Introduction

Using the Premium Solver Platform

Thank you for using the Premium Solver Platform Version 8.0, Frontline Systems' newest and most powerful Solver for Microsoft Excel. The Premium Solver Platform is upward compatible from the Solver bundled with Excel, which Frontline Systems developed years ago for Microsoft. It handles models far larger than the standard Solver, and solves them many times faster. With its support for conic and robust optimization, global optimization, stochastic programming and simulation optimization, it's the most advanced optimization software available anywhere.

Product Editions and Related Products

The Premium Solver product family includes:

- Premium Solver V8.0
- Premium Solver Platform V8.0 (Standard)
- Premium Solver Platform V8.0 Stochastic Edition

The **Premium Solver**, Frontline's basic upgrade to the Excel Solver, includes a subset of the Premium Solver Platform Standard Edition features and three of its five built-in Solver engines, as described later in this Introduction.

The **Stochastic Edition**, new in Version 8.0, includes all of the Premium Solver Platform Standard Edition features, plus extensive new capabilities to define and solve optimization models with uncertainty, using ***stochastic programming*** and ***robust optimization*** methods.

This Guide covers all the features of the Premium Solver Platform – including the new Stochastic Edition – and the five "Solver engines" bundled with it: the standard LP/Quadratic Solver, standard SOCP Barrier Solver, standard GRG Nonlinear Solver, standard Interval Global Solver, and standard Evolutionary Solver. You may also want to download and examine the User Guides for:

- **Risk Solver** (or Risk Solver Engine) V8.0
- Field-Installable **Solver Engines** V8.0

The Risk Solver User Guide describes Frontline Systems' exciting new tool for risk analysis using Monte Carlo simulation in Excel. The Premium Solver Platform and Risk Solver (or its subset Risk Solver Engine) work together to solve models using ***simulation optimization***. Field-Installable Solver Engines "plug into" the Premium Solver Platform and extend its capabilities to solve very large-scale, challenging optimization problems – up to *millions* of decision variables and constraints.

You may find it helpful to read the Solver-related topics in the online Help supplied with Microsoft Excel. These topics document the standard Solver's features and take you through the basic steps of using the Solver; this can help you get started with the Premium Solver Platform. But the Premium Solver Platform, and this User Guide, go *far* beyond the basics covered in the Microsoft Excel Help system.

From Beginner to Expert in Optimization

At over 400 pages, this User Guide is not a 'quick read.' But you *can* use it to get started quickly. **We urge you to watch the video demos available in the Welcome /Help dialog, and try out the examples described in "Getting Started."** You can learn a great deal about optimization by reading the two chapters "Solver Models and Optimization" and "Creating and Solving Models that Include Uncertainty." The sections below starting with "How to Use This Guide" give you more hints for using online Help, this Guide, and our Website **www.solver.com**.

We believe that, if you **master** all the topics in this User Guide, you can justifiably consider yourself an **expert** in optimization. In fact, you'll probably know more about *modern* optimization methods – such as conic programming, global optimization, stochastic programming, and robust optimization – than many professors of Operations Research and Management Science. As a smart business user, you can go beyond the limitations of conventional optimization and linear mixed-integer programming, and accomplish more for your company!

What's New in Version 8.0

The Premium Solver Platform V8.0 is a major new release, designed to analyze and solve *larger* models, *faster* than ever before. Our new Premium Solver Platform Stochastic Edition focuses on **optimization of models that include uncertainty**.

Defining Optimization Models with Uncertainty

Premium Solver Platform Stochastic Edition provides a unified framework for modeling and solving problems that include:

- Uncertainties (random variables) that may appear in the objective and constraints – including decision-*dependent* uncertainties
- Normal or first-stage ("here and now") decision variables
- Later-stage ("wait and see") decision variables, also called recourse variables
- Normal ("hard") constraints, chance ("soft") constraints, and an objective function, that may depend on the normal and recourse decision variables, and on the uncertainties

Models involving uncertainty, like conventional Solver models, are always **created in the same way** in the Premium Solver Platform. Several methods are available for finding optimal solutions for these models, depending on their structure.

The Premium Solver Platform can find *good* solutions – given enough time – to uncertain models of 'arbitrary' form, with non-smooth functions and decision-dependent uncertainties, using **simulation optimization** – even though such models are non-convex and often non-smooth global optimization problems.

But the Premium Solver Platform can *automatically* recognize common special cases – for example **stochastic linear programming** models – and find proven *optimal*

solutions at *faster* speeds for these models. Unlike simulation optimization models, stochastic LPs can be *scaled up* to model operations in large enterprises.

The Premium Solver Platform can also assist you in building models that involve uncertainty. It can **automatically diagnose a model** and point out formulas that violate the requirements of stochastic LPs, or that require the more computationally expensive approach of simulation optimization.

Model Transformation and Solution Methods

Model transformation and solution methods implemented in the Premium Solver Platform Stochastic Edition include:

- **Robust optimization** (RO) methods for linear programming problems with uncertainties affecting the objective and constraints. Chance constraints specify a probability of satisfaction, which is converted to a 'budget of uncertainty.' Monte Carlo simulation is used to obtain bound and shape information for the uncertainties. This information is used to *automatically* create a robust counterpart problem – either an LP or an SOCP – which is then solved. This method is *scalable* to large size (tens to hundreds of thousands of variables and constraints).
- **Robust optimization** methods and **stochastic programming** (SP) methods for *two-stage* stochastic linear programming problems with recourse ("wait and see") decisions. Scenarios are automatically created via built-in Monte Carlo simulation, or they may be drawn from user-defined cell ranges of sample values on the spreadsheet. With the benefit of second stage or *recourse* decisions, solutions are typically 'well-hedged' but not overly conservative. The RO and SP methods are *scalable* to large size, though scalability of the SP methods may depend on specialized Solver Engines.
- High-speed **simulation optimization** methods for problems more general than linear mixed-integer (non-linear, non-smooth or non-convex), where uncertainties may depend on the first-stage decisions. Normal and chance constraints may be used, and a wide range of statistical aggregates can be used to summarize uncertainty in the objective and constraints. A simulation is performed on each major iteration of the optimization. This method is very general, but computationally very expensive, and usually *not scalable* to large size problems.

User Interface for Models with Uncertainty

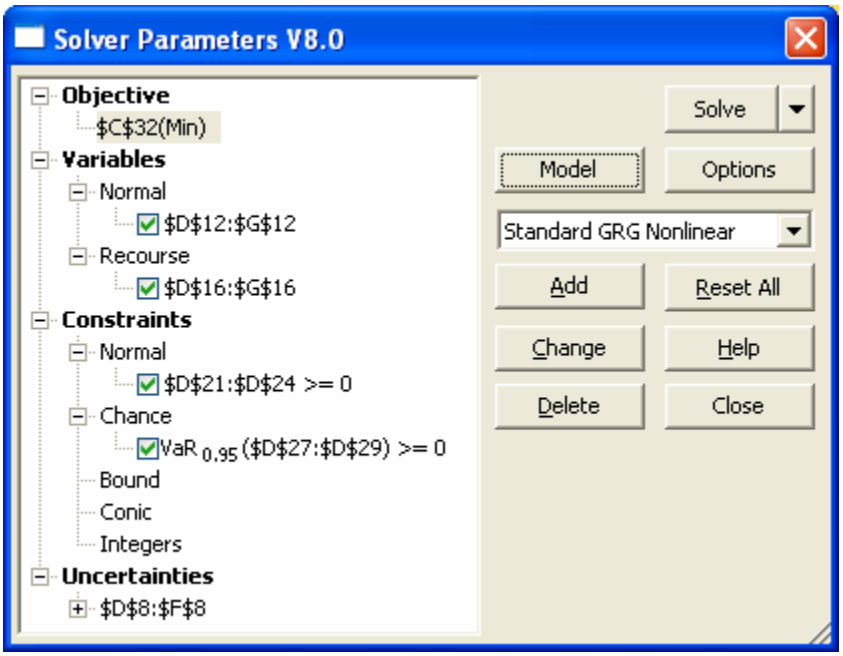
As noted earlier, a model is defined in the same way, regardless of the solution method used. As in the Excel Solver, the **objective** and the left hand sides of **constraints** appear in Excel worksheet cells, and their values are calculated from Excel formulas that ultimately depend on the **decision variable** cells. The objective, constraint and variable cells are selected in the Solver Parameters dialog, as shown on the next page.

What's new is the ability to define **uncertainties** in worksheet cells, and specify either analytic probability distributions, or specific scenario sample values for them. The distribution parameters may or may not depend on the decision variables, and the Platform detects this important difference.

Also new is the ability to define **recourse variables** and **chance constraints**. The Solver Parameters dialog has been revised to depict the entire model in the list box

area, in outline form with groups for normal and recourse variables, normal and chance constraints, bounds, conic and integer constraints, and uncertainties.

To help users examine and work with the model, the Solver Parameters dialog is resizable, and scroll bars appear in the list box area if needed. The check boxes can be used to temporarily remove variables and constraints from the problem.



Other Improvements in Version 8.0

Premium Solver Platform V8.0 also includes several improvements unrelated to optimization of models with uncertainty. The most "user visible" enhancement is direct support for semi-continuous variables, in all twelve built-in and plug-in Solver Engines. Performance of the built-in LP/Quadratic Solver on many linear mixed-integer (LP/MIP) problems is greatly improved. The PSI Interpreter is faster when analyzing and solving models. Macro recording has been enhanced to use either the traditional VBA functions or the Object-Oriented API introduced in Version 7.0. The Object-Oriented API has been enhanced to support creation of Solver models "from scratch," and to support the new functionality of Premium Solver Platform Stochastic Edition.

What's New in Version 7.0

Because the Premium Solver Platform has been enhanced so rapidly in recent years, many users are not familiar with all the capabilities Frontline Systems introduced a year ago in the Premium Solver Platform V7.0 – so we'll summarize them here. Version 7.0 was (and Version 8.0 is) designed to work with Microsoft Excel 2007, Excel 2003, Excel XP, and Excel 2000; it takes full advantage of the new power of Excel 2007, the most extensive upgrade of Excel to be released in many years.

Solving Large Scale, Multi-Worksheet Models

Models Defined Across Multiple Worksheets

When used with any modern version of Excel (Excel 2000, XP, 2003 or 2007), the Premium Solver Platform supports Solver models spread across multiple worksheets in a workbook. It is no longer necessary to keep all of your decision variables and constraint left hand sides on the active worksheet. Yet you can still define a different Solver model (if desired) on each worksheet – and each of these models can include variables and constraints on any sheet in the workbook! You can still use the Load Model and Save Model buttons to create as many sets of model specifications as you like.

Worksheets of 16K Columns and 1 Million Rows

When used with Excel 2007, the Premium Solver Platform supports worksheets with up to 16,384 columns and 1,048,576 rows – far beyond the limits of 256 columns and 65,536 rows in previous versions of Excel. This makes it much easier to lay out your models on a worksheet, without having to split up large tables of information. Many other limits, such as the maximum length of labels and formulas, are also greatly increased in Excel 2007.

Reports with an Unlimited Number of Rows

With previous versions of the Premium Solver Platform, you could easily define and solve models with more than 65,536 variables and/or constraints, but certain *reports* for those models were limited to the 65,536 rows on a single worksheet. In Excel 2007, this limit is increased to 1 million rows. But the Premium Solver Platform will create reports of any size – even in Excel 2000, XP and 2003 – it will "wrap" the data across additional columns if the row limit is reached.

Speeding Up Analysis, Solving and Reporting

Many of the built-in Solvers and field-installable Solver Engines in Version 7.0 and Version 8.0 feature improvements in the speed of solution. But the Premium Solver Platform concentrates on speeding up "end-to-end solution time," which includes setup time, report preparation and report generation time.

Faster Model Analysis

When you first click the Solve button with default options, or when you click the Check Model button in the Solver Model dialog, the Premium Solver Platform's Polymorphic Spreadsheet Interpreter (PSI) "parses" and analyzes your model. Parsing is faster for most models, especially for models spread across multiple worksheets. Even if all of your decision variables and constraints are on one worksheet, if you have many references to data on other sheets, parsing should be faster.

Faster Report Generation

When an optimal solution is found, the Solver does some work to prepare for report generation, which can take some time for a large model, even if you don't select any reports in the Solver Results dialog. And when you do select reports, more time is required to generate the report results. Starting in Version 7.0, both the preparation for reports and the generation of selected reports are much faster, with speedups of 5 to 10 times for report generation.

Reporting Multiple Solutions from Optimization

For global optimization, non-smooth optimization, and mixed-integer programming problems, the solution process used by most Solver engines finds several candidate solutions – for example, locally optimal solutions in searching for a globally optimal solution, or feasible integer solutions with good objective values ("incumbents") for an integer programming problem. In the Premium Solver Platform, the full range of built-in and plug-in Solver engines support the new Solutions Report, which lists objective and decision variable values for each of these candidate solutions (the *best* solution is 'plugged in' to the decision variable cells in your model, as usual). And using the new Object-Oriented API described below, you can easily access any of these alternative solutions in your VBA macro program code.

Function-Based Models and Interactive Optimization

Also new in the Premium Solver Platform are optimization models defined via functions on the worksheet, and *Interactive Optimization* that re-solves each time you change a number on the spreadsheet.

You can define your optimization model using the same interactive dialogs and VBA macros as the Excel Solver and previous versions of the Premium Solver Platform. But the Premium Solver Platform also supports a new style of model definition, using **PSI functions** on the worksheet. These functions are compatible with the family of PSI functions used by Risk Solver.

You can move easily between the interactive dialogs and PSI functions when creating your model. You can define variables and constraints by entering PSI function calls in worksheet cells, and you'll find that these variables and constraints appear in the Solver Parameters dialog the next time you display it. You can also define variables and constraints in the Solver Parameters dialog, and cause PSI function calls to appear automatically in cells on the worksheet. PSI functions also offer a new alternative format for the Load Model and Save Model commands.

Interactive Optimization

The Premium Solver Platform also supports *Interactive Optimization*: If you enable this feature, the Solver will re-optimize your model *each time you change a number* on the spreadsheet. For small to medium size models, this is not only a convenience – it can be a real decision aid: You'll find that insights about your model, and decisions you can make, start to flow intuitively, when you can quickly see the impact of changing a parameter on the optimal solution.

Object-Oriented API for Solver-Based Applications

The Premium Solver Platform includes support for the "traditional" VBA functions used to programmatically control the Solver, such as SolverOK and SolverSolve. But it also provides a new, high level, **object-oriented API** (Application Programming Interface) for optimization that complements the Risk Solver object-oriented API, and closely resembles the object-oriented API of the Solver Platform SDK V7.0, Frontline's highly regarded Software Development Kit for creating optimization and simulation models in a programming language.

The new object-oriented API is more powerful and much more convenient for programming the Solver than the "traditional" VBA functions. For example, instead of writing VBA code using the Excel object model to retrieve decision variable and

constraint values from cells on the worksheet, or obtain sensitivity information from cells on a report worksheet, you can simply reference an API object and property to retrieve each of these values in an array in your program. The object-oriented API can be used from VBA in Excel, or from VB.NET or C# using Visual Studio.

Simplified Installation and Use

The Premium Solver Platform is redesigned from the ground up internally. It uses a single program file **Solver32.xll** that provides the Solver Parameters, Solver Model and Solver Options dialogs, all reports, PSI functions, the object-oriented API, the PSI Interpreter and model analysis, and all five bundled Solver Engines. Solver32.xll is a COM add-in, an XLL add-in, and a COM server. In this version, the add-in file **Solver.xla** is optional – it is needed only if you wish to use the "traditional" VBA functions to program the Solver.

Thanks to this new architecture, the Premium Solver Platform can be installed and used even if the standard Excel Solver was not included when you ran Setup for Microsoft Office and Excel. You can also install and use the Premium Solver Platform V8.0 *at the same time* as the standard Excel Solver, or an earlier (pre-V7.0) version of the Premium Solver Platform or Premium Solver.