DOE SOFTWARE WITH GLOBAL MAP OPTIMIZATION

GAUSSIAN PROCESS MODEL

xCAL

Software and Testing Solutions

www.fev-sts.com

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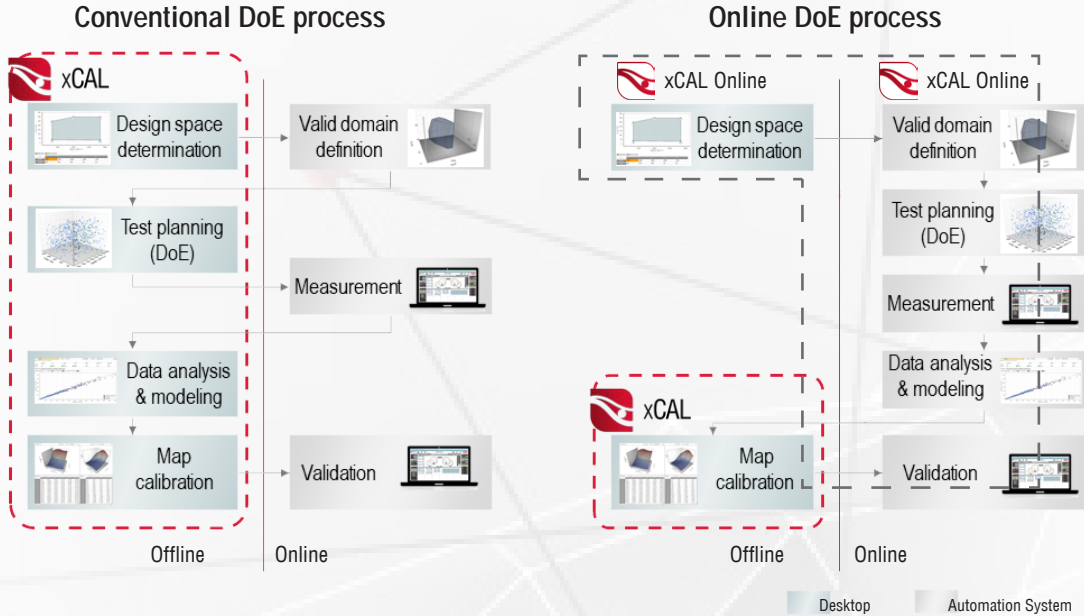## FEV CALIBRATION KNOWLEDGE IN AN EASY-TO-USE TOOL

xCAL™ is a model-based calibration software that integrates the calibration knowledge of FEV into an easy-to-use tool. It makes the powerful DoE technique easily applicable and addresses the particular challenges of automotive development that require tailored adaptations of the generic DoE methodology.

Special emphasis was placed on developing highly reliable and rapid modeling algorithms which are unique on the market. Today's state-of-the-art global modeling techniques based on Gaussian Processes have also been adapted to address the specific characteristics of engine and powertrain modeling. This approach, combined with intuitive visualization and user guidance, enables engineers to quickly investigate and optimize the engine's behavior, for example.
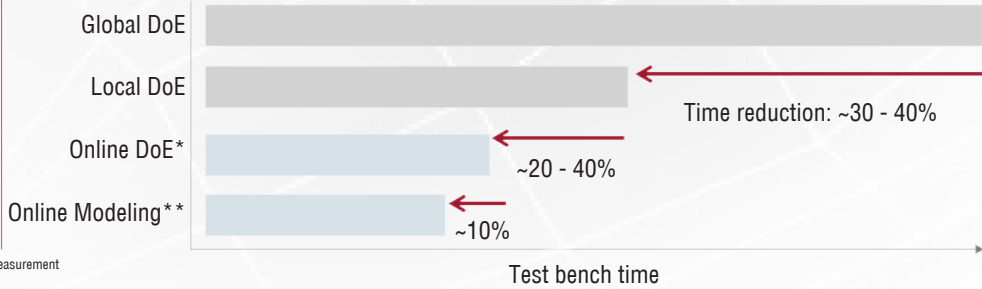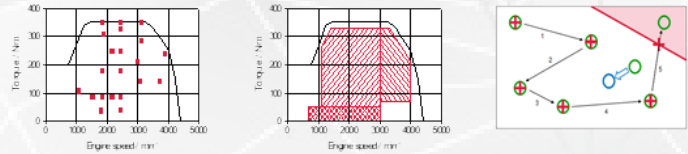
EFFICIENT PROCESS

Additionally, xCAL Online enables online DoE to be efficiently monitored at the test bed, evaluates model quality, and finds optima parameters for a target, validating the optimum with no waiting time. Its active DoE technics enables the modeling in parallel of the test measurement process. The active DoE, as well as the screening capabilities avoiding to cross any limits, decreases the test duration by a 50% while optimizing the quality of the model generated.

Conventional DoE process

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Design space determination → Valid domain definition

Test planning (DoE)

Measurement

Data analysis & modeling

Map calibration → Validation

Offline | Online

Online DoE process

xCAL Online — xCAL Online

Design space determination → Valid domain definition

Test planning (DoE)

Measurement

Data analysis & modeling

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Map calibration → Validation

Offline | Online

Desktop   Automation System

xCAL Online decreases the test duration by ~50% while optimizing the quality of the model generated.

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xCAL Online

|	Test bench time	
Global DoE		
Local DoE		Time reduction: ~30 - 40%
Online DoE*		~20 - 40%
Online Modeling**		~10%

* Online DoE : Valid domain definition, Test planning, Measurement
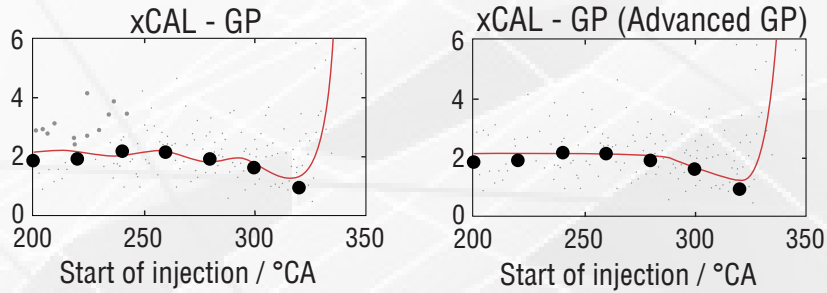** Online Modeling : Online DoE + Modeling

POWERFUL FUNCTIONALITIES

» xCAL solutions

> **Model-based calibration is mandatory with regards to the complexity of development tasks (Optimization, virtual calibration)**
  - State-of-the-art GP model with best-in-class Advanced GP Modeling.
  - Integrated map optimizer with possibility to implement global or cycle optimization.

> **Complex design space**
  - Online DoE algorithms ensure the respect of any limits with screening approaches
  - Large choice of constraints, including convex hull gives the possibility to measure any design space
  - The upcoming limit prediction feature will be able to model any domain even the most complex thanks to the Gaussian Model*

> **Optimization of test time duration**
  - Online DoE techniques such as Active DoE and Online modeling or optimizing helps decreasing drastically the test time, while optimizing the modeling quality
  - The upcoming model-based design space definition will bring the efficiency of operation to the superior level thanks to the adaptive DoE feature*

> **Model-based optimization**
  - Optimization algorithms able to perform either local, global or cycle-based optimization (multi cycle also)
  - Large field of application, such as powertrain, conventional engine, eDrives

> **High expertise required to run the DoE process**
  - The unique workflow approach of xCAL offers high efficiency in term of user guidance. Every action enables the next action required such that any junior user can easily go through all the process
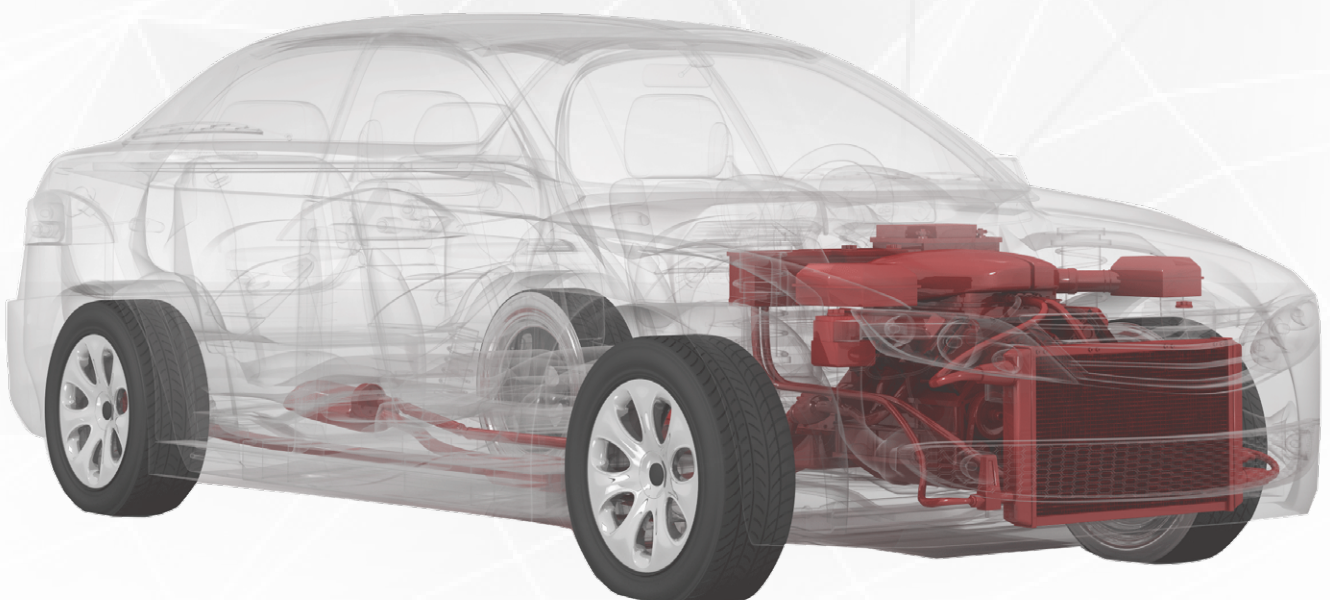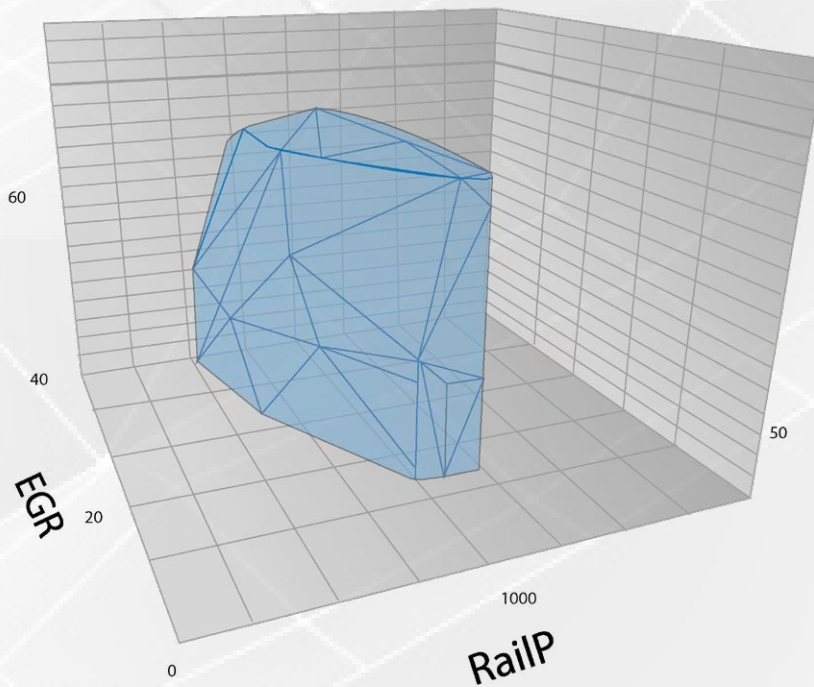
POWERFUL FUNCTIONALITIES

›› ADVANCED GP: OVERFITTING MINIMIZED, OPTIMUM EASILY IDENTIFIED
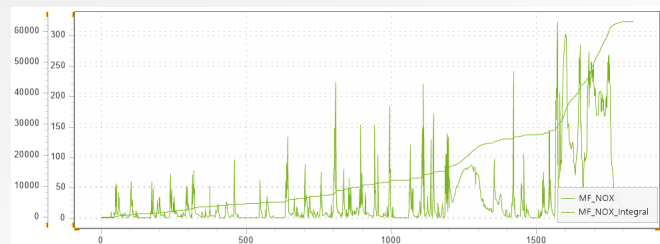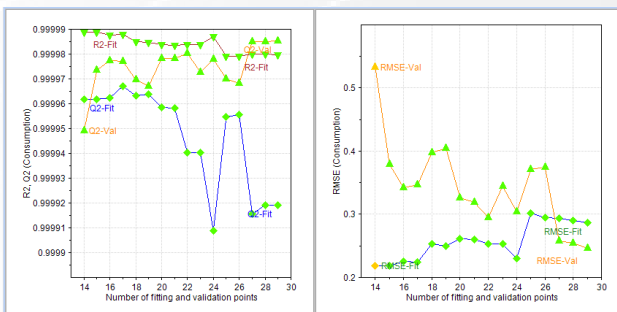

›› COMPLEX DOMAIN DEFINITION WITH CONVEX HULL

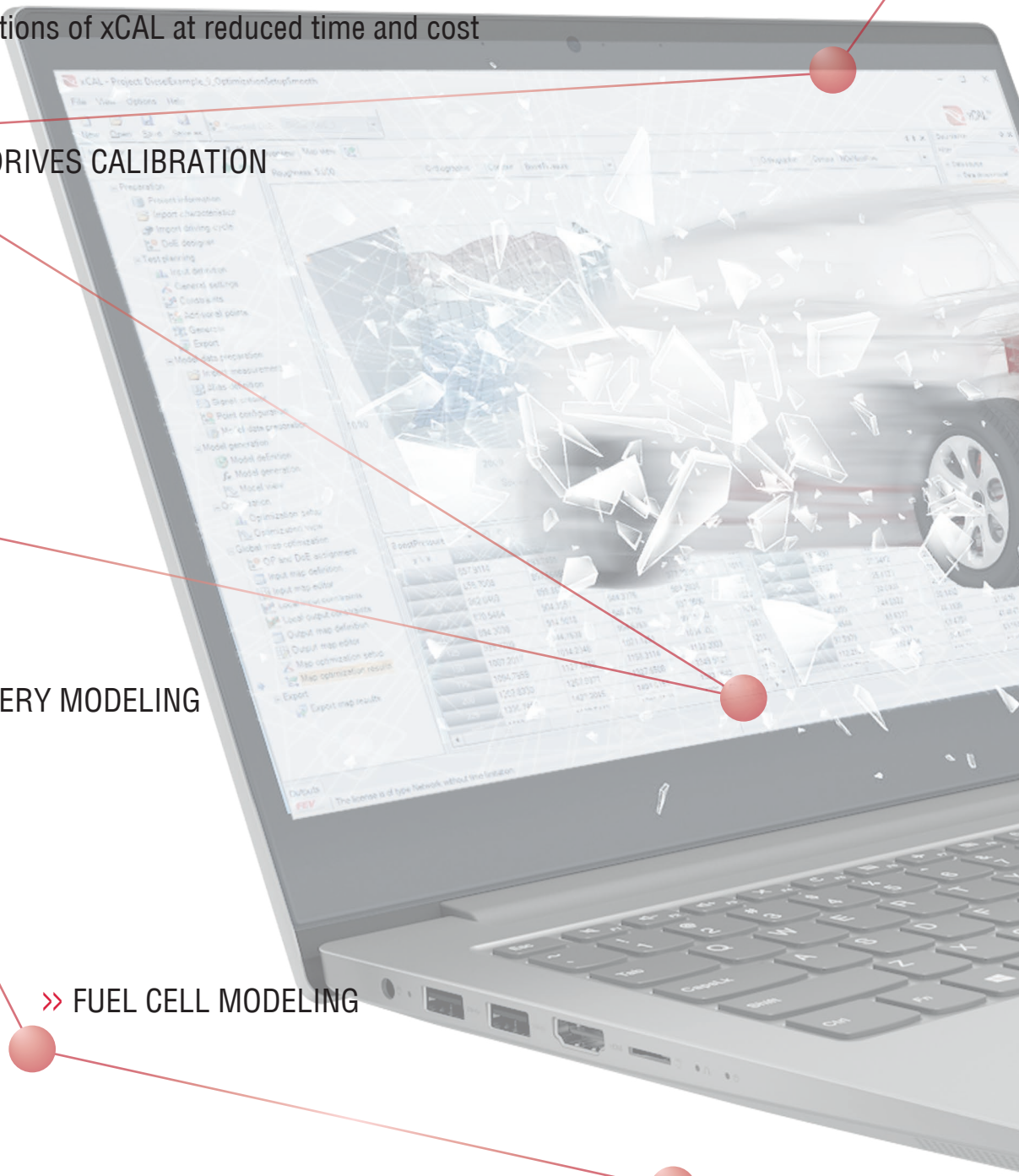## ›› ONLINE MODELING WITH XCAL ONLINE ›› CYCLE GLOBAL OPTIMIZATION

» Broad applications of xCAL at reduced time and cost

» E-DRIVES CALIBRATION

» BATTERY MODELING

» FUEL CELL MODELING

APPLICATION EXAMPLES

» HYBRID POWERTRAIN CALIBRATION

» HARDWARE LAYOUT FROM MODELED DATA BASE

» VIRTUAL CALIBRATION

» EMISSION CALIBRATION OF ICE

» TRANSMISSION CALIBRATION

Excellence in virtual calibration through smartly connected diversity to the benefit of the user

TECHNICAL SPECIFICATIONS

xCAL

Item	Description
Product version	2020_01
Operating system	Windows 7 and Windows 10 (64 bits)
GUI languages	English
GUI	Workflow based platform
xCAL file format	.xml file containing or referencing all data, or zipped so the project can be shared or transferred
Data format	csv, xml, dcm, PaCo
Hardcode	Multi-threaded, multi-instance
Protection	License file or license server

xCAL Online

| Item	Description
Product version	1.5.4
Operating system	Windows XP, 7 (32 bits) and Windows 7, 10 (64 bits)
GUI languages	English
AuSy	MORPHEE 2014 (2.7.1 minimum) (upcoming version is non AuSy dependent)*
Real Time Kernel Frequency	From a minimum of 10 Hz to 2kHz
Protection	License file dongle or license server

# UPCOMING RELEASE OF NEXT XCAL ONLINE IN 2022 (Q3)
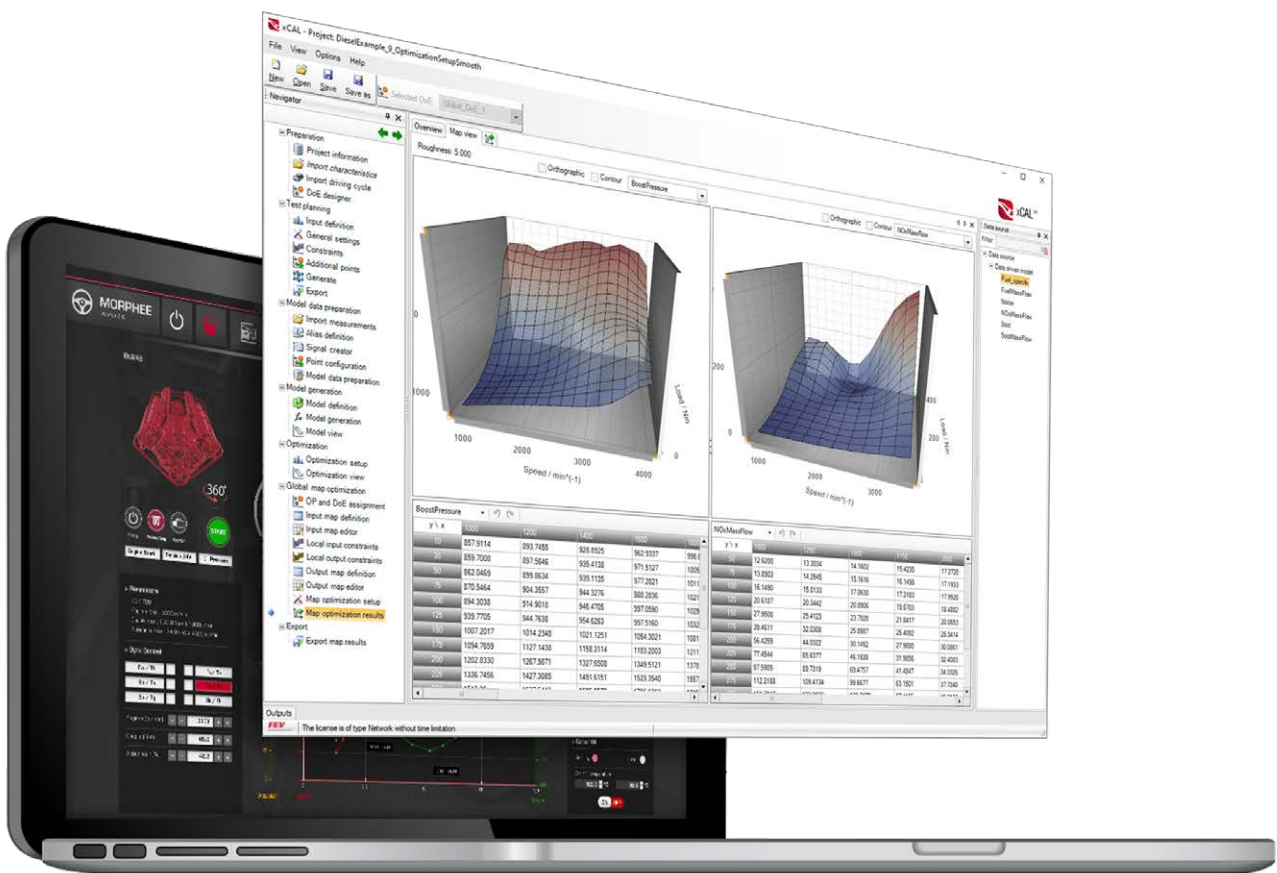
Upcoming release of next xCAL Online in 2022 (Q3)
- Automatic boundary investigations (model based limit prediction)
- Model based adaptive DoE (intelligent selection of next point)
- Desktop version for easier setup by the engineer
- Improved integration Offline / Online for better flexibility
- Easy application to any Automation System thanks to the ASAM ACI standard

THE PROCESS
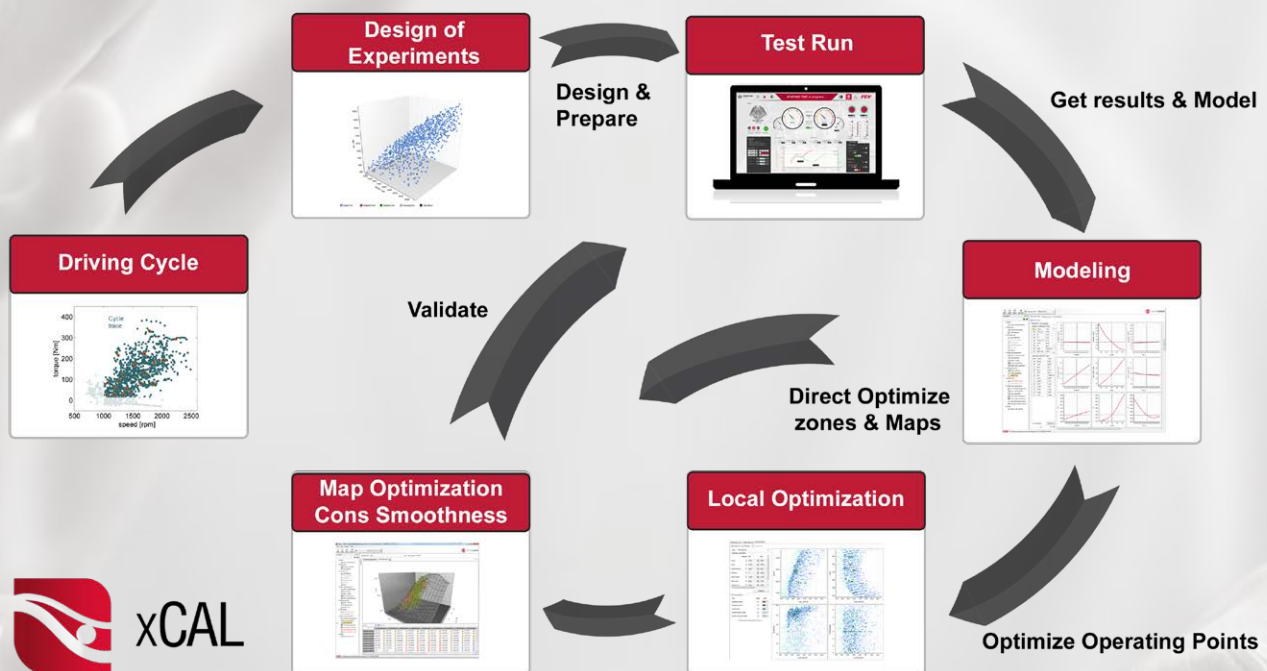
> **Design of experiment**
>   - Different tool configuration for local or global DoE mode
>   - Large choice of constraints, including convex hull gives the possiblity to measure any design space
>   - Different type of test design such as homogeneous (equal distance between each points), or input compression (allows to increase point density in area of interest)

> **Test run**
>   - Online DoE techniques such as Active DoE and Online modeling or optimizing helps decreasing drastically the test time, while optimizing the modeling quality
>   - The upcoming model-based design space definition will bring the efficiency of operation to the superior level thanks to the adaptive DoE feature*

> **Modeling**
>   - State-of-the-art GP model with best-in-class FEV patented Advanced GP Modeling.

> **Optimization**
>   - Optimization algorithms able to perform either local or global optimization
>   - Large choice of configuration with multiple objective (cycle based if required) and multiple constraints
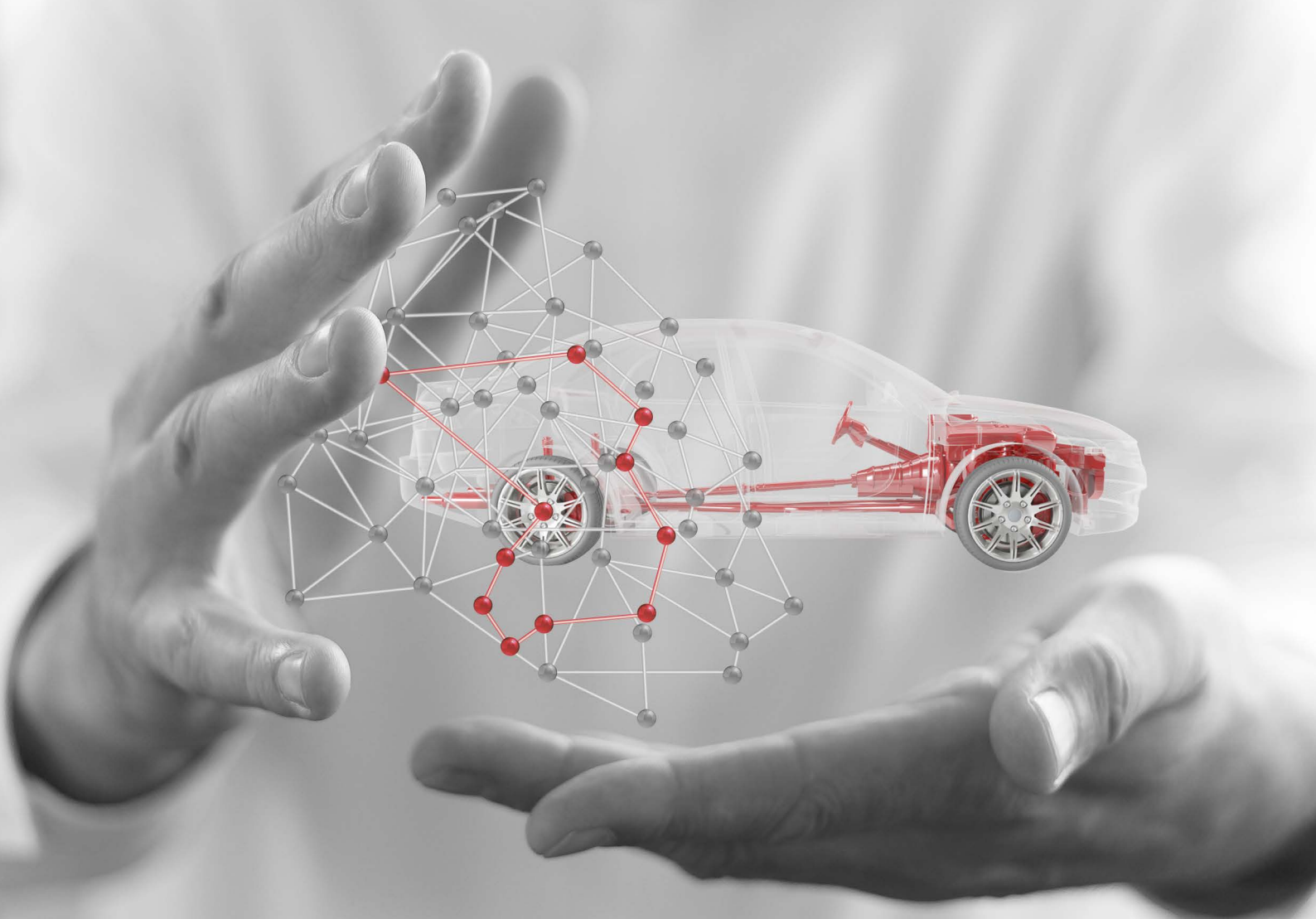
Benefits at a glance

xCAL

- **State-of-the-art:** best in class algorithms and models (FEV patented Advanced Gaussian Process model)
- **Structured:** the workflow leads the work according to the calibration process
- **Flexible:** multiple calibration approaches available including cycle prediction capabilities
- **User-friendly:** workflow based interface providing help to the calibration engineer
- **Advanced:** providing best-in-class algorithms for fast and high accuracy modeling and optimization
- **Independent:** operating efficiently all data and all results generated within the project
- **Powerfull:** possibility to optimize calibrations for multiples criteria and driving cycles
- **Open:** possibility to reuse the models and optimization results in other applications like Excel, Matlab or INCA

xCAL Online

- **Cost effective:** xCAL Online allows to save test bed time and engineering hours
- **Integrated:** uses MORPHEE® and already existing connection to ECU, indicating system and others devices
- **Simple:** only need the AuSy PC at the test bed
- **Safe :** investigate safely combustion settings possibilities in engine physical domain
- **Precise :** model online, validate online directly in the process
- **Efficient :** stop measurement process when enough measurement for a good modelling precision
- **Flexible :** can execute any user-defined test plan within engine limits (e.g. Global DoE test plan...)

And also:

- Free update during the warranty year (new versions available on www.fev-sts.com)
- Free hotline access during the warranty year
- Free blocking bugs correction

Are you interested in innovative, pioneering software solutions?

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