



What are the problems with resilience?

Frank Schweitzer

The magic word

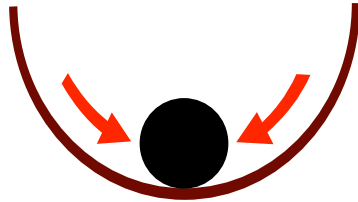
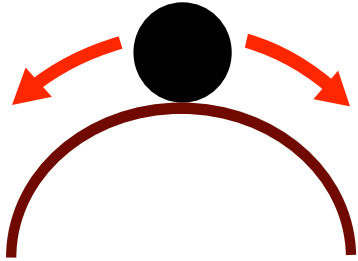
Resilience

- “capacity to *withstand* shocks and ability to *recover* from them”
- **our approach:** two independent dimensions
 - **robustness:** withstand change \Rightarrow *structural component*
 - **adaptation:** respond to change \Rightarrow *dynamic component*

A multidisciplinary concept

- *ecology* (Holling, 1973) \Rightarrow **stability**
 - “ability of a system to return to equilibrium”
- *social sciences* (Sutcliffe & Vogus, 2003) \Rightarrow **flexibility**
 - “maintain a positive adjustment under challenging conditions”
- *engineering:* (Hollnagel *et al*, 2007) \Rightarrow **design**
 - “maintain an acceptable level of service in case of shocks”

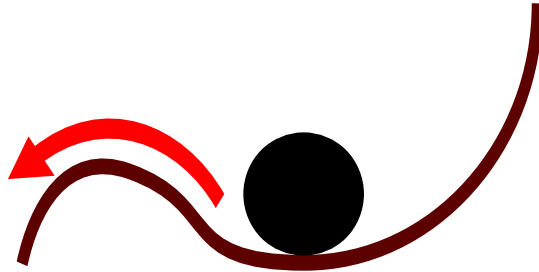
Stability: Un/stable equilibrium



- **A mechanical analogy**

- *stable*: forces drive the system *towards* the equilibrium state
- *unstable*: forces drive the system *away* from the equilibrium state

Stability: Un/stable equilibrium

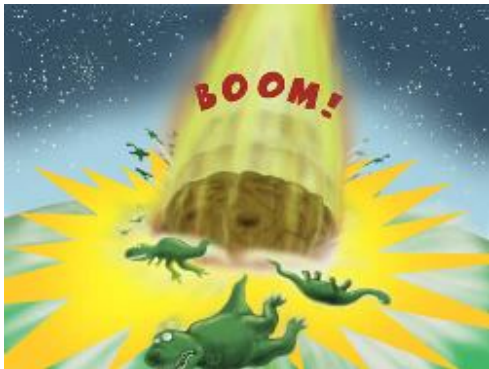


- **A mechanical analogy**
 - *stable*: forces drive the system *towards* the equilibrium state
 - *unstable*: forces drive the system *away* from the equilibrium state
 - *metastable*: **supercritical** forces kick the system *out*

Systemic Impact ...

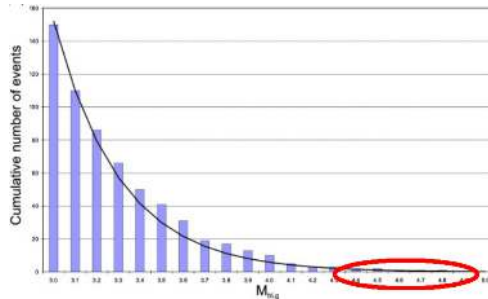


Systemic Impact ...



The probability of extreme events

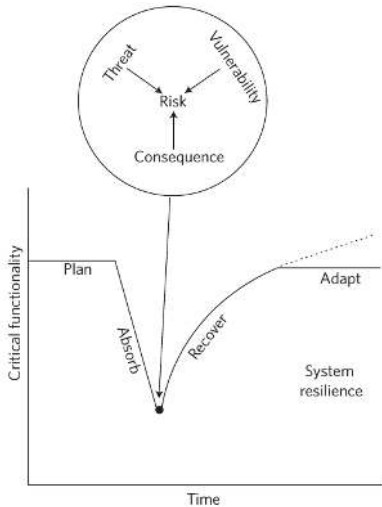
Cumulative prob. distribution for earthquakes \geq MbLg3 (1978-2007) in Granada basin



“Stability analyses suggest that the factor of safety of the San Pedro slope under 1000-yr-return-period earthquake loading may drop below 1.0 ...”

J.L. Justoa *et al.*: Neotectonics and slope stabilization at the Alhambra, Granada, Spain, *Engineering Geology* vol 100, no 3-4 (2008) 101-119

Resilience in engineering



Linkov et al., *Nature Climate Change* (2014)

Resilience

“capacity to *withstand* shocks and ability to *recover* from them”

- **not only** about **stability/robustness**
- **also** about **recovery/adaptation**

Underlying assumptions

- ① well defined **initial** state/ **final** state
- ② well defined **shock**, well defined **impact**
- ③ *time scale separation*
 - shock is **short**, **bound** in time
 - absorption clearly separated from **recovery**

1. Problem: Origin of risk/shock

- **Risk as exogeneous to the system**
 - no direct/short term amplification of risk (\leftrightarrow climate)
 - calculate probability of extreme events and estimate system impact

1. Problem: Origin of risk/shock

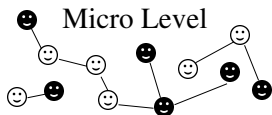
- Risk as exogenous to the system
 - no direct/short term amplification of risk (\leftrightarrow climate)
 - calculate probability of extreme events and estimate system impact
- Risk as **endogeneous** to the system
 - systems generate the conditions of their failure *themselves*
 - ① *interaction*: failure of “the few” gets amplified
 - ② *systemic feedback*: macroscopic coupling
 - ③ *trend reinforcement*: history matters

Systemic risk

- risk that a whole system comprised of many agents fails
- macroscopic property that **emerges** from the nonlinear interactions of agents and is amplified through macroscopic feedback

Emergent phenomena in complex systems

- system comprised of a *large* number of strongly interacting, *heterogeneous* agents
 - examples: brain, economy (firms, banks, households, ...)
 - note difference to the “representative agent” approach



- **challenge:** The micro-macro link
 - How are the properties of the elements and their interactions (“microscopic” level) related to the dynamics and the properties of the whole system (“macroscopic” level)?
- **complex network:** representation of complex system
 - agents: *nodes*, interactions: *links*

2. Problem: How to regulate systems?

Top Down \Rightarrow POWER

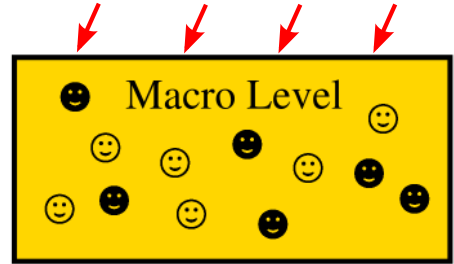
- *hierarchical* planning
- design *boundaries*
- *centralized* control



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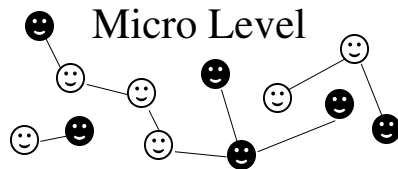
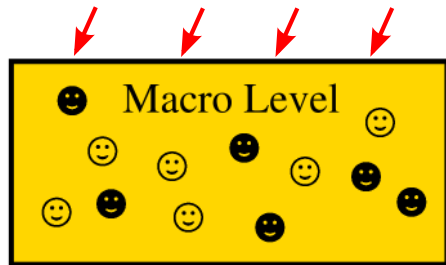
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Bottom Up \Rightarrow INFORMATION

- *decentralized* solutions
- design *interactions*
- target *individual elements*



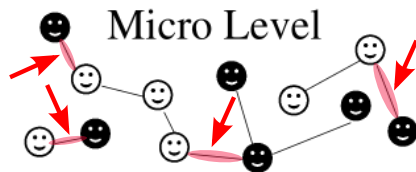
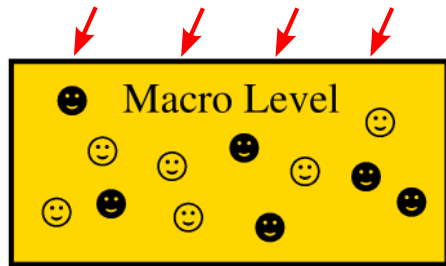
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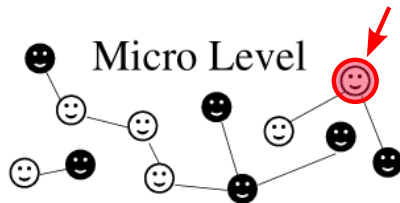
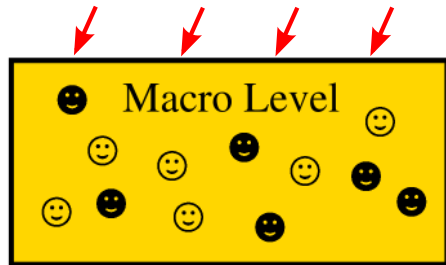
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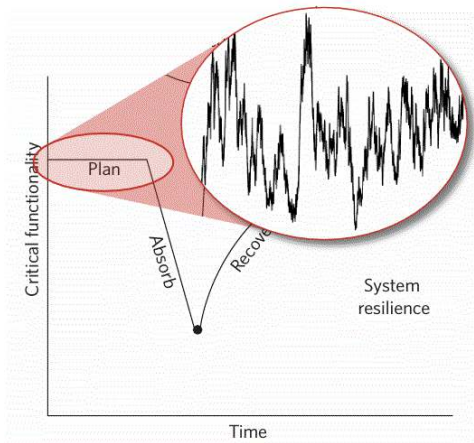
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3. Problem: Highly volatile organizations



Resilience

“capacity to *withstand* shocks and ability to *recover* from them”

- **What is the problem?**
 - What if volatile \equiv normal?
 - **No** separation of time scales
 - How to measure functionality?
 - How to quantify impact?
 - What does “Recover” mean?
- **Our notion of resilience:**
 - **measurable**, not conceptual
 - **dynamic**, not static
 - **social**, not technical system