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On Impacts of Disruptions of Transport and Logistic Systems

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The World Is Suffering from a Polycrisis

<table>
<thead>
<tr>
<th>2 years</th>
<th>10 years</th>
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<tbody>
<tr>
<td>1. Cost of living crisis</td>
<td>1. Failure to mitigate climate change</td>
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<tr>
<td>2. Natural disasters and extreme weather</td>
<td>2. Failure of climate-change adaption</td>
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<td>events</td>
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<td>3. Geoeconomic confrontation</td>
<td>3. Natural disasters and extreme weather</td>
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<tr>
<td>4. Failure to mitigate climate change</td>
<td>4. Biodiversity loss and ecosystem collapse</td>
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<td>5. Erosion of social cohesion and societal</td>
<td>5. Large-scale involuntary migration</td>
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<td>polarization</td>
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<td>6. Large-scale environmental damage incidents</td>
<td>6. Natural resource crises</td>
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<tr>
<td>7. Failure of climate-change adaption</td>
<td>7. Erosion of social cohesion and societal</td>
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<td>8. Widespread cybercrime and cyber</td>
<td>polarization</td>
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<td>insecurity</td>
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<td></td>
<td>10. Large-scale environmental damage incidents</td>
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</tbody>
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Risk categories
- Economic
- Environmental
- Geopolitical
- Societal
- Technological


Some Examples of Possible Disruptions of Transport Systems (incomplete list)

- Building sites
- Accidents
- Failures of critical infrastructures
- Terror attacks
- Earthquakes
- Extreme weather
- Supply shortages
- Cyberattacks, Internet outages
- Blackouts
- Lockdowns
- Collapse of the petrodollar fiat currency system
- Explosion of energy prices
- Economic meltdowns
- Political or military coups
Some Examples of Possible Impacts and Who Is Concerned (incomplete list)

- Depending on the size and location of the disruption(s) and possible cascading effects, the scale of impacts can range from local to global effects, and from single entities to everyone.
- In the very worst case, the functioning of entire societies or civilizations may be at stake. Even though pretty unlikely, according to standard threat analyses, in principle supply chains and public order could break down.
- Overreactions and actionism can make things worse!
Some Examples of Possible Impacts and Who Is Concerned (incomplete list)

- Producers
- Consumers
- Transport and logistic service providers
- Traffic participants
- Public infrastructures and institutions
- Etc.

Are the impacts unevenly distributed over different groups in society and industries?
Yes. Some people and institutions are particularly vulnerable.

Are certain impacts associated with specific transport modes, geographic areas, or institutional features, ...?
Yes. But this cannot be summarized in 20 minutes.
Our main problem is the lack of sustainability.

<table>
<thead>
<tr>
<th>Country</th>
<th>Earths Needed</th>
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<tbody>
<tr>
<td>U.S.A.</td>
<td>5.0</td>
</tr>
<tr>
<td>Australia</td>
<td>4.1</td>
</tr>
<tr>
<td>South Korea</td>
<td>3.5</td>
</tr>
<tr>
<td>Russia</td>
<td>3.3</td>
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<tr>
<td>Germany</td>
<td>3.0</td>
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<td>Switzerland</td>
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<td>U.K.</td>
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<td>France</td>
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<td>Japan</td>
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<tr>
<td>Italy</td>
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<tr>
<td>Spain</td>
<td>2.3</td>
</tr>
<tr>
<td>China</td>
<td>2.2</td>
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</tbody>
</table>
The Limits to Growth (1972): We had 50 years to prepare!

https://en.wikipedia.org/wiki/The_Limits_to_Growth

September 25, 2015

SUSTAINABLE DEVELOPMENT GOALS

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation and Infrastructure
10. Reduced Inequalities
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13. Climate Action
14. Life Below Water
15. Life on Land
16. Peace, Justice and Strong Institutions
17. Partnerships for the Goals

https://sdgs.un.org/goals
Big data, meet Big Brother

China invents the digital totalitarian state

The worrying implications of its social-credit project
"We don’t know who’s using a $100 bill today... The key difference with the CBDC is the central bank will have absolute control on the rules and regulations that will determine the use of that expression of central bank liability, and also we will have the technology to enforce that."

Agustín Carstens, General Manager, Bank for International Settlements
»Es braucht ein neues Finanzsystem«

Zwei ETH-Wissenschaftler erklären, warum die Weltwirtschaft krank ist, Adam Smith unrecht hatte – und wir ganz anders über Geld nachdenken müssen.

https://www.zeit.de/2011/33/CH-Oekonophysik
Finance 4.0 - Towards a Socio-Ecological Finance System
A Participatory Framework to Promote Sustainability

Next Civilization
Digital Democracy and Socio-Ecological Finance - How to Avoid Dystopia and Upgrade Society by Digital Means
Fixing the World, Yes, But How?

- Digital Enlightenment
- Peace Rooms
- Digital Democracy
- Platform for Informational Self-Determination
- City Olympics/Challenges
- Democratic Capitalism
- Finance 4.0+
- Digitally Assisted Self-Organization
Socio-Ecological Finance FIN4+: Participatory Sustainability
Turn Wasteful Supply Chains…

Derived from:
https://www.istockphoto.com/de/vektor/kreisförmige-wirtschaft-gm510477626-86262363
... into a Circular Economy. But How?
Nature has already solved the problem of circularity.
Use nature-inspired solutions!
Use the Internet of Things!

THE INTERNET OF THINGS
An Explosion of connected possibility

Billions of devices

Year

1992 1,000,000
2003 0.5 BILLION
2009 IoT INCEPTION
2013 11.2 BILLION
2014 14.4 BILLION
2015 18.2 BILLION
2016 22.9 BILLION
2017 28.4 BILLION
2018 34.8 BILLION
2019 42.1 BILLION
2020 50.1 BILLION

Use the Internet of Things! But in a Participatory Way!

The Internet of Things (IoT) is an explosion of connected possibility. The graph shows the growth of billions of devices from 1992 to 2020, with a significant increase in the number of connected devices since 2013. The graph highlights the year 2020 with an estimated 50.1 billion devices connected, marking a dramatic rise from previous years.

Mapping Noise and Other Externalities

(Image: KeystoneUSA ZUMA/Rex Features)

https://www.newscientist.com/gallery/sonic-doom-noise-in-pictures/
The No. 1 Principle

Increase positive externalities, reduce negative ones, and ensure fair compensation
FIN4+: Sensor-Based Measurements of Externalities, Combined with Incentives
Circular and Sharing Economy

https://proclim.scnat.ch/de/current/news/uuid/i/3ab5f988-94ca-5f61-bac1-3ed39dd5edf2-Kreislaufwirtschaft_Versorgung_mit_kritischen_Rohstoffen_und_Indikatoren
Can the World be Saved with a "War Room" Approach?

https://www.theguardian.com/commentisfree/2013/sep/15/nsa-mind-keith-alexander-star-trek

Inside the mind of NSA chief Gen Keith Alexander

Glenn Greenwald
A Digital Twin of the World and Its People

Sentient world: war games on the grandest scale

Sentient World Simulation (SWS)

“provides an environment for testing Psychological Operations (PSYOP),”

the paper reads, so that military leaders can ”develop and test multiple courses of action to anticipate and shape behaviors of adversaries, neutrals, and partners”.

A Typical Supply Network Today

https://www.researchgate.net/publication/280158117
A Typical Metabolic Network
Digital Twins Are Lacking Complexity Science!

https://www.researchgate.net/publication/365852772

https://www.nature.com/articles/s43588-023-00431-4

Design: Javier Argota Sanchez-Vaquerizo
There is not only a Price of Anarchy.

There is also a Price of Optimization and Control!
The Price of Optimization is that all goal(s) but the ones optimized for are ignored.

The Price of Control is the loss of freedom, diversity, creativity, innovation...
Globally networked risks and how to respond

Dirk Helbing¹,²

Today’s strongly connected, global networks have produced highly interdependent systems that we do not understand and cannot control well. These systems are vulnerable to failure at all scales, posing serious threats to society, even when external shocks are absent. As the complexity and interaction strengths in our networked world increase, man-made systems can become unstable, creating uncontrollable situations even when decision-makers are well-skilled, have all data and technology at their disposal, and do their best. To make these systems manageable, a fundamental redesign is needed. A ‘Global Systems Science’ might create the required knowledge and paradigm shift in thinking.

Globalization and technological revolutions are changing our planet. Today we have a worldwide exchange of people, goods, money, information, and ideas, which has produced many new opportunities, services and benefits for humanity. At the same time, however, the underlying networks have created pathways along which dangerous and damaging events can spread rapidly and globally. This has increased systemic risks¹ (see Box 1). The related societal costs are huge.

When analysing today’s environmental, health and financial systems or our supply chains and information and communication systems, one finds that these systems have become vulnerable on a planetary scale. They are challenged by the disruptive influences of global warming, disease outbreaks, food (distribution) shortages, financial crashes, heavy ‘Global Systems Science’, in order to understand better our information society with its close co-evolution of information and communication technology (ICT) and society. This effort is allied with the “Earth system science”¹⁰ that now provides the prevailing approach to studying the physics, chemistry and biology of our planet. Global Systems Science wants to make the theory of complex systems applicable to the solution of global-scale problems. It will take a massively data-driven approach that builds on a serious collaboration between the natural, engineering, and social sciences, aiming at a grand integration of knowledge. This approach to real-life techno-socio-economic-environmental systems⁸ is expected to enable new response strategies to a number of twenty-first century challenges.
The Nodes Lose Importance ...
... As Interaction Effects Dominate ...
... And Network Effects Prevail
Cause and Effect in Networked Systems

- Intended effect
- Side effect
- Feedback effect
- Cascading effect
Networked Risks

Source: WEF
Loss of Control through Cascading Effects

Mousetrap fission, by Gerhard G. Paulus, University of Jena, https://www.youtube.com/watch?v=WizTVLYgJtI
Cascading Effects During Financial Crises

US banks failed during the crisis

Failed banks: 0
Losses: 0.0 bns of $
Let us discuss the example of traffic flows in road networks!
Let’s Have A Look at the Challenge of Adaptive Traffic Light Control!

- for complex street networks
- for traffic disruptions (building sites, accidents, etc.)
- for particular events (Olympic games, pop concerts, etc.)
Self-Organized Oscillations at Bottlenecks and Synchronization

• Pressure-oriented, autonomous, distributed signal control:
  – Major serving direction alternates, as in pedestrian flows at intersections
  – Irregular oscillations, but ‘synchronized’

• In huge street networks:
  – ‘Synchronization’ of traffic lights due to vehicle streams spreads over large areas

https://journals.aps.org/pre/abstract/10.1103/PhysRevE.51.4282
Harnessing Complexity by Flexible Adaptation and Decentralization

Stefan Lämmer and DH

Self-control of traffic lights and vehicle flows in urban road networks

Stefan Lämmer\textsuperscript{1} and Dirk Helbing\textsuperscript{2,3}

Published 16 April 2008 • IOP Publishing Ltd


Self-Stabilizing Decentralized Signal Control of Realistic, Saturated Network Traffic

https://www.santafe.edu/research/results/working-papers/self-stabilizing-decentralized-signal-control-of-r
Comparing 3 Ways to Organize a Complex System

Central control, “benevolent dictator”

Travel time minimization, “homo economicus”

Same, but other-regarding coordination with neighbors
Bottom-Up Self-Organization Can Outsmart Optimal Top-Down Control

Stefan Lämmer and Dirk Helbing
Towards Self-Organized Traffic Light Control in Dresden

Stefan Lämmer and Dirk Helbing
The Measurement and Control Area

Stefan Lämmer and Dirk Helbing
Disturbance of Traffic Coordination by Bus and Tram Lines

Tram 1  Tram 2  Tram 6  Tram 10
Tram 11  Bus 75  Bus 94  CarGoTram

Synchronize Traffic by Green Waves or Use Gaps as Opportunities?
Gain in Performance

- Public transport: 2.02 vh, Total delay: 0.89 vh, -56%
- Motorized traffic: 63.9 vh, Total delay: 58.5 vh, -9%
- Pedestrians and Cyclists: 59 s, Average red times: 38 s, -36%

Stefan Lämmer
Comparison of Various Control Approaches

Classical:
- Random
- Adaptive
- Demand

Self-Organizing:
- Analytic+

Machine Learning:
- PressLight
- GuidedLight

Machine learning approaches use pressure as reward

Work with Marcin Korecki et al.
Would Machine Learning Do Any Better?

1) Self-organization approaches perform surprisingly well when compared to machine learning solutions.

2) Combining both methods deliver superior performance and much shorter convergence times.

3) Analytical is not dead – hybrid approaches are best.
Managing Disrupted Systems: Do Approaches Based on Self-Organizing or Machine Learning Work Best?

https://www.researchgate.net/publication/366249147
Managing Disrupted Systems: Do Approaches Based on Self-Organizing or Machine Learning Work Best?

https://www.researchgate.net/publication/366249147
“We cannot control everything top-down”

Interview ▪ Professor Dr. Dirk Helbing, Full Professor of Sociology at the Swiss Federal Institute of Technology in Zurich (ETH) and former traffic scientist at the TU Dresden, speaks about the phenomenon of self-organization in complex systems and about the possibilities of using modern sociological insights for optimizing road traffic.
Alle Farben gleichzeitig wird auch die neue Ampelsteuerung nicht anzeigen. (Bild: Adobe Stock)

Pilotversuch an der Tribschenstrasse

Luzern prüft die Super-Ampel

Die Stadt Luzern führt kommende Woche den landesweit ersten Test mit einer neuartigen Steuerung für Lichtsignalanlagen durch. Diese berücksichtigt auch die Wartezeiten und soll für eine flüssigere Verkehrswicklung sorgen.


Test entscheidet über definitive Einführung

Wirkungsanalyse Selbst-Steuerung

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Full text (PDF, 12.47Mb)

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Abstract
Im Zuge dieses Forschungsprojektes wurden zwei LSA-Steuerungen in einem Untersuchungsgebiet in der Stadt Luzern untersucht. Dabei wurde die bestehende Steuerung (VS-PLUS) mit der neuartigen Selbst-Steuerung für den FussgängerInnenverkehr (FV), den öffentlichen Verkehr (ÖV) und den motorisierten Ind

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Author
Gensler, Alexander
Neuenschwander, Marco
Kouvelas, Anastasios
Dank Superampel müssen alle weniger lang warten

Das dürfte alle Verkehrsteilnehmer freuen: In Luzern wurde eine neue Ampelsteuerung getestet. Fazit: Alle kommen schneller durch den Verkehr.
What does this mean for the management of a complex world?
Resilient systems design and operation
Systemic resilience can be increased by suitably designed mechanisms and systems, protection mechanisms:

- backup strategies, redundancies, reserves, alternatives (‘plan B’)
- simplification, limitation of system size
- less connectivity, decoupling strategies
- diversity
- real-time measurements and adaptive feedback, enabling self-regulation, e.g. coordination mechanisms
- transparency and awareness
- accountability and responsibility
- suitable incentives
- collective intelligence

Drivers of systemic risks:
- less redundancies
- more networking
- higher complexity
- faster dynamics
- high pace of innovation

Drivers of Systemic Risk and How to Respond
Diversity
Decentralization
Modular Design
Distributed Control
Subsidiarity
Strengthening Strong Links Does Not Help!

https://www.flickr.com/photos/val_s/8603033695
Better Performance of Complex Systems by More Autonomy and Suitable Interaction Rules

If complex dynamical systems vary a lot, are hard to predict and cannot be optimized in real-time, distributed control can outperform top-down control attempts by flexibly adapting to local conditions and needs.

(Windt, Böse, Philipp, 2006)
In a quickly changing world, politics and business becomes increasingly similar to disaster response management!

Do this!

I can do this!
Participatory Disaster Response

Helping Hands

Charge Beacon
Solar Charging Stations for emergency power and communication network

amigocloud
Increasing Resilience through Systemic Innovation

Resilience: Coping with Disruptions and Disasters

Introducing participatory fairness in emergency communication can support self-organization for survival

Indushree Banerjee\textsuperscript{1,*}, Martijn Warnier\textsuperscript{1}, Frances M.T. Brazier\textsuperscript{1}, and Dirk Helbing\textsuperscript{2,*}

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\textsuperscript{2}ETHZ, Computational Social Sciences, Zürich, 8092, Switzerland
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ABSTRACT

Participatory resilience of disaster-struck communities requires reliable communication for self-organized rescue, as conventional communication infrastructure is damaged. Disasters often lead to blackouts preventing citizens from charging their phones, leading to disparity in battery charges and a digital divide in communication opportunities. We propose a value-based emergency communication system based on participatory fairness, ensuring equal communication opportunities for all, regardless of inequality in battery charge. The proposed infrastructure-less emergency communication network automatically and dynamically (i) assigns high-battery phones as hubs, (ii) adapts the topology to changing battery charges, and (iii) self-organizes to remain robust and reliable when links fail or phones leave the network. The novelty of the proposed mobile protocol compared to mesh communication networks is demonstrated by comparative agent-based simulations. An evaluation using the Gini coefficient demonstrates that our network design results in fairer participation of all devices and a longer network lifetime, benefiting the community and its participants.
Battery charge inequality over 72 hours

Fair(0)
Participatory fairness (Gini coefficient)
Unfair(0.6)

Time
24 hours
48 hours
72 hours

SOS
mesh

https://www.nature.com/articles/s41598-021-86635-y
Phone participation over 72 hours

Node participation

Full

10%

Time

Day 1

Day 2

Day 3

Day 4

24 hours

48 hours

72 hours

mesh

SOS

https://www.nature.com/articles/s41598-021-86635-y
FuturlCT: Simulator stellt Weltbild auf den Kopf
Lösung globaler Probleme braucht Verstehen unsichtbarer Interaktionen

Galileo 2.0


Während ohne Letzterem die moderne Physik oder Satelliten im All kaum vorstellbar gewesen wäre, sei das neue Umdenken für die Lösung globaler Herausforderungen wie etwa die Finanzkrise nötig. "Wenn wir die Interaktionen richtig wählen, können wir die Tendenz zur Selbstorganisation nutzen. Das läuft auf mehr Bottom-Up-Ansätze heraus, für die es aber die richtigen Spielregeln braucht. Diese gilt es in Simulationen zu erforschen."

Ampeln steuern sich selbst
«An ungelöste Probleme gingen wir mit dem falschen Verständnis heran»

Komplexitätsforscher Dirk Helbing über Gewaltkonflikte, Epidemien und Datenmissbrauch
The world did not sufficiently allow for fundamental socio-economic innovation, thereby producing the perfect recipe for disaster and polycrisis...
What is needed are empowerment, coordination, and self-organization supported by digital assistance.