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A theoretical essay on socio-technical systems design thinking in the era of digital transformation

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Abstract
Digital technology is here to stay. Currently, digital technologies are unleashing the fourth industrial revolution. This so-called digital transformation is about the integration of digital technology into all areas of society. Within organisations, work is fundamentally changing which impacts how organisations will operate and deliver value to customers. Furthermore, but often forgotten, it is also about a cultural change that requires organisations to continually challenge their status quo, experiment, and get comfortable with failure.
Digital possibilities are emerging which cannot be viewed separately from social effects in organised (eco-)systems and for people in those systems. The challenge is to jointly optimise technical and social aspects for creating both added value in a sustainable manner and improve quality of working life. As we have an 'organisational choice', technical possibilities can be aligned with social needs and requirements, and vice versa. This alignment forms the basis of socio-technical systems (STS) thinking, which is necessary for developing sustainable organisational solutions. Sociotechnical theory and practice originally have a focus on optimising social and technical aspects in organisations. Therefore, we choose in this essay for an STS perspective, especially for the STS Design (STS-D) approach which is elaborated by the Lowlands STS school of thought. As digital technologies offer new affordances and constraints for organisational design, we aim, with this essay, to merge STS-D with digital thinking.
We start with a brief sketch of the understanding of current digital technologies. After this, we discuss organisational design in terms of the division of labour and the penetration of digital technology into the nature of work. Then, the STS-D's core design principles and design sequence, specifically from the Lowlands school of thought, are introduced and adapted for digital thinking. This is followed by a section on design routines for unlocking the potential for designing future, digital-receptive workplaces and organisations. We end the essay with some closing remarks and reflections.

Keywords Socio-technical systems design · Digital transformation · Designing organisations · Workplace innovation · Design routines and sequence · Quality of working life · Quality of organisation · Division of labour · Agile organisation.

1 Introduction

With increasing global competition and predicted labour shortages, organisations today face the dual challenge of creating workplaces that are, on the one hand, more productive, agile and innovative, and, on the other hand, aims at healthy workplaces that focus on a high quality of working life. This points to the need for workplace innovation to transform traditionally siloed organisations into modern, 21st century organisations that can meet these challenges. In the manufacturing sector, the term Industry 4.0 is widely used to frame this (Kagermann et al. 2011; Liao et al. 2017; Stock and Seliger 2016). Laloux (2014) speaks more generally of reinvented organisations, also referred to as organisational renewal. In these 21st century organisations,

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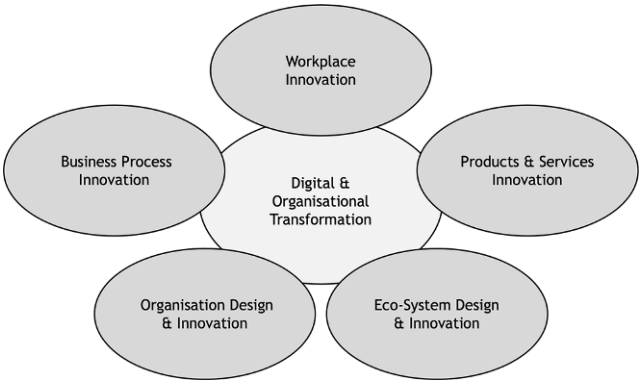

Fig. 1 Digital and Organisational Transformation. (Inspired by Clauss and Scheffler 2021; Oeij et al. 2017; Schwab 2017; De Sitter 1994)

the human factor continues to play a crucial role. However, he calls for social innovation of the workplace (Oeij et al. 2017), with a focus on structural change (through the division of labour) and cultural change (in terms of empowering employees). The objective is to enable employees to participate in organisational change and renewal, thereby improving the quality of working life and organisational performance. Socio-Technical Systems Design (STS-D) theory is based on agile, instead of siloed organisational forms, and therefore STS-D could help to transform these traditional, inflexible organisations that have limited capacity for innovation due to conservative mechanisms (Fruytier and Van Amelsvoort 1991). However, traditional silo organisations are defined by and embedded in their structures, support systems, decision-making systems, facilities, and IT systems (Van Amelsvoort 2000). These organisations are, due to their focus on maximum division of labour and central control of work processes, designed for stable environments and mass production. They are therefore not well suited to respond to the need for agility in dynamic environments with ever-changing customer requirements. An integral approach to the systemic transformation of organisations is therefore urgently needed to achieve agile ways of organising and working.

Digital technologies, at the same time, are in the spotlight and are unfolding at a fast pace. They offer new, unprecedented digital and technological opportunities to market new business models and related products and services (Osterwalder and Pigneur 2010; Teece 2010, 2018). To fully utilise these opportunities, organisations should be able to cope with these technical features by jointly optimising technical and social features in their context (Walker 2018). This implies that, besides the technical aspects, improving quality of organisation and quality of working life should be considered as well. STS-D theory has a long-standing tradition in jointly optimising both social and technical factors resulting in more and lasting effective organisations. Merging digital thinking and STS-D thinking is a promising arrangement for digital and organisational transformation, in order to deal with innovation challenges, such as workplace innovation, product and services innovation, business processes innovation, organisation design & innovation, and eco-system design & innovation. Figure 1 visualizes this by emphasizing the coherence between innovations. In STS terminology the term integral is used to signify coherence (De Sitter 1994). It states that aspects should not be dealt with separately, and afterwards integrated. Instead, the focus should be on the whole, which sets the overall framework for these aspects.

Digital transformation affects the design of jobs, the design of organisations and the interactions and partnerships between organisations and stakeholders such as customers, suppliers and governments. At the operational level, organised networks, supported by digital platforms, are developing that aggregate organisational relationships and services, creating 'blurred boundaries'. Data is also growing in importance. Decision-making in organised networks is becoming more data-driven: evidence is extracted from data to make decision-making more rational. Based on a combination of big data and artificial intelligence, some of this decision-making is becoming automated (Dhondt and Dessers 2022; Lepri et al. 2017). As a result, some tasks are taken over by machines, 'human-machine' cooperation increases, and new tasks emerge. Until now, automation has mainly taken over routine execution tasks. Today's digital technology also allows non-routine 'thinking' tasks to be taken over. We will return to the changing nature of work later in this essay. It is important to recognise that all these developments have profound implications for people, and therefore for the design of workplaces, and for the structures and cultures of organisations and organised networks.

Since its beginnings, STS has been committed to developing solutions for humane and productive workplaces and organisations. STS has its roots in the work of the Tavistock Institute in the 1950s and 1960s (Trist and Bamforth 1951; Emery and Trist 1969). Two key lessons emerged from research into the implementation of new technology in the Durham coal mine. First, a focus on technology alone led to lower productivity and a decline in the quality of working life. Second, a participatory approach with a simultaneous focus on technology and social aspects led to improvements in both productivity and quality of working life. This led to the general, original principles of STS: organisation as an open system (organisations must learn to deal with the external world of stakeholders), organisational choice (there are alternatives to classical Taylor-based organisations), joint optimisation of social and technical aspects, and participatory design. Today, in the digital world, we face challenges similar to those in the Durham case: how can digital transformation increase both productivity and the quality of working life? In our view, digital

Table 1 Digital technologies (non-exhaustive list)

Digital technology	Brief explanation
Internet of Things	describes physical objects with sensors, processing ability, and other technologies that connect and exchange data with other devices and systems over the Internet
Big Data	refers to large data sets used to computationally reveal patterns, trends, and associations
Artificial Intelligence	is the ability of digital machines to perform tasks commonly associated with intelligent beings
Machine Learning	is a form of inquiry devoted to understanding and building methods that 'learn', that is, methods that leverage data to improve performance on some set of tasks
Digital Platform	is a software-based online infrastructure that facilitates interactions and transactions between users
Virtual/Augmented Reality	is a computer-generated environment appearing to be real, making the user feel they are immersed in their context
Blockchain	is a distributed database that maintains a continuously growing list of ordered records, called blocks
Smart Device	is an electronic device, generally connected to other devices or networks via different wireless protocols that can operate to some extent interactively and autonomously
Robotic	is a programmable machine that can complete a task, while the term robotics describes the field of study focused on developing robots and automation

transformation must go hand in hand with organisational transformation; in other words, STS-D and digital thinking need to be merged.

Over the years, different points of attention in STS-D have developed in various directions world-wide: for example, the focus on participative design in the USA, Canada and Australia, democratic dialogue in Scandinavia, and organisation design in the Lowlands (Van Eijnatten 1993; Mohr and Van Amelsvoort 2016). All have in common the design of modern organisations that are humane, productive, agile and innovative (Mohr and Van Amelsvoort 2016). In this essay we take the Lowlands' (Netherlands and the Dutch speaking part of Belgium) STS-D view, in which the division of labour is central, (De Sitter et al. 1997; Vriens and Achterbergh 2011; Kuipers et al. 2020) to show how digital and organisational transformation could be merged from a design perspective. An international, well-known example of STS-D in practice is Buurtzorg (Hamel and Zanini 2020) without using STS-D terminology in their outreaches. We consider division of labour to be key as it offers a common starting point for both digital and organisational design: the division of a core work process into tasks and roles and allocated to people and machines leads to designing execution tasks and related regulation tasks.

The STS-D thinking has developed into an approach for designing productive, humane, and innovative workplaces and organisations. Building on its design principles and design sequence, an advanced STS-digital approach is emerging for jointly optimizing the disruptive features of digital technologies with social requirements for designing 21st century workplaces and organisations.

Building on these emerging efforts and insights, in this essay we present an advanced STS-D theory by focusing on how digital thinking can be incorporated into the design of work and organisations. This is a relevant topic because the transformative nature of digital technologies on economic systems, organisations and people (McAfee and Brynjolfsson 2017; Brynjolfsson and McAfee 2014) has a 'blurring' effect on organisations, jobs and work relations. The systemic boundary between what is inside and outside is becoming more fluid. In addition, the distinction between executive and regulatory tasks performed by humans and machines is becoming more fluid as well. This will significantly change the design of jobs in the digital age. Consequently, these blurring effects should influence the design sequence of STS-D. We therefore believe that designing "joint optimisations" between digital technologies and collaborative people requires digital affordances and constraints to be built into the organisational design from the outset.

We start the essay with our understanding of digital technology. Next, we discuss division of labour and the penetration of digital technology in the nature of work. Building on STS-D principles and the understanding of digital technologies, we continue with incorporating digital technology in the STS-D design sequence. To avoid the inertia of conservative organisational thinking and to stimulate thinking for and from the future, we introduce absurd reverse thinking and design routines for effective digital and organisational transformation. The essay evolved from our previous work on the integration of STS-D and digital technology and builds on these developments (Govers and Van Amelsvoort 2018, 2019).

2 Digital technology and transformation

Digital technology is an umbrella term referring to technology that relies on the use of microprocessors, (hence devices, algorithms and applications that are dependent on computers), to store, process and interpret digitized data. Examples of digital technology are smart devices,

robotics, artificial intelligence, machine learning, internet of things, big data, block chains, virtual and augmented reality. Table 1 sums-up a non-exhaustive list of digital technologies. For this essay focusing on STS-D in the era of digital transformation, digital technology is important as it affects the interactions and division of labour between humans and machines.

We distinguish three perspectives related to digital technology. A first perspective is about *technological areas* in which digital technology has been developing. According to Moore's Law (Moore 1965), digital capacities double every two years, though the cost of digital technologies is halved. For instance:

- Computing developments: hardware and software capabilities are increasing in rapid phase and becoming easier to work with.
- Data developments: vast amounts of data—structured and unstructured—can be stored, processed, and interpreted.
- Connectivity developments: physical systems—computers, mobiles, sensors, and machines—are interconnected via an ever-growing internet network.

A second perspective is about the *features* in which digital technologies have developed (Bounfour 2016). For instance:

- Real-time: results of processed data are becoming instantly available without time delay.
- Anywhere, anyplace: humans can collaborate via digital technologies independent from time and place.
- Intelligence: simulation of human intelligence with machines able to think and act like humans and mimic their actions like learning, recognizing, predicting and decision-making.

A third perspective is about *digital transformation* which is part of the fourth industrial revolution (Prisecaru 2016; Schwab 2017). Schwab (2022) explains the four industrial revolutions as follows: "*Like the First Industrial Revolution's steam-powered factories, the Second Industrial Revolution's application of science to mass production and manufacturing, and the Third Industrial Revolution's start into digitization, the Fourth Industrial Revolution's technologies, such as artificial intelligence, genome editing, augmented reality, robotics, and 3-D printing, are rapidly changing the way humans create, exchange, and distribute value*." In digital transformation, digital technologies are being integrated into all aspects of society (Hanna 2016; Harari 2018). As a result, relationships and interactions between actors are fundamentally changing. While the digital transformation has been referred to as the fourth industrial revolution, it passes through roughly three stages of digital evolution (Maltaverne 2017):

- The first phase is digitisation. This is the transformation of analogue data media (paper) into digital media (databases). This phase started in the 1960s and is still ongoing.
- The second stage is digitalisation. This involves adapting digital technology to business processes. The massive introduction of transactional and management information systems, such as Enterprise Resource Planning (ERP) systems, in the late 1980s marks this phase. This phase is still ongoing.
- The third phase is transformation. This is where new business models are created based on the ability of digital technology and platforms to integrate business processes. This third phase fundamentally changes the way organisations operate and how they deliver value to customers. It is also about changing the way they think about organisation and management and learning to look at it more holistically.

Technological areas and features come together in digital solutions by building on each other. Digital solutions tend to be more disruptive when more areas and features are combined in a concrete digital solution. In other words, digital transformation occurs when multiple technological development areas and features create 'a perfect storm' for developing previously impossible business solutions (e.g., Rogers 2016; Evans 2017). Through such perfect storms, digital technologies are gaining and playing a different role in organisations and interactions: from working *with* digital technologies to working *in and through* digital technologies.

Digital-triggered business models are transforming and disrupting existing industries. According to the European Commission (2018, p. 1): '*digital transformation holds the key to unlocking future growth in Europe*'. Nonetheless, there are also threats, as it can potentially overthrow existing business models and associated products and services: the so-called disruptive effects of digital technology (Mayer-Schönberger and Ramge 2018). Drawing inspiration from Sombert (1863–1941), economist Schumpeter (1883–1950) in the 1930s spoke of the process of creative destruction: successful applications of new technology destroy old professions and create new ones.

For digital technologies to land effectively and productively in organisations, organisational questions must be answered. For example:

- What new ways of interacting in the workplace do digital technologies offer for different forms of collaboration between the customer organisation, employees, and managers?
- What are the implications for organisational quality (efficiency, quality, flexibility, innovation, and sustainability) of the use of digital technologies?

- What does the use of digital technology imply for the quality of working life (challenging and active work for people)?

To use the possibilities of digital technologies, it is essential to rethink and design new ways of organising the work system. Therefore, we should elaborate first on the fundamentals of designing organisations adapted for digital thinking, namely: the division of labour in relation to quality of organisation and quality of working life. In the next section we start addressing this by means of division of labour as a core design step.

3 Designing: division of labour

To understand the implications of digital technologies on work systems, we use the STS-D focus on the concept of division of labour. In producing a product or providing a service, an organisation must design its core work processes in a way that creates value for the customer (Van Amelsvoort and Van Hootegem 2017). The design of core work processes defines the degree of coordination required and the possibilities for self-organisation. A maximum division of labour creates the need for central coordination and hierarchical control, while a minimum possible division of labour creates conditions for self-organisation and horizontal coordination (i.e., more job autonomy). Organisations based on maximum division of labour accommodate fairly stable environments with limited product variations produced in large numbers. As demands for flexibility, innovation and competition for talents intensify, maximum division of labour runs into its limits. In such contexts, agile, flow-based organisations based on the smallest possible division of labour are more effective (Kuipers et al. 2020). In other words, division of labour constitutes an organisational choice to be productive in a more stable or more dynamic environment, as shown in Table 2.

While dividing labour, STS makes a distinction between execution and regulation. Regulation is the mix of control of work (coordination, monitoring and reducing interference) and organising work (norm setting, planning, improving, and designing the work).

Bureaucratic organisations operate on the principle of maximum division of labour, which in turn leads to complexity and rigidity (Achterbergh and Vriens 2009). For a number of reasons, this maximum division of labour is counterproductive. First, bureaucratic organisations are usually featured by (1) simple functions, i.e. the formation of silos between functional departments, each pursuing fragmented goals and interests, and (2) complex interactions, i.e., long hierarchical lines of communication, central decision-making and a large number of rules and meetings. Bureaucracies have many nodes and are therefore vulnerable to the risk of significant interference in core work processes when work cannot be executed as originally planned. Consequently, if the external pressure on the organisation that threatens the planned process intensifies, bureaucratic organisational design will quickly result in productivity problems. These problems can materialise in different ways (Kuipers and Van Amelsvoort 1990; De Sitter 1994; Kuipers et al. 2020):

- unreliable and long lead times due to poorly harmonized processes;
- slow response times;
- difficulty in quality assurance due to insufficiently managed processes and poor communication;
- poor cost control because actual (hidden) costs cannot be monitored and (too) much interference occurs;
- slow and blind decision-making;
- expensive coordination and control mechanisms;
- lack of employee involvement;
- lack of innovative capability due to poor communication between the functions, and a lack of initiative.

In general, the traditional, bureaucratic response counterproductive to these problems is to tighten control by means of centralisation and implement more stringent rules and procedures. These measures are counter-productive because the root cause of these dysfunctions is, in fact, deepened. In contrast, STS-D aims to reduce complexity by minimising

Table 2 Organisational choice: maximum and minimal possible division of labour. (Based on: Kuipers et al. 2020)

	Maximum possible division of labour	Minimum possible division of labour
Demands	Efficiency	Efficiency plus quality plus flexibility plus innovation plus meaningful jobs and plus sustainability
Organisational Design	Mass production	Custom made
	Economy of scales	Economy of human scale
	Simple jobs	Complex jobs
	Separation execution and knowledge work	Mixed execution and knowledge work
	Command and control	Self-organisation and trust
	Hierarchy (vertical coordination)	Network (horizontal coordination)
	Closed work systems	Open work system
	Uniformed systems (one size fits all)	Variety in systems

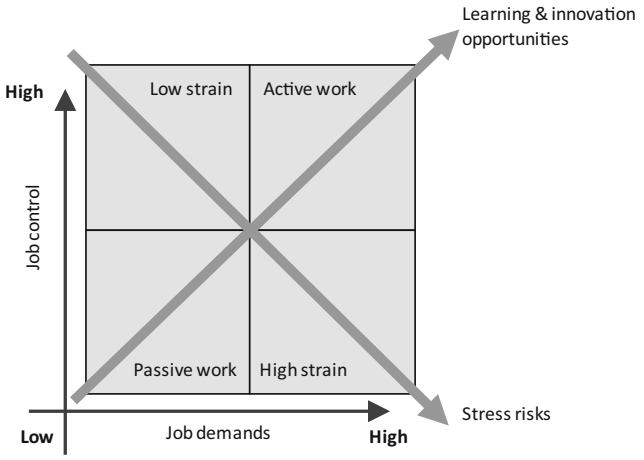

Fig. 2 The Job Demand Job Control model of Karasek (1979; Karasek and Theorell 1990)

the division of labour; more on this in the section on STS-D principles.

The division of labour impacts not only productivity but also the quality of working life; considering for instance Karasek's Job Demand-Control model (Karasek 1979; Karasek and Theorell 1990). In this essay, we are translating Karasek's job control into the more common STS term regulation—as defined earlier. Figure 2 argues that work organisation, in particular a high degree of control (autonomy) in performing tasks is crucial for transforming task demands from risks and stress triggers into learning opportunities.

In this model, job demands are viewed as stressors such as work overload, unpredictable demands, time pressure, role ambiguity, interference, and emotional and physical demands. Job control combines autonomy, decision space, instrumental support from colleagues, constructive feedback on performance, professionalism, flexible resources, appreciation and support from leaders, accurate information and communication. In this context, there are indications that high task demands, and low job control are important predictors of psychological stress and absenteeism. Moreover, De Sitter (1994) argues that high job control leads to commitment and motivation, which translates into positive effects on indicators such as absenteeism, turnover, and stress. In addition, there are indications that a combination of high task demands and high job control in the form of active work is a predictor of an innovative organisation (De Sitter 1994).

In short, job control constitutes an important predictor of employee engagement and, as such, an important point to keep in mind when introducing digital technologies. In fact, STS-D argues that increased job control encourages workers to learn, allows them to cope more effective with disturbances and therefore prepares them better to respond to challenges arising from task demands. This increased level of job control not only impacts employee engagement, but also benefits the organisation by enabling better mobilisation and development of human talent (De Sitter 1994), thus enabling the goals of an agile organisation. Therefore, in our view, the application of digital technology should have regard to the control possibilities of all stakeholders.

A key difference between mechanisation and automation versus digital technologies is that digital also affects executive and regulatory tasks. AI, for example, is being increasingly harnessed to control processes, and in certain areas does so better than humans (McAfee and Brynjolfsson 2017). While technology in general used to target routine—repetitive and simple—tasks, digital technology is rapidly entering the field of non-routine—complex and professional—tasks as well. Tursunbayeva and Renkema (2022) show, for example, how AI can have both positive and negative impacts on the (non-routine) work of health professionals and consequently on their quality of working life.

From a theoretical perspective, we believe that the distinction between execution-routine and routine-non-routine is too coarse for designing work and organisations in a digital environment. Therefore, in 2019, we launched a modified model for the nature of work (Govers and Van Amelsvoort 2019); see Fig. 3. Work is specified by two dimensions: complexity of work and the elements of work. Complexity can consist of repetitive, deductive, and exploratory. Elements comprise of executive and regulatory work (i.e., controlling and organising task elements). The specific types of complexity and elements are illustrated in Fig. 3.

In our opinion, especially intelligent digital technologies can develop potential to penetrate into all work elements of repetitive work and into the regulating work elements of deductive and maybe even explorative work. Malone (2022), for instance, identifies four roles for digital technology to interact with humans which indicate levels of interaction intensity between digital technology and humans:

- *Tool*: the role where computers perform tasks given to them monitored by humans. For instance, a word processor is a tool to support humans in their work.
- *Assistant*: the role where computers perform tasks without direct attention of humans. For instance, IBM's Watson technology processes vast amount of medical literature which is used to support a doctor diagnosing a particular medical case.
- *Peer*: the role where computers perform tasks very much like what humans do. For instance, a computer completely handles an insurance claim received by an app, from receiving the claim till automatically paying the

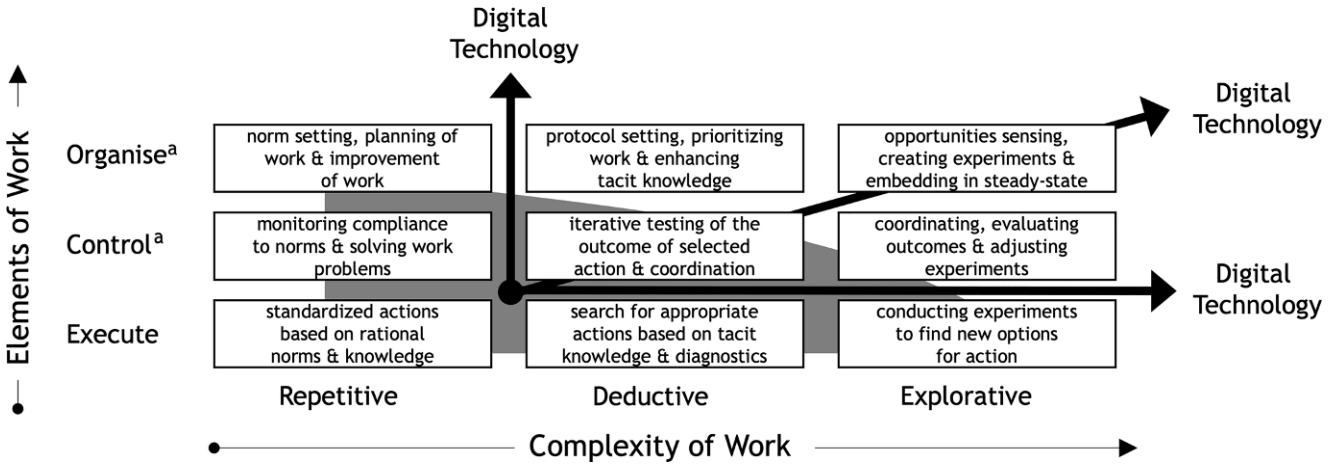

Fig. 3 Penetration of digital technology into the nature of work. (Based on: Govers and Van Amelsvoort 2019. [a]Organise and control are together called regulate in STS)

claim within seconds, if the claim is within a set of parameters.

- *Manager*: the role where computers perform tasks to manage humans. For instance, a workflow system that assigns tasks to people and monitors due dates.

Projected onto our model of the nature of work, we expect that these roles will penetrate the three types of work differently. Repetitive work is expected to be more affected by these roles than deductive and explorative work which are more complex of nature. Figure 3 illustrates the penetration level of digital technologies in work highlighted by the wave in the background and the bold arrows of the figure.

Work is more and more a combination of humans and digital machines working and interacting together. From an STS perspective, it is essential that the human part of work consists of sufficient regulating and organising elements—in Karasek's terminology, sufficient job control. The insights from Karasek's model (Fig. 2) are essential for overseeing the effects on jobs design during the design process to guarantee quality of working-life when introducing digital technologies into workplaces and organisations (Fig. 3). To elaborate further on the STS design sequence and routines adapted for the impact of digital technologies, we first need to explain STS-D principles.

4 STS-D principles

Apart from strategic decisions, we need robust organisations, based on the smallest possible division of labour, that are able to meet the demands of adapting to new technologies and winning the war for talent, as well as being sustainable, flexible and innovative in a dynamic world. From the STS-D perspective, robust organisational design is based on the following five design principles, which form the basis of the design sequence (Van Amelsvoort 2000). Reducing complexity in the division of labour (*Principle 1*) in core work processes by focusing on multiple homogeneous customer families with different needs rather than specialised functional departments is important. Reducing complexity can be achieved by introducing parallel process flows in work units as building blocks (i.e., focused factory or factory within a factory or between factories or a network within a network). Parallel work units (a) provide a better business focus, (b) create the conditions for self-organisation and local regulation and horizontal coordination (see also the next principle), and (c) can apply customised technology. This parallelisation, as it is called in STS-D, is defined as the creation of parallel order flows based on different customer families (e.g., markets, product types) in work units combining execution and regulation. It involves identifying customer families (orders) that are homogeneous in terms of business requirements and therefore impose identical constraints on the execution of the core work process. In order to identify these customer families, criteria for the division of customers into relatively homogeneous subgroups with different strategic requirements must be identified. For example, a construction company builds tangible products. The renovation of a house or the construction of a hospital, on the other hand, are completely different core work processes with different strategic requirements. A miniature organisation can therefore be built around these subsets of customer orders (i.e., one for renovating houses and one for commercial buildings), so that each completes the process from a to z for this group of customer orders. Customer-centricity can also be applied to digital technology. Parallel work units are designed, with each unit having maximum interdependence within the flow, but minimum

interdependence between flows. This implies the design of whole tasks with activities close to each other and the creation of self-organising (virtual) teams, work units, work communities or networks in an ecosystem with a smaller human scale. Complexity in core work processes is reduced by breaking down flows into whole task parts. With the human scale (*Principle 2*) in mind, (virtual) whole task teams of 8–10 people, work communities of 40–50 people and units/networks of up to 200 people can be designed (Kuipers et al. 2020).

Within these organisational building blocks: the principle of self-organisation (*Principle 3*), local (functional and team) regulatory capacity and horizontal coordination can be enhanced. An effective and healthy hierarchy (*Principle 4*) is designed to handle turbulence and interference, and different levels (i.e., organisational layers) add value in terms of operational, tactical, and strategic regulation (Jaques 1990). In terms of human task control (i.e., quality of working life), digital technologies can contribute to more self-organisation and horizontal coordination.

Finally, organisational design also refers to the need for congruent system technology, infrastructure (facilities), procedures and support systems based on minimum critical specification (*Principle 5*) (Cherns 1987). Principle 5 of STS contrasts with the bureaucratic principle of 'one size fits all'. Because the parallel building blocks in the organisation have different business requirements, they will also have different system requirements. Govers (2003; Govers and Südmeier 2016) conceptualised this in the so-called archipelago IT architecture. For example, teams of technical people working on the shop floor and administrative teams working in the office will have different requirements for technology and support systems. Therefore, the design of different support systems should follow the organisational design described above. Furthermore, their design should be based on diversity rather than 'one size fits all', and the focus should be on support rather than control.

With the abovementioned STS principles in mind, we elaborate on the STS-D sequence adopted for the impact of digital technology affordances and constraints; in short: STS-D Design Sequence Adapted for Digital Thinking.

5 STS-D design sequence adapted for digital thinking

According to the general STS principles of open-system and organisational choice, the design of organisations should be strategic and should include all stakeholder of the eco-system. This contrasts with the limited focus on shareholder value alone often witnessed in traditional, bureaucratic organisations (Achterbergh and Vriens 2009; Pasmore et al. 2018). To discover the different stakeholders, the system boundaries of the organisation and the environment should be determined and can be changed during the organisation design process.

The *first step* in the design process is to make strategic choices. From the STS-D perspective, diagnosing, designing, and changing organisations is based on considering environmental conditions and strategic business choices. These strategic choices, in turn, set the requirements for the organisation—the "burning platform"—and dictate the desired direction (see also Adler and Docherty 1998). It is highly recommended that the design is prepared in co-creation with the various stakeholders within the boundaries of the given ecosystem. After all, the best guarantee of success is to bring the whole system into the room (Weisbord 2004). This points to the importance of employee involvement, a hallmark of workplace innovation. In the traditional STS-D theory of the Lowlands, strategic thinking is the starting point and sets the requirements for the design of the organisation and the design process. From a digital perspective, strategic thinking remains the starting point. But as digital technologies provide previously impossible capabilities and conditions for novel business models, strategic decision making becomes an integral part of an ongoing (re)design process. For these digital features and conditions, we are inspired by the technology affordances and constraints theory (Majchrzak and Markus 2014). Affordances suggest the range of possibilities that digital technologies offer, and constraints sketch the limitations of digital technologies which can for instance be organisational, social, or human. To prevent conservative forces from holding back organizations in leaping forward in their vision triggered by digital technologies possibilities and without being blind for their limitations, we suggest enriching the strategic choices step of the organizational STS-D sequence with absurd adverse thinking which is explained in the intermezzo below.

Intermezzo: absurd reverse thinking for making strategic choices inspired by digital thinking

Despite the fact that digital possibilities seem endless, the high expectations do not always come true. In practice technology -ush strategies often end in disappointment. This is usually not due to digital technology itself. It is mainly due to (1) the unfamiliarity with the possibilities of digital technology, (2) the lack of an underlying vision for new business models achievable through digital technology, (3) inertia due to lack of inspiration and creativity to go beyond the current ways of thinking, and (4) conservative mechanism in bureaucratic organisations (Fruytier and Van Amelsvoort 1991). To help organisations to overcome these challenges, we propose—inspired by Govers and Steuns (2020)—to integrate absurd reverse thinking in the strategic deci-

sion-making phase of the STS-D sequence. How does this work? Every organisation is grounded in one or more business models: think about treating patients at a hospital and transporting customers by taxis. Such business models are characterized by a number of crucial business principles that determines their added value and thus the core of their existence. Most organisations and sectors have developed over years successful business models in which digital technology plays a supporting, but not yet a determining role. The transforming and disruptive effects of digital technology lie in the fact that those enable new business models that were previously unthinkable. Yes, they even seemed absurd. In an organisation's current business models—however paradoxical it may sound—there are the seeds to disrupt the organisation by transforming itself with digital technology. By focusing on the 3 to 5 crucial principles on which a present business model is grounded and reversing these as absurdly as possible per principle, the contours of new business models emerge for creating new value for customers. These business models may seem impossible and unrealistic. However, by examining how digital technology can make absurd business models realistic, new directions surface out of the current business model. For example, an organisation can start from the following three digital technology areas: (1) data technology to distil information from business operations to improve business processes, or (2) intelligent algorithms that can support real-time decision-making or make autonomous decisions, or (3) platforms with which actors in the ecosystem can be linked and in which technology plays a dominant role in the design and objective of the platform for tracking and tracing, payments and communication. To illustrate the absurd reserve thinking in a nutshell, we present the following mini-example for a hospital:
– Current principle: diagnostics are performed at the hospital; therefore, the patient comes to health care provider.
– Reversal: diagnostics goes to the patient by applying the anywhere, anyplace feature.
– Required digital technology: wearable technology collects data, and doctor monitors remotely and in real-time.

Recognising that digital technologies create opportunities for new business models and therefore new processes, tasks and roles, the original STS-D sequence should be further adapted. Originally the strategic choice step was followed by the design of the production, control, and technical systems structure. We suggest enriching the whole design journey by adapting it for the affordances and constraints of digital technologies (Majchrzak and Markus 2014) in each of these design steps of the journey. After this STS-D strategic decision-making step adapted for digital technology affordances and constraints, we suggest a distinction is made between designing the core work system (design step 2), designing the regulation system (design step 3) and realising the selected digital infrastructures and systems (design step 4) in which the core work systems and its regulation can function. It is only a descriptive distinction; in practice the design process has a non-linear, dynamic character. The design sequence, however, gives a logic in designing organisations and prevention of chaos. The new STS-D sequence is based on the slogan 'digital thinking inspires vision and organisational design options' which fits with the well-known slogan 'first organise, then automate'. Digital technologies make it necessary to simultaneously discover digital affordances and constraints with the design of the core work system and its regulation before realising digital infrastructures and systems.

The second step is to design the core work system, or how an organisation produces its products or services. The focus is on the ordering and coupling of execution tasks from the perspective of the nature of work (Fig. 3). Assuming that the strategic positioning, such as the need for flexibility, innovation, and healthy work, has been done as a starting point, the first design activity is to design the core work process. It starts with sorting customers into customer families or product families that have different requirements. For each family, the different processes should be mapped. With these process maps, we can now explore the possibilities offered by digital technology: which tasks in the process can be replaced by (digital) technology, which new tasks arise, which tasks are performed by people (employees or customers). Building on this, the (new) processes can be organised. *It is also possible that new products/services or new customer families emerge from digital technology opportunities*. As a result, strategic choices can be discussed again. In any case, this design of the core work system is done by focusing on the big picture and then on the details (i.e., first on the whole, then on the parts). Based on the different customer families with different requirements (see Principles 1 and 2), this means starting with the design of the different (business) units, then the different departments within these units, and finally the design of the work teams and jobs. By combining the design of the core work system with the scouting of digital possibilities, the *requirements* for the design of digital technology are deepened and the design is theoretically also moved to design step 1 'making strategic choices'. This also applies to the next step, the design of regulation.

The third step concerns the design of the control system. In other words, how the core work processes are organised. From the perspective of the nature of work (Fig. 3),

the emphasis is on the ordering and coupling of controlling and organising tasks. It amounts to a redistribution of coordination capabilities by design in reverse order, i.e., from the parts to the whole. It starts with determining what can be organised at the (lowest organisational) local level (i.e., team and function level). Then what can be organised at the level of a larger organisational work unit, and finally what needs to be organised at the organisational level. Next, the consultation and decision-making structure can be further elaborated. The starting point here is that emerging problems require autonomy to solve them at the level where they arise. This means: the task of managing core work processes should be transferred as far as possible to the lowest organisational level. The possibilities for the application of digital technologies will also be explored. For example, digital technologies offer the possibility of automating or better informing certain aspects of regulation. This in turn may eliminate or provide new 'support' for regulatory tasks previously assigned to humans or enable or require new regulatory tasks that 'augment' human roles. Digital technology also blurs the distinction between execution and regulation. The theoretical design implication is that the design steps 2 and 3—the design of the core work system and the regulation system—should be designed with digital in mind. During these two design steps, the (new) opportunities and possibilities of digital technologies should already be considered—in light of the formulated strategic vision on digital technology (design step 1) and of STS's core requirements of organisational performance and quality of working life. Until now, in Lowlands' STS-D, the design and use of information technology has been a derivative of the design decisions in the second and third design steps. In essence, we argue that digital technology becomes an *integral part* of work and organisational design.

In STS-D, information technology has always been seen as a derivative of first and second design steps (Govers and Südmeier 2016). This is no longer tenable, because digital technology is penetrating more and more deeply into workplaces and organisations. Previously, work was done *with* digital technology; we now work more *in* and *through* digital technology. Digital technology has moved beyond information technology by becoming organisational. Still, the required digital systems must be designed or realised. Therefore, *the fourth step is about the actual realisation of digital infrastructures and systems supporting the designed core work system and its regulation.* It focusses on understanding and developing the various digital systems required by the newly designed work systems and regulation from a strategic perspective. We suggest to working with agile methods like scrum sprints to co-create and co-design systems instead of the traditional waterfall method (Rossberg 2019). This is inspired by the STS principle of incompletion stating that as organisations and eco-systems evolve over time, no design can be considered finished (Emery 1959; Cherns 1987).

It may sound as if the adapted four design steps are in one big design melting pot. This is not the case. On the contrary. What matters is the *order of the design focus* and *the design process*. The sequence and focus on the core work system (design step 2), the control system (design step 3) and digital infrastructures and systems (design step 4) provides clarity for workers and designers designing jobs, work systems and organisations in a participatory way. In steps 1, 2 and 3, the possibilities and limitations of digital technology are actively and deeply explored, and consequently digital requirements can be developed. In step 4, the digital infrastructures and systems are actually realised. The realisation of digital infrastructures and systems is rarely imme-

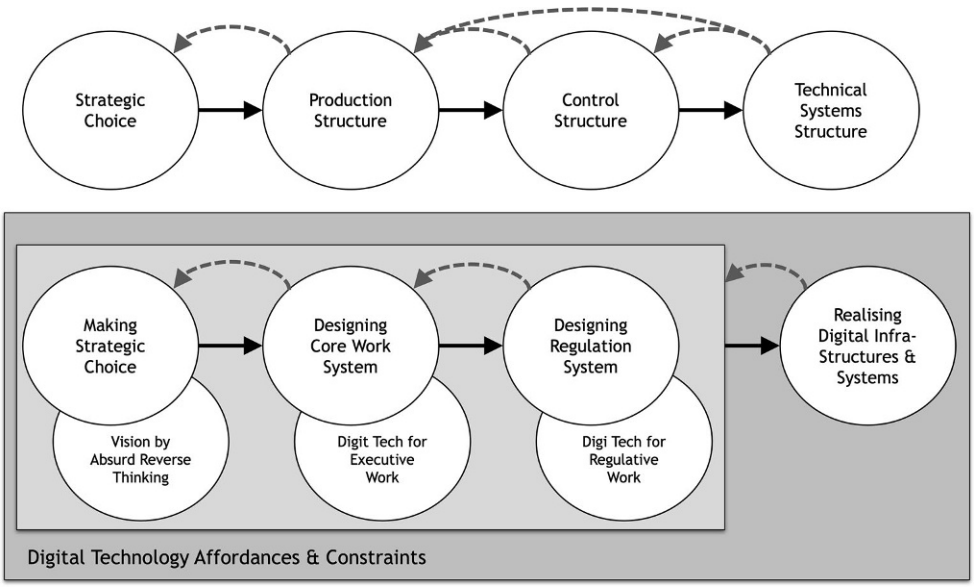

Fig. 4 The Original and New STS Design Sequence

diate; in STS thinking, designs are by definition incomplete and constantly evolving as socio-technical optimisation is a continuous and ongoing process. This is especially true for digital technologies, as digital capabilities are constantly evolving. The capacity for continuous socio-technical optimisation therefore requires new design routines so that workers, digital experts and organisation experts can work together effectively to design humane, productive and innovative organisations.

To summarize, Fig. 4 visualizes the for digital thinking adapted new four-step STS-D sequence.

In the above section the rational of the new STS-D sequence adapted for digital thinking is explained. Still, a transformation is a combination of design and development. In this essay we will not reproduce all the insights of change management theories. Instead, we rather focus on enriching the STS-D sequence adopted for digital thinking with design routines to leap STS-D forward into the 21st century. These detached routines are on itself not new, but the integral combination is, surely in the practice of many organisations.

6 Design routines for leaping the new STS-D sequence forward into the 21st century

In STS, participatory design has been essential from the outset for designing viable human-machine collaborations in agile organisations. In her book Weapons of Math Destruction, O'Neil (2016) demonstrates the urgent need for participatory design. All too often, the algorithms behind big data, artificial intelligence (AI) and machine learning get bogged down in the quicksand of weak correlations that lead to rational outcomes. This becomes a problem when these results are used as causal truths, no longer questioned by humans. Or worse, people use them as rational truths to make decisions. Social undermining can even occur when such algorithms are used by machines in data-driven decision-making, according to O'Neil. To overcome AI's potential dangers, workers, digital experts, and organisational designers should collaborate more closely. This will also create ownership of the new organisation and ways of working. For effective participation, it is crucial that workers understand each other's world and its languages and logics. Without such a common understanding, there is a high risk of undesirable consequences for the joint optimisation and creation of humane, productive, and innovative organisations. In order to better understand the impact of digital technologies on the functioning of organisations and on the quality of working life of people working with and in digital technologies, digital experts could be introduced to STS-D thinking. On the other hand, STS designers could take a greater interest in the workings and mechanisms of digital technologies and the opportunities they create for the design of organisations and workplaces. In our view, an understanding of digital technology should be a necessity for STS-D practitioners, managers, employees and all other members of the design team.

As digital technologies co-determine the design of work and organisation, the languages, and logics of both the digital and organisational worlds must be bridged, if not mixed, in the actual design (Govers and Van Amelsvoort 2018; Pava 1983). In co-determining design, we need to pay attention to customer experiences, operational agility of an organisation, and staff engagement (Govers and Van Amelsvoort 2019).

In addition to the sequence of design questions, we recommend moving away from five dominant bureaucratic design routines and adopting five agile, socio-technical design routines. On the one hand, this is necessary because organisations are faced with increasing diversity and dynamism. This requires routines that support rather than hinder speed of action. On the other hand, it is necessary to find—and to continue to find—the maximum joint optimisation between digital technology and the people who work together. Table 3 outlines the old and new design routines. As already mentioned, these routines are not new in themselves, but the integral combination of them is certainly new in the practice of many organisations.

The five new design routines that need to be learned are critical to the effective landing of digital technology with a positive, transformative effect on networks, organisations, and people. We predict an accelerated and painful end for organisations and professionals who stick to current routines. Transitioning to and from the following five routines is critical for the positive impact of digital technology on organisations and people in organisations.

Table 3 Old and New Design Routines

	Old Design Routines	New Design Routines
1	Functional thinking approach	Process- and chain-focused thinking approach
2	One-fits-all design approach	One-fits-one design approach
3	Expert, top-down & cascade approach	Participatory, exploring & scrum approach
4	'Do more of the same' approach	'Do it differently' approach
5	Conservating of the current approach	Ambidextrous approach

First, move from functional thinking about organisations to process and flow thinking. Based on the needs and desires of customers or customer families, processes are organised into organisational forms consisting of relatively independent units that can respond quickly to customer demand and innovate rapidly. The starting point for the design is the organisation's intended strategy. The primary process and/or primary flow between organisations are the starting point for design.

Second, move away from one-size-fits-all designs. Today's digital technology offers many opportunities to design and implement different customised solutions. This opportunity is still underused because we still think and act too much in terms of the complex and expensive implementation and management costs we experienced, for example, in the ERP era.

Third, move away from the expert, top-down and cascading design approach to a participatory, exploratory and scrum design approach. The dynamics of the environment are so changeable that the traditional approach no longer works; it is too expensive and time-consuming. Instead of elite clubs of (often technical) experts designing a complex IT system and associated working methods top-down, users join IT and organisational experts in short sprints to design, test and deploy organisational and digital processes. In essence, this becomes a continuous design process.

Fourth, move from 'do more of the same' to 'do it differently'. In a continuous design process, it is also important to let go of the myth of best practices. These practices are mostly valuable for the past and the present; they do not inspire the design of tomorrow's processes and organisational forms. Creativity, out-of-the-box thinking and design thinking are new skills that are as important as technical and business knowledge and insight.

Fifth, to move away from preserving current structures, processes and working methods to an ambidextrous approach of perpetuation and exploration. This means that the organisation is increasingly in a state of continuous redesign. At one end, it operates in perpetuate mode, delivering current services and products in an efficient and effective manner. The current processes and organisational forms are organised and managed for this purpose. At the same time, the organisation should ensure that there is a way of exploring the possibility of creating new ways of working, new processes, and new forms of organisation. Otherwise, the development of new services and products will be undermined by current organisational and management principles. In short, organisations and professionals must learn to think and act simultaneously in a perpetuation mode (exploiting the present) and an exploration mode (creating the new). These five routines are not new in themselves, but actually doing them in combination is new and a huge challenge!

7 Conclusion

In this essay, we have proposed a holistic approach to design that integrates digital technologies and organisational design into the STS design sequence. Our starting point is that digital technology is more than just technology. It has evolved into functions and (new) capabilities for the design of work systems and organisations and is an integral part of the STS design sequence. We go further by arguing that digital technologies offer affordances and constraints for organisations and networks in ecosystems to work in and through in realising their strategic choices. We argue, therefore, that STS-D theory must be in step with this development and integrate this thinking into its design sequence. This means that all stages of organisational design should actively incorporate digital technology and absorb digital thinking. This rather than technology following strategy and structure. We also emphasise that digital technology blurs the distinction between executing and controlling. Digital technology may take work away from people. It also creates new forms of work for people. In our view, digital technology is changing the nature of human work, which has implications for the theoretical view of the nature of work itself. Human-machine collaboration is intensifying. In this perspective, maintaining or increasing human work regulation (a combination of responsible autonomy, decision space, instrumental support from colleagues, constructive feedback on performance, craftsmanship, flexible resources, appreciation and support from leaders, accurate information, and communication) is essential for improving the quality of working life. Quality of working life should be constantly monitored during the design process. Digital technology is also blurring the boundaries between organisations. As part of ecosystems, organisations need to learn to work together in networks. And that is why the principle of bringing the whole system into the organisational design space is essential in the organisational design process. The theoretical implications of STS-D work best when they include new design routines needed for more successful participative design. Changing business needs and diverse stakeholders create the need for new ways of organising work systems. Current and future digital technologies can support this; they also have unexpected, disruptive positive opportunities and/or negative effects. As digital technologies continue to evolve, organisations and networks in ecosystems must also evolve, supported by design routines.

A joint optimisation of technical and social aspects, for which we have tried to provide a theoretical basis in this essay, is crucial to exploit these positive opportunities and minimise the negative effects of digital technologies. Smart technology in the workplace also requires smart organisation. We invite both the digital technology community and the organisational design community to further develop

our theoretical attempt in a pragmatic and practical way. It would help and contribute to the empirical deepening and enrichment of the presented digitally advanced STS-D approach. This would unlock the potential of the combination of organisational and digital transformation for future growth that can be of benefit to all stakeholders in modern 21st century organisations and networks in ecosystems.

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