PM323173

Process Modeling Essentials for Industry 4.0

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Learning Objectives

- Learn how to compile existing process information through empirical evidence and existing sensor data.
- Learn how to develop simulations of a process utilizing ProModel Process Simulator integrated with the Factory Utilities.
- Learn about process bottlenecks and deficiencies while generating "what if" scenarios that offer optimization for the process.
- Learn how to use a process simulation to make predictive plans for process innovation and technology enhancements.

Description

Innovations with Process Modeling for Factory Design
This new era of technology is driving a lot of innovation in all aspects of design. All product manufacturers are embracing innovation and new technology in order to maintain or advance their current production cycles. But, incorporating new technology and innovative manufacturing practices requires a solid plan, not a wild guess. The path to innovation must start with a thorough analysis of your current process. It is not enough to say, 'the process is inefficient," or "new tech will solve our problems." It is critical to properly outline and identify bottlenecks or over- and under-utilized equipment and practices. Once the process is properly defined, organizations can move beyond reaction-based decision making to predictive-based planning. In this class, we'll demonstrate how the current Factory Design Utilities may be enhanced with ProModel Process Simulator.

Speakers

Rusty Belcher is a manufacturing application expert working with IMAGINiT Technologies. Rusty provides implementation, training, and support services at every level for all Autodesk, Inc., manufacturing products. His specialty involves the integration of 3D design practices into manufacturing production environments. Over the past several years Rusty has worked directly with Autodesk to develop and author the current Factory Design Suite software training courseware, and he has also developed and recorded many of the tips and tutorial videos available on the Factory Design Suite software's YouTube channel.

David Reaume, Product Manager for Inventor Automation and Smart Factory, has more than three decades of successful experience in nearly every phase of design and manufacturing. His roles and titles within multiple corporations have spanned the breadth of the industry. Dave has served as Mold Designer, User Experience Designer, Product Owner, R&D Specialist, Solutions Architect, Application Engineer, Product Lifecycle Management Services Manager, Director of Software Development, and Engineering/Manufacturing Process Improvement Specialist. Dave also co-founded Logimetrix, the startup that developed iLogic technology and was acquired by Autodesk in 2008.

With his comprehensive knowledge of diverse technologies and systems, including design automation, tooling, software development, and technology platforms, Dave brings an acute problem-solving mentality to all his work along with an ever-present commitment to the end user, always fiercely advocating for the customer.

Process Simulation for Industry 4.0

The phrase “**Industry 4.0**” represents the fourth revolution that has occurred in manufacturing. From the first industrial revolution (mechanization through water and steam power) to the mass production and assembly lines using electricity in the second, the fourth industrial revolution will take what was started in the third with the adoption of computers and automation and enhance it with smart and autonomous systems fueled by data and machine learning. Now that the manufacturing world is so connected, it has never been more essential to understand your current and future process workflows.

Why use Process Simulation?

Accurate Depiction of Reality

Anyone can perform a simple analysis manually. However, as the complexity of the analysis increases, so does the need to employ computer-based tools. While spreadsheets can perform many calculations to help determine the operational status of simple systems, they use averages to represent schedules, activity times, and resource availability. This does not allow them to accurately reflect the randomness and interdependence present in reality with resources and other system elements. Simulation, however, does take into account the randomness and interdependence which characterize the behavior of your real-life business environment.

Using simulation, you can include randomness through properly identified probability distributions taken directly from study data. For example, while the time needed to perform an assembly may average 10 minutes, special orders may take as many as 45 minutes to complete. A spreadsheet will force you to use the average time, and will not be able to accurately capture the variability that exists in reality.

Simulation also allows interdependence through arrival and service events, and tracks them individually. For example, while order arrivals may place items in two locations, a worker can handle only one item at a time. Simulation accounts for that reality, while a spreadsheet must assume the operator to be available simultaneously at both locations.

Insightful system evaluations

Simulation tracks events as they occur and gathers all time-related data for reporting purposes. The information available about system operations is more complete with simulation than with other techniques. With static analysis techniques such as queuing theory and spreadsheets, you know the average wait time and number of items in a queue but there is no way to further examine the data. With simulation, you know the wait time, number of items, minimum and maximum values, confidence interval, data distribution, and the time plot of values. It is always more valuable to know that the number of items in a queue exceeds 10 only 5% of the time than to know that the average number waiting is 2.

Static analysis techniques allow you to use only average parameters. Such limitations can mislead you with estimates that suggest an over- or under-capacity situation. For example, spreadsheets assume that production orders move unconstrained when, in fact, an operator must facilitate the move. This can yield a wildly inaccurate capacity estimate, and can put millions of dollars at risk in unnecessary capital investment or late delivery of orders.

Simulation is the Cornerstone for Decision Support

With Industry 4.0 changing the landscape of manufacturing, it has never been more crucial to understand and predict the future performance of any given process of system. Process Simulation offers a predictive glimpse into the future. The benefits of informed predictive decisions are immeasurable.   The bottom-line savings are realized in the following areas:

Hard-dollar savings

- Lower capital expenditure
- Increased existing facility utilization reduces net cost
- Proper labor assignments prevent unnecessary new hires
- Accurate and insightful facility planning eliminates unnecessary rework costs

Soft-dollar savings

- Facility rearrangement or reassignment of duties increases productivity
- Reduced wait time improves customer satisfaction
- Accurate system depiction ensures valid decision-making information

Labor savings

- Rapid development establishes time and cost data quickly and accurately

Intangible benefits

- Increased understanding of the actual process improves employee education
- Coordinated simulation projects improve teamwork and communication and focus resources in areas which will provide biggest benefit

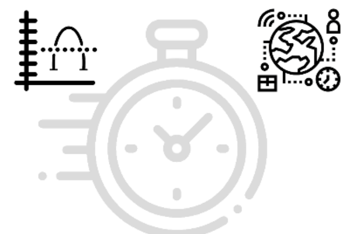
Simulation Modeling vs. Spreadsheet Analysis

Dynamics for Predictive Analysis

Spreadsheets are static and can only provide a quantitative result for one moment in of time, where simulation replicates your dynamic business reality. The idea of “running next year’s anticipated orders through the plant” cannot be done dynamically in a spreadsheet. The power to “look into the future” and understand the impact on multiple key metrics is what simulation provides.

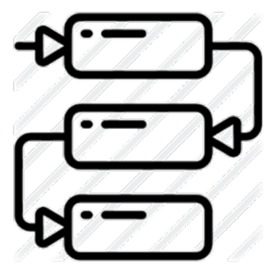
Spreadsheets = Error of Averages

Spreadsheets are also deterministic, meaning that average values are used to describe the behavior of any variable event in order to make calculations. Use of averages for cycle times, resource availability, and arrival patterns for performance analysis quickly leads to a significant cumulative inaccuracy known as the “error of averages.” Simulation allows the user to capture the specific variability of multiple interdependent processes and provides results which are orders of magnitude more accurate than deterministic analysis.



Understanding Interdependencies

What happens when two or three simultaneous events occur, all of which require a single resource? For example, an operator may be responsible for loading and unloading several machines and addressing downtimes. This creates competition for that operator and causes delays downstream for which a spreadsheet cannot account. This interdependence which exists in your business reality is a key component of simulation.



The idea of interdependencies goes beyond competition of resources (labor and machines) to include the impact of skill level, order types, order volume, cost of money over time, and other key issues. Simulation allows the user to quickly see bottlenecks caused by system interdependencies before implementing process changes and improvements.

Experimentation and Data

Spreadsheet based experimentation (manipulating cells and formulas) provides only very basic metrics, and requires cumbersome reports which do not intuitively direct a decision maker to the source of a problem. ProModel collects statistics on all user-defined key performance metrics in a simulation run, which allows for rapid design of experiments with detailed comparative results.

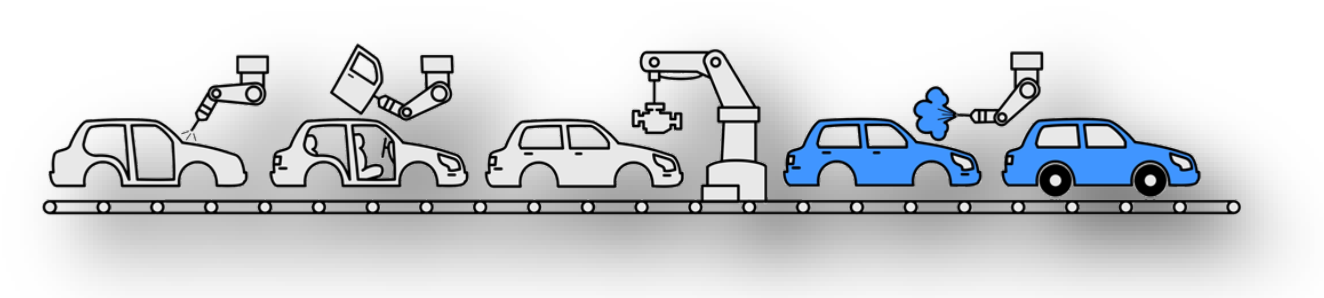
Consider one type of simulation experiment to understand the maximum capacity of a system by testing constrained vs. un-constrained scenarios. This allows the user to understand how the system would perform “in a perfect world” if system constraints were eliminated. Simulation will generate a demand profile for those constraints, showing exactly what the maximum requirements would be, AND at what point in time they are required.

Discrete Event Modeling

Collecting and Depicting the Reality of a Complex Process

The most crucial decision made when we begin to model a complex process is what level of realistic detail should be included. Some processes are made up of many random and interdependent steps. Each step is in itself, a very complex set of circumstances that have to come together to make something happen when, where, and how it is supposed to. So how can we model and simulate a process that is inherently fluid and defies complete description? We break it down to the essential individual steps that must occur for the process to be complete. This design discipline is called Discrete Event Modeling.

Discrete Event Modeling is a simple and versatile way to describe and analyze a dynamic system. By simplifying a complex process to crucial occurrences, the effort to develop a simulation model is greatly diminished. The computational overhead of the simulation is also drastically reduced, only requiring calculations for the truly critical process events. This allows designers to easily run multiple simulations, providing a more thorough picture of the system under various scenarios.



The simple illustration above depicts the complex process of assembling an automobile on a robotic assembly line. It would be virtually impossible to list or record the thousands of events that are required to assembly a vehicle in this manner. Discrete Event Modeling reduces the complexity of the overall process by only considering the super critical events and treating all other low-level details as irrelevant.

1. Basic Chassis Arrives to Line
2. Interior Installation Dashboard / Rear Seats / Front Seats
3. Doors
4. Windows
5. Engine and Transmission Installation
6. Paint and Finish
7. Wheels / Tires
8. Ready for Delivery

Event Modeling Properties

Each occurrence in the Discrete simulation will require a set of properties unique to the situation. Events can usually be described as one of 5 categories.

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<tr>
<td>
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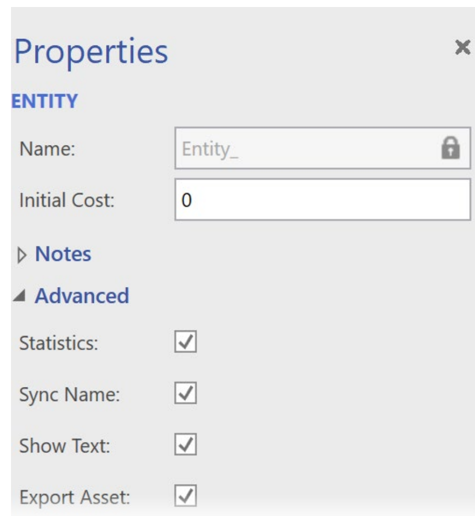
<td>Entity
The items or people that are processed. Examples include documents, customers, parts, etc.</td>
<td>
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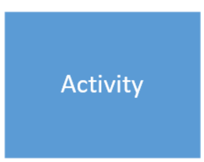
<td>
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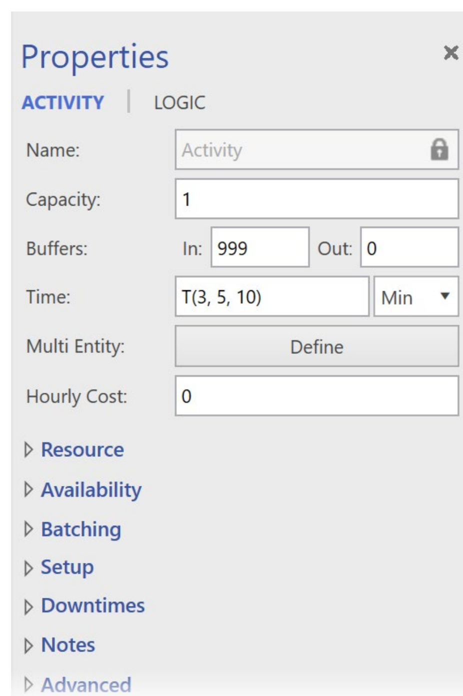
<td>Activity
The processing steps performed for each entity. Examples include check-in, transform, assembly, disassembly and inspection. Activities can have input and output buffers associated with them and tasks can be performed on a batch of entities or one at a time.</td>
<td>
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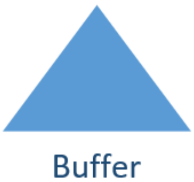
<td>
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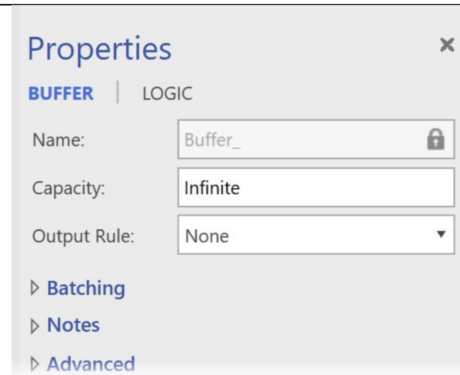
<td>Buffer
The buffer shape provides an area where entities can accumulate and, optionally, be batched.</td>
<td>
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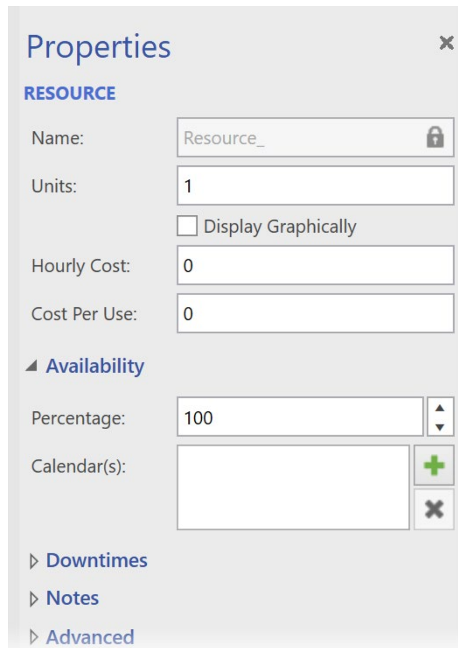
<td>Resource
The agents used to move and process entities. Examples are workers and machines.</td>
<td>
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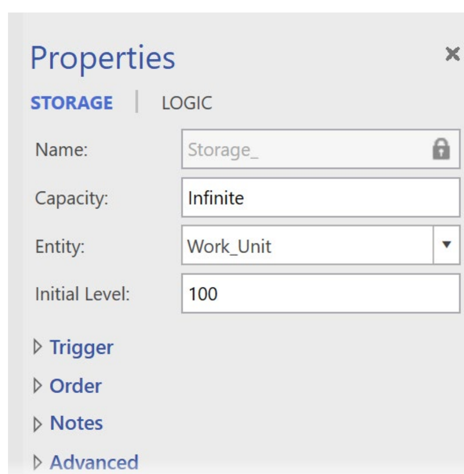
<td>Storage
The storage shape provides an area where entities can be stored and then automatically replenished when triggered by a low quantity or after a certain amount of time.</td>
<td>
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Connections

Connections are used to model the flow of entities through your simulation. The various connector types and their properties are listed below.

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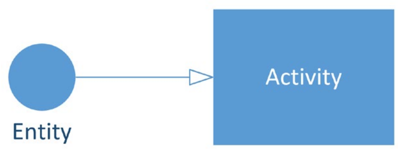
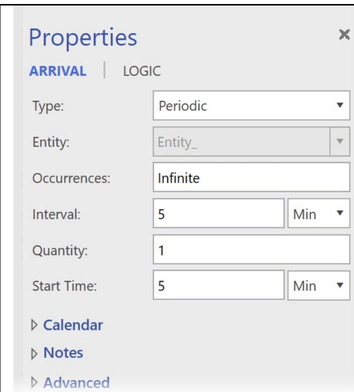
<td></td>
<td>Arrivals
An arrival connects an entity to an activity and defines the rate, schedule, or pattern in which entities are created and arrive at the connecting activity</td>
<td></td>
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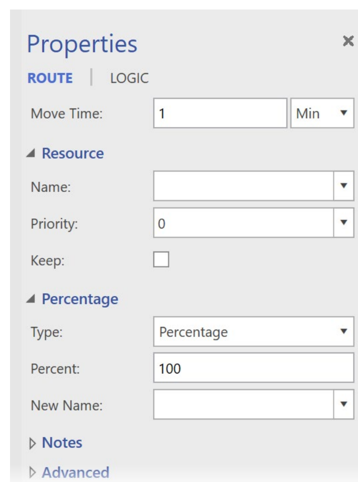
<td>Routings
A routing connects an activity to another activity and defines the movement of entities from one activity to another.</td>
<td></td>
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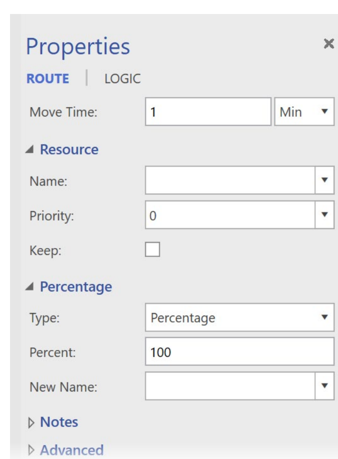
<td></td>
<td>Exit
An Exit is the Connector that ends the Route. It marks the final step in the process.</td>
<td></td>
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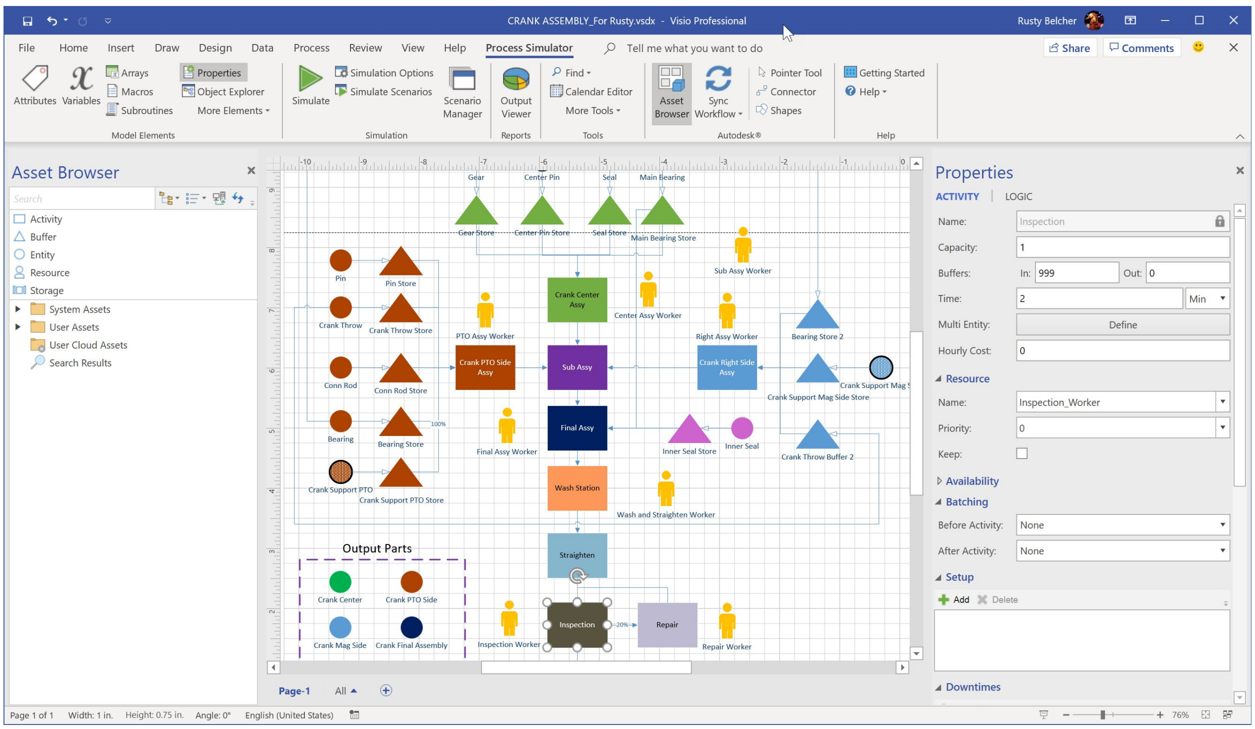
Developing a Process Model

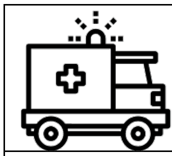
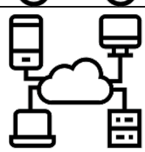
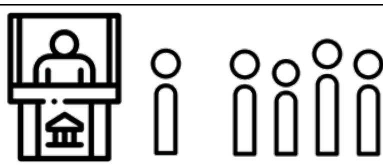
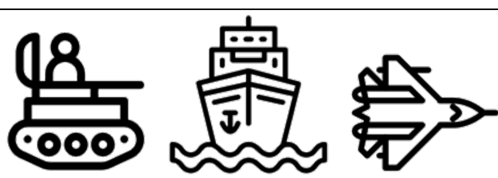
A process model is developed using the occurrence categories and connections to accurately record all events in the process. A traditional flow chart diagram is usually the format of choice for this type of model. After careful consideration of each step, an analysis of the process can begin. The model process can be simulated based on the time and properties input for each step. Multiple scenarios can be run on this Digital Twin revealing numerous issues or bottlenecks in the overall process. The following image shows a typical process model diagram before the simulation is run.



Examples of Discrete Event Modeling

Today our world seems to be built on thousands of complex processes that occur every second of every day. These processes are all around us and we experience and interface with them, multiple time daily. Imagine what happens behind the scenes, when you pick up your mobile device to steam the latest episode of your favorite show. The moment you open the application, hundreds of decision events begin to occur. Your login information is compared to a valid clients list. Your subscription is verified, and your account information is updated with the latest transaction. Your previous viewing history is referenced, and new suggestions are presented. Each event impacts the following like a line of dominoes. Processes like these are always mapped out to ensure the maximum efficiency and reliability.

Discrete Event Simulation is use on almost every type of process imaginable. The list below represents a small fraction of processes enhanced by Process Simulation.

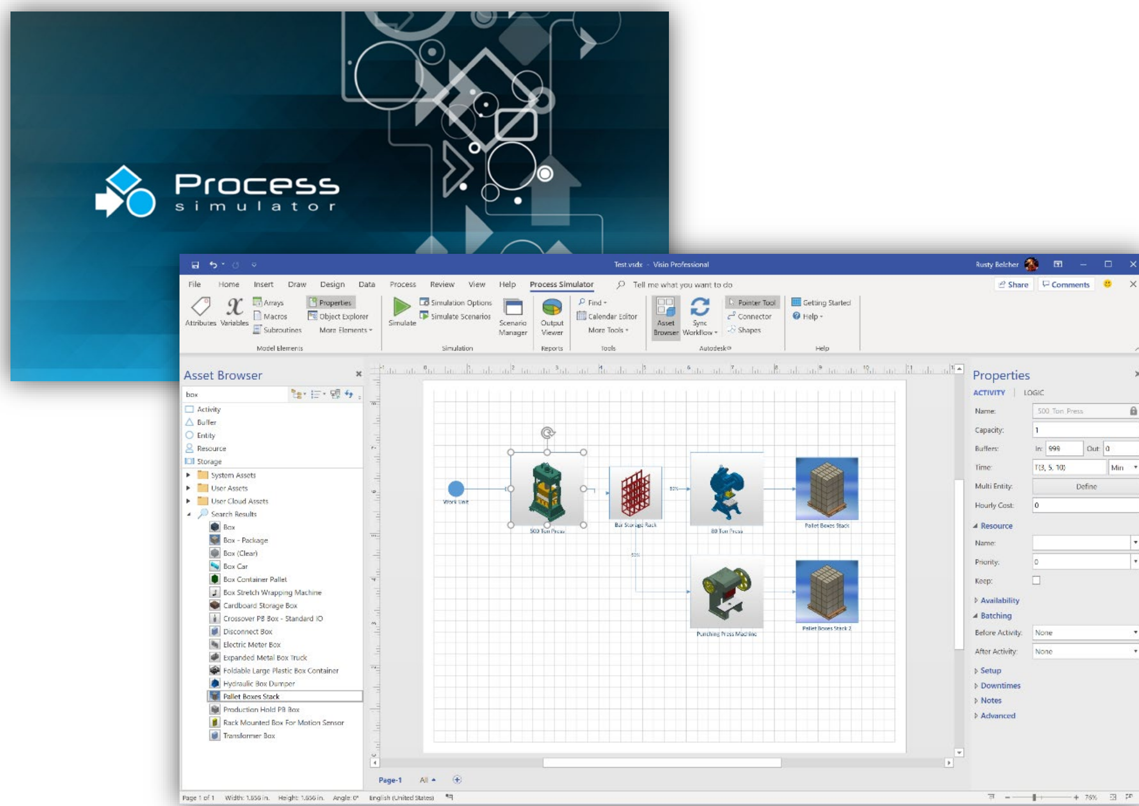
	Emergency Room Triage
	Computer Network Traffic
	Customer Service – Bank Tellers – Fast Food
	Retail Point of Sale
	Airline Schedules – Arrivals / Departures
	Aircraft Ticketing / Aircraft Boarding
	Military Planning / Deployment

Process Simulator Autodesk Edition by ProModel

Process Simulator is a process analysis and improvement tool based on Microsoft Visio and ProModel technology that simulates and optimizes any Visio flow chart. It is a professions level solution for process simulation integrated into the Autodesk Factory Design Utilities. It can be used to bring diagrams to life and analyze how a facility will actually operate. Process Simulator animates and simulates the processes showing activity flow and reports predictive analytics on all key performance indicators.

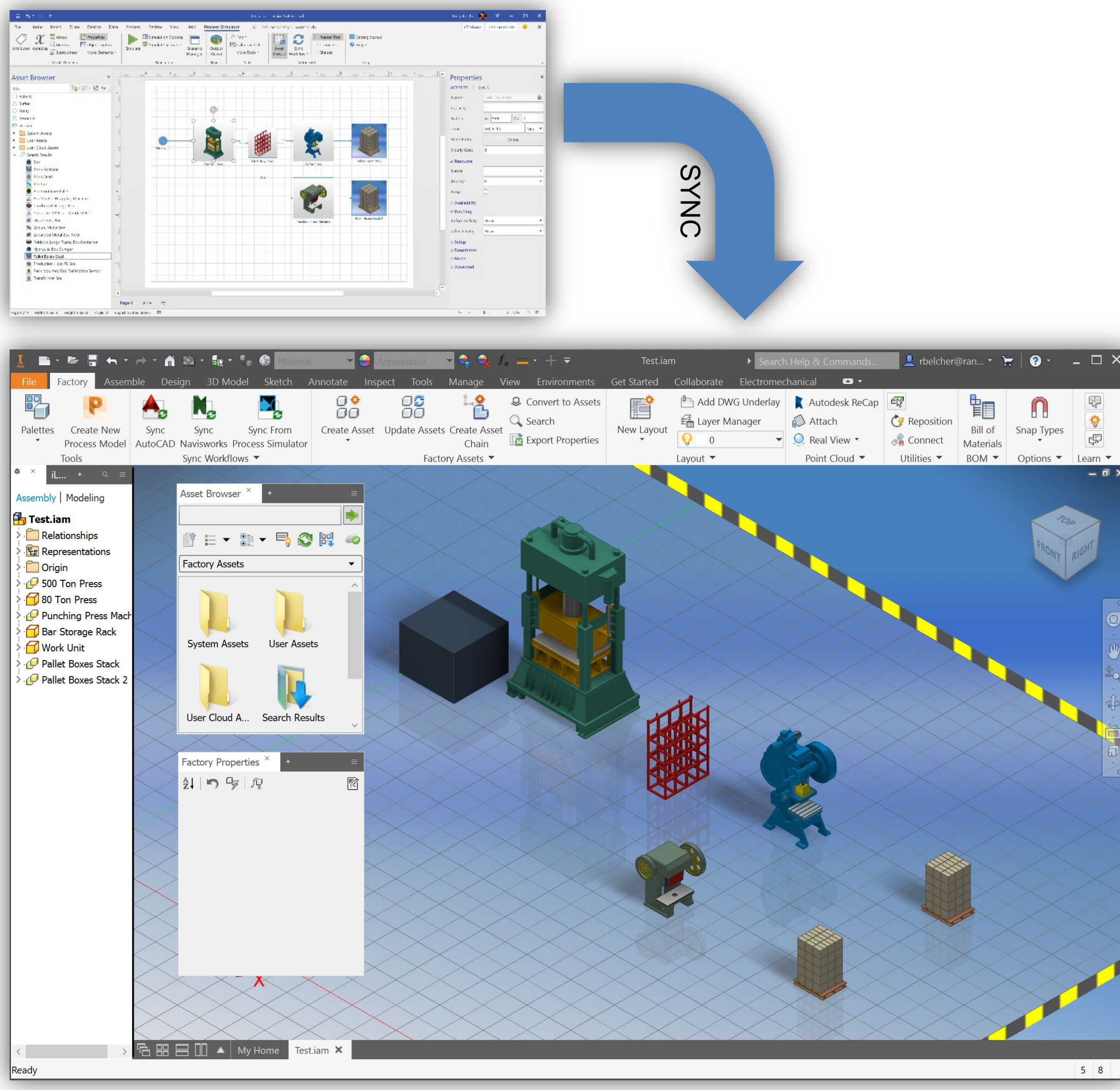
Process Simulator Autodesk Edition vs. Autodesk Process Analysis

ProModel Process Simulator is a professional level simulator that provides critical functionality not available in the Autodesk Process Analysis application native to the Autodesk Factory Design Utilities. Similar to Autodesk Process Analysis, Process Simulator can include Autodesk Factory Assets in the initial flow diagram. At any point in the analysis, the flow chart can be synced to Autodesk Inventor producing a 3D model of the proposed system. Process Simulator can also sync directly to AutoCAD for traditional 2D workflows.



The image above shows a simple process flow diagram in Process Simulator. System designers will utilize Process Simulator to analyze and refine the performance of the workflow before any initial CAD work begins.

The following image shows the 3D result of a simple process model in Autodesk Inventor. This model was developed automatically by syncing the Process Simulator model to Inventor via the Factory Design Utilities.



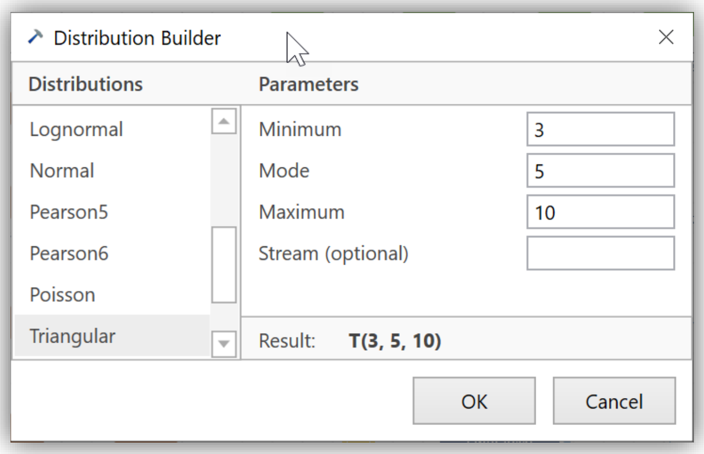
Once the model exists in Inventor the typical factory design process may proceed as usual. There is also an option to Snyc from a Process Simulator model in the AutoCAD application.

Advantages of Professional Level Process Simulation

There are numerous features offered by Process Simulator that make it a Professional Level Analytic Simulation tool. Process Simulator addresses complex Time distributions, workforce calendars, Resource schedules, and Logic based rules for customizing events. Below you will find several of the key advantages Process Simulator offers.

The Measurement of Time

One of the cornerstones of any process model is the length of time any task requires. The answer to this simple question is seldom as simple as a single static value. Tasks always require a variable amount of time to complete. Sometimes the answer is a mean with an over and under discrepancy. Other times, values need to be expressed in logarithmic or geometric progression. In some instances, the answer for time is a random value. Process Simulator offers all these time measurement possibilities and more via the Distribution Builder. This dialog is available anywhere a time value is required.

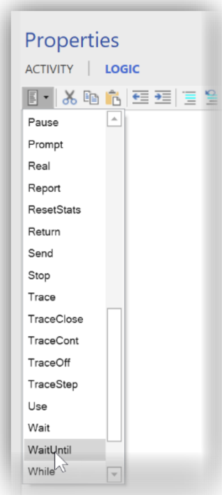


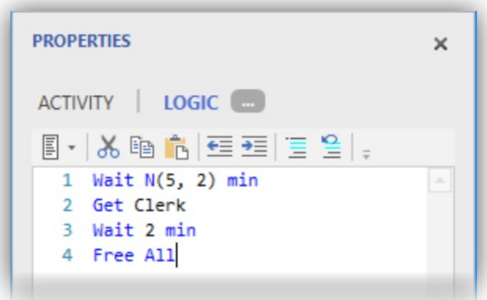
Interdependent Events

In the real world, the actual event processing times vary tremendously, and when we introduce people, equipment breakdowns, breaktimes, and other interdependent factors we will see drastic variation in model results. Events often trigger other downstream events producing an interdependent situation. Activities or Storage events often require resources or batches of entities before a particular task can be completed. Process Simulator offers various methods for establishing event dependency.

Event Logic

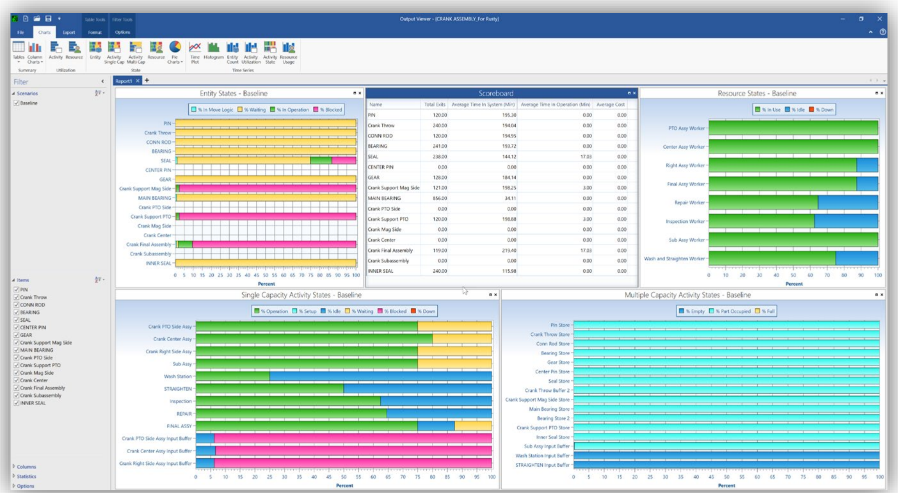
Events are rarely a simple, easily definable occurrence. In many situations some type of "IF THIS, THEN THIS" logic is necessary to accurately define a process step. Process Simulator provides the ability to include logical statements at each process event.





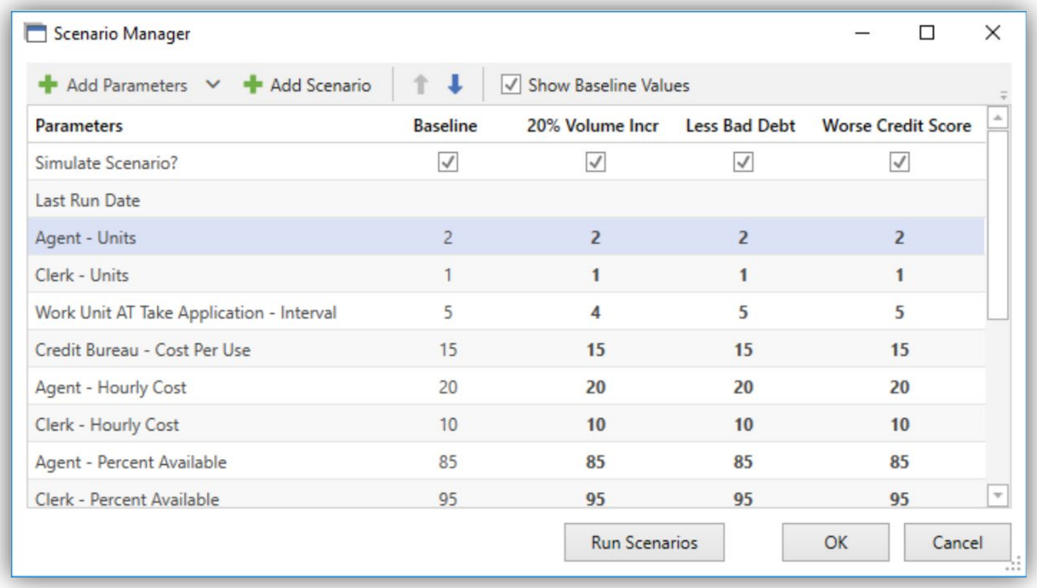
Reporting and Documentation

Process Simulator offers robust reporting features that allow designers to present the findings in any manner they choose. Numerous reports can be generated on a single simulation or reports can highlight specific parameters comparing many different scenarios.



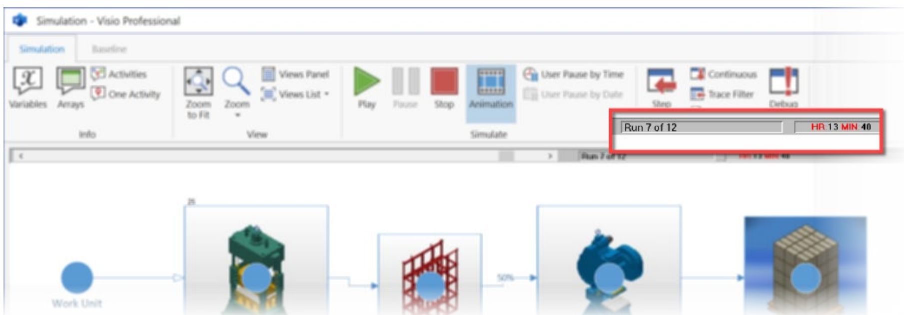
Scenario Manager

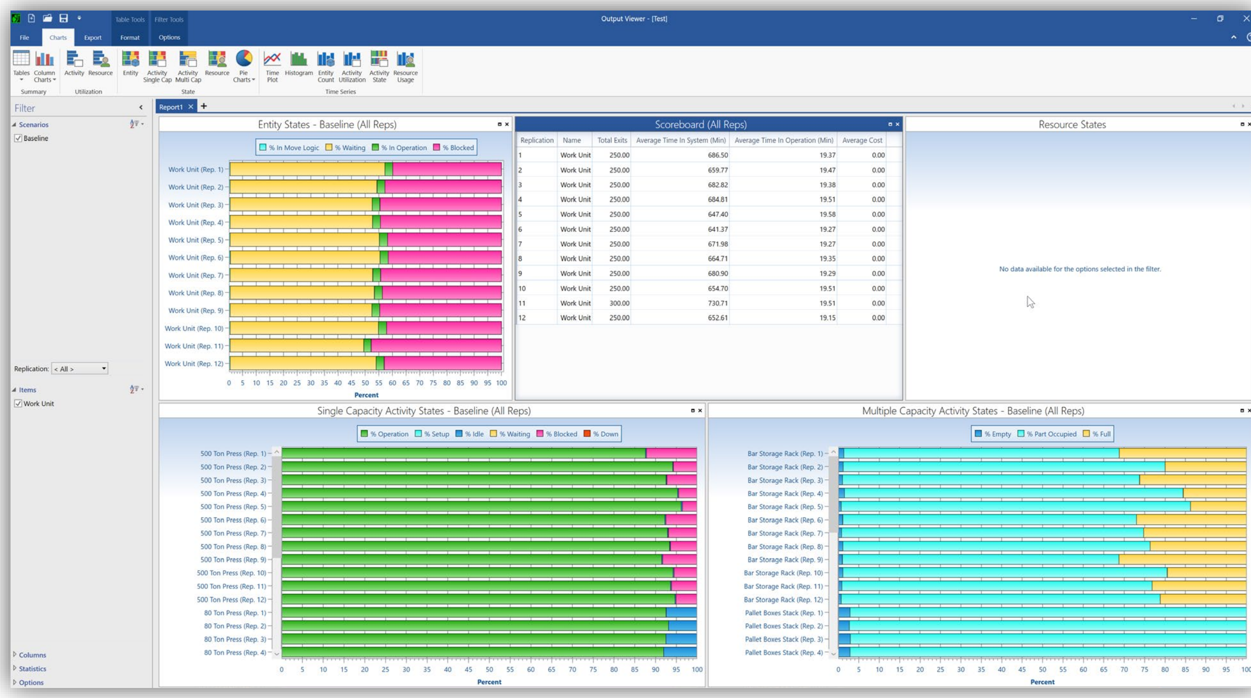
In Process Simulator it is possible to set up multiple scenarios to be run and evaluated side by side in the output report to see how they compare. Scenarios are defined in the Scenario Manager. The scenario manager provides a table where multiple scenarios can be defined, each with a set of unique parameter values. Parameters are values for simulation object properties, for example an activity's capacity, or a resource's number of units. These values, or parameters, can be easily changed in the scenario manager and varied for different scenarios. This is helpful for comparing changes to the model's simulation results without creating and managing multiple models.



Simulation Replication

When any random element is introduced into a model, it becomes essential to test the impact of that randomness more than just a single time. Dealing with variable task times or non-uniform resource schedules requires the simulation be run numerous times revealing the overall impact these random factors have on the overall system. Process Simulator has built in Replication options that can run any simulation as many times as required to accurately reveal the model performance.





Predictive Planning

The power to "look into the future" and understand the impact on multiple key metrics is what discrete event process modeling is all about. Basing your future plans on a simple spreadsheet utilizing the law of averages will always provide an "Estimated" result. Generating a Process Model based on discrete events will generate a more "Predictive" understanding of the future performance of your system. The tools in Process Simulator allow designers to thoroughly study and analyze process behavior, answer any "What If" questions, explore parametric system variables, test the effectiveness of proposed changes, and determine the optimum settings required for maximum efficiency. The answer to these and many more questions provide the confidence and data to support a truly predictive look at the future performance of any process.

Predictive Process Planning and Industry 4.0

As stated earlier, the need for more accurate process planning and simulation will be essential for successfully navigating the new manufacturing landscape of Industry 4.0. With machines collecting and sharing more and more data with each other, the ability to develop more complex and interdependent systems will become more crucial than ever. Understanding and evaluating these systems will likewise become a more sophisticated and demanding science. With Industry 4.0 driving advancement in our connected manufacturing capabilities, it is essential that our process modeling applications also advance from a traditional estimate to a true simulated, predictive plan. Process Simulator – Autodesk Edition delivers this crucial capability to the current Autodesk Factory Design Utilities. The combination of true Discrete Event Simulation and the proven 2D and 3D power of the Autodesk Product and Manufacturing Design Collection will provide all the process design tools necessary to succeed in the world of Industry 4.0