Xpress Optimization Showcase

Using the Power of Optimization to Build Your Competitive Edge

FICO™

Make every decision count™

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Make every decision count™

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Product Sheet

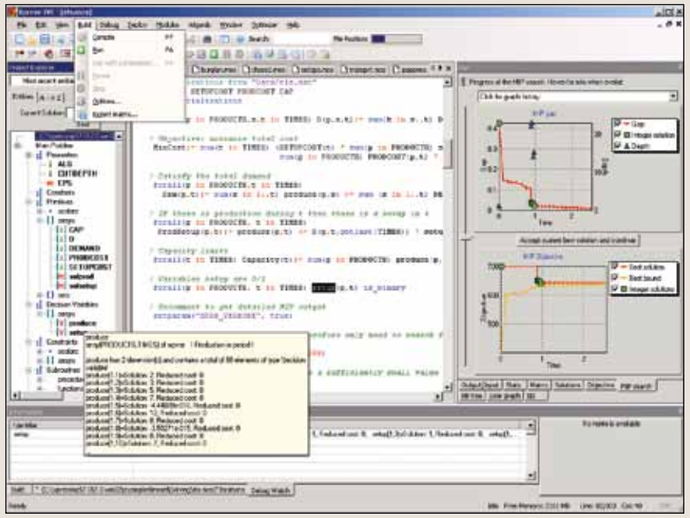
FICO™ Xpress Optimization Suite

decision management tools

FICO™ Xpress Optimization Suite is the premier mathematical modeling and optimization software suite in the world, with the best tools available to aid the development and deployment of optimization applications that solve complex, real-world challenges.

The Xpress Optimization Suite helps organizations solve bigger problems, design applications faster and make even better decisions in virtually any business scenario.

IVE Development Environment



Improvements to the IVE development environment in Xpress 7 help users build optimization applications faster than before and design them to match the way their business works.

FICO™ Xpress Optimization Suite is a set of mathematical modeling and optimization tools used to solve linear, integer, quadratic and non-linear problems. The Xpress Optimization Suite includes two sets of tools: model building and development tools, and solver engines.

» Model building and development tools

Xpress-Mosel is an algebraic modeling and procedural programming language specifically designed to be an easy-to-learn, robust way to interact with Xpress solver engines. It is a fully functional compiled programming language that lets users formulate and solve problems using one or several of the Xpress solver engines, and analyze solutions. Xpress-Mosel now features N-best solution support, making it easier to develop optimization solutions that take advantage of the availability of multiple solutions. It also features multiple problems within one model file for easier implementation of more advanced solution algorithms. Xpress-Mosel models can be developed within IVE, our visual development studio for Xpress-Mosel under Windows. IVE is a complete visual development environment for Xpress-Mosel which incorporates a Mosel program editor, compiler and execution environment, debugger and profiler. It features development and deployment wizards, visualizations of the solve progress and results, and a full drag-and-drop editor for authorizing XAD GUI interfaces. With IVE and XAD, developers have the tools for complete optimization application development, from the mathematical representation of the problem to development of the graphical user interface. This complete tool set provides faster prototyping and deployment along with visualization tools for greater insight into customer problems.

» Solver engines

Xpress-Optimizer features optimization algorithms that enable customers to solve their most difficult business problems. It solves linear programming (LP) problems, mixed integer programming (MIP) problems, quadratic programming (QP) problems and mixed integer quadratic programming (MIQP) problems. Xpress-Optimizer offers multi-threaded processing out-of-the box, exploiting multiple CPU cores to solve clients' most difficult MIP problems. Xpress-Optimizer includes Builder Component library (BCL), an object-oriented API for building, solving and analyzing problems, and C, C++, VB, .NET and Java API support.

Xpress-SLP is a solver for non-linear programming (NLP) problems and mixed integer non-linear programming (MINLP) problems. It uses successive linear approximation, which has been developed from techniques used in the process industries and it is capable of solving large problems with many thousands of variables.

Xpress-Kalis is Constraint Programming software based on the Kalis solver by Artelys. It specializes in discrete combinatorial problems as they frequently occur, for instance, in scheduling and planning problems.

» The competitive advantage of Xpress

FICO is committed to investing heavily in the Xpress Optimization Suite to maintain it as the leading optimization technology, and to providing friendly, high-quality support. With FICO™ Xpress Optimization Suite, you can expect:

- A state-of-the-art optimization engine that is robust, reliable and faster than competing solutions
- The premier visual development environment, IVE, for developing mathematical models, now featuring an intuitive drag-and-drop editor for creating GUIs that seamlessly integrate with the model for rapid prototyping and deployment
- An easy-to-learn, powerful modeling and programming language, Xpress-Mosel, now including support for N-best solutions
- A partner committed to solving all of your most difficult optimization problems

» FICO and the Xpress Suite

The Xpress Optimization Suite is embedded in FICO™ Decision Optimizer, the software component of FICO Custom Decision Optimization. Custom Decision Optimization uses Decision Optimizer software along with a precise, data-guided methodology to solve custom decision problems for our financial services clients in such areas as credit line management, pricing and market offer optimization. These complex decisioning strategies can incorporate any number of predictive models while balancing multiple business objectives (including competing objectives from various departments) and resource constraints, even accounting for ranges of uncertainty.

FICO works in close partnership with its clients and partners, enabling them to get the best possible performance from the Xpress Optimization Suite. The suite is embedded in many software products and solutions as a component, making leading-edge optimization accessible to a wide range of clients and applications. Through expertise in the product and its application, excellent client support and fast-track product development, FICO continues to maintain the Xpress Optimization Suite at the cutting edge.

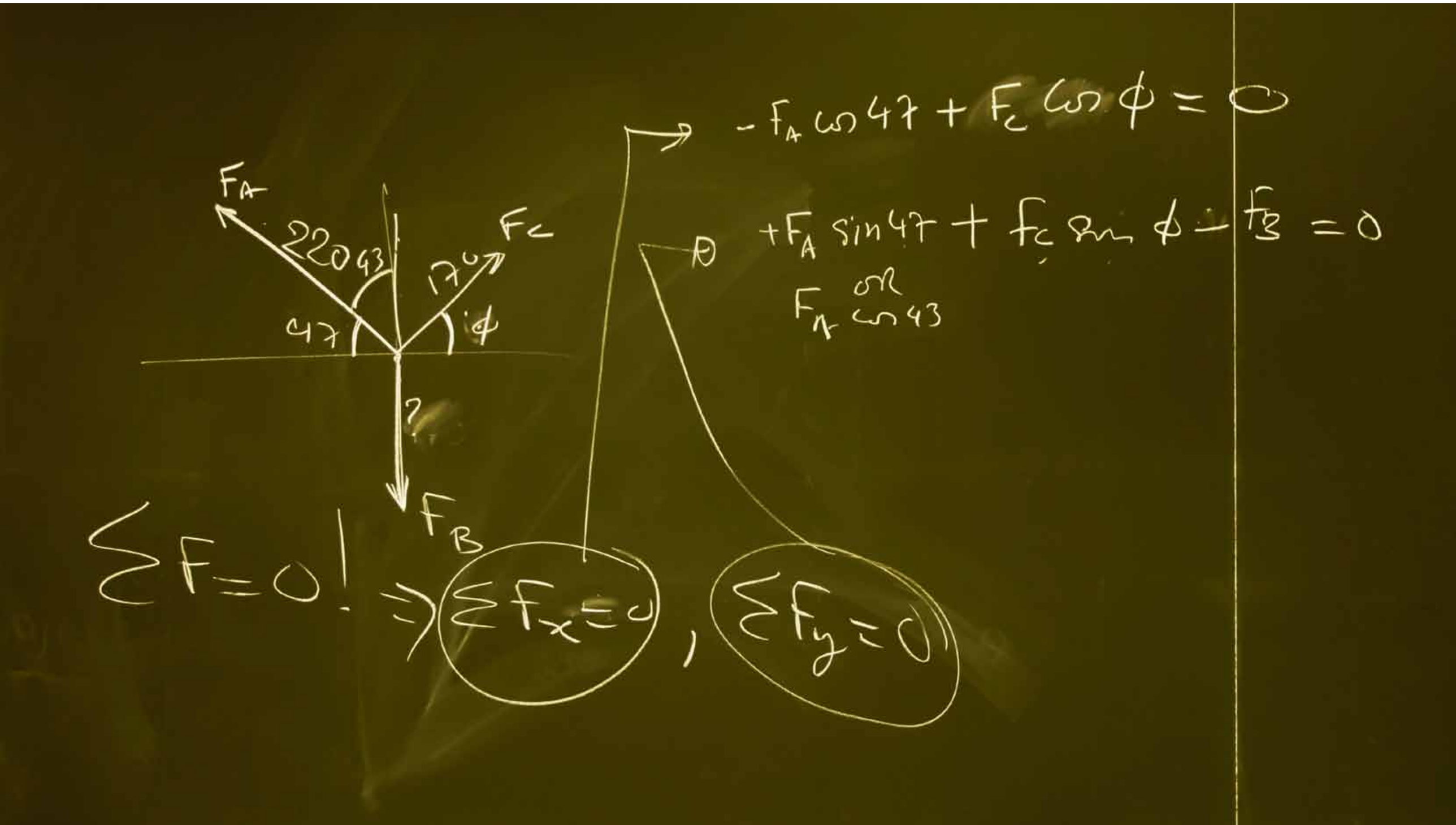
» About FICO

FICO combines trusted advice, world-class analytics and innovative applications to help businesses make smarter decisions. Our solutions and technologies for Decision Management give organizations the power to automate more decisions, improve the quality of their decisions and connect decisions across their business.

Clients in 80 countries work with FICO to increase customer loyalty and profitability, cut fraud losses, manage credit risk, meet regulatory and competitive demands and rapidly build market share. For more than 50 years, we have helped thousands of clients control risk and accelerate business growth through analytics and decision technology. Our innovative applications integrate analytics, optimization, business rules management and other technologies to help businesses make smarter decisions.

For more information and to request an evaluation copy of the FICO™ Xpress Optimization Suite, go to *www.fico.com*.

Case Study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success story: optimization

Optimization soars at American Airlines

Client	American Airlines, serving nearly 100 million passengers annually
Challenge	Increase revenue and reduce costs in a highly competitive, low-margin industry and difficult economic environment
Solution	FICO™ Xpress Optimization Suite
Results	Optimized processes that lead to increased revenue, reduced costs and improved customer service

"The difference between selling a couple of seats or not can be the difference between being profitable or losing money on a flight."

—Armando Silva,
managing director of operations research, American Airlines

For the average airline passenger, a successful flight means getting from point A to point B safely and on time. But for the people who work behind the scenes at American Airlines and American Eagle, success also depends on a long and complex list of other factors—scheduling flights, juggling connections, working around bad weather and assigning crew for nearly 4,000 flights a day.

Add a lagging economy, and it becomes clear: Running a successful airline is no small feat.

"In today's economic environment, and particularly in the airline industry where margins are very small, maximizing revenue and reducing cost is a big deal," says Armando Silva, managing director of operations research at American Airlines. "Throughout our history, but particularly in these tough economic times, this is the challenge we've faced: How do we take it an extra step? How can we continue to improve processes and run a more cost-effective, efficient and safe operation?"

Consider that the company strives to provide a positive experience to 100 million passengers each year, and the sheer scale of its challenges becomes mind-boggling. American Airlines continually works to optimize its operations in a way that can minimize cost and maximize revenue, while maintaining the highest levels of safety and providing quality service to its passengers. The company has worked toward these goals with optimization tools for many years, but the operations research team wanted to push the bar even higher.

Optimization tackles business-critical challenges

The airline industry is intensely competitive. Newer airlines, started in the last decade or two, have considerably lower operational costs than legacy companies such as American Airlines. Fuel prices can spike unpredictably, making profitability on individual flights a challenge. Such razor-thin margins require American Airlines to build efficiency into every part of its operations.

"The difference between selling a couple of seats or not can be the difference between being profitable or losing money on a flight," Silva says. "In a business with challenges that are as complex and large as ours, you have to rely on optimization." And that kind of optimization, Silva says, is "something you can't do by hand or with a simple tool."

American Airlines turned to the FICO™ Xpress Optimization Suite. Xpress is designed to help organizations solve large-scale challenges, and for American Airlines, this includes making critical resource allocation, asset management and scheduling decisions. The technology includes a set of advanced tools for users to develop their own optimization models.

With the help of FICO, American went through an extensive testing and validation process of Xpress. Results were good and runtimes were fast.

"That's a make-it-or-break-it result," Silva says of Xpress's impressive runtimes. "A program that takes 25 hours to run something is not that useful." Based on these results, American decided to implement Xpress at its headquarters in Fort Worth, Texas.

Solving problems with innovation and speed

Today, Xpress touches many important parts of American's operational decisions, from long-term planning to last-minute rerouting of passengers.

First, American Airlines' operations research team works in conjunction with the business units to develop answers to the business issues they are trying to solve. Next, the operations research and decision support group develops the algorithms, processes and methodologies for how to solve these problems. Xpress helps them do this by narrowing down and choosing the best possible answers–a critical capability when the options are virtually innumerable and comparing them is difficult. They then partner with other groups in IT Services to put into production and run the Xpress-based systems on a daily or weekly basis—whatever frequency is required.

Optimization techniques are widely used at American Airlines For example, when a customer visits AA.com and purchases a ticket, the revenue management group must reoptimize to determine pricing and availability for the remaining seats. When a snowstorm hits Chicago, the system operations control, reservations and revenue management groups must reoptimize to determine how, where and when to reroute disrupted customers. When an airplane's maintenance parts are waiting in Dallas, Chicago or any other city American serves, the maintenance and engineering and system operations control groups must reoptimize to get the plane to the same city as its scheduled maintenance. Many of these functions now rely on applications that use Xpress to perform the required optimization.

Silva says Xpress has expanded his team's ability to innovate and apply optimization to improve business decisions and build more productive systems.

"My team is more productive because they have more access to these kinds of tools, Silva says. "They're less constrained by what they can use to solve their problems. It was a hit in my group, that's for sure, when we signed the agreement with FICO."

Better optimization leads to improved customer service

At American Airlines many groups benefit from Xpress-powered applications, such as operations control, scheduling and maintenance and engineering, to name a few. These groups benefit from Xpress and make critical business decisions based on data generated by Xpress applications. These decisions ultimately affect customers, making improved customer service a valuable result of the decision management tool.

"For example, when we have a disruption, we do a better job of getting people to their destination," Silva says. "That is clearly improved customer service."

Optimization spreads throughout the enterprise

When American Airlines selected Xpress Optimization Suite, one deciding factor was the ability to sign an enterprise-wide agreement. That means the OR team can deploy optimization in the face of more challenges throughout the company.

"Cost was limiting the number of optimization applications we were able to use," Silva says. "Now, with an enterprise Xpress license, we're expanding our use of optimization engines into other areas. We're less concerned about monitoring the use of these tools. With the cost savings we have the freedom to use technology where we need it."

Looking forward, Silva says he and his team will continue to scour the enterprise for ways to help the business run more smoothly, better serve its millions of customers and ultimately maximize the company's revenue and profitability.

"The Xpress Optimization Suite agreement with FICO, for us, has been an enabler to do more of these things," Silva says. "Looking forward, we will continue to see where we can use it. We know for a fact there's a lot more to be done out there."

success story: optimization

Honeywell schedules big profits for its clients with FICO Xpress Optimization Suite

Client Honeywell Process Solutions, a division of Honeywell International

Challenge Finding a partner with world-class optimization software that's transparent to the end user

Solution FICO™ Xpress Optimization Suite

Results A partner committed to innovation; an optimization software solution for improved scheduling decisions that can have a multi-million dollar impact for manufacturers

Honeywell

"We've had nothing but a great experience embedding FICO's technology. Embedding Xpress has been a dream; we've had absolutely zero issues."

—Jeff Kelly
Solutions Architect,
Honeywell Process Solutions

Long before gasoline is pumped into your car it flows through a highly orchestrated production process. In order for refineries to manage this process cost-effectively, each element must be carefully coordinated.

One of the keys to success is the production schedule. Yet, for many oil-refineries and other companies in the continuous process industries (oil and gas exploration and processing, petrochemicals, mining, minerals and metals), the production schedule is created through a surprisingly low-tech approach: Humans working manually with spreadsheets.

"I'm often surprised at the rudimentary approach to production scheduling many companies take," said Jeff Kelly, Solutions Architect, Honeywell Process Solutions, a division of Honeywell International. "Manual scheduling may work, but it's slow, inefficient and error prone when compared to optimization software."

A relatively new technology to the continuous process industries, optimization software generates better production schedules, enabling companies in continuous process industries to dramatically improve production efficiency and quality. Unlike manual scheduling, which is restricted by the analytic limitations of the human brain, optimization software uses mathematical algorithms to quickly analyze hundreds of variables to determine the best schedule solution out of many thousands of scheduling scenarios. "Simply put, our customers come to us with the challenge of making better scheduling decisions in an automated and repeatable fashion."

» FICO technology partnership key to success

When Mr. Kelly joined Honeywell Process Solutions his mandate was to build Production Scheduler, a software solution that the company would sell to prospects in the continuous process industries.

Rather than build the solution in-house, Mr. Kelly's strategy was to find a technology partner with exceptional optimization technology. He found that in FICO, a pioneer and industry leader in decision management and optimization software.

"Building our own optimization-based solution wouldn't get us the world-class performance we wanted," said Mr. Kelly. "Instead, we chose the FICO Xpress Optimization Suite, a powerful optimization technology that offered all the algorithms and computing performance to do the thinking for you, to do all the great searching to find better solutions to complex decisions."

Honeywell has sold over 30 copies of Production Scheduler worldwide in the continuous process industries. "We would not have been able to build Production Scheduler without Xpress, and we would not have had the sales we've had without Xpress," comments Mr. Kelly.

» Optimization software enables faster, better business decisions

With powerful optimization software, Production Scheduler solves industrial-scale logistics problems and can help companies achieve quantifiable improvements in manufacturing efficiency and quality.

It does this by modeling the complexity of a manufacturing process, factoring in the hundreds of manufacturing constraints, and determining the best possible scheduling solution. Production Scheduler's optimization software provides the decision-making speed and accuracy to capture market opportunities that a manual scheduling approach would never be able to capitalize on. The solution is designed to handle the full range of scheduling and blending activities, including:

- Crude-oil marine and pipeline scheduling
- Refinery crude-oil scheduling
- Crude-oil blend optimization
- Process unit scheduling
- Blend scheduling and optimization
- Product distribution to terminals

The economic impact of scheduling optimization is significant. For example, in crude-oil blending for a typical oil refinery, the ability to improve inventory and capacity schedules can result in $0.078 profit per barrel each day. While 8 cents appears to be a small financial impact for an oil barrel per day, the downstream affect of scheduling demand-driven production for 100,000 barrels equates to an annual profit increase of $2,850,000.

"Because the Xpress Optimization Suite can quickly model large-scale, complex problems, users of Production Scheduler can make more accurate business decisions and update to what's happening in the plant and market more frequently," says Mr. Kelly. This reduces risk and uncertainty because it allows companies to factor the most current information into their plans. "With automated and optimized decisions you can update to market conditions faster than your competitors can, which enables you to capture market opportunities faster than anyone else."

» Powerful technology that's easy to use

Despite the power of the Xpress optimization software, it's surprisingly user-friendly. A chemical engineer by trade, Mr. Kelly has no formal computer programming training. Yet he had no difficulty building the optimization models that Honeywell's customers would use to solve their production problems.

"Xpress is very easy to use, even for people with little or no computer programming experience," says Mr. Kelly. "It's easy to build models for all kinds of problems that integrate well with the software solvers that create the schedule solutions."

Commenting on Honeywell's decision to embed the FICO™ Xpress Optimization Suite, Mr. Kelly has very positive things to say. "We've had nothing but a great experience embedding FICO's technology. Embedding Xpress has been a dream; we've had absolutely zero issues."

» Optimization software as a strategic asset

Seeing firsthand how much faster and more accurately Honeywell's customers can solve problems with Production Scheduler, Mr. Kelly sees optimization technology as a strategic asset that every continuous process manufacturer should use. This is especially true for North American companies, as many of their competitors in Asia and India are aggressively embracing new technology such as optimization software. "What we are doing for our clients, if you were to draw their operating line when making all decisions manually, we are using that operating line to make them more competitive and profitable with automated scheduling optimization."

Mr. Kelly notes that some companies view optimization software as a risk, questioning whether the time and effort to build models will yield actual performance gains. "People may ask, is this optimizer going to be fast enough? Am I going to spend a lot of time and resources building a model and not have it perform? Well, that's not the case anymore. Xpress has proven to work for large scale, mission critical optimization challenges for our clients." Mr. Kelly sees no risk using the FICO Xpress Optimization Suite. "There's no question in my mind that companies using either Production Scheduler or the Xpress Optimization Suite independently will improve their manufacturing production throughput and quality."

Mr. Kelly is also pleased with FICO's commitment to innovation. "The incremental innovation FICO has added to Xpress has been excellent. The company is continually adding new features and enhancements that we've benefited from."

success story: optimization

Prime Time: The NFL optimizes its playing schedule

Client The National Football League (NFL)

Challenge Develop a game schedule that maximizes television ratings and accommodates the teams and their fans.

Solution FICO™ Xpress Optimization Suite

Results The NFL can address stadium availability issues, minimize the competitive impact of travel, and deliver television schedules that allow the most fans to watch the biggest games.

"We can solve problems now that we couldn't dream of solving five years ago. The NFL continues to ask for more and more complicated models, and with FICO optimization, we are able to deliver."

— Rick Stone,
President of Optimal Planning Solutions

» CHALLENGE

A delicate balancing act takes place behind the scenes of every American football game broadcast at prime time. The NFL's 32 teams play 16 games over 17 weeks at different stadiums across the country. And for every game that's played, television exposure is the key to business success.

Countless factors must be taken into account to arrive at an optimal playing schedule: stadium availability, travel time, days between games, television placement and more. The challenge: How to balance the needs of network partners, the teams and their fans so that the competition is fair and the league turns a healthy profit?

"It's a mathematical problem that could run for a thousand years," says Rick Stone, President of Optimal Planning Solutions, a consultancy that helps professional sports leagues create playing schedules. "Only the most powerful optimization tool can generate a quality playing schedule for a sports league like the NFL."

A decade ago, the NFL began to replace its manual scheduling process with one that relies on computer software to determine the best combination of games for the season. Because of the time-intense process, however, it created no more than a dozen schedules each year before selecting the official one. In 2004, the league wanted to improve its scheduling process by creating and evaluating as many scenarios as possible, and now routinely completes and analyzes thousands of candidates before finalizing the schedule.

Speed and accuracy were deciding factors in the search for an optimization tool. In order to find the best schedule for the season's 256 games, the tool would have to consider 7,000 game options, while accounting for some 20,000 variables and 50,000 constraints. Above all, the schedule needed to maximize the value to the NFL's television partners while being fair to its teams and their fans.

"The NFL scheduling model involves countless constraints that must be satisfied to ensure that each team is being treated fairly, including the number of consecutive home or road games, travel schedules and the number of days off between games," says Stone.

A number of internationally known technology companies bid on the opportunity to help the NFL solve its scheduling challenge, but few were able to deliver a workable solution due to the complexity of the problem. Optimal Planning Solutions selected FICO from among leading providers of optimization software in part because of superior service and software performance.

"Scheduling the NFL season is an extremely difficult task and we need the most powerful optimization software that's available," says Stone. "FICO™ Xpress Optimization Suite outperforms other optimization tools, including CPLEX, for our sports-scheduling challenges."

» SOLUTION

To meet the rigorous scheduling demands, the NFL and Optimal Planning Solutions turned to the Xpress Optimization Suite software for a new level of analytic precision and power. The tool's ability to solve mixed-integer linear and quadratic programming problems at industry-leading speeds, combined with the company's track record for top-notch service, persuaded the NFL to make the switch.

The NFL takes advantage of parallel implementations for even faster results. Working across eight CPUs simultaneously, Xpress system can produce an NFL schedule in 24 hours, which allows the league to choose the best among thousands of possible schedules over the course of a two-month planning effort.

"Xpress allows us to evaluate infinitely more scheduling options than were possible with a manual process," says Michael North, Director of Broadcast Planning and Scheduling for the NFL. "And this capability has improved the quality of our schedules significantly."

FICO's optimization software not only meets the NFL's scheduling needs today, but it also has proven that it can keep up with the increasing complexity each new football season brings, as the league adds new variables and constraints. The advent of Thursday games, for example, added a new set of requirements to the schedule, as have changing travel and game-spacing requirements.

» RESULTS

A decade ago, it took half a dozen people sitting in a room 14 hours a day for three months to come up with a satisfactory schedule—the quality of which could only be evaluated after the football season had come to a close. Today, the same process can be accomplished in much less time, with an outcome that accounts for many more variables and constraints than ever before.

FICO's optimization also has enabled the NFL to improve the way it creates television packages. In the past, some television placements were determined only after the schedule was set, but with FICO's software the NFL is able to create the schedule and corresponding television packages at the same time.

Faster, more thorough and accurate schedules have translated into higher revenues for the NFL, as the league's television, sponsorship and licensing revenue has grown substantially in the last five years.

"We can solve problems now that we couldn't dream of solving five years ago," says Stone. "The NFL continues to ask for more and more complicated models, and with FICO optimization, we are able to deliver."

"Xpress outperforms other optimization tools, including CPLEX, for our sports-scheduling challenges."

— Rick Stone, *President of Optimal Planning Solutions*

success story: optimization

Optimization drives $19 million gains at Avis

Client Avis Europe, a leading car rental company in Europe, Africa, the Middle East and Asia

Challenge Maximize the use of every automobile in the company fleet

Solution FICO™ Xpress Optimization Suite

Results Two-point increase in fleet utilization, translating into an economic impact of $19 million.

AVIS Europe

"Because of Xpress, the utilization of our fleet has gone up by one or two percentage points. This is a big, big deal for a car rental company."

*— **Jens Utech,** director of backoffice and station systems, Avis Europe*

In the rental car market, success can be measured by a simple calculation: The number of days a car is rented divided by the number of days the company owns that car. And Avis Europe is continually striving to achieve that perfect number.

"It's straight supply-and-demand forecasting; taking fleet information and working out which customers to sell to and how to best distribute our cars," says Jens Utech, Avis Europe's director of backoffice and station systems. "But getting it right is a complex business process that involves many variables."

Each year, Avis Europe serves more than 8 million customers at more than 3,800 locations via the Avis and Budget Brands. It's Europe's No. 2 car-rental agency, controlling 17.7% of the €8.81 billion market in 2007, which comprised 1.2 million vehicles and 44 million rentals.

Avis Europe is perpetually seeking the ideal car-distribution formula—one that maximizes profit and sets pricing appropriate for demand. Previous methods had relied on managers' intuition and produced satisfactory results, but Utech and Avis Europe's board felt that more could be done.

» From "no forecast and no sophistication" to optimization accuracy

For many years, Avis Europe's methodology was to ask fleet managers and station managers to examine the reservation system, using routines that had been in place for years, and use that information to predict future demand.

"Every Friday at 7 a.m., one transporter of cars would go from London Heathrow to Mayfair, due to demand in downtown London on weekends," says Utech. "That's what we always did—but there was no way to evaluate if we could do better."

Pricing analysts would comb through the same data with "no forecast and no sophistication," says Utech, in order to come up with their estimation for appropriate rental fees.

It wasn't difficult to see that margins could be increased through more accurate measurements and decision making so Avis decided to investigate optimization software as a means to more accurately forecast and increase rental utilization. Utech helped narrow Avis Europe's choices, running head-to-head proof-of-concept tests between the industry's two top programs, FICO Xpress Optimization Suite and ILOG's CPLEX, with benchmarks recorded both for long-runtime solutions as well as those derived from truncated optimizations.

"In both dimensions, FICO™ Xpress Optimization Suite was superior to ILOG," says Utech, whose company faces a daily overnight cycle to optimize short-term planning strategy. "In the fixed-time scenario the results were much better, and even when we ran the longer-runtime the results were still better. Xpress is simply a superior product."

» A fast rollout yields impressive results

Using Xpress Optimization Suite, Avis Europe was able to roll out an initial pilot program in only a few weeks. Within the year, a new data-driven forecasting system was deployed. At its heart was the systems-based forecasts which were fed into Xpress. The program then created precise recommendations for fleet distribution and utilization.

"It tells us, for example: On Friday morning, bring only four cars from Heathrow to Mayfair, and bring another four from Stansted Airport," says Utech.

This kind of precise fleet management is just one of the program's benefits. Another is its suggestions for sales restrictions based on rental duration and locations for pick-up and care return. These strategies ensure that the highest possible percentage of Avis' cars go to its most profitable customers.

"To boost profitability, it could tell us not to accept any rental reservations made for less than three days during specific time periods—Christmas, for example," says Utech. And though Avis has not yet implemented pricing-specific optimization, its fleet-use forecasts lead directly to clues for appropriate pricing. "It will tell us that in a special-event situation, we will run out of cars, so it will prompt us to consider raising prices beforehand," says Utech.

» Decisive recommendations, demonstrable improvement

Avis Europe has implemented the program across every key market on the continent. Utech estimates that the program has accounted for a two-point increase in the company's fleet utilization, which correlates to a $19 million increase in incremental analyzed benefits. "This," he says, "is a big, big deal."

Additional benefits include smoother business processes in the areas of pricing and car distribution. Transparency in decision making has also increased with the Xpress reports on the number of reservations at stake for every decision.

Utech feels that Avis Europe's customer base is also experiencing a more subtle benefit: "Even though we haven't made changes to our customer interface, we're now in a better position to put the right car in the right place for the right customer."

"In the fixed-time scenario the results were much better, and even when we ran the longer-runtime the results were still better. Xpress is simply a superior product."

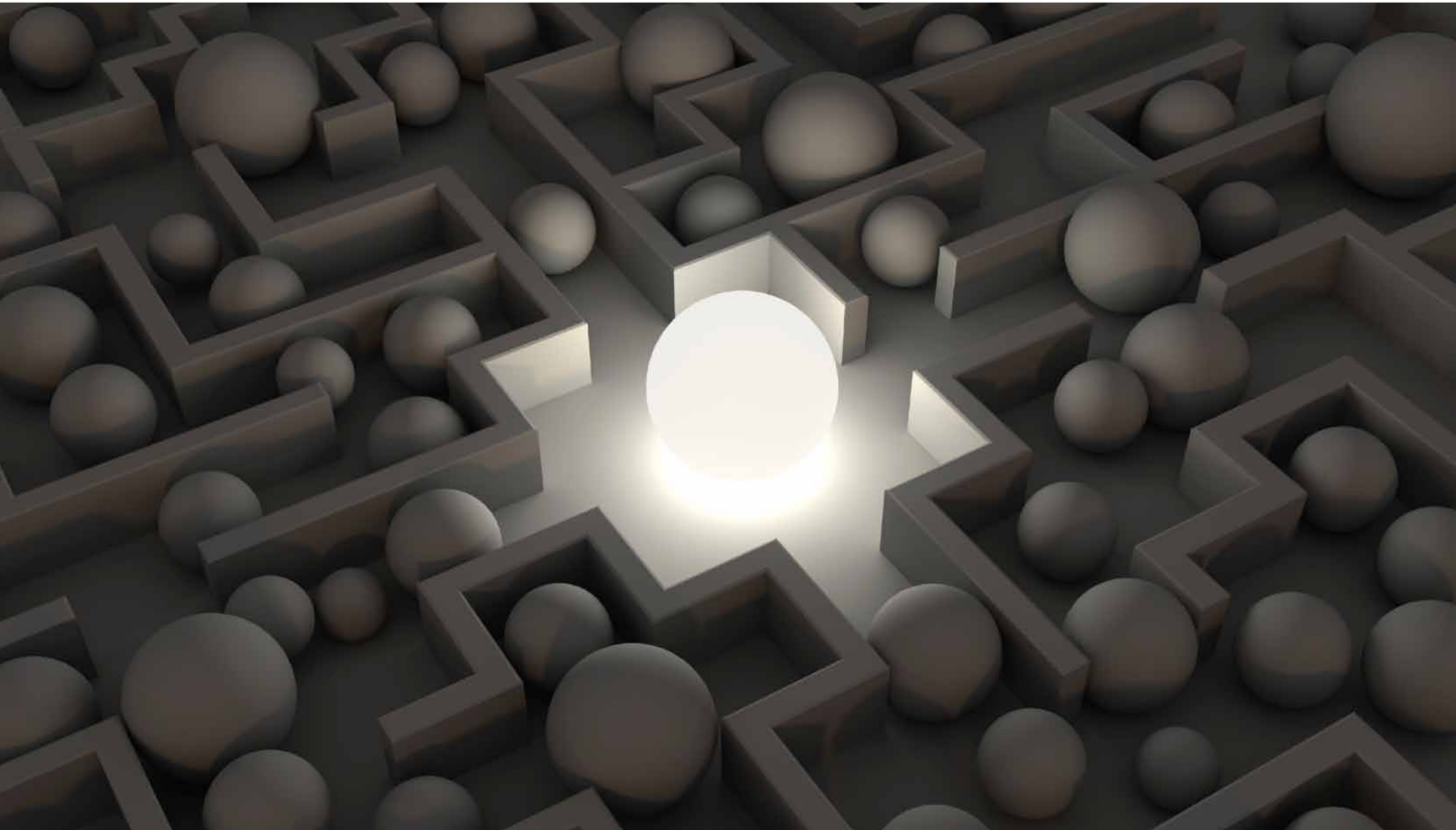
*— **Jens Utech,** director of backoffice and station systems, Avis Europe*

The overall success of the project is leading the company to implement additional automation with Xpress and begin fleet-planning optimization for car-purchasing cycles.

Through it all, says Utech, the service Avis Europe has received from FICO has been exemplary, with responses to specific challenges often coming in less than an hour and actual code patches arriving in less than two weeks.

"There's a strong desire to help, to listen to our problems and to solve them constructively," says Utech. "FICO is clearly a better proactive partner than just about anyone else I can think of in the industry."

White Paper



white paper

Solving the Unsolvable

Conquering gigantic optimization problems with FICO™ Xpress Optimization Suite

January 2011

As problems grow in complexity, advanced solver engines are needed that can tackle large-scale optimization problems. Organizations that solve problems efficiently at all levels of complexity have a unique competitive advantage.

» Summary

Solving large, complex optimization problems can be a daunting task. Conquering them effectively, however, can be the difference between success and failure in today's highly competitive marketplace. For example, retail organizations can efficiently manage floor space, energy companies can optimize production scheduling, marketers can effectively target the right audience with the right offers, personnel planners can generate equitable staff schedules, and transport enterprises can ensure reliable delivery at the least cost.

As problems grow in size and scope, it becomes increasingly difficult to get answers in a timely manner. Recent improvements in optimization solver engine performance have not been sufficient to deal with the challenge of these increasingly complex problems. In many cases, optimization problems are too large to fit into memory, require too much time to compute or are simply too hard to solve.

For these reasons, simply boosting the computational horsepower is often not enough. As one of the ways to address the scalability issue, next-generation solver engines must look for ways to decompose problems into smaller, more manageable components. Doing so will allow even the most complex problems to be solved so that key tactical, strategic and operational decisions can still be made with confidence. Organizations that solve problems efficiently at all levels of complexity have a unique competitive advantage.

» What Is Large-Scale Optimization?

Historically, 16- and 32-bit architectures imposed strict limitations on the size of the problem to be crunched without decomposition. Optimization problems that had 1 million variables and 1 million constraints were on the periphery of solvable sizes. Introduction of 64-bit architectures expanded the spectrum of problem sizes and has made it possible to dramatically increase the size of solvable problems. However, on one hand, some super-large-scale problems are still beyond the hardware capability, and on the other hand, the solver performance decays non-linearly with the growth of the problem size. Therefore, large-scale optimization introduces an added level of complexity that requires creativity to ensure a solution to the problem can actually be derived within the acceptable time limit.

FIGURE 1: FICO™ XPRESS CUTS SOLUTION TIMES DRAMATICALLY

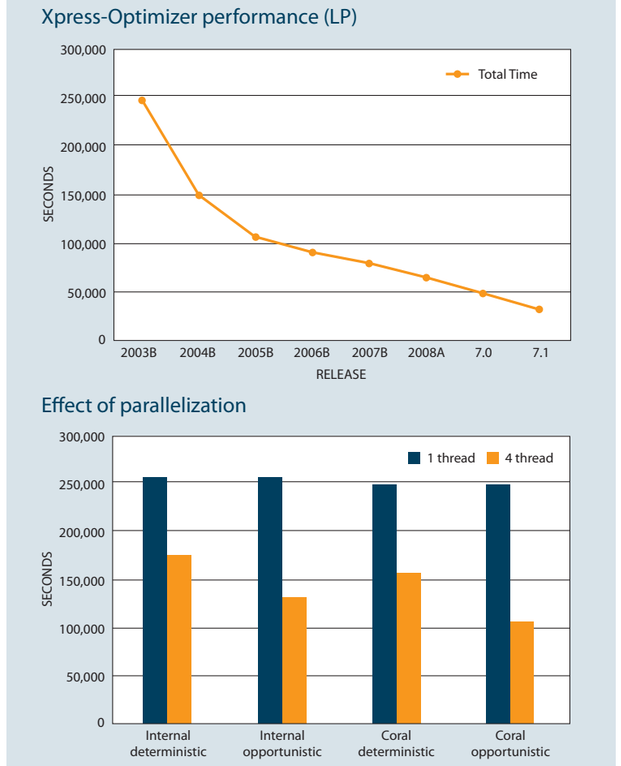


Figure 1 shows improved performance for linear programming across releases and greater speeds through parallelization.

Modeling optimization problems is usually an intellectually challenging exercise. Depending on the problem being solved and the number of constraints that need to be considered, the process for creating an adequate model can take a considerable amount of time without the right set of tools. The situation becomes further complicated once a valid model is developed. You are then faced with deciding how to integrate the optimization execution software that utilizes the designed model with a computer application or a suite of products.

To make this process easier, feature-rich solver engines such as FICO™ Xpress Optimizer have been developed to help streamline the task of creating and deploying models for optimization problems. Leveraging a product like Xpress Optimizer, companies can quickly model and implement complex decision making processes across the organization.

Increasingly, however, problems are growing in both complexity and size, so traditional solver engines will no longer suffice. With large-scale optimization, while performance still remains a key concern, new methods must be introduced to enable solving of problems that cannot otherwise be solved. To this end, the FICO Xpress Optimization Suite has introduced new capabilities that make large-scale optimization problems more manageable and help turn the unsolvable into solvable. The key element in making this happen is *decomposition*.

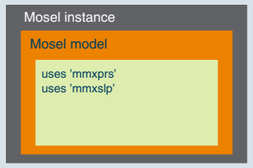
Decomposition is simply the process of breaking large optimization problems into smaller, more manageable sub-problems and solving them either sequentially or in parallel. There are two well-known methods to decomposition, namely Benders, a row generation approach, and Dantzig-Wolfe, a column generation approach.

The solvers and modeling tools of FICO Xpress Optimization Suite support the implementation of decomposition approaches in various ways. Most importantly, the unique features of Xpress-Mosel, the modeling language in the Xpress Optimization Suite, make it a particularly suitable platform for

Decomposition is the process of breaking large optimization problems into smaller, more manageable sub-problems and solving them either sequentially or in parallel.

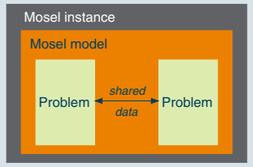
» Decomposition with Xpress-Mosel

the development of decomposition.
Xpress-Mosel is a high-level modeling language combined with standard functionality of programming languages allowing for the implementation of models and solution algorithms in a *single environment*. Through its open, modular architecture, *extensions to the language* can be made without any need for modifications to the core system. The *platform-independent* compiled models (BIM) are portable across all platforms supported by Xpress and protect your intellectual property on deployment. Various *library interfaces* are available for embedding models into applications (C, Java, C#, VB). Model development and analysis is supported by the visual development environment Xpress-IVE and a set of tools (debugger, profiler).



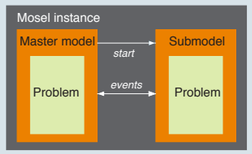
Multi-Solver

Xpress-Mosel is designed with an open, modular architecture. Solvers are modules that are loaded into a model as needed. The Xpress suite comes with a comprehensive set of optimization solvers from which you can choose the one that is best suited for your problem type, or you can use *several solvers in combination* within a single model. Other modules—for example, providing data interfaces or graphics—are also available, and users can even write their own modules to enhance the Mosel language according to their needs.



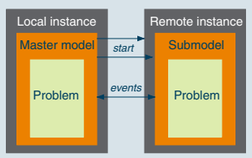
Multi-Problem

With Xpress-Mosel, *multiple optimization problems* can be defined within a single optimization model, making the process of handling large-scale optimization problems much easier. At any point a single problem is active, it is possible to switch back and forth between various other problems, allowing for the retrieval of solution information across problem components. Problems can share data, make use of common decision variables and easily copy constraints from one problem to another or duplicate a problem altogether.



Multi-Model

Xpress-Mosel also allows multiple optimization problems to be implemented as *separate model* (files). This approach is most suitable if the optimization process should be spread along several threads and executed in parallel. Xpress-Mosel's unique implementation characteristics make parallel and multithreaded optimization easily accessible. Readily available communication mechanisms include synchronization of concurrent models based on event queues and data exchange through shared memory.



Multi-Node

Release 7.1 of Xpress extends Mosel's capacities for handling multiple models to distributed computing using several *Mosel instances* (running locally or on remote nodes connected through a network). This facility opens new perspectives for the implementation of decomposition approaches, using all the computing power available in your local network. Moving from a multi-model application on a single instance to a multi-node application only requires few changes in a model, largely due to the concept of I/O drivers—prefixes to the file name that indicate how to access a given file (remotely, in memory, compressed, etc.).

Schemes of decomposition and concurrent solving that can be implemented with Xpress-Mosel include:

- Simple parallel runs (different data instances; different algorithm configurations).
- Decomposition approaches (Benders; Dantzig-Wolfe).
- Column generation (loop over top node; branch-and-price).
- Cut generation (cut-and-branch; branch-and-cut).

Problem solving approaches that involve parallel execution of (sub)models can only be implemented as multiple models, whereas sequential solving can be formulated either way. For sequential algorithms, the developer may choose between the two design options. For more detail on these techniques, refer to the whitepaper *"Multiple models and parallel solving with Mosel"*, located on ***http://optimization.fico.com***.

» Case Study— Retail Space Planning

Challenge:

Retail space planning requires the solution of relatively large Mixed Integer Programs (MIP), very combinatorial in nature, for which the current cutting-edge MIP technology would not find a solution of good quality, even if the solver is left to run for a very long time. Feasibility pump in conjunction with local-search heuristics and other classes of heuristics implemented in Xpress-Optimizer are key techniques of specific broader meta-heuristics designed for retail space optimization. In this case, it is desirable to have Xpress heuristics that can be executed very quickly and to have a modeling environment that gives the user easy and efficient ways to handle multiple large or small models/ MIPs in a sequential or parallel fashion.

Solution:

The core MIP models for space planning are very large and combinatorial in nature. Xpress-Mosel has been a key choice in the implementation of space optimization for a top US retailer, as it gives efficient ways to handle multiple models and fast interfaces between them (e.g., shared memory). As an example, Mosel can have sub-models running meta-heuristics in parallel, while the Xpress MIP solver attempts to close the optimality gap for the core model, within the allowed time. As soon as a meta-heuristic finds a better solution (which is frequent in this type of application) then the solution is submitted to the master model that is solving the core model. Mosel also proved to be a good choice with regard to development time, as the analysts/developers could focus more on the mathematical programming aspects and not as much on how to implement complex decompositions, interfaces and synchronization mechanisms to handle multiple models and solvers in the same project.

FIGURE 2: RETAIL SPACE OPTIMIZATION

Optimized shelf layouts created by Xpress.

Benefit:

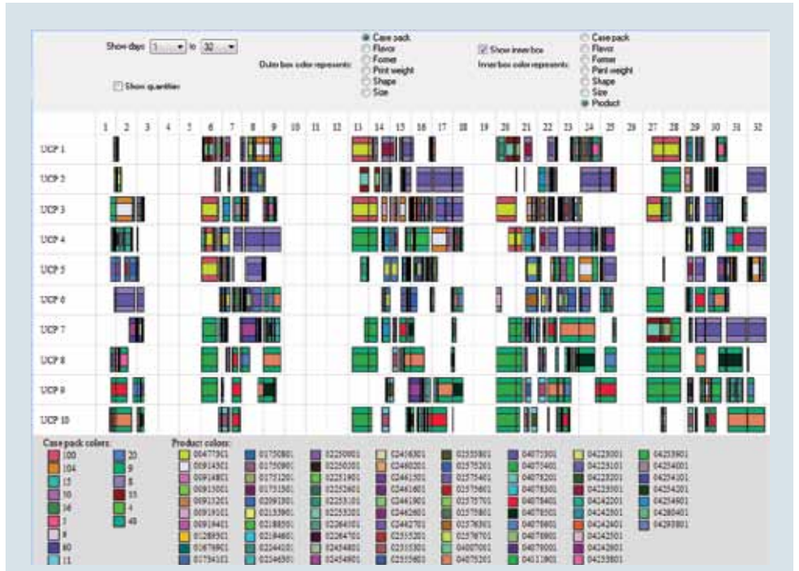
One of the key performance goals was to achieve a good quality solution, between 1% and 2% optimality gap, in a very short time, meaning less than 10 minutes. This could only be achieved with the decomposition approach presented above.

» Case Study— Production Scheduling

Challenge:

Production scheduling requires the solution of very large MIPs. A standard way to solve these problems is to apply chronological decomposition heuristics. As in the previous case, having an effective modeling and development environment is crucial in first finding the required quality solutions and then being able to deliver the model in time for deployment.

FIGURE 3: PRODUCTION SCHEDULING OPTIMIZATION



This Gantt chart generated by Xpress shows optimized production sequence and packaging types.

Solution:

Xpress-Mosel has been used for a large US food/drink manufacturer and has been recently enhanced to support multi-million, more automated production/packaging lines together with the old standard lines. This addition has increased the difficulty of solving the underlying MIPs, which are solved by applying other specific hierarchical decomposition heuristics implemented efficiently and effectively using Mosel. Tuning the Xpress MIP solver for these optimization problems proved to be a crucial step in getting the solve times reduced, as well as in getting the required quality solutions. The Xpress visual environment for Mosel modeling and development, called Xpress-IVE, and the Xpress-Tuner have been proficient tools to perform the tuning step.

Benefit:

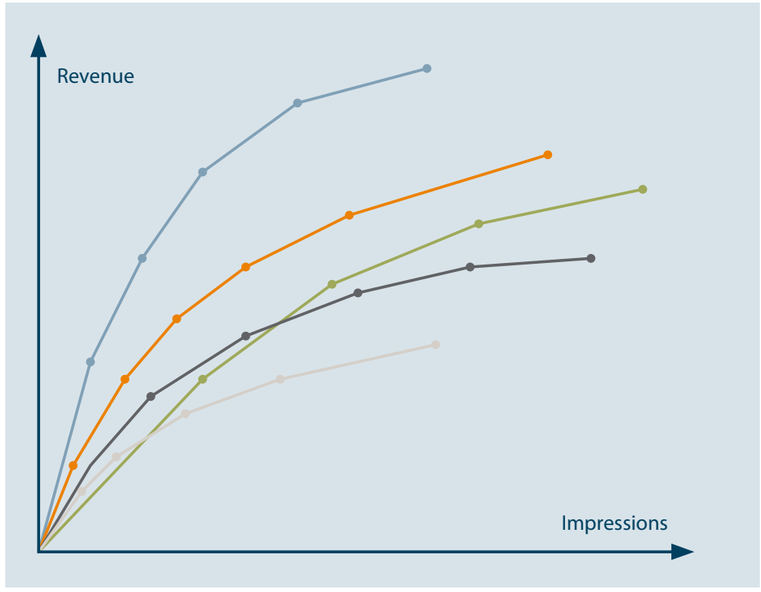
By using this approach we were able to bring down the solve times to approximately five minutes on average, which fulfilled the customer requirements.

» Case Study— Online Advertising

Challenge:

Online advertising allocation and pricing models are frequent in today's Internet market. High volumes of bids need to be processed within extremely short time spans.

FIGURE 4: MAXIMIZING THE IMPACT OF ONLINE ADVERTISING



With efficient implementation of special-ordered sets, Xpress can effectively approximate non-linear functions.

Solution:

The Xpress MIP solver has been selected for several years now by one of the largest software players in the market. The model requires the efficient solution of very large linear programs with both hard and soft constraints that include non-linear terms to handle complex cost and inventory functions. The size of this model is much superior to the size of the models from the previous cases. Therefore, in this case, the interface adopted is Xpress-BCL 64 bit. BCL is an object oriented library interface to Xpress-Optimizer. As a library it requires less overhead in its use than the high-level modeling in Mosel and it grants direct access to advanced functionality of the Optimizer library.

Benefit:

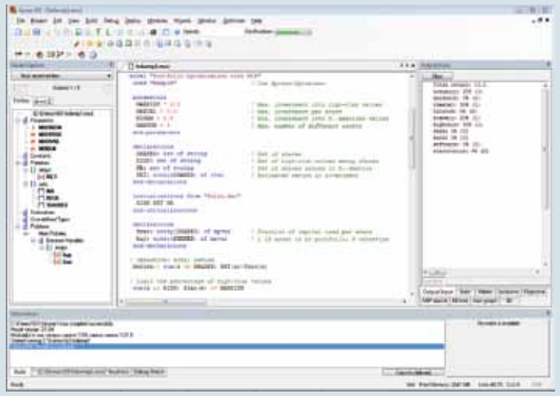
Using very efficient implementations of special ordered sets, Xpress has an effective way to approximate the non-linear functions and hence solves the advertising model within the available time limit.

» About the FICO™ Xpress Optimization Suite

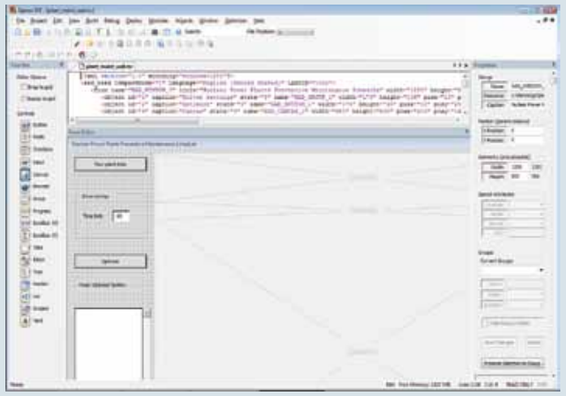
The Xpress optimization suite includes a wide range of fast solvers and modeling interfaces. The modeling and solving environment of Xpress-Mosel is an easy-to-learn modeling and programming language that supports your efforts from rapid prototyping to in-depth model development and tuning. It comes with a visual development environment (Xpress-IVE), that makes it easier for developers to get new optimization initiatives to market faster. The suite also benefits from the close link between Xpress-Mosel and the Xpress solvers and is thus the perfect tool for the implementation of decomposition approaches. An alternative modeling interface is the builder component library Xpress-BCL. This object-oriented library adds advanced modeling functionality to your preferred programming language (available in Java, C, C++, .Net).

FIGURE 5: FICO™ XPRESS VISUAL DEVELOPMENT ENVIRONMENT

Xpress-IVE model editor



Xpress-XAD application design



To get the most out of our software, training courses and consultancy ranging from just a few hours to fully implementing customer specific solutions are offered.

Learn more about Xpress

Xpress website: ***www.fico.com/xpress***
Xpress documentation & whitepapers: ***http://optimization.fico.com***
Searchable on-line examples database: ***http://examples.xpress.fico.com***
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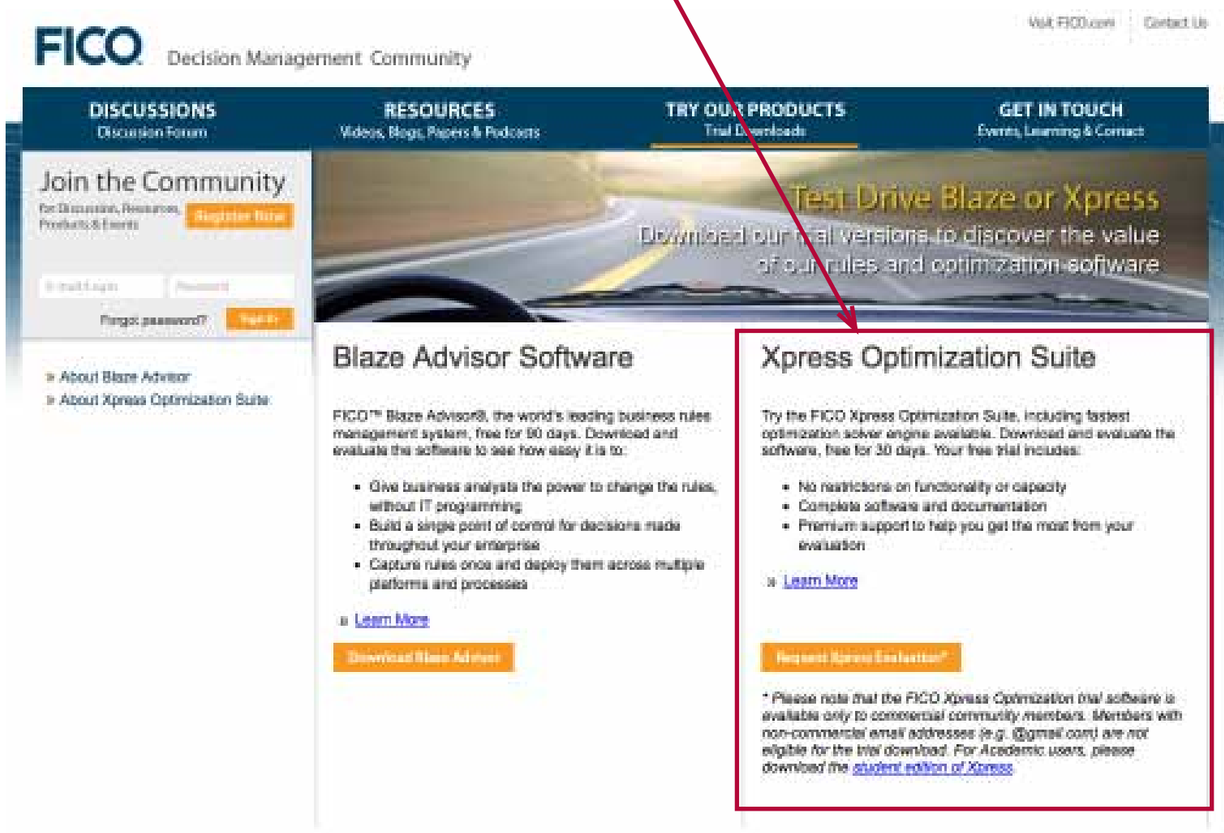

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