A
ccording to a recent study by the ARC Advisory Group, transportation management software (TMS) is predicted to continue robust growth. In 2001, ARC estimates that software purchases and installations were in excess of $800 million — and over the next five years, the market is projected to grow 16.4 percent annually.

TMS is an expansive area, broadly including procurement, optimization, execution and tracking. Different software modules can include contract management, bid optimization,
planning and execution, parcel shipments, international trade logistics and fleet management.

Optimization has many of its historical roots in the transportation and logistics business. One of the most famous problems was designing optimal convoy size for North Atlantic crossings during World War II. (Large convoys permitted a small number of destroyers to protect a large number of freighters. However, since the convoy moved only as fast as the slowest ship, if you divided the convoy into smaller pieces, they might be better able to elude German submarines.) During the war, Americans were introduced to optimization by the British, who had been operating a global empire for more than 100 years, and had developed a variety of methods to optimize the allocation of resources and to improve logistics.

Today, “optimization” is quite frequently used to describe an intended outcome that may not be intended — or even realistic. Much like supply chain management (SCM) and electronic data interchange (EDI) optimization has achieved such publicity that senior management expects their company to be using (or at least purchasing) this technology. Despite great expense, the results are often disappointing. Sometimes the problem is related specifically to optimization. However, more often generic information technology issues arise. In some cases, companies will successfully navigate numerous project perils — only to let the system fail when implemented.

When considering optimization there are three major areas to contemplate:

- **Utilize a Decision-making Hierarchy.** Optimization decision-making must be based on a complete view of one’s operations to be effective. Myopic optimization of a localized activity without regard to the effects imposed on neighboring processes often leads to significant inefficiencies. (This refers to a local optimal solution — rather than a global solution. An example would be saving labor at a single freight terminal that caused operating disruption throughout the network.) Unfortunately, optimizing one’s entire operation is often an overwhelming task and not practical.

  The best way to approach a solution is to utilize a hierarchical strategy. This method feeds informed decisions made at a regional level down to the managers and optimization techniques controlling local operations. This hierarchy ensures that the goals of a region have influence and priority over local issues. They offer a structure under which local problems can be effectively coordinated and resolved.

  This approach emphasizes that technology is not a substitute for management. In fact, it is consistent with the effective use of management by objectives (MBO), which aims to increase organizational performance by aligning goals and subordinate objectives throughout an organization. For MBO to work, employees must get clear input in identifying their objectives and available resources and time lines for task completion. As with MBO, any optimization project should also include ongoing tracking and feedback in order to reach and maintain management’s objectives.

- **Avoid Process Over-simplification and Complex Optimizations.** For optimization to succeed, users must avoid over-simplification of the underlying business process. The most common pitfall is the installation of a black box combined with the promise of large staff reductions. A decision support system (DSS) should be true to its name — it is a support system. Its role is to enhance the effectiveness of management and end users — not replace everyone with a computer.

  Many software providers can design a DSS to effectively solve simple, routine optimization tasks. However, the question to consider is how frequent is the routine and how simple are an organization’s optimization problems? Exceptions to routine occur, as do intractable complexities in optimization objectives and constraints. Many companies like to describe their systems as robust. Yet the key to robustness and success with a DSS is to encourage and keep resourceful and experienced managers and end users in the decision
loops associated with their responsibilities.

Key points:

1. Understand Optimization Basics. Optimization problems are made up of two basic ingredients:
   1) The objective function defines the business result that we are seeking. The aim is to either minimize or maximize. A shipper may be seeking to minimize cost or time. A carrier may be seeking to maximize revenue and profit yield. The objective function contains variables that dictate its value. In some cases, these unknowns carry well understood values (e.g., cost or time). However, some variables may be more difficult to define (e.g., utility or risk).
   2) Constraints delineate the allowable range of unknowns. They permit variables to take on certain values — but exclude others. Some define common sense (e.g., time cannot be negative), while others represent capacity (e.g., speed limits — and other constraints).

The optimization problem is then to find values of the variables that minimize or maximize the objective function while satisfying the constraints. That being said, there is a vast amount of hype and misinformation that often accompanies the terms optimization, artificial intelligence, and simulation. It is necessary to understand what each can and cannot do.

There are two types of optimization:

1) Deterministic optimization reflects problems in which all parameters are defined and static. Such problems are a significant simplification of real life. Yet, finding an optimum solution to many deterministic problems is very difficult — if not impossible. A classic example of deterministic optimization is developing routing solutions where all factors are known — and remain unchanged. Be aware that today’s most powerful computers using state-of-the-art algorithms could take decades of CPU time to solve relatively small instances of these seemingly simple, deterministic problems.

2) Stochastic optimization reflects real-life problems that are probabilistic in nature. As an illustration of the difference between a deterministic optimization problem and a stochastic one, consider a routing problem once more. In the deterministic version, all travel times between points are known — and they never change. In the more realistic stochastic version, traveling from Chicago to Los Angles might be described by a normal distribution with a mean of 63.5 hours and a variance of 12.8 hours. Stochastic optimization problems are virtually impossible to solve optimally. In fact, the mathematics required to solve simple systems such as network possessing between several nodes — with general arrivals and service time distributions — is yet to be discovered.

Heuristics, artificial intelligence, and simulations are often deployed in response to the difficulty (or intractability) of calculating optimum solutions to deterministic and stochastic problems.

- Heuristics and artificial intelligence are procedures often applied to deterministic problems. They do not guarantee an optimum solution. Instead, they seek to find a feasible solution (of decent quality) in a reasonable amount of time.
- Simulations are procedures mainly applied to stochastic problems. They do not optimize. They seek only to reveal a set of possible realizations — or trial solutions to the problem. If a vendor tells you that he will use simulation to find an optimum solution to your problem, he’s pulling your leg.

There are several other optimization related issues that arise.

- In some cases, there is no objective function. The result is to find a set of variable values that satisfy all the constraints (e.g., it is necessary to process a certain number of transactions through a constrained network). There is no intention to optimize anything. This type of problem is called a feasibility problem. Interestingly, such problems are mathematically neither easier nor more difficult to solve than those with objective functions.
- In other cases, there are multiple objective functions. The user is seeking to simultaneously optimize a number of different objectives. Consider for example a hazardous
material shipper seeking to minimize cost, maximize transit, and eliminate accidents. Usually, in cases like this, different objectives are not compatible because the values of variables that optimize one objective may be far from optimal for the other objectives. The most common solution approach is to redefine problems with multiple objectives as single-objective problems. Different objective functions can be weighted to form a combination function, or some objectives can be restated as constraints. Note that such mathematical manipulation of optimization objectives and constraints can lead to very strange results, underlying the need for resourceful and experienced end users to remain in the decision loop.

**IT Considerations.** Beyond the mathematical aspects of the intended solution, there are information technology concerns. The management information system (MIS) designed within a successful decision support system must possess several essential qualities:

- It must serve all levels of management.
- It must be user-friendly and accessible.
- It must provide a focal point for the facility’s different functional areas.

These characteristics encourage buy-in of the support system, and lead to improved communications between all employees and stakeholders.

The system must have comprehensive technology behind it to ensure that it possesses all pertinent data.

- If the amount of information to be accessed by the system is minimal, the application may interface directly with production data through end users. However, this is rarely utilized because data requirements are often large, and the production application will experience performance degradation.
- Automatic downloading in read-only mode from established database systems is the preferred mechanism for obtaining needed information. Automatic downloading minimizes user entry while read-only mode protects the host systems.

There is another aspect to data integrity that is often overlooked. The incoming data must be filtered for errors and unreasonable values to maintain the integrity of the DSS. Otherwise the users will experience GIGO (garbage-in, garbage-out.)

**Management of Deployment.** Even after the mathematics of optimization and information technology issues are addressed, management must still deploy — and maintain — the decision support system. The means by which DSS is integrated and deployed in an organization are critical to its success. The new application should strive to be compatible with the company’s structure by properly setting user access and privileges. However, it is of the utmost importance to first consider whether the underlying flow of control in an organization is well designed and compatible with both the current business environment and the potential of the proposed DSS. Otherwise, one runs the risk of perpetuating ineffective and stifling management practices or worse yet, installing a system that will be ignored. Organizational redesign efforts are often referred to as reengineering or BRP. These efforts need to be addressed in concert with the design of any DSS and should be referred to throughout the entire duration of any system project.

There are still several more opportunities to ensure a project’s failure. Most of the potential pitfalls involve a lack of a sufficient budget or poor budget planning. The budget for software acquisition, development and integration should not represent the total project cost. Unfortunately, if project budgets are strained, it is natural to look for places to save money. The result is often “defeat snatched from the jaws of victory.”

- Implementing a DSS involves choosing suitable types and numbers of platforms on which to deploy the system, as well as assigning workstations to appropriate users. Hardware deployed in the field may be inadequate and may be necessary to upgrade.

http://www.americanshipper.com/prince/AUG02_optimization.htm

12/10/2003
• A training plan with adequate resources needs to be enthusiastically accepted by all parties, and then executed diligently. On-site coaching and outright assistance should be made available throughout startup.

Ultimately, it will be time to place the system into production. Determining the startup pace is often more art than science — requiring a balance between the objectives of senior management, local management, and the technology providers.

• Senior management often wants the system to go live at the largest facilities first in order to maximize return on investment.

• Local management wishes to generate user acceptance and enthusiasm and minimize labor and production disruptions.

• Technology providers always want sufficient time in a non-critical production environment to allow the system to stabilize.

In an ideal situation, users will have been thoroughly trained and will have generated grass roots enthusiasm for the new product.

Finally, decisions must be made about how non-invasive the system must be during rollout. Will users be allowed to ignore — or easily override — the system until confidence is established? Or, will there be absolute commitment to the system — right, wrong or indifferent? While business continuity arguments can be made for the former, human nature and resistance to change may mandate the latter. Hopefully, in either case, user acceptance and enthusiasm will lead to valuable feedback in the form of suggestions for future system refinements and enhancements.

**After It’s Running.** Once the system is up and running, management cannot ignore the need to continue to sustain and improve a DSS application.

• **System Flexibility, Adaptability.** An effective DSS must be able to adapt quickly to unexpected events, such as critical equipment failures or personnel shortages. This feature will enable the system to continue to support management through crisis periods. Complex operating environments are also dynamic from a long-term perspective. They will experience ever-changing technology, processes, and equipment.

A DSS must be flexible and adaptable to keep pace with these changes. Systems with these traits are easier to deploy at multiple sites, where each site may possess a different demand profile, operating objective, facility configuration, and/or management style. In turn, deployment at multiple sites allows for centralized support, refinement, and enhancement — an assurance that the decision support system will continue to mature.

• **System Training, Sustainment.** Deploying an effective DSS requires a significant training and integration support budget. Unfortunately, after a successful deployment, the training team and system integrators often declare victory and then vanish — leaving local operating staffs with the implicit tasks of systems effectiveness evaluation, ongoing systems training, and the training and mentoring of new employees. Local operations rarely have time — or adequate budgets — to support such efforts even though their productivity and survival is critically linked to the effective use of the new DSS.

To make matters worse, the increasing sophistication and complexity of today’s systems requires end users to have more schooling, greater language fluency, and better employee retention. However, the profile of an end user in most industries is heading in the opposite direction, mainly due to constant cost pressures and low unemployment. The result is that investment in a new DSS and more importantly, the benefits derived from such a system are lost in a matter of months without an effective and sustainable training program.

Optimization is a very powerful tool that can effectively support resourceful and experienced managers and end users in solving complicated problems. However, optimization is not a “one-size-fits-all” solution that can be easily implemented, especially without making a serious management commitment. Although the term has entered the
business mainstream, it is frequently misunderstood — and often misapplied. Not all qualitative issues can be simply converted to quantitative terms. When all the jargon is stripped away, what most companies seek from optimization is an effective decision support system. The issues discussed above are fundamental to the design and deployment of a DSS within any complex operating environment, however, ultimately we must recognize that technology by itself is not sufficient — real management will always be required. Thomas A. Feo is president and co-founder, and Theodore Prince is senior vice president for marketing and sales of Optimization Alternatives Ltd. Inc., an Austin, Texas, company that develops and deploys large-scale control and decision support systems to manage freight transportation.