

**22nd Annual International  
Symposium of the International  
Council on Systems Engineering  
(INCOSE 2012) and the 8th Biennial  
European Systems Engineering  
Conference 2012 (EuSEC 2012)**

**Rome, Italy  
9-12 July 2012**

**Volume 1 of 4**

**ISBN: 978-1-62276-916-2**

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2012) by INCOSE-International Council on Systems Engineering  
All rights reserved.

Printed by Curran Associates, Inc. (2013)

For permission requests, please contact INCOSE-International Council on Systems Engineering  
at the address below.

INCOSE-International Council on Systems Engineering  
7670 Opportunity Road, Suite 220  
San Diego, CA 92111

Phone: (800) 366-1164 or (858) 541-1725  
Fax: (858) 541-1728

[info@incose.org](mailto:info@incose.org)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2634  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

Volume 1

## **SESSION 1– TRACK 1: SECURE & ROBUST SYSTEMS**

<b>1.1.1 Development of Patrolling Schemes for Improved Border Security Performance through an Evolutionary Approach</b> .....	1
<i>Mohammed Muaafa, Jose Emmanuel Ramirez-Marquez</i>	
<b>1.1.2 Applying Model Based Systems Engineering Approach to Smart Grid Software Systems Security Requirements</b> .....	13
<i>Sitaraman Lakshminarayanan, Manyphay Souvannarnarth</i>	
<b>1.1.3 Need for Robust Systems Engineering in a Time of Budget Austerity</b> .....	21
<i>Rich Rosenthal, Sarah Sheard, William F. Neuendorf</i>	

## **SESSION 1 – TRACK 2: KNOWLEDGE MANAGEMENT**

<b>1.2.1 The Architecture and Design of a Corporate Engineering Data Repository</b> .....	31
<i>Gan Wang, Lori Saleski</i>	
<b>1.2.2 SE in a Cloud: Retiree Knowledge Capture and Consumption Optimization</b> .....	49
<i>Kenneth R. Shelby Jr., Shahram Sarkani, Thomas A. Mazzuchi</i>	
<b>1.2.3 Designing a Knowledge Management System (KMS) for a Complex Engineering Environment</b> .....	69
<i>Neha Saraf, Carys Siemieniuch</i>	

## **SESSION 1 – TRACK 3: APPLYING SE TO INNOVATION**

<b>1.3.1 How to Use Systems Architecture to Specify the Operational Perimeter of an Innovative Product Line</b> .....	84
<i>Johanna Berrebi, Daniel Krob</i>	
<b>1.3.2 Tailoring Systems Engineering Processes in a Conceptual Design Environment: A Case Study at NASA Marshall Spaceflight Center’s ACO</b> .....	100
<i>C. Dauphne Maples, John Mulqueen, Leo Fabisinski III</i>	
<b>1.3.3 Systems of Innovation I: Summary Models of SOI Health and Pathologies</b> .....	115
<i>Bruce C. Beihoff, William D. Schindel</i>	

## **SESSION 1 – TRACK 4: SE EDUCATION**

<b>1.4.1 Program Accreditation and the Graduate Reference Curriculum in Systems Engineering (GRCSE™)</b> .....	131
<i>David H. Olwell, Stephanie Enck, Nicole Hutchison, Art Pyster, James Anthony</i>	
<b>1.4.2 Systems Engineering Education for Confirmed Engineers: Experience Feedback</b> .....	139
<i>Omar Hammami, Jean-René Ruault</i>	
<b>1.4.3 The Open Academic Model and the Impact of the Stevens Systems Engineering Program</b> .....	157
<i>Kahina Lasfer, Art Pyster</i>	

## **SESSION 1 – TRACK 5: PANEL**

<b>1.5.0 Role of Decision Analysis in Early Systems Decision Making</b> .....	170
<i>Frank Salvatore, William Miller, Gregory Parnell, Robert Kenley</i>	

## **SESSION 1 – TRACK 6: DIFFERENT APPROACHES TO ARCHITECTURE**

<b>1.6.1 xFFBD: Towards a Formal Yet Functional Modeling Language for System Designers</b> .....	171
<i>Bruno Aizier, Vincent Chapurlat, Stéphanie Lizy-Destrez, Daniel Prun, Charlotte Seidner, Jean-Luc Wippler</i>	

<b>1.6.2 Generic Approach for Systems Design Optimization in MBSE</b> .....	185
<i>Henry Broodney, Dolev Dotan, Lev Greenberg, Michael Masin</i>	
<b>1.6.3 What Makes Motif Patterns of Engineering Systems Architectures to Look Alike?</b> .....	202
<i>A. S. Shaja, K. Sudhakar</i>	

**SESSION 2 – TRACK 1: SE METHODS APPLIED TO SECURITY SYSTEMS**

<b>2.1.1 Security Systems Engineering: Using Functional Decomposition to Resolve a Confused Taxonomy</b> .....	217
<i>Marcus A. Thompson, Michael J. Ryan, Alan C. McLucas</i>	
<b>2.1.2 A Novel Approach to Large System Performance Prediction Via Markov Analysis</b> .....	228
<i>Roberto Petrucci, Domenico Vigilante</i>	

**SESSION 2 – TRACK 2: DECISION MANAGEMENT**

<b>2.2.1 Decision Management (DM) as the Engine for Scalable Cross Domain Systems Engineering (SE)</b> .....	242
<i>Pradeep Mendonza, John A. Fitch</i>	
<b>2.2.2 A Decision Support Framework for the Software Systems Engineer</b> .....	256
<i>Robert J. Knapper, Peggy S. Brouse</i>	

**SESSION 2 – TRACK 3: TECHNOLOGY ASSESSMENT**

<b>2.3.1 The U.S. Department of Defense Technology Transition: A Critical Assessment</b> .....	272
<i>Azi Sharif, Junfang Yu, Jerrell Stracener</i>	
<b>2.3.2 It’s All Rocket Science: On the Equivalence of Development Timelines for Aerospace and Nuclear Technologies</b> .....	286
<i>Maxime Crépin, C. Robert Kenley, Bernard El-Khoury</i>	

**SESSION 2 – TRACK 4: MAKING A CASE FOR SE**

<b>2.4.1 A Case of Systems Engineering in Daily Life</b> .....	301
<i>Cheol Woo Lee, Hyundai Rotem</i>	
<b>2.4.2 Systems Engineering Saves the Day!</b> .....	311
<i>Cecilia Haskins, Alexander Welland</i>	

**SESSION 2 – TRACK 6: SE FOCUSED ON HUMAN FACTORS**

<b>2.6.1 Graphical Representation of Situation Awareness in Joint Cognitive Systems</b> .....	325
<i>Patrick Hew, Lydia Byrne, John O’Neill</i>	
<b>2.6.2 Sociotechnical Systems Resilience</b> .....	340
<i>Jean-René Ruault, Frédéric Vanderhaegen, Dominique Luzeaux</i>	

**SESSION 3 – TRACK 1: HOW IT ENABLES SE**

<b>3.1.1 The Impact of IT on Product Architecture and Project Outcomes</b> .....	356
<i>Tucker J. Marion, Marc H. Meyer, Gloria Barczak, Greg Brown</i>	
<b>3.1.2 Machine Learning Technologies for the Requirements Analysis in Complex Systems</b> .....	372
<i>Manuela Nardini, Francesco Ciambra, Francesco Garzoli, Danilo Croce, Diego De Cao, Roberto Basili</i>	

**SESSION 3 – TRACK 2: DECISION MANAGEMENT**

<b>3.2.1 Systems Engineering Decision Making May Be More Emotional Than Rational!</b> .....	387
<i>Brian E. White</i>	

<b>3.2.2 Enhancing the System Development Process Performance: A Value-Based Approach .....</b>	<b>402</b>
<i>Manuel Mastrofini, Giovanni Cantone, Forrest Shull, Madeline Diep, Carolyn Seaman, Davide Falessi</i>	

**SESSION 3 – TRACK 3: PANEL**

<b>3.3.0 Identifying the Top Challenges for International Research in Systems of Systems Engineering.....</b>	<b>417</b>
<i>Michael Henshaw, Alkis Konstantellos, John S. Fitzgerald, Alberto Sangiovanni Vincentelli, Armando Walter Colombo, Vincent Heuveline, Mo M. Jamshidi</i>	

**SESSION 3 – TRACK 4: SE PRINCIPLES**

<b>3.4.1 Yes Systems Engineering, You Are a Discipline.....</b>	<b>434</b>
<i>Joseph Kasser, Derek Hitchins</i>	
<b>3.4.2 Putting the System Back Into Systems Engineering .....</b>	<b>450</b>
<i>Bernhard Meyer</i>	

**SESSION 3 – TRACK 6: IMPROVED REQUIREMENTS WITH MBSE**

<b>3.6.1 Rapid Prototyping and Validation of Human Factors Model in a Model Based Naval Systems Engineering Application .....</b>	<b>466</b>
<i>H. Gopinathan, Andrea Tocci, Francesco Ciambra, D. Frisoni</i>	
<b>3.6.2 Next Generation Requirements Engineering.....</b>	<b>479</b>
<i>John Favaro, Silvia Mazzini, Hans-Peter De Koning, Rudolf Schreiner, Xavier Olive</i>	

**SESSION 4 – TRACK 1: PANEL**

<b>4.1.0 Using V&amp;V to Create Win-Win Supply Chain Partnerships : A Technical Approach to Deliver Business Benefit .....</b>	<b>493</b>
<i>Anne O'Neil, Sam Chan, Kuldeep Gharatya, Heikki Viika, Claude Andlauer, Dan Barrett</i>	

**SESSION 4 – TRACK 2: APPLYING SE TO BIOMEDICAL APPLICATIONS**

<b>4.2.1 Platforms for Engineering Experimental Biomedical Systems .....</b>	<b>508</b>
<i>Matthew Mosteller, Mark Austin, Shah-An Yang, Reza Ghodssi</i>	
<b>4.2.2 Application of Systems Engineering to Improve Extracorporeal Membrane Oxygenation (ECMO) Therapy .....</b>	<b>523</b>
<i>L. Drew Pihera, Tommer Ender, Brian Taylor, Nicholas Bollweg, Matthew L. Paden, Andrew Lopez, Scott King</i>	
<b>4.2.3 A Systems Approach to Medical Device Compliance with IEC 60601-1:2005.....</b>	<b>538</b>
<i>Chad Gibson, Fritz Eubanks, Felicia Hobson</i>	

**SESSION 4 – TRACK 3: SYSTEMS THINKING**

<b>4.3.1 The Barriers to Systems Thinking.....</b>	<b>550</b>
<i>Richard Beasley</i>	
<b>4.3.2 Integrating Systems Science, Systems Thinking, and Systems Engineering: Understanding the Differences and Exploiting the Synergies .....</b>	<b>565</b>
<i>Hillary Sillitto</i>	
<b>4.3.3 Emergence: The Illusion of Knowledge .....</b>	<b>581</b>
<i>George R. McConnell</i>	

**SESSION 4 – TRACK 4: USING MBSE IN PRODUCT LIFECYCLE MANAGEMENT**

<b>4.4.1 Using MBSE Methodology to Drive a PLM Initiative .....</b>	<b>596</b>
<i>Daniele Ciriello</i>	
<b>4.4.2 MBSE Feasibility Study to Improve PLM Business Solution System Specification and Design.....</b>	<b>607</b>
<i>Marco Alemanni, Elena Valfrè, Angelo Corallo, Maria Elena Latino</i>	

<b>4.4.3 Efficiently Managing Product Baseline Configurations in the Model-Based System Development of a Combat System Product Family</b> .....	622
<i>Steven W. Mitchell</i>	

**SESSION 4 – TRACK 5: MBSE IN AVIONICS**

<b>4.5.1 Systems Modeling with SysML - An Experience Report</b> .....	633
<i>Erik Herzog, Jessica Hallonquist, Johan Naeser</i>	
<b>4.5.2 Model-based Automatic Generation and Selection of Safe Architectures</b> .....	645
<i>Helene Condat, Carsten Strobel, Andreas Hein</i>	
<b>4.5.3 Model-Based Systems Engineering in an Integrated Environment</b> .....	666
<i>Christi A. Gau Pagnanelli, Ronald S. Carson, John R. Palmer, Michael E. Crow, Barbara J. Sheeley</i>	

**SESSION 4 – TRACK 6: ACADEMIC PROGRAM – INVITED PANEL**

<b>4.6.0 Can We Improve Professional Systems Engineering Practice through a Graduate Reference Curriculum Model (GRCSE)?</b> .....	683
<i>Richard D. Adcock, David H. Olwell, Wolt Fabrycky, Ariela Sofer, Vincenzo Arrichiello, Timothy Ferris</i>	

**SESSION 5 – TRACK 1: V&V IN TRANSPORTATION**

<b>5.1.1 Verification &amp; Validation, an Inconvenient Truth</b> .....	694
<i>Erik Elich, Paul Schreinemakers, Maarten Vullings</i>	
<b>5.1.2 Entering a Brave New World - Applying Systems Engineering to American Infrastructure Projects - Case Study: The California High-Speed Train Project</b> .....	707
<i>Oliver M. Hoehne</i>	

Volume 2

**SESSION 5 – TRACK 2: APPLYING SE TO HEALTHCARE DELIVERY**

<b>5.2.1 The Facility Location for Emergency Response – A Multi-objective Approach</b> .....	722
<i>Ivan Hernandez, Jose Ramirez-Marquez</i>	
<b>5.2.2 Human Systems Integration in Next-Generation Expeditionary Medical Treatment Facilities</b> .....	737
<i>Dennis J. Folds</i>	

**SESSION 5 – TRACK 3: PERCEPTION MATTERS**

<b>5.3.1 Emergence: All in the Minds</b> .....	749
<i>George R. McConnell</i>	
<b>5.3.2 Information Technology (IT) Project Management Failures: Historical and Evolutionary Walk through from a Social Dynamic Perspective – A Primer to “Preemptive and Adaptive Project Management”</b> .....	762
<i>Rosana Stoica, Peggy Brouse</i>	

**SESSION 5 – TRACK 4: MAKING IMPROVEMENTS TO THE PRODUCT LIFECYCLE**

<b>5.4.1 An Experimental Methodology to Evaluate Concept Generation Procedures Based on Quantitative Lifecycle Performance</b> .....	777
<i>Michel-Alexandre Cardin, Gwendolyn L. Kolfshoten, Daniel D. Frey, Richard De Neufville, Olivier L. De Weck, David M. Geltner</i>	
<b>5.4.2 Introducing Systems Engineering Views in Product Lifecycle Management</b> .....	802
<i>Frederic Autran, Dieter Scheithauer</i>	

**SESSION 5 – TRACK 5: MBSE USED FOR SOS**

**5.5.1 A SysML-based Approach for the Specification of Complex Systems** ..... 817  
*Paolo Petrinca, Mario Gammaldi, Lucio Tirone*

**5.5.2 Connections in Systems of Systems** ..... 831  
*John S. Osmundson, Gary O. Langford*

**SESSION 5 – TRACK 6: ACADEMIC PROGRAM – INVITED PANEL**

**5.6.0 How Can INCOSE Help Those Creating New Systems Engineering Masters Programs?** ..... 844  
*Avigdor Zonnenshain, Gerrit Muller, Barry Boehm, Khim Teck Yeo, Michele Luglio, Richard Adcock*

**SESSION 6 – TRACK 1: PANEL**

**6.1.0 System Verification and Validation: Methodology and Tools throughout System Life Cycle** ..... 856  
*Paul Davies, Tony Vento, Marco Lisi, Clotilde Marchal, Alfonso Farina*

**SESSION 6 – TRACK 2: PANEL**

**6.2.0 Systems Engineering on Center Stage in the Biomedical Industry** ..... 857  
*John Gardner, Shahid Shah, Melissa Rosen, Rick Schrenker*

**SESSION 6 – TRACK 3: PANEL**

**6.3.0 Can We Train for Systems Thinking?** ..... 863  
*Avigdor Zonnenshain, Hillary G. Sillitto, Joseph Kasser, Eric Honour, Uzi Orion, Cecilia Haskins, Moti Frank, Patrick Godfrey*

**SESSION 6 – TRACK 4: IMPROVING PROJECT PLANNING**

**6.4.1 Systems Engineering Business Context: The Evaluation of the South African Systems Engineering Industry** ..... 870  
*Charl Harding*

**6.4.2 The 7 +/- 2 Uses For An Estimation Tool** ..... 886  
*Andrew J. Nolan, Andrew C. Pickard*

**SESSION 6 – TRACK 5: USING MBSE IN THE PHYSICAL DISCIPLINES**

**6.5.1 A Collaborative Process Based on Systems Engineering and Mechatronics Methods** ..... 899  
*Françoise Caron*

**6.5.2 MBSE Supports Manufacturing System Design** ..... 920  
*Ola Batarseh, Leon McGinnis, Jim Lorenz*

**SESSION 6 – TRACK 6: ACADEMIC PROGRAM – PANEL**

**6.6.0 What is the Value of the SE Body of Knowledge for INCOSE and SE?** ..... 931  
*Richard Adcock, Art Pyster, Jean-Claude Roussel, David D. Walden, William D. Miller, Kevin Forsberg*

**SESSION 7 – TRACK 1: INVITED PANEL**

**7.1.0 Program Management and Systems Engineering: A Partnership for De-risking Complex Programs** ..... 940  
*Terry Cooke-Davies, Séverin Drogoul, Meg A. Selfe, Pedro A. Jiménez Minchillo, Todd W. Zarfos*

## **SESSION 7 – TRACK 2: TRANSPORTATION**

<b>7.2.1 UK Railway System Reliability - Modelling the Future – A Case Study</b> .....	945
<i>Nigel Best, Bradley Hyland, Suzanne Waters</i>	
<b>7.2.2 An Introduction to Applying Systems Engineering to In-Service Systems</b> .....	963
<i>Marcel Van De Ven, Joe Talik, Jonathan Hulse</i>	
<b>7.2.3 FasTracks Transit Program Oversight Using Systems Engineering Principles</b> .....	979
<i>Timothy Stokes</i>	

## **SESSION 7 – TRACK 4: INDUSTRY VALUE BUILT-IN**

<b>7.4.1 Towards a Value-Driven Design Methodology – Enhancing Traditional Requirements Management Within the Extended Enterprise</b> .....	994
<i>Anne Monceaux, Mario Kossmann</i>	
<b>7.4.2 What's Fundamentally Wrong? Improving Our Approach Towards Capturing Value in Requirements Specification</b> .....	1010
<i>Tom Gilb, Lindsey Brodie</i>	
<b>7.4.3 Understanding Airlines' Value Perceptions For Value-Based Requirements Engineering of Commercial Aircraft</b> .....	1024
<i>Xinwei Zhang, Guillaume Auriol, Claude Baron, Hakki Eres, Mario Kossmann</i>	

## **SESSION 7 – TRACK 5: CAPABILITY**

<b>7.5.1 An Incremental Hybridisation of Heterogeneous Case Studies to Develop an Ontology for Capability Engineering</b> .....	1040
<i>Huseyin Dogan, Michael Henshaw, Julian Johnson</i>	
<b>7.5.2 Applying Systems Engineering Principles Towards Developing Defence Capabilities</b> .....	1056
<i>Corné Smith, René Oosthuizen</i>	
<b>7.5.3 Common Sense – Uncommon Practice? Capability Engineering Examples from Rail and Defence</b> .....	1071
<i>Duncan Kemp, Jennifer Mollett</i>	

## **SESSION 7 – TRACK 6: ACADEMIC PROGRAM – INVITED PANEL**

<b>7.6.0 How Can We Continue to Grow the INCOSE University Student Divisions Program?</b> .....	1089
<i>Richard D. Adcock, Dave Mason, Steven Corns, Richard Freeman, James Armstrong</i>	

## **SESSION 7 – TRACK 7: REQUIREMENTS ENGINEERING**

<b>7.7.1 Getting the Right Requirements Right</b> .....	1096
<i>Joseph Kasser</i>	
<b>7.7.2 A Survey on Industrial Practices in Requirements Engineering</b> .....	1112
<i>Gauthier Fammuy, Ghassen Foughali</i>	
<b>7.7.3 The Requirements Engineering Process Design for Six Sigma</b> .....	1132
<i>Hakan Yurt, Peggy Brouse</i>	

## **SESSION 8 – TRACK 1: APPLIED PROJECT MANAGEMENT**

<b>8.1.1 The Factors that Lead to Unidentified Risks in Software-intensive Projects</b> .....	1146
<i>Efrat Yuval, Tsvi Kuflik, Meir Tahan</i>	
<b>8.1.2 Principles of Systems Engineering Management: Reflections from 45 Years of Spacecraft Technology Research and Development at the Mullard Space Science Laboratory</b> .....	1160
<i>M. R. Emes, A. Smith, A. M. James, M. W. Whyndham, R. Leal, S. C. Jackson</i>	



## **SESSION 8 – TRACK 2: MANAGING ENTERPRISE SYSTEMS**

- 8.2.1 Enterprise Systems Engineering - Practical Challenges and Emerging Solutions** ..... 1176  
*Peter Brook, Tom Riley*
- 8.2.2 Infrastructure Control Modeling Language (ICML)** ..... 1193  
*Erik W. Aslaksen*

## **SESSION 8 – TRACK 3: BEST PRACTICES IN RISK PREVENTION**

- 8.3.1 Toward Integrating Assurance Case into Risk-Based Requirements Management** ..... 1211  
*David Feng, Curt Eyster*
- 8.3.2 Generated Risk Event Effect Neutralization: Identifying and Evaluating Risk Mitigation Strategies During Conceptual Design** ..... 1225  
*Daniel Krus, Katie Grantham, Susan Murray*

## **SESSION 8 – TRACK 4: VALUE BASED SE IN SPACE**

- 8.4.1 Assessing Uncertain Benefits: A Valuation Approach for Strategic Changeability** ..... 1238  
*Matthew E. Fitzgerald, Adam M. Ross, Donna H. Rhodes*
- 8.4.2 Measuring the Value of Adaptability of Fractionated Spacecraft** ..... 1256  
*Roshanak Nilchiani, Mahmoud Efatmaneshnik, Kia Dalili*

## **SESSION 8 – TRACK 5: PANEL**

- 8.5.0 Practical Experience of Capability and System of Systems Engineering in Defence, Rail, Biomedical and Information Services. Engineering in Defence, Rail, Biomedical and Information Services.** ..... 1273  
*Michael Henshaw, Duncan Kemp, Julian Goldman, Derek Price, Stephen C. Cook, Ricardo Valerdi*

## **SESSION 8 – TRACK 6: ACADEMIC PROGRAM – INVITED PANEL**

- 8.6.0 What is the Future Agenda for Systems Engineering Research?** ..... 1279  
*Paul R. Davies, Timothy L. J. Ferris, Jon Wade, Ricardo Valerdi, Patrick Godfrey*

## **SESSION 8 – TRACK 7: REQUIREMENTS TRACEABILITY**

- 8.7.1 Comprehensive Requirement Traceability Information, and Relations in Project Life-Cycle** ..... 1285  
*Vikas Shukla, Guillaume Auriol, Claude Baron, Xinwei Zhang*
- 8.7.2 On the Complexity of Requirements Flow-down Structures** ..... 1300  
*Jeremy Dick, Brendan Jones*

## **SESSION 9 – TRACK 1: PROJECT MANAGEMENT THEORY**

- 9.1.1 Systems Engineering and Project Management Intersects and Confusion** ..... 1310  
*Eileen Arnold*
- 9.1.2 Antipatterns in Systems Engineering: An Opening Trio** ..... 1336  
*Colin J. Neill*

## **SESSION 9 – TRACK 2: ESSENTIAL SE LEADERSHIP**

- 9.2.1 The One-eyed Systems Engineer – Pirate Or Prophet? An Analysis of the Effectiveness of Different Systems Engineering Leadership Styles** ..... 1349  
*Duncan Kemp, Jon Elphick*

<b>9.2.2 Observations from Applying SE Principles on a Large Research Project Developing Processes, Methods &amp; Tools for Modelling &amp; Simulation of Aircraft Behaviour .....</b>	<b>1368</b>
<i>Tim Lochow, Timo Laudan, Sanjiv Sharma, Peter Coleman</i>	

**SESSION 9 – TRACK 3: USING ROOT CAUSE ANALYSIS TO IMPROVE RISK MANAGEMENT**

<b>9.3.1 A Deterministic Approach to Risk Management .....</b>	<b>1381</b>
<i>Shimon Zeierman</i>	
<b>9.3.2 A Root Cause Analysis Method Using Dual Vee Model for Cause Identification Reliability Improvement .....</b>	<b>1396</b>
<i>Hironori Maejima, Naohiko Kohtake, Yoshiaki Ohkami</i>	

**SESSION 9 – TRACK 4: APPLYING SE STANDARDS**

<b>9.4.1 Synergies between INCOSE SE Handbook, CMMI and DO-178B .....</b>	<b>1411</b>
<i>Antonio Monzon</i>	
<b>9.4.2 The NILS Innovative Process and Approach to Manage and Measure Complex Systems Effectiveness and Availability .....</b>	<b>1427</b>
<i>C. F. Mirko Leonardi, Simeone M. Solazzi, Francesco Ciambra, Michele Sinisi</i>	

**SESSION 9 – TRACK 5: APPLYING SE AFTER DEVELOPMENT**

<b>9.5.1 Characterizing the Accuracy of DoD Operating &amp; Support Cost Estimates .....</b>	<b>1438</b>
<i>Erin T. Ryan, David R. Jacques, Jonathan D. Ritschel, Christine M. Schubert</i>	

Volume 3

<b>9.5.2 Aging Aircraft Fleet Viability .....</b>	<b>1453</b>
<i>Randall C. Bullard</i>	

**SESSION 9 – TRACK 6: SE SKILL DEVELOPMENT**

<b>9.6.1 Developing Expertise in Systems Engineering: Lessons from Other Disciplines.....</b>	<b>1466</b>
<i>James R. Armstrong, Jon Wade</i>	
<b>9.6.2 Developing Systems Engineering Competencies in Undergraduate Students for Industrial Placements.....</b>	<b>1482</b>
<i>Ella-Mae Hubbard</i>	

**SESSION 9 – TRACK 7: SYSTEM INTEGRATION**

<b>9.7.1 Model Based Tool for Planning Optimal Integration Processes Under Severe Uncertainty .....</b>	<b>1490</b>
<i>Meir Tahan, Roy Benish</i>	
<b>9.7.2 “Looking Forward” Engineering Systems Integration.....</b>	<b>1502</b>
<i>Meir Tahan</i>	

**SESSION 10 – TRACK 1: APPLYING SE IN AUTOMOTIVE**

<b>10.1.1 A Commonsense-Driven Architecture Framework. Part 1: A Car Manufacturer’s (Naïve) Take on MBSE.....</b>	<b>1513</b>
<i>Hugo G. Chale Gongora, Alain Dauron, Thierry Gaudré</i>	
<b>10.1.2 Towards a Framework for Variability Management and Integration in Systems Engineering.....</b>	<b>1528</b>
<i>Alain Dauron, Cosmin Dumitrescu, Camille Salinesi</i>	

## **SESSION 10 – TRACK 2: SE COMPETENCY**

- 10.2.1 A Framework to Institutionalize Systems Engineering Skill-Set** ..... 1542  
*Ebad Jahangir*
- 10.2.2 Guide for Selecting an Appropriate Competency Assessment Instrument** ..... 1555  
*Jack Ring*

## **SESSION 10 – TRACK 3: TAILORED PROCESSES FOR SMALL ENTERPRISES**

- 10.3.1 The Development of Systems Engineering International Standards and Support Tools for Very Small Enterprises** ..... 1563  
*Claude Y. Laporte, Gauthier Fanmuy, Ken Ptack*
- 10.3.2 Systems Engineering Lite** ..... 1591  
*James Kolozs, Cody Henderson, John Gardner*

## **SESSION 10 – TRACK 4: SE APPLICATIONS IN LARGE COMPLEX SOS**

- 10.4.1 The Dynamics of Water, Energy, Waste and Environment (WEWE) Systems** ..... 1606  
*Eng Seng Chia, Qiaoyi Chen*
- 10.4.2 Enterprise Integration: A Framework for Connecting the Dots** ..... 1619  
*Ronald L. Stroup, Kenneth J. Kepchar*

## **SESSION 10 – TRACK 5: MBSE CASE STUDIES**

- 10.5.1 An MBSE Case Study and Research Challenges** ..... 1634  
*Quoc Do, Stephen Cook*
- 10.5.2 Three Years of MBSE for a Large Scientific Programme: Report from the Trenches of Telescope Modelling** ..... 1647  
*Robert Karban, Michele Zamparelli, Bertrand Bauvir, Gianluca Chiozzi*

## **SESSION 11 – TRACK 1: SE APPLICATIONS IN ENERGY**

- 11.1.1 Agent-Based Modeling for Smart Grid: Application to Consumer Reaction to Demand Response** ..... 1662  
*Jung-Ho Lewe, Michael Z. Miller, Kristin M. Kelly*
- 11.1.2 Simulation of an Electric Utility Network and Control System in SysML** ..... 1676  
*Matthew Hause, Fabrizio Pugnetti*
- 11.1.3 Engineering Clean Energy Systems** ..... 1690  
*Alex Pavlak*

## **SESSION 11 – TRACK 2: PANEL**

- 11.2.0 Competency Assessment, Is it Really Worth the Effort?** ..... 1705  
*Eileen Arnold, Duncan Kemp, Vincenzo Arrichiello, Richard Beasley, Joseph Kasser*

## **SESSION 11 – TRACK 3: APPLYING LEAN METHODS**

- 11.3.1 Set-based Design – The Lean Tool That Eludes Us; Pitfalls in Implementing Set-based Design in Kongsberg Automotive** ..... 1719  
*Elisabeth Hansen, Gerrit Muller*
- 11.3.2 Rework: Model & Metrics - An Experience Report at Thales Airborne Systems** ..... 1735  
*Edmond Tonnellier, Olivier Terrien*
- 11.3.3 System Concurrent Engineering of a Star Sensor** ..... 1749  
*Geilson Loureiro, Marcio Afonso Fialho, Ana Paula Rabello*

## **SESSION 11 – TRACK 4: APPROACHES FOR SOS**

<b>11.4.1 Systems of Systems (SoS) Engineering: A View from the Inside Looking Out</b> .....	1769
<i>C. E. Siemieniuch, M. A. Sinclair</i>	
<b>11.4.2 Measuring the Requirements Allocation Capacity within a System of Systems</b> .....	1787
<i>David Flanigan, Peggy Brouse</i>	
<b>11.4.3 Impact of Agile Process in Systems Engineering</b> .....	1799
<i>Suresh Pamujula, Kristin Kelly, Rajesh Thoppay, Rusty Fish</i>	

## **SESSION 11 – TRACK 5: MBSE IN SPACE**

<b>11.5.1 Early Formulation Model-Centric Engineering on NASA’s Europa Mission Concept Study</b> .....	1811
<i>Todd Bayer, Seung Chung, Bjorn Cole, Brian Cooke, Frank Dekens, Chris Delp, I. Gontijo, Kari Lewis, Mehrdad Moshir, Robert Rasmussen, David Wagner</i>	
<b>11.5.2 A NASA Space Communications and Navigation SysML Profile Adaptation</b> .....	1827
<i>Patrick Barnes</i>	
<b>11.5.3 Cost-Benefit Analysis of SysML Modelling for the Atomic Clock Ensemble in Space (ACES) Simulator</b> .....	1842
<i>Julien Maurandy, Eberhard Gill, Achim Helm, Roland Stalford</i>	

## **TUTORIALS**

<b>SEP Certification Preparation Tutorial</b> .....	1862
<i>Tom Strandberg, Kevin Forsberg, Daniel Falk</i>	
<b>Applied Systems Engineering: Fundamentals for Project Success</b> .....	1864
<i>David A. Long</i>	
<b>Thinking Outside the Box - In Systems Engineering &amp; Integration</b> .....	1865
<i>Howard Eisner</i>	
<b>Model-Based Systems Engineering: Methodologies, Languages, Complexity Management, and Standardization</b> .....	1889
<i>Dov Dori</i>	
<b>Tutorial on the Systems Engineering Body of Knowledge (SEBok)</b> .....	2045
<i>Dave Olwell, Art Pyster, Nicole Hutchison</i>	
<b>Graduate Reference Curriculum for Systems Engineering (GRCSE™)</b> .....	2066
<i>N/A</i>	
<b>How to Do Systems Engineering Competency Assessment Using the INCOSE SE Competencies Framework: Guidance for Preparing for and Executing Successful Assessments</b> .....	2072
<i>Ian G. Presland, William H. Johnson</i>	
<b>Critical Thinking for the Systems Engineering Enterprise</b> .....	2074
<i>Robert Niewoehner, David F. Rogers</i>	
<b>System Design</b> .....	2094
<i>Gerrit Viljoen</i>	
<b>Impact Estimation: A Basic Systems Engineering Tool</b> .....	2147
<i>Tom Gilb</i>	
<b>Requirements Engineering for Large Systems</b> .....	2181
<i>Brian Berenbach, Henk Broeze</i>	
<b>Requirements Engineering for Contract-Based Systems</b> .....	2182
<i>Brian Berenbach, Henk Broeze</i>	
<b>Essential Model-Based Systems Engineering – Models, SysML, and More</b> .....	2183
<i>David A. Long, Paul W. Logan</i>	

## Volume 4

<b>Tutorial on Systems of Systems</b> .....	2185
<i>Dominique Luzeaux</i>	
<b>The Art of the Trade Study</b> .....	2246
<i>Mark A. Wilson</i>	
<b>From Complex Systems to Complex Systems Engineering</b> .....	2247
<i>Dominique Luzeaux</i>	

<b>The System Concept: Bringing Order to Chaos</b> .....	2298
<i>Regina M. Griego</i>	
<b>Systems Engineering and Total Ownership Cost Estimation</b> .....	2299
<i>Ray Madachy, Ricardo Valerdi</i>	

## **POSTERS**

<b>Agile Collaborative Systems Engineering - Motivation for a Novel Approach to Systems Engineering</b> .....	2384
<i>Emrah Asan, Semih Bilgen</i>	
<b>An Alenia Aermacchi Study and Experience on MBSE Application</b> .....	2399
<i>Luciana Lo Verde, Guido Pavan, Elena Valfrè, Marco Fioriti</i>	
<b>Analyzing Human Machine Interaction and Interfaces through Model Based System Engineering Practices</b> .....	2418
<i>Douglas Orellana, Azad Madni</i>	
<b>Architecting Diesel Engine Control System Using A3 Architecture Overview</b> .....	2429
<i>Bjørnar Wiulsrød, Gerrit Muller</i>	
<b>The Architecture of the Systems Engineering Experience Accelerator</b> .....	2444
<i>Jon P. Wade, George Kamberov, Douglas A. Bodner, Alice F. Squires</i>	
<b>Characteristic-based Risk Assessment and Its Relation with Event-Based Risk Assessment</b> .....	2459
<i>Thijs Mathot, Rob Hamann, Eberhard Gill</i>	
<b>Complex Systems Advanced Modelling</b> .....	2467
<i>Francesco Ciambra, Manuela Nardini, Adriano Protano, Andrea Tocci</i>	
<b>A Custom Requirements Database for the California High-speed Train Project Or “You’re Going to Need a Bigger Boat”</b> .....	2484
<i>Matthew Petty</i>	
<b>Cybernetics and SysML: First Steps</b> .....	2498
<i>Abraham Raheer, Paul Pangaro</i>	
<b>Dependency Analysis in Complex System Design Using the FireSat Example</b> .....	2508
<i>Johannes Groß, Stephan Rudolph</i>	
<b>Developing the Modeling Recommendation Matrix: Model-Assisted Communication at Volvo Aero</b> .....	2522
<i>Rasmus Wibe Rypdal, Gerrit Muller, Michael Pennotti</i>	
<b>Development of Systems Engineering People to Support Major Transformation Plans in Thales (Process, Roles, Methodology &amp; Related Tools)</b> .....	2536
<i>Odile Mornas, Catherine Laporte Weywada, Roland Mazzella, Anne Sigogne, Patricia Pancher</i>	
<b>Documents are an Essential Part of Model Based Systems Engineering</b> .....	2551
<i>Paul Logan, David Harvey, Daniel Spencer</i>	
<b>Efficiency Management in Spaceflight Systems</b> .....	2566
<i>Karen Murphy</i>	
<b>Estimation: A Paradigm Shift towards Dynamic Design-to-Cost and Radical Management</b> .....	2581
<i>Tom Gilb</i>	
<b>Future Combat Systems Case Study for Analysis of System of Systems Approach</b> .....	2599
<i>Tina P. Srivastava, Victor L. Piper, Jose M. Arias</i>	
<b>Gaps in the Body of Knowledge of Systems Engineering</b> .....	2619
<i>Alice Squires, Garry Roedler, David Olwell, Joseph J. Ekstrom</i>	
<b>HAZOP Analysis of Product Requirements for Early Failure Mode Identification</b> .....	2629
<i>Fritz Eubanks</i>	
<b>Investigating Alternative Concepts of Operations for a Maritime Security System of Systems</b> .....	2638
<i>Brian Mekdeci, Adam M. Ross, Donna H. Rhodes, Daniel E. Hastings</i>	
<b>Maestro – A Model-based Systems Engineering Environment for Complex Electronic Systems</b> .....	2651
<i>Manas Bajaj, Andrew Scott, Douglas Deming, Gregory Wickstrom, Mark De Spain, Dirk Zwemer, Russell Peak</i>	
<b>Managing Concurrency in Systems Engineering</b> .....	2668
<i>Dieter Scheithauer</i>	
<b>Managing System of Systems Requirements with a Requirements Screening Group</b> .....	2683
<i>Ronald R. Barden, David D. Evans</i>	
<b>Model-Based Systems Engineering as an Enabler for Regulatory Design Compliance</b> .....	2692
<i>Jered Dean, Cody Henderson, John Gardner</i>	
<b>Model-based Interface Specification for Systems Integration in Systems of Systems Engineering</b> .....	2705
<i>Daniele Gianni, Andrea D’Ambrogio, Pierluigi De Simone, Marco Lisi, Michele Luglio</i>	
<b>A Model-based Method for the Synthesis and Optimization of Systems Architectures</b> .....	2718
<i>Nicolas Albarello, Jean-Baptiste Welcomme</i>	

<b>A Model-based Reference Architecture for Medical Device Development</b> .....	2731
<i>Steven Combs, Chad Gibson</i>	
<b>Modelling Governance within Business Architecture Using Topic Mapping</b> .....	2741
<i>Peter Bryant</i>	
<b>Modularity and Fractionation in Complex Systems: A Value-Centric Approach</b> .....	2751
<i>Babak Heydari, Kia Dalili</i>	
<b>My COCOMO: Building Your Own Incremental Software Build Estimation Tools</b> .....	2766
<i>Andrew C. Pickard, Andy J. Nolan</i>	
<b>A Performance-based Statistical Expert Judgment Model to Assess Technical Performance and Risk</b> .....	2781
<i>Justin W. Eggstaff, Thomas A. Mazzuchi, Shahram Sarkani</i>	
<b>A Principle Modeling Framework for Software Intensive Systems</b> .....	2793
<i>Amir Tomer</i>	
<b>Requirements Management Applied During a Campaign</b> .....	2806
<i>Volker Stephan, Richard Beasley</i>	
<b>Software Patterns for Traceability of Requirements to Finite State Machine Behavior: Application to Rail Transit Systems Design and Management</b> .....	2821
<i>Parastoo Delgoshaei, Mark Austin</i>	
<b>Systems Engineering for the Design of a Smart Energy Box</b> .....	2836
<i>Jon Hickey, Pankaj Kashyap, Jorge Moreno, Naveen Ranganath, Alex Thomas</i>	
<b>Systems Thinking in the Planning of Military Operations</b> .....	2853
<i>A. P. Greeff</i>	
<b>Teaching Them How to Fish: Industry-Focused Student Projects in Systems Engineering</b> .....	2868
<i>Ricardo Valerdi, Avigdor Zonnenshain</i>	
<b>Topic-based Approach for Contract-based Requirements Development</b> .....	2876
<i>Helmut Degen, Jochen G. Kaepfel, Sue Laventhiran</i>	
<b>Using the Guide to the Systems Engineering Body of Knowledge (SEBoK version 0.5) for Undergraduate System Engineering Program Assessment</b> .....	2888
<i>Gregory S. Parnell, Daniel J. McCarthy, Nicholas Hardman, Gary E. Yale</i>	
<b>What's in a Wiki? Using Collaborative Technology for Developing, Reviewing, and Publishing the Systems Engineering Body of Knowledge (SEBoK)</b> .....	2901
<i>Nicole Hutchison, Arthur Pyster, Stephanie Enck, Hans-Peter De Koning</i>	

## **ADDITIONAL PAPERS**

<b>Integrating Reasoning with SysML</b> .....	2908
<i>Henson Graves</i>	
<b>Managing and Understanding Complex Systems Using Traceability and Open Source Software</b> .....	2923
<i>Mark Brörkens, Ömer Gürsoy</i>	
<b>Author Index</b>	