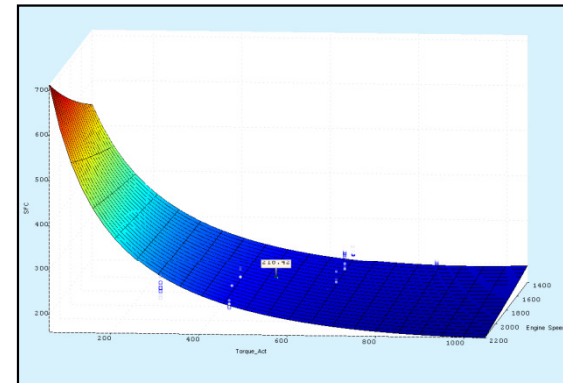
- Fully automated execution of a testruns or testsequences (average 1-2 Minutes per point instead of 5 minutes)
- Customizable testrun visualization
- Real Time capability (Online Controllers)



AVL CAMEO™ Calibration Development Stages

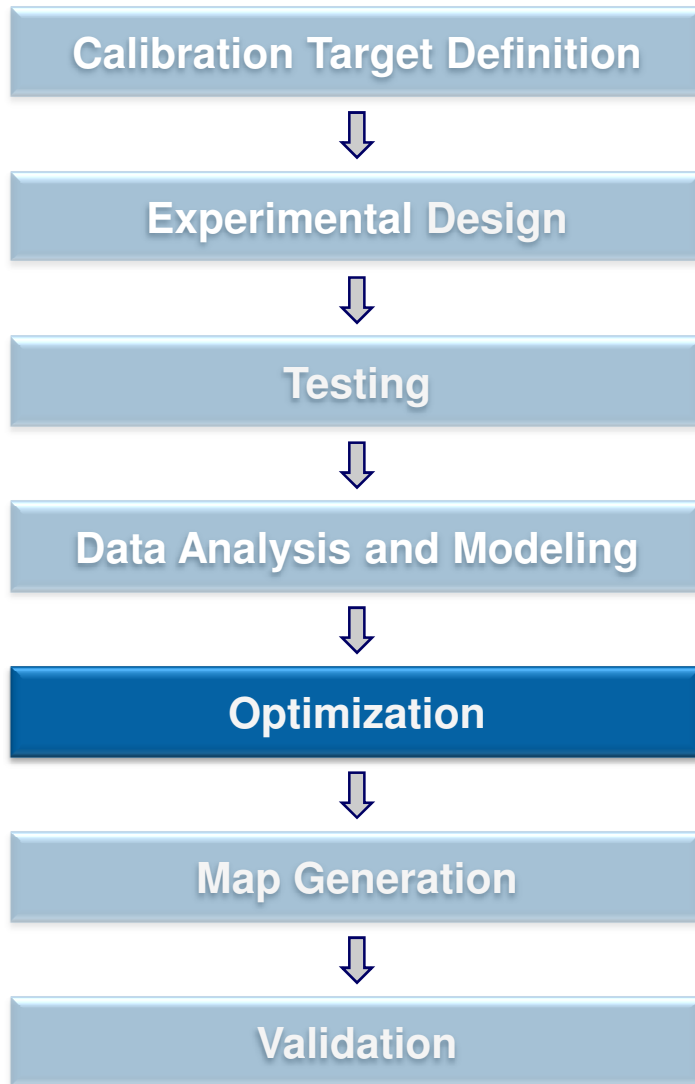


- Raw Data Analysis; Identifying outliers
- Modelling of all relevant target channels with Polynomial Models or Neural Networks

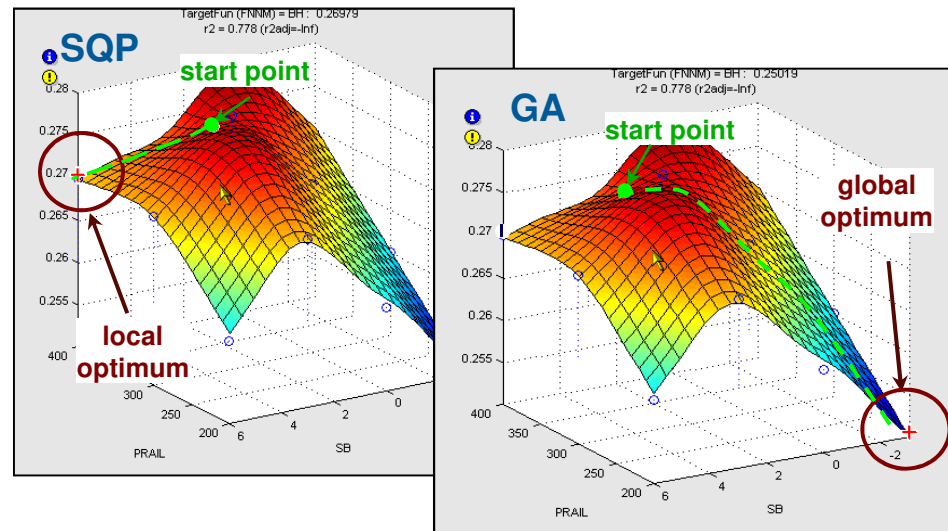


- FreePolyModel
 - Polynomial models up to 5th order
 - Modelterm reduction by means of significance test
 - Manual selection of modelterms
- FastNeuralNetworks
 - Combination of local models by means of weighting functions
 - Linear, quadratic or fullquadratic local models
 - Orthogonal splits
- IntelligentNeuralNetworks

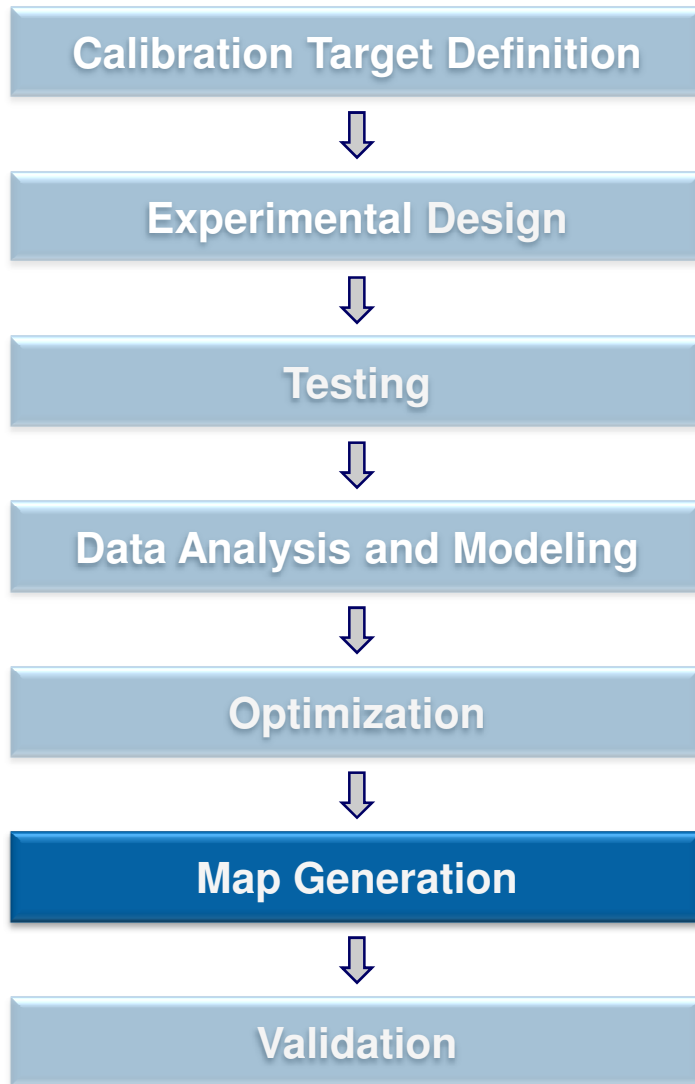
AVL CAMEO™ Calibration Development Stages



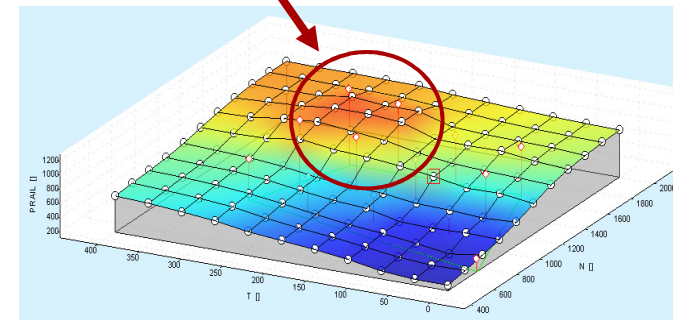
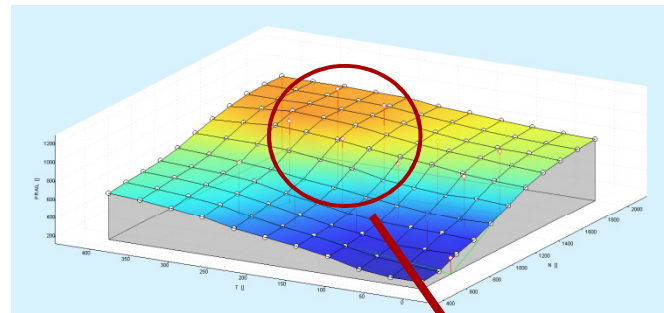
- Optimization constrained by Driving Cycle Constraints
- Possibility of defining Local Constraints
- Different Optimization algorithms:
 - SQP: Sequential Quadratic Algorithm
 - GA: Genetic Algorithm
- Flexible Optimization
- Map Smoothing



AVL CAMEO™ Calibration Development Stages



- Calculating and uploading maps into the ECU
- Model feedback



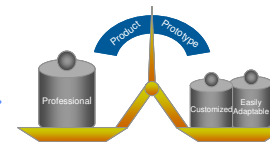
From measurement data to calibration dataset

A typical actual challenge



Situation

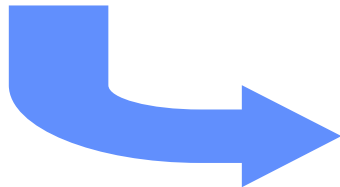
- One of the most time-consuming parts of the calibration work is finalizing control unit parameters from available testbed or vehicle data.
- which usually requires lengthy data-plausibility checking and recalculations, for which a deep knowledge of the control-unit software is often needed.
- This often leads to the need of self-made macros and scripts (e.g. Excel, Matlab)



Need

The actual complexity and time-pressure in the calibration projects require clear defined calibration processes, which lead to the need of:

- professional
- customized
- easily adaptable calibration tools



Problems and Implication

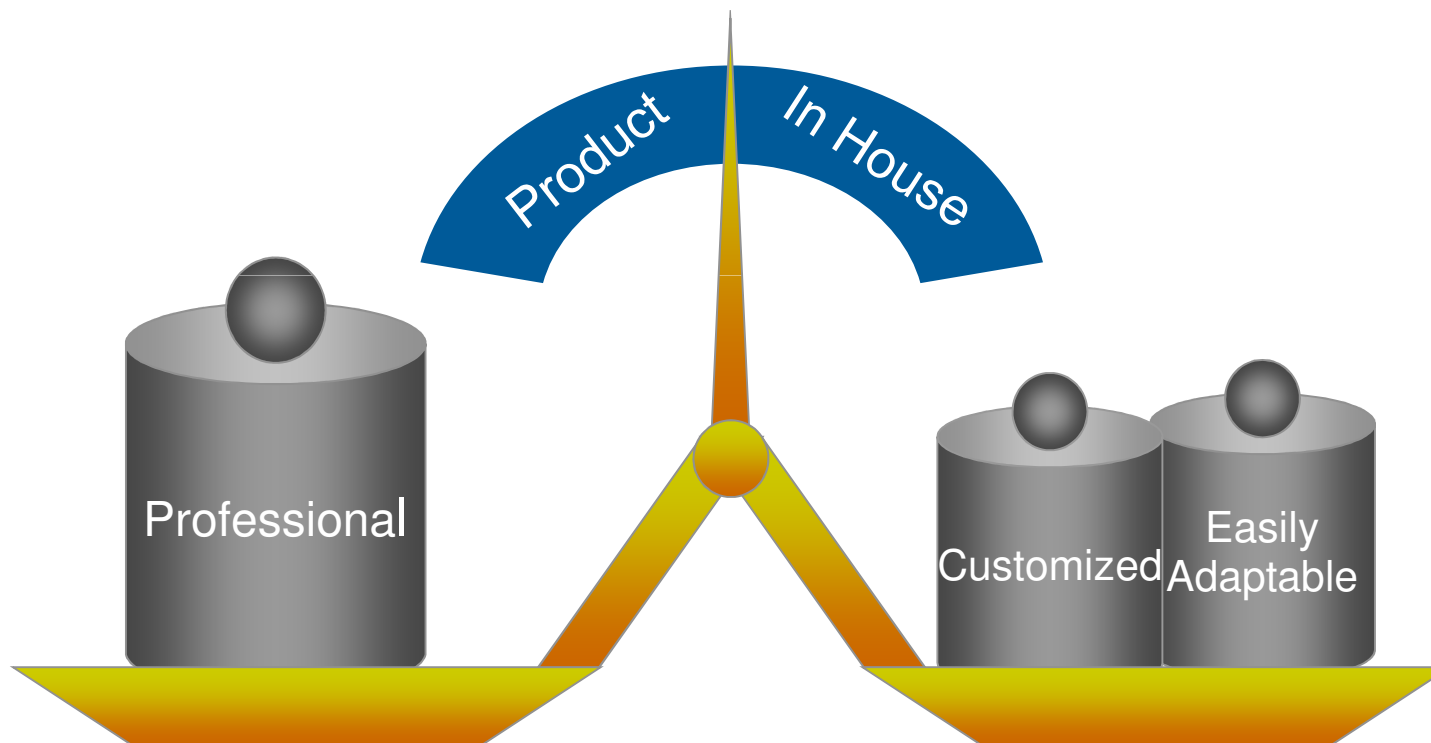
These self-made macros and scripts can be generated quickly and adapted easily, but lead to:

- An heterogeneous tool chain
- Parallel and uncoordinated tools development
- Maintenance issues and time spent for macros and scripts generation
- Risk for low quality of the results

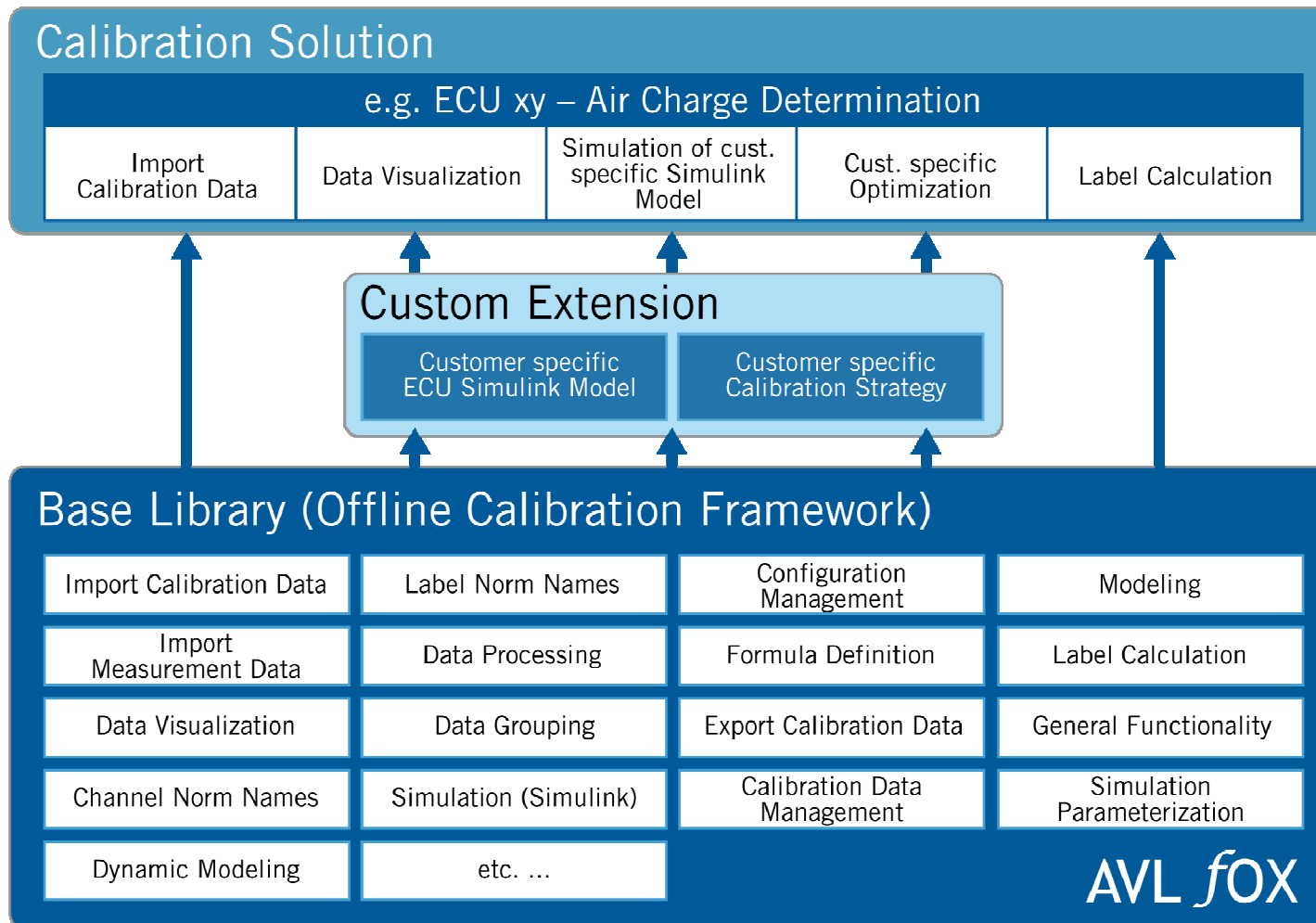
From measurement data to calibration dataset A typical actual challenge



The resulting dilemma

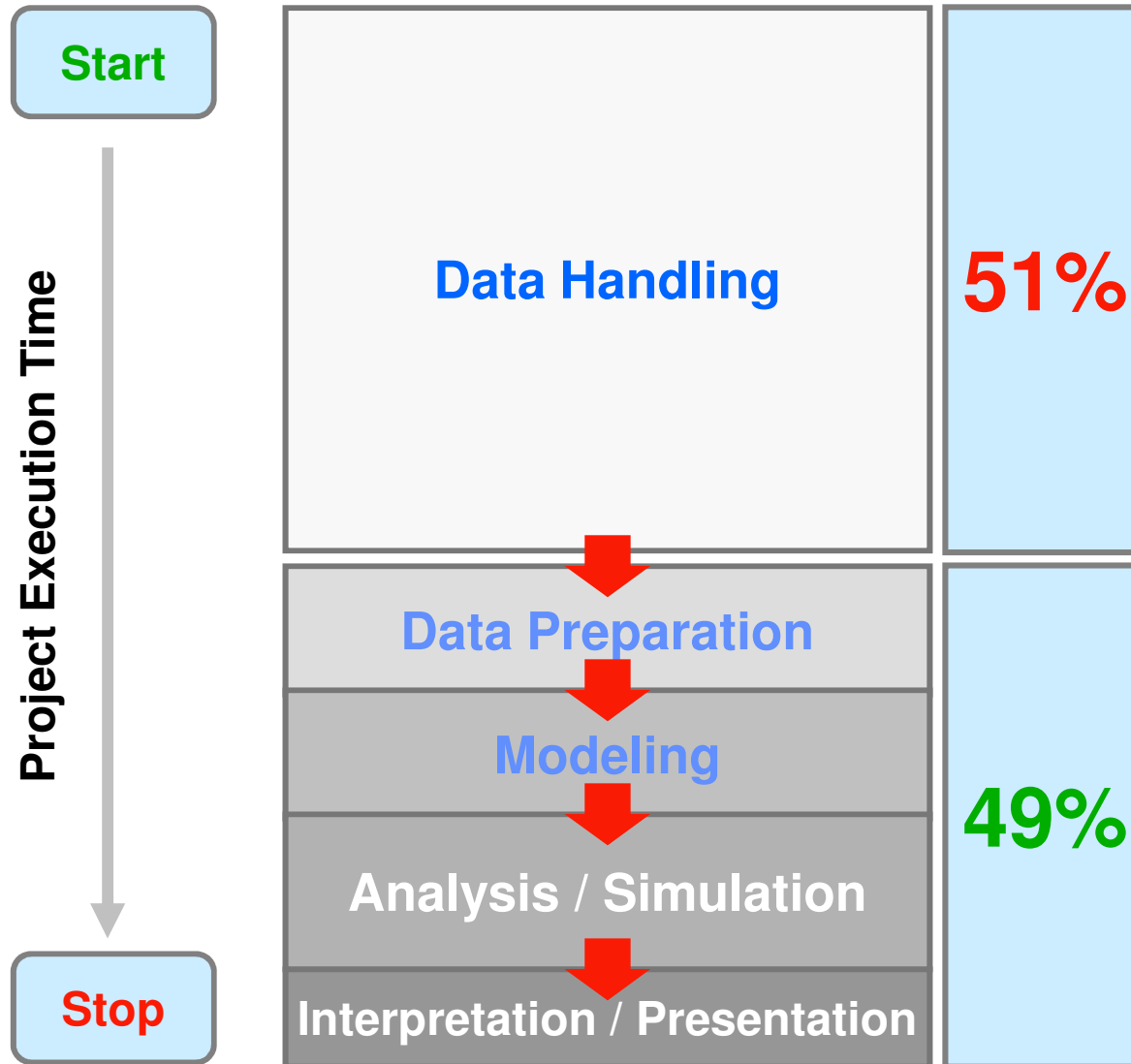


The solution: AVL fOX™ - Fast and customized development through reuse of components



Powertrain Development process

Time share between data handling and productive work



percentage overall time (average across 11 companies of automotive industry, aeronautic and aerospace industry, railway industry)

Source: Prof. Anderl, DiK, TU Darmstadt



Typical challenges where AVL fOX™ can help you

Ready to use
offline calibration
tasks

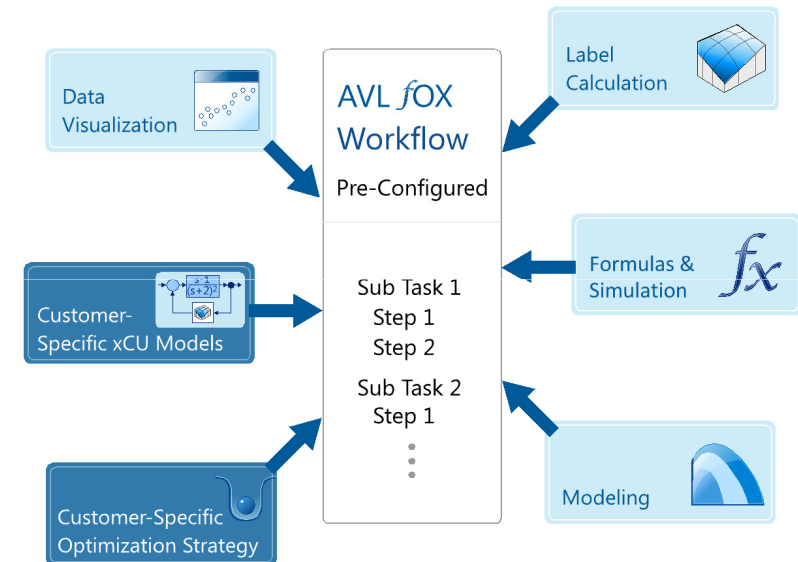
- Torque Mapping
- Charge Determination
- Hydraulic
- Exhaust Temp. Mod.
- DPF Loading
- Clutch Temp. Model
- Raw Emission Model
- Misfire Detection
- OBD Monitoring
- SCR Storage Mod.
- DPF Burning
- Oil Dilution Model
- Catalyst heating
- Inst. AFR Compens.
- ... and more

Investigate the
behavior of your
xCU functions

- fSim
- MapGen

- xCU -Function simulation
- MapExpert
- Mathematical models
- Dynamic data processing
- Statistical analysis
- ... and more

Create your own
custom specific
calibration workflow



Download demo versions and info material:
www.avl.com/xcu_calibration

