# EXTENDSIM 9

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## ABSTRACT

Release 9 is a significant upgrade to the ExtendSim simulation application and includes a number of features that enhance the modeling experience for new and experienced modelers. In addition, this paper reviews the overall ExtendSim architecture and corporate philosophy.

## 1    INTRODUCTION

Major new features in release 9 include enhanced item logging, attributes for flow, support for ADO databases, database reports, a new Excel Add-In, smart connections, and a new Template library. There are numerous other enhancements that assist the modeling process. Plus models built in ExtendSim 9 run faster, use fewer blocks, and require less time to build.

## 2    EXTENDSIM STRUCTURE

An ExtendSim model is created by adding blocks to a model worksheet, connecting them together, and entering the simulation data. Each type of block has its own functionality, dialog, help, icon, and connections. Each instance of a block in the model has its own data. Blocks perform a number of functions in a simulation model including:

- Simulating the steps in a process (Queue, Activity)
- Performing a calculation (Math, Random Number, Equation)
- Interfacing with other applications or data storage (Read, Write)
- Providing a model utility (Find and Replace, Count Blocks)
- Plotting model results (Plotter, Histogram)
- Animating (Animate Value, 3D Scenery)
- Creating a user interface (Popup, Buttons)

The logical entity that moves through the system is referred to as an item. Items carry properties or attributes with them as they progress from one block to the next. Items are represented using lightweight data structures allowing large numbers to exist simultaneously within a model.

The source code for all of these blocks is available and can be viewed or modified by the end user. New blocks can be created from existing blocks or created from scratch. This allows the modeler or developer to create their own libraries for specific modeling domains. Using this capability, a whole range of simulation products are based on the ExtendSim engine. These include applications for pulp and paper manufacturing, chemical process control, biological processes, and analytical chemistry.

Hierarchical blocks contain other blocks (either programmed or hierarchical) that form template models. This helps to organize the model. Hierarchical blocks can be stored in a library and reused in the same

or different models. ExtendSim has tools for creating an interface within the hierarchical block, making it easy for the modeler to expose important parameters and results.

ExtendSim's internal database is an integrated part of the model structure. Many of the modeling components are designed around the database to store and manage data. The database can also be used as part of the fabric of the simulation. As a database record value changes, interested blocks will receive a message notifying them of the change so that they can react accordingly. This powerful capability simplifies communication in complex models, eliminating cumbersome end-of-event status checks and event polling (Diamond, Krahl, Nastasi, and Tag 2010).

Complete information about ExtendSim can be found in the ExtendSim User Guide (Imagine That, 2013).

## 3 EXTENDSIM PRODUCT LINE

ExtendSim is available in four package configurations based on modeling requirements:

- ExtendSim CP: continuous modeling
- ExtendSim OR: adds discrete event simulation
- ExtendSim AT: adds advanced simulation technologies - discrete rate, distribution fitting, advanced resources, database query blocks, scenario management and an Excel Add-In.
- ExtendSim Suite: adds 3D animation

The core features of ExtendSim - interactivity, data scalability, extensibility, as well as our trend-setting user interface - are included in all of the software packages. The appropriate ExtendSim configuration is selected based on the type of modeling, desired analysis features, and presentation requirements. With every package, the modeler has access to the full power of ExtendSim. There is no "loss-leader" version of ExtendSim in the lineup.

Note that in addition to 3D animation ExtendSim Suite contains everything in ExtendSim AT, OR , and CP. Likewise, ExtendSim AT includes discrete rate, Stat::Fit for distribution fitting, the Excel Add-In, scenario management, advanced resource management, and additional DB query options as well as  all of the features in OR and CP.

## 4 EXTENDSIMTHINK

We use the phrase "ExtendSimThink" to characterize how we think about software: accessible, affordable, interactive, powerful, and extensible. This encompassing philosophy drives ExtendSim forward. The end result is an engaging simulation program that can be used by a wide range of modelers for the broadest range of applications.

### 4.1 Corporate Philosophy

Before getting into the features of ExtendSim it is useful to examine  the company and people behind the software. Imagine That Inc, the developer of ExtendSim, believes in making simulation technology available to the widest range of modelers possible. We pioneered an extensible simulation environment that has become the model for the industry. The basic design of ExtendSim - a drag and drop environment with extensible libraries of modeling components - is the same formula used by every simulation program introduced in the last 15 years.

### 4.2 The Inventor

Bob Diamond began programming simulation models for NASA as an undergraduate student. His simulation of the path of a fuel droplet within the Saturn V rocket engine was critical in discovering that the na-

ture of combustion is a chaotic process. In typical Silicon Valley fashion, Bob developed ExtendSim (then called Extend) in his den in 1988. It was designed around the Macintosh user interface and marked the first time that a simulation software program was specifically built for a GUI environment. The basic design of ExtendSim has proven to be timeless. In short, he got it right the first time.

Bob's accomplishments range well beyond the realm of simulation software. His career also included stints as a video and multi-media artist (you can see one of his works, Cloud Music, in the Smithsonian), hardware designer for the Commodore PET computer, and designer of pioneering broadcast digital video equipment at Consolidated Video Systems (CVS). Early video effects used in the popular Sesame Street Children's TV show were developed by Bob.

## 4.3 Open Architecture

The source code of ExtendSim blocks is fully available and modifiable in all four products. No additional or outside development environment is required. This has a variety of benefits:

- The block's precise behavior is available for inspection by anyone using ExtendSim.
- It is very easy to add new features to a block. For over 25 years, Imagine That has been able to add new features and respond to modeler's requests often within one day.
- User developed blocks are as accessible and usable as the blocks developed by Imagine That.
- Because the underlying language, ModL, is compiled model execution speed is fast.

## 4.4 Low Cost

The cost of ExtendSim has always been in line with other technical software. Desktop applications for statistics, linear programming, computer aided design, and project management all fall within the same price range as ExtendSim. By providing high-capability, easy-to-use simulation software at a reasonable price, Imagine That has introduced simulation software to modelers who otherwise would have found the barriers for traditional simulation software too high.

## 4.5 Interactive and Engaging

Even release 1.0 of ExtendSim (Extend at that time) allowed modelers to change parameters and view results while the model is running. In addition, the modular nature and fast turn-around for changes in ExtendSim encourages modelers to experiment and stretch their modeling imaginations. In short, simulation modeling is fun with ExtendSim.

## 5 WHAT'S NEW

ExtendSim 9 furthers the achievements of earlier releases with a variety of new features. Here we will focus on the major new features. There are a number of smaller features that reduce the number of blocks required, speed model execution, increase model scalability, and generally improve the modeler's experience. The subsections below detail the major new features in ExtendSim 9.

ExtendSim 9's new features are distributed across the different ExtendSim packages. Each feature's title indicates the product where it can be found.

## 5.1 Flow attributes (Suite, AT)

An enhancement to ExtendSim's unique discrete-rate technology, flow attributes track the properties of the type of product that is modeled as a continuous flow in a discrete event environment. Examples of flow include bulk material such as grain or ore, liquids and gases, and product in a high-speed production line. A flow attribute is a quality or characteristic of flow that stays with it as it moves through the model such as the product type, color, temperature. Flow attributes provide information about the flow and allow

you to organize quantities or volumes of flow into layers. The entire set of attribute values assigned to a particular layer is what distinguishes it from other layers. In other words, all the units of flow in a layer possess the same set of flow attribute values.

Attributes are assigned to the flow by the model builder. They become linked to sections of flow that pass through the blocks, according to settings in the blocks' dialogs. Some uses for flow attributes include:

- The flow held in a Tank can be organized into individual, distinct layers. This allows you to control where incoming flow is deposited and which type of outgoing flow next exits.
- Flow rates through the Valve block can be calculated based on flow attribute values.
- Flow can be routed through the Merge and Diverge blocks based on flow attribute values.
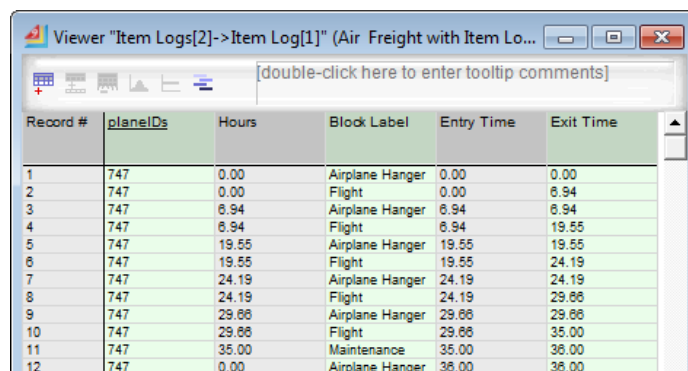
## 5.2    Item Logging (Suite, AT, OR)

In addition to the existing ExtendSim trace features, the Item Log Manager (ILM) block tracks how items change states during a run by doing two things:

- During the simulation run, it directs other blocks in the model to collect data on items as they pass through. These "remote" data collecting blocks include History, Activity, Queue, Queue Equation, and Resource Item. Each of these blocks can be remotely instructed to collect specific item property information for the ILM through its "Data Collection" tab.
- Once the remote blocks have collected the data, the ILM packages it into a report. You can control which types of data are included in the report and the order in which the data appears. This is done on the ILM block's "Configure Log" tab.

Once the run is complete, any number of reports can be generated from the data that has been collected in the remote blocks. These reports can be generated after each run either automatically or manually. You can have one or more ILM blocks in a model with each one responsible for generating its own report. The ILM also supports generating reports across multiple runs.

Figure 1 Illustrates a sample log of aircraft operations. Here we can see the individual plane ID's and their corresponding entry and exit times through various points in the model.



**Figure 1: Sample log of aircraft operations**

## 5.3    ADO Database Support (Suite, AT, OR, CP)

ActiveX Data Objects (ADO) is a method for exchanging information with various databases on-Windows-based computers. ADO sends an entire table of information at one time, providing high-speed

data interchange. The ExtendSim ADO interface allows you to communicate with Access, SQL Server, and MySQL.

Figure 2 shows the dialog of the Data Import/Export block configured for ADO Import from a SQLServer database into an ExtendSim database. The ADO interface is designed so that the modeler can access an ADO database by adding a Data Import/Export block to the model and selecting the internal and external data sources.
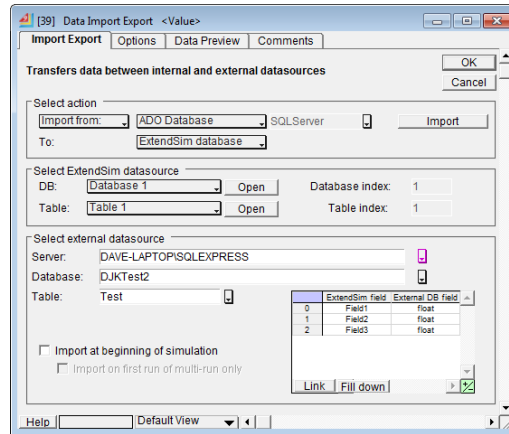


**Figure 2: Data Import/Export configured for ADO database**

## 5.4 Excel Add-In (Suite, AT)

Microsoft Excel has become the ubiquitous repository for simulation data. Excel can be found on nearly every desktop and is often used for ad-hoc analysis. However, because of performance and scalability issues, Excel is a less-than-ideal database. To bridge the gap between Excel as a data repository and the ExtendSim database, we have created an Excel Add-In. The ExtendSim DB Add-In allows an exported ExtendSim database text file to be imported into Excel. The data and structure of the ExtendSim database can thus be edited in Excel, outside of the ExtendSim application. After editing, the database can be exported from Excel as an ExtendSim database text file and imported into ExtendSim.

ExtendSim 9 contains an entirely new version of the Add-In that leverages the latest Excel features to provide most of the database construction and editing features available in ExtendSim. This allows modelers to use Excel to create ExtendSim databases and manipulate information in the Excel spreadsheet application. Figure 3 shows an ExtendSim database in Excel.
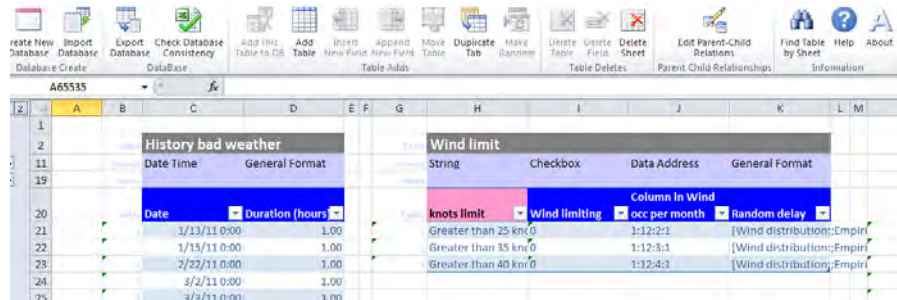


**Figure 3: Excel Add-In**

## 5.5    Smart Connections (Suite, AT, OR)

To speed the modeling process, Imagine That has developed a series of features collectively called "smart connections". These allow the modeler to quickly and easily modify models by moving blocks into strategic positions.

### 5.5.1  Bump Connect

When a block from the Item or Rate library is placed in the model and its input connector is placed on an output connector of the same type, ExtendSim will automatically connect the blocks, space them evenly and align the connectors. This saves a few mouse clicks in the modeling process as the user does not have to draw connection lines between blocks.

### 5.5.2  Insert Over Connection

If a block is moved over an existing connection line so that either the input or the output connector is on that connection line, ExtendSim will increase the spacing between the existing blocks and insert the new block inline between two existing blocks.

### 5.5.3  Connection Routing

If a block is moved, ExtendSim will reroute the connection lines so that they will not cross over the icon of the block. This saves the time required to lay out and organize model connection lines.

## 5.6    Templates Library (Suite, AT, OR)

Many common simulation constructs are created in ExtendSim by combining just a few blocks together. ExtendSim's Templates library contains a number of these constructs in the form of hierarchical blocks. These blocks contain the icon, help, blocks, and animation that can be used directly by the modeler.

Figure 4 shows the Templates library. Modelers would drag a block from this library into the model and change the parameters to reflect their specific modeling situation.
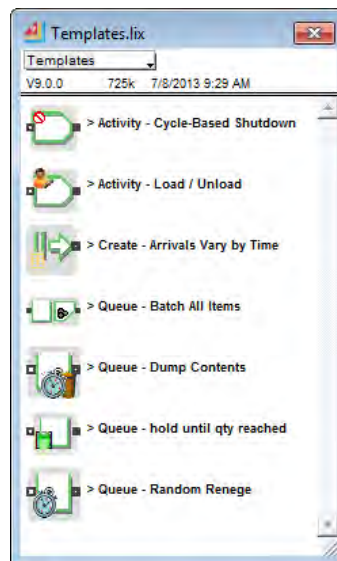


**Figure 4: Templates library**

### 5.7 New Reports (Suite, AT, OR, CP)

The new Statistics (DB) report contains the final values for the output parameters. The statistical data from each simulation run is stored in an ExtendSim database, organized by block type so that there is one table per type of block. Blocks included in the report can be all blocks in the model or a user-defined subset of the blocks. Report tables can be exported to external databases or Excel when the simulation is complete. Of course, ExtendSim's existing text-based reports have been maintained, but the new Statistics (DB) report provides better organization, presentation, and accessibility of model results.

Figure 5 shows a sample queue report for a healthcare model.



**Figure 5: Queue report**

### 5.8 Other Features

Some other features added in ExtendSim 9 include:

- Meter block displays levels in the simulation application (Suite, AT, OR, CP)
- New input and output variables in equation-based blocks (Suite, AT, OR, CP)
- New options in equation based blocks that provide more control on when the equation executes (Suite, AT, OR, CP)
- New options for importing a named range of data from Excel (Suite, AT, OR, CP)
- The ExtendSim database can be automatically resized based on the number of rows in the imported data (Suite, AT, OR, CP)
- New interval statistics records the mean, variance, confidence interval, and standard deviation at specific intervals during the simulation (Suite, AT, OR, CP)
- Quantile statistics can be calculated (Suite, AT, OR, CP)
- Blocks are enhanced so that fewer blocks are required to build models (Suite, AT, OR, CP)
- ExtendSim's shift capabilities are enhanced and interfaced with additional blocks (Suite, AT, OR)
- New options are available for multi-component failure modeling (Suite, AT, OR)
- Transportation has a new option that prevents items from passing one another (Suite, AT, OR)
- There are a number of new functions and message handlers (Suite, AT, OR, CP)

A complete list with more details can be found on the Imagine That web site (www.extendsim.com) or the ExtendSim 9 Reference (Imagine That Inc, 2013).

## 6 EXTENDSIM DELTA

Even before version 9 was released, Imagine That had been working on the delta version, the fourth generation of ExtendSim. This new version will incorporate even more new features and will be built on an

entirely new delta platform, propelling ExtendSim into the future. This release will fully leverage the latest computing hardware and technology. Stay tuned for more details.

## CONCLUSIONS

ExtendSim 9 enhances the modeler's experience. While it is not possible to detail all of the enhancements in this paper, this overview does provide an introduction to ExtendSim 9. Modelers upgrading from ExtendSim 8 will appreciate the increased ease and power of ExtendSim 9. New modelers will continue to enjoy ExtendSim's interactive, engaging environment. Anyone who uses ExtendSim will find it to be a powerful, scalable, and approachable simulation program.

## REFERENCES

Diamond, B., Krahl, D., Nastasi, A., Tag, P. 2010 *ExtendSim Advanced Technology: Integrated Database.* In Proceedings of the 2010 Winter Simulation Conference, B. Johansson, S. Jain, J. Montoya-Torres, J. Hugan, and E. Yücesan, 32-39. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.
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## AUTHOR BIOGRAPHY

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