Model-Based Calibration Toolbox™ Release Notes

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Model-Based Calibration Toolbox™ Release Notes

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Contents

R2014a

Version: 4.7

New Features: Yes

Bug Fixes: Yes

Table editing options to copy, convert, and preserve extrapolation masks and lock table values

CAGE provides new tools for easier locking and extrapolation from desired table values:

- Copy masks and locks from other tables

- Convert masks to locks and vice versa

- Extrapolate using masks and locks rather than just locks

- Smoother extrapolation to locked table cell values

- Revert to previous table version without losing extrapolation mask

- Simplified table inversion

For details, see "Filling a Table by Extrapolation" and "Locking Table Values".

Mask generation from predictive error variance and boundary models

You can generate masks from PEV and Boundary models for any table in CAGE. In previous versions this was only possible if the table was part of a feature calibration.

For details, see "Filling a Table by Extrapolation".

Lookup table shading for relating table values to surface plots

CAGE provides new tools for visually exploring tables. Table cells background color now matches the corresponding 3D surface plot color.

Surface plots of tables are transposed to match the numerical table axes and other calibration tools.

Table and plot are now stacked vertically for better use of screen space.

For details, see "Viewing and Editing a Table".

Summary information for lookup table size, bounds, normalizers, inputs, and history

Table information now displays size, bounds, normalizers, inputs and history in a single place. The Table Information pane provides easier access to the table history to revert to previous values.

For details, see "Viewing and Editing a Table".

Tradeoff plots that zoom inside constraint boundaries

Improved zoom capability in tradeoff plots allows you to set the axes limits to the constraint boundary. This zooms the tradeoff plots inside the constraint boundaries to explore competing objectives in valid regions only. Select **View > Zoom Inside Constraints**. This reduces the y axis scale as the plots do not include regions where the model is extrapolating.

See "Choosing a Table Value at a Specific Operating Point".

Polynomial model deployment

Polynomial models exported to Simulink® are now implemented as MATLAB® Function blocks. This enables code generation for deploying, sharing, and executing Model-Based Calibration statistical models using C code.

See "Export Models to Simulink".

R2013b

Version: 4.6.1

New Features: No

Bug Fixes: Yes

R2013a

Version: 4.6

New Features: No

Bug Fixes: Yes

Import of more Math Operation Simulink blocks and subsystem hierarchy, enabling more complex calibration strategies
Compatibility Considerations: Yes

In R2013a, the CAGE Browser includes new and improved features for importing Simulink models into CAGE for feature calibration with reference to statistical models. New features include:

- Import strategies with multiple out ports.

- Import a strategy hierarchy by creating subfeatures for each subsystem. This makes it easier to understand how the model strategy corresponds to the features in CAGE.

- Reuse tables when importing strategies. CAGE reuses existing tables if they have the same inputs. If tables with the same name use different inputs, CAGE asks what you want.

- Switch blocks now support all operators. Previously CAGE could only parse >=.

See Import a Strategy from Simulink.

Compatibility Considerations

2D tables now use Y (rows), X (columns) input order to be consistent with Simulink. Previously, CAGE parsed the first input as columns and the second as rows. You can use a backward compatibility mode if needed for previously saved strategies.

The Graphical Strategy Editor provides a left to right flow, consistent with Simulink. Previously, the single output was on the left with the strategy on the right.

See Importing Older Strategies.

Import and export of table values and breakpoints in Simulink model strategies

When you import strategies into the CAGE Browser, you can import lookup table values from Simulink into CAGE tables, so you can get table and normalizer data.

See Import a Strategy from Simulink.

Configuration and storage of multiple fill settings for feature filling processes

In the CAGE Browser Feature view, new information panes display all the tables in a feature and any filling factors already set up. You can store, view, and reuse feature filling settings for any of the tables from the top Feature view.

See Saving and Reusing Feature Fill Settings.

Case study example showing calibrating a multi-injection diesel engine

R2013a includes new example files showing how to systematically develop a set of optimal steady-state calibration tables for a diesel multi-injection engine using Model-Based Calibration Toolbox™.

The engine to be calibrated is a 3.1L multi-injection combustion ignition engine with common rail, variable-geometry turbocharger (VGT), and cooled exhaust gas recirculation (EGR).

The aim of the calibration is to minimize Brake Specific Fuel Consumption (BSFC) at specific speed/load operating points across the engine's operating range, and meet the following constraints:

- Limit total NOx emissions.
- Limit maximum turbocharger speed.
- Limit calibration table gradients for smoothness.

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The analysis produces optimal calibration tables in speed and torque for:

- Best main start of injection timing
- Best total injected fuel mass per cylinder per cycle
- Best pilot injection timing relative to main timing
- Best pilot injection fuel mass fraction of total injection mass
- Best exhaust gas recirculation (EGR) position
- Best variable geometry turbocharger (VGT) vane position
- Best fuel rail pressure relative to nominal pressure vs. engine speed

See Multi-Injection Diesel Calibration.

Use model ranges from point-by-point models as optimization bounds

In R2013a, the CAGE Browser uses model ranges from point-by-point models instead of data variable ranges. Providing more precise bounds can help optimizations to converge quicker. For point-by-point models, the variable ranges can be much larger than the bounds for a particular operating point.

In previous releases, CAGE used data variable ranges instead of model ranges. If the data ranges for operating points differ widely across model operating points, this could cause optimizations to run more slowly or fail to converge. The data range often contains large infeasible parts of the space between the bounds that are outside the boundary model constraint. Using more precise model ranges can help the optimization find a feasible result.

R2012b

Version: 4.5

New Features: Yes

Bug Fixes: No

Table filling from optimization results, when optimization operating point inputs are different from table inputs

For some optimization problems, you want to optimize at operating points in different variables to the tables you want to fill, and use response models as normalizer inputs to tables. For example, if your problem requires running an optimization at torque and speed operating points, but you want to fill tables on axes of `mainfuel` (a response model) and speed.

Previously, it required many manual steps to create and fill such tables from your optimization results. The toolbox now provides tools to quickly create tables with response models as normalizer inputs, and select such tables to fill with your optimization results. Now you can use your optimization results to fill tables with different inputs to your optimization operating point inputs.

See Creating Tables From a Model and Table Filling When Optimization Operating Point Inputs are Different From Table Inputs.

Overlay of validation data on boundary model plot views

You can now choose to plot validation data on boundary model plots. This is useful for investigating where validation data lies in the operating envelope compared to the original points used to fit the model.

See Plotting Boundary Models.

R2012a

Version: 4.4

New Features: Yes

Bug Fixes: Yes

Smaller Project File Sizes

CAGE and Model Browser file sizes are reduced by up to 95% for point-by-point projects, enabling easier file sharing.

More Efficient Boundary Modeling

More efficient boundary modeling contributes to reducing file sizes. Identical boundaries are shared between response model fits instead of duplicated.

The convex hull model is simplified for more efficient boundary modeling. In a typical example, using 8 factors and 70 points results in a convex hull with around 35,000 faces. By default, the boundary model now keeps only the most useful facets and can discard around 30% of the facets because they contribute only a small amount to the boundary. The new method is more efficient and includes all data points within the boundary, with the total volume increasing by around 1%. If you want the minimal volume at the expense of a much larger number of facets, you can select a new option, **Keep All Facets**.

See Boundary Model Setup in the Model Browser documentation.

Stored Feature Filling Settings

CAGE projects now store last-used settings for tables, models, data, and optimizations for feature filling. The Feature Filling Wizard can require many steps to set up and you might need to repeat this process many times. Stored settings can save time when using the Feature Filling Wizard repeatedly with slightly different settings.

You can remove saved fill settings using a new menu item, **Feature > Reset Fill Settings**.

See Performing Feature Calibrations in the CAGE documentation.

R2011b

Version: 4.3

New Features: Yes

Bug Fixes: Yes

Improved Design Creation

The design creation process is improved to help you save time and choose good settings for generating efficient candidate sets. The toolbox now warns you if you try to generate a large candidate set of points that will take a long time. Previously, you could try to generate candidate sets that were so large that you could run out of memory. The toolbox now warns and gives you the option to stop and change settings to create a better design more quickly. The toolbox also provides suggestions for better alternative settings.

Support for the Windows 64-Bit Platform

A 64-bit version of Model-Based Calibration Toolbox software is now available for users of 64-bit Windows® and the 64-bit version of MATLAB.

Note the 32-bit version of Model-Based Calibration Toolbox also works on a 64-bit version of Windows, but requires a 32-bit version of MATLAB.

64-bit support required some changes to the appearance of trees in CAGE. Projects in CAGE have a new root project node in the tree. There is no functionality at this project node.

R2011a

Version: 4.2

New Features: Yes

Bug Fixes: Yes

Extra Objectives for Modal Optimization Analysis

You can now specify more than one objective for graphical comparison in modal optimization. You can optimize with one objective, and use the other objectives to explore the results. You can optionally choose a different objective to use to select the best mode.

See Adding Extra Objectives to Modal Optimizations and Analyzing Modal Optimization Results in the CAGE documentation.

New MultiStart Algorithm to Find Local Optima and Create Smoother Tables

If you have Global Optimization Toolbox you can now use the MultiStart algorithm in CAGE. This algorithm tries to identify local optima to help you create smoother tables. Multiple local optimal solutions are often found because of the flat nature of engine responses. The difference in performance between these different solutions can be small and result in tables that are not smooth enough. The new MultiStart algorithm tries to identify multiple optimal solutions for each operating point. You can select the solutions that meet your table smoothness constraints based on the entire table.

See Set Up MultiStart Optimizations and Analyzing MultiStart Optimization Results in the CAGE documentation.

Tradeoff Tool Plots Local Model Ranges

The Tradeoff tool in CAGE now automatically scales plot axes to the local range when switching between different point-by-point models. This avoids having to manually zoom on each graph from the global range to the range of interest.

See Point-by-Point Model Tradeoffs in the CAGE documentation.

Defer Fit Updates

In the Model Browser, you can now delay lengthy updates of dependent fits when leaving the local node. This can be useful when you want to examine a particular global model after removing an outlier at the local level. Defer updates to avoid waiting while updating all other dependent fits.

See Updating Fits in the Model Browser documentation.

Simplified Parallel Model Building

To use parallel processing with model building, you no longer have to use the `mbcmatlabpool` function as well as the `matlabpool` function. The removal of `mbcmatlabpool` simplifies parallel model building by reducing the number of setup steps.

See Parallel Model Building in the Model Browser documentation.

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R2010b

Version: 4.1

New Features: Yes

Bug Fixes: Yes

Equality Constraints

Version 4.1 provides the ability to define equality constraints on models. The feature enables you to optimize performance while meeting demanded operating conditions. See Model Constraints in the CAGE Optimization Setup documentation.

For an example, see Setting Up Constraints in the Getting Started Diesel Case Study.

Feature Filling with Data

You can now fill features directly from experimental data using the Feature Fill wizard. This wizard now enables you to fill feature tables without a model.

You can use data sets in the Feature Fill wizard to fill features over irregular data sets, without gridded data.

See Filling and Optimizing Table Values in the CAGE Feature Calibration documentation.

Data Transfer Between CAGE and the Model Browser

In Version 4.1, you can directly transfer data between Model Browser and CAGE without saving an intermediate file. In CAGE, you can now import data directly from the Model Browser, and export data to the Model Browser.

See Importing Data from the Model Browser and Exporting Data to the Model Browser in the CAGE Data Sets documentation.

R2010a

Version: 4.0

New Features: Yes

Bug Fixes: Yes

Modeling Enhancements

- "New Composite Models for Multiple Operating Modes" on page 24
- "Update Models with Additional Data" on page 24
- "Improved API for Export Models" on page 25

New Composite Models for Multiple Operating Modes

Version 4 of Model-Based Calibration Toolbox enables you to produce optimal calibrations for engines with multiple operating modes. You can use the new *composite* model type to combine a number of models to represent engine responses under different operating modes. You can use the composite model in CAGE to produce optimal calibrations for engines with multiple operating modes. Use for calibration problems where the goal is to fill a single table for all modes or to fill a table for each mode.

You can create a composite model by either:

- Importing to CAGE from the Model Browser
- Combining existing models in CAGE

The composite model consists of a collection of models with an extra mode input. The mode input is an index into the list of models. The component models can have different sets of inputs.

See Creating and Viewing Composite Models in CAGE in the CAGE documentation.

New example projects are provided to illustrate using the new features to produce optimal calibrations for diesel and gasoline engines with multiple operating modes. See Example Composite Models and Modal Optimizations in the Getting Started documentation.

Update Models with Additional Data

You can now update test plans in the Model Browser with new data points while retaining boundary models and validation data.

Previously, when you updated test plan data, the toolbox deleted boundary models and validation data. The toolbox retained local fits, including your outlier selections, if their test data was unchanged after adding new test plan data.

In R2010a, when you update test plan data, the toolbox refits boundary models and retains validation data. Thus, you have less rework to do when fitting models as you collect more data.

The test plan data update functionality is particularly important for building two-stage or point-by-point models. You can load local models into the Model Browser as you collect the data. The update functionality ensures that you do not lose current work when you load data for new tests. The update functionality is also useful when you augment a one-stage design because you need more data to build an accurate model.

Input signal names need to match when update test plan data. The toolbox deletes boundary models and validation data if the input signal names change.

To update data for a test plan, use the Select Data toolbar button or the **TestPlan** menu item. See Use Test Plans to Set Up Designs, Data, and Models in the Model Browser documentation.

Improved API for Export Models

This release introduces improved command-line API support for exporting models. This support includes new methods for calculating confidence intervals and prediction error variance for models. See Export and xregstatsmodel in the Reference documentation.

Optimization Enhancements

- "New Optimization Algorithm for Multiple Operating Modes" on page 26
- "Table Gradient Constraints of Models" on page 26
- "Filter Rules for Table Filling" on page 27
- "Incremental Table Filling" on page 28
- "Support for New Version of ATI VISION" on page 28

• "New Optimization Parameters" on page 29

New Optimization Algorithm for Multiple Operating Modes

Version 4 of Model-Based Calibration Toolbox enables you to produce optimal calibrations for engines with multiple operating modes. You can use the new *Modal optimization* algorithm to select optimal operating modes for such calibrations. This algorithm helps you choose the best operating mode for each operating point. The algorithm can optimize an objective for each operating mode and select the best solution automatically. You must use a composite model for these optimizations.

This release also introduces enhanced optimization output views to help you view the solutions and decide which mode you want to use for each operating point. The enhanced views make it easier to see which solution is selected and to change the selection. These features are also useful for selecting solutions for multiple objective optimizations such as NBI.

You can only use modal optimization for point optimization problems. When you have selected the best mode for each operating point, you can create a sum optimization from your modal optimization results. The toolbox automatically creates a sum optimization for you with your selected best mode for each operating point. For more information see Set Up Modal Optimizations in the CAGE documentation.

New example projects are provided to illustrate using the new features to produce optimal calibrations for diesel and gasoline engines with multiple operating modes. See Example Composite Models and Modal Optimizations.

Table Gradient Constraints of Models

With R2010a you can apply table gradient constraints to models to restrict optimal solutions to smooth responses. Previously, you could only constrain the table gradients of variables. Optimal calibrations need constraints on both model responses and variables. You can now specify a maximum gradient for engine responses as well as control inputs.

Sometimes the inputs for testing differ from the inputs for tables. In such cases, engineers often use a model to derive the table input. To constrain the table gradient you need to define a gradient constraint for models. You

can also define a constraint on the smoothness of the engine response for drivability.

You can define a table gradient constraint for any free variable in your optimization or any model that has a free variable as an input. The Edit Constraint dialog box for the table gradient constraint has been rearranged to simplify workflow.

You can only use table gradient constraints for sum optimizations because the toolbox needs multiple operating points to estimate the table. If you require filling rules to select part of the optimization results for filling, then use the table gradient constraints in combination with application point sets. In particular, if your goal is to fill different tables for each mode, then define application point sets for each mode. For an example, see

Composite Model Example with Separate Tables for Each Mode in the Getting Started documentation.

Filter Rules for Table Filling

You can now apply filter rules to select part of the optimization results for table filling. You can specify an operating mode or any valid expression as a filter when using the Table Filling wizard.

The filter rules are important for modal optimizations. Composite models can require the ability to select part of the optimization results to fill a particular table. For example, you need to discard solutions for other modes when filling a table with an input that is not used for all modes.

- Use filter rules when your goal is to fill a different table for each mode.

- Specify a filter rule with a logical expression using any input or model available for use in table filling.

- The Table Filling from Optimization Results wizard automatically sets up filter rules for you if some inputs are not used for all modes in your composite model.

For an example, see Filling Tables for Operating Modes in the CAGE documentation.

Incremental Table Filling

New settings in the table filling wizard enable you to incrementally fill tables from the results of multiple optimizations with smooth interpolation through existing table values. CAGE can extrapolate the optimization results to pass smoothly through table masks and locked cells. Use these features when you want to use separate optimizations to fill different regions of a lookup table.

Use the new check boxes in the Table Filling from Optimization Results wizard to specify when you want to:

- Use locked table values in extrapolation.

  If your calibration tables have fixed values for some table cells, use locked cells for the table cells with fixed values. Such cells often appear on the edge of a table.

  Select this check box and CAGE smoothly fills the table between fixed table values and optimization results.

- Use existing extrapolation mask in fill.

  Select this check box when you want to fill the same table from multiple optimizations that provide solutions at different operating points. Complex calibration problems can require different optimizations for different regions of a table. The toolbox automatically adds filled cells to the table mask.

  Select this check box for subsequent table filling. CAGE smoothly fills the table between the values in the mask (from previous table filling) and the current optimization results.

See Filling Tables from Optimization Results in the CAGE documentation.

Support for New Version of ATI VISION

The toolbox now supports ATI VISION Version 3.5.1.

You can import and export calibrations directly from/to ATI Vision (via a live link or .mat files). See Importing and Exporting Calibrations in the CAGE documentation.

New Optimization Parameters

A new setting in the Optimization Parameters dialog box for the `foptcon` algorithm allows you to choose one of the `fmincon` function algorithms: `active-set`, `sqp`, `interior-point`. First try the default, `active-set`, the only option in previous releases. If you have sum optimizations which are slow or have problems converging, you can try the new `sqp` or `interior-point` options. For details of `sqp` see New fmincon Algorithm in the Optimization Toolbox™ release notes.

To use the new options in CAGE, see the **Constraint optimization algorithm** setting described in Edit Optimization Parameters in the CAGE documentation.

New Example Projects for Calibrating Engines with Multiple Operating Modes

Version 4 of Model-Based Calibration Toolbox enables you to produce optimal calibrations for engines with multiple operating modes. Examples of applications include: multi-injection diesel engine; inclusion of startup conditions in drive cycles; rich and stoich regions for engines.

New example projects are provided to illustrate using the new features to produce optimal calibrations for diesel and gasoline engines with multiple operating modes. See Example Composite Models and Modal Optimizations in the Getting Started documentation.

R2009b

Version: 3.7

New Features: Yes

Bug Fixes: Yes

Optimization Tools

- New wizards to automate creating an optimization, tables, and tradeoff from a model. The wizards simplify common calibration workflows to create optimizations, and related tables to fill with optimization results, and tradeoffs for investigating results. These utilities make these workflows easier and faster by eliminating many manual steps. See:

  - Creating Optimizations from Models in the CAGE documentation.

  - Creating Tables From a Model in the CAGE documentation.

- Enable difficult diesel calibrations problems by evaluating optimization objectives and constraints over different drive cycles. See Using Application Point Sets in the CAGE documentation.

- Improved tools to analyze and export multi-objective optimization results: an exit flag per solution, improved exit messages, only successful solutions shown on pareto plots, and the ability to export all solutions. See Tools for Optimizations With Multiple Solutions in the CAGE documentation.

- Ability to duplicate and import optimization constraints. See Edit Objectives and Constraints in the CAGE documentation.

- New dialog for selecting calibration items for export. See Exporting Calibrations in the CAGE documentation.

Modeling Tools

- New API for creating and evaluating boundary models, vital for constraining online Design of Experiments (DOE). See Boundary Model Scripting in the Getting Started documentation.

- Ability to negate design constraints, for example, if you want to constrain points to be *outside* a boundary model. See How to Apply Constraints in the Model Browser documentation.

- New model type: interpolating RBF to fit an interpolating surface that passes through every data point. See Global Model Class: Interpolating RBF in the Model Browser documentation.

Point-By-Point Case Study

- New case study demonstrating how to use the tools for a *point-by-point* diesel engine calibration project. The instructions and example files show you how to:

  1 Programmatically create designs, models, and boundary models at each operating point.

  2 Interactively create a multiregion sum optimization, with a constraint applied only at full load points, and a second drive cycle with different weights to evaluate the optimization results at intermediate points.

  For instructions see Point-by-Point Diesel Engine Calibration Case Study.

R2009a

Version: 3.6

New Features: Yes

Bug Fixes: Yes

Optimization Enhancements

- Usability improvements including:
  - The new Table Filling Wizard makes it easier to fill a single table from a model. The wizard automates this process and eliminates a number of manual steps. See Filling a Table From a Model in the CAGE Browser documentation.

  - Utility to automatically create a sum optimization from the results of a point optimization. A common workflow is to use a point-by-point optimization to find good initial values for a sum optimization. This utility makes this workflow easier and faster by eliminating a number of manual steps. See Create Sum Optimization from Point Optimization Output in the CAGE Browser documentation.

  - CAGE Surface Viewer snaps display automatically to point-by-point model operating points. When you are using point-by-point models, these are the points of interest you want to display. See Displaying Point-by-Point Models in the Surface Viewer in the CAGE Browser documentation.

- Support for ATI VISION 3.5. See Importing and Exporting Calibrations in the CAGE Browser documentation.

Modeling Enhancements

- Usability improvements including:
  - New navigation ability in RMSE explorer. You can double-click points to select the test in Model Browser views. This helps you investigate problem tests and avoids the need to enter the test number in the Model Browser. See Using the RMSE Explorer with Local Models in the Model Browser documentation.

  - Process for augmenting space-filling designs. These instructions explain how to augment your space-filling design by keeping your existing points and adding points with the same sequence parameters. See Augmenting Space-Filling Designs in the Model Browser documentation.

  - CAGE and the Model Browser open projects at last displayed node. This memory of your last project view avoids the need to remember where you were working and the Browsers automatically navigate there.

R2008b

Version: 3.5

New Features: Yes

Bug Fixes: Yes

Boundary and Point-By-Point Modeling

- Improved Boundary Editor workflow. Menus, dialog boxes, and the toolbar
  are simplified to streamline creation of boundary models. See Boundary
  Model Setup in the Model-Based Calibration Toolbox Model Browser
  documentation.

- Enhancements to point-by-point modeling tools that are useful for diesel
  engine modeling. You can use a new template for creating point-by-point
  test plans with local models at each engine operating point. You can now
  create boundary models for point-by-point test plans in the Boundary
  Editor. Boundary model constraints are now displayed for local models
  in the Model Selection window to help you evaluate your point-by-point
  models. Exporting your point-by-point models now automates creation
  of items for optimized calibration in CAGE. See Set Up a Point-by-Point
  Model.

R2008a+

Version: 3.4.1

New Features: No

Bug Fixes: Yes

R2008a

Version: 3.4

New Features: Yes

Bug Fixes: Yes

New Design Tools

- Create space-filling, optimal, classical, or custom designs interactively using new command-line functionality. See the toolbox examples, and design scripting documentation.

- New Sobol and Halton sequence space-filling design types can provide highly uniform experimental designs. See Halton Sequence and Sobol Sequence in the Model-Based Calibration Toolbox Model Browser User's Guide documentation.

Optimization Multistart, Surface and Contour Views

- New optimization output contour and surface views that aid in the assessment and use of results for generating optimal lookup tables. See Solution Slice: Results Surface and Results Contour Views in the Model-Based Calibration Toolbox CAGE User's Guide documentation.

- Improved generation of multiple starting conditions to help detect global optima with gradient-based optimization algorithms. See Edit Optimization Parameters in the Model-Based Calibration Toolbox CAGE User's Guide documentation.

Parallel Model Building

Use parallel computing to speed up model building (requires Parallel Computing Toolbox™ licence). See Parallel Model Building in the Model-Based Calibration Toolbox Model Browser User's Guide documentation.

R2007b

Version: 3.3

New Features: Yes

Bug Fixes: Yes

Design Tools

- Command-line definition of inputs for test plans and models.

  See modelinput in the Model-Based Calibration Toolbox Reference documentation, and for examples see Scripting Demos in the Model-Based Calibration Toolbox Getting Started Guide documentation.

- Extended command-line functionality for creating, editing, and fitting local models.

  See LocalModel Properties in the Model-Based Calibration Toolbox Reference documentation, and for examples, see Scripting Demos in the Model-Based Calibration Toolbox Getting Guide documentation.

- Enhanced defaults and previews for space-filling designs, including performance increases, design property improvements, and improved handling of constrained design points. The new defaults are faster to compute and provide symmetrical designs with better space-filling properties. The default **Selection criteria** is now `Minimize RMS variation from CDF`, and **Enforce Symmetrical Points** is now selected by default.

  The number of constrained design points are now displayed in the Design Browser preview, where you can iterate design generation until the desired number of constrained points is achieved. The preview design is now identical to the final design.

  See Setting Up a Space-Filling Design in the Model-Based Calibration Toolbox Model Browser User's Guide documentation.

Optimization Setup and AnalysisTools

- Enhanced optimization set up and analysis, including support for boundary constraint definition in the optimization wizard, ability to rename objectives and constraints, and improved display of table gradient constraints.

  You can now use a right-click shortcut to convert an existing constraint to a boundary model constraint without opening the Constraint Editor. Table gradient constraint output is simplified in the Optimization Output Table and Constraint Summary table to aid analysis, and these constraints are faster to display.

See Overview of Objectives and Constraints in the Model-Based Calibration Toolbox CAGE User's Guide documentation.

- New process suggestions for analyzing optimization results, with advice for detecting problems and improving results.

  See Analyzing Point Optimization Output in the Model-Based Calibration Toolbox CAGE User's Guide documentation.

R2007a

Version: 3.2

New Features: Yes

Bug Fixes: Yes

Modeling API

Extended command-line API to setup models for use as standalone objects or as part of MBC projects. See DIVCP Example.

Accepting Optimization Solutions

New tools to assist in the assessment and use of optimization results for producing optimal lookup tables. See Choosing Acceptable Solutions.

Parallel and Global Optimizations

- Use distributed computing to speed up multiple run optimizations (requires Distributed Computing Toolbox™). See Parallel Computing in Optimization.

- Use Genetic Algorithms and Pattern Search to find globally optimal solutions (requires Global Optimization Toolbox). See Choose Optimization Algorithm.

R2006b

Version: 3.1

New Features: Yes

Bug Fixes: Yes

Optimization Enhancements

- Gradient constraints for controlling table smoothness in optimization-based and feature-based table filling

- Contour plot view for optimization results

- Point-by-point variable bounds for finer control of optimization problems

- Ability to enable and disable optimization constraints for "what if" studies

- Support for starting optimizations from the results of a previous run

  - Solve related "what if" problems faster

  - Refine calibration results by tweaking algorithm settings

- Enhanced user interface for comparing the results of different calibration optimization problems

Modeling Enhancements

- Improved integration of validation metrics within the model selection process

- Enhanced local modeling at each operating point (a complementary approach to building a single, global model)

- Ability to alter variable ranges and refit models automatically

R2006a

Version: 3.0.1

New Features: No

Bug Fixes: No

No New Features or Changes

R14SP3+

Version: 3.0

New Features: Yes

Bug Fixes: No

Command-Line Interface to the Model-Based Calibration Toolbox Software

The command-line interface to the Model-Based Calibration Toolbox software enables the modeling process to be automated using MATLAB commands. In this way, you can simplify the modeling process for technicians and engineers who might not have extensive background and training in this area. You can also access modeling functionality from test bed automation tools.

Improved CAGE Setup

The CAGE Import Tool allows easier reusability of CAGE sessions. You can use the CAGE Import Tool to import models, data sets, optimizations and features from any Model-Based Calibration Toolbox project file produced in CAGE or the Model Browser (`.mat` or `.cag`). This feature can greatly simplify the application of proven feature filling and optimization processes to new engine variants.

Optimization
Compatibility Considerations: Yes

Optimization in CAGE has had major updates:

- Significant speed improvements

- New optimization parameters that help avoid local minima by specifying multiple start points, and running only from feasible start points

- Automatic scaling of objective and constraint values improves numerical stability of algorithms

- Enhanced table filling from optimization results now allows more flexible filling methods: you can exclude infeasible solutions, choose whether to extrapolate, use selected solutions, and apply custom fill algorithms

- Enhanced API for user-defined optimization scripts

- Improved results visualization for drive-cycle optimizations and multiobjective optimizations

- Improved constraint display for non-model constraints (1–D and 2–D tables, ellipsoid, etc.)

Compatibility Considerations

Some existing user-defined optimization scripts may require a call to the function `setRunInterfaceVersion` to fix incompatibilities. You can also do this in the CAGE Browser GUI in the Optimization Parameters dialog.

If you want to use the new `foptcon` optimization parameters (multiple start points and run only from feasible start points) with existing optimizations, you must use the menu item **Optimization > Reset Parameters**.

Calibration Tool Interface

New links to standard industry tools allow import and export of calibrations directly from/to ATI Vision (via a live link or `.mat` files) and ETAS INCA (via `.dcm` files).

Boundary Modeling

You can model boundaries using convex hulls. You can create boundary models for subsets of inputs, which simplifies the boundary identification process for complex engines. Improved visualization tools in the Boundary Editor help you construct accurate constraints. Boundary constraints can now be imported into the Design Editor and exported to Simulink.

Feature Filling

The Feature Fill Wizard uses new algorithms to fill and optimize table values with reference to a model. You can fill multiple tables simultaneously using the wizard, extending the range of calibration problems that CAGE can solve. You can impose gradient and smoothing penalties, and fill tables on a region-by-region basis.

Surface Viewer Movie

The Surface Viewer now has a movie mode that is faster and easier to use, with an interactive progress bar.