

INSIGHT

MANAGEMENT SUPPORT SYSTEMS

Showing You Tomorrow's Opportunities Today

SAILS™

STRATEGIC ANALYSIS OF INTEGRATED LOGISTICS SYSTEMS

*Long-range planning does not deal with future decisions,
but with the future of present decisions.*

—Peter Drucker

SAILS: In Brief

SAILS (Strategic Analysis of Integrated Logistics Systems) is a fully integrated Decision Support System (DSS) that you can use to build, modify, solve and interpret sophisticated strategic supply chain design models. Although SAILS is an off-the-shelf software package, you can easily customize it to meet your requirements —SAILS makes customization possible through an extensive array of model building, input data, and processing options. Flexibility and ease of use are hallmarks of the system.

The classic objective of a network design model has been to establish the number, location, and size of finished goods distribution centers and associated product flows so as to minimize costs and maintain or improve customer service. No longer. Now the mandate is to design the *entire supply chain*, from source of raw materials to the final customer. This emerging view encompasses procurement, multiple stages or processes of manufacturing, distribution center functions, and all related transportation flows. The supply chain function is increasingly viewed as a competitive weapon, not just a service provider, cost minimization is being supplanted by profit maximization (or enhancing shareholder equity), and national borders are dissolving. In short, answering network design questions today is virtually impossible without the help of very powerful decision support tools. There is just too much data to assimilate, and the combinations of

facilities and support patterns number in the trillions. Fortunately, help is readily available for coping with this class of decision problems.

SAILS: The Issues

SAILS allows you to investigate a large number of critical managerial issues as shown in Figure 1. To address a given issue you may change some data and/or assumptions for a given model. In other cases you may even build a new or modified model. Don't worry, it's easy, it's fast, it's intuitive, and best of all, for each such exercise SAILS will establish a *true optimum* (least cost *or* maximum profit) solution.

SAILS: Planning Horizon

Most of the issues in Figure 1 are clearly long-term or strategic. As you use SAILS, it is important not to lose sight of the fact that it is indeed a *strategic* model. While there are no universally accepted definitions of the terms strategic, tactical and operational in the context of mathematical modeling, most practitioners accept the following informal distinctions with respect to the *decision-making time horizon*:

- Strategic: greater than one year
- Tactical: greater than one week but less than one year
- Operational: less than one week

REPRESENTATIVE MANAGERIAL ISSUES

- I SYSTEM STRUCTURE ISSUES**
 - A** Number and Location of Raw Material Suppliers
 - B** Number and Location of Plants
 - C** Number and Location of Production Lines
 - D** Number and Location of DCs
 - E** Assignment of
 - 1** plants to suppliers
 - 2** DCs to plants or other DCs
 - 3** customers to plants or DCs
- II FACILITY OWNERSHIP ISSUES**
 - A** Owned
 - B** Leased
 - C** Public
- III FACILITY MISSION ISSUES**
 - A** Raw Material Suppliers
 - 1** Procurement Levels
 - 2** Costs & Capacities
 - B** Plant Locations
 - 1** Manufacturing Levels
 - a* intermediate products
 - b* finished products
 - 2** Costs & Capacities
 - C** DC Locations
 - 1** Throughput Levels
 - 2** Costs & Capacities
- IV “WHAT-IF” ISSUES**
 - A** Business Decision/Policy Issues
 - 1** Supply Chain Vulnerability
 - 2** Multi-Division Mergers
 - 3** Facility Capacity Changes
 - 4** Transportation Policy
 - 5** Seasonal Demand/Supply
 - 6** International Trade
 - 7** Customer Profitability
 - 8** Product Intros/Deletions
 - 9** Alternative Networks
 - 10** Implementation Analysis
 - B** Environmental Issues
 - 1** Economic Climate
 - 2** Competitive Pressures
 - 3** Disaster Planning
 - C** Sensitivity Issues
 - 1** Cost vs. Customer Service
 - 2** Cost vs. Number of DCs
 - 3** Parametric Analysis of Inputs

As you proceed from a very short-term (operational) perspective to a long-term (strategic) horizon, two things become evident:

- 1 the size and term of the resource commitment increases
- 2 the speed of effecting changes decreases

SAILS was originally designed to analyze *strategic* issues that involve significant resource commitments that can only be altered over considerable lengths of time. However, many users have successfully addressed *tactical* issues as well, such as first-level production planning, production line balancing, seasonal pre-build, and so on.

SAILS: The Mandate

The contemporary mission of corporate management is to enhance shareholder value (equity). Consider the relationship between return on assets (a component of equity), capital turnover, and profit margin:

$$\frac{\text{PROFITS}}{\text{ASSETS}} = \frac{\text{SALES}}{\text{ASSETS}} \times \frac{\text{PROFITS}}{\text{SALES}}$$

$$\text{RETURN ON INVESTMENT} = \text{CAPITAL TURNOVER} \times \text{PROFIT MARGIN}$$

It is easy to establish that logistics significantly influences the three fundamental components of return on shareholder equity:

SALES: customer service, market penetration, competitive weapon

CAPITAL: management of plant, DC, transportation, and inventory assets

COSTS: procurement, manufacturing, warehousing, transportation, inventory holding, associated data processing

SAILS is designed to balance all three components: satisfying customer service objectives while finding the optimum (cost min or profit max) mix of capital and cost. Bottom line: *SAILS focuses on senior management corporate objectives.*

Figure 1. Representative Managerial Issues

SAILS: The Meaning of Logistics Today

Before you can use a strategic supply chain network design model, you must have a clear understanding of what *logistics* means. Interestingly, even experienced practitioners may hold a different view of its meaning, so a definition can be tricky. There is no more authoritative source for a formal definition of logistics than the Council of Supply Chain Management Professionals (CSCMP), the foremost worldwide association of logistics professionals. CSCMP defines Logistics Management as:

... “that part of Supply Chain Management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers’ requirements”.

Ironically, we have observed that the majority of logistics professionals do *not* have the scope of responsibility suggested by the CSCMP definition. Rather, in most instances they are responsible for the movement of product only from the end of the production line to the customer. On the other hand, a growing number of firms have embraced the notion of fully integrated logistics. That is, they are reorganizing the traditional functions (“corporate silos”) of procurement, manufacturing, and distribution into a department responsible for the *entire* logistics function. In short, they are recognizing the benefits of *integrated logistics management*.

SAILS: The Meaning of Supply Chain Management

Beyond integrated logistics there is yet another evolutionary stage. Truly leading-edge firms are establishing partnerships and strategic alliances, including active sharing and management of information flows, with other firms in the logistics channel. In addition, they are recognizing that such functions as supply and demand management, customer relationship

management, order fulfillment, and so on span both intra and inter organizational boundaries. This emerging viewpoint has been labeled *supply, demand or value chain management*.

Supply chain and *logistics* are *not* the same...most experts regard logistics as a subset of supply chain. Consider the CSCMP definition of Supply Chain Management:

“*Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies*”.

Or another, this time from the Global Supply Chain Forum at the Ohio State University:

“*Supply chain management is the integration of the business process, from end user through original suppliers, that provides products, services and information that add value for customers and other stakeholders.*”

In short, the fundamental contribution of supply chain management thinking is the focus on collaborative relationships and boundary-spanning activities within and across firms. Properly implemented, *the entire firm* is focused on, indeed is an integral part of, the supply chain.

SAILS: Validity of Supply Chain Management and Integrated Logistics

So, what does a strategic supply chain network design model have to say about the validity of supply chain management or integrated logistics? If we first examine the relationship between manufacturing and physical distribution of finished goods, we see immediately that the

following considerations may affect the ultimate design of the network:

- plant locations
- plant missions (that is, the products manufactured at each location)
- production costs
- plant capacity limits
- plant-to-DC location freight costs
- plant-to-customer freight costs

SAILS tells us that you can safely *ignore* the manufacturing sector when designing a supply chain network **IF** these conditions are true for *every product* that you distribute and sell to customers:

- the landed cost for any given DC/finished product location is *identical, regardless* of the manufacturing source
- the landed cost for any given direct ship customer/finished product is *identical, regardless* of the manufacturing source
- there are no manufacturing capacity limits

Landed cost is defined here as the sum of *all* applicable manufacturing, warehousing, and transportation costs.

Similarly, just as we examined the relationship between manufacturing and physical distribution of finished goods, we see that the following *procurement* considerations may affect the ultimate design of the supply chain network:

- supplier locations
- supplier missions (the raw materials each one supplies)
- procurement costs
- procurement capacity limits
- supplier-to-plant location freight costs.

Once again, you can safely *ignore* the procurement function when designing a supply chain network **IF** these conditions are true for every raw material required in the manufacturing process:

- there are *no* supplier capacity limits

- the landed cost for any given plant location/raw material is *identical*, regardless of supplier

Landed cost is defined here as the sum of applicable procurement and freight costs.

You will notice that these **IFs** are very big indeed. While they may apply under certain special conditions, they are usually inappropriate. Therefore, considering the more common procurement, manufacturing, and distribution conditions in most businesses, we can conclude that in general, the emerging integrated logistics perspective is both valid and important. **IF** the **IF** conditions apply, **THEN** tying manufacturing and procurement into finished goods distribution is unnecessary and so is the notion of integrated logistics. But in most instances, the **IF** conditions are not satisfied and integrated logistics is the proper choice.

SAILS: Modeling Framework

The integrated logistics and supply chain perspectives are far from being universally adopted. In addition, some logistics networks have no direct manufacturing and/or raw material counterparts. Therefore, to serve the needs of the widest possible spectrum of users, SAILS can model virtually *any* logistics network, from a simple finished goods network to a complete supply chain, including procurement, manufacturing, and finished goods distribution.

Here is a diagram of a simple finished product network:

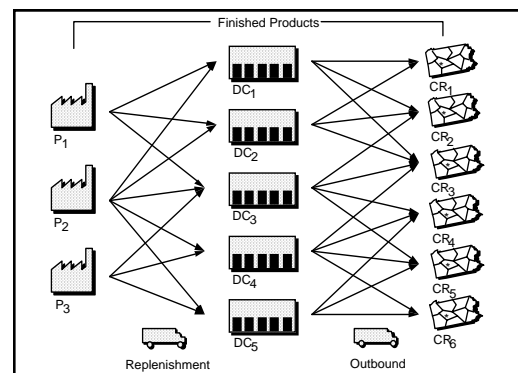


Figure 2. A simple 3-echelon model of a finished product logistics network.

And here is what a comprehensive SAILS supply chain model might look like:

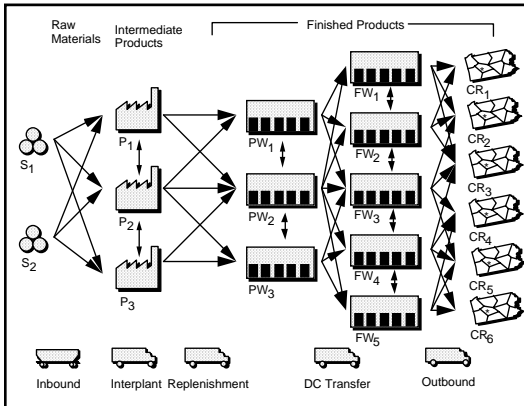


Figure 2. A detailed SAILS supply chain model. You can use SAILS to model a complete supply chain, from source of raw materials to finished product customer. Any number of DC echelons may be represented.

A SAILS model can be even more sophisticated than the model suggested by the above diagram. If we “drill down” inside a plant, we see that SAILS can represent multiple production processes, each of which may take place on multiple process “lines”.

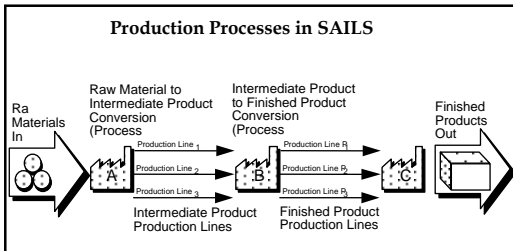


Figure 4. A look inside a SAILS plant. Up to two stages of a manufacturing process can be represented via corresponding production lines. You can endow each line with a fixed cost, min/max capacities, and corresponding violation penalties that span all commodities that can be manufactured on the line. Conversions from raw materials to intermediate products take place at node A, while those from intermediate products to finished products take place at node B. Conversions are governed by either fixed or range-bounded recipes.

SAILS has evolved over the years in response to the evolution of supply chain thought and practice as well as our clients’ analytical needs. They have increasingly thrown tougher and tougher problems at us. As the supply chain management community has become more sophisticated in the use of modeling systems, and the supply chains themselves have become more complex, the need for more modeling power has become ever more apparent.

SAILS: The Interface

The SAILS Graphical User Interface (GUI) is a state-of-the-art module that incorporates these features:

for data entry:

- user-friendly data entry mechanisms including powerful, flexible spreadsheets, lists, boxes, toolbars, and tabbed option screens
- easy interoperability with MICROSOFT OFFICE™
- integrated graphics
- extensive help, including wizards

for results analysis:

- high-resolution flexible mapping package including:
 - ⇒ extensive display customization options including base map, titles, legends, colors, annotations and background choices
 - ⇒ successive and “rubber band” zoom options
 - ⇒ complete data “drill down” for any facility, customer, or transportation link
- extensive business graphics
- prepackaged and customizable reports
- instant export to MICROSOFT OFFICE™ (both EXCEL™ and ACCESS™)

SAILS: Data Inputs

SAILS can accept a wide variety of input data. A list of the principal categories is shown in Figure 5. Note that many categories are *optional*: all those concerned with raw materials and intermediate products, *all* types of facility costs and capacities, and international finance data.

Technically optional is one thing; managerially optional is another matter entirely. No supply chain professional would seriously consider doing a design study without facility and (where applicable) international finance data.

SAILS DATA CATEGORIES

- I NETWORK DESCRIPTION DATA**
 - A Lists of Commodities**
 - 1 raw materials*
 - 2 intermediate products*
 - 3 finished products
 - B Lists of Locations**
 - 1 raw material suppliers*
 - 2 plant locations
 - 3 DC locations
 - 4 customer regions
 - C Miscellaneous**
 - 1 product bundles*
 - 2 customer classes
 - 3 time periods*
- II CUSTOMER DEMAND DATA**
 - A Transaction Files**
 - B Manual Estimates**
- III FREIGHT COST DATA**
 - A Inbound***
 - B Interplant Transfer***
 - C Replenishment**
 - D DC Transfer***
 - E Outbound**
- IV FACILITY DATA***
 - A Raw Material Supplier**
 - 1 procurement costs
 - 2 procurement capabilities
 - B Manufacturing**
 - 1 Overall Plant
 - a fixed costs
 - b capacities & violation penalties
 - 2 production line (process)
 - a fixed costs
 - b capacities & violation penalties
 - 3 production line (process) × product
 - a variable costs
 - b capacities
 - c line rates
 - 4 conversion recipes
 - C Distribution Center**
 - 1 fixed costs
 - 2 capacities & violation penalties
 - 3 product-specific variable costs
 - 4 customer class-specific variable costs

- V SCENARIO GENERATION DATA**
 - A Data Selection Options**
 - B Data Modification Options**
 - C Link Generation Options**
- VI INTERNATIONAL FINANCE DATA***
 - A Duties**
 - B Taxes**

Figure 5. The principal data types in SAILS. An asterisk (*) indicates optional data.

SAILS: Data Preparation Assistance

As you can see, a strategic supply chain network design model has a voracious appetite for data. That's the bad news. The good news is that the SAILS package includes the extensive set of standard data files shown in Figure 6. This list is continually reviewed and updated as more databases become available. In addition, INSIGHT routinely maintains these files and distributes them with periodic software releases.

SAILS STANDARD DATABASE

- I GEOREFERENCE DATA**
 - A 43,000⁺ U.S. locations**
 - B 95,000⁺ international locations**
- II DISTANCE/TIME DATA**
- III MAJOR CITIES LISTS**
- IV MAJOR DC LOCATIONS (U.S.)**
 - A Locations**
 - B Access and Cost Indices**
- V FREIGHT RATES**
 - A Motor Carrier Less-Than-Truckload (LTL)**
 - 1 Yellow Freight System Y500
 - 2 CZAR Lite*
 - B United Parcel Service**
 - 1 rates
 - 2 zones
 - C Class 8 Solutions Truckload Rates**
 - D Norfolk Southern Triple Crown Rates**
- VI SOCIOECONOMIC DATA (U.S.)**

*Requires data from vendor

Figure 6. Major elements of the SAILS standard database.

Data *availability* is one thing; *data analysis* and *manipulation* is quite another. Here SAILS is without peer. It includes a powerful, flexible relational database manager, exceptionally easy to use data entry screens, and an extensive set of analysis/preparation tools. Examples of the latter include:

- ability to process, analyze, and extract data from transaction history files (invoice, bill of lading, and so on). This feature automates the preparation of customer demand and historical transportation flow data, the latter useful when establishing an historical baseline or model validation.
- ability to emulate, at a very detailed level the day-to-day activities of a traffic manager. This built-in *simulation* capability enables SAILS to project the transportation costs of alternative shipment planning policy options, the freight impact of mergers and acquisitions, and so on
- rapid generation of complex, highly detailed freight rate databases
- powerful model scenario generation capability including :
 - ⇒ automatic generation of transportation links
 - ⇒ extensive “lock in/lock out” options
 - ⇒ extensive data scaling options
 - ⇒ rapid modification of facility status and/or mission (commodities procured, manufactured, or stored at a given location)
- market penetration analyses
- ability to generate a comprehensive historical baseline, essential for model and database validation
- detailed projections of the inventory levels required to support a given in-stock rate, both for baseline and optimization scenarios

SAILS: Advanced Modeling

Once you get beyond the basics, SAILS can support a wide variety of advanced analyses, including

- supply chain vulnerability/hardening

- multiple, interdependent time periods in the same model (seasonal demand), manufacturing pre-build, and/or long-term strategic planning)
- profit maximization vs. cost minimization
- cost/time weighting
- international supply chains
- detailed post-optimization inventory deployment

With respect to inventory, SAILS offers the following options:

- a built-in SKU-level analysis at the customer-facing DC echelon, including estimates of cycle, safety, and in-transit inventory required to support a given level of service
- a seamless interface to the award-winning Power Chain Inventory™ product of Optiant, Inc. which provides detailed inventory analysis throughout the supply chain (all echelons)

SAILS: The Solver Engine

The consensus among supply chain network design modeling experts today is that the solution methodology of choice is mathematical optimization, specifically a technique known as *mixed integer linear programming*. Most people have at least heard of linear programming and understand it to be a technique that seeks to *minimize* or *maximize* something while simultaneously honoring certain limitations otherwise known as *constraints*. In the case of a strategic supply chain network design model, we seek to *minimize cost* or *maximize profit* subject to:

- management constraints (demand must be satisfied, specified service levels must be met)
- resource constraints (procurement, manufacturing, and DC operations min/max limits)

If all we had to do was optimize the *flow* of commodities in a network, then a traditional linear programming model would work just fine. But a strategic network design effort almost

always forces us to confront much more difficult questions: the number, location, and size of various types of facilities and (often) the *unique* sourcing of a given set of products for a given customer. These problems give rise to a host of “no go/go” decisions and are represented in a model as “0/1”, or “binary” decision variables. Hence, the term *mixed integer* linear programming.

But why the emphasis on mathematical optimization? Why aren’t competing technologies such as expert systems, heuristics, or dynamic simulation just as acceptable? There are five major reasons.

Nature of Problem. A typical SAILS problem has *trillions* of feasible structural alternatives. While only a few thousand are likely of serious managerial interest, the question of which few thousand is not so simple. Optimization-based algorithms will either implicitly or explicitly sift through *all possible* choices, while even the most advanced heuristic procedure will investigate only a very small number that “seem likely” to be good. Sometimes the heuristic guesses are good ones and sometimes they aren’t, but the important point is that there is no way to know for sure unless the true optimum is also established. If the true optimum is not known, the very real possibility exists for a better answer to be proposed externally by an analyst or manager. Once this happens, and only a single instance is sufficient, solver credibility is permanently compromised.

Tradeoff Complexity. A supply chain model has many components that interact with each other. The most important cost in any supply chain system is the bottom line, not the magnitude of any one cost component. However, the number of tradeoff possibilities is staggering. What compounds the problem is the necessity to examine all components and all tradeoffs simultaneously. While optimization provides such capability, no known heuristic is capable of such a global perspective, with the unfortunate result that many promising alternatives go unexplored.

Cost Savings. A natural consequence of the first two points is that a heuristic solver will likely miss important opportunities for cost savings. In all likelihood, a heuristic will identify some obvious savings; but less apparent sources of

cost reduction, those often not identified by a heuristic procedure, can amount to many times the cost of the most extensive system design study. Few executives consider such savings to be unworthy of consideration! In contrast, optimizing solvers will identify all sources of cost reduction.

Problem Features. It is generally acknowledged that certain problem features dictate certain model formulations if fidelity to the real problem situation is to be maintained. In particular, a mixed integer-linear programming formulation is required whenever one wishes to deal with fixed costs, capacity constraints, economies of scale, cross-product limitations, and unique sourcing requirements. Conversely, heuristic solvers cannot rigorously treat *any* of the above very important features of supply chains.

Run-to-run Comparisons. One of the most compelling reasons for adopting optimization-based solver technology is that only optimization permits reliable comparisons across model scenarios. If a heuristic solver is used, comparisons must be made among solutions whose direction and magnitude of error are unknown.

Reliable run-to-run comparisons are the most valuable aspect of virtually all studies and are absolutely essential if one wishes to explore uncertain formulation or data assumptions, evaluate alternative demand, supply, cost, service, or environmental forecasts, and establish the reasons why two different input data scenarios yield alternative solutions.

In sum, optimization results in fewer runs, superior analysis, better solutions, increased savings, and less risk.

Many software vendors today claim to offer mixed integer linear programming and oftentimes they do ...up to a point. However, they conveniently fail to mention that their solver only works for relatively small problems and/or that it optimizes only a portion of the problem and guesses at the rest and/or that its solution run times can be excessive.

The underlying difficulty here is that the solver engine itself is simply not up to the task. Not so for SAILS. INSIGHT has imbedded into SAILS its proprietary optimization engine, XS, long

recognized as the worldwide reference standard for large-scale, mixed integer linear programming problems. Our aggressive research and development efforts have consistently enabled us to solve larger, more complex models in less time than our competitors. How do we know? — Because, we constantly benchmark the performance of XS against the competition. We also regularly publish what we do in open, peer reviewed academic journals. One can only speculate as to why others do not.

In Short: Why SAILS?

SAILS is the strategic supply chain network design tool of choice today for various reasons:

- it has been used in actual practice for over 25 years
- it has been used across a broad spectrum of clients and industries
- it has the most powerful, flexible, and easy-to-use interface available
- it has the finest set of data preparation tools available
- it has the most powerful solver engine available

Bottom line: *it can save you money and enhance your return on shareholder equity.* In today's environment, enough said.