TRAINING CATALOG

This document contains all FEV STS training offers at client's site, at FEV premises or virtually. Some trainings are available as E-learning on our FEV Academy training platform.

FEV Academy
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2022 key figures:

145 participants took part in the 28 training sessions we have organized through 2022 with overall satisfaction at 81%

Contents

Products Trainings

MORPHEE

Test system Automation, simulation & calibration

Based on an "all-in-one" system, numerous configurations are possible depending on the customer's individual testing environment. As a result, it is possible to combine these three functionalities on a single platform which is installed for an engine test bench — or the three can be operated separately, using third-party tools.
For example, in a calibration configuration, the MORPHEE calibration platform usually operates with third-party automation tools.

The new 64-bit version (second part of 2016) is in line with all new operating systems and boasts outstanding performance with 5 mega samples/sec, e.g. 2500 channels at 2 kHz.

It offers the opportunity to develop new automation concepts for future test beds while taking current and upcoming emission and testing standards such as Euro 7, RDE, etc. into consideration. Furthermore, it is a powerful tool for new powertrain calibration methodologies, such as Road to Rig. Relying on its established qualities of openness and performance, MORPHEE extends its functionalities to allow the use of the same interfaces, the same models and the same tools throughout the entire development process. As a result, the new MORPHEE generation will become a unique platform for validation, combining the three functionalities of test automation, on-line calibration operations at the test bed and real-time simulation.

MORPHEE - User Training - 3 days

By focusing on practical knowledge and hands on experience, the MORPHEE User Training empowers MORPHEE bench users allowing them to be more productive. The user interfaces of MORPHEE run-time and MORPHEE Editor are explained. The training showcases typical usage scenarios like defining new measured and calculated channels, screen and method editing. Delivered in a simulated MORPHEE application environment it enables users to define new automatic test runs with automatic results storage.

Operational goals

- Know how to use the generic user interface of MORPHEE run-time (modes, monitors, components, menus)
- Understand the architecture of a MORPHEE test cell (PC, components, drivers, physical channels)
- Understand the use of measured channels, calculated channels, constants, LUTs, tables, text channels, reference channels)
- Know how to use standard instructions of MORPHEE in an automatic test run
- Know how to set up basic alarm thresholds
- Know how to use a measurement plan for results storage

MORPHEE Application

Our practical training makes use of the simulation capabilities on standard SCALE applications. The customer can choose one of the standard SCALE application environments (engine, e-motor, battery.)

Target audience

Test cell operators who are authorized to modify screens, channels, security thresholds and/or test runs.
All test engineers or test facility support staff on MORPHEE 64 bits test cells.

Prerequisite

- Experience with operating test cells or test cell automation
- Being familiar with a windows PC environment

Training program

1. **Structure of MORPHEE software and hardware on a test cell**
   - MORPHEE architecture: PC, acquisition/communication cards, drivers, components, tests
   - The three modes BENCH, CAMPAIGN, TEST and the transitions between them
   - Separation between test cell specific settings and shared settings like test procedures
2. **MORPHEE standard run-time interface**
   - How to launch MORPHEE multi-modes
   - Control of standard test cell equipment from this GUI (media conditioning, engine and dyno control, I/O modules, special measurement equipment)
   - Standard MORPHEE menus and monitor windows (channels, set values, alarms …)
   - Result data storage: instantaneous values, recorder or stabilized measurements via ALGORITHM
3. **MORPHEE Editor**
   - How to browse between the tabs: Bench Config, Campaign, Test, Components
   - Setting up the three modes in the Editor
   - How to edit standard MORPHEE channels with/without physical / internal channel / [AUTO] link
   - MORPHEE calculated channels, constants, text channels
   - MORPHEE look-up tables (LUT), tables, reference channels
   - How to edit a screen interface (graph, mono/bistable button, gauge, potentiometer, include…)
4. **General functioning of FEV components**
   - Tree of standard FEV components for media control, I/O, measurement devices, dyno, engine …
   - Inheritance between father and son components
   - How to overload an inherited channel, screen or method in a son component
5. **Programming an automatic test run, e.g. a full load test**
   - Programming of test runs in cycle, CCE diagram and AMAP format
   - How to program a user dialog (yes/no question, drop down list, free input text or numbers…)
   - How to program a procedure with conditions (IF, ELSE, GOTO, …)
   - Call of other methods
   - How to use counters and timers
   - Instructions related to the user interface (show/hide elements, messages to operator)
   - How to modify the alarm handling within the test run (activate, deactivate, modify thresholds …)
   - How to use measurement plans for storage
   - How to store a single point or multi-point measurement, instantaneously or stabilized
   - Refuge, restart and alarm cycles, context storage management
   - How to use the MORPHEE online help

MORPHEE - Advanced Training - 3 days

Advanced training for Administrators about the management of a MORPHEE test cell: the participants learn how to set up the Bench Configuration page with the 3 modes as well as the various INI files. They learn to set up advanced securities and how to customize the result storage. They get deeper knowledge about MORPHEE components and about advanced capabilities of MORPHEE software.

Operational goals

- Know how to install or update MORPHEE software
- Know how to set up the functioning of the 3 modes BENCH, CAMPAIGN, TEST
- Understand the functioning of internal and physical channels in detail
- Know how to set up advanced alarm thresholds, reactions and conditions
- Know how to set up the MORPHEE.INI file and other configuration files (CFP, UEditor.config)
- Know how to take advantage of the generic functions of FEV components
- Know how to set up customized results storage (channel groups, file groups, custom storage directories)
- Know how to manage the acquisition frequencies and how to check real-time performance

Target audience

All staff in charge of the installation or administration of a test cell, or who develop MORPHEE components.
Example: test cell / test field managers, MORPHEE support team at customer site.

Prerequisite

- MORPHEE 64-bit User Training plus several months of practical experience on a MORPHEE test cell.

Training program

1. **Installation or update of MORPHEE software**
   - Guided installation step by step: Windows components, license manager, RTX, MORPHEE…
   - Architecture of a MORPHEE PC: acquisition/communication cards, drivers for field busses
   - How to activate an additional driver in the INI file
2. **Setting up the 3 modes BENCH, CAMPAIGN and TEST**
   - Which component is to be loaded in which mode, in which order?
   - Discussion about advantages and drawbacks of the different solutions
3. **Physical channels, MORPHEE channels, MORPHEE alarm monitoring**
   - **D**ifference between physical channels and MORPHEE channels
   - Automatic import of ESERIES channels into IOEDIT (physical channels)
   - [AUTO] link or fixed link between MORPHEE channels and physical channels
   - Detailed setup of alarm monitoring (conditional reaction, delays, hysteresis …)
4. **MORPHEE configuration files**
   - Customization of directories and back-up of your environment with MENV
   - MORPHEE.INI file, UEditor.config file, MORPHEE.cfp file
5. **Detailed functioning of FEV components**
   - Screens and screen elements which are common to all FEV components
   - Management channels common to all FEV components
   - Methods for initialization, stop, alarm handling etc. which are common to all FEV components
   - Setting up the way the transitions between the 3 modes, for each component
6. **How to customize results storage**
   - Storage frequencies and multi-frequency acquisition
   - Review of how to use measurement plans for storage
   - Customization of channel groups and file groups for storage
   - Customization of storage directories
7. **Setting up the acquisition frequencies and the real-time functioning**
   - Setting up the acquisition frequencies (slow, normal, fast) for each project or test
   - How to check real-time performance
   - How to optimize the modes initialization (RTX load)

MORPHEE - Basic Training – E-Learning (1 Hour)

By focusing on practical knowledge and hands on experience, the MORPHEE E-learning courses empower MORPHEE bench users allowing them to be more productive. The user interfaces of MORPHEE run-time and MORPHEE Editor are explained. The training showcases typical usage scenarios like defining new measured and calculated channels, screen and method editing. Delivered in a simulated MORPHEE application environment it enables users to define new automatic test runs with automatic results storage.

Operational goals

- Know how to use the generic user interface of MORPHEE run-time (modes, monitors, components, menus)
- Understand the basic architecture of a MORPHEE test cell
- Understand the use of measured channels and calculated channels
- Know how to create a simple user interface
- Know how to right an automatic test using different available methods
- Know how to use standard instructions of MORPHEE in an automatic test run

MORPHEE Application

Our practical training makes use of the simulation capabilities on standard SCALE applications. The customer can choose one of the standard SCALE application environments (engine, e-motor, battery.)

Target audience

Test cell operators who are authorized to modify screens, channels, security thresholds and/or test runs.
All test engineers or test facility support staff on MORPHEE 64 bits test cells.

Prerequisite

- Experience with operating test cells or test cell automation
- Being familiar with a windows PC environment

Training program

1. **MORPHEE - Introduction and general presentation**
2. **MORPHEE - RUNTIME - Structure and design - 3 modes navigation**
3. **MORPHEE - EDITOR presentation and browser overview**
4. **MORPHEE - EDITOR - Calculation & measurement channels: creation and modification**
5. **MORPHEE - EDITOR - User interface - Screens creation and modification**
6. **MORPHEE - EDITOR - different types of tests - Methods creation & modification**

MORPHEE - Advanced Training – E-Learning (12 Hours - FRENCH)

Advanced training for Administrators about the management of a MORPHEE test cell: the participants learn how to set up the Bench Configuration page with the 3 modes as well as the various INI files. They learn to set up advanced securities and how to customize the result storage. They get deeper knowledge about MORPHEE components and about advanced capabilities of MORPHEE software.

Operational goals

- Know how to install or update MORPHEE software
- Know how to set up the functioning of the 3 modes BENCH, CAMPAIGN, TEST
- Understand the functioning of internal and physical channels in detail
- Know how to set up advanced alarm thresholds, reactions and conditions
- Know how to set up the MORPHEE.INI file and other configuration files (CFP, UEditor.config)
- Know how to take advantage of the generic functions of FEV components
- Know how to set up customized results storage (channel groups, file groups, custom storage directories)

Target audience

All staff in charge of the installation or administration of a test cell, or who develop MORPHEE components.
Example: test cell / test field managers, MORPHEE support team at customer site.

Prerequisite

- MORPHEE 64-bit User Training plus several months of practical experience on a MORPHEE test cell.

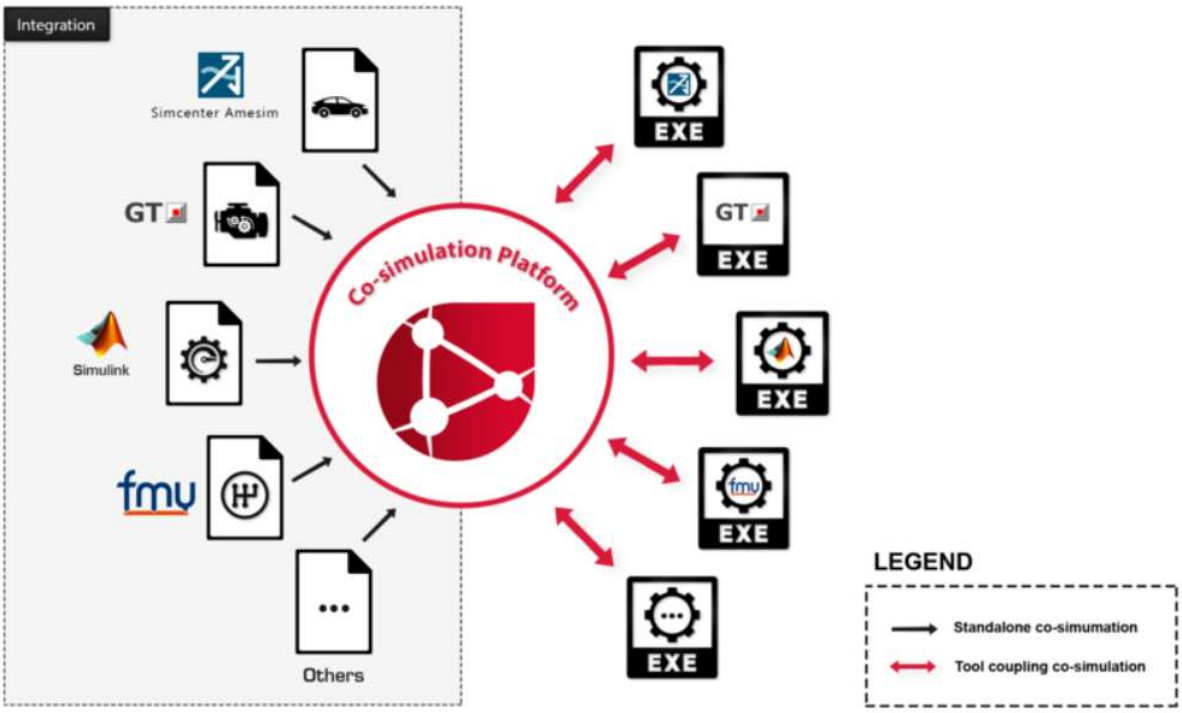
Training program

1. **Introduction, vocabulary and a reminder of MORPHEE architecture**
2. **MORPHEE Modes, Tests, Components and Test bed configuration**
3. **MORPHEE Editor and MORPHEE Executive**
4. **MORPHEE Installation and Switch tool**
5. **MEnv and Mtoolbar tools**
6. **New Test creation**
7. **Internal and physical channels, drivers, quantities, instruments and methods**
8. **ECU Configuration**
9. **Ethercat**
10. **Channels, Storage and alternative functions**

xMOD

xMOD is an application software that facilitate stand alone and tool coupling co-simulation between several simulation tools. The main idea of xMOD is to combine, within the same platform:

- **Heterogeneous model** integration environment
- Virtual **experimentation laboratory**



xMOD - Basic Training - 1 day

The concept of X-mod is to provide a platform that starts from scratch without the need of any existing models. It is empty allowing the user to import by himself his models for execution. The latter takes place within ideal performance conditions. The platform is user-friendly assuring continuity from the execution on the user's portable PC up to the execution on a test bench PC in real time (Hardware in the loop). The xMOD platform allows the exchange between the different services to happen smoothly. It also makes it possible to send simulations ready for execution for someone else without having to reconfigure.

The following training will help you understand the main use of xMOD and its basic features. It will also equip you with the practical knowledge needed to construct and run a simulation

Operational goals

- Understand xMOD-MORPHEE target and Block library
- Know the third-party tools for compiling
- Construct a simulation using xMOD basic features
- Compile and run a simulation

Target audience

- Control and simulation engineers

Prerequisite

- No prerequisites are needed

Training program

1. **Introduction**
   - Introduction: xMOD main usage and objectives
   - A skim on the workflow and concept of xMOD
   - A general overview on the xMOD editor

2. **Models generation**
   - Generating models using xMOD MORPHEE Target
   - Compiling models using third party modeling tools
   - xMOD-MORPHEE target Block Library

3. **Constructing a simulation**
   - Using the generated models (compatible to xMOD) to create quantities, simulations, screens and methods.
   - Learn the different basic features:
     i. Quantities
     ii. Dashboards
     iii. Records
     iv. Calibration
     v. Methods
     vi. Native Blocks
   - Tool coupling:
     vii. AMESim
     viii. GT-Power
     ix. Simulink
   - FMI

4. **Running a simulation**
   - xMOD Express

xMOD - Advanced Training - 2 days

The concept of X-mod is to provide a platform that starts from scratch without the need of any existing models. It is empty allowing the user to import by himself his models for execution. The latter takes place within ideal performance conditions. The platform is user-friendly assuring continuity from the execution on the user's portable PC up to the execution on a test bench PC in real time (Hardware in the loop). The xMOD platform allows the exchange between the different services to happen smoothly. It also makes it possible to send simulations ready for execution for someone else without having to reconfigure.

Operational goals

- Advanced compilation of several heterogeneous models (and associated debugging methodology)
- Optimize model execution, with multi-solver / multi-core methodology
- xMOD Build: Automatic compilation tool presentation
- Handling xMOD HiL solution with its specific drivers

Target audience

- Control and simulation engineers

Prerequisite

- xMOD basic training

Training program

1. **xMOD setup and configuration**
2. **xMOD concept**
3. **xMOD Target**
   - Target configuration
   - Compiling a Simulink model
   - Compiling an AMESim model
   - Compiling a GT-Suite model
4. **xMOD Editor**
5. **MIPS construction**
6. **Simulation construction**
7. **Creation/Edition of xMOD quantities**
8. **Creation Edition of dashboards**
9. **xMOD Methods**
   - Cycle
   - Diagram
10. **xMOD Build**
11. **Simul Build**
12. **xMOD Express**
13. **xMOD tool coupling with Simulink**
14. **xMOD tool coupling with GT-Suite**
15. **xMOD tool coupling with AMESim**
16. **Using xMOD utilities from Matlab**
17. **Configuring RTX RTOS**
18. **Compiling models for RTX**
19. **Drivers:**
    - CAN
    - VMIC
    - Ethernet

OSIRIS

Combustion Analysis System

OSIRIS is Turnkey's fast acquisition system. Originally designed to sample data at each engine revolution crank angle, it can also work as a time-based oscilloscope. Quick to install and easy to use, it covers all the needs of engine engineers during every step of a powertrain development.

OSIRIS - User Training - 2 days

OSIRIS training level 1 is about installation, configuration, TDC correction and use of OSIRIS, in acquisition mode and in simulation mode (office use).

Operational goals

- Understanding the foundations of crank angle-based acquisition
- Configuring the software for OSIRIS Evolution II or Evolution 3
- Performing a TDC correction with or without TDC sensor
- Applying the basic functions PMAX, burned rate and knock level
- Displaying the data in tables and in CA-, P/V- or X/Y-graphs
- Configuring data storage and convert files into other formats
- Knowing how to access the available optional functions

Target audience

All staff working with OSIRIS, on a test bed, on board in a vehicle or at the office.

Prerequisite

- Understanding of the working principle of an internal combustion engine
- Experience with engine testing
- Basic Windows operating knowledge

Training program

1. Introduction
   - Basics of fast acquisition of pressures based on engine crank angle
   - The basic signals: CDM and TRIG
   - Overview of the whole system: OSIRIS, sensors, amplifiers, encoder, multiplier, host
   - OSIRIS rack with front and rear I/O
   - System performance depending on engine speed and angular resolution
2. Adjustment of hardware parameters and TDC + vertical signal corrections
   - Engine parameters (engine type and dimensions)
   - Coding system parameters (source of the signals ANGLES and TRIGGER)
   - Parameterization and calibration of analog channels
   - Troubleshooting on sensor and encoder connections
   - TDC correction using a TDC sensor or the thermodynamic method with corrections
   - Offset correction of analogue channels (CA offset and vertical offset)
3. Acquisition, standard calculations, display and storage
   - How to apply the standard vectoral and scalar calculations of OSIRIS basic package
     - FIR filtering (low pass, band pass and high pass)
     - Standards pressure calculations (PMAX, IMEP, Max Pressure gradient)
     - Calculations of heat release and burned rate (CA10, CA50, CA90, CAxy)
   - How to display measured channels and calculations as tables, CA based graph, PV graph or X/Y graph
   - Generic monitoring function in OSIRIS
   - Results storage and conversion to other file formats (I-files, text files)
4. OSIRIS options: calculations, monitoring and communication interfaces
   - PMAX or KNOCK monitoring with digital output on alarm
   - Injection analysis based on a needle lift signal
   - Analysis of injection windows based on multiple pressure gradients dP/dA
   - Noise meter function (analysis of combustion noise in dB with human ear filter “A”)
   - FFT analysis of rotational vibrations based on the instantaneous engine speed
   - Host interface via INDI protocol or via DCOM
5. Advanced functions of OSIRIS
   - How to customize calculations via scripts
   - Automatic file naming

OSIRIS - Advanced Training - 2 days

OSIRIS training level 2 about different available calculations: their goal, how they work and how to configure them.

Operational goals

- Know the goal of OSIRIS calculations
- Know how to check the configuration of the entire chain (synchronization, calibration, TDC, filtering)
- Understand how the OSIRIS calculations work
- Know how to parameterize OSIRIS calculations
- Know how to apply OSIRIS calculations to results data (XODF)

Target audience

Engine engineers and other users which have in their daily tasks to configure and use advanced OSIRIS calculation functions, such as heat release, combustion noise or knock, etc.

Prerequisite

- Advanced knowledge of internal combustion engine operating cycles (PV diagram…)
- Compulsory OSIRIS user training

Training program

1. Introduction and recalls
   - Recall about necessary checking of the entire configuration chain (synchronization, channels gain and offset, TDC offset setting)
   - Recall about FIR filtering functions
2. Standard pressure calculations: advanced configuration
   - Use of pressure calculations at customized crank angles
   - Pmax calculation angular range setting
   - Distribution law setting (real angles of opening and closing of valves)
   - Kappa calculation angular range setting (polytropic coefficient)
3. Heat release calculations: configuration and use
   - Calculation algorithm basic explanations
   - Configuring 3 calculation channels in one operation: heat release, fraction burnt, average gas temperature
   - Filtering and averaging prior to calculation
   - Intake pressure and temperature as input of the calculation
   - Combustion start and end detection setting
   - Considering thermal losses through the cylinder walls
   - Applying cycle results to the fraction burnt channel (CA10, CA50, …)
4. Multiple/maxi pressure gradients: configuration and use
   - Setting maximum pressure gradient calculations (standard supply)
   - Setting multiple maximum pressure gradient calculations (optional supply)
   - Use of these results for detecting injection windows
   - Checking of results using derivation channels
5. Knock calculations: configuration and use for monitoring (alarms)
   - KNOCK calculation principles
   - MAPO calculations principles (Maximum Amplitude of Pressure Oscillations)
   - Prerequisite for an efficient knock detection
   - Setting low and high knock alarms
   - Calculation results: knock level, low knock %, high knock %
   - Activation of a digital output upon alarm detection
   - Setting the MAPO calculation (pass-band filter configuration)
   - Calculation results: MAPO and MAPO angle
   - Activation of a digital output upon alarm detection through the generic monitoring function
6. Combustion noise: configuration and use
   - Noise calculation principles (steps of the calculation)
   - Low-pass filter configuration
   - Considering the human ear answer
   - Considering the engine block attenuation
   - Results: total noise, noise level, slope
7. Needle lift signal analysis: configuration and use
   - Explanation of available cycle results: height, width and angle for 1 to 3 injections
   - Configuring the calculations (considering signal noise for calculation and detection)

FLEX Lab

Manage all test cell data from a web browser

FLEX Lab™ is a web-based technology solution to manage all test cell data. Easy rollout and cross-platform system, it requires only a modern web browser.

FLEX Lab™ System provides a proven and an open solution for data storage and retrieval, test system utilization tracking, and live monitoring of any system through configurable data schema and dashboards, also, data from every test cell is stored in one central location.

FLEX Lab – User Training - 2 days

During this course, the client will learn how to use FLEX LAB system interface with conventional Engine data model. He will learn as well how to use TestManager to operate the MORPHEE modes.

Operational goals

- Define MORPHEE specific data (Norm-names, Units, Test types, Conditioning Units, Sensors/Actuators,)
- Define UUT (engine) specifications and parameters
- Define Test request and parameters
- Access to test data

On test bed PC:

- Define test bed parameters
- Test order selection and campaign mode
- Start automatic tests
- Tests sequences
- Access local measurement data

Target audience

- Test cell operators
- Test Engineers

Training program

1. Introduction
2. General synopsis
3. FLEX LAB System
    - Users and groups
    - MORPHEE norm-names and quantities
    - Test types
    - Engine specification and parameters
    - Test orders definition
    - Testing equipment
    - Fetching Measurement Data
    - Global libraries

4. Test Manager Client
    - Basic features
    - Bench view and parameters
    - Starting campaign mode: Test order selection
    - Test descriptions
    - Starting test mode
    - Test sequence
    - Accessing measurement data

5. MORPHEE Environment Tool
    - . How to configure TestManager

FLEX Lab – Administrator Training - 5 days

Operational goals

- Customize the Flex Lab data model and views
- Dashboard settings: Widget, KPI
- TMS installation and configuration (optional)
- Yield Metrics installation and configuration (optional)

Target audience

- Administrators
- Test Engineers

Prerequisite

- The participant must be familiar with MORPHEE system (basic training).
- Good IT and programming skills are required
- Familiar with modern web browser (Google Chrome, MS Internet Explorer).

Training program

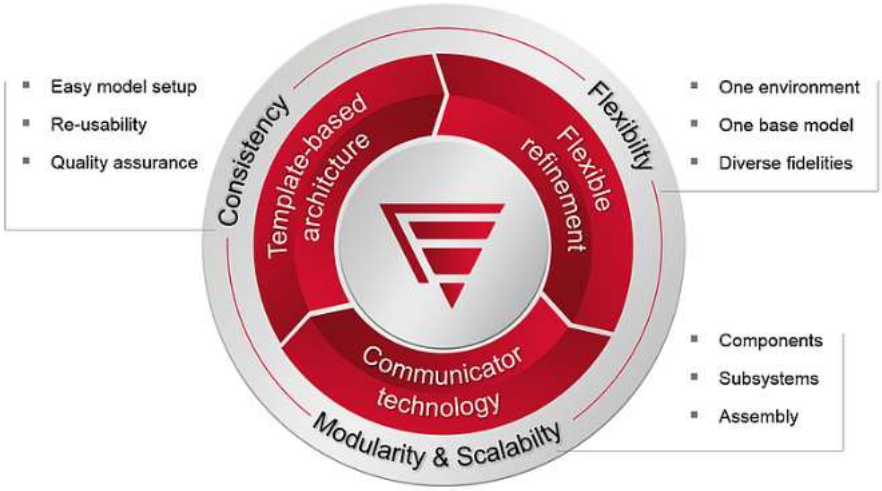
1. Introduction
2. General presentation (basic courses)
3. Global Synoptic
4. Configuration files
5. Database objects
6. Model file
7. Model compilation
8. Main configuration file
9. Modules/Plugin configuration
10. Grid configuration
11. GUI settings
12. Dashboard: Widget, KPI
13. TMS configuration (option)
14. Yield Metrics configuration (option)

Virtual DYNAMICS

System-level Simulation

Virtual Dynamics is an advanced simulation software for dynamic analysis of powertrain, driveline and their components. It is a suite of products composed of Virtual Engine and Virtual Gearbox together providing all building blocks needed to create dynamic models of engine, transmission, conventional and hybrid-electric drivelines. Virtual Dynamics uses the core technology of the world leading Multi-Body-Simulation Software MSC Adams as numerical integrator, pre- and post-processing features. The template-based architecture perfectly combines the advantages of single purpose software – ease of use and multi-purpose software - no limitations in extendibility.

Virtual Dynamics is a truly open system – featuring a powerful scripting language for task automation, the ability to customize the user interface, support for own solver routines and extending the modeling component library with own user-defined elements. Wizards automate and accelerate the creation of complex models like crank and drive trains. Models and corresponding data are organized in databases, strengthening data management even for global scale companies. Advanced generic 3D contacts plus fast analytical approaches for powertrain-specific contacts ensure a vast scope of application.



VIRTUALDYNAMICS Training - 2 days

VIRTUALDYNAMICS provides the tools for reliable, efficient and high-quality powertrain and driveline development. This training includes theoretical and practical knowledge about modelling and simulating the desired components or systems using VIRTUALDYNAMICS. Relevant scenarios, dedicated tools and expert tips to help the user unlock more potential from the software and increase productivity.

Operational goals

- Familiarity and comfort with the VIRTUALDYNAMICS.
- Introduction to software concepts, graphical interface and post processor.
- Understanding the modelling architecture and useful general tools.
- Theoretical and practical learning of the desired modules* and their specific capabilities.
- Apply the knowledge to manually build a working model.
- Perform some fundamental analysis and evaluate the results.
- Clarify specific customer requirements from the software.

VIRTUALDYNAMICS Application

The available suite of products under VIRTUALDYNAMICS provide simulation capabilities of powertrain and driveline applications. This practical training introduces the different tools and methods to perform multi-body dynamic investigations. The customer may choose one or more of the standard VIRTUALDYNAMICS modules*. Basic and advanced level training for all modules are available as required. The operational goals as well the training program are flexible to be adjusted based on user request and experience.

*Crank train, *Gear train, *Valve train, *Piston and rings, *Timing and accessory drive, *Electric motor *special request.

Target audience

All engineers requiring dynamic analysis of conventional and hybrid-electric powertrain and driveline at system or component level.

Prerequisites

- Fundamental knowledge of engineering mechanics in structural and dynamic domain.
- Understanding of the working principles of the powertrain system under consideration.

Training program

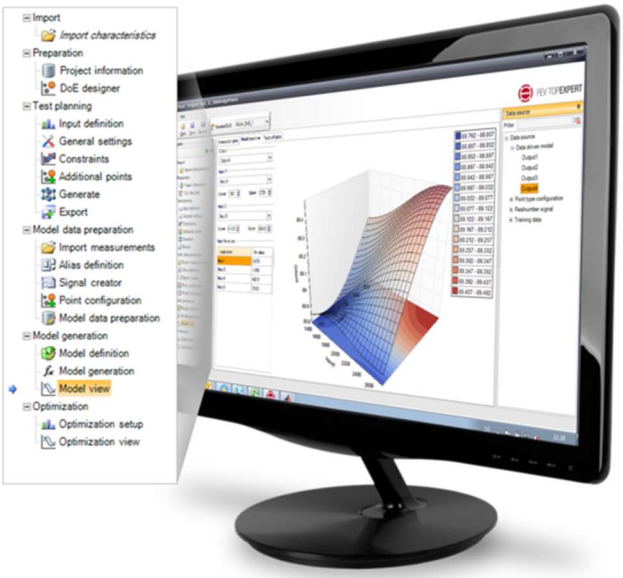
1. **Getting started with VIRTUALDYNAMICS**
   - Understanding the software concepts.
   - A look at the general and special tools.
   - Learn how to interact with the software.
2. **Detailed introduction to the desired modules and its capabilities**
   - Comprehensive review of all the necessary components.
   - Identifying the available fidelity levels of modelling along with their pros and cons.
   - Overview of some relevant examples.
3. **Practical exercise with a relevant model**
   - Utilizing the necessary tools to build up a model.
   - Creating an example model from scratch as a team exercise.
   - Learning the best use practices and general industry approaches.
4. **Advanced analysis and evaluation**
   - Establishing the model boundary conditions and solver parameters for an optimal analysis.
   - Model customization with personal requirements and preferences.
   - In-depth analysis of the results using the post processor.

xCAL

Advanced DoE techniques with innovative modeling algorithms

Today, it is hard to imagine powertrain development without Design of Experiments (DoE). The main challenge, though, is to make this powerful technique easily applicable for all calibration engineers which are typically not familiar with the mathematical background of this approach. At the same time, powertrain development poses challenges requiring for specific adaptions of the generic DoE methodology.

A new software tool featuring DoE based application processes have been developed at FEV and is available since Q1/2015. FEVcal 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 to the market. The today's state-of-the-art global modeling techniques based on Gaussian processes have been adapted to address also the specific characteristics of engine and powertrain modeling. This approach, combined with intuitive visualization and user guidance, enables the engineer to quickly investigate and optimize for example the engine's behavior



xCAL Training - 1.5 days

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xCAL is a model-based calibration software that integrates the calibration knowledge of FEV into a unique and easy-to-use tool. It can be used to model engines, transmissions or simulations and find optima or optimize calibration maps. Focusing on practical knowledge and hands-on experience, the xCAL training empowers users to become familiar with advanced calibration approach. The training includes theoretical and practical knowledge about the Design of Experiments (DoE) as well as test case scenarios related to combustion engine modeling and optimizing.

Operational goals

- Know how to use the generic user interface of xCAL.
- Understand the architecture of the DoE workflow (Preparation, Test planning, Data preparation, Model generation, Optimization).
- Know how to build a DoE test matching with the given requirements (usage of all the functionality regarding the complex domain definition, selection of the appropriate design).
- Know how to prepare/post-process the measured data before modelling.
- Know how to create a model, to analyze its quality, choose an appropriate transformation, and check the outliers.
- Know how to perform different types of optimization (single point, maps or cycle optimization).

The training will be split into two parts

- xCAL BASIC
- xCAL ADVANCED (Global map optimization).

xCAL Application

The xCAL training is demonstrated via different examples, for gasoline and diesel engine.

Target audience

Calibration or simulation engineers.

Prerequisites

- Experience on combustion calibration.

Training program

1. **Motivation and introduction to DoE**
   - Use cases
   - Motivation for DoE
   - Introduction to DoE
2. **xCAL at a glance: User interface and first DoE project**
   - User interface
   - Activities overview
   - Project example
3. **xCAL in depth: Test planning**
   - Difference local and global DoE.
   - Design types
   - Additional points
   - Constraints
   - Exercise
4. **xCAL in depth: Modelling**
   - Model types
   - Model statistics
   - Overfitting
   - Transformations
   - Outlier analysis
   - Exercise
5. **xCAL in depth: Optimization**
   - Optimization objective
   - Cost functions
   - Exercise
6. **xCAL in depth: Global map optimization**
   - Optimization of an operating area
   - Cycle trace
   - Applications
   - Constraints & Objective
   - Map smoothness
   - Exercise
7. **xCAL help and support**
8. **References**

Control

Model Based Control for 1 dyno (engine test bench) - 2 days

Focusing on a better understanding of general controller behavior and practical experience, this training enables the user to use the Model Based Control effectively. The training includes theoretical and practical knowledge about the Model Based Control for 1 dyno (engine test bench) as well as showcases of a typical tuning procedure with a demo version.

Operational goals

- Understand the basics of control and regulation.
- Understand the different types of Control Modes.
- Know how to setup the Model Based Control in MORPHEE SCALE (interfaces, signal flow, referenced components).
- Understand the different control algorithms of model-based control (Mode 1, 3 and 4).
- Know how to configure the controller settings.
- Know how to tune all speed and torque controllers.

Target audience

Test cell operators which will be able to tune and setup all control modes for engine test benches.

Prerequisites

- Experience with operating test cells or test cell automation.
- Being familiar with a WINDOWS PC environment (handling test files and folders).
- Being familiar with the user interface of MORPHEE Run-time.

Training program

1. **Basics of control and regulation**
   - Difference between open- and closed-loop control.
   - Characteristics to rate the control quality.
   - Stability, sensitivity and robustness.
   - Different control modes and their area of application.
2. **SCALE Environment**
   - Integration of the model-based control in SCALE.
   - Interface to referenced components.
   - Integration of the SIMULINK control model.
3. **Control Modes**
   - Mode 1: Speed / Throttle
   - Mode 3: Torque / Speed
   - Mode 4: Speed / Torque
4. **Controller Tuning**
   - Preconditions before starting the model-based controller.
   - General settings (Drag Prevention, Torque Offset, Filter).
   - How to record an engine map.
   - Tuning procedure for the different control modes.
   - Demonstration and training of the controller handling with a demo-version.

Project Trainings

End of Project Training - 1 day

This training targets the client test bench operators and engineers. It aims to guide them on how to operate the bed taking into consideration the specification of their solutions.

Operational goals

- Know the different parts of the bench and the equipment
- Understand the different Modes in MORPHEE
- Understand the different security states
- Know the different bench components and their functions
- Understand the different interaction between the components
- Understand the different test stages
- Learn how to start and operate a sample Test

Target audience

- Operators
- Test bed Engineers

Prerequisites

- Prior experience and knowledge of test bed
- Recommended to have had a Basic MORPHEE Training

Training program

1. **Structure of MORPHEE software and hardware on a test cell**
   - General presentation of the test cell
   - MORPHEE architecture: PC, acquisition/communication cards, drivers, components, tests
   - The three modes BENCH, CAMPAIGN, TEST and the transitions between them
   - Separation between test cell specific settings and shared settings like test procedures

2. **MORPHEE standard run-time interface**
   - How to launch MORPHEE multi-modes
   - Control of standard test cell equipment from this GUI (media conditioning, engine and dyno control, I/O modules, special measurement equipment)
   - Standard MORPHEE menus and monitor windows (channels, set values, alarms …)
   - Result data storage: instantaneous values, recorder or stabilized measurements

3. **MORPHEE Editor**
   - How to browse between the tabs: Bench Config, Campaign, Test, Components

4. **General functioning of test bed components**
   - Presentation of standard/specific FEV components for media control, I/O, measurement devices, dyno, engine…
   - Explanation of each component specific function

5. **Launching an automatic test run, e.g. a full load test**
   - Understand how an automatic test takes place
   - Explanation of each component specific function
   - How to manage results and how to retrieve stored data
   - How to perform measurement plans

To note: *Customization of such training is possible to a certain level if agreed by both FEV and client if the foreseen training duration is not exceeded.*

Customized Training – X days

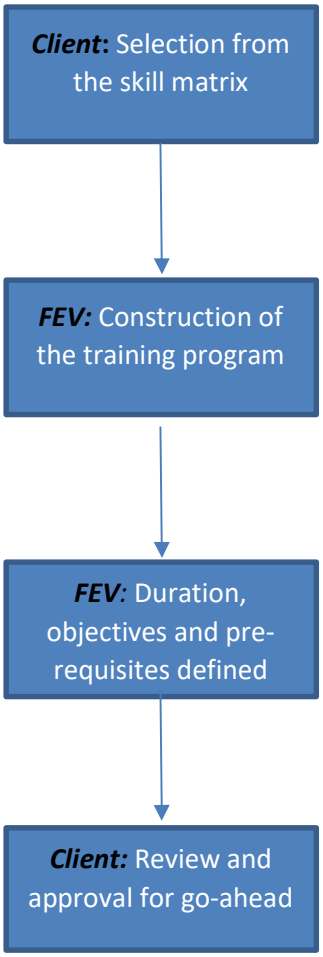
FEV training team have created an exhaustive product and skills matrix. The aim is to provide our customers the possibility to construct a tailored training based on their needs. This matrix could be found at the appendix section at the end of this training catalogue.

Operational goals / Prerequisites

The training goals and pre-requisites will be defined once the skills selection is done by the customer.

Training program

1. The training program will take time to be defined depends on the complexity of the skills needed.
2. The duration will be based on the clients selected skills.
3. Material documentation needs to be customized and adapted as much as possible.



Delivery types

Training at FEV Premises

The face to face trainings are held on preplanned sessions at FEV facilities. It could accommodate up to 8 participants.

- Each participant will be provided with a PC with the latest software needed
- Drink & food are provided
- Handbook (including lectures and exercises) is to be provided

Training at Customer's site

Customers could request a training at their site. Accordingly, customers need to take the following points into consideration:

- Prepare a dedicated training room for the session to take place.
- Equip the room with PCs as such to have one PC per participant
- Limit the number of participants to 6 per session

Virtual training

FEV is offering as well live virtual trainings. Using our online digital solutions, the clients are able:

- To save time as participants will only log-in for 2-3 hours and then get back to their jobs
- To have schedule flexibility
- To save cost with no travel and accommodation expenses needed
- To review the training content anytime afterward as such training could be documented upon request

The participants will be provided with a link to access the online training. Our sophisticated solutions will allow for the training to professionally monitor the session. Out of the available tools we list the followings:

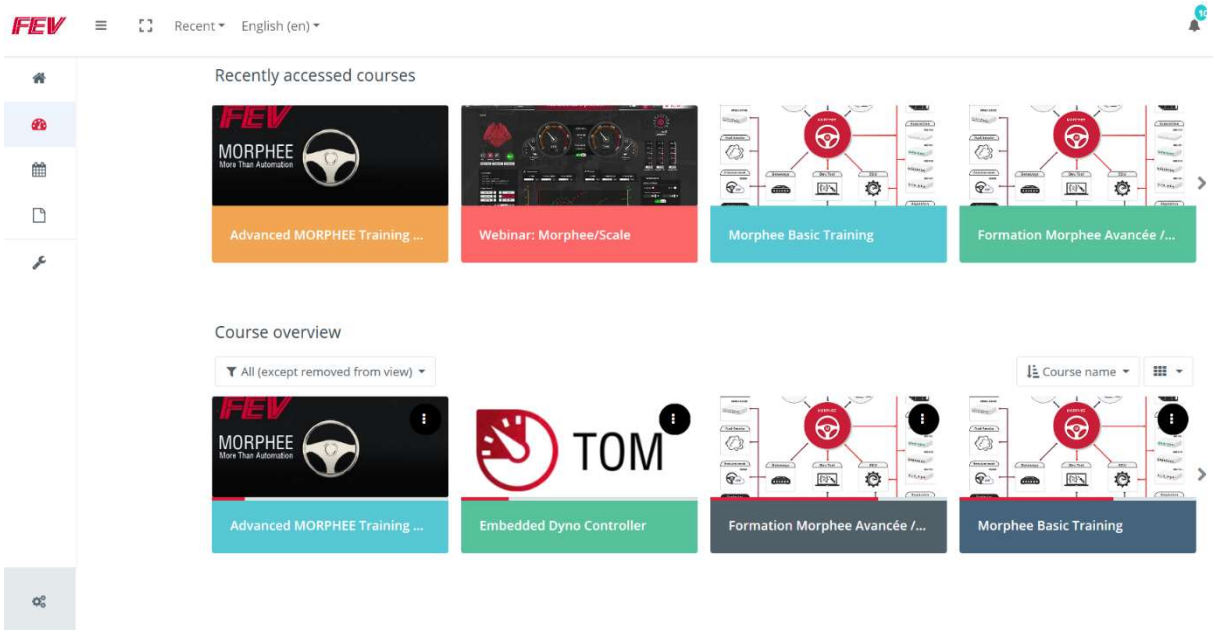
- Ability for participants to raise hand (virtually) and write down questions
- Ability for trainer to do quick Q&A and get quick results
- Ability for trainer to manage and control microphones

E-learning on *FEV Academy*

FEV Learning management system – *FEV Academy* – is now available. It will offer upon request any training as an E-learning course. This offers the ability to:

1. Train large number of audiences
2. Have a self-paced training solution
3. Track each learner progress

FEV training team can take your requests to a higher level and offer a full training program. Again, based on the skill matrix, an A to Z tailored E-learning courses with a defined path can be developed.



Appendix – Skill Matrix

#	Subject	Work package	Sub-work package		Skills and training topics
1	Building	1. Information System	1.1 - Data Management	FEVFLEX, FLEXLAB, TMS, YIELD METRICS	FEVFLEX training
2	Building	1. Information System	1.1 - Data Management		Generalities on server and database design
3	Building	1. Information System	1.1 - Data Management		Interface commissioning and maintenance
4	Building	1. Information System	1.1 - Data Management		Data model structure and process analysis engine battery and vehicle example
5	Building	1. Information System	1.1 - Data Management		SQL data base and studio setup and commissioning
6	Building	1. Information System	1.1 - Data Management		FLEXLAB - General configuration and commissioning
7	Building	1. Information System	1.1 - Data Management		FLEXLAB - Campaign and tests management
8	Building	1. Information System	1.1 - Data Management		FLEXLAB - Tables creation and modification
9	Building	1. Information System	1.1 - Data Management		FLEXLAB - Parameters creation and modification
10	Building	1. Information System	1.1 - Data Management		FLEXLAB - Administration and maintenance (users, permission, test field creation)
11	Building	1. Information System	1.1 - Data Management		FLEXLAB - TMS - training - user and commissioning
12	Building	1. Information System	1.1 - Data Management		FLEXLAB - YIELDMETRICS - training - user and commissioning
13	Building	1. Information System	1.1 - Data Management		TESTMANAGER - Campaign loading
14	Building	1. Information System	1.1 - Data Management		TESTMANAGER - Test loading

15	Building	1. Information System	1.1 - Data Management		TESTMANAGER - Reference test management
16	Building	1. Information System	1.1 - Data Management		TESTMANAGER - Link and transfer to server
17	Building	1. Information System	1.1 - Data Management		TESTMANAGER - Plugins management
18	Building	1. Information System	1.2 - Data Evaluation	UNIPLOT, FEVALYS …	UNIPLOT - installation and setup, basics template and reporting - advanced automatic reporting
19	Building	1. Information System	1.2 - Data Evaluation		FEVALYS
20	Test Cell	2. Simulation Platform	2.1 - Simulation Software	xMOD and application (Vehicle, E-motor, Battery simulation (EiL, BiL, EMIL, PiL …)	xMOD - Installation, setup, and basics // advanced?
21	Test Cell	2. Simulation Platform	2.1 - Simulation Software		xMOD - Configuration creation
22	Test Cell	2. Simulation Platform	2.1 - Simulation Software		xMOD - Insert models and run a simulation
23	Test Cell	2. Simulation Platform	2.1 - Simulation Software		xMOD - GUI management
24	Test Cell	2. Simulation Platform	2.1 - Simulation Software		xMOD application EIL
25	Test Cell	2. Simulation Platform	2.1 - Simulation Software		xMOD application other (Vehicle, E-motor, Battery simulation (EiL, BiL, EMIL, PiL …)
26	Test Cell	2. Simulation Platform	2.2 - Simulation Hardware	PC + keyboard + mouse + screen + boards + cabinet etc. ...	XMOD SLINK and UDP to MORPHEE - CAN interface
27	Test Cell	2. Simulation Platform	2.2 - Simulation Hardware		vCAP platform for simulation

28	Test Cell	2. Simulation Platform	2.2 - Simulation Hardware		MIO - modules for simulation
29	Test Cell	2. Simulation Platform	2.2 - Simulation Hardware		From simulation to hardware in the loop
30	Test Cell	3. Calibration System	3.1 - Calibration Software	xCAL and MMBC, INCA	xCAL and MMBC, INCA
31	Test Cell	3. Calibration System	3.1 - Calibration Software		ECU calibration principle and MCD3 interface
32	Test Cell	3. Calibration System	3.1 - Calibration Software		MCD3 - Interface to MORPHEE MCD3 (protocol, connection and component)
33	Test Cell	3. Calibration System	3.1 - Calibration Software		Fast ECU access in MORPHEE - ES951 Etas box in ETherCat - KPA studio
34	Test Cell	3. Calibration System	3.2 - Calibration Hardware	xCAL and MMBC, ETAS box	Fast ECU Access in MORPHEE - ES951 Etas box in EtherCAT - KPA Studio
35	Test Cell	3. Calibration System	3.2 - Calibration Hardware		ECU systems and Engine harness generalities
36	Test Cell	3. Calibration System	3.2 - Calibration Hardware		xCAL and MMBC, ETAS box
37	Test Cell	4. Automation System	4.1 - Automation Software	MORPHEE, SCALE core and devices, drivers	MORPHEE - Introduction and general presentation
38	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Installation - Update rules and startup MENV - MASTER CD
39	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - MENV - Backup and configuration management
40	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Customization, configuration files and tools
41	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Protection rules - MACAO codes - dongles - licensing
42	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Plugins - template - libraries definition and utilization
43	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - RUNTIME - Structure and design - 3 modes navigation

44	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR presentation and browser overview
45	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - Quantities & Measurement channels creation and modification
46	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - User interface - Screens creation and modification
47	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - different type of cycles - Methods creation & modification
48	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - Method types; Alarms cycle, Stop cycle, Resume cycle, refuge cycle
49	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - Component design and rules
50	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - declare components in MORPHEE modes
51	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - Components group and mode switching management
52	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - Components parameters settings
53	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - Component tree - Application management standard and specific
54	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Acquisition - measurement plan, channels list and data logging creation
55	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Acquisition - multi frequency - customization of storage, file format
56	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Diagnostics - logbook and postmortems
57	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Bench-Campaign-Test mode loading log and errors analysis
58	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Alarms creation and monitoring - MORPHEE monitors using
59	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Control - open and closed loop -(PID)

					measurement and automation basics
60	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - EDITOR - Scripting - C# in MORPHEE methods
61	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - RTX real time and Windows time, frequency and RTX optimization
62	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - SCALE - Introduction and general presentation
63	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - SCALE - Flow chart and state machine
64	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - SCALE - Customization, commissioning, preparation and utilization
65	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - SCALE - SCALE development rules (component, interface, channels)
66	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Driver list - list of driver's installation principle and description
67	Test Cell	4. Automation System	4.1 - Automation Software		MORPHEE - Drivers development
68	Test Cell	4. Automation System	4.2 - Automation Hardware	PC + keyboard + mouse + screen + boards + cabinet	MORPHEE - hardware integration - PC integration - RTX installation and setup
69	Test Cell	4. Automation System	4.2 - Automation Hardware		MORPHEE - Physical channels configuration - generalities
70	Test Cell	4. Automation System	4.2 - Automation Hardware		MORPHEE - MIT - Conditioner - Sensor - Physical channels creation
71	Test Cell	4. Automation System	4.2 - Automation Hardware		MORPHEE - Protocol, interface and driver's declaration
72	Test Cell	4. Automation System	4.2 - Automation Hardware		MORPHEE - PC board integration and 3rd party configuration tool generalities
73	Test Cell	4. Automation System	4.2 - Automation Hardware		MORPHEE - Channel calibration rules and good practices

74	Test Cell	4. Automation System	4.2 - Automation Hardware		KPA STUDIO - Installation of Master, license activation, Studio installation
75	Test Cell	4. Automation System	4.2 - Automation Hardware		KPA STUDIO EtherCat board configuration
76	Test Cell	4. Automation System	4.2 - Automation Hardware		KPA STUDIO Module definition and configuration
77	Test Cell	4. Automation System	4.2 - Automation Hardware		KPA STUDIO Physical channel configuration
78	Test Cell	4. Automation System	4.2 - Automation Hardware		KPA STUDIO Project handling - module address, adding, removing, diagnostics
79	Test Cell	4. Automation System	4.2 - Automation Hardware		KPA STUDIO ECAT file generation
80	Test Cell	4. Automation System	4.2 - Automation Hardware		KPA STUDIO load and update device libraries
81	Test Cell	4. Automation System	4.2 - Automation Hardware		KPA STUDIO Physical channel range definition and calibration
82	Test Cell	4. Automation System	4.2 - Automation Hardware		EtherCat protocol
83	Test Cell	4. Automation System	4.2 - Automation Hardware		EtherCat Hardware connection principle
84	Test Cell	4. Automation System	4.2 - Automation Hardware		EtherCat Connection setup and parameters
85	Test Cell	4. Automation System	4.2 - Automation Hardware		EtherCat Commissioning and diagnostic on failure - KPA diagnostic, status
86	Test Cell	4. Automation System	4.2 - Automation Hardware		EtherCat network Maintenance
87	Test Cell	4. Automation System	4.2 - Automation Hardware		CAN - Protocol basics
88	Test Cell	4. Automation System	4.2 - Automation Hardware		CAN - Device connection and wiring
89	Test Cell	4. Automation System	4.2 - Automation Hardware		CAN - Connection settings and parameters

90	Test Cell	4. Automation System	4.2 - Automation Hardware		CAN - Commissioning and validation
91	Test Cell	4. Automation System	4.2 - Automation Hardware		CAN - CANalyser and error diagnostics
92	Test Cell	4. Automation System	4.2 - Automation Hardware		CAN - MORPHEE CAN driver configuration and utilization in components
93	Test Cell	4. Automation System	4.2 - Automation Hardware		AK - Protocol basics
94	Test Cell	4. Automation System	4.2 - Automation Hardware		AK - Device connection and wiring
95	Test Cell	4. Automation System	4.2 - Automation Hardware		AK - Connection settings and parameters
96	Test Cell	4. Automation System	4.2 - Automation Hardware		AK - Commissioning and validation
97	Test Cell	4. Automation System	4.2 - Automation Hardware		AK - Error diagnostics and maintenance
98	Test Cell	4. Automation System	4.2 - Automation Hardware		AK - MORPHEE AK driver configuration and utilization in components
99	Test Cell	4. Automation System	4.2 - Automation Hardware		PROFIBUS - Protocol basics
100	Test Cell	4. Automation System	4.2 - Automation Hardware		PROFIBUS - Configuration software tools utilization (SYCON?)
101	Test Cell	4. Automation System	4.2 - Automation Hardware		PROFIBUS - CIFx board definition and settings
102	Test Cell	4. Automation System	4.2 - Automation Hardware		PROFIBUS - GANTNER modules configuration (ICP and TestCommander)
103	Test Cell	4. Automation System	4.2 - Automation Hardware		PROFIBUS - Commissioning and validation
104	Test Cell	4. Automation System	4.2 - Automation Hardware		PROFIBUS - Error diagnostics and maintenance
105	Test Cell	4. Automation System	4.2 - Automation Hardware		PROFIBUS - Physical channel configuration (from module to MORPHEE)

106	Test Cell	4. Automation System	4.2 - Automation Hardware		PROFIBUS - MORPHEE Profibus driver configuration and utilization in components
107	Test Cell	4. Automation System	4.2 - Automation Hardware		PLC and interface process logics, relays and control
108	Test Cell	4. Automation System	4.2 - Automation Hardware		Safety rules with testing activities
109	Test Cell	4. Automation System	4.2 - Automation Hardware		Design and architecture
110	Test Cell	5. Data Acquisition	5.1 - Acquisition	I/O conditioning (MIO, Beckhoff…) + boombox	Basics on signal conditioning and acquisition
111	Test Cell	5. Data Acquisition	5.1 - Acquisition		EMC and interferences
112	Test Cell	5. Data Acquisition	5.1 - Acquisition		Protocols - network - fieldbus and analog connection
113	Test Cell	5. Data Acquisition	5.1 - Acquisition		Serial link RS232-RS422 RS485 Communication support
114	Test Cell	5. Data Acquisition	5.1 - Acquisition		Ethernet TCPIP Communication support
115	Test Cell	5. Data Acquisition	5.1 - Acquisition		MIO modules basics
116	Test Cell	5. Data Acquisition	5.1 - Acquisition		MIO - Setup MIO-A**
117	Test Cell	5. Data Acquisition	5.1 - Acquisition		MIO - Setup MIO-D**
118	Test Cell	5. Data Acquisition	5.1 - Acquisition		MIO - Setup MIO-F01 (interface web)
119	Test Cell	5. Data Acquisition	5.1 - Acquisition		MIO - Setup MIO-T10/T11
120	Test Cell	5. Data Acquisition	5.1 - Acquisition		MIO - Setup MIO-R01/R02
121	Test Cell	5. Data Acquisition	5.1 - Acquisition		Other I/O modules other bus
122	Test Cell	5. Data Acquisition	5.2 - Sensors	Sensors (Pressure, Temp, flow etc.…)	Generalities on sensors - temperature, pressure, flow - International standards - Metrologic
123	Test Cell	5. Data Acquisition	5.2 - Sensors		Speed and Torque - Principles of rotational measurement
124	Test Cell	5. Data Acquisition	5.2 - Sensors		High speed measurements - Pressure, flow, signals and principles

125	Test Cell	5. Data Acquisition	5.2 - Sensors		Calibration, range definition and Metrologic's
126	Test Cell	5. Data Acquisition	5.2 - Sensors		I/O configuration in MORPHEE
127	Test Cell	5. Data Acquisition	5.2 - Sensors		Diagnostic, monitoring and maintenance
128	Test Cell	5. Data Acquisition	5.3 - Measuring Devices	Measuring equipment (devices), Smokemeter, Opacimeter, particulates blowby, FTIR, Emission bench, Dilution tunnel, CVS including blower, xRate, OSIRIS (power or combustion)	Measuring devices in engine testing
129	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Devices and interfaces: protocol AK INDI, DCOM and functions
130	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Emission measurement, flow measurement Richness & lambda loop by loop around engine
131	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Exhaust gas measurement Smokemeter, opacimeter, particulates, emission
132	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Emission focus; FTIR, Raw and diluted gases, Engine or vehicle - PEMS; CVS, dilution tunnel)
133	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Blowby, Air flow, fuel flow, (EGR, Turbo) air loop measurement and structure (Temp Pres Flow QTP)
134	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Fuel consumption and conditioning- commissioning and maintenance - FUELCON-FUELRATE
135	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Air flow measurement - commissioning and maintenance- AIRRATE (Sensiflow)
136	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Blowby measurement - commissioning and maintenance - BLOWBYRATE
137	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Measurement on power conversion - POWER METERS - YOKOGAWAs

138	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		Measurement on battery testing - Impedance meter
139	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Combustion analysis - Fast Data Acquisition system
140	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Power meter - OSIRIS
141	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Installation, update, PC configuration, system connection
142	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Acquisition Env - Cylinder pressure sensor
143	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Acquisition Env - Encoder, CDM and trigger signal, angle-based acquisition
144	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Acquisition Env - Hardware configuration - system overview
145	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Acquisition Env - Time base acquisition
146	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Create a configuration - file, acquisition and engine definition
147	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - TDC tuning and configuration
148	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Physical channels - types, creation and calibration
149	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Calculation channels - types, creation
150	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Standard pressure calculations
151	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Heat Release calculations
152	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Multiple/maxi pressure gradient
153	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Knock calculation

154	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Combustion noise - Engine noise measurement
155	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Needle lift and injection analysis
156	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - FFT analysis and rotational vibration based on engine speed
157	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Data filtering
158	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Monitoring function management
159	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - GUI management
160	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Troubleshooting on Sensors and encoders
161	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - interface with MORPHEE or else (DCOM, CAN, …AK...)
162	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Storage, data logging, file format and conversion
163	Test Cell	5. Data Acquisition	5.3 - Measuring Devices		OSIRIS - Script calculation and automatic file naming
164	UUT	6. UUT Control	6.1 - Controllers	DCU, TOM, SPARC, EMCON …	Generalities on Dyno Controllers on the market interface and functions - system view
165	UUT	6. UUT Control	6.1 - Controllers		Engine Control modes PID and feedforward
166	UUT	6. UUT Control	6.1 - Controllers		Double loop PID tuning (Dyno& engine)
167	UUT	6. UUT Control	6.1 - Controllers		DCU3K - interface, commissioning, using and maintenance
168	UUT	6. UUT Control	6.1 - Controllers		DCU3K - Integration into testing system
169	UUT	6. UUT Control	6.1 - Controllers		DCU3K - Settings and general parameters
170	UUT	6. UUT Control	6.1 - Controllers		DCU3K - Control modes global knowledge
171	UUT	6. UUT Control	6.1 - Controllers		DCU3K - Control from MORPHEE (EtherCat, Profibus, Analog)

172	UUT	6. UUT Control	6.1 - Controllers		DCU3K - diagnostic and maintenance
173	UUT	6. UUT Control	6.1 - Controllers		MORPHEE embedded controller (TOM) and PID tuning
174	UUT	6. UUT Control	6.2 - Actuators	EPS, SERVOCRAFT, AT LIN …	Mechanical and ePedal (Servocraft, EPS3K, AT-Lin) MORPHEE embedded solution control and interface
175	UUT	6. UUT Control	6.3 - Dynamometers	Frame + Electrical motor + Torque meter,	EC dyno commissioning, maintenance and design
176	UUT	6. UUT Control	6.3 - Dynamometers		AC dyno design, commissioning and maintenance
177	UUT	6. UUT Control	6.3 - Dynamometers		PM dyno design, commissioning and maintenance
178	UUT	6. UUT Control	6.3 - Dynamometers		Machine regulation
179	UUT	6. UUT Control	6.4 - Inverter	Drive ABB, PWR3000	ABB drive commissioning and maintenance - global world contract
180	UUT	6. UUT Control	6.4 - Inverter		ABB drive - configuration tools drive windows
181	UUT	6. UUT Control	6.4 - Inverter		ABB drive - commissioning rules
182	UUT	6. UUT Control	6.4 - Inverter		ABB drive - Maintenance and diagnostics
183	UUT	6. UUT Control	6.4 - Inverter		ABB drive - Torque and speed measurement sensor and settings
184	UUT	6. UUT Control	6.4 - Inverter		ABB drive - certification
185	UUT	6. UUT Control	6.4 - Inverter		ABB drive - EtherCat interface
186	UUT	6. UUT Control	6.4 - Inverter		ABB drive - Profibus interface
187	UUT	6. UUT Control	6.4 - Inverter		ABB drive - Analog interface
188	UUT	6. UUT Control	6.4 - Inverter		ABB drive- Control modes and PID tuning
189	UUT	6. UUT Control	6.4 - Inverter		PWR3K commissioning and maintenance
190	UUT	6. UUT Control	6.5 - Charge / Discharge cabinet, Battery Emulator	Charge discharge cabinet (HEINZINGER,	Charge/discharge cabinet generalities, dimension, performances and interface

				DIGATRON ,	
191	UUT	6. UUT Control	6.5 - Charge / Discharge cabinet, Battery Emulator		HEINZINGER cabinet commissioning and maintenance
192	UUT	6. UUT Control	6.5 - Charge / Discharge cabinet, Battery Emulator		DIGATRON cabinet commissioning and maintenance
193	UUT	6. UUT Control	6.6 - Emotor Emulator		
194	UUT	6. UUT Control	6.7 - Rollers		Chassis dynos generalities
195	UUT	6. UUT Control	6.7 - Rollers		Market review and interface for each
196	UUT	6. UUT Control	6.7 - Rollers		Emission bench or performance bench
197	UUT	6. UUT Control	6.8 - Shaker		
198	UUT	7. UUT Conditioning	7.1 - Conditioning units	xCON (Lubricant, Air, Fuel, …)	Generalities on UUT conditioning air loop, lub loop, fuel loop, air loop
199	UUT	7. UUT Conditioning	7.1 - Conditioning units		xCON interfaces, commissioning and maintenance LUBCON-COOLCON
200	UUT	7. UUT Conditioning	7.1 - Conditioning units		Conditioning devices on the market and interfaces
201	UUT	7. UUT Conditioning	7.1 - Conditioning units		E-coolCON design, commissioning and maintenance
202	UUT	7. UUT Conditioning	7.1 - Conditioning units		Cooling and safeties
203	UUT	7. UUT Conditioning	7.1 - Conditioning units		Connection of process and facilities
204	UUT	7. UUT Conditioning	7.2 - Climatic chamber		Climatic chamber in battery testing: Binder safeties, control and measurement
205	UUT	7. UUT Conditioning	7.2 - Climatic chamber		Climatic function in chassis dynos
206	UUT	7. UUT Conditioning	7.2 - Climatic chamber		Climatic function commissioning and maintenance
207	UUT	7. UUT Conditioning	7.2 - Climatic chamber		Interface to Automation system

208	UUT	7. UUT Conditioning	7.2 - Climatic chamber		Climatic function with eMotor and eAxle
209	UUT	7. UUT Conditioning	7.2 - Climatic chamber		Climatic function in Engine testing
210	UUT	7. UUT Conditioning	7.3 - Vehicle fan		Cooling and fan in testing environment - suppliers integration and maintenance
211	UUT	7. UUT Conditioning	7.3 - Vehicle fan		Blower function in Chassis dynos - vehicle testing and wind speed closed loop control
212	Test Cell	8. Mechanics	8.1 - Base plate		Design, structure, suspension, damping solutions, analysis, installation, transportation
213	Test Cell	8. Mechanics	8.2 - Trolleys		Standard trolleys, docking system, UUT mounting and damping, match plate, alignment
214	Test Cell	8. Mechanics	8.3 - Shaft / Transmission		Mounting and alignment - maintenance and diagnostic
215	Test Cell	8. Mechanics	8.3 - Shaft / Transmission		Study and specification, vibration analysis torsional vibration analysis
216	Test Cell	8. Mechanics	8.3 - Shaft / Transmission		Torsional vibration tool chain
217	Test Cell	8. Mechanics	8.3 - Shaft / Transmission		Vibration measurement
218	Test Cell	8. Mechanics	8.4 - Crane		
219	Test Cell	9. Electrical engineering	9.1 - Power cabinet		N2 homologation (France) safeties and electric work
220	Test Cell	9. Electrical engineering	9.2 - Control cabinet		Commissioning and maintenance principle
221	Test Cell	9. Electrical engineering	9.3 - Power connection box		Measurement/ switch boxes for E-testbeds
222	Test Cell	9. Electrical engineering	9.4 - Safeties		Safeties in testing (engine, battery, vehicle) - machine EU directive - rotating machine safety
223	Test Cell	10. Climatic	10.1 - Exhaust gas extraction		Measurements and dimension basics (flow, pressure, temp) - closed loop control - interface
224	Test Cell	10. Climatic	10.2 - Ventilation		Commissioning and maintenance principle
225	Test Cell	11. Acoustic	11.1 - Acoustic treatment of the test cell		

226	Test Cell	11. Acoustic	11.2 - Noise attenuation in ventilation		Flow and noise, ventilation noise Principles
227	Test Cell	12. Fire & Gas	12.1 - Fire detection		Overall safety of the test cell - from human being to machine operation)
228	Test Cell	12. Fire & Gas	12.2 - Gas detection	HC CO/CO2, H2, GPL, GNV detection ...,	HC CO/CO2, H2, GPL, GNV detection ...,
229	Building	13. Building	13.1 - Civil works	Civil works, Dismantling, Isolation, Fuel Distribution, water piping, TGBT, Cooling tower, Chiller	General principle for civil work
230	Building	13. Building	13.2 - Dismantling		
231	Building	13. Building	13.3 - Isolation		
232	Building	13. Building	13.4 - Fuel / Gas Distribution		Fuel safeties in testing sites
233	Building	13. Building	13.5 - Water piping		Facilities distribution and rules
234	Building	13. Building	13.5 - Water piping		process water treatment in testing sites engine or else
235	Building	13. Building	13.6 - TGBT		N2 homologation (France) safeties and electric work
236	Building	13. Building	13.6 - TGBT		Electrical power distribution principles, rules, generalities
237	Building	13. Building	13.7 - Cooling tower		Cooling the process water: principle and circuit design
238	Building	13. Building	13.8 - Chiller		Compressor installation, supplier, interface commissioning and maintenance
239	Overall	14. Services	14.1 - Project management		Project management process in STS

240	Overall	14. Services	14.2 - Packaging / transport		Shipping rules in STS
241	Overall	14. Services	14.3 - Maintenance / Warranty		Maintenance training for STS - rules and process
242	Overall	14. Services	14.4 - Training		Training a trainer for STS
243	Overall	14. Services	14.5 - Documentation		
244	Overall	14. Services	14.6 - Final acceptance		Commissioning engineer process in STS