SOLEtech

May 2002 • SOLE – The International Society of Logistics • Volume 5.5

System Synthesis, Analysis, Evaluation, And Design Optimization

Ben S. Blanchard, CPL, Fellow, Professor-Emeritus, Virginia Tech

Preamble

The past few issues of the ***SOLEtech*** have addressed the system engineering process with respect to steps including the problem definition and needs analysis, development of system requirements (feasibility analysis, operational requirements, maintenance concept, and the development of technical performance measures), functional analysis, and functional packaging and requirements allocation — refer to Blocks 1, 2, and 3 of the system engineering process illustrated in Figure 1, March 2002 ***SOLEtech***. Given the allocation of requirements to the applicable elements of the system, it is now appropriate to evaluate the various possible alternative design approaches that may be considered in arriving at a recommended design solution. This, in itself, constitutes an iterative process involving *synthesis, analysis, and evaluation* - refer to Block 4 in Figure 1, March 2002 ***SOLEtech***.

Design Synthesis

Synthesis refers to the combining and structuring of components in such a way as to represent a feasible system configuration. The requirements for a system have been established, some preliminary trade-off studies have been completed, and a baseline configuration is developed to demonstrate the concepts discussed earlier (i.e., results from the activities discussed in the October 2001-April 2002 issues of the ***SOLEtech***). Synthesis is *design.* Initially, synthesis is employed to develop preliminary concepts and to establish basic relationships among the various components of the system. Later, when sufficient functional definition and decomposition have occurred, synthesis is used to further define the "hows" (in response to the "what" requirements). Synthesis involves the selection of a configuration that could be representative of the form that the system will ultimately take, although the final configuration may be quite different. The synthesis process usually leads to the identification of several possible alternative design approaches, which will be the subject of further analysis, evaluation, refinement, and optimization.

Analysis, Evaluation, and Design Optimization

Throughout the overall system design effort, there are numerous occasions where alternative approaches are defined and evaluated, leading to further design definition. There are possible trade-offs involving such issues as the evaluation and selection of different technologies, different materials, alternative system packaging schemes, alternative maintenance diagnostic routines, the evaluation and selection of COTS items, alternative maintenance and support policies, the incorporation of automation versus the accomplishment of functions by human means, and so on. Later, there may be alternative manufacturing processes, detailed maintenance plans, alternative logistic support structures, and/or alternative methods of material recycling and disposal that need to be considered. In general, the approach followed in the accomplishment of almost any trade-off study (or evaluation) is illustrated in Figure 1. One must first define the problem, identify the specific design criteria or measures against which the various alternatives will be evaluated (i.e., the applicable TPMs — see Figure 3 in the February 2000 ***SOLEtech***), select the appropriate evaluation techniques/methods, select or develop an analytical model to facilitate the evaluation process, acquire the necessary input data, evaluate each of the candidates being considered, perform a sensitivity analysis and identify the potential areas of risk, and finally recommend a course of action. This process can be "tailored" and applied at any point in the system life cycle. In essence, I am referring to an on-going iterative analytical process, involving the application of many different models/ tools to help solve a wide variety of problems, and which constitutes an inherent part within the overall system engineering process, or what is referred to as *system analysis.*

Referring to Figure 1, and given the problem definition, the analysis objectives, and the selection of evaluation criteria, the analyst needs to identify the appropriate analytical techniques/

In This Issue:

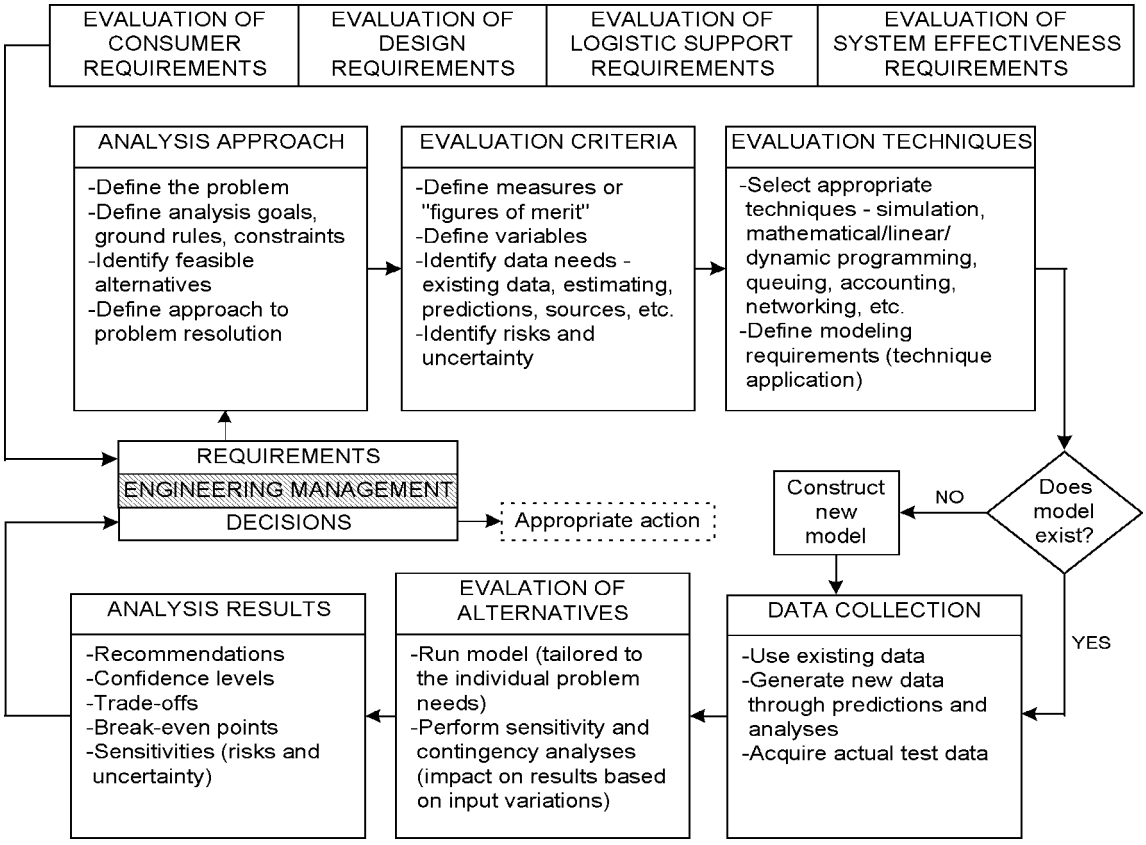


Figure 1. A generic systems analysis process

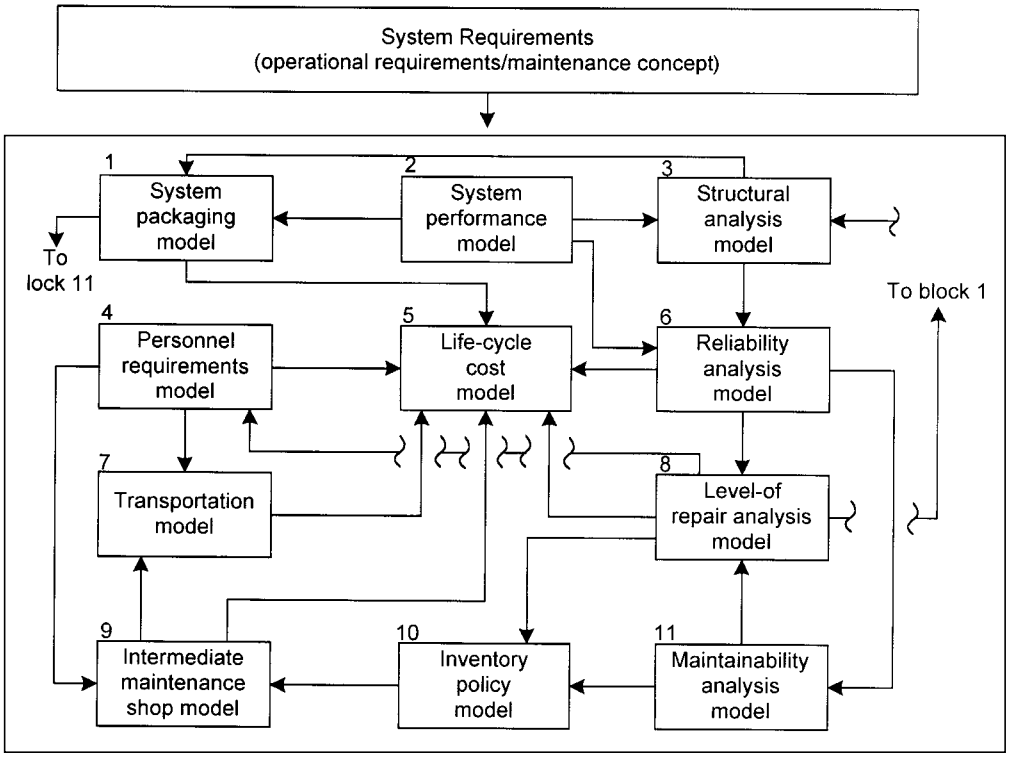


Figure 2. Application of models (example)

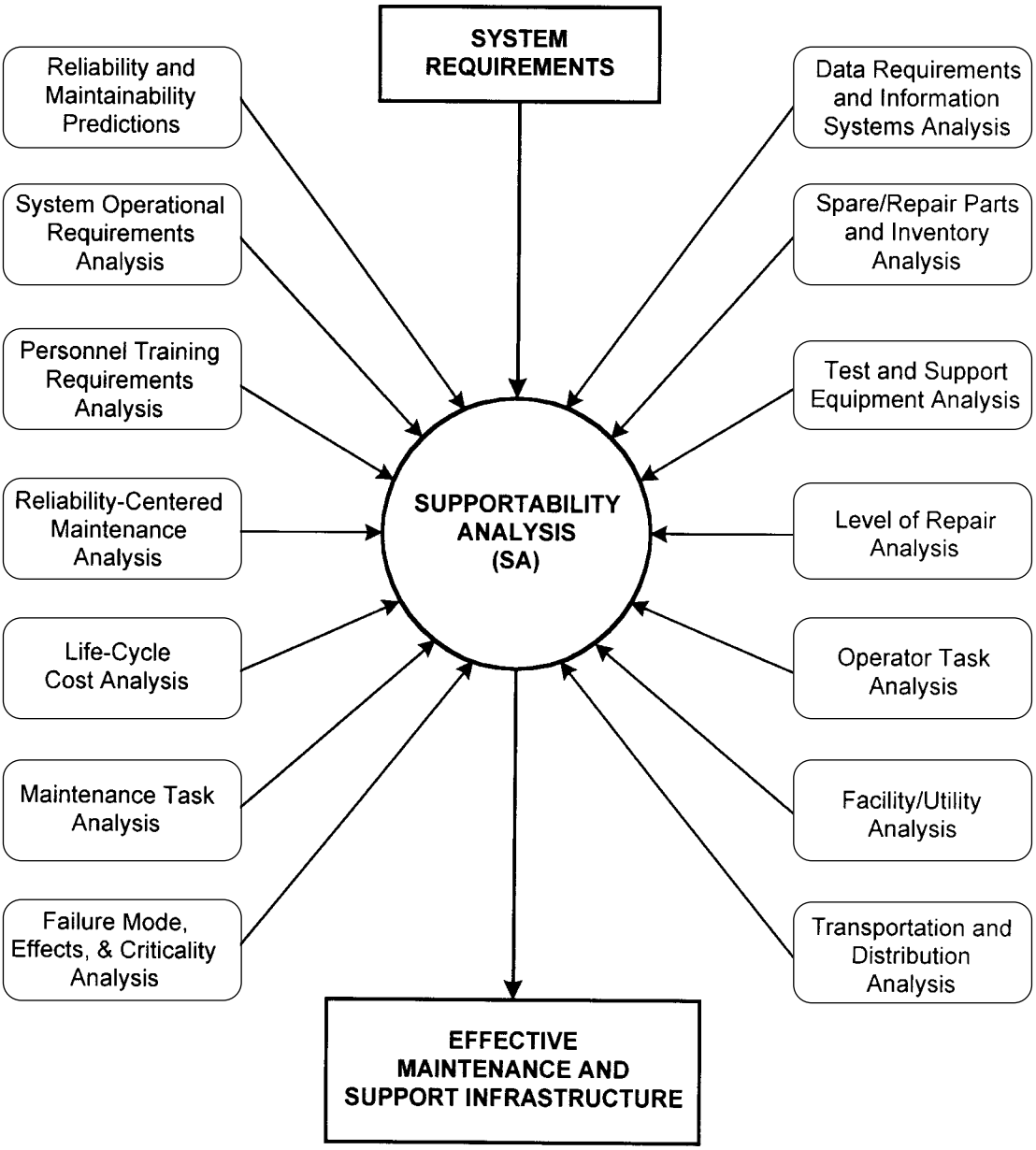


Figure 3. Supportability analysis and supplemental analysis efforts

methods that are available and can be used in accomplishing a specific trade-off. Depending on the nature of the evaluation effort, one may wish to apply simulation methods, linear and/or dynamic programming, queuing theory, accounting methods, and/or a combination of various operations research tools as an aid in solving a given problem. Knowledge of these methods and how they can be applied to the problem at hand is key to the subsequent selection of the appropriate computer-based *model* to be utilized in facilitating the analysis objectives.

A "model" (as identified in Figure 1) may include either a single computer-based entity or an integrated set of tools as shown in Figure 2. The objective is to select (or develop) a model that incorporates the appropriate mathematical techniques and has the necessary characteristics, sensitive to the problem being addressed, that will allow the analyst to gain the required visibility for evaluation of the system as a whole and/or any of its elements on an individual basis. For example, and referring to Figure 2, it may be desirable to determine the life-cycle cost of the system overall (using the "LCC Model"), identify the high-cost contributors, determine some "cause-and-effect" relationships (using the "Inventory Policy Model), re-evaluate an earlier repair-level decision (using the "Level-Of-Repair Analysis Model"), and then review the results in terms of life-cycle cost (using the "LCC Model"). In other words, the objective is to consider these models (and others as applicable) as an *integrated tool set* that can be utilized, on an iterative basis, throughout the system life cycle, and which constitutes an inherent part of the

overall system analysis effort. The subject of "models" will be discussed further in subsequent issues of the ***SOLEtech***.

Supportability Analysis

The *supportability analysis (SA)* constitutes an iterative and continuous analytical process, which is inherent within the systems engineering process (described earlier), that includes the integration and application of various techniques and methods to ensure that supportability requirements are considered both in the development of new systems and in the re-engineering of existing systems currently in operational use. Although part of the overall systems analysis activity mentioned earlier, the emphasis here is on **supportability in design**. It involves the utilization of different analytical models/methods to solve a wide variety of problems of varying magnitudes, and the depth of application must be appropriately "tailored" to the specific program need. The supportability analysis should not be a unique and separate activity addressed as an independent entity, but represents a vehicle directed toward the design, development, and assessment of both the prime mission-related elements of the system and the maintenance and support infrastructure. More specifically, the supportability analysis is accomplished to:

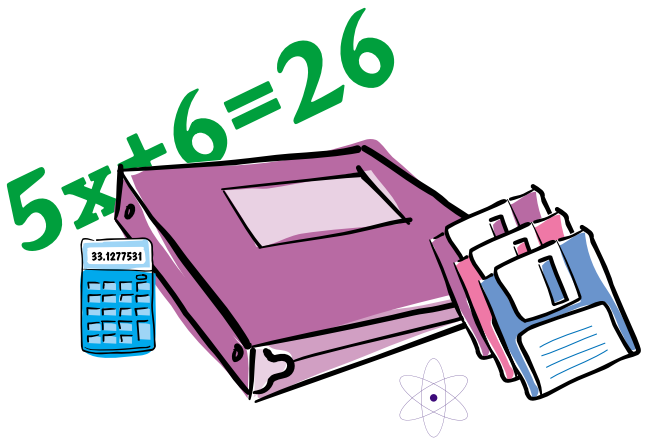
1. Aid in the initial establishment of supportability "design-to" requirements (i.e., *design criteria*) in conjunction with accomplishment of the feasibility analysis, development of system operational requirements and the maintenance concept, and in the identification and prioritization of technical performance measures (TPMs);
2. Aid in the synthesis, analysis, and design optimization effort through the conductance of trade-off studies and in the evaluation of various design alternatives. Specific applications may include the accomplishment of life-cycle cost analysis (LCCA); failure mode, effects, and criticality analysis (FMECA); fault-tree analysis (FTA); level-of-repair analysis (LORA); reliability-centered maintenance (RCM) analysis; operator and maintenance task analyses (OTA/MTA); etc.; and
3. Aid in the evaluation of a *given* design configuration (whether preliminary or final) with the objective of determining specific maintenance and logistic support requirements including maintenance personnel; training and training support; spares, repair parts, and associated inventories; test and support equipment; maintenance software; packaging, handling, transportation, warehousing, and distribution; facilities; technical documentation; and logistics management information (refer to the elements shown in Figure 1 in the December 2001 issue of ***SOLEtech***).

In accomplishing a supportability analysis (SA), one should view the process as a total *integrated* effort, involving the proper combining and application of a wide variety of models/tools, throughout the system life cycle, as illustrated in Figure 3. The results of such a process will, of course, lead to the development of a *logistics management information (LMI)* package (i.e., a logistics *database* – to be discussed in a subsequent issue of the ***SOLEtech***). Again, it is important that this activity be viewed within the context of the over system engineering process.

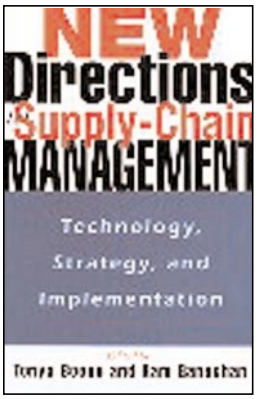
It should be noted that the principles and concepts associated with the supportability analysis (SA) are not new and have been applied on a number of programs in the past. I first became familiar with the process in the late 1950s when it was referred to as the *maintenance engineering analysis (MEA)*. In years to follow, there were other titles given to the process to include *maintenance-level analysis (MLA)*, *maintenance engineering analysis data (MEAD)*, *maintenance engineering analysis records (MEARs)*, *maintenance analysis data (MAD)*, *logistic support analysis (LSA)*, and so on. Regardless of what it is called, the principles, concepts, and applications remain the same - *it is the implementation of such that continues to be the challenge*!

Summary

The objective herein was to evolve from a good definition of "requirements" for the system and its major elements (described in the January-April 2002 issues of the ***SOLEtech***) to the accomplishment of preliminary and detail design through the process of synthesis, analysis, evaluation, and design optimization. This is an iterative analytical process, involving the application of different models/tools/methods to solve a wide variety of problems. Included within this analytical process is the accomplishment of the "supportability analysis" which, in turn, leads to the definition of logistic support resource requirements (personnel, spares/repair parts, test equipment, transportation, facilities, etc.) and the subsequent assessment of the maintenance and logistic support infrastructure in the field. From this point, my plan is to address some of the models/tools (and their applications) shown in Figure 3.



Book Reviews



New Directions in Supply-Chain Management: Technology, Strategy, and Implementation

Tonya Boone and Ram Ganeshan (Editors), American Management Association (AMACOM), 1601 Broadway, New York, N.Y. 10019, 2002 (ISBN 0-8144-0637-8)

Supply chain management, a process for simultaneously integrating and managing the requirements of suppliers and customers, has been recognized over the past few decades as an important tool for production line efficiency and competitive advantage. However, the field has started to undergo a radical transition as recent technology breakthroughs have started a snowballing process of technology, strategy, and implementation. In ***New Directions In Supply Chain Management***, the editors and 18 of the field's top young scholars examine the impact of computer technology on a field that has become the bedrock for electronic commerce and the Internet.

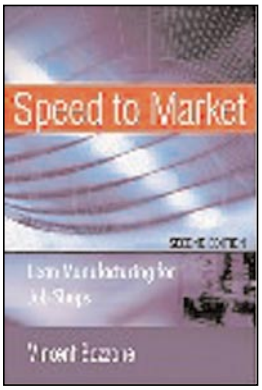
This book is divided into three sections. Section 1 explores how technology, and particularly the World Wide Web, has transformed supply chain operations. Section 2 focuses on how technology has revolutionized the development of products and services. Section 3 covers issues in knowledge management and the sharing of information. Taken together, they bring a new perspective to this complex field and demonstrate how the present state and future of supply-chain management can come together to form a blueprint for success. A more detailed breakout of the material by Sections and Chapters follows:

1. **Section 1: Integrating New Technologies into Supply-Chain Operations** — (1) *The Relationship-Technology Interface: A Path to Competitive Advantage*; (2) *Digital Marketplaces and Efficient Supply Chains: Can They Co-Exist?*; (3) *Internet Retailers' Dilemma of Operational and Market Efficiencies*; (4) *A Case Study of an ERP Implementation: Promises, Phantoms, and Purgatory*; and (5) *Web-Enabling the Supply Chain: An Exploratory Case Study.*

2. **Section 2: Technology-Based Product and Service Development** — (6) *Identifying and Managing Programmatic Efficiency Differences Across Technology-Based Product Development Capabilities and Uncertainty Environments*; (7) *Management of Information Technology Driven Product Development Processes*; (8) *Mass Customization: Strategy and Operational Considerations*; (9) *Towards Effective Software Development: A Conceptual Framework of Software Project Types, Development Processes, and Functional Outcomes*; and (10) *Management the New Service Development Process: Multi-Disciplinary Literature Synthesis and Directions for Future Research.*

3. **Section 3: Knowledge Management and Supply Chain Integration Issues** — (11) *Inward Technology Transfer: A Key Link in the Technology Supply Chain*; (12) *Experienced-Based Productivity Improvements in Project Environments*; (13) *Antecedents and Performance Outcomes of International Subsidiaries' Technology Sourcing Decisions*; (14) *Pricing Supply Flexibility: The Impact of Variability and Information Asymmetry*; (15) *Vendor-Managed Inventory in Production-Constrained Settings*; and (16) *Supply-Chain Integration: Putting Humpty Dumpty Back Together Again.*

Throughout, this book shows how the pace of technology change has generated both challenges and possible solutions as companies tackle the complex demands of supply chain relationships. The contributing authors address such difficult issues as how to align supply chain strategy with the strategic goals of the parent organization, share knowledge effectively throughout the organization, and optimize the measurement of performance and productivity. They also suggest how Internet retailers can reconcile their operational needs and market efficiencies and continue to maintain profitability as they assess digital marketplaces and their place in the organization.



Speed to Market: Lean Manufacturing for Job Shops, 2nd Edition

Vincent Bozzone, American Management Association (AMACOM), 1601 Broadway, New York, N.Y. 10019, 2002 (ISBN 0-8144-0694-7).

The challenges faced by job shops (order-driven, custom manufacturing companies) are entirely different from those of the corporate giants. For thousands of these small and mid-size companies, simply offering quality products at fair prices is not enough. The real name of the game is *serving customers quickly.*

Contrary to conventional wisdom, customer wait time is not just a function of manufacturing processes. Every step in the order fulfillment sequence takes time, from responding to the Request-For-Quote to sourcing materials, and from preparing

Book Reviews (Continued)

documentation to delivering the finished product. So, in order to decrease total lead time, the company has to maximize efficiency not just on the shop floor but through every department and at every stage.

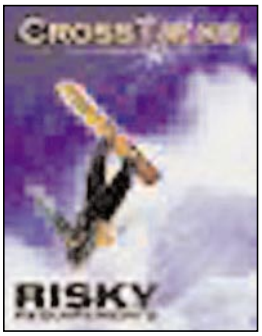
This book shows why traditional "lean manufacturing" approaches embraced by huge, make-to-stock companies often have a negative impact on smaller shops, which custom-create each product to the exact specifications of a particular customer. Through a review of the material in this book, one can gain some insight on how to save days, weeks, or even months off product delivery schedules, keep customers happy, maintain repeat business flowing in, and increase profits. A more detailed breakout of the material by Parts and Chapters follows:

1. **Part 1: Speed to Market** — (1) *Leapfrogging Lean*; (2) *Process Thinking*; (3) *Cutting Lead Time in Sales and Estimation*; (4) *Cutting Time in Preproduction Areas*; (5) *The Shop Floor*; (6) *Continuous Improvement*; and (7) *Implementation.*

2. **Part 2: Solution Strategies for Common Job Shop Problems** — (8) *When Scheduling is Out of Control*; (9) *Hockey Stick Blues*; (10) *The Thorny Issue of Job Shop Overhead*; (11) *The Big Picture Perspective*; and (12) *What Business Are You Really In?*

3. **Part 3: Appendixes: Tools of the Trade** — (A) *Is This Your Shop?*; (B) *Detailed View of a Job Shop Business Process*; (C) *How to Conduct a Business Systems Review*; (D) *How to Conduct a Process-Step Value Analysis*; (E) *Dynamic Problem Solving*; and (F) *Drawing the New Organization Lines: Information Technology as the New Organization Structure.*

Elsewhere …



CrossTalk - The Journal of Defense Software Engineering

The theme of the April 2002 issue (Vol. 15, No. 4), published by the Software Technology Support Center (STSC), Ogden Logistics , Hill AFB, UT 84056-5205 (**www.stsc.hill.af.mil**) is "Risky Requirements." Included in this issue are the following articles which may be of interest: *Requirements Risks Can Drown Software Projects* by Theron R. Leishman and Dr. David A. Cook; *Recommended Requirements Gathering Practices* by Dr. Ralph R. Young; *Reducing Risks Through Proper Specification of Software Requirements* by Al Florence; *Seven Characteristics of Dysfunctional Software Projects* by Michael W. Evans, Alex M. Abela, and Thomas Beltz; *Add Decision Analysis to Your COTS Selection Process* by Barbara Cavanaugh Phillips and Susan M. Polen; and *Prerequisites for Success: Why Process Improvement Programs Fail* by David Cottengim. [Editorial note: I found this issue to be of particular interest, especially in view of our discussions on system engineering presented in the past six issues of ***SOLEtech*** - BSB].

The theme of the May 2002 issue (Vol. 15, No. 5) is "Forging The Future Of Defense Through Technology." Included in this issue are the following articles which may be of interest: *What Are the Future Challenges of Software Technology ?* by LCOL. Glen A. Palmer; *A Study of Best Practice Adoption by Defense Acquisition Programs* by Dr. Richard Turner; *Achieving CMMI Level 5 Improvements with MBASE and the CeBASE Method* by Dr. Barry Boehm, Dr. Daniel Port, Apurva Jain, and Dr. Victor Basili; *U.S. Defense Department Requirements for Information Security* by Kevin J. Fitzgerald; *What is Software Quality Assurance?* by Dr. Linda H. Rosenberg; *Surviving the Top 10 Challenges of Software Test Automation* by Randall W. Rice; and *Information Security System Rating and Ranking* by Dr. Rayford B. Vaughn, Ambareen Sira, and Dr. David A. Dampier.

Journal of Business Logistics

The latest issue of the *Journal of Business Logistics* (Vol. 23, No. 1, 2002), published by the Council of Logistics Management (CLM), 2805 Butterfield Road, Suite 200, Oak Brook, IL 60523, includes the following articles which may be of interest: *The Effects of Culture and Human Resource Management Policies on Supply Chain Management Strategy* by R. Bruce McAfee, Myron Glassman, and Earl. D. Honeycutt; *Logistics Managers' Learning Environment and Firm Performance* by

Elsewhere (Continued)

Alexander E. Ellinger, Andrea Ellinger, and Scott B. Keller; *Driver Relationships with Customers and Driver Turnover: Key Mediating Variables Affecting Driver Performance in the Field* by Scott B. Keller; *IT Applications in Supply Chain Organizations: A Link Between Competitive Priorities and Organizational Benefits* by Nada R. Sanders and Robert Premus; *Information Support for Reverse Logistics: The Influence of Relationship Commitment* by Patricia J. Daugherty, Matthew B. Myers, and R. Glenn Richey; *The Adoption of Form Postponement Strategy in a Global Logistics System: The Case of Taiwanese Information Technology Industry* by Jyh-Shen Chiou, Lei-Yu Wu, and Jason C. Hsu; *Logistics and Assortment Depth in the Retail Supply Chain: Evidence from Grocery Categories* by Robert E. Stassen and Matthew A. Waller; and *Logistics Social Responsibility: An Integrative Framework* by Craig R. Carter and Marianne M. Jennings.

Calendar of Events

1. *International Conference Of Maintenance Societies (ICOMS-2002)*, organized by the Maintenance Engineering Society of Australia (MESA), Hilton Hotel, Brisbane, Queensland, Australia, May 21-24. SOLE is a co-host along with the Institute For Research in Maintenance (IFRIM), Society of Maintenance and Reliability Professionals, and the Plant Engineering and Maintenance Association of Canada. The Conference Chair is Adrian Rex, the theme is "Changing The Future," and the Conference will include a variety of workshops and technical paper presentations in the areas of *maintenance management, maintenance strategy, maintenance planning, maintenance engineering, asset management, maintenance resources, condition monitoring,* and *case studies in maintenance.* Keynote Speakers will include B. Noble and F. Stapelberg who will address "Managing the Future: The Significance of Quality Maintenance in West Australia's Term Network Contracts for Long-Term Maintenance of Roads and Highways;" Ben Blanchard who will cover "Key Performance Parameters in Change Management;" and J. Moubray who will cover "21st Century Maintenance Organization." Papers presented in Brisbane will be broadcast simultaneously to a conference venue at the Central Queensland University's campus in Gladstone. For further information, contact Sally Nugent, P.O. Box 634, Brentford Square, Victoria 3131, Australia (**icoms@corrprev.org.au**) and/or visit web site **www.mesa.org.au**.

2. *EUROMAINTENANCE 2002: 16th International Maintenance Congress*, sponsored by the European Federation of National Maintenance Societies (EFNMS) and hosted by the Finish Maintenance Society, Helsinki, Finland, June 3-5. For additional information, contact Hannu Vallanen (tel: +358-9276-7688; fax: +358-9290-0081; e-mail: **hannu. vallanen@kunnossapito.fi**). Also visit web site **http:// www.kunnossapito.fi/call-pap.htm**.

3. *3rd Annual Life-Cycle Costing In Defence Conference*, co-sponsored with SOLE, The Hatton, London, United Kingdom, June 17-18. For additional information, refer to the material presented in the April ***SOLEtech*** and contact Teri Arri at tel: +44(0) 20 7827 6162 or e-mail: **tarri@smi-online.co.uk**. For online registration, visit web site **www.smi-online.co.uk/lcc2.asp**.

4 *2002 Digital Human Modeling For Design And Engineering Conference*, Munich, Germany, June 18-20. For additional information, contact John R. Miller (**jrmiller@sae.org**) and/or visit web site **http://www.sae.org/calendar/gvmtgs.htm**.

5. *12th Annual International Symposium On Systems Engineering*, sponsored by the International Council On Systems Engineering (INCOSE), Riviera Hotel and Casino, Las Vegas, NV, July 28-August 1. The theme is "Engineering 21st Century Systems: Problem Solving Through Structured Thinking." The program will include six technical tracks, 138 technical paper presentations plus poster sessions, 11 full-day and six half-day tutorials, an Academic Forum, numerous exhibits, and several technical tours. For additional information, contact PCMI (tel: 1-858-565-9921; e-mail: **incosepcmisandiego.com**. Also, visit web site: **http://www.incose.org/** for up-to-date information.

6. *2002 International Military And Aerospace/Avionics COTS Conference, Exhibition, And Seminar*, Mission Valley Marriott Hotel, San Diego, CA, August 7-9. For further information, contact Edward B. Hakim (tel: 732-449-4729; fax: 775-855-0847; e-mail: **ebhakim@bellatlantic.net**).

7. *37th Annual International Logistics Conference And Exposition (SOLE-2002)*, sponsored by the International Society of Logistics (SOLE), Pointe South Mountain

Calendar of Events *(Continued)*

Resort, 777 South Mountain Parkway, Phoenix, AZ 85044, August 10-15. The theme is "21st Century Logistics: The Global Bridge." For additional information, contact John Davis, General Chair (**JDavisCPL@aol.com**) and/or SOLE Headquarters (**solehq@erols.com**). Also, visit the SOLE web site **http://www.sole.org**.

8. *15th International Congress And Exhibitions On Condition Monotoring And Diagnostic Engineering Management (COMADEM)*, University of Birmingham, United Kingdom, September 2-4. For additional information, contact Professor B.K.N. Rao (**rajbknrap@btinternet.com**) and/or visit web site **http://www.comadem.com**.

9. *Council Of Logistics Management's Annual Conference*, sponsored by CLM, Moscone Center, San Francisco, CA, September 29-October 2. The theme is "The Rules Are Changing..." The Keynote Speaker for the opening session will be Michael L. Eskey, Chairman and CEO, United Parcel Service. For further information, contact CLM Headquarters at **clmadmin@clm1.org** and/or visit web site **http://www.clmadmin@clm1.org/conf2002/index.asp**.

10. *18th International Logistics Congress And Exhibition (ILC-2002)*, sponsored by SOLEurope and hosted by the Munich Chapter, Gasteig Arts Center, Munich, Germany, October 6-9. The Conference theme is "Outsourcing Life-Cycle Support: Sharing The Opportunities, Sharing The Risks." For additional information, visit web site **www.sole-muc.de** and/or visit the SOLE web site **www.sole.org.**

11. *28th International Symposium For Testing And Failure Analysis (ISTFA-2002)*, Phoenix, AZ, November 3-7. For further information, contact Donald D. Dylis at **DDylis@IITRI.org** or contact **ISTFA@ asminternational.org**.

12. *15th International Conference-Software And Systems Engineering And Their Applications (ICSSEA-2002)*, Paris, France, December 3-5. The theme is "Development And Globalization." For further information, contact Jean Claude Rault (**rault@cnam.fr**) and/or visit web site **www.cnam.fr/CMSL**.

13. *2002 Winter Simulation Conference*, Hyatt Regency Hotel, San Diego, CA, December 8-11. The theme is "Exploring New Frontiers." For additional information, contact John M. Charnes (**jmc@ku.edu**) and/or visit web site **www.wintersim.org**.

14. *The International Symposium On Product Quality And Integrity (RAMS-2003)*, sponsored by 10 technical societies (to include SOLE), Tampa Waterside Marriott Hotel, Tampa, FL, January 27-30, 2003. The theme is "Transforming Technologies For Reliability And Maintainability Engineering." For further information, visit web site **www.rams.org** or the SOLE web site **www.sole.org**.

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- Management Organisation
- Supply Chain Management

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- Software Support of Business Processes
- Network Organisation
- Electronic Market-places, Portals
- Application of Standards (e.g. AECMA)
- Future Trends

SPEAKERS AND EXHIBITORS

Authors wishing to present their work at the conference are requested to submit an abstract in the English Language to the Conference Secretariat, no later than

May 31st, 2002

The abstract should not exceed 500 words and may include lecture topics, issues addressed, work carried out and results achieved or expected. Please include a short CV in paragraph format and the full mail and e-mail address for further contacts. Abstracts will be reviewed by the programme committee. Upon acceptance, authors will be asked to prepare and submit the full paper which will be required in Winword 97/2000 or MS-Powerpoint format, no later than **May 31st, 2002**. The submission of materials must be in electronic format, and use of e-mail will be the principal means of communication.

Exhibitors wishing to present their products or services are invited to make the reservations for their booth with the Conference Secretariat, no later than

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