



Strategic Planning Applications Using GoldSim

White Paper

Abstract

Strategic planning typically involves development and evaluation of one or more alternative strategies to identify the approach that offers the greatest potential for success. When the outcome is dependent on complex systems that are difficult to predict, even the most sophisticated planners may conclude that the unknowns are insurmountable, and end up making a decision based on intuition. GoldSim provides a decision framework that can be used to elevate business strategy from an intuitive to a more rational, quantitative approach.

GoldSim is a powerful and flexible Windows-based computer program for carrying out probabilistic simulations of complex systems, and is used to support management and decision-making in business, engineering and science. The program is highly graphical, highly extensible, able to directly represent uncertainty, and allows you to create compelling presentations of your model. This paper provides a brief overview of GoldSim, with special emphasis on strategic simulation.

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Introduction

The Strategic Planning Challenge. Strategic planning typically involves development and evaluation of one or more alternative strategies to identify the approach that offers the greatest potential for success. When the outcome is dependent on complex systems that are difficult to predict, even the most sophisticated strategic planners often conclude that the unknowns are insurmountable and end up making a decision based on intuition.

Although smart, experienced managers who rely on intuition to make decisions are frequently correct, they would probably be even more successful if they could augment their qualitative judgment with a more quantitative approach to strategic planning. The challenge is to find an approach that can incorporate all the knowledge available to strategic planners into a quantitative framework that can be used to simulate future behavior of the system and predict the outcome of alternative strategies.

The Solution: The solution to the strategic planning challenge is to use computer simulation to predict the outcomes associated with alternative strategies. The term *simulation* is used in different ways by different people. As used here, simulation is defined as the process of creating a *model* (i.e., an abstract representation or facsimile) of an existing or proposed *system* (e.g., a business process or complex engineered system) in order to identify and understand those factors that control the system and/or to predict (forecast) the future behavior of the system. Almost any system that can be quantitatively described using equations and/or rules can be simulated. In a *dynamic simulation*, the system changes and evolves with time, and your objective in modeling such a system is to understand the way in which it is likely to evolve, to predict (forecast) the future behavior of the system, and to determine what you can do to influence that future behavior.

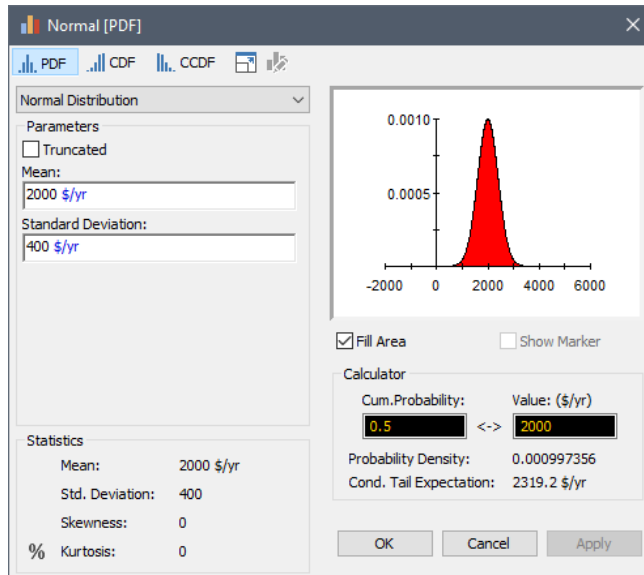
Simulation is a powerful and important tool because it provides a way in which alternatives strategies can be evaluated without having to experiment on a real system, which may be prohibitively costly, time-consuming, or simply impractical to do. That is, simulation allows you to ask "What if?" questions about a particular strategy.

The GoldSim Probabilistic Simulation Environment. GoldSim is a powerful and flexible simulation program that can be applied to almost any type of complex strategic planning effort. Examples of strategic planning issues that can be addressed with GoldSim include:

- What contingency plans should we put in place to minimize the likelihood of delaying the project or exceeding the budget?
- Which equipment-financing program will result in the highest long-term profitability?
- Which treatment options will achieve discharge requirements at the lowest life-cycle cost?
- Which mine-closure alternative will minimize long-term risk?

Three key features of GoldSim make it unique and powerful:

GoldSim is extremely flexible. GoldSim has been developed such that it provides the user with a structured environment for defining the system, but is intentionally flexible such that the user can define just about any type of system with as much detail as desired. This makes it feasible for the user to create a simulated system that maps well to the actual system.



Uncertainty in processes, parameters and future events can be explicitly represented. Uncertainty in processes and parameters can be represented by specifying model inputs as probability distributions. The impact of uncertain events (e.g., accidents, labor disruptions, lawsuits, sudden changes in economic conditions) can also be directly represented by specifying the probability and consequences of such “disruptive events”. GoldSim uses an enhanced Monte Carlo method to propagate uncertainty in input parameters to uncertainty in performance.

GoldSim is highly graphical. GoldSim was specifically designed to allow you to create highly graphical models of complex systems. This not only makes it easier to build and maintain complex models; it also allows models to be easily presented to and understood by diverse audiences.

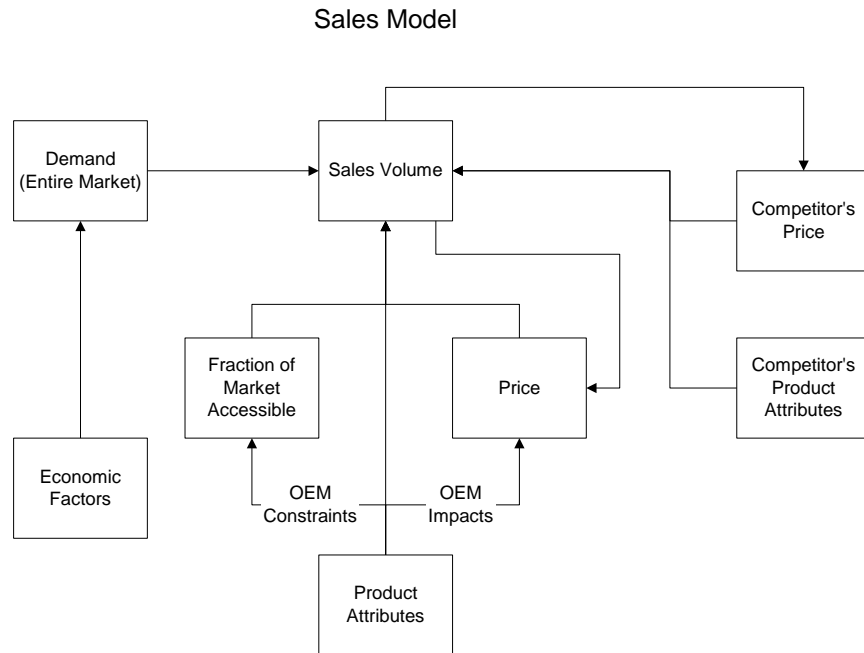
The GoldSim Strategic Planning Methodology

The GoldSim Strategic Planning Methodology is designed to support the full spectrum of planning and decision-support activities, from a strategic level to a more detailed operational level. The overall objective of the GoldSim methodology is to empower decision-makers to design and select the strategy that offers the highest likelihood of success. The key tenets of the GoldSim Methodology are described below:

- 1) **Establish Clear Objectives:** The methodology starts by reviewing and clearly stating the objectives of the exercise, and an assessment of their feasibility. Defining the objectives is critical to keep the analysis focused, on time, under budget, and ultimately, successful.
- 2) **Decomposition:** It is important to understand that a GoldSim model will not provide useful results if it isn't based on an understanding of the system to be modeled. Therefore, building a conceptual model of your system is probably the most important part of any simulation effort. The greater your understanding of the critical factors that determine the behavior of your system, the more likely your simulation effort will provide useful results.

Building a good conceptual model of the system involves an analysis phase that results in decomposition of the system into a series of linked subsystems that define the key components of the system, the

relationships between these components, and all relevant feedback mechanisms. Decomposition typically results in an influence diagram that is a conceptual picture of the system, its main components, and their interactions. An example of such a diagram is shown below:



- 3) **Integration:** In order to address the full range of influences identified in the decomposition, the analysis must provide an integrated model of the system that couples each of the subsystems, rather than treating each part of the system independently. Developing such an integrated understanding of the system typically involves input and feedback from many people within the organization and thoughtful investigation of how the different elements of the system relate.

The integration phase provides a critical opportunity to foster communication, and get buy-in and support from a broad range of constituents within the organization (e.g., operational managers, technical experts, senior management). As a result, prior to even running the simulation model, most people find that the exchange of information and ideas that occurs while formulating the conceptual model in and of itself provides valuable insights and better understanding of the system.

- 4) **Top-down/relevance driven:** Models of large, complicated systems can be difficult to calibrate, explain, and maintain. As a result, the analysis should begin at a high (simplified) level and detail should be added only when the preliminary results indicate that the additional detail is necessary and relevant.
- 5) **Explicit uncertainty:** Complex systems have many uncertainties: How much will it cost to develop a new product? How will prices for raw materials change? How will competitors respond to market conditions?

What new technologies will emerge in the next five years? How will the general economy influence sales?

Since most strategic planning addresses systems with significant uncertainty, it is critical that the analysis explicitly accounts for the full range of possibilities (rather than relying on conservative estimates). This includes uncertainties in costs and durations of activities, uncertainties in the consequences and effects of carrying out various activities, and uncertainties regarding the occurrence of outside events (e.g., accidents, lawsuits) or new developments (e.g., a change in interest rates, changes in political office, changes in economic conditions).

Incorporating uncertainty regarding the *consequences* of carrying out various activities and/or the occurrence of unanticipated incidents or developments can alert the strategic planner to flaws in the strategy and provide guidance for improving the strategy. Typically, it is not possible to eliminate the possibility of unanticipated incidents or developments (e.g., a drop in commodity prices). However, if these possibilities are explicitly considered in the planning stage of the project, then additional activities can be carried out beforehand and/or contingency plans can be prepared that will reduce the likelihood of the incidents or lessen the impact should they occur.

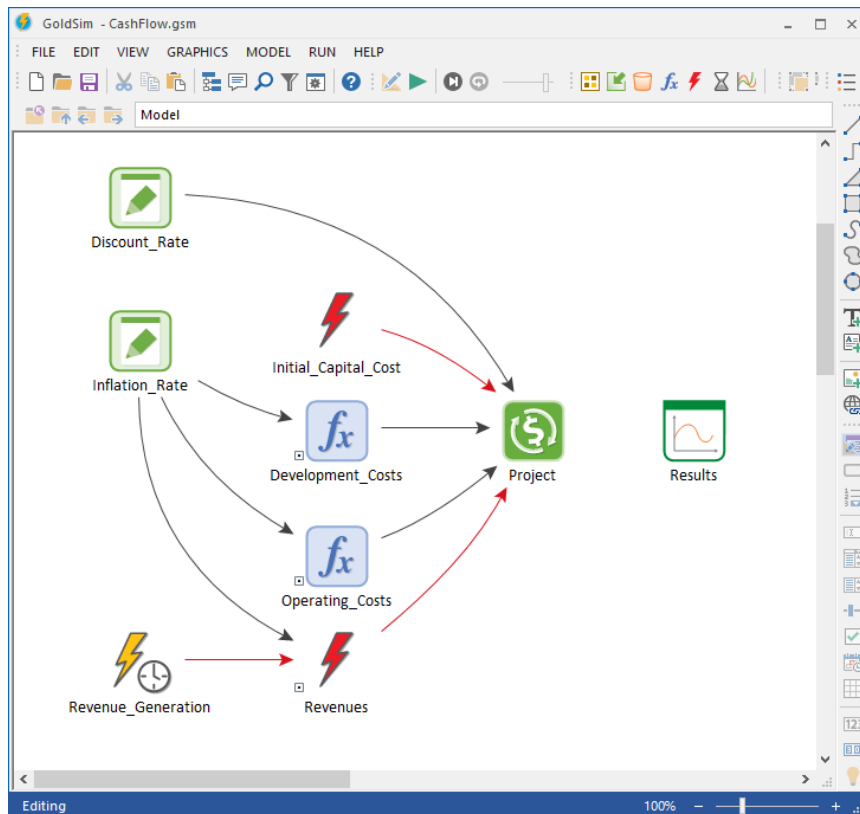
- 6) **Dynamic Simulation:** Sound strategic planning must allow for changes in the plan depending on future conditions. It should be expected that managers will make future decisions based on information available at the time. For example, when simulating a supply chain, a good model must simulate the manner in which production managers would respond to changing demands.

In short, the simulation model should specify the planned responses to the uncertain aspects of the strategy, and how these in turn will affect the manner in which the system behaves from that point forward. Thus, good strategies incorporate the contingency plans necessary to respond to new developments or incidents in the system. Dynamic (time dependent) simulation provides the mechanism to then predict the full range of possible futures, analyze the results, and communicate findings to stakeholders and decision-makers.

- 7) **Communication:** The process should be conducted in a clear and transparent manner that provides the means to communicate the structure of the model and the results to the stakeholders. This communication element is critical for several reasons:
- Communication during the model development phase is necessary to ensure that the conceptual model accurately represents reality.
 - Stakeholders find it much easier to trust an analysis that they can understand.
 - Decision makers need to be able to quickly understand a model and the associated results in order to make informed decisions.

Overview of the GoldSim Simulation Framework

GoldSim is a powerful and flexible platform for visualizing and numerically simulating nearly any kind of physical, financial or organizational system. In a sense, GoldSim is like a "visual spreadsheet" that allows you to visually create



and manipulate data and equations. Unlike spreadsheets, however, GoldSim allows you to readily evaluate how systems evolve over time, and predict their future behavior. The GoldSim simulation environment is highly graphical and completely *object-oriented*. That is, you create, document, and present models by creating and manipulating graphical objects (referred to as *elements*) representing data and relationships between the data. Based on how the various objects in your model are related, GoldSim automatically indicates their influences and interdependencies by visually connecting them in an appropriate manner.

Because simulation can be such a powerful tool for understanding and managing complex systems, a variety of simulation tools currently exist. The following

combination of features, however, makes the GoldSim approach unique:

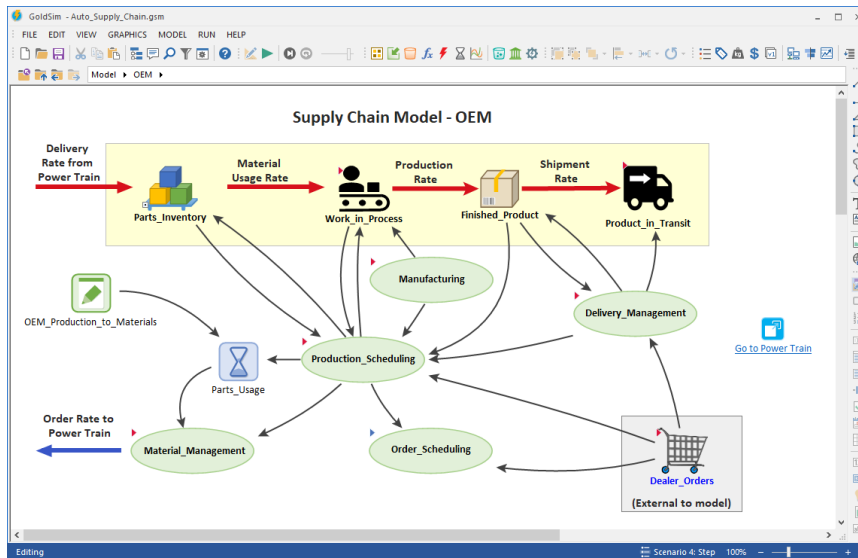
- **GoldSim is user-friendly and highly graphical**, such that you can literally draw (and subsequently present) a picture (an influence diagram) of your system in an intuitive way without having to learn any arcane symbols or notation.
- **GoldSim is extremely flexible, allowing it to be applied to nearly any kind of system.** The software allows you to build a model in a hierarchical, modular manner, such that the model can readily evolve as more knowledge regarding the system is obtained. Hence, a GoldSim model can be very simple or extremely complex.
- **Uncertainty in processes, parameters and future events can be explicitly represented.** Uncertainty in processes and parameters can be represented by specifying model inputs as probability distributions. The impact of uncertain events (e.g., earthquakes, floods, sabotage) can also be directly represented by specifying the occurrence rates and consequences of such "disruptive events".

- **GoldSim is highly extensible.** You can dynamically link external programs or spreadsheets directly into your GoldSim model. In addition, GoldSim was specifically designed to support the addition of customized modules (program extensions) to address specialized applications.
- **GoldSim allows you to create compelling presentations of your model.** A model which cannot be easily explained is a model that will not be used or believed. GoldSim was specifically designed to allow you to effectively document, explain and present your model. You can add graphics, explanatory text, notes and hyperlinks to your model, and organize it in a hierarchical manner such that it can be presented at an appropriate level of detail to multiple target audiences.

GoldSim provides a wide variety of built-in objects from which you can construct your models, and, if desired, you can program your own custom objects, and link them seamlessly into the GoldSim framework.

A System Integration Tool. Most complex projects are multi-disciplinary in nature. That is, the various components of a system (e.g., a proposed mine) which must be considered when planning a project (e.g., building the mine) must be represented by sub-models, which typically must be built by people from a wide variety of disciplines. For example, a model intended to evaluate

alternative strategies for developing a new product would likely include sub-models that were developed by design engineers, industrial engineers, procurement specialists, marketing and sales professionals, economists, and numerous other individuals. Because GoldSim is flexible and powerful enough to represent practically any aspect of your system, and because GoldSim provides unique capabilities for building your model in a hierarchical, modular



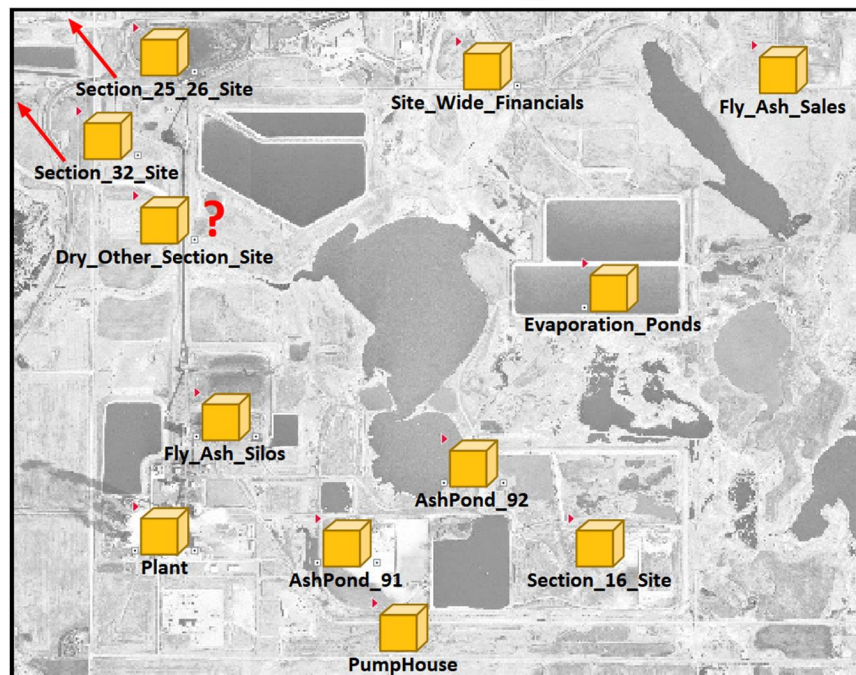
manner, it is ideally suited to act as a system integrator. In fact, this was the original and primary use for which GoldSim was designed.

GoldSim Strategic Planning Examples

A few strategic planning applications are listed below:

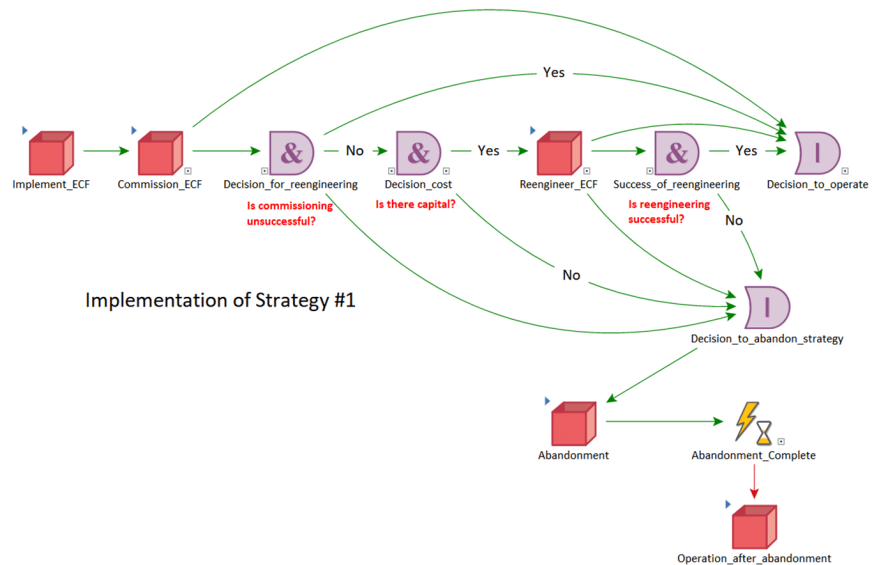
Strategic Analysis of Power Plant Waste Management Options. GoldSim was used to evaluate the engineering feasibility and financial impacts of a number of coal combustion by-product management strategies for a lignite-fired power generation facility.

Coal Creek Station Coal Combustion Byproducts Mass Balance



The power plant generates nearly a million tons per year of coal combustion by-products. The model simulated the transport and storage of four different coal combustion by-products, attaching costs and revenues to the off-site sales of materials as well as the construction of new storage facilities and closure and/or reclamation of developed sites. The GoldSim model also used to perform a mass balance of the different by-products. Overlaid on top of the mass balance was a financial model that tracked capital, engineering, closure, operational and maintenance costs through time. The model helped identify an alternative by-product management strategy that will save the client approximately \$2 million over the current strategy.

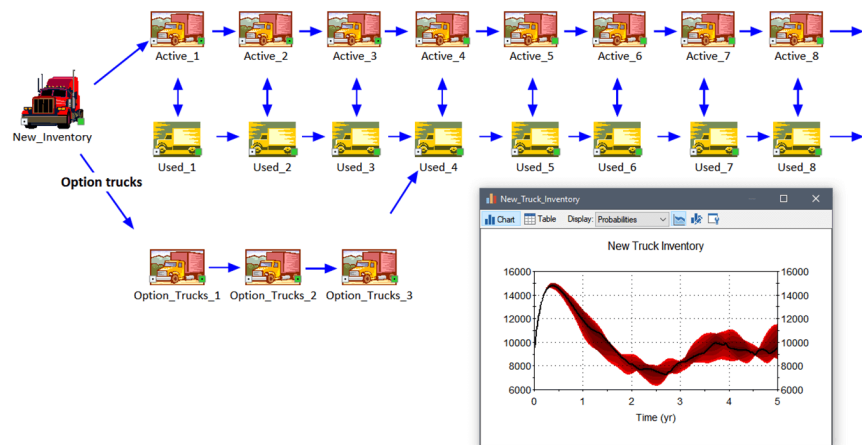
Evaluation of Pulp and Paper Mill Effluent Treatment Alternatives. An industrial facility was faced with the problem of upgrading their effluent treatment technology in order to stay within regulatory compliance. The process of upgrading the facility was quite complex (a multi-year project), and expensive. There were a multiple strategies (consisting of various combinations of technologies) that could potentially provide a solution that would meet the regulatory requirements.



In order to evaluate the various strategies, each alternative was simulated using GoldSim. The simulation stepped through time, simulating the success or failure, the duration, and the cost of each task involved in implementing the strategy. The tasks included things such as designing, testing (e.g., via a pilot plant), permitting, and building the solution, and incorporated the complex precedence requirements, uncertainties, and interactions between tasks. The primary performance measure for the simulation was the cost of implementing and operating the treatment strategy. Because the model was probabilistic, predicted costs (presented in terms of Net Present Value) were presented as probability distributions. The model was successful in communicating the risks associated with each of the alternatives, and was subsequently used to select and defend a strategy.

Simulating the Truck Market. GoldSim was used to build a first-order model intended to better understand the dynamics of the long-haul truck market. In particular, how would decisions regarding new truck pricing and buy-back options impact future truck sales and prices assuming a range of future economic conditions? A secondary objective was to better understand how the current system (set in motion by decisions made over the last few years) would likely evolve over the next few years.

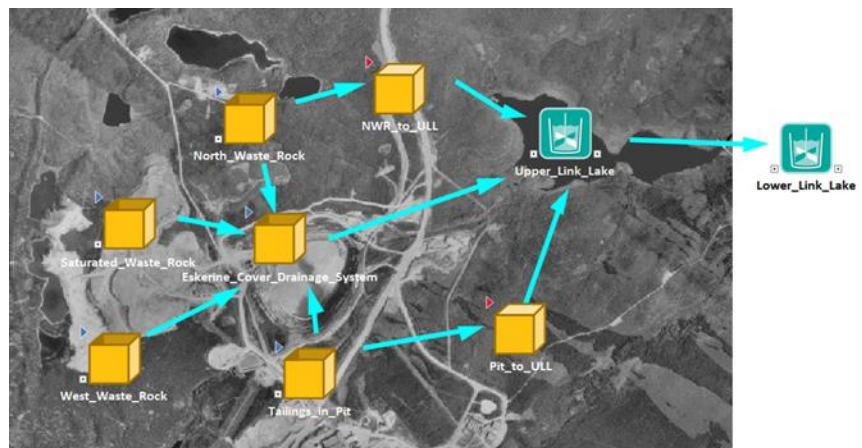
Truck Inventories (New and Used)



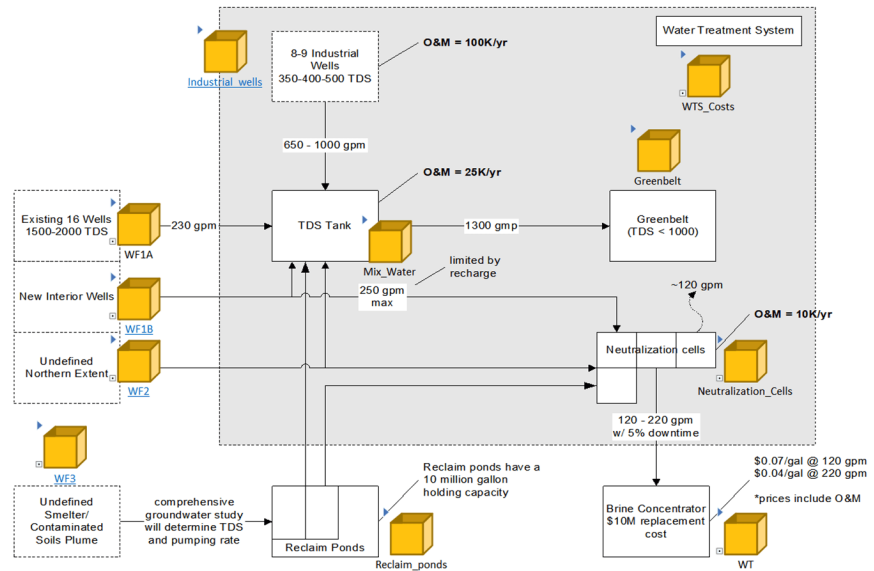
This model included two classes of vehicles (active and used) and eight age groups (referred to as an *aging chain*). The model assumed that active vehicles would have a high utilization and active vehicles would be transferred to used vehicle lots if demand dropped (i.e., their owners would not let them sit idle for long). Some trucks left the system early (due to wrecks) and the remaining trucks left the system when they reach eight years, (i.e., they are scrapped or exported). The model simulated the number of active and used trucks in each age category, the price of new and used trucks, and the sales rate of new trucks, all as a function of time.

Remediation and Closure of Uranium Mill Tailings and Mine Workings.

GoldSim has been used to evaluate alternative remediation and closure options for abandoned mine workings and tailings facilities associated with former uranium mining operations in Europe and North America. From the early phases of the project through detailed technical studies, GoldSim has been used extensively to assess the performance of facilities (relative to regulatory water quality criteria) and direct alternative engineering designs for tailings and waste rock management at closure.



Evaluation of Closure Options for a Smelter Complex. GoldSim was used to evaluate alternative strategies for closing a smelting complex. The purpose of the effort was to provide a diagnostic understanding of the performance of the closure alternatives, identify the components or factors that have the greatest influence on performance, and provide a tool that could be used to develop and evaluate other closure strategies (“what if” analyses).



The simulation of the baseline closure plan indicated that periods of high precipitation would require the use of a brine concentrator for one to two months during a 10 to 20 year period. An alternative plan was developed that involved constructing a pipeline to transport the water during the summer months to a nearby ranch for agricultural use. This approach eliminated the need for the brine concentrator, saving an estimated \$20 million over the projected duration of the closure activities.

Summary

Simulation using GoldSim software can greatly improve strategic planning efforts when the outcome is based on complex systems that are difficult to predict. Planners can incorporate all the knowledge regarding the critical systems into a computer model that can be used to simulate future behavior of the system and predict the likely outcome of alternative strategies. GoldSim software is designed to provide probabilistic predictions of system performance that allow planners to:

- Evaluate alternative strategies,
- Identify and mitigate risks,
- Maximize financial performance, and
- Defend the selected strategy (e.g., to shareholders, managers, and regulators).

In this way, the GoldSim approach provides a method by which alternative strategies can be evaluated without having to experiment on a real system, which may be prohibitively costly, time-consuming, or simply impractical to do.

About the GoldSim Technology Group

The GoldSim Technology Group is dedicated to delivering software and services to help people understand complex systems and make better decisions. The GoldSim Technology Group focuses on building great simulation software and supporting the technical aspects of building effective GoldSim models. To provide other dimensions of complete solutions, we maintain close relationships with partners around the world, including consulting firms with specific industry expertise.

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