

design. This quantitative tradespace exploration method can be used in conceptual design of SoS to enable the comparison of a large number of design alternatives on the same tradespace, as well as to study the changes in the value delivery of SoS over changing contexts as is demonstrated in two case studies presented in this paper. SoSTEM can thus be used as a conceptual design tool by decision makers in selecting value robust SoS designs.

XI. Acknowledgements

Funding for this research was provided by the Systems Engineering Advancement Research Initiative (SEArI), a research initiative within the Engineering Systems Division at the Massachusetts Institute of Technology. SEArI (<http://seari.mit.edu>) brings together a set of sponsored research projects and a consortium of systems engineering leaders from industry, government, and academia. SEArI gratefully acknowledges the support of the Charles Stark Draper Laboratory and the U.S. Government in this research.

References

- ¹INCOSE, "Systems Engineering Handbook v.3: A Guide for System Life Cycle Processes and Activities," Tech. rep., June 2006.
- ²Maier, M. W., "Architecting Principles for Systems-of-Systems," *Systems Engineering*, Vol. 1, No. 4, 1998, pp. 267–284.
- ³Sage, A. P. and Cuppan, C. D., "On the Systems Engineering and Management of Systems of Systems and Federations of Systems," *Information Knowledge Systems Management*, Vol. 2, No. 4, 2001, pp. 325–345.
- ⁴Boardman, J. and Sauser, B., "System of Systems - the meaning of OF," IEEE International Systems Conference, Los Angeles, CA, 2006.
- ⁵Eisner, H., Marciniak, J., and McMillan, R., "Computer-Aided System of Systems (S2) Engineering," Vol. 1, IEEE International Conference on Systems, Man and Cybernetics, Charlottesville, VA, October 1991, pp. 531–537.
- ⁶Keating, C., Rogers, R., Unal, R., Dryer, D., Sousa-Poza, A., Safford, R., Peterson, W., and Rabadi, G., "System of Systems Engineering," *Engineering Management Journal*, Vol. 15, No. 3, 2003, pp. 36–45.
- ⁷Carlock, P. G. and Fenton, R. E., "System of Systems (SoS) Enterprise Systems Engineering for Information-Intensive Organizations," *Systems Engineering*, Vol. 4, No. 4, June 2001, pp. 242–261.
- ⁸DeLaurentis, D. A., "Understanding Transportation as a System-of-Systems Design Problem," AIAA Aerospace Science Meeting Exhibit, 2005.
- ⁹Ross, A. M., *Managing Unarticulated Value: Changeability In Multi-Attribute Tradespace Exploration*, Ph.D. thesis, Massachusetts Institute of Technology, 2006.
- ¹⁰Ross, A. M. and Rhodes, D. H., "The System Shell as a Construct for Mitigating the Impact of Changing Contexts by Creating Opportunities for Value Robustness," IEEE Systems Conference, Honolulu, HI, 2007.
- ¹¹Chattopadhyay, D., Ross, A. M., and Rhodes, D. H., "A Framework for Tradespace Exploration of Systems of Systems," Conference on Systems Engineering Research, Los Angeles, CA, April 2008.
- ¹²Ross, A. M. and Rhodes, D. H., "Using Attribute Classes to Uncover Latent Value During Conceptual Systems Design," IEEE International Systems Conference, Montreal, Canada, April 2008.
- ¹³Richards, M. G., Ross, A. M., Shah, N. B., and Hastings, D. E., "Metrics for Evaluating Survivability in Dynamic Multi-Attribute Tradespace Exploration," AIAA Space, San Diego, CA, September 2008.
- ¹⁴Hall, D. L. and Llinas, J., "An Introduction to Multisensor Data Fusion," *Proceedings of IEEE*, Vol. 85, IEEE, January 1997, pp. 6–23.
- ¹⁵Ross, A. M., Rhodes, D. H., and Hastings, D. E., "Using Pareto Trace to Determine System Passive Value Robustness," IEEE International Systems Conference, Vancouver, Canada, March 2009.
- ¹⁶Chattopadhyay, D., Ross, A. M., and Rhodes, D. H., "Demonstration of System of Systems Multi-Attribute Tradespace Exploration on a Multi-Concept Surveillance Architecture," Conference on Systems Engineering Research, Loughborough, UK, April 2009.
- ¹⁷Defense Science Board, "Integrating Sensor-Collected Intelligence," Tech. rep., Joint Defense Science Board Intelligence Science Board Task Force Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, Pentagon, Washington, DC, December 2008.
- ¹⁸Ross, A. M., McManus, H. L., Long, A., Richards, M. G., Rhodes, D. H., and Hastings, D. E., "Responsive Systems Comparison Method: Case Study in Assessing Future Designs in the Presence of Change," AIAA Space 2008 Conference and Exposition, San Diego, CA, September 2008.
- ¹⁹Chattopadhyay, D., *A Method for Tradespace Exploration of Systems of Systems*, Master's thesis, Massachusetts Institute of Technology, June 2009.