

SUPPLY CHAIN SIMULATION AND ANALYSIS WITH SIMFLEX™

Edward J. Williams
Ali Gunal

Production Modeling Corporation
Three Parklane Boulevard, Suite 1006 West
Dearborn, MI 48126, U.S.A.

ABSTRACT

As businesses and industries become steadily more global in their operational scope, and more intensely competitive, achievement of a lean, efficient, reliable supply chain increases in both importance and complexity. Recent research comprises many ideas to help engineers and managers construct and maintain such a supply chain. Additionally, numerous software vendors have endeavored to develop software packages specifically adapted to the modeling and analysis of supply chains. To earn regular value-added use within a business, such a package must offer high analytical power, ease of learning and use, and ability to interface with databases and spreadsheets for convenient import of data and export of results. This paper presents an overview and brief tutorial of SimFlex™, a supply-chain simulation software package offering these virtues.

1 INTRODUCTION

Improvement of supply chains has become of vital importance to many businesses, for many reasons including rapid globalization, intensifying competition, attractive benefit-to-cost ratios, the trend away from frequent price-shopping and toward long-term relationships (such as vertical deintegration) with trusted suppliers (Hopp and Spearman 2001), and the increasing realization that localized improvements to factories and warehouses are of limited value if the supply chain within which they operate is inefficient (Teach 2002). Shankar (2001) has further emphasized that supply chain integration ought to encompass both the upstream (supply side) and the downstream (customer side) of the supply chain. For example, Raytheon has saved \$400 million (U.S.) by linking supply chains (Avery 2001).

Due to the many and influential sources of stochastic variation and interdependencies within supply chains, simulation is a highly effective tool to help engineers and managers make operationally and economically sound business decisions (Simchi-Levi, Kaminsky, and Simchi-Levi 2003). Successful applications of discrete-event simulation and


analysis of supply chains are appearing more frequently in the literature (Wyland, Buxton, and Fuqua 2000). An early survey (Matwijec and Buxton 1999) enumerates specific ways simulation can be used to improve supply chain performance. Illustratively, Merkurjev et al. (2002) used simulation to assess the bullwhip effect under different information-sharing strategies. Jain, Choong, and Lee (2002) extended the scope of a simulation study of computer assembly operations for the explicit inclusion of supply chain integration. Bruzzone, Mosca, and Revetria (2002) have constructed a web-integrated logistics designer (WILD II) to integrate modeling techniques and Nash Equilibrium Architecture when analyzing supply chains. Increasingly and justifiably, attention to supply chain analysis, management, and improvement is spreading from large companies to smaller ones; indeed, the smaller companies and their larger counterparts are often participants in the same supply chain (Chapman, Ettkin, and Helms 2000).



2 OVERVIEW OF SIMFLEX™




SimFlex™ is owned by Flextronix, the largest contract manufacturer, and marketed largely through rigorously vetted resellers capable of providing analytical model-building, training, and support services to clients using it. SimFlex™ is a software tool, compatible with Microsoft™ Windows operating systems, dedicated to the simulation and analysis of supply chains; it combines high analytical power with ease of learning and use, ability to interface to data stored in Microsoft™ Excel and/or Access, readily available animation, and user-customizable reports. Hence, SimFlex™ can attack strategic planning problems on many fronts, including manufacturing (e.g., where to place facilities?), transportation (e.g., which transport modes and routes?), procurement (e.g., from where and whom?), distribution (e.g., what type(s) of logistics facilities?), sales (e.g., channels versus direct?), and tradeoffs (e.g., profit versus market share?, service level versus inventory?). SimFlex™ analyses can readily accommodate multiple performance criteria and run multi-scenario comparisons.

3 MODEL CONSTRUCTION AND INPUT

After opening SimFlex™, the analyst chooses a geography (e.g., “World,” “Europe,” “Great Britain,” “Canada,” ...) and a map underlain by a detailed geographic database of cities and their relative locations. As examples of the high level of detail available, the United States database includes information on the towns Duluth, Minnesota; Superior, Wisconsin; and Virginia, Minnesota; all in the north-west Great Lakes region. The European database includes information on the towns Hastveda, Lund, and Orkelljunga in southern Sweden. Next, the analyst places icons repre-

senting corporate headquarters , corporate or sup-

plier plants , distribution centers (warehouses) ,

terminals , sales offices , and customers  on the map. Next, the analyst specifies details pertinent to each of these entities via menus opened by right-clicking on each icon. For a plant, the analyst specifies details of its suppliers, production policy, production and inventory control, delivery policy, and cost-&-time structure. Additionally, the analyst may specify plant operating hours by a schedule of weekly, monthly, or yearly periodicity. Ware-

housing capacity at a plant may be simulated with respect to any or all of receiving, storage, or dispatching capacities. For a distribution center, the analyst specifies details of its suppliers, inventory control, capacity constraints, delivery policy, and cost-&-time structure. Here too, extremely fine detail is available to the analyst. For example, the inventory control specification allows the analyst to stipulate that a distribution center has excess capacity available at $x\%$ inventory-carrying cost. Inventory control may be specified as MRP [Materials Requirements Planning], PTO [Produce to Order; a synonym within SimFlex™ is “MTO” [Make to Order]], Reactive, Passive, or a “fixed plan” specified by the analyst via an input file. The delivery policy specification allows the analyst to stipulate, with one mouse click, that consignments are consolidated. The specification of logistics (transport) services permits setting costs (fixed, per mile, per shipment, or any combination of these), pick-up time, drop-off time, and speed. The cost-&-time structure specification allows apportionment of costs among categories including vehicle loading, vehicle unloading, monthly cost per unit weight in storage, transit container costs, and fixed daily costs. The analyst can group customers by defined segments to specify which distribution center, by default, supplies each customer. Further, the analyst can group customers by market niche. For simulation, customer buying strategies may be specified; these specifications include supplier-selection periods and customer tolerance thresholds for weighted service parameters such as availability of ordered material, percentage of orders filled completely and/or correctly, and per-

centage of tardy deliveries. Customer demand is specified in units of items/year, with frequency of orders and requested delivery time also specified.

4 MODEL EXECUTION AND OUTPUT

After choosing “Simulation” on the main menu, the analyst sets execution parameters such as warm-up period, run length, and number of replications. Additionally, the analyst may choose whether to import customer orders from a specified source or to generate them randomly. After starting the run, animation appears upon a background of the geography map originally chosen by the analyst and populated with headquarters, plants, distribution centers, terminals, sales offices, and customers. This animation displays a digital calendar and clock. All transmissions of a purchase order upstream in the supply chain, and all transmissions of a shipment downstream in the supply chain, are shown. Significant events such as stockouts are highlighted in red. SimFlex™ routinely generates complete financial statements based on bills of material [BOMs] to any desired depth. Activity-based costing [ABC] reports are provided on request. Scenarios competing for managerial adoption can be automatically compared in output once they have been modeled. Graphical flow analysis output superimposes logistical flows (the thicker the line, the heavier the traffic) upon the map originally chosen by the analyst at model build time.

5 CASE STUDY

The fictional Printex Company manufactures printers (having two components) and facsimile machines (also having two components), thereby serving thirty customers in the United States. The supply chain comprises a vendor’s plant in Guadalajara, México; the corporate manufacturing plant in Amarillo, Texas; two distribution centers (Los Angeles, California, and Chicago, Illinois), and the customers.

The analyst must specify the products and their hierarchical component structure, much as shown in Figure 1 on the next page.

Another step in building this model involves specifying the facilities and their locations. Figure 2, shows a portion of the map just after this work is completed. The dashed lines (green) specify linkages to customers; the solid lines (yellow) specify linkages to distribution centers. Conveniently, the solid (yellow) lines are labeled, as is indicated here, by the total number of products which travel along each such linkage. Hence, an incorrectly specified or illogical grouping of customer supply assignments is readily noticeable.

Other significant steps in constructing the model are specification of customer demand and distribution-center inventory control policies, as shown in Figure 3 and Figure 4.

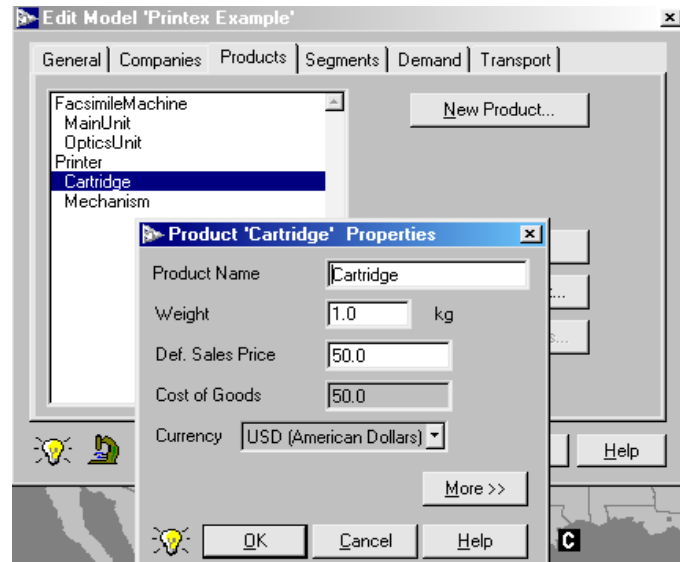


Figure 1: Specification of Products and their Component Structure

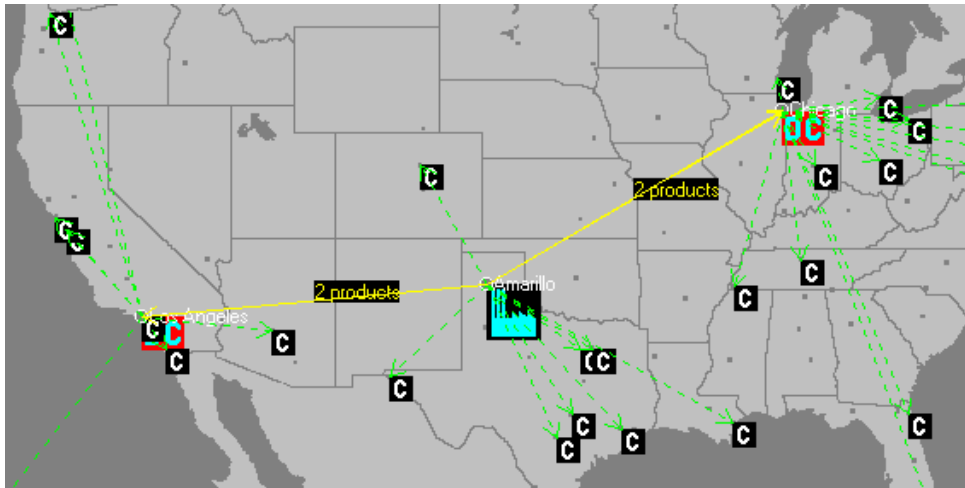


Figure 2: Specification of Supply Chain within Geographical Context

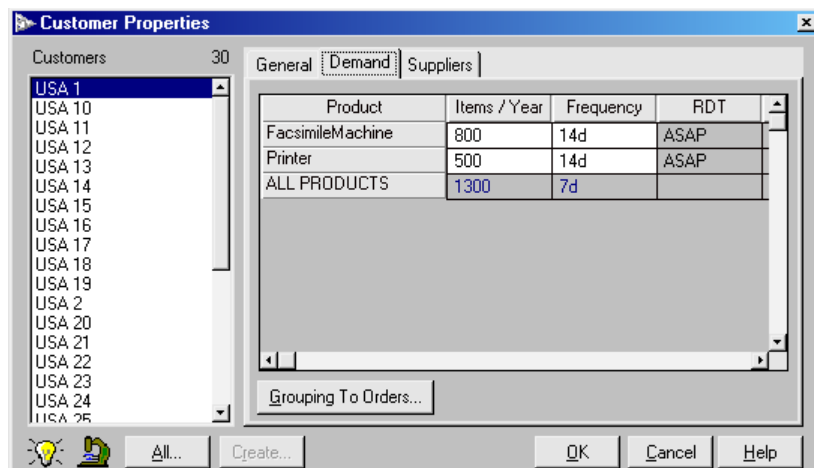


Figure 3: Specification of Customer Demand

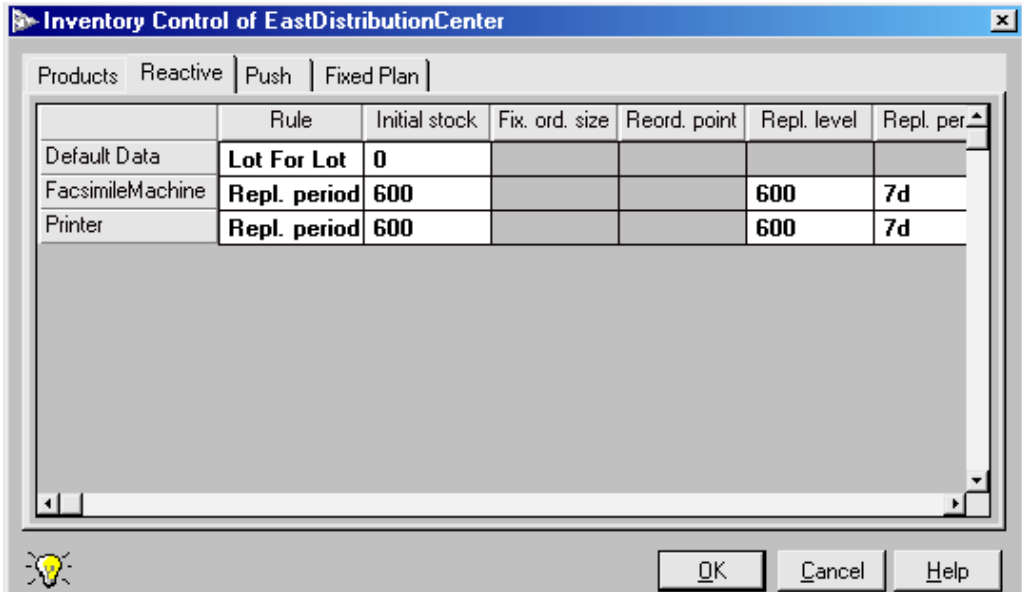


Figure 4: Specification of Inventory Control Policy

Next, the analyst specifies logistics services and delivery policies, as illustrated in Figure 5 and Figure 6. The specification of logistics services accommodates options such as whether the service is a default one, and the cost calculations (e.g., per shipment or per unit of distance). Pickup time, drop time, order processing time, and minimum charge can all be specified.

The specification of delivery policies permits (for either a manufacturing plant or a distribution center) choice of routes, whether rerouting will be allowed during delivery, allowing or forbidding breaking of orders, and whether

consignments can be consolidated. Estimated delivery time and safety margin can be specified.

Before running the model, the analyst can select Analysis/Analysis Manager from the main menu to specify particular graphs desired, such as a chart of finished goods inventory at the manufacturing plant as a function of time and/or a chart of total inventory at the western distribution center as a function of time. Figure 7 shows one stage in this specification. A large number of standardized reports and formats are conveniently available. Analyses are available for either market total demand or market daily demand.

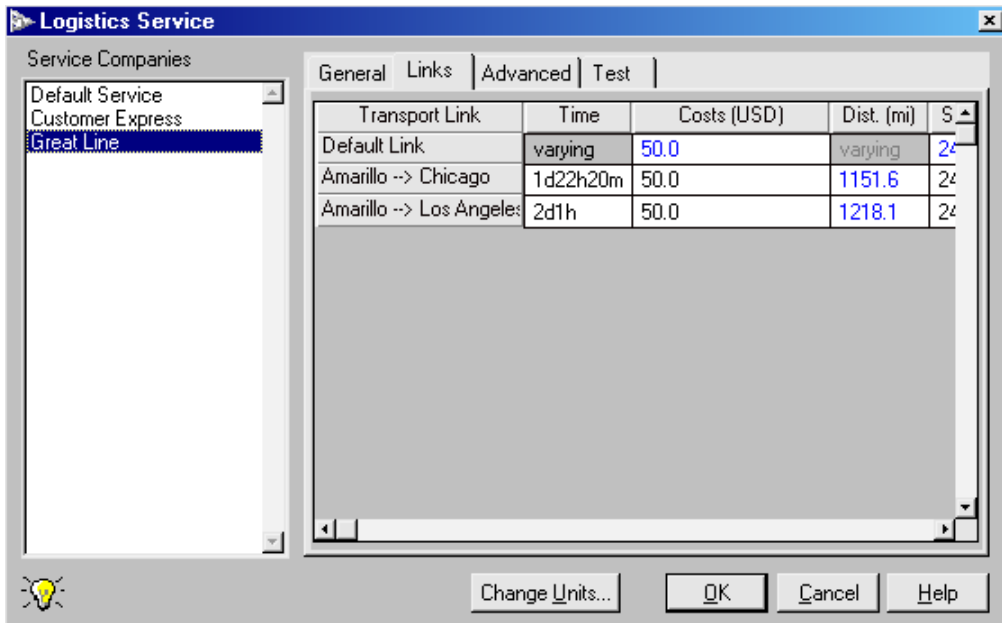


Figure 5: Specification of Logistics Service

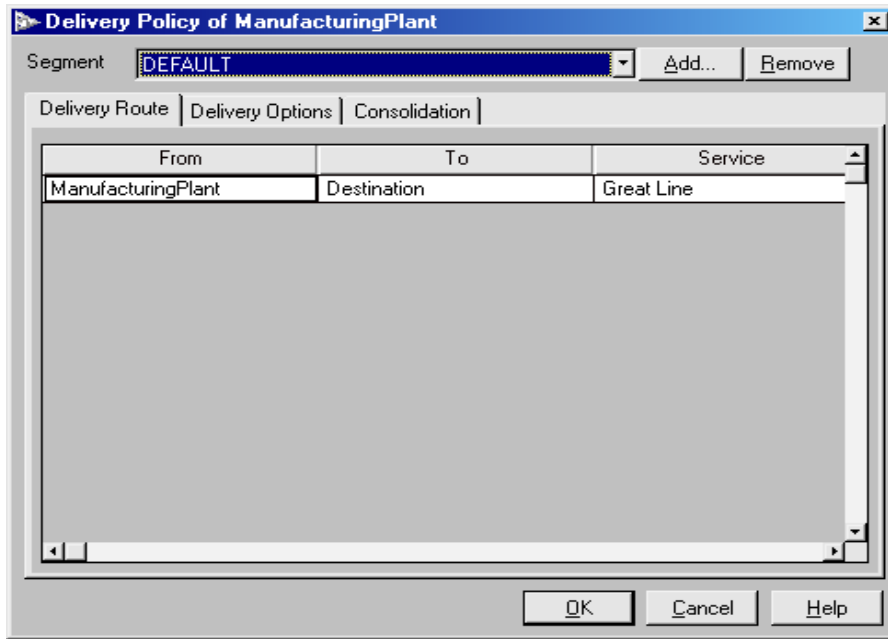


Figure 6: Specification of Delivery Policy

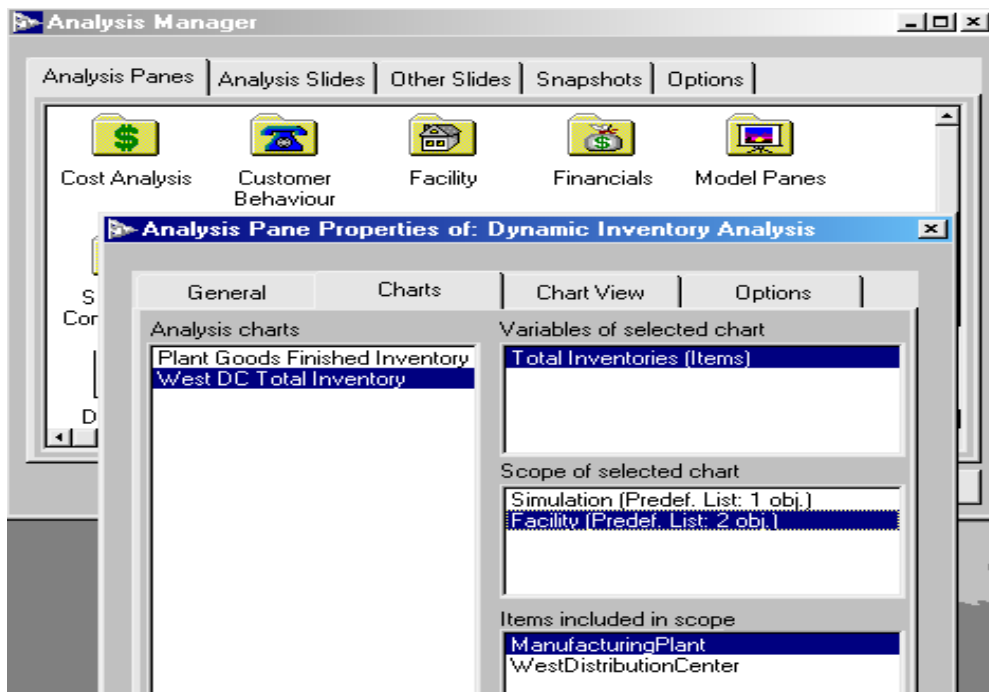


Figure 7: Specification of Output Charts

After running the simulation model and viewing the animation as described in the previous section, the analyst can revisit the “Analysis Manager” main menu choice to select and view both default output and the explicitly built charts, two examples of which are shown in Figure 8. Standard hyperlinks are provided between charts, and the analyst can specify additional hyperlinks. If the model geography spans countries with different currencies, the ana-

lyst may choose the currency in which results will be displayed. The analyst may specify whether the Analysis Manager automatically closes when an analysis pane is opened, and whether charts will have borders. Charts may be readily and conveniently reformatted for compatibility with PowerPoint®, and the analyst may specify whether to open them in PowerPoint® or PowerPoint® Viewer.

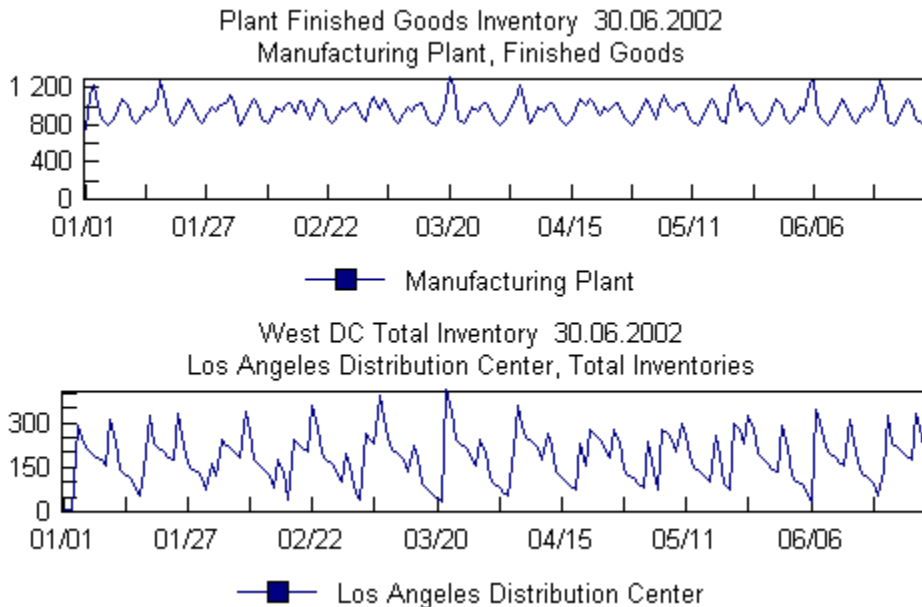


Figure 8: Examples of Analyst-Specified Output Charts

6 SUMMARY AND CONCLUSIONS

In this paper, we have first summarized the motivations for simulation analyses of supply chains. Next, we described and illustrated the use and capabilities of SimFlex™, a software tool for such analyses. SimFlex™ combines the ability to undertake highly detailed modeling with ease of learning and use, modular model building, and convenient interface, both for input and for output, with other computer software tools. Output reports, charts, and graphics are extensive, customizable, and consistent with accounting standards for financial statements. Therefore, SimFlex™ is not only a powerful analytical tool in its own right, but capable of interfacing smoothly with ERP software.

ACKNOWLEDGMENTS

The authors warmly acknowledge the assistance of Rost Misytin and Brigitte Bullon, of Flextronics; and Onur Ülgen, of Production Modeling Corporation and the University of Michigan – Dearborn, toward ensuring the correctness and clarity of this paper.

REFERENCES

- Avery, Susan. 2001. "Linking Supply Chains Saves Raytheon \$400 Million." *Purchasing* 130(16):27-34.
- Bruzzone, Agostino G., Roberto Mosca, and Roberto Revetria. 2002. "Supply Chain Management Dynamic Negotiation Using Web Integrated Logistics Designer (WILD II)." In *Proceedings of the International Workshop on Harbour, Maritime and Multimodal Logistics Modelling and Simulation 2002*, eds. Agostino G. Bruzzone, Yuri Merkurjev, and Roberto Mosca, 3-11.
- Chapman, Sharon, Lawrence P. Etkin, and Marilyn M. Helms. 2000. "Do Small Businesses Need Supply Chain Management?" *Industrial Engineering Solutions* 32(8):31-36.
- Hopp, Wallace J., and Mark L. Spearman. 2001. *Factory Physics*, 2nd ed. New York, New York: The McGraw-Hill Companies, Incorporated.
- Jain, Sanjay, Ngai Fong Choong, and William Lee. 2002. "Modeling Computer Assembly Operations for Supply Chain Integration." In *Proceedings of the 2002 Winter Simulation Conference*, Volume 2, eds. Enver Yücesan, Chun-Hung Chen, Jane L. Snowdon, and John M. Charnes, 1165-1173.
- Matwijec, Ted, and Ken Buxton. 1999. "Using Simulation in Supply Chain Management." In *Proceedings of the International Workshop on Harbour, Maritime and Multimodal Logistics Modelling and Simulation 1999*, eds. Agostino G. Bruzzone, Yuri Merkurjev, and Roberto Mosca, 208-211.
- Merkurjev, Yuri A., Julija J. Petuhova, Rik Van Landeghem, and Steven Vansteenkiste. 2002. "Simulation-Based Analysis of the Bullwhip Effect Under Different Information Sharing Strategies." In *Proceedings of the 14th European Simulation Symposium*, eds. Alexander Verbraeck and Wilfried Krug, 294-299.
- Shankar, Venkatesh. 2001. "Integrating Demand and Supply Chain Management." *Supply Chain Management Review* 5(5):76-81.
- Simchi-Levi, David, Philip Kaminsky, and Edith Simchi-Levi. 2003. *Designing and Managing the Supply*

Chain: Concepts, Strategies, and Case Studies, 2nd ed. New York, New York: The McGraw-Hill Companies, Incorporated.

Teach, Edward. 2002. "Working on the Chain." *CFO* 18(9):83-90, September 2002.

Wyland, Brad, Ken Buxton, and Ben Fuqua. 2000. "Simulating the Supply Chain." *Industrial Engineering Solutions* 32(1):37-42.

AUTHOR BIOGRAPHIES

EDWARD J. WILLIAMS holds bachelor's and master's degrees in mathematics (Michigan State University, 1967; University of Wisconsin, 1968). From 1969 to 1971, he did statistical programming and analysis of biomedical data at Walter Reed Army Hospital, Washington, D.C. He joined Ford Motor Company in 1972, where he worked until retirement in 2001 as a computer software analyst supporting statistical and simulation software. After retirement from Ford, he joined Production Modeling Corporation, Dearborn, Michigan, as a senior simulation analyst. Also, since 1980, he has taught evening classes at the University of Michigan, including both undergraduate and graduate simulation classes using GPSS/HTM, SLAM IITM, SIMANTM, ProModel®, or SIMUL8®. He is a member of the Institute of Industrial Engineers [IIE], the Society for Computer Simulation International [SCS], and the Michigan Simulation Users' Group [MSUG]. He serves on the editorial board of the *International Journal of Industrial Engineering – Applications and Practice*. During the last several years, he has given invited plenary addresses on simulation and statistics at conferences in Monterrey, México; İstanbul, Turkey; Genova, Italy; and Rīga, Latvia. His email and web addresses are <ewilliams@pmcorp.com> and <www.personal.umd.umich.edu/~williams>.

ALI GUNAL serves as the Director of Services at Production Modeling Corporation. He received his Ph. D. degree from Texas Tech University in Industrial Engineering in 1991. Ali has been involved in consulting engagements with companies like Sony, Samsung, Volkswagen of America, Nestle, Sara Lee, and Medtronic in areas of supply chain management and manufacturing improvement through the application of information technology. In addition, he has an extensive background in application of simulation and other analytical methods to manufacturing management problems. Prior to joining PMC, he worked at i2 Technologies as a senior consultant, and later served as an Operations Research Specialist for the State of Washington, where he developed a simulation system for modeling and analysis of civil law suit litigations. He is familiar with several simulation systems including AutoMod, Arena, Quest, Robcad, and Igrid. His email address is <agunal@pmcorp.com>.