By Irv Salmeen and Gint Puskori

Editor's note: This is another in a series of articles profiling members of the INFORMS Roundtable.

OR/MS at Ford Motor Company

As the world's third largest car and truck manufacturer, Ford Motor Company's operations reflect nearly all of the OR/MS topics familiar to the INFORMS community. (We use OR/MS in a colloquial sense and rely on context to distinguish operations research from management science, when it is necessary to do so, especially in historical accounts. Otherwise we blur the boundaries and use mainly the term O.R., implying its broadest meaning.)

An early 1900s precursor of the management science part of INFORMS was Henry Ford's moving assembly line, possibly the earliest large-scale application of "scientific" management applied to assembly-line layout. Henry Ford's moving assembly line evolved over several years and in the same period when Frederick Taylor was laying the foundations for what came to be called "scientific management." Historians seem to be undecided on the extent to which Henry Ford was directly influenced by Taylor – or vice versa – and whether the moving assembly line was "scientific" or trial-and-error tinkering.

O.R. officially came to Ford following the end of World War II with the arrival of a group of 10 U.S. Army Air Force veterans from the Statistical Control Command, an operations management group that coordinated material and troop logistics and in the course invented new ways to approach massive logistics problems. The "Whiz Kids," as this group came to be known, modernized the Ford Motor Company's management practices. Since then, O.R. practice in Ford has tracked the ebb and flow of O.R. practice throughout industry and business. Over the years, many organizations within Ford's different operating units created groups that today we would recognize as O.R., although they were not necessarily named O.R., and these organizations also dropped O.R. when they fulfilled their missions, business needs changed or they failed to deliver on expectations.

The Ford Motor Company does not now have an organization named O.R., although individuals with undergraduate or graduate O.R. degrees (the kind earned in engineering colleges) are scattered throughout the operations. Today, many Ford operations in need of O.R. (for example, supply-chain, outbound logistics, plant-floor production scheduling) use outside O.R. suppliers because operational organizations cannot maintain an O.R. staff to solve problems as they arise. Unfortunately, while outside O.R. providers solve many problems, they sometimes fail for various reasons: the provider didn't understand the business and local conditions; data did not exist because they were never collected or the information systems could not be accessed; and occasionally the business did not adequately specify the problem.

Individual O.R.-trained internal staff working with the suppliers might help to avoid these failures, but there is a class of fundamental failures that arise when the complexity of the problems in combination with Ford-specific circumstances put the problem beyond the capabilities of off-the-shelf solutions of typical providers. This is especially true today when the complexity of the business combined with rapidly changing technology creates problems not previously encountered. Despite occasional failures, Ford has incorporated many O.R.-based solutions that are running invisibly in the background of Ford's daily operations.

The highly visible business challenges facing Ford, and generally the entire automobile industry, are well described in the popular business press. Less well described are challenges arising from extremely fast changes in all kinds of technologies, especially those driven by advances in computers and computing. These advances are happening at rates far faster than the automotive business can digest or comprehend, and they affect the products, the business and manufacturing operations, and policy and strategy. From an O.R. practitioner's perspective these challenges are opportunities, made possible by the computational horsepower now available from laptop to supercomputer, to solve problems of extraordinary depth and complexity. Equally important as raw computational horsepower has been the rapid growth through the 1990s in the availability of cheap data storage, which has driven the astonishing growth of transactional, observational and experimental data in volumes unimagined 10 years ago. The availability of all of these data and computational capability raises the question of what to do with it? The answers lie in the interface between research and practice. Therein lie opportunities for O.R. practitioners to contribute in new ways to business success.

All About the Roundtable

INFORMS has two types of members: individual and institutional. The latter (usually a company) joins by joining the INFORMS Roundtable and appointing as its representative the person in overall charge of O.R.

The Roundtable has been very active since its founding in 1982, with three meetings each year and much communication in between. It, its member institutions and its member representatives take a strong interest in how INFORMS serves the needs of practitioners, and have undertaken many initiatives and provided many services toward this end. These involve, for example, public awareness of O.R., both of the annual INFORMS conferences, continuing professional education, one of the prizes and various committees.

In addition, the Roundtable has an advisory responsibility to INFORMS. One bylaw states that it "… shall regularly share with INFORMS leadership its views, its suggested initiatives and its implementation plans on the important problems and opportunities facing operations research and the management sciences as a profession and on the ways in which INFORMS can deal proactively with those problems and opportunities …" By tradition, it meets with the newly elected INFORMS president-elect each spring to discuss practice-related topics of interest to him or her, and with the entire INFORMS Board each fall to discuss topics of mutual concern.

The Roundtable membership comprises about 50 organizations. Further information is available at http://roundtable.informs.org.

This series of articles aims to share with the INFORMS membership at large some information and insights into how O.R. is carried on in practice today.

Research and Advanced Engineering

THE FORD MOTOR COMPANY'S organization that works in the research-practice boundary is its Research and Advanced Engineering, a 2001 merger of its former Research Laboratory with Advanced Engineering. Ford established a Scientific Research Laboratory in the 1950s for the purpose of understanding the business implications of new science and technology. At various times in its history, the "Lab" engaged in selected, specialized applied mathematics problems that today's INFORMS community, looking back, would recognize as classical O.R. In response to the rapid technological advances in computers and computing, the Research Lab in the mid-1990s gathered a small group of physicists and engineers to explore business applications of advanced mathematical modeling, especially the then nascent field of data-mining and the growth of data-intensive simulation methods (e.g., agent-based methods and neural networks) applied to complex systems. This small group was the nucleus for what became in the late 1990s a 25-person department in the "Lab" devoted to business modeling and O.R. Today, this group, the Business Systems Analytics Group, is the one organization in Ford that comes closest to an O.R. activity with a broad enterprise perspective, including supply chain, plant floor logistics, purchasing, marketing and sales, warranty and product development.

In addition, Marketing and Sales has a 20-person O.R.-like group devoted to specific functional needs. The technical foundations of this Marketing and Sales Group partly stem from a collaboration begun in the late 1990s between Research and Marketing, and that collaboration continues today. Finally, Ford Credit, run as a separate business from the Motor Company, has had for many years an O.R. activity related to financing of vehicle sales to customers through its dealer network.

In addition to applications of explicit O.R.-related methods to business problems, we should point out that many engineering projects within the Research and Advanced Engineering organization use optimization, simulation and other mathematical methods found in the O.R. toolkit. Of particular note is an especially strong Research and Engineering group in applied control theory; O.R. historians know the strong connection between control theory and modern optimization problems taught in O.R.

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The 25 people in the Research and Advanced Engineering's Business Systems Analytics group have degrees (about half with Ph.D.s) in physics, theoretical chemistry, computer science, data-mining, AI, O.R., mechanical engineering, mathematics and statistics, electrical engineering and library science. Several also hold MBA degrees.

About a third of the group's projects are related to marketing questions, for example, econometric and economics models for consumer demand, understanding consumer preferences through the analysis of transactional data, understanding the chain of events from dealer-orders to manufacturing scheduling, and determining vehicle configurations that best match consumer demand and manufacturing constraints.

Other projects include models for commodities pricing, supply-chain and supplier contracts, factory-floor layout, factory-floor information systems and manufacturing scheduling, risk and uncertainty management in volume forecasting and product decision-making, analysis of warranty data and data-base search technologies. A guiding principle is to view all of these problems from a systems-perspective (enterprise view) and engage business-partners across organizational boundaries. For example: marketing questions are tightly coupled to manufacturing and supply-chain problems; business risks and uncertainties propagate across the business because of these couplings; IT owns and provides data and ultimately administers computer-based computational "tools" that emerge from the solutions; operational solutions across systems have to be compatible with financial systems; and so forth.

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The Group's Deliverables

A FREQUENTLY ASKED QUESTION IS: What are the deliverables from this work? Often the deliverable is a "tool," ideally a desktop (laptop) or server-based tool that the business can apply routinely. Usually, these tools are custom-written solutions linked to commercially available programs, such as optimization or statistical packages. These "tools," however, usually arise from a novel framing of the business problem. For example, certain aspects of daily sales rates have the characteristics of a Poisson process, a feature not readily apparent from sales data. By formulating sales as a random process and carrying out Poisson regression, it was possible to gain insights into the implications of fluctuations in sales rates.

Another example has been the framing of consumer-demand and manufacturing supply, taking into account the spectrum of competitive effects, in order to better understand the properties of dynamic pricing and their effects on distribution channels (retail sales, retail leases, rental car sales). A third example was a factory-floor scheduling problem and its dependence on the management of information flow in the manufacturing scheduling system. A fourth example was a systems-dynamics model for steel prices to understand how China's infrastructure construction affected steel demand. This model in combination with an econometric time-series analysis of historical steel prices to estimate mean-reversion tendencies provided a statistical forecast of future steel prices.

The Business Systems Analytics Group also investigates evolving new methods. A notable recent example is the exploration of advances from experimental and behavioral economics. About five years ago, the group was working with the Marketing activity responsible for auctioning cars returned to the company at the expiration of retail leases or bought back from rental companies. The Marketing organization knew that under some circumstances the receiving dealer could avoid transportation and auction transaction costs by buying cars directly from Ford and thereby improve Ford's used car revenue. The question was, how much to charge the dealer – too much and the dealer would prefer auctions; too little and Ford lost revenue. The Business Systems Analytics Group built a game-theoretic model for the dealer-Ford interaction and calibrated the assumptions in the model by conducting economics experiments in collaboration with Hewlett-Packard Lab's experimental economics group. These experiments resulted in a pricing model that increased the "take rate" by the dealers and improved Ford's revenue.

A second example of work in experimental economics was to address a decision problem related to CAFE (corporate average fuel economy) regulations. The problem arises because small, fuel-efficient cars are less profitable than larger cars and trucks. In the established business practice, small cars are one business and large cars are another business, and the low-profit small cars make it possible to meet CAFE regulations while selling the more profitable large vehicles. Internally, small cars essentially subsidize the large cars, yet there was no means of capturing this subsidy in the internal finance systems. The economics experiments were to set up an internal trading scheme by which the large car business would bid for small car profits and, in essence, pay an internal tax to enable them to build the large cars and transfer the "profits" to the small car lines. The results have yet to be implemented, but they revealed the opportunities and requirements for implementation.

Looking for Problems

WE ARE OFTEN ASKED: how does the Business Systems Analytics Group find problems and customers, and how do the results get implemented? The Group is a hybrid between a classical "research" and an internal consulting group. In the research mode, the Group identifies problems because it studies the research literature and various problems of the Ford business, recognizes opportunities for bringing new results into the business, carries out some exploratory work, and then takes the results to the business – knocking on doors and using long-established personal connections into the business.

In this mode, the Group is like any research-entrepreneur activity, and less than 10 percent or so of such projects actually achieve implementation. There are many reasons why projects do not achieve implementation, but these reasons are typical of those in which new ideas are taken to any established business. In some cases, the ideas are not very good because the researchers didn't understand the business problems as well as they thought. In other cases, the costs of changing business practice would be too high to justify. But, when results eventually were implemented, the improved revenues or avoided costs have been in the tens of millions of dollars or more. Importantly, the successful implementations were often built upon the lessons learned from projects that did not directly result in implementation.

In the internal consulting mode, someone in the business requests help. These requests come about largely by internal networking: someone in the business, often at an executive level, knows someone who knows the Business Systems Analytics Group. In many cases, projects are funded by the business as an internal budget transfer. The hard part of these problems is usually to render them tractable from both O.R. and relevant business perspectives. This is a more or less standard challenge in the O.R. consulting business. The only advantages our internal Group has as a "consultant" compared with an external consultant, are usually better understanding of the business, better knowledge of and access to internal data systems, a closer ownership of the problem and motivation to solve it, and in some cases possibly lower cost to the business.

The core problem for practitioners of O.R. in a large, complex business such as Ford is that O.R. is a service to the business. The practitioner's main challenge is to gain the confidence and trust of the business; only rarely will someone in the business share the technical enthusiasms of the O.R. practitioner. For practitioners in a business of selling O.R. solutions or "tools" (e.g. SAP or IBM Business Services), their business necessarily supports the O.R. technical personnel with sales support personnel to search out customers. In contrast, for practitioners employed within a business, O.R. services and "tools" are not usually the mainstream interests of the business, even though the internal O.R. practitioners may produce a path to improved profitability.

Consequently, internal technical practitioners must be their own salesmen, and they must invest in understanding the business and building relationships that lead to trust and implementation of their work. In the end, however, the business, not the O.R. practitioner, will be rewarded for the improvements, which is reasonable because the business decision-makers bear the responsibility for profit and loss. In some respects, there are similarities between O.R. practitioners working inside a company and other professional staffs such as legal staff or IT. The traditional business paradigm is to answer the questions: Who are our customers, what will we make, how will we sell it, how will we profit? Internal practitioners need a dual view of these questions – from their company's perspective and from their own professional perspective. ORMS

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