In today’s world, where globalization is a fact of business life, where competition is fiercely intense and where concerns such as energy security and climate change are global in scope, a science-based approach to decision-making and problem-solving is essential.

At General Motors, operations research provides that framework, particularly for complex issues and systems that involve multiple objectives, many alternatives, trade-offs between competing effects, large amounts of data and situations involving uncertainty or risk. In truth, for an entity the size of General Motors, these are the only kind of challenges the company faces because GM is huge and no issue is simple!

With products that range from electric and mini-cars to heavy-duty full-size trucks, monocab and convertibles, GM offers a comprehensive range of vehicles in more than 120 countries around the world. Along with its strategic partners, GM sells and services vehicles under the Chevrolet, Buick, GMC, Cadillac, Opel, Vauxhall, Holden, Baojun, Wuling and Jiefang brand names. GM also has significant equity stakes in major joint ventures in Asia, including SAIC-GM, SAIC-GM-Wuling, FAW-GM and GM Korea.

GM has 212,000 employees located in nearly 400 facilities across six continents. Its employees speak more than 50 languages and touch 23 time zones. The work they do demonstrates the depth and breadth of the auto business – from developing new vehicles and product technologies to designing and engineering state-of-the-art plants, organizing and managing the company’s vast global supply chain and logistics systems, building new markets and creating new business opportunities.

The work is multifaceted, but whether in Detroit, Frankfurt, Sao Paulo or Shanghai, the goal is straightforward: offer products and services that establish and maintain a deep connection with customers around the world while simultaneously generating revenue and profit for the company.

Considering the complexity of the challenges in the auto business and the speed at which change is occurring in every arena – technology, business, materials and resources, governmental policies and regulations – it is critical to employ a scientific approach in thinking about and attempting to understand problems and implement viable solutions. Today, no area of GM is untouched by analytical methods.

**The Early Years**

Even before the industry entered the current period of globalization and profound technological change, operations research was valued within GM. As early as the 1960s and 1970s, GM employed analytical techniques for transportation studies and traffic flow analyses. In the 1980s, GM...
developed analytical principles and used mathematical optimization methods to improve assembly line job sequencing. In the 1990s, it patterned warranty cost reduction analyses after Centers for Disease Control epidemiology studies.

In 2005, GM won the Franz Edelman Award from INFORMS for its work on production throughput analysis and optimization. Even when overall industry production capacity is above demand, it is usually the case that demand for certain “hot” vehicles exceeds planned plant capacities. In such cases, an increase in production capacity will generate larger profits via more sales revenue and/or overtime cost avoidance.

GM’s operations research team analyzed production throughput using math models and simulation, identified cost drivers and bottlenecks, and developed a throughput improvement process to increase productivity and reduce costs. The resulting software has been enhanced over a 20-year period to extend GM’s capabilities, enabling it to accommodate product and manufacturing flexibility, variable control policies and more complex routing. The software is used globally in GM plants, as well as to design new production systems and processes.

This long-term effort is just one example that demonstrates how GM has applied O.R. methods to change the way it leverages operations research and advanced analytics on a continuing basis. The importance of activities like this in a company the size of GM cannot be fully measured. For plant throughput alone, the savings are estimated at more than $2 billion over the past two decades. But just as important as the economic benefits is the mindset—the scientific approach to problem-solving, decision-making, scheming the business, and identifying new opportunities.

**O.R. at GM Today**

Given the success of the work described above, the R&D Operations Research team broadened its mission about five years ago and today provides a research capability within the company focused on tackling long-term strategic challenges. With the wide-ranging scope of potential assignments, the O.R. team is composed of Ph.D. and master’s-level technical experts, along with subject-matter experts with hands-on and executive leadership experience in key areas of the business, such as manufacturing, supply chain, engineering, quality, planning, marketing, and research and development.

Projects are aligned with top company priorities, which are based on a combination of business performance drivers and senior leadership input. The work may start with targeted questions, e.g., what’s the opportunity of (fill in the blank), or it can focus on improving operational effectiveness through process improvements in areas such as manufacturing productivity, capital or supply chain management, or dealer inventory management. Many opportunities to improve revenue management exist through the application of tools and systems that help decision-makers optimize portfolio planning, reduce complexity, target incentives, or optimize content and packaging. In addition, given the large new data streams coming from the intelligence available in today's vehicles, new emphasis is being put on improving vehicle efficiency, quality and diagnostics, as well as more deeply understanding customers so GM can provide differentiated value through new automotive products and services. The team’s implementation model comprises a mix of:

- analysis by internal consultants to understand the issue,
- capability development, including analytical principles, math models and tools, and
- partnering with stakeholders and decision-makers early to scope and maximize the potential impact of implemented solutions.

**O.R. Drives Transformation**

The R&D Operations Research team recently received two “team GM Transformer” Awards for developing business tools that use “big data” and analytics to improve decision-making. This is an internal award that rewards employees who are lead-
ing change across the company by finding significant and innovative ways to drive GM business priorities.

One of the O.R. team’s Transformer Awards recognized new analytic tools to support GM’s Product Development activity. These include a range of tools that help guide engineering decisions to reduce complexity in the vehicle and powertrain, apply market research to vehicle attribute balancing and optimize portfolio planning in light of greenhouse gas performance objectives. The other award was for development of a new approach to optimizing inbound logistics. This tool is being expanded to support its use by all vehicle programs early in the vehicle development process.

With the exponential growth in data, the ever-expanding digital connection to customers and the introduction of exciting new vehicles technologies, this is an exciting time for operations research at GM. With so many research-rich opportunities, the team is always mindful of the characteristics that are key to successfully applying O.R. methods and achieving organizational excellence, including the ability to:

• choose the right problem to address;
• see and convince others that a complicated problem is important and solvable;
• work as part of a team toward a common and well-defined goal;
• have tenacity in chasing down details and data, and then equal tenacity in the implementation of a solution;
• get the model to the right level of detail for the purpose at hand so it is not too complex, nor too data intensive, but sufficiently detailed to capture the salient characteristics and trade-offs;
• engage the key stakeholders in the process of development and implementation, in order to gain joint ownership. Technology transfer is something that takes place between consenting adults; and
• deliver an O.R. solution to decision-makers in a form or format that they can understand and act upon.

O.R. practitioners who embody these characteristics can have a profound impact on their organization, help their company rise above the competition, and most importantly provide increased value to customers. As the world goes global – as innovation strives to create more, faster, better and at less cost; as new business and technology paradigms emerge – endless opportunities abound to take advantage of operations research and reap the substantial good that can be realized from its practice.

Jonathan H. Owen is Director of Operations Research at GM R&D. David J. VanderVeen, now Director of Analytics in GM Global Product Development, was formerly Director of GM R&D Operations Research. Lerinda L. Frost leads executive communications and business support at GM R&D.