

---

# Resilience as an Engineered System Property

---

DOES IT MAKE SENSE?  
WHAT SENSE DOES IT MAKE?

DRAFT WORKING PAPER

Chong Tang, Kevin Sullivan, ...

## Abstract

The concept of resilience as a system property has garnered considerable attention in recent years. Yet the status of the concept remains unsettled. We do have various *mechanisms* that support diverse, often narrow conceptions of resilience. At the same time, the literature addressing this property is sparse; there is little in the way of a broadly shared, precise understanding of what constitutes such a property; it is unclear whether the putative property is redundant with other recognized system properties, such as survivability; and we lack notations for specifying resilience properties independently of underlying mechanisms, and methods for assuring the satisfaction of such resilience specifications. This paper presents a survey and analysis of concepts of resilience as a system property, distinct from mechanisms, and assesses the status of the concept and needs for future research and development.

## Bibliography

### References

- [1] A. Azadeh, V. Salehi, B. Ashjari, and M. Saberi, “Performance evaluation of integrated resilience engineering factors by data envelopment analysis: The case of a petrochemical plant,” *Process Safety and Environmental Protection*, vol. 92, no. 3, pp. 231–241, 2014.
- [2] J. Bergström, R. van Winsen, and E. Henriqson, “On the rationale of resilience in the domain of safety: A literature review,” *Reliability Engineering & System Safety*, vol. 141, pp. 131–141, 2015.
- [3] D. Bodeau, R. Graubart, J. Picciotto, and R. McQuaid, *Cyber Resiliency Engineering Framework*, 2012, no. September.
- [4] O. Diez and A. Silva, “Resilience of cloud computing in critical systems,” *Quality and Reliability Engineering International*, vol. 30, no. 3, pp. 397–412, 2014.
- [5] J. Fitzgerald, P. G. Larsen, K. Pierce, M. Verhoef, and S. Wolff, “Collaborative modelling and co-simulation in the development of dependable embedded systems,” *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 6396 LNCS, pp. 12–26, 2010.

- [6] S. Flood and J. Schechtman, "Ocean & Coastal Management The rise of resilience : Evolution of a new concept in coastal planning in Ireland and the US," *Ocean and Coastal Management*, vol. 102, no. January 2002, pp. 19–31, 2014.
- [7] S. R. Goerger, A. M. Madni, and O. J. Eslinger, "Engineered resilient systems: A DoD perspective," *Procedia Computer Science*, vol. 28, no. Cser, pp. 865–872, 2014.
- [8] C. Guariniello and D. DeLaurentis, "Communications, Information, and Cyber Security in Systems-of-Systems: Assessing the Impact of Attacks through Interdependency Analysis," *Procedia Computer Science*, vol. 28, no. Cser, pp. 720–727, 2014.
- [9] M. Bellare and P. Rogaway, *The exact security of digital signatures-How to sign with RSA and Rabin*, 1996.
- [10] J.-C. Laprie, "From dependability to resilience," *38th Annual IEEE/IFIP International Conference On Dependable Systems and Networks*, p. Fast abstracts, 2008.
- [11] N. Leveson, N. Dulac, D. Zipkin, J. Cutcher-Gershenfeld, J. Carroll, and B. Barrett, "Engineering Resilience into Safety-Critical Systems," *In Resilience Engineering: Concepts And Precepts*, pp. 95–123, 2006.
- [12] M. Liu and D. Hutchison, "Towards Resilient Networks Using Situation Awareness," *PGNet2011*, 2011.
- [13] T. Lu, J. Zhao, L. Zhao, Y. Li, and X. Zhang, "Towards a Framework for Assuring Cyber Physical System Security," vol. 9, no. 3, pp. 25–40, 2015.
- [14] J. Lundberg and B. J. Johansson, "Systemic resilience model," *Reliability Engineering & System Safety*, vol. 141, pp. 22–32, 2015.
- [15] A. M. Madni and S. Jackson, "Towards a conceptual framework for resilience engineering," *IEEE Systems Journal*, vol. 3, no. 2, pp. 181–191, 2009.
- [16] A. M. Madni and M. Sievers, "Systems Integration: Key Perspectives, Experiences, and Challenges," *Systems Engineering*, vol. 14, no. 3, pp. 305–326, 2011.

- [17] R. Neches and A. M. Madni, “Towards Affordably Adaptable and Effective Systems,” *Systems Engineering*, vol. 14, no. 3, pp. 305–326, 2011.
- [18] R. M. Pietravalle and D. M. Lanz, “Resiliency Research Snapshot,” 2011.
- [19] M. G. Richards, D. E. Hastings, D. H. Rhodes, and A. L. Weigel, “Defining Survivability for Engineering Systems,” *Conference on Systems Engineering Research*, pp. 1–12, 2007.
- [20] A. W. Righi, T. A. Saurin, and P. Wachs, “A systematic literature review of resilience engineering: Research areas and A research agenda proposal,” *Reliability Engineering & System Safety*, vol. 141, pp. 142–152, 2015.
- [21] C. Rochas, T. Kuzecova, and F. Romagnoli, “The concept of the system resilience within the infrastructure dimension: application to a Latvian case,” *Journal of Cleaner Production*, vol. 88, pp. 358–368, 2014.
- [22] G. a. Shirali, I. Mohammadfam, and V. Ebrahimipour, “A new method for quantitative assessment of resilience engineering by PCA and NT approach: A case study in a process industry,” *Reliability Engineering and System Safety*, vol. 119, pp. 88–94, 2013.
- [23] M. Sievers and A. M. Madni, “A Flexible Contracts Approach to System Resiliency,” pp. 1002–1007, 2014.
- [24] Stockholm Resilience Centre, “What is resilience?” Tech. Rep., 2014.
- [25] C. Systems, “Resilient Cyberphysical Systems,” no. December 2012, pp. 2012–2013, 2014.
- [26] Various, “System Resilience at Extreme Scale White Paper,” *Computer*, 2009.
- [27] D. Woods, “Four Concepts for resilience and the Implications for the Future of Resilience Engineering,” *Reliability Engineering & System Safety*, vol. 141, pp. 5–9, 2015.
- [28] D. D. Woods, “Prologue: Resilience Engineering Concepts,” *Resilience Engineering: Concepts and Precepts*, pp. 1–6, 2006.
- [29] H. Yang, F. Ye, Y. Yuan, S. Lu, and W. Arbaugh, “Toward resilient security in wireless sensor networks,” *Proceedings of the International*

*Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc)*, pp. 34–45, 2005.

- [30] Y. Yuan, Q. Zhu, F. Sun, Q. Wang, and T. Bas, “Resilient Control of Cyber-Physical Systems against Denial-of-Service Attacks.pdf,” pp. 0–5, 2013.
- [31] E. Hollnagel, D. D. Woods, and N. Leveson, Eds., *Resilience Engineering: Concepts And Precepts*. Ashgate Pub Co, 9 2006.
- [32] J. Knight, E. Strunk, and K. Sullivan, “Towards a rigorous definition of information system survivability,” *Proceedings DARPA Information Survivability Conference and Exposition*, vol. 1, 2003.