

**21st Annual International
Symposium of the International
Council on Systems Engineering 2011
(INCOSE 2011)**

**Denver, Colorado, USA
20-23 June 2011**

Volume 1 of 4

ISBN: 978-1-61839-115-5

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© (2011) by INCOSE-International Council on Systems Engineering
All rights reserved.

Printed by Curran Associates, Inc. (2011)

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

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
Web: www.proceedings.com

TABLE OF CONTENTS

VOLUME 1

SESSION: 1

NEW RISK MANAGEMENT METHODS

Recommended Verification Approach for Human Rated Systems Based on Lessons Learned on the Orion Launch Abort System	1
<i>Kenneth Bocam, Darko Filipi, Benjamin Herbert, Charlotte Pappageorge, G. Fitz Vernon</i>	
How Applying Models in Work Group Sessions Can Help to Retrieve Information for Making FTA and FMECA Analysis	14
<i>Gerrit Muller, Mike Pennotti, Levi Vigdal</i>	
Challenges Based Risk Management	28
<i>Michal Shabtay, Avigdor Zonnenshain</i>	

REQUIREMENT DEVELOPMENT

Increase Requirements Understanding by Playing Cooperative Games	40
<i>David Gelperin</i>	
On the Use of a System Need Statement in Functional Decomposition	54
<i>Michael Ryan</i>	
Technical Baseline Repair	67
<i>Jeremy Kipp</i>	

MODELING APPLICATIONS

Practical SysML Applications: A Method to Describe the Problem Space	84
<i>Raymond Jorgensen, David Lempia</i>	
What Is the Smallest Model of a System?	98
<i>William Schindel</i>	
Applying Systems Engineering Modeling Language (SysML) to System Effort Estimation Utilizing Use Case Points	113
<i>Mary Bone, Robert Cloutier</i>	

TECHNICAL OPERATIONS INVITED PRESENTATIONS

DARPA and NSF Advances in Systems Engineering: META and Value-Driven Design	127
<i>William Miller</i>	
Architecture Session: A Brief History of Models and Model Based/Model Driven Approaches	128
<i>C.E. Dickerson, Dimitri Mavris, Kelly Griending</i>	

SESSION: 2

SUSTAINABLE ENERGY APPLICATIONS

Systems Practices for Sustainability	130
<i>Walt Sobkiw</i>	
Systems Engineering Provides Successful High Temperature Steam Electrolysis Project	143
<i>Emmanuel Opere Jr., Charles Park</i>	

SE PROCESS IMPROVEMENTS

When Is Enough Enough? Tailoring Processes in Systems Engineering	157
<i>Andrew Nolan, Andrew Pickard</i>	
What Is Technical Integrity and How to Measure It?	169
<i>Michael Edwards</i>	
Is Requirements Engineering Really Necessary?	185
<i>Joy Beatty, Brian Berenbach, Mark Sampson, Karen Smiley, Paul Solomon</i>	

LEAN SYSTEMS ENGINEERING

Combining Lean and Sustainable Concepts with Systems Engineering for Manufacturing Enterprises 188
Masaru Nakano

A Framework for Supporting the Transition to Lean Systems Engineering 199
Steffen Gruenwaldt, Wilfried Hofstetter, Herbert Palm

TECHNICAL OPERATIONS INVITED PRESENTATIONS

MBSE Initiative 214
Sanford Friedenthal

NDIA (National Defense Industrial Association) ROI 215
Joseph Elm, Eric Honour

SESSION: 3

ENERGY SYSTEMS

A Look at the U.S. Energy System – A Strategic Impact Model (2050 SIM)..... 217
John Collins, Layne Pincock

System Verification and Validation through Reliability, Availability, Maintainability (RAM) Analysis & Technology Readiness Levels (TRLs) 233
Emmanuel Opere, Charles Park

INCREASING VALUE OF SYSTEMS ENGINEERING

A Study of Systems Engineering Effectiveness: Building a Business Case for SE..... 247
Joseph Elm

A More Flexible Approach to Valuing Flexibility 262
John Colombi, David Jacques, Erin Ryan

BEST PRACTICES IN SPECIFICATION DEVELOPMENT

System Phases, Modes, & States: Solutions to Controversial Issues 278
Charles Wasson

X-Driven Development: Finding the Right Combination of Approaches for Systems Engineering 293
Jonathon Chard, Hazel Woodcock

PANEL

Integrating MBSE Into a Multi-Disciplinary Engineering Environment 306
Sanford Friedenthal, Don Williamson, Alex Jimenez, Mark Hoffman, Nicholas Di Liberto, Hans Peter De Koning

TECHNICAL OPERATIONS INVITED PRESENTATIONS

System Science - 3 Reports: System Pathologies; Unified Systems Science Theory; Unified Ontology of Scientific Method & Systems 311
James Martin

Lean SE (Lean Enablers for Systems Engineering) 312
Bo Oppenheim, Deb Secor

SESSION: 4

RISK PREVENTION

Diogenes, a Process for Finding Unintended Consequences 314
Terry Bahill

Managing Risk in NASA’s Deep Space Network 340
John Dokken, John Todd, Mona Witkowski

Expert-Based Single Point Failure Analysis 356
Jean Baladi, James Hendrix

INVITED SYSTEMS OF SYSTEMS TUTORIAL

Systems of Systems: Trends and Challenges 365
Dominique Luzeaux

IMPROVING PRODUCT DEVELOPMENT TEAMS

Satellites to Supply Chains, Energy to Finance - SLIM for Model-Based Systems Engineering
Part 1: Motivation and Concept of SLIM 366
Manas Bajaj, Russell Peak, Alex Phung, Andy Scott, Miyako Wilson, Dirk Zwemer

Systematic Approach to the Development, Evolution, and Effectiveness of Integrated Product Development Teams (IPDTs) 393
R. Douglas Hamelin, Margie Jeffs

Satellites to Supply Chains, Energy to Finance - SLIM for Model-Based Systems Engineering
Part 2: Applications of SLIM 408
Manas Bajaj, Russell Peak, Alex Phung, Andy Scott, Miyako Wilson, Dirk Zwemer

RETHINKING COMPLEX SYSTEMS

Is System Engineering Overdue For a Fix? 430
Jeffrey Grady

Next Generation Systems Engineering: Expansion, Foundation, Unification 459
Duane Hybertson

Niteworks: Systems Thinking and Methods Within a Collaboration Paradigm 473
David Evans, Michael Wilkinson

MBSE PAPER SESSION

A Historical Perspective of MBSE with a View to the Future 488
Cecilia Haskins

“Are We There Yet?” Assessing Quality in Model Based Systems Engineering 505
Matthew Hause

A MBSE Feasibility Study Using the Systems Integration Sandpit 518
Stephen Cook, Quoc Do, Bojan Lovric

SESSION: 5

RISK & PROJECT MANAGEMENT

A Comparison of Correlation in Technical and Programmatic Risk and Cost Risk 529
Joseph Krupa

Triple Your Chances of Project Success - Risk and Requirements 538
Louis Wheatcraft

INVITED SYSTEMS OF SYSTEMS SESSION

Understanding 'System-of-Systems' in the Defense Context 554
Chu Ngah Ng, Siow Hiang Teo

Examining Survivability of Systems of Systems 564
Daniel Hastings, Brian Mekdeci, Donna Rhodes, Adam Ross

BEST PRACTICES FROM THE ENERGY SECTOR

Evolution of a Unique Systems Engineering Capability 577
Robert Caliva, James Murphy, Kyle Oswald

Integrating the Life-Cycle Process Utilizing SysML 592
Georgia Artery, Mark De Spain

EXPLORING SE COMPETENCIES

Would the Real Systems Engineer Please Stand Up? 605
Duncan Kemp, Jennifer Mollett

Competencies Required for Successful Acquisition of Large, Highly Complex Systems of Systems 624
James Armstrong, Kenneth Kepchar, Devanandham Henry, Arthur Pyster

ACADEMIC FORUM PANEL

Undergraduate Programs in Systems Engineering..... 643
Mary Good, Dan McCarthy, Scott Nowlin

MBSE PAPER SESSION

Model-Based Standards Authoring..... 645
Alex Blekhman, Dov Dori, Richard Martin

Attribute-Oriented Modeling Approach and Its Application to Modeling of Spacecraft Functions 655
Takahiro Yamada

SESSION: 6
PANEL

Is System Security Engineering Failing? If So, What Can System Engineering Do About It? 665
Rick Dove, Kristen Baldwin, Jennifer Bayuk, Donna Rhodes, John Snoderly

MANAGING COMPLEX SYSTEMS

Complexity Types: From Science to Systems Engineering..... 668
Ali Mostashari, Sarah Sheard

A Framework for Considering Cost Uncertainty for Complex Interdependent Systems Based on Weighted Nodal Analysis 678
Barry Healy, Thomas Mazzuchi, Shahram Sarkani

CAPABILITY SYSTEMS ENGINEERING

Process Patterns for Agile Capability Engineering Methodology: The PACEM Project..... 693
Christophe Necaillle

Capability Engineering - An Analysis of Perspectives..... 707
Andrew Daw, Andrew Farncombe, Alan Harding, Michael Henshaw, Duncan Kemp, Peter Lister, Malcolm Touchin

BEST PRACTICES FROM THE TRANSPORTATION INDUSTRY

Tailoring the Systems Engineering Life Cycles: Goal Oriented Engineering Phasing 723
Richard Bosch, Paul Brouwer

A Systems Assurance Perspective Towards Generic Systems Engineering 742
Samuel Chan, Oh Sin Hin, Hong Joyce, Yap Kwee Sen

ACADEMIC FORUM PANEL

Integrating Systems Engineering into Engineering Curricula Through Capstone Projects Thinking Panel 762
Beth McGrath, James Nemes, David Umphress, Cliff Whitcomb

MBSE PAPER SESSION

Using MBSE with SysML Parametrics to Perform Requirements Analysis..... 764
Yvonne Bijan, Henson Graves, Jerrell Stracener, Timothy Woods, Junfang Yu

Determining the Right Solution Using SysML and Model Based Systems Engineering (MBSE) for Trade Studies 778
Graham Bleakley, Andrew Lapping, Adrian Whitfield

SESSION: 7
SYSTEM OF SYSTEMS

Modeling Pilot Workload for Multi-Aircraft Control of an Unmanned Aircraft System 791
John Colombi, David Long, Jason McGrogan, Michael Miller, Michael Schneider

System of Systems Engineering Facilitates Integration of Large Scale Complex Systems 806
Ghazi Albakri, Thomas Mazzuchi

Architectural Patterns for Self-Organizing Systems-of-Systems	851
<i>Rick Dove, Craig Nichols</i>	

PANEL

Soft Skills - What You Haven't Been Told About Delivering Successful Systems!	863
<i>Richard Beasley, Heidi Davidz, Wiljeana Glover, Adrian Terry, J. Van den Hoek Ostende</i>	

INNOVATION & TECHNOLOGY

A Model for Consumer Product Development Form a Systems Perspective	880
<i>Tim Ferris</i>	
Assessment of Readiness for Internal Technology Transfer - A Case Study	893
<i>Dag Bergsjø, Ulf Hogman, Daniel Corin Stig</i>	
‘That Wasn’t Meant to Happen!’ Managing the Hidden Risks of System Novelty	908
<i>Richard Beasley, Jonathan Holt</i>	

IMPROVING SYSTEMS ENGINEERING

Capacity for Engineering Systems Thinking (CEST) and Project Success	921
<i>Sharon Ashkenasi, Moti Frank, Arik Sadeh</i>	

VOLUME 2

Unraveling Systems Engineers from Systems Engineering: Frameworks for Describing the Extent, Variety and Ambiguity of Systems Engineering and Systems Engineers	933
<i>Hillary Sillitto</i>	
Unifying Systems Engineering: Seven Principles for Systems Engineered Solution Systems	954
<i>Derek Hitchins, Joseph Kasser</i>	

IEEE SECURITY SYSTEMS

(68639) - Monitoring and Management Approach for Cyber Security Events Over Complex Systems	965
<i>Paul C. Hershey, Charles B. Silio Jr.</i>	
(71899) - Computing the Impact of Cyber Attacks on Complex Missions	973
<i>Evan Elsaesser, Lewis Loren, Scott Musman, Mike Tanner, Aaron Temin</i>	
(78239) - Architecting a Secure Enterprise Data Sharing Environment to the Edge	979
<i>Bassam S. Farroha, Deborah L. Farroha</i>	

SESSION: 8

HUMAN FACTORS APPLICATIONS IN DEFENSE

Enhancing the Usability of Human Machine Interface on the Handheld Interagency Identity Detection Equipment (HIIDE™)	985
<i>Kelly Faddis, John Howard, Jerrell Stracener</i>	
Linking Cognitive Data to Design in Navy Command and Control	1001
<i>Beth Crandall, Cynthia Dominguez, Anna Grome, Christopher Nemeth, Matthew O'Connor, Robert Strouse</i>	

PANEL

I Know What I Want! Supply Chain Views on Delivering Requirements	1016
<i>Ronald Birkelbach, Jon Elphick, Kuldeep Gharatya, Duncan Kemp, Tom McPharlin, Nout Verhoeven</i>	

SE APPLICATIONS IN THE BIOMEDICAL SECTOR

Psychological Health in the United States Military: Making Sense of What We Know	1026
<i>John Hess, Cody Kamin, C. Robert Kenley</i>	
Using FMEAs to Improve Healthcare Study Design	1037
<i>Pat Baird</i>	

YOUTH ENGINEERING EDUCATION OUTREACH

Student Division Program Panel Discussion..... 1046
David Mason, Cecilia Haskins, Eric Luster, Eric Smith, Tom Willard

ACADEMIC FORUM PANEL

Graduate Reference Curriculum in Systems Engineering (GRCSE)..... 1049
Tim Ferris, Aaron Chia, Rich Freeman, Karl Geist, Peter Jackson, Daniel Prun

IEEE ENERGY SYSTEMS

Energy Conservation in Cloud Infrastructures..... 1052
Sanket Dangi, Avinash Mehta, Mukesh Menaria, Shrisha Rao

Local Energy Storage As a Decoupling Mechanism for Interdependent Infrastructures 1057
Alexis Kwasinski

SESSION: 9

SYSTEM TEST IMPROVEMENTS

Validation: Losing Its Differentiation from Verification?..... 1064
James Armstrong

An Ontology for Unmanned and Autonomous Systems of Systems Test and Evaluation 1074
Susan Ferreira, Jenny Tejada

SYSTEMS ENGINEERING STANDARDS

**Transforming Systems Engineering from a Cargo-Cult to a Rigorous Evidence-Based Profession:
Empirical Research Into the Foundations of ISO 15288 and ISO 26702** 1084
Ad Sparrius

Challenges in Supporting the Creation of Data Minable Regulatory Codes: A Literature Review 1097
Brian Berenbach, Krzysztof Wnuk

BEST PRACTICES FOR THE BIOMEDICAL INDUSTRY

Adaptive Systems Engineering: A Medical Paradigm for Practicing Systems Engineering 1114
Christopher Dieckmann, R. Douglas Hamelin, Ron Klingler

Assurance Cases: A New Form of Requirements Traceability Matrix for Medical Devices..... 1126
Fritz Eubanks, Melissa Masters

ACADEMIC FORUM PANEL

ABET Accreditation of SE Programs: How Is It Going and Why are We Doing it?..... 1137
David Olwell, Rick Adcock, Phil Brown, John Farr, Julie Ryan, Steve Sutton

IEEE COMPLEX SYSTEMS

(70349) - Normative Approach to Six Sigma Project Selection..... 1140
Mahmood Al Kindi

(71879) - Integration of Operation in Process Systems: Complexity and Emergent Properties 1145
Ali G. Hessami, Nicos Karcanias

SESSION: 10

APPLICATIONS FOR SOFTWARE SYSTEMS

Software Systems Analysis Using Stress-Strength Probability Functions 1151
James Wilder

Legacy Software System Integration..... 1162
Peggy Brouse, Robert Knapper

DECISION ANALYSIS

An Investigation on the Applicability of Data Distribution Service (DDS) Middleware As a Systems Integration Tool 1177
Stephen Cook, Quoc Do, Stephen Franklin

Using Boolean Operators in Multiple-Domain Matrices 1189
Maik Maurer, Martin Strattnr

TRAINING SYSTEMS ENGINEERS

Applying the Plan-Do-Check-Act Cycle to Develop Best Practices in Remote Online Systems Engineering Education 1203
Robert Cloutier, Alice Squires

The Development of an Architecture Framework for Systems Engineering Process Simulators 1216
Misagh Faezipour, Susan Ferreira

INCREASING VALUE OF SYSTEMS ENGINEERING

Sizing Systems Engineering Activities to Optimize Return on Investment 1225
Eric Honour

Convergence of Expert Opinion Via the Wideband Delphi Method: An Application in Cost Estimation Models 1238
Ricardo Valerdi

SESSION: 11

BEST PRACTICES FOR IT SYSTEMS

SOA in Enterprise Architectures: Overlooked Misperceptions, Pitfalls and Tangible Benefits 1252
Murthy V. Rallapalli

SpaceESB – A Proposal of an Enterprise Service Bus for Spacecraft Conceptual Design 1264
Ariana De Souza, Walter Dos Santos

Identifying the Most Critical Documents and Reviews for Small Information Technology Projects 1273
Peggy Brouse, Michael Mulhearn

BEST PRACTICES FROM THE AUTOMOTIVE SECTOR

Project Validation "The New Way to Secure Target Fulfilment in Project" 1286
Sasko Cuklev, Romy Johnsson, Carsten Lindgren

Systems Concurrent Engineering of a 'Green' Car 1297
Javier Alarcon, Geilson Loureiro

INTEGRATING SYSTEMS ENGINEERING SUCCESSFULLY

Transforming the Enterprise Using a Systems Approach 1312
James Martin

The Three Ts of Systems Engineering – Trading, Tailoring, and Thinking 1332
Richard Beasley, Richard Partridge

Behavioral Models and Improved Quality in Architecture-Centric Engineering 1349
Peggy Brouse, Christopher Jacobson

PANEL

People or Process: Which Is More Important? 1360
Avidor Zonnenshain, Cecilia Haskins, Eric Honour, Joseph Kasser, Uzi Orion, Hillary Sillitto

SESSION: TUTORIALS

Modeling with SysML 1364
Sanford Friedenthal, Joseph Wolfrom

Architecture Frameworks & Modeling 1366
James Martin

Bias Amelioration in Tradeoff Studies	1367
<i>Eric Smith</i>	
On Principles of Complex Systems Engineering - Complex Systems Made Simple	1566
<i>Brian White</i>	

VOLUME 3

Systems Architecting: A Business Perspective	1818
<i>Gerrit Muller</i>	
Synergistic Model-Based Systems Engineering with SysML and OPM	2116
<i>Dov Dori, Yariv Grobshtein</i>	
Establishing and Using a Risk Management Program Effectively	2513
<i>Mark Powell</i>	

VOLUME 4

SESSION: POSTERS

A Simple Prescription for Requirements Success	2588
<i>Jeffrey Grady</i>	
Simple Techniques for Applying Systems Engineering Principles When You're New to the Game	2710
<i>Lori Braase, Robert Caliva, R. Douglas Hamelin, Charles Park</i>	
Requirements Engineering for Large Scale Systems: Contract Based Systems	2790
<i>Brian Berenbach, John Worl</i>	
Requirements Engineering for Large Scale Systems: Processes and Tooling	2791
<i>Brian Berenbach, John Worl</i>	
What Forest? All I See are These SE Trees!	2792
<i>Mark Powell</i>	
Scenario-Based Requirements Engineering Facilitating Interaction Design	2855
<i>Hermann Kaindl</i>	
Defining Operational Concepts Using SysML: System Definition from the Human Perspective	2889
<i>Raymond Jorgensen</i>	
Engineering Requirements in Product Lines	3013
<i>Hermann Kaindl, Mike Mannion</i>	
Thinking Outside the Box - In Systems Engineering and Integration	3090
<i>Howard Eisner</i>	
Correlating Product and Process Measures As a Model for Systems Engineering Measurement	3138
<i>Ronald Carson</i>	
Considerations for a Generalized Reuse Framework for System Development	3152
<i>Gan Wang</i>	
Systems Engineering for Advanced Manufacturing: Unit Op Insights from Model-Based Methods	3169
<i>William Schindel</i>	
Examining Survivability of Systems of Systems	3184
<i>Brian Mekdeci, Adam M. Ross, Donna H. Rhodes, Daniel E. Hastings</i>	
Enabling the Net-Centric Systems Model through Adapting Enterprise Security Services to the Mobile Users	3196
<i>Bassam S. Farroha, Deborah L. Farroha</i>	
Identifying Agile Security Patterns in Adversarial Stigmergic Systems	3212
<i>Jena Lugosky, Rick Dove</i>	
Stakeholder Approach to Better Understand the Psychological Health Services in the Military	3229
<i>Andrea Ippolito, Jayakanth Srinivasan</i>	
Author Index	