

# **Model-Based Calibration Toolbox™ Release Notes**

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*Model-Based Calibration Toolbox™ Release Notes*

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## Summary by Version

This table provides quick access to what's new in each version. For clarification, see “Using Release Notes” on page 2.

<b>Version (Release)</b>	<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
<b>Latest Version V4.3 (R2011b)</b>	Yes Details	No	Bug Reports Includes fixes
V4.2 (R2011a)	Yes Details	No	Bug Reports Includes fixes
V4.1 (R2010b)	Yes Details	No	Bug Reports Includes fixes
V4.0 (R2010a)	Yes Details	No	Bug Reports Includes fixes
V3.7 (R2009b)	Yes Details	No	Bug Reports Includes fixes
V3.6 (R2009a)	Yes Details	No	Bug Reports Includes fixes
V3.5 (R2008b)	Yes Details	No	Bug Reports Includes fixes
V3.4.1 (R2008a+)	No	No	Bug Reports Includes fixes
V3.4 (R2008a)	Yes Details	No	Bug Reports Includes fixes
V3.3 (R2007b)	Yes Details	No	Bug Reports Includes fixes
V3.2 (R2007a)	Yes Details	No	Bug Reports Includes fixes
V3.1 (R2006b)	Yes Details	No	Bug Reports Includes fixes
V3.0.1 (R2006a)	No	No	Bug Reports at Web site

<b>Version (Release)</b>	<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
V3.0 (R14SP3+)	Yes Details	Yes Summary	Bug Reports at Web site
V2.1.1 (R14+)	No	No	Fixed bugs
V2.1 (R14)	Yes Details	No	Fixed bugs
V2.0 (R13+)	Yes Details	No	No bug fixes

## Using Release Notes

Use release notes when upgrading to a newer version to learn about:

- New features
- Changes
- Potential impact on your existing files and practices

Review the release notes for other MathWorks® products required for this product (for example, MATLAB® or Simulink®). Determine if enhancements, bugs, or compatibility considerations in other products impact you.

If you are upgrading from a software version other than the most recent one, review the current release notes and all interim versions. For example, when you upgrade from V1.0 to V1.2, review the release notes for V1.1 and V1.2.

## What Is in the Release Notes

### New Features and Changes

- New functionality
- Changes to existing functionality

## **Version Compatibility Considerations**

When a new feature or change introduces a reported incompatibility between versions, the **Compatibility Considerations** subsection explains the impact.

Compatibility issues reported after the product release appear under Bug Reports at the MathWorks Web site. Bug fixes can sometimes result in incompatibilities, so review the fixed bugs in Bug Reports for any compatibility impact.

## **Fixed Bugs and Known Problems**

MathWorks offers a user-searchable Bug Reports database so you can view Bug Reports. The development team updates this database at release time and as more information becomes available. Bug Reports include provisions for any known workarounds or file replacements. Information is available for bugs existing in or fixed in Release 14SP2 or later. Information is not available for all bugs in earlier releases.

Access Bug Reports using your MathWorks Account.

## **Documentation on the MathWorks Web Site**

Related documentation is available on [mathworks.com](http://mathworks.com) for the latest release and for previous releases:

- Latest product documentation
- Archived documentation

## Version 4.3 (R2011b) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 4.3 (R2011b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- “Improved Design Creation” on page 4
- “Support for the Windows 64-Bit Platform” on page 4

### 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.



## Version 4.2 (R2011a) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 4.2 (R2011a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- “Extra Objectives for Modal Optimization Analysis” on page 5
- “New MultiStart Algorithm to Find Local Optima and Create Smoother Tables” on page 5
- “Tradeoff Tool Plots Local Model Ranges” on page 6
- “Defer Fit Updates” on page 6
- “Simplified Parallel Model Building” on page 6

### 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 “Setting 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.

# Version 4.1 (R2010b) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 4.1(R2010b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- “Equality Constraints” on page 7
- “Feature Filling with Data” on page 7
- “Data Transfer Between CAGE and the Model Browser” on page 8

## 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 “Feature Fill Wizard” 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.

## Version 4.0 (R2010a) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 4.0 (R2010a) :

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- “Modeling Enhancements” on page 9:
  - New composite models to represent engine responses for multiple operating modes
  - Ability to update test plans with new data points while retaining boundary models and validation data
- “Optimization Enhancements” on page 11:
  - New optimization algorithm for selecting optimal operating modes
  - Filter rules to select part of the optimization results for table filling
  - Incremental table filling from results of multiple optimizations with smooth interpolation through existing table values
  - Table gradient constraints of models to restrict optimal solutions to smooth responses
- “New Example Projects for Calibrating Engines with Multiple Operating Modes” on page 15

### Modeling Enhancements

- “New Composite Models for Multiple Operating Modes” on page 10
- “Update Models with Additional Data” on page 10
- “Improved API for Export Models” on page 11

## **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 “Test Plan Level” 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 11
- “Table Gradient Constraints of Models” on page 12
- “Filter Rules for Table Filling” on page 13
- “Incremental Table Filling” on page 13
- “Support for New Version of ATI VISION” on page 14
- “New Optimization Parameters” on page 14

### **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 “Setting 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” in the Getting Started documentation.

### **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 “Using the Optimization Parameters Dialog Box” 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.

## Version 3.7 (R2009b) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.7 (R2009b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- 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 “Editing Objectives and Constraints” in the CAGE documentation.
- New dialog for selecting calibration items for export. See “Exporting Calibrations” in the CAGE documentation.
- New API for creating and evaluating boundary models, vital for constraining online Design of Experiments (DOE). See “Boundary Models” 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.
- 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”.

## Version 3.6 (R2009a) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.6 (R2009a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- 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.
  - 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.
  - 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.
  - 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.

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

## Version 3.5 (R2008b) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.5 (R2008b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- 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 “How to Set Up a Point-by-Point Model”.



## Version 3.4.1 (R2008a+) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.4.1 (R2008a+):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
No	No	Bug Reports Includes fixes

## Version 3.4 (R2008a) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.4 (R2008a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- Create space-filling, optimal, classical, or custom designs interactively using new command-line functionality. See the new Model-Based Calibration Toolbox Demos, and “Designs” in the Model-Based Calibration Toolbox Reference 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.
- 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 “Using the Optimization Parameters Dialog Box” in the Model-Based Calibration Toolbox CAGE User’s Guide documentation.
- 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.

## Version 3.3 (R2007b) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.3 (R2007b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

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

See `modelinput` in the Model-Based Calibration Toolbox Reference documentation, and for examples see “Command-Line 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 “Command-Line 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.

- 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.

## Version 3.2 (R2007a) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.2 (R2007a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are:

- Extended command-line API to setup models for use as standalone objects or as part of MBC projects. See DIVCP Example.
- New tools to assist in the assessment and use of optimization results for producing optimal lookup tables. See “Choosing Acceptable Solutions”.
- 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.

## Version 3.1 (R2006b) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.1 (R2006b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Bug Reports Includes fixes

New features and changes introduced in this version are organized by these topics:

- “Optimization Enhancements” on page 26
- “Modeling Enhancements” on page 27

### 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

## **Version 3.0.1 (R2006a) Model-Based Calibration Toolbox Software**

This table summarizes what's new in Version 3.0.1 (R2006a):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
No	No	Bug Reports at Web site



## Version 3.0 (R14SP3+) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 3.0 (R14SP3+):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	Yes—Details labeled as <b>Compatibility Considerations</b> , below. See also Summary.	Bug Reports at Web site

New features and changes introduced in this version are:

- “Command-Line Interface to the Model-Based Calibration Toolbox Software” on page 29
- “Improved CAGE Setup” on page 29
- “Optimization” on page 30
- “Calibration Tool Interface” on page 31
- “Boundary Modeling” on page 31
- “Feature Filling” on page 31
- “Surface Viewer Movie” on page 31

### 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

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.

## Version 2.1.1 (R14+) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 2.1.1 (R14+):

<b>New Features and Changes</b>	<b>Version Compatibility Considerations</b>	<b>Fixed Bugs and Known Problems</b>
No	No	Fixed bugs

## Version 2.1 (R14) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 2.1 (R14):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	Fixed bugs

New features and changes introduced in this version are organized by these topics:

- “CAGE New Features” on page 33
- “Model Browser New Features” on page 34

### CAGE New Features

There is new functionality in CAGE tradeoff views, model views, tables, data sets and features.

### Tradeoff Enhancements

- There is improved zooming on graphs
- You can now remove tables
- There is much more information in the table display
- Enhanced multimodel import interface
- You can set inputs to table values

### Optimization Enhancements

- New streamlined filling of calibration tables using optimization results
- You can now perform mixed point and sum optimizations

## **Tables Functionality**

- Simplified table creation -- you can select size, initial value and inputs all at once, and normalizers are automatically initialized across variables; so there is no longer any need to go to the Calibration Manager or initialize normalizers (except in features)
- You can convert tables directly to models
- New table arithmetic tool allows you to perform operations on whole tables or selected cells
- New extrapolation mask creation options in tables (from boundary models and Prediction Error)
- The Tables view is now one of the Data Objects and no longer a Process (this used to be called Manual Calibration)

## **Models Enhancements**

- You can now import models from multiple files simultaneously
- Boundary models are enabled in the Surface Viewer and Models View
- You can use the new Model Properties dialog to view information such as the model type, definition, inputs, availability of Prediction Error Variance and constraints, creation date, user name, and toolbox version
- There is improved zooming on the model connections graph

## **Data Sets and Features Enhancements**

- Data sets are significantly faster for larger datasets
- You can now copy feature strategies to the clipboard

## **Model Browser New Features**

There is new functionality in the Data and Design Editors and modeling interfaces.

## Data Editor Enhancements

- You can now select and remove outliers in the Data Editor plots
- You can apply test notes to help you identify and sort problem data for analysis in the Data Editor
- You can select noted tests to view them in other plots and tables
- There is a new improved interface for importing data from the Workspace

## Design Editor Enhancements

- You can display the number of overlapping design points in the projection graphs
- You can round columns of the design

## Modeling Enhancements

- Now you can export models directly to CAGE
- You can clip using boundary models in the Prediction Error Variance viewer
- It is now easier to build exported Simulink models in Real-Time Workshop -- to build your exported models, you no longer need to copy all .c and .h files from mbc/mbcstimulink to the directory where you are building the Simulink models.

## Version 2.0 (R13+) Model-Based Calibration Toolbox Software

This table summarizes what's new in Version 2.0 (R13+):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems
Yes Details below	No	No bug fixes

New features and changes introduced in this version are organized by these topics:

- “CAGE New Features” on page 36
- “Model Browser New Features” on page 37

### CAGE New Features

- Optimization capability for base map calibration in CAGE. For example you could maximize fuel economy at a single point or over a drive cycle within emissions requirements, using Fuel and NoX models. You can perform multi-objective optimizations, such as minimizing fuel consumption while maximizing torque within emissions constraints. You can also incorporate your own algorithms in provided templates.
- Automatic fill of Tradeoff, using the optimization scripts.
- Significantly faster CAGE evaluation.
- Support for more blocks in CAGE strategy parsing -- all standard Simulink lookup tables and the relational operator block.
- Considerable usability improvements in the new Surface Viewer in CAGE.
- Use of boundary models in CAGE (in the response surface viewer and optimization views).
- Improved multi-model tradeoff (one model for all sites, greatly reducing file size).



## Model Browser New Features

- Boundary modelling for understanding complex operating envelopes using nonparametric surfaces.
- Stepwise improvements in terms of speed and large data set handling. Automatic stepwise is available for RBF models and prune as a stepwise option for all linear models.
- More efficient fitting and handling of large data sets (size ~ 1000 to 10000 points).
- New and improved Data Editor with increased functionality. There are new viewing options similar to the Design Editor so you can view your data in many ways simultaneously. You can now access the Data Editor to view and export your modeling data from all nodes in the model tree. For example, this allows you to extract the value of MBT from all your local models and export them to the workspace. The Data Editor retains a memory of view settings.
- User-defined and transient models available as one-stage models.
- New Tree Regression methods for fitting RBF's.
- Local Multi-Models for site specific models. You can fit a variety of different models to each test and choose criteria to automatically select the best fit for each.
- Ability to fit the same model to all tests using Local Average Fit. This allows you to fit global models to your data while also being able to view the fit to each test individually.
- Much improved data selection and matching to designs.
- New enhancements to design augmentation. You can easily use the data matching functions to add all your data to a design as fixed points, in order to augment the design and collect more data.
- Flexible summary statistics for models and you can use these criteria to automatically select best models, in addition to using them as diagnostic statistics when comparing models.
- Memory of settings for a test plan retained by response surface, cross-section view, and validation data.

- Ability to display boundary models in Model Browser response surface viewer and cross-section viewer.

## Compatibility Summary for Model-Based Calibration Toolbox Software

This table summarizes new features and changes that might cause incompatibilities when you upgrade from an earlier version, or when you use files on multiple versions. Details are provided in the description of the new feature or change.

<b>Version (Release)</b>	<b>New Features and Changes with Version Compatibility Impact</b>
<b>Latest Version V4.3 (R2011b)</b>	None
V4.2 (R2011a)	None
V4.1 (R2010b)	None
V4.0 (R2010a)	None
V3.7 (R2009b)	None
V3.6 (R2009a)	None
V3.5 (R2008b)	None
V3.4 (R2008a+)	None
V3.4 (R2008a)	None
V3.3 (R2007b)	None
V3.2 (R2007a)	None
V3.1 (R2006b)	None
V3.0.1 (R2006a)	None
V3.0 (R14SP3+)	See the <b>Compatibility Considerations</b> subheading for this new feature or change: “Optimization” on page 30
V2.1.1 (R14+)	None
V2.1 (R14)	None
V2.0 (R13+)	None