BY MICHAEL GRANT

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

O.R. Soars at Boeing

BOEING IS THE WORLD'S LEADING AEROSPACE COMPANY and the largest manufacturer of commercial jetliners and military aircraft combined. With additional capabilities in rotorcraft, electronic and defense systems, missiles, satellites, launch vehicles and advanced information and communication systems, the company's reach extends to customers in 145 countries. In terms of sales, Boeing is the largest U.S. exporter.

Headquartered in Chicago, Boeing employs more than 155,000 people in 48 U.S. states and 67 countries, with major operations in the Puget Sound area of Washington State, southern California and St Louis. Total company revenues for 2005 were $54.8 billion.

Boeing is organized into three business units: Boeing Commercial Airplanes, Boeing Integrated Defense Systems and Boeing Capital Corporation. Supporting these units is the Shared Services Group, which provides a broad range of services to Boeing worldwide, and Boeing Engineering, Operations & Technology, which helps develop, acquire, apply and protect innovative technologies and processes.

Operations Research at Boeing

THE NATURE OF THE BUSINESS and the breadth and depth of technology and products provides a very rich environment for operations research (O.R.) opportunities. There are literally hundreds of people practicing O.R. in the company. Within Boeing Engineering, Operations & Technology, there is even a group called "Operations Research."

Often, organizational developers debate the pros and cons of either housing O.R. practitioners centrally or dispersed in various program or functional areas. At Boeing, the answer is "yes" – people practice O.R. throughout the company in both centrally designed organizations and in a dispersed manner, particularly when the O.R. application is focused or sustained in a business unit.

The Boeing Math Group

THE FORMAL Operations Research Group resides in Bellevue, Wash., and is part of a larger group of mathematicians and engineers collectively known as *The Boeing Math Group*. The formal name of the group is Mathematics and Engineering Analysis. As other industry groups have experienced, marketing one's services as an O.R. or Math Group can be challenging. Fortunately at Boeing, people both inside and outside of the company know about *The Boeing Math Group*, even though there's no organization with that title.

The O.R. Group consists of between 10 and 20 professionals ranging in experience from less than five years to more than 40 years. The larger math group has about a hundred professionals who work in complimentary groups with titles such as: Geometry and Optimization, Applied Statistics, Mathematical Modeling and Computational Mathematics. It's conceivable that the entire group practices O.R. in some way or another. Approximately two-thirds of the members have earned their Ph.D. and almost all have a graduate degree.

The O.R. group is part of a research and development organization within Boeing known as Phantom Works. The group is primarily funded through direct work in support of internal Boeing customers in the major business units. Most of the projects tend to be the more technically advanced and challenging projects that can benefit from the services of a highly experienced, technically advanced group of O.R. practitioners. A significant portion of the work is funded through internal research and development dollars targeted for both short- and long-term research. Members of the group need to be proficient in conducting basic and applied research in an industry setting.

Clearly, one can say that Boeing has applied O.R. since the beginning. However, it's hard to determine exactly when the formal group started. It's also difficult to know how many groups within Boeing practice O.R.

Application Areas

HERE ARE A FEW EXAMPLES within the Boeing Math Group that provide an idea of how O.R. is making a positive impact on the company.

New products – 787 Dreamliner. Responding to customers' preferences, Boeing is in the process of developing a new super-efficient aircraft known as the 787 Dreamliner (illustration). The plane will be assembled in Everett, Wash., starting in 2007 and will enter service in 2008.

The fact that Boeing opted to produce a much more efficient aircraft as opposed to a much faster, sonic cruiser is a result to some extent of choice modeling analysis conducted by statisticians in the Math Group. Other contributions from the group include simulations and experimental design and analysis of data to address passenger comfort. With the 787, passengers will notice improvements from an interior environment with higher humidity to increase comfort and convenience.

As much as 50 percent of the 787 primary structure will be made of composite materials. The process to produce the fuselage structure using composite materials involves the use of an automated tape-laying machine. Mathematicians are working to find the optimal sequence of passes of the tape laying heads to produce the structure in the most efficient manner.

Operations research is also supporting the sales and marketing teams who are interfacing with airline customers throughout the world. O.R. analysts are developing fleet optimization and assignment models to help determine the best mix of aircraft for an airline to fly in their inventory and the best strategy for determining which aircraft will operate on each flight segment.

Air transportation modeling. Challenging opportunities in the context of supporting a safer and more efficient air transportation system provide the basis for many O.R. projects in the group. Analysts are working with business units to determine strategies for modernizing the nation's air traffic management system. Improving airlines' performance also contributes to improvements in the air transportation system.

Developing models, simulations and tools are essential in understanding how future air operations will benefit from upgrades and renovations to the systems. One such tool used to assess a range of operational concepts for collaborative flow management is the Boeing National Flow Model (NFM), a dynamic simulation model representing the U.S. National Airspace System. O.R. Group members have embedded baseline and advanced airline schedule recovery models in the NFM and are working to better address the impacts of disruptions such as convective weather on the system.

System of systems technologies. O.R. is critical in designing system-of-systems (SoS) architectures. One characteristic of a SoS is that the systems are developed independently and come together to perform a new function as a super-system. This creates a very complex environment and is typical in the context of military operations. O.R. analysts are developing algorithms for distributed optimization to support advanced concepts in the military decision making structure. Boeing is the lead integrator on many major defense programs to include the Army's Future Combat Systems (FCS) program.

One of the more challenging SoS problems is how to allocate limited resources in an optimal manner in real-time in an environment where control of the resources may or may not be under the control of a central authority. These problems are generally very large, extremely complex and require significant computational capability. Scientists will be working on these problems for many years to come.

Spares and inventory management. Boeing operates the aviation industry's most comprehensive spare-parts sales and distribution network, maintaining inventory for about 500,000 different types of parts to support the worldwide fleet. Members of the O.R. Group are applying inventory control theory, forecasting and discrete event simulation to analyze and develop tools and systems in support of managing the spare parts inventory. Staff members also perform analysis in support of supply chain management activities to ensure higher levels of customer service and reduced costs for parts and logistics support.

Data fusion, tracking and sensor location. The process of combining data from multiple disparate systems is common in many Boeing products, especially in systems involving sensors or tracking devices. Another challenge related to sensors is the classical O.R. problem of where and how many sensors to deploy to achieve a specified level of coverage. Members of the group have been working these problems for years, and they will continue to look for new and better ways of accomplishing these tasks. One new area of interest is in sequential, Monte Carlo estimation. Some members of the group have earned patents for their work in developing trackers. This area continues to be a fertile environment for research and development.

The Operations Research Practice at Boeing

WHILE IT'S DIFFICULT TO discuss all of the O.R. projects at Boeing, it is easy to comment on the success of the O.R. practice. Throughout the company, practitioners are making contributions that directly impact the bottom line. Opportunities abound for operations research activities.

In the O.R. Group, analysts are developing and applying techniques in many areas of the company. Fostered by a unique, professional environment, members tackle the most difficult and challenging problems. As a result, Boeing is better able to develop and provide highly reliable and safe airplanes for travelers throughout the world and to better equip the military with the most technically advanced systems to defend the United States and its allies. ORMS

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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.