## **CONTENTS**

# SYSTEMS ENGINEERING AND MANAGEMENT FOR SUSTAINABLE DEVELOPMENT



Systems Engineering and Management for Sustainable Development - Volume 1 No. of Pages: 381 ISBN: 978-1-905839-00-1 (eBook) ISBN: 978-1-84826-900-2 (Print Volume)

Systems Engineering and Management for Sustainable Development - Volume 2 No. of Pages: 354 ISBN: 978-1-905839-01-8 (eBook) ISBN: 978-1-84826-901-9 (Print Volume)

For more information of e-book and Print Volume(s) order, please **click here** 

Or contact : eolssunesco@gmail.com

## SYSTEMS ENGINEERING AND MANAGEMENT FOR SUSTAINABLE DEVELOPMENT

Editor Andrew P. Sage

Eolss Publishers Co. Ltd., Oxford, United Kingdom

© Eolss Publishers/ UNESCO, 2008 for this edition

Information on this title: www.eolss.net/978052189344

ISBN- 978-1-905839-00-1 (Adobe e-Book Reader) ISBN- 978-1-84826-900-2 Library Edition (Hard Copy)

The choice and the presentation of the facts contained in this publication and the opinions expressed therein are not necessarily those of UNESCO and do not commit the Organization.

The designations employed and the presentation of material throughout this publication do not imply the expression of any opinion whatsoever on the part of UNESCO concerning the legal status of any country, territory, city, or area, or of its authorities, or the delimitation of its frontiers or boundaries,

This information, ideas, and opinions presented in this publication are those of the Authors and do not represent those of UNESCO and Eolss Publishers.

Whilst the information in this publication is believed to be true and accurate at the time of publication, neither UNESCO nor Eolss Publishers can accept any legal responsibility or liability to any person or entity with respect to any loss or damage arising from the information contained in this publication.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage or retrieval system, without prior permission in writing from Eolss Publishers.

The above notice should not infringe on a 'fair use' of any copyrighted material as provided for in section 107 of the US Copyright Law, for the sake of making such material available in our efforts to advance understanding of environmental, political, human rights, economic, democracy, scientific, and social justice issues, etc. If you wish to use copyrighted material from this e-book for purposes of your own that go beyond 'fair use', you must obtain permission from the EOLSS Publishers.

Every effort has been made to trace and credit all the copyright holders, but if any have been inadvertently overlooked, UNESCO and Eolss Publishers will be pleased to make the necessary arrangements at the first opportunity.

#### **British Library Cataloguing-in-Publication Data**

A catalogue record of this publication is available from the British Library.

#### Library of Congress Cataloging-in-Publication Data

A catalog record of this publication is available from the library of Congress

### **CONTENTS**

#### Preface

## **VOLUME I**

#### Systems Engineering and Management for Sustainable Development

Andrew P. Sage, George Mason University, USA

- 1. Introduction
- 2. Systems Engineers
- 3. The Systems Engineering Point of View
- 4. Definitions of Systems Engineering
- 5. History of Technological Development and Systems Engineering
- 6. Systems Engineering and Management Knowledge
- 7. Methodological Frameworks, Systems Engineering, and Management Processes
  - 7.1. Logical Steps of Systems Engineering
  - 7.2. Life-cycle Phases of Systems Engineering
  - 7.3. A Two-dimensional Framework for Systems Engineering
  - 7.4. Life-cycles or Stages of Systems Engineering
  - 7.5. Systems Engineering Processes
- 8. Other Specific Life-cycle Methodologies for Systems Acquisition, Production, or Procurement
- 9. Sustainable Development, Industrial Ecology, and Systems Engineering and Management
- 10. Challenges, Pitfalls, and the Need for a Multiple Perspective Viewpoint in Systems Engineering and Management
- 11. Conclusion and Associated Writings

#### Life Cycles for Research, Development, Test, and Evaluation

Floyd G. Patterson, Jr., George Mason University, USA

- 1. Introduction
- 2. Research, Development, Test, and Evaluation Life Cycles 2.1. Life Cycle Architecture
  - 2.2. The Relationship of RDT&E to Other Life Cycles

#### Life Cycles for System Acquisition

Floyd G. Patterson, Jr., George Mason University, USA

- 1. Introduction
  - 1.1 Approaches
    - 1.1.1. Grand Design
    - 1.1.2. Evolutionary Design
- 2. Commonly Used Life Cycles
  - 2.1. Waterfall Cycles
    - 2.2. Variations of the Waterfall Model
    - 2.3. Concurrent Engineering Cycles
- 3. Current and Future Trends
  - 3.1. ISO 9000
  - 3.2. The Capability Maturity Models
  - 3.3. SPICE
  - 3.4. Acquisition Strategies
  - 3.5. Concurrent Design
    - 3.5.1. Deferring the Commitment
    - 3.5.2. Shortening the Learning Curve

82

69

xiv

1

ii

#### The Planning and Marketing Life Cycle

Floyd G. Patterson, Jr., George Mason University, USA

#### 1. Introduction

- 2. Planning and Marketing
  - 2.1. Life Cycle Interfaces
  - 2.2. Product Life Cycle
  - 2.3. ISO 14000
  - 2.4. Strategic Planning

#### System Basics

Tibor Vámos, Hungarian Academy of Sciences, Hungary

- 1. Introduction
- 2. Basic Principles of System Performance
- 3. Continuous System Processes, Computational Models
- 4. Control, Observation, Feedback
- 5. Conclusions

#### **User Needs and Requirements, and Life Support System Specifications** James D. Palmer, *George Mason University, USA*

- 1. Introduction
- 2. Problems and Issues Concerning Requirements Development
- 3. Requirements Process
  - 3.1. Problems and Issues to be addressed by the Requirements Development Process
  - 3.2. Definition of Terms Used in a Requirements Process
  - 3.3. A System Life Cycle Process for Requirements Management
  - 3.4. Requirements Process Functions
    - 3.4.1. Elicitation
    - 3.4.2. Examples of Typical Elicitation Activities
    - 3.4.3. Organization
    - 3.4.4. Assessment
    - 3.4.5. Prototyping
    - 3.4.6. Transformation
    - 3.4.7. Requirements Process Model Summary
    - 3.4.8. Requirements Management as Part of the Process
- 4. Quality Characteristics for User Needs and Requirements
- 5. Contemporary Requirements Practices
- 6. CASE Tools for Support of the Requirements Process
  - 6.1. CASE Tools for the Requirements Process
- 7. Future Perspectives for User Needs and Requirements Engineering

#### System Requirements

Ruth T. Buys, CMS Information Services, Inc., USA

- 1. Introduction
- 2. Identifying System Requirements
  - 2.1. Points of View
  - 2.2. Functional, Nonfunctional, and Other Requirements
  - 2.3. Understanding the Domain
  - 2.4. Feasibility of a Solution
  - 2.5. Constraints
  - 2.6. Validating and Verifying Requirements
- 3. Requirements Identification Strategy

126

- 3.1. Waterfall
- 3.2. Alternative Life Cycle Models
- 4. Methodologies and Techniques to Identify User Requirements and System Specifications
  - 4.1. Interviews
  - 4.2. Questionnaires
  - 4.3. Facilitated Application Specification Techniques (FAST)
  - 4.4. Joint Application Development (JAD)
  - 4.5. Rapid Application Development (RAD)
  - 4.6. Integrated Product Team (IPT)
  - 4.7. Prototypes
  - 4.8. Use Cases
  - 4.9. Artificial Intelligence and Expert Systems
  - 4.10. Other Tools and Techniques

#### Value System Design for Sustainability

Arthur D. Hall, III, Fredericksburg, VA 22408-2056, USA

- 1. Introduction
- 2. Relations between Systems Methodology and Fractal Geometry
- 3. A Close Look at Value Systems Design (VSD)
- 4. How the VSD Process Works
- 5. How Can You Test a VSD for Quality?
- 6. How to Design and Test a Value System
- 7. Theories of Value and Multi-phase Effects
- 8. Teamwork and Freedom
- 9. Summary and Conclusions

#### **Configuration Management**

Peggy S. Brouse, George Mason University, USA

- 1. Introduction
  - 1.1. Definition of Configuration Management
  - 1.2. History of Configuration Management
  - 1.3. Application of Configuration Management
- 2. Configuration Management within the System Lifecycle
  - 2.1. Project Initiation Phase
    - 2.1.1. Inputs to the Project Initiation Phase
    - 2.1.2. Project Configuration Management Plan
    - 2.1.3. Outputs from the Project Initiation Phase
    - 2.1.4. Measurements
    - 2.1.5. Project Initiation Phase Baseline
    - 2.2. Requirements Definition Phase
      - 2.2.1. The Identification Function
      - 2.2.2. The Control Function
      - 2.2.3. Requirements Definition Phase Baseline
    - 2.3. System Design Phase
    - 2.3.1. System Design Phase Baseline
    - 2.4. Development Phase
    - 2.5. Formal Test Environment Control 2.5.1. Development Phase Baseline
    - 2.6. Integration and Test Phase
    - 2.6.1. Integration and Test Phase Baseline
    - 2.7. Deployment and Maintenance Phase
- 3. Configuration Status Accounting and Configuration Auditing
  - 3.1. Configuration Status Accounting
  - 3.2. Collection, Recording, and Maintenance of Data

190

- 3.3. Status of Proposed Engineering Changes
- 3.4. Change Traceability
- 4. Configuration Management Responsibilities
- 5. Configuration Management in Process Improvement
- 6. Configuration Management Tools

#### Decision Technology Systems, Concurrent Engineering, and Supply Chain Management in Life Support 243

Guisseppi A. Forgionne, University of Maryland Baltimore County, USA

- 1. Introduction
- 2. Life Support Process
  - 2.1. Sequential Engineering
    - 2.1.1. Operational Inefficiencies
    - 2.1.2. Knowledge Transfer Difficulties
  - 2.2. Concurrent Engineering
  - 2.3. CE Challenges
- 3. Enabling Information Systems
  - 3.1. CE Support Gaps
    - 3.1.1. Environmentally-Cognizant Enterprise Modeling
    - 3.1.2. Data Access and Reporting
    - 3.1.3. Knowledge Transfer
  - 3.2. Knowledge Representation
  - 3.3. Integrated Systems Support
  - 3.4. Concurrent Engineering Life Support System (CELSS)
    - 3.4.1. Inputs
    - 3.4.2. Processing
    - 3.4.3. Outputs
    - 3.4.4. Feedback Loops
  - 3.5. Applications
    - 3.5.1. Automobile Emission Testing
    - 3.5.2. Breast Cancer Detection
    - 3.5.3. Railroad Crossing Investments

#### System Architectures for Life Support Systems

Alexander H. Levis, George Mason University, USA Lee W. Wagenhals, George Mason University, USA

- 1. Introduction
- 2. On Architectures
  - 2.1. Architects and Architectures
  - 2.2. Architecting in Systems Engineering
- 3. Architecture Development Process
  - 3.1. Structured Analysis Approach
    - 3.1.1. Functional Decomposition and Activity Model
    - 3.1.2. Data Model
    - 3.1.3. Rule Model
    - 3.1.4. Dynamics Model
    - 3.1.5. Integrated Dictionary and Model Concordance
  - 3.2. Object Oriented Approach
    - 3.2.1. UML Elements and Diagrams
    - 3.2.2. An Object Oriented Process
  - 3.3. The Physical Architecture View
- 4. Conversion to the Executable Model
- 5. Conclusion

### Systems Integration of Systems for Life Support

James D. Palmer, George Mason University, USA

1. Introduction

2

6

- 1.1 Objectives for a SI Methodology
- 1.2 Definition of Systems Integration
- 1.3 Role of SI in Systems for Life Support
- SI in Life Support Systems and an SI Life Cycle
- 3 SI Strategy for Success
  - 3.1 Strategy Implementation
  - 3.2 Implementation and Integration Activities
  - 3.3 Risk Management as Part of the Strategic Plan
- 4 The Audit Trail
  - 4.1 Audit Trail Process
  - 4.2 Documentation and Indexing
  - 4.3 Steps to take to embed an Audit Trail
- 5 Quality Assurance in SI
  - 5.1 Quality Assurance and Testing
  - 5.2 A Process for Fusion of Quality Assurance in SI
  - Subcontractor Management for SI
- 7 Subsystem Integration and Delivery
  - 7.1 Traceability
  - 7.2 Potential conflicts and resolution procedures
  - 7.3 Risk analysis and management
  - 7.4 Consistency of requirements
    - 7.4.1 Potential ambiguities in evaluation procedures 7.4.2 Testability
    - 7.4.3 Audit Reports and Sign-off
- 8. Risk Management
  - 8.1 Approaches to Risk Management for SI
  - 8.2 Components of a Risk Management Plan for SI
  - 8.3 Traceability as part of Risk Management

#### Manufacturing and Networked Information Systems for Life Support

T. Govindaraj, Georgia Institute of Technology, USA

- 1. Introduction and Overview
- 2. Background
  - 2.1. Self-sustained communities in relative isolation
  - 2.2. Increased mobility and the evolution of manufacturing
- 3. Evolution of information systems
  - 3.1. The context
  - 3.2. Relationship between information and manufacturing
  - 3.3. Networks, technology, and people
- 4. Information for sustainable production

#### About EOLSS

## **VOLUME II**

#### **Life-Cycle Costing: An Effective Tool for Total Assest Management** Benjamin S. Blanchard, *Virginia Polytechnic Institute and State University, USA*

- 1. The Need for Life-Cycle Costing
- 2. Application of Life-Cycle Costing Methods

307

325

1

- The Life-Cycle Cost Analysis Process
   The Benefits of Life-Cycle Costing
- 5. Conclusions

Maintenance and Support: A Critical Element in the System Life Cycle Benjamin S. Blanchard, Virginia Polytechnic Institute and State University, USA		11
1. 2. 3. 4.	Introduction The Elements of Maintenance and Support The Design for System Maintenance and Support Conclusions	
Evaluation in Systems Engineering19Wolter J. Fabrycky, Academic Applications International, Inc., USA19		
1. 2.	<ul> <li>Introduction</li> <li>Integration and Iteration in System Design Evaluation</li> <li>2.1. A Morphology for Synthesis, Analysis, and Evaluation</li> <li>2.1.1. Synthesis</li> <li>2.1.2. Analysis</li> <li>2.1.3. Evaluation</li> <li>2.2. Discussion of the Ten Blocks</li> <li>2.2.1. The Technologies (Block 0)</li> <li>2.2.2. The Customer (Block 1)</li> <li>2.2.3. Need, Functions, and Requirements (Block 2)</li> <li>2.2.4. The Design Team (Block 3)</li> <li>2.2.5. Design Synthesis (Block 4)</li> <li>2.6. Top Down &amp; Bottom Up (Block 5)</li> <li>2.7. Estimation and Prediction (Block 6)</li> <li>2.8. Physical and Economic Databases (Block 7)</li> <li>2.9. Design Evaluation (Block 8)</li> </ul>	
<ol> <li>3.</li> <li>4.</li> <li>5.</li> </ol>	<ul> <li>2.2.10. Design Decision Schema (Block 9)</li> <li>Cost Effectiveness Evaluation</li> <li>3.1. Cost Effectiveness Criteria</li> <li>3.2.1. Identifying Evaluation Criteria</li> <li>3.2.2. Displaying Multiple Criteria</li> <li>3.3. Cost Breakdown Structure</li> <li>3.3.1. Research and Development Cost</li> <li>3.3.2. Production and/or Construction Cost</li> <li>3.3.3. Operation and Support Cost</li> <li>3.3.4. Retirement and Disposal Cost</li> <li>3.4. Life-Cycle Cost Profiles</li> <li>3.5. Calculating Economic Equivalence</li> <li>3.5.1. Money Flow Modeling</li> <li>3.5.2. Economic Optimization Modeling</li> <li>Choosing the Preferred Alternative</li> <li>4.1. Cost Analysis Goals</li> <li>4.2. Decision Guidelines and Constraints</li> <li>System Evaluation Examples</li> <li>5.1. Moving Electrical Energy</li> <li>5.2. Crossing an Obstacle</li> <li>5.3. Procuring and Storing Consumables</li> <li>5.4. Designing and Deploying Repairables</li> </ul>	

vii

### Evaluation of Programs and Policies for Life Support Systems

James M. Tien, Rensselaer Polytechnic Institute, USA

- 1. Introduction
- 2. Evaluation Approach
  - 2.1. Evaluation Process
  - 2.2. Evaluation Framework
  - 2.3. Threats to Validity
- 3. Evaluation Design
  - 3.1. Test Hypotheses
  - 3.2. Selection Scheme
  - 3.3. Measures Framework
  - 3.4. Measurement Methods
  - 3.5. Analytic Techniques
- 4. Concluding Remarks

#### **Decision Networks and Command Organizations**

Krishna R. Pattipati, University of Connecticut, USA Candra Meirina, University of Connecticut, USA Andras Pete, University of Connecticut, USA Georgiy M. Levchuk, University of Connecticut, USA Ruan, S., University of Connecticut, USA David L. Kleinman, University of Connecticut, USA

- 1. Introduction
- 2. Single Human Detection Model
  - 2.1. Overview
  - 2.2. Formulation as a Hypothesis Testing Problem
  - 2.3. Individual Expertise: The Receiver (Relative) Operating Characteristic (ROC) Curve
- 3. Distributed Detection Model
  - 3.1. Overview
  - 3.2. Graph Representation of Tasks and Organizations 3.2.1. Graph Representation of Tasks
    - 3.2.2. Graph Representation of Organizations
  - 3.3. Formulation as a Distributed Hypothesis Testing Problem
  - 3.4. Optimal Decision Rules
  - 3.5. Organizational Expertise: Team ROC Curve
  - 3.6. Special Case: Same Hypotheses at all DMs
  - 3.7. Matching Organizations with Tasks
    - 3.7.1. Problem Formulation and Solution Methodology
    - 3.7.2. Performance of Organizations with Nondecomposable Tasks
    - 3.7.3. Performance of Organizations with Decomposable Tasks
    - 3.7.4. Discussion
- 4. Structural Congruence between Tasks and Organizations
  - 4.1. Introduction
  - 4.2. Task Decomposition
  - 4.3. Building Organizations from Tasks: An Illustration
- 5. Design of Congruent Organizations for Specific Missions
  - 5.1. Introduction
  - 5.2. Phase I: ResourceTask Allocation 5.2.1. Mission Planning
    - 5.2.2. Scheduling
  - 5.3. Phase II: DMResource Allocation
  - 5.4. Phase III: Organizational Hierarchy
  - 5.5. Congruent Organizational Design via Group Technology and a Nested Genetic Algorithm
- 6. Robust and Adaptive Organizations
  - 6.1. Need for Flexibility, Robustness, and Adaptation

58

- 6.2. Concepts of Flexibility, Robustness and Adaptation
- 6.3. Design of Robust and Adaptive Organizations
- 6.4. Effects-Based Design of Robust Organizations
- 6.5. Robust Action Strategies to Induce Desired Effects
- 6.6. Mission Monitoring and Failure Diagnosis
- 7. New Directions
  - 7.1. Organizational Performance Measures
  - 7.2. Agent-based simulation of Organizations
  - 7.3. Network-centric Heterarchical and Holonic Organizations7.3.1. Design of Heterarchies7.3.2. Holonic Scheduling
  - 7.4. Conclusion

#### **Principles and Tools of Total Quality Management**

James L. Melsa, Iowa State University, USA

- 1. Introduction
- 2. Total Quality Management Tools
- 3. Total Quality Management Philosophies
  - 3.1. Visionary Leadership
    - 3.2. Customer Driven Excellence
  - 3.3. Agility
  - 3.4. Organizational and Personal Learning
  - 3.5. Management by Fact
  - 3.6. Valuing Employees and Partners
  - 3.7. Focus on the Future
  - 3.8. Managing for Innovation
  - 3.9. Social Responsibility
  - 3.10. Focus on Results and Creating Value
  - 3.11. Systems Perspective

#### **Environmental Regulation: Developments in Setting Requirements and Verifying Compliance** 142 Rex V. Brown, *George Mason University, USA*

#### 1. Introduction

- 1.1. Problem Background
  - 1.1.1. The Social Purpose of Safety Regulation
  - 1.1.2. Balancing competing interests
  - 1.1.3. Deficiencies in Common Practice
  - 1.1.4. Policy Criteria
  - 1.1.5. Distinct Regulatory Tasks
- 1.2. Methodological Perspectives
  - 1.2.1. "Impersonal" Decision Analysis
  - 1.2.2. "Personal" Decision Analysis
- 1.3. Structure of Paper
- 2. How Requirements Should Be Set
  - 2.1. Basic Issues
    - 2.1.1. Theory versus Practice
    - 2.1.2. Conflict between relevant and verifiable requirements
    - 2.1.3. Quantitative, Qualitative, and Ambiguous Requirements
  - 2.2. What Form : Ends, Means or Acceptable risk?
    - 2.2.1. Hierarchy of variables determining risk
      - 2.2.2. Ends: Public Interest alone
      - 2.2.3. Means: Specific Measures
      - 2.2.4. Trading Off competing ends
      - 2.2.5. Performance on a single sub-end : acceptable environmental protection
      - 2.2.6. Acceptable risks at lower tiers of means-ends

- 2.2.7. Motivational considerations affecting level of requirement
- 2.3. Mixed Requirements
  - 2.3.1. "Progressive Tightening" Mix
  - 2.3.2. "Progressive Loosening" Mix
- 2.4. Formal Validation of argument
  - 2.4.1. Quantifying the Model
  - 2.4.2. Compensation Among Variables
  - 2.4.3. Specifying requirements does not assure compliance
- 3. How to Verify Compliance with Requirements
  - 3.1. The Meaning of Compliance
    - 3.1.1. Interpreting of risk assessments
      - 3.1.2. Desirable properties of a risk assessment for decision processes
      - 3.1.3. Desirable properties for public scrutiny
  - 3.2. Risk assessment approaches
    - 3.2.1. Documented Safety Assessment (DSA)
    - 3.2.2. Judgmental Safety Assessment (JSA)
    - 3.2.3. Comprehensive Safety Assessment (CSA)
  - 3.3. Considerations for policy use
    - 3.3.1. DSA as an approximation to CSA
    - 3.3.2. Suspect default assumptions
    - 3.3.3. Avoiding "Uncertainty"?
    - 3.3.4. Regulator confidence in DSA
    - 3.3.5. Technician Confidence
    - 3.3.6. Motivational effects
    - 3.3.7. DSA's decision aiding potential
    - 3.3.8. Limited decision applications of DSA
  - 3.4. Integrating Documented and Judgmental Risk Assessment
    - 3.4.1. Graphic Illustration
    - 3.4.2. Case Study : Reactor Backfit
    - 3.4.3. Cost Impediment?
    - 3.4.4. Action Implications
- 4. Concluding Comments
  - 4.1. Technical work to be done
    - 4.1.1. DSA development
    - 4.1.2. Addressing " assessment uncertainty"
  - 4.2. Political Issues
  - 4.3. Paradigm Shifts

#### **Risk Management and Risk-Based Decision-Making**

Yacov Y. Haimes, University of Virginia, USA

- 1. Introduction
- 2. The Complexity of Risk Modeling; Assessment and Management of Large Scale Systems
- 3. Systems Engineering, Risk Analysis, and Large-Scale and Complex Systems
- 4. Holistic Approach to Risk Assessment and Management
- 5. On the Definition of Vulnerabilities in Measuring Risks to Infrastructures
- 6. Hierarchical Holographic Modeling for Identifying Risk Scenarios
- 7. Expected Value of Risk
- 8. The Partitioned Multi-objective Risk Method
- 9. Risk of Extreme Events
- 10. The Fallacy of the Expected Value
- 11. The Partitioned Multi-objective Risk Method
- 12. Conclusions

#### The Policy Implications of Industrial Ecology

Brad R. Allenby, AT&T Engineering Research Center, USA

#### Thomas J. Gilmartin, *Lawrence Livermore National Laboratory*, USA Thomas E. Graedel, *Yale University*, USA

- 1. Introduction
- 2. Stewardship of the Earth
  - 2.1. Sustainability within a Closed System
  - 2.2. Industrial Revolution and Global Perturbations
  - 2.3. Master Equation
  - 2.4. Population and Wealth
  - 2.5. Technology's Role
- 3. Emergence of Ecological Perspectives
  - 3.1. Environmental Paradigm of the 1960s to the 1980s
  - 3.2. Need to Move Beyond the Symptomatic Approach
  - 3.3. Complex Systems Treatment of the Economy and Nature
  - 3.4. Integration of Scientific, Technological, Environmental, and Economic Considerations
- 4. Ecological Approaches
  - 4.1. Continuation of Current Trends: Unsustainable Growth
  - 4.2. Radical Ecology: Severe Contraction
  - 4.3. Deep Ecology: Managed Contraction
  - 4.4. Industrial Ecology: Potentially Sustainable Development
- 5. Industrial Ecology
  - 5.1. A New Intellectual Framework
  - 5.2. Desirable Carrying Capacity with Continued Evolution
  - 5.3. Objective Basis
  - 5.4. Complex Systems
  - 5.5. Appropriate Technology
  - 5.6. Foundational Research
- 6. System Elements of Industrial Ecology
  - 6.1. Systems Imperative
  - 6.2. Human Systems
  - 6.3. Natural Systems
  - 6.4. Materials
  - 6.5. Energy Systems
  - 6.6. Indicators and Indices
- 7. Policy Implications of Industrial Ecology
  - 7.1. Adaptable Policy
  - 7.2. Dealing with Complexity
- 8. Public Roles
  - 8.1. Population
  - 8.2. Environmental Awareness
  - 8.3. Dematerialization
- 9. Industry Roles
  - 9.1. Design for Environment
  - 9.2. Internalizing Externalities
  - 9.3. Account for All Product Cycle Costs
  - 9.4. Design for Optimized Life Cycle at Both Head and Tail Ends
  - 9.5. Leased, Robust, Upgradable, Modular Products
- 10. Government Roles
  - 10.1. Distributed Control
  - 10.2. Collaborative Research
  - 10.3. Efficiency, Recycle, and Reuse
  - 10.4. Decarbonization
  - 10.5. Material Data and Standards
  - 10.6. Government Specifications
  - 10.7. Eco-Tax and Eco-Labels
  - 10.8. Closing the Loop
- 11. Conclusions

#### Human Factors and Global Problems: A Systems Approach

Kim J. Vicente, University of Toronto, Canada

- 1. Introduction
- 2. Why Can Human Factors Help Solve Global Problems
- 3. A Systems Approach Design Principles
  - 3.1. Behavior Shaping Constraints
  - 3.2. Salient, Immediate, Feedback
  - 3.3. Conclusions
- 4. Application Examples
  - 4.1. Conserving Energy Expended by Desktop Computers
  - 4.2. Reducing Photocopier Paper Wastage
  - 4.3. Conserving Residential Utility Consumption
  - 4.4. Reducing Water Wastage from Faucets
  - 4.5. Conclusions
- 5. Conclusions and Future Work

## Telecommunications Systems Engineering for Life Support

J. Mark Pullen, George Mason University, USA

- 1. Life Support Telecommunications Issues
- 2. Principles of Telecommunications
- 3. Telecommunications Terminology
- 4. Analog and Digital Communications
- 5. ATM Networks
- 6. Multimedia Communication for Life Support
- 7. Major Network Components
- 8. Transmission Media
- 9. Packet Switched Communications
- 10. Protocol Layering
- 11. Supporting Protocols
- 12. Multicasting
- 13. Telecommunication Systems Management
- 14. Network Security

## Operational Sustainability Management for the Infrastructure: The Case of Emergency Response 269

Giampiero E.G. Beroggi, Spring Analytica, Inc., Switzerland David Mendonça, New Jersey Institute of Technology, USA William A. Wallace, Rensselaer Polytechnic Institute, USA

- 1. Introduction
- 2. The Process of Emergency Response
- 3. Opportunities for Supporting Decision Making
  - 3.1. Support for Operational Risk Management
    - 3.2. Support for Improvisation
- 4. Technologies for Decision Support
  - 4.1. Multimedia and Hypermedia
  - 4.2. Virtual Reality
  - 4.3. Group Decision Support Facilities
- 5. Methodologies for Providing Decision Support in Emergency Response
  - 5.1. Individual Decision Support
  - 5.2. Multi-Expert Decision Support
  - 5.3. A Theoretical Framework for Improvised Decision Making by Teams 5.3.1. Blackboard-based Decision Support

- 5.3.2. Adapting and Encoding Approaches to Improvisation 5.3.3. Case Study: Chemical Plant Fire
- 6. An Illustrative Example: The Port of Rotterdam
- 7. Concluding Comments

About EOLSS