

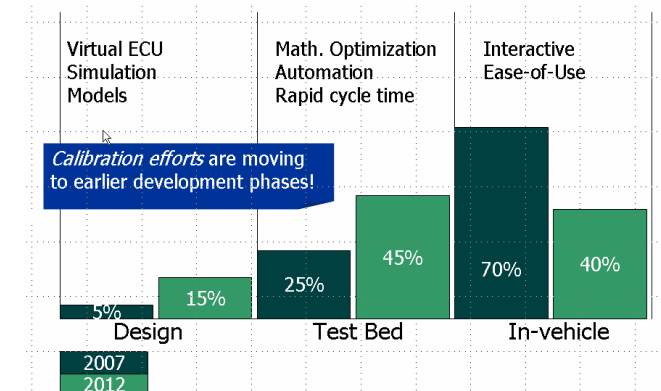
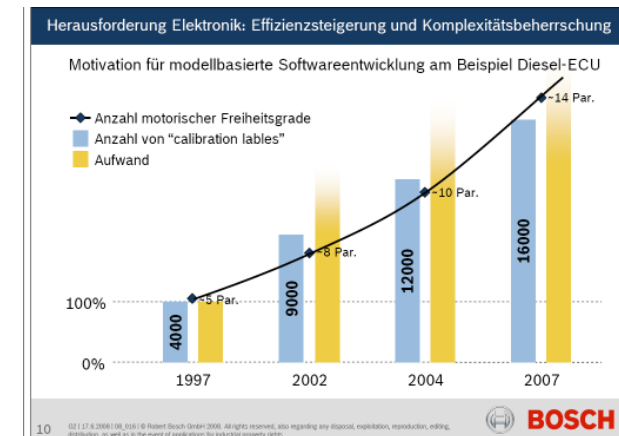
CaliAV© - Autopilot to efficient best-practice MCD

A new approach for process-oriented and tool based automation of calibration tasks for modern powertrain systems



Market Trends

- Continuously increasing number of the application tasks
 - More software control functions
 - New diagnostics functions
 - Increased environmental regulations
- Growing complexity of application
 - More complex controllers
 - Model-based functions require calibration
- Increased quality requirements
 - Quality depends from the individual expertise
 - Calibration results are rarely reproducible
 - Additional workload through retrospect documentation



Guided Calibration

Calibration efforts become the cost-driver in projects

- Although calibration & validation tasks move to test cells and virtual environments, in-vehicle calibration is and will be indispensable
- Today invehicle-calibration is still
 - Largely **manually** performed by calibration engineers
 - **Informal** process driven by expert know how
 - **Growing** number of functions through diagnostics and environmental requirements
 - Increasing **complexity** of software control functions
 - **Distributed** know-how across teams
 - Requires **repetition** for software-releases and variants
 - **Narrow** project schedules and reduced test vehicles
 - Intense **manual** documentation of work results at delivery
- Some OEM/Tier1 automate and standardize selected tasks with scripts, this requires IT skills AND calibration skills
- “Guided calibration” addresses the automation of routine-tasks and the use of best-practice for calibrators by supporting structured, controlled and repeatable processes

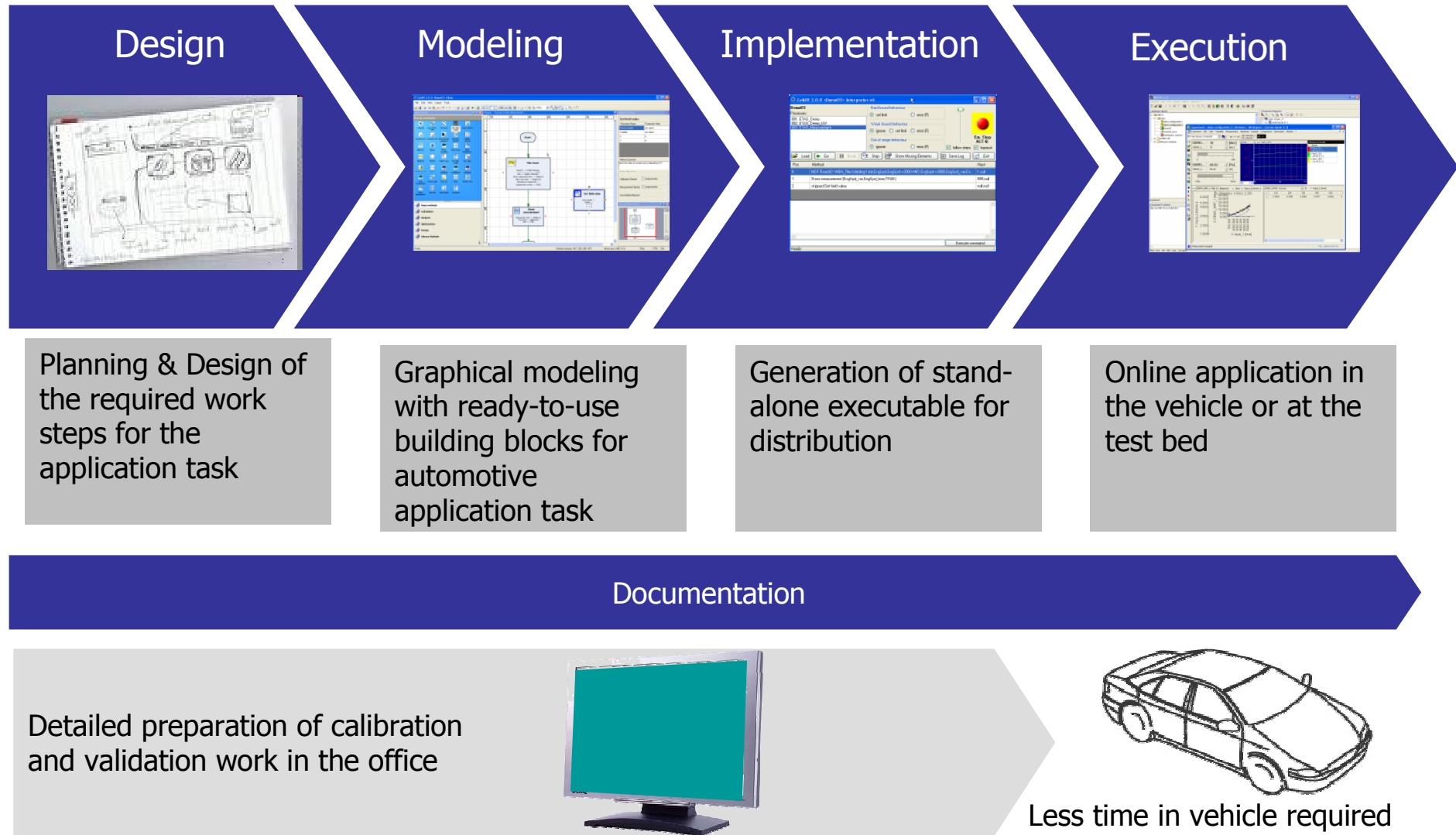
Guided Calibration

Shortcomings of traditional automation approaches

- Software development collides with calibration expertise
 - Skills rarely combined in one person
 - Requirement management from calibrator to developer is required
 - Work procedure becomes software code -> hard to understand
 - IT Support required for calibration departments
 - Software maintenance required
 - new MATLAB release
 - New ECU software release
 - New INCA release
 - Budget required!
- Unsatisfactory flexibility in the car
 - Calibration engineer has no chance to apply -even minor- modifications
 - Unclear transparency (black-box)
- Opposition from calibration engineers

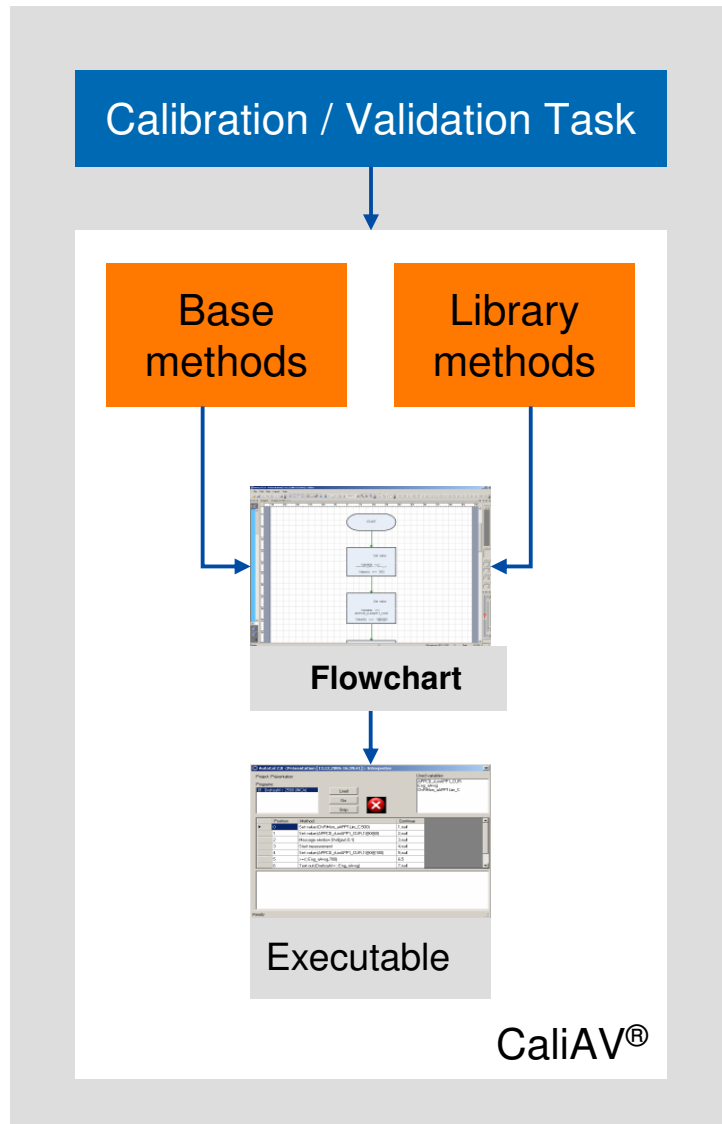
Guided Calibration

Structuring the application process



CaliAV – Guided Calibration for INCA

Overview



Base methods

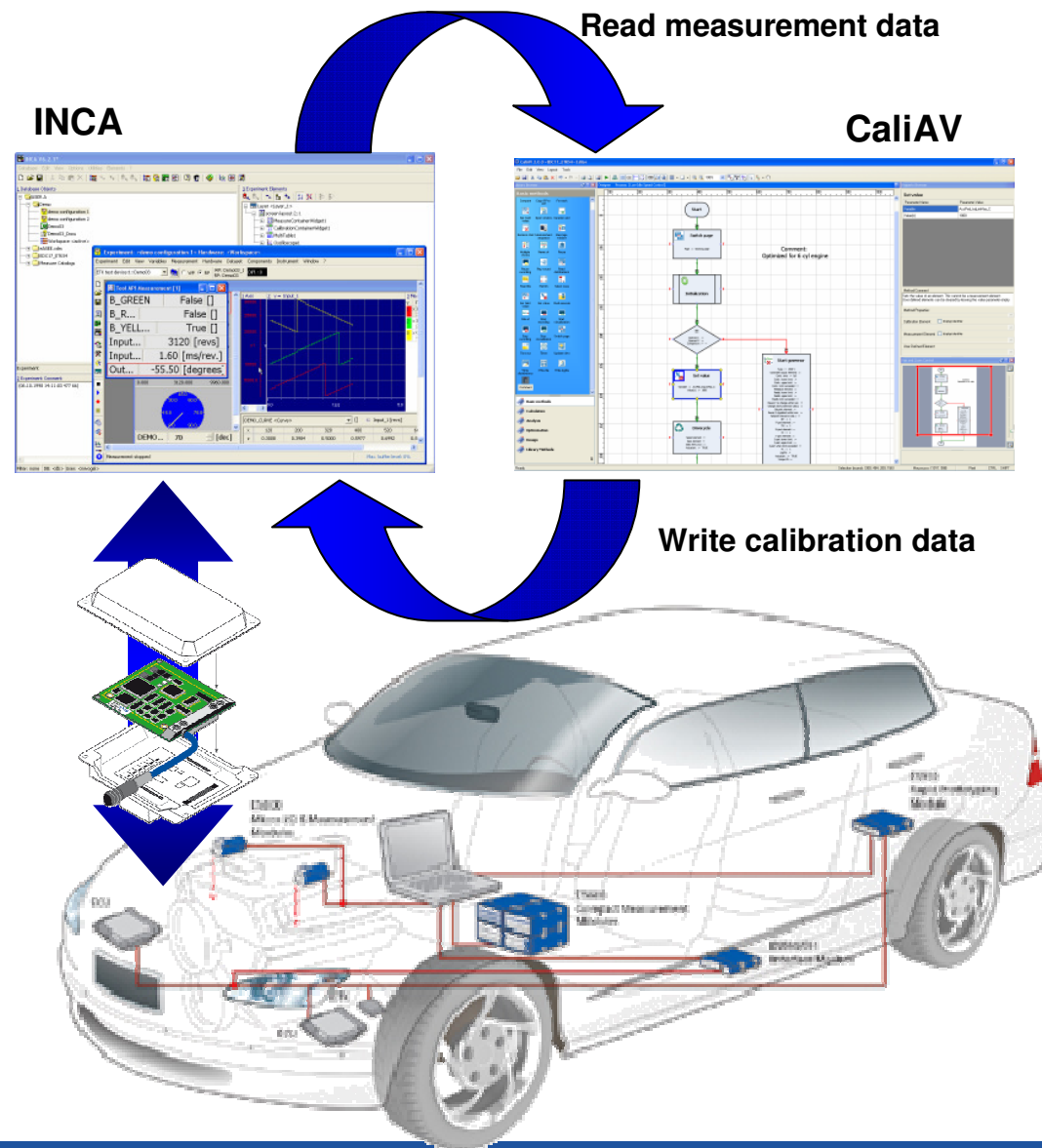
- Read / Write of characteristics and signals
- User input/output functions
- Design methods (i.e.. Polyfit)
- Optimization methods (i.e. Simplex algorithm)
- Iterations (i.e. loops)
- Bypass methods (i.e. configurable PID governor)
- Stimuli generation (i.e. sine-wave, APRBS)
- Drive-cycle generation (i.e. FTP75-cycle)
- Interface to MATLAB®
- Mathematical and statistical methods (formula editor, fourrier transformation, filters, histogram, mean-/min-/max value etc.)
- Visualization methods (oscilloscope, histogram generation and modification of curves and maps)

Library methods

- For re-use of commonly used sub-sequences

CaliAV creates graphical and executable specifications for application processes!

CaliAV – Guided Calibration for INCA Overview



Guided Calibration

Solution Building Blocks

- Creation environment
 - Create or modify sequences
 - Graphical modeling
- Execution environment
 - Closely connected with MCD-Tool (INCA)
 - Run sequences with or w/o interaction
 - Interact with calibrator and display results
- Management environment
 - Administrate a repository of sequences and base functions
 - Hardware and label abstraction layer
- Guided sequences
 - Provided by a solution expert or crafted by the customer

CaliAV – Guided Calibration for INCA

Existing real-world examples

- Low-idle speed control
- Online optimization for variable camshaft
- Online optimization for variable valve lift control
- On- and offline optimization for transitional correction
- Anti surge control
- Exhaust recirculation and boost pressure control
- Engine smoothness control
- Catalytic converter diagnostic
- Misfire detection
- Offline optimization of lambda probe
- Lambda sensor diagnostics
- System analysis of exhaust recirculation valve
- Drivability analysis and base calibration load alteration
- Monitoring of start-stop function
- Automatic calibration & validation of thresholds for sensor diagnostics

Guided Calibration Benefits

- Improved calibration quality
 - Reproducible for each function and measurement
 - Reduction of application errors
 - Validation of work results
 - Easily repeatable for each variant
 - Highly accepted by calibrators as they can specify the degree of complexity and automation
 - Easy creation of sequences
- Reduced vehicle-usage
 - Planning of calibration tasks in the office
- Process documentation
 - Improved skill-up phase for new calibrators
 - Process conformity to test bench and dyno cells
 - Global best-practice for all ECUs, software releases and functions

CaliAV V2.0

Project Management

The screenshot displays the CaliAV 2.0.0 <Virtual ECU> software interface. The main window is divided into several sections:

- Left Panel (Library methods):** A tree view showing various project files and methods. A red box labeled "ECU Project / Software" points to the top of this panel. A red box labeled "Guided Calibration Sequences" points to the bottom of this panel.
- Top Panel (Process configuration comment):** Contains text describing the process configuration, such as "Simulink Throttle Model" and "Generated with MILDesk".
- Bottom Panel (Selected measurement elements and Selected calibration elements):**
 - Selected measurement elements:** Lists elements like "Sine_Wave_Generator...Sum" and "Throttle_Plant...Lookup_Table1".
 - Selected calibration elements:** Lists elements like "Throttle_Controller.PID_Controller...Kd_Gain", "Throttle_Controller.PID_Controller...Ki_Gain", and "Throttle_Controller.PID_Controller...Kp_Gain". A red box labeled "Selected measurement and calibration labels for the process" points to this section.
- Bottom Right Panel (ETAS and IAV Products logos):** Displays the logos for ETAS and IAV Products, along with the text "CaliAV® Guided Calibration for INCA" and "© IAV Products".

CaliAV V2.0

Process Design

The screenshot displays the CaliAV 2.0.0 Editor interface. The main workspace shows a sequence modeling diagram with the following steps:

- Start**: An oval node at the top.
- MDF Read**: A rectangular node containing configuration details:
 - Filename := D:\MDA_Files\data...
 - Measurement element := EngSpd
 - Filter := EngSpd > 2000 AND ...
 - Return measurement vector := EngSpd_var
 - Return time vector := EngSpd_time
 - Synchronize to sample-rate :=
 - Organize parts in matrix := FALSE
- Get field value**: A rectangular node with configuration:
 - Returnvariable :=
 - Variable :=
 - X := 0
 - Y := 0
- Show measurement**: A rectangular node containing:
 - Measurement vector := EngSpd_var
 - Time vector := EngSpd_time
 - Wait := TRUE

Callouts and interface elements:

- Library with basic methods**: Points to the 'Basic methods' section in the Library Browser on the left.
- Sequence Modeling**: Points to the main diagram area.
- Context-sensitive help per method**: Points to the 'Get field value' method details in the Property Browser on the right.
- Ready-to-Use Toolboxes and Custom Libraries**: Points to the 'Basic methods', 'Calculation', 'Analysis', 'Optimization', 'Design', and 'Library Methods' sections in the Library Browser.

The Property Browser for 'Get field value' includes a table of parameter values:

Parameter Name	Parameter Value
Returnvariable	set value!
Variable	set value!
X	0
Y	0

Method Comment: Gets the value of a map/curve, indexed by X/Y

Method Properties: display identifier (checkbox)

Calibration Element: display identifier (checkbox)

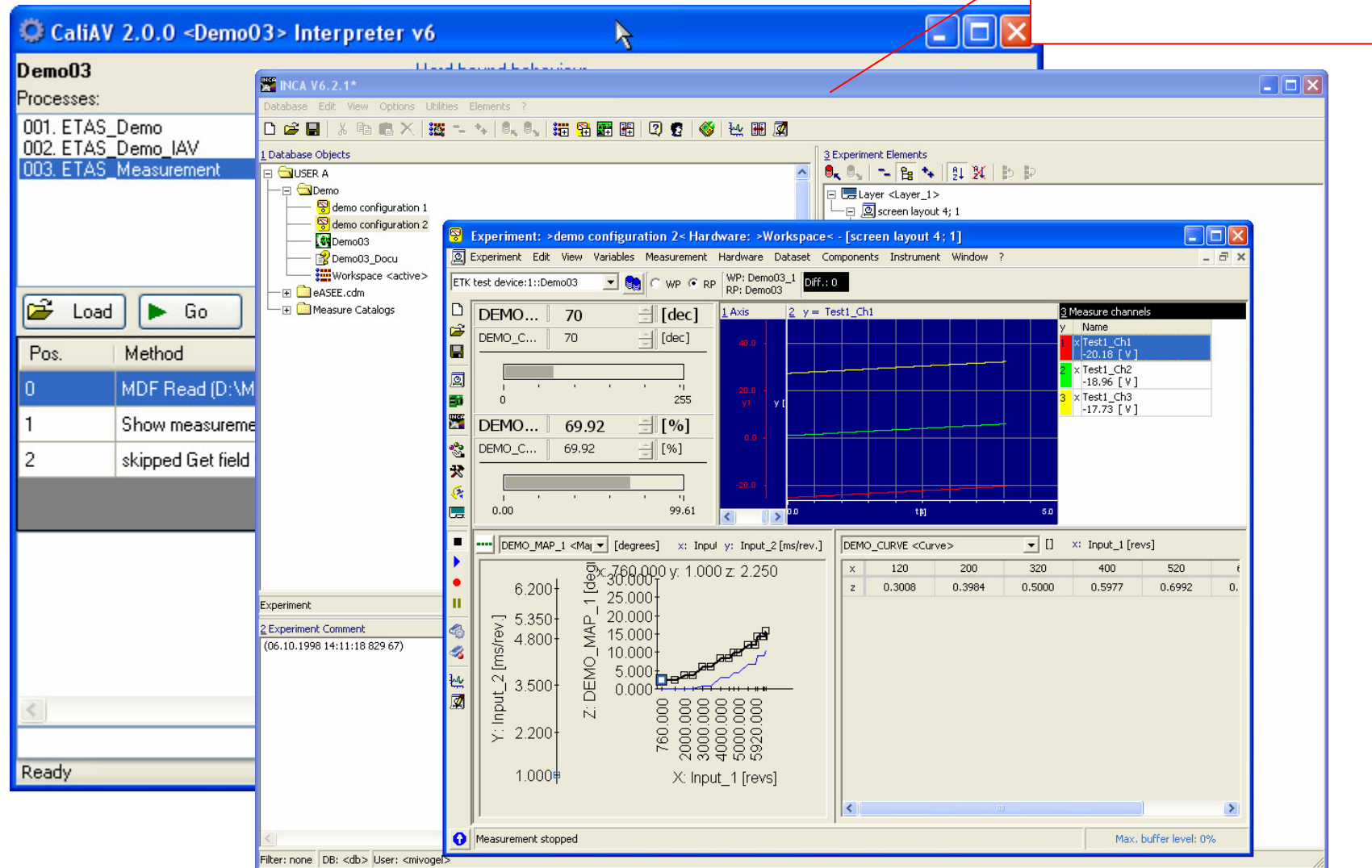
Measurement Element: display identifier (checkbox)

User Defined Element

Pan and Zoom Control: A small thumbnail view of the diagram.

Status bar: Selection bounds: {617, 283, 200, 167} Mouse pos: (496, 114) Pixel CTRL SHI...

CaliAV V2.0 Execution



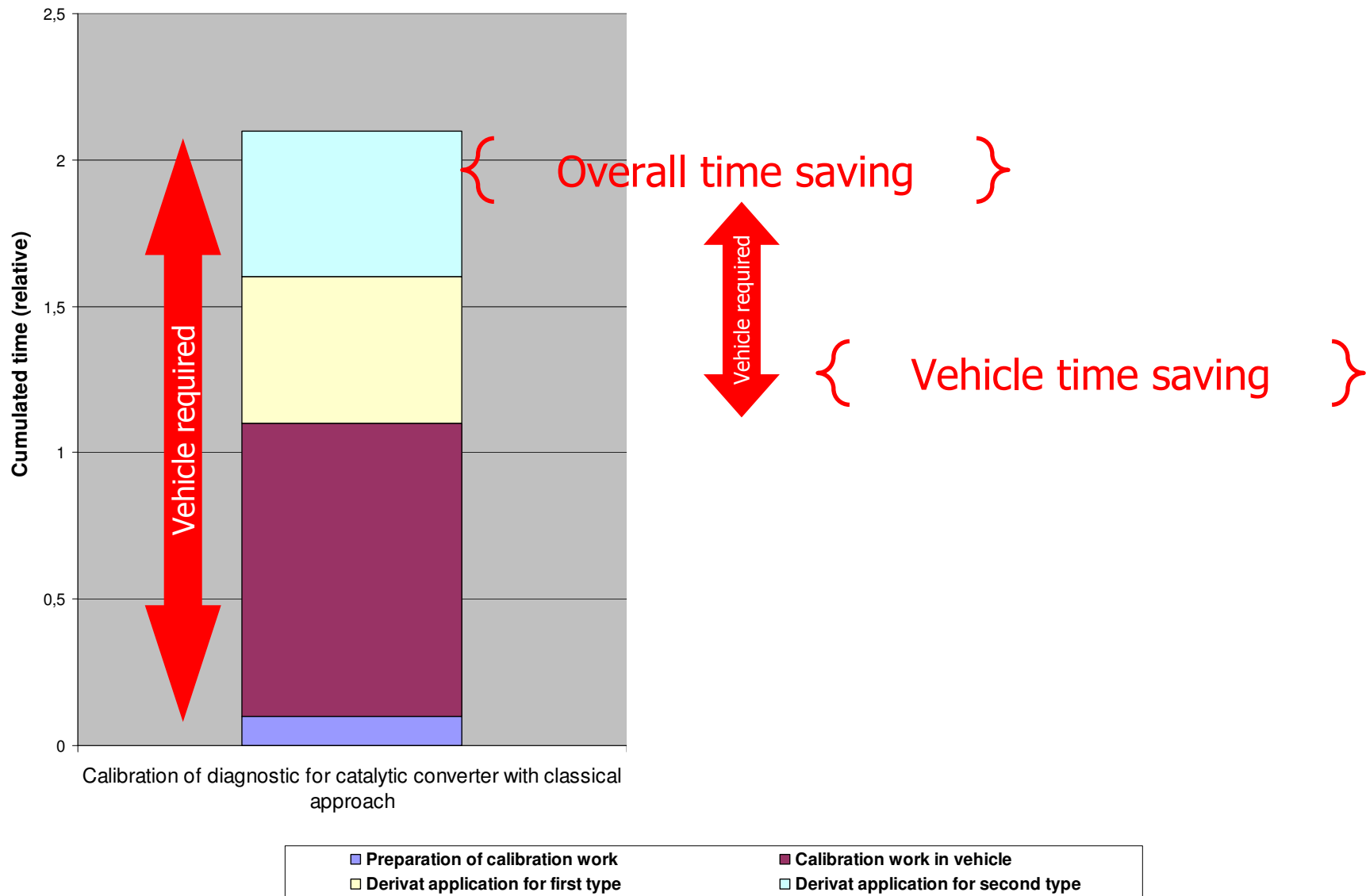
Guided calibration

Cost saving potential

- Repeatable processes
 - Initial effort to model the sequence, offline at the desk
 - Effort pays off for each variant and ECU software release
 - Best-practice for all departments, teams, suppliers
- Reproducible results
- Reduction of error
 - Manual inputs and data transfers are reduced
 - Constraints and conditions can be covered in the sequence
- Coordination efficiencies
 - Test vehicles are used more efficiently

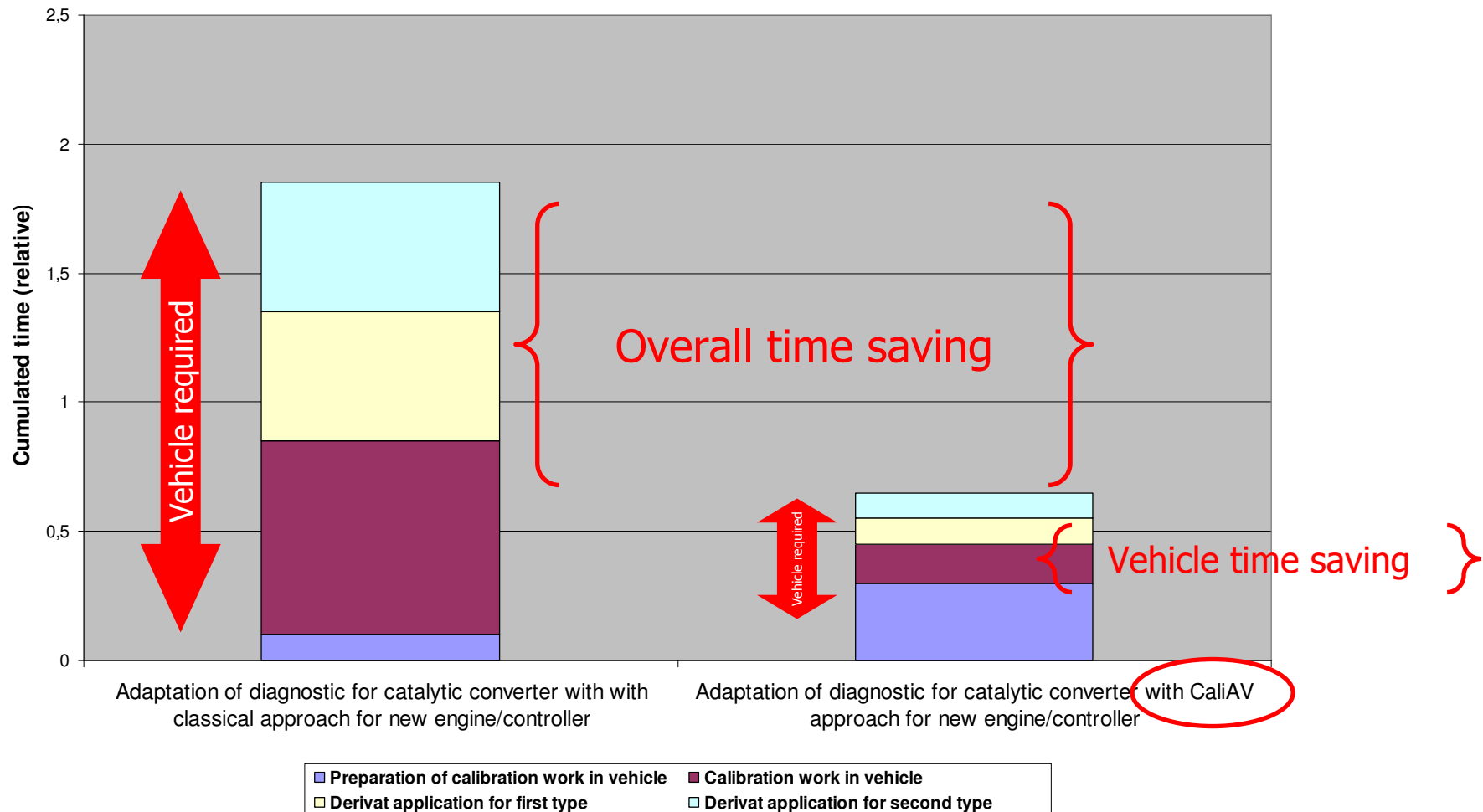
Guided Calibration

Calibration efforts for a catalytic converter for 3 vehicle variants



Guided Calibration

Efforts after a new ECU software release



Guided calibration

Cost savings compared to traditional approaches

- Calibration Domain-experts do not require software development support
 - No meetings/discussions/clarification/budgets required
- Graphical procedures are easy to understand
 - Simple maintenance, easy to adopt, ready for documentation
 - Reuse and skill-transfer of existing sequences
- Domain-specific out-of-the-box blocks readily available for modeling
 - CaliAV provides >80 base methods to access and manipulate ECU labels
 - INCA tool adapter and ECU software project administration
- True differentiators (cannot be build with MATLAB)
 - Drivecycle generators
 - Parallel controllers (interrupt driven)
- Complete integration with ETAS INCA
 - Ensures compatibility of both tools
 - Same requisitioning and support channel

Thank you for your attention

