Workbook

for preparing the

European Round Table

Structuring Research on Sustainable Digital Environments

Bonn, September 19

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Participants

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Danube University of Krems (Austria)

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Logistics

1.1 Meetings

Monday, September 2017 20:00	Welcome and get together (softdrinks, bear and wine)	Forum of the Hotel Collegium Leoninum in D.53111 Bonn, Noeggerathgasse 34;

Tuesday, September 2017 9:00-16:45	Expert Roundtable	Room No. of the Hotel Collegium Leoninum in D53111-Bonn Noeggerathgasse 34;

1.2 Phone in case of emergency management

Roland W. Scholz (24 hr): +41 79 422 44 01

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Reception of Leoninum Hotel: +49 228 6298 0

1.3 Travel expense report

For the “input providers” (inner circle) we are following the lean administration device. We need a sheet with

- Participant’s name and address:
- Purpose: European Round Table Structuring Research on Sustainable Digital Environments Bonn
- List of receipts, list of expenses, sum of expenses
- Flight tickets

Send these information per (surface) mail to

Susanne Wolke: Donau-Universität Krems
Zentrum für Kognition, Information und Management
Dr.-Karl-Dorrek-Straße 30
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Schedule for the European ERT-SDE (Moderation: Peter Parycek and Roland Scholz)

	Time	**Topic**	
Opening	9:00-9:25	Welcome and presentation of the participants; opening address of Dr. Schneider, BMBF on Digital Transition and Sustainability	Scholz, Parycek Schneider
	9:25-9:50	Goals, critical challenges, procedure, potential outcomes	Scholz
Block 1 Society: Transitions from the industrial age	9:50:11:00	1. Industrial Change	Schuh & Prote
		2. Economic Change	Bartelsman
		3. Environmental systems (from living to material flows)	Höjer & Hilty
Break			
Block 2 Psychology, genetics	11:10-12:00	4. Personality & Social Interaction	Diefenbach & Montag
		5. Genetics	Franke
Lunch Break			
Block 3 Data and AI in different fields	12:50-13:40	7. Cybersecurity- cyberwarefare	Parycek & Pereira
		6. Big Data Management	Hill[1]
Block 4 Ethics, normativity and and sustainability	13:40-14:50	8. Ethics	Dowek & Kirchner[1]
		9. Global social change	Helbing & Klauser*
		10. STS and Sustainability	Grunwald & Renn
Break			
Final discussion	15:00- max. 17:00	Part 1: Overarching structures that ask for reorganizing science Part 2: Follow up	Scholz, Parycek & Schneider

[1] Not personally present at the roundtable.

Focus

The focus of the ERT-SDE is the identification, description, and first appraisal of *unintended side effects* (also called *unseens* rebound effects, see Glossary) of the digital transformation, its impacts on key (sub-) systems of society and environment.

Goals

The goals of the European ERT have been formulated in the invitation of April 5, 2017:

The European Expert Roundtable takes aim at:

(i) Identifying positive or negative unsee(ns) that are linked to digital transitioning;
(ii) Reflecting in what way(s) the unsee(ns) can become best subjects of science in an overarching way; and
(iii) Projecting (from the science perspective) what unsee(ns) might become subjects of transdisciplinary processes (i.e., science–practice discourses that relate different types of knowledge in order to efficaciously master complex relevant societal challenges).

Products

According to the goals, based on the E-ERT, the organizers provide

- A *structured list (or perhaps even a classification/Taxonomy) of major unseens*, which allow to better understand the (i) *specific, digital nature-based origins (causes)*[2] , (ii) the related major *societal impacts of change* (of power, wealth, knowledge, values, etc.) and (iii) the *processes and actors* involved.
    - This list is prepared by the *Propositions* which can become subject of qualitative or multivariate statistical ordering.
- Few (i.e., 7+/- 2) *prototypical examples*[3] which reveal the necessity of developing overarching structures for science research and for a better utilization of existing science knowledge for developing mitigation and adaptation strategies. The prototypical examples may be used as an intermediate step to develop what is called overarching structures. [4]

[2] The ERT SDE is not just dealing with technology transitioning in general. The focus is on the *new quality of digital-information based technology* including seemingly unlimited capacities of storing, operations, retrieval, and transmission in an increasing degrees of autonomy of the control systems (Antsaklis, 2017), AND "hybrid" structures. There is no expert of control theory and AI in the European-ERT, the question of autonomy—including the question of biocomputers (i.e., computers that operate when including GMO-modified living cells)—is not dealt with in detail. This question has been touched by a proposal of the Tokyo-ERT. Nevertheless, the participants are asked to explicate *what is new* (i.e., digital) with respect to a certain *unseen*.

[3] Automotive driving is the most discussed and developed case which includes technological, economic, social-convenience, ethical, legal and other dimensions. The change from face to face and dyadic interaction by phone to seemingly

[4] The turn from environmental or human system to coupled human-environment systems in which basic and applied social and humanities science has to be inextricably coupled with knowledge from engineering and natural sciences may serve as example.

    - We have not focused the prototypical examples in the preparation. This was done to avoid a subject related biasing to certain phenomena. One target is to understand the generics of societal change and evolution heralded by digitalization. Thus, those who suggest a prototypical example are asked to describe essentially (historically new) and
- First *ideas for topics/subjects of transdisciplinary processes*. The idea is, given a special unseen or prototypical example, to identify representatives of key stakeholder groups, who may be interested in a mutual learning process between practice and science for better understanding and for developing socially robust orientations for mitigation and adaptation processes

Some suggestions for preparation discussion[5]

As the term ERT conveys, as group of experts sit around a table, in some virtual equal distance which does not provide privilege or superiority to any member. We suggest substitute members by perspectives, as we think that relating the different perspectives is a most important issue.

All participants are asked to read all propositions in advance. Thus, the propositions will not be presented by a presentation of the input provider(s). The Input providers are asked to convey in few sentences

- Why the propositions have been chosen and what unseens are specifically tricky (from a societal or science perspective)

- Based on this first the other input providers (in particular those who feel closer with respect to the goals and products of the ERT) and all other participants should *comment* the propositions and ask questions. Please to not present the propositions step by step. Try to explain the background and the key messages of the propositions in an integrative manner. After a brief discussion *which focuses the understanding of the propositions*, the next input provider may follow.

The last 10-20 minutes of each block may be devoted to identify

- similarities of causes, impacts and processes/actors
- prioritize proposiitons with respect to the three goals

[5] For keeping the introduction of the workshop short and to dedicate all time on the discussion of the contents, we describe some suggestions for the course of the discussion a this page

Propositions of the Input Providers

Propositions on the Perspective Industrial Change

Günther Schuh[6] and Jan-Philipp Prote[7]

Industrie 4.0 as enabler for cross-domain collaboration in industrial practice (Proposition 1: *Cross-domain Industrie 4.0*)

Industrie 4.0 will enable a new level of cross-domain collaboration within producing companies, facilitated by exchanging and using information from production, development and the user experience in real-time and on an adequate level of granularity.

Comment: Industrie 4.0 allows for aggregating and synchronizing data from a highly application related granularity level (e.g. MES-, ERP-, CAD-data) to enriched smart data for multi-domain-use. Having created such a multi-modal information access, companies will be able to develop smart expert systems that serve as a cross-domain decision support for complex decisions reaching from development over production to usage of products. Examples for those complex decisions are an allocation of products in a global production network, an automated generation of work plans, or an efficient and effective handling of change requests generated by changing customers' requirements. Consequently, cross-domain decisions can be made significantly faster and in higher quality, leading to a competitive advantage by sustainable cross-domain collaboration. In order to ensure the sustainability of the cross-company collaboration and to secure that *added value is allocated according to the input factors* of the different shareholders in the supply chain, special rules for allocation might be necessary. In addition, special attention has to be paid to *security matters* and it has to be defined how and in which form data can/has to be shared to avoid industrial espionage and know-how loss.

[6] Professor, Managing Director, Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

[7] Chief engineer, Head of Production Management Department, Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Change of qualification profile (Proposition 2: *Labour qualification*)

The qualification profile of all hierarchy levels will change requiring more IT skills, a profound and fast understanding of complex decisions and interdisciplinary knowledge. Especially interdisciplinary skilled IT specialists, which are able to use their IT knowledge in the respective system context, are needed. A manager's or specialist's working time will have a higher value-adding share by less actively searching for information but more evaluating information for process and product innovations. On the other hand, less qualified employees will be enabled by IT solutions to perform (more) complex tasks.

Comment: Today, employees need to spend a high value of their working time on "waiting and searching" for information. In future, Industrie 4.0 is expected to dramatically decrease this share by actively analysing and preparing information on large scale and (almost) real time, highly aligned to the employees' need. This change has major consequences on the qualification profile of the respective workers.

Blue-collar workers on the one hand will face an increase in guidance for their work, associated with faster and data-based decision-making on the shop floor. This requires an intuitive understanding of collaborating with information systems. White-collar workers on the other hand will be relieved of analysing data as computers have a huge advantage on this task, but will have to process information as a result of the analysed data in larger quantities and in more dimensions. Thus, interdisciplinary qualification will be a basis for getting a profound understanding for complex decision. Nevertheless, to include all different employees in the future industrial change is one of the bigger challenges of the digitalized age.

Customer-driven, agile product development and production of goods (Proposition 3: *Customer driven production*)

Not only the agile product development will become aligned to the individual customer needs and requirements. Also the production process no longer "prevents innovations", but is fast adaptable to any kind change in the customer needs and thus product specifications.

Comment: Traditionally the customer's needs, opinion and experiences are only partly involved in the development and the production planning process. Therefore, the mostly longstanding process was often hardly adaptable to any kind of change in the customer's needs. To handle those uncertain requirements in today's volatile and changing market environments an agile product development and an agile production are inevitable. The customer should be effectively included in the process and quick early-stage-prototypes should be used to test functionality and customer satisfaction. By distributing the development in short and iterative sub-processes, so-called sprints, the agile product development integrates all changes in customer requirements and thus the customer itself. Those changes also highly influence the production cycle, where a fast implementation of all change requests will be possible due to the cross-domain collaboration in the company based on Industrie 4.0. Thus, the whole company will become more and more customer-driven effecting all domains. However, since the agile approach is

fundamentally different to the existing methods, special attention should be paid to avoid outpacing part of the workforce or the loss of efficiency in the system. In order to secure the latter coordination and synchronisation of development and production processes becomes even more important.

Development of innovative business models (Proposition 4: *Innovation winner and losers*)

Industrie 4.0 offers huge opportunities for conventional companies as well as new players to evolve and create new business models using new digital solutions and services. Existing customer needs can be satisfied more efficient or new customer needs can even be created.

Comment: Industrie 4.0 allows new perspectives on existing business models and the exploitation of entirely new business areas partly substituting traditional business models. New products are possible to build, but also new companies, often in the IT sector, demand existing or not-yet-existing market shares. Shared platforms or clouds for example are created to act databased as an intermediary between the producer and its customer and allow a better holistic understanding of the customer's true needs. In mainly four areas new business models enabled by Industrie 4.0 can be expected. First, products can be enriched or even substituted by smart services, which create a benefit for the customer e.g. predictive services. Second, all gathered data can be refined as smart data to enable e.g. cloud solutions or a web-based data management. Third, the product itself can be adapted and enhanced, to achieve a cyber-physical product. Last, the production engineering can be enriched by digital IT systems e.g. 3D-assembly instructions. All those new business models are a possible threat to traditional models and hence are necessary to consider in order to stay competitive. Economic and industrial domains, regions and players which do not master/are not open to think and try out new (data based) business models, are endangered to not participate in the benefits of these new business models and might be outperformed by (new) competitors.

References

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Propositions on the Perspective: „Economic Change“

Eric Bartelsman[8]

Transformation of Production Technology (Proposition 1 – *Production Transformation*)

Digital technology is enabling a rapid increase of the importance of the factor 'knowledge' in the production function used to supply goods and services, and is thereby changing the role of traditional factors land, labor, and capital. The impact of this transformation on the economy may be comparable to the historical shifts from hunting/gathering to farming (land) or from farming to industry (capital).

***Comment*:** The so-called 'Kaldor facts' have guided our theories about long run economic growth, but current observations don't fit the facts anymore. One main observable that no longer seems to hold is the constancy in shares of income going to capital and labor. Production functions with intangible assets and non-constant substitution elasticities between intangibles and capital or labor inputs can help explain the changes in historically observed relations of long-run growth. Further, the transformation also may help explain the increasing dispersion in productivity and profitability across firms or the increasing inequality in earnings across workers.

Changes in demand for tasks (Proposition 2 – *Task × labor-skills*)

Recent theoretical and empirical research on labor distinguish different tasks that workers undertake. As current digital technologies are adopted and new technologies emerge, researchers try to evaluate which tasks are substituted for by the technology and which tasks are complements to the technology.

***Comment*:** The main idea behind the task-based model is to distinguish tasks along two dimensions, namely routine vs non-routine and manual vs analytical tasks. Current occupations can then be mapped to the types of tasks they require. To find the effects of technology to individual workers' earnings one further needs to know the relationship between worker skills (education), occupation, and tasks. Changes in income distribution can be understood through changes in supply of the ability to undertake tasks and demand for those tasks (changing under influence of technology). In this framework, total employment generally is not affected by shifts in technology, because direct substitution of some tasks is offset by demand induced increases in tasks elsewhere.

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Income Inequality (Proposition 3)

With the changes in technology, the share of income going to labor and tangible capital decreases while the share for intangible capital (knowledge) increases. Further, the income accruing to knowledge is becoming more skewed to the top earners.

***Comment*:** In traditional economic theory, returns to production inputs rise with their marginal contribution. The returns to knowledge input are more difficult to analyse within the theory, because knowledge is non-rival in production. Once knowledge exists, it is no longer scarce and its marginal cost becomes zero: its use in one setting does not preclude its use elsewhere. Demand will shift to the 'best' bit of knowledge, greatly skewing returns. In case of network effects, the earnings winner need not be the 'best' bit of knowledge. This latter possibility harms the incentives to develop the best intangible asset and instead diverts resources to attempt winning the network.

Rethinking Intellectual Property Rights (Proposition 4)

The system for stimulating development of new knowledge and intangible assets through patents, copyrights, subsidies, and prizes needs to be recalibrated for a world with self-teaching robots fed by user and device generated data.

***Comment*:** Much has been written about intellectual property rights and the tradeoffs they generate between incentives for knowledge creation and the monopoly distortions in the use of goods produced with this knowledge. The system does not function well to provide returns to small incremental additions to knowledge leading up to protectable innovation. A new twist to the argument comes when transactional data, e.g., between a physician and patient or from internet-connected devices, gets used to improve the functioning of machines owned and developed by third parties.

References:

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[4] Mokyr, Joel, Chris Vickers, and Nicolas L. Ziebarth. 2015. "The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?" *The Journal of Economic Perspectives* 29(3): 31–50.

Propositions on the Perspective: Environmental Systems

Mattias Höjer[9] and Lorenz Hilty[10]

Macro-Economic (Proposition 1: *Productivity-increase rebounds*)

To the extent that the digital transformation leads to an increase in productivity, society will be forced to either increase demand for the goods produced or decrease demand for human labour, with potential negative impacts on environmental systems.

Comment: Increasing labour productivity logically leads to either increased consumption (a) or decreasing demand for human labour (b). To the extent that society will continue on road (a), the damage to our live-supporting systems by the prevailing patterns of production and consumption will be intensified, unless the digital transformation will at the same time be used to decouple value-creation from resource flows (growth in consumption but not in natural resource use [1]. This can in principle be done by dematerializing products (substituting services for tangible goods and better utilization of capital goods) and by supporting a closed-loop economy, i.e., using intelligent recycling for keeping anthropogenic materials flows in the technosphere and minimizing their exchanges with the environmental systems [2]. To the extent that society takes road (b), the digital transformation could be used to support forms of labour markets and finding new ways of distributing social income.

Contextualising environmental effects (Proposition 2: *ICT-ambiguities*)

Create assessment methods highlighting the importance of context when evaluating ICT.

Comment: Digitalisation is changing society. But society is deciding what effects digitalization has on the total environmental effect [3]. This insight is both encouraging and discouraging and more research is needed in developing assessment methods that highlights this. The insight is discouraging since it means it is really hard to come with clear statements regarding the actual effect of an ICT-service [4, 5]. And it is encouraging because it shows the room for wise decision. ICT in combination with other measures can reduce resource use and environmental impact. ICT alone may well lead to increased resource use and environmental impact. In order to get a better understanding of how this works, and to get a common language, interdisciplinary work is needed.

Digitalisation and regional development (Proposition 3)

Encourage research on digitalisation and sustainable regional development

[9] KTH Royal Institute of Technology, Sweden
[10] University of Zurich and EMPA, Switzerland

Comment: Digitalisation is changing the way we live, our daily activity patterns. This can be studied and presumably either adapted to or in some way planned for – there are both proactive and reactive approaches to the change. An example of the changes we can foresee: the Swedish telecom operator Telia recently moved some 5000 employees to one and the same office, from a number of previous locations [6]. Meanwhile they reduced office space drastically and introduced entirely flexible seating. The new office is well located from a public transport point of view. Preliminary findings show that suddenly hardly anyone takes the car to work and that new activity patterns are emerging. More people work from home, or from a place near home some days a week. With more people staying in the area where they live during daytime, the structure of the region can start changing. Is this something regions should adapt to? Encourage? Try to work against? And what potential environmental effects can come of this? Telia is just one example. Change affecting regions come in many different ways.

Means and measures for buildings (Proposition 4)

Investigate how we can create new principles and measures for use of buildings, and how digital solutions can support a more efficient use of buildings.

Comment: The Swedish road agency works according to a "four-step principle" when analysing new investments. The first looks for opportunities to reduce demand. If not enough, they try to increase intensity of current infrastructure use. If not enough, they look at minor complements to the current infrastructure. And only as fourth step, they build new infrastructure. Recently, we suggested a corresponding principle for building: 1. Reduce demand. 2. Intensify use of indoor space. 3. Rebuild. 4. Construct new buildings [7]. The four-step principle can be strongly supported by new measures (kWh/activity instead of kWh/m2) and digitalization has a key role in creating opportunities for using space more efficiently and thus reduce demand. This has potentially large-scale effects on how cities and regions work and on total energy use in the building stock and for building new buildings.

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[7] Höjer, M. Ringenson, T, Erman, M. Digitalisation for environmental sustainability in a regional context – a four-step principle, 2nd International Conference Smart and Sustainable Planning for Cities and Regions 2017 Bolzano/Bozen (Italy), 22-24 March 2017, pp 150-151

Propositions on the Perspective: Social- and Neuropsychology: Digital communications and ontogenetic development

Sarah Diefenbach[11] & Christian Montag[12,13]

HCI as social interaction and self-reflection (Proposition 1 – *Human-Robot*)

Human-machine interaction must be considered as a form of social interaction and self-reflection.

Comment: With technology getting "smarter", taking the role of a conversation partner or making the impression of a living being (e.g., social robots), a central question is to what extents mechanisms from social psychology, describing interaction between humans, apply to human-computer interaction (HCI) and human-robot interaction (HRI) [1]. This is particularly relevant for trust and acceptance of technology use, but also manipulation or unintended side effects. A replication of the classical group pressure Asch-paradigm (a line assessment task) showed that a robot's judgments had more impact on one's own judgments than that of other humans [2].

Another important research question is to what extent technology-initiated routines also shapes self-reflection, self-presentation and the impression one makes on others. Studies on the "selfie-paradox" [3] showed a systematic discrepancy between judgments on own and others' selfies: while own selfies were judged as more authentic and self-ironic, others' selfies were judged as more self-presentational.

Fragmentation of everyday life (Proposition 2 – *Fragmented Life*)

Technological overuse induces a fragmentation of life and Internet Use Disorder.

***Comment*:** Problems arising from the fast developing digital worlds are already visible in everyday (work) life. Constant distraction and fragmentation of our lifes due to technological overuse can result in loss of productivity [4]. In addition, one needs to take into account that humans do not excel in multitasking, because they rather process information on a serial compared to parallel level. These principles need to be strongly considered in the design of work places in digital worlds. There is first evidence that dependent on personality structures overuse may cause Internet addiction which asks for therapeutic interventions [5].

Brain research on DMI (delayed memory impacts; Proposition 3 – *Psychoneuroinformatics*)

There is a need for interdisciplinary psychoneuroinformatical research on epigenetic, molecular genetic and endocrinological processes related to interactions with digital worlds.

[11] Affiliation: Market and Consumer Psychology, Department of Psychology, LMU Munich, Germany
[12] Affiliation: Department of Molecular Psychology, Institute of Psychology and Education, Ulm University, Germany
[13] Affiliation: Key Laboratory for NeuroInformation/Center for Information in Medicine, School of Life Science and Technology, University of Electronic Science and Technology of China, Chengdu, China

***Comment*:** Research in the area of the already introduced topics such as trust, etc. can be enhanced by the inclusion of neuroscientific methods, including epigenetic, molecular genetic and endocrinological approaches. To name a few biological candidates, the stress hormone cortisol can be well investigated in the context of technostress and the neuropeptide oxytocin in the context of trusting artificial intelligence. Finally, brain imaging procedures need to be mentioned, because first studies show i) that digital worlds might shape our brain functionality (e.g. smartphone usage shape motoric areas of the brain) [6] and ii) recent evidence demonstrates that individual differences in brain volumes of the nucleus accumbens can predict the use of the Facebook application on smartphones. This field requires a combination of data from psychology, the neurosciences and computer science (real-life behavior tracked at the intersection of the Internet of Things (IoT)) perhaps resulting in a new research discipline called *Psychoneuroinformatics* [7].

Digital worlds around emotional needs (Proposition 4 – *Emotional needs*)

Fulfilling basic emotional needs will always remain the central basis for creating positive experiences with technology.

Comment: We would like to address that from the perspective of today humans will not much change with respect to their brain architecture in the next hundreds of years (although with the development of the gene scissor CRISPR/CAS 9 we cannot be ultimately sure). Considering the lengthy process of evolutionary development, humans very likely will possess the same needs in hundreds of years as today. These psychological needs arise from primal emotional systems, which have been carved out in much detail by Jaak Panksepp [8] using both deep brain stimulation and pharmacological challenges of the mammalian brain. His work resulted in the primal emotions of *SEEKING, LUST, CARE, PLAY* and *FEAR, RAGE, SADNESS*[14]. Here, recent work demonstrated that emotional urges arising from these in-built tools for survival relate to different facets of online usage/addictive tendencies. These primal (emotional) needs represent a building block around which digital-technological worlds need to be designed in order to provide humans with a health-promoting environment in line with our evolutionary heritage.

Digital Depression and digital etiquette (Proposition 5 – *Digital Depression*)

The continuous presence of technology threats happiness, well-being, and social norms.

Comment: Technology pervades all aspects of our lives, and exerts continuous impact on thinking, feeling and social interaction. In contrast to impairments of cognitive abilities ("digital dementia"), the term "Digital Depression" [9] underlines threats to subjective well-being and happiness, and the unintended side effects of social media, fitness trackers, and continuous smartphone use. For example, smartphone mediated behavior often break up established social norms, e.g., full attention for the conversation partner versus parallel smartphone use [10]; fixed appointments versus last minute

[14] These a written in bold letters to characterize them as primal emotions (and to not confound them with same sounding terms in the psychological literature).

cancelling/delay of a date via WhatsApp. It therefore needs a conscious reflection on a digital etiquette, i.e., the integration of technology in established culture, the adequate use of technology in social settings or intentionally technology-free areas. This aspect not only refers to peoples' private lives and wellbeing, but also is highly relevant for the working domain, where digital etiquette becomes part of the business culture design.

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Propositions on the Perspective of Genetics

Lude Franke[15]

DNA surveillance (Proposition 1)

With a DNA profile that is costing only €30 (2017 price) it will become possible to predict who is at high risk for developing disease and what kind of lifestyle changes might help to prevent to get these diseases.

Prices of genetic assays have fallen in the last decade tremendously. The cost is now only €30 to generate a DNA profile, and with ever increasing knowledge how to predict disease based on this DNA information, it is now becoming possible to infer who is going to get a certain disease and who is not.

However, this is also presenting important ethical, legal and societal implications: To what extent do individuals want to know that they are at increased risk for developing Alzheimer's disease or cancer? And it is likely that drug development will keep up a similar pace, such that if you know that you have this high risk of cancer, and thus should seek have regular medical check-ups to detect cancer at a very early stage, also feel confident that should such a disease emerge, you have a very high chance of getting cured?

Certain countries (e.g. the Netherlands) currently have laws in force that allow insurance companies to ask clients whether DNA testing has been conducted and if so, what the outcomes have been in order to set an insurance fee. Will this lead to individuals who will have to pay excessive insurance fees because of their genetic make-up? And will law enforcement agencies be allowed to request such DNA information in order to solve criminal acts?

DNA-based pharmaceutics production **(Proposition 2)**

Developments in genetics will enable generation of a tremendous amount of insight in the pathology of disease, which will help pharmaceutical companies to decrease drug-development costs.

The cost of drug development is increasing rapidly. ***While the cost of the development of a new drug was $1 billion 10 years ago, it is now over $2 billion.*** One major reason why costs have increased is that drug companies often do not know which particular biological process, gene or protein to target, because it is unclear what the 'key driver' of disease is. Consequently, pharmaceutical companies typically rely upon costly screening facilities that systematically test hundreds of thousands of different

[15] Affilation: University of Groningen, Faculty of Medical Sciences, Head of Research and Education section, Groningen, The Netherlands

chemical compounds for potential therapeutic effects. Strategies that could help these companies to better choose what specific compounds to test, would potentially save costs and time to bring drugs to market.

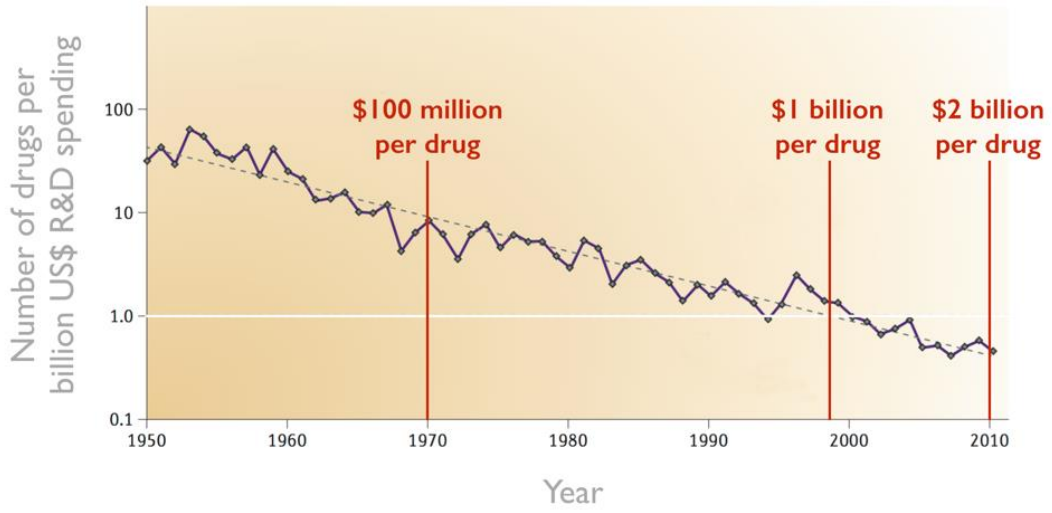

Figure 1: Problem of current drug discovery (adapted from Scannell *et al*, Nature Reviews Drug Discovery 2012)

Paradoxically, the study of healthy individuals can help to improve drug discovery substantially, by using genetic information in conjunction with effects on genes, metabolites and proteins: Since 2006 over 10,000 genetic risk factors have been identified. Some of these increase type 1 diabetes risk, others increase the risk for cancer, while others increase cholesterol levels. Having one or two genetic risk factors, for instance for type 1 diabetes, will not be sufficient to cause this disease. You need to carry many of these risk factors in order to get sick. This means there are many healthy individuals that have a few risk factors for type 1 diabetes. As such, when investigating healthy individuals for these 10,000 genetic risk factors it becomes clear that for each of these risk factors, healthy individuals can differ in their 'genotypes' (some having the risk-increasing alleles, some having the risk-decreasing alleles). This means that individuals differ slightly in their risk for developing certain diseases.

It is this subtle difference that we can exploit: by knowing who is at slightly increased and who is at slightly decreased risk for a certain disease and by also having measured the activity of genes, metabolites and proteins it is possible to ascertain whether this genetic risk is having an effect on them. By doing this systematically it will become possible to identify the specific biological processes that are disrupted in disease, which will provide pharmaceutical companies with important information where to concentrate their efforts on. Given the fact that data generation costs have fallen sharply, computational capacity has grown explosively and new machine learning techniques are now becoming available we expect that data drive drug discovery will enable the pharmaceutical industry to increase its efficiency to develop new drugs while improving the efficacy of these drugs.

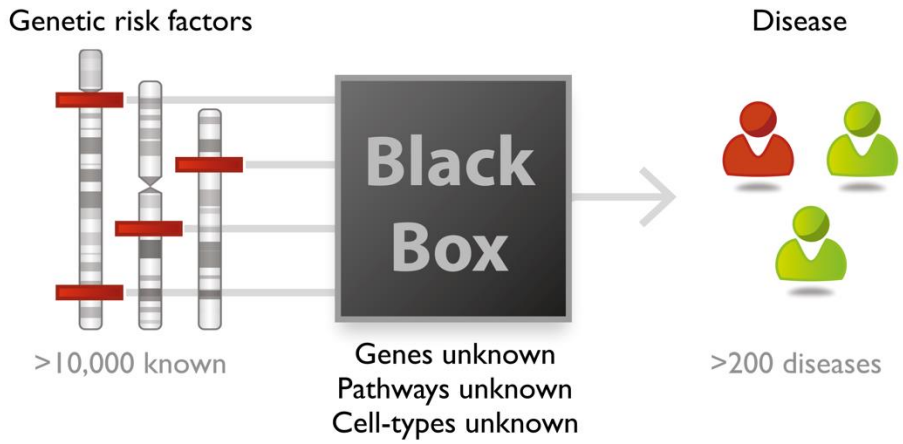

Figure 2: The mechanisms leading from genetic risk factors to diagnosable disease currently constitute the 'black box' of missing knowledge.

DNA-based disease curing (Proposition 3)

It will become technically possible to cure rare, genetic diseases by changing DNA.

The CRISPR-CAS9 technique now makes it possible to very specifically change DNA. In theory this also will make it possible to cure rare, genetic diseases, by changing the DNA of embryo's. While this might be a very sensible strategy to consider for couples who both are carriers of a very severe mutations (and thus having very high chances of getting a child that will get critically ill), setting this in motion will show a very slipperly slope: what diseases to consider, and also where to stop? These are important things to think about right now, given the tremendous pace at which these technological developments have progressed in the last few years.

Propositions on the Perspective Big Data Analytics

Peter Parycek[16,17] and Gabriela Viala Pereira[18]

Transformation of governance models (Proposition 1: *Governance transformation*)

Digital transformation is changing the process of policymaking and altering governance models in a disruptive way. The pervasiveness of the data concept in these workflows when combined with artificial intelligence and automated decision-making process, as well as the growing number of well-organized digital heterogeneous communities, has significant implications for the transformation of governance structures.

Comment: There are implications for data analytics and automated decision-making in governance, such as the value conflicts over the ends and means of data, which require ethical algorithms and informed decision-making by stakeholders. An interesting aspect pertains to the impact of digital transformation in government. The pervasiveness of big data analytics is transforming governance into a rational process in a self-organized digital environment. The actors and the players are not fixed, but are continuously evolving and moving from the different disciplines. Consequently, governance models will be organized in a dynamic way. The roles, actors and data owners are not clearly defined. Yet, the process for defining clear problem-oriented solutions that target the needs of citizens and guarantee of cohesive societies is clearly described.

Governance knowledge gap (Proposition 2: *Governance gap*)

Different scenarios of global governance show that dealing with uncertainty, the uncontrolled creation of systematic risks, a lack of public accountability, and lack of knowledge about how to operate in global systems endanger the effective delivery of comprehensive solutions for societal problems. Issues surrounding personal data protection and privacy are also impacted, stemming from the misinterpretation of demands and a lack of context-specific solutions.

Comment: Information sharing and cooperation, together with participatory practices in policymaking, are key elements in discussions surrounding the use of ICT to enable collaborative governance [1]. There is a need to reconstruct governance and democracy into hybrid forms of organized cooperation that go beyond national government [2]. Effective collaborative governance requires the generation of value by applying collective intelligence for innovative solutions to societal problems. Building the necessary competences, and bridging the information and knowledge gap among stakeholders, involves the development of strong accountability and transparency in an environment of trust.

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Resilience strategy for new governance models (Proposition 3: *Resilient governance*)

The application of emerging technologies to governance implies new ethical issues, together with environmental, privacy and equality aspects. To effectively tackle these concerns, legal solutions need to be sought for anticipated problems.

Comment: The digital transformation of public services should be developed in a responsible manner, one that comprehensively addresses the social and ethical dimensions of change. To achieve this, Stahl [3] recommends that a regulatory framework and adequate infrastructure for the development of social/societal responsibility be provided. In the context of smart governance, we raise two main issues suggested by the author in support of this requirement: [1] the need to address the wide range of current and new ethical issues arising from ICT, modelled along the lines of environmental, privacy or equality impact assessments; and [2] the need to proactively consider legal solutions to resolve those problems that might arise from the application of future and emerging technologies to public administration [3]. Further, and following Markus and Mentze [4], in order to minimize the negative consequences of new governance models and to create a resilience strategy, *future-oriented* methods of sociotechnical analysis are required. These may be built into the techniques used by policy makers to develop policies and public services. This approach may also be deployed to design related governance arrangements; including "non-functional" requirements such as security, privacy, safety, quality of life, and contained systemic risk.

Intelligent digital ecosystems combining data and people (Proposition 4: *Data x people ecosystems*)

The combination of data resources and human resources is the foundation for smarter decisions and evaluation at all stages of the policy cycle. There is a need to change the relationship between humans and algorithms that leads to a socio-material practice of automated decision-making. This requires a high level of trustworthiness of data sources to avoid unreasoned decisions.

Comments: The use of data-driven decisions in policymaking implies modifications in the relationships between humans and algorithms within the framework of knowledge-based activities. These changes can lead to automated decision-making. They may also have consequences for those outcomes of the policymaking process that are data-driven. Examples include the questioning of the extent that sources are reliable, privacy issues and the digital divide. The possibility that the use of ICT will have negative consequences can never be completely predicted or eliminated. Potential risks, however, can often be mitigated through careful sociotechnical analysis in advance of system building [4]. In order to avoid unwanted/unreasoned decisions based on imbalanced, biased or erroneous algorithm-people interactions, Artificial Intelligence literacy has to be developed amongst human decision makers. This would facilitate the prevention and identification of possible mistakes, and aid in the development of techniques for guaranteeing the trustworthiness of data providers.

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Draft propositions for the perspective cybersecurity and warfare

Richard Hill[19]

Definition of War (Proposition 1)

The nature of war is changing and acts that are not at present considered to be "war" may become the primary means by which war is waged in the future.

Comment: There are differing definitions of the term "cyber warfare"[20]. Strictly speaking, it refers to massive state-organized assaults, akin to conventional warfare, but it is also used more generally. Indeed, the term "war" is often used figuratively, as in economic war[21], the war on drugs, and the war on terrorism. A recent academic work uses "cyber war" figuratively to refer to utilization of digital networks for geopolitical purposes, including covert attacks against another state's electronic systems, but also the variety of ways the Internet is used to further a state's economic and military agendas[22].

As Clausewitz said, war is the continuation of politics by other means. The "other means" are the use of force. Such force has traditionally been used to kill, imprison, or enslave a more-or-less large number of people, and/or to destroy buildings, factories and infrastructure – sometimes only military but at times also civilian.

But alternative types of force are emerging: cyber-attacks can degrade infrastructure, and even military capabilities, to the point that an adversary is forced to yield.

Cyber-war Prevalence (Proposition 2 – *Cyber War*)

Cyber-war may replace mass killings and bombing as the preferred way of forcing an adversary to submit.

***Comment*:** It is increasingly apparent that the security of IoT devices is inadequate[23] and that that could have catastrophic consequences[24]. Further, unlike physical weapons, cyber-weapons can be replicated at essentially no cost.

The WannaCry[25] incident can be considered a harbinger of things to come: a state-sponsored cyber-attack on the infrastructure of another country (e.g.,Fro the electrical power grid, the airline control

[19] http://www.apig.ch and http://www.hill-a.ch

[20] This section is largely taken from Hill, Richard (2015), "Dealing with Cyber Security Threats: International Cooperation, ITU and WCIT", in Maybaum, M., Osula, A.M, and Lindström L. (Eds.), *Proceedings of the7th International Conference on Cyber Conflict: Architectures in Cyberspace*, 2015, NATO CCD COE Publications

[21] Freeman, Kevin D. (2015), "Financial Warfare Threatens America", Global Economic Warfare, 6 March 2015 <http://globaleconomicwarfare.com/2015/03/financial-warfare-threatens-america-2/>

[22] Powers, Shawn, and Jablonsky, Michael (2015), *The Real Cyber War: The Political Economy of Internet Freedom*, University of Illinois Press

[23] See for example p. 107 of the Global Internet Report 2016 of the Internt Society, available at: https://www.internetsociety.org/globalinternetreport/2016/

[24] See for example: http://www.itu.int/en/ITU-T/Workshops-and-Seminars/01072016/Documents/S1P3_Corinna_Schmitt_v3.pdf ; see also the "weaponization of everything", p. 2 of the report of the Global Commission on Internet Governance, available at: http://ourinternet.org/sites/default/files/inline-files/GCIG_Final%20Report%20-%20USB.pdf

system, government computer systems, etc.). Such an attack could paralyse a state in the same way that intensive aerial bombardment can paralyse it.

With the increasing importance of ICTs, and the increasing dependency of everything on ICTs, we may reach a stage where force can be used effectively to destroy ICTs systems, thus achieving the desired goal of forcing an adversary to surrender without having to kill people directly or to bomb facilities.

This is very different from the current use of ICTs in warfare.

Geneva Digital Convention (Proposition 3 – *Digital-war Convention*)

There is a need for a treaty under which states agree, inter alia, not to attack civilian digital infrastructure in times of peace, not to acquire or stockpile malware, and immediately to inform concerned manufacturers when they become aware of vulnerabilities in software or hardware.

Comment: In March 2017, Wikileaks published information on use by the US Central Intelligence Agency (CIA) of various hacking tools and malware[26]. Apparently the CIA has lost control of its arsenal of hacking tools, which are now available to entities other than the CIA, including presumably cyber-criminals. Attacks using these tools cannot be traced back to the source of the attack.

In mid-May 2017, the WannaCry[27] attack prompted Microsoft to renew the call it had made a few months earlier for a "Geneva Digital Convention" [28].

Microsoft has made three specific proposals:

- Clauses for a binding treaty[29]
- An agreement between high-tech companies[30]
- The creation of an organization that would seek to attribute cyber-attacks, that is, to determine who initiated the cyber-attack[31]

I would go further than what Microsoft has proposed regarding treaty clauses.

Mass Surveillance (Proposition 4)

Surveillance of citizens other than on the individual order of a judge violates human rights, is not effective, and is a form of cyber-attack.

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[25] https://www.theguardian.com/technology/2017/may/12/nhs-ransomware-cyber-attack-what-is-wanacrypt0r-20

[26] https://wikileaks.org/ciav7p1/

[27] https://www.theguardian.com/technology/2017/may/12/nhs-ransomware-cyber-attack-what-is-wanacrypt0r-20

[28] https://blogs.microsoft.com/on-the-issues/2017/05/14/need-urgent-collective-action-keep-people-safe-online-lessons-last-weeks-cyberattack/#sm.00017arazqit2faipqq2lyngzmxx4 ; see also: https://www.wired.com/2017/05/microsoft-right-need-digital-geneva-convention/

[29] https://mscorpmedia.azureedge.net/mscorpmedia/2017/05/Digital-Geneva-Convention.pdf

[30] https://mscorpmedia.azureedge.net/mscorpmedia/2017/05/Tech-Accord.pdf

[31] https://mscorpmedia.azureedge.net/mscorpmedia/2017/05/Attribution-Organization.pdf

Comment: It is well-know that many states, including states that consider themselves to be democratic, have implemented mass surveillance. By "mass surveillance" I mean any form of surveillance and/or eavesdropping that is not necessary and proportionate and authorized by the national courts of the target of the surveillance.

The stated goal of such surveillance is to combat what the states in question consider to be terrorism.

But such surveillance is not and cannot be effective in countering individual acts of violence: could it prevent bank robberies?

In my view, mass surveillance violates the human right to privacy and it is form of cyber-attack.

Lethal Autonomous Weapons Systems (Proposition 5: *Lethal warbots*)

Lethal Autonomous Weapons Systems have limited potential, because either they are constrained in scope, or they can be deactivated on command.

Comment: A Lethal Autonomous Weapon System (LAWS) can be defined as a system designed to select and attack military targets (people, installations) without intervention by a human operator.

For example "ground-force" LAWS could attempt to destroy a specific type of target in a specified volume unless it is specifically instructed to cease.

We underline the key point: to what extent is the system autonomous[32]? If it is fully autonomous, then it is far too dangerous to be deployed, because there is no guarantee that it will not attack friendly forces (either because it fails to distinguish them from adversary forces, or because it malfunctions).

But if the LAWS can be instructed to cease operation, what guarantee is there that the adversary will not be able to send such instructions? Or, worse, change the programming of the LAWS so that it attacks the party that originally deployed the LAWS?

In addition to the above practical issues, and governance issues, there are of course ethical issues associated with LAWS.[33]

[32] P. J. Antsaklis (2017), "Control Systems and the Quest for Autonomy", *IEEE Transactions on Automatic Control*", Vol. 62, No. 3, March 2017, p. 1013

[33] G. E. Marchant et al. (2011) "International Governance of Autonomous Military Robots", *Columbia Science and Technology Law Review*, Vol. 12, p. 272

Propositions on Ethics and the Digital

Claude Kirchner & Gilles Dowek[34]

Ethics, Digital, and Law (Proposition 1)

In the developing digital world, create instruments to stimulate and organise the useful and necessary complementarities and synergies between ethics and law.

***Comments*:** The complementarities between ethics and law are both fundamental and non-trivial to organise. One should create, for instance at the European level or at the nations levels ethical committees in charge of the general thinking about ethics in the digital world including ethics of usages, ethics of conception, general ethics impacted by the digital. These committees should interact with the legislator to allow for the ethical thinkings to sow laws in the appropriate way. A typical example concerns personal data. Conversely, the legislator should be able to seize ethical committees.

Ethics, Digital, and Science (Proposition 2)

Organise the appropriation and development by scientists of the ethical reflexion about the general development of sciences as well as the operational ethical questions posed by scientific experimentations and developments.

Comments: The digital revolution, issued from sciences and technologies, deeply impacts the scientific method itself with strong consequences in all fields of science. Typically in France, a national committee (*http://cerna-ethics-allistene.org*) has been set-up to conducts a conceptual and methodological reflection on the ethics of scientific research in Digital Science and Technology. IRB or operational ethics committees have been created in universities (e.g., *http://www.univ-toulouse.fr/recherche-doctorat/recherche/comite-d-ethique*) or research institutes (e.g., *https://www.inria.fr/en/institute/organisation/committees/coerle)*.

Note moreover Unesco's initiative to revise its main texts and recommendations concerning scientific research, scientists and ethics: the 1974 ``Recommendation concerning the status of scientific researchers'' (http://portal.unesco.org/en/ev.php-

[34] Both scienctists are working at INRIA (78153 Le Chesnay Cedex, France) as Directeur de recherche (Kirchner) and duputy scientific director (Gilles). Both are initiators and members of the Operational Legal and Ethical Risk Assessment Committee (COERLE).

URL_ID=13131&URL_DO=DO_TOPIC&URL_SECTION=201.html) and the 1999 ``Declaration on science and the use of scientific knowledge'' (http://www.unesco.org/science/wcs/eng/declaration_e.htm).

Ethics, Digital, and Innovation (Proposition 3)

Consider ethics as a competitive argument for industry 4.0.

Comments: Algorithms, formal mechanisation, machine learning, automation and robotisation transform industry and economy. In the context, ethics shall become a differentiating argument that empowers consumers and users. Typically how shall we allow a user to choose a search engine that takes ethical and independently certified engagements about the treatment of personal data? How shall we enlighten the choice of a product build in a fully automated factory, with its consequences on efficiency, human labor and the human role in the society?

Ethics, Digital, and Cybersecurity (Proposition 5)

Ethical hacking and high security informatics labs should be developed and organised in frameworks allowing cybersecurity certification as well as ethical assessments.

Comments: Cybersecurity is a universal, perpetual and crucial concern of the digital society. Like in biology where high security labs (labeled P1-P4) have been created and monitored, high-cybersecurity labs should be developed in the academic world and not only in the military, police or governmental information labs. These academic labs should be developed under a strict academic control to allow for ethical hacking and the ethical development of concepts and tools to understand and master malwares and cybersecurity threats.

Impact of the digital world on ethics: towards formal ethics (Propositon 6: *Formal Ethics*)

Develop the study of ethics itself in the deeply renewed context of the digital world, by providing concepts, models and tools to formalize and study ethics and its foundational corpuses.

Comments: Humanities are profoundly impacted by the digital revolution. Ethics do not escape this and we now need to understand how could we use the digital concepts and tools to model the idea of ethical values or the notion of dilemmas or of conflict. In addition for humans to better understand ethics and its developments, this will in particular allow us to better understand how we can learn machines to get ethical behaviours and possibly to develop ethical reasonings.

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Propositions on the Perspective: „Global Social Change“

Dirk Helbing[35]

Digital Upgrade of Democracy (Proposition 1 – *Democracy Upgrade*)

Digital technology allows to design a new form of democracy with transparent, uncensored, fair and moderated discourses, in which AI is used to support the constructive exchange of ideas and the identification of different perspectives that need to be integrated. Responsible behavior and high-quality contributions would be promoted.

Comment: More and more people claim that digital democracy is the evil that makes our world ungovernable (1). Modern mass media and social media tend to create 'filter bubbles', which are reinforcing opinions, while reducing the ability to handle different points of view. Digital information becomes increasingly personalized, manipulative, and deceptive.

But instead of trying to revive governance principles of the past, which have failed to embrace the complexity and diversity of modern societies, we should engage in digitally upgrading democracy through the use of Massive Open Online Deliberation Platforms (MOODs) (2). Letting people decide about "yes" or "no" is not enough. Citizens should be able to continuously engage in online deliberation processes, where they can feed in their ideas and voice their preferences on different aspects of a topic. A refined, more inclusive process would enable people to learn about and to unfold the different aspects of a complex political topic.

Finance 4.0+ (Proposition 2)

In order to solve the challenges of the 21st century, the financial system has to be altered into a multi-currency system representing different positive and negative externalities and incentivizing behavior that is aligned with our societal goals and values.

Comment: Computer simulations about the world's future predict severe resource shortages –and linked to this – an economic collapse. This is known at least since "The Limits to Growth" study commissioned by the Club of Rome, and the "Global 2000" study issued by the US government. The UN Sustainability Agenda 2030 is giving the world less than 15 years of time to solve this problem.

It is necessary to create a multi-dimensional incentive and reward system beyond money. We call this system finance 4.0+. This can now be built by combining the Internet of Things, blockchain technology and complexity science. To boost a circular economy, we need a system that can measure, value and trade positive and negative externalities – external effects of interactions between people, companies

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and the environment. Desired values can be agreed on in a participatory, subsidiary way, as suggested in proposition 2.

Democratic Capitalism (Proposition 3)

The digital technology has the potential to reinvent the money system such that it empowers people to be innovative and to engage in social and environmental projects. Moving beyond venture capitalism towards crowd funding for all would enable participatory budgeting and democratic capitalism.

Comment: One cannot put the interests of a few hundred people over the well-being of society as a whole. As long as the mechanisms of the monetary and financial system don't benefit everyone, the world will not be stable and sustainable on the long run. Fortunately, there are alternatives. The failed approach of pumping trillions into the economy from the top by means of "quantitative easing" could be replaced by a new approach, where the money is created from the bottom. The idea is (3) that everyone would regularly get an "investment premium", which would have to be distributed to people, companies or institutions with good ideas, or those who are engaged in social or environmental projects. Then money and resources would flow into the activities we find most important. This would boost innovation in a pluralistic manner. Such an approach would combine our two most successful organizing principles – democracy and capitalism – in a new way, and replace today's market-driven democracy, where capitalism threatens to destroy democracy.

City Olympics (Proposition 4)

Competitions for the best kinds of technologies, solutions for resource shortages, and a quick implementation of new solutions can be achieved through Global City Olympics.

Comment: Cities and social communities can be important agents of global change. A combination of competition and collaboration among cities can advance us in our efforts to solve the challenges of the 21st century. Thus, I follow Elinor Ostrom and suggest a "polycentric" approach to solving global problems (4). The idea of "City Olympics" (5) may become a powerful tool. City Olympics would have a sportive spirit. Cities all over the world would engage in friendly competitions to achieve the best scientific and technological progress, as well as mobilize collective action to counter climate change. They would reach the highest possible degree of citizen engagement. After the competitive phase of each Climate Olympics, there would be a cooperative phase, where the best ideas, technologies and urban governance concepts would be exchanged among the participating cities.

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Propositions on the Perspective: Sustainable Development

Armin Grunwald[36,37] and Ortwin Renn[38]

Digital efficiency rebounds (Proposition 1: *Efficiency rebounds*)

The increase of efficiency by digital technology is linked to rebound effects regarding material use and natural resources use. These rebounds should become subject of research and political efforts

Comment: There is no automatism towards realizing more sustainability by expanding digitization. While in the previous wave of digitization (late 1990s, expectations of an emerging "New Economy") big hopes addressed a de-materialization or immaterialization of economic processes with much lower consumption of natural resources, reality has shown that these promises were only partially met. Academic studies demonstrated that the potential for energy conservation and material reduction were less pronounced due to high energy consumption of digital facilities themselves, automation of conventional industrial processes without major technical innovations in manufacturing itself and short live spans of many electronic devices. Most important, however, has been the rebound effect by which more efficiency also increased consumption and waste production. Bringing together digitization and requirements of sustainability will need dedicated research and political effort. Most notably, digital strategies need to be designed in a way that sustainable practices and principles are not treated as byproducts but as parallel objectives

Digital Threats Related to Democracy (Proposition 2: *Digital democracy*)

Digital services have the potential to enhance procedures of direct democracy but they also threaten basic human rights such as privacy, personal freedom and sovereignty.

Comment: While IT technologies have often been seen as a strong supporter of further democratization for decades now (cp. e.g., the high expectations towards the Internet in its early stage) it becomes more and more obvious that digitization will lead (or: already led) to severe challenges to democracy (loss of privacy, omnipresent surveillance, Big Data, socio-bots etc.). It is in particular discomforting that political blogs are fed by intelligent software programs that scan all entries and provide opinionated responses giving the impression that the opinions raised in these blogs are shared by millions of people. Some observers credit this automatic response machine for the surprising success of the Trump presidency. Because sustainable development involves (following the Rio documents) democratic ideals such as participation, open discourse and access these new developments of manipulating the open public discourse and nudging strategies must be carefully observed and analyzed. This is first of all an issue for

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regulation and political participation in an internet era, but is also a more fundamental issue of authorship and identity that need to be addressed. Beyond monitoring and regulation, there is the need to explore the possibilities and opportunities for e-democracy but also to understand the barriers and constraints.

Loss of and redefining Labor (Proposition 3: *Redefining labor*)

Digital Services have the potential to serve the sustainable development goas (SDGs) particularly in many low-income countries. However, it is crucial that local actors are in control of this modernization effort.

Comment: Further digitization has high potentials not only to help the industrialized countries to keep or extend their welfare but also to support development in developing countries. However, those potentials will not be effective by themselves but rather need dedicated scientific and political effort. Strategies are needed that assist people in particular remote areas with rural infrastructure to make use of digital services for business, education and social communication.

Transdisciplinary, transformative and transition management (Proposition 5: *Transdisciplinarity*)

Digital services are a key example for the need of interdisciplinary and transdisciplinary research programs. It is important to include the technical, economic, social and psychological impacts in technology assessment and to strive for an integrated knowledge application and governance including major stakeholders and the affected public.

Comment: All these research activities may not start from scratch. The many approaches and experiences in transdisciplinary research, transformative science, transition management, technology assessment, sustainability science etc. provide theoretical and empirical foundation on which further dedicated studies can build. The methodological instruments as well as the transdisciplinary approaches are readily available to shape the future landscape of researching the relations between digitization and sustainability. What is needed now is the political will and the respective funds to do so.

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Glossary

The input providers and participants come from a wide range of disciplines. Only some of them have worked in the emerging field of sustainability science or science technology and science (STS). Thus a couple of concepts unknown. Further, some concepts such as "tarnsdisciplinarity" are defined in various ways.

For clarifying how we (Scholz, Parycek and Steiner) use the terms and how they are defined, we briefly compose some definition and comments on key concepts

Digital revolution, transition, and transformation

Digitalization (synonymously used with digitization) describes the representation of a digital or analog (real world) object or process in digital representation. A digit is an element of a place number system (or place value system or positional numerical system; i.e. in which the place of a digit maters). A digit has a value with respect to a base (e.g., 2 (in case of binary numbers) or ten in case of decimal system. Thus digital structures are discrete and they allow for computation. Digitalization means more than transferring to discrete structure. The opposite of digital means analog which considers continuous (real number-based) continuous changes of aspects of the environment.

Digital technologies are machines that master digital representation and computing. They also include the interfaces between the digital and analog worlds (e.g., sensors, D/A converters, actuators and robots, 3D printers, etc.). The transitor and many other technological inventions contributed to the development of digital computers. We may state that both, knowledge about digitalization and about digital technologies induced the technological transition.

We can consider the year 2002 as the start of the ***digital age*** if we refer to the criterion that the majority of human produced information has been stored digitally (Hilbert and Lopez, 2011). The digital transition started already after World War 2 with the invention and spread of semiconductor transitors (Brinkman, Haggan, & Troutman, 1997). The **digital revolution** can be considered as a socio-economic, cultural revolution (in the sense of Schumpeter's Business Cycles, (Schumpeter, 1939)). The series of Expert Roundtables on Structuring Research for SDE targets unintended side effects. Thus, we are on the one hand on the the level of real world phenomena such as automatization by AI-driven machines or digital devices which produce virtual environments. On the other hand, digitalization strongly changes structures, functions, etc. of the inner science systems. The French sociologist of science and technology, Bruno Latour (Latour, 1996) inferred based on thorough investigations of laboratory work that the ubiquitous presence of digital computers „in the material practices of the laboratory reflects a larger shift in the epistemological foundations of science from experiment to simulation" (Ensmenger, 2012). As the aspiration is "structuring research for SDE" this means that also the unintended side effects on the science system itself ask for a critical view.

To describe socio-technical changes, we find (at least) three phrases: digital revolution, digital transformation, and digital transition (Another phrase often used is “information revolution”.) The first is often used in comparison to other socio-economic revolutions such as the agricultural or industrial revolutions. We also speak about digital or information age. The second is frequently invoked in the management literature. The third one, digital transition, is used less often. But in the different context of sustainability science, there is a broad literature on “transition” including transition management, energy transition, etc. In this paper, we use the phrase digital transition to convey that there are many lessons from such literature to discuss this issue at hand.

Sustainability/Sustainable Development

Based on an inquiry of an expert panel (Laws et al., 2004), sustainable development is defined (Scholz, 2017) as a proactive, ongoing inquiry (i.e., multi-stakeholder and interdisciplinary process; see Figure 1) on system-limit management (i.e., on preventing hard landings and collapses of valuable systems) in the framework of inter-and intragenerational justice (see Figure 3).

Sustainable development is a proactive, ongoing inquiry (i.e., multi-stakeholder and interdisciplinary process; see Figure 1) on system-limit management (i.e., on preventing hard landings and collapses of valuable systems) in the framework of inter-and intragenerational justice.

The differentiation of the more science based resilience assessment, the policy and political processes based ongoing inquiry and of the normative (value and religion-based normative pillars is important for ERT.

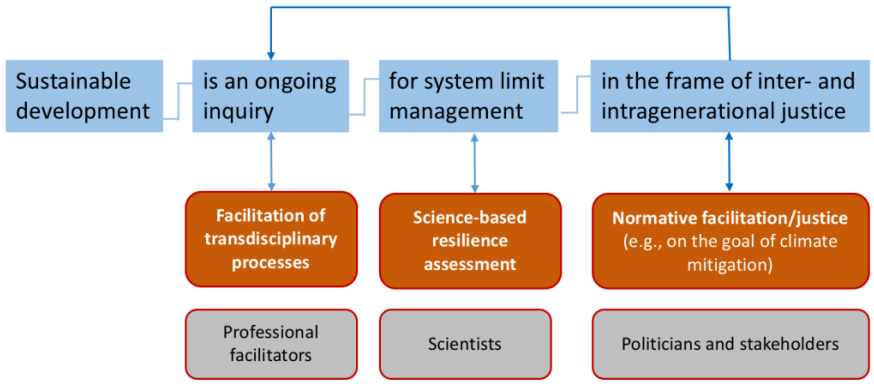

Figure: Definition of sustainable development

Transdisciplinarity

There are different notions of transdisciplinarity. The following goes back to the Zurich 2000 conference (Klein et al., 2001; Scholz, Mieg, & Oswald, 2000). It has been recently elaborated (Scholz & Steiner, 2015) and has been related to s
Td (Td processes)

- Has become a third mode (methodology) of doing and utilizing science but is increasingly becoming a method of the emerging sustainability science (Scholz & Marks 2001)

- Means going beyond sciences (not only beyond disciplines; Klein et al. 2001) and switching from doing science for to science with society
- Start from an ill-defined, complex, socially relevant problems
- Include(s) (see Figure 3)
    i. a targeted interdisciplinary process
    ii. a moderated processes of stakeholder discourse or mitigation
    iii. a facilitated process of relating science and practice
- Follow(s) four functions (Scholz 2011)
    i. Capacity building (for scientists and practitioners; Häberli & Grossenbacher-Mansuy 1998)
    ii. Consensus building, primarily on what is the "problem" (Scholz 2000)
    iii. (Analytic) Mediation, i.e., anticipatory management of losses and benefits of (sustainable) transitions/transformations
    iv. Political legitimation
- Is based on mutual learning by relating and/or integrating different epistemics, e.g. (see Figure 4)
    i. knowledge and values (e.g., modes of validation) from practice in science and from different perspectives
    ii. Modes of causation and validation from different modes of science (Id and Mode 1 Td)
    iii. Different cultures (e.g., in stakeholder mitigation)
- Asks for theory-practice discourses with equal rights when accepting the otherness (of roles and knowledge) of the other which can be best realized by co-leadership
- Provide socially robust orientations (not solutions) which are of interest for practice and sciences

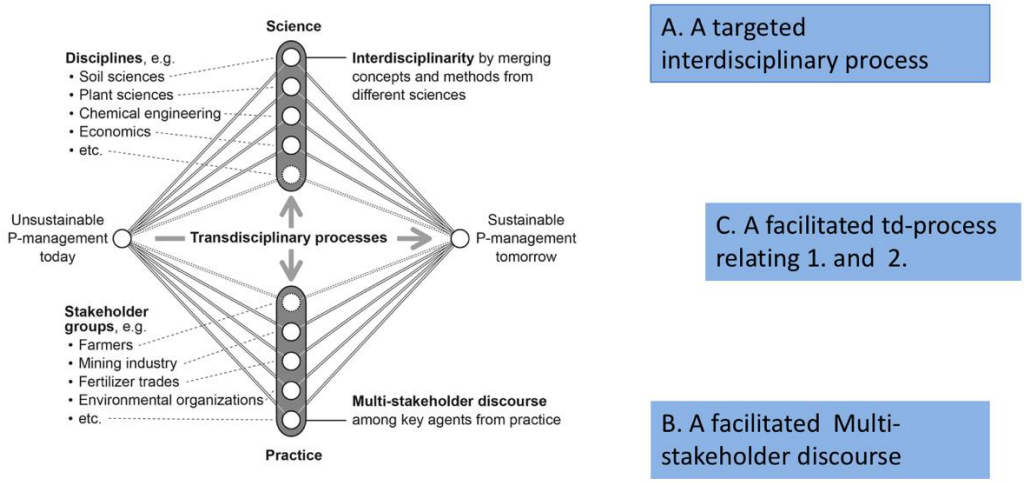

Figure: Mains streams (a, B, and C) of a transdisciplinary process

Unsee(n) (Unintended Side Effect)

The ERT-SDE focus on the unintended feedback loops of digital technologies on social, environmental, economic, political, ethical, and other systems. One interesting issue is to design research (programs) that allows us to anticipate these unintended side effects (the Unsee(ns)) in order to plan and activate responses. We argue that there are many social mechanisms of unseeing related to the Unsee(ns).

Please note that unintended side effects are not the barriers which harm development.

The following definition just distinguishes barriers from unseen(ns) and distinguishes between unseens on the same system (e.g. delayed economic rebounds) and unseens on other systems.

A formalized definition of unintended side effect

The digital transformation DT makes governmental policy system (probably) smarter, more evidence based, etc. (etc. means a set of different properties according to 1. and 2.). The intended impacts are called B_{pol}^{+}

(1) $A = DT \rightarrow v(B_{pol}^{+})$

The transition "→ " is linked to a couple of barriers $D_1, D_2, \ldots, D_m, \ldots$ We chose the label D_m as a barrier can also be seen as a **d**efector. Thus the intended results on the policy system (*pol*) is seen as a subsystem of the societal system. Thus, we can formally consider the valued state of a political system given a certain process (and stage) of the digital transformation DT and of (states of) barriers $D_1, D_2, \ldots, D_m, \ldots$

(2) $v(B_{pol}^{+}) = f(A, D_1, D_2, \ldots)$

Usually certain each barrier is subject of various compensatory actions. Formally, we denote the action that are taken to reduce or pass denote D_m as $M_{m,1}, M_{m,2}, \ldots$

The management of coping with the barriers is different from mitigating the or adaptating of the unintended side effects.

Given a certain process of the digital transformation (and a certain sets of barriers and means to cope with the barriers), the unintended side effects consist of

a) the undesired side effects on the political system $v(B_{pol}^{-unint.})$

b) the unintended side effects on other systems $v(B_{polother}^{-unint.})$

Other systems can be the economic, environmental, social identity, or other dimensioned system.

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