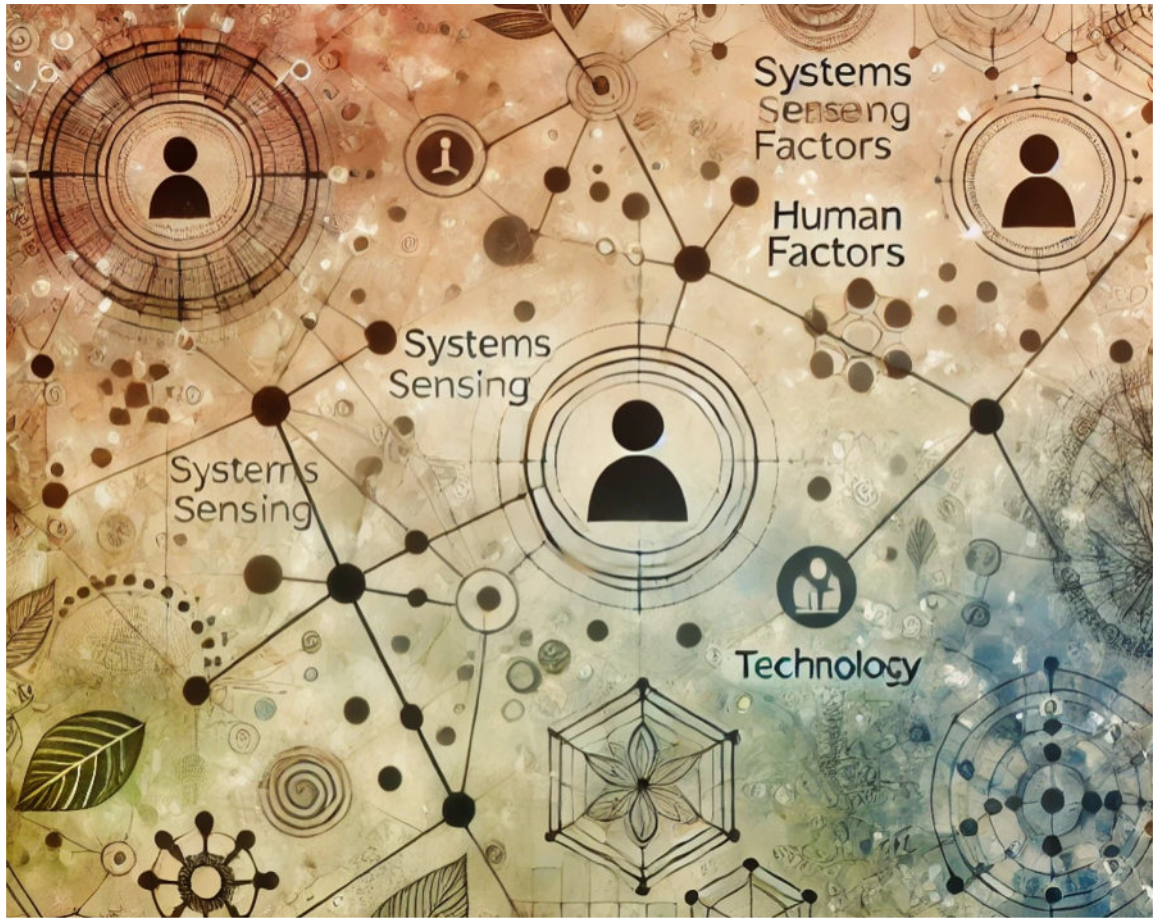
From Systems Engineering to Systems Sensing: How to (non)engineer Living Systems?

Building bridges

Swiss Systems Engineering Society

Day 2024

Tobias Luthe



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AI
AI

What terms or questions come to your mind when you think about "systems engineering versus systems sensing"?

1 Go to wooclap.com

2 Enter the event code in the top banner

Event code
ZZHTMZ

Go to **wooclap.com** and use the code **ZZHTMZ**

What terms or question-keywords come to your mind when you think about the topic of "systems engineering to systems sensing"?

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Storyline

Systems thinking recap

Emergence in complex systems

From systems engineering to systems sensing

Building bridges?

Embracing emotional and cultural change

AI & systems sensing

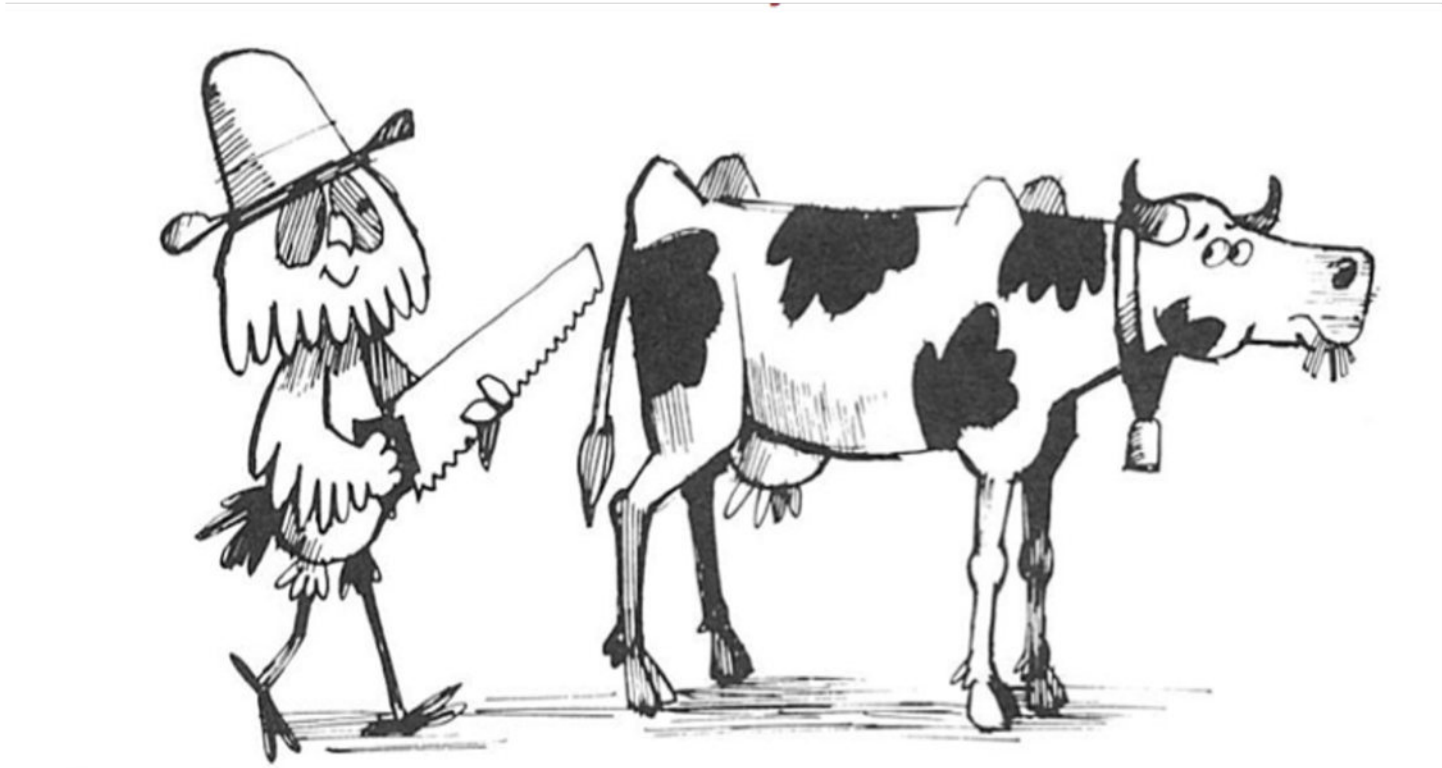
How to learn systemic design?

Wrap-up

Systems thinking recap

What is a System?

A system consists of elements, of relations, and has purpose.



Systems Thinking

Thinking in terms of relationships, in terms of patterns, of connectedness, and in terms of context.

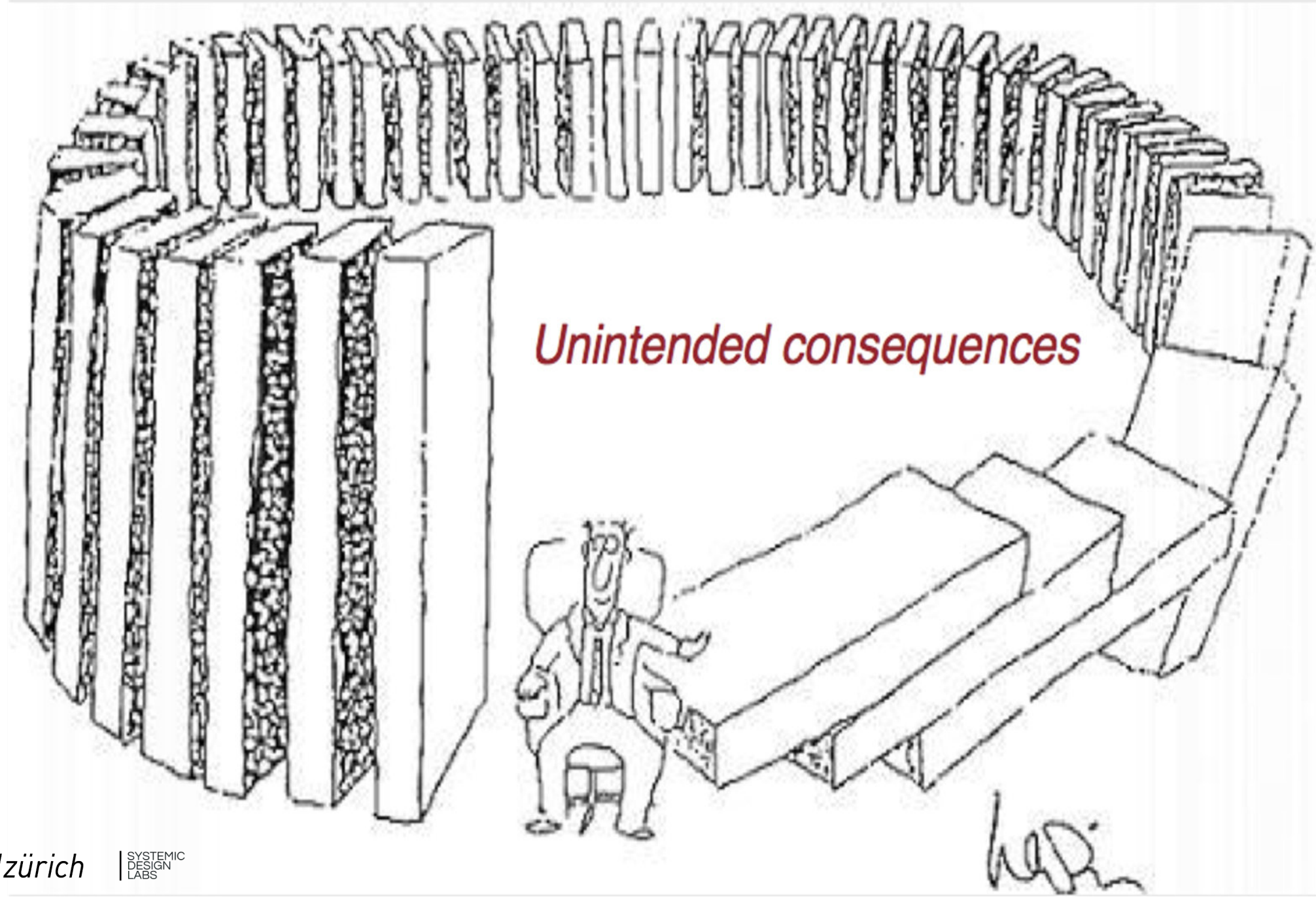
Fritjof Capra, DRRS

Complex ≠ Complicated

Complicated systems are highly structured, predictable, and solvable through expert knowledge and analysis (e.g. a car engine).

Complex systems are dynamic, nonlinear, emergent, adaptive, and require continuous interaction and feedback to navigate due to their unpredictability (e.g. a city traffic system with individual behaviors of drivers and other users). They are often self-organizing through feedback loops.

In practice, **complicated** systems are like puzzles that can be solved, while **complex** systems are more like living organisms that must be managed, adapted to, and continuously learned from.


Unintended consequences

Complicated systems can be engineered

Complex systems need to be sensed

Biological systems

Mechanical systems

Cognitive systems

Political systems

Energy systems

Health systems

Social systems

(...)

Socio-technical systems (STS)

Social-ecological systems (SES)

Emergence in complex systems
- hemp -

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A living systems lab

Enacting living systems
as real-world mountain
laboratory and bioregional
weaving hub
for research, education and
entrepreneurship in
sustainability transitions and
regenerative design.

Hemp systems - technical composites

Skis, e-car chassis, wind rotor blades, ….

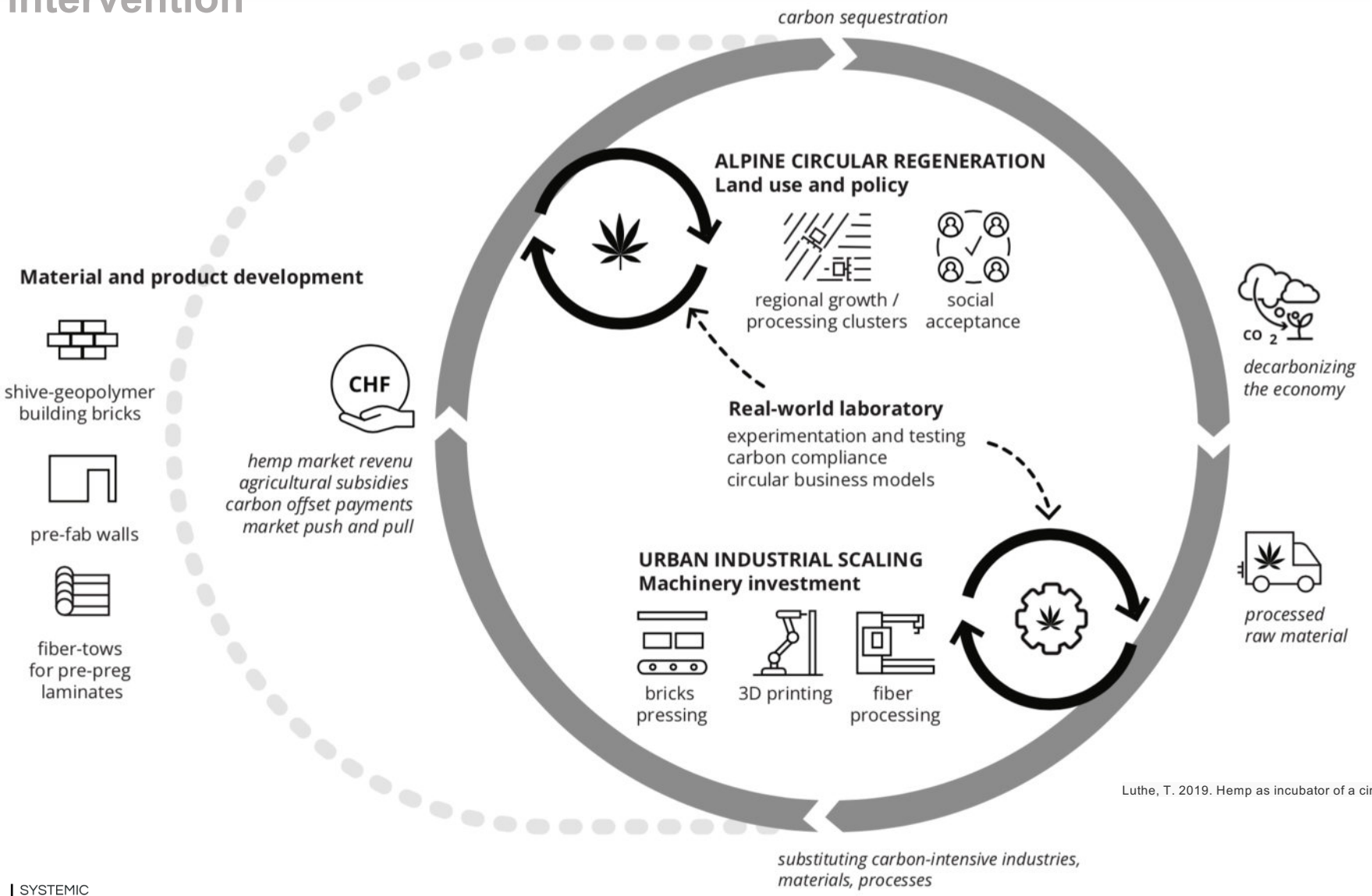
Hemp systems - building materials

Insulation and structural wall systems

Habert G and T Luthe, work in progress

Synergistic momentum

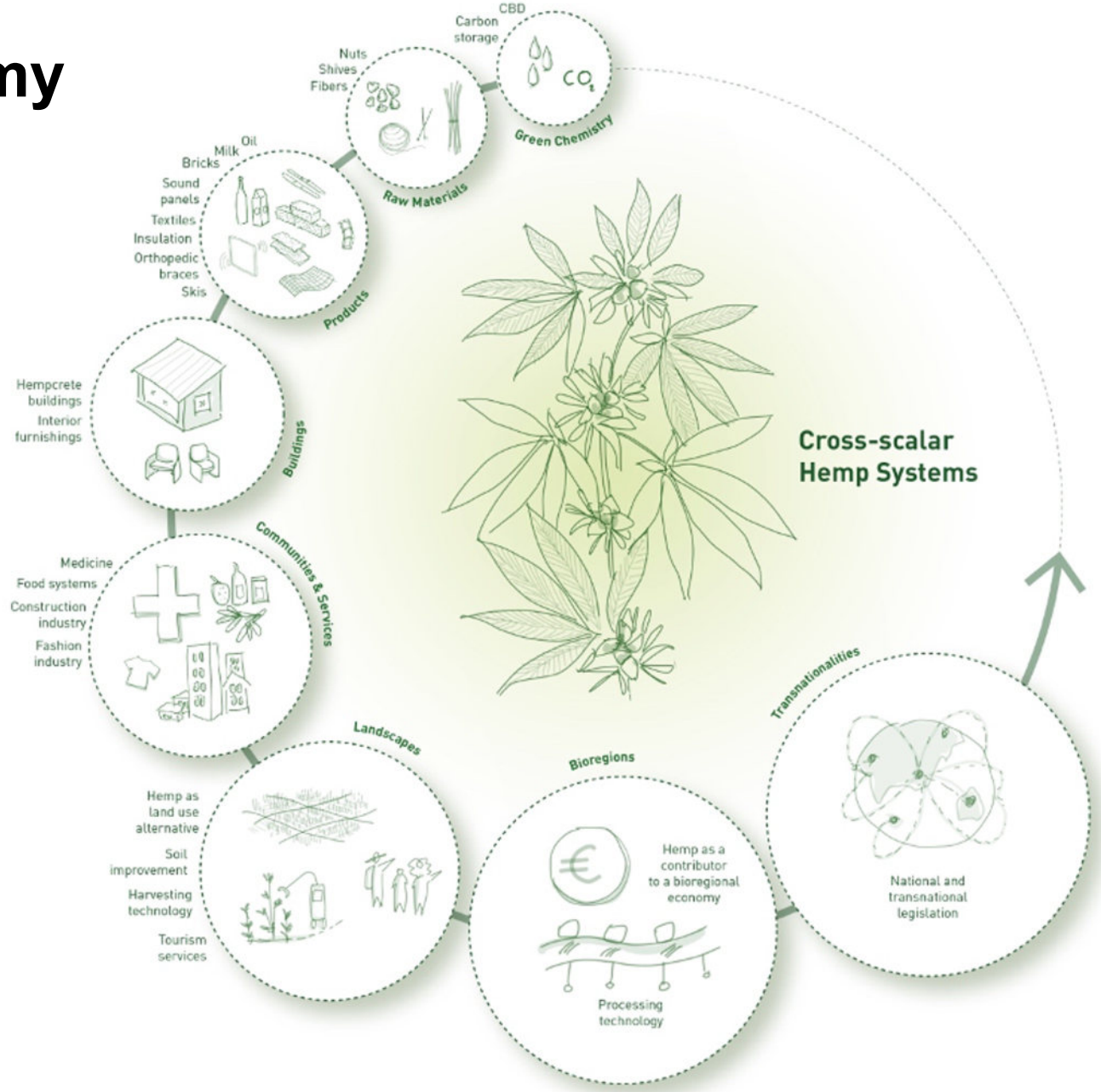
Systemic intervention



Luthe, T. 2019. Hemp as incubator of a circular economy. Hanf Magazin 06-2019.

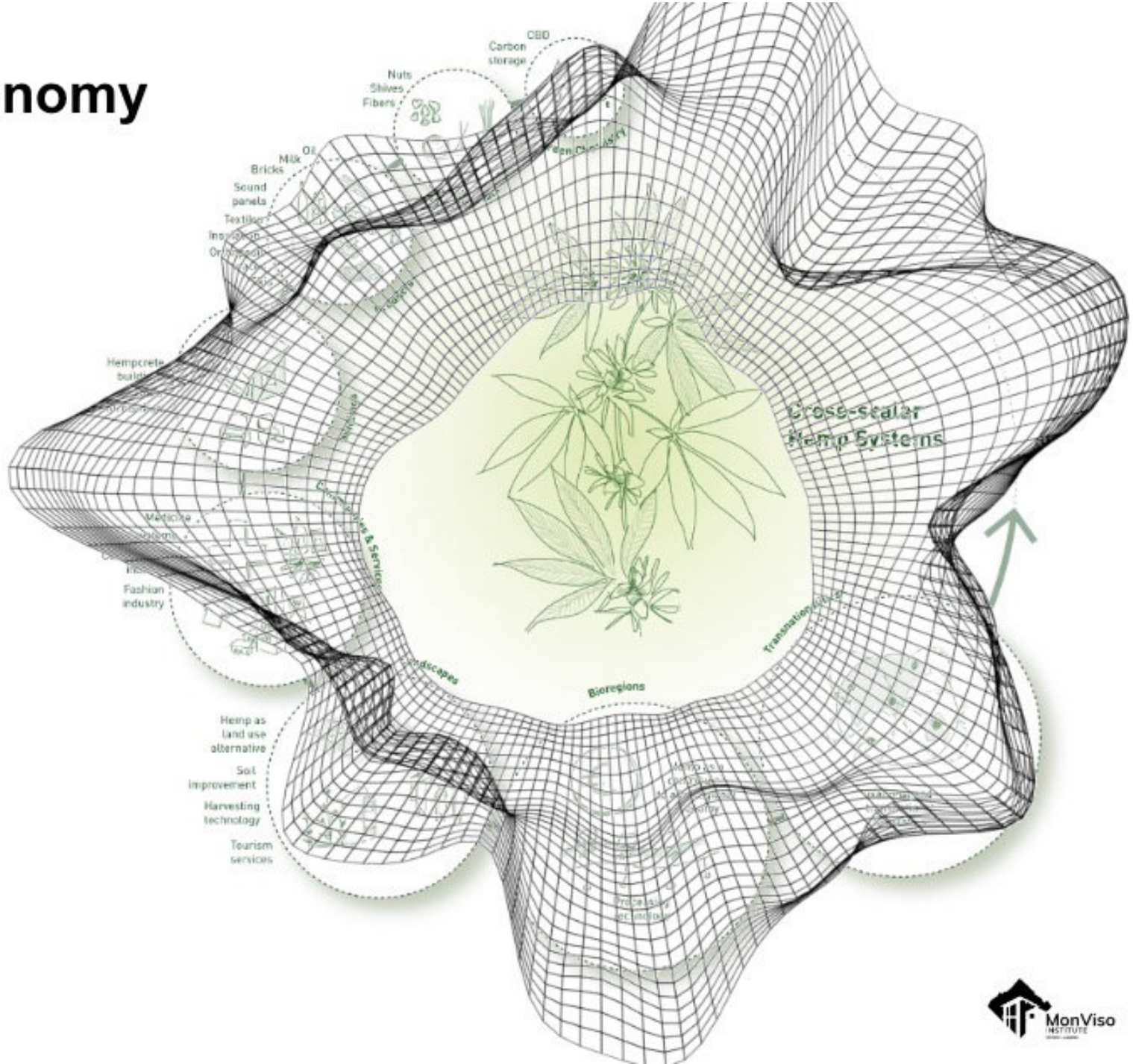
Designing a hemp economy

Synergizing the whole system



Designing a hemp economy

Synergizing the whole system



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From systems engineering to systems sensing

Systems engineering - *solutioneering*

Strengths and limits of traditional systems engineering

Strengths in complicated systems

Control, centralized authority, safety

Precision, technical mastery

Predictability, modeling and simulation, long-term planning

Limits in complex systems

(S)low adaptive flexibility, top-down hierarchy

Risk-aversion, fear of uncertainty

Standardized frameworks, top-heavy regulations, resistance to new tools

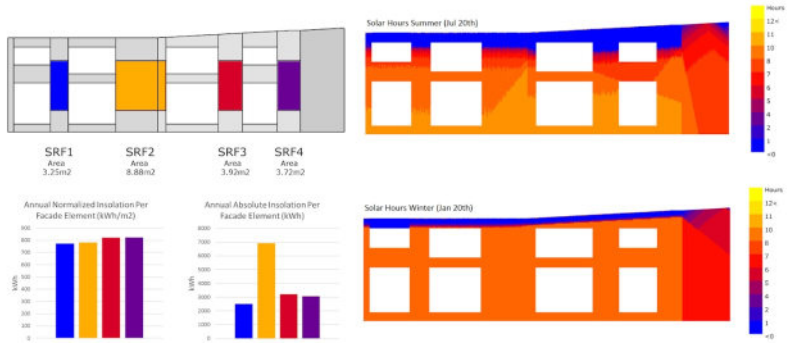
Discipline-specific silos, fixed governance models

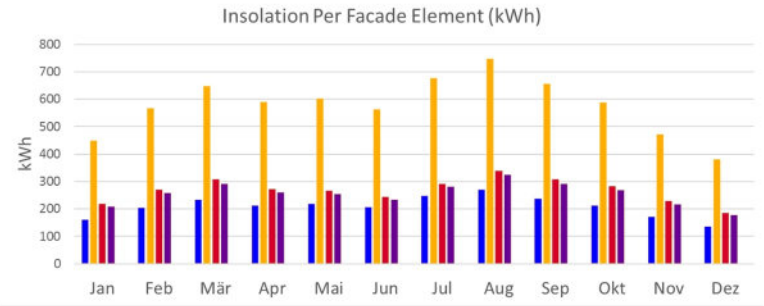
Technical over human skills, little relevance of emotional intelligence

(...)

“The data doesn’t hold…”

“After submitting my semester thesis, at first I felt not very comfortable to see my passive house energy modeling data being used for engaging building authorities in a local community to argue for permission for a solar facade.
Until I saw that not the accuracy of my model, but the fact that I developed a proxy for an informed, visual dialogue was the actual powerful driver to engage with praxis.”
Master student, Integrated Building Systems





We are (part of) living systems

Living systems are cell-based biology.

We are living systems.

Living systems are **dynamic, self-organizing, and emergent**, which are challenging traditional engineering methods focused on control.

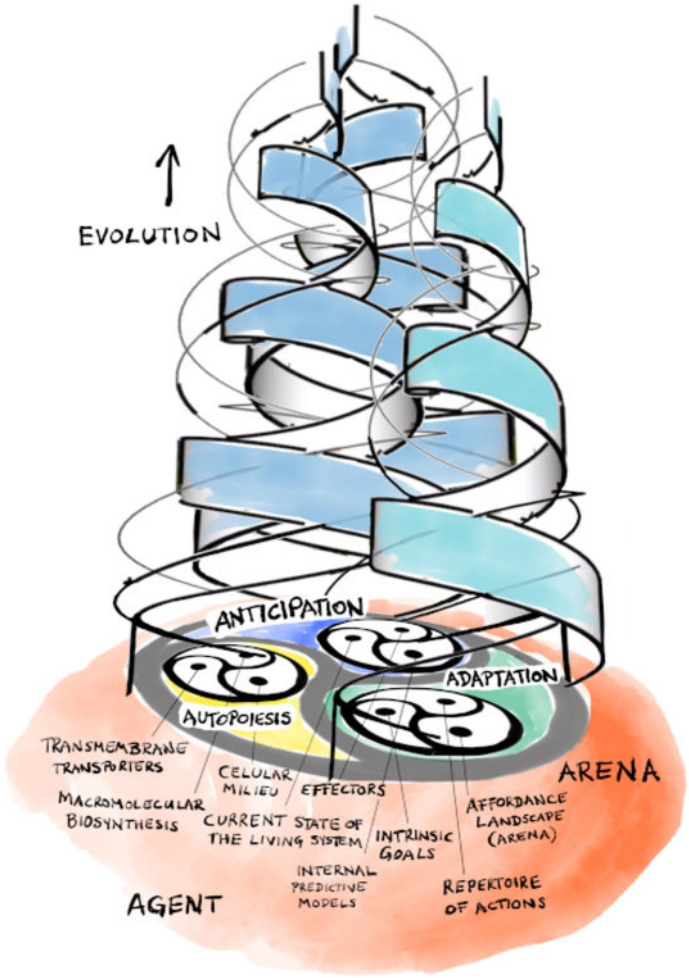
Machines are made by connecting its parts for the constructor's purpose

Self-organization (autopoiesis): living organisms self-manufacture

Evolution: living things construct themselves through development and evolution. Their purpose is to continue living.

Interaction: organisms don't need fixing. They need nurturing. All you need to do is to allow them to thrive. The rest will happen all on its own.

Johannes Jaeger: "AI is Artificial Mimicry." https://arxiv.org/abs/2307.07515.



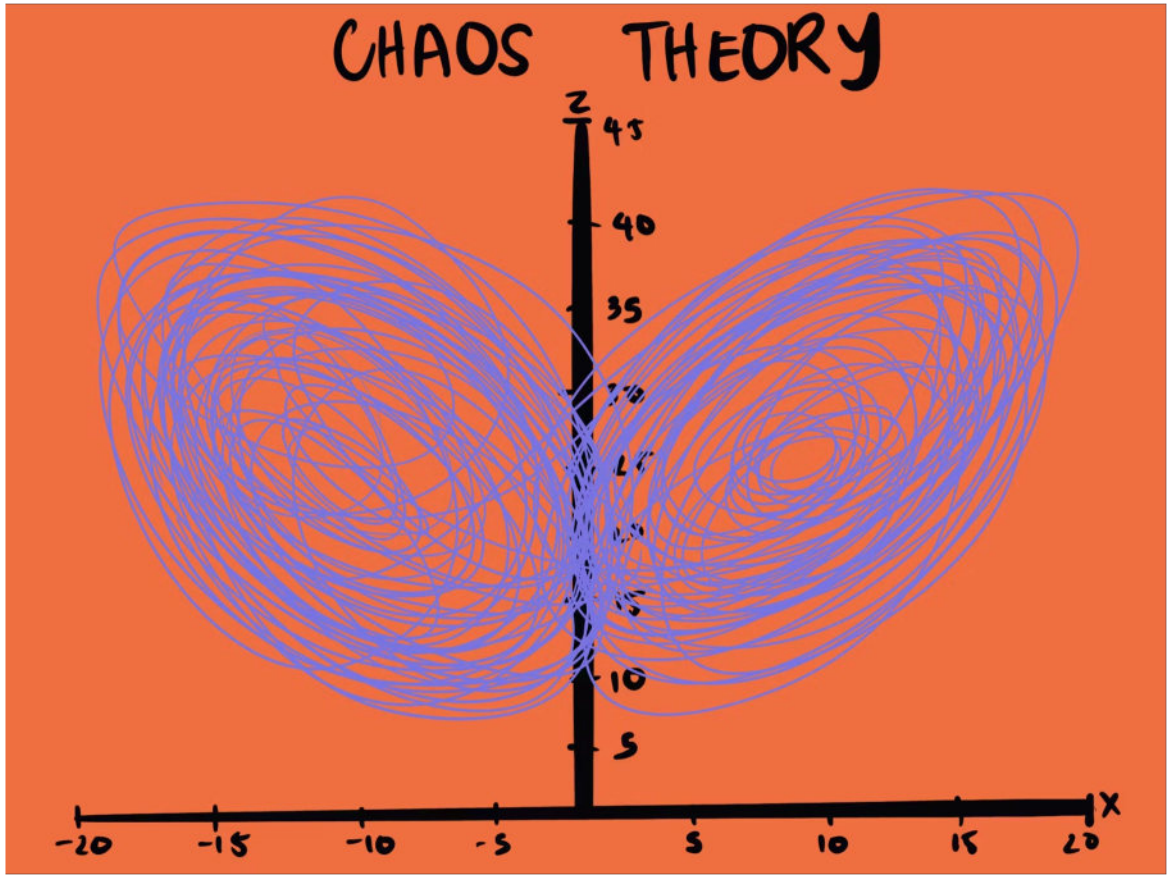
http://www.johannesjaeger.eu/blog

Nonlinear, uncertain, adaptive, sensitive

Emergence refers to the **spontaneous formation of new behaviors or properties** from the interaction of system components - which **cannot be predicted** by studying the individual components in isolation.

Through emergence, living systems are **fundamentally unpredictable**.

Butterfly effect: small initial conditions in a complex system can result in significant, often unpredictable, outcomes. (Edward Lorenz)



https://thedecisionlab.com/

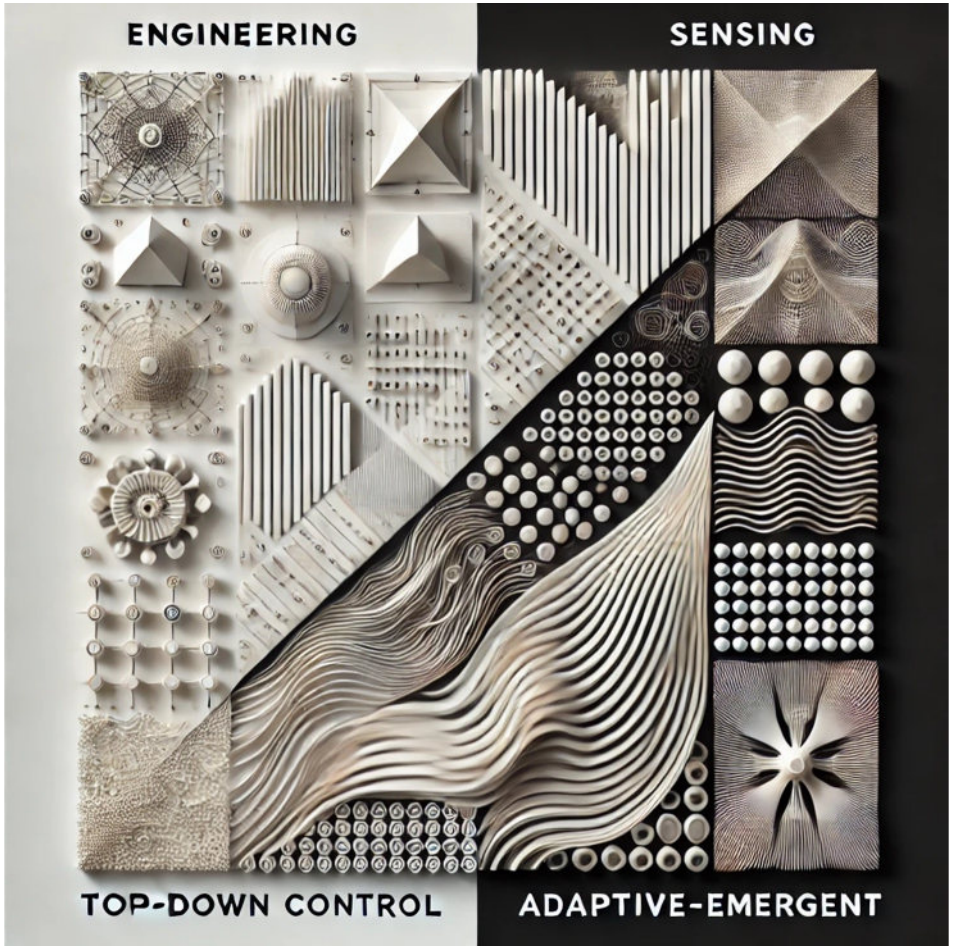
Top-down control vs. bottom-up and cross-scale sensing

Complex systems require sensing, which is based on **dynamic, real-time feedback** and adaptation rather than rigid control.

S. sensing comes with the need for **emotional intelligence to handle complexity and ambiguity.**

It is **enacting** systems.

Mindfulness and feedback-driven decision-making have been shown to improve emotional regulation and adaptability in the brain (via the prefrontal cortex and amygdala).

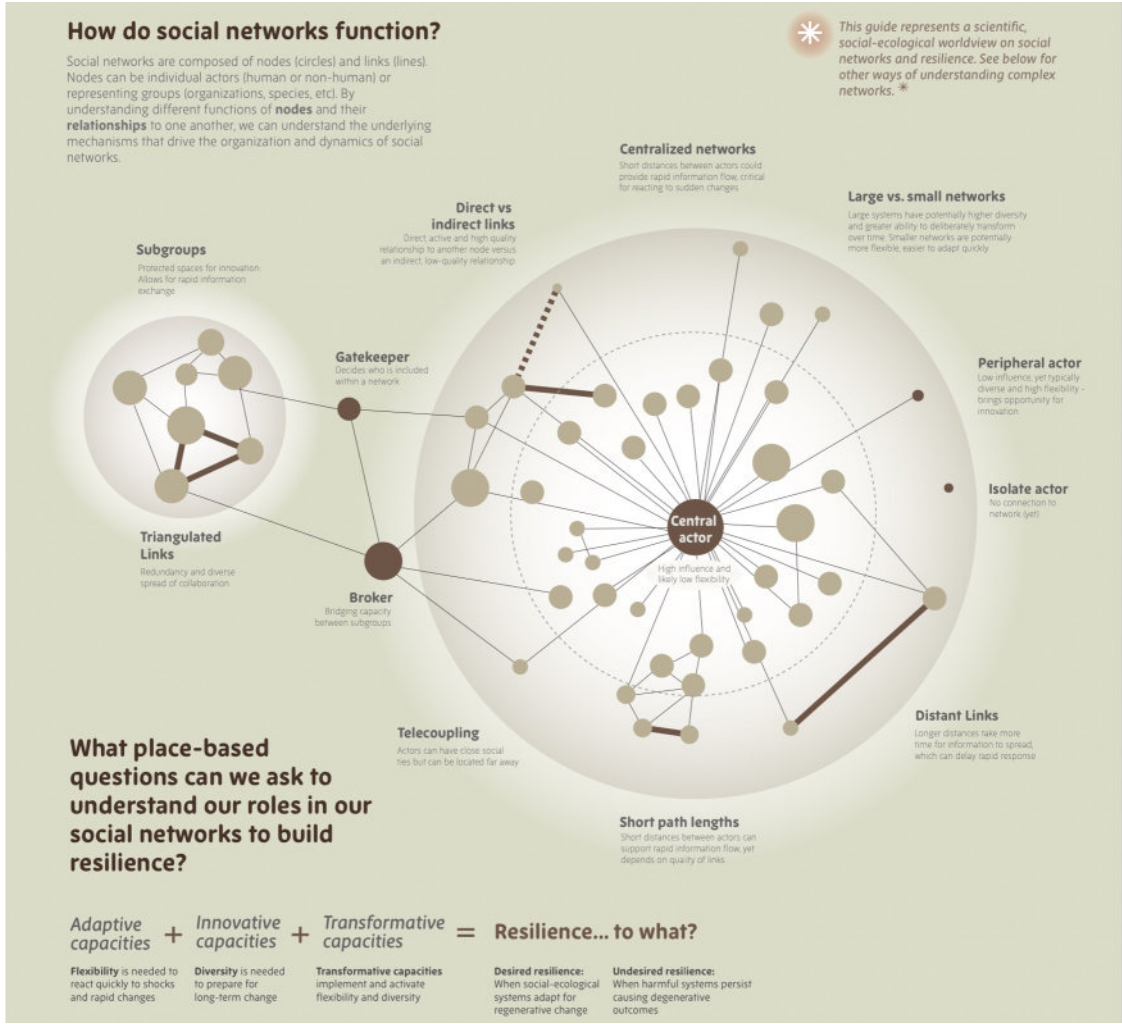


Building bridges?

Building bridges

Build bridges

Sometimes…
we build bridges,
we let bridges grow,
a system may benefit from no bridges.



Fitzpatrick and Luthe, 2024

Building bridges

Let bridges grow

Sometimes…
we build bridges,
we let bridges grow,
a system may benefit from no bridges.

Living Root Bridge in Meghalaya, India. Source: revolvingcompass

Building bridges

No bridging

Sometimes…
we build bridges,
we let bridges grow,
a system may benefit from no bridges.

Venice lagoon. Source: MonViso Institute

Not bridging - not building - (non)engineering

Postactivism - non-acting is a form of acting

“Postactivism, it is my way of describing the flows and possibilities that proceed from the moment when things no longer fit.

This is postactivism. When we have come to the end of the rope, to the very end of the world, and there are no more words.

https://www.bayoakomolafe.net/post/what-i-mean-by-postactivism

Embracing emotional and cultural change

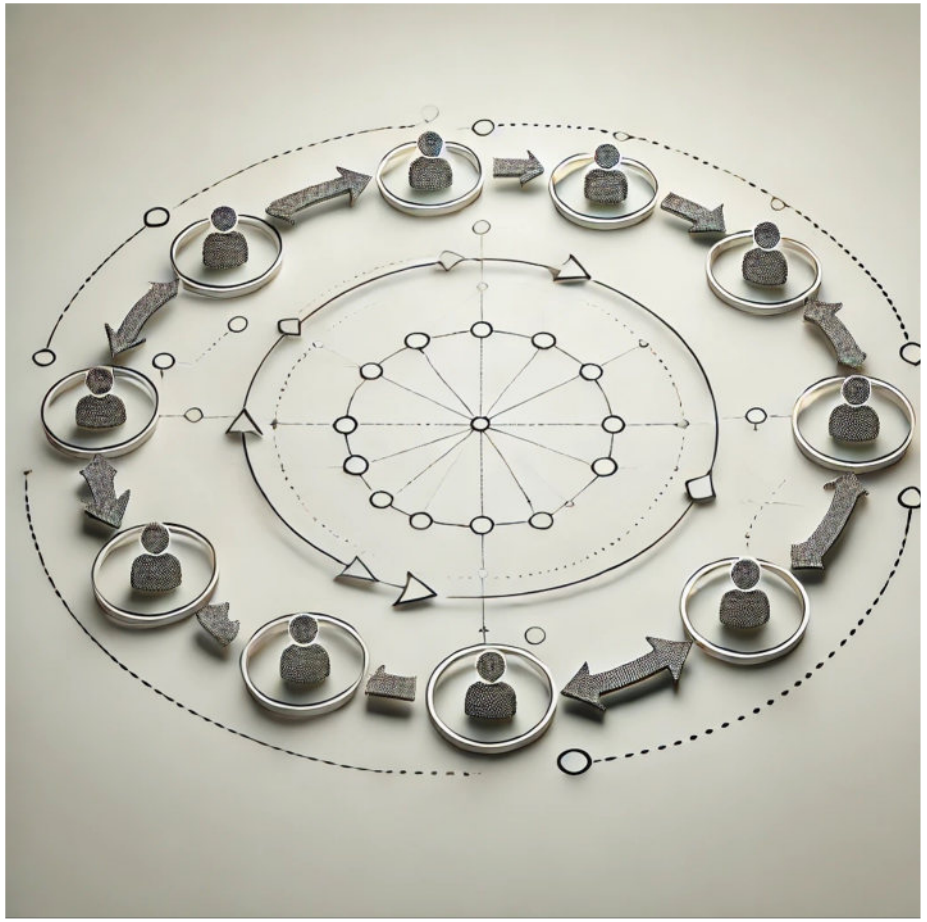
Characteristics of emergence and emotional adaptability

Living systems need a life-centered approach

Living systems, through emergence and self-organization, need a human, or life-centered approach.

Emotional intelligence is important in creating adaptable, collaborative teams that can work in these unpredictable environments.

Practices like **empathy** and **collaborative problem-solving** activate the brain's social and creativity centers (e.g., mirror neurons and the default mode network), enabling better team performance.



From control to adaptability

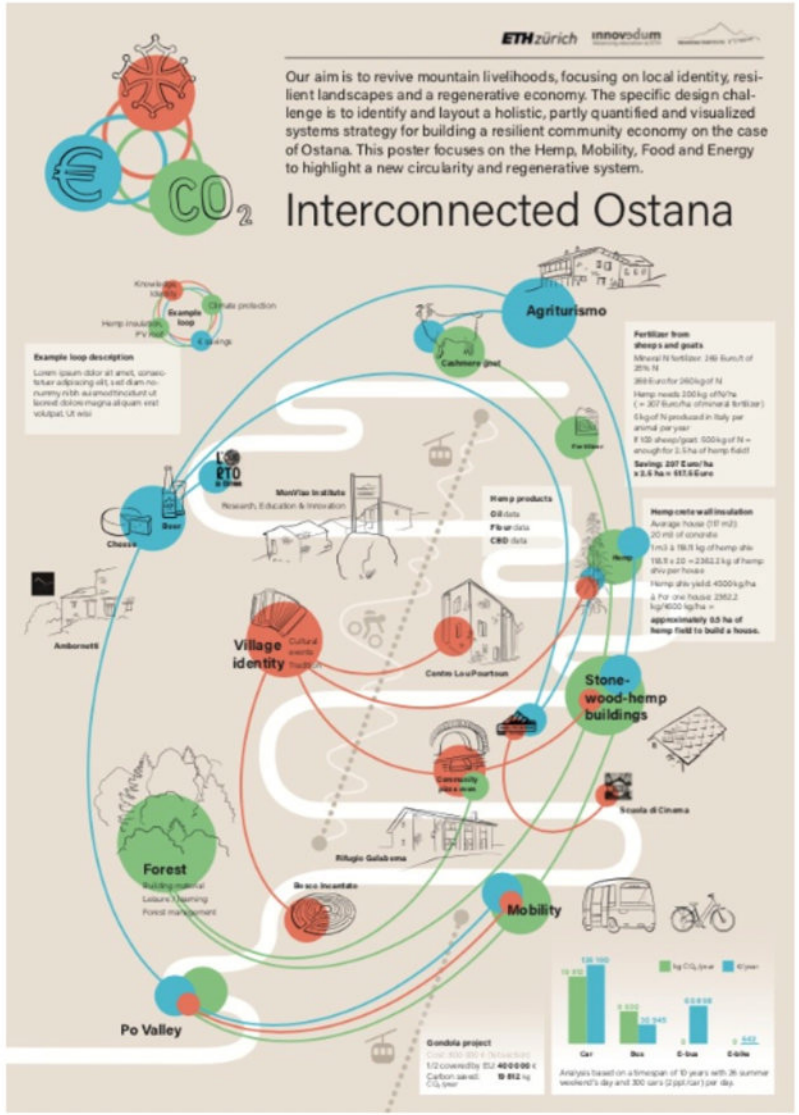
Engineers often face resistance to uncertainty and change. Emotional intelligence (EQ) can help teams better navigate these challenges by **developing self-regulation, empathy, and personal growth mindsets.**

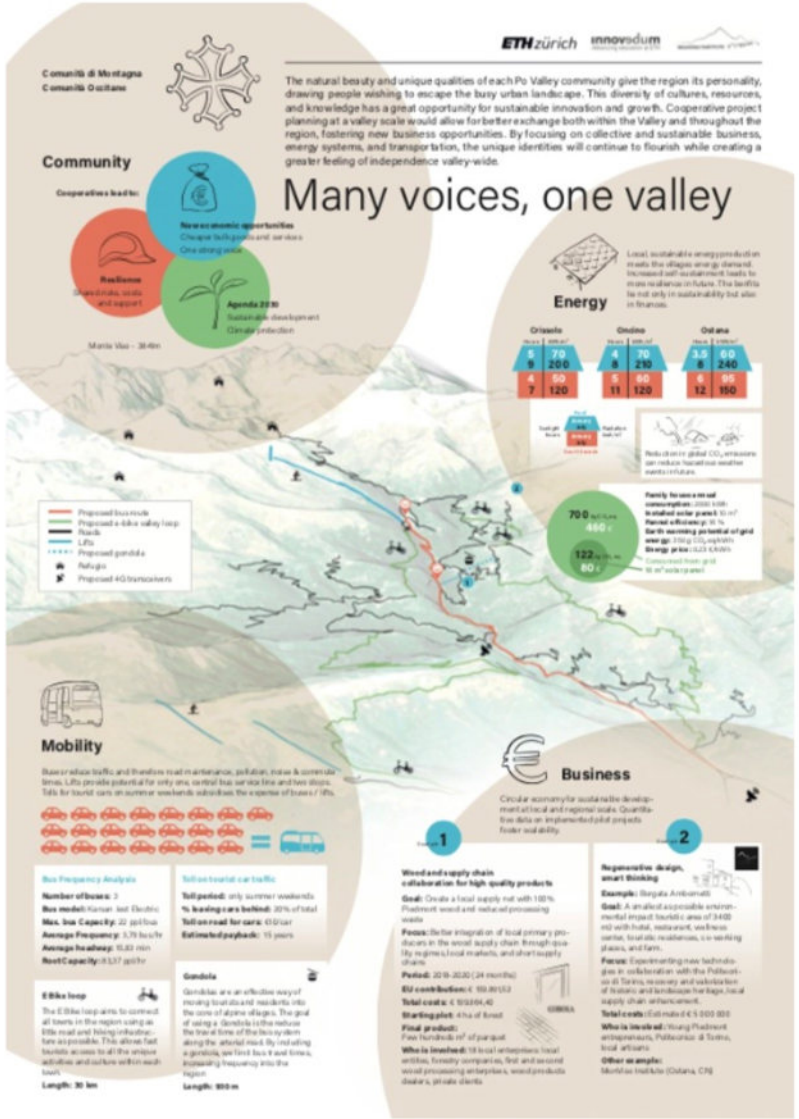
In the spectrum from control to adaptability, a “personal growth mindset” and “emotional regulation” can bridge this gap.

Practices like mindfulness and reflection help strengthen the prefrontal cortex, leading to better **emotional regulation and more adaptive behavior** in high-pressure environments.

“We do systems, not graphics…”

Master student, Integrated Building Systems





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Emotional intelligence: a crucial tool in systems sensing

Being comfortable navigating ambiguity

Engineers need to be comfortable navigating ambiguity and collaborating across disciplines.

There is a high **need for emotional intelligence** (EQ emotional quotient) in engineering teams—self-awareness, empathy, adaptability—**when dealing with uncertainty and complexity.**

Key elements of emotional intelligence: **self-awareness, empathy, collaboration, and adaptability.**

“What is the essence?”

The design task was to build a “circular skateboard” from regenerative materials. I first thought into bio-based composites, CAD and vacuum lamination. The SDL course made me rethink my approach: what is the essence and purpose should my board deliver? How simplistic, in terms of low input and sufficient output, can I design? I came up with a stick board from the hazelnut bush in the garden, mounted on a recycled wheelbase, totally fine to long-board to the bakery.”

Master student, Engineering Design

Developing emotional intelligence through training

EQ can be practiced

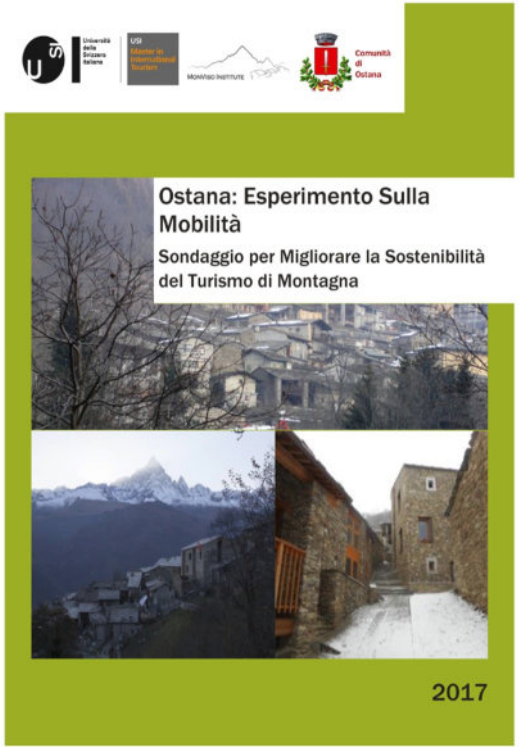
There are practical ways we can develop EQ through training, mindfulness, empathy exercises, and reflection. Such practices can rewire the brain and improve team dynamics.

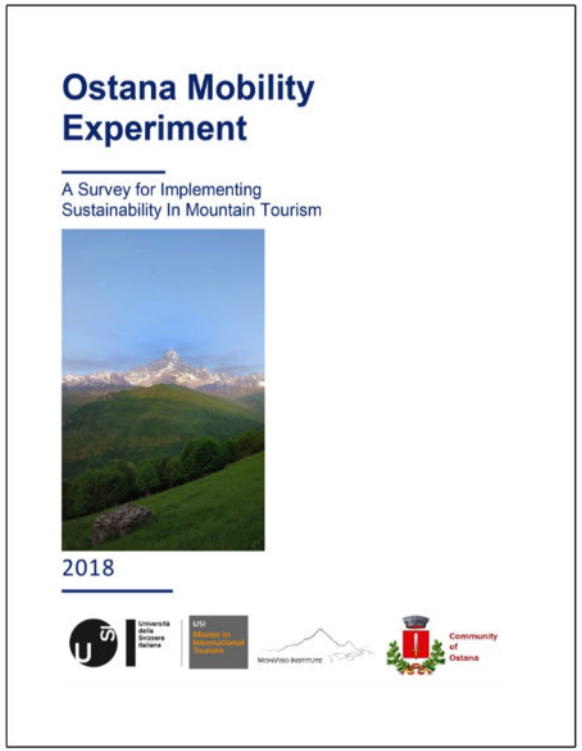
Hard evidence from neuroscience studies shows how these **practices lead to measurable changes in brain function and enhance emotional regulation and collaboration** in complex problem-solving environments.

https://doi.org/10.1016/j.copsyc.2018.12.005

Transforming a community mobility system?

Better data lacks emotional coherence





Evolving work and governance styles for adaptive systems

Siloed, rigid vs. collaborative, flexible

Reframing cultural expectations within organizations—moving from rigid expectations of certainty and control toward **valuing flexibility, experimentation, learning through failure.**

New work styles include collaborative, iterative approaches and a strong **feedback loop culture**. **Emotional intelligence is key** in supporting these adaptive work styles.

Collaborative problem-solving stimulates areas of the brain related to **cognitive flexibility** (e.g., the dorsolateral prefrontal cortex), improving creativity and resilience.

“Transforming through Interbeing.”

The experience of the PhD school “alpine-urban resilience” in the small Italian mountain community changed my perspective on making a difference: the fact that we PhD’s were asking questions and indicating real interest to the locals, adding some visual dialogic tools to informed conversations, made me aware of Interbeing. Being part of transformation processes by respectfully listening and curiously asking questions.”

ETH PhD student, SDL PhD summer school, real-world lab MonViso Institute

Cultivating adaptive, transdisciplinary teams

Increasing resilience in uncertainty

Engineering teams can thrive in an emergent systems environment by fostering collaboration across disciplines (biology, design, data science) and work types (industry, academia, embodied practice).

Adaptive cultures that value learning, experimentation, and iterative processes **will be more resilient in the face of complexity.**

The role of AI in systems sensing

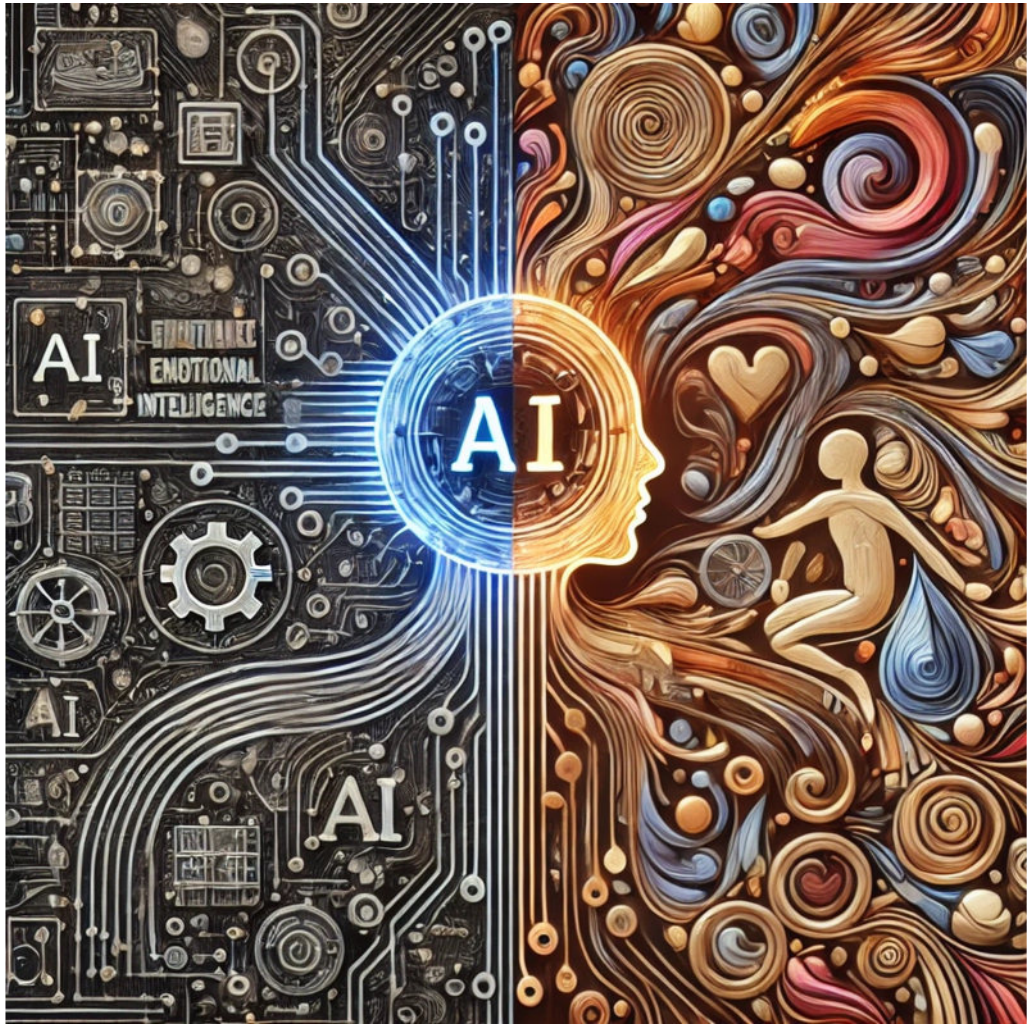
Human’s emotional intelligence is key in adaptive processes

AI can provide real-time data, predictive modeling, and feedback to help engineers sense emergent patterns, but it cannot replace the human skills required to manage complexity.

Importance of emotional intelligence alongside AI, noting that **AI can’t handle emotional, social, and cultural complexities**, but human intelligence (particularly emotional intelligence) can.

Humans’ emotional intelligence (rooted in neural systems like the mirror neurons) complements AI in collaborative, adaptive processes.

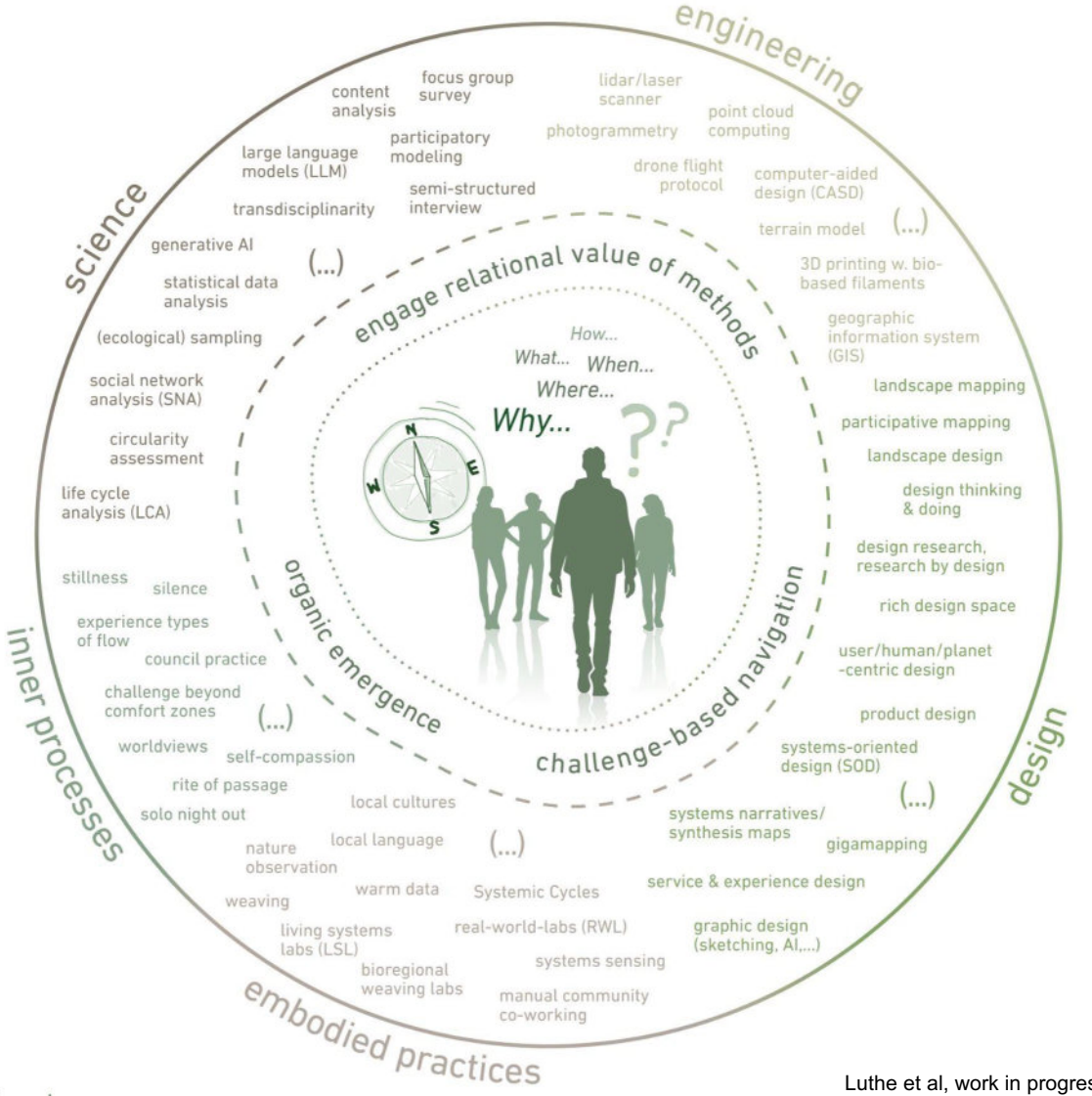
Example: City mobility transition project



Systemic design
bridges
systems engineering
and
systems sensing

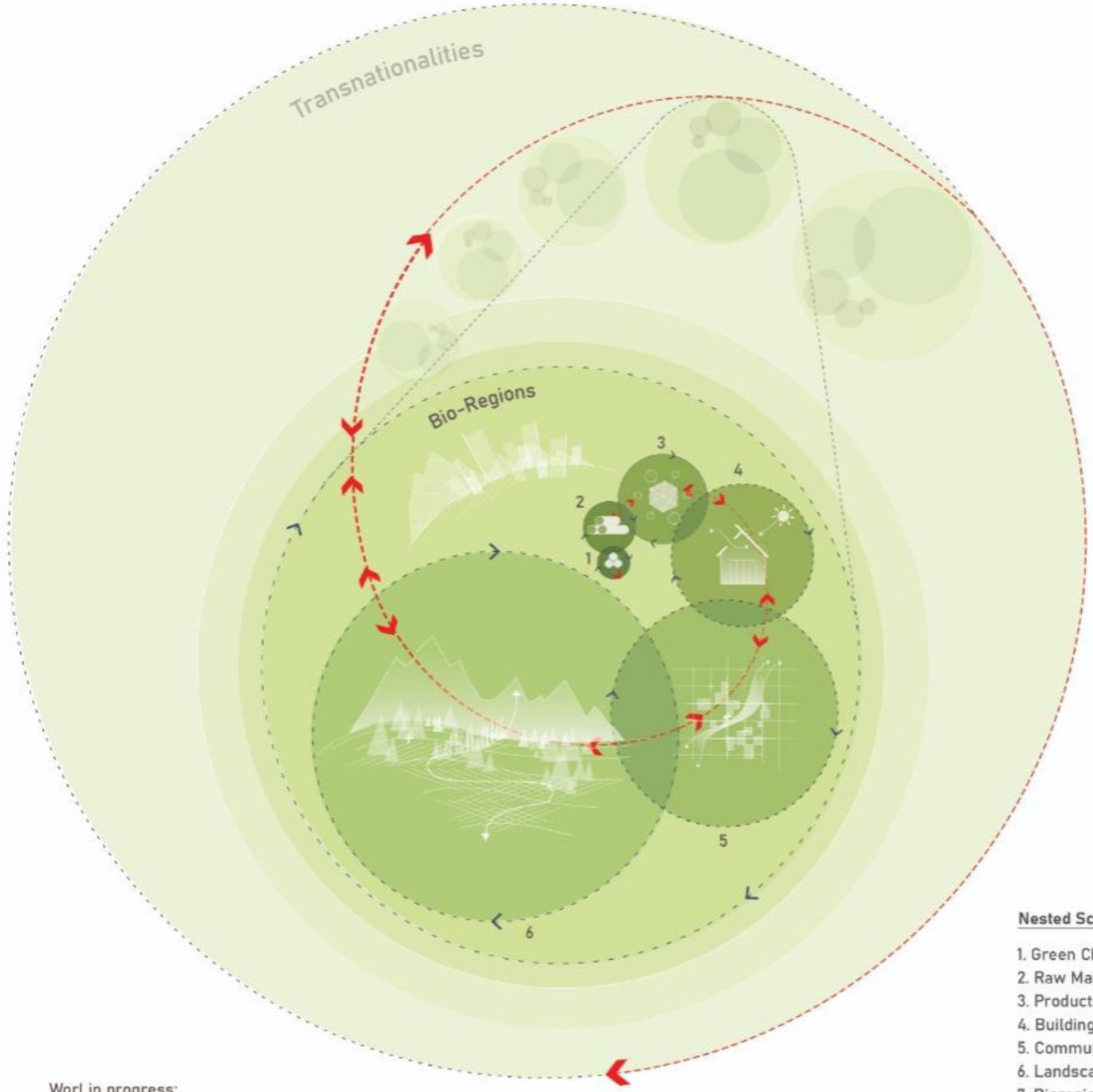
Systemic Design:

Navigating the relational value of different modes of inquiry



Review phase.

Luthe et al, work in progress



Nested Scales

1. Green Chemistry
2. Raw Materials
3. Products
4. Buildings
5. Communities + Services
6. Landscapes
7. Bioregions
8. Transnationalities

Worl in progress:
Luthe, T. Fitzpatrick, H. Wahl, D.

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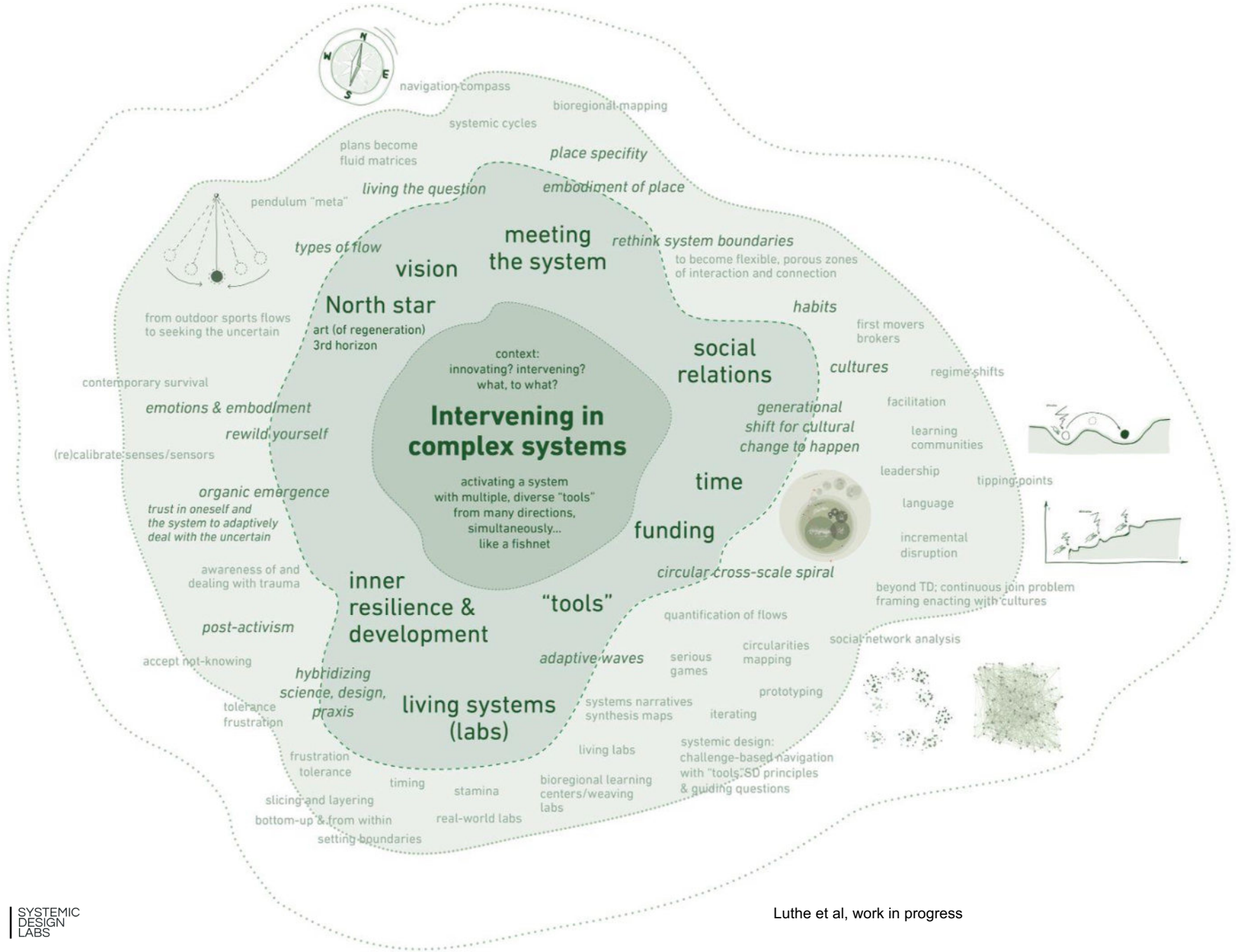

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Luthe et al, work in progress

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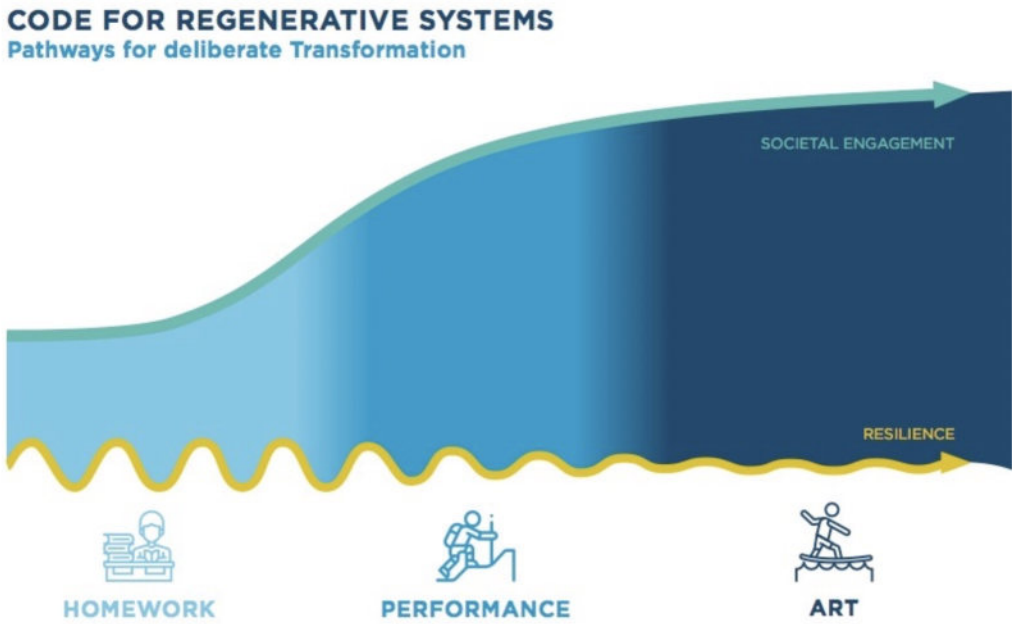

Luthe T. and B. Marias, work in progress

SOCIETAL ENGAGEMENT / level of engagement		HOMEWORK	PERFORMANCE	ART
Criteria - Systemic, ESG	(specification/ comment)	on based in headquarter country Know where you are (Mapping) > Portrait Define where you want to go (True North) > pick at least two reference points to find your position on the map	Fuzziest area. most difficult start. more invest. needing results. experiment. will loop and fail. Regulation based ion best in class country	Clear goal and vision. In line with kinetic energy to create a flow (wind, wave, terrain, etc.) Keep the motion. Anticipating and co-designing future regulations.
Systemic		**ESG-related KPI's to be specified for each sector case**		
MINDSET & ATTITUDE	of your organizations's journey / Style / Ambition / Embrace values / New narratives	Initiating internal actions	Experimenting with systemic change	Regeneration
SYSTEMS THINKING	Holism	Understanding the organization as a system	Optimize systems structure and apply concept of leverage	Living (programmed) holism
DESIGN PHILOSOPHY		Regulation based (e.g. fair working conditions, environmental management)	Systemic (Eco-Social Life Cycle Design, Industrial Ecology)	Circularity (e.g. C2C) Low-Tech<>high tech, traditional local knowledge Bio-sourced / Bio-Based Open-source
LEADERSHIP STYLE		Problem solving, strategic, outcome oriented	Team oriented, collaborative, servant leadership	Systemic, holding space for the purpose
Place specifity / Local context				
Environmental		minimizing negative environmental impacts	go beyond mitigation and actively contribute to restoring ecosystems	regeneration is happening and can be demonstrate
energy use and efficiency				
waste		waste reduction	5R	no waste - outputs are new resources, fully circular
biodiversity loss			active local biodiversity improvements	
greenhouse gas emissions				
carbon footprint		carbon footprint reduction / analysis from 500+	carbon footprint analysis	
water management				
Social				
fair pay and living wages		fair pay and living wages		
equal employment opportunity		equal employment opportunity		
employee benefits				
workplace health and safety		workplace health and safety		
community engagement				
responsible supply chain partnerships				
labor laws		adhering to labor laws		
CAPACITY BUILDING tools		*Conferences, External Technical advices, Literature, Online researches*	*Master Class, Peer learning, Professional Degrees, External experts*	*Immersive Retreats (lectures, workshops, outdoor activities), living labs/real-world labs* *Peer Coaching, Culture of Experimentation*
GOVERNANCE	Decision making	Understand your current decision making processes	Experiment with new governance models	Adaptive governance
risk management				
compliance				
avoiding conflicts of interest				
accounting integrity and transparency				
ORGANIZATIONAL MODEL /corporate governance		Corporation (vertical)	Collaboration (horizontal)	Cooperation (system)
BUSINESS MODEL / ethical business practices	Attitude & type	Rethink business model	Experiment with new business model (e.g. contributive economy)	Implemented regenerative business model (e.g. Commons//Symbiosis/Inclusive Economy)
			strategic foresight workshop	
STRATEGIC STEERING TOOLS / SCALES OF INFLUENCE		Direct scale of influence ?		Biomimicry, Doughnut Economy, Climate Collage,
IMPACT		Measure and reduce negative impact > propose how to measure/what indicators, e.g. know your supply chain, your co2 footprint, happyness of your employees	optimize positive vs negative impact	Becoming netpositive, restoring systems
Impact assessment tools		ISO certifications, Carbon Footprint, Internal Carbon Pricing	Life Cycle Assessment Environmental Profit & Loss Higg Index Happiness indicator	Science-based targets Local Footprint (might be performance) B Impact Assessment tool
PROGRESS INDICATORS /accounting integrity and transparency		Reduced negative footprint Efficiency	Optimized balance negative/positive Effectiveness	Abundance Deliberated transformation
COMMUNICATION & Outreach		Basic information	Stakeholders engagement and integrated reporting	Radical transparency Open and collaborative
Tools		CSR reporting, ideally GRI	Sustainability Strategy	Co-design and shared transformative roadmap
Further categories can be added and resorted				
RESILIENCE	Crises, Transitions & Adaptive Waves: adaptive, innovative and transformative resilience; diversity > preparing for change, flexibility > responding to change	Adapt in response to (potential) change	Innovate-transform in foresight of change	Regenerate ("surf adaptive waves")

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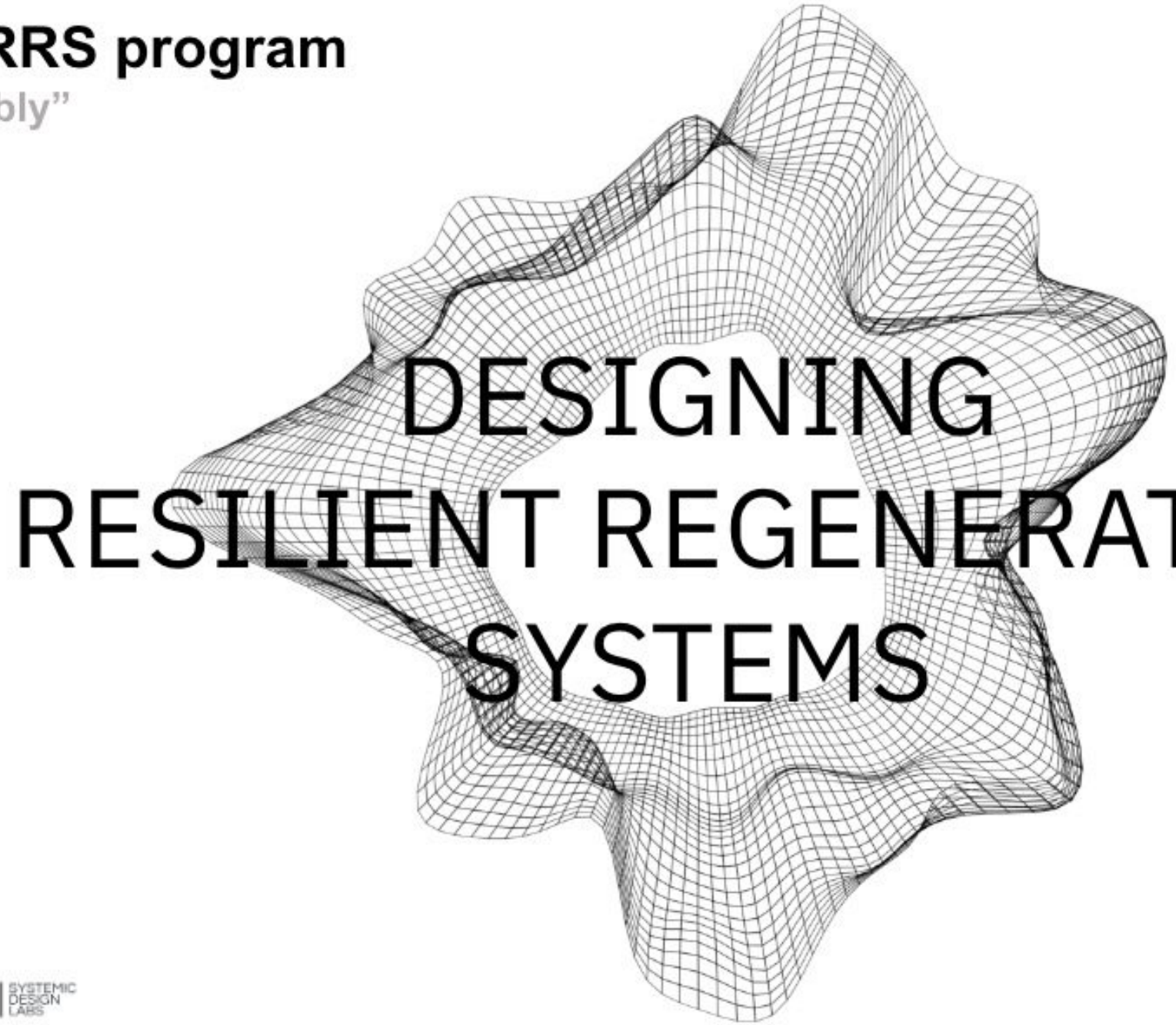
Learning Systemic Design

ETH DRRS program

The “wobbly”



DESIGNING RESILIENT REGENERATIVE SYSTEMS

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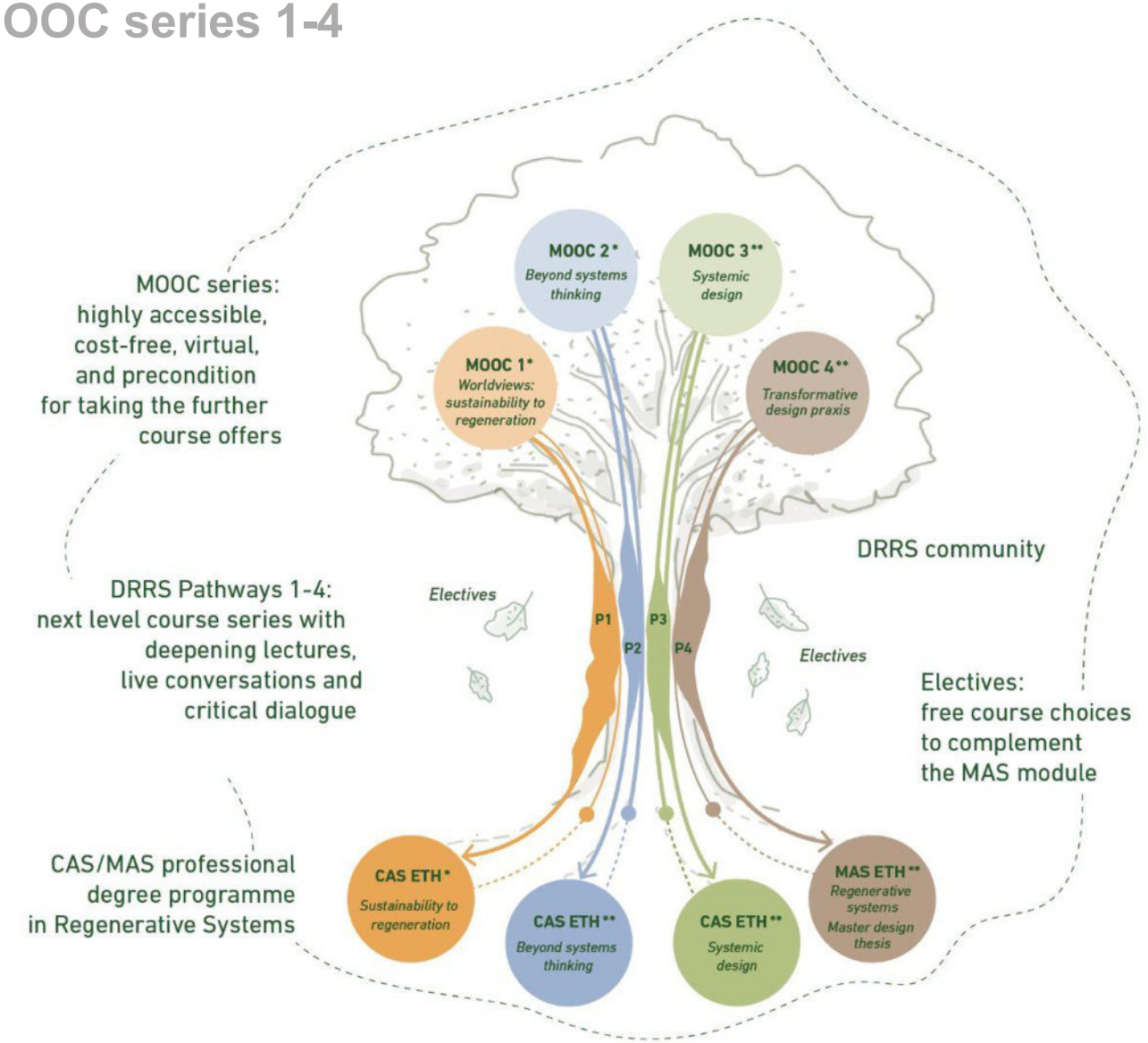
MAS ETH in Regenerative Systems

CAS 1-3 and MOOC series 1-4



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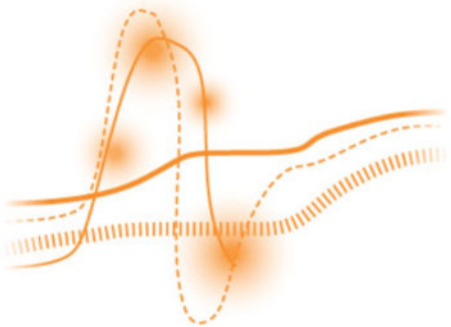
Melody of flexible DRRS MAS learning pathways

CAS#1

Sustainability to Regeneration

Learn to unlearn

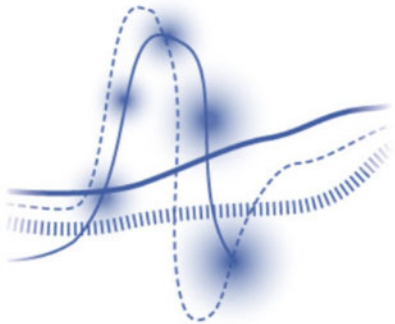


MOOC#1

CAS#2

Beyond Systems Thinking

Meta-awareness

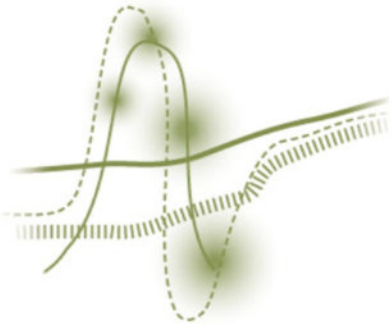


MOOC#2

CAS#3

Systemic Design

Navigating methods - relations



MOOC#3

MAS

Transformative Real-World Practice

QUEST to design thesis

MOOC#4

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Organic emergence

The inner capacity to befriend uncertainty

ETH DRRS program

Systems Engineering provides stability through structured curricula, accreditation processes, and foundational governance.

Systems Sensing enables real-time adaptation, personalized learning, and emergent curricula based on data from students, educators, and societal trends.

To successfully balance both approaches, the education system must:

- Develop **adaptive governance models** that can integrate real-time feedback and rapidly changing societal needs.
- Foster **inter- and transdisciplinary collaboration** between educators, researchers, technologists, and cognitive scientists - and practitioners out in the field.
- Shift the academic culture to one that values **continuous learning and adaptation** over static, rigid models of education.
- Implement **neuroscience-backed practices** like empathy training, feedback loops, and adaptive learning to improve student outcomes and emotional intelligence in educational institutions.

Wrap-up

Summary

From systems engineering to systems sensing

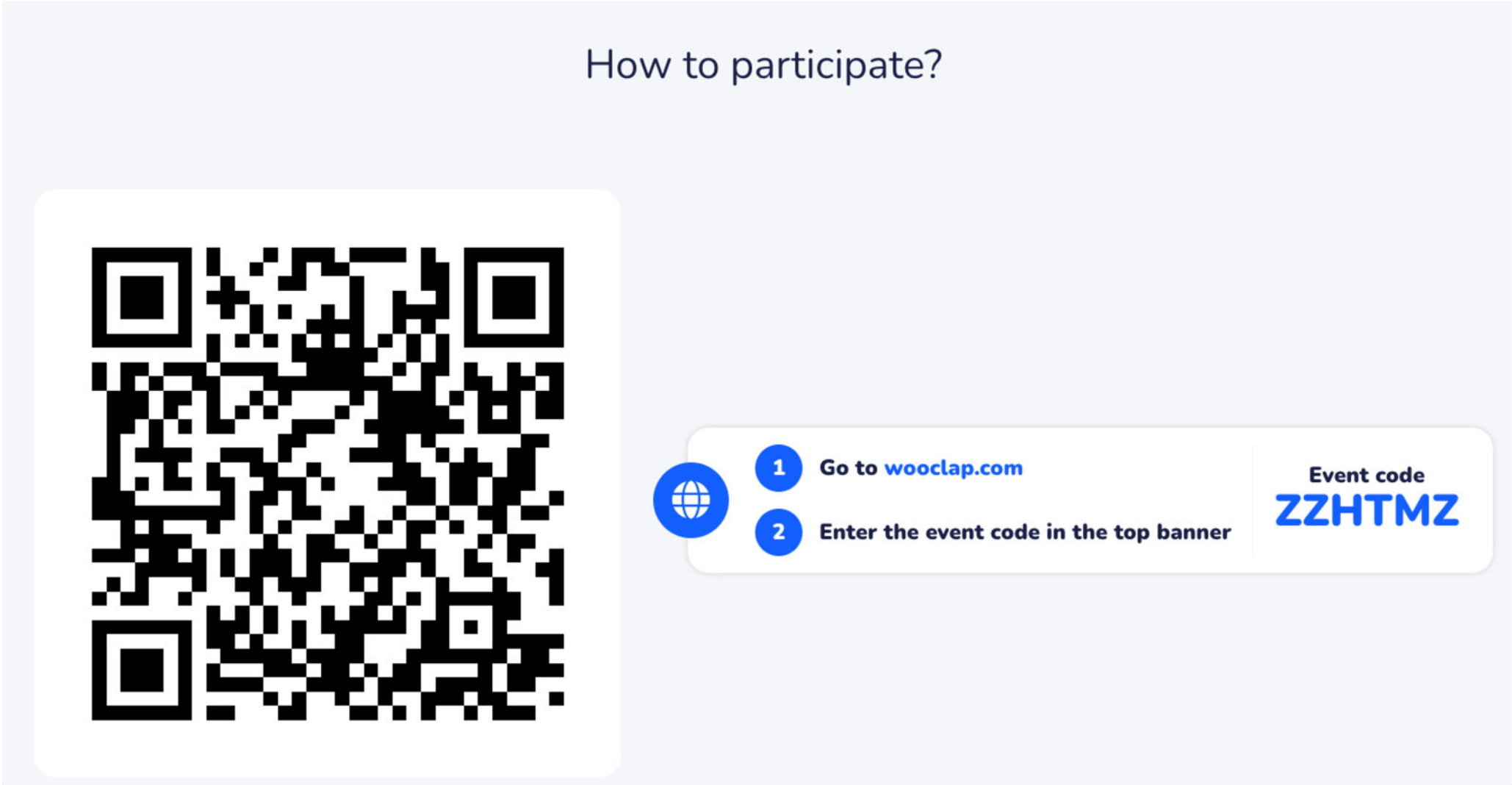
As systems engineers we can learn **meta-cognitively** about our own practices, not just as a technical field but as a **complex adaptive system** itself.

By combining systems engineering with systems sensing, engineers can:

- Implement **feedback loops** that allow their methodologies to evolve in real-time.
- Embrace **emergence** as a natural outcome of complex system work.
- Use **emotional intelligence** to foster better collaboration and adaptability.
- Shift **governance structures** to support more agile, responsive systems engineering practices.

By **sensing our own practices** and reflecting on the field's inherent complexity, systems engineers can evolve into more flexible, adaptive problem solvers capable of thriving in an increasingly interconnected, dynamic world.

What presented terms, keywords, concepts (...) describe or trigger my cognitive or mental state now after this presentation?



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Go to **wooclap.com** and use the code **ZZHTMZ**

What presented terms, keywords, concepts (...) describe or trigger my cognitive or mental state now after this presentation?

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Living the question

Asking ourselves to reflect beyond our traditional roles

How do we balance the desire for control with the need for adaptability in our own practices?

What feedback mechanisms do we have in place for sensing and adapting to new challenges in the field of systems engineering itself?

In what ways are we over-reliant on deterministic, top-down models, and how can we incorporate sensing and emergence into our methodologies?

How are emotional intelligence, collaboration, and human factors currently influencing our technical work, and how should they?

How does governance in the systems engineering field need to evolve to keep pace with the complexity and adaptability required in modern systems?

How open am I, myself, to allow for sensing and emergence to gain more acceptance and inclusion in the systems engineering field?

Building bridges

How to (non)engineer living systems

Practice to science
transdisciplinary

Waterfall to agile
adaptability

Startup to corporate
evolution

Methodology to practice
systemic design