

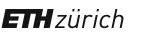
Resilience - concept and strategy to cope with unexpected and ambiguous disruptions

Hans R Heinimann, Programme Director

Future Resilient Systems @ CREATE

Singapore













Hans R. Heinimann 25.06.2018

(FRS) FUTURE 未来 RESILIENT 韧性 SYSTEMS 系统















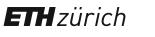


Perspective





















Key Messages

- 1. Resilience: framework and strategy to cope with ambiguity and unexpectedness
- 2. Building resilience: (1) making systems more robust, (2) recoverable, and (3) reconfigurable
- 3. Interconnectedness: driver for ambiguity and unexpectedness (emergence)
- 4. **Regime shifts** cannot be predicted with historic data











Urbanisation – The Main Driver



Interdependencies of Infrastructure Systems

WA

- 1. How robust and resilient against a set of multi-hazard disruptions
- 2. How do system topology, interconnections and feedback loops affect robustness and resilience
- 3. How to detect / anticipate critical regime shifts







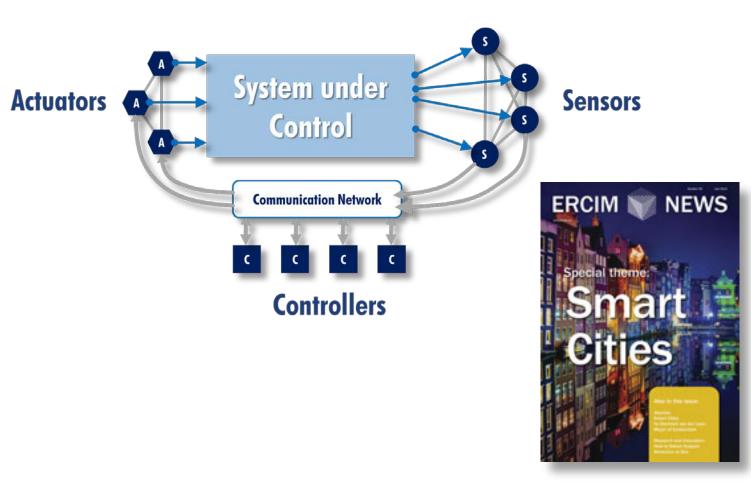
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SMU



Cyber-Physical Systems



Cyber-Physical-Human Systems

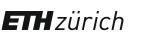
Focus on

- Algorithms
- Physical components
- Human agents

Capabilities

- Shared perception
- Shared decision-making
- Shared learning and adaptation
 - Machine learning
- Sensing from sensors, networks, people









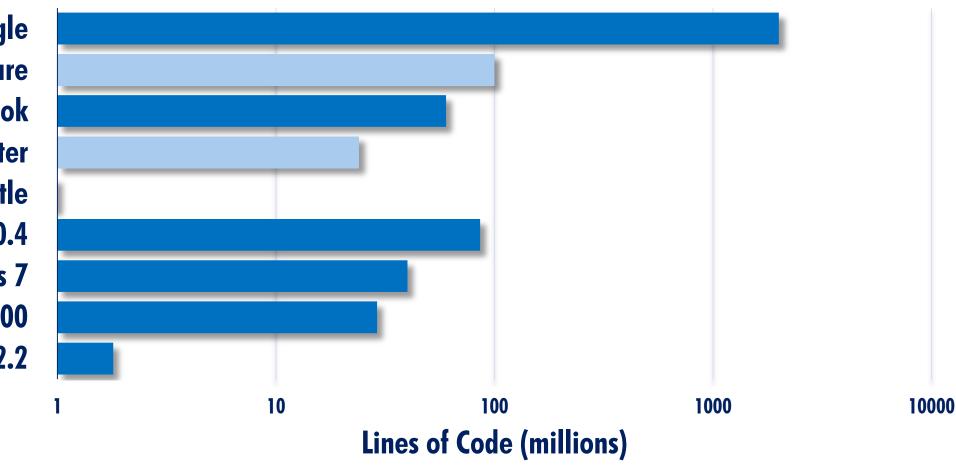




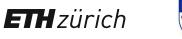
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Cyber-Part Trends | Lines of Software Code

Google **Car Software** Facebook F35 Fighter Space Shuttle **Mac OS X 10.4** Windows 7 Windows 2000 Linux V2.2







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Artificial Intelligence

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Artificial / Augmented

- Perception
- Sensemaking
- Action design
- Choice
- Action release
- Action control









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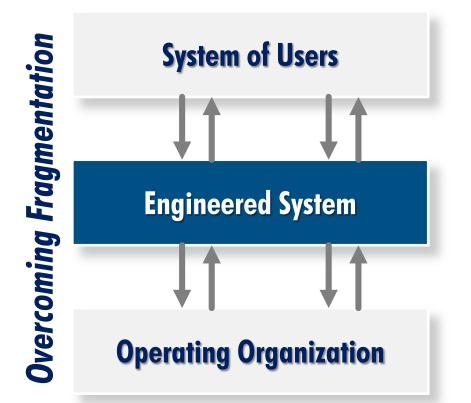
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Socio-Technical Perspective



Engineered Resilient Systems













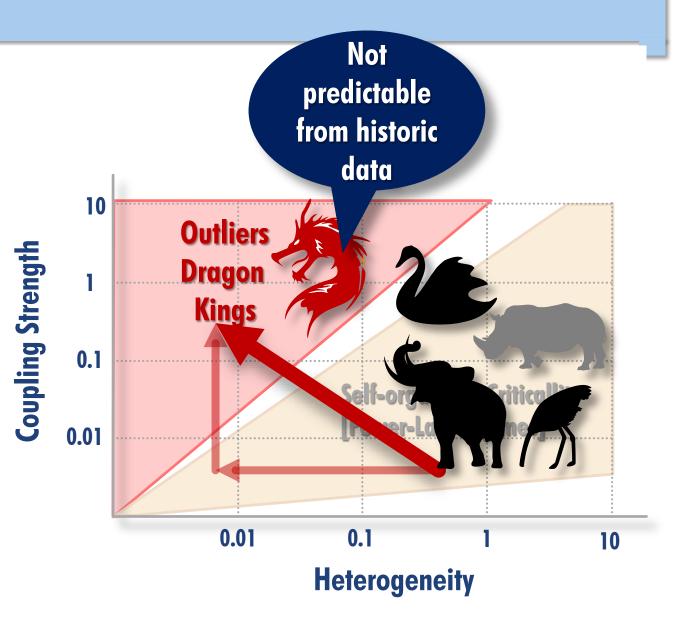


Regime Shifts (Osorio et al. 2010)

"Even if it is of *low likelihood*, SINGAPORE will do something about it if the *consequence is very high*"

Joo Koon train collision, Nov-15-2017











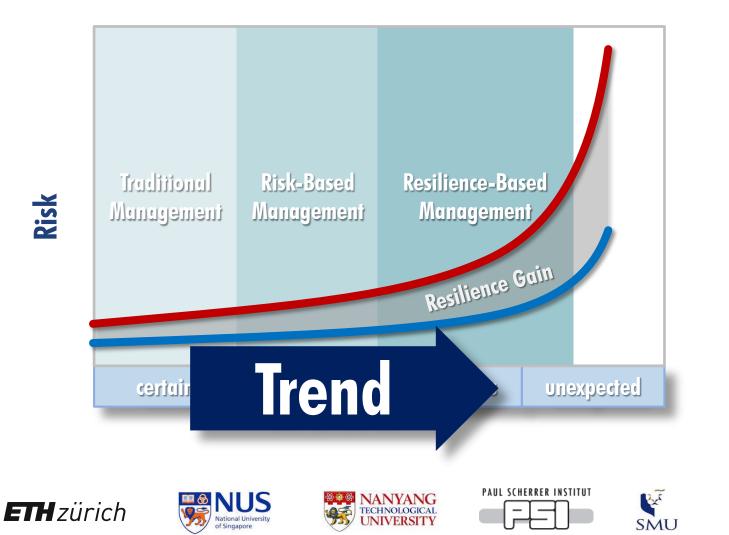






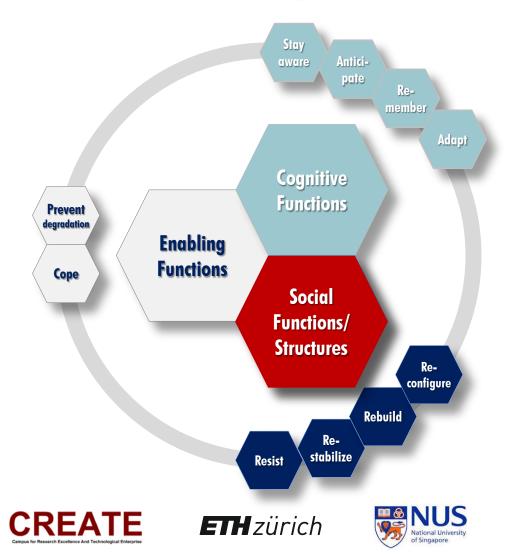
CREATE

Increasing Ambiguity and Unexpectedness



MURRAY, R.M., J.C. DAY, M.D. INGHAM, L.J. REDER, and B.C. WILLIAMS. 2013. Engineering Resilient Space Systems. Pasadena, CA: Keck Institute for Space Studies. Accessed [Aug-22-2016]. [http://www.kiss.caltech.edu/study/systems/] 82 p.

Resilience – Building Blocks



- 1. resist within acceptable limits of degradation,
- 2. restabilize critical functions,
- 3. rebuild functions, and
- 4. reconfigure the flow of substances, energy and services.

COUPLED with

- 5. staying aware,
- 6. sensemake and anticipate,
- 7. respond,

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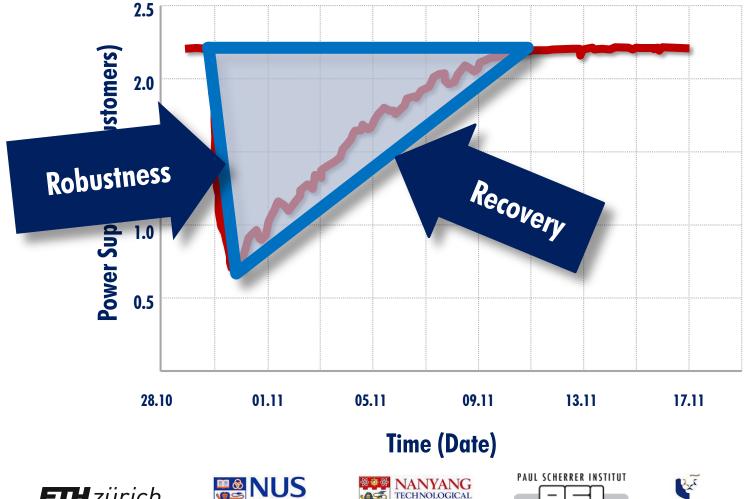
8. update and adapt.







Building Resilience









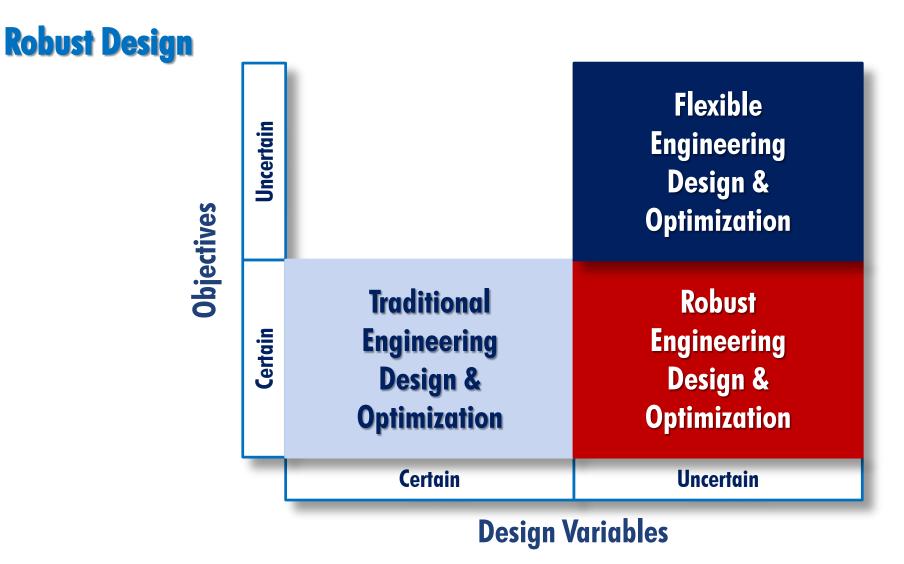
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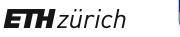














National University

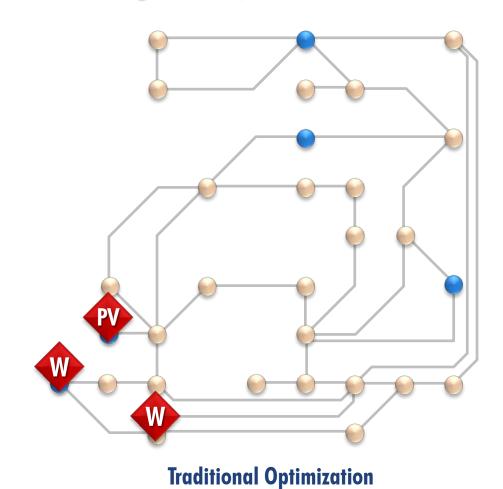
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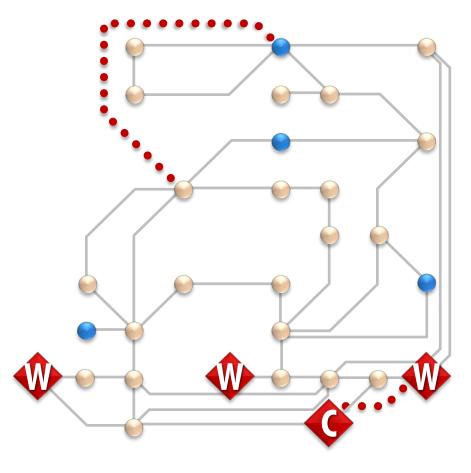






Robust Design – Key to Resilience IEEE-30





Robust Optimization







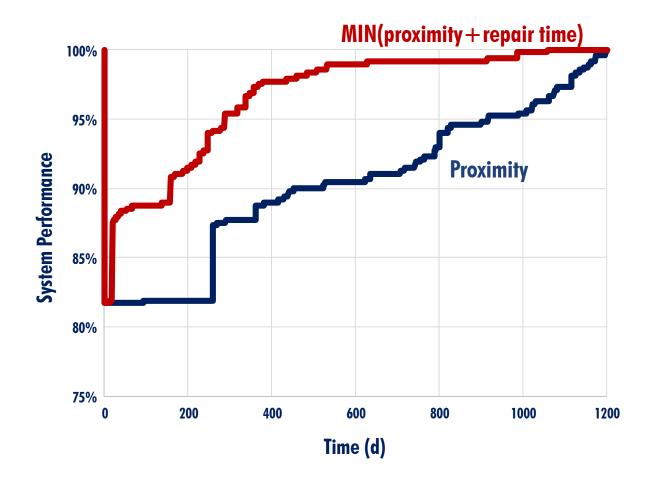






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Influence of Repair Tactics on Recovery



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Nazli Yonca Aydinl, H. Sebnem Duzgun, Hans Rudolf Heinimann, Friedemann Wenzel , Kaushal Raj Gnyawali (forthcoming): Evaluation of operational resilience enhancement strategies for rural transport networks und geohazards





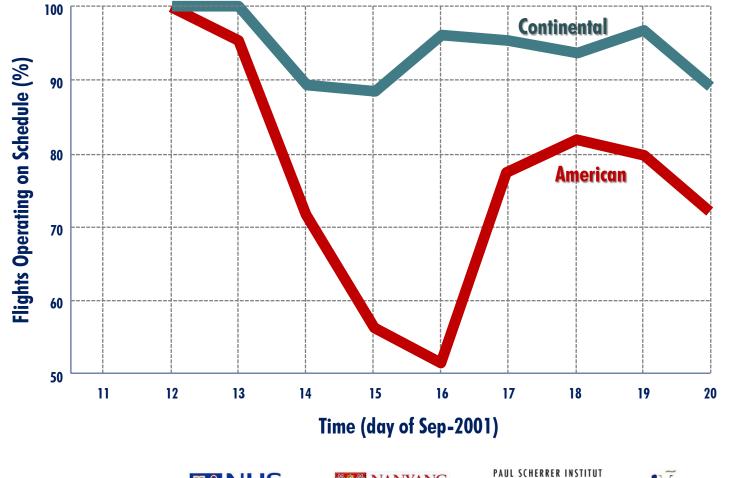








Flight Operations Recovery After 9/11



YU, G. and X. QI. 2004. Disruption management : framework, models and applications. Singapore ; River Edge, NJ. World Scientific. 294 p.



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Social Resilience











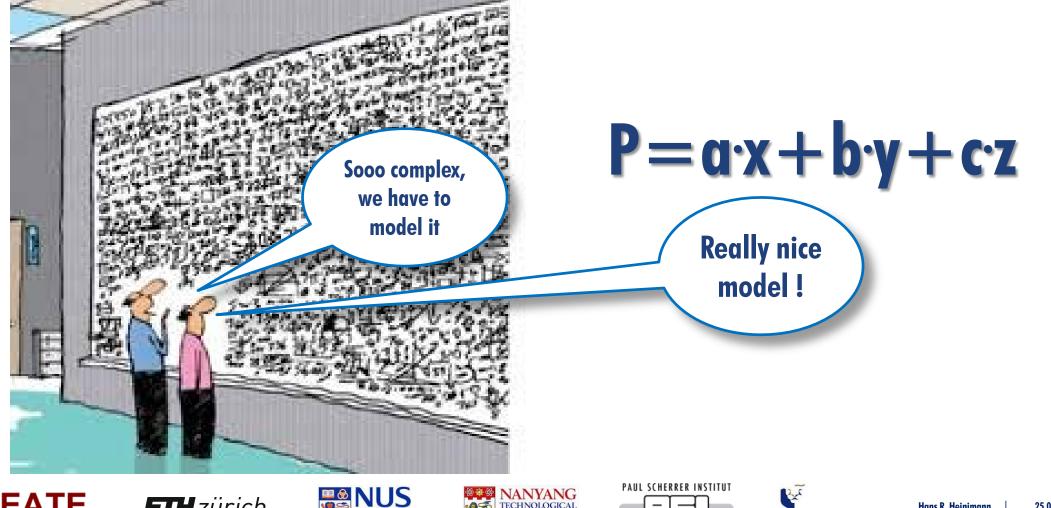




of social interactions

(FRS)	FUTURE	未来
	RESILIENT	韧性
	SYSTEMS	系统

Pitfalls...







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- 3. Interconnectedness: driver for ambiguity and unexpectedness (emergence)
- 4. Regime shifts cannot be predicted with historic data
- 5. Resilience change to no to be changed [B Walker 2018]



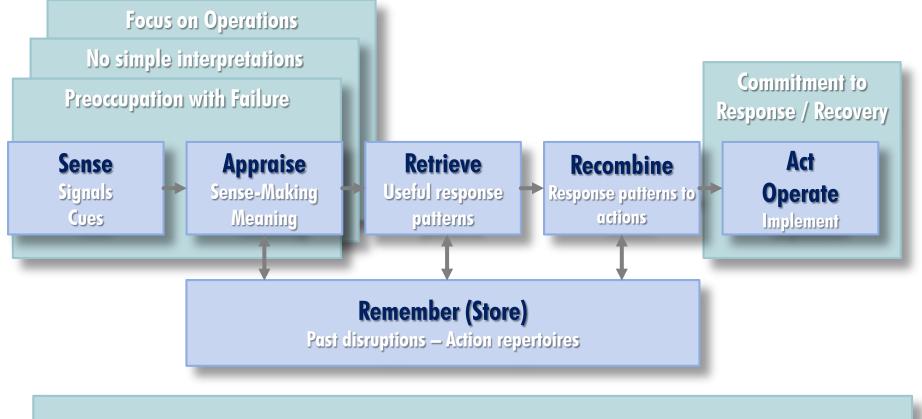








High Reliability Organisations (HRO) [Weick, Hollnagel, Woods]



Flexible Organizational Structures













22