Optimization Toolbox™ Release Notes

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Optimization Toolbox™ Release Notes

Contents

Summary by Version

This table provides quick access to what's new in each version. For clarification, see "Using Release Notes" on page 1.

Version (Release)	New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Latest Version V4.3 (R2009b)	Yes Details	Yes Summary	Bug Reports Includes fixes	Printable Release Notes: PDF Current product documentation
V4.2 (R2009a)	Yes Details	Yes Summary	Bug Reports Includes fixes	None
V4.1 (R2008b)	Yes Details	Yes Summary	Bug Reports Includes fixes	None
V4.0 (R2008a)	Yes Details	Yes Summary	Bug Reports Includes fixes	None
V3.1.2 (R2007b)	No	No	Bug Reports Includes fixes	None
V3.1.1 (R2007a)	Yes Details	Yes Summary	Bug Reports Includes fixes	None
V3.1 (R2006b)	Yes Details	Yes Summary	Bug Reports Includes fixes	None
V3.0.4 (R2006a)	No	No	Bug Reports Includes fixes	None
V3.0.3 (R14SP3)	Yes Details	No	Bug Reports Includes fixes	None

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

The 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.

Version 4.3 (R2009b) Optimization Toolbox Software

This table summarizes what's new in Version 4.3 (R2009b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	Yes Summary	Bug Reports Includes fixes	Printable Release Notes: PDF Current product documentation

Enhanced Exit Messages in Selected Solvers

Enhanced, clearer exit messages in `fsolve`, `lsqnonlin`, and `lsqcurvefit`, with links for more information. For more information about the enhancements, see "Exit Flags and Exit Messages".

Compatibility Considerations

For solvers with enhanced exit messages, the content of `output.message` contains many more characters than before. User code that relies on this field might need to be modified in order to display the larger exit message satisfactorily.

fmincon Interior-Point Algorithm Robust to Certain Errors

The `fmincon` interior-point algorithm attempts to continue when a user-supplied objective or constraint function returns `Inf`, `NaN`, or a complex result. For more information, see "fmincon Interior Point Algorithm".

Changes in quadprog

The large-scale `quadprog` algorithm now uses the `TolFun` and `MaxIter` tolerances for deciding when to end iterations when there are only linear equality constraints, instead of the `TolPCG` and `MaxPCGIter` tolerances.

The `quadprog` `output` structure now contains the `constrviolation` field, which reports the maximum constraint function at the final point.

Compatibility Considerations

For large-scale linear equality constrained problems, the default values of the tolerances are much tighter than before, so `quadprog` can take more iterations, but the resulting solution should be more accurate.

Changes in linprog

The large-scale interior-point algorithm of `linprog` now has a backtracking mechanism for the case of stalling, and performs LDL factorization when there is rank deficiency. For more information, see "Large Scale Linear Programming".

The `linprog` `output` structure now contains the `constrviolation` field, which reports the maximum constraint function at the final point.

Compatibility Considerations

The interior-point algorithm of `linprog` might arrive at different solutions than before, and can solve more problems than before.

Multiobjective optimValues Changes

The `optimValues` structure, used by output functions, has two new fields to better reflect the state of multiobjective solvers:

- For `fgoalattain`, the `optimValues.attainfactor` field contains the value of γ, the attainment factor.
- For `fminimax`, the `optimValues.maxfval` field contains the value $\max_i F_i$, where F is the vector of objectives.

Furthermore, the value stored in `optimValues.fval` has changed. Now `optimValues.fval` contains the vector F of objective function values. For a complete description of the current `optimValues` structure, see "Fields in optimValues".

Compatibility Considerations

User code that uses the `optimValues.fval` field within an output function in `fgoalattain` and `fminimax` might need to be updated to avoid errors

Version 4.2 (R2009a) Optimization Toolbox Software

This table summarizes what's new in Version 4.2 (R2009a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	Yes Summary	Bug Reports Includes fixes	Printable Release Notes: PDF Current product documentation

Parallel Gradient Estimation Available in fmincon Interior-Point Algorithm

The `fmincon` solver's `interior-point` algorithm can now compute finite differences in parallel in order to speed the estimation of gradients. For details on how to use this parallel gradient estimation, see the "Parallel Computing for Optimization" chapter in the User's Guide.

Enhanced Exit Messages in Selected Solvers

Solvers print exit messages by default at the end of their runs. The exit messages are different in R2009a for several solvers, and the messages have been enhanced with new functionality. The following sections describe the new features and changes. There is more information in the "Exit Flags and Exit Messages" section of the User's Guide.

The following solvers have enhanced exit messages:

- `fgoalattain`
- `fmincon`
- `fminimax`
- `fminunc`
- `fseminf`

Links to More Information Window

The enhanced exit messages include hyperlinks within their exit messages. These hyperlinks bring up a window containing further information about the terms used in the exit messages.

Link for More Detail in Command Window

A `<stopping criteria details>` hyperlink may appear at the end of an exit message, depending on the solver and setting of the `Display` option. This link causes the solver to print more detail about the exit conditions to the MATLAB Command Window.

New Display Option Values Control Default Detail

There are new values of the `Display` option to control whether detailed exit messages appear instead of the default (simpler) messages. The new values are:

- `'final-detailed'`
- `'iter-detailed'`
- `'notify-detailed'`

These settings have the same effect as the corresponding settings without `'-detailed'`, but give detailed exit messages instead of the default exit messages. For solvers without the new exit messages, the `'-detailed'` options give the same behavior as without `'-detailed'`.

Messages in Output Structure

For solvers with enhanced exit messages, the `message` field of the output structure contains both the default (simpler) and the detailed exit messages,

separated by a line of text stating `Stopping criteria details:`. The message field does not contain hyperlinks; it contains only text.

Compatibility Considerations

For solvers with enhanced exit messages, the content of `output.message` contains many more characters than before. User code that relies on this field may need to be modified in order to display the larger exit message satisfactorily.

Change in linprog Simplex Algorithm

The simplex algorithm of `linprog` now detects when there is no progress in the solution process. It attempts to continue by performing bound perturbation.

Compatibility Considerations

The simplex algorithm of `linprog` might arrive at different solutions than before, and can solve more problems than before.

Change in fminunc Exit Flag

One exit flag in the `fminunc` medium-scale solver was changed from –2 to 5. This flag appears when the solver predicts a change in function value at the next step in its iterations will be less than the `TolFun` tolerance. This condition can occur at a relative minimum, which should be reported by a positive flag.

Compatibility Considerations

This change might cause users (or code) that examine exit flags to evaluate a result more favorably than previously, since positive exit flags represent normal termination of solvers.

New demos

There are two new demos:

- A demo showing how to use Symbolic Math Toolbox™ functions to help calculate gradients and Hessians. Run the demo at the MATLAB command line by entering `echodemo symbolic_optim_demo`.

- A demo showing how to use `fseminf` for investigating the effect of parameter uncertainty. Run the demo at the MATLAB command line by entering `echodemo airpollution`.

Furthermore, the optimization tutorial demo now shows how to include extra parameters. Run the demo at the MATLAB command line by entering `echodemo tutdemo`.

Version 4.1 (R2008b) Optimization Toolbox Software

This table summarizes what's new in Version 4.1 (R2008b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	Yes Summary	Bug Reports Includes fixes	None

fsolve, lsqcurvefit, lsqnonlin Algorithm and Options Changes

- The Levenberg-Marquardt algorithm was refactored in the solvers `fsolve`, `lsqcurvefit` and `lsqnonlin`. It is now a more standard implementation, that accepts and preserves sparse Jacobians.
- Choose between the algorithms used in `fsolve`, `lsqcurvefit` and `lsqnonlin` using the new `Algorithm` option.
- There is a new `ScaleProblem` option that can sometimes help the Levenberg-Marquardt algorithm converge.
- The default `fsolve` algorithm, `'trust-region-dogleg'`, has been validated to work with sparse Jacobians.

Compatibility Considerations

- The refactored Levenberg-Marquardt algorithm can cause `fsolve`, `lsqcurvefit` and `lsqnonlin` to yield different answers than before.

- The previous way of choosing the algorithm at the command line was to set the `LargeScale` option to `'on'` or `'off'`, and, for all solvers but `fsolve`, to set the `LevenbergMarquardt` option to `'on'` or `'off'`. For `fsolve`, in addition to the `LargeScale` option, you needed to set the `NonlEqnAlgorithm` option appropriately. `LargeScale`, `NonlEqnAlgorithm`, and `LevenbergMarquardt` are now ignored, except when choosing to use the Gauss-Newton algorithm.
- The Gauss-Newton algorithm warns that soon it may no longer be available.
- The default value of the `MaxFunEvals` option in the refactored Levenberg-Marquardt algorithm is now 200*`numberOfVariables`; the previous value was 100*`numberOfVariables`.

Optimization Tool Enables Parallel Functionality

You can now access built-in parallel functionality in Optimization Tool for relevant Optimization Toolbox™ solvers and, if licensed, Genetic Algorithm and Direct Search Toolbox™ solvers. The option is available when you have a license for Parallel Computing Toolbox™ functions.

Central Finite Differences Available in Selected Solvers

The following solvers can now use central finite differences for gradient estimation:

- `fgoalattain`
- `fmincon`
- `fminimax`
- `fminunc`
- `fseminf`

The `fmincon` active-set algorithm and `fminunc` medium-scale algorithm gained central finite differences this release. The `fmincon` interior-point algorithm already had them, and the trust-region-reflective algorithm for both solvers requires a user-supplied gradient, so does not use finite differences.

To use central finite differences, use `optimset` to set the `FinDiffType` option to `'central'` instead of the default `'forward'`. This causes the solver to estimate gradients by formulae such as

$$\nabla f(x) \approx \left[\frac{f(x+\Delta_1 e_1) - f(x-\Delta_1 e_1)}{2\Delta_1}, \ldots, \frac{f(x+\Delta_n e_n) - f(x-\Delta_n e_n)}{2\Delta_n} \right],$$

instead of

$$\nabla f(x) \approx \left[\frac{f(x+\Delta_1 e_1) - f(x)}{\Delta_1}, \frac{f(x+\Delta_2 e_2) - f(x)}{\Delta_2}, \ldots, \frac{f(x+\Delta_n e_n) - f(x)}{\Delta_n} \right].$$

Central finite differences take twice as many function evaluations as forward finite differences, but are usually much more accurate.

Central finite differences can work in parallel for gradient estimation in `fgoalattain`, `fmincon` active-set algorithm, and `fminimax`. For details on how to use this parallel gradient estimation, see the "Parallel Computing for Optimization" chapter in the User's Guide.

lsqnonneg Refactored

`lsqnonneg` was refactored. It can now use sparse matrices, and it preserves sparsity during its execution.

Finite Difference Algorithm Tweaked

A subroutine for gradient estimation by forward finite differences in nonlinear solvers had a bug that affected it when the current point `x` had a component with the value 0. Forward finite differences are typically calculated with a step size proportional to `sqrt(eps)`, which is about $1.5*10^{-8}$. When a component of `x` was 0, the step size would instead be proportional to `DiffMinChange`, which has a default value of 10^{-8}. There is now no difference in step size when `x` is 0.

Compatibility Considerations

Nonlinear solvers can run slightly differently whenever an iteration causes a component of `x` to be zero, and gradients are estimated by forward finite differences.

DerivativeCheck Tolerance Changed

The `DerivativeCheck` option enables you to ascertain whether the derivative (gradient) functions that you supply for objective or constraint functions give *approximately* the same values as those estimated by a solver using finite differences. The meaning of "approximately" has changed. Now it means the relative error of each component of the gradient is less than 10^{-6}, unless the size of an analytically given component is smaller than 1, in which case it means the absolute difference is less than 10^{-6}. Previously, the gradients were considered approximately equal if the maximum absolute error in any component of the gradient was less than (10^{-6} * norm of analytic gradient) + 10^{-5}.

Compatibility Considerations

Some problems will now report violations of the `DerivativeCheck` condition, when previously they would not.

Version 4.0 (R2008a) Optimization Toolbox Software

This table summarizes what's new in Version 4.0 (R2008a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	Yes Summary	Bug Reports Includes fixes	None

Parallel Computing Toolbox Software Support in fmincon, fminimax, and fgoalattain

`fmincon`, `fminimax`, and `fgoalattain` can take finite differences in parallel in order to speed the estimation of gradients. For details on how to use this parallel gradient estimation, see the "Parallel Computing for Optimization" chapter in the User's Guide.

Combined and Extended optimtool

The Genetic Algorithm and Direct Search Toolbox GUIs `gatool` and `psearchtool` have been combined into the Optimization Tool GUI. To access these GUIs, type `optimtool` at the command line, and choose the appropriate solver.

Furthermore, three new Genetic Algorithm and Direct Search Toolbox solvers were added to Optimization Tool: `gamultiobj`, `simulannealbnd`, and `threshacceptbnd`.

Optimization Tool shows Genetic Algorithm and Direct Search Toolbox solvers only if these solvers are licensed.

New fmincon Solver, New Option Algorithm for fmincon, Option LargeScale Changed

The new interior-point algorithm is a large-scale algorithm that can handle all types of constraints. It has several new options, explained in the `fmincon` function reference pages.

`fmincon` now has three algorithms. Choose between them by setting the new option `Algorithm` to:

- `'trust-region-reflective'` (formerly known as `'large scale'`)
- `'active-set'` (formerly known as `'medium scale'`)
- `'interior-point'`

By default, `Algorithm` = `'trust-region-reflective'`.

Compatibility Considerations

The previous way of choosing the algorithm at the command line was to set option `LargeScale` to `'on'` or `'off'`. `LargeScale` is now ignored, except when `LargeScale` = `'off'` and `Algorithm` = `'trust-region-reflective'`. In this case, the `'active-set'` algorithm is used, to minimize backward incompatibility.

External Interface to KNITRO Libraries

Use the new `ktrlink` function to call KNITRO® optimization libraries from Ziena Optimization, Inc. KNITRO libraries must be purchased separately. The External Interface chapter of the User's Guide describes the `ktrlink` function.

Default PrecondBandWidth = Inf in lsqcurvefit, lsqnonlin, and fsolve

The default value of the `PrecondBandWidth` option changed from 0 to `Inf` for the `lsqcurvefit`, `lsqnonlin`, and `fsolve` solvers. This change was beneficial in the vast majority of tested problems.

In Optimization Tool, the default in **Algorithm settings > Subproblem algorithm** is now **Cholesky factorization**, instead of **Preconditioned CG** = 0.

Compatibility Considerations

The new default can lead to slower performance for problems with high-dimensional nonlinearities. If this happens, change the default to another value such as 0 (the previous default).

New Option TolConSQP with Incompatible Default Value

The new `TolConSQP` option exposes a parameter that was fixed at `eps` before. The parameter is used in the `fmincon`, `fminimax`, `fgoalattain`, and `fseminf` solvers.

Compatibility Considerations

The new default value is `TolConSQP` = 1e–6. This did not affect a vast majority of tested cases, and was beneficial in some. If you want exactly the same behavior as before, set `TolConSQP` = `eps` using `optimset`.

Field constrviolation in Output Structure

The `constrviolation` field now exists in the output structure for the `fgoalattain`, `fmincon`, `fminimax`, and `fseminf` functions; it measures the nonlinear constraint violation.

Version 3.1.2 (R2007b) Optimization Toolbox Software

This table summarizes what's new in Version 3.1.2 (R2007b):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
No	No	Bug Reports Includes fixes	None

Version 3.1.1 (R2007a) Optimization Toolbox Software

This table summarizes what's new in Version 3.1.1 (R2007a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	Yes Summary	Bug Reports Includes fixes	None

Changes introduced in this version are organized by these topics:

Changes to Outputs of Multiobjective Solvers

- `fminimax` now returns the value of `max(fval)` in the output `maxfval`.
- The iterative display of `fminimax` and `fgoalattain` have changed.

Compatibility Considerations

- The third output argument of the solver `fminimax`, `maxfval`, is described in the documentation as the maximum of the objective functions in the input `fun` evaluated at the solution `x`, that is, `max(fval)`. Before this release, `fminimax` actually returned the maximum of the objective functions in the reformulated minimax problem internally constructed by the algorithm. This value was typically very close to, but not necessarily equal to, `max(fval)`. `fminimax` now returns the exact value of `max(fval)` in the output `maxfval`.
- The iterative display for `fminimax` includes a new column with header `Objective value` that reports the objective function value of the nonlinear programming reformulation of the minimax problem. The column header `Max{F,constraints}` has been changed to `Max constraint`, and the column now contains the maximum violation among all constraints, both internally constructed and user-provided.

  The iterative display for `fgoalattain` now shows the value of the attainment factor in the `Attainment factor` column. A new column, `Max`

`constraint`, contains the maximum violation among all constraints, both internally constructed and user-provided.

Version 3.1 (R2006b) Optimization 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	Related Documentation at Web Site
Yes Details below	Yes–Details labeled as **Compatibility Considerations**, below. See also Summary.	Bug Reports Includes fixes	None

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

New Optimization Tool

The Optimization Tool is a graphical user interface (GUI) for performing common optimization tasks with the Optimization Toolbox. Using the `optimtool`, you can do the following:

- Select a solver and define your optimization problem.
- Set and inspect optimization options and their default values.
- Run problems and visualize results.
- Import and export problem definitions, algorithm options, and results between the MATLAB workspace and the Optimization Tool.
- Automatically generate M-code to capture, automate, and recreate your problem.

- Access built-in help.

Plot Functions Option Added

You can now specify the `PlotFcns` option in the `optimset` function or using the Optimization Tool for use with an Optimization Toolbox solver. With this option, you can plot various measures of progress while the algorithm executes. You can select from several predefined plots, or you can write your own.

Output Function Option Enhanced to Accept Multiple Functions

You can now specify more than one output function in the `OutputFcn` option.

Changes to the Output Function

The output function input `x` and fields in the `optimValues` structure have the following changes that address bugs in previous releases:

- `residual` now returns the residual vector for `lsqnonlin` and `lsqcurvefit`.
- `resnorm` contains the sum of squares and has been added for `lsqnonlin` and `lsqcurvefit`. The previous field `fval` has been removed for these functions.
- `procedure` has been removed for `lsqnonlin`, `lsqcurvefit`, and `fsolve`.
- `x` now returns the expected shape and size for `fgoalattain` and `fminimax`.

Compatibility Considerations

The above changes to the input `x` and `optimValues` structure have the following compatibility considerations in the output function:

- If you have references to the `residual` in a previous version, note that the value of this field has changed for `lsqnonlin` and `lsqcurvefit`. This fixes the problem addressed by the bug report S-289285.
- Any references to `fval` for `lsqnonlin` and `lsqcurvefit` need to be updated to `resnorm`. This fixes the problem addressed by the bug report S-289285.

- Any references to `procedure` for `lsqnonlin` and `lsqcurvefit` need to be removed. This fixes the problem addressed by the bug report S-291974.
- Previously, for `fgoalattain` and `fminimax`, `x` returned a column vector with an additional last element. If you have references to the values for `x` in a previous version, the extra element must be removed and the output vector may need to be reshaped. This fixes the problem addressed by the bug report S-315658.

Version 3.0.4 (R2006a) Optimization Toolbox Software

This table summarizes what's new in Version 3.0.4 (R2006a):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
No	No	Bug Reports Includes fixes	None

Version 3.0.3 (R14SP3) Optimization Toolbox Software

This table summarizes what's new in Version 3.0.3 (R14SP3):

New Features and Changes	Version Compatibility Considerations	Fixed Bugs and Known Problems	Related Documentation at Web Site
Yes Details below	No	Bug Reports Includes fixes	None

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

Notify Parameter Added to Display Option for Five Functions

You can now set the optimization option `Display` to `'notify'` for the functions `fmincon`, `fminunc`, `fminimax`, `fgoalattain`, and `fseminf`. When `Display` is set to `'notify'`, the output is displayed only if the function does not converge.

Compatibility Summary for Optimization Toolbox Functions

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.

Version (Release)	New Features and Changes with Version Compatibility Impact
Latest Version V4.3 (R2009b)	See the **Compatibility Considerations** subheading for each of these new features or changes: • "Enhanced Exit Messages in Selected Solvers" on page 4 • "Changes in quadprog" on page 5 • "Changes in linprog" on page 5 • "Multiobjective optimValues Changes" on page 5
V4.2 (R2009a)	See the **Compatibility Considerations** subheading for each of these new features or changes: • "Enhanced Exit Messages in Selected Solvers" on page 7 • "Change in linprog Simplex Algorithm" on page 9 • "Change in fminunc Exit Flag" on page 9

Version (Release)	New Features and Changes with Version Compatibility Impact
V4.1 (R2008b)	See the **Compatibility Considerations** subheading for each of these new features or changes: • "fsolve, lsqcurvefit, lsqnonlin Algorithm and Options Changes" on page 11 • "Finite Difference Algorithm Tweaked" on page 13 • "DerivativeCheck Tolerance Changed" on page 14
V4.0 (R2008a)	See the **Compatibility Considerations** subheading for each of these new features or changes: • "New fmincon Solver, New Option Algorithm for fmincon, Option LargeScale Changed" on page 16 • "Default PrecondBandWidth = Inf in lsqcurvefit, lsqnonlin, and fsolve" on page 17 • "New Option TolConSQP with Incompatible Default Value" on page 17
V3.1.2 (R2007b)	None

Version (Release)	New Features and Changes with Version Compatibility Impact
V3.1.1 (R2007a)	See the **Compatibility Considerations** subheading for each of these new features or changes: • "Changes to Outputs of Multiobjective Solvers" on page 19
V3.1 (R2006b)	See the **Compatibility Considerations** subheading for each of these new features or changes: • "Changes to the Output Function" on page 22
V3.0.4 (R2006a)	None
V3.0.3 (R14SP3)	None